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Atmospheric Chemistry and Physics Discussions

Interactive comment on “What can we learn from European continuous atmospheric CO_2 measurements to quantify regional fluxes – Part 1: Potential of the network” *by* C. Carouge et al.

C. Carouge et al.

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Reply to reviewer #1 on: What can we learn from European continuous atmospheric CO2 measurements to quantify regional fluxes, Part 1: Potential of the 2001 network. C. Carouge1, P. Peylin1,2, P. J. Rayner1, P. Bousquet1, 3, F. Chevallier1, and P. Ciais1

Comment 1: Grid distance: Concerning the grid resolution, we went through the article and made sure to keep a consistent value of 40 km in the text and the figures.

Comment 2: Title & Abstract: Following the comment on clarifying the network used we changed “Potential of the network” to “Potential of the 2001 network” in the title. In the abstract we modified the sentence “a network of 10 stations such as in 2001.” to “a network of 10 stations from the AEROCARB project such as in 2001 (http://www.aerocarb.cnrs-gif.fr/).”

Comment 3: Section 2: The paper is based on a pseudo-data experiment. Thus, we are rather free in the building of the flux scenario. What matters therefore is the uncertainty in the anthropogenic fluxes which influences the difference between the “true” flux and the prior we use in the inversion. Within Europe, uncertainties in anthropogenic fluxes are smaller than those for the biosphere but will still contribute. To clarify this point in the article we added a sentence in section 2.1 on page 18595, line 14 and add a discussion in the conclusions on the consequences of anthropogenic emissions on the quality of the inversion.

Comment 4: P.18597, line 5: We think there is some understandable confusion from the Referee. In the comment, the Referee declares the retro-tracer would retract to a single point while going backwards in time. This would be true if a retro-tracer and a tracer were representing the same field with only the time going backward or forward. But the retro-tracer does not represent exactly the same field than a tracer. A tracer plume represents the locations reached, at a given time, by a tracer emitted from a source point. After enough time the tracer would spread all over the world. A retro-tracer plume represents all the locations where a tracer was a given amount of time before a given measurement. In other words, a measurement is composed of a multitude of air parcels. All these air parcels followed different trajectories before coming to the point of measurement. A retro-tracer represents all those trajectories, and thus a retro-tracer plume spreads out when time goes backwards: diffusion process acts the same in both time directions. To make this point clearer in the article, we added some explanation on page 18597, line 8.

Comment 5: P.18599, line 24: Concerning the correlation lengths used in this experiment, the explanations have been changed on page 18599, line 24. In the setup used, we neglect the cross-correlations in time and space. This simplification implies to reduce the correlations in space and in time when combining them in one covariance matrix. Thus, to counterbalance this effect, the correlation e-folding lengths have been enhanced. We think that grid cells influenced by the same synoptic weather system or covered by the same biome are likely to have correlated flux errors. The synoptic weather system have a typical size of 1000 km. In Europe, biomes are quite intertwined. So the size of the weather systems are likely to be larger than the surface covered uniformly by a same biome. To maximize the correlation length we thus choose an e-folding correlation length of 1000 km.

Comment 6: P.18600, line 8: To calculate the daily uncertainty per grid cell over the North Atlantic, we assume a constant uncertainty per day and per squared meter as it is done for European grid cells. Considering the time and spatial correlations applied and the total yearly uncertainty of 0.05 GtC.year-1, we then derived a daily uncertainty per grid cell of 0.5 gC.m-2.day-1. A full explanation was added in the text on page 18600, line 8.

Comment 7: Section 2.5.3: Yes, error correlations are zero unless the fluxes have either the same location or the same time. The implementation of flux error correlations in CO2 inversions is relatively new. At the scale studied in this paper; the knowledge of these correlations is poor considering that only one article was written on the subject to our knowledge (Chevallier et al. 2006). Starting from two separate time and space correlation matrices, it is possible to compute a full correlation matrix, including cross-correlations in time and space. However, this calculation is infeasible at our resolution when the correlations are not constant in time as for the SP4 case in the second part of this study. In a first approach, we thus decided to use a simpler combination of the two correlation matrices but then neglecting the cross-correlations. Doing so, the values of the time and the spatial correlations can not, mathematically, be preserved. With the formulation used in this paper, this means that all correlations are divided by 2, thus reaching a maximum of 0.5. The text of the section was modified to clarify this point. We also note that, although a computational artifact, the final form of the space-time correlation reduces correlations and hence preserves more degrees of freedom in the fluxes and thus reduces the risk of an unrealistically optimistic result.

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Comment 8: P.18601, line 22: We could decompose the product by storing H and P matrices in files and multiply a group of line of H by all covariances and storing the resulting lines (HP) in a file. Then, the groups of lines of HP and of H are read again and multiplied together considering the lines of H are the columns of HT. This process would be very time consuming but not impossible. For this reason, we chose to develop the time windows inversions. We also note that this use of time-windows is relatively standard in applications like CarbonTracker (Peters et al., 2007).

Comments 9, 10, 11: P.18602, line 4/11/13-15: One other delicate part in the method is the management of the time to reduce matrices size. We decided to use sequential time windows to solve smaller inversion problems instead of one full year inversion. Following the comments received, this part was reviewed. In particular: We added an explanation of “offset” line 11 The sentence “we keep the middle month” was replaced by “estimated fluxes for the middle month only are used to build estimated fluxes for the entire year” For the comment on “linearly decreasing the prior flux errors” (lines 13-15), we have changed “errors” by “variances” and added numbers line 15 to clarify the method. We kept the word “prior” because in this sentence, we truly speak about the prior flux variances as they are defined in section 2.5.

Comment 12: The problem of signal compression noted by the reviewer is, indeed, a concern when fitting data but we do not think it is such a concern in our Bayesian context. In a non-Bayesian framework a weak relationship between the unknowns and the data will manifest itself in low variability among the unknowns but also weak correlations with any real signal. In the Bayesian case however, the retrieved fluxes will simply remain at their prior values so that no statistic of the flux, either the correlation or the NSD, will change compared to the prior.

Comment 13: Table 2: Concerning the comment on the values in Table 2, all discrepancies between the text and the table have been corrected.

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Comment 14: P.18603, line 15: The “inverted fluxes” was not a good choice of words. We scanned the text and did the appropriate changes. On page 18603, line 15: “inverted” was replaced by “prior, posterior and true”.

Comment 15: The reasons for the regional patterns in differences between the biosphere models is indeed an interesting point but one which we don't believe we should take up here. The thrust of the article is the performance of the inversion system. Given that our performance metric is based on improvement of the posterior over the prior estimate it is, though, fortunate that we have regions with better and worse priors. This probably reflects what would happen in a real case.

Comment 16: The conclusions have been enhanced by adding a summary of the method used.

Technical comments The technical comments have been taken into account and the specified modifications have been made in the text.

P.18594, line 10-12: “information content of observing system” was replaced by “information content of potential observations” P.18601, line 21: “3650x2700000” is used P.18604, line 27: the typo was corrected with “deseasonalized” P.18605, line 26: “both” was replaced by “combined” P.18607 and Figure 5: the references to Figure 5 in the text were modified to correspond to the figure. Table 2: the order of the lines was modified by placing the results for all pixels of Western Europe first and the SP pixel after.

References: Chevallier, F., Viovy, N., Reichstein, M., Ciais, P., On the assignment of prior errors in Bayesian inversions of CO2 surface fluxes, Geophys. Res. Lett., 33 (13), L13802, 2006

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Discussion Paper

Miller, J. B., Bruhwiler, L. M. P., Petron, G., Hirsch, A. I., Worthy, D. E. J., van der Werf, G. R., Randerson, J. T., Wennberg, P. O., Krol, M. C., Tans, P. P., An atmospheric perspective on North American carbon dioxide exchange: CarbonTracker, P. Natl. Acad. Sci. USA, 104 (48), p. 18925-18930, 2007

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 18591, 2008.

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