WORLD METEOROLOGICAL ORGANIZATION

COMMISSION FOR BASIC SYSTEM

COORDINATION GROUP ON
NUCLEAR EMERGENCY RESPONSE ACTIVITIES

MELBOURNE, AUSTRALIA, 5-9 MAY 2008

CBS-DPFS/CG-NERA/Doc. 9.3
Rev.1

(28.IV.2008)

ITEM: 9

Original: ENGLISH

THE CTBTO-WMO EXERCISE 2007-OBJECTIVES, SCENARIO AND MAIN RESULTS

(Submitted by CTBTO Preparatory Commission, Provisional Technical Secretariat)

Summary and purpose of document

This document describes the objectives, the assumed scenario and the results of the joint CTBTO-WMO Exercise 2007 in Atmospheric Backtracking after a hypothetical nuclear explosion. The exercise took place in December 2007 and involved the PTS, 7 RSMCs and 2 NMCs.

Proposed Action

The Group is invited to review the results of the joint Exercise, and to consider and discuss further steps for improvement.

Purpose of the exercise

The CTBTO-WMO Exercise 2007 was a part of the CTBTO/PTS “Small-scale Focused Test” (SFT) Program. “Small-scale” in this context means that only a limited part of the whole Verification System was checked in one test. The exercise served the following purposes:

- To test and benchmark the PTS-WMO cooperation in Atmospheric Transport Modelling
- To test and benchmark the IDC capability of seismoacoustic-radionuclide data fusion
- To develop and test procedures and their related products

The following WMO Centres participated (see also Annex I):

RSMC Beijing (China)
RSMC Exeter (United Kingdom)
RSMC Melbourne (Australia)
RSMC Montreal (Canada)
RSMC Obninsk (Russian Federation)
RSMC Toulouse (France)
RSMC Washington (United States)
NMC Offenbach (Germany)
NMC Vienna (Austria)

The composition of this group is formed along quite similar requirements compared to that of the ENSEMBLE project (Galmarini et al., 2004) as far as its spread in geographic location and ATM methodology is concerned.

Description of the exercise

Similar to the previous tests between CTBTO and WMO, an atmospheric transport model in forward mode was applied to construct an artificial measurement scenario at the radionuclide stations of the International Monitoring System after a hypothetical nuclear explosion. In this exercise, the release location was the epicentre of a selected seismic event from the Standard Event List 3 as produced by the PTS. The selection of the scenario as well as the forward computation was done by an independent scenario production group. The group then passed on the synthetic measurements to the section in the PTS tasked with monitoring and data analysis, taking into account the exact timelines from the operational manuals regarding RN monitoring and data analysis after Entry into Force of the treaty. This section was not informed about the scenario assumptions. Under the procedures agreed on before, the PTS then issued “Requests for Support” to the participating WMO RSMCs and NMCs, taking into account the detecting sites as well as non-detecting surrounding sites. The whole experiment schedule is described in Annex II. As the scenario evolved, requests were sent during 10 consecutive days, involving a total of 102 different radionuclide measurements. The RSMCs/NMCs sent their backtracking results to the PTS within 24 hours after notification. The PTS used these computations to produce source location results, which were updated daily, and to fuse (overlay) these results with all seismic events recorded during the period of interest, with the aim of identifying the event selected by the scenario generation group. The results of the automated and interactive analyses were attached to the PTS Secure Web Page for access by PTS authorised users.

Scenario

The scenario generation group selected a SEL3 seismic event on 2 December 2007 20:21:47 UTC at Latitude 36.5706°, Longitude 29.789 0°, located on the territory of Turkey.

The event selection process was done according to predefined and standardised criteria[1]. The associated forward model computation assumed an instantaneous release of 10^{15} Bq of a passive tracer from the exact event location. The forward model then indicated 77 detections with activity concentrations above 0.1 mBqm^{-3} within the first 15 days after the event. The first detection occurred on 7 December 2007 at a site in Russia. This is Day III of the experiment schedule (Annex II). The evolution of the plume in the first week is illustrated in Annex III. According to the operational timelines, this sample would haven been categorized by 10 December 2007 morning Vienna time, and the first notification to WMO Centres was sent out by noon that day. Further notifications were sent out daily, until 19 December 2007. On this day, the notifications were discontinued because there was no further change in the source location results.

Response statistics

The 9 participating WMO Centres delivered 917 of the 918 data sets requested. In 87% of the cases, the delivery was in time. In 76% of the cases, delivery was timely and technically correct. The response rate and timeliness of the responses has substantially improved compared to preceding experiments. For further detail consult Annex IV

Main results in terms of source location, data fusion and ensemble modelling

PTS/IDC used the Web-Grape software (PTS, 2005) for interactive source location (ATM) analysis. The software worked well for the source location task (Annex V). However, as the scenario progressed and the amount of data processed increased, performance issues were encountered. PTS/IDC issued 10 data fusion bulletins, which were put on the secure web page. All bulletins were issued timely according to the expected schedule for normal business hours.

Regarding fusion capability, the source location results allowed PTS/IDC to locate the SEL3 event within 150 km and 20 hours (Annex V). Two other SEL3 events in the same geo-temporal space could not be distinguished from the **selected** one as they were located too close in space and time. Therefore an exact fusion spotting the right one of the three remainders was not possible, but the right one was never screened out, except for the second detection day.

In the December 2007 experiment, only at this second detection day (Day IV of the experiment schedule shown in Annex II) a substantial improvement of the source

[1] The first 3-4 SEL3 events after 1 Dec 2007 00:00:00 UTC are selected for further consideration if they are:

- On-shore events within latitude ranges 60S-20S or 20N to 80N with epicentres more than 10 degrees from each other
- located using more than 6 defining phases

Finally the SEL3 event will be chosen from this shortlist on basis of ATM predictions aimed at maximizing the number of stations which are predicted to be "touched" in the following 10 days.

- Time elapsed from SEL3 origin time to predicted first detection by a RN station: 3 – 6 days
- Forward ATM from selected SEL3 epicentre confirms that virtual detections will exceed 10 mBq/m3 for a 1 kT underground explosion.

```
Result: EVENT  4481537 TURKEY
               Date; Time            2007/12/02; 20:21:47.72
               Latitude; Longitude   36.5706; 29.7890
               Smaj; Smin            40.3; 23.3
               Az; Depth; Err        138; 0.0f;
```

location was encountered from the multi-model (ensemble) modelling approach. At this day the source location derived from the PTS model would have screened out the selected SEL3 event in contrast to the ensemble model's location. For all other days the benefit of the ensemble approach was limited to the confirmation of PTS source location and interactive analysis results.

The overall mutual agreement of the models has substantially improved since the last CTBTO-WMO experiment in 2005. One reason for this lies in the fact that now all models utilized at least 10^3 or much more particles per sample for the backtracking calculation, in contrast to 2005 where some models utilized only 500 particles (or centres of puffs). Another reason stems from the fact that the modelling took place in the northern hemisphere across landmasses. There is an improved quality of the wind field analysis there versus the southern hemispheric which was the case in the 2005 experiment.

Summary

In December 2007 the 3rd CTBTO-WMO response experiment took place as part of the CTBTO/PTS "Small-scale Focused Test" (SFT) Program. The exercise served the following purposes:

- To test and benchmark the PTS-WMO cooperation in Atmospheric Transport Modelling
- To test and benchmark the IDC capability of seismoacoustic-radionuclide data fusion
- To develop and test procedures and their related products

The real-time testing of the PTS-WMO Atmospheric Backtracking Response System was successful, although certain improvements in communication and timeliness are required. Nevertheless the response rate and timeliness has substantially improved compared to all preceding experiments. The IDC capabilities regarding data fusion were demonstrated, and a first set of procedures was worked out and implemented. A daily Data Fusion Bulletin product was issued, which can serve as a template for future requirements specification of this additional product of the CTBT verification system.

References

Becker, A., Wotawa, G., De Geer, L.-E., Seibert, P., Draxler, R.R., Sloan, C., D'Amours, R., Hort, M., Glaab, H., Heinrich, P., Grillon, Y., Shershakov, V., Katayama, K., Zhang, Y., Stewart, P., Hirtl, M., Jean, M., Chen, P. (2007), Global backtracking of anthropogenic radionuclides by means of a receptor oriented ensemble dispersion modelling system in support of nuclear-test-ban treaty verification. Atmospheric Environment, 41, 4520-4534

Wotawa, G., Becker, A. and De Geer, L.-E. (2006), PROPOSAL FOR A TECHNICAL IMPLEMENTATION OF THE CTBTO-WMO ATMOSPHERIC BACKTRACKING RESPONSE SYSTEM FOR CTBT VERIFICATION PURPOSES, WMO Document CBS-DPFS/CG-NERA//Doc. 8.3.

De Geer, L.-E., Wotawa, G. and Becker, A. (2006), A CTBTO-WMO Response System, WMO Document CBS-DPFS/CG-NERA//Doc. 8.1.

PTS, 2005: A new tool for NDC analysis of atmospheric transport calculations. *CTBTO Spectrum*, **7**, December 2005, pages 19 and 24. http://www.ctbto.org/reference/outreach/spectrum_issues_singles/ctbto_spectrum_7/p19.pdf

Wotawa, G., Becker, A. and L.-E. De Geer, 2004: Cooperation between CTBTO and WMO: The first co-ordinated CTBTO – WMO Experiment 2003 – Summary, Lessons learned and steps towards a future operational implementation, WMO Document CBS/ERA/CG/Doc. 8.2.

Becker, A., Wotawa, G. and L.-E. De Geer (2004): Review on new PTS modelling capabilities supporting the emerging CTBTO – WMO response system including a proposal for standardised model inter-comparison. WMO Document CBS/ERA/CG/Doc. 8.3.

Galmarini S. et 30al, (2004), Ensemble dispersion forecasting – Part I: concept, approach and indicators. *Atmospheric Environment* **38**, 4607-4617.

PTS, 2004: Technical Report CTBT/PTS/TR/2004-1, 77 pp, Preparatory Commission for the Comprehensive-Nuclear-Test Ban Treaty Organisation, Provisional Technical Secretariat, P.O. Box 1200, A-1400 Vienna, Austria.

Wotawa, G. et al. (2003), Atmospheric transport modelling in support of CTBT verification - Overview and basic concepts, Atmospheric Environment, 37, 2529-2537.

Wotawa, G. and De Geer, L.-E. (2001), Cooperation with the CTBTO, WMO Document CBS ERA/COG/Doc.8(1).

Annex I: Participants in the December 2007 CTBTO-WMO experiment and their modelling approaches

Participant	Name of Organization	WMO ID	Met. Input Data	resolution	Model Used
WMO RSMC Melbourne	Bureau of Meteorology, Australia	AMMC	NMOC, GASP	2.5°x2.5°, 6h	HYSPLIT V4.7
WMO NMC Vienna	Austrian Met. Service, ZAMG, Vienna	*ATNC*	ECMWF, 4DVAR	1°x1°, 3h	FLEXPART V5.0
WMO RSMC Beijing	China Meteorological Administration, China	BABJ	CMA, GDAS	0.56°x0.56°, 3h	HYSPLIT V4.6
CTBTO, PTS Vienna	Provisional Technical Secretariat, CTBTO	*CTBT1*	ECMWF, 4DVAR	1°x1°, 3h	FLEXPART V5.1
CTBTO, PTS Vienna	Provisional Technical Secretariat, CTBTO	*CTBT2*	US NCEP, GDAS	1°x1°, 6h	FLEXPART V5.1
WMO RSMC Montreal	Canadian Meteorological Centre, Canada	CWAO	CMC, GDAFS	1°x1°, 6h	MLDP0 V Global
WMO RSMC Exeter	Meteorological Office, United Kingdom	EGRR	MetOffice, Re-An.	0.55°x0.83° 3h	NAME V8.12
WMO RSMC Washington	NOAA Air Resources Laboratory, Maryland, USA	NARL	US-NCEP, GDAS	1°x1°, 3h	HYSPLIT V4.6
WMO RSMC Toulouse	Meteo France, France	MEFR	ARPEGE-Tropique	0.5°x0.5°, 3h	MOCAGE-Accident
WMO RSMC Obninsk	ER Centre of Roshydromet (FEERC), Russia	RUOB	FEERC, SMA	1.25°x1.25°, 6h	STADIUM V2
WMO NMC Offenbach	Deutscher Wetterdienst (DWD), Germany	RTHO	GME, DWD	0.5°x0.5°, 1-6h	GME-LPDM V2.1

Annex II: Schedule of scenario creation and 3rd CTBTO - WMO experiment

Chosen SEL3 event at: ***Sunday, 2 December*** (**1st detection** happens at **Day III, 1st request** happens at **Day VI, *Monday, 10 Dec***):

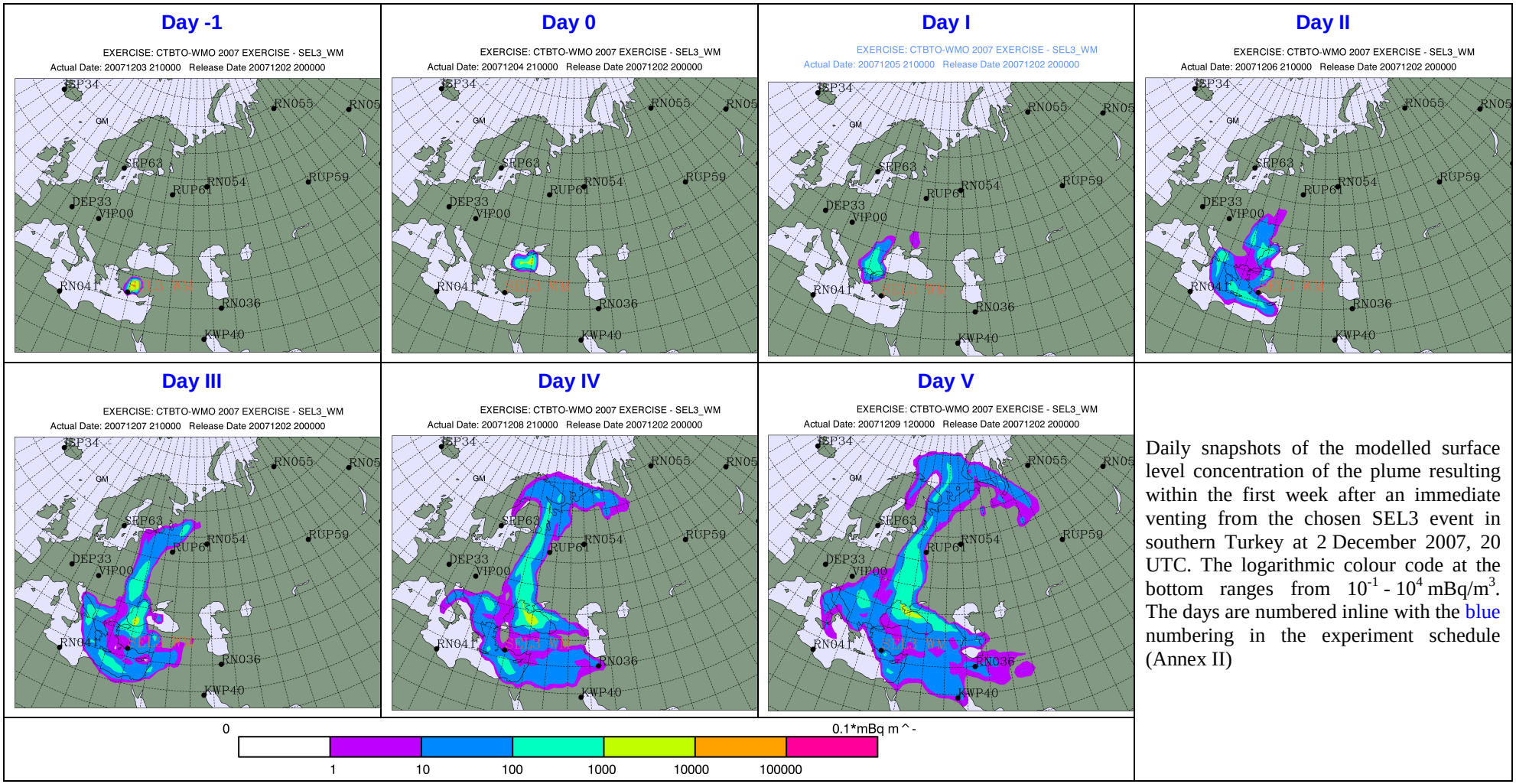
- The SEL3 day can be also earlier (01- 03 December) depending on the travel time of the plume until the 1st detection (**Day IV**, **V** or **VI**)
- If no SEL3 events meet the criterion at this or the former days, the table dates shift forward until the day where a suitable SEL3 event is found

IDC only																					
Week Day	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**0**	**1**	**2**	**3**	**4**	**3**	**3**
Date in 2007 week	**1201**	**1202**	**1203**	**1204**	**1205**	**1206**	**1207**	**1208**	**1209**	**1210**	**1211**	**1212**	**1213**	**1214**	**1215**	**1216**	**1217**	**1218**	**1219**	**1220**	**1221**
SRS field Evaluation 1:00-1:04 AM	**Possible event days**				**Shortlist possible SEL3 Events**				**Select Source Web-Grape-ECAL & 1st FA S Run**												
1st FA-Scenario (S) Run	CS days covered				1		2	3		**1st Run**											
2nd FA S Run	Additional CS days covered								4	5	6			**2nd Run**							
3rd FA S Run	Additional CS days covered											7	8	9		**3rd Run**					
4th FA S Run	Add. CS days covered														10	11	12		**4th Run**		

All Participants																					
Date in Dec 2007	**SA**	**SU**	**MO**	**TU**	**WE**	**TH**	**FR**	**SA**	**SU**	**MO**	**TU**	**WE**	**TH**	**FR**	**SA**	**SU**	**MO**	**TU**	**WE**	**TH**	**FR**
	01	**02**	**03**	**04**	**05**	**07**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Day	**-3**	**-2**	**-1**	**0**	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**XIII**	**XIV**	**XVIII**	**XIX**	**XX**
Course of virtual nuclear scenario		**SEL3 Event**			**RN detection at CS day**		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**					
	RN categorization available for CS day								**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**			
IDC performs by 8 UTC										**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**		**IDC internal report**
										support request released to the participants											
Participants perform by 8 UTC											**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**	
											provision of requested backtracking results										

1st Forward Analysis (FA) Run starts at Day VI: Forward Simulation Time: 120 hours (5 days) covering Days 0, I to IV, (V)
2nd FA run starts at Day IX: Forward Simulation Time: 192 hours (8 days) covering Days 0, I to VII, (VIII)
3rd FA run starts at Day XII: Forward Simulation Time: 264 hours (11 days) covering Days 0, I to X, (IX)
4th FA run starts at Day XV: Forward Simulation Time: 336 hours (14 days) covering Days 0, I to XIII, (XIV)

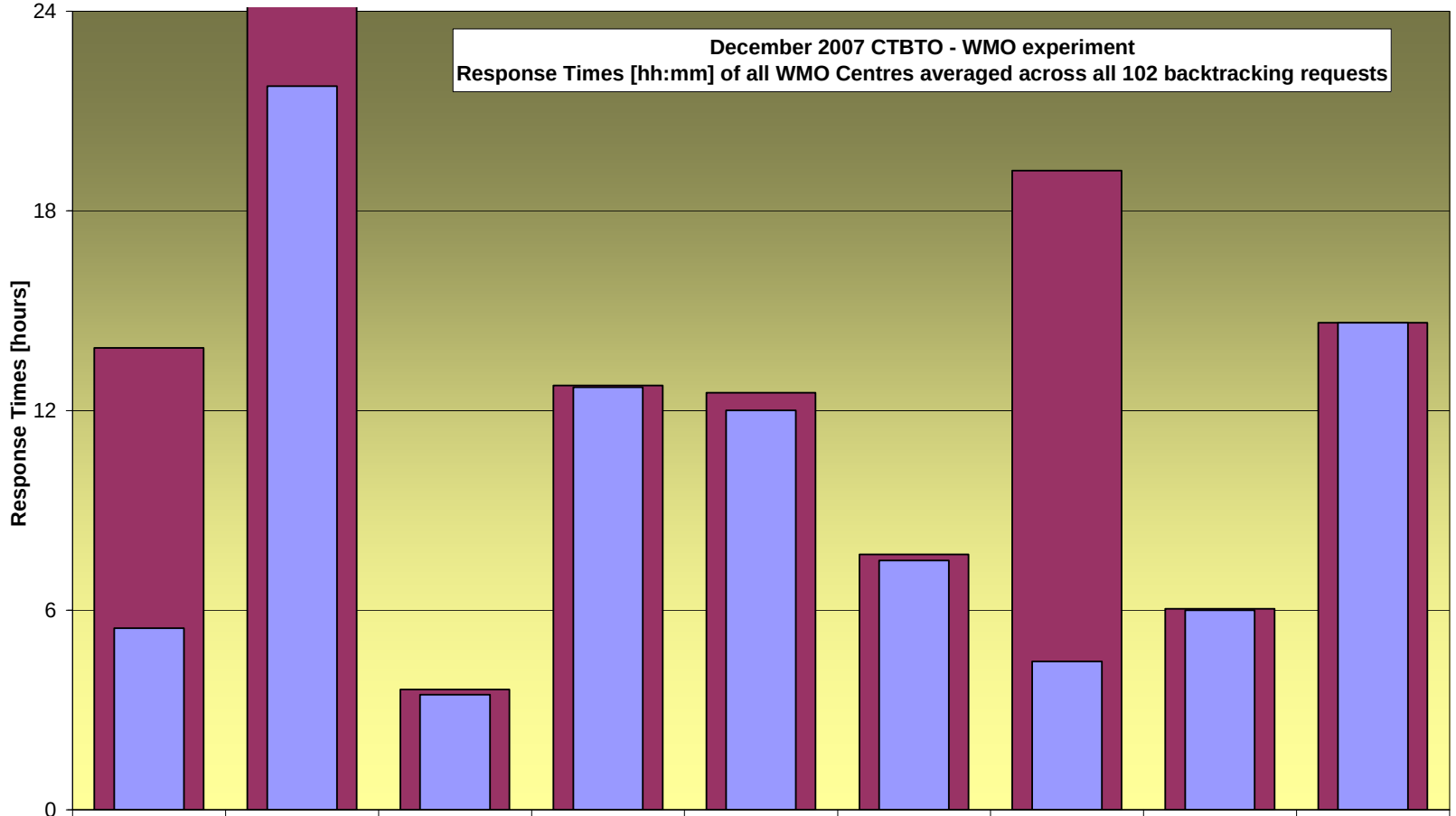
Annex III: First week evolution of the simulated nuclear plume scenario of the 3rd CTBTO - WMO experiment



Daily snapshots of the modelled surface level concentration of the plume resulting within the first week after an immediate venting from the chosen SEL3 event in southern Turkey at 2 December 2007, 20 UTC. The logarithmic colour code at the bottom ranges from 10^{-1} - 10^{4} mBq/m^3. The days are numbered inline with the blue numbering in the experiment schedule (Annex II)

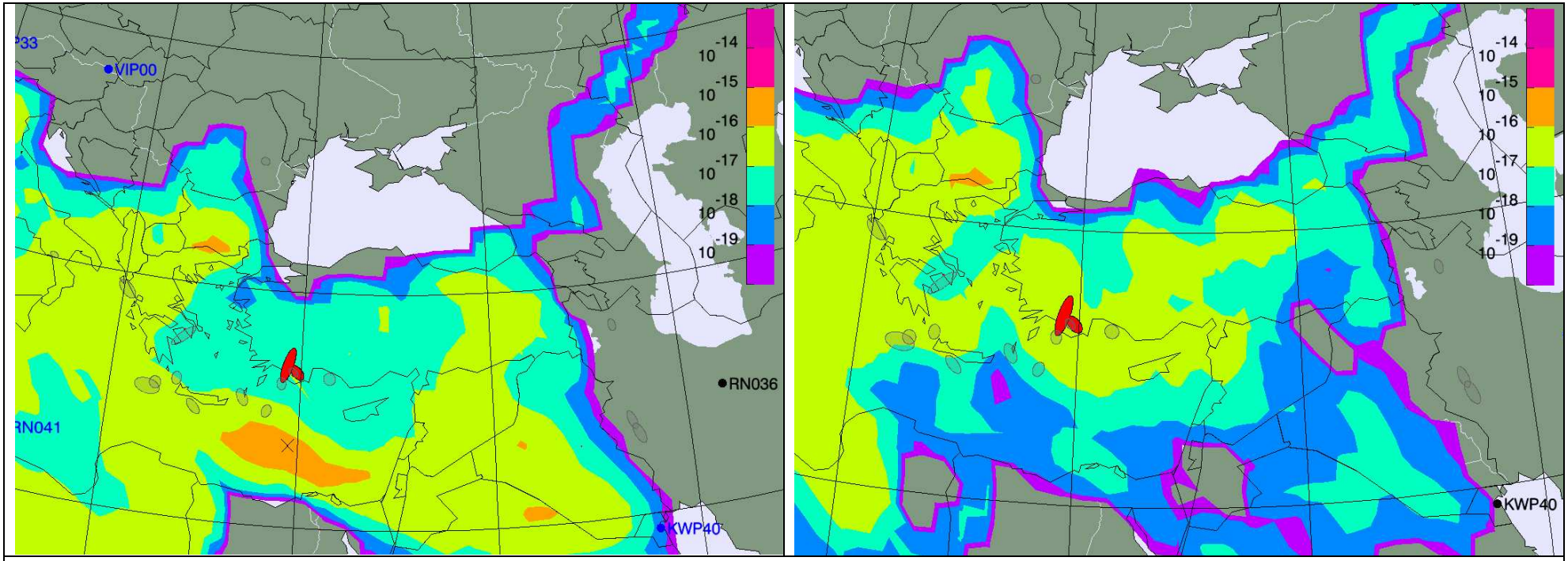
Annex IV: Response rate during the December 2007 3rd CTBTO – WMO experiment

- The 10 days detection scenario involved 102 samples and thus 102 requests for SRS fields from 20 different RN stations
- PTS received in total 917 of 918 (99.89%) requested SRS fields during the December 2007 exercise
- 799 of 918 (87%) of requested SRS files where delivered in time, i.e. within 24 hours since release of request Email
- At any of the 10 days there where at least 9 WMO and/or NDC centres responding the request. The overall percent age was 100%
- At any of the 10 days there where at least 7 WMO and/or NDC centres responding in time. The overall percentage was 90%
- 6 participants (NMC Offenbach, RSMCs Exeter, Beijing, Montréal, Melbourne, Toulouse) responded complete and in time across all requests



	RSMC Washington	RSMC Obninsk	NMC Offenbach	RSMC Exeter	RSMC Beijing	RSMC Montreal	RSMC Melbourne	RSMC Toulouse	NMC Vienna
Final SRS file arrived	13:52	25:21	3:36	12:45	12:32	7:40	19:12	6:02	14:38
First SRS file arrived	5:27	21:45	3:27	12:42	12:00	7:29	4:27	6:00	14:38

Annex V: Backtracking of SEL3 based nuclear source including Data Fusion



Quantitative Field-of-Regards post-processed with WEB-GRAPE on basis of the PTS backtracking results for the simulated RN samples at RN036 (Teheran, top graph) and KWP40 (Kuwait, bottom graph), collection stop date 12 December 2007. The 3 hours covering the SEL3 period are plotted showing an increased sensitivity into the SEL3 region in particular for the Kuwait station.

Annex VI: Model Agreement, January 2005 vs. December 2007 experiment

Comparison of the WMO centres Overlap (Figure of Merit in Space) during January 2005 and December 2007 experiments. The left box shows the best congruent case of the 55 samples examined in January 2005 (Becker et al. 2007). The right box shows an arbitrarily chosen case with regard to the 102 backtracking requests examined during the December 2007 experiment. It is noticeable that this case outperforms the best case of January 2005 in terms of model agreement and overlap visualized for the three hours time period indicated in the calendar of the PTS post-processing software *WEB-GRAPE*. The better wind field analysis on the northern hemisphere might be one explanation for the better overlap in 2007.

Best congruent case in 2005		An average case in 2007 (1st detection of predicted scenario)	
RN Station Sample Overall Agreement / Overlap	NZP46; 26 January 2005; 6 UTC 50.90% / 42.11%	RN Station Sample Overall Agreement / Overlap	RUP61; 07 December 2007; 06 UTC 54.19% / 50.01%