**Atmospheric
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Discussions**

Interactive comment on "What can we learn from European continuous atmospheric CO$_2$ measurements to quantify regional fluxes – Part 2: Sensitivity of flux accuracy to inverse setup" *by* C. Carouge et al.

Anonymous Referee #2

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General comments: Carouge et al. have chosen a very reasonable set of pseudo data experiments to try and understand what factors will lead to the best optimization of CO2 fluxes from the European network of atmospheric CO2 measurements. The paper leverages two different models forced by climatologies from two different years to derive a prior and pseudo data set. The difference between the posterior estimate and pseudo data set provide a measure to evaluate each experiment. By design the prior data set is much different from the pseudo data set to insure that improvement can be detected. It would be nice to understand how a range of different priors might

affect the conclusions. In particular, one test changes the error covariance matrix to match the decorrelation length scales of the difference between prior data and pseudo data. The result of this test suggests that applying a single decorrelation length scale to the error covariance matrix leads to a better posterior estimate. It can be argued that an unrealistic prior may (especially in the time domain) may the cause of this. It is also unclear why a this test was called "apparently physically-based". Wouldn't it be more "physically-based" to construct an error covariance matrix based on the decorrelation length scales of the pseudo data?

This study and the experiments performed have the potential to provide insight not just for the European Network but other localities as well. The authors should give some thought to how these lessons can be extended in a more general sense. An example of this can be seen brief summary how adding more stations to the network improves the estimate. While it goes without saying that "increasing the European atmospheric network density improves the area with significant error reduction in the flux retrieval", one wonders how much better the posterior estimate might be with double the sites verses 4 times the sites. What sites have the most impact on improving the posterior estimates?

Overall, this paper suffers most from awkward sentence structures which in light of the need for a clear and concise explanation of the results makes it difficult to follow. The author and co-authors (some of whose native language is English) should take more care in the final version of this paper.

Specific comments: Conclusion does not say anything about how the increase in stations will help the inversion. Technical comments: Overall - It is unclear in the text whether all the R and NSD statistics that are referred to are smoothed to take seasonal variability out. P. 18622 Line 5 what does "identical twin" approach mean? Line 6 "In this [study], the focus is put on the sensitivity of flux accuracy to the inverse setup, varying the prior flux errors .." Line 22 "which [] integrate[s] the flux heterogeneity over regional and continental scales." Line 25 "it is possible to infer information [about the

distribution of sources and sinks at the surface]." P. 18623 Line 4 "CAO8 was only able to explore a.."

Line 6 be specific about what "these" means

Line 10 "world, it will work in a real case but we can be confident that if an inversion setup is unsuccessful with pseudo-data it is unlikely to work in realistic conditions." Not sure this is true. In particular your prior may be particularly unrealistic and may prevent other parts of the inversion from working correctly.

Line 15 "If one strongly trusts the correctness of the prior spatial structure of the sources and sinks as usually defined by models of ecosystems, or of air-sea fluxes, one needs to use only a few number of regions to solve for, whereas if not, one must increase the resolution of the solution." Not convinced this is true. This makes it sound like there is need for more spatial resolution if you do not believe the prior. Please clarify.

Line 29 "In this paper, we perform three categories of sensitivity tests [] to investigate .."

P. 18624 Line 1 Enumerate starting with colon followed by 1), 2) etc. "parameterization" not with "s" P. 18626 Line 4 add Peters et al. 2007 Line 20 "The fact that TURC has a very different structure from ORCHIDEE[] and that it is integrated with climate forcing of a different year, maximizes the difference between prior and true NEE." Explain why that "maximizes" the differences. What was special about that year? P. 18627 Line 16 SP4 - How much of the error correlation patterns is based on biases rather than uncertainty (variance v. bias)? P. 18631 Line 6 "This result [confirms] the [dependence] of the [result on the] prior in Bayesian inversions but also suggests the overall procedure may work better with an improved prior." This a key point which needs to be proved by introducing multiple priors (run experiment forced with data from different years) Line 15 not sure the meaning of "significance analysis" has been explained. Line 17 "These limited improvements from the prior fluxes [error covariance] illustrate the fact that []er-

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ror covariances .." Line 20 remove sentence. It is not necessary. Line 26 You find spatial aggregation helps with the SP2 run. Isn't aggregation a substitute for the lack of correlation? P. 18632 Line 8: "In this case, the spatial prior error correlation plays an important role in correcting [for] large prior NEE variability compared to the truth, which was not the case in SP2." Line 14 "[at] all aggregation [levels]" P. 18634 Line 1 "It [turns out]" Line 1 "the simpler isotropic choice is more neutral, and appears to be more robust for obtaining an accurate retrieval of the daily fluxes in our framework". This does not prove that this will always be the case. I am concerned that large scale (offsets in seasonal drawdown or build up) and small scales (fronts moving through) between years have produced in correct error covariance matrixes that make it worse not better. Is there not a smarter way to produce a error covariance matrix?

Line 10 "The implementation of a full prior flux error correlation matrix, including cross-correlation between space and time, in the inversion is thus a potential way to improve the results at small aggregation scales." effectively increasing the tolerance of the fit will also increase bias. This statement needs more qualification.

P. 18635 Line 14 " ...because this test is limited to a 3-months summer period (June-September) for computational reasons." This needs more explanation. This seems like a serious limitation in the paper that the same diagnostics cannot be used to understand the network resolution issue.

Line 19 "Although the absolute value of the error reduction depends on the prior error setup, the relative differences between grid-points can be considered as a robust indication of the network's ability to retrieve fluxes."Is this true in the event that the prior and true fluxes are the same?

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 18621, 2008.