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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Mesoscale inversion: first results from the CERES campaign with synthetic data" *by* T. Lauvaux et al.

T. Lauvaux et al.

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1. (The authors):The main goal of this paper was to discuss the impact of various measurements in constraining fluxes. Practically we aimed to contribute to the planning for the ongoing CERES campaigns. For this purpose, the reduction of error is a helpful and widely used statistic. We used the general result that such reductions of uncertainty depend on uncertainties on prior fluxes and data and on the Jacobian matrix. Neither variations in fluxes nor concentration affect the statistic. However, the spatial and temporal resolution we choose for our unknown fluxes does reflect assumptions about prior knowledge. We have chosen to correct, at each pixel, the mean flux over the four day period. This indeed implies confidence in the diurnal cycle of the prior flux but does not deny the existence of such a cycle. For an analogy consider the treatment of the annual cycle in the annual mean inversions common in the CO2 literature, e.g.

Gurney et al., (2002). We could choose any temporal resolution between this and the independent solution hour by hour. as a general rule, the more unknowns we add, the less information will be provided for them. The other impact of the diurnal cycle is on the model error. Here there is a case for increasing the error at night. We have performed this test but find it makes surprisingly little difference. The relative spatial extent of the influence function by day and by night means that most information is added by day-time measurements anyway so weakening the impact of nighttime measurements has little effect.

In our system, the Jacobian matrix represents the linearized transport during the period, and doesn't depend on the prior fluxes. No biosphere model nor inventories were used to calculate it.

2.(Referee3): Will this be presented in a companion paper, or is this considered not feasible/reliable ? In principle all information should be available to solve equation (2). The paper would be much more convincing if it included a detailed comparison with observations. This would allow a much better assessment of model performance.

(the authors): The flux inversion will be presented in a forthcoming paper with more detailed studies of the covariance errors and prior fluxes as detailed before. Like the Observing System Simulation Experiments (OSSEs) in Numerical Weather Prediction, this paper presents our preliminary impact study that motivates it.

3.(Referee3): On page 10454 the authors discuss the weaker vertical mixing in the model compared to (meteorological ?) observations. How severe is this problem ?

(the authors): The lagrangian coupling with an eulerian model implies the parametrisation of the turbulent vertical mixing as we only solve the turbulent kinetic energy by closing the energy budget. By the way, we noticed a weaker vertical mixing during the afternoon due to the extreme conditions of instability in the boundary layer (more than 30°C at the ground during the campaign). Even if the scheme used to estimate the vertical mixing showed good agreement during periods with a more stable boundary

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layer, we estimated lower values by 20 to 30% during the afternoon. But it remains difficult to assess the impact on the particle distribution. It could affect the surface signal by decreasing the number of particle contacts at the surface. As we explained in the discussion, we forced the vertical mixing to more realistic values, but the entrainment/detrainment scheme was not physically consistent with the new values, and particles were lost passing the boundary layer top. The development of a more sophisticated scheme requires validation campaigns as ETEX (European Tracer Experiment - Klug et al, 1993) but will only be treated in the transport uncertainty for our CO2 flux inversion.

Some further comments: (Referee3): Title "... synthetic data": As I understand, the authors do not apply any synthetic data (i.e. observations generated by an atmospheric model), but avoid the use of observational data and use only their estimated uncertainty.

(the authors): There are two equivalent methods for generating the error reduction. One starts with a set of fluxes deemed to be true, generates synthetic data via the transport model, perturbs these synthetic data and uses the resulting concentrations in an inversion. This is the classical set-up for an OSSE. In the special case of linear models and Gaussian errors, one can achieve the same thing with an analytic matrix expression. We used this method but retained "synthetic data" in the title to highlight the link to the more general case.

(Referee3): page 10446, lines 17-18: why is the maximum number of observations 8140 x 102 x 2+ 8140 x 2040 x 10 ? I do not understand the factor 8140 here (which is the number of optimized surface fluxes + boundary conditions)

(the authors): This mistake was corrected as follows: "The number of elements in the J matrix is finally 8140 x 102 x 2 + 8140 x 2040 x 10.

(Referee3): page 10447, line 18: the applied observation error of 4 ppm is of course crucial for the derived error reduction. Estimating the observations error (which should

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include the model representativeness error) from the comparison with aircraft data may significantly underestimate the potential model representativeness error for the surface measurements, in particular during night.

(the authors): See the general comment.

(Referee3): page 10452 ("virtual Bicarosse tower of 300m"): I find the discussion of this experiment very poor. What are the concrete conclusions from this experiment ? What would be the optimal measurement height for the use in the inversion system ?

(Tha authors): We added at the end of the results chapter: "Overall, it seems that the use of tall towers, should be treated carefully in regional inversions. Although they are easier to model (and hence allow more aggressive use of the data) their placement in the domain may mean much of their influence on surface fluxes is lost."

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 10439, 2007.