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.

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.

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.

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?

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

Line 212: I like the umlaut in El Nino.

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.

Line 230: typo

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

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.

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

Reference:

Yin, Y., Byrne, B., Liu, J., Wennberg, P., Davis, K. J., Magney, T., et al. (2020). Cropland carbon uptake delayed and reduced by 2019 Midwest floods. AGU Advances, 1, e2019AV000140. https://doi.org/10.1029/2019AV000140