An EnKF GEOS-Chem System for estimating terrestrial NEE and ocean CO_2 fluxes

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Why CO_2 ?

- A long-lived GHG with unknown “sink” mechanism
- “sink” accounts for nearly half of the current fossil emissions annually
- Uncertainty in future climate projections is a function of how this “sink” evolves over the near future.
- Diagnosing ***where the sources/sinks occur*** and then being able to ***attribute them to mechanisms*** is the name of the game.

Data used to optimize CO_2 fluxes (NEE)

NOAA: using NOAA surface data (2005-2010), flasks and continuous tower data

- ***GOSAT***: using ACOS b2.10 *column average* CO2 (6/2009-9/2011)

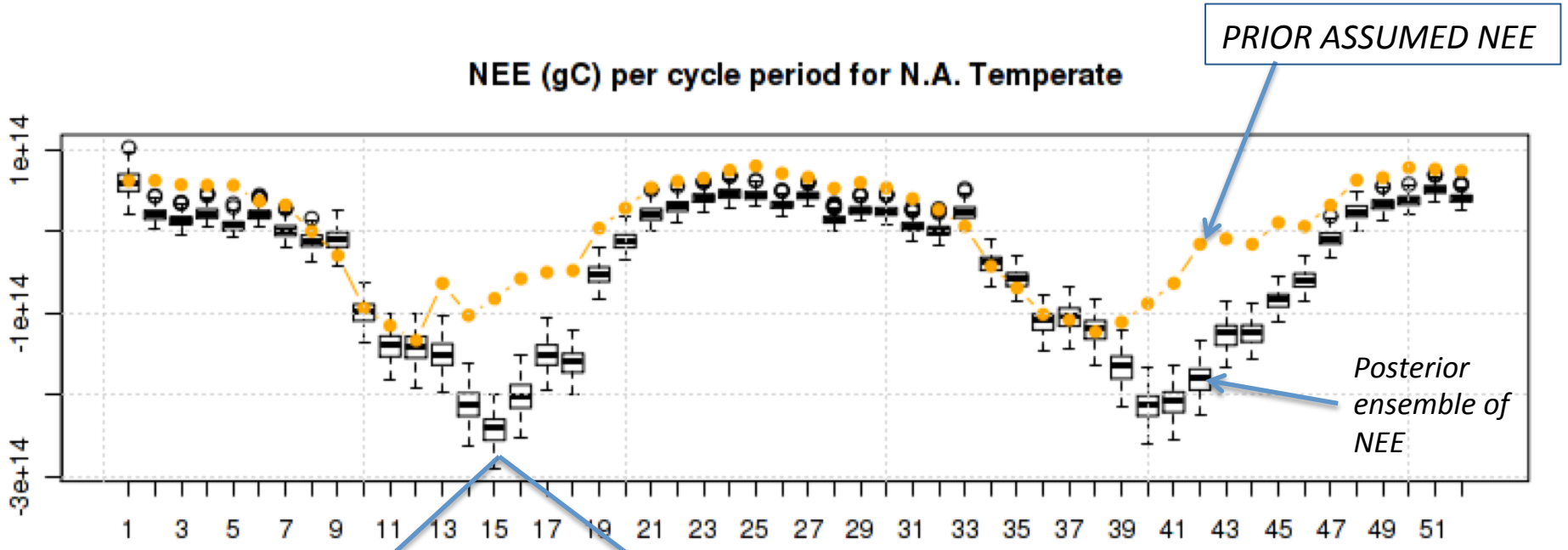
CO_2 Inversion Framework

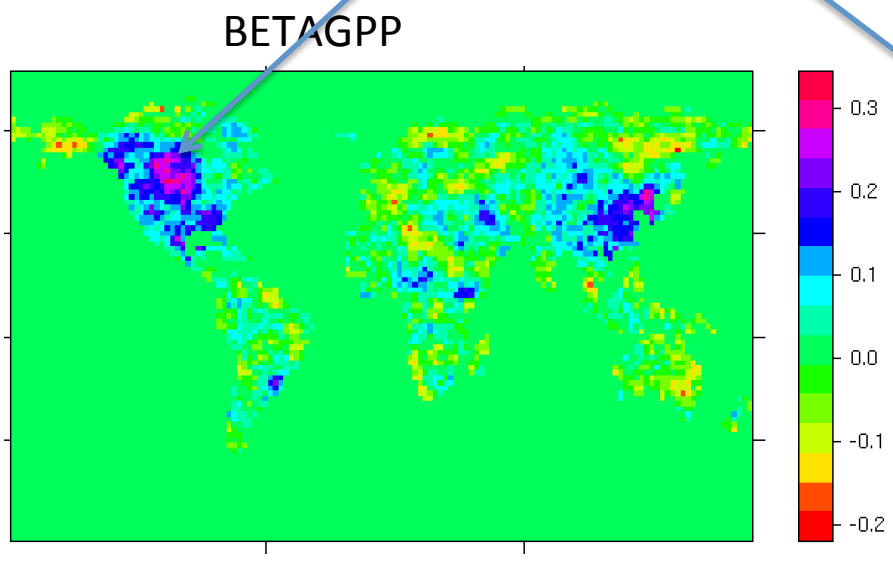
For each assimilation cycle….

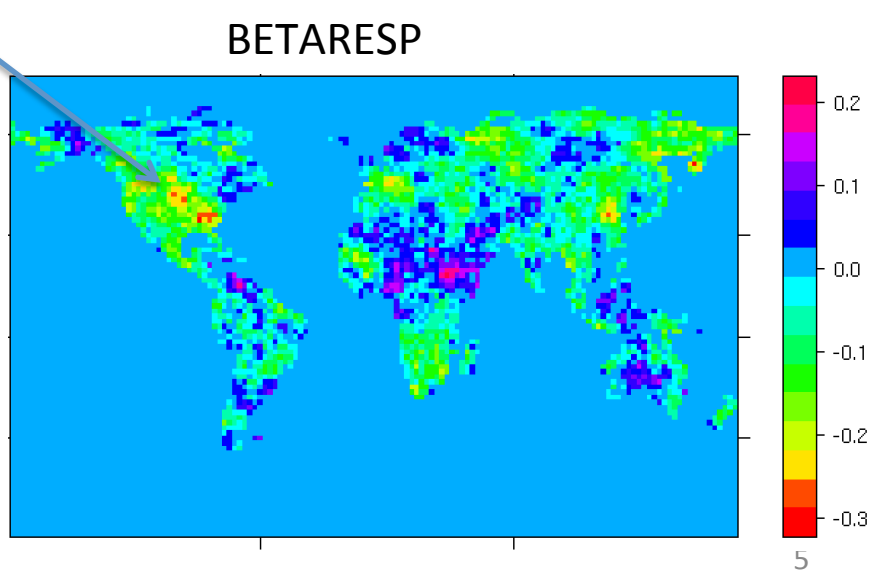
$$\text{Posterior NEE}(x,y,time) = (\beta_{RESP}(x,y)+1)SiB_RESP(x,y,time) - (\beta_{GPP}(x,y)+1)SiB_GPP(x,y,time) + \text{Fossil}(x,y,time)$$

- NEE is "optimized" by *multiplicative corrections* to a priori respiration and GPP fluxes from SiB.
- Correction factors (betas) are fixed through the assimilation cycle (14 days) but vary cycle to cycle.
- Betas *include some memory* from previous two time steps w/ continuous refreshing back towards "prior" fluxes.

EXAMPLE OF WHAT THE INVERSION IS DOING FOR ONE CYCLE



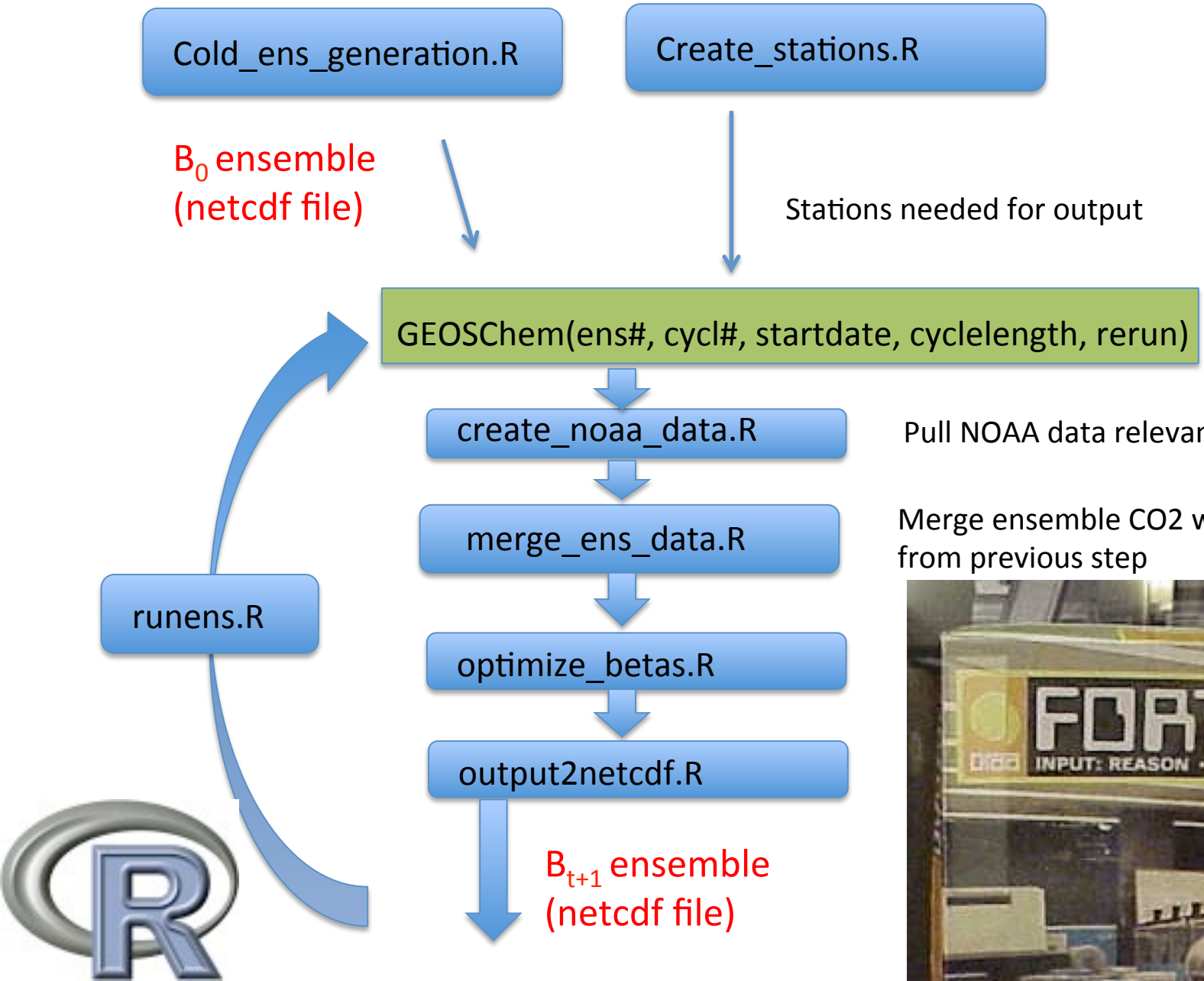




General Inversion Details

- Transport run with MERRA 1 x 1.25 (2D fields at 0.5 by 0.667) gridded to 2 x 2.5 (10 times higher resolution than previous 6 x 10 work).
- Inversion at 2 x 2.5, 16,000 state variables (~3700 land for GPP and RESP and ~ 10,000 for Ocean NEE), not *independent* of course.
- Using Tippett et al 2003 "direct method" EnKF, EnSRF (not MLEF/EnTF)
- Inversion cycles of length 14 days, *no* smoother window currently
- Localization applied in case of surface data to prohibit spurious long distance flux correlations.
- A priori fluxes generated from MultivariateNormal(0,Σ) with 800 km decorrelation length scale for land (1600 km for oceans) and 20% standard deviation on GPP and Respiration (10% for Ocean NEE). Exponential cov structure.

The code flowchart (in situ)

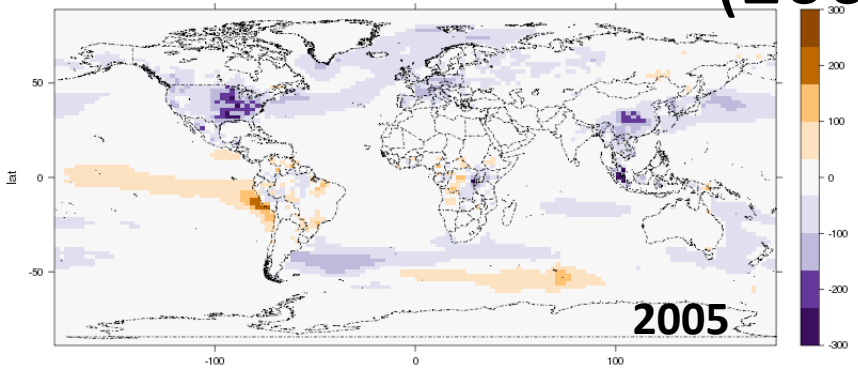


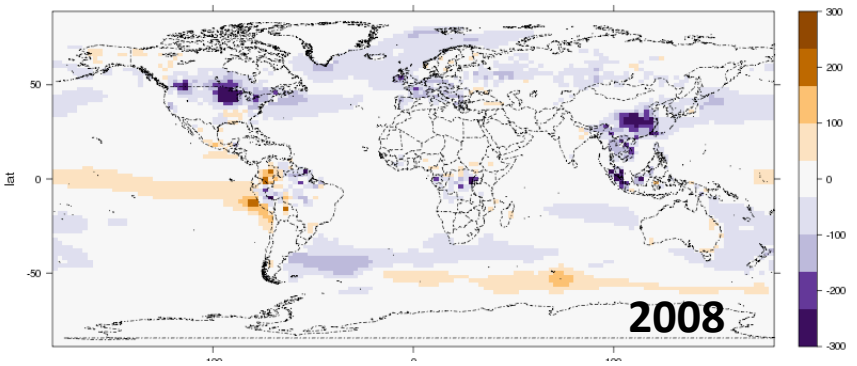
Pull NOAA data relevant to cycle *t*

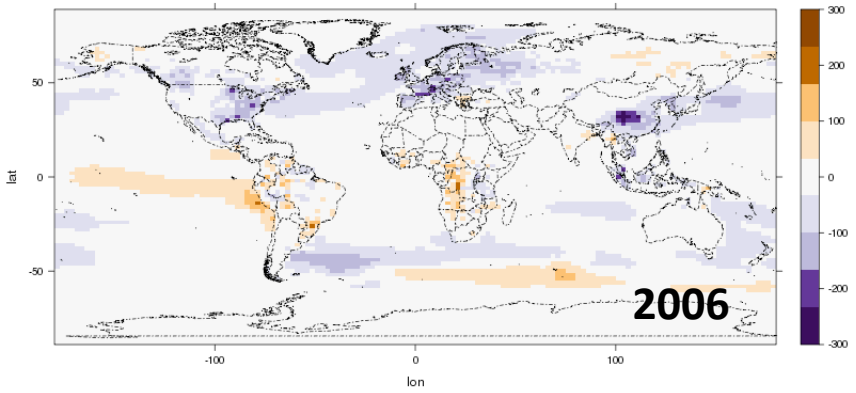
Merge ensemble CO2 with observations from previous step

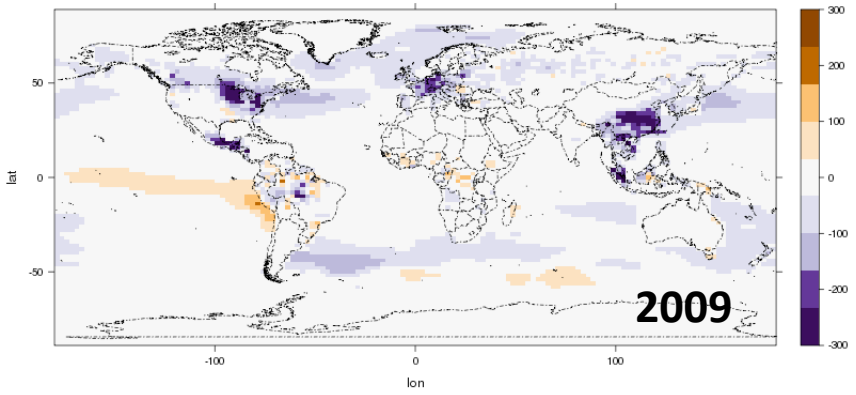
NOAA Inversions

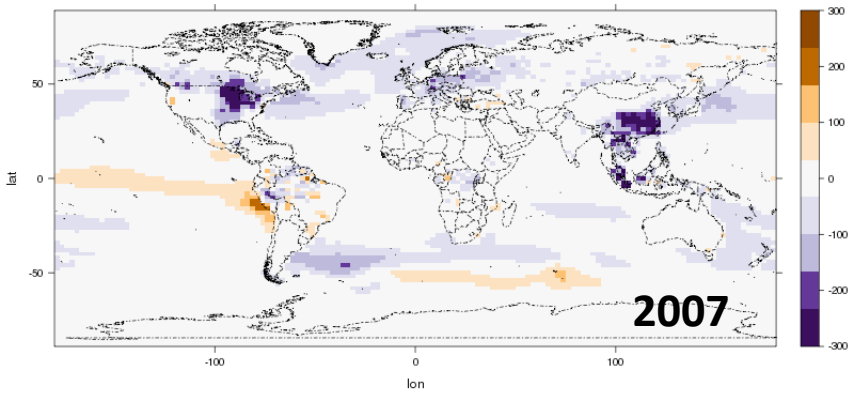
Annual NEE estimates using NOAA data (2005-2010)

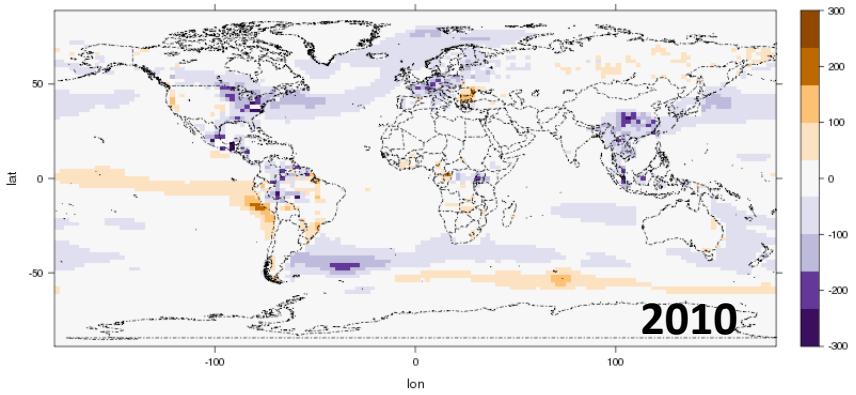










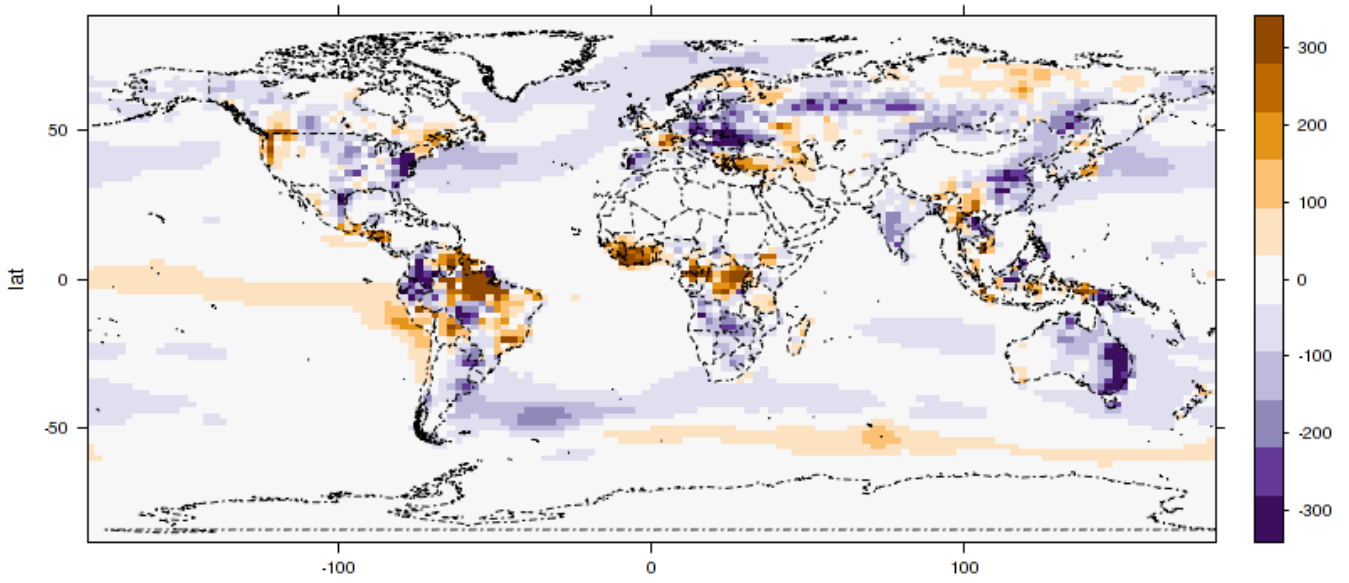


GOSAT/NOAA Inversions

INVERSION COMPARISON (2010), *gC m^-2 per year*

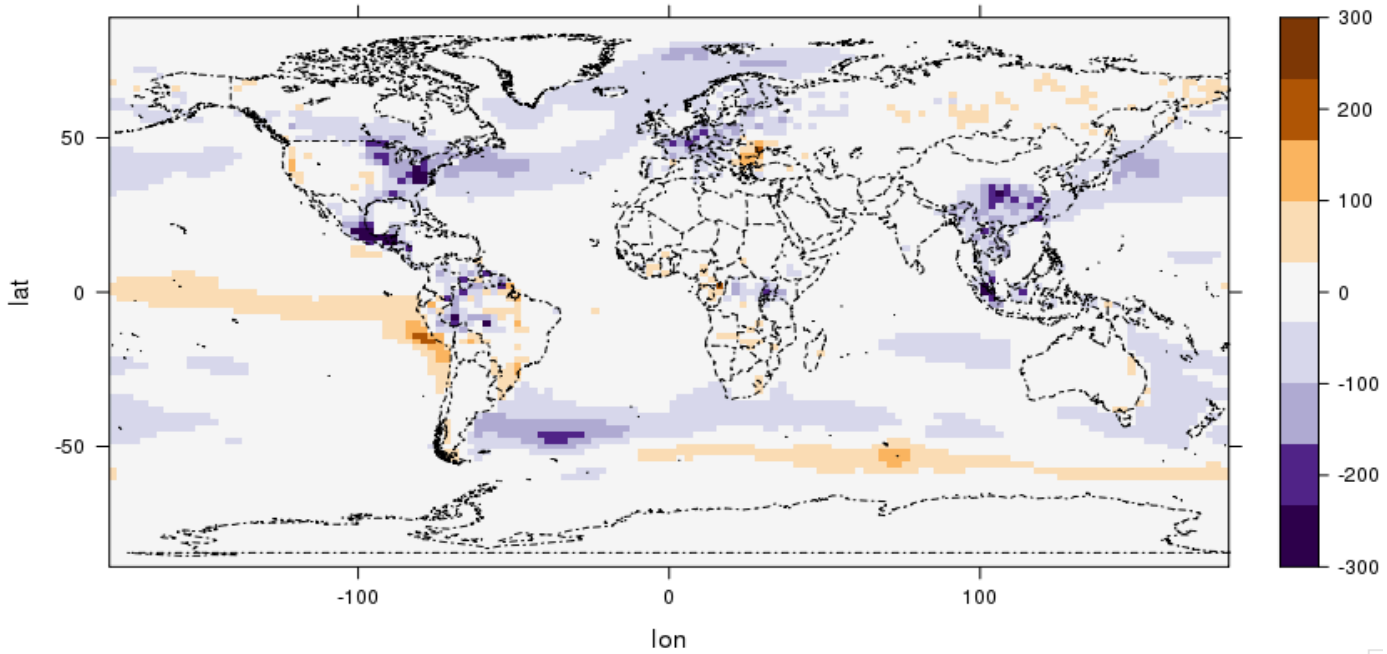
GOSAT

- Strong European sink
- Gradient across boreal Asia
- Strong gradients across Amazon and Equatorial Africa
- Australian anomaly?



NOAA

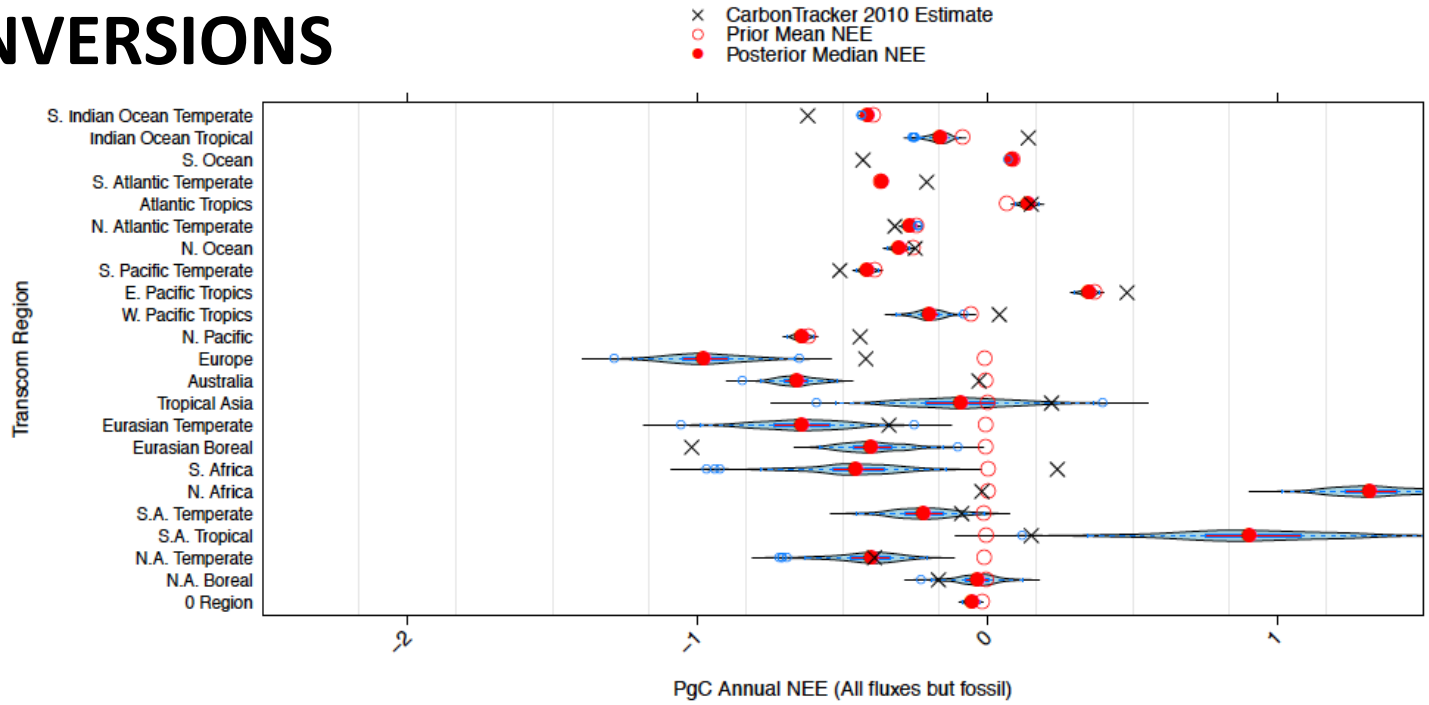
- Agrees somewhat w/ GOSAT across N. America and China
- Can't say much across tropics or high latitude boreal regions



REAL DATA INVERSIONS

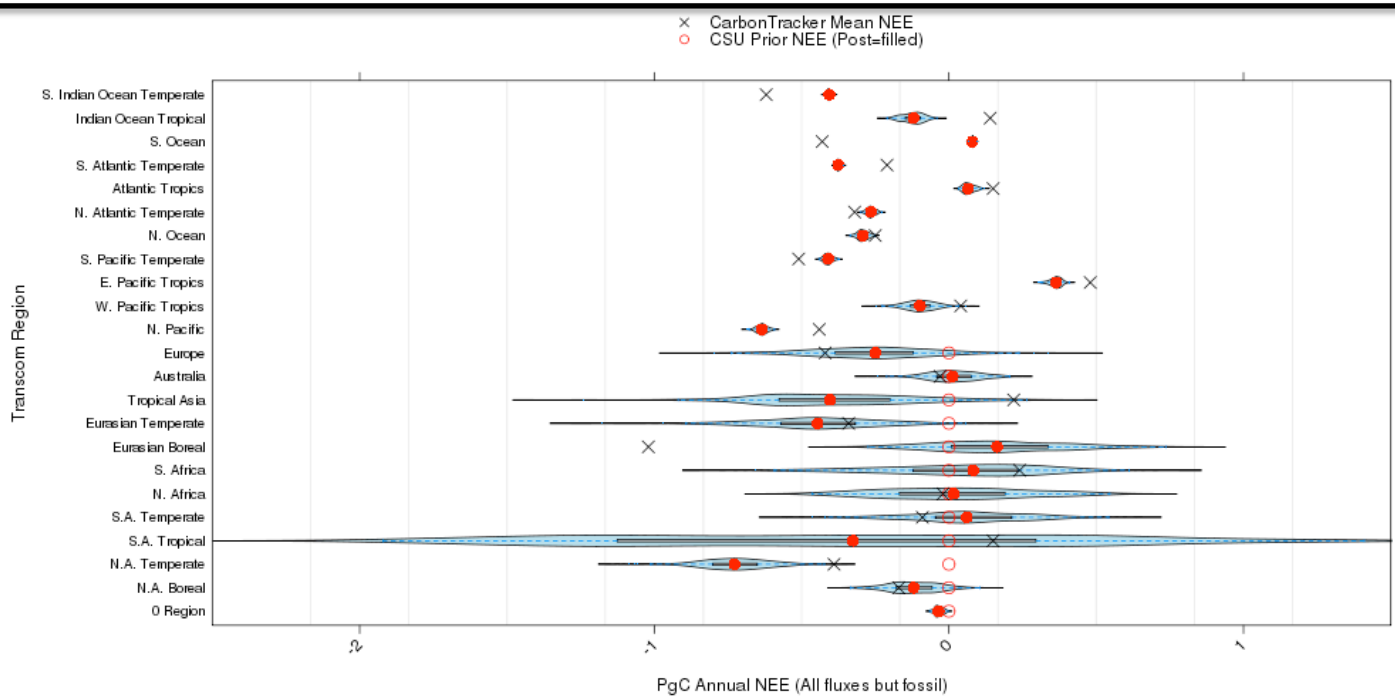
GOSAT

- Strong European sink
- Strong sources over portions of Africa and South America



NOAA

- Uncertainty w/ NOAA data much higher than GOSAT, in particular for tropics where there is little NOAA data



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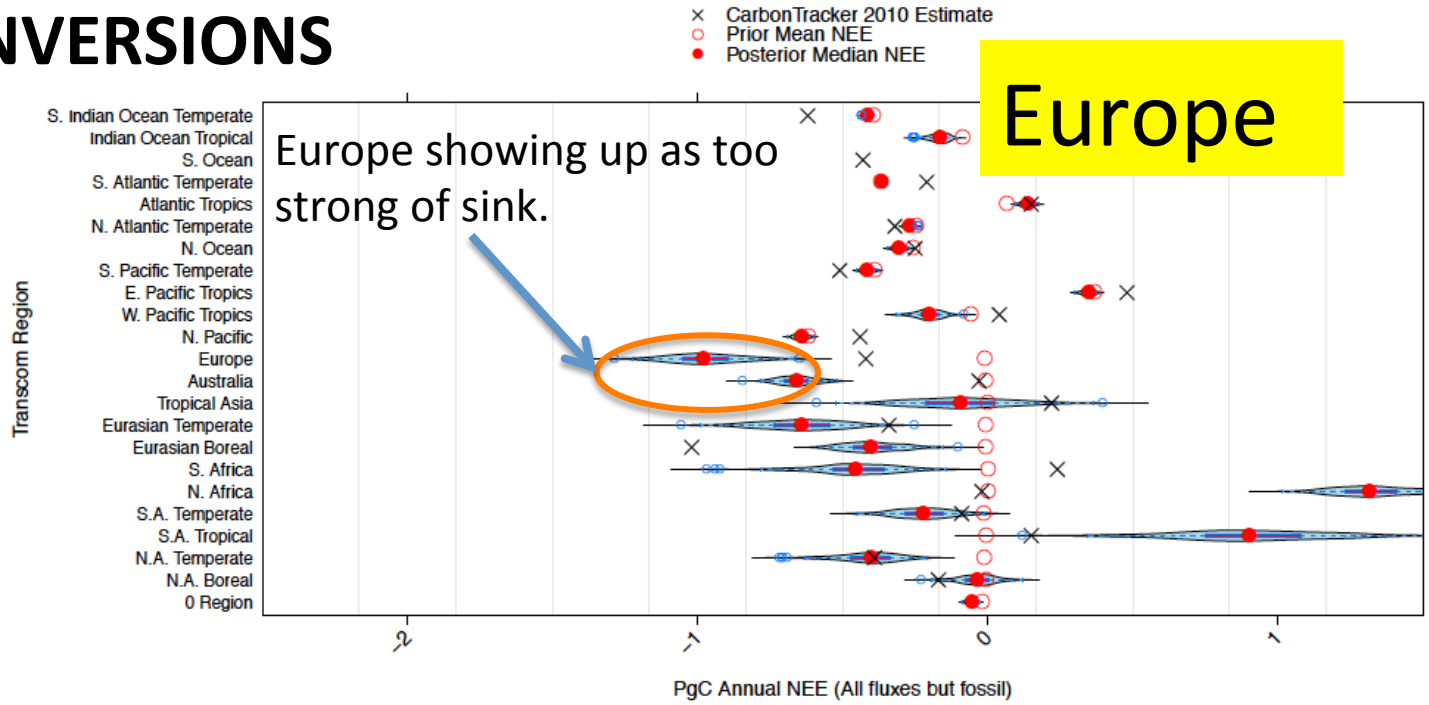

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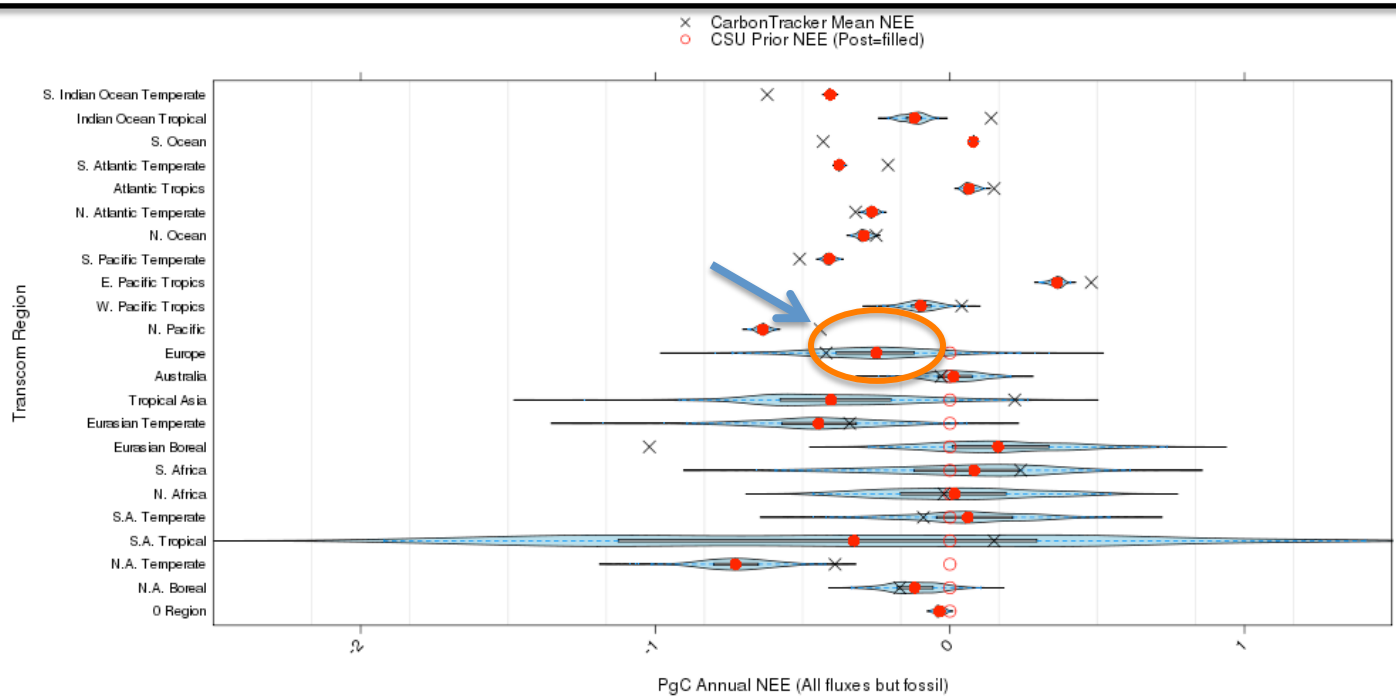

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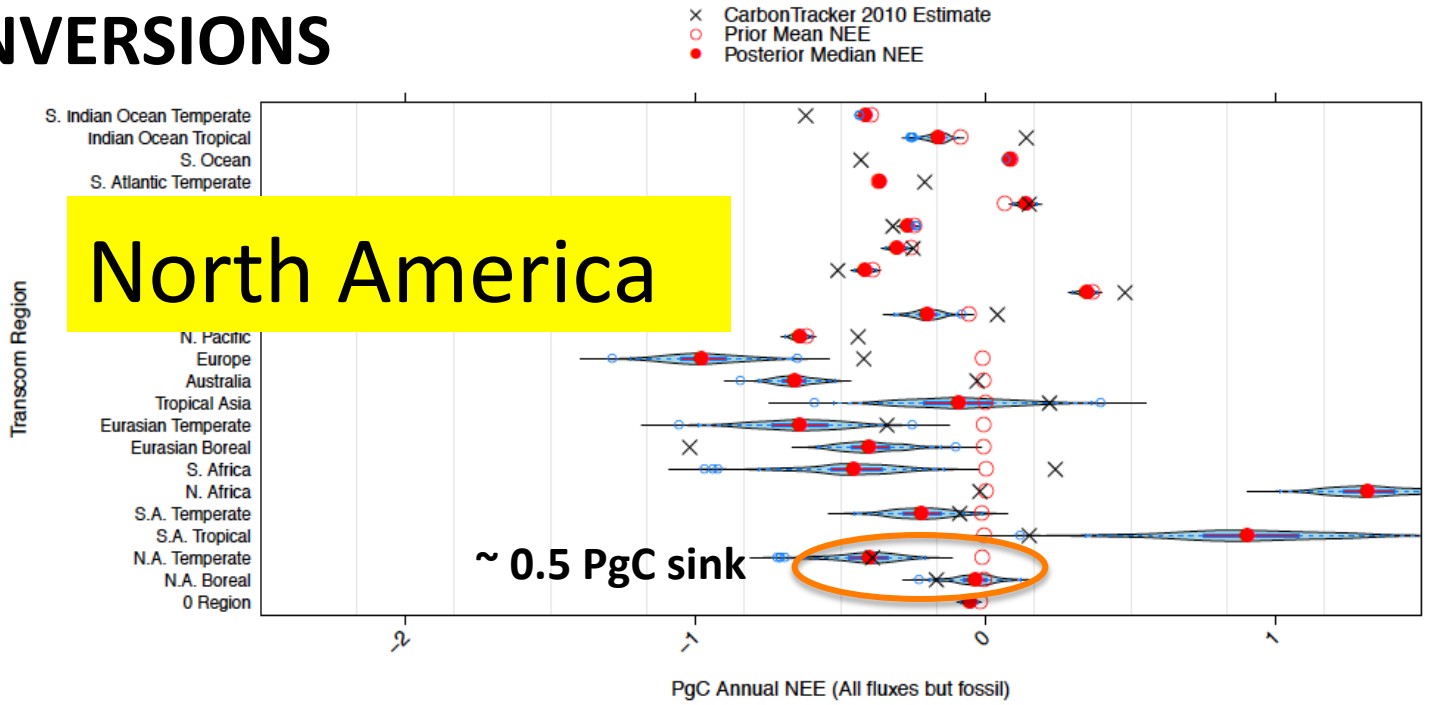

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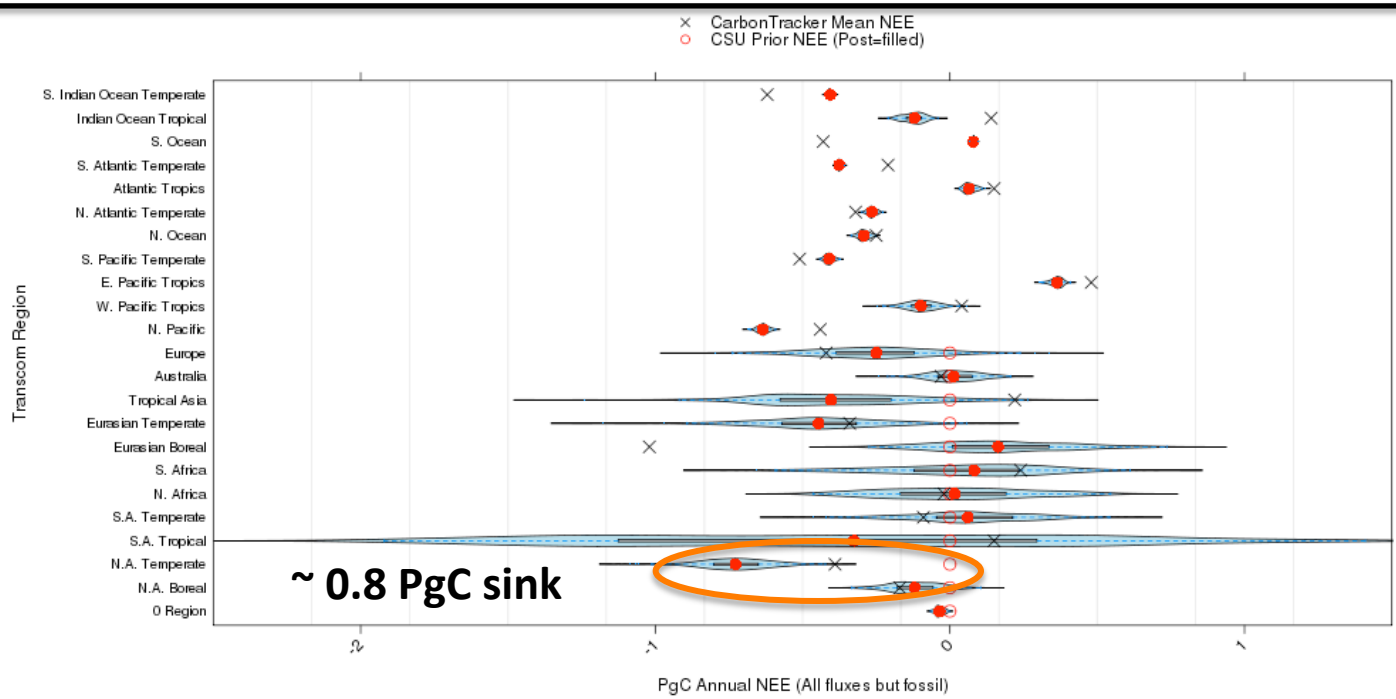

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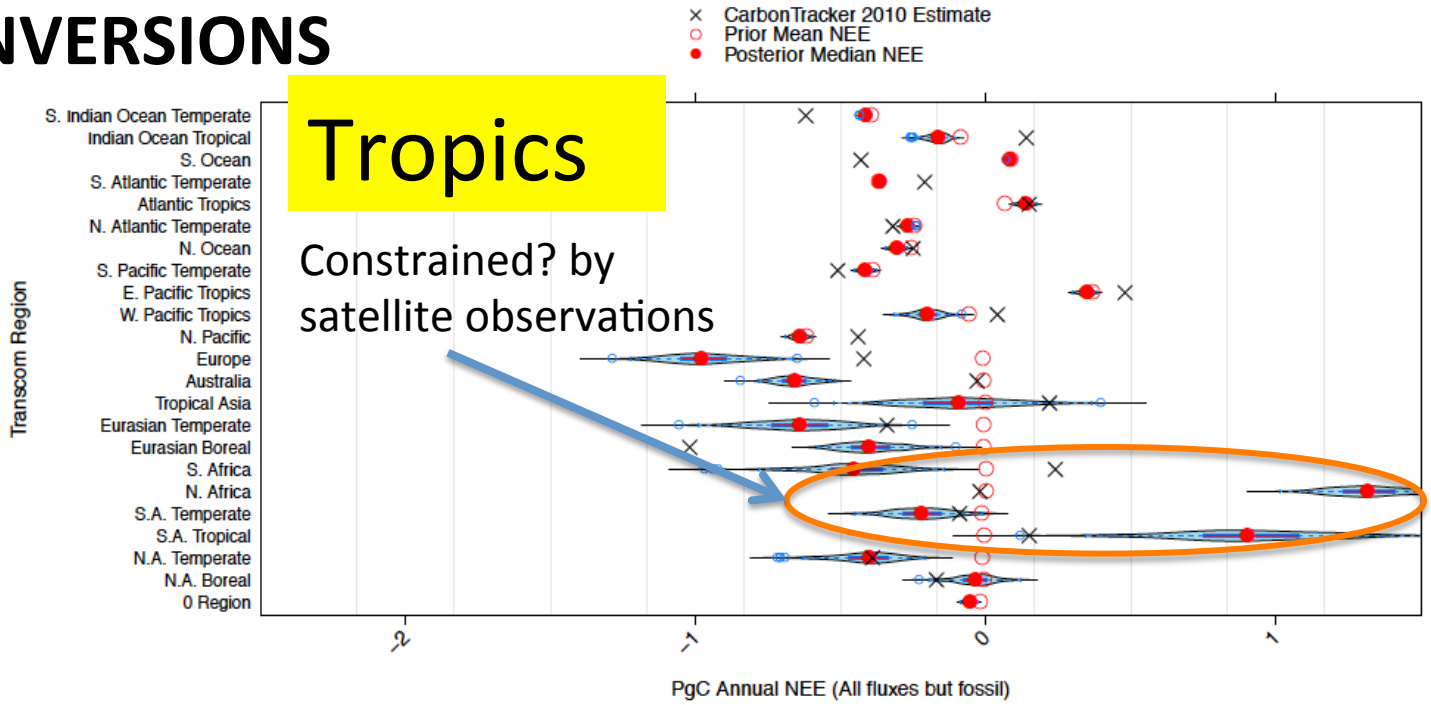

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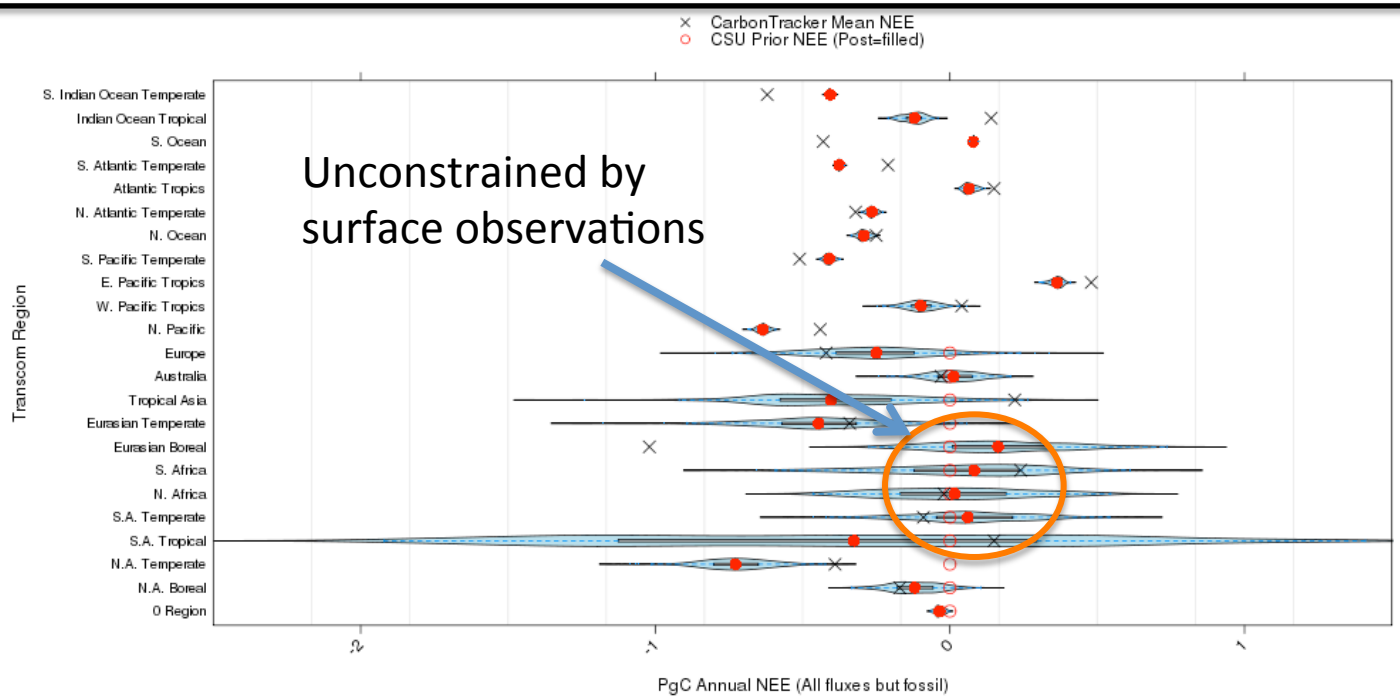

Summary/Future

- Start playing w/ mixing satellite and in-situ together as a joint constraint
- Develop more diagnostics to investigate reasons for sources, i.e. influence matrix etc.
- We welcome others who need to optimize surface fluxes to use code (w/ chemistry?)
  - https://github.com/biocycle/GEOS-Chem
  - https://github.com/aschuh/REnKF
- interested in like comparisons of estimated NEE/Ocean CO2 fluxes.

Global Change Biology

Global Change Biology (2013) **19**, 1424–1439, doi: 10.1111/gcb.12141

Evaluating atmospheric CO_2 inversions at multiple scales over a highly inventoried agricultural landscape

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Abstract

An intensive regional research campaign was conducted [illegible]ogram (NACP) in 2007 to study the carbon cycle of the highly productive ag[illegible]ern United States. Forty-five different associated projects were conducted ac[illegible]se of nearly a decade involving hundreds of researchers. One of the prima[illegible]paign was to investigate the ability of atmospheric inversion techniques to [illegible] ratio data to estimate CO_2 flux over the major croplands of the United S[illegible] an inventory of CO_2 fluxes. Statistics from densely monitored crop pro[illegible]rn and soybeans, provided the backbone of a well studied bottom-up inve[illegible] to evaluate the atmospheric inversion results. Estimates were compared to [illegible] inversion systems, representing spatial scales varying from high resolutio[illegible] (CSU) and global (CarbonTracker), coupled to different transport models [illegible] inversion-based mean CO_2-C sink estimates were generally slightly larger, 8[illegible]U, and 21% for CarbonTracker, but statistically indistinguishable, from the inventory [illegible]While the comparisons show that the MCI region-wide C sink is robust across inversion sy[illegible]l scale, only the continental and mesoscale inversions were able to reproduce the spatial patter[illegible]he region. In general, the results demonstrate that inversions can recover CO_2 fluxes at sub-regional sc[illegible] with a relatively high density of CO_2 observations and adequate information on atmospheric transport in the region.

Keywords: agriculture, atmospheric inversions, carbon cycle, CO_2 emissions, inventory, Mid-Continent Intensive

Received 6 November 2012; revised version received 6 November 2012 and accepted 10 December 2012

new paper " plug"

Thanks