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Backtracking of noble gas measurements taken in the aftermath of the announced October 2006 event in North Korea by means of the PTS methods in nuclear source estimation and reconstruction

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In brief: The announced October 2006 event in the Democratic Peoples Republic of Korea (DPRK) has been the first real test of the technical capabilities of the Vienna based Provisional Technical Secretariat (PTS) to the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) to detect and locate a nuclear test event. As the meteorological situation governing the East Asian region in the time of regard has been discussed previously (Becker et al., 2007a) this paper stepwise demonstrates the backtracking results and conclusions that have been taken on the DPRK event based on the Yellowknife measurements only, the mobile measurements by Ringbom et al. (2007) in the Republic of Korea (ROK) only, and finally tries to reconcile and constrain the analysis on basis of both measurements. The presentation will illustrate the backtracking studies done at the PTS related to the announced October 2006 event in North Korea, which provides an example for the kind of forensic studies needed to clarify the nuclear character of potentially treaty relevant detections in the PTS IMS system.

Additional details: To provide analysis of possible source regions explaining the measurements the PTS has developed and operates a backtracking system yielding so-called source-receptor sensitivity (SRS) field data files for each radionuclide (RN) sample raised in the IMS (Wotawa et al., 2003, Becker et al., 2007b). In its stan-

dard configuration the backtracking system runs the diagnostic Lagrangian Particle Dispersion Model (LPDM) FLEXPART Version 5.1 (Stohl et al., 2005) on basis of the 4DVAR analysed wind field data retrieved at 1 degree horizontal and 3 hours temporal resolution from the European Centre for Medium-Range Weather Forecasts (ECMWF). Recently this system has been extended to cover also the xenon samples raised in the network of the International Noble Gas system.

Using this backtracking system the radioactive noble gas observations at Yellowknife, Canada, were shown to be consistent with a hypothesised release of radioactive Xenon at the time and location of the October 2006 DPRK event (Saey et al. 2007a, b) as follows:

- The Yellowknife measurements have been sensitive into the DPRK event region during the 9, 10 and 11 October 2006.
- An initial release of ^{133}Xe on the order of 10^{15} Bq at the October 2006 event location in DPRK is needed to explain the measurements
- However, the remote character of the Yellowknife detections in time ($>$ 12 days) and space ($>$ 7000 km) yields an unavoidable inaccuracy in the backtracking so there was an insensitivity of the detections towards the assumed release time across the first 72 hours past the event time.
- The Yellowknife measurements alone could neither fully constrain the xenon-133 release scenario nor be conclusive on the nuclear part of the October 2006 event attribution.
- However, additional constraints could be derived from the Yellowknife stations' fingerprint information comprising the history of the three years of xenon measurements taken before. They helped to exclude other known sources of man-made radionuclides by scale analysis of the release strengths required at any point on the globe to reproduce the detections encountered. This is done by folding the release assumptions with the data base of source-receptor sensitivities raised and updated at the PTS (Wotawa et al., 2008). Applying this method, no other known xenon source then a release during the announced October 2006 event in North Korea is consistent with the Yellowknife detections.

In contrast to the global source-receptor distance of the Yellowknife measurements the mobile measurements at Kansong, Republic of Korea (ROK), raised and published by Ringbom et al. (2007) constitute a regional geo-temporal ($<$ 250 km, $<$ 2 d) source-receptor distance the backtracking problem regarded. Consequently the accuracy of

the applied backtracking was enhanced by an accordingly refined spatial resolution (0.2 degrees) of the backtracking model systems set-up. Backtracking in this set-up revealed that the October 2006 measurements at Kansong where sensitive into the area of interest, however, rather 2-4 days after the DPRK event time!

- The Kansong measurements show a strong sensitivity to the DPRK event location for 11, 12 October (days 3 and 4) and a much weaker one for 10 October (day 2).
- The absence of sensitivity of the Kansong measurements for the 9 October (day 1) across the DPRK event, does not tell, that there has been no release during this time, but it does also not confirm it.

Using PTS standard and enhanced backtracking for both, the Yellowknife and the ROK measurements reveals that they monitored essential parts of the release scenario of the October 2006 event in North Korea.

- The joint evaluation of the measurements indicate that the measurements in Yellowknife and in South Korea ARE NOT INCONSISTENT regarding the release, they just monitored different temporal parts of the whole (probably rather complex) scenario
- The Kansong measurements indicate, that there has been a later seepage of ^{133}Xe during days 2-4 after the event (10-12 October) with a total release of 1.5-6x10^{13} Bq
- This seepage needs to be distinguished from the initial release of 1x10^{15} Becquerel immediately after the event that presumably led to the Yellowknife detection. The temporal course of this initial release can range from immediate venting to a release stretched across the first 24-36 hours after the explosion. For the latter the Kansong measurements served the constraint.
- Additional measurements with sufficient sensitivity during the first two days after the event are missing or not published yet. They are needed to entirely resolve the release scenario caused by the DPRK event.
- In a full-scale INGE network, however, the two 12 hourly samples taken at day 1 (10 October) at station RUX58 would have resolved almost all of the remaining uncertainties of the emission scenario for day 1. Another station Takasaki (JPX38) would have contributed to the monitoring of the DPRK event location

during day 2. Unfortunately the installation and certification of both stations was not completed at the time.

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