Influence of Resolution on the Performance of FLEXPART with ECMWF Data in the ATM Challenge 2016

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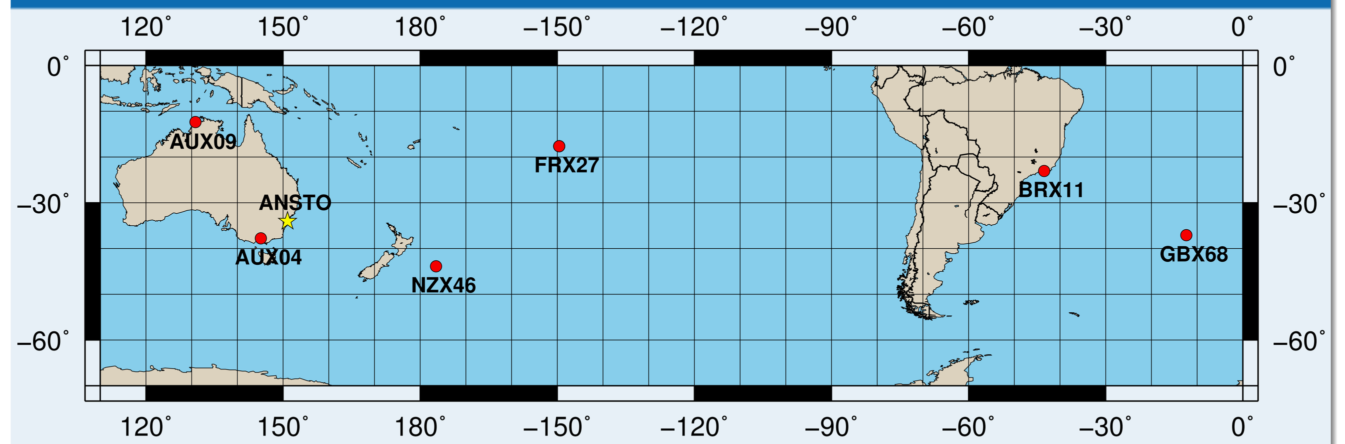
ABSTRACT

In the context of the Atmospheric Transport Modelling (ATM) Challenge 2016, we simulated the Xe-133 concentrations resulting from emissions by the ANSTO facility in Eastern Australia at various IMS noble gas stations. The stations are located at a wide range of geographical areas, from Australia over the Pacific to South America. All simulations were based on ECMWF 0.125 degree meteorological input data and carried out with FLEXPART in backward mode. Due to the highly different transport distances, suitable sampling grid sizes vary accordingly. We study the impact of the sampling grid resolution in the horizontal and vertical on the quality of results.

The Atmospheric Transport Modelling Challenge 2016

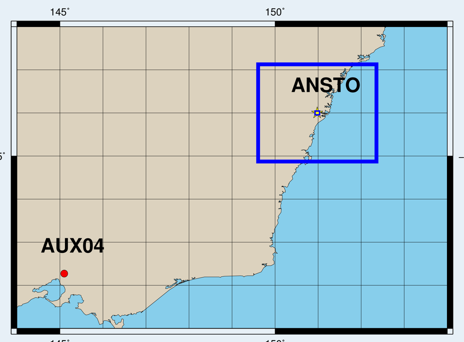


- Simulate Xe-133 concentrations at six IMS RN stations (see map; 24 hour mean concentration measured) resulting from emissions of the ANSTO medical isotope production facility during four weeks in May / June 2016.
- Many groups participated, Paper by C. Maurer et al. in preparation for *J. Environ. Radioact.*. See also other SnT contributions.
- Use temporal resolution between 1 h and 24 h of the emissions
- **BOKU/UNIVIE approach:**
  - Backward simulation with FLEXPART
  - ECMWF 0.125° / 3 h input
  - Use output grid with horizontal resolution of ca. 10 km and extent of 250×250 km^2, and vertical layers 0 / 100 / 500 / 1 000 / 15 000 m
  - Aggregate subdomains of variable shape and size from this output domain in order to find best resolution

Resolutions overview

Table 1: Subdomains used in evaluation of backward simulation runs. Numbers 1 – 8 refer to the IDs used in result plots as a categorical axis. The plot shows the 250 km domain (blue) and the 10 km domain (tiny blue).

	Horizontal subdomain size			
Vertical layer	10 km	70 km	130 km	250 km
100 m	1	–	–	–
500 m	2	4	–	–
1 000 m	3	–	5	6
15 000 m	7	–	–	8

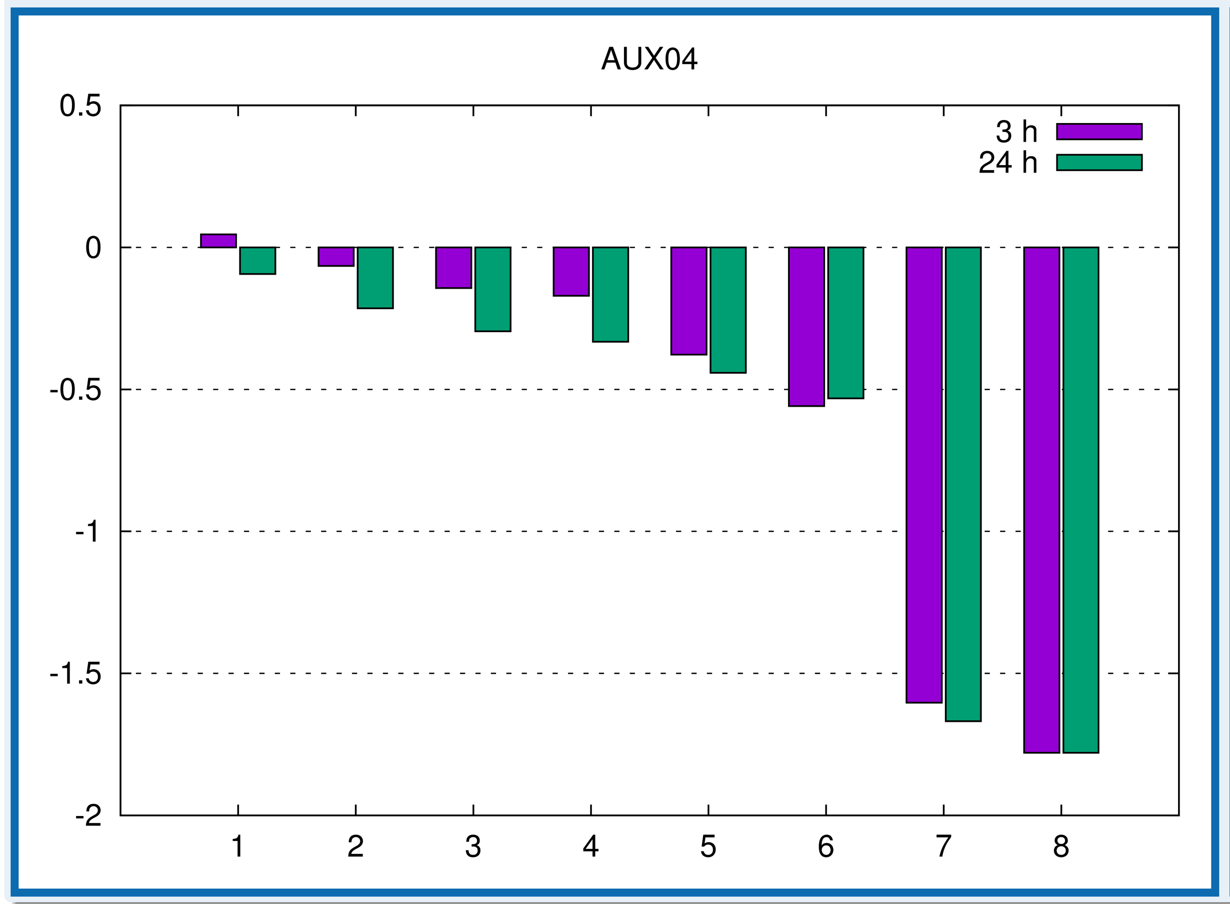


Rationale

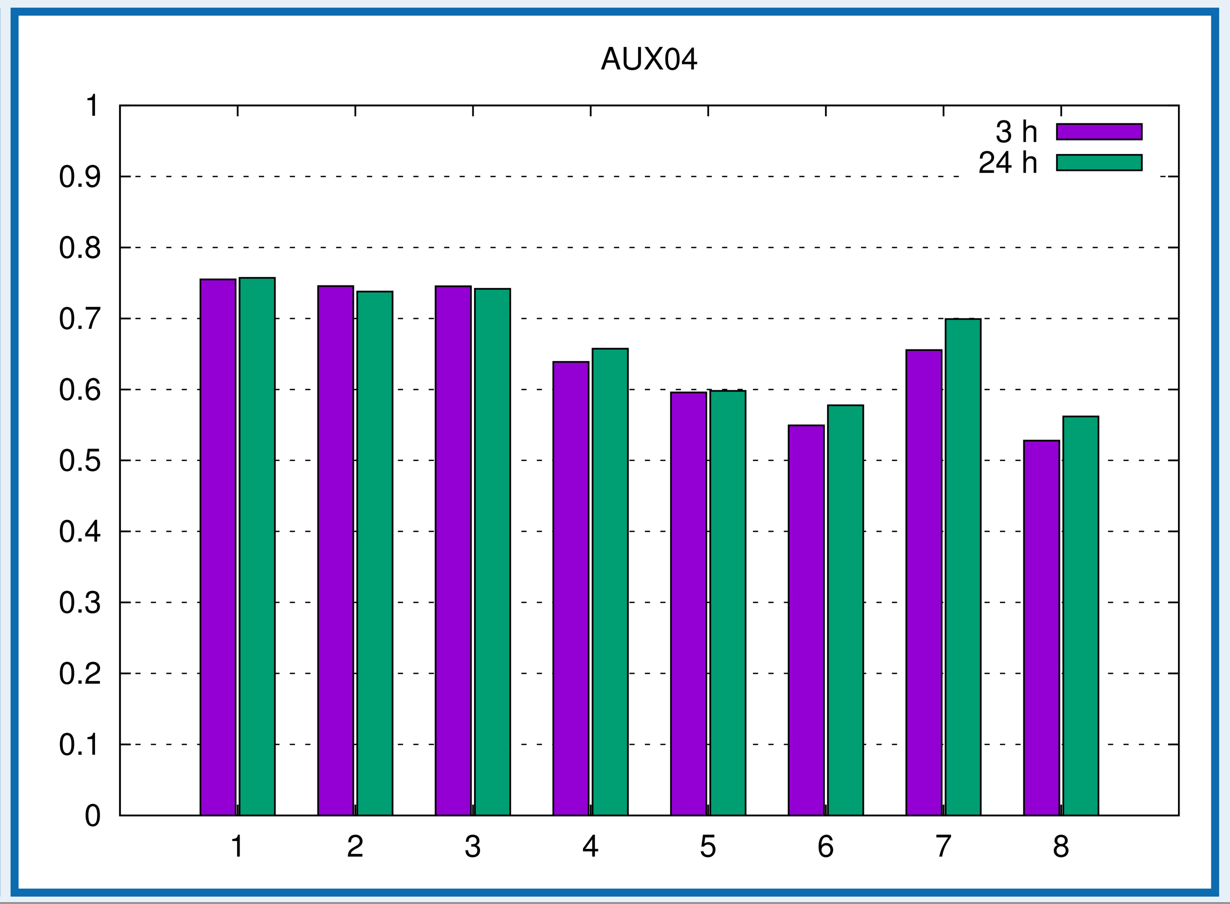
- Horizontal and vertical resolution should be consistent (#7 is for comparison only)
- Small cells should be appropriate to shorter transport distances (with smaller error), larger cells for longer distances (larger error)
- Vertical layer for sampling (from ground to the height given) should be in the boundary layer
  - 100 m is a kind of standard among FLEXPART users
  - 500 m is a compromise for better counting statistics
  - 1 000 m might still be considerable for long-range transport, at least for comparison
  - 15 000 m to catch the whole troposphere – not expected to give realistic values, but can give a hint in cases where horizontal transport might be ok, but height distribution being wrong, e.g. due to unsatisfactory boundary-layer height parameterisation in the model

Fractional bias and correlation coefficient at AUX04

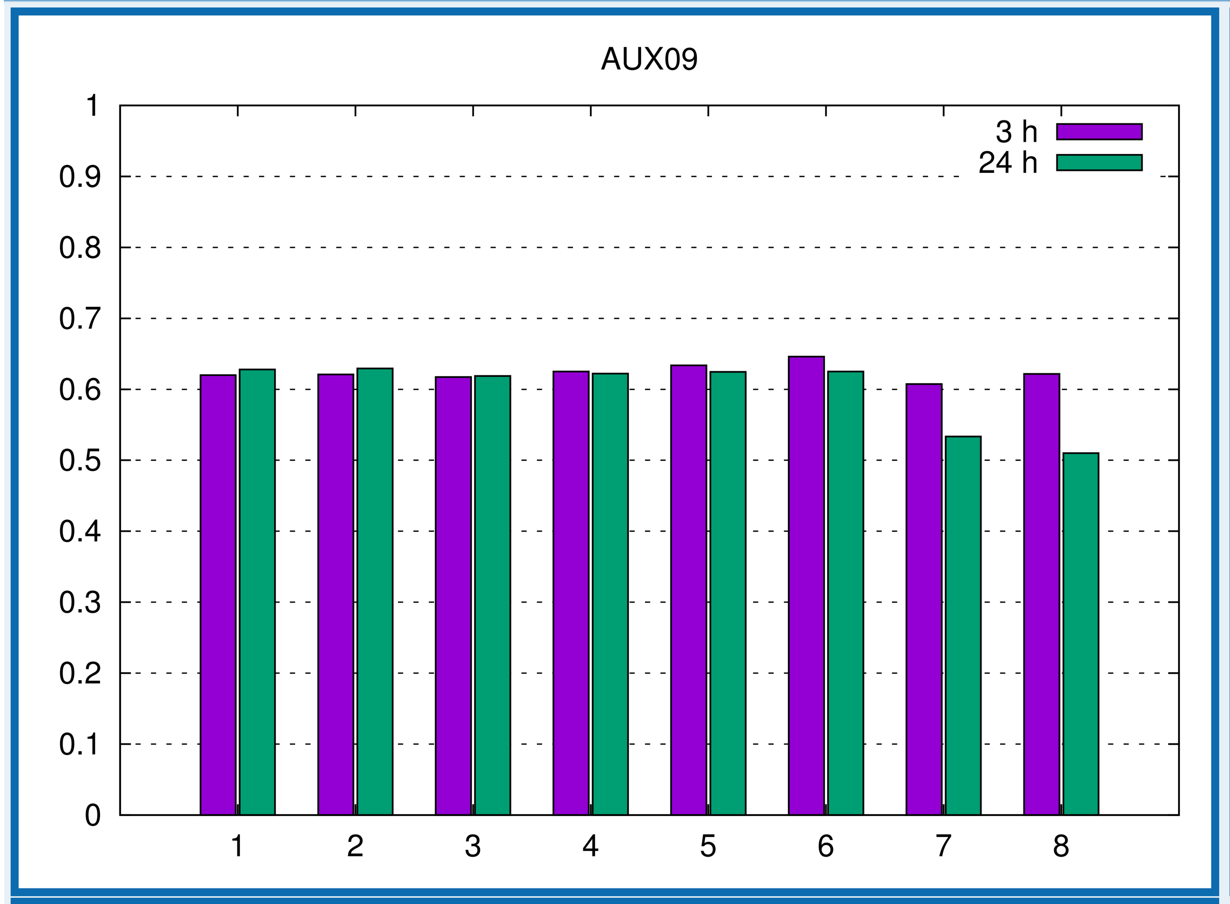
Fractional bias

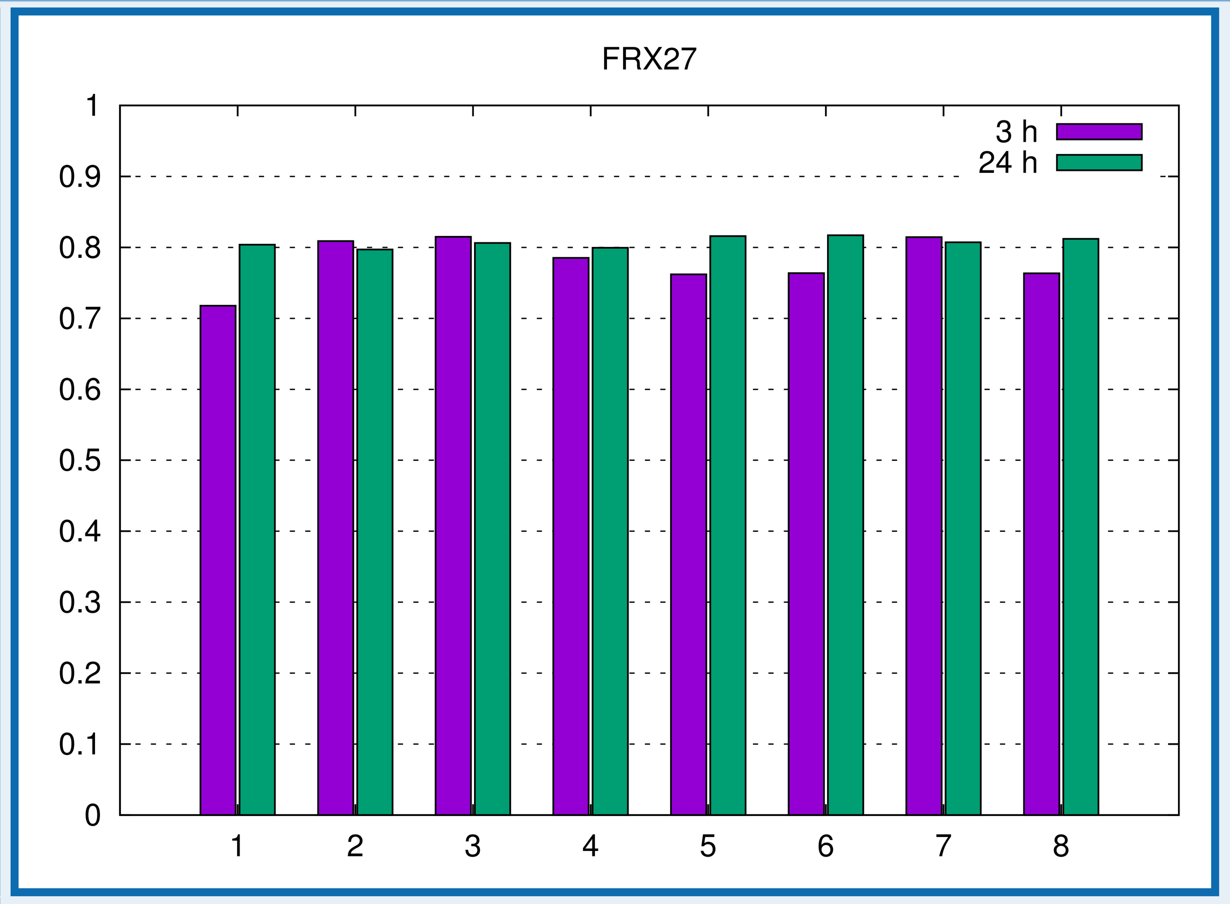


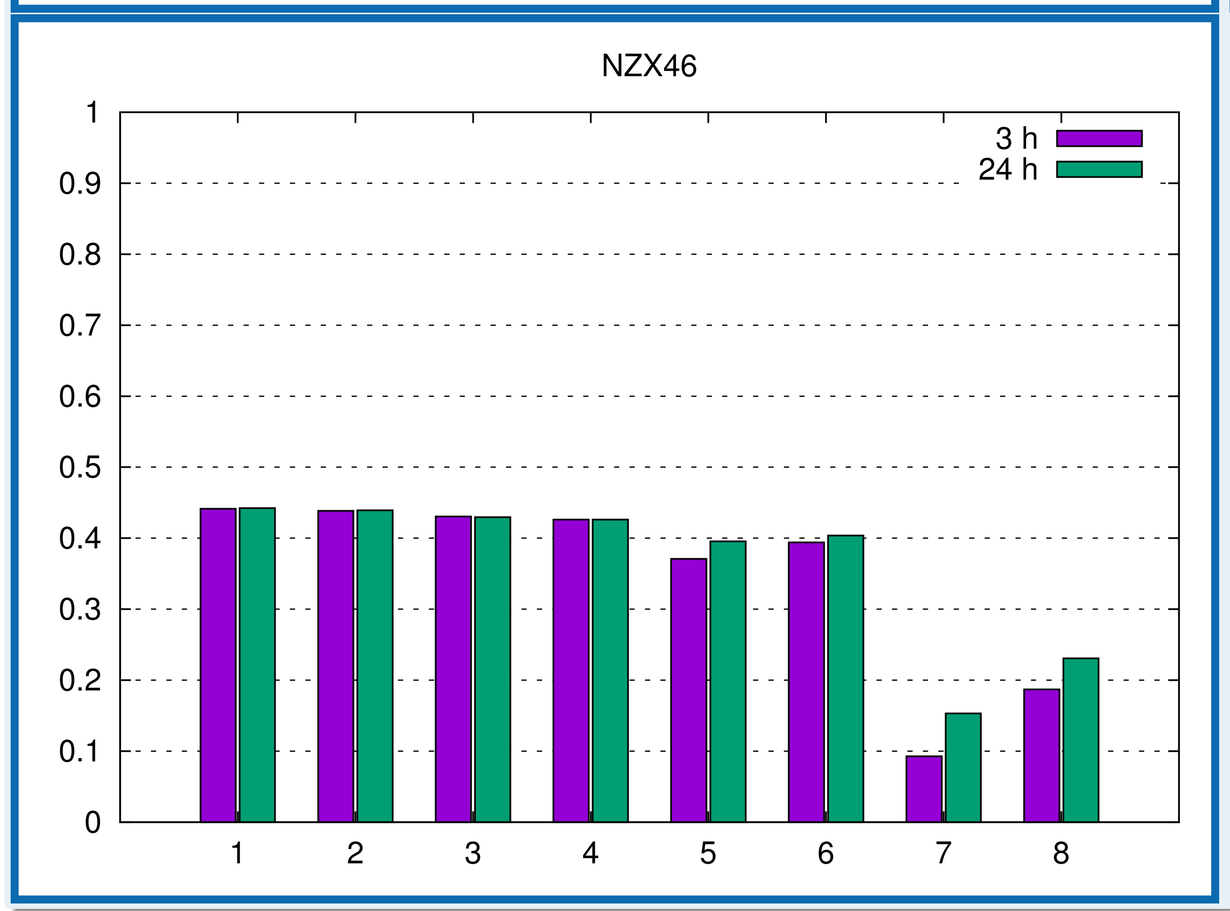
Correlation coefficient



Correlation coefficient at AUX09, FRX27, NZX46







BOKU/UNIVIE general results

- Very good results for AUX04
- Moderate to good correlation for AUX09, NZX46, FRX27, but severe underprediction (reason for this not yet clear, might be a scaling issue). Therefore, only correlation coefficient but no bias shown for them.
- No contribution from ANSTO calculated for BRX11 and GBX68, at least not within the boundary layer. Therefore no results for these two stations are shown.

Explanation for figures:

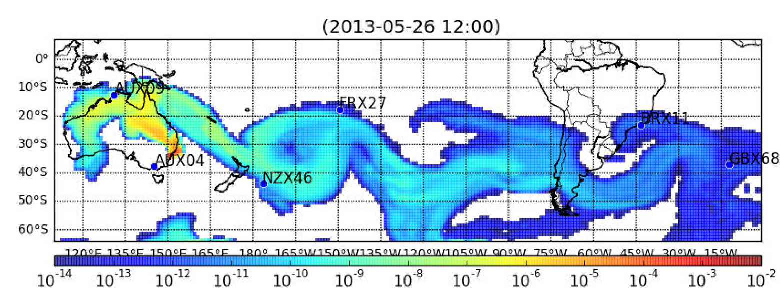
The bars show the correlation coefficient (one plot: fractional bias) for the eight different output subdomains representing the source (particle sampling volume in backward run) as explained in Table 1.
The two colours represent two different source time resolutions as indicated.

Results with respect to resolution

- For the closest station (AUX04), the bias is quite small for the highest resolution and degrades with increasing subdomain size (vertically as well as horizontally).
- The correlation is very similar for all cases based on 10 km resolution. This indicates that at the given transport distance (and in this specific case) the horizontal accuracy of transport (and time!) was closer to 10 km than to 70 km! The fact that even the 15 km column gives good results just indicates that no particles were at higher levels.
- Interestingly, at the other stations, there is not much difference between the various resolutions. Even if 10 km is not always the best, it is also not much worse at lest if combined with 500 m vertical layer.
- If we restrict ourselves to the cases with the best results, then a source time resolution of 3 h gives a small advantage to 24 h – but if the result is not so good, smearing out the source in time obviously helps to achieve some score.

Conclusions

- Backward modelling allowed for extreme flexibility in evaluation: with a single run for each measurement, all options for source resolution (horizontal, vertical, temporal) can be served by post-processing.
- High resolution pays off – at least, if high-quality, high-resolution meteorological input is available.
- A good representation of the boundary layer appears to be important. If in doubt, use a thicker vertical layer.
- Misses in time and / or space are of course possible and are more likely at larger distances, and at the finges of the main transport band. They should be accounted for with a suitable uncertainty estimate (currently, approach would be ensemble-based.)
- Especially for the closest station, higher resolution of the source is clearly beneficial. For larger distances, this advantage fades out or may turn into its opposite as smoother distributions are more robust against transport errors.
- Obviously, everything is case-dependent, and we have to be careful with respect to generalisations.
- There are many more issues to be explored in this (and the first) ATM challenge, for example
  - reason of underprediction in BOKU/UNIVIE simulation;
  - reason for not simulating a contribution from ANSTO at the BRX11 station;
  - influence of horizontal and temporal resolution of input for the above findings;
  - observed versus simulated boundary-layer heights and role of coastal and island conditions;
  - role of convection;
  - explanation of difference in performance of different models / set-ups in the challenge.



Example of FLEXPART output from a test run in forward mode using a constant emission rate, indicating scale of plume features (6 h mean values).

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