3. ADVANCES IN SENSORS, NETWORKS AND OBSERVATIONAL TECHNOLOGIES

Conveners:

PATRICK GRENARD
International Monitoring System Division
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Scripps Institution of Oceanography
United States of America

Invited Speakers:

MICHEL ANDRÉ
Technical University of Catalonia
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DAVID SIMPSON
Institutions for Seismology (IRIS)
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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 demonstrate 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 $Ml \geq 1.5$. 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

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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.