INTERNATIONAL DATA CENTRE

Highlights in 2010

Introduction of infrasound processing into provisional operations

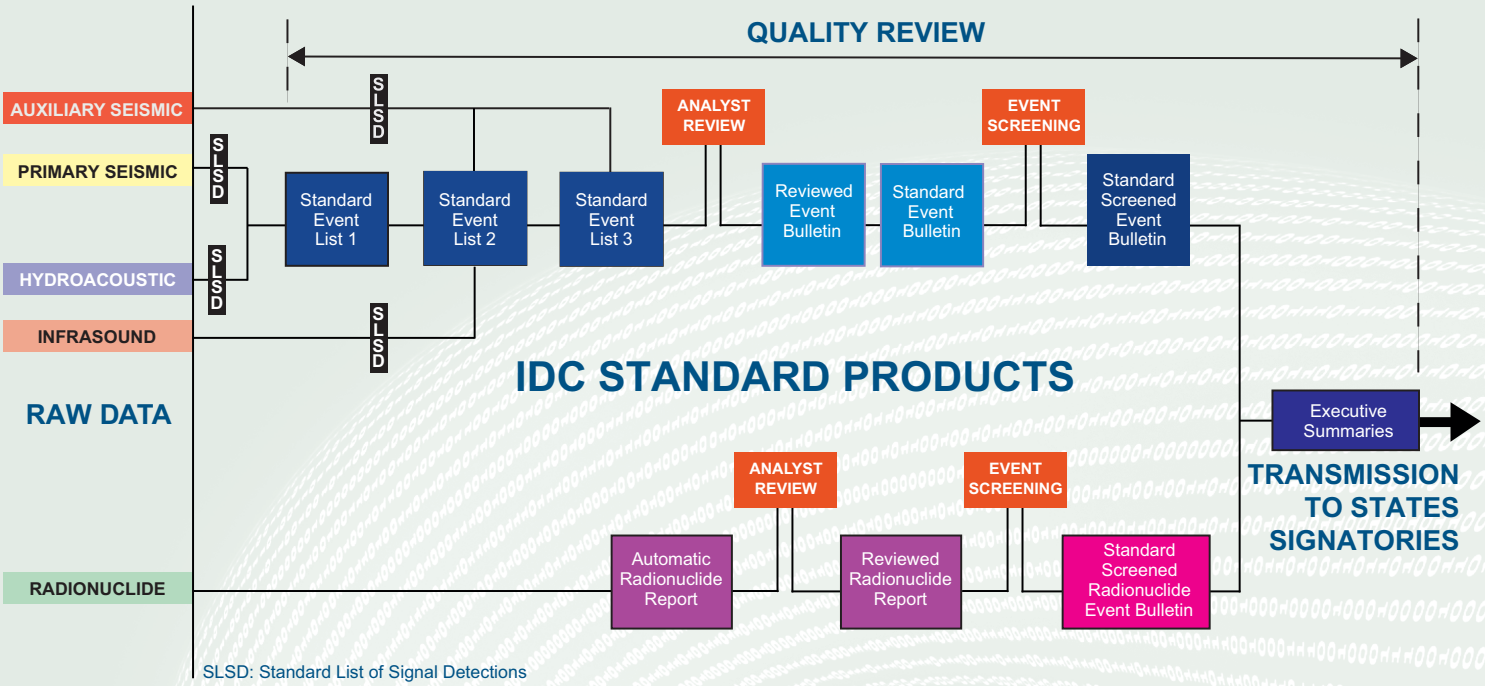
Completion of the migration to Linux for the waveform processing and analysis systems

Conclusion of tsunami warning agreement with France

The International Data Centre (IDC) is designed to collect, process, analyse and report on data received from facilities of the International Monitoring System, including the results of analyses conducted at certified radionuclide laboratories. The data and products are then made available to States Signatories for their final assessment. Data and products are received and distributed through the Global Communications Infrastructure.

The IDC is situated at the Headquarters of the CTBTO Preparatory Commission in the Vienna International Centre. A relational database management system forms the core of all information management. Full network redundancy has been created at the IDC to ensure high availability. A mass storage system provides archiving capacity for more than 10 years of verification data. The software utilized in operating the IDC is mostly developed specifically for the CTBT verification regime.

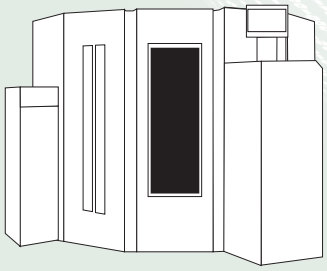
From Raw Data to Final Products

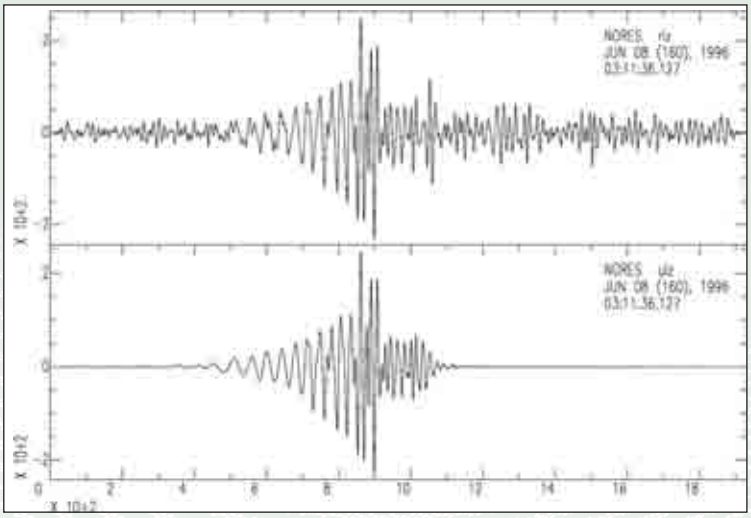


The data collected by the IMS under provisional operations are processed immediately when they reach the IDC. The first automated data product, known as Standard Event List 1 (SEL1), is completed within one hour after the data have been recorded at the station. This data product lists preliminary events recorded by the primary seismic and hydroacoustic stations.

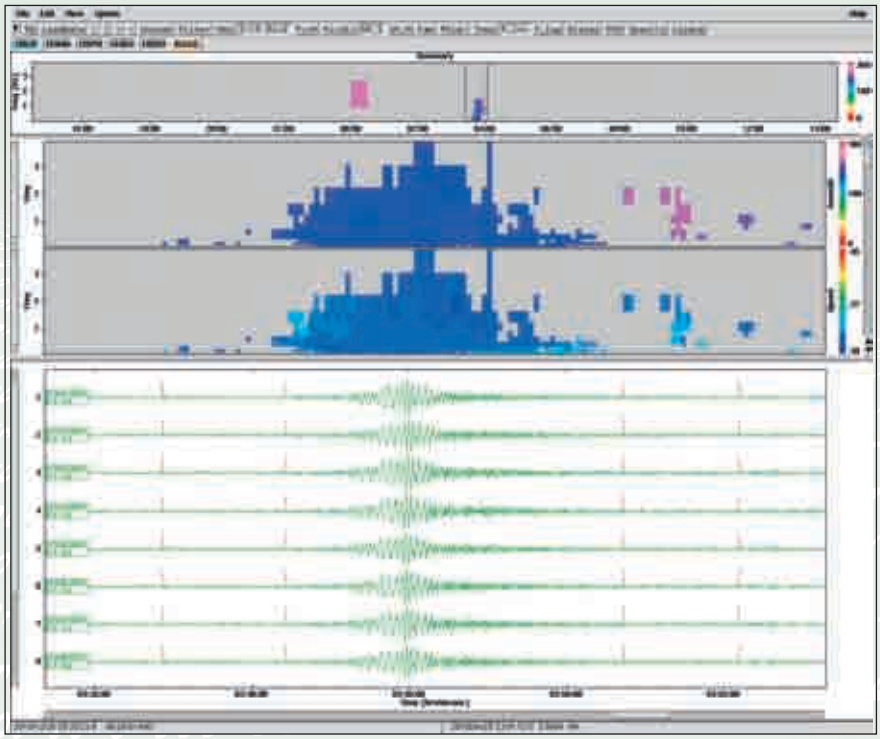
Requests are then made for data from the auxiliary seismic stations. These data, together with the data from the infrasound stations and any data arriving late, are used to produce a more complete event list, SEL2, four hours after the recording of the data. SEL2 is improved again after six hours have elapsed to incorporate any additional late-arriving data, to produce the final automated event list, SEL3.

Analysts subsequently review events recorded in SEL3 and add missed events to prepare the Reviewed Event Bulletin (REB). The REB for a given day contains all those events detected at IMS seismic,





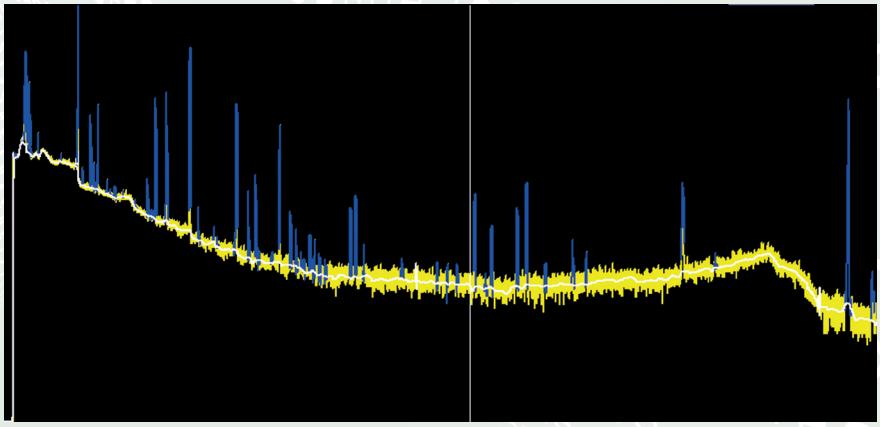
Example of a Rayleigh surface wave recorded at IMS station PS28 in Karasjok, Norway. Surface waves propagate on the surface of the earth, as opposed to body waves, which penetrate deep into the earth's interior. The upper figure shows the vertical motion data recorded on the PS28 seismometer after a nuclear test at Lop Nor, China, in 1996. The lower figure shows the same waveform after a process known as phase match filtering.



An infrasound signal recorded by IMS station IS53 in Fairbanks, Alaska, USA, together with data from 11 other infrasound stations, was associated with a suspected bolide explosion over the north Pacific Ocean on 25 December 2010. Plots are shown for the eight detector channels. The detection attributes, azimuth and speed, are displayed in time–frequency plots calculated by the IDC software.

hydroacoustic and infrasound stations which meet specific criteria. During the current provisional operating mode of the IDC, the REB is targeted to be issued within 10 days. After the Treaty enters into force, it is planned to release the REB within approximately two days.

Observations from events recorded by IMS radionuclide particulate and noble gas monitoring stations typically arrive several days later than the signals from the same events recorded by the seismic, hydroacoustic and infrasound stations. Radionuclide particulate data undergo both automatic and reviewed processing to produce an Automatic Radionuclide Report and then a Reviewed Radionuclide Report (RRR) for each full gamma ray spectrum received. The information in the REB and RRR will eventually be fused, associating seismoacoustic events with radionuclide detections.



A radionuclide gamma spectrum produced with the new IDC analysis software AutoSAINT/SAINT2, which is used for analysing data from radionuclide particulate detectors and noble gas systems based on high purity germanium gamma detectors.

SUPPORT AND BUILD-UP

In 2010, support and build-up of the IMS continued with the testing and evaluation of data from new stations. Newly installed or upgraded stations were introduced into IDC operations. Other stations were installed in the IDC test bed.

IDC application software has been converted and updated to run on open source systems (Linux). The software for waveform data, which had been thoroughly tested in 2009, was put to operational use in January 2010. The new software developed for the analysis of data from both radionuclide particulate and noble gas monitoring stations went through initial system-wide testing in October 2010. The performance of the software was found to be excellent, although some of the features still needed adjusting. The final tuning of the software is under way and the software is planned to enter provisional operations in early 2011.

Infrasound monitoring is an important verification technology as it can be used to detect and locate an atmospheric nuclear explosion. The IDC introduced routine infrasound signal analysis into operations in February 2010. The initial level of automatically detected false events and probability of detection were sufficient to allow interactive review of the infrasound results. Work will continue to improve the automatic detection of infrasound events so as to provide more accurate results to the analysts for review.

OPERATIONS CENTRE

A system for reporting and tracking problems in the IMS network was delivered to station operators. This software improves performance in PTS communications with station operators.

The state of health system was deployed in operations. The system software facilitates the tasks of monitoring and detecting incidents and problems in the IMS network (stations, GCI links, servers, databases, hardware, software, etc.).

A prototype of an 'alert manager system' was developed. It is currently in the testing phase in the Operations Centre. This system is able to detect incidents automatically on the basis of information collected in the state of health system.

A JIRA support system was fully established in operations for reporting and tracking incidents and problems. The requests sent to the PTS by authorized users, such as NDCs, station operators and Permanent Missions, are managed with this software.

NATIONAL DATA CENTRES

A National Data Centre is an organization with technical expertise in the CTBT verification technologies. Its functions may include sending IMS data to the IDC and receiving data and products from the IDC.

The PTS continued to provide the 'NDC in a box', a software package for use at NDCs, enabling them to receive, process and analyse IMS data. Efforts were also made to further improve the software.

A total of 114 secure signatory accounts, one for each requesting State Signatory, had been established by the end of the year, and 1191 users from these States Signatories had been authorized to access IMS data and IDC products and receive technical support.

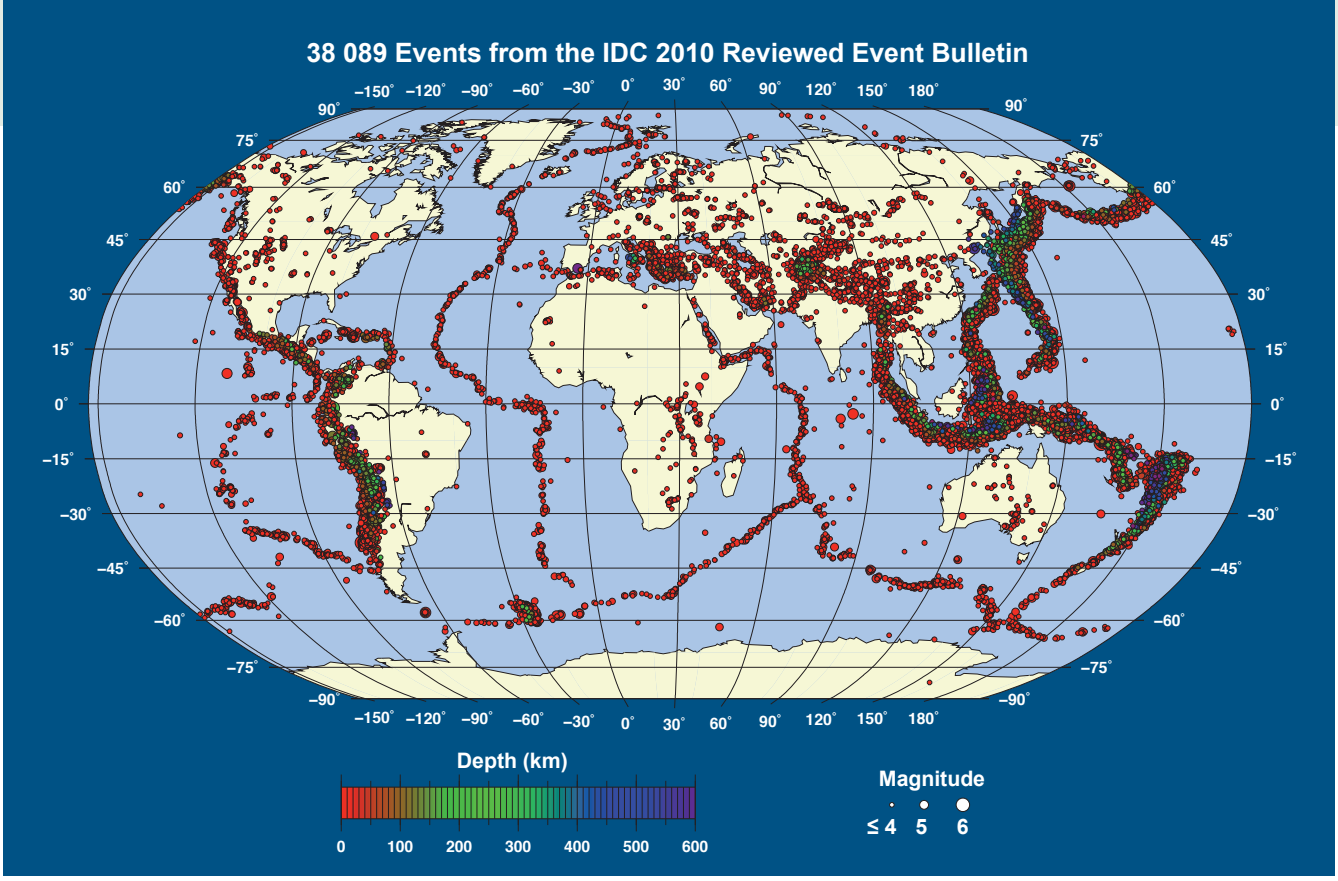
Work was continued on strengthening 14 NDCs, in particular in Africa, in Latin America and in South-East Asia, the Pacific and the Far East, by providing them with training, experts and basic equipment.

INTERNATIONAL NOBLE GAS EXPERIMENT

Additional noble gas systems were transferred into IDC operations during 2010. At the end of 2010, a total of 27 noble gas systems were in provisional operation at IMS radionuclide stations. Data from these stations are sent to the IDC and processed in the testing environment. Specific software to enable the monitoring of state of health parameters of these stations has been further developed.

Xenon analysis software for automatic and manual spectrum processing was developed further and is approaching the operational stage. Analysts were trained to use the review software. New procedures for product delivery using XML based techniques continued to be tested with some NDCs.

Distinguishing the civil anthropogenic background level of airborne radionuclides from radiation emissions due to Treaty-relevant events is still a challenging task that involves nuclear physicists, statisticians and meteorologists. The PTS has worked on understanding data collected from



the continuously increasing number of IMS noble gas systems in its database and created historical data sets for testing the method of categorization. Site specific descriptive parameters have been developed for use in attaching indicators to spectra and for distinguishing abnormal radioxenon concentrations from typical background. This has been done in cooperation with scientists from more than twenty institutions worldwide in the International Noble Gas Experiment (INGE) and discussed at workshops and scientific meetings.

Control room of the Operations Centre.

The European Union is supporting activities to explore the anthropogenic xenon background and to develop new mobile measurement systems for performing long term measurements of this noble gas in the field. In the first phase of this new project, container based noble gas measurement systems have been designed to allow autonomous operation under field conditions. The manufacture of two of these systems has been started. The systems are expected to be delivered to the PTS in mid-2011. After testing in Vienna, a two week training course is planned and thereafter the systems will be shipped to sampling locations.

Within the overall framework of quality assurance/quality control of IMS noble gas data and for the certification of noble gas systems, procedures to assess and validate the calibration of noble gas detectors have been developed. Within the regular quality assurance/quality control programme, 91 samples from

22 stations were reanalysed at five radionuclide laboratories with noble gas measurement capability. The comparison of station and laboratory analyses showed generally consistent results. The establishment of a regular scheme to remeasure samples is an important component of the quality assurance/quality control programme to ensure continued high quality of data after certification.

TRACKING RADIONUCLIDES THROUGH THE ATMOSPHERE

The CTBTO–WMO response system continued into its third year of provisional operation. This system enables the Commission to send requests for assistance in the case of suspicious radionuclide detections to nine Regional Specialized Meteorological Centres or National Meteorological Centres of the World Meteorological Organization located around the world. The centres respond to these requests by submitting their computations to the Commission with a target response time of 24 hours.

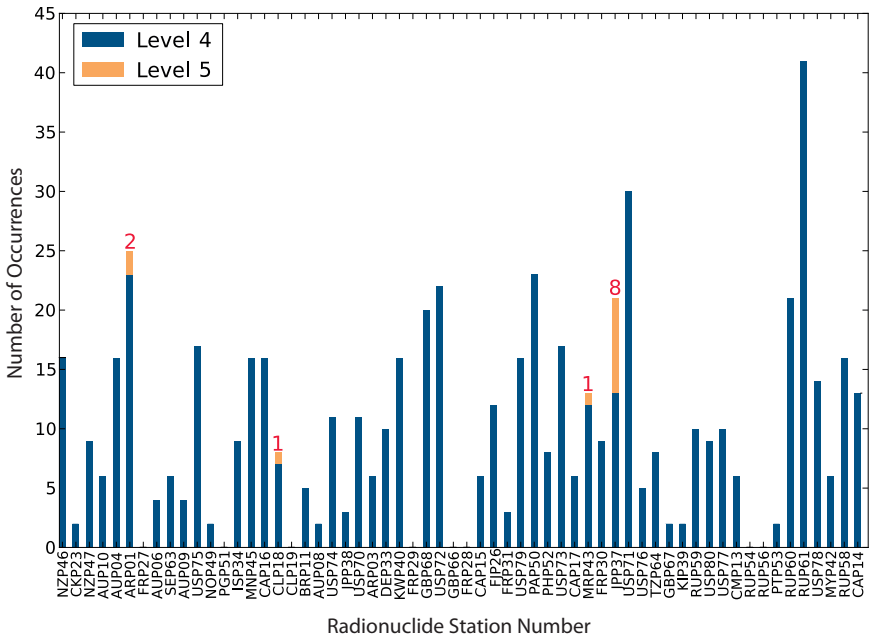
This system is intended to corroborate the backtracking calculations of the Commission, and all centres benefit from the feedback and evaluation of the backtracking systems and methods in use. To maintain the response system at a high level of preparedness, it was agreed that regular announced and/or unannounced system tests would be made.

The PTS continued to enhance its capabilities to perform atmospheric transport modelling and to reliably deliver high quality products to States Signatories. Atmospheric backtracking calculations are performed daily for each of the IMS radionuclide

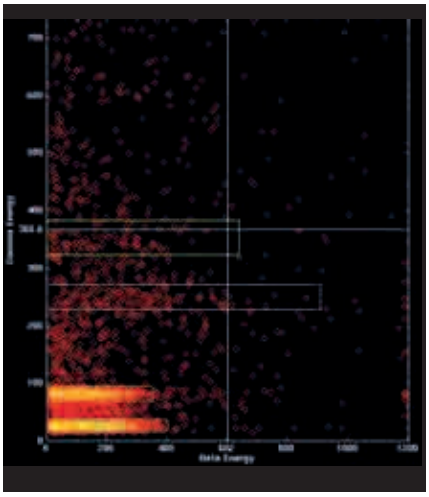
Overall Distribution of Treaty-Relevant Radionuclide Occurrences in 2010

Most detections refer to three nuclides, sodium-24, caesium-137 and cobalt-60, which are primarily due to cosmic radiation, to resuspension of fallout from the Chernobyl accident in 1986 or to historical atmospheric tests.

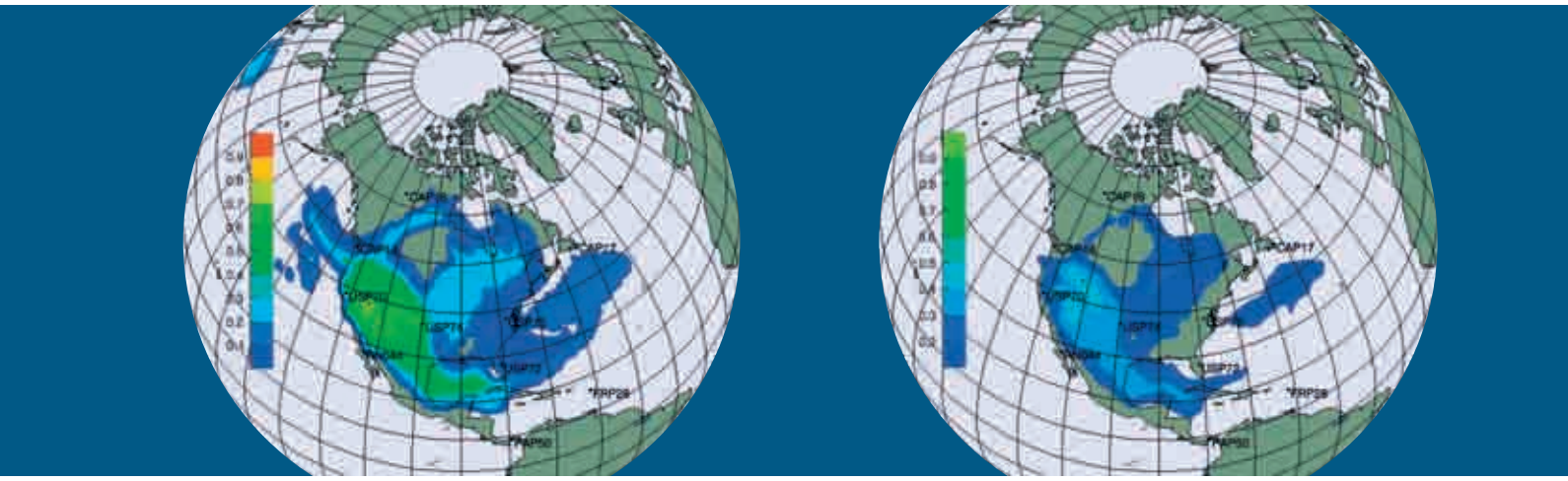
594 Level 4 and Level 5 Radionuclide Events Recorded During 2010 by IMS Stations in IDC Operations



A Level 4 radionuclide particulate spectrum indicates that the sample contains an anomalously high concentration of a single anthropogenic radionuclide (fission product or activation product) which is on the standard list of relevant radionuclides. A Level 5 radionuclide particulate spectrum indicates that the sample contains multiple anthropogenic radionuclides at anomalously high concentrations, out of which at least one is a fission product.



Coincidence histogram generated with the IDC processing package "bg_analyze/Norfy", which is used for analysing data from noble gas systems based on beta–gamma detectors.



Sample results of atmospheric transport modelling in the 2010 NDC Preparedness Exercise. The two figures present the calculated possible source region (PSR, shown in colour) for a fictitious release of radionuclides. *Left:* the PSR obtained using the backward modelling computations of the PTS. *Right:* the average PSR obtained from the backward modelling contributions of nine Regional Specialized Meteorological Centres of the WMO. In both cases the PSRs were built up by combining the projected fictitious detections made over the period 27–30 October 2010 at radionuclide stations of the IMS and using the PTS analysis software known as WEB-GRAPE. The two figures are similar, demonstrating that the WMO results confirmed the PTS calculations.

stations with near real time meteorological data obtained from the European Centre for Medium-Range Weather Forecasts. Using software developed by the PTS, States Signatories can combine these calculations with radionuclide detection scenarios and nuclide specific parameters to define regions in which sources of radionuclides are possibly located.

LESSONS LEARNED FROM THE SECOND ANNOUNCED NUCLEAR TEST BY THE DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA

On 25 May 2009, the Democratic People's Republic of Korea announced that it had conducted its second nuclear test. The monitoring system performed well on that occasion for a variety of reasons. The IMS network had grown considerably since the announcement by the Democratic People's Republic of Korea of its first nuclear test in 2006, with 65 stations having been certified during this time. A wide range of ongoing sustainment activities helped to ensure a high level of data availability. The key systems throughout the network, including the IMS, the GCI and the IDC, as well as NDCs, were running well. Bearing in mind that the PTS is operating under guidelines for provisional operation, it was fortunate that computer systems were running normally and that key staff were available at short notice to address issues as needed.

The relevant material concerning the second test was collected and distributed in a timely manner, beginning with the initial briefing for States Signatories which was held on the morning of 25 May 2009. All relevant information was posted on the IDC secure web site, which provided an optimum means of access for all users on a single web site. This event also served to demonstrate the importance of conducting a technical review of any verification related material prior to release by the organization.

While the event in the Democratic People's Republic of Korea appeared in the Standard Screened Event Bulletin (SSEB), the values of the IDC body wave magnitude and surface wave magnitude placed the event very close to the event screening 'decision line'. Following investigations and subsequent discussions by experts, a recommendation to modify this event screening criterion was implemented.

The forward atmospheric transport modelling predictions are dependent on the assumed venting or seepage from the event and are subject to uncertainty in the meteorological fields. These points need to be clearly conveyed in order to preclude any unrealistic expectations.

Although there were no radionuclide observations which could be associated with the 2009 event in the Democratic People's Republic of Korea, the IMS noble gas stations were functioning correctly and the observed data could be used to place a constraint on the level of containment of noble gases. The lack of indicative radionuclide observations in the IMS noble gas network also

Left: **laying optical fibre cables to integrate the database grid into the infrastructure of the storage area network.** ***Right:*** **servers in the computer centre.**

shows the importance of the on-site inspection (OSI) component of the verification regime. For an OSI, the local noble gas signatures may be detectable up to 4–6 months after an underground nuclear test in the case of venting or seepage.

TSUNAMI EARLY WARNING SYSTEMS

In November 2006, the Commission endorsed a recommendation to provide continuous IMS data in real time to recognized tsunami warning organizations. The Commission subsequently entered into agreements or arrangements with a number of tsunami warning centres approved by the United Nations Educational, Scientific and Cultural Organization (UNESCO) to provide data for tsunami warning purposes. In 2010, an agreement was finalized with the tsunami warning centre in France. This brought to eight the number of such agreements or arrangements that the Commission has entered into: with Australia, France, Indonesia, Japan, the Philippines, Thailand and the USA (Alaska and Hawaii). Additional agreements or arrangements were being developed with Malaysia and Sri Lanka.

TECHNOLOGY FORESIGHT

The Commission is engaged in a technology foresight exercise in support of its commitment to uphold the relevance of its technology-intensive system, as well as to ensure awareness of developments in science and technology that could enhance performance and efficiency of systems and operations. It is a continuous process whereby scientists and technologists meet, interact, debate and jointly define future courses for Treaty related research and development. This involves an iterative cycle of workshops on various themes, definition of pilot projects and funding of these projects from various sources.

In its current phase, the technology foresight exercise is focused on identifying the scientific and technological developments that may affect future PTS operations. The aim of this phase is to deliver a medium- to long-term integrated technology forecast for the Commission. Several steps have been taken to engage the organization and the wider science and technology community in this activity. The technology foresight initiative has been presented at a number of meetings, and a paper describing the approach and initial results has been distributed. A Web based collaboration platform is being developed and is expected to become fully operational early in 2011.

SCIENCE AND TECHNOLOGY 2011

Verification of compliance with the Treaty poses challenges whose resolution depends crucially on the promotion and exploitation of scientific research and technological developments. The credibility of the verification system being established by the Commission, and its ability to detect, locate and identify nuclear explosions both rely on a continuing engagement with the specialist communities that drive advances in relevant instrumentation, processing and analysis methods. Recognizing the strategic importance of this, initiatives taken by the Commission such as "Synergies with Science" in 2006 and "International Scientific Studies" (ISS) in 2009 have provided fora for it to interact with the global scientific community.

The publication issued after the ISS Conference, entitled *Science for Security: Verifying the Comprehensive Nuclear-Test-Ban Treaty*, provided an overview of its achievements and the dialogue which took place there. The conference also allowed a synthesis to be made of potential topics in the further refinement of the verification system. This will help to guide future priorities for enhancement of verification capabilities.

The outcomes of the ISS project are helping to shape the next initiative to engage the scientific community, which will be a conference on "Science and Technology 2011", to be held at the Hofburg Congress Centre in Vienna on 8–10 June 2011. Preparations for this conference are under way. A programme committee meeting was held on 26–28 August 2010, at which the goals and themes of the conference were decided. A call for papers was launched on 1 November on the public web site, which included an area for submission of abstracts and registration. The conference will place more emphasis on oral presentations than the 2009 ISS meeting and will address the issues of data access for scientific work and funding of technical and scientific work related to the activities of the Commission. Promotional efforts included the distribution of a brochure and a poster.

A project to establish a virtual Data Exploitation Centre (vDEC) was initiated at the end of 2009 and progressed during 2010. The project included a Workshop on Machine Learning and Earth Structure in Montpellier, France, in September. A legal framework has been put in place for scientists to access data on the platform free of charge.