UEF2019

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CTBTO experience in visualisation of ensembles and derived products

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Introduction

The Atmospheric Transport Modelling (ATM) operational system deployed and used at CTBTO produces source receptor sensitivity (SRS) fields, which specify the location of the air masses prior to their arrival at any radionuclide station of the International Monitoring System (IMS) network (Figure 1). Currently the ATM operational system is based on a Lagrangian Particle Dispersion Model, FLEXPART, driven by the global meteorological fields provided by the European Centre for Medium-Range Weather Forecasts (ECMWF) and the US National Centers for Environmental Prediction (NCEP) at a resolution of 0.5 degree.
Based on the SRS fields several products are calculated. They are made accessible via the Web connected Graphic Engine (Web-Grape) and its online version: Web-Grape Internet Based Service (Web-Grape-IBS). This presentation will give an overview of the functionalities based on multi models (ensembles) and demonstrate the most interesting cases.

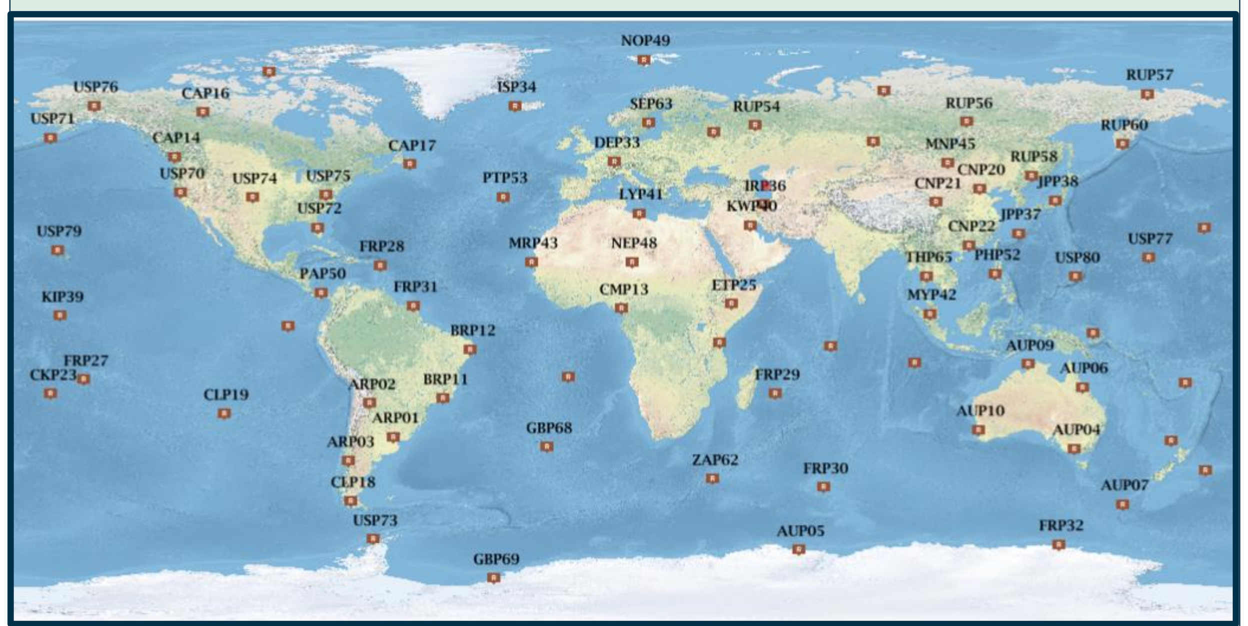

Figure 1. *Map showing location of all radionuclide IMS stations.*

Web-Grape

Web-Grape (ver.1.8.5) is a software system that allows for post-processing and visualization of ATM calculations using the SRS (Source Receptor Sensitivity) data stored (and daily processed) at the International Data Centre (IDC). This software system can be used to calculate several ATM products like for example: Field of Regard (FOR), Possible Source Region (PSR), as well as their multiple model versions (MMFOR, MMPSR) by including SRS data collected from the Regional Specialised Meteorological Centres (RSMCs).

The MMFOR functionality allows to calculate, overlap and inter-compare the FOR products for an ensemble of models. A related functionality, MMPSR, is derived from the overlapping or simple averaging of an ensemble of single model PSR results.

The application allows to calculate statistics corresponding to the MMFOR and MMPSR evaluations. The metrics utilized for the statistics are the well-known Model Agreement (RNK), Model Overlap (also called Figure of Merit in Space, FMS), Pearson Correlation (R^2) and fractionated bias (FBias).

SRS-fields with NCEP & ECMWF

Figures 2A-B show two examples of MMFOR outputs for two SRS files, generated with ECMWF and NCEP meteorological data, respectively. The result of comparison depends not only on the air transport time but also on the geographical location.

A)

B)

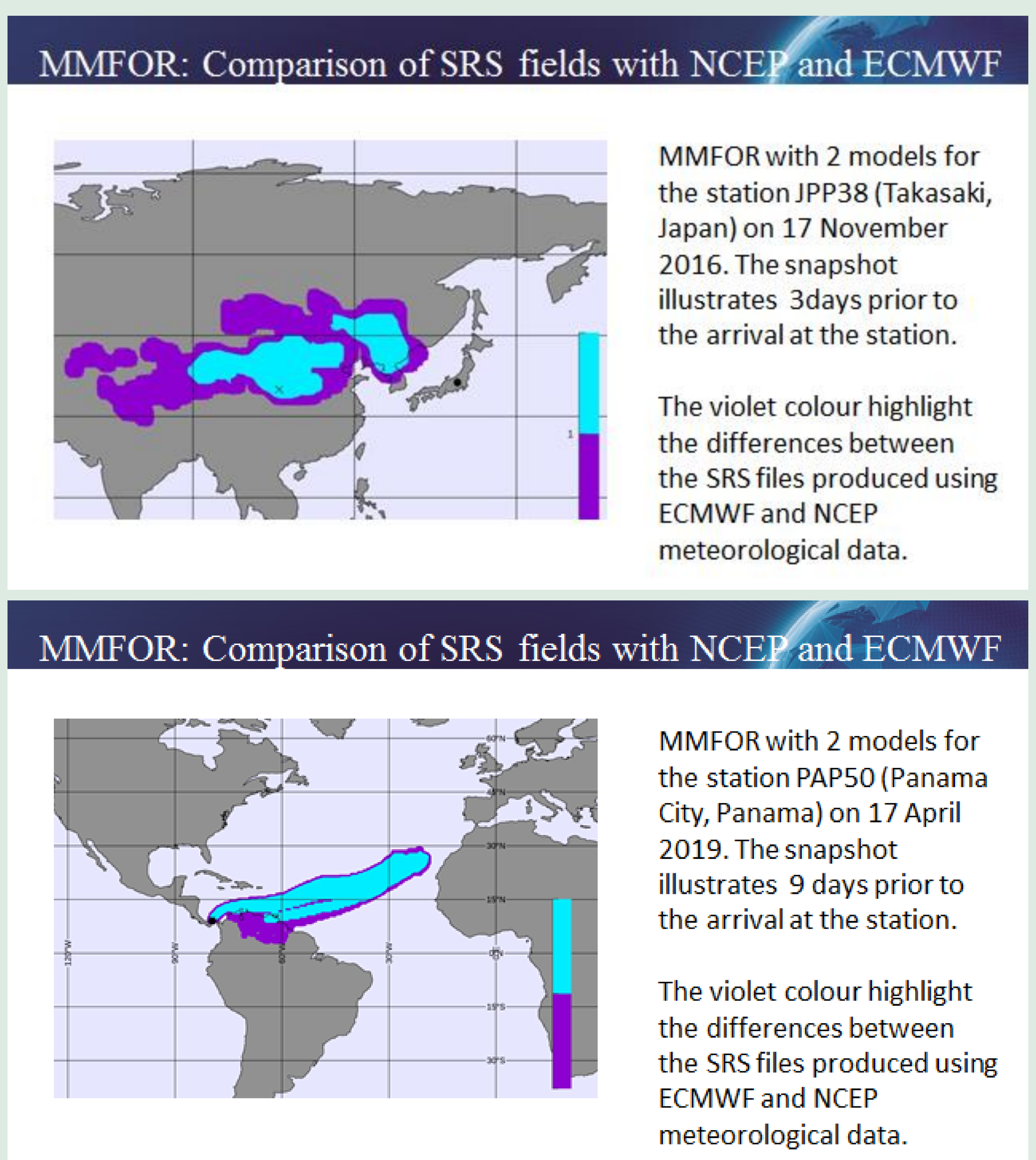

Figure 2. *A) JPX38 (Japan), B) PAP50 (Panama)*

Multi models from WMO RSMCs

World Meteorological Organization (WMO) supports CTBTO by coordinating the ATM computations performed on request in the framework of the joint CTBTO-WMO Level 5 support system. Each detection identified by the IMS particulate network as Level.5 (Multiple Anomalous Anthropogenic Radionuclide Measurements) gives rise to a request for support issued to the Regional Specialised Meteorological Centres (RSMCs). In response, the RSMs produce and upload their own backward simulations. MMFOR functionality is used to display and compare their results (see Figure 3).

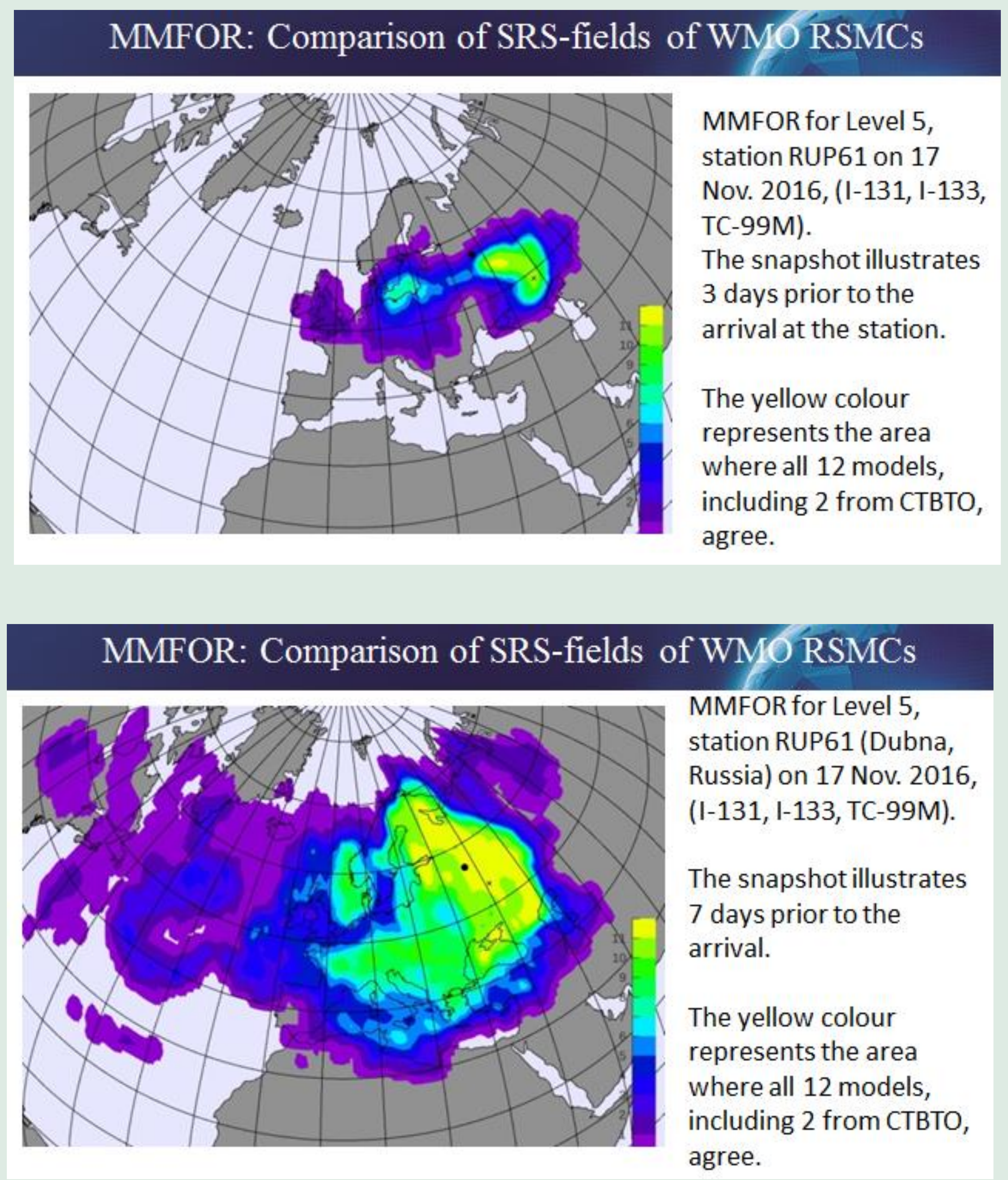

Figure 3*. Example of MMFOR results.*

Level 5 and Fukushima Event

Following the Fukushima accident in March 2011 many IMS stations until May 2011 observed multiple anomalous detections classified as Level 5. The first station was JPP38 in Takasaki (Japan) but shortly afterwards, Level 5 was also confirmed at other stations. On 20 March 2011, at the IMS station CAP14 (Resolute, Canada) the spectrum was confirmed as Level 5 due to detection of nuclides I-131, I-132, Cs-137, Cs-134 and Te-132. In response to the CTBTO request for support, RSMCs send their own simulations (see Figure 4).

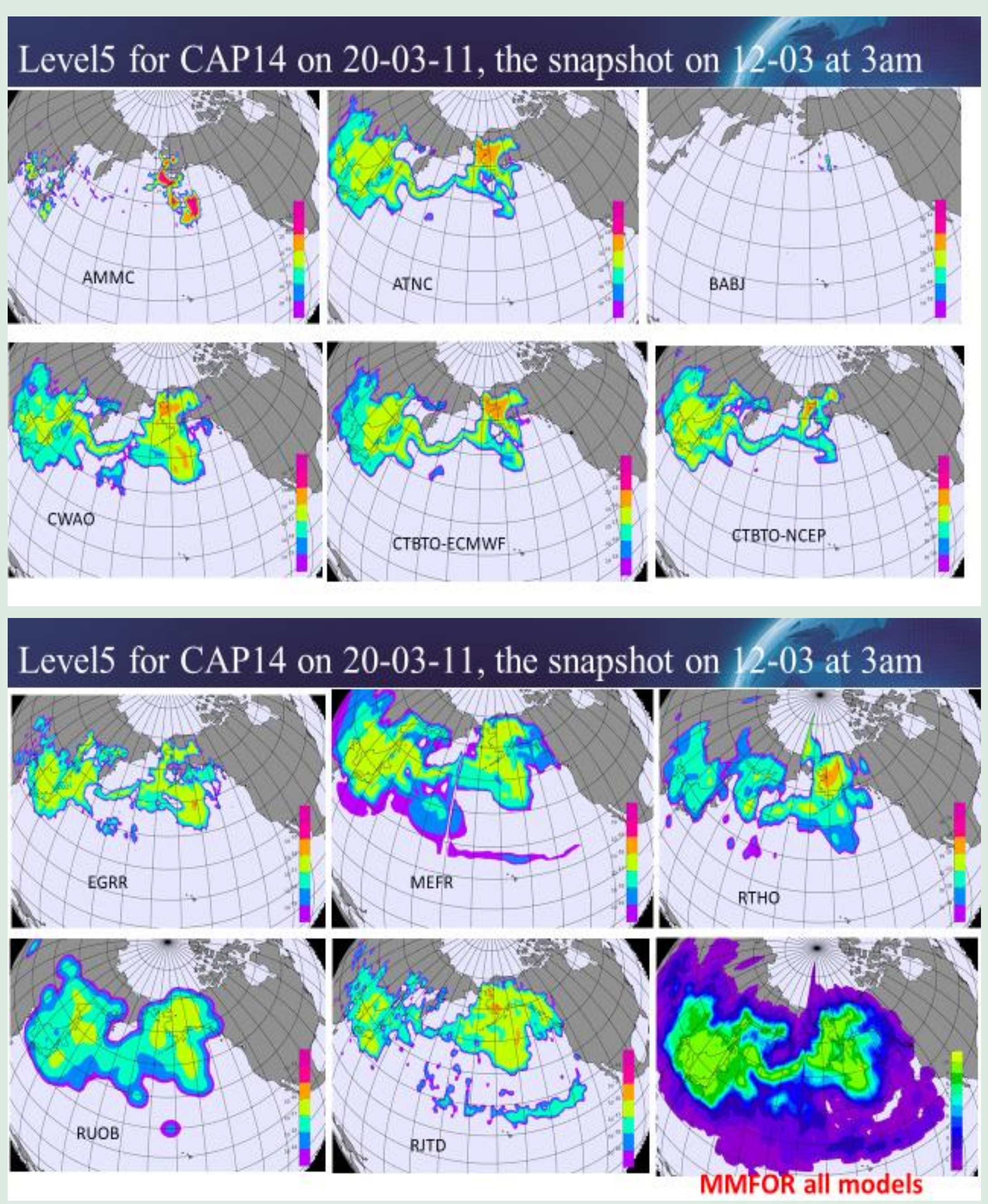

Figure 4*.Comparison of air mass backward simulations (SRS files from RSMCs received in response to Level 5 at CAP14. All snapshots illustrate the same situation i.e. 8 days prior to the arrival at the station. The last (bottom-right) image shows the overlapping result, MMFOR, for all models.*

Possible Source Region (PSR)

The Possible Source Region (PSR) allows for estimating the geographic origin of a release by combining SRS information with the pertaining scenario of measurements (radionuclide detections) in the IMS network. The correlation coefficients between the measured and simulated activity concentration values (ATM results) are calculated for each grid point in space and time (see Figure 5).

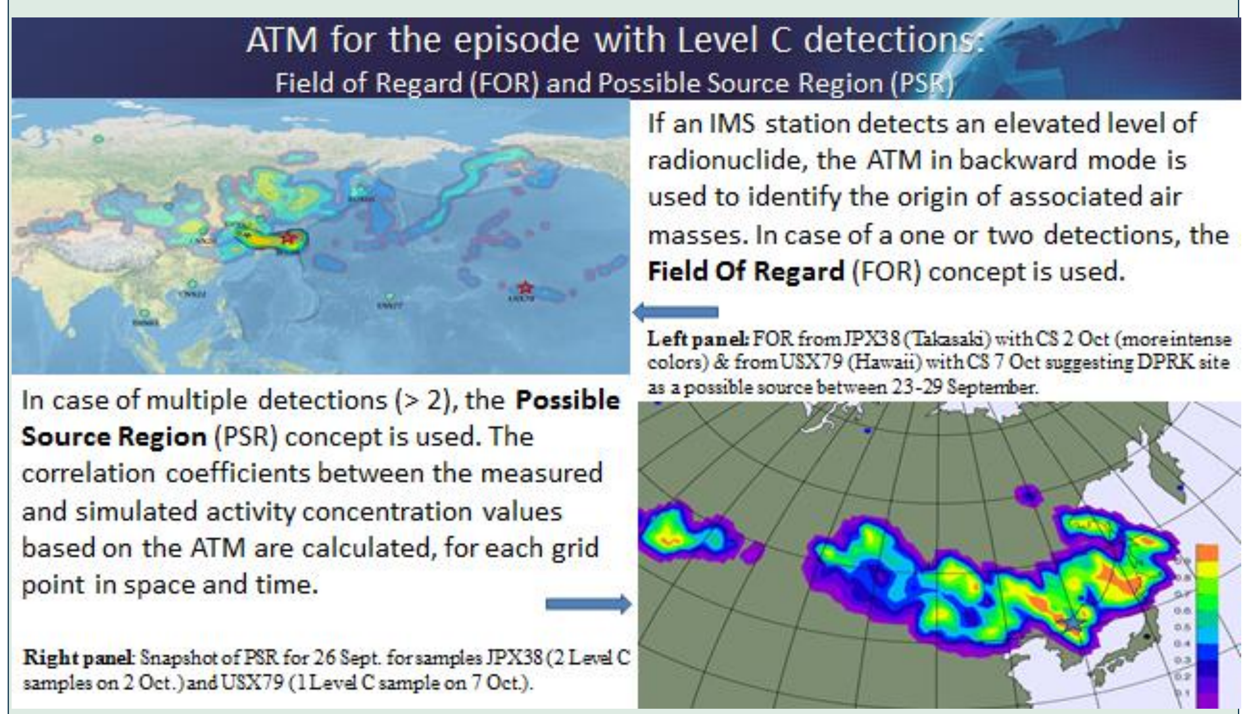

Figure 5. *Concept of FOR and PSR explained for Level C detection i.e. anomalous xenon detection.*

PSR and Fukushima Event

The FOR denotes the possible source region for material detected within one single sample; the PSR concept allows to get a more precise information based on multiple detections. To generate PSR for this case, 9 models with the largest agreement between them were selected i.e. 7 WMO models and 2 CTBTOs (see Figure 4). The results are presented in Figure 6.

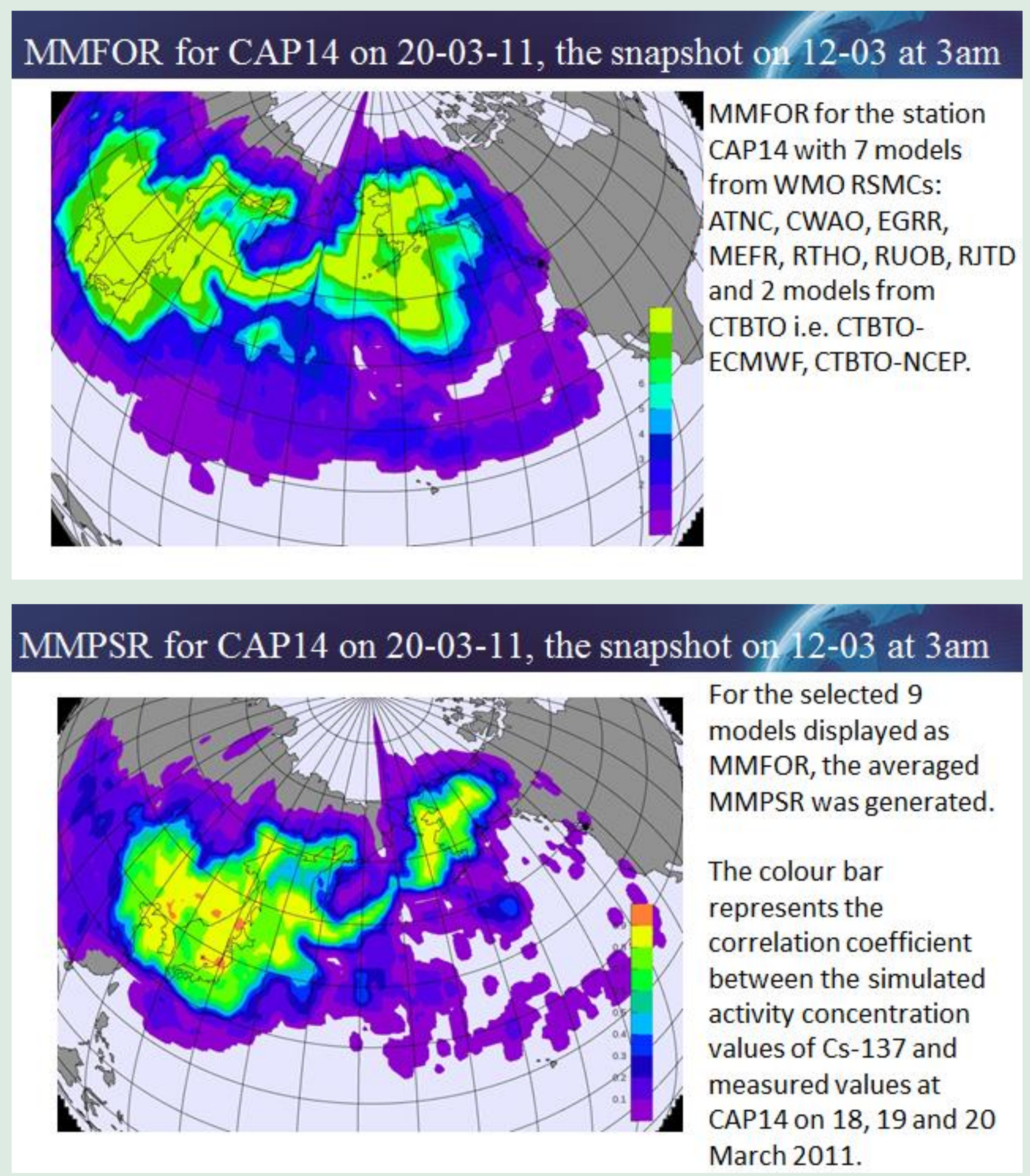

Figure 6. *MMFOR and MMPSR for CAP14.*

Concluding remarks

Identifying sources of air pollution following detections at sampling stations is a common challenge to many organizations. ATM systems are essential for this purpose. However, this is not a simple task given the diffusive nature of the atmosphere and the limitations on estimating its true state. The use of several detections can help to limit the effect of diffusivity and the use of different ATM systems can compensate the limited knowledge of the state of the atmosphere. The CTBTO aims at identifying the possible location of a source associated with radioactive detections at its monitoring stations. To this end, FOR from several RSMCs are combined with Web-Grape to form MMFOR. In addition, MMPSR are also produced if more than 2 detections are available. The ability to identify the location of a release is greatly improved by combining guidance from different centres. The CTBTO initiated a project with ZAMG in 2018 to further develop this approach by using members from the ECMWF EPS.