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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "The potential for regional-scale bias in top-down $CO_2$ flux estimates due to atmospheric transport errors" *by* S. M. Miller et al.

**Anonymous Referee #2**

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The paper presents a novel approach to quantify the impact of transport errors on uncertainties in flux estimates derived with inverse modelling. It uses a global meteorological data assimilation system (CAM-LETFK), in which atmospheric CO2 is transported as passive tracer. This way, ensembles of realizations of meteorology and atmospheric CO2 transport, consistent with meteorological observations, are used to study error variances and covariances in simulated CO2. Simulation results are analysed in two case studies to assess the impact on fluxes retrieved by inverse modelling. The paper is well written, and I recommend publishing after the following minor comments are addressed.

General comment: Not all sources of transport model uncertainty are captured by an ensemble of forecasts with a single transport model. Somewhere in the paper it should clearly be listed which uncertainties are not included (e.g. spatial representation error/model resolution, uncertainty arising from imperfect parameterizations of turbulent processes and cloud transport, other structural model errors such as numerical diffusion).

Specific comments: P23684 L12: “correlated errors can bias” I suggest to replace this by “spatially correlated errors can bias”

P23694 L4-6: The case that the ensemble does not encapsulate the CO2 measurements might also be related to differences in the transport models used here and for CT (TM5). This should be mentioned.

P23695 L17-18: “most existing top-down studies will underestimate the uncertainties in estimated CO2 fluxes” here references should be given as this is quite a strong statement. Some inverse modelling systems e.g. use error inflation to allow for covariance on timescales shorter than a week (e.g. Rödenbeck et al., 2003).

P23695 L25: I suggest dropping the comma after “top-down”

P23696 L5-8: It might not a property of the tall towers to be more or less sensitive, but a property of the transport model. It should be mentioned that there is not really a difference expected, given the vertical resolution of the transport model. In that context, it would be appropriate to mention the number of vertical levels in the lowest km as this information seems hard to find for the reader.

P23696 L8-9: I have difficulties averaging the bar plots for marine sites to 76%. There are three bars that are of scale, and the others average to something around 35% in February and 45% in July.

P23698 L3-5: Figs. S16 and S17 do not really provide any information regarding the uncertainty represented in the meteorological ensemble, as they only show monthly



ACPD
14, C8264–C8266, 2014





mean values for each of the variables. A parameter that might be interesting in this regard is the coefficient of variation for the boundary layer height (PBLH), as a small uncertainty in PBLH will lead to a large uncertainty in tracer in regions with low average PBLH.

Supplement S1, P1, first line of 3rd paragraph: suggest replacing “for each for the” by “for each of the”

Supplement S2, P4, 4th paragraph: I don’t quite understand why there is a need for manually setting inflation factors to 0.4 (the lowest values globally); in the text “unphysical temperature estimates near the tropopause” are mentioned. Are there no satellite data in this region available that are assimilated? Kalnay et al., (1996) mentions that TOVS sounder data are assimilated; also there should be a few radiosonde data in that region.

Supplement S3, P8, figures S7 and S8: The colour scale labelling seems to be wrong; I would expect a significantly smaller range for monthly averaged concentrations than for 6 hourly concentrations

Supplement S5, table S1: it should be mentioned (in the legend or in the text on page 16) that the locations for each of the sites can be seen in Figure 4, panel a).

Supplement S6, Figure S15: SSR should have units (ppmˆ2?), those should be added

References: Rödenbeck, C., Houweling, S., Gloor, M. and Heimann, M.: CO2 flux history 1982–2001 inferred from atmospheric data using a global inversion of atmospheric transport, Atmos. Chem. Phys., 3(6), 1919–1964, 2003.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 23681, 2014.