

Interactive comment on “Constraining the CO₂ budget of the corn belt: exploring uncertainties from the assumptions in a mesoscale inverse system” by T. Lauvaux et al.

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We thank the reviewer for his/her comments. Our answers are listed below.

P20860, eq 1: We clarified the description of the flux vector x : "The inverse system used in this study is an analytical inversion framework (Tarantola, 2004) correcting for temporally averaged fluxes over 7.5 day periods, separated into the averaged daytime (6am to 6pm) and nighttime (7pm to 5am) components at 20km resolution."

In the inversion system, the boundary conditions vary in time only, with one time series for each tower. The spatial dimension is considered in the direct simulation, and in the pre-processing. We added a description for the boundary conditions: "In our inversion,

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the boundary conditions are defined for each tower separately and vary only in time (i.e. no spatial description of the inflow in the inversion). The initial inflow is computed in the direct simulation and corresponds to the influence of the boundaries at the observation locations. The spatial component is considered during the pre-processing using the aircraft data and the influence functions (one for each boundary) to correct for biases. Here we adjust the overall inflow for each tower and at each time step using the surface tower mixing ratios but no explicit adjoint model."

P20860: each time period is computed independently, without any error propagation. This choice is motivated by previous studies (Chevallier et al., 2006) showing that temporal flux error correlations are low after few days. The weekly inverse fluxes might vary significantly but the constraint from the prior fluxes limit the week-to-week changes. We added to the paragraph: "Inverse fluxes over 7.5 day periods are decorrelated from one period to the next, considering the low correlation in daily flux errors after few days (Chevallier et al., 2006)."

P20860, L15: We corrected the sentence: "For the boundaries, we defined two different time frequencies that are applied to the different boundary condition time series for each tower"

P20860, L17: We corrected the dimension.

P20861, L5: We replaced (REF) by (Gu et al., 2008)

P20861: The LAI for crops (not for the other natural ecosystems) is now computed using different sets of vegetation parameters based on the literature, instead of the LAI derived from the NDVI product highly affected by clouds. The model allocates carbon to the different pools and use the allocation of carbon to the leaf pool to compute the LAI. The detailed description of the crop module in SiB is described in Lokupitiya et al., 2009, where NDVI-based LAI was compared to site observations and model-derived LAI.

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P20862: We changed the acronym to CTv09 to avoid the confusion. We agree that the version of the system and the actual year of the fluxes are misleading. We also added that fluxes of the year 2007 were used.

P20862, L15: We added "weekly averaged" to indicate the temporal resolution in our calculation. We computed the flux errors based on the maximum difference in combination with the seasonal cycle to smooth the temporal variability of the flux errors instead of using directly a weekly model-data mismatch. In addition, representation errors between site observations and grid point fluxes can be large. This technique limits the over-estimation of weekly flux mismatches. We added one sentence to clarify our choice: "The combination of the observed seasonal cycle and the maximum model-data mismatch limits representation errors due to site-level observations compared to grid point modeled fluxes."

P20862: "error correlation" can be used in this case. The distance is implicitly accounted for (vegetation fractions are pixel-based). We combined two correlation matrices, one considering the ecosystem fraction, and one the distance.

P20862: We added the different ecosystems we considered here, based on SiB vegetation classes.

P20863: We corrected the equation and the terms.

P20863: We clarified the last sentence: "The prior error variances were finally slightly modified to adjust the ratio between the observational constraint and the prior errors. We used the reduced chi2 value to adjust the flux error variances (kaminski et al., 2001). However, the adjustment of the flux errors remains lower than 10\% compared to the initial estimates."

P20867: We re-wrote the paragraph to clarify the temporal error correlations. We refer also to Lauvaux et al., (2009) with a full description of the method and the temporal structures in the observation errors.

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P20868, section 2.5.2: we re-wrote the paragraph and moved the second part to the discussion section.

P20868, l15: we corrected the description of the boundary attribution in the different paragraphs.

P20868, l15: "Cardinal": We added the following sentences: "The choice of four cardinal bounds is due to the lack of extensive datasets in space. We limit our correction here to the mean wind direction represented by the four bounds of our domain."

P20868, l16: We replaced "bound" by "boundary"

P20868, l20: We removed "vertical"

P20868, l20: The PBL height is determined by using the TKE profile from WRF. We added the following sentence: "The PBL height is determined with the LPDM particle distribution over the column, defined by higher densities of particles within the PBL, directly related to the TKE profile from WRF."

P20868, l21: We explain now how we attributed the corrections to the boundaries using the particle distribution. We also modified the figure 2 to clarify the steps.

P20868, l24: As explained in the previous corrections, we clarified the difference between the time series at the tower locations, and the use of aircraft data to remove biases.

P20868, l26: We removed the term "grid".

P20869, top: We explain now in the paragraph how we removed the biases: "The corrections were then applied to the initial CTv09 inflow time series by removing the mismatches between aircraft data and the modeled mixing ratios."

P20869, top: The data have a uniform distribution over the column. We didn't apply any weighting factors.

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P20869, bottom: We added "correction of the boundary conditions" to clarify the sentence.

P20871, I19: We modified the sentence to make it clear: "We analyse here model-data mismatch using prior fluxes and pre-processed boundary conditions to characterize..."

P20872, I4: We replaced "clear structure" by "vertical gradient between the PBL and the free troposphere".

P20872, I23-24: We added the terms Lagrangian and Eulerian at the beginning of the paragraph and indicated the related models for both of them.

P20874, I3-4: We clarified the end of the paragraph: "The very large residuals in June (more than 20ppm) are observable within the two lower levels of the PBL, where the TM5 model is usually underestimating the vertical mixing (vertical profiles show clear unexpected gradients during convective days). We used the differences of the averaged mixing ratios over the higher levels of the PBL (black diamonds) not to consider these large differences in the lower levels of CT\$_{v09}\$."

P20874, I23: We simply averaged the two sites and used the standard deviation to represent the variability. We added in the text: "(averages of the two sites)".

P20875, I10: The irrigation is a common practice in the West of our domain, with dryer conditions in summer compared to Illinois and Iowa for example. It represents a significant part of the western Corn Belt where about half of the maize surface is irrigated. We added "in the Western Corn Belt" to clarify this point.

P20875, I14: We re-phrased the sentence as follows: "In the model, the presence of soybean with a lower uptake compensates for the large corn uptake."

P20875, I19: We corrected the sentence.

P20876, I19: We modified the sentence.

P20877, I5-6: We indicated "nighttime".

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P20877, I8: We have re-arranged the paragraph in the same order as table 1.

P20877, I11: We have corrected the description of the reference case in section 2.1 and 2.4.

P20878, I6: This point was clarified in the boundary condition section. We describe here the boundaries as described in the inversion system, i.e. time series at the tower locations.

P20878, I7-8: We replaced "avoiding" by "limiting".

P20878, I21: We added "TM5" to clarify the sentence. We are here considering errors observed at the boundaries using the aircraft data. Vertical mixing errors affect WRF as well, but no significant biases have been identified in the PBL. Potential temperature profiles and CO₂ mixing ratios have similar distributions than observed by the aircraft or by radiosondes (paper in preparation).

Section 4.2: We replaced "assuming" by "using".

P20879, I28: The boundary correction (0.3ppm to 0.8ppm) corresponds to the standard deviations of the corrections, which have a limited impact on the posterior fluxes. The means are very similar, and so the posterior fluxes. We clarified this point.

P20881, I22: We corrected the formulation.

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