North Korea: a real test for the CTBT verification system? Part II: noble gas observations

by MSc Paul R.J. Saey, Dr Andreas Becker and Dr Gerhard Wotawa

Part I of this article in *CTBTO Spectrum* 9 described the analysis method and results obtained from waveform data for the event that took place in the Democratic People's Republic of Korea (DPRK) on 9 October 2006. The Provisional Technical Secretariat (PTS) made a location and time determination of the event in the Reviewed Event Bulletin (REB), which is sent out to all States Signatories. While waveform data are utilized for event location and could be used to differentiate between an earthquake and an explosion, detections of relevant radionuclides or noble gases are the prerequisite to identify the nuclear origin of an event unambiguously. But only a detection of them at one of the International Monitoring System (IMS) radionuclide or noble gas stations could provide the PTS with the input to assist the State Signatories in identifying the DPRK event as having a nuclear origin.

In order to spot the potentially relevant IMS radionuclide stations, PTS utilized its atmospheric transport modelling (ATM) expertise. ATM provides updated information on the propagation of a possible release of radioactivity into the atmosphere based on the most accurate weather analysis globally available.

Radioactive release and the significance of noble gas

If a nuclear explosion took place in the atmosphere, above ground or insufficiently contained below ground, a large amount of debris would be ejected and transported by the wind. Once these particles passed an IMS radionuclide station, they would be measured and a signal identifying the origin of these radioactive particles would be found. In the case of the DPRK event, the closest IMS radionuclide particulate stations that could capture the signal were located at Takasaki and Okinawa in Japan and at Sand Point in Alaska. They did not measure any relevant radionuclides after the event. Even a re-measurement of the filters in CTBT-certified laboratories did not reveal any traces of a nuclear test.

However, a well contained underground explosion is not expected to release any particulates into the atmosphere. Noble gases created by the explosion may nevertheless leak out, and IMS noble gas stations would alone be capable of indicating that the event was nuclear. The time the gas needs to reach the surface is dependent on its diffusivity, upon the power of the explosion and upon the underground environment. It is reasonable to assume that a more immediate venting would eject a substantially larger fraction of the available noble gas than a later seepage.

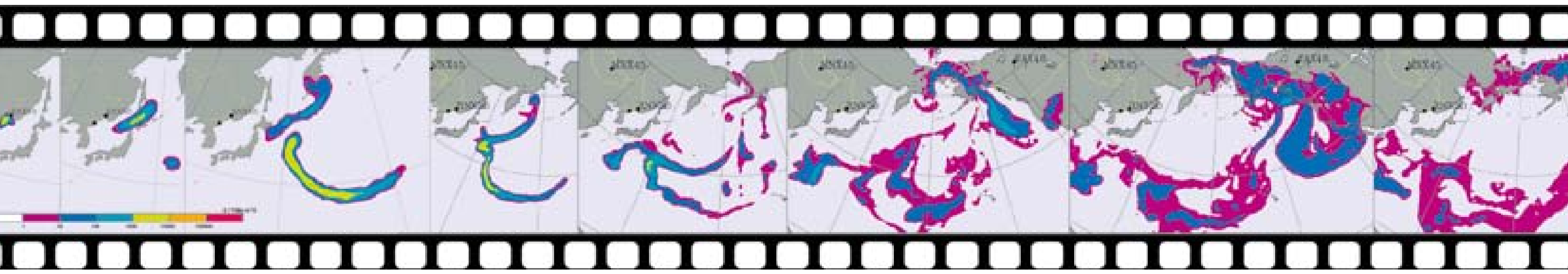
The build-up of the noble gas system

When the PTS was established in 1997, no noble gas monitoring systems were commercially available that fulfilled the IMS minimum requirements. Therefore, the International Noble Gas Experiment (INGE) was established to design, develop, build, install and test such machines (see also *CTBTO Spectrum* 1 and 8). By October 2006, ten of the planned forty experimental noble gas stations had been installed. No station was close to the DPRK. At the time of the event it was thus an open question whether the amount of release would allow for a detection at an operating station, located in the direction of the plume and requiring intercontinental transport of air over thousands of kilometres.

Xenon-133 detections at Yellowknife, Canada

According to ATM calculations, the debris would reach the nearest operating noble gas station in Yellowknife, Northern Canada, on 22 October 2006 with two peaks on the 23rd and 27th. Interestingly, alternative forward ATM calculations with up to two days delay in release times predicted the same double peak signal. This indicates that the peak pattern at Yellowknife was rather shaped by the geographical conditions (i.e. mountain ranges in Alaska and Northern Canada) than by the release time of the device.

The station in Yellowknife detected, as predicted, above-background levels of xenon-133 on 21 and 25 October with somewhat lower



THE ABOVE FILMSTRIP SHOWS FROM LEFT TO RIGHT THE MOVEMENT OF THE XENON-133 PLUME IN TERMS OF CALCULATED GROUND LEVEL CONCENTRATIONS ASSUMING A SURFACE EMISSION OF 10^{15} BECQUEREL AT THE TIME AND COORDINATES OF THE 9 OCTOBER EVENT. THE SCENE ON THE FAR LEFT ILLUSTRATES HOW THE PLUME STARTS TRAVELLING TO THE EAST, WHILE THE SHOTS ON THE FAR RIGHT SHOW THE PLUME ARRIVING AT THE YELLOWKNIFE STATION (CAX16).

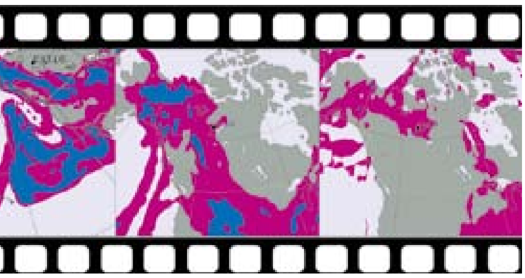
Secretariat snapshots

values between 22 and 24 October, thus resembling the calculated double peak pattern. Backtracking calculations were evaluated to exclude other known sources of noble gas from facilities closer to the station. Consequently, the ejection of xenon-133 characteristic for a one-kiloton nuclear explosion on the Korean peninsula at the time of the REB event was the most realistic source scenario to explain the observed concentration pattern in Yellowknife.

Conclusion

The Yellowknife detection of the DPRK test demonstrated that noble gas stations are capable of providing evidence of the nuclear character of an event, even though the network is not complete. Once the complete verification system is in place, the fusion of data from the radionuclide and waveform networks in conjunction with state of the art atmospheric modelling will provide an unprecedented system for locating and identifying nuclear events. ■

MSc Paul R.J. Saey is a nuclear physicist working as a PTS Radionuclide Officer, Dr Andreas Becker and Dr Gerhard Wotawa are meteorologists, both working as PTS Atmospheric Sciences Officers. The three were involved in the set-up and operation of the PTS noble gas and atmospheric transport systems utilized for the characterization of the DPRK event.



A new platform for exchange with the scientific community

by Dr Andreas Becker and Dr Frank Graeber

“The success and efficiency of our verification regime relies on a permanent dialogue with scientific institutions about the latest developments in their areas of expertise and their adaptation to our needs”.

These words by the CTBTO Executive Secretary, Tibor Tóth, in his opening address to the CTBTO scientific symposium held in Vienna in 2006 encouraged staff members of the Secretariat to initiate a new scientific session on “Research and Development in Nuclear Explosion Monitoring” at the General Assembly of the European Geosciences Union (EGU). The event, with more than 8000 participants, was held in April 2007 in Vienna.

42 contributions underline importance of meeting

The session was designed to provide a forum for all verification technologies. Forty-two papers were submitted that covered all relevant fields, including seismology, infrasound, hydroacoustics, nuclear physics and atmospheric backtracking. A variety of topics critical for detection, location and characterization of nuclear explosions, including case studies based on natural and man-made events were presented.

PTS contributed 17 papers

By contributing 17 papers, the Provisional Technical Secretariat (PTS) increased the visibility of the CTBTO, thus contributing to enhanced public awareness of the Preparatory Commission’s work. Lassina Zerbo, Director of the International Data Centre Division, presented an overview of the CTBTO monitoring system and four other papers described the system in more detail. Many fruitful discussions were initiated among PTS staff members and the Conference participants that may serve as a basis for enhanced activities with the scientific community.

How to detect and localize an event?

Accurate event characterization was one of the main topics of the session as this constitutes a key challenge for each of the CTBT verification technologies. Natural and man made sources, particularly smaller events, may generate signals, which to a certain extent display properties similar to those originating from Treaty-relevant sources. The correct discrimination of such signals poses a significant challenge to the monitoring system and to the automatic and interactive processing software. This requires research and development in quite different fields, depending on the technology in question.

Infrasound

A better understanding of infrasound propagation in a dynamic atmosphere greatly improves the association of signals and the location of events. However, experimental verification of propagation predictions for high altitude infrasound sources recorded at long ranges is difficult to perform due to the rarity of upper air explosion events. Henry Bass, Director of the National Center for Physical Acoustics at the University of Mississippi, presented a paper on an experiment involving moderately sized high altitude explosions. Six other external and two PTS papers presented case studies (e.g. the Buncefield fuel depot explosion in December 2005 near London, United Kingdom) and studies on the capabilities of certain infrasound arrays with regard to event characterization and monitoring of upper atmospheric dynamics.

Hydroacoustic

One of the two hydroacoustic papers presented initial results from a controlled source experiment in the southern ocean, which was designed to study errors in predicted estimates of transmission loss and source location. A PTS paper described a method for identifying seismic waves at IMS hydrophone triads, which represents a good example for positive synergy effects between waveform technologies.

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