Quantifying uncertainties and confidence level in ATM simulations

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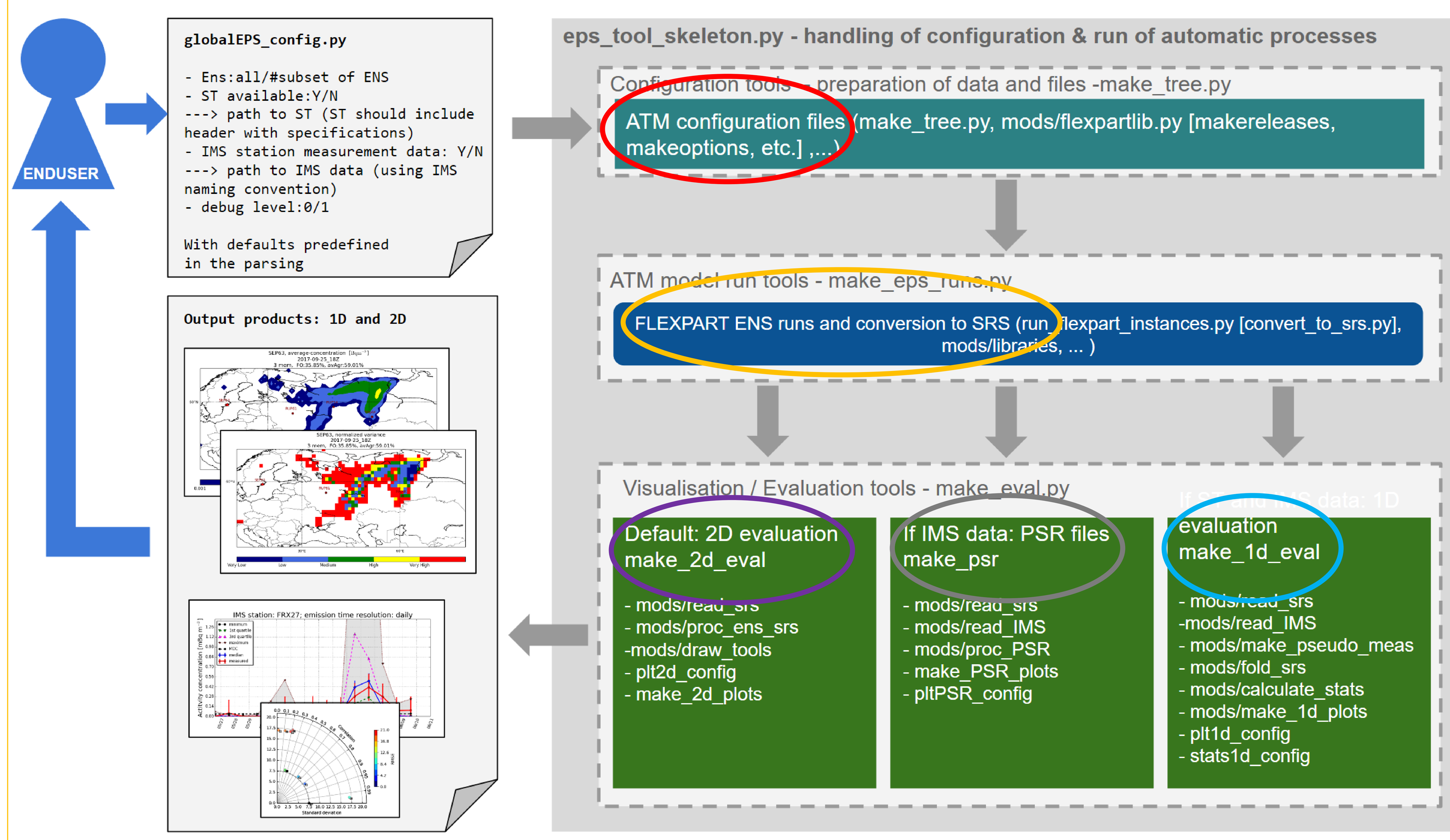
1. Background

The Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) has developed an atmospheric transport modelling (ATM) pipeline in order to produce source-receptor-sensitivity (SRS) fields to indicate possible source regions for potential releases of radionuclides (RN) related to hypothetical or actual detections at RN stations. CTBTO mainly uses ATM guidance in backward mode to link a measurement from an IMS station to a possible source location. However, ATM is also used in forward mode to predict detections related to a potential radioactive release. Different ATM systems will generally produce different solutions because a) the input meteorological fields are different, b) the transport and dispersion models are different or configured differently, and c) the source term is specified differently. CTBTO in collaboration with Zentralanstalt fuer Meteorologie und Geodynamik (ZAMG), under funding from European Union Council Decisions VII, has initiated a project to study the impact of different meteorological input coming from an EPS to better estimate the source location and to quantify the level of confidence. This presentation will describe the project and present initial results.

2. System Prototype Design for evaluation of EPS driven ATM

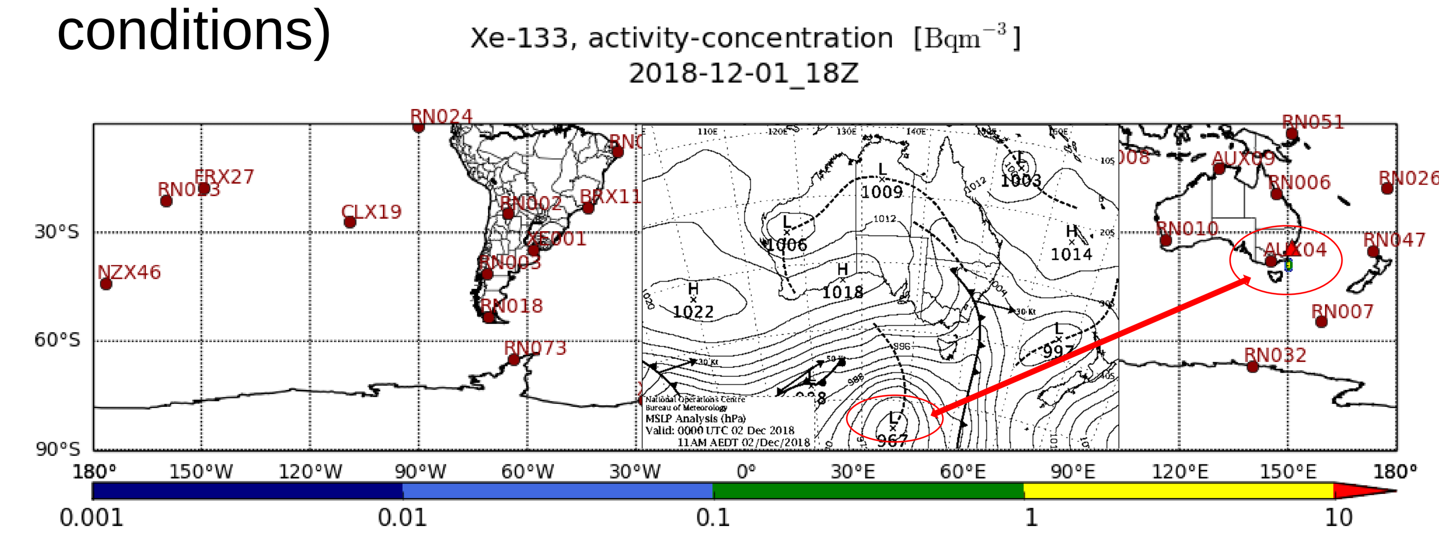


- Namelist file for configuration
- **Launch atmospheric transport model FLEXPART runs based on** (randomly selected or full) **ECMWF-EPS input at** selected locations, either the **source location (fwd) or** any (or all) of the **IMS stations (bwd).**
- Postprocess FLEXPART results.

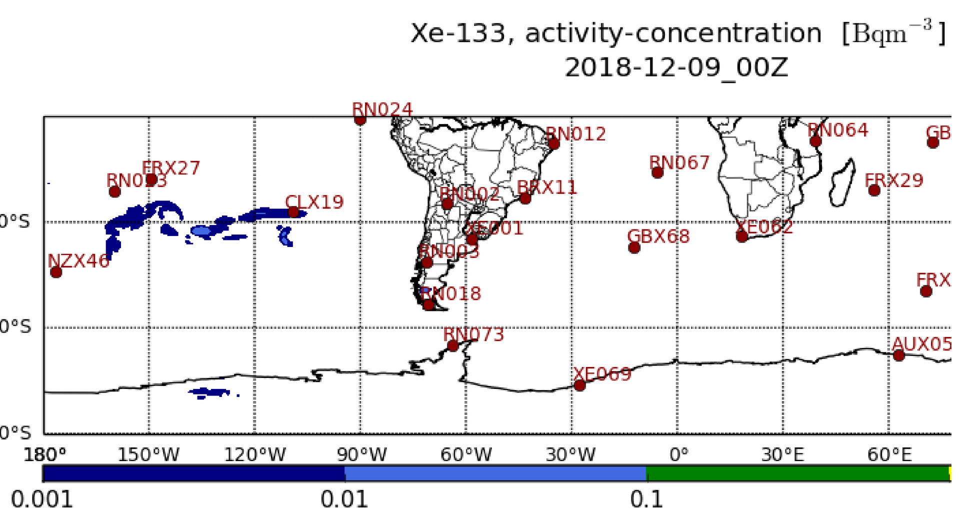
- Plot **(ensemble) Source Receptor Sensitivity (SRS) fields/Fields of Regard (FOR).**
- Calculate and plot the **(ensemble) Probable Source Region (PSR)-fields** if **measurements** are available and can be **correlated with SRS values** for each grid point and time step.
- **Fold SRS fields with a source term** if both the source term and measurements are available, plot resulting time series and perform **statistical evaluation**.

3. Test cases

1. **Real case** (11.3.-25.3.2011) - **Fukushima NPP accident**: Real IMS Cs-137 and Xe-133 measurements and source term from *Stohl et al.* (2012).
2. **Synthetic cases** (1.12.2018-15.12.2018), producing pseudo-measurements based on FLEXPART and NCEP-GFS data:
   1. **Hypothetical ANSTO puff release** (1E15 Bq Xe-133, 1.12., 00:00-01:00 UTC, summer time conditions, unfavourable situation in terms of measurements)
   2. **Hypothetical DPRK-test site puff release** (1E15 Bq Xe-133, 1.12., 00:00-01:00 UTC, winter time conditions)

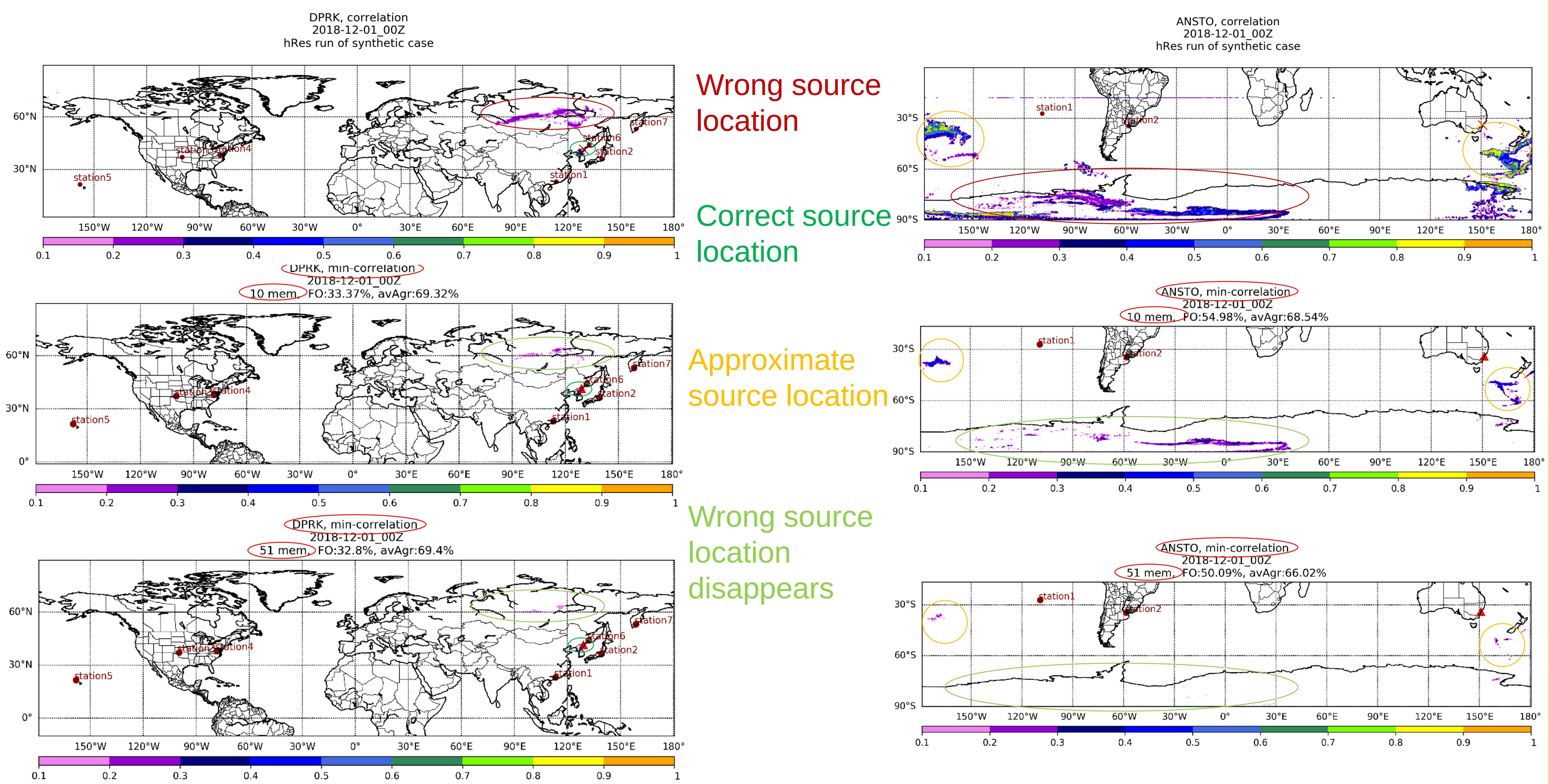


Hypothetical ANSTO plume gets sucked up by intensive low pressure system!



Plume reappears in the ground layer only ~week later based on NCEP data!

4. Benefit of ECMWF-EPS-driven dispersion runs



5. Preliminary conclusions

- The **best PSR ensemble metric** turns out to be the **ensemble minimum** as only those **parts of the PSR fields are kept** which are **at** (DPRK test case) **or near** (ANSTO case) to the **actual source** and **no threshold** needs **to be defined**. The **performance increases** when **switching from** a **10 member to** the **full ensemble**. Whereas when dealing **with activity concentrations** the **"worst case" (ensemble maximum)** is extremely **relevant**, it is **not so for PSR fields**.
- **Probability of exceedance** plots applied to PSR fields **suffer from using a fixed threshold**. This is **unlike the situation with activity concentration values**, where a generally useful threshold is easier to define. In essence **thresholds need to be redefined for every case** based on those values **deduced from the operational run**. For the DPRK test case this prerequisite was met by chance.
- **Average and median results** are **very similar**. They show a **small improvement** in terms of being able to locate the source region **for the DPRK test case**.