Review: Global atmospheric CO2 inverse models converging on neutral tropical land exchange but diverging on fossil fuel and atmospheric growth rate

Benjamin Gaubert et al.

Summary: Here Gaubert et al. use recent meridional flight observations to test the latest itteration of atmospheric inversion models and their ability to capture vertical profiles of atmospheric CO2. There results are somewhat reassuring in that the inverse models with inversed complexity actually appear to becoming more accurate and precise over time, which is not always the case with global scale model development. The authors also arrive at an interesting conclusion that the largest sources of error currently limiting inversion modeling is the spatially explicit fossil fuel inventories and the atmospheric growth rate- two terms that are thought to be well constrained at the global scale. While my expertise are not specifically in inverse modeling, I think that this is an interesting study that highlights the current limitations and advances in inversion approaches and should be published after minor revision. With that in mind I have a couple of ideas that might give this paper impact beyond the inverse modeling community.

General Comments:

The global fossil fuel emission inventories only differ by ~10% (Ballantyne, Andres, and Houghton 2015) but it appears that the spatial-temporally explicit inventories differ considerably. It appears that the ACTM (IEA) simulation is the most anomalous among the models considered; however, ACTM (CDIAC) vertical profiles in the northern hemisphere look the most unusual (Fig S2) which seems odd. Is there any way to simply plot the differences in IEA and CDIAC emission estimates to demonstrate how which emission inventory you select for your simulation may greatly alter your results?

Is there anyway to create figure of how NE uptake relative to T+SE uptake has changed over time? This information is nicely compiled in table 2, but it is hard to discern any patterns, such a figure could be very interesting to researchers outside the atmospheric inversion community.

There is interesting recent work on changes in relative forest cover, especially within the the tropics, using LANDSAT data that may be relevant to your results (see (Hansen et al. 2013) and subsequent work.

Specific Comments:

P2 L3 You may want to specify in the final sentence that it is the regional fossil fuel emission estimates that dominate the uncertainty.

P3 L21 You say what Frankenberg did, but what did Frankenberg discover? This seems particularly relevant because of the conclusion about the growth rate uncertainty. If we had a gridded XCO2 growth rate for every grid cell on Earth would this improve inversion estimates of regional fluxes? It is my understanding from work by Houweling that the XCO2 GOSAT measurements do not improve the inversions that much.

P3 L25 What are the 'a priori assumptions' you are referring to?

P3 L30 change to 'global carbon budget estimates (LeQuere et al. 2016)' You also cite LeQuere 2016 and 2018 is this intentional?

P5 L9 Is this a riverine DIC flux to the ocean? This 0.45 PgC/yr is much less than the recent estimate of 2.1 PgC/yr emissions from inland waters (Raymond et al. 2013).

P6 L14 How much does this gradient vary from the tropics to high latitudes- is this just the NE gradient?

P6 L 28 You might want to present the instrument precision first and then let the reader decide if it is 'negligible'.

Figure 1. Avoid acronyms in figure captions if you can Day of Year instead of DOY. Also define 'LT' and 'UT' in caption. Do the HIPPO measurements here represent averages across many years for the same day, or is this just for a single years observations.

P8 L9 - 11 It seems that you are comparing mean from present study to range from Transcom

Figure 2 report actual statistics of relationship in D and let reader decide how significant it is. Use lower case letters on panels for consistency with text.

P9 L12 How are they consistent? Explain. It looks like the slope of the relationship changes in S7 in the land only figure. Is this important?

P9 L25 and in Figs. 3 and 2

P9 L33 See work by Hansen et al. showing no net change in tropical forest cover because decrease in S American deforestation compensated by increased SE Asia deforestation.

P11 L27 'Conversely…' Is this a complete sentence and it is hard to tell any trend from Table 2.

P16 L32 seems like considerable NE land uptake and not 'modest'

P17 L5 What is LSCEa? Is this CAMS?

P17 L8 the same as RECCAP Group 1

P18 L 1 Once again see work by Hansen on changes in forest cover, especially in the tropics.

P18 L 14 'is not practical' really maybe this is opportunity for suggestions on the next inversion MIP.

P18 L 18 see uptake uncertainties by Ballantyne et al. 2015 and change ' limit our ability to assess the natural fluxes at regional scales…'

References:

Ballantyne, A. P., R. Andres, and R. Houghton. 2015. "Audit of the Global Carbon Budget: Estimate Errors and Their Impact on Uptake Uncertainty." http://www.biogeosciences.net/12/2565/2015/bg-12-2565-2015.pdf.

Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, et al. 2013. “High-Resolution Global Maps of 21st-Century Forest Cover Change.” *Science* 342 (6160): 850–53.

Raymond, Peter A., Jens Hartmann, Ronny Lauerwald, Sebastian Sobek, Cory McDonald, Mark Hoover, David Butman, et al. 2013. “Global Carbon Dioxide Emissions from Inland Waters.” *Nature* 503 (7476): 355–59.