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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Calibrating satellite-derived carbon fluxes for retrospective and near real-time assimilation systems" *by* Brad Weir et al.

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Reviewer comments in red, responses in black.

Review: Calibrating satellite-driven carbon fluxes for retrospective and near real-time assimilation systems, by Weir et al.

Summary: The authors describe a CO2 surface flux product that operates in retrospective and forecast modes, and can be provided with short latency. The product is shown to have comparable skill to full flux inversions that take much longer to calculate. Flux components such as biofuel, biomass burning, fossil fuel, and ocean flux

are taken from near real-time or published datasets. Terrestrial carbon flux is obtained from CASA-GFED; the innovation, or "hook" here is the imposition of an empirical land sink that concentrates the terrestrial sink in the northern extratropics during spring and summer, which is consistent with emerging inversion results (as opposed to placing the sink in the tropics or southern extratropics). This product, LoFI, is a suitable "prior" for inversion studies, as it has total surface flux (and spatiotemporal distribution of flux) comparable to optimized fluxes from recent inversion projects.

Review: This is a good paper. It is concise and well-written, and the product it describes has value to the scientific community. I've had the opportunity to see LOFI results presented in meetings and workshops, and I recognize this value. My formal recommendation is to accept the manuscript for publication, with minor revisions.

Initially I was a little concerned with the empirical sink, as it seemingly violates some accepted aspects of biophysics. After some thought, however, I realize that the authors are less concerned with maintaining fidelity to established physical relationships than they are with maintaining fidelity with flux inversion results, which do not take the physics into account. Inversions just say "here is what we think the flux map looks like".

Take heterotrophic respiration. There is a rich body of literature that describes how respiration increases with increasing temperature, and this is the basis for the so-called "Q10" relationships present in just about every model that simulates surface CO2 flux (CASA as well, I believe). In LoFI, they reduce respiration as temperature increases. As stated previously, I think this is tolerable because making this assumption produces the flux map that they want. However, I think the authors need to acknowledge that this assumption violates accepted biophysical theory.

The authors agree and have tried to better emphasize this in the revised text.

I'm also a little concerned about the strong MAM uptake in the Midwest crop region, shown in the third row of Figure 3. Yin et al. (2020), in a paper describing carbon uptake delay induced by floods in 2019, show (their Figure 2) show that in most years

crops aren't even planted until April or May. It's hard to believe that these regions would show a significant sink immediately after plant date.

This is a good find and something we're working on improving. Newer versions of LoFI actually mask out croplands when applying the empirical sink because of this exact problem. The version of CASA-GFED 3 that we start with maintains a robust net crop sink because it, by design, includes a corn and soybean harvest. Getting the empirical land sink to work with harvests and lateral fluxes will be a major undertaking, but it's underway. We'll note this in the revision.

Again, I'm ok with this as long as the authors acknowledge that they are trying to reproduce the maps suggested by inversions, and not doing so with a strong regard for biophysical processes. I'd like them to find a way to say "Hey, we don't care about the biophysics. The inversions tell us this is the pattern we want to have, and this is how we get it." I think this admission is important.

We agree and have tried to emphasize this in the revised paper. Our eventual goal would be to do something like this in a biophysically consistent way in, for example, CASA. This study was a first step in that direction.

Other than that, I don't have much to add. Good paper, nice read, valuable product. Good job, wish all my reviews were this easy.

Specific Comments:

Lines 152-153: The Midwest crop harvest is not a true sink. They don't take the harvest and bury it deep in the ground. The harvest is respired back, from feedlots and from people who eat food made from the harvest. This must be accounted for in models. What does CASA do about this?

There was some sloppy wording here that we thank the reviewer for pointing out. CASA removes carbon from its aboveground pools to account for the corn and soybean harvest (so that it does not respire this in the fall). That's it. Presumably we should have

some lateral flux to deal with exactly the issues that the reviewer raises, but that is an active area of research and something we hope to develop further in future versions. We've made some small changes to this paragraph to hopefully make the explanation clearer.

Line 177: Where does the land cover change map come from?

It's extrapolated from GCP (see the last sentence of that paragraph). We've added "global total" here to try and make it more clear that we just need a single number, not a spatial map.

Line 212: I like the umlaut in El Nino.

Just making sure people are still reading. This is fixed now.

Figure 1: It is hard to see LoFI in this plot. Is it directly under baseline? If the lines were thicker and the shading lighter, it would be easier to see. The scale can be shrunk too.

It's because it's identical to the baseline. We've made a note of this in the figure caption. We've kept the baseline in the ocean plots for consistency across plots. An alternative would've been to drop it in all plots, but we didn't find one preferable to the other and our choice made the figures easier to generate.

Line 230: typo

Fixed.

Lines 269-270: Boy, that discrepancy is really hard to see. Can you give us a number in the sentence describing it?

We were trying to point out the discrepancies between the blue line and the grey shading, which appear to us to be fairly visible. We've added that to the text to make sure it's clear.

Figure 4: A line at the equator might be helpful, to show how many stations are in the

Northern Hemisphere, and how many in the south. For those of us that don't have all the stations memorized yet.

We've updated the figure to indicate what hemisphere the sites are in.

Figure A3: It is really hard to see GFED. I really had to work my old eyes to see the tropical JJA difference.

We agree, but that's also our goal: we want QFED and GFED to be as close as possible. So the fact that you have to struggle to see these differences while the differences with and without the empirical sink are so obvious helps us justify using QFED in place of GFED.

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