**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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Marked with "A:" are answers of the authors to those comments.

It is very informative to see TM3-STILT compared w/ TM3, but it would seem a comparison with STILT and a data derived boundary as used previously w/ STILT (Gerbig et al., 2003 JGR; Matross et al., 2006 Tellus; Miller et al., 2008 ACP) would also be informative on whether merging STILT within a global model is worth the computation, or whether a more data derived boundary performs just as well. It should also be noted that model output has been used as a boundary condition before in a more rudimentary manner (Kort et al., 2008 GRL), representing a bridge between data-derived boundary

conditions and the approach described here.

A: The main reason not to use an LBC (lateral boundary condition) for CO2 from measurement based climatology is that such climatology exists only for the northern Pacific, not for the northern Atlantic, which is the dominant origin of air masses over Europe. Lack of airborne profile data together with larger variability over the northern Atlantic prevents us from generating such a climatology that could be used as LBC for regional simulations over a European domain. Although the computation of the LBC for the regional domain is costly, it is done only one time for each DoI/PoI and can be re-used for any regional model nested in this DoI/PoI. The advantage of this approach to calculate the boundary CO2 is that it can give a reasonable boundary estimate in an area with no/few measurements available for DoI/PoI. This is especially important in applications for such large domains, such as Europe.

In section 3.1, the need to subtract the NF from the global model to create Cff is not clear. If the air parcels travel far enough back to be removed from the regional signal, then the global model output at those points should simply be representative of Cff. Even if air has circulated over the European continent previously, that wouldn't be captured in the STILT trajectories so having European sources in Cff would actually be important in accurately modeling Cff in those cases.

A: The coupling of the global and the regional models was done to be used in the two-step scheme (Rödenbeck et al., 2009 ACP) for atmospheric inversions. The global and the regional models are used sequentially in separate inversion steps, coupled only via the data vector. The near field contribution to the CO2 signal should be compared to the "observations – far field influence (Cff)". The near field signal has to be subtracted from Cff in order to avoid double counting of the near field influence. The separation of the trace gas signal into far field and the near field parts for an atmospheric inversion is presented in detail in the paper by Rödenbeck et al.(2009, www.atmos-chem-phys.net/9/5331/2009/). We added an explanation into the chapter 3.1. into the description of the A'TM3 transport operator.

It is also unclear why the large-scale seasonal signal must be fit and removed with a harmonic function (section 4.2). Should this not be captured in the Cff computed from the global model with posterior fluxes? And if not captured by the global model, doesn't this failure suggest the global model is not capturing important variability and a data-derived interpolated boundary condition would do a better job?

A: the seasonal cycle was removed from the CO_2 concentration time series because we focused on the effects of the transport resolution on the variability of the trace gas signals. Otherwise, including the season cycle in the time series would increase the model-to-data match (due to correlations governed by the large scale seasonal patterns) but such approach would not allow a fair analysis of the role the transport scales play in representing the fine scale variability of trace gas signals.We added this explanation to the text (section 4.2).

p. 23191 l.4-5: The statistical error of using 100 particles is not going to be strictly 13%, as that number was derived using different wind fields over a different continent with different spatial flux distributions. The uncertainty is likely in that ballpark, but not limited to 13% as stated.

A: we agree. Indeed the statistical error for the regional contribution to the CO_2 mixing ratio estimated with an ensemble of 100 particles is not strictly 13% but is of this order of magnitude. A correction was added.

p. 23191 l.10-12: It would be useful to go one more step to show footprint and surface source equation for Cnf here, since with CO_2 the authors are not using volume sources, but instead surface sources. A brief mention of what layer is considered to be in contact with the surface also should be added.

A: The layer, which is as thick as 50% of the local mixing height, is considered to be in contact with the surface. We added this information into the text. Because the thickness of the 'contact' layer varies we would like to leave the formulation of the Cnf in terms of surface volumetric units, not a 2D-footprint.

p. 23191 l.18-20: This sentence needs to be restructured; it is currently misleading as to what a particle trajectory is.

A: we rephrased the definition of the particle trajectory as following: A trajectory of a particle is the path followed by the particle along the mean wind direction starting at the location (receptor) at time tr.

p. 23192 l 1: 72 hours seems a short time to experience the full near field. Can the authors comment on this time period choice- does it take most of the 100 air parcels off the continent out over ocean?

A: The period of 72 hours was chosen to minimize the computational cost of the trajectory simulations and at the same time to provide realistic footprints. Strictly speaking, 72 hours period does not guarantee that all particles leave the model domain, but most of them (as it was tested for one the most easterly stations at Hegyhatsal, just few percent of particles did not leave the domain). The period of 72 hours is sufficient to capture most of the regional influence at the receptor (according to Gerbig et al, 2009, www.biogeosciences.net/6/1949/2009/, a midday observed signal is dominated by the surface fluxes from the near field area around the location where the observation is taken). For the future use of TM3-STILT in inversions the particle trajectory length will be increased.

p. 23192 l. 11: Care must be taken when describing the NF region as having a resolution of 0.25x0.25. The authors should distinguish specifically whether this refers to flux fields and/or driving met fields. It could also be noted that an LPDM is not strictly limited by the underlying met field resolution.

A: the clarification was added pointing out that the 0.25x0.25 deg resolution corresponds to the flux field resolution: "... with 108×188 (latitude by longitude) grid cells corresponding to a spatial resolution of 0.25×0.25 deg of the tracer flux field".

p. 23193 l.6-7: What version of the EDGAR database is being used?

A: the version of EDGAR data is 3.2. We added the following: " . . . the anthropogenic emission fields taken from the EDGARv3.2 emission database (Olivier et al., 2005; van Aardenne et al., 2005) that was linearly extrapolated to 2006. . ."

p. 23196 l. 11, 12, 15: the quantity x and t get mixed up in this equation, and the harmonic function is referred to as both c(x) and c(t).

A: indeed, the variables x and t were mixed up. Corrections were made; c(t) is used throughout the text.

Section 5.2 The autocorrelation behavior at KAS is very confusing–would the authors comment on what may cause the course-scale TM3 model to show a more rapid drop off with time (matching the data) than the STILT-TM3 model?

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. We added this discussion part to the end of the chapter "5.2. Autocorrelation analysis".

p. 23200 l. 13: This paper did not demonstrate the ability to resolve temporal scales of less than 1 hour and this claim should be removed.

A: authors agreed with this point. In the text the following change was made: '. . . system is able to resolve both atmospheric transport and the source/sink patterns of CO2 on fine spatial (less than 1°) and temporal (1 hour) scales . . .'

p. 23188 l.1-2: suggest change to "transport models used in simulating"

p. 23188 l.10-11: suggest change to "near-field contribution enabling the usage of

different model types for global (Eulerian) and regional (Lagrangian) scales.

p. 23188 l.15-16: suggest change final sentence to "Autocorrelation analysis demonstrated that the TM3-STILT model captured temporal variability of measured tracer concentrations better than TM3 at most sites."

p. 23188 l.18-21: Suggest rewording this sentence.

p. 23188 l.23, 26: "This makes the model" the should be removed. "observation and that can be used for inferring" that can be should be removed. I will not comment further on this, but the authors should go through and remove such extraneous words throughout to add clarity to the paper.

p. 23199 l 11-12: The sentence starting "Clearly, the" should be removed. It is redundant with the more detailed description of the figure that follows.

A: authors are very grateful for these remarks that helped to make the text more clear, we followed each of these.

p. 23198 l.6: Are the dots on the figure red or orange?

A: the dots are indeed orange, we corrected the text accordingly.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 23187, 2009.