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What can we learn from a comparison of ECMWF- and NCEP-driven SRS fields?

Monika Krysta, Anne Tipka and Robin Schoemaker

CTBTO IDC/SA
Vienna International Centre, Wagramerstrasse 5, 1220 Wien, Austria

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INTRODUCTION AND MAIN RESULTS

ATM simulations at CTBTO use meteorological fields from two sources, ECMWF and NCEP. Downstream tools indicate that two instances of thus generated ATM products differ in spatial extension at the lowest levels of the atmosphere. It is conjectured that differences in definition and resolution of vertical levels cause discrepancies. However, more studies are needed to reach a definitive conclusion.

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Inspiration from Data Fusion results

On its Secure Web Portal, IDC shares access to a Data Fusion capability linking radionuclide detections with waveform events using operational atmospheric transport modelling (ATM) backtracking calculations. For each radionuclide sample, backtracking calculations are computed in two copies using two sources of meteorological fields - one using the meteorological information from the European Centre for Medium-Range Weather Forecasts (ECMWF) and another one driven by the meteorological fields generated by the US National Centers for Environmental Prediction (NCEP).

A closer examination of the results indicates that for a given radionuclide sample, ECMWF-driven ATM backtracking calculations tend to link to more waveform events. The differences are not systematic, and counterexamples can be found, but the point is generally true.

A list of waveform events connected to a particular radionuclide sample is created by an overlap of ATM backtracking outputs with the location and time of waveform events. The discrepancies indicate that frequently it is the ECMWF-driven ATM output which occupies a larger geographical region than the NCEP-driven one. In this work it is investigated if this is indeed the case and what may be the reasons behind this phenomenon.

Analysis

There are many radionuclide stations and even more samples. Consequently exhaustive visual inspection is not feasible. Several stations were selected for these studies, either due to their importance for data fusion or representativity of meteorological conditions. Two issues were considered. First, the geographical extension of a backward plume was studied with a focus on its final form, i.e. after 14 days of backtracking. In addition, scatterplots were generated. Each point represents one time step and indicates the number of grid points in the field of regard generated for the ECMWF and NCEP meteorological fields. While the scatterplots constitute an objective assessment of the spatial extension of the SRS fields, their visual inspection allows identification of the regions where discrepancies occur.

So far backtracking simulations for 6 stations have been analysed. Two of the stations are located in the northern hemisphere, JPX38 and KWP40, two in the equatorial region, KIP39 and AUX09, and two deeper in the southern hemisphere, CLP19 and CLP18. We analysed 12 samples for each station, one per each calendar month of 2024. The reason for probing the entire year was to account for seasonality in regions monitored by those stations, especially for those in the equatorial region.

Results

The following observations could be made based on scatterplots:

- JPX38: **5** cases where ECMWF backtracking gives larger retroplumes and 4 cases for NCEP
- KWP40: all **12** cases show larger retroplumes for ECMWF meteorological fields
- KIP39, AUX09, CLP19: **9** cases where ECMWF backtracking gives larger retroplumes and 2 cases for NCEP
- CLP18: **10** cases where ECMWF backtracking gives larger retroplumes

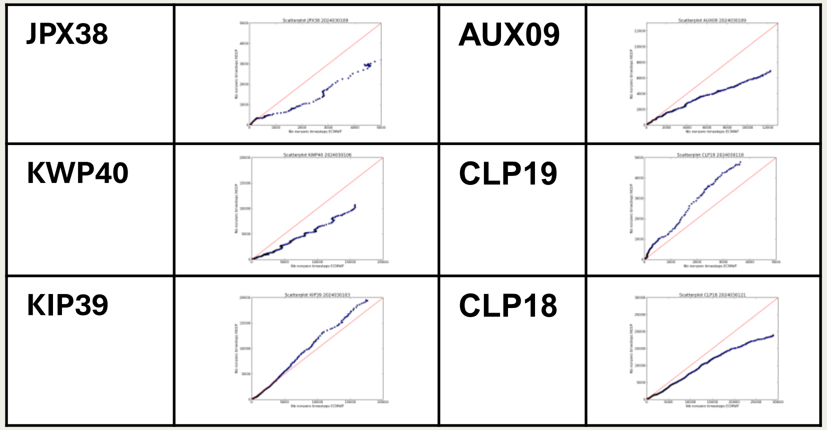

Fig. 1 Scatterplots comparing the spatial extension of ECMWF- and NCEP-driven meteorological plumes for the radionuclide samples with the collection stop on 1st March 2024. Backtracking for JPX38, KWP40, AUX09 and CLP18 has a larger spatial extension for the ECMWF meteorological fields.

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What are the reasons for these discrepancies?

First, FLEXPART source code was examined. It contains a handful of routines having two parallel versions - one for the treatment of the ECMWF and one for the NCEP meteorological fields. It was conjectured that the discrepancies in the horizontal geographical regions indicated by two types of retroplumes have their origin in different quantities of air being transported vertically. Consequently, special attention was paid to those factors responsible for vertical motions in the atmosphere. However, no conceptual differences in the treatment of the two sources of meteorological fields could be identified.

There is, however, one exception, and this resides in the meteorological fields themselves. The ECMWF meteorological fields are defined on 137 so called model level fields, which account for a ratio of pressures of the air column between the current level and the top of the atmosphere to the pressure of the entire air column at this location. Therefore, they very closely follow the terrain. The NCEP meteorological fields used for the ATM simulations come on 33 vertical levels, which represent constant pressures. They do not follow the terrain as closely as model levels. In addition, even if the model top is located lower for the NCEP fields, the vertical resolution is much lower for the latter.

What are the reasons for these discrepancies?

The next question addressed was where these differences in the definition of vertical fields could be exhibited. The higher density of vertical levels could be beneficial for regions with complex orography and complicated the lower-most layer of the atmosphere, i.e. the planetary boundary layer. If an average height of the PBL is 3000m, there would be, roughly, as many as 33 ECMWF vertical levels to resolve it and only 9 in the NCEP product.

Examples of retroplumes

One region where these differences could play a significant role would be over the mountainous regions in central Asia. Indeed, a closer inspection of the retroplume for JPX38, 1st March 2024, for which the scatterplot indicated larger spatial extension for the ECMWF meteorological fields, we see in the attached plots the differences in the regions occupied by two retroplumes.

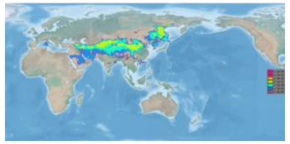
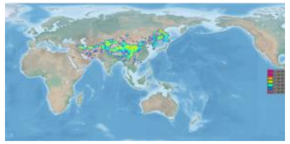
Station	ECMWF	NCEP
JPX38		

Fig. 2 Retroplumes for ECMWF and NCEP meteorological fields for JPX38, for the collection stop time on 1st March 2024. Larger geographical regions occupied by the former can be identified.

Even if the situation illustrated in Fig. 2 is more typical, counterexamples like the one in Fig. 3 for station KIP39, collection stop on 1st March 2024, can also be encountered. These plots illustrate a case where larger regions are occupied by an NCEP-driven plume. Possibly, the geographical location of the plume, largely over the North Pacific, contributes to this phenomenon but the underpinning reasons still need to be understood.

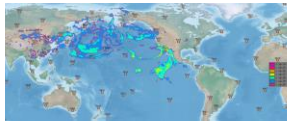
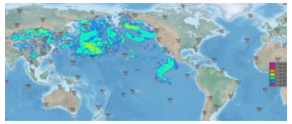
Station	ECMWF	NCEP
KIP39		

Fig. 2 Retroplumes for ECMWF and NCEP meteorological fields for KIP39, for the collection stop time on 1st March 2024. Larger geographical regions occupied by the NCEP-driven plume can be identified.

Conclusions

ECMWF-driven retroplumes often indicate broader geographical regions than the NCEP-driven ones. One plausible reason seem the differences in the definition of vertical levels for both sources of meteorological fields, implicating their vertical resolution, capability of resolving the planetary boundary layer and defining vertical transport. This conjecture, however, needs further investigation.

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