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Discussions

Interactive comment on "On the ability of a global atmospheric inversion to constrain variations of CO₂ fluxes over Amazonia" *by* L. Molina et al.

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General Comments

This paper evaluates CO2 fluxes over Amazonia that have been calculated using two atmospheric inversions, a control case and one that includes extra atmospheric CO2 measurements for the Amazonian region. The analysis focuses on the seasonal cycle of fluxes and on interannual variations, particularly years that were notably dry or wet. The overall impression of the results is that the fluxes vary quite substantially across the Tropical South American region and at times it is difficult to determine what extra information the Amazonian CO2 data adds. The authors acknowledge this, noting in their abstract that 'the results revealed critical limitations that prevent global inversion

frameworks from capturing the data-driven seasonal patterns of fluxes across Amazonia' and recommending in their conclusions that denser observing networks and regional models might be required to overcome the limitations.

While I agree that this is a valid conclusion from this study, there are two other suggestions that I would like to make, one which could be incorporated into a revision of this paper, while the other targets future inversion work. Firstly, much of the current analysis looked at, for example, the seasonal cycles averaged across the full time period of the inversion. Given the intermittent nature of the Amazonian atmospheric CO2 data, I wonder whether analysis targetted at periods when certain sites were active might yield clearer inversion impacts. Some suggestions are given in the specific comments below. Secondly, I think that as an inversion community we need to be smarter about how we include continuous CO2 measurements into our inversions. Each site has different characteristics and each transport model will represent those sites in different ways. We need to understand what parts of the CO2 record we can most reliably simulate and consequently include in the inversion. Afternoon measurements (as used here) may be appropriate for continental sites with large diurnal cycles, but I would suggest that coastal sites need a different selection strategy. Likewise the choice of sampling location from a transport model (nearest grid-point or an interpolation between points) might be dependent on the characteristics of the observing location.

I recommend that the paper be published with minor revisions to address the technical corrections and to clarify and extend the analysis a little based on the suggestions in the specific comments.

Specific Comments

Sometimes it is not clear which region an analysis has been performed for, with various terms used e.g. 'Tropical South America/TSA', 'whole region' (p 1926, line 15; p 1932, line 17), 'entire study area' (p 1926, line 16). Please ensure that each region is defined. Also in the text the inversion without extra sites is usually referred to as MACCv10.1

while the figures are labelled with CH2010. It would be preferable to use one or the other consistently in text and figures.

p 1924, line 5: Were the ocean fluxes not examined or just not presented in this paper? Just as the discussion of Fig 8 mentioned the possibility of dipoles in the flux across the South American region, a change in fluxes over the land can end up being compensated in the ocean. Given that some of the extra observing sites are coastal, I would expect that it would be worth at least checking the impact of the inversion on the ocean regions around South America.

p 1924, line 9: how does this length scale (500km) compare with the distance between the four sites added to the inversion?

p 1925, first paragraph: it would be good to have some additional information about each site e.g. latitude, longitude, a brief site description e.g. the surrounding vegetation, distance from coast, sampling height. For ABP (line 10), are the weekly measurements selectively sampled under onshore flow, i.e. are they intended to minimise continental signals? How is the transport model sampled to represent these sites e.g. interpolation to the site location, nearest grid-cell? An offshore grid-cell can be more appropriate for a coastal site (e.g. Law et al, Tellus, 62B, 810-820, 2010).

p 1925, line 23 and p 1926, line 5: 'typical' circulation, 'typical' footprints. Is there much of a seasonal shift in circulation? A sentence to comment on this might be helpful.

p 1925, line 25 to p 1926, line 1: Since MAX is a continuous site, are you able to distinguish in the CO_2 observations between periods of onshore vs offshore flow (e.g. periods of relatively constant 'background' CO_2 versus highly variable CO_2 events). If so, what proportion of the data is from onshore? Is your afternoon data selection favouring onshore flow e.g. due to a sea-breeze circulation? It seems plausible to me that your data selection may be removing those observations that are more likely to have been influenced by the land region.

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p 1926, line 18-22: 'root mean square of the annual biases' It's not clear to me what exactly has been calculated here - the difference between the CO_2 predicted at a site from the two sets of priors?? 'given that the mean transport error at the yearly scale should be far smaller according to the hypothesis made when setting-up the inversion system.' I don't understand this sentence.

p 1927-1928, section 3.1 and figure 4: These figures are quite hard to read as the observations are sometimes obscured but they are probably adequate to illustrate the main points covered by the text. (Figures that showed more detail might lead to more insights into the inversion behaviour?) As noted throughout the section the ABP results do not seem consistent with the other sites. The simplest explanation would be that somehow in the analysis/figure the CH2010 and INVSam timeseries have been inadvertently switched. Assuming that this has been checked, it is really difficult to explain how an inversion without ABP (CH2010) can fit the ABP data better than the INVSam case where ABP is included, especially when there is almost no temporal overlap of other Amazonian sites with ABP, so little possibility that the ABP fit is being compromised by fitting other nearby sites. As plotted it appears that the INVSam case is weakly retaining the seasonality of the prior at ABP while CH2010 manages to almost completely remove it. Were there any inversion settings different between CH2010 and INVSam which could explain this?

p 1928, line 12: I'm guessing the correlations are relatively low because you are using daily data but are estimating 8 day mean fluxes. It might be worth calculating the correlations on a monthly timescale as it would be interesting to see if they show a clear improvement between CH2010 and INVSam because of an improved seasonal cycle.

p 1929, line 25-27: Perhaps it is also worth reinforcing the limited temporal coverage of the observations as another reason why there isn't a large impact on the seasonality.

p 1930, line 3-12 and figure 6b: Am I correct in understanding that for the inversion this

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is just a regional selection of the data, the inversion itself doesn't do anything differently depending on the pft? If this is right, it might be worth mentioning. In Fig 6b the CH2010 line looks very similar to the CH2010 line in Fig 6a. Is this correct? The other cases all look noticeably different between Fig 6a and Fig 6b.

p 1930, line 13-26: The flux tower precipitation and NEE plots (Fig 6c-f) are not really described in the text and need to be more strongly linked with the results presented in the rest of Figure 6.

p 1931, line 14-18: The change in seasonality in Zone 1 for the INVSam case might be even clearer if the seasonal cycle was calculated separately for 2002-2005 (when SAN was active) and 2006-2010. A stronger signal in the earlier period would be good confirmation of the influence of SAN data.

p 1932, line 1-13 (Figure 8): This is an interesting figure but how do the INVSam flux corrections compare to the CH2010 flux corrections? Are the CH2010 ones more uniform across the region? This is another figure where averaging over 2002-2005 and 2006-2010 separately would be interesting to try and maximise the signal from SAN.

p 1932-1933, section 3.2.2: I assume the FLAT inversion included the 4 Amazonian sites. This should be noted in the text. Fig 10a shows a large difference in flux anomaly between CH2010 and INVSam for 2008. Any ideas why, since during this year only ABP data is available and it is relatively remote from zone 1? I'm not sure that I am convinced that 'some patterns of the IAV in the NEE from the inversion seem robust and strongly driven by atmospheric measurements' (p1934, line 24) - even for the significant drought/wet years the results seem quite mixed depending on which region is considered and what prior was used.

Technical corrections

p 1917, line 13-15: Suggest rewrite start of sentence as 'We focused on the NEE impact of the strong droughts ...'

p 1919, line 14: 'reversal' instead of 'reversion'?

p 1919, line 16: delete ')' at end of sentence

p 1920, line 20: 'the inverted pattern ...' Do you mean the opposite pattern is seen in S and W Amazonia compared to E Amazonia? I would rewrite this sentence and avoid the word 'inverted' because of the potential confusion with using an inversion method to estimate fluxes.

p 1921, line 5: Figure 1 could be referenced here

p 1921, line 15-22: I would consider moving this description of the J2011 data until later (maybe have a short section 2.3 for 'comparison data') in which case you need to change 'J2011' on p1921, line 27 to 'independent flux estimates'.

p 1921, line 22: replace 'were' with 'where'

p 1925, line 17-21: I think the sampling periods are adequately covered in the figure and it is probably sufficient to reduced these three sentences to 'The longest records were from ABP and SAN.'

p 1926, line 9: Suggest paragraph break before 'To further ...'. Suggest add 'designed to remove interannual variations' following '"flat prior"'.

p 1926, line 17: insert 'variability and' between 'spatial' and 'the temporal'

p 1928, line 7: 'amplitude of variations', on what timescale? seasonal?

p 1930, line 26: suggest paragraph break before 'To examine'

p 1931, line 19: suggest add 'other' before 'sub-regions'

p 1931, line 21: suggest add 'where the dry season is potentially earlier and more extreme (Fig 6c,f)' after 'Amazonia.' and delete following sentence 'Both ... (2011)'.

p 1931, line 23: suggest delete 'here' and add 'any' between 'provide' and 'further'

p 1931, line 28: might want to note that the slight modifications to NEE are to be expected since there is not much data in the southern part of the TSA region.

p 1933, line 2: suggest adding to the end of the sentence 'opposite to the response for the whole TSA region.'

Figure 1: It would be helpful to label the red sites, perhaps with their initial letter.

Figure 2: The vertical line between 2008 and 2009 appears to be missing

Figure 3 caption: perhaps give local time as well as UT for the sensitivity plots

Figure 6 caption: The caption doesn't actually say that it is a NEE anomaly that is shown.

Figure 7 caption: Replace 'Dominating PFTs' with 'Dominant PFT'