Inverse Model Carbon Flux Estimates for Amazonia in 2007

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Introduction

→ ***Tropical and Amazonian carbon fluxes are poorly constrained at regional and continental scales, because almost no tropical atmospheric CO_2 data is used in CO_2 inversion studies.***

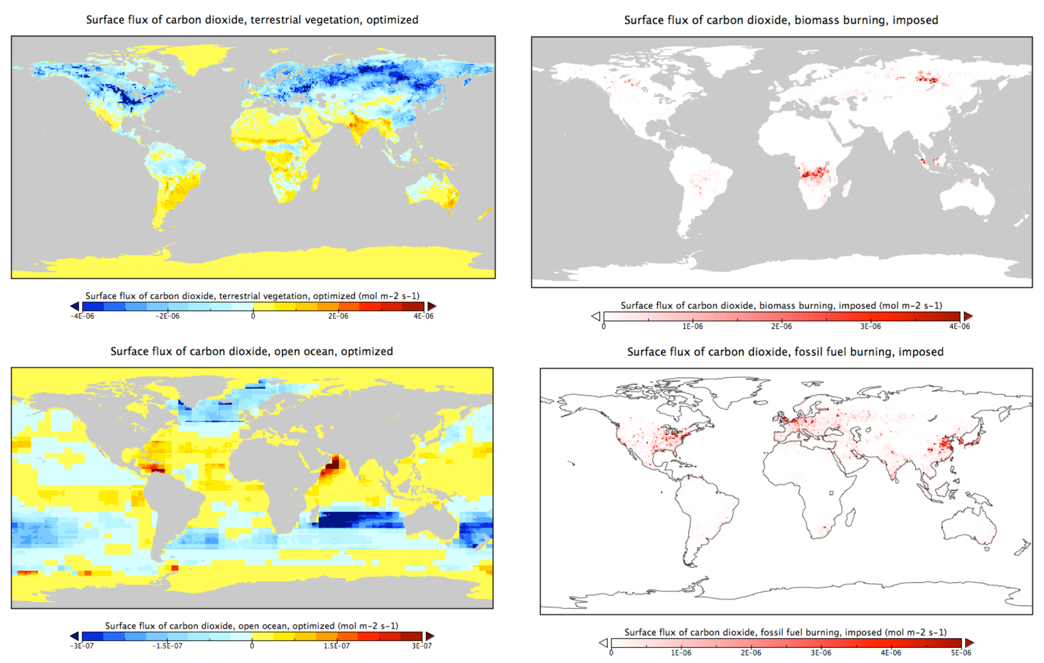
→ Thus, tropical carbon fluxes are solved as a residual to the rest of the globe, resulting in a wide range of uncertain estimates.

→ Here, for the first time, we use a time series of aircraft CO_2 measurements collected above Santarem (55W,3S) within the global data assimilation model CarbonTracker to improve the large scale constraint on Amazonian fluxes.

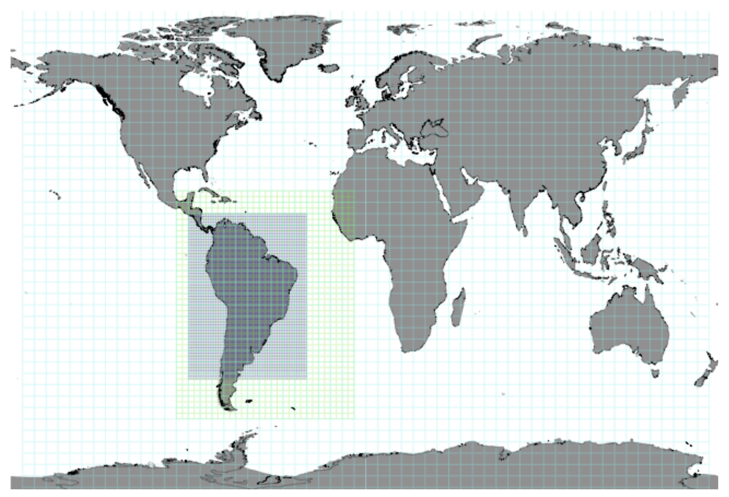
→ With the imminent launch of the OCO and GOSAT CO_2 satellites, understanding the vertical CO_2 structure, carbon fluxes and transport in the tropics takes on added importance. By using data and models in an assimilation system like CarbonTracker, we can make the best use of the satellite column CO_2 data.

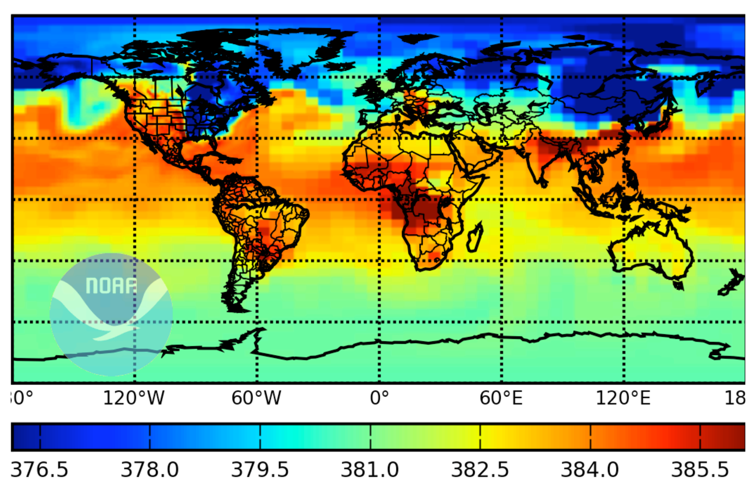
How does CarbonTracker Work?

First Guess Fluxes



TM5 Transport Model (w/ S. America zoom)

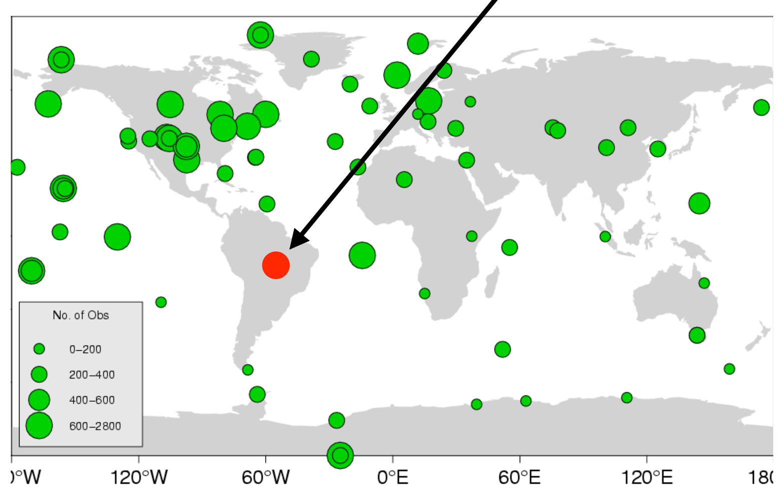




Predicted CO_2

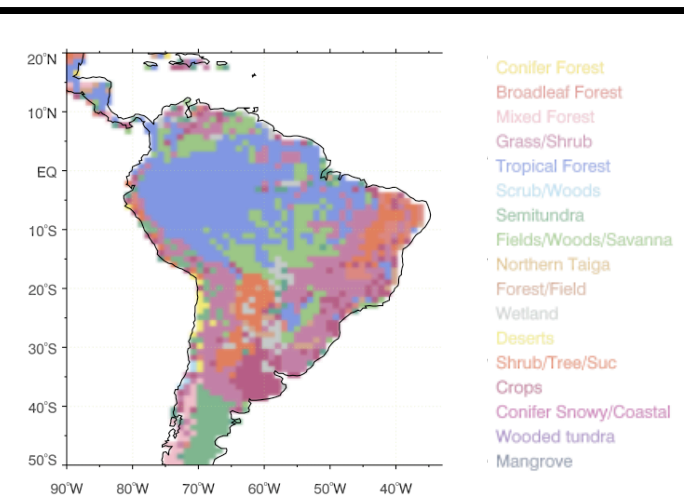
ΔCO_2 = Predicted - Observed

Santarem (SAN)



Observed CO_2

Apply scaling factors to high-res first-guess fluxes



Ensemble Kalman Filter

•Minimize ΔCO_2 by solving for scaling factors for fluxes from predefined 'ecoregions' (above)

•The filter uses a 5 week moving window to optimize fluxes over time.

References

1. http://Carbontracker.noaa.gov
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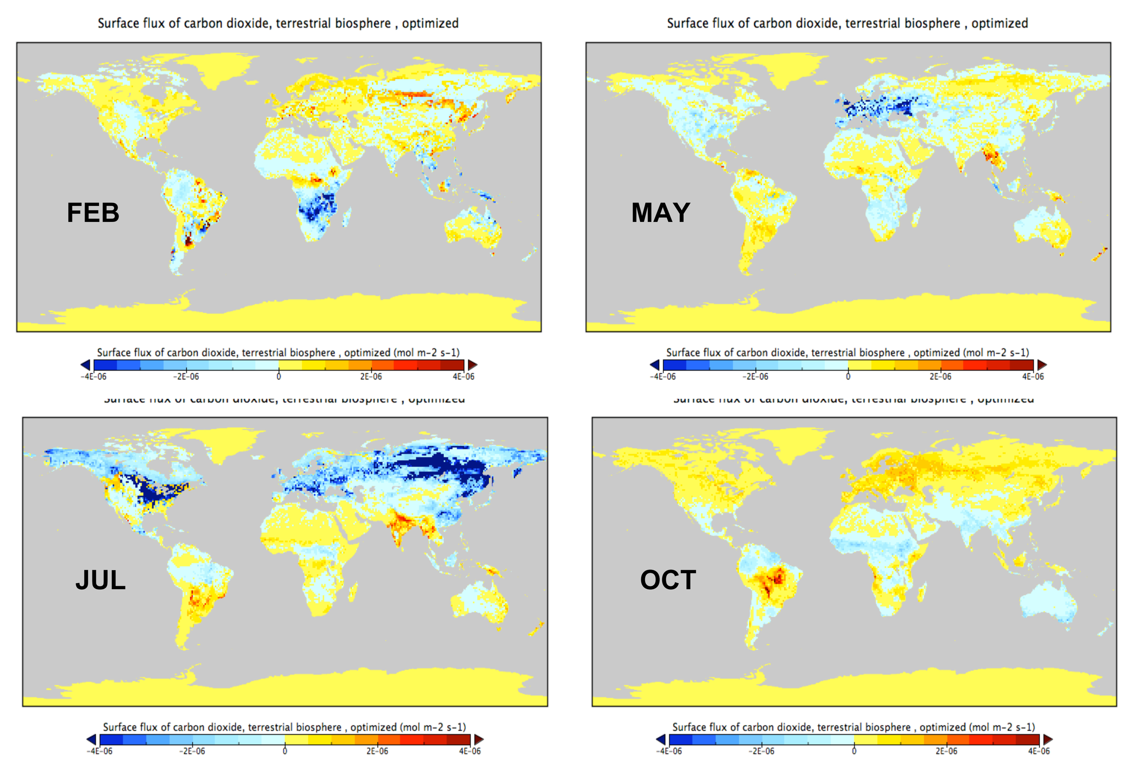
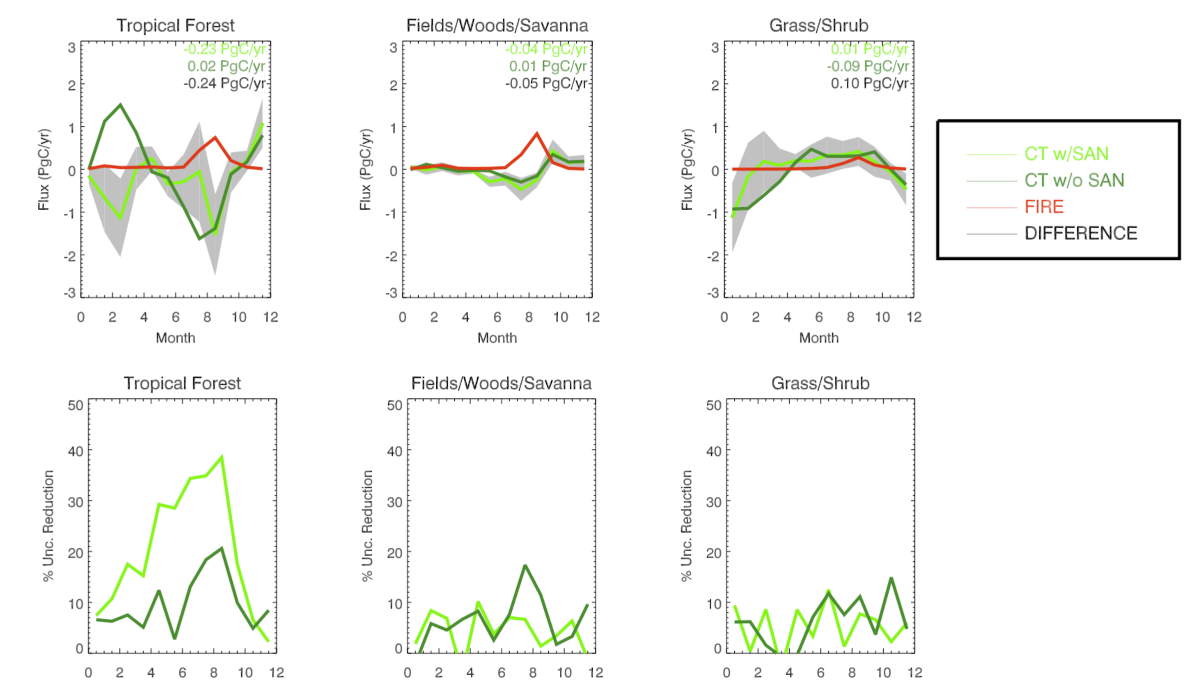
3. Peters, W., A. R. Jacobson, C. Sweeney, A. E. Andrews, T. J. Conway, K. Masarie, J. B. Miller, L. M. P. Bruhwiler, G. Petron, A. I. Hirsch, D. E. J. Worthy, G. R. van der Werf, J. T. Randerson, P. O. Wennberg, M. C. Krol, and P. P. Tans (2007), An atmospheric perspective on North American carbon dioxide exchange: CarbonTracker, *PNAS*, *104*(48), 18925-18930.
4. Peters, W., J. B. Miller, J. Whitaker, A. S. Denning, A. Hirsch, M. C. Krol, D. Zupanski, L. Bruhwiler, and P. P. Tans (2005), An ensemble data assimilation system to estimate CO2 surface fluxes from atmospheric trace gas observations, *J. Geophys. Res.*, *110*(D24), -.

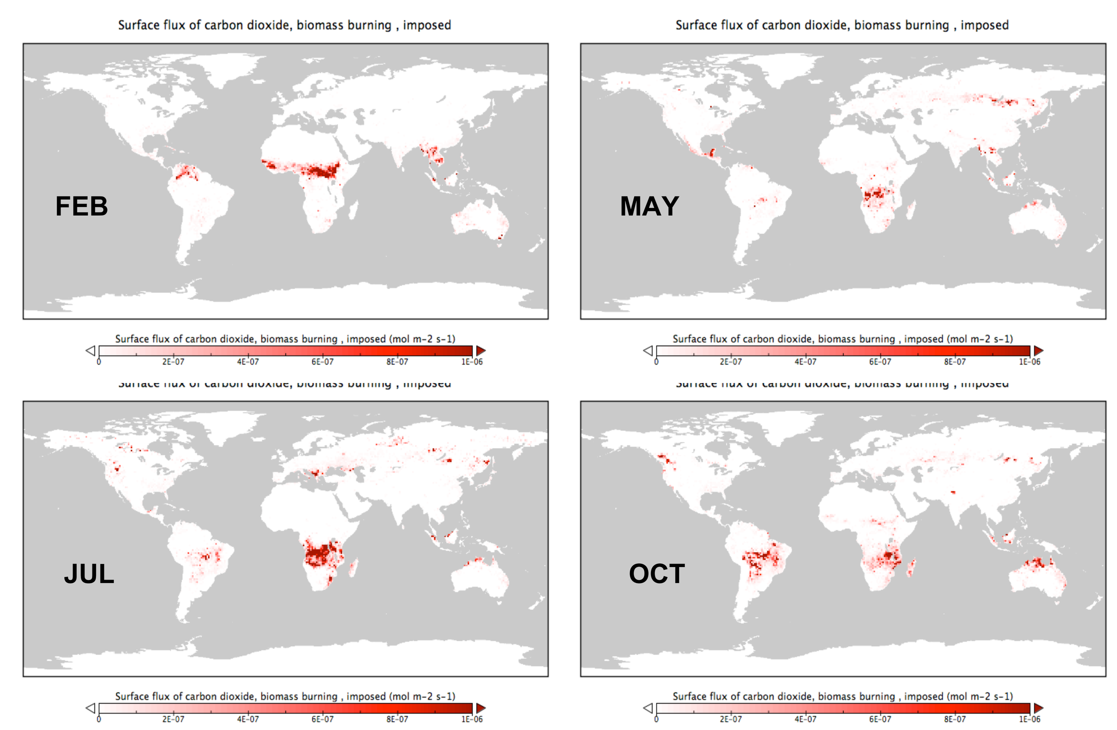
Results

Optimized Biosphere Fluxes

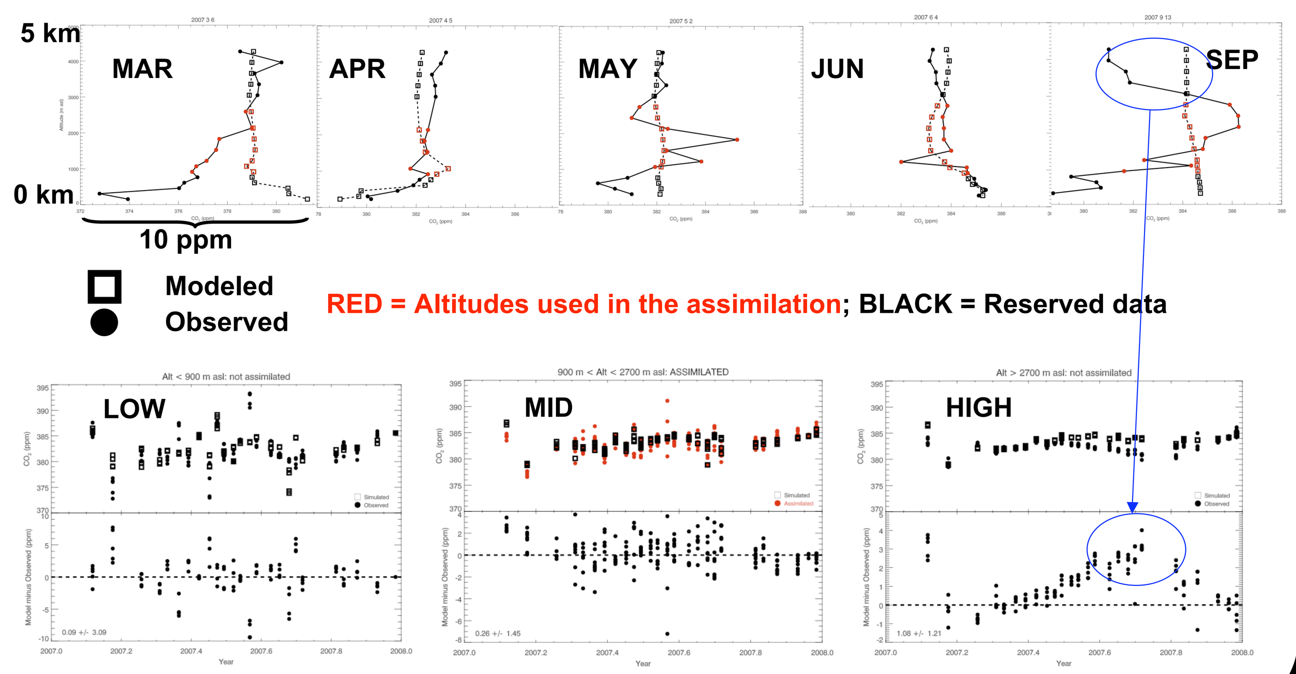




CASA/GFED Fire Fluxes



Comparison with SAN data



Discussion

→ The introduction of SAN data into the CarbonTracker assimilation, has a substantial effect on the atmospheric 'top-down' estimate of Amazonian carbon flux, primarily in the tropical forest ecoregion. As can be seen in the ***optimized biosphere flux*** time series (top right), there is a substantial change in the flux and a large reduction in uncertainty from the standard CarbonTracker inversion. The annual carbon flux we estimate is a sink of ~0.2 PgC/yr. There is very little uncertainty reduction for other ecoregions.

→ There are many caveats to this preliminary analysis. One of the most important is that we assume the region upwind of SAN (to the east) is representative of the entire Amazonian forest. This is because we have only one forest ecoregion in tropical South America. However, as more observations are added, we will be able to subdivide Amazonian forest into several ecologically meaningful regions, and derive more accurate carbon fluxes.

→ The ***comparison with SAN data*** show times of poor and good agreement between the model and observations. As we improve both our transport model and our first guess flux models, we will be able to better represent the observations and have greater confidence in the fluxes we calculate. One specific problem is that the CASA/GFED fire fluxes are only a monthly mean product. This means it will be almost impossible to represent accurately atmospheric variability resulting from fires. We see this, e.g., in the SEP vertical profile example. The model attempts to match the plume by pulling the entire (flat) modeled profile towards the plume, surely resulting in a flux bias. In fact, we see in the October biosphere flux map (above) a large source in October. This is likely the result of fire emissions being "assigned" by the model to net ecosytem exchange (NEE). Other profiles show good matches to observations, but in general, atmospheric variability is much greater than represented in the model.

→ The presence of large above-PBL variability in the data offers a cautionary note to the interpretation of satellite column data, e.g. from OCO and GOSAT. Because the satellites cannot see vertical structure, higher than expected CO_2 columns could easily be wrongly interpreted as having their origin in the PBL.

→ For this assimilation we assimilated only mid-level data from the profiles. We were worried that the lower level would be too locally influenced and we wanted to reserve the higher data as an independent check on model performance. The drawback of this approach is that the mid-level often has large gradients due to fire plumes as mentioned above and boundary layer (PBL)/free troposphere transitions. In the future we will focus on assimilating the lower level, with the exception of the lowest level, which should result in more robust fluxes.