

Ad Hoc Expert Group for the Evaluation of Atmospheric Models Used at the PTS for Radionuclide Transport

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Introduction

An **ad hoc** expert group is formed under the auspices of the Provisional Technical Secretariat (PTS)¹ for the evaluation of meteorological tools used at the PTS. The experts shall review the performance of the atmospheric transport models available at the PTS and provide advice to develop these tools, if required. For practical details, see sections 4 and 5.

Atmospheric transport calculations are needed to identify possible source regions for radionuclide events and to perform fusion (i.e. co-association between events detected by several technologies) between seismoacoustic and radionuclide events. Within the PTS, the International Data Centre (IDC) has in-house capabilities (Release 2 software) for atmospheric transport modeling (HYSPLIT and OMEGA), including interface to a commercial visualization tool (EDGE). In order to describe possible regions from which detected radionuclides might have been originated, so-called Field of Regard (FOR) are determined (see Appendix 1). HYSPLIT is used for FOR calculation on a routine basis. The results are incorporated in Reviewed Radionuclide Reports (RRR), whereas OMEGA is intended for special cases providing increased accuracy, especially for FORs to be included in the Standard Screened Radionuclide Event Bulletin (SSREB) for Level 4 and 5 events.

Outside the PTS, the national meteorological centres have developed various dispersion models. These models could be used for the evaluation of the calculations performed within the PTS.

The activities of the ad hoc expert group are envisaged as follows:

- (a) Review the evaluation plan to have joint understanding of the content of the evaluation process (see the tasks below).
- (b) Perform the relevant analyses using tools already available at the national meteorological centers.
- (c) Compare results of national models with the results achieved by the PTS tools.
- (d) Provide proposals, as appropriate, for the improvement and future development of operational software at the PTS.

Evaluation Tasks

The experts are asked to consider PTS capabilities to model atmospheric transport with regard to single radionuclide stations and with regard to the whole station network on a global scale.

Evaluation of IDC Atmospheric Modeling for Single Stations (Task 1)

- (a) PTS selects the evaluation period (30 consecutive days starting from an announced first data day).

¹ Evaluation Section (Office of the Executive Secretary) in cooperation with the Scientific

- (b) PTS selects the sites (stations) which are used for the evaluation (only 5 stations will be used).
- (c) PTS generates FORs with three different methods: HYSPLIT backward analysis and forward analysis mode, as well as OMEGA forward analysis mode. This is done with different meteorological input data sets: MRF data from NCEP/NOAA, GEM data from CMC and if available, German model data from the DWD.
- (d) The experts identify with their models those regions which they consider are the sources of hypothetical anthropogenic radioactive material in the samples collected at the station. As far as possible, relative weight should be assigned to each identified region. Possible indicators might be release time information (e.g. from isotopic ratios), overlap of possible source regions related to different stations, as well as derived minimum source region concentrations. If possible, turbulent mixing, dilution and scavenging (e.g. wash-out by rain) should be taken into account in order to derive the release activity at any spot that could lead after a given transport time (e.g. 24, 48, 72 hours) to air concentrations of 10 or 30 $\mu\text{Bq}/\text{m}^3$ for Ba-140 and 1 $\mu\text{Bq}/\text{m}^3$ for Xe-133 averaged over the sample collection period of 24 hours at the radionuclide station site.
- (e) The experts compare FORs with their results.

Evaluation of IDC Atmospheric Modeling of the Station Network (Task 2)

Regarding scenarios for nuclear explosions it makes sense to divide the globe into two regions, oceans and land masses. All experts from the group use the same definition (initial proposal from the PTS).

The sources are assumed to be either on sea or land with arbitrary locations. No prejudice should be given to any particular region. Detection capability calculations are performed as follows:

- (f) PTS selects the evaluation periods (25 periods of 14 days covering all seasons).
- (g) The 79 known sites from the Treaty for radionuclide particulate stations as well as the 39 defined sites for gaseous samples are used (possible coordinate changes are provided by the PTS).
- (h) PTS uses the backward analysis mode of HYSPLIT to generate a combined FOR for 3, 5, 10, and 14 days. This is done for both the particulate and the gaseous sample networks and differentiated by sea and land.
- (i) The experts apply whatever method they think is appropriate to estimate the part of the globe (differentiated by gas and particulate network as well as by source regions on sea and land) from which a radioactive emission on surface level would be detectable at a radionuclide station. Normalized detection levels in each region should be calculated for different seasonal conditions. If possible, dilution and scavenging should be taken into account by using an assumed source strength of 2.4 PBq for Ba-140, 0.13 PBq for Xe-133 on land, 13 PBq for Xe-133 on sea and an assumed detection limit of 10 or 30 $\mu\text{Bq}/\text{m}^3$ for Ba-140, 1 $\mu\text{Bq}/\text{m}^3$ for Xe-133.

Guiding Evaluation Questions

The following questions should guide the evaluation work:

- (j) Are the models currently used at the IDC scientifically sound?
- (k) Are the meteorological input data used by the IDC adequate?
- (l) Is the Field-of-Regard approach adequate or are there alternatives?
- (m) What improvements on input data, modeling methodology and presentation of results can be recommended with regard to the current IDC software?
- (n) Are there other models or other input data that could be recommended as possible alternatives?
- (o) Given the uncertainties in the meteorological analysis plus the uncertainties in the dispersion calculations, what can be achieved in "assisting State Parties to identify the

source of specific events?" What information should be prepared, and in what form should it best be reported?

Practical Considerations

As adopted by the 13th session of the Preparatory Commission (CTBT/PTS/INF.293/Rev.1), the 2001 Programme and Budget includes for the major Programme 5 (Evaluation) resources for ad hoc expert group meetings in Vienna. In such ad hoc expert groups, specialists are engaged to provide advice to the Preparatory Commission. The Commission support is limited to travelling costs and to Daily Subsistence Allowance. Costs, such as personal fee, translation or interpretation are not included.

The experts interested in participating in the ad hoc expert group shall express their candidature to the PTS through one of the contact points below. The PTS will evaluate the CVs and the modeling capabilities the experts have at their disposal. Eventually, at its discretion, the PTS will select a group of five scientists (or less).

The timetable is as follows:

- (p) The experts should express their interest to the PTS by 8 Jan 2001. The experts shall provide CV and a detailed description of their modeling capabilities, and clearly express if they can perform the work required, i.e., Tasks 1 and 2 should be referred separately.
- (q) The PTS will notify selected experts by 12 Jan 2001.
- (r) The first meeting is scheduled at 22-23 Jan. The goal is to review the evaluation plan and to agree the contents of the work.
- (s) The second meeting takes place at the end of April (5 days). Modeling results are presented and a draft report is provided.
- (t) The final meeting takes place at the end of June. The report shall be finalized including conclusions and proposals, as appropriate, on how to develop PTS modeling capabilities.
- (u) Based on the report of the **ad hoc** expert group, the PTS provides the results to the 16th session of the Working Group B.

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APPENDIX 1. TOOLS FOR ATMOSPHERIC TRANSPORT MODELING WITH PTS

A.1 DEFINITION OF FIELD OF REGARD (FOR)

By definition²:

“The field of regard (FOR) identifies an area within which air has a non-zero probability of moving forward over a specific time interval and arriving at a site or a point location. The area identified is based on the release of air parcels at grid point locations from which the air parcels grow by diffusion/dispersion and move with the atmospheric flow. If the parcels grow in size and move over the site or point location and have grown large enough to impact the site at a user defined minimum concentration (minimum detection level), then that particular parcel contributes to the probability distribution. The area enclosing the union of all parcels over a period of time which impact the site defines the FOR. The ratio of the parcels from any particular grid point that arrive/impact at a station to the total number of air parcels released from all grid points that arrive/impact at that station taken from all releases for all the grid points in the region of interest determines the probability distribution needed to define the most likely source area, or the FOR. The time specified for the field of regard is the initial time of release of air parcels from any of the grid points. If the FOR is a 48-hour FOR, air parcels require 48 hours or less travel time from any grid point to arrive at (or pass through) the site or point location. All diffusion and dispersion are calculated from a unit volume release as initial conditions. Probabilities associated with the grid points in the FOR images are color scaled from blue (lowest probability) to yellow to red (highest probability).”

A FOR can be computed in forward and backward mode. Computations in both modes can be based on meteorological analysis or meteorological forecast data. Backward mode means that the transport calculation is performed backward in time from the measurement location (e.g., HYSPLIT backward trajectories). This is computationally very efficient, especially if the number of stations is relatively small. As alternative to backward modeling, it is also possible to compute transport from a number of pseudo-release points forward in time, and to sample these particles (trajectories) at the receptor location. This concept is the only one possible for embedded dispersion calculations (transport modeling integrated into meteorological modeling as done in OMEGA).

Applying these definitions, the FOR calculations currently established at PTS/IDC can be classified as follows:

- (v) Forward Analysis (FA) FOR uses analysis data in the forward mode
- (w) Forward Forecast (FF) FOR uses forecast data in the forward mode
- (x) Backward Analysis (BA) FOR uses analysis data in the backward mode

A.2 Coarse Resolution Atmospheric Transport Model FOR Data

HYSPLIT computes FOR both in the backwards as well as in the forward analysis mode for each site where a radionuclide station is located. The calculations are performed on a global scale, and only a very coarse grid size is used (2x2 degrees).

The forward analysis mode is configured to generate 24-, 48-, and 72-hour FORs for each site. The backward analysis mode is used to generate the union of FORs for all sites together and going 14 days back in order to provide an assessment for the network performance.

FORs produced by HYSPLIT have a resolution of approximately 150-200 km. The coarse resolution model provides a FOR probability distribution for air parcels traveling with the general circulation of the atmosphere. Very little account is taken for orographic and local effects.

² Quote from the secure PTS web page <https://www2.ctbto.org>, see also <http://www.pidc.org/web->

A.3 High Resolution Atmospheric Transport Model FOR Data

FORs produced from OMEGA have a resolution of approximately 50 km. The high resolution model provides a FOR probability distribution for air parcels traveling according to the laws of diffusion/dispersion, thermodynamics, and orographic forcing. The daily FORs provide a first look at the region which defines the most likely source of air which moves through the site over a period of 48-hours or less. This 48-hour period begins at the time specified with the FOR image. Local effects such as sea/land breezes will influence the area defined by the FOR.

Using this high resolution model, FOR data can be produced from higher resolution grid data.