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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Technical Note: A new coupled system for global-to-regional downscaling of CO_2 concentration estimation" *by* K. Trusilova et al.

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Answers of the authors to the comments of the referee are indicated by "A:"

One major point needs clarification in this paper. The TM3 model you use for the comparison is at the global scale, even if the higher resolution grid, used as input for STILT, is available. The performances of STILT are then better because you use higher resolution wind fields and flux fields as input, and you compare the results to the coarse resolution grid of TM3. Why not using the TM3 concentrations from the regional domain of interest (DoI) at high resolution?

A: Yes, the TM3 and STILT are driven with meteorological input data on different res-

olutions. The finest resolution of the TM3 that uses NCEP reanalysis fields is ∼1.8 degree. This resolution is too coarse for the regional atmospheric inversion over Europe. That is why we nest the regional model STILT into the TM3 grid. We do not aim at model comparison as such, but demonstrate what regional nesting brings in terms of capturing the fine scale variability of the trace gas signals.

Evaluation of Lagragian models are usually done by comparing the simulated concentrations by the Eulerian model to the Lagrangian model, at the same scale, using the same flux inputs. Otherwise, you compare a global model designed for large scale influence (general circulation mainly using averaged data) to a mesoscale model that will perform better at the point location. You should include results using the smaller domain of the TM3 model at higher resolution that will be comparable to STILT.

A: In this technical note we do not aim at evaluation of either of the models. For the presented coupling scheme, which implies the separation of the near field and the far field signals, any regional model can be used, not necessarily the Lagrangian model STILT. Our purpose is to demonstrate advantages of using the proposed scheme of nesting, which uses the coarse global model to resolve the far field influence and the fine-scale regional model to resolve the near field signal.

There is also another issue. In the paper, the main attempt is to show that the newly developped TM3-STILT shows better agreement with the concentration data than TM3 at low resolution. Actually, TM3 is not used to invert fluxes with hourly concentrations, but using averaged concentrations. Global scale inversions avoid misrepresentation of the local variability by averaging the high frequency temporal variability. If you expect to extract the local signal from concentrations, it has to perform better than global models but you shouldn't compare them at the same temporal resolution. The aim is to capture the local variability, giving a far field residual that is better than the averaged concentrations. If you capture half of the local variability for example, you will bias the global inversion maybe more than averaging the concentrations that substracts 80% of the local signal (a pure guess). You should focus more on the potential improvement using your TM3-STILT system compared to actual inversions, and not concluding only that higher resolution means better model-data agreement.

A: The TM3 model uses hourly data for inversions, selected for daytime periods at stations where continuous data are available. We demonstrate a way two independent models – a global Eulerian and a regional Lagrangian – can be coupled through the data vector (Rödenbeck et.al, 2009).\\ The TM3-STILT will be used in the atmospheric inversion of the trace gas surface flux over Europe according to 2-step inversion scheme (Rödenbeck et.al, 2009). In this scheme the global inversion on a coarse scale is done first (in a usual way, with the averaged concentrations), then the inversion over the DoI is done independently (no feedback to the global domain). But, prior to the DoI inversion, the contributions of the far field are subtracted from the time series of trace gas concentrations that constrain this inversion. \\ However, we do not aim to discuss inverse applications in this technical note.

P23189-3-4: add references

A: two references were made: to the atmospheric chemistry-transport zoom model TM5 (Krol et al., 2005) and in the nested regional transport-chemistry model HANK (Hess et al., 2000)

18-21: The Lagrangian approach includes also several issues compared to Eulerian models. Parametrization of the vertical mixing, evaluation of the footprints, amount of data for a long period of time, determination of the "surface layer",... are some of the issues of the method. Please re phrase the sentence to clarify this point.

A: The specification of the surface layer, a clearer description of particle trajectories, and their interaction with the surface were added to the chapter “2 Modelling system”.

P23190-1-3: Explain why you don’t compare a regional Eulerian model to a regional Lagrangian model. Is there any justification for comparing the two methods at different scales?

A: As mentioned above, we do not aim at model comparison as such here but demonstrate advantages of the nesting of a regional into a global model, which can be used for future regional inversions.

P23191-1: This sentence is very confusing. Do you use STILT coupled to the TM3 wind fields or to the ECMWF operational data?

A: The model STILT uses ECMWF operational data. Clarification was added.

P23191-4: "was set to 100": Unclear. Explain what "100" means (per time step? Total per tower? per observation?).

A: An ensemble of 100 particles per receptor point is used in each STILT simulation. Clarification was added.

P23191-16-17: what is the height of your "surface layer"? This is a technical paper, more details could be given about this parametrization of the model, or references.

A: The height of the surface layer is 50% of the mixing layer (clarification was added to the chapter 2 Modelling system).

P23191-1-2: How many particles are still in the DoI after 72 hours? This should be accounted as a loss of information if particles are still present in the DoI.

A: most but not all particles initiated during daytime hours leave the domain after 3 days. Few percent of particles may stay in the domain as tested for one of the most easterly stations at Hegyastal. This information loss is rather small because the signal at the receptor is dominated by the near field of around the measurement location (Gerbig et al, 2009, www.biogeosciences.net/6/1949/2009/). For the future use of TM3-STILT in inversions the particle trajectory length will be increased.

P23194-6-7: This is a subjective conclusion. This CFF component could potentially bias your regional inversion if the area is not dominated by the mesoscale circulation. Misrepresentation of synoptic events could lead to a biased estimate of the regional fluxes. Could you give an estimation of the errors due to the CFF component on the regional balance? This is not directly in the scope of the paper, but the potential errors due to wrong boundary conditions could affect the results of this paper, and decrease the overall performance of TM3-STILT.

A: We agree that the term “sufficiently good” may be misleading in general sense. In this study, the CFF is calculated using Fposterior from the first step global inversion; this would be the best possible estimate of the CFF in the present framework, because it is consistent with observations used in the global inversion. We remove the word “sufficiently” in order to avoid that the conclusion sounds subjective.

P23195 (about nighttime data): Arguments 1 and 2 seem very similar. The two means that well mixed conditions are required to simulate correctly the atmospheric circulation (at least the vertical motions). One could wonder if nighttime data are of great interests considering their spatial representativity. Flux towers could potentially measure very similar footprints during the night. Inversions are interesting, first of all, because they represent a larger area at the surface than flux towers, which is not clear during the night. Is it what you mean by "are representative of the well mixed boundary layer"?

A: Yes. The global atmospheric models as well as the coupled system TM3-STILT are not yet able resolve the boundary layer evolution during the night and nocturnal hours well enough. Especially large uncertainties are present in the near-surface dynamics, where the shallow boundary layer is resolved by one or few more (in case of regional models) layers only.

P23197-7-11: This conclusion doesn’t really help the reader. What is the point you make here? Is it just saying that a 4x5deg is not able to reproduce the local variability?

A: We agree that the main goal of regional modelling (and our goal of regional nesting) is to better resolve the local variability then the global models do. We chose to start from the demonstration of modelled time series at selected stations showing that the global model obviously misses some part of the fine scale variability (figure 2). This

is the starting point for our work, which motivated to look for better solutions, such as regional nesting, to resolve fine scale signals. We feel it would be useful to remind the reader in the beginning of the discussion what we start from and what our efforts have brought.

P23198-12-14: This conclusion is important. Several stations are located in mountainous areas (Puy de Dome, Schauinsland). STILT-TM3 seems not able to capture the local variability. Could you explain the major limiting factors to reproduce the local dynamics (vertical mixing, valley breeze, free troposphere/PBL exchanges)

A: The poor behaviour of the autocorrelation curve at the KAS station may be explained by errors in positioning the receptor point at this mountain site. The STILT model requires setting the receptors vertical coordinate as the height above ground, which can be easily measured or estimated. However, the receptor point is placed above the smoothed terrain in the model. Therefore, the model output at this sampling height may actually correspond to a different height above sea level (where the observations refer). The positioning of the sampling height remains the major problem for modelling of mountain regions.The discussion in the chapter “5.2. Autocorrelation analysis” was extended including the discussion of the site positioning problem that influences results at KAS station.

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