**Atmospheric
Chemistry
and Physics
Discussions**

Interactive comment on "Constraining the CO$_2$ budget of the corn belt: exploring uncertainties from the assumptions in a mesoscale inverse system" *by* T. Lauvaux et al.

Anonymous Referee #1

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This paper presents methods for and results of inversions on a regional scale, with real observations (from towers and aircraft) as input and with the results compared to eddy correlation flux measurements. Much attention is given to various error sources, including sources which are very important on smaller scales but which have not received much attention so far, such as lateral boundary conditions and crop modeling. This makes the paper in principle also useful for setting up regional inversion studies for other areas. The set-up of the research is well-considered and complete, in my opinion. The introduction is well-written. In reading the remainder of the paper, however, I found that many pieces are hard to understand, because of confused, lacking or even contradictory information. There are also serious problems with the legibility of some

important figures. As a consequence, there are some details about which I cannot yet give a judgment because I do not understand them. So I would recommend a revision (thorough revision for some sections, also revision of figures) indicated below. I would like to see a number of clarifications before giving a final judgement.

Specific comments

P20860, Eq.1: "x" is defined as "unknown flux" but x is a number and the flux has a time series during each half day, how are these two exactly related? I have a similar question about the incorporation of unknowns for the boundary conditions, which vary also spatially.

P20860: the state vectors each concern one week, but results are given for many weeks. Are they solved separately, or is there a coupling ? In the first case, are there possible problems with the relaxation from the initialization ? In the second case, how is the coupling done ?

P20860, L15: "tower": why tower ?

P20860, L17: $49 \times 49 \times 2 + 180 \times 8 = 6242$.

P20861, L5: "REF": what is REF ? Is this OZ in figure 1 ? Are these data used or not ?

P20861, second half: are LAI observations ever used ?

P20862: "CT2009": are these data for 2007? If so, is this a good acronym ?

P20862, L15 etc: (1) "maximum difference": why maximum difference ; (2) it should be made clear for which kind of numbers (average to which spatial/temporal resolution) the maximum difference is calculated.

P20862, bottom: name "error correlation" cannot yet be given, it has not yet been corrected for distance etc.

P20862, bottom: "one given ecosystem": This remains vague to me. What is eco_1 ?

P20863, Eq. 1 : Where is C_t explained ?

P20863: I do not understand the last sentence.

P20867, 1st paragraph: A more explicit description is desired of the way in which temporal correlations in the concentration errors are prescribed.

P20868, section 2.5.2: This paragraph is sometimes quite difficult to understand, and should be entirely rewritten. There is inadequate wording and ordering. It is sometimes not clear whether a sentence describes a step, or is a summary of future steps.

P20868, L15: here and elsewhere in the paper (section 3.3), it is sometimes suggested that each aircraft profile sites is connected to one boundary, and sometimes (line 17 for example) that the two in the South East are connected to both boundaries. This has to be clarified.

P20868, L15: "cardinal": why cardinal ?

P20868, L16, and passim: the word "bound" is often used but I think that "boundary" is more appropriate.

P20868, L20: "integrated over two vertical": It may be better to delete "vertical"

P20868, L20: how are PBL and free troposphere discerned ? Is this a diagnostic tool of WRF ?

P20868, L21: "we computed the eight different corrections for the boundary inflow": I would think that this cannot be done until data points have been connected to boundaries, which is however a later step.

P20868, L24, and passim: the text speaks about "towers" whereas aircraft sites seem to be meant. Check this and the other pages on this point !

P20868, L26: simplified grid of two levels: strange terminology, say that the grid points are integrated into just two levels, or something like that, and avoid "grid" to denote the

result

P20869, top: how is correction performed? by adding a constant amount ? a full description is required (and a summary added in section 2.1)

P20869, top: do the measurement levels have a vertically uniform distribution ? if not, are weights applied when averages of the measurements (or their difference with model values) or calculated ?

P20869 bottom – P20870 top: I assume that the statements about temporal variation are about the correction on the boundary conditions, not about the boundary conditions as such, is this right ? It should be made clear here and elsewhere where the correction is explained.

P20871, L19: Model: Are these prior results ? Are the boundary conditions not yet preprocessed ? Make this explicit.

P20872, L4: "no clear structure": what does this mean? no discernable PBL top ?

P20872, lines 23-24: I recommend to introduce the qualifications Lagrangian and Eulerian for the two models, already as soon as possible.

P20874, lines 3-4 : I do not understand this.

P20874, L23: how are the data from the two EC-stations combined ?

P20875, L10: "irrigated": how representative is this for the area ?

P20875, L14: "which decreases the large absolute corn growth uptake": I find this formulation a bit obscure, saying just "which decreases the uptake" would be clearer.

P20875, L19: "all year long": the results are only for a half year.

P20876, L19: "in our first test": has this test already been described ? This should be indicated.

P20877, L5-6: "consistently lower mixing ratios": does this concern nighttime mixing

ratio? Make explicit.

P20877, L8: Prior flux variance: The items in table 1 are described in an order which is different from the order in the table, is there a good reason for this ?

P20877, L11: It was stated in sections 2.1 and 2.4 (last paragraphs) that temporal correlations in the concentration errors are prescribed, and it was announced there that this would be compared to an inversion without correlations. But now and in table 1 the opposite is indicated. How is this contradiction to be explained ? Should "rho $\neq$ 0" be "rho = 0" ?

P20878, L6-7 (again): "tower location": isn't this aircraft location ?

P20878, L7-8: "avoiding the increase of the dimension of the state vector": but the dimension is increased to optimize for the boundary conditions.

P20878, L21: "vertical mixing errors": specify (TM5 ?). Is WRF to be trusted in this respect (the results indicate some problems with WRF too) ? Can this have consequences at this point ?

Section 4.2: the words "assumption" and "assuming" are inappropriate for what is just the use of a certain resolution in the calculations. E.g. "assuming hourly concentrations" (before middle of 1st paragraph).

P20879, L28: But the final surface flux balance remains similar ...": This seems to contradict previous results. Is this actually about fluxes or concentrations ? Unclear.

P20881, L22: "nighttime signals": what does this mean ? Nighttime transport ? The sentence should be reformulated.

Section 5, general: This section has been kept very short. More can be said about other topics such as: conclusions from comparing the performance of the two prior models (different crop modeling), modeled and observed time series of fluxes etc. Further, if results appear insensitive to certain model settings, this can also be mentioned

as a conclusion. Check for other important subjects among the results.

P20882, L23: "The impact of boundary conditions ....": this sentence seems to contain a contradiction.

Figure 2: "weekly corrected ..": why corrected ? the optimization has not yet been done, see figure.

Figure 3: This figure is illegible in several ways (do not hesitate to increase the number of figures if this is necessary for a legible presentation).

Figure 4: legend inside the figure: red and blue are reversed ? Legend below figure: "Over the 7 months ...": better to put "Averaged" before this ?

Technical corrections

P20857, L12 : "at the scale they have been": insert "on which"

P20861, L27: typing error.

P20864, L12: "Protection": "Prediction".

P20868, L22: "values": value.

P20870, L13: "peformance": performance.

P20872, L12: observational spelled wrong.

P20872, L28: "square root of the square" : square root of the mean square.

P20875, L26: characteristics misspelled.

P20876, L7-8: "posterior" used too often.

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