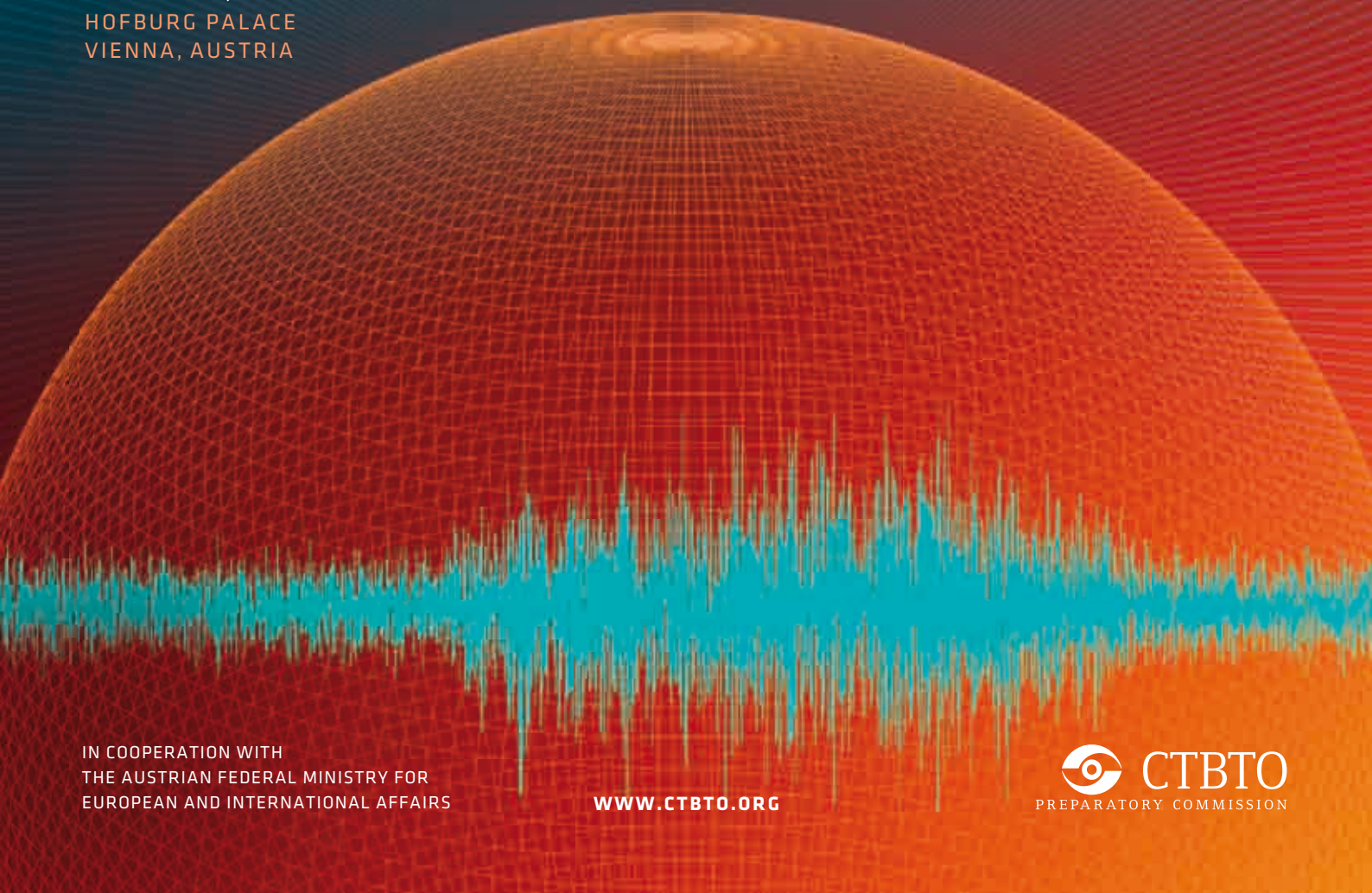
BOOK OF ABSTRACTS

COMPREHENSIVE NUCLEAR-TEST-BAN TREATY: SCIENCE AND TECHNOLOGY 2011

8–10 JUNE

HOFBURG PALACE
VIENNA, AUSTRIA



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CTBTO
PREPARATORY COMMISSION

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"Given the highly specialized technological focus of the CTBT verification mandate, staying abreast of scientific developments may be our greatest challenge as an organization. The constant close interaction with the scientific community is a must."

Tibor Tóth, Executive Secretary of the CTBTO Preparatory Commission, addressing participants during the Opening Ceremony of the International Scientific Studies Conference on 10 June 2009

Foreword

Lassina ZERBO
CTBT: S&T2011 Project Executive

After gaining a Ph.D. in Geophysics (Paris XI – Orsay, France), Zerbo has pursued an active career in research and exploration geophysics with BHP Billiton and Anglo American. He was programme manager for operations and research in various technologies (airborne radiometrics and electromagnetics; airborne gravity gradiometry; 3D seismics and complex resistivity) then Divisional Principal Geophysicist for Africa, based in Johannesburg. Since October 2004 he has served as the Director of the CTBTO International Data Centre Division.

The S&T2011 Programme Committee and the project team welcome you to Vienna for this scientific conference organized by the Provisional Technical Secretariat (PTS) of the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO). The Preparatory Commission is responsible for developing the Treaty's verification regime, whose primary purpose is to ensure that any nuclear explosion is detected, located, and described sufficiently well for it to be identified.

The verification regime includes the global network of 337 stations and radionuclide laboratories of the International Monitoring System (IMS); the International Data Centre (IDC) where data are received, forwarded to States Signatories, processed, analysed and archived; the Global Communications Infrastructure (GCI) for transmitting IMS data and IDC products; and the infrastructure and methodology required to conduct On-Site Inspections (OSIs).

The Treaty and its Protocol impose wide-ranging demands on its verification regime, whose components are being developed and refined against a background of rapid scientific and technological advances since the Treaty was negotiated in the mid 1990s. Nevertheless, the main focus of the PTS is the establishment of a continuous operational capability. It must rely on partnerships with external bodies performing research and development to ensure that the latest relevant advances are brought to a near-operational level of maturity before being tested and ultimately incorporated into the operational effort.

Accordingly, the goals of S&T2011 are to discuss advances in science and technology relevant to test ban verification, to explore scientific applications of the CTBT verification infrastructure, and to encourage partnerships and knowledge exchange between the CTBTO and the broader scientific community. It is essential that the verification effort be enhanced through the adaptation and implementation of new ideas and through the paced adoption of novel technologies; indeed Article IV of the Treaty imposes a requirement for such continuous improvement.

S&T2011 follows the September 2006 Symposium on Synergies with Science, and the International Scientific Studies conference held in June 2009 (ISS09). Ties between the scientific community and the PTS have been progressively strengthened, and several projects are underway that show the benefits of such ties both to the PTS and to the broader scientific and engineering community involved.

In the current world of instant communication, information exchange and globalization, the CTBTO is not an isolated island of international cooperation and investment-sharing. It is, however, unique in its international network of sensors that record and transmit data in real time for the purpose of providing States Signatories with the ability to feel confident that no violation of the Treaty will occur without its being recorded. The strengths of the IMS network and IDC processing are that they will endure as long as the need exists and that the quality, reliability and timeliness of the data and products are paramount to the mission. These strengths provide a powerful instrument to foster the involvement of scientists everywhere, both in support of the science of test ban verification, and in the wide range of civil and scientific applications of IMS data.

Over 300 research contributions and review presentations were received, representing a broad range of original effort. You will find that the reach of the Conference is truly global, and that interest is evident even among scientists from States that have not yet signed or ratified the Treaty.

The abstracts are organized around the five Conference themes:

1. The Earth as a complex system
2. Understanding the nuclear explosion source
3. Advances in sensors, networks and observational technologies
4. Advances in computing, processing and visualization for verification applications
5. Creating knowledge through partnerships, training and information / communication technology

Contributions are both oral and poster; with posters displayed throughout the conference. There will also be an exhibitors' display showcasing some of the technologies used by the CTBTO in its daily work; we encourage you to visit this display and examine the latest sensor and data collection technologies now available from market providers.

A special session will be held on the devastating 11 March 2011 Tohoku earthquake in Japan, its associated

tsunami, and the subsequent emission and dispersion of radioactive particulates and noble gas from the Fukushima nuclear plant. All four technologies currently in use to monitor for nuclear tests at the PTS registered one or more consequences of this magnitude 9.0 earthquake, which offers a dramatic reminder of the vast potential for IMS data to contribute to real-time warning systems and civil applications such as disaster management. Eight tsunami warning centres receive IMS data continuously in near-real-time, but much more could be achieved.

The Conference will also include two panel discussions, which will cover topics highly relevant to the CTBTO's engagement with the scientific community including mechanisms for partnerships with CTBTO and ideas for technology support programmes.

This Conference is part of a continuing process of engagement. It will allow scientists to present and discuss their work, assimilate advances that have occurred during the past two years, and interact with their peers. Much of the work has benefitted from regular technical meetings and workshops that have occurred on a more frequent basis. Such meetings have fostered regular interchanges and cross-fertilization. Some communities of experts relevant to nuclear test ban verification, such as the seismological community and the radionuclide community, have done so for many years and the fruit of their collaboration is evident in the many posters and presentations of this Conference. The infrasound and machine learning communities have made a more recent entrance into this field and have already opened up specializations that show great promise.

We are grateful to individual States and groups of States for contributing financial support for a variety of workshops, targeted projects, and prospective investigations of long-term technical trends. This is a tribute to the interest that States have shown in our endeavor to harness modern technologies and scientific knowledge to benefit peace, trust and stability by verifying compliance with the Comprehensive Nuclear-Test-Ban Treaty.

Contents

Dr Richard Garwin

Keynote Speaker

Almost 50 years after the first hydrogen bomb, code named Ivy Mike, was tested by the United States in 1952, *The New York Times* received a transcript of a recording by Dr Edward Teller, the theoretical physicist who became known as 'the father of the hydrogen bomb' describing the bomb's secret history. "So that first design," said Teller, "was made by Dick Garwin.

Dr Richard L. Garwin is one of the most widely respected scientific advisers to the United States government on a range of issues including the safety of nuclear weapons and arms control. In addition to his key role in the design of nuclear weapons, he has made major contributions to a number of fields such as instruments and electronics for research in nuclear and low-temperature physics; computer elements and systems, including superconducting devices; communication systems; the behaviour of solid helium; the detection of gravitational radiation; and military technology.

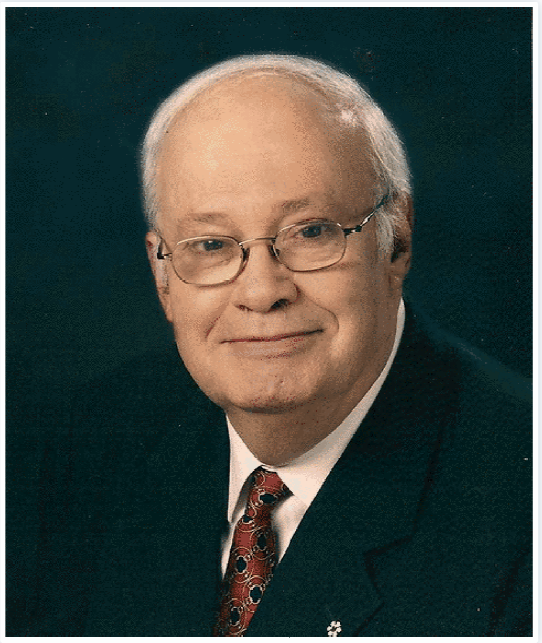
Garwin has also spent much of his career promoting arms control and warning about the need to halt the proliferation of nuclear weapons. In his concluding remarks to the Senate Foreign Relations Committee Hearing on the Comprehensive Nuclear-Test-Ban Treaty (CTBT) on 7 October 1999, Garwin stated: "On the basis of my experience in the nuclear weapons program, I agree with those U.S. military leaders who have reviewed the benefits and costs to U.S. security from a CTBT and strongly support the Treaty. Our national security will be improved by ratification and impaired by further delay. It is thus greatly in our interest to ratify the CTBT now."

Garwin joined the IBM Corporation as a scientist in 1952, with the proviso that he could spend one third of his time working with the U.S. government on matters of national security. Over the years, Garwin has advised administrations — both Republican and Democrat — on such diverse topics as antisubmarine warfare, military and civil aircraft, sensor systems, ballistic missile threats, satellite reconnaissance and new technologies in health care. He served on the President's Science Advisory Committee from 1962 to 1965 and from 1969 to1972, and was chairman of the Arms Control and Nonproliferation Advisory Board for the Department of State from 1994 to 2001. Over the past 15 years, Garwin also participated in several of the influential JASON studies on stockpile stewardship. The U.S. Department of Energy's Stockpile Stewardship Program ensures the safety, security and reliability of the country's nuclear weapons without nuclear testing.

Garwin is a long-time member of the Pugwash Conferences and has also served on the Pugwash Council. He is an IBM Fellow Emeritus and was a professor-at-large at Cornell University, an adjunct professor of Physics at Columbia University, and a professor of Public Policy at Harvard University. He is also a fellow of the American Physical Society and a member of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. Garwin has authored and co-authored numerous books, published over 500 papers, and has been granted 45 U.S. patents. Since his retirement from IBM in 1993, Garwin has received several prestigious awards: in 1996, he received the R.V. Jones Foreign Intelligence Award and the Enrico Fermi Award; in 2002, he was awarded the National Medal of Science, the United States' highest honour in the fields of science and engineering.

Dr David Strangway

Keynote Speaker



The geophysicist Dr David Strangway joined NASA in 1970 as Chief of the Geophysics Branch, where he was responsible for the geophysical aspects of the U.S. space agency's Apollo missions. While at NASA, Strangway designed lunar experiments for Apollo astronauts and was also involved in the examination of returned moon rocks that contributed to further knowledge of the solar system

Dr Strangway has a wealth of experience in the mineral exploration industry, especially in magnetic and electro-magnetic techniques.

Strangway's experience in the education sector extends back to 1961 when he began his teaching career as an Assistant Professor of Geology at the University of Colorado. He was President of the University of British Columbia from 1985 to 1997 and is the founder, first President and Chancellor of Quest University Canada, a private non-profit arts and sciences university. He is also President Emeritus of the University of Toronto and the University of British Columbia.

In addition to serving on numerous scientific and academic committees over the years, he has worked with more than 50 government, private-sector, and non-government organizations in a variety of capacities. After 30 years of service to Canada's academic, research and innovation communities, Strangway joined the Canada Foundation for Innovation (CFI) in 1998 as President and Chief Executive Officer, where he remained until 2004. CFI is an independent corporation created by the Government of Canada to strengthen the capability of Canadian universities, colleges, research hospitals, and other non-profit institutions to carry out world-class research and technology development

Strangway is the author or co-author of more than 165 research papers, including results of lunar sample studies and experiments. Strangway's research has focused extensively on magnetic studies and electromagnetic sounding, both terrestrially for exploration and mapping and in lunar mapping and exploration. He has also served on a number of scientific and academic committees on behalf of governmental or private sector organizations since 1971

In recognition of his scientific works, Strangway has received several awards including the NASA Exceptional Scientific Achievement Medal in 1972 for his scientific contributions to NASA. He was made an Officer of the Order of Canada in 1996 for being "internationally respected as an outstanding scientist and senior academic administrator."

PROGRAMME COMMITTEE MEMBERS

JOSÉ ACHACHE
is the Director of the GEO Secretariat, Switzerland.

Achache became the first Director of the GEO Secretariat in 2005. GEO is a voluntary partnership of governments and international organizations, providing a framework within which these partners can develop new projects and coordinate their Earth observation strategies and investments. As of December 2010, GEO's Members included 85 countries and the European Commission. In addition, 58 intergovernmental, international, and regional organizations with a mandate in Earth observation or related issues have been recognized as Participating Organizations.

Prior to leading GEO, Achache was the Director of Earth Observation at the European Space Agency (ESA). While at ESA, he developed the Global Monitoring for Environment and Security (GMES) program in partnership with the European Commission.

From 1996 to 1999, he was deputy director of the Research Division at the French Geological Survey and the following year became its director. In 1999, he joined the French Space Agency (CNES) as advisor to the President and was appointed Deputy Director General of CNES in 2000. Achache has published numerous scientific papers in international journals on a range of subjects including geophysical imaging, planetary sciences, and Earth observation from space.

RICHARD G. BARANIUK
is a Professor of Electrical and Computer Engineering at Rice University, United States of America.

Baraniuk is a founder of the open education movement, which aims to share knowledge and teaching materials freely over the internet. He was also one of the framers of the Cape Town Open Education Declaration, a major international statement promoting open resources, technology and teaching practices in education. In 1999, Baraniuk launched Connexions, one of the first initiatives to offer free, open source textbooks via the web and one of the most used open education platforms worldwide. Connexions received the Tech Museum Laureate Award in 2006.

As a featured speaker at Technology Entertainment and Design (TED) 2006, a global set of conferences designed to disseminate "ideas worth spreading," Baraniuk discussed the application of music-sharing concepts to create materials for open-source e-learning. He has received several awards including the Internet Pioneer Award from the Berkner Center for Internet and Society at Harvard in 2008.

Baraniuk has been active in the development of digital signal processing and image processing systems. He is a leading researcher in the field of compressive sensing and is interested in sensor network architecture and network simulation. He is a Fellow of the Institute of Electrical and Electronics Engineers and the American Association for the Advancement of Science.

STEVE BRATT
is the First Chief Executive Officer of the World Wide Web Foundation.

The Web Foundation is a not-for-profit organization, founded by Web inventor Tim Berners-Lee and launched from its parent organization, the World Wide Web Consortium (W3C).The Web Foundation focuses on connecting and empowering all people on the planet through the Web, and ensuring that this powerful medium advances in a free and open manner. Bratt joined the W3C in 2002 as Chief Operating Officer, and later became Chief Executive Officer.

From 1997 to 2001, Bratt was the first Coordinator of the International Data Centre (IDC) Division of the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization. During this time, he was influential in establishing the verification system's data centre, global communications infrastructure, and standards for data exchange between more than 300 worldwide sensors and 170 nations. From 1984 to 1997, he led research initiatives first at the Science Applications International Corporation and then at the Defense Advanced Research Projects Agency. These initiatives aimed to develop advanced concepts for real-time global sensor monitoring, intelligent data analysis and international telecommunications in support of negotiations for the Comprehensive Nuclear-Test-Ban Treaty.

EVGENY GORDEEV
is the Director of the Institute of Volcanology and Seismology, Far Eastern Branch of Russian Academy of Sciences, Petropavlovsk-Kamchatsky, Russian Federation.

Gordeev became the Director of the Institute of Volcanology and Seismology (IVS) in 2004, when the Institute was created by combining the Institute of Volcanology and the Institute of Volcanological Geology and Geochemistry. The IVS engages in worldwide scientific collaboration in the fields of volcanology, geodynamics, seismology and geothermy.

Prior to leading the IVS, Gordeev was the Director of Kamchatkian Branch of the Geophysical Survey, Russian Academy of Sciences (KBGSRAS) from 1979 to 2004. The main aim of KBGSRAS is to monitor seismicity in Kamchatka in the Russian Far East, where the total number of tectonic earthquakes in the Kamchatkian Catalogue now exceeds 120,000. Gordeev also participated in the installation of the CTBTO's International Monitoring System seismic array (PS36) and infrasound station (IS44).

Gordeev started working at the IVS in 1972, where he carried out research on volcanic seismology, ocean microseism, prediction of earthquakes, high-frequency seismic noise and seismicity in subduction zones. He has published over 200 papers in both Russian and international journals. In 2008, he was elected as an Academician at the Russian Academy of Sciences.

GERHARD GRAHAM
is the Executive Manager-Scientific Services at the Council for Geoscience (OGS) in Pretoria, South Africa.

Graham is responsible for the Geophysics, Seismology, Analytical Laboratory, Geochemistry and Spatial Data Management Business Units, and Information and Collection Management at the CGS (legal successor of the Geological Survey of South Africa). He presides over several of CGS's national facilities; National Seismological Network, Geoscience Museum, National Core Depository and the Geoscience Library. He leads the participation of the CGS in Africa Array. Graham serves as the principal contact for South Africa under the Comprehensive Nuclear-Test-Ban Treaty. He has held a number of positions of increasing responsibility within the Geophysics Division of the CGS since 1984 and has also worked on projects in Lesotho, Swaziland, Namibia, Mozambique, and Pakistan.

Graham has published over 30 scientific research and review papers, over 230 scientific/technical reports and made more than 20 formal presentations. He was the chair of the Local Organizing Committee for the International Association of Seismology and Physics of the Earth's Interior (IASPEI) 2009 General Assembly held in Cape Town, South Africa. He has received four awards in exceptional achievements in science.

PATRICK GRENARD
is the Chief of the Engineering and Development Section at the International Monitoring System (IMS) Division, CTBTO.

Grenard has over 20 years of experience in systems engineering and specializes in underwater acoustics. As officer and engineer in the French Defense department, he held various positions in the French Naval Hydrographic and Oceanographic Service from 1989 to 1997 and at the Technical Centre for Naval Systems from 2006 to 2008, covering the design, operation, testing and evaluation of scientific instrumentation and complex systems in oceanography, geophysics, and underwater warfare. He has managed projects at the national and international level including a navy oceanographic ship construction programme. In 2007 he became chairman of the French Executive Committee for Military Oceanography and the French Ministry of Defence representative at the European Defence Agency for the thematic group on Underwater Systems Related Technology.

During his initial assignment to the CTBTO from 1998 to 2005, Grenard was involved in the design and installation of the first IMS hydroacoustic stations. He subsequently assumed responsibility for the Operation and Maintenance Support Group, which laid the foundation for the IMS Operations and Sustainment programme.

VANDA GRUBIŠIĆ
is a Professor and the Chair for Theoretical Meteorology at the Department of Meteorology and Geophysics, University of Vienna.

Grubišić is an atmospheric scientist specializing in the field of mesoscale atmospheric dynamics focusing on airflow and precipitation processes in complex terrain. She has studied dynamics of phenomena such as atmospheric wakes, gravity-wave critical levels, atmospheric cellular convection, orographic precipitation, and mountain lee waves and rotors. She has extensive experience with observational work in atmospheric sciences, including the conduct and management of major mountain meteorology field campaigns.

Grubišić has held a number of teaching, research, and management positions with institutions in the United States and her home country, Croatia. From 1995 to 2009, she held several prominent positions at the Desert Research Institute in Nevada and the National Center for Atmospheric Research (NCAR) in Colorado, and retains visiting appointments with both institutions. She is currently on the Advisory Committee for the Directorate of Geosciences of the U.S. National Science Foundation. Grubišić has also been a Visiting Professor at the Department of Geophysics at the University of Zagreb since 2006.

FEIHONG KUANG
is an associate professor and an expert on arms control technology at the Northwest Institute of Nuclear Technology (NINT) in Xi'an, Shaanxi Province, China.

Kuang's main areas of expertise are nuclear technology and arms control. He is also an expert member of the Chinese delegation to the CTBTO Working Group meetings concerned with the examination of verification-related issues. Kuang was engaged in nuclear technology application and radiation protection research until 1996. He has worked on CTBT verification technologies and has also conducted atmospheric radionuclide transport research, especially related to an on-site inspection (OSI), since 1997.

Kuang has participated in a number of OSI activities organized by the CTBTO, including the Integrated Field Experiment 2008 (IFE08) in Kazakhstan from August to September 2008, where he served as the deputy leader of the Visual Observation sub-team. He played a similar role in the inspection of a simulated nuclear test site during the OSI Directed Exercise in Jordan in November 2010.

RONAN J. LE BRAS
is the Head of the Software Integration Unit, at the International Data Centre (IDC) Division, CTBTO.

Le Bras joined the IDC in 2001 and is now Head of the Software Integration Unit. He has contributed key items to the IDC system, notably the data fusion stage of automatic waveform processing, which combines multiple stations of three waveform technologies into a single automatic bulletin. He has managed projects and teams in nuclear monitoring for the past 16 years while employed by Science Applications International Corporation and the CTBTO.

Previous to his involvement with nuclear monitoring, Le Bras worked as a software engineer and then research geophysicist for oil and gas exploration while employed with Etudes-Production Schlumberger in Paris, France, and Sierra Geophysics in Kirkland, WA, USA. He developed new methods of underground imaging, gained experience in many aspects of software lifecycle and project management methods. His interests lie primarily in making innovative methods available to operational systems, all aspects of signal processing multi-resolution analysis, and efficient processing of large amounts of data.

ZHENFU LI
is a senior expert at the Northwest Institute of Nuclear Technology (NINT) in China.

Li has been a senior expert at the NINT in Xian City, China, and an expert member of the Chinese delegation to the CTBTO Working Group's meetings on verification issues since 2000. Prior to this, he was the director of the NINT. His main professional fields are data acquisition and processing and arms control verification techniques. Prior to 1996, he was engaged in the physical diagnostics of nuclear tests. Since 1997, his work has focused on CTBT verification research, especially on the On-Site Inspection science and techniques.

SUSAN LOZIER
is a Professor of Physical Oceanography and Chair of the Earth and Ocean Sciences Division in the Nicholas School of Duke University, United States of America.

Lozier is a physical oceanographer with extensive experience in the study of the ocean's large-scale meridional overturning circulation. She has also focused on the ocean's water mass distribution and variability, Lagrangian pathways of ocean flow and physical constraints on ocean biology. With each line of research, her focus is on the ocean's role in climate variability and climate change. Most recently, she has conducted research on understanding the physical controls on ocean productivity.

Lozier has been a member of the Duke faculty since 1992. She was the recipient of a National Science Foundation Early Career Award in 1996, was awarded a Bass Chair for Excellence in Research and Teaching in 2000, received a Duke University Award for Excellence in Mentoring in 2007, and was selected as an American Meteorological Society Fellow in 2009. She is also the originator of the programme Mentoring Physical Oceanography Women to Increase Retention, which aims to reduce the barriers to career development for junior women scientists in the field.

PETER D. MARSHALL OBE CMG
Peter Marshall is a former head of the UK Ministry of Defence CTBT Monitoring Unit, which is part of the UK Atomic Weapons Establishment.

The Unit is responsible for providing authoritative advice to the UK Government on issues related to the detection, location and identification of nuclear explosions and is currently the UK's CTBT National Data Centre (NDC).

Marshall has been involved in nuclear test detection research since 1958 and has authored or co-authored numerous peer reviewed papers on seismological source discrimination. He was a technical advisor to the UK Delegation at the 1977-1980 USSR, U.S., and UK Trilateral Test Ban negotiations in Geneva and a UK Delegate to the UN Committee on Disarmament meetings of the Group of Scientific Experts from 1975 to 1988.

He was a member of the UK Delegation to the 1994-1996 CTBT negotiations and was Chairman of the Scientific Expert Group responsible for the design of the International Monitoring System. He is now semi-retired but continues to be involved in CTBT monitoring activities on a part-time basis with the UK NDC.

In recognition of his contributions to arms control verification, Marshall was awarded the Order of the British Empire (OBE) in 1990 and was appointed to the Companions of the Order of St Michael and St George (CMG) in 2002.

ROBERT G. PEARCE
is a full-time consultant with the International Data Centre at the CTBTO.

Robert Pearce worked as a research fellow for the UK Government at the Blacknest seismological research group from 1997 to 1980, where he specialized in methods of discriminating between explosions and earthquakes. After a period as a geophysicist in the coal industry, he took up an academic position at the University of Cardiff, UK, where his research interests included earthquake and exploration seismology. He later worked at Delft University of Technology in the Netherlands before moving to the University of Edinburgh in 1989. In 1998 he was employed by the CTBTO where he worked for ten years in the International Data Centre, latterly as Chief of its Monitoring and Data Analysis Section. During this period of progressive build-up of the verification system he was responsible for the team of data analysts and for the preparation of reviewed event bulletins and reviewed radionuclide reports.

MATJAZ PRAH
is the Coordinator of the On-Site Inspection (OSI) Division, CTBTO.

Prah has spent nearly 20 years in the field of nuclear safety and security. He was Licensing Manager at the Krško Nuclear Power Plant in Slovenia and later Director General of the Croatian National Nuclear Safety and Security Regulatory Body from 2005 to 2008. He was also Chairman of the National Authority for implementation of the CTBT in the Republic of Croatia. On several occasions, Prah served as Head of the Delegation of the Republic of Croatia, participating in International Atomic Energy Agency General Conferences as well as in CTBTO Preparatory Commission meetings and CTBTO Working Group meetings concerned with the examination of verification-related issues.

He has led and participated in a number of nuclear safety and security international and regional activities and has cooperated with various scientific institutions. Prah has also authored numerous papers in the areas of nuclear non-proliferation, illicit trafficking of nuclear material, nuclear regulatory legislation and nuclear safety and nuclear reactor systems. He joined the OSI Division at the CTBTO in 2009, where he has been involved in building up the operational readiness of the OSI verification regime element.

PAUL G. RICHARDS

is a Special Research Scientist at Lamont-Doherty Earth Observatory, Columbia University.

Richards has been on the faculty of Columbia since 1971, where he has conducted research on the theory of seismic wave propagation, the physics of earthquakes, the interior structure of the Earth, and the application of seismological methods to explosion and earthquake monitoring. He is a co-author of the globally acknowledged advanced text book "Quantitative Seismology." Prior to formal retirement in 2008, Richards was Professor of Natural Sciences at Columbia University.

Richards has written numerous professional papers on the application of seismological methods to the monitoring of nuclear testing. He served two terms as a visiting scholar at the U.S. Arms Control and Disarmament Agency in 1984 and 1993, and spent sabbaticals at the U.S. Department of Energy's Lawrence Livermore National Laboratory in 1989 and Los Alamos National Laboratory in 1997.

Richards was elected a Fellow of the American Academy of Arts and Sciences in 2008. He is a former president of the seismology section of the American Geophysical Union, has served on the Board of Directors of the Seismological Society of America, and received that society's 2009 medal for outstanding contributions in seismology.

JOACHIM SCHULZE
is the Deputy Director of the Fraunhofer- Institute for Technological Trend Analysis (Fraunhofer INT) in Germany.

The Fraunhofer INT advises the German Federal Ministry of Defense and other governmental departments as well as industry on questions of technology and on how to plan and realize new research and technology projects. In addition, it creates and continually updates an overview of the general research and technology landscape and of the entire spectrum of technological developments. The INT also performs its own experimental and theoretical research on the effects of ionizing and electromagnetic radiation on electronic components and systems.

Schulze participated in the negotiations for the Comprehensive Nuclear-Test-Ban Treaty from 1994 to 1997 as Scientific Adviser to the German Disarmament Delegation. From 1997 to 2002, he was the first Chief of the Radionuclide Section of the International Monitoring System Division at the CTBTO, where he was responsible for the establishment and operation of the Treaty's radionuclide network. He served as Assistant to the CTBTO's former Executive Secretary, Dr Wolfgang Hoffmann, during the initial establishment of the organization.

JACK SHLACHTER
is Deputy Division Leader of Theoretical Division at the Los Alamos National Laboratory (LANL) in the United States of America.

Shlachter began his career at LANL in 1979 in the Controlled Thermonuclear Research (CTR) Division, pursuing studies on a novel approach to magnetic fusion. He has been employed as a staff member at LANL since 1982. Between 1985 and 1987, Shlachter was a subject matter specialist at the International Atomic Energy Agency in Vienna, Austria. Upon his return to LANL, he continued with his research, exploring additional magnetic fusion schemes. With the dissolution of the CTR Division in 1990, Shlachter joined the Physics Division, working on a variety of pulsed cylindrical implosion systems driven by capacitor banks and high explosives. He served in numerous line management positions within the division, including the Division Leader from 2004 to 2008. Shlachter was the Coordinator of the International Data Centre at the CTBTO in Vienna in 2008. In 2009, he joined the core team at LANL developing the MaRIE (Matter-Radiation Interactions in Extremes) proposal, where he has been focusing his efforts on the Fission Fusion materials Facility pillar.

GERARDO SUÁREZ REYNOSO
is currently a senior research scientist at the Institute of Geophysics, National Autonomous University of México (UNAM).

Suárez has had an active career as a researcher in geophysics and as a programme leader in related applications. From August 1997 to July 2006, Suárez was the first Director of the International Monitoring System (IMS) Division of the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), and was influential in shaping the Treaty's verification system in its early stage. Prior to joining the CTBTO, Suárez held positions of increasing responsibility at UNAM and from 1982 to 1985, he worked as a research scientist at the Lamont-Doherty Geological Observatory at Columbia University. He has also taken part in or chaired various national and international committees in the field of Earth Sciences and natural disasters.

He is also Director General of Terracon Ingeniería, a multinational and multidisciplinary company engaging in Sciences of the Earth and Civil protection programmes, which incorporates expertise in various scientific fields related to disaster prevention and management. In addition, Suárez is Chairman of the International Federation of Digital Seismographic Networks.

KIYOSHI SUYEHIRO
is President and CEO of the Integrated Ocean Drilling Program Management International (IODP-MI).

IODP-MI is a marine research programme supported by 24 countries that explores the Earth's history by using scientific ocean drilling to sample and monitor subseafloor environments.

Suyehiro has spent nearly 30 years in the research field of marine seismology and was Executive Director of Research and Development at the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) from 2003 to 2009. He also currently chairs the Partnership for Observation of the Global Oceans (POGO).

He has led and participated in a number of marine seismological research works and has authored many papers in the areas of subduction zone structure and dynamics, island arc structure and evolution, and seafloor and borehole sensor system developments and networking. His recent works include establishing permanent geophysical observatories in ocean boreholes to monitor earthquakes and tsunamis.

INVITED SPEAKERS

JOSÉ ACHACHE
Executive Director
Group on Earth Observations (GEO) Secretariat
Switzerland

Topic: "Building Synergies between Earth Observation Systems"

MICHEL ANDRÉ
Professor and Director of the Laboratory of Applied Bioacoustics
Technical University of Catalonia
Barcelona, Spain

Topic: "Integrated solutions for a sustainable development of the offshore industry: live monitoring of noise and acoustic events"

RICHARD G. BARANIUK
Professor of Electrical and Computer Engineering
Rice University, United States of America

Topic: "Networks of Knowledge"

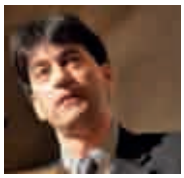
ELISABETH BLANC
Research Director
Commissariat à l'Energie Atomique (CEA)
France

Topic: "Infrasound: from the detection of explosions to atmospheric studies and climate"

CATHERINE DEGROOT-HEDLIN
Associate Project Scientist
Scripps Institution of Oceanography
University of California, San Diego
United States of America

Topic: "Rupture Pattern of Large Earthquakes inferred from Hydroacoustic Data"

BOB JONES
Head, CERN Openlab project
European Organization for Nuclear Research (CERN)
Geneva, Switzerland



Topic: "Distributed E-Infrastructures for Data Intensive Science"

HARRY MILEY
Chief scientist
Nuclear Explosion Monitoring Program serving the National Nuclear Security Administration/NA-22
Pacific NW National Laboratory
United States of America

Topic: "Event characterisation using radionuclide detections"

EMILE OKAL
Professor
Department of Earth and Planetary Sciences
Northwestern University in Evanston
Illinois, United States of America

Topic: "Extracurricular Geophysics, or Tsunamis in the Complex Earth System"

ANDERS RINGBOM
Deputy Research Director
Swedish Defence Research Agency
Division of Defence & Security Systems and Technology
FOI, Sweden

Topic: "Global Atmospheric Noble Gas Background"

DAVID SIMPSON
President
Incorporated Research Institutions for Seismology (IRIS)
Washington, DC
United States of America

Topic: "Open data resources and shared instrumentation facilities to support research in seismology"

HARRI TOIVONEN
Director of Laboratory
Security Technology
Radiation and Nuclear Safety Authority (STUK)
Helsinki, Finland

Topic: "New and Novel technologies for CTBT radionuclide analysis purposes"

CHRISTINE WING
Senior Fellow
Center on International Cooperation
New York University
United States of America

Topic: "Transnational Cooperation: Novel approaches to complex problems."

JAY ZUCCA
Programme Director for Nonproliferation
Global Security Principal Directorate
Lawrence Livermore National Laboratory, United States of America
Task Leader TechnologyRefreshment
Working Group B of the CTBTO Preparoty Commission

Invited Speaker for the closing session

HOST COUNTRY LIAISON

H.E. Alexander Kmentt
Ambassador
Director for Disarmament, Arms Control and Non-Proliferation
Federal Ministry for European and International Affairs
Austria

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1. THE EARTH AS A COMPLEX SYSTEM

Conveners:

IVAN KITOV
International Data Centre
CTBTO

ROBERT G. PEARCE
International Data Centre
CTBTO

PAUL G. RICHARDS
Lamont-Doherty Earth Observatory
Columbia University
United States of America

Invited Speakers:

ELISABETH BLANC
Commissariat à l'Energie Atomique (CEA), France

CATHERINE DEGROOT-HEDLIN
Scripps Institution of Oceanography, Univesity of California, United States of America

EMILE OKAL
Department of Earth and Planetary Sciences, Northwestern University
United States of America

ORAL PRESENTATIONS:

T1-O1. Infrasound: from explosion monitoring to atmospheric studies and climate

Elisabeth Blanc
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This presentation reviews the scientific work performed, in the infrasound topic, in relation with the Earth system. This work has been undertaken to better understand the atmospheric effects which control the infrasound propagation. First studies, using as source, supersonic aircrafts, volcanic eruptions and ocean swell, allowed to determine the infrasound deviation produced by the stratospheric winds and then to improve the localization precision.
However, the precision of atmospheric models is not sufficient to explain all observations. Recent work shows that small scale disturbances and gravity waves significantly increase infrasound reflections towards the ground. New atmospheric tomography studies extract atmospheric parameters from infrasound signals to improve the atmospheric models. Detection capability maps are computed to predict the detection conditions everywhere in the world. Ground trust events as explosions, volcanoes, meteorites, are intensively used to validate the simulations. Dense acoustic and seismic networks are developed at a semi-continental scale for a better description of sources and propagation. The Eyjafjallajökull eruption on April-May 2010 was recorded by many infrasound arrays across Europe, revealing the source dynamics of ash eruptions. New projects proposing infrasound monitoring of the ash clouds present a large interest for aircraft safety. Large scale atmospheric waves play a key role in atmospheric mixing and atmospheric global circulation. Their assimilation in the atmospheric models is needed to improve the prediction of tropospheric weather and climate. Observations of the atmospheric dynamics by infrasound, Lidar and airglow layer networks are proposed by the ARISE project, opening new challenging studies in relation with climate.

T1-O2. Rupture dynamics of large earthquakes inferred from hydroacoustic data

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Within the past decade, hydroacoustic arrays have been installed as part of the IMS (International Monitoring System), allowing for unprecedented observations of megathrust earthquakes occurring at subduction zones along continental margins. Each array consists of three hydrophones moored at the ocean sound speed minimum depth, configured as a triangle with sides of approximately two kilometers in length, allowing for accurate estimation of the receiver to source azimuth. Data from IMS hydrophones have been used to analyze the rupture dynamics of three large earthquakes: the December 2004 Sumatra-Andaman and March 2005 Sumatra events caused by subduction along the Sunda Trench, and the February 2010 Chilean rupture. For the first event, hydroacoustic arrivals with durations up to thirty minutes were recorded at three locations within the Indian Ocean. Analysis of a series of short time windows within the coda shows that the apparent source of the hydroacoustic energy moved northward along the Sunda trench, tracking event rupture. The data imply that the rupture proceeded in two distinct phases; initially it progressed northwest along the Sunda trench with a velocity of approximately 2.4 km/s for 600 km, then slowed as it propagated further to the northwest. For the second event, the rupture proceeded southward for several hundred kilometers. For the final event the sole recording hydrophone array was located in a sound shadow with respect to part of the rupture zone. However, it recorded hydroacoustic arrivals for over 30 minutes prior to its total destruction by the tsunami generated by the rupture.

T1-O3. Extracurricular geophysics, or tsunamis in the complex earth system

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Over the past seven years, two catastrophic tsunamis, the 2004 Sumatra and 2011 Tohoku events, have made this Japanese idiom a worldwide household word. In addition, since the Sumatra disaster, no fewer than 10 additional tsunamis have provoked damage and death along the shores of the Pacific and Indian Oceans, on a scale unrivaled since the 1960s. The considerable progress in instrumentation across many disciplines of science and engineering has allowed recording of tsunamis on an unprecendented scale, occasionally by instruments which had not been designed for this purpose. Such records often illustrate a form of weak coupling between two intrisincally different media (e.g., the ocean, the solid Earth, the atmosphere), which requires exceptionally large sources to be clearly observed. In turn, they provide insight into the nature of such effects and of the physical agents controlling the coupling. The examples which we will examine include tsunami records by land-based and ocean-bottom seismometers, hydrophones, infrasound stations, magnetometers and GPS arrays, as well as perturbations they induce in the optical properties of the atmosphere. Some of these observations lend

themselves to reasonably accurate quantification, and could thus lead to fascinating suggestions in terms of improving tsunami warning procedures, even though such endeavors obviously face phenomenal challenges.

T1-O4. Monitoring of explosive volcano eruptions in Kamchatka and the Kuriles Islands on acoustic data from IMS and KBGS RAS stations

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On the Kamchatka peninsula, an IS44 acoustic station, located at the observation site Nachiki (NCHK), was installed for monitoring of unauthorized nuclear explosions (IMS). The Kamchatka Branch of the Geophysical Survey the Russian Academy of Sciences (KBGS RAS) operates a station, located at the observation site Paratunka. These stations monitor large explosive eruptions from Bezymianny, an andesitic type of volcano, which is located at a distance of over 361 km from NCHK station. This paper presents the study of kinematic and dynamic parameters of signals accompanying the 2009—2010 eruptions of Bezymianny. Wave disturbances that accompanied the December 16, 2009 eruption produced an impulse-type signal likely related to a powerful lightning stroke that occurred during the formation of an eruptive cloud. An explosive eruption of Kizimen, an andesitic type of volcano, took place in early 2011. Wave disturbances from this eruption were recorded at both stations.
It was noted that a low-frequency discharging phase of over 60 s occurred at the early recorded acoustic signals accompanying large eruptions of andesitic volcanoes. Apparently the discharging phase occurred due to the rapid condensation of superheated juvenile vapor being ejected to the atmosphere during strong explosions.
An effort has been made to add acoustic channels at the KB GS RAS seismic telemetry stations located next to the volcanoes in order to record infrasound signals in close proximity to the source.

T1-O5. Civil applications of CTBT verification software and technologies: Volcano eruption in Iceland

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In April and May 2010 the eruption of the volcano Eyjafjallajökull in Iceland substantially affected the European airspace, causing a high economic impact. During this event, the Austrian Meteorological and Geophysical Service (ZAMG) was able to set up a volcanic ash modeling system within a few hours. This could only be achieved due the experience gained during the annual NDC Preparedness Exercises. To simulate the ash plume the atmospheric transport (ATM) model FLEXPART was applied in a configuration similar to the one used by the PTS. To visualize the results of the atmospheric transport modelling (ATM) the software-Package WEBGRAPE developed by the PTS was utilized. Austria was among the first countries reacting to the volcano eruption and provided model results to the national aviation authorities for decision making. A comparison with monitoring results showed a very good model performance.
Beside ATM that is important to forecast plume propagation, data from the CTBTO/IMS Infrasound monitoring network is important to detect eruptions and to monitor the volcanic activity. In a recent study, signals were investigated during the eruption period and compared with the source information of the Volcanic Ash Advisory Center (VAAC) in London.
Generally, the volcano event in Iceland can serve as an example of the usefulness of CTBTSoftware, IMS-Data and NDC preparedness regarding civil applications in the field of disaster management.

T1-O6. Determination of an uncertainty radius for back tracing infrasound signals to source caused by atmospheric wave activity

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Infrasound propagation in the atmosphere strongly depends on the dominant temperature and wind structure. For modelling purposes these parameters are usually determined using a combination of climatologies and numerical weather forecast models. However, climatologies and numerical weather forecast models are not able to adequately represent gravity wave signatures. Even planetary wave activity is only included in parts in climatologies. But gravity and planetary waves are usually very variable in time and space and can make up differences of several ten Kelvin in the middle and upper atmosphere leading to an incorrect source determination when tracing back the infrasound signature.

A concept for the determination of an uncertainty radius around the infrasound source is presented relying on a near-real time consideration of wave signatures. A first case study for infrasound propagation modelling based on ERA-40 and TIMED/SABER temperature measurements covering the middle atmosphere is shown.

T1-O7. Argon 37: What is the suspicious threshold activity in soil air?

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The radioactive noble gas Argon-37 has a high potential for on-site inspections (OSI) under the Comprehensive Nuclear-Test-Ban Treaty (CTBT). The characterisation and understanding of natural background concentrations in soil air and their controlling factors are the basis for an unambiguous identification of artificially elevated values. In the talk a review about production, release and transport of Argon-37 in the shallow subsoil is given.

T1-O8. The South Sarigan submarine volcanic eruption, May 2010: an example of International Monitoring System waveform data synergy.

David Green[1], Laslo Evers[2], David Fee[3], Robin Matoza[4], Mirjam Snellen[5], Dick Simons
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Three waveform technologies are utilized within the International Monitoring System (IMS) of the Comprehensive Nuclear-Test-Ban Treaty Organization: seismic, hydroacoustic and infrasound. Integrating data from combinations of the three technologies is useful for identifying and characterizing sources close to the interfaces between the solid earth, ocean and atmosphere. This synergy is clearly illustrated by an analysis of the south Sarigan (16.6N, 145.8E) submarine volcanic eruption in the northwest Pacific during May 2010. A detailed chronology of the volcanic unrest, lasting approximately 2.5 days, can be constructed from recordings at IMS stations. The earliest signs of volcanic activity consisted of repeating swarms of impulsive hydroacoustic signals recorded at a range of over 2200km (H11, Wake Island). As the eruption progressed the swarms of activity become more closely separated in time and larger in signal amplitude, allowing associated seismic signals to be identified at teleseismic distances. During the climactic phase of the eruption, contemporaneous with reports of a 12km high volcanic plume, infrasound was also generated and recorded at a range of 1580km (IS39, Palau). The identification of associated infrasound suggests that the eruption at this time had both submarine and subaerial components. This study shows that the IMS can provide excellent data which can assist in monitoring volcanic activity and understanding volcanic processes in largely inaccessible and poorly monitored submarine environments.

T1-O9. Next-level shake zoning for modeling seismic-wave propagation in the U.S. Intermountain West

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A multi-institutional collaboration is developing “Next-Level ShakeZoning” procedures tailored for defining potential earthquake shaking and hazards across the many geologic basins of the U.S. Intermountain West. These procedures include deterministic modeling of seismic wave propagation through detailed regional 3-d geologic models. The 2008 Wells and Mogul events in Nevada showed in particular that a generalized statistical approach, as taken by the USGS ShakeMap tool, cannot match actual data on shaking from earthquakes in the Intermountain West, even to first order. Next-Level ShakeZoning relies on physics and geology to define earthquake shaking hazards, rather than statistics. Excellent new data sets are now available for parts of Nevada. Clark County, Nevada has completed the very first effort in the U.S. to map earthquake hazard class systematically through an entire urban area, resulting in an unprecedented 10,721 geotechnical site characterizations over a an area of 500 square miles. Using the new Parcel Map in computing shaking in Clark County for scenario earthquakes is crucial for obtaining realistic predictions of ground motions. In an educational element of the project, a dozen undergraduate students are computing 50 separate earthquake scenarios affecting Las Vegas Valley, using the Next-Level ShakeZoning process. Despite affecting only the upper 30 m, the Vs30 geotechnical shear-velocity from the Parcel Map shows unexpectedly large effects on even the longer-wavelength 0.1-Hz to 1.0-Hz shaking predictions. The detailed geotechnical data, with the fully 3-d Next-Level ShakeZoning scenarios, show many areas of shaking amplification and de-amplification that traditional 1-d methods cannot predict.

T1-O10. Ground motion studies for critical sites in north-east Bangladesh

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Seismic sources in and around Bangladesh are capable of causing major earthquakes. The northeastern region of Bangladesh, separated from the rest of the country by the mighty rivers Jamuna and Padma, can be affected by large magnitude earthquakes in different fault zones. According to Professor Bruce Bolt, the 1885 magnitude 7.0 Bengal earthquake originated within this region. This paper utilizes comprehensive and systematic seismic hazard assessment studies to assess probable ground motion at two critically important sites in this region: (i) 4.8 km long Bangabandhu Bridge over Jamuna river and (ii) proposed nuclear power plant site at Rooppur. The Bangabandhu Bridge has been designed for major ground shaking and uses earthquake protection devices. The country's first nuclear power plant is planned to be constructed at Rooppur on the banks of Padma river. An up to date earthquake catalogue has been formed up to 2009 incorporating historical earthquakes and using data from various sources. As part of the study, attenuation law describing attenuation of ground motion within Bangladesh has been developed by the authors from isoseismals of major earthquakes and compared with other attenuation laws. Using multiple seismic source zoning and standard probabilistic hazard assessment procedures, the peak ground acceleration is estimated at the two sites for different return periods. The site effect of surface soil is studied considering one dimensional vertical wave propagation and equivalent linear model for soil. Results obtained for Jamuna bridge site are compared with design earthquake spectrum used for the seismic design of the bridge

T1-O11. Prediction of aftershocks distribution using artificial neural networks

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In this paper an approach is presented to predict the concentration and the trend of aftershocks of earthquake. The method is based on inputting first aftershocks to Kohonen artificial neural network. Artificial neural networks, which are inspired from human brain, consist of several artificial neurons which are connected with some weight vectors to each other. Artificial neural networks are able to classify a large volume of input data (i.e. earthquake catalogue) simultaneously and in parallel, and can recognize seismic patterns very well. Kohonen neural networks consist of several neurons that effect mutually on each other to display important statistical characteristics of the input space (i.e. first aftershocks). Combination of associative and competitive learning rules results in formation of Kohonen's self-organizing feature map (SOFM) algorithm. SOFM algorithm has converged; the feature map computed by the SOFM algorithm indicates that concentration and the trend of aftershocks precisely. Kohonen artificial neural networks have become powerful intelligent tools in recent years, used widely in pattern recognition and data clustering.

T1-O12. Neural classification of infrasonic signals from hazardous volcanic eruptions

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Large volcanic eruptions radiate infrasonic signals which can be detected by the global infrasound array network and used for early warning to the aviation industry. The Acoustic Surveillance for Hazardous Eruptions (ASHE) team performed detailed studies of the 2006-2010 eruptions of Tungurahua volcano and prototyped real-time eruption notification systems for evaluation by the DC Volcano Ash Advisory Center (VAAC). The International Civil Aviation Organization (ICAO) and World Meteorological Organization (WMO) gave a positive evaluation of the ASHE project during the 2010 International Airways Volcano Watch Operations Group (IAVWOPSG 5) coordination meeting. They requested that an ad hoc working group consisting of the IAVWOPSG Members of Australia, Canada, France, Japan and New Zealand (a) examine the development and testing of a prototype, real-time "significant" eruption notification system for the VAACs, (b) pursue the collaborative work between VAACs and CTBTO, and (c) report back to the IAVWOPSG/6 Meeting (Senegal, Fall 2011). Thus one of our

primary technical aims is to evaluate and reduce false alarm rates. Using a training data set consisting of well-characterized infrasonic eruption signals, Florida Tech developed neurocomputing signal classification algorithms that can identify hazardous eruptions and supplement existing array signal processing methodologies. The neurocomputing approach also permits an assessment of the classifier performance through receiver operating characteristic (ROC) curves. In this work, our international team seeks to extend this prototype signal classification algorithm to other events of interest with the objective of reliably identifying "significant" eruptions.

T1-O13. Seismicity and seismic hazard assessment of the arid western regions of South Africa

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There are two nuclear reactors in South Africa, a research reactor at Pelindaba near Pretoria and a power-generating reactor at Koeberg near Cape Town. High level radioactive waste (HLW) in the form of spent fuel is currently stored in the designated spent-fuel pools on the Koeberg site. The shorter lived, low- and intermediate-level waste (half-life ≤31 years) is sent to the Vaalputs National Radioactive Waste Disposal Facility in the Northern Cape Province, currently managed by the South African Nuclear Energy Corporation (Necsa).
According to the Radioactive Waste Management Policy and Strategy for the Republic of South Africa it is prudent to begin gathering the data needed to assess future HLW disposal sites, and explore other options like the reprocessing of spent nuclear fuel.
Site selection criteria for a nuclear waste disposal site include proximity to settlements, agricultural potential of land, geological stability and seismic activity. This study will make a detailed investigation of the seismic activity in the arid western region of South Africa, as this region is likely to prove suitable, in principle, for the disposal of radioactive waste.
The current Necsa seismic database shows that the Vaalputs site is seismically stable, yet there has been sporadic seismic activity in Namaqualand with swarms in 1996, 2001, and again (near Augrabies) in 2010. The network will be used to assess the reliability of the reported magnitudes, to define active faults and seismotectonic zones, and to derive seismic source mechanisms. This will yield more accurate seismic hazard assessments.

T1-O14. Crustal thickness and average VP/VS ratio variations in northern Viet Nam from teleseismic receiver function analysis

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A 24-station broadband seismic array was installed in northern Vietnam since December of 2005. High quality data were collected from this array observation. In this study, we use the teleseismic receiver function technique to determine the crustal thickness and Vp/Vs ratios beneath each station and map out the lateral variation of Moho depth under northern Vietnam. The best estimations of crustal thickness and Vp/Vs ratios are found when the three converted phases (Ps, PpPs and PpSs+PsPs) are stacked coherently. By stacking receiver functions from different distances and directions, effects of lateral structural variation are suppressed and an average crustal model is obtained. The best estimation of crustal thickness from 24 broadband stations beneath the northern Vietnam area is 30.8 km on average and varies from 26.5 km to 36.4 km. A thinner Moho is found in the Red River delta with depth variation from 26.5 km to 29.5 km. The northwestern part is represented by deeper Moho which varies from 30.5 km to 36.4 km, under Nui Con Voi Range suture, the Moho depth is deepest that ranging from 33 km to 36.4 km. The Moho is found to be relatively flat in the northeastern part beneath this array, those values are about 29km to 32 km. A new relationship between Moho depth and Bouguer gravity anomaly was proposed for northern Vietnam. A Vp/Vs ratio on average is found to be 1.71, with higher ratios of 1.70 to 1.82 in the northwestern part and lower ratios of 1.64 to 1.70 in the northeastern part and Red River delta. The higher ratios in the northwest may suggest ductile phenomena in the lowermost crustal layer and the lower ratios are probably related to a general absence of mafic lowermost crustal layer beneath northeast and Red River delta areas.

T1-O15. Scattering and intrinsic attenuation structure in Central Anatolia, Turkey using BRTR (PS-43) array data

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We attempt to obtain the attenuation structure in the region of Central Anatolia (Turkey) analyzing about 250 local earthquakes recorded with the IMS primary array station BRTR (PS-43). We have applied Coda Normalization method for the measurement of Qs-1 as a function of frequency. Additionally Multiple Lapse Time Window Analysis (MLTWA) method was applied in order to get a better picture of the crustal structure and the seismic hazard of the region. MLTWA method allowed a separation between the intrinsic attenuation and scattering attenuation. Preliminary results show a relatively low attenuation compared to western and eastern anatolia regions. A study of the regional and site attenuation of seismic waves of earthquakes in this area will contribute in predicting earthquake generated ground-motion and becomes vital in making decisions for earthquake regulations and building codes and also may improve signal interpretation in order to contribute to the verification system.

T1-O16. Detection of earthquake hazard in southwest peninsular India – Spurt of various unusual geological incidents

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The mounting prototype of seismicity in Kerala together with sudden surge of various unusual geological incidents during 2001 swell over a huge area in a 550 km long segment trending northwest-southeast clearly designate towards the unstable state of the crustal block in this part of the peninsular shield. It seems that the incident of sudden spurt and slaughter of sequences of incidents are the surface manifestation of entrenched tectonic activity which have caused possibly due to change in stress regime by the process of redistribution of stresses along certain active fault in central Kerala region. The series of strange geological incidents have occurred all the way through the Kerala State (Southwest Peninsular India) for the period of the year 2001 mainly in two active phases i.e. February to March, and June to November 2001. This argument is also supported by the sequential patterns of cumulative number of incidents with time. In the beginning during February-March 2001, oscillations and rise in water levels, wavy formations and spouting up of water in the open wells, cracks in the buildings, perceptible ground fissures, shaking of trees/bushes and enhanced micro-earthquake activity have occurred. Collapse of shallow open wells, draining of water, lowering of water level, land subsidence, ground fissures etc., and further increased microearthquake activity were the prevailing incidents in various parts of the State during June to November 2001. Interestingly, no such incidents had occurred in the past in this region. The rate of recurrence of all the above incidents, including micro-earthquakes activity, reduced considerably to background level beyond November 2001 except a few earthquakes during 2002 and 2003. This parade of incidents was preceded by two moderate size earthquakes of M~5 on 12 December 2000 and 7 January 2001 which were not capable to trigger such widespread incidents in the region. Using the spatial distribution of these incidents including micro-earthquake activity and past significant earthquakes, an east-west trending potential area (10.7-10.9 oN; 76.0-76.8 oE) is delineated in the central Kerala region as the preparatory zone for the location of future earthquake

T1-O17. Upper crust structure under CTBTO station «Petropavlovsk-Kamchatsky» by endogenic microseismic activity

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CTBTO station «Petropavlovsk-Kamchatsky» includes PS36, IS44 and RN60. Primary seismic station PS36 consists of an 11-element array and one CRF, which receives data from the remote collection arrays and transmits it to IDC (Vienna, Austria). PS36 is located in central part of Kamchatka peninsula in the area with low human activity. At early stages, emplacement of large intrusives and an intense Paleeeogene-Neogene hydrothermal activity were associated with this zone. Fractures of this zone control outflows of the Nachikinsky hydrothermal deposit in near-field region of PS36. For investigation of crust structure we used microseismic emission as sensitive indicator of the stress distribution in the medium and PS36 as multichannel array. The construction of images of deep noise sources reduces to the analysis of the spatial distribution of their intensity. The method reduces to the estimation of the energy of weak coherent radiation from various points of the medium. For the reconstruction of microseismic emission field, we estimated the measure of the similarity of

seismic signals (Semblace) as a ratio of the signals summarized over all sensors of the group to the sum of the energies of each sensor separately calculated for each sampling point covered by array. To eliminate storm microseisms and local high-frequency surface interferences, band-pass filtering of 2-6 Hz was applied. The most intense anomaly is connected with the position of the Nachikinsky hydrothermal field, corresponded to most fractured zones of rocks. Our results are in good correlation with geological data, magnetotelluric and deep seismic sounding.

POSTER PRESENTATIONS:

T1-P1. Tsunami numerical simulation applied to tsunami early warning system along Sumatra region

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Western Sumatra region is tectonically active region that often lead to catastrophic earthquakes and tsunamis. Disaster is a complicated issue that concerned the community, as happened all of a sudden. In some cases the earthquake that occurred among potential tsunami. Sumatra is an area that often experience a major earthquake recurrence. Historical data shows this region experienced a major earthquake every 200 years. It could be argued that in this period Sumatra region has been in the last cycles, and in the near future will have a potentially major earthquake cause a tsunami. To answer these concerns have developed software to model the tsunami, so that regard when the tsunami disaster will occur and how big run-ups and expansion of the resulting tsunami inundation, could be the arrival time calculation and simulation, it is done by creating a scenarios tsunami modeling before the real tsunami occurs. The scenarios was made as much as possible into a database of tsunami modeling. To generate a tsunami modeling in large quantities will require a variety of mechanisms fault scenarios, subsequently scenarios variations are grouped in segments taken in areas prone to tsunamis, so that the database does not widen. This scenarios is based on the values of fault parameters and modified in such a way as to produce the type of fault models with historical data approach the mechanism of fault conditions in that segment. As another reference to estimate the location of disturbances in these segments, done by observing the deformation history of geological processes and the relative movement of the earth's crust, and in complex cases such as the movement of the double-couple on the plate obtained through the method of calculation analysis. Then do as well the validity of the calculation results with historical data and the results of a survey on the same segment.

T1-P2. Seismic hazard assessment for Zambia and surrounding areas

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Seismic hazard potential for Zambia and surrounding areas was estimated by applying the probabilistic seismic hazard analysis with hazard computed for peak ground acceleration (PGA) in gals for a 10% probability of exceedence for periods of 50 and 100 years. The hazard was computed for grid sites with a grid cell size of 0.25° by 0.25° using Donovan's global attenuation relation and McGuire's EQRISK (1976) hazard computation program. The area covered is bounded by latitudes 6°S-20°S and longitudes 20°E-36°E with seismic data derived from the Eastern and Southern Africa Regional Seismological Database (ESARS-DB).
The results, which have been presented as seismic hazard contour maps, show that high PGA values are associated with seismically active areas of the Kariba dam area and the well defined rift zones of Tanganyika, Rukwa, Malawi, Shire, Urema Trough and the southern extremity of the Eastern Branch of the Eastern and Southern Africa Rift System (EARS). The low to intermediate PGAs correspond to the rest of the study area, the areas of insipient rifting and the regions adjacent to the seismically active areas mentioned above. Within Zambia, the regions adjacent to the seismically active areas have intermediate PGA values. The range of PGA values, from the low around the centre of the Bangweulu Block to the highest around Kariba, is 170-290 and 220-370 gals for the 50 and 100 year periods, respectively. This suggests that Zambia and the surrounding areas are potentially vulnerable to seismic hazard, especially those regions adjacent to and within the seismically active areas. In geological terms, the low PGA values correspond to the stable cratonic nuclei while the intermediate to high PGA values are associated with the mobile belts within the region.

T1-P3. Evidence for infragravity wave-tide resonance in deep oceans

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Ocean tide refers to the oscillatory motion of seawater forced by the gravitational attraction of the Moon and Sun with periods of a half to a day and wavelengths of the semi-Pacific to Pacific scale. Ocean infragravity waves are sea-surface gravity waves with periods of several minutes and wavelengths of several dozen kilometres. We report the first evidence of the resonance between these two ubiquitous phenomena in deep oceans mutually very different in period and wavelength. The evidence comes from long-term, large-scale observations with arrays of broadband ocean-bottom seismometers located at depths of more than 4000 m in the Pacific Ocean. This observational evidence is substantiated by a theoretical argument that infragravity waves and the tide can resonantly couple and that such coupling occurs over unexpectedly wide areas of the Pacific Ocean. Through this resonant coupling, some of ocean tidal energy is transferred in deep oceans to infragravity wave energy.

T1-P4. Hydro-tremors and incidence of ground rupturing in the northern parts of India: A plausible model

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Phenomena of hydro- seismicity caused by the hydrologic triggering of earthquake activity on critically stressed faults have been observed in many regions of the world. Although, such tectonic earthquakes may be small in magnitude but enough to cause considerable ground rupturing, subsidence and developments of cracks in the building, etc. The hydro-tremors have been explained by a mechanism that takes into account the entrapped air/gas in pore spaces of soil above water table which gets compressed maximum due to the actual pore-fluid pressure following heavy rainfall, and upon relaxation of pore-fluid pressure i.e. due to the horizontal diffusion of near surface water, the pressure of the compressed air/gas oscillates, and this causes hydro-tremors to generate. Sudden relaxation of compressive pore-fluid pressure causes effective stress to develop along the horizontal direction and escape from the capillary channels through the soil to the surface, rupturing the ground surface. The incidences of ground rupturing have been found in areas, experiencing depleted amount of rainfall over the years coupled with withdrawal of subsurface water, and have been reported from many parts of the northern states of India. A notional model has been presented to study the causative effects.

T1-P5. Shallow structure study using gravity data

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The LUSI mud volcanoe blast that occurred on May 29, 2006 has had a prolonged impact, even up until now (early 2011). One of the consequences can be viewed geologically: subsidence is causing houses to suffer cracks. BMKG, in-cooperation with PT. Lapindo Brantas has conducted a survey of gravity around the location of LUSI in 2008. The author tried to analyse the structure using gravity data measured on 5-12 July 2008.
Gravity measurements carried out around LUSI included as many as 171 points. To separate the anomaly the author used the spectral analysis of the bouguer anomalies and the second vertical derivative method. Spectrum analysis showed that the source of some regional anomalies lie at a depth average of 1800 m, and other regional anomalies at a depth average of 130 m. Based on the forward modeling method with a 2D structure we can identify the structure that caused LUSI to experience many new cracks and also caused the subsidence in the area around LUSI.

T1-P6. Analysis spatial and temporal b-value variability seismicity north of Sulawesi

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The changes of b-value was inversed proportionate to the level of stress an area. A high stress level stress in an area likely reflected of low the b-value. In this research, it was used an earthquakes database from NEIC catalog at the North Sulawesi and its surrounding areas included Latitude:7oLU - 1oLS and Longitude: 118oBT - 130oBT with the depth 0 - 675 km in the period 1973 - 2009. For temporal and spatial analysis, the research was divided into grid to grid to map the b-value and a value. b-value calculation was done on each grid point in the

constant distance 110 km containing a number of earthquake occurrence. In this method, the distance varied density of the earthquake in the area of research. Grid size can be vary, in this research, it was chosen the processing of data grid 0.2o x 0.2o and the number of seismic events N = 10. The result showed the minimum of b-value was around 0.6 and its maximum around 2.3, the minimum of a-value around 3.7 and the maximum avalue around 13.2. It also can be identified by qualitative approach through return period with the earthquake magnitudo 5 in the area of research in the period of about 0.3 to 1.6 year, magnitudo 6 about 6 to 13 years and magnitudo 7 about 25 to 115 years.

T1-P7. Seismic anisotropy from IDC data

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This study focuses on constraints on seismic anisotropy within the Earth that data from the CTBTO network can provide. We also discuss how that information can be used to improve detection and localization capabilities of the network.
Seismic anisotropy is of considerable interest to the Earth science community, since it allows constraining in-situ deformation within the Earth using surface observations. The CTBTO network is of particular interest, since it extends over otherwise sparsely instrumented areas. There is thus potential for better understanding seismic anisotropy in the Earth's interior. On the other hand, anisotropy has characteristic effects of various kinds on seismic waves, and understanding these effects can improve network performance. One of these effects is to modify the polarization orientation of P-waves, another is to split shear-waves into multiple, orthogonally polarized waves. Techniques for detection and localization may be hindered by anisotropy, and we will address remedies. If available, we will show examples and results from the virtual Data Exploitation Centre (vDEC).

T1-P8. The RN50 station of the International Monitoring System (IMS) as a reference station to the airborne particles pollution in Panama City

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The 3M filter with airborne particles from the Snow White at the RN50 Station of the IMS is weighed daily to know the amount of μg/m3 of the collected particles, as an indicator of airborne particles pollution in the covered area of Panama City. This data, which covers 6 years (2005-2010), indicates that the pollution is more severe during the dry season (without rain and winds) in correlation with the activities of the weekdays. In the rainy season (a lot of rain and little wind) there is less pollution without correlation with the activities of the weekdays. By Mössbauer Spectroscopy, we saw superparamagnetism indicating the presence of nanoparticles (the most hazardous to health) in the air during both the dry season and the rainy season, but with a larger percentage of particles of this size during the rainy season. The intense building construction in Panama City shows that it contributes to the pollution of the environment by the presence of elements such as Ca, Mg, Fe, Cu, Zn, which were analyzed by Inductively Coupled Plasma – Optical Emission Spectroscopy, ICP- OES. The Station RN50 of the IMS is then, in addition to its contribution as part of the monitoring network to detect nuclear explosions (IMS) and to monitor the background radiation near the Panama Canal locks, a reference station to the airborne particles pollution in Panama City.

T1-P9. Observations of acoustic-gravity waves in the Czech Republic

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A measurement system has been installed in the Czech Republic that allows us to monitor wave activity in the lower and upper atmosphere. In this paper, we focus on observations of infrasound and short period gravity waves. The measuring system consists of five microbarographs located at three sites (one triplet and two single sensors) situated in central, north, and western Bohemia; distances between the sites are of the order 60-170 km. A differential microbarograph (model type ISGM03) with an operational frequency range from 0.001 to 10 Hz were installed at each site. Doppler frequency shift measurements allowed us to monitor wave activity at ionospheric heights. The sounding system consists of five transmitters, one permanent receiver and one mobile receiver used for measurements in the field. This arrangement of sensors provides even coverage of the western part of the Czech Republic. A sounding frequency of 3.59 MHz was used in this exercise. Here we present observations of infrasound produced by weak earthquakes during earthquake swarms in Western Bohemia in October 2008. Infrasound was detected by microbarographs located close to the earthquake epicenter. Meteorological processes in the troposphere are one of the efficient source mechanisms of atmospheric waves.

Over the long term we have been monitoring the ionospheric response to various meteorological phenomena using our Doppler sounding system. The ionosphere is, however, sensitive to many external sources in the geospatial environment, such as oscillations of the geomagnetic field. By comparing the Doppler shift measurements with local geomagnetic field fluctuations we are able to distinguish ionospheric oscillations induced by the geomagnetic field.

T1-P10. Detection and identification of low-magnitude seismic events near Bala, central Turkey

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Belbasi Seismic Station is composed of two seismic arrays. One is a medium-period borehole seismic array with a radius of about 45 km located in Ankara, and the second is a short-period borehole seismic array with a radius of about 3 km located in Keskin. Both arrays consist of seven elements. Each array has a broadband seismometer located at the middle element of the circular array. Bala earthquake occurred on December 20, 2007 had produced many aftershocks that were monitored extensively by the Keskin array. In this study, Keskin SP array detection capability of the local earthquakes occurred in middle part of Anatolia has been analyzed using aftershocks data. Array based waveform correlation and STA/LTA methods are applied to the aftershock data set and detection capability results are compared both with the National Earthquake Monitoring Center (NEMC) and The Scientific and Technological Research Council of Turkey (TUBITAK) network. During 20-31 December 2007, 1.132 aftershocks within 0.8–5.0 magnitude range were detected using STA/LTA method, whereas the number of detected earthquakes was 1.401 within 0.5–5.0 magnitude range when using waveform correlation method. The results clearly indicate that array stations have much higher detection capability when compared to single stations, especially at the lower magnitude levels when using waveform correlation method.

T1-P11. Source effects vs. site effects of Vrancea earthquakes recorded in Romania

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Bucharest is one of the most affected cities by earthquakes in Europe. Situated at about 150 km epicentral distance from Vrancea seismic area, Bucharest had suffered many damages due to high energy Vrancea intermediate-depth earthquakes. Different studies focused on the Vrancea subcrustal source of earthquakes pointed out the strong lateral inhomogeneous distribution of the seismic radiation. This implies characteristic macroseismic distributions, extremely elongated along NE-SW direction, and sharply restraint toward NW. Many authors ascribed this particular radiation to the predominant focal mechanism noticed for the major Vrancea shocks (Enescu, 1997). However, a few recent papers showed that the lateral variation in the subcrustal region seems to be more important (e.g., Popa et al., 2005; Radulian et al., 2006). We plan in this paper to asses the importance of the source and path of the Vrancea earthquakes on the ground motion parameters in the area of Bucharest. The fault plane solutions of most Vrancea earthquakes indicate a nearly pure thrust mechanism with the B-axis striking NE, which is typical for the strongest events. We analyze the influence of focal mechanism radiation and source frequency content on the ground motion parameters in Bucharest area. After analyzing all the potential factors, we show that these important variations cannot be explained by local site effects alone. The level of the site effects as well as the frequency content of the seismic waves are strongly influenced by deep tectonic structure in the area at the crustal and subcrustal levels.

T1-P12. Geophysical investigation for lake level rise

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Geophysical methods provide the tools for solving various geological problems. In this research, vertical electrical sounding (VES) and magnetic methods are carried out in the vicinity of Lake Beseka. The site is situated at about 200km east of Addis Ababa in the main Ethiopia Rift valley. Considerable changes have been taking place for many years, which resulted in an increase of the surface area of the lake originally from 3.3 km2 to about 45 km2. The study is performed to obtain the subsurface information that has been contributing to the lake level rise. The variation of resistivity with depth is studied by a progressive increase of the Schlumberger current electrode configuration. In order to get reasonable subsurface information, the apparent resistivity curve plotted in the field had been compared with a set of theoretically calculated master curves. The layer parameters, resistivity and thickness, obtained by iteration process were used to construct the geoelectric sections for each profile to show different lithological units in the vertical direction. The results of the vertical electrical sounding surveys show that the resistivity of the different aquifer systems is low in the vicinity of the lake and increases

away because of the intrusion of the saline lake water. It has been found that no input of water to the lake is possible from the adjacent farm lands, as the water table gets deeper as one goes away from the lake. In addition to VES, magnetic survey was carried out using scintrix made proton precession magnetometer and monitored with a selected base station for diurnal correction. The magnetic survey is applied to delineate subsurface structures (faults/shear zones), which have been created due to the tectonic activities taking place in the area. The total field magnetic map of the study shows that the northwestern part of the lake is characterized by exposed or shallow depth volcanic rocks. But, the northeastern part of the lake is generally seems to be magnetically quite. The NNW and SSE inferred fault may intersect the NNESSW trending fault, which the thermal springs apparent in the area may come to the surface.

T1-P13. Atmospheric transport processes over the Kathmandu valley, Nepal.

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The air mass transport characteristics over the Kathmandu valley have been studied to assess the spatial and temporal distributions of decoupling of valley's air mass with the regional flows. The study has been carried out with the applications of Mesoscale Meteorological Model (MM5), Weather Research and Forecast (WRF) and a Chemical Transport Models. The model predictions have been compared with observed data. The study reveals that Kathmandu valley typically shows a plateau-basin dual nature. The nighttime near surface air mass remains largely calm. However, the intermittent downslope winds organize a weak flow system that often develops valley wide anticlockwise circulation at about 150 m above the floor, which slowly but effectively induces mass exchange in the lower layer of cold air mass during the nighttime. Two very gentle wind systems, southwesterly and northwesterly, composed of regional scale deep upslope and plain-to-plateau winds regularly intrude into the Kathmandu valley close to noontime and continue till the late evening. Upper air from more than 3 km above the mean sea level comes down and sweeps across the valley floor in the afternoon. Spring season of Kathmandu appears to be relatively windy compared to winter. No strong decoupling of valley's air mass with the regional air flows appear to persist for more than 24 hours or so in and around the valley. The surrounding mountaintops, particularly, the eastern and southeastern mountain tops appear to be the most suitable sites for regional background aerosol concentration measurements.

T1-P14. 1-D Velocity model for use by the SANSN in earthquake location

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Knowledge of the velocity model of an area is essential both for earthquake location and tectonic implication. Locating earthquakes using an unreliable model contributes in part to the uncertainties of active fault mapping and unexplained scatter of seismic locations. Given that we strive to continually improve our location abilities, it is necessary to always improve on the model used in the location process. The travel time inversion method was used to estimate a 1 - D velocity model that can be utilised by the South African National Seismic Network (SANSN) in seismic data analysis. It should be noted that the velocities obtained are approximately equal to the average velocity of the 3D structure within the same depth range that has been sampled by the data. In order to test the new model, it was used to relocate a sample of well recorded data from the SANSN database and results compared to previous data analyses. The new model VM1 was found to provide improved locations compared to the previously published CGS locations especially when considering the clustering of events in the mining areas as well as the observed reduction in location errors. Station corrections were calculated and showed strong lateral variations across the region. The velocity model will continue to be improved with time as more seismic stations are installed throughout the country especially in the southern part and thus more data are collected.

T1-P15. Determining of the contrast zones based on the analysis of microseismic noise

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The techniques developed for determining the epicenters of the contrast zones and for estimating their spatial distribution. The detection of underground contrast heterogeneity is based on areal measurements of the microseismic fluctuations. As it's shown by the studies, an underground heterogeneity causes an increased contribution of high-frequency components in the total energy of microseismic noise in the epicentre zone. The relation of the horizontal amplitude component to the vertical one is the most stable characteristic of microseismic noise. Different relation values for different sites of the crust reveal their structural difference. The ratio of horizontal to vertical components is higher at close distances to the heterogeneity. The maximal values

are observed in the epicenter. The study of microseismic features in the epicentre zone shows that the occurrence of an underground contrast area sometimes modifies quasi-harmonic components of the noise spectra. These components appear in spectra as peaks of different amplitudes. The analysis has shown that quasi-harmonic components are present in all microseismic records. These quasi-harmonic components can be divided into two types by the origin: man-caused and natural-resonance. It is shown that in the absence of amplitude modulation of microseismic background as a whole, an external disturbance coming from the environment, such as the tidal force causes responses of different rock massifs in the form of modulation of background microtremors in different frequency intervals. Thus the maximal change of spectral density amplitude is detected for quasi-harmonic fluctuations. The obtained results can be used in additional to classic OSI methods.

T1-P16. Tectonic stress field and recent movements of the earth's crust in the Manila subduction zone and adjacent faults

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In this paper, 4 models of average stress states have been calculated on the base of focal mechanism data and 25 focal mechanisms of the largest earthquakes belong to different segments of Manila subduction zone and adjacent faults are chosen. In order to identify the recent movement pattern in the studied fault systems, some consent criteria of classifying focal mechanisms and average stress states have been drawn out. Based on comparative analysis of the special correlation between the stress distribution patterns with kinematic-geometric parameters of faults, characteristics of average tectonic stress field and recent tectonic movements have been defined for the systems/or segments of the active faults in the studied region.

T1-P17. Sensitivity analysis of infrasound based source verification: influences of atmospheric conditions and surface orography

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The detection and verification of natural or anthropogenic signatures using the infrasound technique is based on propagation modeling between source and receiver. Atmospheric background conditions as well as orography significantly influence the propagation path of infrasound signals and may therefore permit or prohibit signal detection.
Infrasound propagation modeling is performed at the German Aerospace Center (DLR) using the improved 3d ray-tracing model HARPA/DLR. Case studies of infrasound propagation are presented with respect to different atmospheric temperature and wind fields using climatological, weather forecast and satellite data. Furthermore, influences of reflection by uneven surface orography on infrasound propagation are described using advanced German Aerospace Center (DLR) terrain models.
A sensitivity analysis of atmospheric/orographic influences on infrasound propagation will be presented quantifying the differences in propagation paths and emphasizing the importance for source verification.

T1-P18. Detection, location and screening of seismic, hydroacoustic, infrasound and tsunami waveforms associated with May 29, 2010 S-Sarigan submarine volcano eruption, Marianas islands

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On May 29, 2010 a strong submarine volcanic eruption occurred in the Marianas Islands. The energetic phase was brief and sent an ash and gas cloud as high as 12,000 m. This event was detected by its infrasound waves and by seismic and hydroacoustic phases all over the world. Two small local tsunamis were also recorded by a neighbouring tide gauge. The source was accurately relocated using all the recorded phases and placed on a bathymetric map. The geophysical dat were correlated with witnesses' reports. From the analysis of these different data, a credible scenario of crisis development was deduced.

T1-P19. Dissipated energy by S-Sarigan paroxysmic eruption and explosive discrimination on hydroacoustic waveforms

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The submarine volcanic eruption of a vent south of Sarigan island, Mariana, on May 29, 2010, generated an explosion comparable in energy to a medium-size nuclear explosion. The event phases were used to estimate by different empirical and theoretical methods the dissipated energy in ground, water and atmosphere. The discrimination criteria were applied to the hydroacoustic phases to confirm the explosive mechanism.

T1-P20. Infrasound studies of some local and regional events detected by I33MG

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Sixty infrasound stations are installed around the world within the framework of the International Monitoring System (IMS). The purpose of these stations is the detection of a nuclear test of more than 1 kiloton, but they can also detect infrasound signals from many geophysical phenomena such as ocean tides, cyclones, lightning, and volcanoes. Data collected since 2001 from IMS station I33MG located in Madagascar and from surrounding stations allowed us to study 3 natural event types: volcanic eruptions, tropical cyclones and lightning. In this analysis the PMCC method was used for the data processing and the tau-p method, using the HWM and MSIS climatology models, for the ray tracing. Volcanic eruptions from Karthala (Comoros) and Piton de la Fournaise (Reunion) provide high frequency records. Two types of pattern are observed in these records: those with continuous, and those with sporadic signals. Every year several tropical cyclones form over the South-Western part of the Indian Ocean, theses cyclones generate infrasound in the microbarom frequency band when they occur over deep ocean. Lightning records are observed during the rainy season from September to March and they dominate the high frequency signal detections recorded at I33MG. Propagation of signals through the atmosphere is dependent on temperature and wind.

T1-P21.Acoustic observations of stratospheric solar tides: Examples from the eruption of Eyjafjallajökull, Iceland, April-May 2010

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The summit eruption of Eyjafjallajökull, Iceland, between 2010 April 14th and May 20th was recorded across at least 14 microbarograph arrays located in mainland Europe, north Africa and north-west Greenland, at ranges between 1740 and 3670km. Four of these arrays (IS18, IS26, IS43, IS48) are part of the International Monitoring System that is being constructed as one of the verification measures for a Comprehensive Nuclear-Test-Ban (CTBT). Within the detection timeseries diurnal variations in infrasound signal characteristics (signal amplitude, arrival azimuth, apparent speed and frequency content) have been identified, associated with infrasound propagating along stratospheric propagation paths from the volcano. As the signal detection time series were noisy and unevenly sampled, periodicities within the data were identified using a Lomb-Scargle periodogram analysis and a CLEAN sampling function deconvolution. The results of infrasound propagation modelling through state-of-the-art meteorological profiles suggest that stratospheric wind variations generated by solar tides may explain the diurnal structure of the observations. Analyses which rely on accurate understanding of the acoustic travel path will be affected by solar tidal wind variations (e.g., network detection capability studies, source location, and source size characterization), many of which are of concern for CTBT verification monitoring. Solar tidal wind variations present a challenge for propagation modelling because the effects act over timescales and lengthscales comparable to those encountered in long-range (1000's km) infrasound propagation. However, the study of infrasound from continuous sources such as volcanoes shows promise as a tool for identifying and analysing tidal structure within the stratosphere and upper atmosphere.

T1-P22. Adaptively parameterized surface wave tomography: Methodology and a global model of the upper mantle

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Observations of seismic surface waves are a very powerful tool to constrain the lateral structure of the Earth's upper mantle, including its anisotropy, because they sample this region with an almost constant sensitivity along the raypath. Like all global seismic databases, the set of surface-wave data available to us has a geographically inhomogeneous coverage, which leads to difficulties, particularly in the appropriate choice of model parameterization. On a global scale most tomography models today are still parameterized uniformly. No consideration is given to the inhomogeneous data coverage and resulting inhomogeneous model resolution due to under- or overparameterization of many areas. If the local resolving power of seismic data is not taken into account when parameterizing the model, features will be smeared in the final model, with subsequent misinterpretation. Parameterization density has to change locally, for models to be robustly constrained without losing any of the accurate information available in the best sampled regions. We have implemented a new algorithm for upper-mantle surface-wave tomography, based on adaptivevoxel parameterization. High resolution is achieved in regions with dense data coverage, while lower resolution is kept in regions where data coverage is poorer. This way, parameterization is everywhere tuned to optimal resolution, minmizing both the computational costs, and the nonuniqueness of the solution. We illustrate our method, including appropriate regularization operators, and numerical shortcuts to keep computational costs at a minimum. The latter could be potentially enormous since the spacing of our global grid is locally as small as ~50 km. We apply our method to the derivation of a global model, with resolution particularly enhanced in the european lithosphere and upper mantle. Our results are in agreement with large-scale features which have already been observed in earlier studies, inlcuding e.g. the Trans-European Suture Zone, the Panonian Basin, opening of the Aegean and Western Mediterranean, possible smallscale upwellings under Iberia and Massif Central, subduction under the Aegean arc. The very deep cratonic root underneath southern Finland is a particularly robust feature of our maps.

T1-P23. Unexpected high seismic activity observing near the Ulaanbaatar area, capital city of Mongolia: Improved relocation by using array-based earthquake location technique

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Important seismic activity has been taking place near and within Ulaanbaatar area since 2005 and it is still active up to today. This area, which could be one of most seismic active zone around Ulaanbaatar, dramatically increases the seismic hazard of the capital of Mongolia where is concentrated about of 1/3 of the Mongolia population and the majority of industries of the country. The number of earthquakes occurred between 1970 and 2010 contains totally more than 2500 events, 900 events recorded during 1970 - 2004 and 1340 events occurred from 2005 to 2009. There were 508 earthquakes corresponds only for 2009, and 310 events were already occurred beginning of 2010. Distribution of these swarms, with more than 2000 events with magnitude between 0.5 and 4.2, has interconnected the major active structures in Ulaanbaatar area by a steeply dipping fault surface striking East-West Hustai and North to South Emeelt fault. The 2005/2009 swarm mostly occupied the Emeelt fault and shows increasing number of events of extreme site of this structure. The Hustai fault area activated by the 2009/2010 swarm, however, is shows probably main potential structure which could produce large earthquakes, starts to be break and moving. In addition to the complexity of the tectonics context, the lack of large magnitude earthquake in this area conjugated with the recent triggered high seismic, which has been well monitored by local digital seismic network, makes the study of this earthquake activity fundamental for the estimation of Ulaanbaatar seismic hazard.
In this presentation, we will present and discuss array-based earthquake location technique estimates resulting from PS25 array signal in order to improve the location accuracy of seismic activity around Ulaanbaatar area.

T1-P24. Vp/Vs ratio and seismic activity at active structure of Ulaanbaatar area, the capital city of Mongolia

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Variations in seismic velocities and Vp/Vs ratio can be used to identify precursory activity which may precede large earthquakes and as well as volcanic eruptions. The observation of such variations before large earthquakes has been observed several month or years prior to before large earthquakes. Anomalously high seismic activity occurs around the Ulaanbaatar, capital city of Mongolia since 2005. This area, which could be one of most seismic active zone around Ulaanbaatar, dramatically increases the seismic hazard of the capital of Mongolia

where is concentrated about of 1/3 of the Mongolia population and the majority of industries of the country. Since the beginning of this high seismic activity in middle of 2005, more than 3000 earthquakes with magnitude between 0.5 and 4.2 have been observed by our network through this area. Since 1994, we have a better detection and location of the seismic activity around Ulaanbaatar when a seismic network has been installed around the capital in collaboration with DASE France. Later on it was upgraded by PS25 seismic array which is located on the area of main structure (Hustai Fault) reactivating, in frame of CTBTO activities. Therefore, it gives unique chance to us to control evaluation of clustering and spatial distribution of these seismic activities in real time. We analyzed seismic velocity variations of earthquakes recorded at the permanent stations of the Ulaanbaatar Network, which is located just above the seismic activity. Beside this, we investigated data from quarry blasts located around Ulaanbaatar city waiting 5- 300 km away. We present result of study Vp/Vs variations with related seismic events and clusters area as well as methods that we used.

T1-P25. Investigating body wave energy in ambient seismic noise

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The microseismic frequency band contains a large amount of coherent energy, which has generated much interest recently because of its use in surface wave tomography as well as its apparent link to temporal changes in ocean wave behavior. Although the dominant component of this energy travels as surface waves, body waves also contribute a significant portion at slightly higher frequencies. The surface wave noise appears to be generated by ocean wave interaction along the coastline, however, several studies have indicated that the body wave energy may originate from the deep ocean suggesting the possibility of different mechanisms for the generation of surface and body wave noise. Further exploration of the nature of body wave noise is necessary to better understand how and where it is generated, and what additional information we might gain from it. We investigate source locations of this body wave noise generation using a back-projection technique and data from the small aperture seismic arrays of the International Monitoring System. Array analysis using this data provides a powerful tool for placing constraints on the direction and mode of incoming coherent energy. By simultaneously utilizing information from several arrays around the Pacific Ocean we can place tighter constraints on noise generation located there. Preliminary results project one month of noise from January 2009 to an area in the middle of the Northern Pacific, consistent with independent results from a traditional frequency-wavenumber analysis and supportive of the possibility of a persistent deep ocean generation for microseismic P-waves.

T1-P26. Characterization of the Carancas meteor fall from infrasound signals

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The use of the Infrasound Monitoring System to study bolide sources is now well documented.
Analyzing a meteor's entry through its infrasound signal has proved effective in determining crucial characteristics of a meteor fall. For the case of the meteor fall in Carancas (Peru) in 2007, some authors have argued that the dominant process of the sound generation was from fragmentation. These conclusions are strongly dependent on the processing of the recorded signals and do not substantially rely on existing analytic models within the field of meteor physics.
In our goal of offering an alternative explanation, we have begun analyzing the possible N-wave signal created from a single-body source. A stochastic source model has been developed in order to determine the resultant shock wave. Once weak shock levels are obtained, Whitham's nonlinearization method is used to determine how the propagation front evolves over the remaining distance to the station.
In our initial model, various unknowns were assigned random variables and a statistical analysis of all possible outcomes was considered. This included deriving the probability of obtaining a given signal and how the random diameter affected this probability. This model has now been extended to incorporate a random atmosphere through the use of stochastic processes. Through comparison of our results to recorded infrasound data, we aim to show that it is possible that an N-wave type signal could have originated from the Carancas meteor scenario, hence that the meteorite did not fragment upon entry.

T1-P27. The OGS local virtual seismic network in South-Central Europe as an array: exploiting depth phases to locate upper mantle discontinuities

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The Centro di Ricerche Sismologiche (CRS, Seismological Research Center) of the Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS, Italian National Institute for Oceanography and Experimental Geophysics) in Udine (Italy) after the strong earthquake of magnitude Mw=6.4 occurred in 1976 in the Italian Friuli-Venezia Giulia region, started to operate the North-eastern Italy (NI) Seismic Network: it currently consists of 13 very sensitive broad band and 21 simpler short period seismic stations, all telemetered to and acquired in real time at the OGSCRS data center in Udine. Real time data exchange agreements in place with neighbouring Italian, Slovenian, Austrian and Swiss seismological institutes lead to a total number of 94 seismic stations acquired in real time, which makes the OGS the reference institute for seismic monitoring of Northeastern Italy.
In this study we use P, pP, S and sS phases from global events recorded by the OGS local virtual seismic network in South-Central Europe to study upper mantle discontinuities above earthquakes in the subducted Pacific Plate. We use the time lag between the surface-reflected depth phase and a precursor to determine the discontinuity depth. Accurate estimation of reflector depth depends on a velocity model of the source-side mantle structure. In contrast to typical one-dimensional velocity models, our source-side structure is oceanic, with a shallow Moho and thin crust overlain with water. The time lag between the direct P and pP or S and sS arrivals without accounting for source structure can be as large as 5 s when compared to a purely continental model like iasp91 or ak135.
We identify upper mantle discontinuities using slant stacking and depth-migrated standardized waveforms. The processing shows S-to-P arrivals from the 660 km discontinuity, the 410 km discontinuity, and shallower upper mantle ones of uncertain origin.

T1-P28. Observations of atmospheric radionuclide cycles: The benefit for global paleoclimate studies

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Paleo-records of cosmogenic radionuclides provide important clues on their past production rate and related solar and geomagnetic activity. More precisely, 14C stored in tree rings/sediment and 10Be archived in polar ice cores are currently the only possible tools to extend our knowledge of solar activity to the past. However, while efforts in production rate reconstructions of both radionuclides agree fairly well in view of decadal to centennial variability, they systematically deviate, for unknown reasons, on the millennial time scale. This finding calls for investigating the controlling hand-over of the atmospheric production signal into the climate archives. In case of aerosol-borne 10Be, atmospheric transport and deposition might convert the atmospheric production signal and necessitates a thorough understanding of the global atmospheric 10Be cycle. Depending on aerosol lifetime only, radionuclide ratios – like 10Be/7Be – are valuable tools to examine the radionuclides' cycles and we report in this respect on findings of our longterm monitoring at Neumayer Station in coastal Antarctica. However, while on the one hand atmospheric measurements of 10Be (or 22Na, which basically carries the same information) are rare, a proper understanding of the global atmospheric 10Be cycle might require a large set of globally distributed, longterm measurements. Finally, we address the CTBTO radionuclide network as being unique in contributing to this kind of research on the global scale. In this context, also network related side effects are discussed as the potential of these natural radionuclides to provide an independent quality control tool through their strongly constrained spatio-temporal source distribution.

T1-P29. Effect of anisotropic inhomogeneities in the atmosphere on long-range sound propagation from explosions

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The model of the formation of anisotropic fluctuations in wind velocity and air temperature in a stably stratified atmosphere is described. This model takes into account the scattering effects of anisotropic-inhomogeneities of

effective sound speed on the propagation of acoustic waves in the atmosphere. Experimental detections of stratospheric, mesospheric and thermospheric arrivals from explosions (from both surface-based explosions and volcanic eruptions) in acoustic shadow zones are explained by the results of calculations of the scattered acoustic field using the parabolic-equation method. Calculated acoustic signals with a fine structure of wind velocity and air temperature taken into account were compared with signals recorded in the region of an acoustic (geometric) shadow. Thus, the possibility of acoustically sounding the fine structure within the middle and upper atmosphere is being considered.

T1-P30. Comparison of recurrence curves from the IDC and ISC catalogs

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The well-known linear relationship between magnitude and cumulative number of earthquakes has a slope (-b) which is close to unity for magnitudes above which the record is complete. Although this linearity is often used to estimate the magnitude threshold of completeness, the situation is complicated by the mixing of event populations for which the b-value is different, and by the fact that the completeness threshold itself depends upon location. One way to mitigate this is to compute b value separately for different geographic regions.
Therefore, we have calculated and compared frequency/magnitude distributions for 50 seismic regions defined at the IDC using the IDC and ISC seismic event catalogs. Relevant measurements of body wave magnitude, mb, cover various periods, including the IDC operation one between 2001 and 2011. Bulletin completeness was roughly estimated for several seismic regions with appropriate number of events.

T1-P31. Inverse modelling of the 2010 Eyjafjallajökull eruption and comparison with infrasound signals

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In April and May 2010, an eruption of the Eyjafjallajökull volcano in Iceland, lasting several weeks, emitted large amounts of ash into the atmosphere, causing widespread disruption of the air traffic over Europe. Inverse modelling has been done to derive the time- and height-dependent emission of ash from atmospheric transport modelling and ash total colum values derived from SEVIRI and IASI satellite observations (Stohl et al., 2011). This eruption has been observed by a number of infrasound arrays in Europe and on Greenland at distances on the order of 2000 km (Matoza et al., 2011). We are presenting an overview of the inverse modeling methodology and the main results. The time series of the ash mass flux and the corresponding plume top heights, mostly varying between 5 and 10 km, will be compared with the time series of the infrasound signals at selected locations. Specifically, we shall compare the onset and decay of ash emission and infrasound. As surveillance of volcanoes has been suggested as a possible civilian application of the IMS infrasound network, this contribution will help to better understand possibilities and limitations of this approach. Acknowledgment: A part of this work is financed by the European Space Agency (ESA) through the SAVAA project.

T1-P32. Using the International Monitoring System infrasound network to study large-scale atmospheric waves

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The majority of the operational IMS infrasound stations use absolute pressure sensors that measure pressure fluctuations with frequencies ranging from DC to tens of Hertz. This frequency range encompasses the entire domain of infrasounds as well as that of gravity waves and meteorological processes. A recent study, which has demonstrated the accuracy of the IMS pressure measurements up to 24 hour period, has opened the way to the study of gravity waves from IMS pressure measurements.
Among gravity waves, atmospheric tides are waves with periods corresponding to integral fractions of a solar day (primarily diurnal and semidiurnal). They are produced by the atmospheric solar heating combined with upward eddy conduction of heat from the ground. Their importance is high as they regularly cause oscillations in atmospheric wind, temperature and pressure fields. The seasonal variations of the diurnal (S1) and semidiurnal

(S2) pressure oscillations are studied from IMS pressure measurements. The results are in good agreement with previous modelling and observations. However, strong variations in S1's amplitude - not predicted by global modelling – are also observed during short time-period on continental stations. These variations are not only detected by IMS infrasound sensors but also by the absolute pressure sensors part of IMS meteorological stations. The study of these phenomena is of high importance since it can modify atmospheric wind profiles and influence the propagation of infrasonic waves.

T1-P33. Remote monitoring of volcanic eruptions using the International Monitoring System infrasound network

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Many volcanoes in remote locations are not monitored individually but can still pose a threat, especially to aviation. Explosive volcanic eruptions are known to produce infrasound which can propagate over distances of thousands of kilometres within the atmosphere, and together with the growing International Monitoring System (IMS) network of infrasound stations could present an opportunity to monitor these remote volcanoes. In this work a dataset including 120 eruptive events at 40 volcanoes has been investigated to assess the capability of the IMS network for use in global volcano monitoring. Detected events range from Strombolian activity at Mount Erebus (Antarctica) recorded at a range of 25 km distance, to the Plinian eruption of Manam Volcano (Papua New Guinea) recorded at ranges of over 10,000 km distance. Despite complications inherent in such a global study (e.g. propagation effects and variable noise levels) relationships between infrasound and eruption characteristics are emerging from the data. In general signals with lower frequencies, higher amplitudes and greater acoustic power are generated by eruptions with higher plume heights, and are detectable at greater distances. This work adds weight to the idea that a global network of infrasound stations such as the IMS could be used to remotely monitor volcanoes.

T1-P34. Infrasound propagation in the atmosphere

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The infrasound wave propagation in the Earth's atmosphere are investigated. The results of calculations of linearized kinetic equations were obtained by the relaxation collision model of Stubbe. The generalized polytropic coefficient were considered for the plane wave. The graphics of the dependance damping coefficient of the infrasound wave from frequency and from collision frequency.

T1-P35. Explosion of crater lake in the "Cameroon line" area: seismic contribution

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In the Gulf of Guinea (Africa), the "Cameroon volcanic line" is geologically unusual in extending through both the ocean and the continental crust. In the inland, there are crater lakes, both of them have already exploded in a limnic eruption which resulted in the release of a large amount of a carbon dioxide coming from volcanic activity: - The Lake Nyos, in the Oku volcanic plain suddenly exploded on August 21, 1986, and emitted a large cloud of CO2, which suffocated 1,700 people and 3,500 livestock in nearby villages. - Lake Monoun lies in the Oku Volcanic Field, it exploded and released of a large amount of carbon dioxide that killed 37 people." The paper describes the tectonic evolution and seismicity of "Cameroun line" together with the explosions of crater lakes. We notice that many of the tectonic phenomena follow the previous structural lines and different clusters of epicenters are identified. Although the area is one of relatively low seismicity, the implication of earthquake is considerable in the occurrence of lake explosions; specially, shaking the crater lakes which explode and release the gas. By these natural events, we want to make known the area of Cameroon line which is propitious site to the diversion.

T1-P36. Computation of pressure change in the sea from acoustic and tsunami waves excited by a sub-oceanic earthquake with a finite-difference scheme for seismic waves

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Pressure sensors in the sea are very useful for monitoring tsunami waves generated by earthquakes under the sea floor. In this study we propose a modelling method of acoustic and tsunami waves as well as seismic waves based on the elastodynamic equation for a gravitating flat earth model with a sea layer. We here simplify the equation by adopting the Cowling approximation which retains the initial acceleration of gravity and by assuming the acceleration of gravity to be uniform over the computational region. We formulate the equation into a velocity-stress form (i.e, a set of the first-order equations) to apply a staggered-grid finite-difference time-domain (FDTD) method which is often employed for earthquake ground motion simulations. This scheme can simultaneously model all of the seismic waves in the solid earth and acoustic and tsunamis waves in sea from sub-oceanic earthquakes. This can calculate pressure changes in the sea due to acoustic and tsunami waves, which may be extracted from the pressure sensor records in the sea. In this presentation we will show numerical scheme and some computational examples.

T1-P37. Environmental impact of the nuclear tests in Argentina

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A statistical procedure was used to analyze the temporary variation of the 90Sr and 137Cs concentrations. The obtained results allowed to assess the environmental impact of the radioactive fallout in South America produced for the past nuclear explosions. The objective of this research is increase the knowledge of the contamination from atmospheric nuclear weapon tests in the South Pacific.
Samples of wet deposition and fresh milk were taken in Buenos Aires city and the surroundings since 1960.
Radioactive fall-out from the stratosphere and troposphere generated important peaks in 1964, 1965 and 1966. A secondary peak of fallout tropospheric came from South Pacific in 1970, 1971 and 1972.
Two sets of data are clearly distinguished, before and after the nuclear weapon tests. The maximum concentrations of 90Sr in wet deposit and milk were registered in 1964. Concentration activity of deposit and milk were 83.6 MBq/km2 and 240.8 mBq/liter. Today, activity of 90Sr and 137Cs are less than 0,02 MBq/km2 and 10 mBq/liter respectively.
In the case of 137Cs, the maximum concentrations in wet deposit and milk were measured in 1966. Concentrations in deposit and milk were 95 MBq/km2 and 944 mBq/liter. Today, 90Sr and 137Cs values are less than 0.60 MBq/km2 and 4.7Mq/liter respectively.
The results show that the environmental concentration was decreasing along decades although slower in recent years. This effect is only observed in long term of sampling. Nowadays, the radioactivity concentrations are very low and close to stabilized and the observed oscillations come from resuspension phenomenon.

T1-P38. Evaluating 238U/235U in U-bearing accessory minerals

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U-daughter geochronology and nuclear forensics utilise the absolute value of the present day 238U/235U ratio. For decades this value has been assumed to be invariant and equal to 137.88, but recent experiments indicate that there is potential for per mil level variation in 238U/235U in natural materials, hypothesized to be the result of redox reactions. These studies have largely focused on materials formed in low-temperature environments and U ore deposits. At present there is no published high-precision high-accuracy 238U/235U data for U-bearing accessory minerals commonly used for U-Pb geochronology.
We present accurate and precise 238U/235U determinations (absolute uncertainties of ~200 ppm) for a suite of common U-bearing accessory minerals from a variety of geological environments and ages. Measurements have been made by multi-collector TIMS and ICPMS, accurately correcting for mass fractionation using the IRMM

3636 233U-236U double spike. These results indicate that accessory mineral 238U/235U ratios are lower than the 'consensus' value of 137.88 and record limited but resolvable variation. Systematic discordance has been observed in closed-system minerals and used to reassess the relative decay constants of 238U and 235U. These studies derive λ235U relative to λ238U by assuming equivalence between 238U-206Pb and 235U-207Pb dates and using assumed values (i.e. 137.88 or 137.80) for the present-day 238U/235U ratio. Our new determination of coupled 238U/206Pb, 235U/207Pb and 238U/235U measurements on the same closed system zircons permits further refinement of λ238U/λ235U estimates using parameters whose values and uncertainties are all traceable to SI units.

T1-P39. Time series analysis of the seismic events worldwide

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A time series analysis with the seismic events occurred worldwide from February 2000 to February 2011 was carried out. This analysis was done with the REB events recorded in the IMS network of CTBTO. As a whole, 301,723 events have occurred in this period and the number of REB events published by CTBTO is about 75 events each day. The numbers of events per year has been slightly increased recently, but this can be regarded as due to the newly installed IMS stations in the world. The number of large earthquakes whose magnitude is more than or equal to 6.0 and the value of energy released by the events have stayed relatively constant. The released energy value is relatively high in 2004, when the earthquake and tsunami occurred off the coast of Northern Sumatera on 24 December. During this 11 year period, no additional trend was found. Data collected over a longer time period may yield different results.

T1-P40. Phase velocity and attenuation parameters in the Iranian Plateau

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Regarding to the development of regional seismic discrimination methods, we will introduce information related to the seismic propagation as well as associated to geologic-tectonic and geophysical data. The shape of the attenuation curves and spatial variation of seismic phase velocities are established for the Southern and Northwestern of Iranian Plateau from empirical data. The data set comprised Parsian Seismograph Karkheh, Seimareh, Siahbisheh, Karun local dam dense networks which recorded earthquakes near to Iran and Pakistan Border like 7.2 Mw (2011/01/18).
Distribution of our stations allows us to compare seismic velocities in the Iranian Plateau minus Zagros region with Iranian Plateau with Zagros region path. We found an unusual seismic velocity beneath the Zagros region.
The findings support the hypothesis that postcritical reflections from the Moho discontinuity play an important role in determining the shape of the attenuation. Moreover, we have compared our results with coefficient of anelastic attenuation which has been obtained for this region before. One of the studies has been done by Nuttli (1980) on different seismic phases by World Wide Standard Seismograph Network (WWSSN) in Shiraz, Tabriz and Mashhad. Moreover, Shoja-Taheri et al (2007) have determined the coefficient with strong motion data records by National Strong Motion Network of Iran recently. Comparison between our average Q factor and Nuttli's value, illustrates a good correlation in contrast with the study of Shoja-Taheri et al.

T1-P41. Do triggered earthquake patterns depend on trigger faulting style?

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Aftershocks normally occur in the fault zone of the mainshock, where coulomb stress changes is positive. The number of aftershocks depends on pre-stress conditions and mainshock stress drop. But recently Schorlemmer (2005) and Narteau (2009) show that b-value and c-value depend on faulting style. We have performed the similar type of analysis for aftershock sequences, using global data. We show that the aftershock rate(R), which is tested for different time windows shows that R(normal)>R(thrust)>R(strike-slip). The K*-value, which is independently calculated using the Ogata (1983) technique also shows similar pattern as that of rate, that is: K*(normal)>K*(thrust)>K*(strike-slip). Furthermore, we also show that that p-value is also dependent on fault mechanism, that is: P(normal)>P(strike-slip)>P(thrust) and a positive correlation between p-value and K* shows that our model is consistent to with the Omori law.

T1-P42. The physics of tsunami: basics understanding and its disastrous effects

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The explanation based on physics energy conservation and wave properties have been used to understand this phenomenon of Tsunami generation and its development. It is Series of water waves generated by huge and sudden perturbation e.g. earthquakes, slides, volcanoes, asteroids, having Wave period: 2-200 minutes Run-up heights 10-100 m, (Flooding of shoreline). They can be generated when the sea floor suddenly displaces the overlying water vertically. A tectonic earthquake when they occur beneath the sea, the water above the deformed area is displaced from its equilibrium position. Waves are formed as the displaced water mass, acting under the force of gravity, tries to regain equilibrium. When large areas of the sea floor elevate or subside, a tsunami can be created. The waves sweep across the open ocean at high speed and have caused severe damage to costal areas thousand of miles from the earthquake which generated them. An eye-witnesses of December 26, 2004 accounts in understanding tsunami effects. To understand the mechanism of tsunami propagation and the selection of certain section of coastline for waves of destructive amplitudes it is necessary to recognize the depth dependence of wave velocity which is the feature of shallow water wave. The velocity of this class of wave may be derived by assuming equipartition of the potential and kinetic energies of the wave motion. In the present article quantitative derivation of tsunami speed and its disastrous effect has been discussed. The tsunami's energy flux, being dependent on both its wave speed and wave height, remains nearly constant. As a result, the tsunami's speed decreases as it travels into shallower water and its height increases. When it reaches the coast, it may appear as a rapidly rising or a series of breaking waves. Being human inability to predict earthquakes and since earthquake magnitude does not determine tsunami impact, resulting tsunamis can be detected by seabed monitors and ocean buoys leaving adequate time for evacuation and information dissemination technologies though, is a minor part of the solution and a mechanism needs to be in place to interpret alerts, relay the warning to local communities through awareness and enable them to undertake quick action.

T1-P43. Assessment of tsunami damage using remote sensing and GIS and expected benefits of disaster early warning systems to tsunami vulnerable areas

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The catastrophic tsunami, generated by an earthquake off Banda Ache Sumatra, Indonesia, of magnitude 9.1 on the Richter scale, at 00:58:53 UTC on 26/12/2004 with an epicenter 250km SSE, hit many countries in Asia, severely affecting India, Indonesia, Sri Lanka and Thailand. The Northeastern, Southern and Western provinces of Sri Lanka was severely affected by this tsunami, resulting in a conformed death toll of 30,196 casualties. Additionally, agriculture was affected, destroying 259 km² of paddy area, causing extensive salinisation, sediment deposition, saline intrusion and destruction to irrigation canals. The study assessed the damage caused to civil structures and city infrastructure, agriculture, coastal systems and fisheries in the Galle Municipal Area using high resolution satellite images and differential GPS data. The results indicated that the major livelihood activities including tourism, fisheries and agriculture and were seriously affected. Further, the study emphasises on the usefulness of the application of remote sensing technology in damage detection and the importance of establishing comprehensive Early Warning Systems in tsunami-prone areas. The need for such system was much felt during the two recent earthquakes in Japan and resultant tsunamis, with a magnitude of 8.9 on 11/03/2011 and 7.1 on 07/04/2011respectively. Although these quakes did not directly affect Sri Lanka, they caused panic due to the lack of a sound warning system and awareness on the same. At present, the International Data Centre provides information on seismic activity only to the Geological Survey and Mines Bureau of Sri Lanka. However, a comprehensive Early Warning System could be established in the country, if this information was permitted to be shared with other relevant agencies, such as the Disaster Management Centre, Metrological Department, National Aquatic Resources Agency and would also lead to detailed research if Universities were permitted to access the said data.

T1-P44. Seismic monitoring in Azerbaijan in aspects of seismic hazard assessment

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Azerbaijan is situated in the active collision zone of Arabian plate with Eurasian and characterized by high seismic activity (Shamaka earthquakes 1667, 1902; Gyandja earthquake, 1167; Mashtaga earthquakes 1842, 1953, Baku earthquakes 1910, 1922, 1935; Caspian earthquakes 1961, 1963, 1986, 2000). The first seismic station was set up in Baku by the Nobel brothers in 1903 to study the seismicity of the Absheron peninsula and

to provide the countermeasures against consequences of a potential destructive earthquake (Shamakha, 1902). Currently, 26 digital telemetric seismic stations of Kinemetrics were operating in Azerbaijan at the Republican Center of Seismological Service (RCSS). Since 1996 the Institute of Geology operates telemetric system of seismic monitoring ISS, which consists of 3 stations of South Africa production. The system is situated on the Absheron peninsula and registers the seismic events. ISS system can be effectively used for controlling the landslide situation in Baku city (the capital of Azerbaijan), which is valuable for diminishing the losses of probable future displacements of the large massive of grounds. In 1998, GPS network in Azerbaijan was established by the Institute of Geology at Azerbaijan National Academy of Science in collaboration with Massachusetts Institute of Technology (MIT) and as a result of study, the distribution of horizontal velocity pattern was traced, which contains significant basic physical information for maintaining the prediction of seismic hazard. GPS observations in Azerbaijan (3 constant operational stations on the 31 sites with annual measurements) and surrounding areas of the Caucasus region are providing quantitative constraints of the geometry of active fault systems, and rates of present-day deformation. For controlling seismic events alongside the main oil pipeline Baku-Tbilisi-Ceyhn (BTC), which is one of the strategical regions of the country, seismic station by Guralp Systems Limited was installed in the western part of Azerbaijan (in the Sheki city) operating in an on-line regime. Besides, 5 additional ISS stations were installed on the Kura Depression zone. Azerbaijan National Data Center (Az-NDC) processes, analyzes and stores the data from IDC. On the basis of datasets from RCSS, ISS and Az-NDC it helps to trace the distribution of earthquakes' epicenters, analyze the seismic regime and earthquake re-occurrence and study the interrelation between geodynamic processes with seismic activity in the Caucasus region and Caspian Sea.

T1-P45. The ARISE project

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ARISE is a new European Research Infrastructure project selected by the European commission in April 2011.
ARISE proposes to design a new infrastructure that integrates different station networks in order to provide a new "3D" image of the atmospheric dynamics from the ground up to the mesosphere with unprecedented spatio-temporal resolution. The implied networks are:
- the International infrasound network developed for the verification of the Comprehensive nuclear Test Ban Treaty (CTBT). This system is unique by its quality for infrasound and atmospheric wave observations,
- the Network for the Detection of Atmospheric Composition Changes (NDACC) which uses Lidar to measure stratospheric dynamics,
- the Network for the Detection of Mesopause Changes (NDMC), dedicated to airglow layer measurements in the mesosphere, and additional complementary stations and satellite data. The infrastructure extends across Europe and outlying regions, including polar and equatorial regions.

Atmospheric waves play a key role in atmospheric mixing and global circulation in the stratosphere and mesosphere. Planetary waves can lead to sudden stratospheric warming while gravity waves generate predictable tropical oscillations of mean wind, which can lead to enhanced predictability of climate. Parameterization of gravity waves is needed for accurate simulation of mean climate and variability, but parameters are uncertain due to lack of long-term high-resolution observations.
ARISE expected benefits would be a better description of the atmosphere, leading to an improved accuracy in short and medium range weather forecasts. The measurements will be used to improve the parameterization of gravity waves in the stratosphere to better resolve climate models. Such description is crucial to estimate the impact of stratospheric climate forcing on the troposphere. In the long term, data will be used for monitoring changes in the occurrence of extreme events and trends in the middle atmosphere climate. The benefits also include civil applications related to monitoring of natural hazards as volcanoes.

T1-P46. A report of natural background radiation hazard in southern Tamil Nadu, India and its effect on habitat and environment

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Exposure and quantification of radioactivity has become significant in recent years with the gratitude of the consequence and urgency of environmental/climatic problems around the world. The radioactivity even in minor quantities will build up in human body and subsequently, lead to unknown and erratic health complications in particular those related to sustainable development, agricultural production, habitat, ecosystem and forest. This paper report the detailed radiation exposure rates at closely spaced intervals obtained along the beach sectors from Thengapattanam to Kanyakumari and the surrounding hinterlands regions of Tamil Nadu. High intrinsic radioagenic source, with radiation exposure rate ranging from 500 to 2600 R/h, have been identified in the weathered hillocks around Inayam and Midalam localities. In addition, a very high radiation exposure rate ranging from 1000 to 6000 R/h were found within the rock population of syenite body and in the boulders around Puttetti. Further, the radiation exposure rate along the connected beaches around Midalam, Kurumpanai and Manavalakurichi is observed to be lower than that of hinterlands ranging from 200 to 1600 R/h. Public concerns of radiation exposure of safety in high background areas are of great social and civil relevance. The construction materials used for dwelling purposes from these areas should be avoided from health hazard point of views. Significant radiation doses will certainly enter the human body as most of the people have the habit of sitting and sleeping on the floor. People living in the region are expected to receive significant radiation, which may get accumulated in the human body causing long-term health problem. It is also advisable if the area falls having already natural background radiation hazard must be avoided for the future nuclear power plants/reactors.

T1-P47. Forecast of the earthquakes' aftershocks in the common operations of seismic risk reduction

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The experience of seismological researches in different worldwide areas has shown convincingly that the main strikes of large crustal earthquakes are proceeding by aftershocks within the areas of foci of these major earthquakes. The energy of aftershocks doesn't exceed the energies of their main shocks. The more powerful is the main shock, the more powerful are aftershocks and the longer, according to the Omori-Utsu law, they are continuing. So, major earthquakes can be sequenced by quite strong aftershocks, and as the main shock can lead to catastrophic consequences. Aftershocks are dangerous also by the fact that as a result of strong main earthquake the aftershocks hit and damage buildings already have been weakened. The problem of aftershocks forecast seems much less difficult, because the locations of their occurrence are already known and one knows where to install the monitoring geophysical network. Experience of tectonomagnetic researches in seismic regions of Tajikistan showed that some earthquakes at least with a magnitude above 5 is preceded by anomalies in local geomagnetic field variations up to the first nT with the durations featuring for medium-term earthquake precursors. For example, Kairakkum earthquake on Oct. 13, 1985 was preceded by anomalies of up to 4 nT and after the main shock there were anomalies of about 1 nT 1-3 days before all the aftershocks with magnitudes above 2.5. Detection of anomalies in local geomagnetic field variations before strong aftershocks enables to predict them in principle and provides making relevant decisions during recovery stage after major earthquakes.

2. UNDERSTANDING THE NUCLEAR EXPLOSION SOURCE

Conveners:

MIKA NIKKINEN
International Data Centre
CTBTO

MATJAZ PRAH
On-Site Inspection Division
CTBTO

MARTIN KALINOWSKI
Centre for Science and Peace Research,
University of Hamburg
Germany

Invited Speakers:

HARRY MILEY
Pacific NW National Laboratory
United States of America

ANDERS RINGBOM
Swedish Defence Research Agency (FOI),
Sweden

HARRI TOIVONEN
Security Technology Radiation and Nuclear
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Finland

ORAL PRESENTATIONS:

T2-O1. Understanding the radionuclide source term for underground nuclear explosions

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The design of the International Monitoring System (IMS) radionuclide network and the design of an On Site Inspection depend critically on the radionuclides emitted from an underground test. The largest uncertainties in understanding the detectability of radionuclides in the IMS and OSI originate from the relatively unstudied processes that govern the transport of radioactive material from the site of an explosion to the accessible environment, i.e. the atmosphere, surface waters, and the surface soil, including the top few meters of soil. A surprising recent result is that Xe-131m may be the most important xenon isotope available for OSI, and backgrounds arising from natural and anthropogenic sources should be very low. A new idea about the collection of radioactive material at depth will be presented. The results of several recent investigations into transport and natural backgrounds will be reviewed, especially concerning noble gas, and suggestions for future research directions in radionuclide source terms will be presented.

T2-O2. The global atmospheric noble gas background

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The 40 station noble gas network in the International Monitoring System (IMS) is well underway to be finalized. Presently, more than 1000 air samples per month are measured with respect to the four isotopes 133Xe, 133mXe, 131mXe, and 135Xe, and the resulting spectra are transmitted to the International Data Center (IDC), and to the National Data Centers around the world. In addition, several measurement campaigns have been performed at key locations in order to further increase the global radioxenon data set.
Studies of the observed atmospheric activity concentrations and isotopic ratios and the use of atmospheric transport modeling has gained new knowledge of the anthropogenic radioxenon background as well as new insights in the possibilities to detect nuclear explosions using radioxenon detection.
Among the most important result from the collected data is the conclusion that the global background is dominated by releases from facilities producing medical isotopes.
An updated analysis of the global radioxenon background will be presented, as well as an assessment of the global coverage of the radioxenon network, including possible improvements of the network with respect to the number of installed noble gas stations and station locations.

T2-O3. New and novel technologies for CTBT radionuclide measurement and analysis

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Many of recent advances in radiation detection technology have their origin in nuclear security and safeguards. These R&D efforts are promising also from the point of view of the CTBT verification. The present paper reviews the radionuclide detection technologies and seeks for scientific and technical improvements, also from the point of view of other disciplines, such as optics. The radionuclide particle detection system of the CTBTO is state-of-the-art technology from 1990's. The major drawback is the filter itself which is large and provides bad geometry for the data acquisition. The detection limits could be essentially improved through better sampling technology facilitating the use of novel non-destructive measurement technologies – in addition to gamma spectroscopy. The noble gases – krypton, xenon and argon – produced in an underground nuclear test may leak to the surface. The CTBT verification technology has thus far been focused on xenon. However, the gas sampling, measurement and analysis are not yet fully optimized. The quality of the monitoring results is based on the reliability of the isotope ratios. This target can be improved by high-purity standards. In addition, the nuclear decay data must be known much better than today. Of particular importance are the direct fission yields. Advanced argon measurement technology could reveal an underground nuclear test months after the detonation. However, the low-energy photons and electrons are a major challenge for the detection system.

T2-O4. Numerical experiments on explosions triggering earthquakes

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Seismic triggering from underground nuclear explosions are of considerable interest in the context of verification and test limitation treaties. Whether and how underground nuclear explosions (UNEs) can trigger earthquakes is still not fully understood. To date exists no strong evidence of a causal connection between UNEs and large earthquakes. Analysis of local seismic recordings of UNEs at the Nevada Test Site show, however, that some tectonic stress is released simultaneously with the explosion (USGS website), suggesting that the explosions release elastic strain energy stored in the rock, and consequently inhibit the activation of earthquake. We develop 3D numerical models of UNEs near potential active faults to evaluate the possibility of earthquake faulting activation or inhibition. The explosion source is modeled as an equivalent point source in an elastic medium. Modeling is performed for wavelengths long compared to the characteristic source dimensions and for explosion from kiloton to megaton TNT-equivalent. The earthquake is modeled as a dynamically running shear crack on a frictional interface embedded in a linearly elastic continuum. The state of stress and frictional properties on the active faults are hypothetically set to represent a fault in the hypocentral area close to rupture initiation. Stress distribution on the fault is stochastically represented so that average stress drop is around 3MPa, as statistically derived from seismological observations of past earthquakes. Fault rupture, if activated, is triggered when the stress overcome the strength of the fault. The level of the dynamic stress perturbation on the fault after the explosion is evaluated.

T2-O5. Unstructured grid simulation of the atmospheric pressure-driven subsurface xenon-tracer transport

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Source discrimination for underground nuclear explosions can be affected by differences in the diffusivities of the four CTBT-relevant radioxenon isotopes during migration through geologic media caused by atmospheric pumping. Calculations on arrival times of these isotopes and their surface concentration levels, depending on weather patterns, are critical in narrowing down the on-site inspection activities such as soil gas sampling according to the CTBT provisions. A better understanding of the surface concentration level distributions can support optimised soil gas sampling schemes. A prior numerical test-site model for the Nonproliferation Experiment was realized through a uniform porous medium traversed by a narrow, millimeter-width fracture. We revisit the experiment by simulating the experimental data using a higher-order accurate finite volume - finite element method, which is implemented into the Complex System Modeling Platform (CSMP). This enables us to predict the arrival times and concentrations with greater accuracy. Additionally, the combination of finite volumes and finite elements allows for better geometric flexibility. We can therefore study tracer transport in more complex, but geologically more realistic, fracture models and evaluate how the predictions change compared to the prior model. This study presents results on time of arrival of the four CTBT-relevant xenon isotopes as well as their surface concentration levels and isotopic activity ratios.

T2-O6. Analysis of fission products in air samples due to nuclear explosion source

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The most important source of artificially created radionuclides is neutron-induced nuclear fission. The chemical and physical forms of the active species determine deposition, migration and uptake are radioactivity by living organisms. A variety of systems and processes may introduce radioactivity into the environment. Human activities involving nuclear weapons and the nuclear fuel cycle (including mining, milling, fuel enrichment and fabrication, reactor operation, spent fuel storage and reprocessing and waste storage), leading to significant creation and release of radioactivity. The physical and chemical form of radionuclides may vary depending on the release and transport conditions in addition to the element properties. After a peer review of literature data about nuclear fission products, it is observed that no clear chemical species, chemical compounds, or chemical processes were available after actual releases of nuclear fission products during planned releases, accidents, or in nuclear detonations. Detection and measurements of fission products are necessary in the field of nuclear safety and radiation protection, as well as reducing the expected potential risk associated with the radionuclides of interest. A programme has been undertaken to develop a simple analytical technique for easy detection of fission products in air samples. The objective of this study is to provide a simple analytical technique for detection and analysis of radionuclides due to fission products in air samples. This technique will be utilized for rapid detection and analysis of fission products in air samples due to nuclear explosion source. Observed radionuclide

concentrations are reported and isotope ratios and meteorological air parcel trajectories are used to characterize the source.

T2-O7. Modelling of elastic waves generated by a point explosion

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During the explosion the avalanche emission of energy take place. A shock wave is arisen. It causes plastic deformation. In case of homogeneity medium in the souse area the plastic wave front must be redial. It is evidence that the elastic deformation became effective when density of the released energy became proportional to the density of energy of elastic deformations. It takes place on surface of earthquake source. Spherical symmetry is true only near the hypocenter. On the surface of source this symmetry can be failed, but not as much that approximation form of source became irregular. To the full sufficiency can consider the approximation form of source as a rotational ellipsoid. So Generated waves caused due to the elastic deformation of rocks appear only on the surface of source and then propagate trough the medium. As per our model the tension – compression deformation (comprehensively tension) will be considered. This deformations produce body waves on the surface of source.
Conditions of equilibrium of the ellipsoid boundary can be obtained by the analogue equation of Laplacian one. In this equation instead of capillary tension coefficient (elastic module) will be taken incompressibility or bulk modules K multiplied on the characteristic size of ellipsoid c.
The free oscillations frequency spectra of elongated rotational ellipsoid (source of xplosion) is calculated.
This model give us possibility to solve inverse task by analyze discrete spectra of source self oscillation. So it is possible to determine linear parameters of source. After this It is possible to calculate the release energy of explosion. From theoretical point of view very interesting is to calculate synthetic seismograms by spectra of explosion.

T2-O8. The source time function of an explosive source

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The purpose of this paper is to draw the attention of the seismological community to a published method for determining the source time function of an explosive source, where there is more than one explosion at the same site. It is normally impossible to measure the source signature of an explosive source, because the incident and scattered fields overlap in time. The problem can be solved when a second explosion occurs at the same site: the source signatures are related by a scaling law, which follows from the invariance of the medium parameters with the size of the charge. The volume injection function of the larger shot is an amplified and stretched version of that of the smaller shot, the amplification factor being equal to the ratio of the source energies and the time stretch factor being equal to the cube-root of this ratio. At a given receiver, the response to one shot is a convolution of the source signature with the impulse response of the earth, plus noise. The two shots and the scaling law give three independent equations relating the three unknowns: the two source signatures and the impulse response of the earth (plus noise). We present a test of this idea using published dynamite data and a third shot which puts the theory at risk.

T2-O9. Effects of non-isotropic explosion sources upon the utility of the Ms-mb discriminant

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The Ms--mb discriminant was discovered nearly fifty years ago, and was effective for distinguishing between earthquakes and explosions in the era of teleseismic monitoring. It is still useful, though now it competes with methods based upon regional signals. In that competition, it will be of interest to see how small a seismic event can be, and still have a reliably-measured surface-wave magnitude---assigned, perhaps, on the basis of a stack of recordings from numerous broadband stations. The discriminant works well for sources large enough that body waves (from earthquakes) are radiated incoherently. But why does it also work well when source dimensions are small enough for the resulting body waves to be coherent? Patton and Taylor (Geophysical Research Letters, 2008) took a new look at plausible non-isotropic terms in the moment tensor representation of an underground nuclear explosion. In the context of tectonic release via a strike-slip fault mechanism, Patton and Taylor demonstrated the merits of including also the possibility of a type of horizontal tension crack. Such a phenomenon leads to spall, and suppression of surface waves, and hence to a reduced Ms. In this paper their method is extended in two ways: (1) by allowing for a more general type of shear faulting; and (2) by discussing

effects on body waves as well as surface waves---finding cases where the non-isotropic terms proposed by Patton and Taylor can enhance mb.

T2-O10. Temporal evolution of the radioxenon signature from underground nuclear explosions

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This paper reviews radioxenon signatures from underground nuclear explosions. A typology of radionuclide releases from underground nuclear explosions distinguishes five different modes. The uncontained distribution, a containment failure and an operational release could possibly be detected by the International Monitoring System. The barometrically driven seepage and the migration into soil gas are modes that offer detection opportunities during on-site inspections. Each of these modes produces a typical signature and has its own challenges for detection. The main difference is the temporal evolution of the releases.
Data from underground nuclear tests at Nevada offer a comprehensive information base for understanding the radionuclide signature. About 500 cases of atmospheric radioactivity releases from underground nuclear tests are analyzed. The reported data compare well with theoretically derived xenon activities. Conclusions are drawn on the main features of releases that can be expected as a function of release time.
These findings are relevant for developing and validating methods to be applied in global monitoring of atmospheric radioactivity with respect to indications of an underground nuclear explosion. In particular, it is important for fusing radionuclide and seismic events to have an understanding of the possible delay time between the explosion and the radioactive release. For uncontrolled test releases, the release occurs within a few minutes up to several hours. This is smaller than or similar to the time resolution of state-of-the-art atmospheric transport simulations for source location (3 hours). However, operational releases can have a significant delay, typically between one day and one week.

T2-O11. Seismo-acoustic energy partitioning from shallow and surface explosions

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Estimation of the yield of shallow or surface nuclear and chemical explosions will require multiple signal technologies and improved understanding of the relative partitioning of seismic and acoustic energy. The 2007 and 2009 HUMBLE REDWOOD experiments (Albuquerque, New Mexico, USA; Foxall et al., 2008; 2010) and the 2009 and 2011 Sayarim explosions (Negev Desert, Israel; Gitterman, 2009) provide unique datasets to study the seismo-acoustic energy partitioning for shallow sources at near-source and local distances. In this paper, we present an analysis of the seismic and acoustic signals generated from three explosions conducted as part of the 2011 Sayarim calibration experiment. The explosions ranged from 10 kg to 102,140 kg of ANFO detonated on the surface. A seismo-acoustic network was deployed at distances between 1 and 37 km from the explosions. The data confirm that the largest of the calibration explosions produced near-source (< 6 km) overpressure signals consistent with a complete and simultaneous surface detonation of 102 tons of ANFO (~80 tons TNT). For this shot, we observe acoustic amplification at local distances (20-40 km) that can be explained by the atmospheric wind velocity profiles at the time of the explosion. For the smaller calibration shots, we note amplification of the overpressure signals at near-source distances (< 5 km), possibly due to site effects or local wind velocity profiles. Conversely, the seismic ground motion is much less than would be expected for fully coupled explosions, and can be modeled by using an amplitude suppression factor of ~3 with intermediate-strength rock coupling.

T2-O12. Medical isotopes studies

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The use of medical isotopes in diagnostic procedures, specifically 99Mo for vascular blockage studies, is increasing worldwide at a high rate. Today, four major producers dominate the production of 99Mo, but closures and spreading of demand for the short-lived isotopes have prompted announcement of several new facilities in the planning stages. Preliminary studies of emissions from the major existing facilities suggest that screening

IMS detection of these emissions is possible, but challenging, based on isotopic ratios. There are several ways to reduce this challenge that will be discussed: reduced emissions via improved practice, stack-monitored emission data flowing to the International Data Center, and tagging the emission with a tracing agent like SF6. Worldwide cooperation on the sharing of information about these approaches is underway, and will be reported.

T2-O13. The IAEA Department of Safeguards: Crossover novel technologies

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The International Atomic Energy Agency (IAEA) Novel Technologies Project examines the emerging and future verification requirements of the safeguards inspectorate, especially in relation to the detection of undeclared nuclear activities, materials and facilities. The Project is providing access to a wider range of methods and instruments that can be applied to enhance safeguards, as well as establishing a systematic mechanism through which the inspectorate can identify and analyse gaps in its technical support capabilities. This paper discusses possible crossover technologies currently under consideration that may also be of relevance to test ban verification, such as on-site and location specific noble gas sampling or the microseismic monitoring of underground facilities and activities.

POSTER PRESENTATIONS:

T2-P1. Application of geophysical methods while revealing UNE signatures at Semipalatinsk Test Site (for OSI purposes)

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For effective OSI tasks solution it is necessary to understand how UNE signatures are visualized in geophysical fields, in particular, to reveal consequences of UNEs and their discrimination within the inspected area. Various geology-geophysical technologies such as seismometry, electromagnetometry, thermometry and atmogeochemical surveys are applied at Semipalatinsk Test Site within borehole UNEs sites. The main purpose of these investigations is to determine UNE phenomenology and monitor geodynamic processes that occur at near-the-focal areas of UNEs. The presentation gives basic results of complex geology-geophysical observations within one of the borehole at Semipalatinsk Test Site. The paper also highlights methodical and technical aspects of application of geophysical methods to solve OSI tasks, such as determination of observational system configuration, equipment parameters setting etc.

T2-P2. A near-regional verification analysis of North Korean nuclear tests

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A 16-station seismic network, operating since 2004 at the Sino-Korean border, was at the right time and right place to capture two recent North Korean nuclear tests. Featuring textbook examples of near-regional phases Pn, Pg, Lg and Rg ($150 \leq \Delta \leq 346$ km) — recorded along pure-continental paths — the data offer the only opportunity to date for evaluating the capability of an out-country network to monitor at close proximity North Korea's compliance with a future Comprehensive Nuclear Test Ban Treaty. I demonstrate, using newly derived Q models, that the mb(Lg) for the October 9, 2006 and May 25, 2009 tests are 4.32±0.13 and 4.86±0.13, respectively. Assuming that the magnitude-yield relations used in published studies hold, mb(Lg) of 4.32 and 4.86 would imply yields of 1.2 and 6.5 kt, respectively, or 2–3 times the reported values. The North Korean nuclear tests are said to distinguish themselves from others in their near-complete suppression of tectonic stress release and tensile failure, thus preventing destructive interference of Rayleigh waves between explosive monopole and extensional CLVD sources (Patton and Taylor, GRL, 35, L14301, doi: 10.1029/2008GL034211). This presumably explains the reported failures of Ms–mb plot to separate the North Korean explosions from Eurasian earthquakes. I show that the North Korean events are correctly identified by Ms–mb(Lg), a largely untested discriminant, and by Pg/Lg amplitude ratio (3–11 Hz). I also find Ms–mb does work but it is not robust since teleseismic P waves from lowmagnitude events are not only feeble but also sensitive to source radiation pattern and station geology.

T2-P3. Contribution of isotopes production facilities and nuclear power plants to Xe-133 worldwide atmospheric background

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Monitoring atmospheric activity concentration of radioxenon is relevant to provide evidence of atmospheric or underground nuclear weapon tests. However, the interpretation of measurements is impacted by the fact that many nuclear facilities emit these isotopes in the atmosphere leading to a significant worldwide background in radioxenon. The average value on the globe depends on the considered area, because directly connected to the regional density of facilities and the frequency and amplitude of their releases. The characterization of the background levels in radioxenon around the world can be carried out by the analysis over a long period, of measurements resulting from International Monitoring System (IMS) noble gas stations. An additional way is to simulate the worldwide background in radioxenon using global Atmospheric Transport Models (ATM). In the present study, Xe 133 global atmospheric dispersion is simulated over a period of 3 years. The atmospheric releases of radioxenon of the main contributors of which annual source terms are known have been considered: the Nuclear Power Plants (NPPs) and medical Isotopes Production Facilities (IPFs). Simulation results are compared to measurements issued from relevant IMS noble gas stations. It is highlighted that the background can be locally complex, and especially, it is shown that some large peaks may be due to the equal contribution of local and distant sources. Without knowledge of the local background level, such peaks, if observed, could be wrongly analyzed as being due to a major contributor. These results demonstrate that the analysis by atmospheric transport modeling of real peaks must take account of an as accurate as possible estimate of the local background noise.

T2-P4. Study on underground vacancy detection based on vertical gravity gradient measurements

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Vertical gravity gradient measurement is a technique that can be used for detecting geologic structure and small anomaly mass. However, it is rather difficult to carry out the vertical gravity gradient measurement, and not enough measurements are obtained, and therefore researchers make less progress on its application. Based on the requirements of On-Site-Investigation(OSI), the gravity anomaly and vertical gradient are calculated at different places with the given position and size of underground vacancy with the method of direct calculation of gravity anomaly; and the detecting ability using vertical gradient is studied with the calculation results; and the influence of underground vacancy's position and size on gravity anomaly and vertical gradient is analyzed, and an experiment has been carried out with the CG-5 gravimeter in this article. The results show that if the precision of gravity gradiometers is 10-6E, the detection depth of vertical gravity gradient measurement can reach the level of 1km; at the same time, it shows a great advantage over that based on gravity anomaly measurements.

T2-P5. Spectral ratios of regional phases recorded at the Dongbei Seismic Network for the North Korean explosions in 2006 and 2009

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We analyze regional phases recorded at stations of the Dongbei seismic network from the North Korean explosions in 2006 and 2009. The stations are located between about 160-350 km from the North Korean test site and are equipped with broad-band high-fidelity instruments. The analysis focuses on the frequency dependence of spectral ratios 2009(phase)/2006(phase) for the phases Pn, Pg, Lg, and Rg. Spectral estimates of the initial Pn phase are corrected for preceding ambient noise while secondary phases are corrected for the coda of preceding phases so that Pg is corrected for the coda of Pn and so on. This affords more conservative estimates of the spectra of secondary phases than the commonly used correction for ambient noise preceding the initial phase. Spectral ratios for a given phase are averaged over stations and instrument components. Spectral ratios for both the initial Pn phase and the following Pg phase show similar scalloping between 5-30 Hz suggesting differences in emplacement depths between the two explosions. A model based on surface-reflected P fitted to the the scalloping resulted in depths of 140 and 260 m for the 2006 and 2009 explosions respectively. The Lg spectral ratio between 0.5-12 Hz has pronounced minima at about 2 and 10 Hz, possibly due to Rg- and P-imprinting respectively. Relative amplitudes of the Lg phase based on the maximum trace amplitude at the dominant period (about 0.5 sec) would lead to smaller relative magnitudes for the two explosions than would other regional phases.

T2-P6. CTBT related activities of Turkish National Data Center

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Bogazici University - Kandilli Observatory and Earthquake Research Institute (KOERI) is acting as the Turkish National Data Center (NDC) and responsible for the operation of the International Monitoring System (IMS) Primary Seismic Station (PS-43) under Belbasi Nuclear Tests Monitoring Center for the verification of compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT). PS-43 is composed of two sub-arrays (Ankara and Keskin): the medium-period array with a ~40 km radius located in Ankara and the short-period array with a ~3 km radius located in Keskin. Each array has a broadband element located at the middle of the circular geometry.
On 25 May 2009, The Democratic People's Republic of Korea (DPRK) conducted a nuclear test. Corresponding seismic event was recorded by IMS and IDC released first automatic estimation of time (00:54:43 GMT), location (41.2896°N and 129.0480°E) and the magnitude (4.52 mb) of the event in less than two hours time (USGS: 00:54:43 GMT; 41.306°N, 129.029°E; 4.7 mb). During our preliminary analysis of this event, a clear P-arrival at 01:05:47 (GMT) at BRTR SP array was observed, which was not associated to the event in SEL3. The result of the f-k analysis performed in Geotool software, provided by CTBTO and installed at NDC facilities in 2008, was also indicating that the arrival belongs to the DPRK event. The arrival was included in REB, however when comparing our f-k results with IDC-REB, however, it was noticed that our calculation and therefore corresponding residuals with reference to REB residuals are much better. The outcome of this analysis was communicated to CTBTO and the case story represents an example of cooperation

T2-P7. Features of geomagnetic anomalies

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These studies experimentally demonstrated that there is an anomaly of the Earth geomagnetic field in the ground zero zone both prior to and after the underground nuclear explosion (UNE).

T2-P8. Discrimination of natural earthquakes and artificial explosions in 2010, North Korea

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Seismo-acoustic analysis was conducted to discriminate surface explosions from natural earthquakes in North Korea for 2010. Seismic events were analyzed from Korea Institute of Geoscience and Mineral Resources(KIGAM)'s seismic station network and 7 seismo-acoustic array in the Republic of Korea and 5 Korea-China joint seismic stations in China. 119 seismo-acoustic events corresponding to 29.9 percent of total seismic events were analyzed and magnitude(ML) was in range of 0.8 to 2.7. More than 98 percent of seismo-acoustic events were concentrated in day time and occurred around the Joongkang, Pyeongyang and Wonsan regions. In Joongkang, the magnitude from 2.6 to 2.7 as a relatively large-scale were observed and Pyeongyang region accounted for approximately 34 percent of the total seismo-acoustic events.

T2-P9. Tritium in the air as an indicator of nuclear testing venues

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Nuclear explosions cause large amount of tritium, which has very long half-life and its natural content in the atmosphere is only a small fraction of the total. On a par with the chemical inert RNG, tritium, as an isotope of hydrogen, effectively incorporates into the air and when creating certain conditions for sampling, can be found even in quite small amounts, about 1 Bq/m3.
Inspecting the possibility of using tritium as an indicator was conducted at two test sites "Degelen" and "Balapan" located at the former Semipalatinsk test site.
In the territory of 'Degelen" mountain massif nuclear weapons tests were conducted in a horizontal mine workings - the tunnels, located inside the rock, with a cross section of from 9 m2 to 25 m2 and a depth of 1500 m. The nuclear charge was placed at the end of the tunnel in a specially designed box.

At "Balapan" site nuclear tests were conducted in vertical workings - boreholes, partly with casing pipes of various diameters and below the open hole with a diameter of 900 mm. Borehole depth was 500-600 m.
After the nuclear testing, both the boreholes and tunnels have been partially "conserved" – being constructed special sealing complex, a combination of cement plugs and gravel backfill, the entrance to the tunnel was carefully poured with the rock and ground, and razed, borehole head was poured with soil.
When studying the tritium content in the atmosphere of "Degelen" site there was recorded the presence of tritium in air, not only within the tunnels, but also outside, at the tunnel portal and their estuarine areas, even when the tunnels were completely "conserved." The content of tritium in the air at the outlet of the tunnels ranged from 1 to 300 Bq/m3 at the "conserved" tunnels and hundreds of Bq/m3, and in some cases, thousands of Bq/m3 of tritium at the area of an open tunnel.
In the territory of "Balapan" site when investigating the level and distribution of tritium in the vicinity of the warfare boreholes there was found that the content of tritium in the atmosphere even at a distance from the immediate scene of the explosion, is a few and tens of Bq/m3. In particular, the content of tritium in the atmosphere near the mouth of one of the warfare boreholes was 70 Bq/m3.
Studies have shown the fundamental possibility of determining the tritium in the air in small amounts, as well as, most importantly - the fact of tritium appearance on the surface of the nuclear testing ground.
All of this confirms the possibility of using radionuclide tritium as an indicator of underground nuclear explosion venues, even after dozens of years after the event.

T2-P10. Design based approach to OSI sampling strategy

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We propose the use of designed based approach for assessing the sampling strategy in an On-site Inspection in the frame work of the verification of the Comprehensive Test Ban Treaty.
The dispersion of radioactive products from an underground nuclear test will follow the migration paths of the geophysical environmental in which the test has been conducted. The identification of the transport mechanism through the geosphere and the biosphere can be combined with the modeling of the migration paths, in order to identify the accumulation points to be surveyed.
As the OSI has to be conducted in a relative short time it's important to dedicate a big effort to design an effective and reliable sampling/survey strategy in order to collect the right number of information for the OSI purpose. In this framework the grid base sampling strategy may be not as effective as in other environmental survey sampling because of the nature of the source event and the different physical features of the analytes.
In this work we present the application of AMBER, a compartment model based software that depict and give numerical quantification of the migration paths of radioactive particles in soils, rocks and water tablet, for the design of OSI sampling strategy. This software was commercially available and it was originally designed for the assessment of a radioactive waste disposal. We demonstrated its effectiveness in a different application and its possible customization for the OSI purpose.

T2-P11. Nuclear test fall-out determination by plutonium isotopic composition

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The assessment of plutonium isotopic composition is important for determination of the artificial radionuclide source. During the last century the Northern hemisphere was influenced by fall-out of nuclear weapon tests and Chernobyl accident releases. As 238Pu/239+240Pu and 240Pu/239Pu isotopic ratios are equal to 0.04 and 0.180 in fall-out dominated regions, respectively, and are as high as 0.51 and 0.408 in the emission from the Chernobyl fourth reactor thus there is a possibility to determine the radionuclide contamination source by plutonium isotopic composition. For this purpose, samples of undisturbed grassland soils were taken from ten locations which reflect the whole geographical area of Lithuania. 238Pu/239+240Pu activity ratio was measured by the alpha spectrometric technique and interpreted along with 240Pu/239Pu isotopic ratio measured by the inductively coupled plasma high resolution mass spectrometry. 238Pu/239+240Pu activity and 240Pu/239Pu isotopic ratios varied within 0.02 – 0.25 and 0.173 – 0.196, respectively. Based on linear interpolation, it has been evaluated that fall-out from nuclear weapon tests is predominant. It is shown that mass spectrometric results complement alpha spectrometric ones, as well. Thus, the possibility to determine the origin of artificial plutonium by assessing its isotopic composition is clearly demonstrated.

T2-P12. Finding and identifying radioactive material by carborne search for OSI deployment

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The CTBTO verification system comprises an On-Site Inspection (OSI) to verify the suspicion of a banned nuclear test. An OSI comprises different methods of verification, one of them being the radiological survey of the inspection area.
The radiological survey is done by airborne survey, carborne survey and environmental sampling, thereby narrowing the inspected area with each step. Our institute operates a measurement car with highly sensitive neutron and gamma detection systems. We investigated search strategies with the gamma detectors of this system. Of course large area surveys should be done by gross gamma counting. One problem with gamma survey are variations in background which may lead to incorrect identification of relevant spots or, even worse, to a miss of relevant spots due to high background. Therefore, our gamma detectors are equipped with special software, called NBR (natural background reduction). This is a proprietary technique which allows discriminating artificial from natural gamma radiation in a simple way without qualified spectral information and is therefore suitable, e. g., for plastic scintillators. This technique has proved to be valuable for the detection of artificial radiation for example at border crossing stations. This procedure was investigated for OSI operations where different nuclides are involved (see e.g. the list of relevant nuclides in the On Site Inspection Test Manual). After locating a refined search with hand-held devices can only be done with blinded instruments according to the treaty.

T2-P13. The use of explosion aftershock probabilities for on-site inspection planning, deployment, and reporting

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An estimate of aftershock activity due to a theoretical underground nuclear explosion is produced using a simple aftershock rate model (Ford and Walter, 2010). The model is developed with data from the Nevada Test Site and Semipalatinsk Test Site, which we take to represent soft- and hardrock testing environments, respectively. Estimates of expected magnitude and number of aftershocks are calculated using the models for different testing and inspection scenarios. These estimates can help inform the Seismic Aftershock Monitoring System (SAMS) deployment in a potential On-Site Inspection (OSI) by giving the OSI team a probabilistic assessment of potential aftershocks in the Inspection Area (IA). The aftershock assessment combined with an estimate of the background seismicity in the IA and an empirically-derived map of threshold magnitude for the SAMS network could aid the OSI team in reporting. We apply the hard-rock model to a scenario similar to the 2009 DPRK explosion and produce an estimate of aftershock activity.

T2-P14. Analysis and modeling of shear waves generated by explosions at the San Andreas Fault Observatory at depth

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Using multiple deployments of an 80-element, 3-component seismic array stretching from the surface to 2.3km depth we examine recordings of chemical explosions to better understand the generation of shear waves by explosive sources. The well is near-vertical in the upper 1.5km and gradually transitions to a dip of 38 degrees at the deepest recording location. The chemical shots are high velocity boosters buried 3-4 m and fired electrically, ranging in size from 5-10lbs. The shotpoints are offset from the wellhead by approximately 40m. The recordings have a strong, impulsive P arrival on the vertical channels. Additional, coherent phases arrive later on the vertical channel propagating at the P velocity. We have preliminary evidence for a weak S arrival on the horizontal channels. The predicted theoretical response for observations directly below a shallow source, agrees with our observations, indicating that the S should be weak at vertical incidence, strengthening as the incidence angle decreases. We have also examined attenuation in the near surface. The upper 450 meters are highly attenuating; Q(P) ranges between 20 and 50.We compare our observations with synthetic waveforms on a suitable 1D structure using the Direct Radial Integration method of Friederich and Dalkolmo (1995), which handles a layered transversely isotropic medium with anelasticity. For a zero-offset, shallow-burial source the synthetics yield a highly impulsive P in addition to a small S. Given this result, we are exploring f-k filtering methods to mute the P in our data so that we can better accentuate the S arrival.

T2-P15. Emerging science for nuclear test monitoring

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Ongoing research and development efforts enable future capabilities to better counter threats posed by weapons of mass destruction. Cooperative research with global partners improves international collaboration to detect and characterize weapons of mass destruction, and enhances a host nation's sustainment of scientific programs. Recent topics that are relevant to the CTBTO identify science focus areas to address challenges of an on-site inspection. Recent topics have included research for a number of basic science areas. For example radiation sensitive materials that change their optical properties and novel sensing materials used as indicators of container or seal integrity between inspections will be explored. These novel sensing materials can help provide unique assurance against tampering to assist verification. In addition integration of multiple sensor technologies and techniques using advanced mathematical methods to improve seismic location algorithms and modeling of explosions. More general topics that are planned for the future and that are relevant to the International Monitoring System and International Data Center include: alternative remote sensing materials and methods; new methods and modeling for radiochemical analysis, sample collection, concentration and selectivity; and novel long-range methods for example environmental changes.

T2-P16. On-site inspection strategy for subsurface detection of noble gases from an underground nuclear test

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Detection of significant levels of short-lived Xe-133 and Ar-37 isotopes in soil gas at the site of a suspected nuclear explosion is an excellent indicator that the event was nuclear in origin. Using computer simulations and field tests, we have developed a strategy for sampling subsurface gases in the context of an on-site inspection. This strategy takes into account a variety of challenges that must be addressed by the inspection team during its search-area-reduction and noble gas sampling activities. These challenges include (1) integration of different lines of evidence and expert opinion in the search area reduction phase, (2) sampling buried fractures that transport gases from depth, (3) avoiding dilution and contamination of subsurface samples by atmospheric gases, (4) implementing sample quality control indicators in the subsurface sampling procedure and (5) computer-controlled operation of sampling stations to optimize the sample-acquisition process and minimize manpower requirements. Most of the capability required is “off the shelf”. We describe the theoretical basis for this strategy and offer suggestions for its implementation.

T2-P17. Analysis into the evolution of radionuclide inventory with time for some scenarios of nuclide migration into the atmosphere after a nuclear test

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An underground nuclear test first produces a cavity filled with a hot gas of radioactive fission products. High pressure and temperature may cause them to move to the surface and then into the atmosphere. Gas cooling and condensation with time is accompanied with the radioactive decay of fission fragments which become more or less mobile depending on physicochemical properties –condensation temperature and ability to form volatiles. The main scenarios of radionuclide migration into the atmosphere are as follows: 1) The cavity remains leaktight as long as to allow radionuclides to condensate. In this case only radioactive noble gases (RNG) and volatiles move to the atmosphere; 2) Fast (within several hours after the explosion) migration of most volatile radionuclides and RNG to the surface and slow migration in the explosion region; 3) Fast (without cooling) migration of most radionuclides to the surface and into the atmosphere, and further movement through the environment in the form a hot gas cloud. Some of the radionuclides which reach the atmosphere condensate during cooling and deposit onto the surface forming a radioactive plume. The others (RNG and volatiles) move through the atmosphere till become non-volatile due to decays and deposit onto the surface. The further decay of deposited nuclides and their compounds may make them volatile again and allow their further transport in the atmosphere. The paper aims to analyze radionuclide inventory on the surface and in the atmosphere for some times in the specific scenarios of radionuclide migration into the atmosphere and further transport.

T2-P18. Proficiency test program for CTBT radionuclide laboratories: An update

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The Comprehensive Nuclear-Test-Ban Treaty (CTBT) Protocol provides for 16 radionuclide laboratories to support the network of radionuclide monitoring stations being established as part of its verification regime. These laboratories support radionuclide stations by: (i) corroborating the results of routine analysis of a sample from an IMS station, in particular to confirm the presence of fission products and/or activation products, (ii) providing more accurate and precise measurements and (iii) clarifying the presence or absence of fission products and/or activation products in the case of a suspect or irregular analytical result from a particular station (CTBT/WGB/TL-11/5/Rev. 10). The expert services provided by these laboratories are utilized in the QA/QC program of the IMS radionuclide network. In turn, the Proficiency Test Exercise (PTE) is a means of assessing the level of accuracy of nuclide identification and measurement by laboratories and of triggering corrective actions when there are discrepant results. Since 2000, the Provisional Technical Secretariat (PTS) has organized annual PTEs, the results of which were presented during the International Scientific Symposium in 2009. The poster presents a snapshot of the IMS laboratory network and an update on the scope of the PTEs and the grading scheme that has been applied to PTE results since 2009.

T2-P19. Proposal for an information-led search logic during an on-site inspection

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The provisions under which an on-site inspection (OSI) can be conducted constrain the timelines (before and during the inspection), the size of the area to be inspected, the number of inspectors, the techniques authorized by the Treaty, and also the way these techniques can be applied. The inspection team functionality and the search logic applied must operate within these constraints. In this paper we present a new search logic specifically designed to accommodate the constraints of an OSI. The concept of reconnaissance and hypothesis testing missions are introduced as the building blocks of an inspection's technical activity. The key requirements of an effective search logic methodology are defined, including inter alia robustness, and development of new missions based on the site specific information available. The advantages of the information led search logic to the unique problems of an OSI are discussed in the context of alternative heuristic and probabilistic approaches. A detailed methodology has been developed to implement the information led search logic and it is hereby presented. The successful application of the methodology to an OSI is demonstrated by applying it to case studies based on previous OSI field exercises.

T2-P20. Barkhan (Baluchistan) earthquakes of June 26 and July 12, 1999: Source process from teleseismic body waves

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Source process of the June 26 and July 12, 1999 earthquakes, which occurred in the eastern part of Kirthar Sulaiman shear zone near Barkhan in the province of Baluchistan, were studied using the teleseismic body waves recorded at the IRIS Global Seismographic Network. The P and SH waveforms of these events were inverted to double couple source using the method of Kikuchi and Kanamori. The azimuthal coverage of seismograph stations is good enough to resolve some details of heterogeneous moment tensor. Aftershocks of the earthquakes were plotted to have information about the orientation and length of the fault involved. It was found that the movement on the eastern section of the Karmari thrust was responsible for these earthquakes. The focal mechanism solutions show thrust faulting. The strike, dip and slip of the causative fault of the June 26 earthquake are respectively 243o, 39o and 92o and that of July 12, earthquake are 237o, of 32o, and 111o. The seismic moment is estimated as Mo = 2.3 x 1017 Nm for June 26 and Mo = 3.3 x1017 Nm for July 12, 1999. The solution of the event is compared with fault plane solution derived from first motion polarity data recorded by local seismic network, USGS and also with the Harvard CMT solution. The moment tensor solution is in agreement with those obtained from first motion polarity, USGS and CMT solution.

T2-P21. Exploitation of the IMS and other data for a comprehensive, advanced analysis of the North Korean nuclear tests

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The October 9, 2006 and May 25, 2009 underground nuclear tests in North Korea provide a unique data set to demonstrate advanced techniques in the processing and analysis of IMS data for verification purposes. We analyzed the available short-period seismic data in an attempt to define accurate locations, depths and yields for these two events. The location of the 2009 explosion relative to the position of the 2006 event was estimated using the Joint Hypocenter Determination (JHD), Double Difference (DD) and Differential Waveform Interferometry (DWIF) location algorithms. All of these relative location techniques yielded similar results, indicating that the 2009 test was conducted about 2.5 km west-northwest of the 2006 test. These locations were subsequently integrated with the local topographic data and satellite imagery to define accurate absolute locations for these two explosions. The corresponding source depths could not be reliably determined using the currently available arrival time data. Consequently, we implemented a new approach using broadband P wave spectral ratios of the two explosions at common regional stations to obtain estimates of the corresponding broadband source spectral ratios. The resulting network-averaged source spectral ratio was then compared with theoretical Mueller/Murphy based source spectral ratios to estimate best-fitting source depths and associated yields. The results indicated that the two explosions were not detonated at any common depth in the 100 to 800 m depth range; rather the observations are best fit by source depths of about 200 m for the 2006 test and 550 m for the 2009 test.

T2-P22. Stable coda estimates from P and S codas at regional and near-teleseismic distances

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For nearly the past 2 decades, regional shear wave coda has been shown to provide the most stable estimates of the explosion and earthquake source, making its use ideal when station coverage is sparse. As a result, moment-magnitude is determined with unprecedented stability from as few as one station and is being used in a number of explosion monitoring applications. In spite of its success, a significant magnitude bias exists for S-based regional magnitudes such as mb(Lg) and mb (Lg-coda) between explosions and earthquakes when compared to their teleseismic mb(P) counterpart. In this study, we first show preliminary results for regional and near-teleseismc P-coda for both earthquakes and explosions to see if a bias still exists with the teleseismic mb. In addition, there is a point of debate on whether the regional P-coda calibration will remove the effects of the path and upper mantle effects which bias teleseismic mb(P) estimates for some test sites. We find that the P-coda does not exhibit a magnitude bias between earthquakes and explosions, in sharp contrast to S-based magnitudes such as mb(Lg) when compared to the teleseismic mb(P). We plan to give a summary of regional coda research and specifically address our recent P-coda findings.

3. ADVANCES IN SENSORS, NETWORKS AND OBSERVATIONAL TECHNOLOGIES

Conveners:

PATRICK GRENARD
International Monitoring System Division
CTBTO

MATTHIAS AUER
International Monitoring System Division
CTBTO

JOHN BERGER
Scripps Institution of Oceanography
United States of America

Invited Speakers:

MICHEL ANDRÉ
Technical University of Catalonia
Spain

DAVID SIMPSON
Institutions for Seismology (IRIS)
United States of America

ORAL PRESENTATIONS:

T3-O1. Integrated solutions for a sustainable development of the offshore industry: live monitoring of noise and acoustics events

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The next decades will see increasing levels of offshore industrial development that will lead to increased amounts of noise pollution in the oceans. Amongst these developments, oil and gas prospection, navy exercises as well as offshore windmills are already playing a leading role in introducing considerable amount of noise in an increasing number of areas, but demand for offshore nuclear power plants is expected to be high in regions experiencing power shortages and requiring stable energy supplies. Underwater sound sources produced by these activities present the highest intensity amongst those anthropogenically generated in the sea, reaching more than 230 dB re 1 μPa at 1m from the source. These sounds can have physical, physiological and behavioural effects on the marine fauna in the area of action: mammals, reptiles, fish and invertebrates can be affected at various levels depending on the distance to the sound source. Marine mammals could be one of the more sensitive groups of marine species because they have a highly developed auditory system and use sound actively for feeding and for social communication. It is also known that marine mammals are vulnerable to the effects of habitat loss or reduced survival and reproduction rates. The problem faced by the industry, and more generally by the society, is that many economically important activities at sea are at risk because of a lack of information about the effects of anthropogenic sound on marine mammals and especially a lack of available tools to mitigate these effects. The challenge here is to implement technological developments that combine the interests of the industry and the good environmental status of the oceans. Based on the existing technology successfully implemented at underwater observatories worldwide (European Sea-floor Observatories Network of Excellence, ESONET, European Member States; ANTARES, France; NEPTUNE, Canada; Kushiro, Japan) by the Laboratory of Applied Bioacoustics of the Technical University of Catalonia (LIDO, Listen to the Deep-Ocean Environment, http://listentothedeep.com), a real-time passive acoustic monitoring solution is available to mitigate the potential effects of noise associated to the offshore industry.
The LIDO acoustic detection, classification and localization (DCL) system can be integrated in a series of expandable radio-linked autonomous buoys that are timely deployed in areas of action. In that case, the DCL is performed at buoy level. A mesh network allows buoy-to-buoy communication and an alert service provides the ship/offshore platform with the DCL analysis: the real-time continuous monitoring of cetacean presence.
The advantages are relevant:
- The LIDO DCL is automated and performed regardless sea state or light conditions
- No expertise is needed onboard the survey vessels/offshore platforms since the alert service informs on the identification and position of cetacean species that is displayed on a user-friendly interface
- The real-time continuous monitoring of cetaceans allows determining areas of exclusion depending on the sound source and the species involved.
- The decision-taking regarding the management of the offshore activity in presence of cetaceans falls under scientifically contrasted, objective and standardised procedures that ensure the sustainable development of the activity.
- The LIDO DCL is supported by virtually any hardware, e.g. towed arrays, gliders, AUV, ROV, radio-linked autonomous buoys, cabled observatories.
We also show some T-phase observed by DONET. The array of instruments placed on the seafloor operates as a monitoring system for ocean acoustic wave generations. Many acoustic waves with duration of approximately 100 seconds arrive at DONET from southwest. According to the theoretical travel time calculated from JMA hypocenter bulletin, we found that they are T-phase associated with earthquakes generated along Ryukyu trench.

T3-O2. Open data resources and shared instrumentation facilities to support research in seismology

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Over the past three decades, improvements in sensor design, digital signal processing, communications technologies, power systems and data management have led to remarkable advances in our ability to remotely and continuously monitor many aspects of the geo-environment. These technologies and their use in seismology (many of which grew out of nuclear monitoring programs in the 1960-70's) now find application in a broad spectrum of research programs on the nature of the earthquake source, deep Earth structure and the dynamics of the crust and lithosphere, and for practical applications in earthquake monitoring, hazard assessment, climate change and resource exploration. The IRIS Consortium, led by the US academic research community and in collaboration with US federal agencies and many international partners, has helped establish a national and international culture of open data sharing and pooled instrumentation resources to support the collection,

archiving and distribution of data for use in monitoring earthquakes and supporting seismological research. The data from these multi-user facilities, and research results that emerge from their use, find direct application in many aspects of research and monitoring related to the Comprehensive Test Ban Treaty.

T3-O3. Challenges and growth for NEPTUNE Canada

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NEPTUNE Canada (NC) is the world's first regional cabled ocean network, located in the northeast Pacific Ocean, off British Columbia's coast. It is constituted with a 800km backbone fibre-optic cable loop which powers a series of scientific nodes located at the coast (Folger Passage), continental slope (ODP 889; Barkley Canyon), abyssal plain (ODP 1027), and ocean-spreading ridge (Endeavour) in water depths of 20-2660m. Over the 25 years of the system design life, scientists will be able to investigate a wide range of ocean processes and events as well as collect real time data and imagery to be stored in a unique database. Initial data flow started in December 2009, with over 10TB of data and video imagery archived to date. Challenges have been and continue to be considerable. Beyond the difficulties encountered when designing, manufacturing and installing the main infrastructure, instruments and cables normally used for short term experiments have to be adapted to long term deployments in extreme environments such as a ridge. On the data side, the ever increasing size of the database, the diversity of data types and data products increases the complexity of a data delivery system which aims at being transparent to the users. Still, the main challenge is to ensure a continuous growth in the user base as the real power of the network lies with the scientists. The more they become involved, and interact in multidisciplinary groups, the more relevant and the more efficient NC will become.

T3-O4. The effectiveness of radionuclide monitoring: assessed with a natural airborne tracer

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In atmospheric radioactivity monitoring the "coupling" of monitoring stations to the upper troposphere is of major importance. Above-ground nuclear explosions deposit most radioactive debris toward the tropopause and a key component in monitoring site selection is the degree of coupling between a station and the upper atmosphere. Uncoupled stations might "miss" plumes passing overhead, with serious consequences. Coupling is difficult to assess experimentally but monitoring experience over the last decade indicates the possible application in this of a naturally occurring tracer, sodium-24. Sodium-24 is produced in the atmosphere by cosmic-radiation spallation reactions with argon and detected in the IMS particulate radionuclide network. Its production rate peaks in the upper-troposphere/lower-stratosphere and the 15h radioactive half-life limits long-range transport. Intuitively, detection in ground-level air is the result mainly of vertical transport from high altitudes. Variations in rates of 24Na detection between IMS monitoring stations may therefore provide clues as to relative degrees of atmospheric coupling. This paper analyses 24Na detection rates at IMS radionuclide stations since 2005. Detection rates vary widely, from ~20% of samples at one station to almost zero at others. A few stations demonstrate the expected annual variations in detection frequency, but most do not. Latitudinal effects are evident but the significant gaps in detection could mean the IMS network effectiveness is seriously impaired by lack of coupling at many stations. Application of ¬24Na to the coupling issue is discussed and differences between stations analysed geographically. The need for further meteorological effort combined with 24Na data analysis is highlighted.

T3-O5. The Optical Seismometer – a new technology for seismographic observations

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We have developed a new optical interferometric seismometer that has significant advantages over conventional feedback seismometers. The new seismometer employs laser interferometry to measure the motion of an inertial mass relative to its frame rather than the traditional electronic displacement transducer. Advantages include:
1. The linear, high-resolution, optical displacement transducer provides about a 30-bit resolution digital output without a high-resolution analog-digital converter;
2. It measures absolute displacement referenced to the wavelength of the laser light;
3. The bandwidth and resolution are sufficient to resolve the GSN low noise model from DC to > 15 Hz.
4. The dynamic range is sufficient to record the largest teleseisms and most regional and local earthquakes.
5. The technology allows the laser and other electronic elements to be located hundreds of meters from the sensors with the only connection made by fiber.

6. It is suitable for either vault or borehole installations. Electronics in the seismometer are unnecessary — only an optical fiber connection to the seismometer is required, eliminating heat from electronics in the sensor package, noise pickup from connecting electrical cables, and susceptibility to lightning strikes.
7. Unlike standard feedback seismometers whose outputs depend upon numerous electronic and mechanical components, the calibration and response of the optical seismometers are described by only three simple and time-invariant parameters whose values can be confirmed at any time through examination of the data.
We present data demonstrating the performance of our prototype vertical and horizontal component optical seismometers, which meet CTBTO requirements.

T3-O6. Data for OSI multi-spectral and infrared instrument development

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The Comprehensive Nuclear-Test-Ban Treaty (CTBT) permits Multi-Spectral and InfraRed Imaging (MSIR) as part of an On-Site Inspection (OSI) to reduce the search area for the location of a possible underground nuclear explosion (UNE). Dedicated airborne MSIR measurements have not been made for historical or recent UNE's, so commercial satellite data has been used to determine if there are MSIR observables associated with recent UNE's. MSIR data from commercial satellites has been used to show that there are detectable surface observables which can be used to greatly reduce the search area for the location of the UNE. The techniques used (e.g., change detection) typically identify a region of interest less than 1 km^2 in size (compared to the nominal 1,000 km^2 search area), and the few false positives have been resolvable as such by using visible imagery. Commercial satellite data can be used to characterize those observables and help generate the technical specification for airborne MSIR sensors to support an on-site inspection as allowed by the CTBT. Prior published literature describes using commercial satellite spectral data to measure environmental factors, and surface shock from underground explosions.

T3-O7. The Optical Fiber Infrasound Sensor – improved wind noise reduction

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The Optical Fiber Infrasound Sensor (OFIS) has now been under development for twelve years. The instrument has undergone extensive testing and has proven to have a number of advantages over traditional pipe rosettes fitted with microbarometers or microphones. These include:
1. Reduction in wind noise of up to 10 dB (at 1 Hz) compared to pipe-arrays of similar size;
2. A design that nullifies resonance;
3. A wide dynamic range digitization system, integral to the sensor, removing the need for a highresolution data recorder;
4. A configuration in which the sensor is completely buried beneath the ground surface (save for a solar panel and data link antenna) removing the need for any above ground obstructions;
5. A sensor comprising a sealed volume, reducing potential for water intrusion;
6. The capability to undergo continuous calibration without interruption of data collection;
7. Configurable such that the laser and other electronic elements can be sited hundreds of meters from the sensors with the only connections being made by optical fiber. We present data demonstrating the performance of an OFIS in varying wind conditions, deployed adjacent to an operational IMS infrasound array (I57US).

T3-O8. A new underground radionuclide laboratory - RL16

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The International Monitoring System (IMS), in addition to a series of radionuclide monitoring stations, mandates sixteen laboratories capable of verification of radionuclide field measurements, as well as more in-depth studies of field-obtained samples. Several State Parties host and maintain such a radionuclide laboratory (RL) and all RLs participate in a series of round-robin testing exercises to ensure consistent quality of laboratory verification capabilities. This presentation highlights new developments in a low-background detector system for radionuclide particulate measurements being built in a new shallow underground clean facility at Pacific Northwest National Laboratory. Specifics such as low-background materials, active shielding methods, and expected improvements in sensitivity, as well as the benefits of operating in a shallow underground location and in a cleanroom environment, will be covered.

T3-O9. Figure of merit for choosing Xe background study locations

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The International Noble Gas Experiment (INGE) is ringing the Earth with a network of 40 xenon monitoring systems, of which is about 2/3 are in operation. The occasional detection of radioactive xenon in the Earth's atmosphere by this network, in the absence of a nuclear explosion, poses a discrimination challenge: how reliably can one screen out normal civilian nuclear activities like power generation and medical isotope production? Discrimination may rely on the ratios of any of several xenon isotopes detected, such as Xe-133m/Xe-133. To create and test screening methods using xenon isotopic ratios, a small international collaboration led by the Provisional Technical Secretariat of the CTBTO has been measuring the background of xenon isotopes in various parts of the Earth where few xenon measurements have been made or where large xenon sources are known. It has been proposed that to optimize the study of xenon backgrounds, a Figure of Merit could be constructed, using atmospheric transport calculations and the known locations of reactors and medical isotope facilities. It should be possible to identify and prioritize locations for scientific study by computation of expected signal intensity and careful consideration of current INGE network coverage. We present the results of ongoing studies to define an acceptable Figure of Merit based on forward calculations of xenon concentrations from nuclear facilities that currently exist, are planned, or are likely to exist in the next 5 years. By removing locations that are well covered by INGE, the best locations for background study can be selected.

T3-O10. Production of Xe standards for the calibration of noble gas sampler stations and laboratory equipment

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Recent achievements on producing pure samples of 131mXe, 133mXe, 133Xe and 135Xe at the Accelerator Laboratory of the University of Jyväskylä, Finland, are presented. A high resolution mass purification process employing the IGISOL/JYFLTRAP facility ends in the implantation of an ultra-pure beam of ions into solid catcher foils. Solid catchers are employed due to the low kinetic energy of the mass-purified ions (30 keV) and the requirement of excellent vacuum inside the Penning trap setup. Since often gaseous xenon samples are needed for the calibration of noble gas collection and detection setups, work related to the foil-to-gas conversion has been started in Finland. In particular, we have studied the diffusion properties of xenon atoms in aluminium and graphite. Based on improved understanding we have made a preliminary design of a device capable to efficiently transfer the xenon from the foil to a measurement cell or to a transportation container.Currently the Laboratory at Jyväskylä is being upgraded and the construction work should be finished by the end of 2011. Among other devices this upgrade introduces a third particle accelerator to the University of Jyväskylä. The K=30 MeV cyclotron will mainly serve the upgraded IGISOL/JYFLTRAP facility making the scheduling of xenon production runs much easier. Current status of the construction work will also be presented.

T3-O11. Xenon diffusion reduction using surface coatings on plastic scintillators in beta-gamma coincidence detection systems

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A major drawback with the current setup of the beta-gamma coincidence detector systems used within the IMS to detect radioxenon is that during measurements the radioactive gas diffuses into the plastic scintillator cell holding the sample. It has been estimated that 3-4% of the xenon sample remains in the cell after it has been evacuated. This residual activity results in an elevated detection limit for the following measurements.
One approach to remove or reduce this "memory effect" is to coat the surfaces exposed to radioxenon with a material able to stop xenon diffusion without significantly impairing detector properties such as efficiency and resolution.

In this work two coating materials have been investigated. Al2O3 and SiO2 of varying thicknesses (20-400 nm) have been deposited onto flat plastic scintillator surfaces using Atomic Layer Deposition and Plasma Enhanced Chemical Vapour Deposition, respectively. The coatings have been tested, with respect to their ability of stopping xenon diffusion, by exposure to radioactive xenon and subsequent measurement of the residual activity. The study shows that all coated samples present less memory effect than uncoated ones. For Al2O3 a dependence on coating thickness was observed, and a 400 nm coating was found to almost completely remove the memory effect. The successful coating will now be tested with respect to detector efficiency and resolution using a complete betagamma coincidence detector system.
The work presented is a collaboration between Uppsala University, the Swedish Defence Research Agency (FOI) and University of Texas at Austin.

T3-O12. The EarthScope USArray Transportable Array: Results from large-scale network operations

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The EarthScope USArray Transportable Array is providing unprecedented seismological observations for continental- and global-scale studies of Earth structure and seismicity. The rolling deployment of the Transportable Array (TA) component of USArray has now occupied over 1,000 sites in the western half of the United States, from the Pacific coast to the Mississippi River. The three-component broadband TA stations are deployed in a grid-like arrangement, with 70 km separation between stations. At any given time, there are approximately 400 installed stations and each station is operated for two years. All data are distributed openly and without restriction. The stations utilize a highly uniform design, which facilitates both efficient operations and utilization of the data. The full 400 station array routinely delivers greater than 98% data availability in real time, and provides consistently low-noise performance with simple vaults installed in a wide range of terrains. Automated analysis of station state-of-health channels, combined with innovations in quality review of the data, contributes to the overall performance of the network. Over time the station design has also been carefully evolved to enhance performance and acquire new observations. Most recently the TA stations are being augmented with absolute barometric pressure and infrasound sensors.

T3-O13. Measuring mesopause temperature perturbations caused by infrasonic waves - An innovative sensor approach

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Many geo-hazards such as earthquakes, tsunamis, volcanic eruptions, severe weather, but also nuclear explosions, produce acoustic waves with sub-audible frequency, so called infrasound. This sound propagates from the surface to the middle and upper atmosphere causing pressure and temperature perturbations. Temperature fluctuations connected with the above mentioned events usually are very weak at the surface, but the amplitude increases with height because of the exponential decrease of atmospheric pressure with increasing altitude. At the mesopause region (80–100 km height) signal amplitudes are about two to three orders of magnitude larger than on the ground.
The GRIPS (GRound-based Infrared P-branch Spectrometer) measurement system operated by the German Remote Sensing Data Center of the German Aerospace Center (DLR) derives temperatures of the mesopause region by observing hydroxyl (OH) airglow emissions in the near infrared atmospheric emission spectrum originating from a thin layer at approximately 87 km height.
The GRIPS instrument is in principle suited for the detection of infrasonic signals generated by e.g.larger explosions and other geo-hazards. This is due to the fact that the infrasound caused by such events should induce observable short period fluctuations in the OH airglow temperatures. GRIPS can thus complement existing measurement networks sensing infrasound in the atmosphere in order to achieve better verification.

T3-O14. Optimal design of a noble gas monitoring network

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The Comprehensive Nuclear Test Ban Treaty (CTBT) noble gas monitoring network has 40 systems. Noble gas monitoring experience has provided an understanding of the global radioxenon background created from nuclear (primarily medical isotope production) facilities. Combined with improvements in both meteorological modeling techniques and monitoring technology improved site criteria. A two-step approach was used - the first metric ranks individual site performance in a background free world. However, this does not result in globally balanced coverage. The tropics, having low atmospheric dispersion, are difficult to monitor equally. To compensate, a latitude scaled source term was used for the ranking of station. Particle dispersion models were used to simulate nuclear releases from network "holes" to find non-IMS sites locations that could fill these "holes". The second metric scored sites to measure background emitters, thus allowing for the discounting of civilian background sources from potential nuclear test emissions. These two approaches were combined to select an optimal network. Global contour maps to compare network performance with various constraints and configurations. Some scenarios considered include: the "best" 40 sites to the current 39 station network design, the performance improvements gained by increasing the system sensitivity - representing a realistic next-generation monitoring system, a complete 80 noble gas network, the effects of moving expensive or operationally difficult (Antarctic) stations to alternative sites. An optimal design comprised of approximately 57 IMS noble gas system was found to have the capability to assess background source interference while providing globally uniform coverage.

T3-O15. Potential of the International Monitoring System (IMS) radionuclide network for inverse modeling

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We have evaluated the potential of the radionuclides IMS network for inverse modeling using a recent multiscale data assimilation technique. We have computed an optimal spatial grid of the source parameter space with a fixed number of variables. By construction, this adaptive grid maximizes the number of degrees of freedom for the signal, and hence the quality of a potential source retrieval. This optimization takes into account the monitoring network, the meteorology over one year (2009) and uses the FLEXPART Lagrangian transport model to relate the source parameters to the observations. The larger a grid-cell, the more uncertain the estimated source would be in the area. Observing the size of the cells, uncertain regions (such as the tropics) are easily spotted. The results depend on the nature of the model (Eulerian or Lagrangian), which will be explained. This adaptive grid can also be used to implement faster source inverse modeling algorithms.

POSTER PRESENTATIONS:

T3-P1. Characterization of 2010 Mentawai earthquake based on source mechanism analysis by using regional and CTBT monitoring station

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Since 1990 – 2010 the authors collect 30 tsunamigenic earthquake around Indonesia region (95º E - 141º E / 11º S – 6º N). Furthermore we make the characterization of those events to support tsunami warning consideration. Some events categorized as tsunami earthquake which has various magnitude, shallow depth, long rupture duration, high rupture energy and unfelt shaking, e.g. 1994 and 2006 Java. Recently 2010 Mentawai earthquake was confusing to be characterized as the anomalous tsunami because of the anomalous tsunami has not included in the system of Indonesian Tsunami Early Warning System (Ina-TEWS) which is only based on magnitude and hypocenter determination. The aim of research is to make the accurate and fast determination type of tsunami event to confirm the level of tsunami warning. The improvements is derived by using source mechanism parameters with W-phase method which has succeded to identify tsunami earthquake the 1992 Nicaragua and established in JMA and PTWC. It can explain energy and long wave period of P, PP, SP separeted from surface waves. The velocity of 4.5 – 9.0 km/s is faster than Rayleigh wave because of non-effected by various material

of plate tectonic. The input parameter of long period seismogram derived from IRIS and CTBT stations which the distance less than 40º.

T3-P2. Analysis of the first arrival of P-wave of Ina-TEWS and CTBT stations to support earthquake early warning

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The authors make the analysis of first arrivals of the P wave from Indonesian Tsunami Early Warning System (Ina-TEWS) and CTBT stations. These are used for earthquake early warning, Magnitude determination, and potential earthquake hazard mitigation based on Seismogram acceleration. This research is focused on the study of energy duration of high frequency, and the maximum displacement of P-waves by observing broadband seismograms. The further analysis consists of deconvolution, recursive filtering for data restitution, and applying a Butterworth filter of second order. The Butterworth filter uses high frequency 0.075 Hz to cut the effect of drift, and band-pass frequency 2-4 Hz for use in magnitude calculation. We choose potentially damaging earthquakes to be greater than Mw 6.0.
Based on the trigger on the 3 seconds the first arrival P-wave, the dominant period (Td) was calculated by using data Cisompet Seismological station, Garut (CISI station) and tested for data CTBT, Bandung (LEM station).
This research resulted determination of the P-wave arrival time accurately using integrated skewness and kurtosis. Performent data from CTBT stations is very high. Signal to noise ratio >1000 after passing through the filter.
Such riset conducted to find out a rapid magnitude estimations from predominant frequency of displacement are Log Td = 0.2406 M – 1.3665, (R= 0.73) or M= 4.156 log (Td) + 5.6797.
Furthermore, this formula can be used to support earthquake early warning in West of Java.

T3-P3. Detection of tsunami and T-phase by the Dense Oceanfloor Network System for Earthquakes and Tsunamis (DONET)

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DONET is a cabled network observatory with real-time recording systems in the seismogenic zone of M8 class mega-thrust earthquake off-shore of Kii-peninsula in the Southern part of Japanese Islands. The network consists of an array of 20 stations with an interval of 15-20km, and each station includes broadband seismometer, strong motion seismometer, quartz-type pressure gauge, differential pressure gauge, hydrophone and thermometer. The network has partly inaugurated its operation in 2010.
An early detection of tsunami is one of the main observation targets of DONET. Tsunamis, generated by August 13, 2010 Mariana Islands earthquake (Mw 6.8), were successfully detected by the pressure gauge of DONET. The arrival time and amplitude of observed tsunami are well explained by synthetics computed with the fault mechanism solution of this earthquake. The observed tsunami shows clear dispersion of group velocity, presumably due to the emplacement of stations in the deep ocean. They were detected at DONET stations significantly earlier than at terrestrial stations, which demonstrates a capability of the accurate early tsunami warnings along the coast of Japanese Islands.

T3-P4. A technique to determine the self-noise of seismic sensors for performance screening

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Seismic noise affects the performance of a seismic sensor and is thereby a limiting factor for the detection threshold of monitoring networks. Among the various sources of noise, the intrinsic selfnoise of a seismic sensor is most diffcult to determine, because it is mostly masked by natural and anthropogenic ground noise and is also affected by the noise characteristic of the digitizer. Here we present a new technique to determine the self-noise of a seismic system (digitizer + sensors). It is based on a method introduced by Sleeman et al. (2005) to test the noise performance of digitizers. We infer the self-noise of a triplet of identical sensors by comparing coherent waveforms over a wide spectral band across the set-up. We will show first results from a proof-of-concept study done in a vault near Albuquerque, New Mexico. We will show, how various methods of shielding the sensors affect the results of this technique. This method can also be used as a means of quality control during sensor production, because poorly performing sensors can easily be identified.

T3-P5. Seismic noise analysis at some broadband stations of Egyptian National Seismological Network

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The background noise at some investigated sties named Siwa, Hurghada, Abou-Dabbab, and Farafra sites was analyzed to assess the effects of permanent seismic vault construction. Also to determine the time needed for noise at these sites to stabilize and to choose the non-noise sites for installing and constructing the permanent broad band stations. We calculated the power spectral densities of background noise for each component of each broadband seismometer deployed in the different investigated sites. We compared them with the high-noise model and low-noise model of Peterson (1993). Noise levels were considerably higher at Abou-Dabab site, but it still below of high-noise model of Peterson (1993). Based on the obtained analysis, the seismology department decided to install the broad band stations at these sites taking into consideration all required precautions for installing these stations. After construction we measured the noise stability and the efficiency of station to record regional and teleseismic events. The results of this study could be used to evaluate station quality, improve those processes that require background noise values, such as automatic association and to improve the estimation of station and network detection and location thresholds.

T3-P6. Improvement of the equipment for measurements of atmospheric xenon radionuclides

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Khlopin Radium Institute has developed the improved version of equipment for the measurement of atmospheric xenon radionuclides. This equipment includes new kind of high-efficiency sampling installation combined with the sample-processing unit and special low-background gas-volume spectrometer of β-γ-coincidences. This equipment is suitable solution to a wide range of tasks, including atmospheric xenon monitoring in areas of NPP emission influence, on-site inspections and measurements of background xenon radioactivity and can be used both in mobile and in stationary deployment variants. The main feature of developed equipment is the reaching of the cryogenic temperatures, required for xenon adsorption, using the analyzed air itself instead of the external helium gas-cooling machine. The performance of sampling is 25 m3 per hour with efficiency 65%, the sampling cycle duration ranges from 3 to 7 hours. On the base of the developed complex in the Khlopin Radium Institute the prototype of mobile laboratory has been organized. The main task of this laboratory is the monitoring of xenon radionuclides in the atmospheric air and the further improvement of designed equipment.

T3-P7. Using the Garni IMS auxiliary station records in operation of the next-generation real-time seismic intensity display system in Armenia

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Recently, a number of real-time seismic systems have been designed for providing rapid information after seismic event. Those systems have been developed in the countries where densely populated areas are especially vulnerable to earthquake disaster.
After the Great Hanshin-Awaji Earthquake (Kobe, Japan, M6.8, 6430 casualties, $120billion property losses) the Real-Time Seismic Intensity Display System was introduced in Japan on the base of strong motion seismographs.
In the frame of ongoing joint Japan-Armenia Project for the seismic risk assessment and risk management planning in the Republic of Armenia it is planned to implement such system in Yerevan city. That system will automatically determine the distribution of seismic intensity during an earthquake. The earthquake alarm information will be sent in real-time to the Disaster Prevention Center of the Ministry of Emergency Situations (MES) of the Republic of Armenia. The host computer at the Center upon receiving information will estimate seismic intensity using data about site location and site amplification response due to soil condition.
The seismic intensity distribution information will be basic material for MES RA, providing the opportunity for central and local governments to undertake necessary actions in emergency.
Data obtained from IMS Garni station will be used in new seismic system verification activities.

T3-P8. Seismic networking in the south Pacific region

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The South Pacific Islands Region operated at least fifteen seismic stations, four Global Positioning System stations and eight tide gauges with twenty one seismic stations that are under constructions. One of the main reasons is because the Pacific Ring of Fire is an active system of seismic activities which has influenced the region in the past. Tsunamis that have traversed the vast Pacific Ocean have originated from earthquakes located in Alaska, Chile, Peru, Mexico, Hawaii, Aleutian Isles, Japan, Philippines, Papua New Guinea and many other places in the region. Similarly earthquakes and volcanic eruptions have devastated human lives as well as the environment. Recent events like the Chile earthquake in 2010 measured 8.8 on the moment magnitude scale which generated a pacific wide tsunami, Samoa Tsunami in 2009, the Aitape tsunami in 1998 to name a few have caused deaths, loss of livelihoods and economic impacts to the region. There is a need to harmonize all existing stations and ease the flow of data. The global scientific community can benefit by sharing of the available data. The ultimate goal is to improve seismic hazard and tsunami early warning capability in the region so that safety and security of humans and livelihood is ensured. It is anticipated that each Pacific Island country receives timely warnings, acted upon and disseminate information to the wider public in an improved timely manner.

T3-P9. Developing a block diagram for the earthquake warning device

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Additional determination of the earthquake characteristics from the data of each separate station is perspective way in developing the earthquakes early warning systems. It allows using advantages of a method of the single sensor and, first of all, to reduce a radius of a dead zone, in which the warning is impossible, up to 20 kilometers and even less. However if the separate stations are used as a part of a seismic network, the end user are lost such their useful properties, as possibility of independent activity and simple way to transfer a warning signals. This work is devoted elimination of these contradictions.

T3-P10. New tiltmeter developed in Institute of Physics of the Earth of the Russian Academy of Sciences

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A tiltmeter has been developed at the Institute of Physics of the Earth of the Russian Academy of Sciences as the regular equipment for geophysical observatories and other observation posts. The tiltmeter is intended for relative measurement of tilts of a terrestrial surface in two mutually perpendicular directions for the purpose of studying tidal deformations, research of modern earth movements, research of harbingers of earthquakes in the form of abnormal inclinations, and also deformations of the bases and parts of large engineering constructions.
The tiltmeter which has been developed possesses record-breaking high precision 0.0001 arc sec. in a range of measurement +/-2 arc sec.; thus it has extremely high long-term tool stability (tool drift of "zero" no more +/-1 arc sec. per year). The combination of these major technical characteristics makes this tiltmeter an outstanding achievement in the field of geophysical instrument making. Sensor action is based on the principle of a vertical pendulum. In the sensor design a metal pendulum (length about 100 mm) is suspended on an elastic suspension over the ceramic part fixed on the case. The pendulum has a natural period of 0.6 seconds and air damping. It is isolated from the case and together with a ceramic part forms the differential two coordinate measuring condenser. On a ceramic casing four metal plates serving as facings of the measuring condenser are fixed. At an inclination of the sensor case the pendulum moves with respect to the condenser facings proportionally, making an inclination from these axes. As a result the measuring condenser records signals proportional to the angle of slope of the sensor on its sensitivity axes «N-S» and «E-W».

T3-P11. Superbroadband seismometer for seismomonitoring networks and a tsunami notification service

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For understanding the mechanism of preparation of strong earthquakes and their possible forecast it is necessary to conduct large-scale researches on the basis of dense networks of seismological observations. The basis of the

modern market is led by the same mobile seismometers offered by known world manufacturers, based on easy, short-period pendulums with small moment of inertia. General enthusiasm in the creation of portable seismometers results in engineering achievements to the detriment of developing high quality stationary devices. As a result for last 15 years in the world market there was no new superbroadband model meeting the full necessary requirements of teleseismic observation. Meanwhile, leading seismologists of the world consider that research at long periods is important while in practice no devices exist for this research. A feature of the device offered is the use of a pendulum with a period regulated up to 58 seconds. The vertical pendulum of the seismometer is configured using the Lacoste design. The spring is manufactured from highly stable alloys with unique Russian manufacturing techniques of a twisted cylindrical spring with zero initial length. The astatic mechanical elements used in the device has allowed the development of a compact superbroadband pendulum with inertial weight only 2 kg. As the converter of fluctuations of the pendulum to an electric signal the differential capacitor converter is used with a resolution better 10^-10 m. As a result the seismometer represents a force-balance velocimeter with a response as flat as possible in a range of frequencies 0.0018 – 15 Hz. Devices of this type do not exist in the world now. The seismometer is intended for the modernization of existing teleseismic networks for mass observations.

T3-P12. Modelling global seismic network detection threshold

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The seismic network of the International Monitoring System (IMS) operated by CTBTO has a global coverage but its detection capability is inevitably non-uniform. Network detection capability can be quantified in terms of an "event location threshold" that measures the magnitude of the smallest seismic event that could occur at a location and have a specified probability of being detected and located. Network detection capability can be modelled by numerical methods that use knowledge of seismic station response characteristics and background noise conditions to produce global maps of event location threshold. Such methods may be used to simulate the performance of the current network and to predict the consequences of station outages or future modifications of the network. Data are presented from the NetSim seismic network simulation system for a series of ninety-oneday periods from 2003 to 2010. NetSim takes information describing the locations of stations in the IMS seismic network that were active at the relevant time, and uses data describing background noise measured at those stations specific to the time period under study. Predictions of event location threshold are then made. NetSim predictions are validated by comparison with "Magnitude of Completeness" values calculated for the Reviewed Event Bulletin over the same period. The views expressed are those of the authors and do not necessarily reflect the view of CTBTO Preparatory Commission.

T3-P13. Equipment testing for IMS waveform technologies

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Since the establishment of CTBTO, the Provisional Technical Secretariat (PTS) has implemented a program of equipment testing to assure compliance of International Monitoring System (IMS) station equipment with the minimum technical requirements defined in the IMS Operational Manuals.
The Sandia National laboratory (SNL) in NM, USA has been playing a key role in this effort as PTS' technical counterpart, assisting with time-proven concepts of equipment testing procedures for waveform sensors and digitizers. Almost all digitizers currently in use in the IMS underwent testing at SNL.
The development of a new generation of equipment to satisfy the needs for improvement and sustainment of the IMS requires even more the utilization of state-of-the-art testing methodologies. As part of this renewed effort, two new digitizers were recently evaluated at SNL for basic performance characteristics of bit-weight accuracy, self-noise, clip point, dynamic range, cross-talk, harmonic distortion, timing accuracy, timing drift with GPS loss and system noise analysis for common sensor types used at IMS seismic and infrasound stations.
The units showed satisfactory behavior compliant with key minimum requirements for IMS waveform stations. During the testing process certain issues were addressed with the manufacturer to enhance product quality.
These equipment testing procedures will be extended to the test facility at the Conrad Observatory (CO) of ZAMG, Austria, where the installation of test Infrasound and Seismic equipment allows the comparison of different geometries of infrasound wind noise reducing systems and the assessment of the added value derived by the synergy of co-located infrasound and broadband sensors.

T3-P14. The IDC seismic, hydroacoustic and infrasound global low and high noise models

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The International Data Centre (IDC) of the Comprehensive Nuclear-Test-Ban Treaty Organization in Vienna, Austria, is determining, as part of routine automatic processing, sensor noise levels for all Seismic, Hydroacoustic, and Infrasound (SHI) stations in the International Monitoring System (IMS) operated by the Provisional Technical Secretariat of the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO). Sensor noise is being determined several times per day as a Power Spectral Density (PSD) using the Welch overlapping method. Based on accumulated PSD statistics a Probability Density Function (PDF) is also determined from which low and high noise curves for each sensor are extracted as bounds to the PDF. Global low and high noise curves as a function of frequency for each of the SHI technologies are determined as the minimum and maximum PSD values of individual station low and high noise models respectively, at a specified frequency taken over the entire network of contributing stations. An attempt is made to ensure only healthy station data contributes to the global noise models by additionally considering various automatic detection statistics. In this paper annual global low and high noise curves from 2007 to 2010 will be presented and compared for each of the SHI monitoring technologies.

T3-P15. Long term - real time background noise monitoring around BR235

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Turkish NDC is monitoring the quarry activities in the vicinity of array elements in coordination with AFTAC. The mining activity around BR235 was analyzed in the period of August 2008 and December 2010. The power density spectrum of BR235 long period data was compared with the other elements of the same array in order to evaluate the overall noise effect on the BR235 data. Power density spectrum analysis allows us to determine the precise frequency characteristics of the background noise, which will help us to assess the station sensitivity. The long period data are important for nuclear explosion monitoring, primarily for estimating Ms magnitude; consequently measuring the mb:Ms discriminant. Our preliminary results show some difference in the 10 - 30 second period range amplitudes for these time periods of the data. A detailed analysis of recorded quarry blasts and activities, together with the preliminary results of the noise will be presented by this research.

T3-P16. Bayesian waveform inversion for moment tensors of local earthquakes in the Pannonian basin

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The Hungarian part of the Pannonian basin can be characterized by moderate seismicity with local earthquake magnitudes of mostly less than 3.5. The weak events are usually recorded at only a few stations when the inversion of first-motion polarity data cannot produce reliable focal mechanism solutions. In this study we use a Bayesian waveform inversion procedure in order to retrieve the hypocentral locations and moment tensors of weak local earthquakes that occurred in Hungary. The applied probabilistic inversion procedure takes into account the effects of the random noise contained in the seismograms, the uncertainty of the hypocentre determined from arrival times, and the inaccurate knowledge of the velocity structure, while mapping the posterior probability densityfunctions (PDFs) for the source parameters. The final estimates for the focal parameters are given by the maximum likelihood points of the PDFs, whereas solution uncertainties are presented by scatter density plots. The estimated uncertainties in the moment tensor components are plotted on the focal sphere in such a way that the significance of the double-couple, the CLVD, and the volumetric parts of the source can be assessed. The moment tensor solutions for the selected events have negligible volumetric part, implying the tectonic nature of the events. The retrieved source mechanisms are in agreement with the main stress pattern published for the epicentral regions. The resulting fault-plane solutions correspond to pure strike-slip or strike-slip with thrust faulting mechanisms, implying the compressional characteristics of the stress field in the Pannonian basin.

T3-P17. Romanian infrasound structure: design and data processing

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A 2.5 km aperture seismo-acoustic array has been recently designed and installed in the central part of Romania, in the Vrancea epicentral area, by the National Institute for Earth Physics (NIEP). So far, 7 seismic sites (3C broad-band instruments and accelerometers) and 7 collocated infrasound instruments were deployed. Four elements of the acoustic array (IPLOR) are equipped with infrasound sensors Chaparral Physics Model 25 (0.1 – 200Hz, 2V/Pa@1Hz) and three with MBAZEL2007 microbarometers (+/-50Pa) and additional electrometers and 3C fluxgate sensors. Data from each sensor are digitized and transmitted in real time to the Romanian National Data Centre, where an acquisition system based on the SeedLink software is running.
The array is being used to assess the importance of collocated seismic and acoustic sensors for the purposes of (1) seismic monitoring of the local and regional events, and (2) acoustic measurement, consisting of detection of the infrasound events (explosions, mine and quarry blasts, earthquakes, aircraft etc.).
The infrasound data recorded with the IPLOR array are automatic processed using a program based on the Progressive Multi-Channel Correlation (PMCC) algorithm. A standard detector DFX (Detection and Features eXtraction) used by the International Data Centre (IDC) is applied for the IPLOR data. PMCC detection results are displayed and reviewed through a graphical interface of the Geotool software. High-resolution continuous detection and propagation parameter measurements, i.e. accurate description of the wave train with complex variations of azimuth and velocity, are obtained from IPLOR data using PMCC algorithm.

T3-P18. Analysis of the background noise at the auxiliary seismic station Muntele Rosu

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The auxiliary seismic station Muntele Rosu (AS081, MLR) is part of the International Monitoring System (IMS), being operated by the National Institute for Earth Physics (NIEP, Bucharest) in support of the verification regime of the Comprehensive Nuclear-Test-Ban Treaty. Seismic data from MLR station are forwarded directly to the International Data Centre (IDC) upon request at any time through on-line computer connections and VSAT transmission. Relatively quiet background noise conditions, with very few noise sources (except of the natural environmental one) were observed for the MLR station. The analysis of the background noise at MLR was carried out for one year (between December 2006 and November 2007). For frequencies higher than 1 Hz, the noise level lies 20 dB above Peterson's New Low Noise Model (NLNM). At frequencies below 1 Hz, this difference varies between 10 and 15 dB. Diurnal and seasonal variations are observed in the MLR background noise. For frequencies higher than 1 Hz, daytime noise level is 10 dB above night-time level. The seasonal variation implies frequency dependence: at higher frequencies, the noise level increases during summer, while at microseismic frequencies (0.05 – 1 Hz), this level is highest during winter. These results are consistent with the MLR detection performance reported by IDC for both regional and teleseismic phases. The higher level of the noise during the summer months for higher frequencies affects MLR capability by reducing the number of the detections. This behaviour is associated with the specific seasonal human activity and atmospheric conditions (thunderstorms).

T3-P19. The GSN data quality initiative

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The Global Seismographic Network (GSN) is undertaking a renewed effort to assess and assure data quality that builds upon completion of the major installation phase of the GSN and recent funding to recapitalize most of the network's equipment including data acquisition systems, ancillary equipment and secondary sensors. We highlight here work by the network operators, the USGS' Albuquerque Seismological Lab and UCSD's Project IDA, to ensure that both the quality of the waveforms collected is maximized, that the published metadata accurately reflect the instrument response of the data acquisitions systems, and that data users are informed of the status of the GSN data quality. Procedures to evaluate waveform quality blend tools made available through the IRIS DMC's Quality Analysis Control Kit, analysis results provided by the Lamont Waveform Quality Center and custom software developed by each of the operators to identify and track known hardware failure modes. Devices based on GPS technology unavailable when the GSN began 25 years ago are being integrated into operations to verify sensor orientations. Portable, broadband seismometers whose stable response can be verified in the laboratory are now co-located with GSN sensors during field visits to verify the existing GSN sensors' sensitivity. Additional effort is being made to analyze past calibration signals and to check the system

response functions of the secondary broadband sensors at GSN sites. The new generation of data acquisition systems will enable relative calibrations to be performed more frequently than was possible in the past.

T3-P20. Transportable Xenon Laboratory

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The logistical challenges of supporting a rapid worldwide campaign to measure Xe backgrounds during 2008 and 2009 taught researchers many lessons on the resources needed to carry out a measurement. A cost-savings approach was developed to house a xenon measurement system for shipping and operations, providing a safety and technical envelope for the measurements that enables rapid installation and short to long term operations. Some challenges surmounted by this system are substantial back-up power, environmental conditioning, satellite communications, GPS, and local weather data systems. An additional outcome of this work is the possibility of a new paradigm for more permanent IMS aerosol or xenon installations and self-contained laboratory spaces for OSI use, regardless of the technology that goes inside. A report on the development and deployment of TXL will be given.

T3-P21. Towards an effective on-site inspection – A geophysical view

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For the development of the OSI regime (contributing to reaching operational readiness at entry into force of the Treaty) one of the key tasks is to test surface geophysical methods which are able to detect and delineate the footprints of an underground nuclear explosion (UNE). A footprint can be the geological effect itself caused by the nuclear blast, as well as the constructions (adits, tunnels, pipelines, shafts, any underground structure) necessary to conduct an underground nuclear test. Geophysical field methods applied in mineral prospecting, in geotechnics, or to solve environmental problems do the same: detect small-scale or limited-extent alterations in physical parameters of the rocks. Some would think that the implementation of the geophysical methods into the OSI procedure means a simple task. But it is not an easy game, because

• we have a limited knowledge on the physical nature of the footprints in a previously unknown geological environment;
• the inspectors have a very limited time to select then apply the appropriate methods and instruments;
• the field data acquisition and the computer-based processing/interpretation must be quick but reliable.

This paper presents some results of the geoelectric and active seismic tests on geologic models comparable to a UNE situation. The instrumental and detectability threshold tests were performed over objects of natural and man-made origin, believed that in some aspects exhibit similar alterations to a UNE. The field survey was performed in cooperation with the CTBTO and the Eötvös Loránd Geophysical Institute in Hungary.

T3-P22. Ionospheric detection of the recent North Korean underground nuclear test

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The Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) established the International Monitoring System (IMS) to detect nuclear explosions using seismic, hydroacoustic, infrasound, and radionuclide technologies. However, the IMS observed only the seismic and infrasound responses of the underground nuclear explosion (UNE) near P'unggye, North Korea on 25 May 2009. We studied the total electron content (TEC) measurements of the Global Navigation Satellite system (GNSS) and found traveling ionospheric disturbances (TID) that can be related to this UNE. The TID were observed to distances of at least 550 km from the explosion site propagating with speeds of about 300 - 350 m/s. Thus, the global distributions and temporal variations of the TEC, may provide important information to augment efforts to detect and characterize clandestine underground nuclear explosions.

T3-P23. Infrasound monitoring of explosive eruptions at Shinmoe volcano in Japan

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The Shinmoe volcano on the island of Kyushu in Japan began to erupt around January 26 2011 and continued its volcanic activity through the middle of February 2011. It has been reported that the volcano scattered rocks and ash up to 1.5 kilometers into atmosphere, which caused cancelling several domestic flights. Infrasound signals from the explosive eruptions have been observed at Korea Infrasound Network (KIN) at the distance of 620-880km away from the volcano. The array process using Progressive Multi-Channel Correlation (PMCC) was applied to identify coherent infrasound signals and to compile chronological records of sequential explosive eruptions. These records are then compared with seismic signatures recorded at local seismic stations around the volcano to associate the infrasound records with seismic events. As a result, the infrasound records consist of wave trains of long time duration and impulsive signals that are partly correlated with seismic tremors. In some cases, however, infrasound signals whose corresponding seismic signals are not identified in the seismic data are detected at the network. As a ground truth for infrasound source, calculated infrasound locations using data from the network are compared with the volcano location and characteristics of temporal variations of infrasound travel times and azimuths are also estimated from the detection and location results.

T3-P24. Development of the IMS facilities, experimental seismic and infrasound observation in Ukraine

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The Ukrainian NDC operates the primary IMS seismic station PS45 located in Malin, Ukraine. In the last few years an experimental infrasound array has been collocated with this seismic array. The infrasound array is equipped with K-304-A microbarometers (provided in the former USSR) with frequency band from 0.0033 to 5 Hz. The number of array element is 3, with plans to increase to 4 in the near future. The aperture of the array is 150-160 meters forming an isosceles triangle. The array is currently operating in a test mode and uses infrasound signals from local mining explosions to aid the interpretation and authentication of seismic events. Interactive and automatic data processing is performed using the PMCC and GEOTOOL software provided by the NDC. As the CTBTO IMS stations develop, co-locating seismic and infrasound sensors is a method that can be used for improving data quality in analysis and interpretation. The installation of the microbarometers at the seismic elements can be done for little cost and can use much of the existing infrastructure such as the data transmission subsystem. With this in mind, and using the existing PS45 seismic array configuration as an example, installing both LF and HF infrasound array elements becomes feasible.

T3-P25. Real time seismic monitoring in South-Central Europe: data sharing, cooperation and improvements of the OGS NI Seismic Network

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The Centro di Ricerche Sismologiche (CRS, Seismological Research Center) of the Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS, Italian National Institute for Oceanography and Experimental Geophysics) in Udine (Italy) after the strong earthquake of magnitude Mw=6.4 occurred in 1976 in the Italian Friuli-Venezia Giulia region, started to operate the North-eastern Italy (NI) Seismic Network: it currently consists of 13 very sensitive broad band and 21 simpler short period seismic stations, all telemetered to and acquired in real time at the OGSCRS data centre in Udine.
Real time data exchange agreements in place with neighbouring Italian, Slovenian, Austrian and Swiss seismological institutes lead to a total number of 94 seismic stations acquired in real time, which makes the OGS the reference institute for seismic monitoring of North-eastern Italy. Since 2002 OGS-CRS is using the Antelope software suite on a SUN SPARC cluster as the main tool for collecting, analyzing, archiving and exchanging seismic data, initially in the framework of the EU Interreg IIIA project "Trans-national seismological networks in the South-Eastern Alps".
At OGS-CRS we spent a considerable amount of efforts in improving the long-period performances of the broad-band seismic stations, either by carrying out full re-installations and/or applying thermal insulations to the seismometers: the example of the new PRED broad-band seismic station installation in the cave tunnel of Cave del Predil using a Quanterra Q330HR high resolution digitizer and a Streckeisen STS-2 broad-band seismometer will be illustrated. Efforts have been also put in strengthening the reliability of data links, either from stations to

data centre by exploring the use of redundant satellite/radio/GPRS links, and between different data centres by exploiting the usage of the Antelope "orbxchange" module. An example of the usage of the "orbxchange" module in acquiring data from the seismic station of Acomizza (ACOM) at the border between Austria and Italy in both OGS in Italy and ZAMG in Austria data centres will be presented.

T3-P26. The "Hellenic Unified Seismological Network-HUSN": its implication in the accurate monitoring of the seismicity in the broader area of Aegean Sea

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By the beginning of 2005, through a national project, realized the unification of the seismological networks of the Greek Institutions, that of the Institute of Geodynamics-National Observatory of Athens (IG) and of the seismological laboratories of the Universities of Athens, Thessaloniki and Patras, forming the "Hellenic Unified Seismological Network-HUSN". With this project was made possible: the detailed and precise recording of the seismic activity of the broader area of Greece, the unified calculation of seismic parameters, the publication of common announcements of the occurrence of strong earthquakes, the compilation of a national bulletin of earthquakes and more generally the qualitative and quantitative upgrading of seismological data and seismological research. Moreover, it was created a new automatic system of recording, processing and presentation in real time the seismicity of the broader area of Greece. At present, 109 digital signals from broadband instruments are gathered by IG, from which 41 belong to IG, 23 to Athens, 23 to Thessaloniki and 22 to Patras seismological laboratories. Additionally, waveforms from stations belonging to international agencies, (Geofon and MEDNET) and neighboring countries cooperating with IG are also used. The data are analyzed routinely in detail by the staff of IG, producing a daily report of the located earthquakes, while every month a monthly bulletin is produced containing earthquakes with Ml≥1.5. Information and products are given at the website: www.gein.noa.gr.

T3-P27. Studies of vibrations from wind turbines in the vicinity of the Eskdalemuir (AS104) IMS station

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Styles et al (2005) describe an extensive microseismic and infrasound monitoring programme to characterise the low-frequency vibration spectra produced by wind turbines of various types, both fixed and variable speed. It was demonstrated that small but significant harmonic vibrations (modal eigentones) of the towers, excited by blade passing, tower braking and wind loading while parked, can propagate many kilometres and be detected on broadband seismometers. This lead to protective measures being required to protect the IMS Auxiliary Seismic station (AS104), located at Eskdalemuir in the Scottish Borders, UK. The work established that vibrations of concern in the critical 2 to 6 Hz band are generated by large wind turbines. Propagation laws were derived and an aggregate vibration budget established which would not prejudice the detection capabilities of the Eskdalemuir station. Subsequently, further work has been carried out to determine if small wind turbines (<50kW) should be covered by the same restrictions. The UK Ministry of Defence has issued new guidelines that may allow small wind projects to be developed in the vicinity of Eskdalemuir, providing that measurements confirm that they do not generate significant vibrations within the frequency band of concern. The work may have relevance to other IMS sites where new windfarm developments are planned or already exist.

T3-P28. Re-analysis of noble gas samples from IMS stations at laboratories – a review of the results since 2007

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One element of the QA/QC program for Noble Gas stations (as identified in INF.795 in 2005 and further elaborated by the PTS) is the independent measurement of samples from Noble Gas stations performed by laboratories. In the last 3 ½ year 210 Noble Gas samples from 25 stations have been reanalyzed by 5 laboratories. A comprehensive summary of the results will be presented particularly with regard to agreement of station and laboratory results for Xenon activity concentrations, Isotope ratios, and Stable xenon volume.

T3-P29. Development of a cosmic veto device to improve detection limits of CTBT detectors

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Cosmic radiation contributes significantly towards the background radiation of a gamma spectrometer. Unlike terrestrial radiation, it is not possible to reduce this component using lead shielding, which acts to enhance the effect by a variety of interactions. Instead an anti-Cosmic device may be utilised, which consists of plastic scintillation plates that surround the lead shielding and operates in anticoincidence with the germanium detector. This can reduce the detector background by factors of 4 – 10, improve detection sensitivity, and reduce the count time required for CTBTO samples to achieve an MDA of 24 mBq. This research considers the contributions of cosmic radiation to detector background, the technology available for its reduction, and the systems suitable for utilisation by the UK CTBT Laboratory (GBL15) and IMS stations.

T3-P30. SAUNA - Equipment for low level measurement of radioactive xenon

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The Swedish Automatic Unit for Noble Gas Acquisition, SAUNA was developed at the Swedish Defence Research Agency (FOI) and commercialized by Gammadata 2004. Today, 16 stations within the IMS network of CTBTO have SAUNA Systems installed for noble gas capability.
The SAUNA II performance meets or exceeds the specifications defined by the CTBT requirements for monitoring of radioactive xenon in air samples. The sampling and purification to extract the xenon is performed by preparative gas chromatography. The atmospheric xenon is adsorbed on charcoal beds at ambient temperature and then further processed and purified. The xenon is quantified using a thermal conductivity detector. The activity measurement of the four xenon isotopes, 133Xe, 131mXe, 133mXe, and 135Xe is performed using the very sensitive beta gamma coincidence technique allowing for high sensitivity also for the meta-stable states resulting in MDC:s of 0.3, 0.3, 0.3 and 0.7 mBq/m3 respectively.
To fulfil the requirement of 95% uptime, an efficient organisation, and tools for remote diagnosing of system problems has been our focus for the last years. 2010 has also been the year for starting certification of noble gas stations. We have worked together with PTS to come to solutions for upgrades and improvements to meet the certification requirements which have resulted in several certified stations with SAUNA systems installed.
In the SAUNA Systems product portfolio there are also systems for in field sampling with laboratory analysis, and for reanalysis of archive samples.

T3-P31. Integrating infrasonic arrays into the Utah Regional Seismic Network

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University of Utah Seismograph Stations (UUSS) has operated a regional seismic network in Utah, USA, for more than four decades. Building on the existing infrastructure and technical expertise, UUSS has integrated nine infrasonic arrays into the seismic network with real-time telemetry for continuous data recording. The infrasonic arrays, with apertures of ~150 m, each consist of four sensors with one of the elements co-located with a seismic station. Co-locating acoustic and seismic sensors is part of the design plan to characterize and understand problems related to seismic-toacoustic and acoustic-to-seismic energy coupling. Deploying the infrasonic arrays in Utah has been motivated by the number and variety of local sources that can generate both seismic and acoustic energy, including mining explosions, rocket motor detonations, and earthquakes. The spatial distribution of the infrasonic arrays in Utah allows us to investigate the propagation of acoustic energy with distance, within and outside the "zone of silence". We present examples of infrasound signals generated by sources such as earthquakes, mining explosions, a bolide, and rocket motor detonations and recorded by the infrasonic arrays in Utah. Detection and location of recorded events from processing of continuous data and event-driven analyses are performed with the InfraMonitor software package (developed at Los Alamos National Laboratory). We also report on modeling results based on atmospheric velocity profiles acquired at the origin times of the various events.

T3-P32. Gamma radiation survey techniques for on-site inspection

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As the key techniques which could be used in the initial period of on-site inspection, airborne gamma radiation survey and vehicle-mounted gamma radiation survey are applied to effectively narrow the inspection area by searching radiation anomaly. The role of both of the radiation survey techniques was expatiated in this paper. Based on the results of calculation, the abilities to detect the gamma radiation on surface were compared between airborne gamma radiation survey technique and vehiclemounted gamma radiation technique. The availability of them also was analyzed in combination with the potential inspection scene.

T3-P33. Analysis of network QA/QC and Level 5 samples at certified laboratories

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As a routine practice, the Provisional Technical Secretariat (PTS) requests the radionuclide station operators to send samples to certified radionuclide laboratories based on quality assurance and quality control programme (QA/QC) of the International Monitoring System. In addition, all Level 5 samples from certified stations are split and sent to two independent certified laboratories for measurement and analysis. This is done in accordance to Prepcom decisions to exercise and maintain the procedures and practices for handling Level 5 samples for Treaty verification purposes.
From 2008 to 2010, 436 QA/QC and 27 Level 5 samples (split into 54 half samples) from certified radionuclide stations were sent to certified radionuclide laboratories. This report summarizes the result comparisons of station results against laboratory results based on Be-7 metrics. Probable agreement and discrepant results are further elaborated with a description of (possible) causes for scatter or bias, and any corrective actions planned or taken. Possible reasons for non-confirmation of anthropogenic radionuclides by laboratories for level 5 samples are also discussed.

T3-P34. Mobile radiation measurements for on-site inspections

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One of the major components of on-site inspections of CTBT is to be able to locate and characterize radioactive materials in the inspection area. As the area is relatively large (1000 km2) and may contain difficult terrain, many options have to be considered when planning and executing the radiological survey. One possibility is to use aircraft or car mountable gamma-ray spectrometer that collect data in real time with GPS based geo-referencing. The detector can be a large volume NaI crystal or a relatively large HPGe detector. NaI detectors provide good detection capability due to high efficiency and germanium detectors good identification capability in the field. Time resolution of the measurement has to be down to 1 second, especially if the equipment is used during the overflight. With a helicopter flying 150 km/h, the system is able to scan 200-600 km2 per hour depending the flight line spacing. One important part of the analysis is the modeling of possible ground based hot spots. This requires both relatively simple calibration and 3d modeling capable analysis software. The equipment developed in Finland with appropriate field procedures have been tested in various OSI field exercises during the past decade.

T3-P35. AXS: A xenon sampler aiming at long-time stability

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Radionuclide verification is one of four verification technologies that were stipulated by the Comprehensive Nuclear-Test-Ban Treaty (CTBT). There are three automated radioxenon sampleranalyzers having been equipped in the International Monitoring System (IMS) stations, such as SAUNA, SPALAX, and ARIX. A novel atmospheric xenon sampler (AXS) has been developed in China. The AXS collects and purifies xenon using a polymeric permeation membrane and multistage activated charcoal columns. The received xenon is about 5 cm3 in one sample every 24 h. In order to increase the long-time stability of the sampler, several methods were introduced in the sampler: (1) membrane separation technique reduced the complexity of air preprocessing, (2) room temperature adsorption decreased the operating temperature difference of the devices, (3) many inspection points for diagnosis were preformed. A set of detection processes were used for routine check

as required and fault diagnosis while necessary. High-speed fault diagnosis and sufficient spare parts assured the high-speed repair of equipment failures. All these methods are effective solutions to improve the long-time stability of xenon samplers.

T3-P36. Possible improvements of the detection capability of the CTBT monitoring system using active Compton suppression techniques

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The Comprehensive Nuclear Test Ban Treaty Organization (CTBTO) operates the International Monitoring System (IMS) which in its final stages includes 80 aerosol and 40 Noble Gas stations for the detection of airborne radioactivity. To achieve desired detection capability of the network, the IMS aerosol stations are required to have a minimum detectable concentration (MDC) for 140Ba with 30 Bq/m3, which is one of the key fission products. In case of the detection of two or more relevant isotopes, samples from the IMS aerosol stations are sent to one of 16 the IMS Radionuclide Laboratories for re-analysis and confirmation.
Increasing the detection capability in the IMS network and in the Radionuclide laboratories is one of the key research areas. In 2009 a study was conducted to analyze samples from IMS stations in ultra low-level background facilities. The results showed that the sensitivity for 140Ba could be improved considerably by one order of magnitude, but the results are less favourable for another key radioisotope, 131I. This is due to the fact that the key line of 140Ba at 537.3 keV is above the 478 keV gamma ray of 7Be, whereas for 131I its key line at 364.5 keV is found on the high compton background produced by 7Be. Since a considerable improvement was observed for low level laboratories operating active compton suppression detectors, this techniques in general leads to improved MDCs for isotopes with main gamma lines below 478 keV.
To benefit from these findings, a special test has been discussed with JAEA, already operating high resolution detectors with a NaI guard for active compton suppression. In 2011 up to ten pre-selected samples from the IMS will be sent to JAEA laboratory for re-analysis with a period of 7 days after 7 days decay. Samples with 1 day decay time and 1 day acquisition time are also measured also to evaluate the possible benefit of using similar equipment directly at IMS stations.

T3-P37. Operation of the International Monitoring System network

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The IMS is a globally distributed network of monitoring facilities of four technologies. It is designed to detect the seismic and acoustic waves produced by nuclear test explosions and the subsequently released radioactive isotopes. Monitoring stations transmit their data to the IDC in Vienna, Austria, over a global private network known as the Global Communications Infrastructure (GCI). In order to satisfy the strict data and network availability requirements of the IMS Network, the operation of the facilities and the GCI are managed by IDC Operations. IDC Operations has three functions, namely: to ensure proper operation and functioning of the stations, to ensure proper operation and functioning of the GCI and to provide network oversight and incident management. At the core of the IDC Operations are a series of tools for: monitoring the stations' state of health and data quality, troubleshooting incidents, communicating with internal and external stakeholders, and reporting. An overview of the tools currently used by IDC Operations as well as those under development will be presented. This will include an outline of the PTS strategy for operation and support of the IMS facilities.

T3-P38. Design challenges for a noble gas sampler

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NTS has developed a new radionuclide monitoring device with applications oriented towards the CTBT community. Technical features include radioisotope detection capabilities, high reliability, elimination of the use of cryogenic cooling, and a small design footprint. An oral presentation is proposed to discuss architectural and design challenges for such a system.

T3-P39. A new vision on data acquisition and processing

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Seismologic studies involve a variety of data acquisition and processing methods which have always been the most important challenge facing any manufacturer of data acquisition solutions. The latest data-logger device produced by this firm offers large internal storage; standards-compliant data format; very low power consumption; small dimensions and weight; freedom from extraneous hardware; easy data retrieval; a variety of communication options including IP networking, RF transmission, GSM/GPRS connectivity, state-of-health reporting and configuration over cellular short message service, Wi-Fi access; and many other capabilities which crown a data acquisition subsystem equipped with an accurate and precise A/D, wide range of sensor support including active sensors, and the unique capability of online data processing. With this combination of features the device is arguably a most general, yet sophisticated, seismographic solution which will prove to be extremely enjoyable for any seismologist to use.
Clearly, if such data-logger devices are employed in large numbers a continually increasing wealth of data will accumulate that is best serviceable by integrated, multi-user event extraction and processing software. Such software's potential can be greatly increased by further integration with GIS solutions and report generators that allow rapid combination of datasets into highly professional reports and presentations. This paper intends to offer a survey of the three aforementioned aspects of data acquisition, processing, and post-processing.

T3-P40. Soccoro Island's IMS T-stations record the modification of the strain field due to the passage of tsunamis

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The IMS infrastructure can be used effectively in civil applications, for instance to augment the capacity of organizations charged with warning the authorities about dangerous natural events, such as earthquakes and tsunamis. Relevant IMS data is already forwarded to regional tsunami centres under agreement with CTBTO. This includes seismic IMS stations for accelerated tsunamigenic event detection and hydroacoustic stations for the recording of the passage of the tsunami. In this work, we suggest that data from coastal and island T-stations is also useful for direct detection of the passage of the tsunami. The possibility of observing the passage of tsunamis on these coastal seismic stations was confirmed in the Pacific Ocean for the tsunamigenic Maule, Chile earthquake of 27 February 2010 on the horizontal components of two broad-band seismometers used as hydroacoustic T-station located on Socorro Island, Mexico. Similar observations of long period effects of the passage of tsunami on the horizontal components of near-shore seismometers had been made previously and tentatively explained as long-period components of the propagation modes of gravity waves, where the presence of the island is ignored. Polarization and amplitude analysis of the longperiod arrivals observed at Socorro allows an alternate physical explanation and our preferred explanation is that the island's strain field is responding elastically to the load of the very long wavelength tsunami on the walls of the island. This hypothesis is confirmed by analysis of the passage at Socorro of another tsunami from the September 29th, 2009, Samoa earthquake.

T3-P41. Can OSI use off the shelf techniques?

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A careful consideration of Paragraph 69 in Part II of the Protocol to the CTBT shows that the list of techniques allowed to be used during an on-site inspection (OSI) is 16; moreover, they can be used on or under the ground, from the air, etc. All of these technologies are established scientific methods familiar to experts in fields such as geology, radionuclide measurements, seismometry or geophysics. According to the CTBT Protocol, scientists, functioning as inspectors, are expected to utilize these techniques for detection of observables resulting from a nuclear explosion. However, these observables, their spatial scale, and the amplitude of the anomalies they produce, are much different from what scientists are used to in their daily activities.
It is therefore required to develop a specific concept of operations for each technique different to a certain degree from the one used in scientific campaigns. Also, the difference in resolution of the target means that it is necessary to invest in R&D programs for developing the specific OSI application with appropriate resolution. Some of the techniques need heavy equipment which does not fit OSI field campaigns and require the development of a light, field operable version. For some techniques there are special requirements which require re-engineering to comply with Treaty requirements.

This poster presents the detailed list of OSI techniques and the challenges in their application during an OSI, their adequacy to be used as off-the-shelf equipment or, on the contrary, the need to adapt the technologies to the OSI specifics.

T3-P42. Miniature optical seismic sensors for monitoring applications

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The Department of Energy (DOE) and the National Nuclear Security Administration (NNSA) seek revolutionary innovations with respect to miniature seismic sensors for the monitoring of nuclear detonations. Specifically, the performance specifications are to be consistent with those obtainable by only an elite few products available today, but with orders of magnitude reduction in size, weight, power, and cost. The proposed innovations call upon several advanced fabrication methods and readout technologies being pioneered by Silicon Audio, including the combination of silicon microfabrication, advanced meso-scale fabrication and assembly, and the use of advanced photonicsbased displacement / motion detection methods. Recent development has centered on improved actuator design, increased stability control, mitigation of 1/f noise sources, and compensation for nonideal tilted deployment conditions. Prototypes resulting from these efforts are surpassing Class 3 sensor requirements as outlined by the USGS broadband seismometer requirements for Advanced National Seismic System (ANSS), the Global Seismographic Network (GSN), and the Volcano program. Future efforts will be aimed at further reducing the overall size and power and addressing other commercial readiness aspects of the design such as shock tolerance and long term cycle testing. Current market applications envisioned include military defense, scientific instrumentation, oil and gas exploration, inertial navigation, and civil infrastructure monitoring.

T3-P43. Technology foresight for the Provisional Technical Secretariat of the CTBTO

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The Comprehensive Nuclear-Test-BanTreaty clearly recognizes the need to incorporate future scientific and technological developments into the verification regime. The Provisional Technical Secretariat (PTS) has engaged in a technology foresight exercise, aiming to mobilize the wider science and technology community in support of its mission to sustain and enhance the technological capabilities of the CTBT verification systems and operations. In the first phase of the technology foresight exercise, we are working to define scenarios that illuminate potential future technological developments that may have impact on the verification regime. The scenarios focus on technologies that are relevant to our core mission of detection, localization, and characterization of nuclear explosions. We report the results of expert meetings, foresight surveys, and bibliometric analysis that have taken place in the first half of 2011. In addition, we sketch our initial scenarios and discuss their implications for future technology development.

T3-P44. GCI-II: How CTBT data is transmitted around the globe

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The CTBTO's work monitoring compliance to the nuclear nonproliferation treaty has profound implications for world peace and security. A key factor in accomplishing its goals is the ability to process and analyze data sourced from a collection of geographically dispersed sensors to prove, with a high degree of precision, when and where a nuclear explosion occurs anywhere on the planet. For close to a decade, CTBTO has employed a Global Communications Infrastructure (GCI) employing very small aperture terminal (VSAT) technology to transport this essential data between international monitoring stations (IMS) and national data center (NDC) nodes operated by CTBTO member states in more than 90 countries and the International Data Centre (IDC) in Vienna, Austria. Since 2008, the second generation Global Communications Infrastructure (GCI-II), a truly diverse, global satellite communications network, has been deployed and is currently operating on a very effective and reliable basis. Using a combination of six satellites in geosynchronous orbit above the equator; an interconnected network of teleports, hubs, terrestrial links and remote VSATs on the ground; and operated by a highly sophisticated service infrastructure, GCI-II ensures that the scientists get the data they need to ensure compliance. Most remarkable about GCI-II is its ability to securely and reliably (99.5% availability) transmit near-real-time data from some of the most inhospitable, rugged and remote places on Earth.
This poster is intended to offer attendees a birds-eye view of the network that delivers the data that they work on every day.

T3-P45. Coseismic tectonomagnetic signals as a tool for seismic risk reduction

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The present work is devoted to the estimations of space-time propagation of low frequency local geomagnetic fields, generated by the earthquake source at coseismic stage. The low frequency range allows interpreting the local geomagnetic field anomalies of tectonic origin due to thick enough skineffect layer. An experience of tectonomagnetic researches in Tajikistan's seismic areas led up to the conclusions that earthquakes with the magnitudes 5 and over at least can be conveying by the anomalies up to several nTl. The space-time scales for earthquakes sources and relevant tectonomagnetic effects are describing my means of empirical dependences on their magnitudes. The earthquake with the magnitude 9.0 has the source size about 300 km and the anomaly crust deformation zone up to several thousand kilometers. So within the radius 300 km of earthquake epicenter zone at an average one can expect the tectonomagnetic effects up to the first nTl. Tectonomagnetic effect can be generated for instance by electrokinetic currents or rocks piezomagnetism. The speed of tectonomagnetic signals propagation is equal to the speed of light and the coseismic tectonomagnetic signals can be principally registered immediately by the network within these 300 km. In contrast the travel time of the seismic waves from the epicenter will be taking from the seconds up to 40 s. Registering the tectonomagnetic signals by means of the network of high sensitive magnetometer sites provides possibility to take some automatic protection measures to the operating technical equipment before the intervention of seismic waves and thus reduce the seismic risk.

T3-P46. Development of CZT pixel detectors

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The recent improvements of CdTe and CdZnTe crystals and the availability of photon counting readout electronics like Medipix2 open the possibility of processing CdTe / CdZnTe pixel detectors with small pixels down to 55 µm and high efficiency for X-ray energies above 20 keV. The Medipix can be used with silicon, CdTe / CdZnTe or GaAs detectors with a pixel pitch of 55 µm.
A Different types of pixel detectors have been produced using our own technology with small pixels down to 55 µm and high connection density up to 65,000 pixels. The combination of very fine pitch and energy tresholds opens new areas of application for the high efficient pixel detectors.

T3-P47. Earthworm: A powerful and open-source real-time earthquake and infrasound monitoring software tool

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Earthworm is a modular real-time data acquisition, transport and processing system used for the automatic detection of earthquake hypocenters and magnitudes. The United States Geological Survey started the Earthworm project in 1993 to address the needs of the various regional seismic networks in the United States. Since its inception, the community supported, open source system has been deployed by most of the US regional seismic networks and the National Earthquake Information Center. There are also 150+ registered seismic networks worldwide using Earthworm and an unknown number of academic and commercial users. Earthworm's design goals were modularity, system independence, scalability, connectivity, and robustness. Interest in this modular, scalable and robust system for transporting and processing arbitrary data types has recently increased in disciplines outside seismology. Earthworm's capabilities have been utilized by both network seismologists, and have been adopted by researchers in the fields of infrasound and tsunami monitoring, most notably the Tsunami Warning Centers in the US and the ISLA Infrasound group (Hawaii). Earthworm's modularity and handling of real-time waveform data has allowed researchers to integrate diverse data sets that include the CTBTO's Continuous Data format among many others (tide gauges, SEEDLINK, Earthworm, Antelope, and 20+ seismic digitizers). Earthworm is accessible from many languages (C/C++, Python and Java), and operating systems (Solaris, Linux, OS X and Windows). Under contract to the USGS, ISTI has been managing this open source distribution since 2005. We present an overview of Earthworm, and its use in non-CTBTO monitoring networks.

T3-P48. Exploring the potential of satellite imagery for CTBT verification

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Commercial satellite imagery analysis is an important component in verifying compliance with the Nuclear Non-proliferation Treaty (NPT). In this study, we aim to explore how satellite imagery analysis can contribute to the verification of the Comprehensive Test Ban Treaty (CTBT). One of the main pillars of the CTBT verification regime is the International Monitoring System (IMS) with its monitoring stations and radionuclide laboratories around the globe. Presently, satellite imagery analysis is not included within the IMS. However, the CTBT does not exclude the possibility of using satellite imagery for its verification procedures, but considers satellite monitoring as an additional technology whose verification potential should be examined. Recent studies showed the application of optical and radar imagery for locating underground nuclear testing, surface deformations after a test event and monitoring of pre- test activities. The study explores the technical progress in the field of satellite imaging sensors and satellite imagery analysis to extract CTBTrelevant information in a qualitative and quantitative way. It discusses how satellite data could be used complementary for confirming information gathered from the IMS. The study also aims at presenting the legal and political aspects and the cost benefits of using satellite imagery in the verification procedure.

T3-P49. IS42: A new IMS certified infrasound station in the Graciosa Island, Azores, Portugal

Nicolau Wallenstein[1], João Luís Gaspar[1], Alfred Kramer[2], Juraci Carvalho[2], Paola Campus[3], Georgios Haralabus[2], João Gregório[4], Pierrick Mialle[2], Soares Flávio[1]
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After several years and attempts to establish an International Monitoring System (IMS) infrasound station in the Azores Islands, located in the middle of North-Atlantic Ocean, the cooperation between the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), the Azores Government, the Centre of Volcanology and Geological Risks Assessment (CVARG) and the Santa Cruz da Graciosa Municipality (CMSCG), led to the construction, installation and certification of the IS42 station (I42PT) during the year of 2010. The station was built moderately SE from the central part of the Graciosa Island, in a heavily forested area that grows over recent basaltic lava flows. The array comprises eight data acquisition elements (H1 to H8) and one central recording facility (CRF) where the data are collected before transmitted to Vienna. The geometry of the array is arranged in two groups, namely, a pentagon outer sub-array and a inner triangular sub-array. The distance between the outer elements is approximately 1 Km while the distance between the inner elements is around 200 m. Each array element has 230V independent power supply from the public grid and all the elements are linked to the CRF via optical fiber, in order to guarantee reliability, robustness and high performance. The Centre of Volcanology and Geological Risks Assessment (CVARG) of the University of Azores assures the operation and maintenance of the station and will progressively use the data to support its duties related with volcanic and seismic activity monitoring.

4. ADVANCES IN COMPUTING, PROCESSING AND VISUALIZATION FOR VERIFICATION APPLICATIONS

Conveners:

JEFFREY GIVEN
International Data Centre
CTBTO

DAVID BOWERS
AWE Blacknest
United Kingdom

STUART RUSSELL
Computer Science Division,
University of California
United States of America

Invited Speakers:

ROBERT JONES
European Organization for Nuclear Research
(CERN)
\Switzerland

ORAL PRESENTATIONS:

T4-O1. Distributed e-infrastructures for data intensive science

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The importance of research data for modern science is growing daily, and new initiatives are required to cope with the resulting "data deluge". The emergence of big and complex-data science is here to stay. It will open completely new ways to extract knowledge from the huge amounts of information that are becoming available across a range of research from astronomy to archaeology, and physics to epidemiology. Distributed grid/cloud computing infrastructures are serving more and more international collaborations in many scientific disciplines. Prominent examples including the processing and distribution of physics data from the experiments at the Large Hadron Collider at CERN, will be presented to highlight what is possible today and where commonalities can be exploited. Such distributed infrastructures are built on high-speed networks, high-capacity grid/cloud systems and specialised high-performance computing centres that are continuously evolving. By considering such usage models of e-infrastructures, recent technology developments and the intentions of major scientific collaborations, this talk will suggest some opportunities and challenges for how e-infrastructures can evolve in the future to address these challenges.

T4-O2. Improved signal detection at seismometer arrays

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We apply our recently developed "generalised F" signal detection algorithm to ten days of waveform data recorded at 22 International Monitoring System seismometer arrays. We generate a list of detections for each array, and identify those consistent with first P arrivals from events in the Reviewed Event Bulletin. We find that our method generates more candidate associations with REB events than the automatic detection lists produced by the International Data Centre (IDC), even though the IDC generates twice as many detections overall, suggesting that our method greatly reduces the number of false detections. We find that our approach is an improvement over current methods for detection first P at all epicentral distances. In addition the variability in performance from array to array is reduced relative to the current system. This enhanced performance has the potential to reduce the number of bogus events generated by the global association algorithm in automatic bulletins, and consequently reduce analyst workload.

T4-O3. Improving regional seismic travel times (RSTTs) for more accurate seismic location

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We develop a Regional Seismic Travel Time (RSTT) model and methods to account for the firstorder effect of the three-dimensional crust and upper mantle on travel times (Myers et al, 2010). The model parameterization is a global tessellation of nodes with a velocity profile at each node. Interpolation of the velocity profiles generates a 3-dimensional crust and laterally variable upper mantle velocity. The upper-mantle velocity profile at each node is represented as a linear velocity gradient, which enables travel time computation in approximately 1 millisecond. Fast computation allows the model to be used in routine analysis and in operational monitoring systems. Model velocities are optimized for travel-time prediction using a tomographic formulation that adjusts the mantle velocity at the Moho, the mantle velocity gradient, and the average crustal velocity. We have conducted tomography across Eurasia and North Africa using approximately 600,000 Pn arrivals and tomography across North America using approximately 70,000 Pn arrivals. Tomographic images of mantle velocity at the crust-mantle boundary are consistent with large-scale tectonic features, giving credence to the result. Non-circular validation tests find that Pn travel time residuals are reduced to a standard deviation of approximately 1.25 seconds. Further, location error is reduced to a median of ~9 km for well recorded events. In Eurasia 9 km epicenter error constitutes and improvement of 45% and 23% for North America. The RSTT model parameterization is inherently global, and extending RSTT tomography to new regions is ongoing.

T4-O4. Bayesian inference for the study of low-level radioactivity in the environment: Application to the detection of xenon isotopes of interest for the CTBTO

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This study illustrates the use of Bayesian inference, which is now a popular analysis method for low signal to noise ratios, in an original approach to detect radioactivity in the environment. For the verification regime of the CTBTO, the specific technology of noble gas detection searches for trace levels of xenon isotopes of interest in the environment, and is hence an area of choice for applying Bayesian inference. Unlike previous attempts to apply Bayesian statistics to radioactivity measurement results, that used either improper priors (e.g. a flat prior) or no prior at all, this study makes use of proper priors. We present realistic mathematical candidate functions that can be used to model the prior knowledge necessary to any Bayesian analysis. The priors are parameterized, and a cost optimization algorithm is used, taking into account past observations at each sensor location, in order to select the prior and to estimate its parameters, so that the marginal density distribution best fits the history of the data. The method enables us to model the a priori knowledge, including the true background estimate specific to a sensor location, and sheds new light on the analysis of incoming data. As an example, the probability for the sample radioactivity to be zero given an observed amplitude of the signal can be assessed, which was not the case with previous attempts to apply the Bayesian framework.

T4-O5. Improvements to seismic monitoring of the European Arctic using three-component array processing at SPITS

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The European Arctic, including the former test sites on Novaya Zemlya, is an important region in CTBT monitoring. Novaya Zemlya is characterized by very low natural seismicity with few events observed since the last confirmed test. Event detectability in the region is determined primarily by the small-aperture IMS arrays SPITS and ARCES. The SPITS upgrade in 2004 saw the replacement of short-period seismometers with broadband instruments, increasing the sampling rate from 40 Hz to 80 Hz, and installing three-component instruments at 6 of the 9 sites. Detection and correct classification of secondary phases is crucial for events observed by only a few stations at regional distances. A three-component subarray was deemed necessary to exploit the higher Sn phase amplitudes anticipated on the horizontal seismograms. We demonstrate improved SNR for Sn phases on horizontal beams for several events close to Novaya Zemlya. Horizontal component f-k analysis improves direction estimates and phase classification for low SNR signals. We demonstrate secondary phases which are misidentified by vertical-only f-k analysis but which are classified correctly by 3-C array processing. A significant problem with array processing at SPITS is the overlap in slowness space of P and S phases. Phase identification is improved greatly by comparing the coherence between vertical traces with the coherence between horizontal traces. We advocate augmenting all IMS seismic arrays with multiple 3-component sensors such that array-processing can always be performed on horizontal seismograms over at least a subset of sensors for improved detection and phase identification.

T4-O6. NET-VISA model and inference improvements

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We present our ongoing efforts to develop and enhance NET-VISA (Network Processing Vertically Integrated Seismological Analysis), a Bayesian monitoring system for detecting and localizing seismic events. NET-VISA consists of a probability model and an associated inference algorithm. The probability model, a "forward" or "generative" model based on geophysical knowledge and calibrated from empirical data, describes a prior distribution over seismic events as well as the processes of wave propagation and detection by IMS stations. Given actual observational data (detections and their parameters), the inference algorithm computes the most probable explanation (MPE) in the form of a set of events. At present, NET-VISA misses only half as many real events as the automated bulletin, SEL3, at the same false-event rate, and has half the false-event rate while finding the same number of events as SEL3. In addition, NET-VISA finds many events not detected by the human analysts, but which were confirmed by dense regional networks. We will present various model and inference improvements in NET-VISA resulting in even better performance; the primary improvements include allowing for multiple detections arising from a single arriving phase at a given station, and enhancing the detection probability model to depend on arriving amplitude and local (nonstationary) noise levels. Our inference

algorithm has evolved from a greedy heuristic search for the MPE to a more elaborate combination of MCMC and simulated annealing.

T4-O7. Real-time global seismic wave propagation and non-linear inversion for source and structure

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The last two decades have witnessed rapid progress in computational infrastructures (supercomputers, GPU, cloud computing) and sophisticated numerical techniques. This has enabled seismologists to tackle geophysical scales of interest by solving realistic 3D wave propagation and seismic inversion for Earth-model and excitation-source parameters. We present highly accurate spectral-element techniques for an efficient and rapid determination of these parameters within the framework of adjoint-based non-linear and linearized matrix optimization. Full waveforms are used while allowing for any desired complexity within the misfit function (traveltimes, amplitudes, waveforms, phase/envelope decomposition), source (source time function, radiation pattern, location, magnitude, finite kinematic rupture) and model parameters (wavespeeds, anisotropy, seismic discontinuities, attenuation). In particular, we focus on our own axisymmetric method which solves 3D global wave propagation in a 2D-computational domain for spherically symmetric background structure. This significant drop in computational cost allows for real-time global wave propagation and non-linear adjoint or probabilistic inversions for all of the above-mentioned source properties. It is computationally trivial to reach the highest desirable frequencies (e.g. Hz-range for global distances), which may help in discriminating nuclear explosions from earthquakes within a full-wave teleseismic inversion framework. Moreover, this method relies on a separate treatment of moment tensor elements and can therefore be an efficient tool in discriminating indigenous (i.e. traceless, shear-dominated radiation) from volumetric, explosive wavefield characteristics. We show several examples for wave propagation, source complexities, and sensitivity kernels upon realistic explosion settings to underline the flexibility and applicability of such approaches.

T4-O8. Anomalous infrasound propagation through the dynamic stratosphere

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Long range infrasound propagation strongly depends on the wind and temperature around the stratopause, i.e., at an altitude of 50 km. In this study, we examine how changes in the wind and temperature affect the infrasound propagation and, hence, its detectability.
The temperature increases in the stratosphere, due to ozone, up to values of -20°C (in winter) and 0°C (in summer) at mid-latitudes on the northern Hemisphere. The polar vortex wind is strongest around the stratopause and eastwards in winter, reaching values over 150 m/s. These winds reverse in summer to westwards with a lower strength. In general, the combined effect of wind and temperature leads to the refraction of infrasound. In a down-wind situation, infrasonic energy can be detected by the surface based microbarometer arrays.
However, there are phenomena that drastically change the state of the stratosphere and lead to anomalous infrasound propagation, strongly affecting its detectability. A Sudden Stratospheric Warming (SSW) is an example of such a phenomenon which is unpredictable regarding exact timing and strength although they yearly occur during the northern Hemisphere winter.
The infrasound propagation during a SSW is presented with temperatures rising up to 30°C. Furthermore, we assess how anomalous these conditions are by evaluating years of infrasound recordings combined with atmospheric specifications. It is concluded that the detection capability can both enhanced and reduced due to rapid changes in the stratosphere. Understanding the impact of these changes contributes to the success of infrasound as a verification technique for the CTBT.

T4-O9. On the potential of public available gridded precipitation re-analysis and monitoring products to access the wet-deposition impact on PTS radionuclide monitoring capability

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As part of the Global Precipitation Climatology Project of the World Climate Research Program (WCRP) and in support of the Global Climate Observing System (GCOS) of the World Meteorological Organization (WMO), the Deutscher Wetterdienst (DWD) operates the Global Precipitation Climatology Centre at its Offenbach,

Germany based headquarter (http://gpcc.dwd.de). The GPCC re-analysis and near-real time monitoring products are recognized as the most reliable global data set on rain-gauge based (in-situ) precipitation measurements. One of the most interesting GPCC products (Rudolf and Becker, 2010) is surely the so-called Monitoring Product that is realized roughly two months after the fact based on the data gathered while listening to the GTS to fetch the SYNOP and CLIMAT messages. This product is highly welcome to the satellite based remote sensing community to provide for a gridded data set of highly reliable in-situ precipitation measurements to supplement their products and to calibrate their in-direct precipitation measurements (Gruber and Levizzani, 2008, Chapter 2.2) yielding the Global Precipitation Climatology Project (GPCP) data set (Adler et al., 1995).
Both, the GPCC and the GPCP products bear the capability to serve as data base for the computational light-weight post processing of the wet deposition impact on the radionuclide monitoring capability of the CTBT network on the regional and global scale, respectively. This is of major importance any time, a reliable quantitative assessment of the source-receptor sensitivity is needed, e.g. for the analysis of isotopic ratios. Actually the wet deposition recognition is a prerequisite if ratios of particulate and noble gas measurements come into play. This is so far a quite unexplored field of investigation, but would alleviate the clearance of several apparently CTBT relevant detections, encountered in the past, as bogus.
The presentation will present some example application to illustrate the potential of the GPCC and GPCP products in CTBT context.

T4-O10. A statistical framework for operational infrasound monitoring

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Historically, much infrasound research has been event-based, with known events providing the ground-truth required to inform the search for associated signals. For monitoring nuclear explosions in the atmosphere or underground, reliable techniques are required for operational infrasound data processing that effectively minimize both false alarms and missed detections. A difficulty in working with infrasound data is to adequately account for dynamic variations in the atmosphere, which occur over a variety of temporal and spatial scales. However, contrary to ones intuition, it is not necessary to have a high fidelity atmospheric model in order to perform robust detection, association and location. We present detection, association and location algorithms that assume no a priori knowledge of the atmosphere; however, where knowledge is available we show how it can be used to reduce the associated uncertainties. Rather than exporting seismic techniques to the problem of infrasound monitoring, our techniques were developed 'from the ground-up' to properly account for the unique considerations of atmospheric acoustics. In contrast with other routinely used infrasound detectors, we utilize a contextual detection hypothesis that adaptively accounts for temporally variable correlated ambient noise. Our location scheme allows for the location of infrasound events without any meteorological data through a Bayesian framework. We demonstrate the application of the techniques presented here for a series of ground-truth events, and for routine data processing of large amounts of regional infrasound data.

T4-O11. Reliable Lg arrival time picks and potential for enhanced epicenter

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Lg waves are a prominent phase in seismic records at local and regional distances. They are dispersive and have complex waveforms. Wave propagation characteristics, such as phase and group velocity, are not easily related to crustal model features, as are P and S velocities. However, the slow Lg waves may provide important travel time observations for enhanced epicenter location, but this potential remains unrealized. The reasons are that Lg arrives in the coda of S wave and that original waveforms are complex. The latter was resolved by replacing original waveforms with envelopes using the STA transform. We studied the Lg arrival time problem by associating time picks at Lg amplitude maxima (Z component) in the record envelopes. Validations of Lg onsets are not easy due to the lack of Lg travel time curves. Instead Lg times were converted to group velocities and station-wise consistency of velocities for closely spaced earthquake sources was required. With rare exceptions these group velocities agree within +/- 0.05 sec/deg. We also tested the potential of our Lg arrival times for the epicenter locations using a grid search scheme. These Lg locations were almost identical to the ISC and NEIC solutions. Joint P-Lg locations are problematic because these phases do not have similar wave paths and that Lg travel times are not focal depth dependent. We conclude that our Lg arrival time picking scheme is robust and convenient for practical analysis. Use of Lg arrival times will enhance focal parameter estimation by seismological agencies.

T4-O12. Analysis of classification possibility infrasound signals from different sources based on correlation ability

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In this paper the possibility of classifying infrasound signals based on correlation ability is tested. The classification of atmospheric signals was based on natural infrasound signals that were recorded at Fairbanks, Alaska and Windless Bight, Antarctica from 1980 to 1983. This dataset contains infrasound signals from five different sources: "AIW" for auroral infrasonic waves, "MAW" for mountain associated waves, "VOL" for volcanic infrasound, "Microbarom" for microbaroms and "BombTest" for the 1980 Chinese nuclear test. The theory of testing statistical hypotheses is used for the classification procedure. The possibility of separating signals from these different classes is analyzed. It is shown that signals typically from volcanic and nuclear tests properly separate from signals typically from auroral infrasonic waves, mountain associated waves and microbaroms.

T4-O13. High resolution array processing for earthquake source studies at regional distance

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Back projection of wavefroms recorded by dense telesismic arrays is an emerging technique for earthquake source imaging that, unlike traditional approaches, needs minimal assumptions about the kinematics of the rupture process. Regional arrays can provide higher aperture to distance ratio than teleseismic arrays, and thus higher resolution. However, the complexity of Pn waveforms has prevented seismologists from exploiting this phase for source imaging. Here, we show that the relatively sustained Pn phase enables the application of a high resolution array processing technique, Mulitple Signal Classification (MUSIC), to constrain fault geometry, subevent locations and rupture speed in finite fault inversions. We demonstrate the concept by analyzing the source process of two recent earthquakes. Our analysis of the M7 2010 Haiti earthquake, recorded by the Venezuela National Seismic Network, reveals two major asperities roughly 35km apart. The western subevent is offshore and unconstrained by teleseismic, geodetic and geological data. We associate it to a fault in the Canal du Sud recently identified by marine geophysics and aftershock studies. Our analysis of the bilateral M7.2 2010 El Mayor-Cucapah earthquake, recorded by the SIEDCAR array in New Mexico, reveals a segment with reverse rupture propagation, north of the hypocenter, consistent with eyewitness reports of surface rupture towards the south in that location. This feature, possibly due to the late rupture of a shallow asperity, cannot be recognized by traditional source inversions that assume a connected rupture front, and exemplifies the complementary role that array back-projection techniques can play in earthquake source studies.

POSTER PRESENTATIONS:

T4-P1. Network performance of the CTBT monitoring regime

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The seismic, hydroacoustic, infrasonic and radionuclide networks that constitute the International Monitoring System of the Comprehensive Nuclear-Test-Ban Treaty are subject to technical and environmental influences to their performance. Time-variable map-based quantitative measures of network performance calculated relative to baselines will be shown for each network. Different baselines highlight different aspects of the network performance for various utilizations. A modelbased baseline might be used to examine performance relative to design; an empirical baseline of the operational network highlights possible operational and maintenance issues. For the seismic network, threshold monitoring maps based on the station data and propagation models (Kværna et al, 2002) provide an upper limit of the magnitude of non-detected events. The hydroacoustic network is effectively a coverage map generated from propagation paths. Infrasound network performance mapsare produced in near real-time with recent attenuation estimates, taking into account recent wind models (G2S-ECMWF) and noise estimated at each station (Le Pichon, ISS 2009). As the radionuclide particulate and noble gas networks are dependent on atmospheric transport for their coverage, coverage maps based on a transport model are calculated in conjunction with the minimum detectable concentrations of radionuclides of interest. The maps produced measure performance of the monitoring networks and are intended to include as much of the operational and environmental aspects as possible.

T4-P2. A system for automatic detection of seismic phases in high noise conditions

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Reliable automatic detection of seismic phases is an important problem in seismometry related to many aspects of the theory and practice of seismology. Most seismograph networks distributed over the globe lose much in location and classification accuracy when the noise exceeds a certain level, even though at a single station. The system now under development can contribute to a partial solution of that problem. The main functions of the system include the classification of seismic events and the identification of low amplitude phases upon the background of high seismic noise. Now the noise may be of any kind, whether of natural origin or manmade, ranging from stationary to impulsive. The system is designed to provide early warning of an earthquake that has occurred and is based on the single sensor principle. Since the system is to be installed at the end user, that is, in locations involving high levels of manmade noise, special attention is paid to signal detection just under these conditions. The system implements three detection processes in parallel. The first is based on investigation of the co-occurrence matrix related to the wavelet transform of the signal concerned. The second uses a method based on investigating change points of a random process and on signal detection in a moving time window. The third uses one all-purpose classifier, namely, artificial neural networks. Further, a decision rule is used to achieve the final detection and to assess its reliability. This work discusses the history of the problem, the principles of operation and a possible block diagram of the device, presents some results obtained for test examples, and considers whether the system can be used for reliable detection and for the classification of seismic events at stations of the seismograph network.

T4-P3. Comparison of regional seismic phases interpretation in REB and KazNDC bulletins

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Three seismic arrays (MKAR, KURK, BVAR) and one three-component seismic station (AKTO), installed in Kazakhstan are included into IMS network. These four stations are participating both in REB compilation, and in a compilation of KazNDC regional bulletin. In the work we analyzed the interpretation of the regional seismic arrivals, which were picked in both bulletins (Pn, Pg, Sn, Lg phases) by the following parameters: phase identification, difference in arrival time picks, difference in amplitudes. The following conclusions were made. The vast majority of phase names coincide in both bulletins. As a rule, Pn, Pg, Sn phases in REB bulletin are picked earlier, than in KazNDC bulletin (in average on 0.6 sec), whereas Lg phase in REB bulletin is picked later, than in KazNDC bulletin (in average on 0.88 sec). For some events the difference in arrival times of the same phases in REB and in KazNDC bulletins reaches 8 and more seconds. Several such events were analyzed in more details. We observed decrease of the difference in arrival times with the increase of amplitude of signals. No correlation between distance to the event and difference in arrival times was observed, with the only exception of Pg phase on KURK station. Measured amplitudes of seismic signals in KazNDC bulletin are systematically high, than that in the REB bulletin. It can be explained by the difference in filters that are used during amplitude measurement in IDC and in KazNDC.

T4-P4. Focal depth estimation through polarization analysis of the Pn coda

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A long standing problem in seismology is that of accurately assessing the focal depth of earthquakes. This parameter has become important in monitoring compliance with the CTBT since nearly all earthquakes have depths exceeding 5 km. Challenging here is focal depth estimates for events at local/regional distances and most research efforts focus on picking/matching the elusive pP and sP phases in preceding Pn coda. The task is not simple as we illustrate by generating synthetic seismograms for realistic inhomogeneous crustal models. Main outcomes were that i) Pn is weak and get contributions from both refracted and Moho underside reflections and ii) the Pn coda comprise several pP-like wavelets so which one is the 'presumed' pP ? To answer this problem properly we need to validate secondary phase pickings in terms of lag time and polarization properties. Presumably the pP, sP etc lag times are only focal depth dependent and that polarizations are of P wave type. From 3-compoent analysis we mapped polarization probabilities for Pn and 15 sec of coda and picked presumed pP, sP arrival times. We also stacked Pn waves from stations in narrow azimuth sectors but pP enhancement was modest. Taking the Pn beam trace as representative signal it did not correlated well with coda wavelets. Finally, we attempted successfully group statistics for matching multiple phase picks for individual stations in selecting

proper pP and sP lag times. In conclusion, straight forward polarization analysis should be mandatory in seismic record analysis of local and regional event records.

T4-P5. Evaluating OSI aftershock monitoring efficiency

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We present an approach to evaluating the efficiency of On-Site Inspection tools for microseismic aftershock monitoring based on comparing different processing techniques applied to different synthetic data sets, generated and processed within a single software package. The technique was developed using a combination of different global practices: CTBT monitoring in global security practice and hydrofracture monitoring in the oil/gas industry. The approach evolved from the demands of locating very small microseismic events under at least the following conditions: (1) the signal from near surface sources is characterized by very low signal-to-noise ratio (SNR) – the signal is completely obscured by noise even after multi band-pass filtering, (2) the noise content is considered as highly coherent, and (3) the source function is limited in time to fractions of second. This makes such events undetectable by conventional methods. Time consuming computational procedures can nevertheless be ported to personal computers using generic multi-core or graphics processing unit (GPU) parallelizing. Reasonable 3D location accuracy is achieved for double-couple synthetic sources buried at more than 3 km depth using a multilayered velocity model, and mixed with coherent and incoherent cultural noise generated by a hydrofracture site with construction work activity producing SNR $\geq$ 0.01. The approach includes the possibility of evaluating existing microseismic processing tools by introducing synthetic modeling of seismic signals of given source mechanism which are consistent with the post-explosion aftershock model. A given 3D location is used, with a given seismic velocity model (or velocity model perturbation), and recordings at arbitrarily spaced dense miltichannel seismic networks for actual microseismic background. The ability to detect low energy (ML < -2.5) seismic events can be confirmed utilizing different location algorithms.

T4-P6. Automatic clustering of seismic events in an on-site inspection scenario

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During an On-site Inspection (OSI) it is essential to get a fast overview of recorded seismic signal classes to evaluate the local seismicity, and in particular to investigate on suspicious events eventually representing aftershocks from an underground nuclear explosion (UNE). The seismic aftershock monitoring system (SAMS) of an OSI comprises up to fifty mini-arrays each having six traces of continuous waveform data. The sought-after events can have a magnitude as low as ML -2.0, and a duration of just a few seconds which makes it particularly hard to discover them in the large data set.
To overcome the first challenge of event detection we use a special form of spectrogram, the fourtraces Super-Sonograms to rise these signals from stationary background noise and to test on arraywide signal coherency. The Super-Sonograms proved to be indispensable in manual screening of IFE08 data and got implemented into SAMS.
The second challenge, initially grouping event classes without prior knowledge, i.e., the task of unsupervised classification is handled by Self-organizing Maps (SOM). Clustering is based on features from the Super-Sonograms using Principal Component Analysis (PCA) and a 2-D similarity function optimized for fuzzy comparison of Super-Sonograms. To provide an amplitude-invariant clustering we use normalization.
The SOM creates a map of representatives for each event type arranged by proximity of features, giving us a synoptic and topological overview of the acquired seismic data. In addition, we can analyze the dominant features of the SOM clustering and sonogram compilation of the arranged representatives with PCA.

T4-P7. Large earthquakes' secondary phenomena and their space-ground geodata assessment

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One of the specific consequences of major earthquakes is the landscape transformation caused by the release of accumulated stresses in the earth. Typically, the greatest change of the relief in the form of ground subsidence, loosening or liquefaction, landslides and rock falls are confined to the vicinity of the earthquake's epicenter. Characteristic concentric contour lines with characteristic changes in the landscape turn up around the epicenter of the tectonic earthquakes, asteroid strikes or volcanic eruptions. Since the energy released during the powerful

technical tests and scientific experiments is comparable with the energies of the strongest earthquakes, the existing methods of interpreting aerial or satellite imagery and stability analysis of geological objects, such as mountain slopes, can be used to estimate the energy, amplitude- frequency parameters, and foci of powerful stresses created in the earth's crust in such tests and experiments.
The results of the decoding can be expressed by a map or in the form of spatial databases with the emphasis on getting the most accurate site information about objects, fixed shape and position of the boundaries of the contour of polygonal objects, their area and perimeter.
Analysis of surface residual strain in addition to aerial and satellite imagery allows you to localize isoseism contours, determine the depth of the hypocenter, released energy quantity.
Thus, the modern methods of determining the parameters of strong earthquakes and incidence of large asteroids are worth to be taken into consideration for reconstructing the patterns of powerful technical tests and experiments.

T4-P8. Fuzzy ARTMAP: A neural network for fast stable incremental learning and seismic event discrimination

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The critical first step in the seismic event processing is to identify the class of an unknown detected event. An essential discrimination task is to allocate the incoming event to a group associated with the kind of physical phenomena producing it. This paper proposes a neural network architecture for automatic seismic discrimination between earthquakes and quarry blast. Such architecture, called Fuzzy ARTMAP, combines the salient properties of fuzzy set with adaptive resonance theory to make a powerful network. A map field is added to perform supervised learning. Fuzzy ARTMAP has certain advantages over many other network models and is more suited for classification problem. These characteristics make it an attractive neural network model for investigation into the problem of seismic event discrimination. To reduce the complexity of the neural network model and time computation, important features are derived from seismic signals using signal processing methods. Discrimination results show that Fuzzy ARTMAP deal to favorable levels of learned accuracy, speed and generation even when the amount of training data is limited. Furthermore, Fuzzy ARTMAP provides incremental, stable and on-line learning.

T4-P9. Application of detection probabilities in the IDC Global Phase Association Process

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The Global Association (GA) process at the IDC is an automated procedure that associates detections by stations in the International Monitoring System (IMS) in order to form event hypotheses. These hypotheses will later be reviewed by analysts before the Reviewed Event Bulletin is issued. We have begun investigating ways to improve the GA process for seismic data, in particular by incorporating amplitude data and station detection probabilities in the automatic process. We build on a previous study which has provided regional detection capability estimates for individual primary and auxiliary IMS stations, and use these estimates to develop and test various consistency measures. The purpose of these measures is to provide a means to assess the validity of automatically defined seismic events and the consistency of individual phases associated with such events. By feeding the results of such assessments back to the GA procedure, we anticipate that the results of the global association can be iteratively improved. An important contribution to these assessments will be provided by incorporating the results of the continuous IDC Threshold Monitoring process. The initial results of this study are promising, and this paper will present some case studies illustrating our approach.

T4-P10. Radioxenon analysis methods and atmospheric transport modelling to distinguish civilian from nuclear explosion signals

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The heterogeneous radioxenon background from civilian sources makes it necessary to distinguish between legitimate civilian sources and nuclear explosions. Different approaches have been followed so far, namely: (a) isotopic activity ratios can be used to separate a nuclear reactor domain from the parameter space that is specific for a nuclear explosion. This is especially relevant for sampling at an early stage after the release. After several days the difference becomes less visible; (b) anomalous concentrations with respect to the history of the

measurement site – some sampling stations may repeatedly detect radioxenon from legitimate sources, while others do not; (c) source-receptorsensitivities from atmospheric transport modeling can be used to check for correlations with known civilian sources; (d) filtering the feedback induced by local meteorological patterns.
While each approach improves the ability to determine the character of the samples origin, the combination of these four methods is naturally the next step for the optimization of the analysis process. This project foresees to develop algorithms to standardize and unite the four methods, including testing them under various realistic and "worst case" conditions. A cornerstone of the work will be the acquisition of measurement data for experimental verification. These will most likely come from the INGE (International Noble Gas Experiment) group. Also, the Lagrangian atmospheric transport model FLEXPART will play a crucial role in this. Furthermore, the possibilities of applying GRID computing in the field of ATM will be investigated, and the basic methods and first insights will be presented.

T4-P11. Listening to the SEL: is the ear easier to train than the eye?

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Each day, an automatic data processing system at the International Data Centre (IDC) of the Comprehensive Test Ban Treaty Organization (CTBTO) sifts through gigabytes of waveform data, flagging all potential events which could be related to a suspected nuclear explosion and reporting them in a series of Standard Event Lists (SEL). The events in the final list, SEL3, must be carefully examined by a team of highly trained professional analysts before being published in a Reviewed Event Bulletin (REB). In the process of putting together the REB, analysts discard roughly half of the SEL3 events and make many more corrections. Although analysts make use of information in the SEL, much of the time they resort to looking directly at waveform data. Through experience, they learn to recognize extremely subtle features and sophisticated patterns of arrivals at multiple stations from events across the globe. Since humans are more accustomed to processing waveform information through their ears than through their eyes, we wondered if it might be possible for a non-analyst to hear the difference between SEL3 events that made it to the REB and ones that did not. To this end, we pass “true” and “false” events through an off-the-shelf audio mixer, back-projecting waveforms from various stations as if the listener is standing at the event origin. The success of early trials of this project might motivate the use of audio compression and processing algorithms for seismic data.

T4-P12. Explanation of the nature of coherent low-frequency signal sources recorded by the monitoring station network of the NNC RK

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Automatic processing of continuous data from the I31KZ infrasound array near Aktyubinsk in Kazakhstan over a period of many years has demonstrated numerous sources of coherent signals. In addition to signals generated by recurring mining blasts and other repeating seismo-acoustic events, many long-duration signals are observed that are associated with continuous rather than discrete sources. Prominent signals from the south-west have been associated with oil and gas flares in the Zhanazhol fields at a distance of several hundred kilometers. The PMCC (Progressive Multi-Channel Correlation) procedure also repeatedly detects lower frequency signals (dominating frequencies no higher than 0.5 Hz) arriving from the north-west. These signals are characteristic of microbaroms and are associated with backazimuth measurements consistent with generating regions in the North Atlantic Ocean, at distances of many thousands of kilometer, that have previously been associated with the generation of both microseisms and microbaroms. Analysis of coherent low-frequency seismic noise at the Kazakh seismic arrays Akbulak, Borovoye, Karatau, and Makanchi reveals prevailing backazimuth measurements consistent with the same source regions. The southern-most arrays, Karatau and Makanchi, record in addition presumed microseisms from sources in the Indian Ocean. Additional analysis will now combine meteorological data with directional data for microseisms measured on the network of seismic arrays in western Europe to investigate in more detail the location of source regions of microseisms and microbaroms in the North Atlantic Ocean.

T4-P13. Assessing the improvement capabilities of a generative model 3C-station detector algorithm for the IMS

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The IMS seismic network produces an abundance of time-series data, posing great challenges for on-line processing and unbiased near real-time analysis. To this end, methods borrowed from the field of machine learning and data mining provide elegant solutions. By adhering to the multivariate statistical framework of Dynamic Bayesian Networks we make use of historical data obtained from the LEB bulletin to train a classifier to capture the intrinsic characteristics of signal and noise patterns appearing in seismic data streams. On a per station basis this yields generative statistical models that essentially summarize and generalize the information implicitly contained in the LEB allowing for classifying future and previously unseen seismic data. About 100 waveform snippets of short duration (4-12 secs) are extracted from 1 week of waveform data for training both the signal and noise classes. On a separate test-set we measure (binary) classification accuracy, sensitivity and specificity. Moreover, when testing against unseen data in time we can confirm seasonal dependency of noise characteristics, calling for an adaptive adjustment of the noise class over time which is implemented in a sequential learning fashion. A major obstacle is however the limited comparability between our purely automatic station-level detector and the combined automatic network associator with subsequent manual inspection approach at the IDC. The improvements over SEL3 and LEB bulletins is therefore difficult to quantify without further effort. To allow for a controlled evaluation we generate a semi-synthetic data set from cutting and pasting real waveform data in between station-specific noise samples.

T4-P14. Real time cross correlation estimated program and its application to processing seismic data

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The cross correlation technique is of great importance for signal processing in several domains. In this paper, we discuss a real time program to estimate cross correlation function, as well as its application to two problems in seismic signal processing. In the first case, it has been used as a metric to evaluate the degree of local stationarity of seismic noise. Results from this noise analysis display information about noise sources characteristics, which are very useful for seismic signal processing. Indeed, several different algorithm developed in seismology were based on local stationarity property of background noise. For example, local stationary noise can be effectively exploited to detect weak signals, to extract hidden signals as well as picking phase arrival. By using this method, it is relatively easy to determine seismically quiet site. In the second case, we are interested in the commonly problem in seismology which is detecting and picking P-arrival phase seismic. We explain how the developed method can be used for both P onset detection and picking in the stationary background noise. If the background noise is stationary, we can anticipate that the seismic noise stationarity will be broken when a first arrival of an event seismic arrives. Because of its ability to accentuate abrupt changes in the signal frequency, it can be effectively employed to detect weak signals in a stationary noise background. Examination of the method on seismic signal, recorded by vertical component seismometer of the Agadir's local network, demonstrates good results.

T4-P15. Advances in kernel-based classification of IMS hydroacoustic signals

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Within the CTBTO International Monitoring System (IMS), a network of underwater sensors continually records hydroacoustic pressure waves travelling the world's oceans. Raw sensor data is processed in real time at the CTBTO's International Data Centre in Vienna. After signal detection and feature extraction, reliable classification of events is required. For this task, automated pattern recognition systems are a valuable addition to human-expert categorization. We employ kernel-based machine learning algorithms, in particular support vector machine (SVM) classifiers. This contribution summarizes advances made in classifying IMS hydroacoustic data since the 2009 CTBTO International Scientific Studies Conference. The hydroacoustic signals recorded by the IMS network are represented by features extracted from a filter bank. In the corresponding preprocessing step, not every frequency band necessarily produces real-valued features. Thus, subsequent machine learning algorithms have to cope with inputs of variable dimensionality. We present a task-tailored SVM classifier that addresses this issue. In detail, we pass a representation of each input's missingness pattern, indicating whether a feature is present or not, to the SVM's kernel function, which at the same time

exploits the filter bank structure. To adapt the kernel and regularization parameters, we use advanced maximum-likelihood SVM model selection. The resulting classifiers outperform baseline SVMs and linear discriminant analysis. For a more demanding task of multiclass classification of hydroacoustic signals, however, the current training set size is considered too small for finding appropriate values for the larger number of SVM parameters.

T4-P16. Stockwell transform fingerprints of earthquake waveforms

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A reliable identification scheme of seismic events, as either explosions or earthquakes, is needed in order to have an effective Comprehensive Nuclear Test-Ban Treaty verification regime. Given the greater global distributions of stations and the use of broadband sensors, discriminants based on waveform modelling and analysis have become more important. Families of seismograms can now be collected, analyzed and used as a basis for regional seismic calibration. In this study, we propose to achieve two principal objectives. First, we will characterize individual seismic waveforms from a given regional family by the computation of spectrograms. Secondly, we will analyze the family of spectrograms to determine common spectrogram characteristics. The spectrograms will be computed using the Stockwell transform (S transform), which is a continuous wavelet transform implementation that preserves the absolute phase. A new version of the S transform, based on a dyadic factorization, with an operation count of the order of N log N for a time series of length N, can be employed to handle larger data sets. The resultant family of corresponding S transform amplitudes will be the input to a covariance-driven classification algorithm based on an eigenvector decomposition. A thresholded subset of eigenvectors will be used to define common features of the set of seismograms under consideration. The foregoing algorithm will be tested on a synthetically generated family of chirp waveforms and then the algorithm will be applied to a family of seismograms obtained from the Dead Sea region.

T4-P17. Travel time corrections via local regression

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Accurate event localization for CTBT verification depends on accurate estimation of the travel time between any two points on the Earth. The current system at the IDC uses the standard IASPEI model with station-specific corrections. For the purposes of a Bayesian monitoring system such as NET-VISA, a distribution over travel-time residuals is also needed; up to now, we have used a station-specific Laplacian distribution estimated from all events detected at each station.
Several efforts have been made to improve on the IASPEI model, including 3D velocity models and 2D kriging (Gaussian process regression) to model residuals as a function of event location. In this work we have identified a computationally simple approach based on local linear regression around the point in question, given previously observed residuals for nearby events. The variance of the predicted residual is estimated by a leave-one-out method from the sample variance of the residual predictions for these nearby events using the same method. We find that our new method improves significantly on NET-VISA's station-specific Laplacian model, and that the variance estimates are well-calibrated.

T4-P18. Challenges of infrasound analysis in IDC operations

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Infrasound is one of three waveform technologies which are part of the Comprehensive Nuclear Test Ban Treaty verification regime. Although the first atmospheric event was published in the Reviewed Event Bulletin (REB) in 2003, infrasound detections could not be used by the Global Association Software due to the unmanageable high number of spurious associations. In February 2010 infrasound was reintroduced to the International Data Centre (IDC) operations after six years of offline improvements of the automatic processing. Events with associated infrasound detections posed a new challenge to IDC analysts who previously were routinely analysing events driven by seismic associations.
There are many reasons which make validating infrasound events more complex: a small number of associated phases due to the rather sparse IMS network and the difficulty to automatically identify infrasound phases, the uncertainty of the source to detector distance, the rapid evolution of ambient noise level at the stations, the evolution of the meteorological conditions along the propagation path, etc.

This study will summarize the experience gained during one year of analysis of infrasound events in IDC Operations. It will emphasize on differences between infrasound and seismic events with regard to analyst tools and analysis approach. To illustrate the discussed points we will provide examples of pure atmospheric and seismo-acoustic events included in the REB since February 2010.

T4-P19. Signal-based Bayesian monitoring

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SIG-VISA (Signal-Based Vertically Integrated Seismological Analysis) is a new Bayesian approach to seismic monitoring. Whereas current methods (including our own NET-VISA system) are based on hard-threshold "detections", which suffer from pick error and are necessarily oblivious to events generating sub-threshold signals, SIG-VISA's generative probability model links hypothesized events to measured signal properties. The generative model combines nonparametric signal predictions based on previously measured, nearby events with parametric models of signal envelope shape derived from first principles. In our approach, "detections" by individual stations are replaced by a whole-network statistical measure of the likelihood that an event has occurred. Specialized techniques such "waveform matching" and "double differencing" are realized within our framework as special cases of probabilistic inference; fusion of multiple sensor modalities (seismic, infrasound, hydroacoustic) is achieved simply by augmenting the generative model to account for multiple signal types. At the meeting we expect to report on the a prototype implementation and initial performance results. We anticipate that the new approach will yield substantially lower detection thresholds, possibly approaching a theoretical lower bound that we hope to establish.

T4-P20. Threshold based algorithms for iron buried objects detection using magnetic field mapping

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Magnetic field mapping is one of the techniques that may be used during the continuation period of an on-site inspection. Iron buried objects induce anomalies in the earth's magnetic field that appear on the surface below items and that can be measured by a magnetometer. In this work, two approaches already used in radar detection are introduced and modified to improve the buried object detection. The measurement noises, the weak value of the earth's magnetic field and the variations du to the soil heterogeneity increase the false alarm probability. In order to reduce this last, we introduce a cell-averaging-based threshold algorithm used in radar detection. It consists of doing a comparison between each measure and a weighted average of all the previous measures. The proposed algorithm is validated using simulation data and promising results have been obtained.

T4-P21. Categorization of infrasound detections

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The IMS network of infrasound arrays has demonstrated its capability for detecting and locating infrasonic sources such as mining explosion, air force activity or atmospheric entry of meteoroids.
However, many other sources which are not of primary interest are also recorded by the network. It includes microbaroms, surf noise or volcanoes eruptions that are usually long duration and repetitive signals.
In order to identify and isolate the detections associated to transient signals, which are then used as inputs for network processing (association and location), PMCC bulletins are first "cleaned" with a categorization algorithm.
In this article, we propose a new statistical method to classify the detection background as "noise". We use a kd-tree in the azimuth / frequency domain where the splits are made according to the density separability of the clusters. Then, we perform an amplitude-outlier detection for each cluster before we classify them with respect to their density of number of detections and their duration.
We present the methodology and we compare the results of this new algorithm with those from a state-of-the-art method.

T4-P22. Metrics to determine the effectiveness of computer learning and data mining algorithms developed to aid automatic processing at the International Data Centre (IDC)

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Over the past three years, a series of workshops have been held and a number of projects initiated to apply state-of-the-art computer learning and data mining algorithms to the data-interpretation tasks undertaken at the IDC. Several of the projects are maturing to the point where they need to be tested against each other and against the current IDC processing. Whereas Earth scientists often judge their results by such means as the narrowing of error ellipses, reproducibility, reconciliation with other researchers, physicality, and performance on carefully calibrated ground truth data sets, the typical metrics for measuring the success of learning algorithms are rigorously defined quantities such as precision, recall and confusion matrices which quantify not just the accuracy of the algorithm, but the exact types of mistakes it makes. It is generally very important that validation be done using test data sets that do not include data used to train learning algorithms. The goal of this project is to find common ground, developing a performance environment and metrics which will satisfy the needs of both communities. Because events in the SEL3 may be considerably modified by analysts before they make it to REB, a metric also needs to be developed to decide which SEL3 events correspond to an REB event.

T4-P23. Case study of adding an F-trace algorithm to Geotool

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Geotool is a software system that allows a user to interactively display and process seismoacoustic data from International Monitoring System (IMS) stations. The software can be customized and extended, and supports a type of plug-in library interface that allows users to add functionality to the program. The term plug-in is frequently used to denote a module that is added to a web browser. The browser can function without the plug-in and the plug-in adds some new capabilities to the browser. In order to be able to add plug-ins to the geotool interface, it is necessary to have familiarity with geotool and some experience with the C++ programming language.
This case study shows how to extend an already existing code by adding a new Ftrace plug-in.
The F-trace is calculated for the azimuth and slowness that gives the maximum amplitude at the particular time, hence the beam parameters (azimuth and slowness) are different for every sample of the F-trace. The F-trace is used to determine the probability (using F-statistics) that a signal is present above bandlimited noise in waveforms captured at an array station, applying a time shift using the backazimuth, phase velocity and the array elements location (latitude and longitude) relative to the array centre. Some means of adjusting the parameters of the F-trace calculation are also added (window length, frequency bounds). F-trace and associated probability are implemented as a tool to help analysts at the International Data Centre (IDC) identify different body wave phases.

T4-P24. Analysis of the representativeness of backward atmospheric transport modelling at different resolutions at the Takasaki RN38 IMS station

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Within the Atmospheric Transport Modelling topic in the ISS09, it was recommended to visit ATMrelated aspects, and the determination of the representativeness of large-scale meteorological fields used as input for ATM at different stations and its impacts on the source-receptor sensitivity (SRS) fields were highlighted. Through a contribution of the State Signatory Spain to the CTBTO PTS, a project started last year to investigate the representativeness of the Takasaki RN38 radionuclide station. The station is located on the premises of the Takasaki Radiation Chemistry Research Establishment of the Japan Atomic Energy Research Institute. The city is located in the western part of the Kanto Plain. The Japanese Alps (which here are about 1000 m high) close this plain off in the Northwest, while opens to the Pacific Ocean in the South and East at about 150 km from Takasaki. This topographic situation is conducive to mesoscale meteorological phenomena that may not be resolved in meteorological fields with a resolution of 1 degree as presently used in PTS operations. For this matter, two different episodes, one with westerly advection and one with calm conditions that would allow thermally-induced mesoscale phenomena to develop, have been selected. For each of them, dispersion calculations have been performed using the MM5 meteorological model (with 0.67 km grid spacing in the innermost domain) and the Lagrangian particle dispersion model FLEXPART. The obtained SRS fields will then

be compared with the operational CTBTO runs based on ECMWF wind fields with a horizontal grid spacing of 1.0 deg.

T4-P25. Contribution to the study of seismic background noise application to the region of Agadir

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The study of seismic noise is of major importance in order to understand its features in both time and frequency representations. This study will help in the procedure of mitigating the seismic background noise from signals provided by an effective seismic event. Several methods are currently available for such study. The technique we have adopted in the frequency domain is the computing of the noise power density acceleration spectrum in dB referred to 1 (m/s2)2/Hz. we applied this method to determine the level of seismic background noise at the stations of Agadir's seismic network. We also tried to compare the obtained results with Peterson's noise curves. In the time domain, we have studied the effect of human activities and meteorological changes on large scale (wind, swell and atmospheric disturbances) in spectral amplitude of the three components signal noise records. The main purpose of this part of work is to study the variation of seismic background noise spectral amplitude over the time for different frequency values. Results from this study are useful for determining the frequency domain of each kind of seismic noise (natural and anthropogenic) and fixing the limit between them. In order to perform this work, the method was applied in one hand, to data acquired by a portable 3C seismic station at the laboratory for one week (from 22 to 29 January 2011) with a record of 10 min each hour, in the other hand, to seismic database of Agadir's network.

T4-P26. Performance of an atmospheric source location algorithm at CTBTO

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In order to test performance of the verification system, a realistic scenario is scrutinised by the National Data Centres (NDCs) in an annual Preparedness Exercise (NPE). Those exercises are conceived to challenge the performance of the CTBTO's monitoring system and the analysis tools by a largest possible spectrum of national experts.
Although each exercise has a different flavour, recent events have been based on a set of common assumptions: a scrutinised event is a real waveform event which is accompanied by a fictitious release of radionuclides. This presentation addresses the information which can be inferred from the fictitious detections of radionuclides concerning the location of a source.
The waveform event selected for the NPE2010 has not yet been disclosed. Consequently, an ultimate test of the source location algorithm is not available at this stage, but its performance will be illustrated and possible candidates for the suspected waveform events presented. Secondly, possible source locations resulting from the computations by the participating Regional Specialised Meteorological Centres (RSMC) of the World Meteorological Organisation (WMO) will also be shown and the discrepancies between RSMCs' and CTBTO's results will be discussed. Contrary to the previous NPEs, the fictitious release of radionuclides does not coincide in space and time with the waveform event but has some temporal extension. This adds considerably to the complexity of the analysis and unveils a need for a further development of the tools.

T4-P27. Investigating coupled wave interaction between the atmosphere and near-surface

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Standard methodologies for the analysis of seismic data typically view the Earth's surface as free surface and ignore the presence of the atmosphere. Similarly, analyses of infrasound data often view the surface of the Earth as a rigid boundary. Yet wave coupling between these two different media occurs frequently from both natural sources (such as lightning and earthquakes) and artificial sources (like sonic booms and explosions). These coupled waves are often observed exclusively by either seismic or infrasonic technologies but rarely both. In cases where both technologies observe a common event observations are typically not collocated. This can lead to misinterpretations regarding a coupled wave's origin and/or its characteristics which may provide added insight into properties of a source. Recent attempts to better understand acoustic-seismic or seismo-acoustic coupling, include several experiments and campaigns using collocated microbarometer/seismometer arrays and observing naturally occurring shock waves produced by meteors and artificially by spacecraft re-entries.

Observing simultaneously in both media at calibrated sites has provided insights into how these waves interact across the fluid-solid interface. Following on from prior observations, a series of experiments are being planned to observe and record the hypersonic shock waves of upcoming HiFIRE scramjet tests being performed in Southern Australia. Using multiple joint infrasound/seismic stations, coupling of these hypersonic shocks to the surface will be investigated along with potential automatic identification of similar signals to assist in future meteorite recovery in the region.

T4-P28. Modelling trace species transport and scavenging in deep convective cloud using a general circulation

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Deep convection has a significant impact on the vertical distribution of aerosols. Deep convective updrafts and downdrafts can quickly move aerosols along the vertical until they are scavenged by dry and wet deposition. Trace species are of importance to analyze large-scale transport, horizontal and vertical transport, as well as chemical interactions between aerosols and gaseous species and exchanges between stratosphere and troposphere. Moreover due to their opposite and well-known sources, 7Be and 210Pb are useful for testing and validating deep convection parameterization in a general atmospheric circulation model. With the courtesy of the Comprehensive Nuclear-Test-Ban Treaty Organization, daily data records of 7Be and 210Pb are available from its worldwide network: they provide a good framework for validating General Circulation Models (GCMs). In the present study, we present a new scavenging model for the Emanuel convection scheme implemented in the Laboratoire de Météorologie Dynamique GCM (LMDz). We first analyze the way this new scavenging scheme performs in a single column model: the role of unsaturated downdrafts is emphasized. In a second part, we present GCM simulations results and compare them to observations.

T4-P29. Removing periodic noise: Improved procedures

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We are developing a method for removing periodic noise from recordings to detect weak impulsive events. It could be used e.g. for seismic aftershock monitoring during CTBTO on-site inspections (OSI) where weak pulses may sometimes be masked by signals from aircraft or vehicle engines. We have continued our work (shown at ISS09) in three respects.
First the algorithm to get the parameters of one monochromatic signal contribution was improved by fitting the theoretical line shape to the complex spectrum, yielding frequency, amplitude and phase accurately. With these parameters one can subtract the periodic disturbances one by one, and then transform the data back to the time domain to make impulse events better visible.
Secondly, the procedure can now be applied automatically to longer time intervals. Consecutive spectra (with overlap) are computed; in each one the periodic content is reduced/removed, and then it is back transformed to the time domain to reconstruct a contiguous time signal.
Finally, during OSI tens of seismic mini-arrays can work for weeks, yielding vast amounts of data. In order to find the small time periods with periodic noise, we use an overview. The line content of spectra is measured by the standard deviation in several bands, and time sequences of these numbers are shown in a spectrogram-like style for several sensors simultaneously. Where the graphics resolution is insufficient, the maxima over longer time periods are used. The user can then zoom in on a period of interest, with increasing time resolution. Results with real measurement data are shown.

T4-P30. An alternative approach to waveform event definition criteria

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The criteria allowing a waveform event to be included in an event bulletin are uniquely important in comprehensive nuclear test ban monitoring because of the potential significance of small events. To maximise bulletin quality, such criteria should be based upon the level of confidence that the event is real, and upon the quality of its location estimate. By contrast, the 'event definition criteria' (EDC) for an automatic Standard Event List (SEL) or Reviewed Event Bulletin (REB) of the International Data Centre depend upon the number and type of recording stations, and upon the sum of weights assigned to different types of signal observed at different types of International Monitoring System (IMS) station. Historically, the EDC were introduced with a view to limiting the burden on automatic processing and interactive analysis. With the introduction of infrasound, and

the consequent increased focus on 'fused' events recorded on more than one of the IMS seismic, hydroacoustic and infrasound networks (in some cases with co-located stations), there has been a need to enhance the EDC; the resulting discussions have confirmed that EDC are seen as a means to minimise false events and preserve the best-located ones, whereas the current EDC have never sought to do either, and contain no scientific basis for doing so. Indeed, the majority of events in some SELs may be false, while there are many real, well-located events excluded from the REB. An alternative approach is presented in which the EDC are based solely upon the size and eccentricity of the location confidence ellipse. Although even this approach cannot address false events, it addresses location quality directly. It also simplifies the criteria, which can be applied to any waveform event recorded at any IMS waveform stations. The approach is presented, and a number of benefits are discussed, as well as some possible difficulties.

T4-P31. REB events recorded with all waveform technologies

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Since infrasound technology has been connected to IDC network processing (February 2010 – February 2011) 46 REB events have been recorded with seismic, infrasound and hydroacoustic phases associated. All but one of these events are along the Pacific Rim. 45 of the events have as hydroacoustic recordings T-phases and one event an H-phase. The hydroacoustic observations are dominated by Wake Island (H11) which contributes to 42 (91%) of the events. Looking at all Tphase generating events H11 contributes to 59.9% of these events. Ten of the events have been recorded on more than one hydroacoustic station. The infrasound observations are mostly from three stations: Palau (I39PW), Isumi (I30JP) and Petropavlovsk-Kamchatsky (I44RU) contributing to a total of 34 events. Three of the events have been recorded on more than one infrasound station. The event depths are from shallow down to 217 km and the magnitude (mb) ranges from 3.5 to 6.2. Many T-phase generating events, e.g. ocean ridge or other off-shore events, have very low probability of generating infrasound signals. The dominance of H11 for the 3-technology events appears to be caused by having T-phase generating events around the Pacific Rim also capable of causing shaking of land masses in the region of an active infrasound station and therefore higher probability of recording of infrasound signals.

T4-P32. A novel technique for phase classification and association based on integral and local features of seismograms

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The local characteristics of signals, which are widely used for automatic seismic data processing, can not describe the whole features of signals and the relations of different signals. This is one of the major reasons for hardly reducing the ratio of false alarm and error detection in automatic seismic data processing. Based on the thinking of analysts in interactive processing, a technique relying on the global characteristics of signals was presented for automatic processing in this paper.
Combining local and normalized global characteristics of signals, a two level combination of neural networks, which was applied to identify noises and signals, P-phases and S-phases, respectively was constructed. The first level, which includes two BPNNs (Back propagation Neural Network), one for noises and P-phases identification, one for noises and S-phases identification, were used together to detect noises. The results show that, while keeping the ratios for P- and S-phases identified as noises to a very low level, the ratios for noise identification are 80.5%. Then a BPNN for identifying Pphases and S-phases is trained for each seismic station to distinguish P-phases and S-phases, and the ratios of P-phases and S-phases identification are 96.8% and 90.9%, respectively. The distance flags of phases and classification of phase groups were introduced for phase associations. The signal envelops were also applied to test the phase compatibility. These techniques simplify the procedure for phase associations, and the results for single station were significantly improved, i.e. the accuracy is improved from 83.7% to 93.7% for events within 10 degree.
The results indicate that the technique using the local and global characteristics of signals together in automatic seismic data processing can improve the phase identification and simplify the phase associations.

T4-P33. Monitoring underground nuclear tests by multi-spectral satellite imagery: Sensitive bands and detecting method

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Detecting availably and locating accurately the underground nuclear explosion (UGE) event are key issues of the satellite verification for CTBT. In this paper, three Nevadan underground nuclear tests and their Landsat-TM remote sensing images were selected to study the choice of sensitive bands and the detecting method. First, a fine structure subsection without human activity was picked as the referenced background, which might be considered unchangeable during the underground nuclear test and could be used to match the different images fore-and-aft the test. Second, according to CMR's Nuclear Explosion Database (2000), select the interesting target subsection around the test ground zero. Then, calculate the subsection correlation coefficient fore-and-aft the test images, compared with that of the referenced background. Last, analyze their value differences and ratios, the following conclusions were obtained. (1) The abnormal spectral phenomenon of the UGE is more prominent in the visible-light band images; it is namely that shorter band is more sensitive to the UGE. (2) Subsection correlation coefficient of the visible-light band images can be used as a remote sensing parameter to detect the UGE. (3) Difference and ratio of the subsection correlation coefficient between the sequent visible images are especially effective in detecting and recognizing the covert tunnel UGE, which is usually more difficult to be discovered.
With certain universality and robust performance, this method is also easy to be programmed and automatically operated by machine, and can be used in monitoring large interesting area, giving alarms of suspicious UGE events. Of course, to obtain more exact result, other remote sensing data and more analyzing methods were needed synthetically.

T4-P34. The study of seismic event screening methods of IDC SEL3

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The methods for screening automatically-generated seismic events listed on the SEL3 event list of the International Data Centre (IDC) are introduced in this paper. The screening principles are based on analyzing the regional distribution rationality and the types of stations within the event as well as the parameter availability of signals related to the event. The Reviewed Event Bulletins (REBs) of the IDC are taken as the ground-truth reference. Using the methods, about 42% false events can be screened out, with only few true events miss-classified. Following the screening ideas, we have developed an independent screening software. It can be easily operated and used for different systems at the IDC or some other similar systems.

T4-P35. Introducing noble gas data into IDC operations

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During the past years IDC has started the project to bring data from Noble Gas stations into operations. In a first step automatic processing software and interactive review tools have been developed in the IDC development environment. In a second step the complete set of data processing and analysis software applications have been ported to the so called test environment. A comprehensive test program has been executed to investigate the reliability of the data analysis tools including verification of the data products which are generated through automatic processing and after interactive review. Additional tools have been added to support analysts during the routine data analysis. The tests were performed by comparing the results obtained in the development and the test environment. Additional software was developed and already existing external tools have been used to analyze the samples independently from the IDC software, providing a reference system with independent methods and algorithms. Analysts at IDC have been involved in the validation process and today samples from different Noble Gas stations are processed on a daily basis. The final goal of this project is to move the Noble Gas analysis software from the test environment into the operational system. This presentation focuses on the definition of the test cases, the methods applied and the results obtained.

T4-P36. Methods for monitoring analyst performance

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The specialist skills of waveform analysts are crucial in the preparation of an accurate and reliable bulletin of seismic, hydroacoustic and infrasound events using data from a global sensor network such as the International Monitoring System. Analysts must review and augment automatically generated events lists, many of whose events may be invalid or contain incorrectly associated, wrongly-named or badly-timed signals. Yet the task of measuring the value added by analysts – and hence the quality of the resulting reviewed bulletins – is a difficult one. A basis for the quantitative measurement of performance is presented and tailored to the needs of analyst performance specifically. Crucial elements are the recording of all pertinent analyst actions, the use of a large historical record to establish a baseline against which analyst performance anomalies can be identified, and a close focus on the corrections which senior analysts make to the 'first-pass' analysis performed by those less-experienced. Moreover, performance of analysts must be measured not against actual event hypocentres (even if these were known) but against the best bulletin achievable with the data available, to include valid measures of confidence for all relevant parameters. In the case of the Reviewed Event Bulletin, the measuring of performance is especially challenging in view of the emphasis on small events close to the network event detection threshold, for which a degree of subjectivity, and hence inconsistency between analysts, inevitably enters into the process. The integration of quality into performance measures remains a serious challenge, while remaining the key identifier of a high quality reviewed product. Although no substitute for the expert review of individual actions has yet been devised for this, some ideas towards the automatic measurement of analysis quality are offered.

T4-P37. A regional investigation into the event location threshold using stations of the IMS

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The International Data Centre (IDC) is mandated by the Treaty to produce "standard event lists and bulletins, including the values and associated uncertainties calculated for each event located by the International Data Centre, based on a set of standard parameters". The rules governing what defines an event are set out in the Event Definition Criteria (CTBT/PTS/INF.984). These criteria attempt to strike a balance between the accuracy of the located events and the workload imposed on processing and analysis. In line with the event definition criteria used for IDC bulletins, conventional methods of estimating the event location threshold of the International Monitoring System (IMS) seismic network require signals at three primary seismic stations. We consider the extent to which this may under-estimate the true network capability from the perspective of National Data Centres, which are free to exploit IMS data without any such a restriction. The investigation takes the form of a case study looking at the location threshold in one region using a combination of seismic and infrasound data. The results of the investigation are compared to the outputs of the tools used at the IDC to either model or monitor the detection threshold.

T4-P38. Mitigation of IDC waveform analysts' increasing workload

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There is a general perception that the interactive analysis of seismic, hydroacoustic and infrasound data to produce the International Data Centre (IDC) Reviewed Event Bulletin (REB) is a process designed to compensate for the inadequacies of automatically generated events lists, so that as the quality of automatic processing improves, the analyst burden will decline towards an eventual goal in which the final event bulletin could be produced automatically. It is shown that under the current framework the opposite is true: the analyst burden is set to increase without limit, and this is clearly untenable from a resource perspective. We consider how this paradox can be circumvented. The approach is to ventilate the fundamental question of the purpose of the final bulletin, and thus the purpose of automatic processing and interactive analysis. The fallibility of current automatic processing (and hence the burden on analysts) increases towards lower event magnitude, as does the number of events, since these are dominated by earthquakes whose occurrence follows the Gutenberg-Richter relation. So if the same pattern of fallibility persists as more smaller events are built by incrementally improved versions of automatic processing, it follows that the analyst burden must also increase according to such increments. Whereas the current draft IDC Operational Manual (CTBT/WGB/TL-11,17/19/Rev.4 Section 4.3.2.3 first sentence) effectively requires the REB to be as comprehensive as possible (following the notion of a comprehensive Treaty), the Treaty itself (Protocol Part I paragraph 18) imposes no such requirement on IDC

standard products. This opens the possibility to restrict the events in the final bulletin, or to restrict the review of some such events, according to objective criteria. Moreover, automatic processing could be designed to lessen the increasing analyst burden towards lower magnitude, for example by imposing formal criteria to define a valid arrival (as is already done for peak definition in the IDC processing of radionuclide gamma-ray spectra), or by introducing a probabilistic measure for the validity of an arrival's association to one or more events. Possibilities are explored, together with their attractions and difficulties. It is argued that such considerations need to be visited upon the policy documents governing IDC standard products, and factored into the re-engineering of the ISC applications software which has begun.

T4-P39. Testing and integration of infrasound threshold monitoring software in the CTBTO operational environment

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The ISS-2009 conference in Vienna highlighted the progress made during the last decade by the scientific community to build a global and uniform network of stations, detect and characterize infrasound signals and simulate the propagation of infrasound waves in the atmosphere. One of the major steps forward is the new capability for modeling the dynamic nature of the atmosphere and integrating it in near-real time infrasound data processing. First results of a threshold monitoring tool specific to infrasound technology were presented during ISS-2009. This tool developed at CEA/DASE in cooperation with BGR computes global maps that provide the minimum detectable energy by the IMS network. Since ISS-2009, the detection capability of the IMS network has been assessed using near-real time atmospheric updates and station-dependent real background noise levels. Compared with previous studies, a significant enhancement is the incorporation of station noise characterization. Accurate estimates of the noise levels are obtained by calculating Power Spectral Density (PSD) curves for each station at various times of day for each month. This information is useful in determining more accurately and reliably the IMS infrasound network detection capability. The updated version of the Threshold Monitoring tool is now at the disposal of the Provisional Technical Secretariat (PTS) of the CTBTO. Work is underway at the International Data Center, in the Virtual Data Exploitation Centre (vDEC), to test the tool and adapt it to the PTS operational environment. Comprehensive ground-truth databases provide a statistical approach for evaluating the potential of infrasound monitoring. Accidental and calibration explosions are analysed and used here as benchmark for validating the calculated threshold maps. Such studies help to optimize the siting and maintenance of infrasound arrays with respect to both the number and configuration in order to monitor infrasonic sources of interest. They are an important step to enable a successful monitoring regime for atmospheric or surface events to act as an effective verification tool in any future enforcement of the CTBT.

T4-P40. Validation process of the detector response for noble gas systems

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Within the framework of the preparation phase of the first certifications of Noble Gas Systems, PTS has undertaken in 2010 a validation process of efficiency calibrations of both detector system technologies used in the current IMS Noble Gas monitoring network.
This work describes the whole validation procedures for detection efficiency calibration as well as radon and xenon interference corrections for beta-gamma coincidence detectors used by SAUNA systems.
Further, the validation procedures for detection efficiency calibration of the HPGe detectors used by SPALAX systems are presented. The latter also includes the use of simulations carried out with VGSL (Virtual Gammas Spectrometry Laboratory) which is a software developed by the PTS.
The consistency of the outcomes was also evaluated by comparing PTS results from the validation process with independent re-measurements by IMS radionuclide laboratories of the radioxenon spike samples used in the field measurements.
The methods used and results obtained in the Noble Gas calibration validation processes are discussed here together with recommendations on required research and development to achieve a practical, scientifically sound and robust calibration of the IMS Noble Gas monitoring network.
Disclaimer: "Herein is expressed the views of the authors and do not necessarily reflect the views of the CTBTO Preparatory Commission. The Commission itself takes no responsibility for the content of this abstract."

T4-P41. Xe release calculation from BNPP

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Accurate evaluation of the inventory of nuclear reactors at various states is essential for understanding their contribution to the natural background. The Monte Carlo method is currently capable of performing such simulations based on detailed neutron transport calculations. Although some hybrid methods based on coupling a Monte Carlo code (e.g. MCNP) with a burn-up code (e.g.Origen) have been developed, but they largely are limited in logic and underlying assumptions. Here we have studied inventory of a typical VVER-1000 during the start-up phase using the well-known MCNPX code. We additionally have assumed that the core is clean, and cold at the starting point of process.

T4-P42. Towards an automatic waveform correlation detector system

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For nuclear explosion seismic monitoring, major earthquake aftershock sequences can be a significant problem because each event must be processed correctly to insure that no nuclear tests are missed. Fortunately, the high degree of waveform similarity expected within aftershock sequences offers a way to more quickly and robustly process these events than is possible using traditional methods (e.g. STA/LTA detection). We explore how waveform correlation can be incorporated into an automated event detection system to improve both the timeliness and the quality of the resultant bulletin. Our Waveform Correlation Detector (WCD) compares incoming waveform data to a library of known events. Incoming waveform data that correlates above a specified threshold with a library event is marked as a repeating event. We previously demonstrated that between 30% and 90% of the events in typical aftershock sequences can be recognized as repeating events. In this poster, we explore how to adaptively and in real time determine appropriate parameters such as window length, filter bands, and correlation thresholds. These parameters are crucial to obtaining maximum benefit from the WCD in an operation system. Our system is designed to begin running immediately after a large mainshock, and adaptively determine parameters appropriate to the swarm as it runs. We present results from the adaptive WCD and demonstrate the effect of optimized parameter selection on the effectiveness of waveform correlation.

5. CREATING KNOWLEDGE THROUGH PARTNERSHIPS, TRAINING AND INFORMATION/COMMUNICATION TECHNOLOGY

Conveners:

JERRY CARTER
International Data Centre
CTBTO

JOHN COYNE
International Data Centre
CTBTO

DMITRY STORCHAK
International Seismological Centre (ISC),
United Kingdom

Invited Speakers:

JOSÉ ACHACHE
Group on Earth Observations (GEO)
Switzerland

RICHARD G. BARANIUK
Rice University
United States of America

CHRISTINE WING
Center on International Cooperation
University of New York
United States of America

ORAL PRESENTATIONS:

T5-O1. The global earth observation system of systems

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Recognizing the growing need for improved Earth observations, 140 governments and leading international organizations have established the Group on Earth Observations, or GEO, to collaborate and implement a Global Earth Observation System of Systems (GEOSS) by the year 2015. Countries and organizations are contributing their respective Earth monitoring systems, from satellites in space and in situ instruments on land, in the oceans and in the atmosphere. They are interlinking these systems so that, together, they provide a more complete picture of Earth's systems dynamics.
GEO is developing common technical standards to pool observations and ensure their cross calibration and validation. It is building a web-based infrastructure to ensure easy access to the wealth of data and services contributed to, or generated by, GEOSS. GEO has been promoting the free and open sharing and dissemination of Earth observation data which has already driven significant changes in data distribution policies of several key Earth observing satellites: Landsat, CBERS and the future Sentinels of GMES. GEO is also reflecting on solutions to transition research systems into operational observing systems and ensure their long-term sustainability.
GEO is also coordinating the development of information systems and services such as:
- the Supersites initiative, which ensures coordinated access to critical data and information on natural hazards in geologically active regions. In light of the recent tragedies in Haiti, Chile and more recently Japan, this project created a dedicated web portal where scientists could share in real time their maps of seismicity, tectonics, real and synthetic interferograms, GPS-derived displacement fields and Coulomb stress changes, as well as damage maps, ancillary data, and space images.
See http://supersites.earthobservations.org/
- the Forest Carbon Tracking (FCT) project coordinates the acquisition of observations from multi-spectral and radar (X, C and L-band) satellites, their processing through different models and methodologies and their validation by in situ measurements in 10 selected countries (National Demonstrators). The aim is to establish an operational capacity to support governments with their national reporting activities: the Global Forest Observation Initiative. The GFOI will provide a global monitoring and verification capacity for carbon storage and change in forests. Data and results can be viewed on-line at www.geo-fct.org.

T5-O2. Networks of knowledge

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The last 15 years have seen major shifts in the nature of knowledge production and circulation. The Internet has enabled new modes of authorship, new forms of open licensing and distribution, and new forms of collaboration and peer production to flourish. New online education projects, scientific journals, and reference works have rapidly gained critical mass. But in turn, new anxieties have arisen concerning the long-term sustainability and quality assurance of these enterprises. In this talk, we will review the past, present, and several potential futures of Internet-enabled scholarly publication with a particular emphasis on the global open-access movement in education.

T5-O3. Transnational cooperation: What and why?

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Transnational cooperation to advance and create knowledge can take several forms. One of these is the collaboration among scientists, and other analysts, to develop novel approaches to difficult international policy problems. These approaches are based in science, but their effectiveness derives also from the way in which different scientific communities are able to interact across borders. Several examples will be discussed, with attention to their broader implications for efforts to address other complex international issues.

T5-O4. Capacity building in the context of the Comprehensive Nuclear-Test-Ban Treaty

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The Provisional Technical Secretariat (PTS) was established to prepare the monitoring regime which will be used to monitor compliance with the CTBT, which prohibits nuclear explosions in all environments. The monitoring regime consists of three main components: the International Monitoring System (IMS), the International Data Centre (IDC), and On-Site Inspection (OSI). The IMS consists of a global network of 321 monitoring facilities, which includes seismic, hydroacoustic, infrasound, and radionuclide stations. These stations are designated in the Treaty, are built by the PTS, and are owned and operated by the hosting country. One aspect of capacity building involves training station operators to operate and maintain their IMS stations.
Data from the IMS stations are sent to the IDC, where the data are processed and analyzed. The results of this work, as well as the raw data from the IMS stations, are made available to States Signatories. Work done in these countries is most commonly performed at a National Data Centre (NDC), which is designated by the country for this purpose. The Treaty specifies that it is up to the member States to decide if a treaty relevant event has taken place, and to call for follow up actions, e.g., an On-Site Inspection. The data and products made available by the IDC are used by member states to assess compliance with the Treaty. Another aspect of capacity building involves training staff in member states on acquiring, analyzing, and synthesizing data and products in fulfilling their Treaty obligations. These data may also be used for civil and scientific application such as Tsunami warning.
Capacity Building efforts include a wide range of training and workshop opportunities. Training courses include station operator training, which includes hands on training for the specific type of equipment installed at a station, as well as training on the reporting tools which are used to report station problems. Capacity building opportunities for NDCs include brief introductory course, as well as a longer, two week course, which focuses on accessing and analyzing data and products obtained from the IDC.
Recently a capacity building initiative has started which focuses on providing training, expert services, and equipment in developing countries. Initially the needs of a country are assessed, to see how the project can be tailored to the existing needs and infrastructure. After the equipment is installed, on-site training is provided on how to use data and products in a national context.

T5-O5. Educational outreach as a capacity development strategy, using the Irish example, seismology in schools, Dublin Institute for Advanced Studies (DIAS) Outreach Programme

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In an attempt to attract students to study Earth science and seismology the School of Cosmic Physics, DIAS embarked on an outreach programme in 2007 to promote Earth science, particularly seismology, in schools, upto pre university level. As well as forming the basis for studies in earthquake behaviour, the project addresses 'forensic seismology' such as the Kurst submarine explosion, and the use of seismology as one of the four named verification techniques of the CTBTO. The Seismology in Schools programme seismometers are installed in over fifty schools across the State. Given that the population of Ireland is 4M this number of 1 per 80,000 compares favourably with the U.K. (70 in a population of 70M, 1 per 1M) and the U.S.A. (200 in a population of 300M, 1 per 1.5M) with an penetration of 15-20 times greater. The phenomenal success of our Seismology in Schools programme has been helped significantly by the support from the British Geological Survey (BGS) and IRIS (Incorporated Research Institutions for Seismology) in terms of hardware, software and advice. Similarly, the Directors of the Educational Centres (ATECI, Association of Teacher's/Education Centres in Ireland) funded the purchase of 34 additional seismometers. The seismometer is not used in the schools as a professional recording instrument but helps students visualize what seismology and the recording of earthquakes comprises. Strong emphasis was essential on providing teacher training days on the set-up and operation of the seismometer, and associated software. Regular contact is maintained with the teachers throughout the academic year.

T5-O6. CTBTO contribution to the global earthquake data collection: a view from the International Seismological Centre (ISC)

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The International Seismological Centre (ISC) is a non-governmental non-profit organization supported by 57 research and operational institutions and charged with production of the ISC Bulletin – the definitive global summary of seismicity based on reports from 120 networks worldwide. The Reviewed Event Bulletin (REB), produced by the International Data Centre (IDC) based on the data of the International Monitoring System (IMS)

is an important integral part of the ISC Bulletin. It is a set of consistently produced waveform measurements and seismic event solutions that make large positive effect on completeness of the ISC Bulletin especially in oceanic areas. In return, the ISC Bulletin, based on an unrestricted network of 5,000 seismographs, serves as an important benchmark for monitoring detection capabilities of the IMS network. The ISC also provides a set of alternative man-made picks at academic sites co-located with IMS. The IASPEI Reference Event List (GT), maintained by the ISC can be used for testing improvements in event location algorithms used at the IDC. The UK Foreign and Commonwealth Office along with partners from Nordic countries funded the original project to make the ISC database of seismic events securely linked with computer facilities of Preparatory Technical Secretariat and National Data Centers. The ISC Bulletin data have been made available through dedicated software designed to offer the ISC data in a way convenient to monitoring community. IDC CTBTO has now taken over the funding of this project with further capabilities of the system being planned and developed at the ISC.

T5-O7. The IMS network and the International Federation of Digital Seismograph Networks FDSN - a long and winding road

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The International Federation of Digital Seismograph Networks (FDSN) was created to foster collaboration among operators of broadband seismograph stations around the world. Its main goals are the standardization of data formats and data exchange protocols, improvement of data quality, establishing standards for instrumentation, coordinating station siting, and encouraging free and open access to data in real-time. The FDSN membership represents the main seismic operators of the scientific community worldwide. CTBTO is an active member of the FDSN. More than half of the IMS auxiliary seismic (AS) network is owned, operated and maintained by FDSN members. This bridge between the nuclear monitoring and the seismological communities has resulted in better data quality, a strong capacity building effort, and improvements in data transmission. The high quality and data availability requirements for IMS stations continue to be a challenge to most local operators. In this respect, the synergy between CTBT and FDSN has resulted in tangible benefits to both parties. FDSN provides access to a vast pool of experience in operating high-quality seismic stations, in direct benefit to the IMS station operators. CTBT, in turn, has supported the efforts to improve the technical capacity of station operators and to modernize equipment and facilities. FDSN promotes exchange and cooperation among its members on CTBT-related issues. Besides continuing the current path of productive collaboration, FDSN seeks to extend this cooperation to the open exchange of data. This would provide peer-review quality control and motivation for the community to support operators in providing highest quality data, supporting both parties in fulfilling their missions.

T5-O8. Contributions of the scientific community to CTBT monitoring and verification

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The scientific community has always played an important role for nuclear test monitoring. The opportunities and capabilities for scientists to make significant contributions have constantly evolved. They are making improvements to the methods and technologies for global monitoring, enhance the understanding and support for the CTBT in the public and diplomatic communities and they are able to derive independent data analysis and interpretation for suspicious events.
Based on systematic considerations the contributions of the scientific community are analyzed with regard to the different stages of verification and to the various degrees of integration with the official procedures. This paper picks up the three stages of verification (fact-finding, review, assessment) described by Den Dekker (2001), extends them by a fourth stage (determination of a rule violation according to the treaty text and related regulations). These four stages are framed by a preparatory stage (development of verification methods and procedures) and a post-processing stage (political judgment on treaty compliance). The degree of integration of scientific activities with the official procedures (indirect or informal interaction, official contribution) are adopted from Meier/Tenner (2001) and extended by the case where a norm but no treaty is in force.
From both parameters a matrix is formed with the stages in the lines and the degree of interaction in the columns. The fields in the matrix are used to locate a number of historic cases where scientists contributed to the monitoring and verification of the CTBT.

T5-O9. Infrasound calibration in the Eastern Mediterranean

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The CTBTO has a continuing interest in collaboration on experiments in its monitoring technologies to test, calibrate, and validate its sensors and processing systems. An important class of experiments measures the signals from events generated under controlled, or otherwise well-characterized, environments. The resulting ground-truth datasets provide important information on the usability of the IMS data to detect, locate, and quantify events.

Experiments related to infrasound monitoring are of particular interest, because routine global infrasound analysis is still in its infancy at the CTBTO, and a ground-truth data set is actively being assembled. Equally valuable to the nature of the infrasound sources is the propagation medium which demonstrates significant spatial and temporal variations. Therefore, conducting atmospheric events of known energy release under known conditions provide valuable data on how well the variables can be controlled in the data processing.

Two controlled atmospheric events of known energy release were conducted in the Eastern Mediterranean in January 2011. The first event was carried out on 24 January 2011, with an energy release of 8 tons of TNT equivalent. The second event was carried out on 26 January 2011, with an energy release of 80 tons of TNT equivalent.

In order to better record the infrasound signals at local and regional distances, a large scale deployment was carried out, which deployed over twenty temporary infrasound arrays in over fifteen countries. This collaborative undertaking included over fifty participants from over twenty countries. The equipment used for this temporary deployment included contributions from a number of different countries, as well as from the CTBTO.

This large scale collaborative effort also provided an opportunity to build knowledge and understanding of infrasound technology, through firsthand experience in site selection, deployment, field operation, data acquisition, and station processing. Data from this campaign are being analyzed, and will provide insight into atmospheric propagation and network processing.

T5-O10. Ghana's experience in the establishment of a National Data Centre

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The Government of Ghana in a bilateral agreement with the Preparatory Commission for the Comprehensive Nuclear Test - Ban Treaty Organisation have established a National Data Centre in Ghana with the aim of monitoring the testing of nuclear explosions. Seismic, hydroacoustic, radionuclide and infrasound methods are used for the monitoring. The Data Centre was commissioned on 3 February, 2010 at the Ghana Atomic Energy Commission. At present Ghana does not have any operational, centralised data (seismic, hydroacoustic, radionuclide and infrasound) acquisition system with the capability of accessing data from other international stations. Hence, the importance of setting up the National Data Centre which would enable us constantly monitor, manage and coordinate both natural and man-made seismic activities in the country and around the globe, upload data to the International Data Centre (IDC) as well as receive and use International Monitoring System(IMS) data and IDC products for treaty verification and compliance. Apart from these, the Centre also accesses and analyzes seismic waveforms relevant to its needs from the International Data Centre; makes data available to its stakeholder Institutions for earthquake disaster mitigation; reports on all aspects of disasters related to seismic to the relevant government agencies that deal with disasters; makes recommendations to the government of Ghana on earthquake safety measures; provides information to assist government Institutions develop appropriate land and building policies. The Centre in collaboration with stakeholder agencies periodically organises public lectures on earthquake disaster risk mitigation.

T5-O11. Creating knowledge and building capacity in Uganda

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In Uganda, a developing country, the knowledge of CTBTO activities goes relatively unnoticed. The CTBTO would gain greatly from engaging the young scientific community and developing this capacity by using knowledge networks that focus on region specific needs. This can be done by developing programs or projects that are geared towards the local science colleges for example calls for proposals from students at higher institutions of learning, this would bring about a situation where local research capacity is nurtured to deal with the problems arising in our particular situations such as landslides, earthquakes. Creation of networks necessitates Member States that have National Data Centers located in Africa to open up and allow for internship

opportunities on the continent for example in South Africa and Tanzania. This would create a deeper understanding of CTBTO activities; build local expertise and platforms for regional cooperation. This model for networking would further cascade the trainings to allow inter regional trainings for example in East Africa to identify expertise that can be engaged to create awareness of CTBTO activities. This proposal seeks to address the need for creation of networks which would take advantage building the local expertise/ capacity in the activities of CTBTO and the technologies used to solve pertinent problems affecting Member States. Furthermore, there is need create awareness of CTBTO at a pre-service institutions (local Universities, relevant tertiary institutions/ICT schools) to stimulate local research capacity and enhance participation in the CTBTO

T5-O12. A CTBT implementation process in Panama to forge broader partnerships

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In regard to CTBT implementation, many factors can cause problems: from the absence of related laws, regulations, policies and programs that should be in place to facilitate CTBT implementation to outmoded bureaucratic practices that hinder the effective operation of the monitoring facilities. The leadership of the Station RN50 of the IMS in Panama wants to make sure that CTBT has a first-rate implementation to ensure the continuing operation of that Station in the years to come. To attain that result, the CTBT implementation must be a participatory, deliberative process inclusive of a variety of stakeholders to generate greater understanding of CTBT norms and contribute to an effective internalization of those norms. This proposal seeks to reflect on the following aspects of the CTBT implementation process as a way of forging broader partnerships for the CTBT goals:

Who are the main stakeholders –from civil society, government, private sector, and academy- that should be involved in the CTBT implementation process to contribute to a sense of ownership of the CTBT mission and goals? Further, what are the elements of an advocacy plan for adopting legislation to implement CTBT that are participatory and inclusive?

Is it desirable to develop and integrate human rights standards and practices into an effective CTBT implementation process? Should the linkage between human rights (e.g. right to life, right to a safe and healthy environment) and the ban on nuclear testing be brought into the foreground as a way of strengthening the CTBT implementation?

A CTBT implementation merely "on the books" would be not only insufficient, but rather dangerous: it would put the reliability of the whole CTBT monitoring system into question. So, on CTBT matters, effectiveness of the national laws, regulations, and practices is paramount. The chances for reaching that level of effectiveness increase when the CTBT implementation process opens up to the participation of an array of relevant stakeholders from civil society, government, academy, and private sector. It is expected that as a result of collaborative, long-term participation in the CTBT implementation process, institutional partnerships will be established, contributing thereby to the continuing operation of the RN50 Station of the IMS in the years to come.

T5-O13. Methodology for on-site inspections and lessons learned from different verification regimes

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Methodology for On-Site inspections and lessons learned from different verification regimes

On-site inspections, though intrusive in nature, is one of the most important and effective mechanism as a verification tool in order for a treaty to achieve its objectives. The IAEA safeguards inspection regime, which verifies the non-proliferation of nuclear weapons, has accumulated broad experience in the methodology and technology of conducting inspections on international, regional or national levels. The OPCW inspection regime, which verifies the prohibition of Chemical Weapons, though relatively new, has developed quite an effective methodology for their objectives. Other inspection regimes used for verifying other purposes, e.g. biological weapons, trafficking, illegal transport activities or networks and others provide different methodologies to achieve their goals.

Experience of these different methodologies of inspection regimes provide important lessons that could contribute important lessons learned for the effective implementation and conduct of a CTBTO On-Site inspection for the detection of possible nuclear test explosion. Discussion of the methodology and objectives of the main inspection regimes and Examples of possible common methodology and technology for different inspection regimes with that of the CTBTO are here discussed.

POSTER PRESENTATIONS:

T5-P1. More and more data formats, is it a plus?

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Ever since the revolution in information technology went rapidly forward in the last two decades, going in parallel with the ever-growing demand for scientific data, more and more makers of data loggers are each independently inventing his exclusive data format and communications protocols. Although this might cost data analysts and technologists more time and effort in format conversion and data manipulation, this may be giving us the advantage of having multiple systems at the same data center, as in the Jordan NDC, where completely separate systems act as a backup for each other, and enhance competitiveness between scientists using these different technologies.
Would we rather break the borders between these data formats and give more time and effort to scientific issues?? An answer is needed before it is too late.

T5-P2. The construction and development of the radionuclide station (RN42) at Tanah Rata

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One of Malaysia's obligations towards the Comprehensive Nuclear-Test-Ban Treaty (CTBT, is for the establishment in Malaysia, of a radionuclide monitoring station for the detection of radioactive fall-out due to nuclear weapon test explosion. The radionuclide monitoring station, named the RN42 station is situated at the Malaysian Meteorological Department (MMD) station at Tanah Rata in Cameron Highlands. The paper will glimpse through the construction and development phases of the radionuclide monitoring station and will highlight some of the challenges faced in implementing a project of this nature.

T5-P3. The recently acquired broadband and strong motion sensors network in Ghana and the access to CTBTO's data and products will help Ghana to update its National Seismic Hazard Assessment for a sustainable infrastructural development

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Seismic research in Ghana dates back to the colonial days and the first documented earthquake occurred in the year 1636. The first seismic equipment known as the Milnes Single boom was installed in Ghana in the year 1914. The south-eastern part of Ghana, especially the Capital City - Accra has been subjected to a significant number of earthquakes. Prominent amongst them is the 1939 earthquake of magnitude 6.4 which shook the entire Country and caused major destruction and loss of lives. The Government of Ghana was therefore compelled to operate an analogue seismic network in the southern part of Ghana in the year 1973. The seismic phase data obtained from the local earthquake recorded by this analogue system has since been used to perform hypocentral location and magnitude determination of seismic events. The magnitudes of the major seismic events and their frequencies are a threat to lives, infrastructure and the economy of Ghana. Moreover the identified active fault systems in Ghana run through the Capital city, Accra. In this circumstance of faulting directly under a high population centre, and with vulnerable buildings on weak foundations, moderate earthquakes may cause considerable casualties, loss of life and property. To better understand the seismicity in and around Ghana, it is important to determine the depth and faulting type through moment tensor inversion to know the kind of stress field operating in and around the country. But due to insufficient data this objective and many others have not been achieved. The Government of Ghana is therefore in the process of setting up a network of six seismic broad band stations to transmit real time seismic data, and ten standalone strong motion accelerometers on electrical power facilities and water supply and sewage treatment facilities. Also CTBTO has established a National Data Centre in Ghana and have given us access to use their data and products for seismic research. Ghana's emerging economy can realize a medium term real growth and development through a sustainable rapid infrastructure development that respects the environment for the ever growing population and industrial development. To achieve this, there is the urgent need for us to make a very good use of the above mentioned seismic infrastructural developments in the country to obtain Ground Motion Estimates to generate a new national seismic hazard map. This will then form the basis for a new Building Code Provision for new buildings, Seismic Rehabilitation of existing buildings, Seismic Design Criteria for Bridges, Dams, Overhead Transportation Systems and other Critical or Lifeline Structures based on the technical consideration and our

economic circumstances. Laws and Regulations also need to be elaborated for protection against earthquakes and to protect against the abuse of the natural environment.

T5-P4. The CTBTO link to the International Seismological Centre

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The CTBTO Link to the database of the International Seismological Centre (ISC) is a project to provide access to seismological data sets maintained by the ISC using specially designed interactive tools. The Link is open to National Data Centres and to the CTBTO. By means of graphical interfaces and database queries tailored to the needs of the monitoring community, the users are given access to a multitude of products. These include the ISC and ISS bulletins, covering the seismicity of the Earth since 1904; nuclear and chemical explosions; the EHB bulletin; the IASPEI Reference Event list (ground truth database); and the IDC Reviewed Event Bulletin.
The searches are divided into three main categories: The Area Based Search (a spatio-temporal search based on the ISC Bulletin), the REB search (a spatio-temporal search based on specific events in the REB) and the IMS Station Based Search (a search for historical patterns in the reports of seismic stations close to a particular IMS seismic station).
The outputs are HTML based web-pages with a simplified version of the ISC Bulletin showing the most relevant parameters with access to ISC, GT, EHB and REB Bulletins in IMS1.0 format for single or multiple events. The CTBTO Link offers a tool to view REB events in context within the historical seismicity, look at observations reported by non-IMS networks, and investigate station histories and residual patterns for stations registered in the International Seismographic Station Registry.

T5-P5. Datasets for monitoring research at the International Seismological Centre

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The International Seismological Centre (ISC) is an independent, non-governmental, non-profit organization supported by more than 50 research and operational institutions around the world. The mission of the ISC is to produce the ISC Bulletin – the definitive and most complete summary of world seismicity based on seismic reports from over 120 institutions. The ISC collects and maintains various data sets that are useful resources for monitoring research and other seismic studies, such as the IASPEI Reference Event List of globally distributed GT0-5 events, the groomed ISC bulletin (EHB), the IDC REB, USarray data, and historical ISS (International Seismological Summary, 1918-1964) bulletins. The ISC, jointly with NEIC, maintains the International Seismographic Station Registry and provides a number of additional services available from its web-site.
The International Seismological Centre (ISC) location algorithm remained virtually unchanged in the past 40 years. The introduction of the ak135 travel-time predictions in event locations since data year 2006 presented an opportunity to incorporate state-of-the-art methodologies in the ISC location procedures to further improve the accuracy of event locations in the ISC bulletin. From data year 2009 the ISC uses the new location algorithm to produce the ISC bulletin. The new location algorithm uses all ak135 predicted phases in the location; obtains the initial hypocentre via the Neighbourhood Algorithm; accounts for correlated model error structure; performs iterative linearized inversion using a priori estimates of the data covariance matrix; obtains depth-phase depth via depth-phase stacking; and provides robust network magnitude estimates with uncertainties. The new ISC location algorithm was validated by relocating more than 7,000 events in the IASPEI Reference Event List, as well as by relocating the entire ISC bulletin. We show that the new ISC location algorithm provides small, but consistent location improvements, considerable improvements in depth determination and significantly more accurate formal uncertainty estimates. We demonstrate that the new algorithm, through the use of later phases and testing for depth resolution, considerably tightens the event locations, thus providing an improved view of the seismicity of the Earth.

T5-P6. New ground truth events in Central Asia.

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Ground truth events play important role in the evaluation of the IDC data products. In this work we present information about two GT events, occurred in the Central Asia in 2009. First event is an explosion, detonated at Kara-Zhyra coal mine on 28 of November, 2009, at 07h20'36" The yield of the explosion was 49 ton TNT equivalent. Coordinates of the explosion are: 50.018323 N, 78.726551 E. Kara-Zhyra coal mine is located on the territory of the Former Semipalatinsk Test Site in Kazakhstan. This event was chosen as a test event for the

NPE09. Information submitted by the mine's authorities, allowed us to estimate the exact coordinates of the explosion with accuracy of about 1 kilometer. REB solution was at 6.532 km off to the GT coordinates. The second event is so called "Kambarata" explosion, detonated in Kyrgyzstan on the 22 of December, 2009 at 05h 54' 33.645''. Coordinates of the explosion, as measured by GPS are: 41,77467N, 73,33122E. In this case the REB location was in 15.19 km. off to the GT coordinates. The yield of the explosion was 2800 ton TNT equivalent. The purpose of the "Kambarata" explosion was to create the dam for hydroelectric power plant. For both of the two GT events the evaluation of the automatic and interactive IDC products was made. The comparison of the locations results using different velocity models was accomplished and new travel time tables were created.

T5-P7. International Training Center in support of the CTBTO

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The official opening ceremony for the "International Training Center in Support of the CTBTO" was held in Almaty (Kazakhstan) on 21 June 2010. This training center, in the first place intended for participants from Central Asian countries, is created on the basis of the Kazakhstan National Data Center. Financial support was provided by the Ministry of Foreign Affairs of Norway. The seismological center NORSAR in Norway provided scientific and technical support. The Institute of Geophysical Research of the National Nuclear Center of Kazakhstan prepared the new training Center with rooms for lectures and exercises. The duration of the training course is one month. The course program includes lectures and exercises on seismic data processing using different software products. In the beginning of each course a number of lectures, covering such topics as the CTBTO, the International Monitoring System, the International Data Center and its products are given. The lectures and exercises are guided by the most experienced specialists of the Kazakhstan NDC. The training is accomplished in the Russian language. This is helpful, since many specialists from post- Soviet countries have poor knowledge of the English language. Up to the present time, specialists from Tajikistan, Turkmenistan, Kyrgyzstan and several institutes in Kazakhstan have successfully completed the course. The next course will be for colleagues from Uzbekistan. Training courses will help increase the effectiveness of nuclear test monitoring, as well as facilitate solving the task of seismic hazard estimation and reduction of seismic risk in the seismically active region of Central Asia.

T5-P8. Building capacity to sustain disaster management and preparedness through civil applications of CTBTO's global verification regime

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Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) verification regime and the International monitoring system can assist host countries to effectively utilize the early warning system into their National disaster management and preparedness plans. In addition to its actual purpose of detecting nuclear explosions, the CTBTO's global verification regime can offer a wide range of civil and scientific applications. These applications have the potential to contribute significantly to sustainable development, knowledge expansion and human welfare. Tanzania has been experiencing a number of disasters that have caused losses of life, property and destruction to environment. National disaster management plans needs efficient and effective response systems, including infrastructure and financial components, emergency plans, procedures and internally consistent operational criteria to be critically factored into the guidelines on developing relevant national capabilities. The Tanzania National disaster management plan was formulated with objectives to develop higher level of preparedness, response and mitigation capacity for all types of disasters; promote public knowledge and awareness of disaster and enhance the involvement of the community in disaster management.; establish and maintain an effective institutional arrangement for the coordination, cooperation, collaboration and financial arrangements; promote research and technological development, establish and strengthen information systems appropriate for specific hazards at all levels. Under the National disaster management plan the country has a national radiological emergency preparedness plan that is incorporated in the whole national plan and strategies. Tanzania is hosting a CTBTO radionuclide station in Dar es salaam and has also a National Data Center capable of receiving IMS data. In this case the information, early warning systems and technology support will very much strengthen information systems on specific hazards than may emanate both within the country and outside. In this presentation, the authors will highlight the usefulness of CTBTO information including the use of virtual data exploitation platform in building capacity to sustain disaster management and preparedness.

T5-P9. Experiences gained by NDC Austria during the NDC Preparedness Exercise 2010

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The NDC Preparedness Exercise 2010 (NPE 2010) was the first radionuclide triggered test conducted by the National Data Centers (NDCs) of CTBT States Signatories. As part of the exercise, the German NDC selected a seismic event. It was assumed that this event was the epicentre of an underground nuclear fission explosion. By means of atmospheric transport modelling (ATM), concentrations of the four Radioxenon isotopes which would result from this hypothetical explosion were calculated by the Austrian NDC and interpolated to the IMS station locations. Participating NDCs only received information about the concentration of the isotopes at the station locations without knowing the underlying seismic event. The aim of the exercise was to identify this event.
As first step of its data analysis, NDC Austria applied the software-package WEBGRAPE to calculate the possible source region pertaining to the measurement scenario. As a result 41 possible seismic events were identified. Due to the ratio of the Xenon isotopes, the timeframe of the event was further constrained and the number of possible events was reduced. A subsequent analysis excluded events that were clearly of natural origin and the remaining events were further investigated using the software-package GEOTOOL. Forensic studies revealed the only possible event.
Some important conclusions were drawn based on the results of the exercise: First of all the concept of a radionuclide driven exercise proved to be important because the capabilities of the NDCs were tested across all technologies. Second it was demonstrated that the analysis of isotopic ratios of xenon-isotopes can be helpful in constraining the event period. Last but not least the verifiability of the treaty critically depends on a comprehensive knowledge of all technologies and their joint application.

T5-P10. Knowledge exchange and cooperation between National Data Centers (NDC)

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NDC Preparedness Exercises (NPE) provide an important opportunity to trigger the cooperation and Knowledge Exchange not only between established NDCs but also between established and new NDCs. Seismic knowledge is frequently available among new and emerging NDCs, but knowledge about Atmospheric Transport Modelling (ATM) and data fusion is lacking.
The goal of the project was to support the participation of the Tunisian NDC in the NPE2010. In this process the following aspects of knowledge-transfer were considered namely a step-by-step approach which finally results in a comprehensive knowledge about the training topic. In cooperation between the two NDCs a project concerning the software-package WEBGRAPE was started and a first tutorial was developed which can be used in further NDC Preparedness Exercises to facilitate participation.

T5-P11. The new digital seismic network KRNET: Perspectives and capacity development

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During the last decade, national networks for seismic monitoring in Central Asia were equipped with digital stations. In 2008, within the frame of CTBT capacity building, NORSAR, with support from the Ministry of Foreign Affairs of Norway, provided the Institute of Seismology of the National Academy of Sciences of the Kyrgyz Republic with ten digital broad-band stations. Most of these stations have been installed in the seismically highly active south of Kyrgyzstan. The stations together with the KNET stations located in the north and northwest of Kyrgyzstan, have provided a good coverage of Kyrgyz territory, and have allowed significant improvement of the accuracy of seismic event locations in the region. Owing to carefully conducted site surveys with respect to geology and seismic noise characteristics, all new sites are highly sensitive both to local and regional events. The KRNET stations recorded the nuclear explosion conducted by North Korea on 25 May 2009, as well as the strong chemical explosion conducted on 22 December 2009 in the territory of Kyrgyz Republic to construct the hydroelectric power station "Kambar-Ata2". The latter explosion can be used for calibration of seismic stations in the region. The KRNET data are used for seismic hazard assessment and seismic zoning and to study crust and upper mantle. The Institute of Seismology archives several thousands of historical seismograms of nuclear explosions, which after digitizing can be used both for seismic station calibration and identification of nuclear explosions and earthquakes.

T5-P12. The Republic of Mali's participation in the CTBT verification regime

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The landlocked Republic of Mali with an area of 1,241,000 square km has political borders with several countries: Algeria, Mauritania, Senegal, Guinea, Niger, Côte d'Ivoire and Burkina Faso.
The location of the country is a preferential area for the activities of CTBTO.
Structurally, Mali is one part of the West African craton, which is not absolutely stable as demonstrated by an earthquake which hit the Republic of Guinea in 1983. The epicentre of the earthquake came from Atlantic Ocean.
The geology of Mali is composed of many rock types with different age. The oldest terrain (2.100 m.y) contain lot of gold (actually we have six gold mines), some uranium occurrences and other important minerals.
Uranium surveying is very advanced and the deposits could be mined in the medium to long term. The Republic of Mali has ratified and signed the contract for the entry into force of the CTBTO respectively on February 18th and August 4th, 1998.
Since a long time ago, the country is sheltering an Auxiliary Seismic Station (ASS 062) at KOWA (Mopti).
Recent works included the installation of solar panels, blinded battery connection system of the Auxiliary Station of KOWA (ASS 062) by the Oman Solar company. Mali is also preparing to get a National Data Center (NDC). The equipments have already arrived at Bamako.
Future works will focus on sending and receiving data through IMS (in Vienna) and Bamako Station through the VSAT antenna.
Some of DNGM young geologists are receiving training for the inspection sites and also for the data interpretation in the frame of the CTBTO activities in Mali and in the sub region.
The contact between CTBTO and Mali is ensured by the National Directorate of Geology and Mines (*DNGM*).
We will present the status of the installation of AAS062 and of the Mali NDC.

T5-P13. CTBTO capacity building follow-up visits in Africa

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The technical follow-up visit to Member States under the Capacity Building project in Africa is one strategic component utilized to provide technical assistance to beneficiary Member States. The objective is to support the local National Data Centre (NDC) in their efforts to establish a sustainable routine use of International Monitoring System (IMS) Data and International Data Centre (IDC) products to fulfill their verification responsibilities.
Prior to the mission the NDC's needs and interest are pre-assessed using the Country Profile. During the initial kick-off meeting with the NDC staff, the proposed tailored Agenda and an interactive onthe- job technical hands-on training methodology is discussed refined as needed. The round table discussion addresses and prioritizes the pressing needs and interest of the NDC. The five days technical hands-on on-the-job training focuses on step-by-step seismic data analysis techniques using NDC-in-a-Box software, and is typically the primary achievement of the follow-up visit. The basic theoretical background knowledge pertinent to routine data analysis techniques is presented.
The technical visit identifies the missing gaps and addresses key elements for the day to day functions of the NDC including operational and analysis working procedures.
The efforts made during this project are expected to result in the increased use of IMS data and IDC products for treaty verification as well as for civil and scientific purposes in the country. This visit also provides an opportunity to become familiar with infrasound and hydroacoustic data, in addition to seismic data, depending on the needs and interests of the participants. To consolidate partnership and sustain the achievement of the project in a country, a strategy and roadmap is proposed. After the visit, the usage of data and products by the NDC can be reviewed, to assess how the NDC is building upon the knowledge used during the visit. It is also important to provide venues for the exchange of experience with other institutions, for both bilateral and/or regional cooperation.

T5-P14. The "Global Seismological Observation" training course

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The International Institute of Seismology and Earthquake Engineering of the Building Research Institute (hereafter referred as the IISEE) has been providing a training course entitled "Global Seismological Observation" in cooperation with Japan International Cooperation Agency (JICA) and Japan Meteorological Agency since 1995. The course objective is to nurture personnel who have knowledge and advanced techniques

of global seismological observation and are able to play important roles in the seismological monitoring for nuclear tests. The course duration is about two months and the IISEE gives this training once every year for participants from developing countries who apply to this course through JICA local offices. The number of participants is around ten every year. In total, 149 participants from 69 countries have participated in our training course by March, 2010. The course program has the following subjects: (1) the CTBT, the IMS, and National data center, (2) Seismological observation, (3) Data analyses (hypocenter determination, array analyses, source mechanism, discrimination techniques, etc.). Since 2003, lecturers from the PTS have visited us to provide a lecture on the CTBT, the IMS and the IDC. In this presentation, we introduce our training course and show how ex-participants are actively working in the relevant fields.

T5-P15. Advances in data distribution systems, high-level product generation, and the measurement of data quality metrics at the IRIS Data Management Center

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The IRIS Data Management Center (DMC) manages the largest concentration of broadband seismological data in the world. DMC data and services are free and open. A rich variety of request tools are currently being extended using Representational State Transfer (REST) web services. These new methods of providing access to data will greatly simplify a research or monitoring group's ability to retrieve information quickly, reliably, and in a form that is readily usable. In addition to raw time series data, the IRIS DMC is developing higher-order products intended to raise the level from which subsequent research begins. These products include such things as ground motion visualizations, a variety of event plot displays, synthetic seismograms, management of tomographic models along with visualization tools, GCMTs, calibration information, and receiver functions. These products are available through web services from the IRIS DMC's new product management system, SPUD. A final project, being built using web services, is an entirely new implementation of the IRIS DMC's quality assurance system, QUACK. The new system will use web services in a manner that allows attributes of data quality for any time series channel (seismic, infrasound, hydro acoustic, etc) to be calculated. The modular system will include several improvements over the existing system, providing better scalability, flexibility, and usability. This presentation will introduce an overview to these new services (data access, products, and quality metrics) to the CTBTO community.

T5-P16. Database of digitized historical seismograms for nuclear tests monitoring tasks

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Continuous seismological observations in Kazakhstan started in 1927. Detailed observations by permanent network of seismic stations started in Kazakhstan and Kyrgyzstan in 1951. To record nuclear explosions at regional distances, temporary stations were installed. Archives of different Organizations contain thousands of seismograms of nuclear explosions from different areas of the world. IGR NNC RK started to transfer historical analog seismograms containing nuclear records into digital form in 2005. Digitizing technology was developed, information about stations parameters, recording equipment and sources was collected. Up to the present moment more than 3000 seismograms of nuclear explosions conducted since 1961 and recorded at regional and teleseismic distances were digitized. Currently the created database is efficiently used to solve different investigative tasks of seismology: to improve and test nuclear tests monitoring technologies, to develop new methods of nuclear explosions identification, to enhance accuracy of its parameters evaluation, to calibrate stations of the CTBTO International Monitoring System, to precise regional travel-time curves, to investigate lithosphere and asthenosphere structure at the regions of nuclear tests conduction, to investigate geodynamics and consequences of underground nuclear explosions influence on medium.

T5-P17. Identification of industrial blasts in seismic bulletins for Kazakhstan Territory

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Currently the territory of Kazakhstan possesses large amount of mineral deposits developed by industrial blasts; total number of blasts recorded by seismic stations reaches several thousands per year. The explosions yield at the most quarries is from 15 to 40 tons, but at individual large quarries the average yield may reach 100 and 200 tons, and maximal explosion yield may reach 600 tons. The IGR NNC RK solves the task of identification of seismic events nature in order to distinct between industrial blasts and earthquakes on two directions: scientific investigations on development of discrimination techniques of quarry blasts by seismic records, search of

discriminators and criteria, field works on investigating industrial blasts at active quarries and other facilities with creation of a database of industrial blasts and atlas of ground-truth explosion records. Special attention is paid to search of ground-truth explosions for which accurate parameters explosion, explosion coordinates at an individual quarry and corresponding records of a station are available. Data of ground-truth explosions are used to investigate velocity characteristics of geological medium, to enhance events localization accuracy and test abilities of monitoring stations networks. In 2010 the IGR NNC RK under financial support of AFTAC conducted an experiment on recording several chemical explosions on the territory of quarries located in Western Kazakhstan. The explosions were recorded by permanent and temporary station networks. The précised travel-time curves for this Kazakhstan region were received.

T5-P18. Creating a seismic network and knowledge through collaborations, training in Zimbabwe

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"Education is the most powerful weapon that you can use to change the world" Nelson Mandela once said, so I believe there is need to carry out capacity buildings in developing countries for the global development of Seismology and continuous operation of the earthquake monitoring system. Success and sustainability of a seismic network depends on addressing local needs, developing partnerships' and collaborations in research. There is need for greater collaborations in the funding of setting up of more seismic stations in Zimbabwe since currently two stations are working There is a greater need for an increase in our station network in Zimbabwe in this era of global climate change as more data is needed for basic research into the earth's structure. Modern seismology also involves monitoring nuclear explosions and earthquake disaster risk reduction. An increase in the seismic stations/ networks is needed locally, regionally and globally in order to improve earthquake and nuclear explosions monitoring. Regular trainings are also needed to acquire skills to operate the seismic network and to fully utilize the data. This would create a system in the organization whereby earthquake monitoring and analysis is done by qualified personnel who can easily monitor the equipment and infrastructure at the same time producing useful, reliable output for sustainable development. Greater opportunities are also available in research areas and collaborations would be greatly appreciated using the available data (MATP-CTBTO).There is greater need for CTBT and us (NDC) to determine the potential mechanisms for research collaborations, scientific studies and pilot projects that would greatly enhance capacity building. The results would be used to alert and inform the public, government, nongovernmental organizations on seismic hazard analysis and the mapping of earthquake hazards in Zimbabwe. Support and collaborations in research would contribute to the development of policies and mitigation practices that would help to reduce the effects of the seismic hazards. The booming sector of construction and mining would greatly benefit as seismic and aseismic areas would be demarcated and mapped and also building codes would be made. A viable earthquake monitoring system would produce information on earthquake locations, size and would help in the rapid dissemination of information and the prompt estimation of the loss due to the disaster.

T5-P19. IMS sustainment for an operational, reliable and credible IMS - a close coordinated and joint effort achievable goal

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The International Monitoring System (IMS) is to consist of 321 monitoring facilities, scattered around the globe, of four different technologies.
But how to ensure that this global network remains operational, reliable and credible?
The entire life cycle of a system goes from conceptual design, installation/fabrication to operation & maintenance until disposal. This is commonly referred to as through life sustainment of a system. Planning for optimal and cost effective sustainment of any system always requires efficient cooperation by all involved in the various life cycle stages.
Specifically to the International Monitoring System (IMS), the Treaty has been created as a universal Treaty of unlimited duration. Accordingly, the IMS is intended to exist in perpetuity. Ownership and responsibilities as detailed in the Treaty add another level of complexity which makes it even more important to clearly plan and secure sources of support with an unequivocal common goal in mind.
Currently, the PTS which monitors and manage the network centrally in Vienna, establishes contracts with several facility operators. Equipment support contracts are also established with major equipment vendors and Facility Agreements (FA) are established with every countries hosting IMS facilities.
This paper details the various sources of support involved in sustaining the IMS, concentrating on their specific roles in achieving the common goal of Ensuring the highest level of data availability from the IMS, and attempt to draw conclusions as to their efficiencies and possible way forward to ensure that the IMS remains operational, reliable and credible.

T5-P20. IMS sustainment – Modeling and logistic support analysis – from theory to reality sustainment

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The International Monitoring System (IMS) is to consist of 321 monitoring facilities, scattered around the globe, of four different technologies, design, equipment types and environments.
Still, this network is expected to reach extremely high level of reliability, 98% for waveform technologies and 95% for radionuclide. Minimum operational downtime is therefore the ultimate goal at optimal costs.
As of today, the network is over 80% certified and operational and is comprised of more than 15,000 items from over 2,500 different models in XX different countries. Support scenarios can therefore not be left to inspiration of the moment. Supportability data from various sources such as reliability information from the equipment vendors, historical field data, failure analysis, etc will be used to produce support scenario simulations, network and stations modelizations, failure probabilities, hypothetical repair and shipping times, and so on, with the objective to increase our confidence in all possible support scenarios and our ability to react in a timely manner.
Result of such simulations will be instrumental in validating the Integrated Logistic Support (ILS) strategy, the Engineering Design and associated redundancy requirements and ultimately the overall Network effectiveness and capability.

T5-P21. ORFEUS: Facilitating seismological observatory cooperation and open data access

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ORFEUS (Observatories and Research Facilities for European Seismology; www.orfeus-eu.org) coordinates the seismological observational research infrastructures in Europe and its surroundings and promotes open data access.
Consequently, ORFEUS is the core seismology partner in the European Research Infrastructure initiative EPOS (European Plate Observing System: www.epos-eu.org).
We will present five aspects of ORFEUS and its data center operations. First, the Virtual European Broadband Seismic Network (VEBSN), coordinated by ORFEUS, is a consortium of seismological observatories (currently 54 networks and more than 500 stations), which agree to exchange real time (or close to real time) data for observational and long-time archiving purposes; this concept facilitates efficient data access for research. Secondly, the European Integrated waveform Data Archive (EIDA), based on a data transfer protocol ArcLink, aims at linking together large data archiving facilities (currently four) and providing the user with one data access interface. Thirdly the EC-project NERA (www.nera-eu.org; grant 262330), managed by ORFEUS integrates the seismological and the acceleration observational research infrastructure relevant for the seismological and earthquake engineering communities in Europe. Fourthly, ORFEUS implements new innovative data access facilities based on web services and portal technologies in collaboration with the EMSC. The seismic data portal (www.seismicportal.eu) provides the first step of this initiative well coordinated globally with other similar initiatives. Finally, data quality management: ORFEUS and its networks develop efficient tools for automatic quality control (QC). Diverse networks, equipment, operators, real-time data transfer, incomplete data information, etc all hamper data quality. We will present a short concise overview.
All this work is done in collaboration with the ORFEUS, VEBSN and NERA participants.

T5-P22. Cooperative seismology between Michigan State University in the USA, and Russia

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Michigan State University in the USA, and several seismic networks and institutions in Russia, primarily in the east, have been cooperating in seismology for over 20 years. Our cooperative program has produced a large seismological database, and the most complete seismicity map of eastern Russia. One main focus is the improvement of hypocenter determinations and the acquisition of high quality GT data. We have recently determined GT0 or GT1 locations for all PNEs that were conducted in Yakutia. For about half of these PNEs, published coordinates were seismically determined, and we find that the locations move about 7 km on average to the new GT0 or GT1 location. We are actively researching a new set of GT determination criteria for use with the seismological data of eastern Russia. In this region, most recorded seismological phases reported are secondary Pg and Sg (Lg onset) phases, which are not compatible with the GT criteria established by Bondar.

With the assistance of mining companies in the Magadan region, we record blasting at both permanent and temporary seismic stations, and analyze the data in the same manner as earthquakes, with particular attention to secondary phase time picks. Subsequently, through statistical methods applied to varying recorded phases and station distributions, we determine a set of rules for GT classification of events.

T5-P23. Processing results from the infrasound campaign in the Eastern Mediterranean

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In its effort to improve the knowledge on infrasound technology and extend its worldwide collaborations, the PTS has proposed to conduct an experiment in the eastern Mediterranean region during the winter months, when the different weather patterns favor observation in Middle-East and Central Asia. The PTS invited interested Member States to collaborate on this experiment and encouraged capable organizations to deploy sensors to observe the explosion at various distance ranges and azimuths. Two controlled atmospheric events of known energy release were conducted in the Eastern Mediterranean in January 2011. The first event was carried out on 24 January 2011, with an energy release of 8 tons of TNT equivalent. The second event was carried out on 26 January 2011, with an energy release of 80 tons of TNT equivalent.
The infrasonic waves produced by the largest explosion were detected by the 3 IMS infrasound stations IS31 (Kazakhstan), IS46 (Russia) and IS34 (Mongolia) at distances up to 6,250 km. Seismoacoustic signals were also detected by the regional auxiliary IMS seismic stations (EIL, MMAI and ASF). The event produced by the second explosion appeared in the standard products of the IDC.
In addition to the IMS network and in order to better record the infrasound signals at local and regional distances, a large scale deployment was carried out, which deployed over twenty temporary infrasound arrays in over fifteen countries. This collaborative undertaking included over fifty participants from over twenty countries.
This large scale collaborative effort also provided an opportunity to build knowledge and understanding of infrasound technology. The scope of this work is to present the results of the processing and analysis from the infrasound campaign. These results will allow to better understand the propagation of infrasonic waves produced by explosive sources. It will also help to improve the calibration of the infrasound sensors and the enhancement of processing algorithms.

T5-P24. Regional infrasound observations from the Sayarim 2011 experiment

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A large-scale experiment, designed to test and calibrate the IMS infrasound network, was conducted in January at the Sayarim Military Range in Israel. The experiment consisted of two explosions, of 10t and 100t TNT equivalent. The explosions were carried out by the Geophysical Institute of Israel under contract to the CTBTO Preparatory Commission.
The 10t explosion took place on 24 January at 1217 UTC, the 100t explosion took place on 26 January at 0917 UTC. Infrasound arrays were installed throughout the region to record the signals received from the explosions.
This presentation will focus on the regional recordings in Israel. In Israel, complicated waveforms with stratospheric and thermospheric arrivals were measured at 307, 330 km and 360 km to the north of the source location. The evolution of the arrival's waveforms and wavefront parameters will be discussed and compared to theoretical predictions that involve atmospheric specifications.

T5-P25. Potentials of using radionuclide monitoring derived-data for scientific research

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One of the CTBTO verification systems is the operation of radionuclide monitoring station for air particulates. The Philippines through the Philippine Nuclear Research Institute operates and maintains such type of verification regimes, RN-52 Station. The station is co-located at the Weather and Radar Station of the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) in Tanay, Rizal, Philippines. RN-52 is a manual station, whose primary function is to provide continuous monitoring of the levels of radioactivity in the air. This involves collection of particulate materials on a filter; performance of gamma

spectroscopy to identify radionuclides in the air filter samples and transmittal of raw spectral data using the Global Communications Infrastructure(GCI)to the International Data Centre (IDC) for processing and analysis. The designated operator manually operates the station daily to change the filter and complete the daily routine. Other tasks such as data collection, data formatting and transmission are performed automatically.
This poster will present two ways of possible utilization of air particulates data for conducting scientific studies. One such study is the assessment of the contribution of natural radionuclides in the air particulates to the effective dose estimate of Filipinos. In this study, the concentration of natural radionuclide from the Uranium and Thorium series and Potassium-40 will be source from the RN52 data and will be processed and integrated in the calculations for dose assessment purposes. The other prospective use would be on the measurement of the atmospheric flux of natural radio nuclides such as Be-7 and Pb-210 for the establishment of the inventory of these radionuclides which can be used as tracers of soil movement. The concentration of Be-7 and Pb-210 will be analyzed and a comparative analysis in conjunction with the concentration of these radionuclides in the soil will be made.

T5-P26. Regional cooperation in science and technology capacity building for IMS and CTBT verification regime

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Since the inception of preparatory commission for Comprehensive Nuclear Test Ban Treaty Organisation (CTBTO) in 1996, more States have expressed the willingness to sign and ratify the Comprehensive Nuclear Test Ban Treaty (CTBT). However, cooperation in science and technology capacity building for CTBT verification regime at regional levels and State parties in Africa is slowly growing.
IMS and CTBT verification regime requires that high quality human resources verification technologies are trained and sustained.
PTS as provided in paragraph 43 of CTBT has to effectively operate IMS, IDC, routinely receive process, analyse and timely report on data to the NDCs and regional data centres for verification regime to work. Scientists and civil society need to be encouraged to support the CTBT activities of non proliferation and State Parties have to meet their financial obligations to CTBTO.
Equally too, more human resources in all verification technologies have to be trained where PTS and State Parties should workout comprehensive capacity building programmes aimed at including the all verification technologies courses. Universities and research centres can play a vital role in sustaining information technology support and training. For instance Makerere University in Uganda has now got an infrastructure. PTS needs to negotiate MOUs with Universities and encourage them to offer courses that will create a pool of professionals to support the Treaty on a long term.

T5-P27. Using infrasound data of Nairobi Station (IS32) to study Bududa landslide in eastern Uganda

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On 1st March 2010 between 12 Pm and 1 Pm of that day, Bududa area on slopes of Mt Elgon in Eastern Uganda was devastated by a catastrophic landslide that buried 300 people and left others homeless. The landslide was triggered by heavy rainfall. The infrasound (IS32) station data from Nairobi was used to study the event. The International Monitoring System (IMS) comprises of monitoring technologies such as seismological, radionuclide, hydroacoustic, and infrasound, supported by communication and certified laboratories infrastructures. Article IV paragraphs 1 and 16-18 of Comprehensive Nuclear Test Ban Treaty (CTBT) calls for establishment of a verification regime consisting of other elements and an IMS and data exchange. The IMS data can be used for research and civil protection. Thus, a request for infrasound data recorded at Nairobi Infrasound station (IS32) for a period of February to March 2010 representing pre-Bududa landslide, Bududa landslide and post Bududa landslide was submitted to International Data Centre (IDC). The data was received from IDC on a Compact Disk (CD) and studied. The landslide history was recorded by IS32 station in Nairobi. Infrasound stations record useful data for landslide studies; however more research and capacity building is needed to improve our models in landslide prediction and early warning systems. These efforts demonstrate the strength of IMS verification technologies in civil protection.

T5-P28. Government initiatives and international cooperation in seismology providing knowledge and training in Namibia

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The Geological Survey of Namibia established a National Seismological Network in 2000 which has expanded to seven seismological stations to date, with a view to improve seismological records and ultimately generate a Seismic Hazard Map of the country. As a signatory of the Comprehensive Nuclear-Test- Ban Treaty (CTBT), the government in cooperation with CTBTO established an International Monitoring Station (IMS) in Tsumeb which monitors nuclear explosions worldwide. Collaborative projects include researches in Geosciences and weather studies with AfricaArray, with the main objective of studying the crustal studies. Walvis Bay Ridge Passive Source and Active Seismic Experiments with German Research Centre for Geoscience (GFZ) wwith a view of understanding the roll of the plume-lithosphere interaction during break-up of the Southern Atlantic Ocean and lithospheric structure of the passive volcanic margin of Namibia. More recently, seismology in schools project in collaboration with the British Geological Survey has been started, with a primary object of encouraging learners to take science as career.

T5-P29. National earthquake monitoring and tsunami early warning system in Thailand

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After the destructive Indian Ocean tsunami in 2004, a National Earthquake Monitoring and Tsunami Early Warning System was developed and established in Thailand at the Thai Meteorological Department (TMD). The system components follow the UNESCO/IOC concept of an end-to-end tsunami warning system which has been widely applied to manage earthquake risk and tsunami hazard. Firstly real time earth observatories and water level stations were installed throughout the country to monitor local and distant earthquakes including the observation of abruptly changing sea water level at the coast in real time .
Currently there are many monitoring stations for automatically detecting earthquakes. The system comprises 40 seismic stations, 9 tide gauge stations, 4 GPS stations including real time input of more than 200 signals from other seismic station networks, one DART buoy from NOAA and 9 tide gauge stations to detect tsunamis. Due to the high capacity of monitoring system, within few minutes after an earthquake automatic analysis will give results of epicentre, then information and warning messages will instantly notify assigned channels and lists (via SMS , Fax, Web site, TV, Radio , Siren tower etc). All people in the risk area would continuously be alerted and follow the further official warning messages as they have practised in advance. In addition, coordination among agencies concerned, such as UNESCO/IOC, USGS, JMA, CTBTO, IRIS, AEIC have been involved for sharing data and information. Measures and management of earthquake and tsunami disaster at the national level, international level or regional level have been developed in order to save lives and properties in the future.

T5-P30. Science, technology and values in the context of global threats

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Even though it is not yet in force, the Comprehensive Nuclear Test Ban Treaty, which was approved by a significant majority of the United Nations General Assembly in 1996, is an impressive achievement. It shows that nations are prepared to renounce some part of their own self-interest in favour of an international agreement aimed at preventing harm to the world's population as a whole. By contrast, international agreement on implementing ways to slow down (and eventually reverse) anthropogenic global warming, which stands to inflict considerable harm on much of the world's population, is proving difficult if not impossible to achieve. The questions posed in the first part of this paper are: To what extent can the success of the CTBTO serve as a model for getting nations to collaborate on slowing global warming? Which differences between the two situations would militate against the CTBTO's being a viable model?
The larger question raised by this issue concerns the role played by values in the transitions between science and technologies and their deployment and use. Since the atomic bombing of Hiroshima and Nagasaki, the 'neutrality of science' argument (which claims that scientists who do the ground-work for lethal technologies can remain morally blameless) is no longer plausible. What kinds of life values are relevant in this context, and how can they alleviate our insistence on using technologies that stand to harm rather than enhance human life on the planet?

T5-P31. Large-scale explosion sources at Sayarim, Israel, for infrasound calibration of the International Monitoring System

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Recently two large-scale calibration explosions were successfully conducted by the Geophysical Institute of Israel (GII) at the Sayarim Military Range, Negev desert, Israel, on 24 and 26 January 2011. The experiment included two on-surface explosions of 10 tons and 100 tons of ANFO explosives, conducted in different time of the day. The explosives were assembled as a pyramid/ hemisphere on the soft sediment surface, and detonated upward. Near-source high-pressures in airshock waves were measured, and preliminary results correspond to expected peak-pressure values for these charges.
The experiment was a collaboration between the CTBTO in Vienna, Middle East and European countries and the USA. The main goal of this calibration experiment is to provide fully controlled infrasound sources (the strongest since the establishment of the IMS network), monitored by extensive observations for calibration of IMS infrasound stations in Europe, Middle East and Asia. The experiment is intended to contribute to the understanding of the infrasound propagation in the atmosphere, under winter conditions and improve IMS monitoring capabilities. The infrasound signals from the 100 tons shot were observed at IMS infrasound stations in Russia, Kazakhstan and Mongolia up to a distance of 6,250 km.
GII conducted a previous calibration explosion of a similar yield at the same Sayarim site in August 2009 under summer weather conditions. Clear infrasound signals were recorded at that time at many regional and IMS stations to the West and North-West, up to a distance 3,500 km, near Paris, France. This pair of large-scale explosions in different seasons (weather patterns) demonstrated clear favorable westward and eastward propagations. An extensive dataset of audio-visual, acoustic, seismic and infrasound records was obtained at wide range 0.1-6,250 km, based on broad international cooperation in observation of these explosions.

T5-P32. Problematics of the remote consequences of influence of amazing factors of the nuclear weapon on direct participants of military-nuclear actions

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T5-P33. Partnership in multidisciplinary research in earth and polar sciences: the contribution of the European Science Foundation

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The current year is a key milestone for the European Science Foundation with the culmination of several scientific initiatives.
In this framework, it is of paramount importance to encourage coordination of policy, strategy and governance of new opportunities for interdisciplinary scientific research in several frontier areas.
The Life, Earth, Environment and Polar Sciences Unit of the European Science Foundation has a special focus on Earth Sciences and science in Polar Areas.
The mandate of the Life, Earth, Environment and Polar Sciences Unit inside ESF makes it especially tailored to develop a close interaction with CTBTO, being a natural playground to facilitate the partnerships and knowledge exchange between the CTBTO and the broader scientific community working in areas related to the four CTBTO's monitoring technologies.
Some examples of coordination of networking activities and potential links with a number of
CTBTO activities will be provided.

6. SESSION ON THE 11 MARCH 2011 JAPANESE EVENT AND ITS AFTERMATH

ORAL PRESENTATIONS:

JS-O1. Source process and broadband waveform modeling of 2011 Tohoku earthquake using Spectral-Element Method

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We have calculated broadband synthetic seismograms for Mar. 11, 2011 Tohoku earthquakes using the Spectral-Element Method. We use finite source models by using a set of sub-events distributed along the fault surface, retrieved by inversion of body waves (Nakamura et al, 2010). The finite source model used in this simulation estimates Mw to be 9.1. The fault dimension is 460 km times 240 km with the source duration time of 150 sec. We use the Earth Simulator2 of JAMSTEC to calculate preliminary synthetic seismograms for this finite source model. We used 726 processors of the Earth Simulator 2, which should provide synthetic seismograms that are accurate up to about 5 second and longer. The comparison of the synthetic seismograms with the observation for this event shows that synthetic P-waveforms model the observed seismogram quite well, reflecting that the finite source model is quite precise. This source model shows that the maximum slip occurs at depth of 20 km and propagates to shallower region, which is consistent with the fact that the tsunami excitation was significant for this event. Azimuthal dependence of misfits of synthetic waveforms and observation, especially for surface waves, may reflect the discrepancies of three-dimensional mantle structure used in this simulation with the actual Earth. We also will discuss some of the phases recorded in association with these earthquake and tsunami on infrasound monitoring station at Isumi, Japan.

JS-O2. Magnitude determination using duration of high frequency energy radiation for the 2011 Off the Pacific Coast of Tohoku Earthquake

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We applied a technique to determine earthquake magnitudes using durations of high frequency energy radiation and the maximum displacement amplitudes to the 2011 Off the Pacific Coast of Tohoku Earthquake. The estimated duration of high frequency energy radiation is 170.5 s, which is consistent with the centroid time shift 69.8s from the Global CMT solution. The estimated magnitude is 8.96, which well agrees with preliminary analyses for this earthquake. Compared to the December 26, 2004 Sumatra earthquake (Mw 9.0), this event is characterized by shorter duration of high frequency energy radiation and larger displacement amplitude. We found azimuthal dependence of the measured durations of high frequency energy radiation, which suggests the rupture propagation in the southwest direction.

JS-O3. Analysis of the Fukushima accident by the French National Data Centre

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From 11th of March 2011 following the Earthquake/Tsunami leading to a severe accident at the Fukushima nuclear power plant, CEA-DAM through its National Data Centre has automatically and interactively processed and analysed the whole daily set of data provided by the Particulate and Noble gas Network radionuclide stations. In addition, the French laboratory, as support of the network of the International Monitoring System (IMS) in the frame of CTBT, has performed expert assessment of some IMS particulate samples, notably regarding specific fission products likely to help the understanding of the Fukushima accident scenario. More generally very useful feedback was achieved from these analyses dealing with the chronology of detections, amount of nuclear material released in the atmosphere, isotopic and chemical signatures. It was found that the high activity concentrations observed at the Takasaki, Japan stations, led to dead time and memory effect on the radionuclide detection systems, especially those related to the beta-gamma detection module for analysing xenon isotopes. As a consequence, the French NDC had to applied special procedures to be able to analyse the sample.
In parallel, atmospheric transport modelling at mesoscale and global scale was performed in order to predict the evolution of the plume on Japan area and on a worldwide scale. Atmospheric transport simulations exhibit good spatial and time agreement with detections from the radionuclide Network stations.

JS-O4. Tsunami infrasound: 2004 Sumatra and 2011 Tohoku case studies

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Infrasonic signal associated with tsunamigenesis appear to possess recurrent signal features which could be used for early event identification. From the 2004 Sumatra earthquake and tsunami we learned that infrasonic signals associated with the coseismic ground displacement near the epicenter appear to radiate primarily above 0.2 Hz. Deep infrasound in the 0.02-0.2 Hz range may be radiated by the vibration of distant mountain as well as be indicative of the interaction of a tsunami with coastline features and bathymetry. Below 20 mHz, acoustic-gravity waves can provide information on the very large scale (~1000 km) coseismic uplift and subsidence of the sea bottom and associated swelling and depression of the sea surface over the source region. We present observations of the 11 March 2011 Tohoku earthquake and tsunami by the IMS infrasound network and compare these observations with seismic and tsunami models, as well as with other geophysical characterizations of this event.

JS-O5. Canadian monitoring of Fukushima incident

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The March 11 seismic event near Japan and subsequent radionuclide observations caused by damage to the Fukushima Nuclear facility resulted in a verification scenario similar to the one that would arise after an atmospheric nuclear test. Large data sets generated from the International Monitoring System of the Comprehensive Nuclear Test Ban Treaty Organization and Canadian national equipment were analyzed to determine the nature and magnitude of the event. Various Canadian assets were used including: a network of NaI detectors, aircraft surveillance, high volume aerosol samplers, and soil samples to provide guidance to decision makers on the nature and impact of the event. A discussion of the tools used, their capabilities, and results will demonstrate how national technical means can complement the information received from the IMS and IDC.

JS-O6. A window into the complexity of the dynamic rupture of the 2011 Mw 9 Tohoku-Oki earthquake

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The Mw 9 earthquake that occurred off-shore Tohoku, Japan, on March 11 2011 is by far the best recorded earthquake in the history of seismology and will undoubtedly spawn a broad range of studies that will deeply transform earthquake science. In particular, this event provides a unique opportunity to address, through high resolution observations, fundamental questions about the physics of dynamic earthquake rupture, including the initiation of rupture, the complexity of its propagation and its arrest. Here we focus on key direct observations of the spatio-temporal evolution of the rupture process of the Tohoku earthquake. We analyze seismic data available soon after the event using source imaging methods that are weakly dependent on model assumptions. We backprojected teleseismic waveforms applying high-resolution array processing techniques to obtain a high-frequency (HF) image of the rupture process of this mega-earthquake. We then identified prominent features of the local strong-motion recordings that we associate to the main phases of the rupture process. Our results reveal, with unprecedented detail, rich patterns of high frequency radiation from the deep portions of the seismogenic zone. Our observations open a direct window into the complexity of dynamic rupture, including phases of slow and extremely fast rupture, and its relation to the heterogeneous nature of the subduction interface.

JS-O7. Detection of elevated Xe-133 following the Fukushima nuclear accident

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We report on the first measurements of short-lived gaseous fission products detected outside of Japan following the Fukushima nuclear releases, which occurred after a 9.0 magnitude earthquake and tsunami on March 11, 2011. The measurements were conducted at the Pacific Northwest National Laboratory (PNNL), located more than 7000 km from the emission point. First detections of 133Xe were made starting early March 16, only days after the earthquake. Maximum concentrations of 133Xe were in excess of 40 Bq/m3, which is more than ×40,000 the average concentration of this isotope in this part of the United States.

JS-O8. Response of the Austrian Meteorological and Geophysical Service and the National Data Centre Austria to the nuclear accident in Fukushima: Atmospheric transport modelling and situation assessment based on CTBTO radionuclide data

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On 12 March 2011 at about 6:30 UTC (7:30 CET), the first explosion was reported from block 1 of the nuclear power plant in Fukushima Daiichi. Only minutes afterwards, the Meteorological and Geophysical Service of Austria (ZAMG) started its model simulation of the event. As transport model the Lagrangian Particle Diffusion model FLEXPART Version 8 based on input data from the European Centre for Medium-Range Weather Forecasts (ECMWF) was used. In its assignment as National Data Centre of Austria, ZAMG has real-time access to the global radioactivity data of CTBTO. These data were used to validate the model simulation, and to estimate the emission sequence of key radionuclides. Data and modeling results related to the accident were made available to the public. Results show that the ZAMG model worked well in describing the hemispheric-scale transport. CTBTO data and information disseminated to the member states through the secure web page and briefings proved to be extremely valuable for the assessment of the situation.

JS-O9. Operational experience of CTBTO related to the Fukushima nuclear accident and long term perspectives

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The release of fission and activation products from the Fukushima nuclear power plant on the aftermath of the 11 March 2011 Tsunami posed a number of challenging questions for the CTBTO radionuclide network. The challenges applied to the sample analysis, sample handling, sample dispatch, laboratory analysis, data analysis and atmospheric transport modeling. All the operational radionuclide stations in the northern hemisphere detected the release; most of the detections were initially level 5 samples (multiple fission products detected). The CTBT radionuclide system performed well during this event. Some lessons were learned about procedures needed for this kind of situation handling in the future and also on possible dynamic range of the future measurement equipment.
The CTBTO is involved in the worldwide response to the Fukushima events. Although this response was not based on any preparedness plan and procedures, it appears to fit well the purpose because of the performances of the network and the usefulness of the measurements that are made available to the Member States and the international community. The results provided by the network will continue to have a key role to facilitate the various decision-making processes also during post event phase. In that perspective, the relationships need to be considered between CTBTO and the other international organizations involved in the response to nuclear emergencies, including Fukushima. The presentation identifies some subjects that need to be considered in this kind of co-operation.

POSTER PRESENTATIONS:

JS-P1. Pressure signals on IMS hydrophones at Wake Island due to the M9.0 event on March 11th 2011 off the coast of Japan

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International Monitoring System Hydrophone sensors at Wake Island measured three different types of pressure signal as a result of the magnitude 9.0 event that occurred off the coast of Japan on the 11th of March 2011. Acoustic pressure signals were first recorded as the seismic phases from the event propagated past hydrophone locations, causing radiation of acoustic signals into the water. Next, the acoustic T-phase was detected as sound that coupled into the ocean near the event epicenter reached Wake Island. Finally the tsunami generated by the event was observed as it passed over the hydrophones, changing local sea level and consequently generating a low-frequency pressure signal. These data are displayed and the features of each signal discussed.

JS-P2. Assessment of release scenarios for the Fukushima Dai-ichi Nuclear Power Plant accident

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Dispersion of radioactive material released to the atmosphere from the Fukushima Dai-ichi Nuclear Power Plant Accident in Japan was modelled to assist the Australian Government in effectively providing public health advice to its citizens. This advice on protective measures required estimation of radiation doses for locations in Japan based on credible scenarios and atmospheric dispersion modelling. To undertake the assessment relied on deriving an appropriate nuclear reactor source term and accident release scenario that could be matched against the limited observational data. Evaluation of the atmospheric dispersion model and its input source term and release scenario was undertaken by comparison and refinement of predictions with concentration measurements taken downwind from the actual release. Short-range forward dispersion analyses were used to refine rel! ease magnitudes for different release times to deliver the activity concentrations measured at the Comprehensive Nuclear-Test-Ban Treaty radionuclide station at Takasaki, Gunma, Japan, using a 1% core release scenario with predictive weather conditions. Further comparisons were then made to ground based gamma dose measurements, estimated release rates and long range atmospheric dispersion modelling. This paper presents the approach taken to justify the release scenario by coupling monitoring data with atmospheric simulations.

JS-P3. Source modeling earthquake as tsunami generation in Japan (East of Pacific Plate)

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In most cases, an earthquake occurring next to a coastline segment generates a tsunami in a relatively short time. The West of Pacific area has experienced repeated large earthquakes, such as the Japan event on March 11, 2011. The time at which the tsunami disaster will occur, the arrival time, how high (run-up) the waves are, and the extent of the resulting immersion area (Inundation) and the simulation can be calculated by creating a tsunami modeling scenario. To create tsunami modeling parameters, millions of fault scenarios should be tested in anticipation of a possible tsunami on the plate boundary segments prone to tsunamis, for instance in the Western Pacific in the case study on plate boundary of pacific . The Scenarios were prepared based on the values of fault parameters and will bemodified in such a way as to produce the fault model which match the future expected fault conditions on this segment. Estimating the fault location on the segment can be done by observing crustal deformation or relative motion of the earth's crust, or in complex cases such as the movement of the double-couple in the crust, can be obtained by calculating and analyzing historical data and then validating the result by comparing to survey results. Also, another criterion for prediction of tsunami run-up and tsunami inundation is to do it based on calculation of released energy of earthquake and the return period of earthquakes at this location.

JS-P4. Experimental check of work on an adaptive algorithm for detection of onset times of low amplitude seismic phases based on time series analysis with use of Japan earthquakes data records in March 2011

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The ultimate goal of processing is to measure the characteristics of a useful signal in a situation where the seismogram is a complicated superposition of very different types of wave motion. The very process of obtaining these characteristics can be viewed as a mathematical problem in its own right. The process is based on a search for patterns that connect the original signal to the physical parameters listed above, as well as formulating these patterns as efficient computational techniques. Unlike the Fourier transform, the wavelet transform provides a 2D representation of the signal under study, frequency and time being treated as independent variables. As a result, we are able to examine the properties of the signal in a physical space (the time) and a scale space (the frequency). The algorithm in question is designed for the fastest real time detection of a sudden change in the properties of a process as more information is becoming available. The problem is formulated so that the onset of low amplitude seismic phases is to be automatically identified during a time interval no longer than four seconds. The algorithm is based on the continuous wavelet transform. This is an adaptive algorithm, since it incorporates time-dependent individual characteristics of the time series of interest.

JS-P5. The International Data Centre analysis of the aftershock sequence following the March 11, 2011 earthquake off the coast of Japan

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The M9.0 megathrust earthquake off the coast of Japan on 11 March 2011 resulted in an unprecedented number of aftershocks being built by the automatic processing system of the CTBTO. These aftershocks imposed a workload on the waveform analysts of its International Data Centre (IDC) which was many times the average, falling back close to the average only after some months; the ensuing analysis of the sequence therefore took some months to complete. The IDC draft operational manual prescribes that the daily reviewed bulletin must be completed within 48 hours of the end of the recording day 98% of the time after Entry into Force (EIF) of the Treaty. Events such as this Japanese earthquake sequence will impose an even greater challenge to this schedule than it does upon the current pre-EIF target of issuing the reviewed bulletin within ten days. The results of the analysis of the aftershock sequence are presented and examined in terms of the scientific outputs, the impact on analysis, and lessons learned for the IDC. In view of the cumulative delay in analysis created by a prolonged aftershock sequence, meeting of the post-EIF requirement is favoured by skipping days entirely early in the sequence, to avoid a prolonged failure to meet the imposed target. The formulation of this requirement may therefore need review.

JS-P6. Bulgarian experience with Fukushima event in March 2011

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After the Chernobyl accident the Bulgarian population is extremely sensitive to radioactivity. Even follow the rumors of possible increasing of radioactivity in the environment a lot of people took some non-useful medicines “to protect” their health. Due to the possible impact of the accident at the Fukushima nuclear power plant we have to organize proper radiation protection for the population. It was of prime importance to know the level of radioactivity transferred in the air from Japan to Bulgaria.
As the NCRRP is a part of the Bulgarian NDC to the IDC of CTBTO, we use the data from the IDC. We follow the IDC ATM and make our model of the level of radioactivity and data of upcoming radioactive particles in Bulgaria. We found 25 March was the first day of the Fukushima impact. Every day we checked the data for North transfer from the SEP63 FOI, Stockholm Sweden, and the data for the West transfer from DEP33 Schauinsland/Freiburg, Germany. It was very important to know at least 2-3 days in advance the possible radionuclide content in the Bulgarian air.
In the paper are presented Bulgarian measurements of the radionuclides content in the air. We sampled at least 350 m3 of air every day and provide gamma spectrometry analyses of at least 0.017 mBq/m3 and±16 hours. The specific activity of I-131 varies between 0.052 0.026±0.018 mBq/m3. The activity of Cs-137 and Cs-134 varies from 0.054±1.92 0.07 mBq/m3 respectively. We±0.06 mBq/m3 and from MDA to 0.0477±mBq/m3 to 0.63 measured traces of Cs-136, Te-132 and I-132. The results are compared with IDC data for the DEP33, SEP63 and JPP38 station results.

The CTBTO data from the radionuclide monitoring system are very useful for the prediction and assessment of the public dose, taking decisions and informing the population.

JS-P7. Infrasound signals excited by upheaval and subsidence of ocean surface during the tsunami genesis related to 11 March event

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Observed infrasound records at IMS stations in East Asia relating to the disastrous tsunamigenic earthquake occurred at Mar. 11, 2011 in Japan had been analyzed. And long period acoustic signals which might be excited by uplifting and subsiding ocean surface during the tsunami genesis were detected in the records observed at I30JP, I34MN and I45RU. The on-set time of these signals coincided with the time predicted by the distance between the tsunami source region and each station, and the shape of these signals also coincided with the water level changes of the tsunami source estimated by the fault model of the event. I34MN and I45RU are located the direction along the fault width, and I30JP is located the direction along the fault length. Infrasound signals observed at both I34MN and I45RU had relatively shorter wave lengths than the signal of I30JP had. It also coincided with the geographical relation between the tsunami source and stations. When Tsunami early warning provides to the public, the possibility of the tsunami occurrence and its height are estimated by only using the hypocenter location and the magnitude and not using the information about the tsunami source area and actual initial height in the source region, therefore, Tsunami warning may not have enough accuracy now. According to the analysis results, if infrasound observation network would deploy along the coast line at the front of subduction zone, real-time data observed through the network would improve the tsunami warning information.

JS-P8. Detection of aerosol radionuclides in the United States following the Fukushima nuclear accident

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Several measurements of aerosol radionuclides emitted by Fukushima reactors were made in the United States. These included 131I, 137Ce, and others up to a few milliBq per cubic meter. Isotopic ratios clearly distinguish this event from other observations, such as Chernobyl and historic weapons tests, showing a strength of the International Monitoring System design.

JS-P9. Some measures to face potential impacts of Fukushima nuclear accident in Burkina Faso

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The probability for the Burkina Faso local population to develop deterministic effects after Fukushima nuclear accident is zero. However, stochastic effects remain possible as the two countries have concluded multilateral and bilateral agreements, particularly in the field of international trade in product for human or animal consumption and the possibility for their people to travel to/from Japan. Therefore, the Burkina Faso nuclear safety regulatory body has implemented a strong and sustainable strategy to avoid any negative impact both to the environment and the health of populations. Actions related to sensitization, communication and information with regard to the accident had been conducted in order to reduce the widespread fear of nuclear. For the time being, the national legislative framework has been improved, focusing on (i) authorization certificate b! efore food importation from Japan, (ii) in situ inspection in collaboration with customs and the National Public Health Laboratory prior to consumption or sale in local markets and (ii) compliance with the IAEA code of conduct related to radiological food analysis. The long term strategy aims to build a Radionuclide identification laboratory using gamma spectrometric methods. For this purpose to be achieved, staff capacity building is needed as technical assistance and expert advice have been obtained from the IAEA and the United States Department of Energy through the Global Threat Reduction Initiative already.

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Preparatory Commission for the
Comprehensive Nuclear-Test-Ban Treaty Organization
Vienna International Centre
P.O. Box 1200
1400 Vienna
Austria

Printed in Austria

June 2011