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### **COOPERATION WITH THE CTBTO**

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#### **Summary and purpose of document**

This document describes transport modelling needed for CTBTO purposes, the products of prime interest and outlines some co-operation steps between WMO RSMCs and PTS from the IDC perspective.

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#### **Action proposed**

The meeting is invited to consider the proposals in this document and to make recommendations.

## **CO-OPERATION BETWEEN WMO RSMCS AND PTS/IDC FROM THE IDC PERSPECTIVE**

### **1. Introduction**

According to its draft operational manual (1), the International Data Centre (IDC) of the CTBTO Preparatory Commission, Provisional Technical Secretariat (PTS), has the following tasks related to Atmospheric Transport Modelling (ATM) in the context of the verification of the Comprehensive Nuclear-Test-Ban Treaty:

- To calculate, as part of the automated processing, an automated Field of Regard (FOR) for each radionuclide sample, indicating possible source areas for the detected radionuclides
- To provide, for cases categorised as levels 4 (containing one anomalous anthropogenic radionuclide) and 5 (containing multiple anthropogenic radionuclides), an estimate of the region of the world that could have been the origin of the detected radioactivity utilising atmospheric transport models
- To perform Expert Technical Analyses with enhanced atmospheric transport calculations to assist a State Party in identifying the source of specific radionuclides detected.

To fulfil these tasks, the IDC currently operates two different ATM models as part of the IDC Release 3 software developed by the prototype IDC [pIDC]. Currently also an alternative model is tested.

A formal co-operation agreement between the PTS and the WMO was recently concluded. As part of this agreement, co-operation between the WMO Regional Specialised Meteorological Centres (RSMCs) and the IDC is foreseen inter alia within the field of Atmospheric Transport Modelling. This is for the benefit of the PTS to keep abreast with state of the art technology, adding value to the IDC in-house capability and also to have the best resources available in case a clandestine nuclear explosion is suspected. This paper describes the calculations needed for CTBT purposes, what products are of prime interest and further outlines some co-operation steps between WMO RSMCs and PTS from the IDC perspective.

### **2. IDC needs and possible products**

There is no guidance in the current draft of the IDC operational manual on in what specific cases the computations from WMO RSMCs would be requested. It is clear, however, that such calculations are only foreseen when

- there is a request for Expert Technical Analysis from a Member State that has some suspicion of a Treaty violation
- the Radionuclide Verification subsystem is flagging a level 5 (i.e. when multiple CTBT relevant radionuclide have been detected at a station).

Such services from RSMCs are similar to what is covered under existing agreements with the International Atomic Energy Agency (IAEA). But there are differences:

- Calculations for the CTBTO will not focus on where air masses are going, but rather on where they are coming from. This requires different definitions and different technical procedures (e.g. model set-up)
- A possible IDC request will not be related to an event that did occur on the day of the request. The event, that means a specific radionuclide measurement, will be at least 3 days old. Since the measurement is caused by a release taking place a number of days before detection, there is the obvious need to have operationally available meteorological analysis data at least one week backwards in time
- The calculations will not be as time-critical as in the emergency response case

## 2.1 Field of Regard definition and standardisation

The Field of Regard definition provided by the IDC operational manual is rather general ("indicating possible source areas for the detected radio-nuclides") and has to be put in a technically concrete form to assure that IDC and each RSMC calculate a comparable product. In a recent report from an Ad Hoc Expert Group on the Evaluation of Atmospheric Models used at the PTS (2), the following technical specification for a Field of Regard were provided:

A Field of Regard (FOR) is an area where a prescribed source would contribute enough activity to a measured sample to exceed a prescribed detection threshold. If the detection threshold is zero, then the FOR is called "Maximum FOR".

In this definition, the FOR area does not depend on assumptions about a source, but on the ratio between a prescribed source strength and a specific detection threshold, which is called dilution ratio. To apply the idea of a maximum FOR in future IDC-WMO co-operation would have disadvantages. Doing so, the maximum FOR area would not depend on a defined dilution ratio, but on a ratio that is specific to the model implementation and depends on the model accuracy like e.g. on the number of particles simulated (Lagrangian model) or numerical diffusion (Eulerian model). We therefore suggest that the basic FOR computations should be performed according to the following standards:

- A dilution ratio in the range of  $10^{18}$ - $10^{20}$  m<sup>3</sup> ( $10^{18}$  m<sup>3</sup> corresponds to venting some 5% of the xenon-133 produced in a 1 kt underground nuclear explosion and  $10^{20}$  m<sup>3</sup> corresponds to all barium-140 produced in a 1 kt explosion. Xenon and barium are used to specify the two PTS networks for aerosol borne and gaseous radionuclides and the required detection limits are  $\leq 1$  and 0.03 mBq/m<sup>3</sup> respectively.
- Possible source is between 0 and 30 m (equally distributed)
- Sampler is 2 m above ground
- Diffusion is considered
- Radioactive decay is not considered
- Deposition is not considered

In specific cases, considering radioactive decay and deposition might be of interest.

It has to be noted that the dilution ratio as assumed here is by orders of magnitude larger than the usual IAEA emergency response scenario would require and might pose a challenge to the models.

## **2.2 Calculation Methods**

A FOR can be computed applying an Eulerian or a Lagrangian transport model in forward or in backward mode. There has been some discussion in the scientific community whether backward computations including diffusion are scientifically sound, since diffusion is an irreversible process. Recent publications, however, state that the computation of source receptor matrices in backward mode is equivalent to the computation in forward mode (3). This is also consistent with recent work performed within our organisation. For example, the Ad Hoc Expert Group on the Evaluation of Atmospheric Models used at the PTS (2) recommended that the backward mode is the preferable mode to compute a FOR, since backward methods are numerically more efficient. If the computations are done for one station, only one retro-plume has to be calculated and evaluated (see Figure 1), while a typical forward approach would require thousands of forward plumes.

As far as the future co-operation between RSMCs and IDC is concerned, it should be up to the modelling institution which method it wants to apply, but all technical specifications should be made fully transparent.

## **2.3 Planned IDC Post-processing**

The IDC plans not only to make available the single RSMC FOR computations to the State Parties, but also to generate an aggregated product, that contains information on possible source regions identified by only one single model, by any number of models or by all models together. This shall give the decision makers the opportunity to take into account uncertainties of the computations, which might strongly differ from one meteorological situation to the other (see Figure 2). It is planned that the IDC creates a secure web site where both single and aggregated results can be viewed by authorised users. Together with the results, a joint statement of all participating centres could also be presented there.

To make the IDC post-processing doable the Field of Regard results must be communicated to the IDC as ASCII data files, preferable in an agreed standard format or at least in a format where an interface is supplied to the IDC to automatically translate it to a standard format.

In a future step, as soon as the co-operation between RSMCs and IDC is well in progress and the IDC has got improved in-house capabilities, it is suggested to change the exchanged products from a FOR to a more general source-receptor matrix (SRM). A SRM is the quantitative sensitivity of a receptor (ambient concentration)  $y$  to a source  $x$ . Receptor and source are continuous functions in space and time. If the relationship is assumed to be linear, it can be written as follows:

$$y_l = m_{il} \times x_i$$

where  $m_{il}$  is an element of the source receptor matrix  $M$  that gives the contribution  $y$  for measurement  $l$  due to a source  $x$  in the spatial-temporal cell  $i$ . In this case, the RSMCs and the IDC would exchange SRMs, and the IDC would compute the FORs (with any technical specification it might consider appropriate) in a standardised post-processing step.

### **3. Planning of future WMO/RSMC-PTS/IDC co-operation**

The IDC and most RSMCs have already conducted a first informal test in May 2000 (4). The test successfully demonstrated that a RSMC-IDC co-operation can work and produce fruitful results. This first test was carried out in a manner similar to the regular exercises conducted for emergency response. In the future, we will have to start establishing a parallel track to the WMO-IAEA co-operation to serve the specific CTBT related requirements. This parallel track, however, should make use as much as possible from experiences gained and procedures already developed or under development. The IDC proposes to develop a Technical Operations Manual for CTBT purposes within the following two or three years that might be agreed to become binding possibly in 2004 or 2005. This will in some respects resemble the Emergency Notification and Assistance Technical Operations Manual (5).

The IDC suggests the following next steps towards an operational WMO/RSMC-PTS/IDC co-operation:

- Outline for a Technical Operations Manual for RSMC-IDC co-operation (1<sup>st</sup> quarter 2002)
- Field of Regard inter-comparison activity (2<sup>nd</sup> quarter 2002)
- Second informal exercise (3<sup>rd</sup> or 4<sup>th</sup> quarter 2002)
- Regular exercises (beginning 2003)

#### **3.1 Development of standards and procedures, Field of Regard inter-comparison activity**

A first outline for co-operation standards could be prepared at a meeting in the first quarter of 2002. As a first step in planning of the future cooperation, the IDC would like to explore together with the RSMCs the status with respect to the following relevant capabilities:

- Ability to compute Fields of Regard following the definitions provided in section 2.1
- Model set-up that can operationally make use of meteorological analysis data over a period of at least 1 week backward in time
- Capability to submit results in an electronic form that is suitable to be further processed by software supported visualisation and inter-comparison (preferably in an agreed format)

As soon as procedures and standards are worked out and the existing capabilities are explored, the IDC suggests a first test under non-real-time conditions. During this test, each participant computes Field of Regards for an agreed number of stations (tentatively: 3-5 stations) during an agreed time period (tentatively: 5-10 days). Afterwards, the IDC compares the results and discusses the differences together with the RSMCs. The activity will help the participants to assess their results and to develop or refine as needed the FOR calculation procedures. It was noted during the work of the Ad Hoc Expert Group on the Evaluation of Atmospheric Models used at the PTS that Fields of Regard from different models computed even with similar specifications may differ systematically.

### **3.2 Second informal RSMC-IDC exercise**

If the inter-comparison exercise is finished successfully and appropriate procedures have been set up, a second informal exercise is suggested for the second half of 2002. The purpose of this exercise would be to test the above mentioned capabilities in real-time. In this context, it shall be mentioned that no interested RSMC will be excluded from the exercises even if it cannot fulfil these criteria at that time. These criteria are subject to further discussion and their development will reflect the progress made at RSMCs to respond to CTBT related requirements. The need to submit results in electronic form is well in line with the standards that are suggested in the context of the emergency response activities to become the operational procedure from 2003 onwards.

### **3.3 Regular RSMC-IDC exercises**

Based on the experience gained in the second informal RSMC-IDC exercise, the co-operation procedures are further developed and tested with regular exercises from 2003 onwards. For these exercises, the IDC plans to set up a web page for a joint presentation of the RSMC results in an aggregated and informative way.

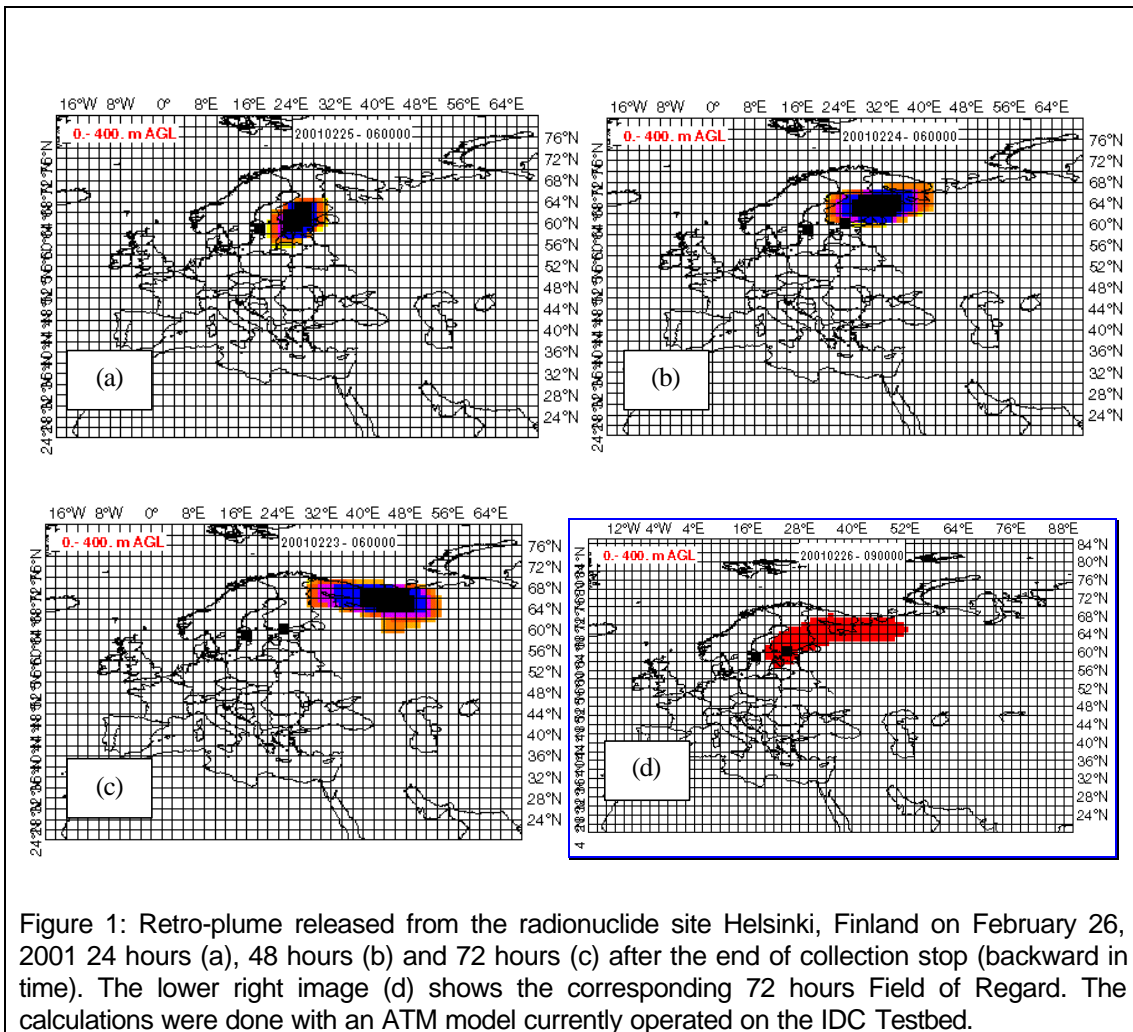
#### 4. Summary and conclusion

In the context of the verification of the Comprehensive Nuclear-Test-Ban Treaty by means of Atmospheric Transport Modelling, a co-operation between the WMO RSMCs and the International Data Centre has been agreed on. As part of this co-operation, it is envisioned that Fields of Regards (FOR) are computed by interested RSMCs and disseminated by the IDC together with its own results to assist CTBT State Parties in identifying possible source regions for CTBT relevant radionuclides detected in samples. These Field of Regard computations should all be standardised and based on predefined dilution ratios. To initiate the future co-operation, it is suggested that a FOR inter-comparison activity is conducted and an outline for co-operation standards is developed early next year. In the second half of next year, an informal exercise between WMO RSMCs and the IDC could then follow. From 2003 on, more regular and more automated exercises are assumed. For these exercises, the IDC plans to set up a web page for a joint presentation of the RSMC results in an aggregated and informative way. Eventually, a Technical Operations Manual for WMO/RSMC-PTS/IDC co-operation will be developed and agreed upon.

#### ● **References**

- (1) *Document CTBT/WGB/TL-17/2 (CTBTO Preparatory Commission, Working Group B)*
- (2) *Document EVAL-102/01/450 (CTBTO Preparatory Commission, Evaluation Section)*
- (3) *Seibert, P. & Stohl, A. (1999) Inverse Modeling of the ETEX-1 release with a Lagrangian particle model. Contribution to the third CLOREAM Workshop, Ischia, Italy September 1999.*
- (4) *Kalinowski, M. B., De Geer, L.-E., Jean, M.: Informal Test between the International Data Centre and WMO Regional Specialised Meteorological Centres Conducted on 3 and 4 May 2000. Technical Note PTS/IDC-2000/01, October 2000*
- (5) *IAEA: Emergency Notification and Assistance Technical Operations Manual, EPR-ENATOM 2000, date effective: 1 December 2000, Vienna 2000.*

Figures





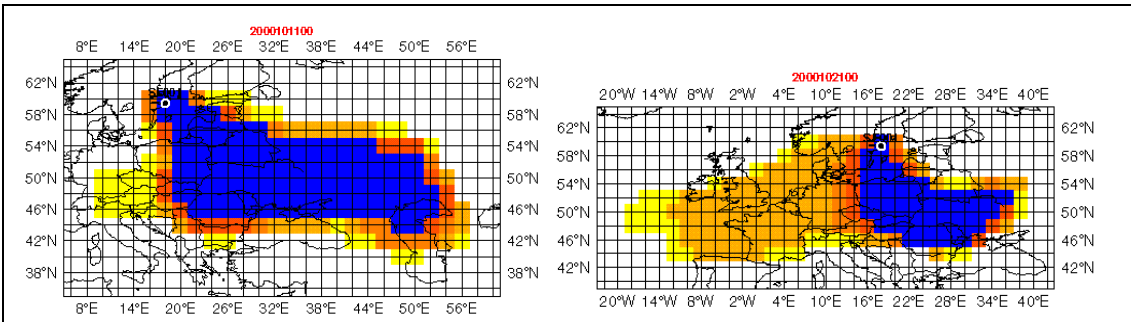


Figure 2: Fields of Regard (FOR) computed for the site Stockholm, Sweden, by 5 external experts with their models in the framework of the Ad Hoc Expert Group on the Evaluation of Atmospheric Models used at the PTS. The two plots are colour-coded according to the number of models agreeing with the respective FOR region (yellow: region indicated by only one model; dark blue: region identified by all participating models). On October 11, 2000 (left), all 5 models show excellent agreement (more than 80% of the area is agreed by all models). On October 21 (right), on the other hand, more than 50% of the FOR area is covered by only 2 out of 5 models.