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Comparison of receptor-oriented dispersion calculations based on ECMWF data and nested MM5 simulations for the Schauinsland monitoring station

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Schauinsland in the Black forest (SW Germany) is a mountain station at 1205 m asl with environmental monitoring programmes as a GAW regional station, as a CTBTO radionuclide station, and as a national radioactivity monitoring station. It is situated next to the Upper Rhine valley with a height of only 250 m. In global operational models, these topographical details are far from being resolved. ECMWF fields with 1 degree resolution, as presently used for the operational CTBTO/IDC calculation of fields of regards (source-receptor sensitivity [SRS] fields) the terrain height at Schauinsland is only 600 m. Therefore, the question was raised if a high-resolution simulation with a mesoscale model and a corresponding transport and diffusion model would yield more accurate source-receptor relationships, and furthermore, if significant differences could then be found between Schauinsland and the Freiburg station at the foot of the mountain.

In order to answer this question, simulations with the MM5 model were carried for 10 episodes each lasting about 5-10 days, representative of different weather situations and seasons. MM5 was set up with four nest levels and grid distances of 0.67 / 2 / 6 / 18 / 54 km. ECMWF analyses were used for initial and boundary conditions and the mother domain was nudged towards the ECMWF data. For the dispersion calculations, the latest version of the Lagrangian particle dispersion model FLEXPART (V6.2) was adapted to run with MM5 output. ECMWF-based simulations were carried out for particle releases at the receptor in 5 m agl (same as in FLEXPART-MM5), at the real height above sea level (1200-1210 m), and inbetween (910-920 m).

Comparisons between meteorological observations at the stations Schauinsland, Freiburg and Feldberg (the highest peak of the Black Forest) indicate superior performance of the high-resolution MM5 data in most though not all episodes and parameters. Most notably, MM5 tends to simulate too cool daytime temperatures under fair-weather conditions. On the other hand, the thermal wind system, the channeling of the flows, and the vertical stability can only be captured with the high-resolution model.

Plotted SRS fields of selected days indicate good general agreement between ECMWF-based and MM5-based simulations on some days and substantial deviations on other days, caused mainly by orographic influences on the wind fields. The differences between standard and high-resolution dispersion calculations is greatest in the regional range, and diminishes at longer distances. Furthermore, HYSPLIT trajectories were also evaluated to provide output formally similar to the FLEXPART model, and are included in the comparisons.

In order to decide if the considerable effort for the high-resolution dispersion modelling does not only yield subjectively more plausible patterns but whether it allows a better description of source-receptor relationships, the SRS fields were multiplied with emission inventories of NOx and CO and a homogeneous radon exhalation rate over land areas, and resulting concentrations compared with measurements. It was found that when using 0.5 degree resolution EMEP emission data without spatial and temporal disaggregation, and the relatively short back tracking of 2-4 days, in general the agreement is weak, with a slight margin in favour of the MM5-based calculations. Disaggregated emission data should help to provide a more conclusive answer.

In conclusion, it could be demonstrated that high-resolution meteorological modelling with MM5 can describe dispersion-relevant features in the Black Forest regions much better than ECMWF 1 degree data. For the analysis of single episodes, the computing power of a good standard PC is sufficient. From the point of view of dispersion calculation with the aim of identifying radionuclide sources, it seems that for distances of more than a few hundred kilometres and as a screening tool, ECMWF-based calculations are good enough even for receptor sites in complex terrain such as the Black Forest. However, if potential sources are located in the near field, high-resolution calculations are desirable. Also, if there are any ambiguities in the overall assessment of a situation, where minor difference could play a role or where consequences of decisions are heavy, such calculations might also be desired.

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