

ISS09

INTERNATIONAL
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International Scientific Studies Conference Vienna, 10-12 June 2009

(In Cooperation with the Austrian Federal Ministry for European and International Affairs)

The International Scientific Studies Conference (ISS09), held in Vienna on 10-12 June 2009, brought together **SIX HUNDRED PARTICIPANTS** from **NINETY-NINE COUNTRIES**. It provided scientists and scientific institutions with a unique opportunity to present their **ANALYSES AND FINDINGS CONCERNING ALL ASPECTS OF THE COMPREHENSIVE NUCLEAR-TEST-BAN TREATY (CTBT) VERIFICATION SYSTEM**. The ISS aim is to foster the CTBTO Preparatory Commission's ability to keep pace with scientific and technological progress and to strengthen cooperation between the organization and the scientific community. The ISS project is a forum for building a durable and long term interaction with the scientific community at large.

Several panel discussions and keynote lectures focused on the capability and readiness of the CTBT verification regime to detect nuclear explosions worldwide. The conference also examined the scientific and technical progress since the Treaty opened for signature in 1996. More than **TWO HUNDRED POSTERS** were presented that covered the full



range of technologies related to the CTBT. They included, in addition, other cutting edge fields that have the potential to enhance substantially the effectiveness of the verification system, such as data mining and data exploitation. The poster exhibition was the first event ever where so many contributions were presented on all the science and technology areas relevant to CTBT verification.



Ban Ki-moon, Secretary-General of the United Nations: "In light of the announced nuclear test by the Democratic People's Republic of Korea on 25 May 2009, the ISS Conference is timely."



600 participants
from **99** countries



Tibor Tóth, Executive Secretary of the CTBTO Preparatory Commission: "Constant close interaction with the scientific community is not an optional undertaking for the CTBTO but a 'must' to remain credible."

Michael Spindelegger, Austrian Foreign Minister: "It is crucial to ensure that sufficient resources were devoted to the CTBT to complete the installation and certification of remaining monitoring stations. It is equally important that the international scientific

community continues to ensure that the Treaty and its verification system benefit from the latest scientific and technical developments."

remains difficult owing to the complex nature of wave propagation through the atmosphere.

It was noted that atmospheric explosions can also be detected by the seismic network, as seismic signals are created when atmospheric shock waves hit the ground. However, these signals are substantially weaker than those generated from an underground explosion.

The monitoring of radionuclide particulates and radioactive noble gases was considered to be the other key technology for the detection of

PANELS ON THE READINESS AND CAPABILITY OF THE CTBT VERIFICATION SYSTEM

Four panel discussions addressed issues related to the readiness and capability of the CTBT verification regime, focusing in particular on the International Monitoring System (IMS) and on-site inspection (OSI).

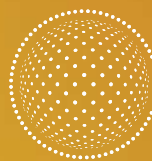
Panel 1: Explosions in the Atmosphere

A nuclear explosion in the atmosphere produces shock waves, thermal radiation and nuclear radiation. The infrasound and radionuclide technologies are therefore of most relevance for monitoring for such explosions.

Of these two technologies, infrasound has been undergoing a renaissance as an area of scientific study, particularly with the recent implementation of the CTBT

infrasound network, which is larger and more sensitive than any previously operated networks. Although the detection capability of the infrasound network can vary strongly, depending on atmospheric conditions, it was stated that explosions of 1 kiloton (kt) or even less can be detected around the globe. While detectable, estimating their locations with high precision using infrasound observations



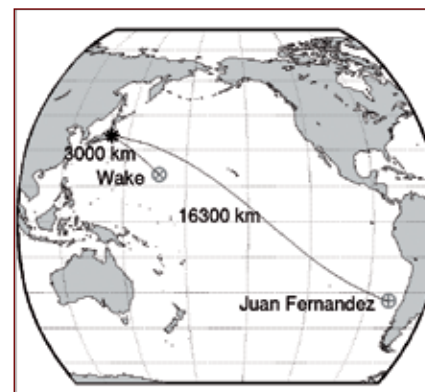


atmospheric nuclear explosions. Significant progress has been made in this field over the last decade, in particular with the establishment of the first ever network of noble gas detection stations. It was concluded that radionuclide measurements are today sensitive enough to detect any atmospheric nuclear explosion anywhere on the earth down to very low yields. Analysed in isolation, radionuclide observations can provide only limited information on the precise location of an event. However, greater precision can be achieved when such observations are combined

with information from other sources, such as infrasound and satellite observations.

Panel 2: Underwater Nuclear Explosions

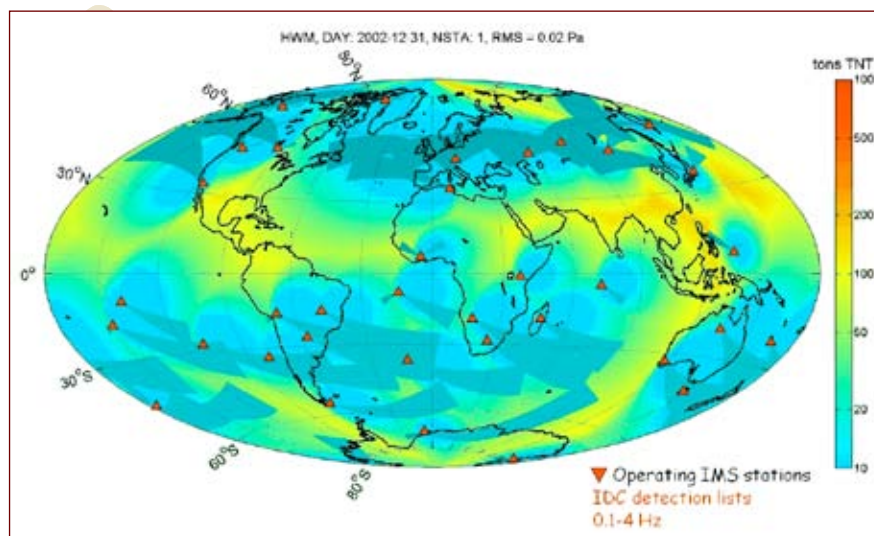
Hydroacoustic observations were considered in the discussions to be the key technology for the detection of underwater nuclear explosions. The example of an explosion of 20 kg of TNT off the coast of Japan was used to highlight the detection capability of this technology, where signals from the explosion were detected by IMS hydrophone sensors in the Juan Fernández Islands off the coast of Chile, about 16 000 km away. A natural waveguide in the oceans creates these extremely favourable conditions for the propagation of hydroacoustic waves. Consequently, this provides for a capability to monitor explosions in the oceans that is orders of magnitude greater than in any other environment. The hydroacoustic network is not



Hydroacoustic detection of a 20 kg underwater charge.

designed to detect signals from the Arctic Sea as this area is well covered by the highly sensitive seismological networks of the Northern Hemisphere. This was used as a good example to highlight the complementary nature of the different IMS monitoring technologies.

Another relevant feature of underwater nuclear explosions is that both radionuclide particles and, in particular, radioactive noble gases will most likely be released into the atmosphere. Such releases therefore



Infrasound detection capability.

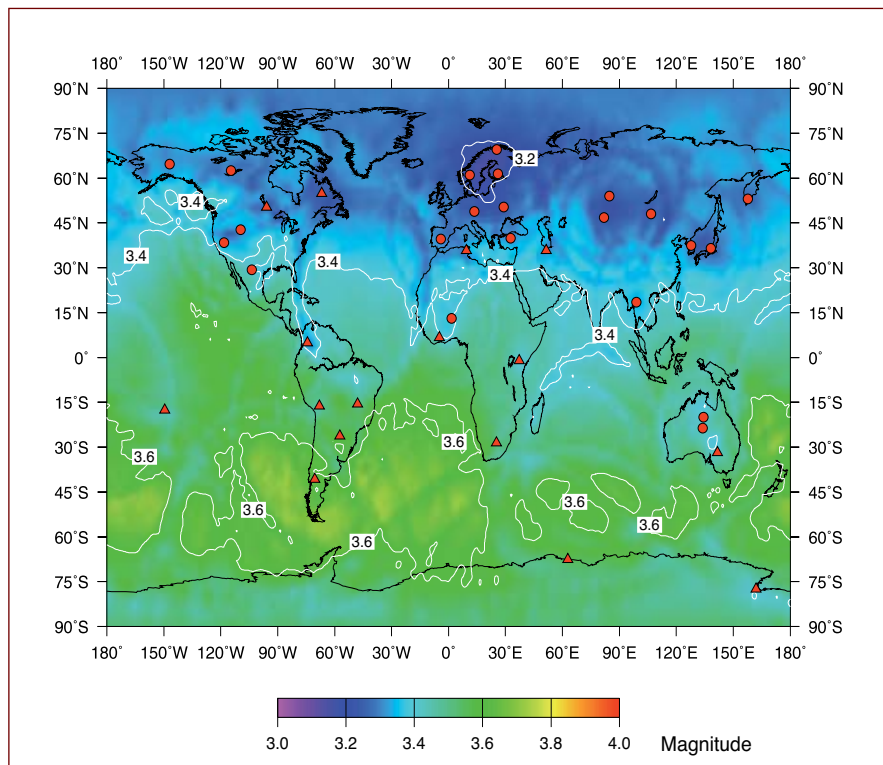
have a high probability of being detected by the radionuclide monitoring stations of the IMS.

Given the exceptional ocean monitoring capabilities of the IMS, there is a high degree of certainty that any underwater nuclear explosion would be detected. In such a case, the main obstacle would be the identification of the perpetrator. This question of attribution would be addressed by the States Signatories using nuclear forensics or any other national technical means at their disposal.



Panel 3: Underground Nuclear Explosions

The detection of underground nuclear explosions was seen as representing a particular challenge when compared with the detection of atmospheric and underwater explosions. This is due to the fact that most of the fissile components produced during a nuclear explosion, in other words the evidence of a nuclear explosion, remain in the resulting cavity. In addition, no obvious surface effects may be



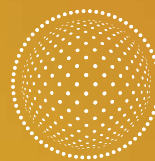
IMS detection capability in 2007.

observed following an underground explosion. Much work has thus been devoted over the last 60 years to ways of overcoming these challenges. Efforts have focused on enhancing the seismological monitoring technology and also, during the last decade, on the observation of radioactive noble gases.

Significant improvements of the seismic monitoring networks over the last 10 years were identified by the panel, with continued improvements expected over the forthcoming decade. In particular, it was noted that the IMS seismic network is capable, with a high degree of probability, of detecting globally any event with a magnitude greater than 4, which is generally assumed to correspond to an explosion of the order of 1 kt.

However, there is strong regional variation in this detection capability. An example showed how events one order of magnitude, or 10 times, smaller can be detected in many parts of the Northern Hemisphere. It was also discussed how States Signatories can use data from the large number of high quality stations operating for seismological purposes that are not part of the IMS, which means that they will be able to detect and locate even smaller events in most regions of the world.

To locate an event with a high degree of precision is an essential part of seismological monitoring. The complexity of the earth, with its strong regional variations, makes it important to calibrate the travel times using events with known



locations. At the current level of development, events can be located with an uncertainty of about 20 km in most parts of the world. In well calibrated areas, and with observations well distributed in all azimuths around the event, the precision of location will increase further.

The panel noted that seismic monitoring is complicated by the large number of earthquakes that occur every day. The responsibility of distinguishing seismic observations from earthquakes and nuclear explosions and of making a final assessment on the nature of an event rests with States, as specified in the Treaty. The panel discussion highlighted the fact that seismological observations alone cannot distinguish between a nuclear and a chemical explosion. In their final assessment, States may also use other observations, such as radionuclide measurements, or any other information related to the event that may be available.

Radionuclide observations will provide definitive evidence of the nuclear nature of an explosion. The radioactive noble gas xenon is the most likely radioactive substance to be observed from an underground nuclear test. Xenon is produced in large amounts, stays inert and travels long distances. It is therefore the element most likely to leak from a cavity created by an explosion and be detected. Actual release of xenon depends on a number of factors, still not fully understood, including geology, depth and the way the explosion is conducted and sealed. The half-life of the nuclear

isotopes involved is a limiting factor, giving a window of opportunity of only approximately three weeks after an event to detect a noble gas release.

The use of radionuclide technology to detect and locate underground nuclear explosions was discussed at length, particularly in light of the nuclear explosion announced by the Democratic People's Republic of Korea on 25 May 2009. No noble gases have been detected by the IMS from this event. After the first nuclear explosion announced by this country in October 2006, radioactive xenon detected at an IMS station in Canada was traced back to its likely source in the Democratic People's Republic of Korea. Three factors were identified as generally determining whether a release of noble gases can be detected or not: how much is released, how the gases are carried by the wind and the sensitivity of the detector system itself.

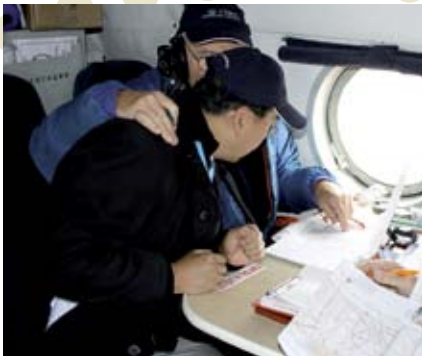
Panel 4: On-Site Inspection

The possibility of conducting intrusive on-site inspections after entry into force of the Treaty was considered an essential element of the CTBT verification regime. The panel discussed in detail the procedures leading up to an OSI, in particular the process of calling for an inspection. This involves scientific analysis and political assessments of data provided by the IMS and any other data or information available to a State, followed by a decision on whether or not to request an OSI. A request then has to be approved by the Executive Council of the CTBTO. Comparisons were made with processes that exist in the monitoring functions of the Organisation for the Prohibition of Chemical Weapons and the Strategic Arms Reduction Treaties as well as in the inspections by the International Atomic Energy Agency. A particular challenge for an OSI in the context of the CTBT is the rapid decay and



subsidence of evidence near any perceived event location. This is particularly the case with radionuclide releases and seismic aftershocks.

The Integrated Field Exercise carried out in Kazakhstan in September 2008 showed the feasibility of deploying an on-site inspection team in a challenging environment and conducting activities over a prolonged period. The panel



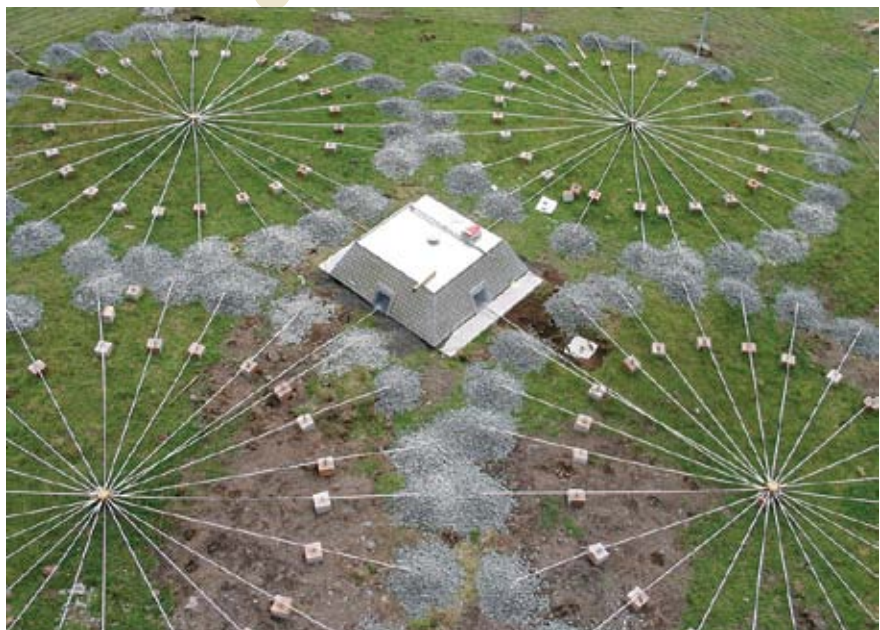
discussion concluded that this exercise produced many valuable lessons on logistics and on how to manage an OSI. It was noted that the inspection team during an OSI can use many geophysical and radionuclide technologies and that there is a clear need to better understand how these technologies can be used to detect evidence of a nuclear explosion. It was also noted that much of the knowledge needed resides in the scientific community, in particular within the geo-exploration sciences.

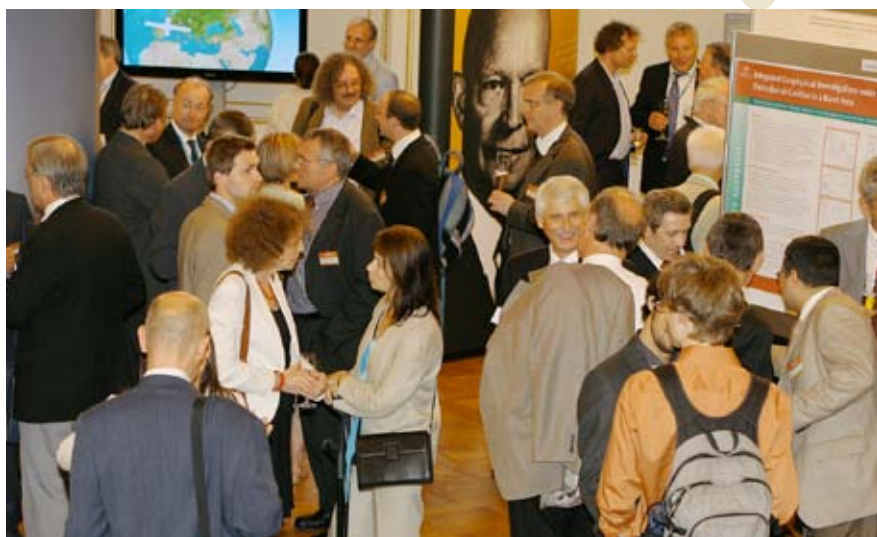
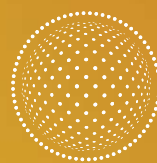
SCIENCE AND THE CTBT

On day 2 of the ISS Conference, scientific contributions to CTBT verification were presented in the form of posters and, in addition, keynote lectures provided overviews of the different scientific areas covered by the conference.



Contributions on infrasound described the detection capability of the IMS infrasound network and how that capability varies strongly with atmospheric conditions. To understand the complex infrasound signal propagation in the atmosphere, a number of studies had been conducted on the basis of observations of natural phenomena,





Contributions on OSI covered a broad spectrum of the geophysical technologies available for an inspection. On the basis of experience with the use of those techniques for civil applications, it was discussed how they may be used for OSI purposes. Several studies examined radionuclide monitoring in the context of an OSI. Contributions also addressed issues related to the planning and conduct of an inspection and the importance of having a systemic perspective on an OSI. In addition, experiences and lessons learned from the large scale exercise conducted in 2008 were presented.

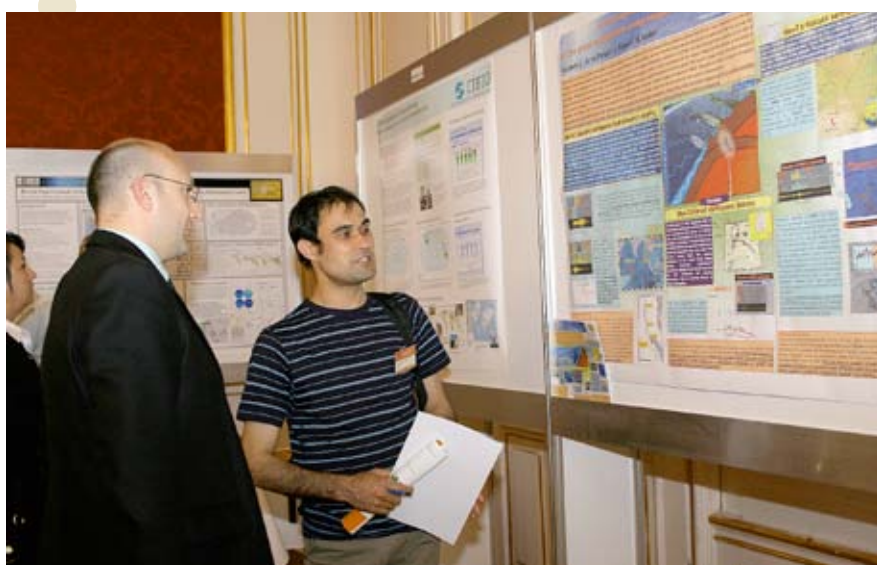
such as meteorites and cyclones, and accidental explosions. Other contributions addressed the scientific and civil applications of infrasound technology to monitor volcanic eruptions and to improve our understanding of the atmosphere, which might be of interest in relation to climate change studies.

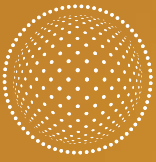
Studies presented on hydroacoustic technology illustrated the exceptional wave propagation in the oceans leading to a very high detection capability. New methods and algorithms for detection and localization of hydroacoustic sources were introduced. A number of studies addressed hydroacoustic observations of whales and the calving of icebergs, and the possible use of hydroacoustic observations to study long term variations in the temperature of the oceans.

The large number of posters on seismology focused on assessing the detection and location performance of the IMS and on how to identify signals as coming from earthquakes

or explosions. Several thousand seismological stations are operating around the world for scientific or emergency response purposes and their capability and usefulness for CTBT verification were addressed. Studies were also presented on new methodologies that could improve the seismological capability, taking into account our increasing knowledge of the three dimensional structure of the interior of the earth.

The presentations on radionuclide technology related both to the IMS and to OSI. A number of contributions described major scientific advances in the monitoring of noble gases over the last 5-10 years. These studies addressed technical developments of the monitoring equipment and discussed how to further improve its





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sensitivity and reliability. Studies were also presented on xenon background levels on a global scale and on efforts to screen out the disturbing releases coming from medical isotope production facilities.

Atmospheric transport modelling (ATM) is carried out to understand how radionuclide material is transported from a source to monitoring stations. ATM presentations reflected scientific studies to improve existing models, especially on how to increase the resolution and include small scale atmospheric conditions. Contributions also focused on the application of ATM within the CTBTO Preparatory Commission and

on studies of specific events. Other important issues addressed were how to validate the models and how to apply them for meteorological and other civil purposes.

Several contributions on system performance addressed the IMS from a holistic point of view. Other studies considered the performance of the different components of the verification system, such as the timeliness, completeness and quality of the IMS data collection and management system, including the global communication system. Also presented were studies of the timeliness and quality of the bulletins provided to States Signatories as a result of the analysis

at the International Data Centre in Vienna.

The dramatic developments in the area of data mining and data exploitation and their relevance for CTBT verification were recognized already at the CTBTO symposium on "Synergies with Science" in 2006. During the ISS Conference, different techniques and computational methods for improving the performance of a system based on past experience were presented. More specifically, the focus was on scientific developments that might be used to improve the analyses of the vast amounts of data recorded by the IMS. A great potential was identified for advanced data mining and data exploitation techniques, including machine learning, to be used to enhance the detection and location capabilities of the IMS monitoring network and to reduce uncertainties. Some applications to improve seismological data analysis procedures used by the CTBTO Preparatory Commission have already been identified and are being developed with scientific institutions. Ideas were also presented on how data mining procedures might facilitate the analysis and interpretation of data and information collected during an OSI.

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