ISS Topic Area Atmospheric Transport Modelling: The operational CTBTO-WMO Atmospheric Backtracking Response system for CTBT Verification-Status and plans

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Summary

In the last 10 years, CTBTO and WMO designed and tested a unique atmospheric backtracking response system. This system gives CTBTO the opportunity to request support from Regional Specialized Meteorological Centres around the globe in the event that anomalous radionuclide detections are encountered in the International Monitoring System (IMS). The Centres then, in near-real time, compute Source Receptor Sensitivity (SRS) Fields pertaining to the measurements under scrutiny, to supplement the PTS in-house computations. The response system entered into the PTS provisional operations on 1 September 2008. In order to ensure its full functionality, regular tests and exercises are held. The last exercise took place in October/November 2008 and was a full success. The atmospheric backtracking ensemble modelling approach improves the reliability and credence of radionuclide source location results, and takes into account the uncertainty of the meteorological analyses and the transport simulations (see Becker et al., 2007).

Description of the Response System

Currently, eight WMO Regional Specialized Meteorological Centres and the National Meteorological Centre Vienna are part of the CTBTO-WMO response system (see Figure 1; Chen et al., 2009). Whenever an anomalous measurement at an IMS Radionuclide (RN) station is encountered (Particulate RN network, noble gas network), CTBTO sends out requests for support, specifying the coordinates of the stations as well as start and stop times of the measurements. So-called Source Receptor Sensitivity (SRS) fields (see Wotawa et al., 2003) are requested not only for the station where the anomalous sample was encountered, but for the neighbouring sites as well. The WMO Centres deliver their results within 24 hours. The SRS fields (Unit: m⁻¹) are computed by means of backward (adjoint) atmospheric transport modelling and have a horizontal resolution of 1° and a temporal resolution of 3 hours.

Radionuclide source location analysis and data fusion

Based on a RN measurement scenario, CTBTO uses SRS fields to compute a possible source region for the radionuclide(s) measured. A measurement scenario cᵢ is defined as set of i concentration measurements at m different stations, at least one of which has a non-zero (or above detection limit) concentration value. One can calculate the respective concentration scenarios resulting from all nₓ×nᵧ×nₚ different grid cell source scenarios (or elementary source scenarios) as follows

\[ c_{i,k} = M_{ij} S \]

where \( c_{i,k} \) is the set of i concentration measurements pertaining to the respective elementary source scenario, and \( M_{ij} \) is the SRS field pertaining to the measurement a, is a constant source factor, for example 10⁻¹⁵ Bq. Afterwards, one can correlate the measurement scenarios resulting from the elementary source scenarios with the true measurements. Regions with high correlation coefficients mark grid cells in space and time where an elementary source would yield a resulting set of measurements that is consistent with the observations.

The geo-temporal correlation fields can be overlaid with events recorded with other monitoring technologies, for example seismic emission signals. This analysis is called radionuclide-seismic data fusion, and helps to establish whether the suspiscious radionuclide measured by the IMS could possibly have originated from a seismic event recorded at the same location and time (see Figure 2). CTBTO uses the software WEB-Grape for source location and data fusion analyses (see Chen et al., 2009). This tool was developed by a contractor and is distributed to all Member States.

CTBTO-WMO Exercise 2008

As part of the National Data Centre (NDC) Preparedness Exercise 2008 (NPE 2008), a CTBTO-WMO Exercise was conducted. The following scenario was developed:

- The NDC Germany selected a seismic event from the seismic event list 1 (SEL1; see Figure 3)
- A forward transport model was used to identify affected radionuclide stations and to compute (hypothetical) tracer concentrations
- The CTBTO Fusion officer receives the hypothetical measurement scenario according to the true operational timelines

Results of the exercise 2008

During the exercise 2008, the main (hypothetical) detection scenario was encountered at IMS RN station 2 for 24-hour samples with collection stop between 29 October and 2 November 2008 (RN002; see Figure 4). The influence of other stations was much weaker. CTBTO sent out requests for support to WMO Centres at five consecutive days, covering the detections at station RN002 and the non-detections at four neighbouring sites. Since source location results did not change any more after five days, the exercise could be discontinued. The response of the WMO Centres was within technical specifications and timely. The sources cases overlap with the seismic error ellipses (see Figure 5) identified two seismic events that lie within or close to a correlation maximum. CTBTO and WMO Centre source location results were relatively similar. The selected seismic event was among these two identified ones.

Conclusions

The CTBTO-WMO response system in atmospheric backtracking is in CTBTO provisional operations since 1 September 2008. Since then, the system is triggered every time an anomalous RN measurement is encountered within the IMS particulate network (Level-5 detection), which happened five times to date. No requests for support have been sent out regarding noble gas detections, because a NG categorization scheme is not in place yet. One full-scale CTBTO-WMO exercise has been held in autumn 2008. During all operational cases and the exercise, the response system worked very well. WMO Centres delivered timely and within the defined technical specifications. CTBTO staff used the WMO results for source location and data fusion purposes.

References


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