Using ECMWF ensemble products to drive ATM ensemble simulations at CTBTO

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CTBTO PREPARATORY COMMISSION | COMPREHENSIVE NUCLEAR-TEST-BAN TREATY ORGANIZATION

CTBTO's mission

CTBTO is an international organization monitoring for compliance with the Comprehensive Nuclear Test-Ban-Treaty (CTBT). For that purpose CTBTO operates a global network of **seismic, hydroacoustic, infrasound** and **radionuclide** stations. The role of the radionuclide network is to detect the presence of anthropogenic radionuclides indicative of a nuclear explosion, if one is conducted.

Role of ATM

Radionuclide detections are supported by the Atmospheric Transport Modelling (ATM) calculations, essentially, but not exclusively, in a **backward** mode. The ATM outputs identify regions of presence of air masses in the time periods preceding their sampling at a station. Consequently, they indicate regions where the **sources** of detected radionuclides could have been located.

ATM calculations

CTBTO operates an off-line community Lagrangian Particle Dispersion Model FLEXPART. For its operational ATM backtracking calculations CTBTO uses ECMWF **deterministic** meteorological fields. These result in one instances of backtracking simulations for each radionuclide sample.

Sources of uncertainty

ATM calculations are inherently uncertain. The main **sources** of uncertainty, listed in the order of importance of their impact, are:

- source term specification
- meteorological information
- parameterisations of sub-grid scale processes

Why is uncertainty assessment important?

One of CTBTO's most important activities at present is to develop the **assessment of ATM uncertainty**. This will assist States Signatories in making informed decisions regarding location and origin of detected radionuclides and hence support Treaty verification.

Meteorological uncertainty

In order to assess meteorological uncertainty, the meteorological community makes appeal to ensemble modelling. Following these footsteps, CTBTO is implementing an ATM ensemble with the aim of assessing the contribution of the meteorological uncertainty to the overall ATM uncertainty.

Which ensemble?

Ensemble of Data Assimilations has been identified as the approach best accounting for the needs of ATM at CTBTO. At present, 4 analyses are extracted per each 24h cycle. They are intertwined with short term forecasts to limit a necessity for interpolation between analyses over long time intervals. For the needs of the ATM ensemble simulations, the same meteorological fields are used as in deterministic operational ATM.

In practice, due to disk size requirements and computational footprint, the following ATM ensemble configuration is used

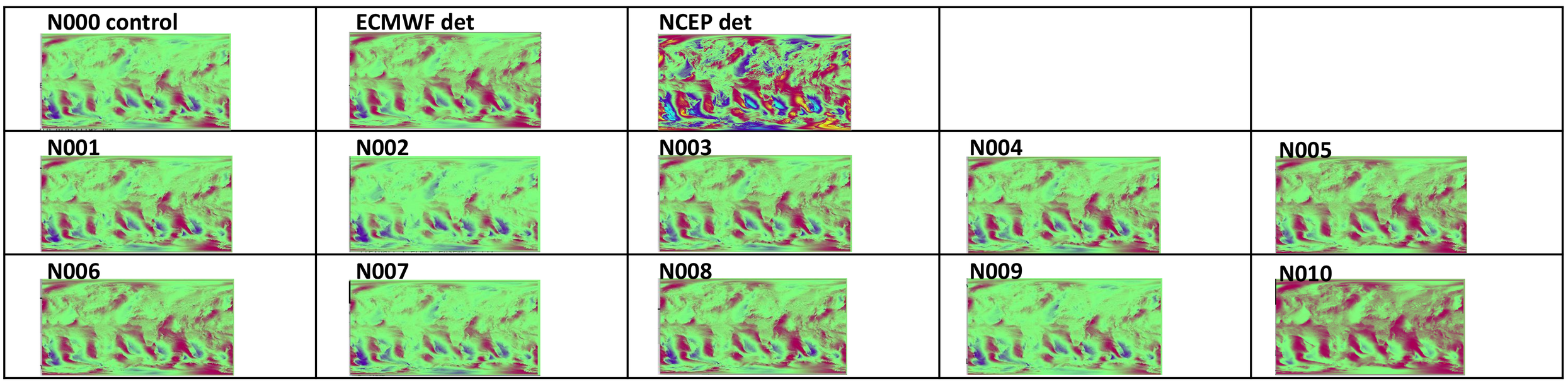
- 10 first EDA members are used to simulate a 10-member ATM ensemble (also due to a lack of straightforward access to timestep +9h for the ensemble members beyond the first 10)
- EDA control is used to generate ATM control
- 1.0 degree and 3 hours resolution of meteorological input and ATM output

How to assess ATM uncertainty?

- raw ATM ensemble shared with States Signatories
- ensemble statistics (remembering that the ensemble size is small at present) like mean, standard deviation; min, max; quartiles
- plots to visualise overlapping ATM ensemble members

Ensemble of Data Assimilations

V component of horizontal velocity on 20250801 0000
control and 10 ensemble members



ATM ensemble

AUX09: collection stop at 20250801 0600 snapshot at 20250727 0600
control and 10 ensemble members