In situ CO_2-based evaluation of the CMS flux product (and S. American Inversions)

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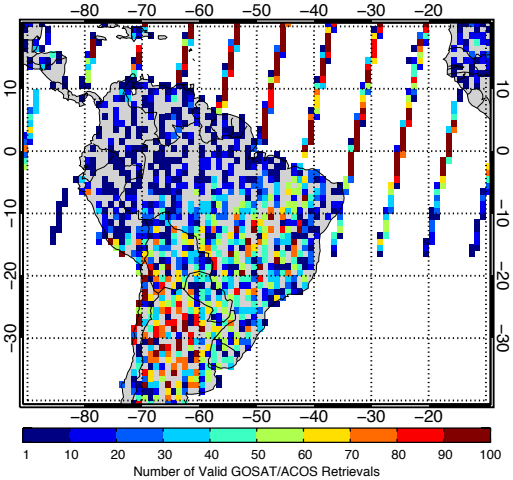
Collaborators: Kevin Bowman, Junjie Liu, JPL
Also: Caroline Alden (Stanford), Sourish Basu (NOAA)

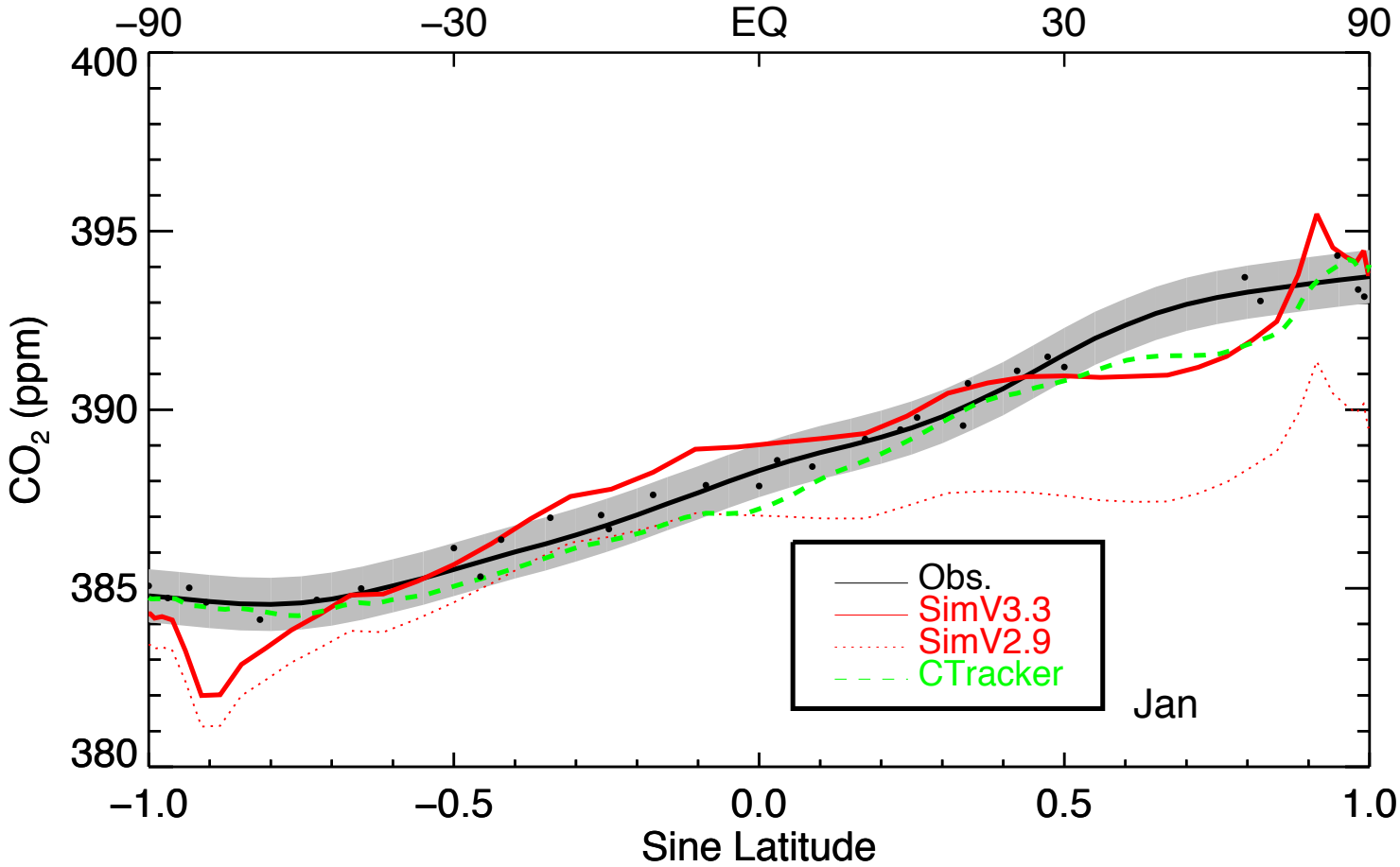
Objectives

1. Use calibrated (***in situ***) measurements of CO2 from NOAA to evaluate JPL/CMS data assimilation system.
2. Use measurements of Amazonian CO2 from light aircraft to help fill in GOSAT/ACOS data gaps above a critical region.

Dry season valid retrievals (ACOS 2.?)



Differences in Observed and Simulated N-S gradients of CO2



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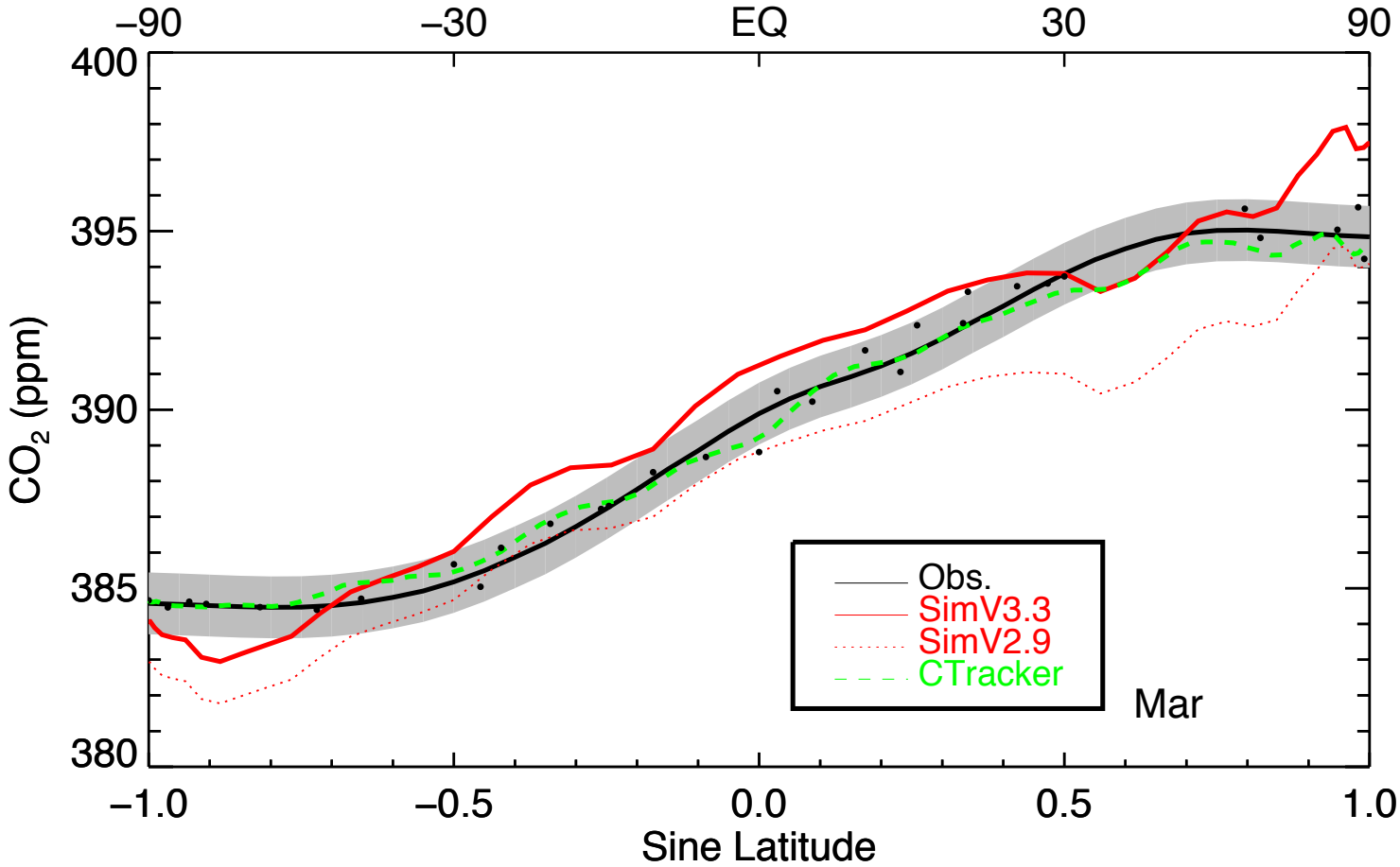

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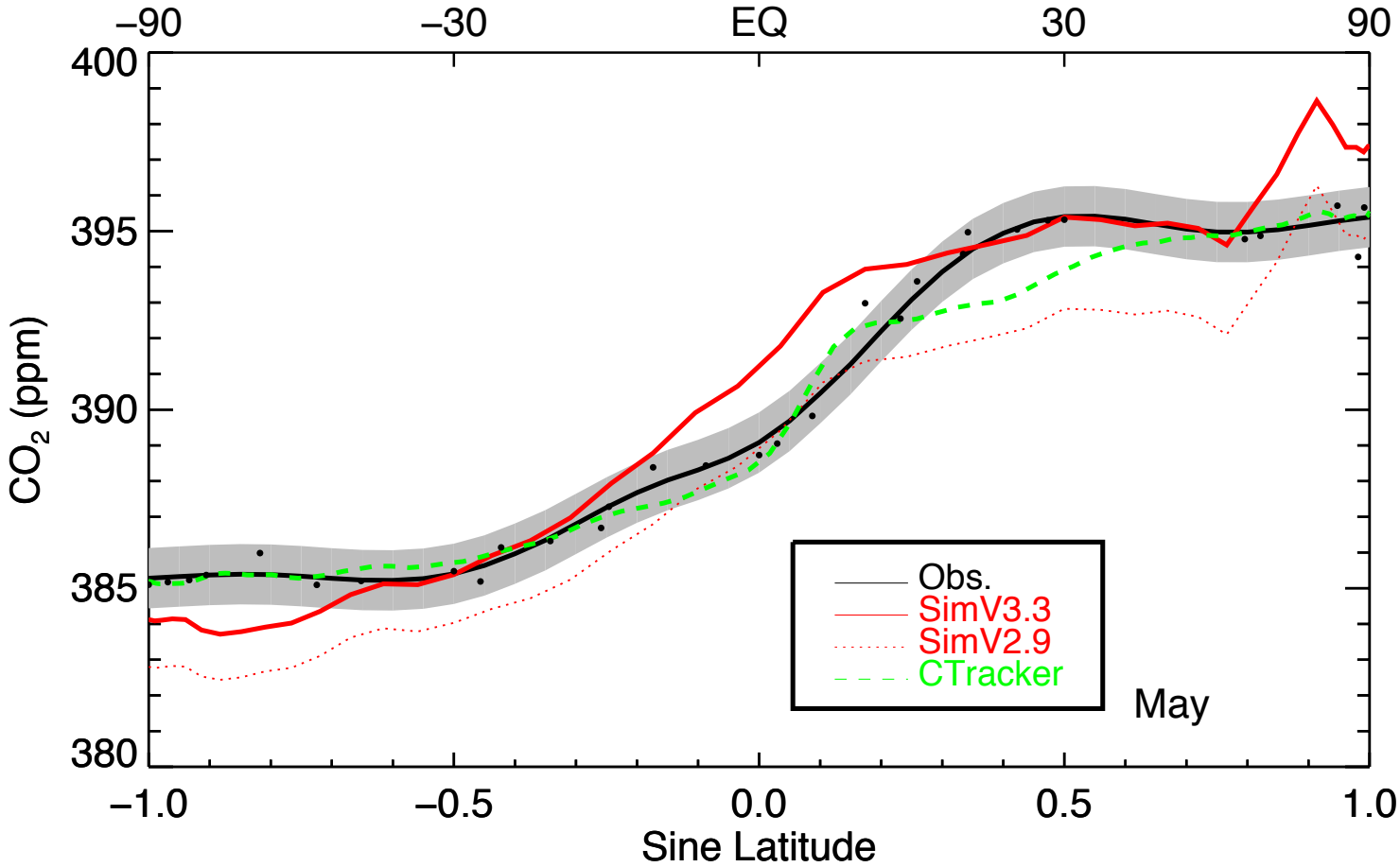

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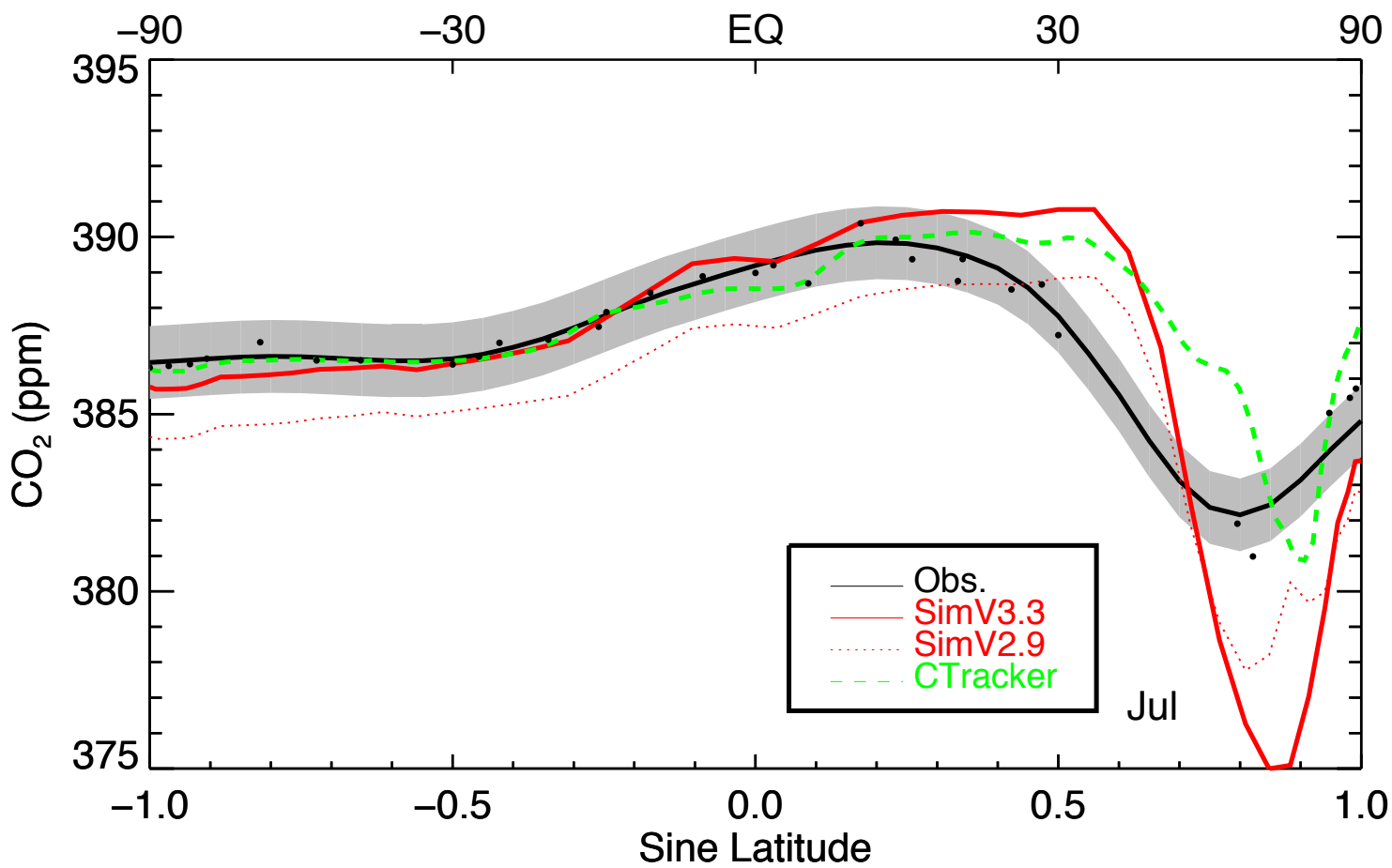

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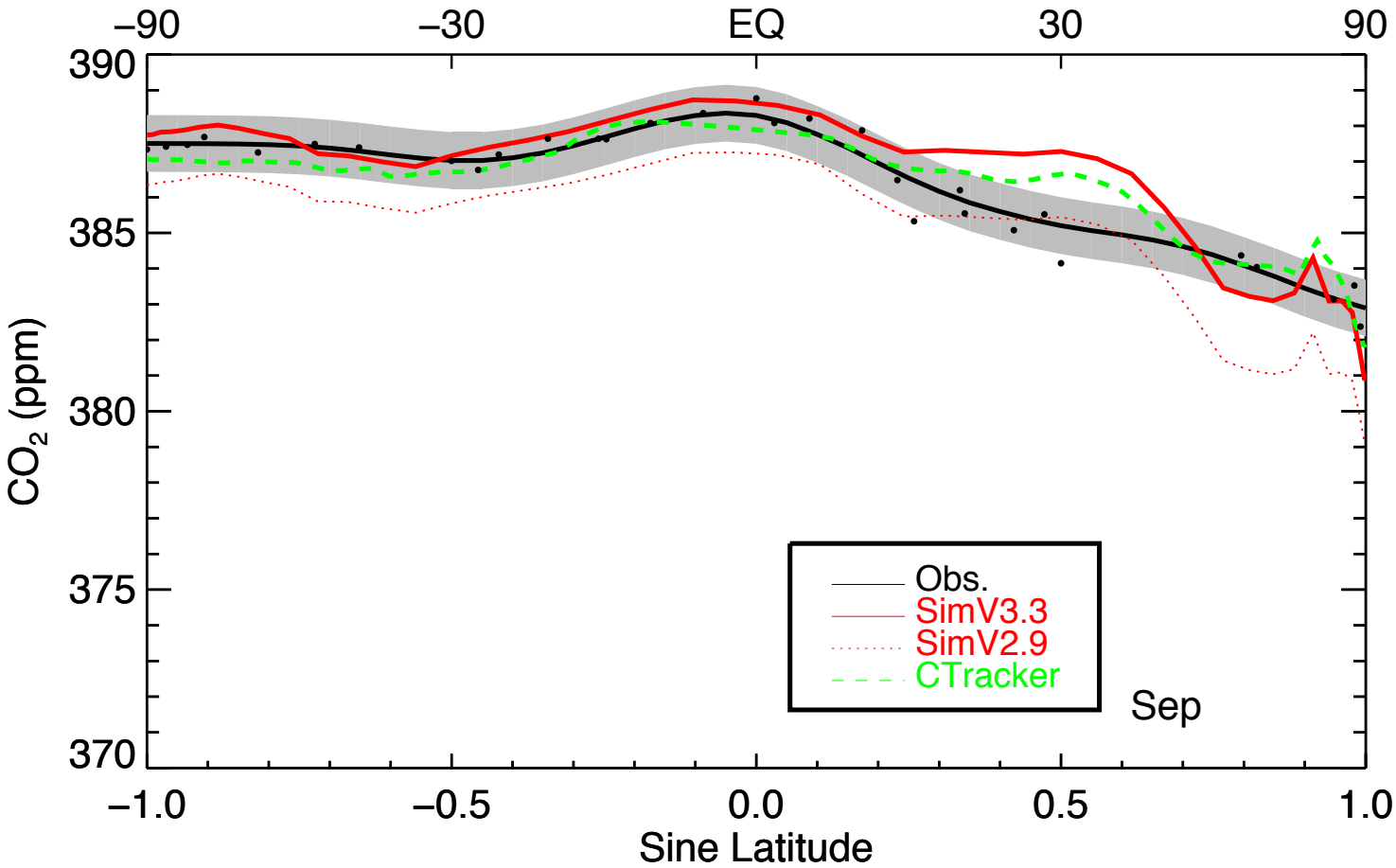

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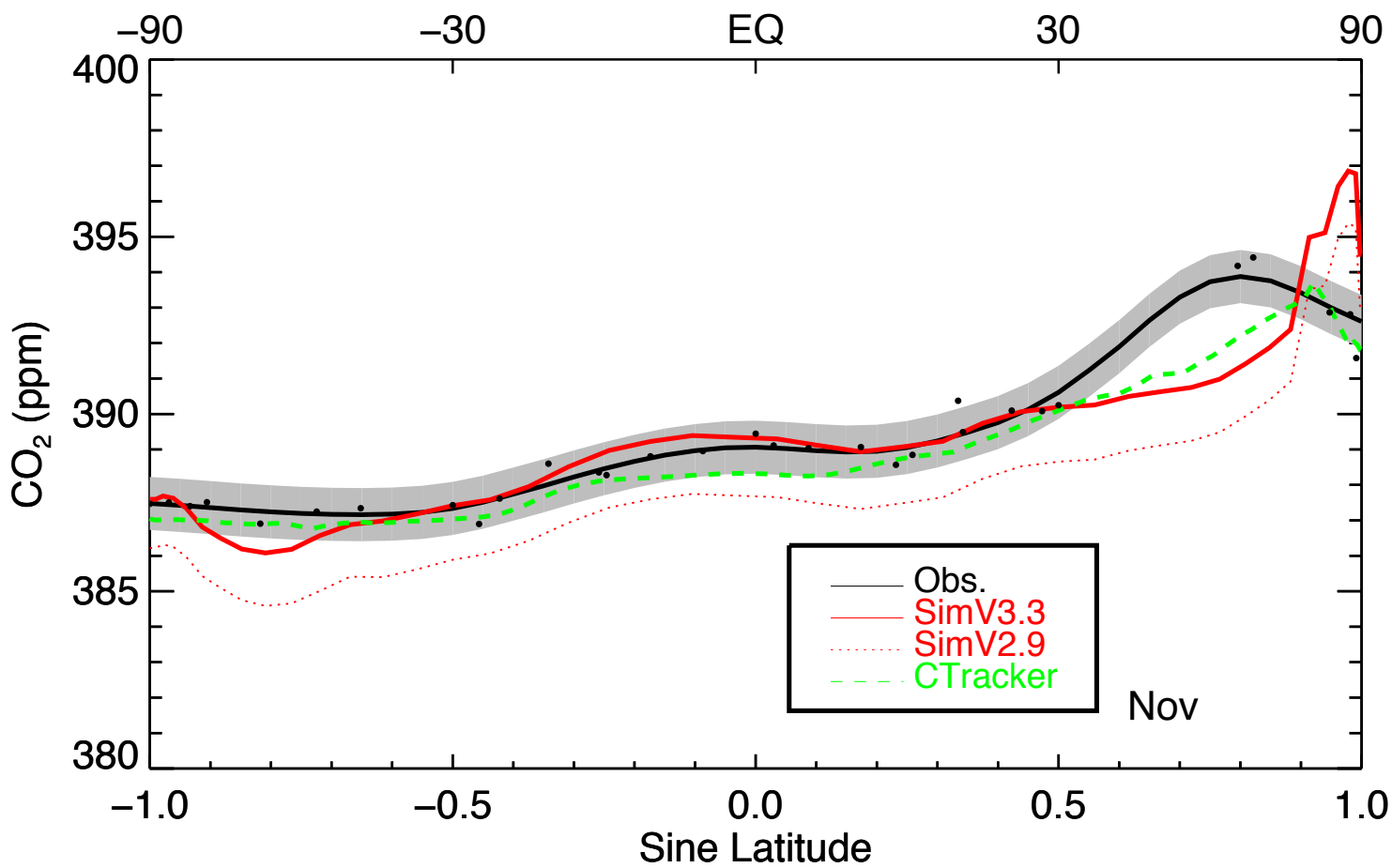
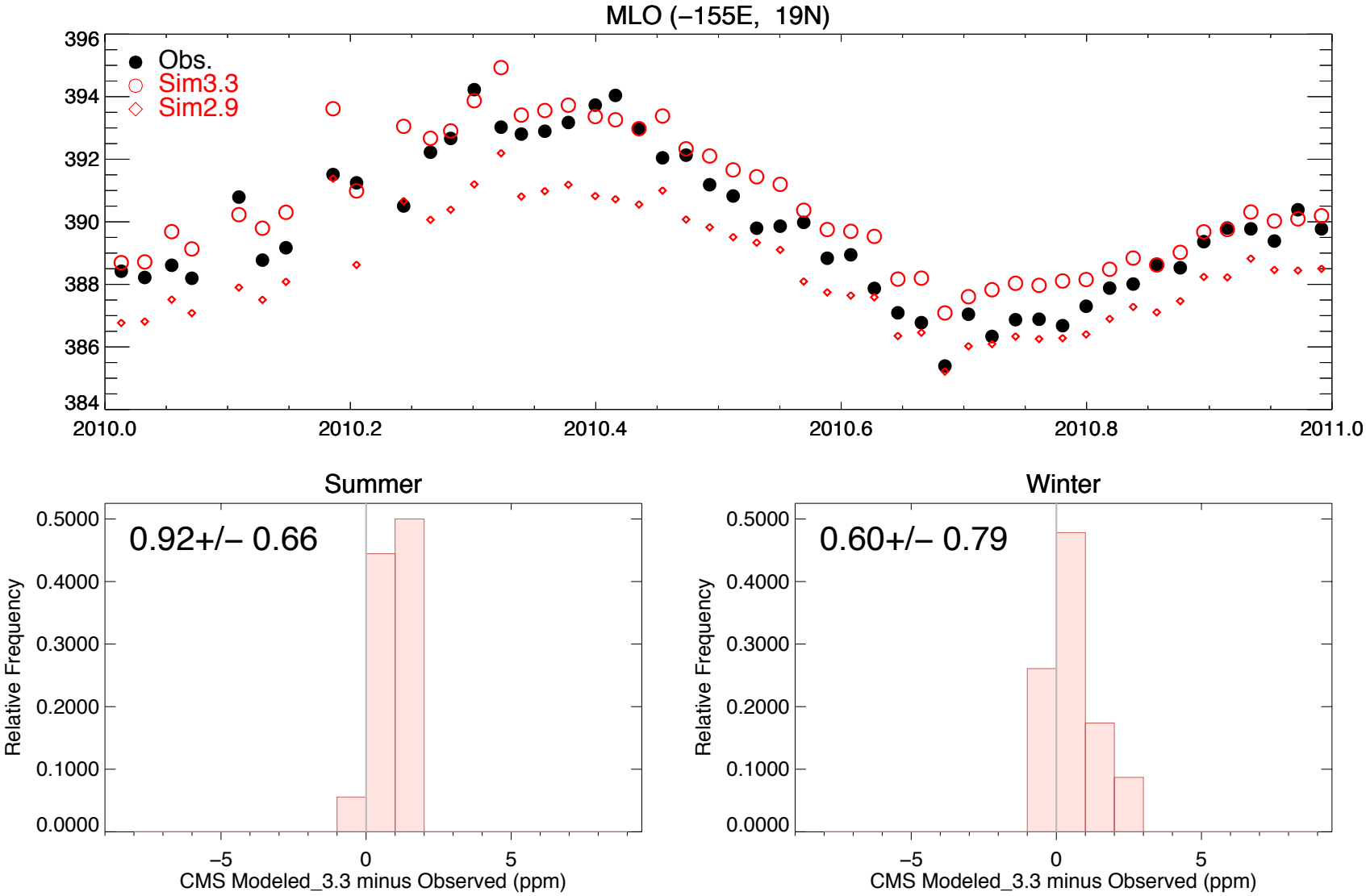


Differences in Seasonal Cycles of CO2



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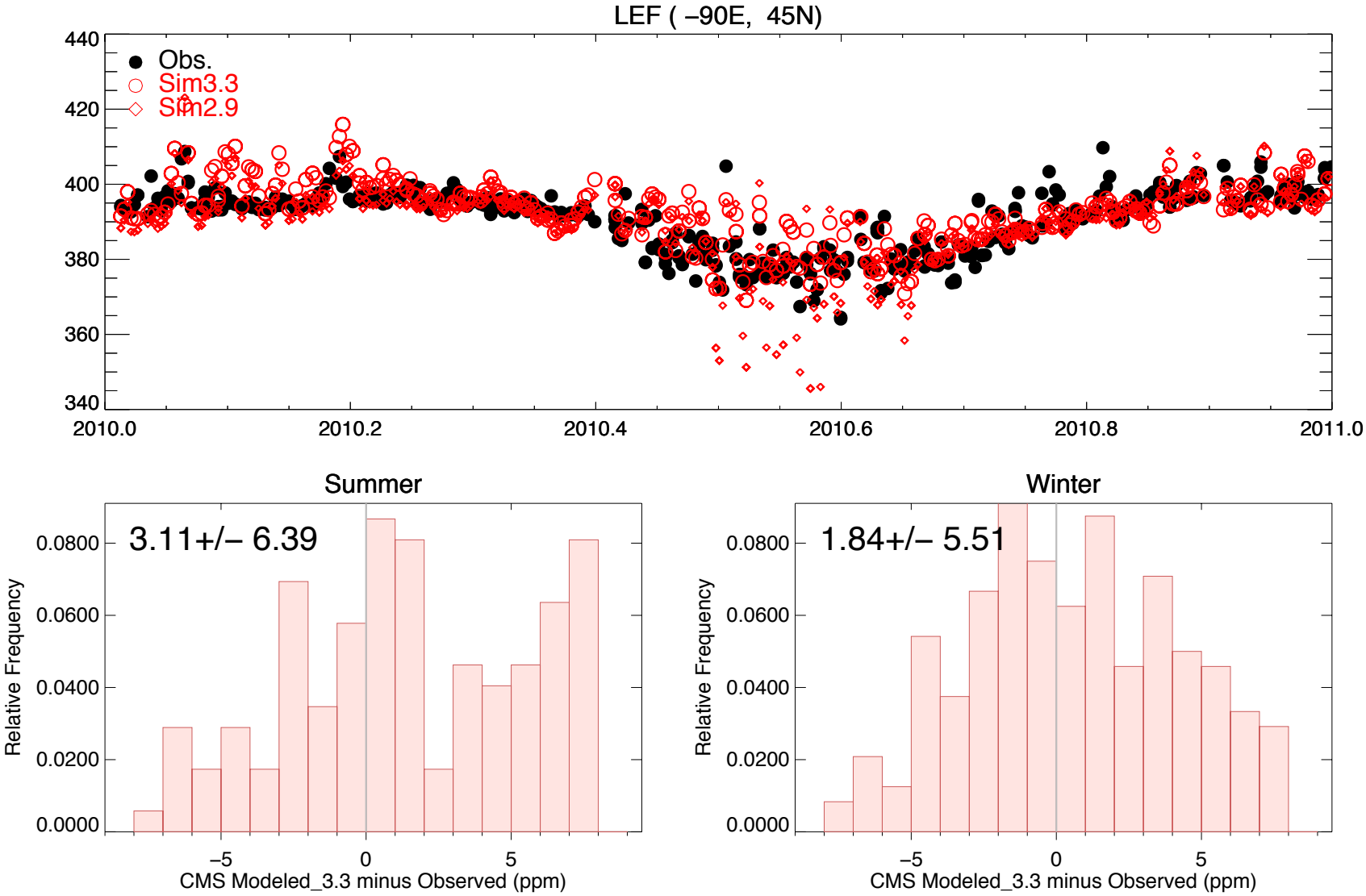

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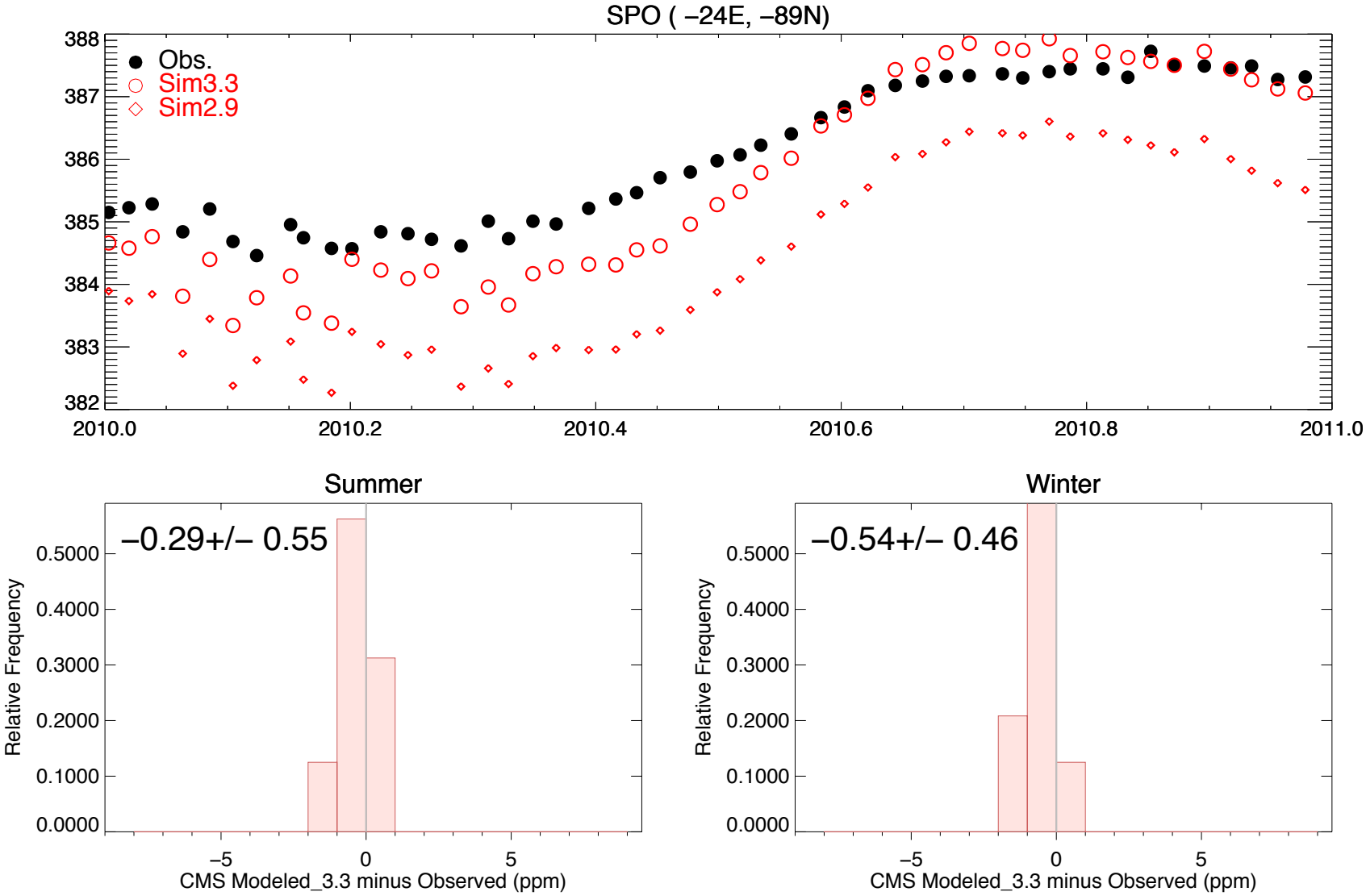
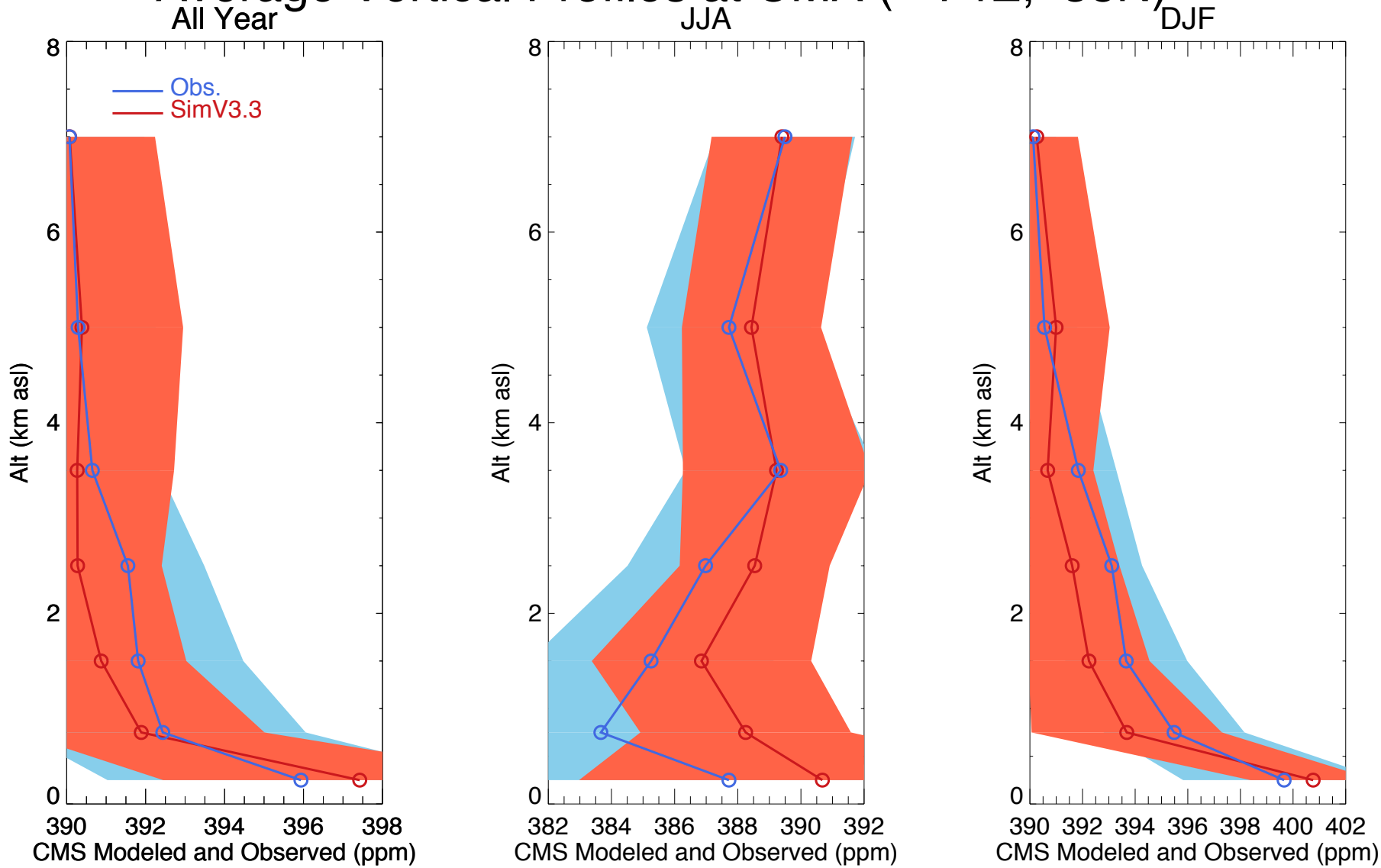


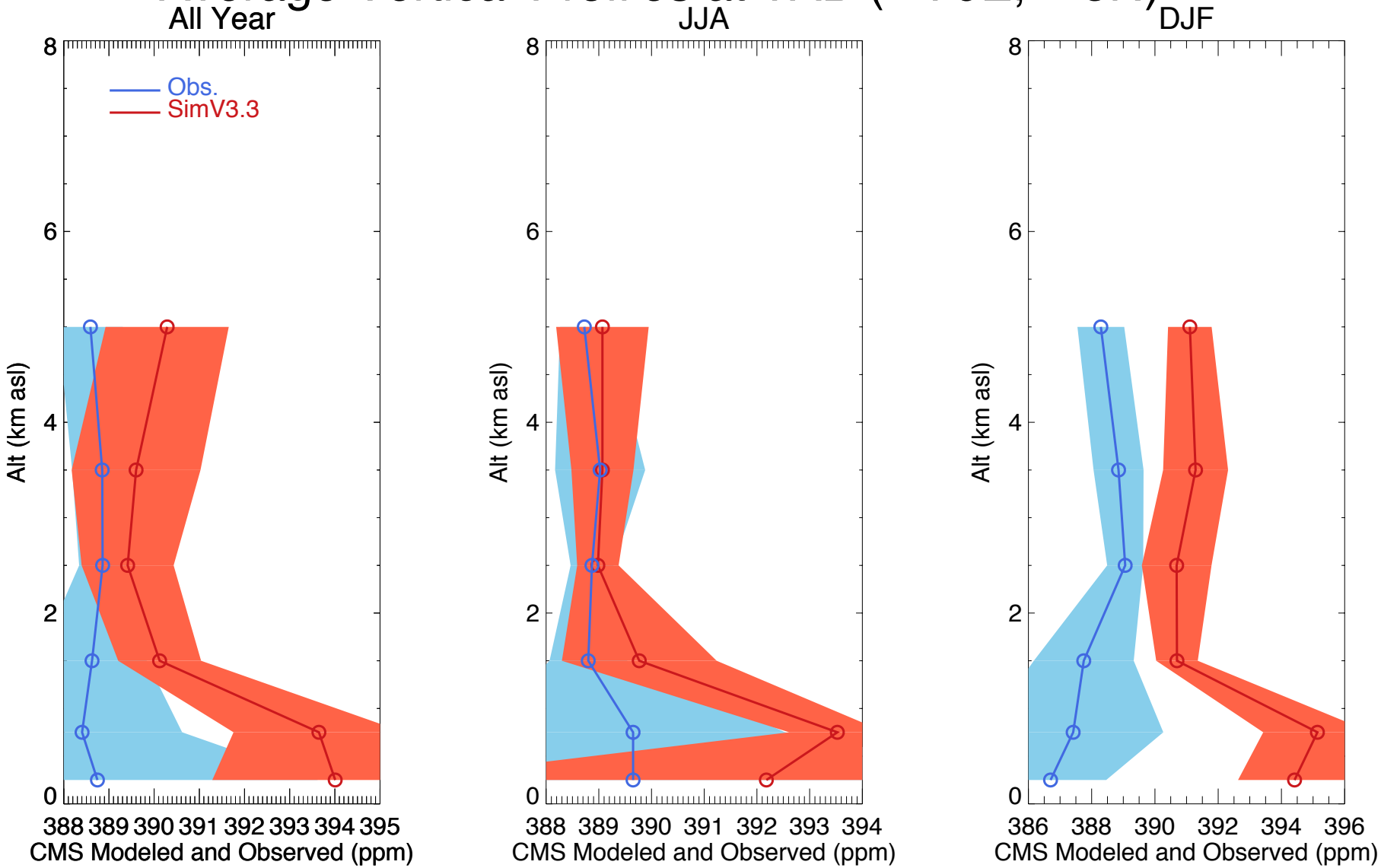
Differences in Vertical Profiles of CO2

Average Vertical Profiles at CMA (–74E, 38N)



Differences in Vertical Profiles of CO2

Average Vertical Profiles at TAB (–70E, –5N)

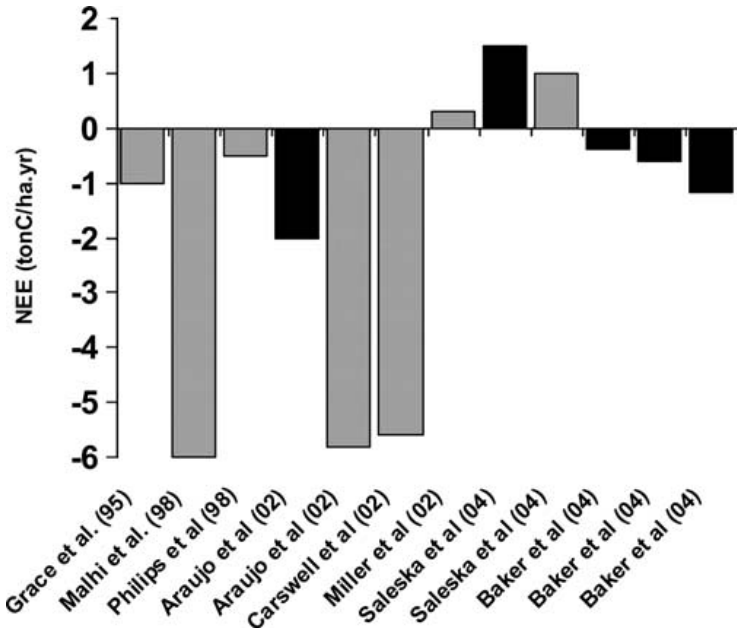


South American Regional Inversions

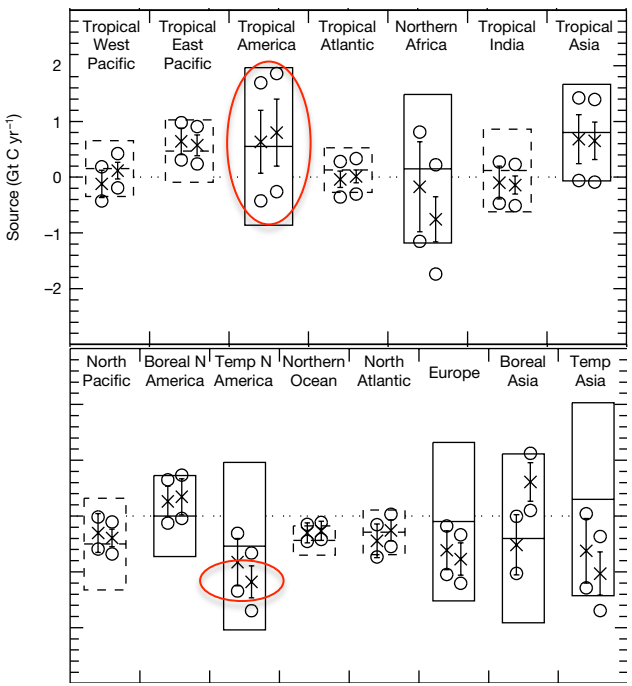
Amazonian C flux has been woefully underconstrained

The "Residual dumping ground" of global inversions

-- Prof. Denning



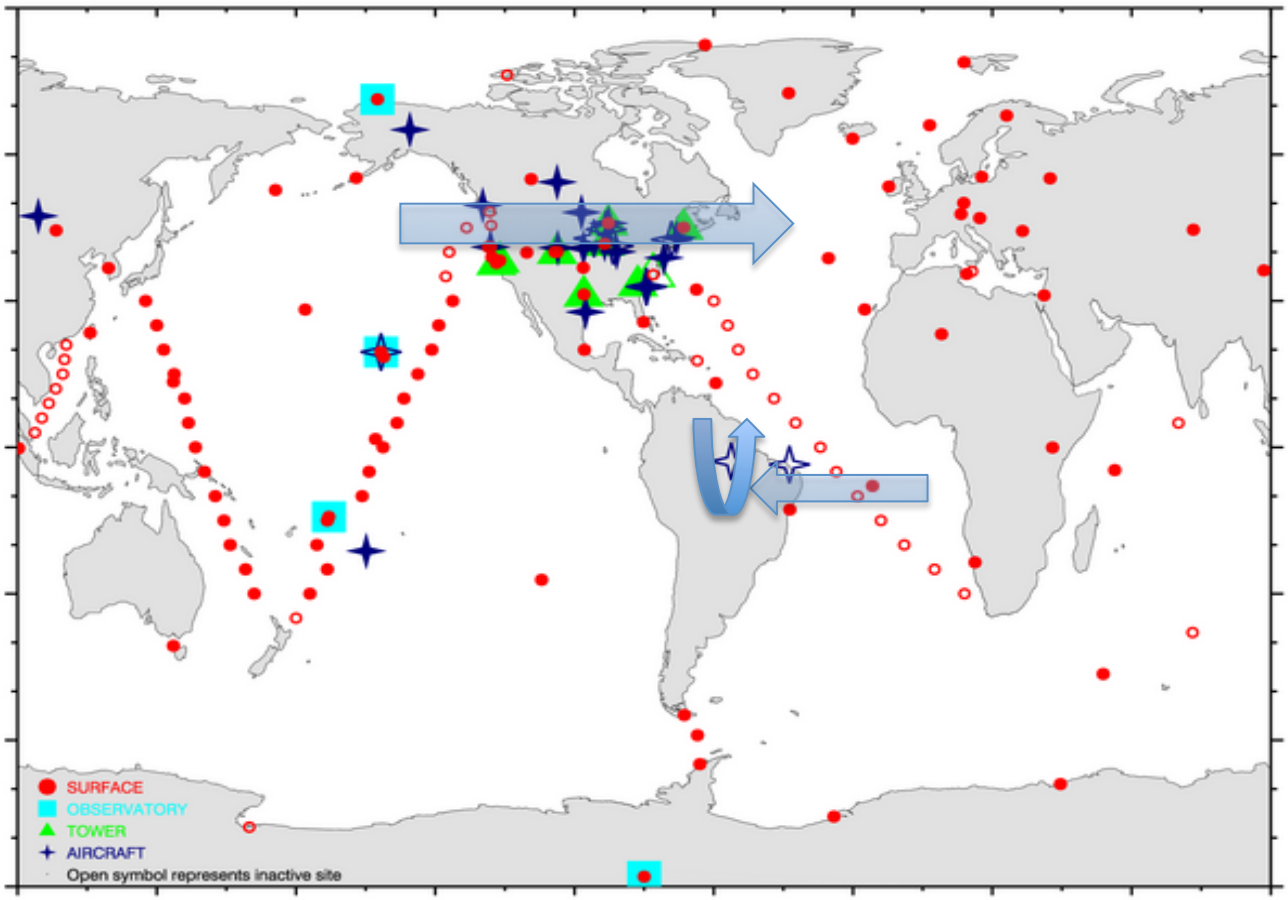
J. Ometto et al., 2005, Oecologia



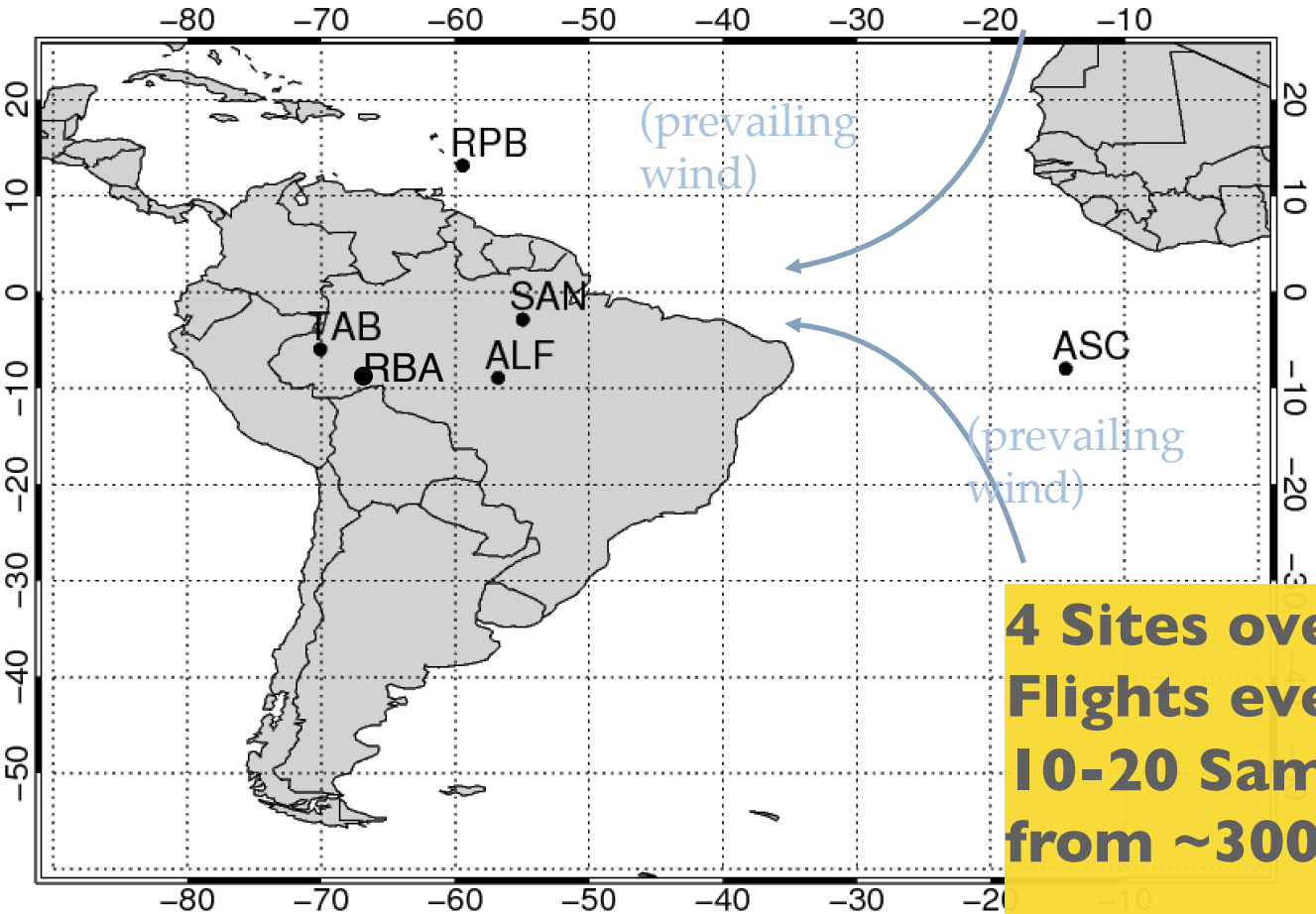
Gurney et al., 2002, Nature

S. American estimates vary wildly…not so for the temperate north,especially in the last ~ 5 years (more obs).

Amazonian C flux has been woefully underconstrained…because we don't have enough observations (in the right places)



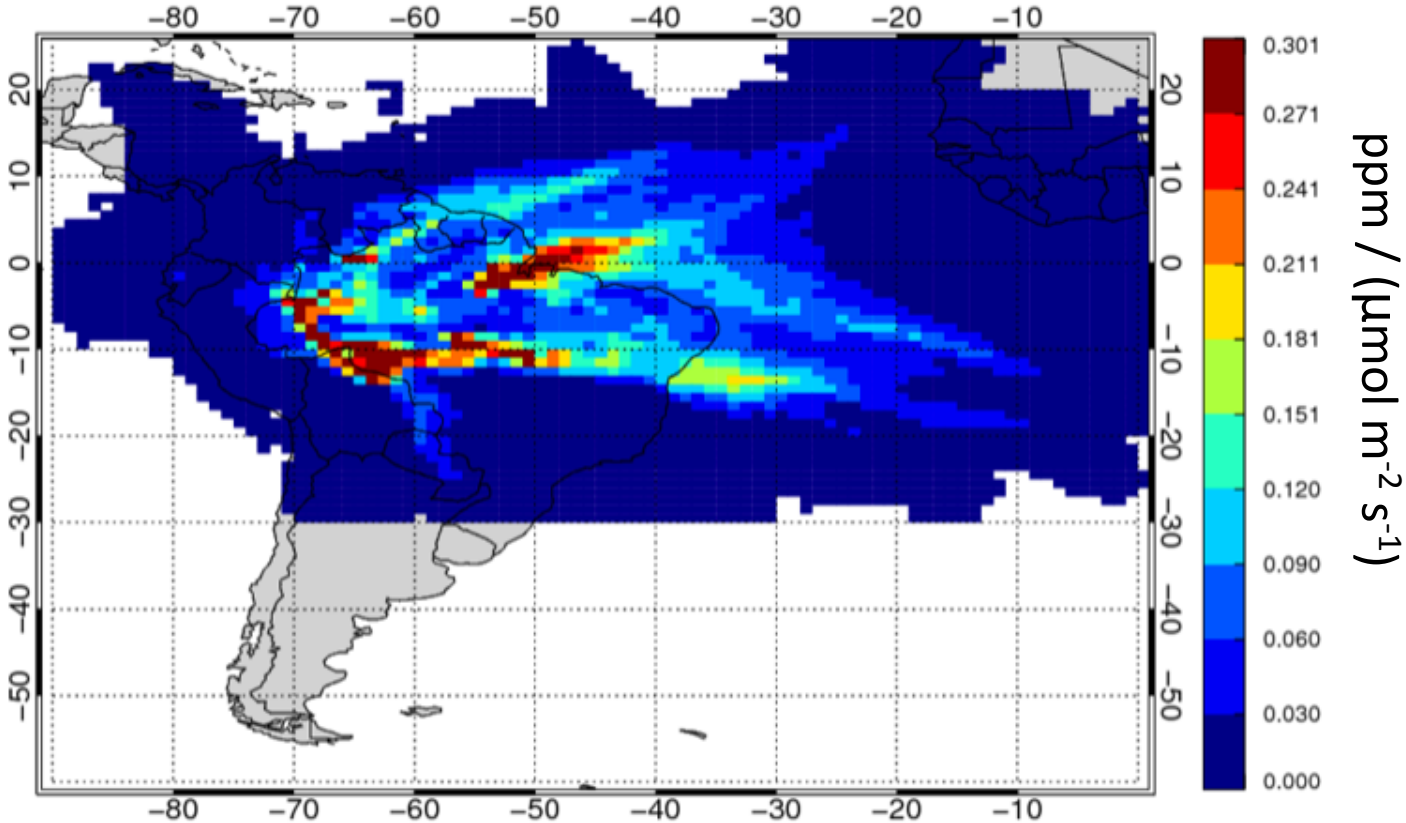
Domain and Observation Sites:



4 Sites over Amazon Basin
Flights every 2-3 weeks
10-20 Samples Each Flight
from ~300 m to 4400 m

2 "boundary" sites
Weekly Sampling

Lagrangian Particle Dispersion Modeling:
By running imaginary particles backwards through time (using known meteorology) we can determine the influence (footprints) of surface fluxes on measurements.



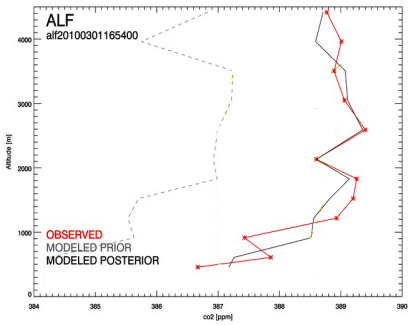
I'll show results from 2 Lagrangian Particle Dispersion Models:

- FLEXPART with GFS meteorology
- HYSPLIT with NAMS meteorology

Regional Inverse Modeling

→ Use observations to optimize first-guess (*a priori*) biosphere fluxes

- CO2_pred = Flux X Footprint + CO2_bg



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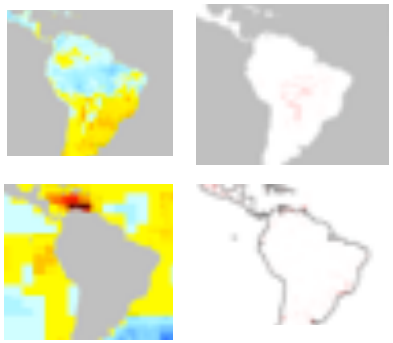

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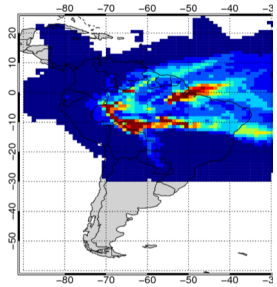

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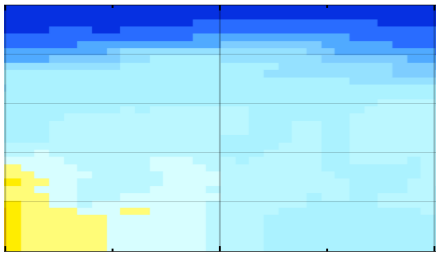


Prediction | Prior Flux | Footprint | Background

ΔCO2 = CO2_obs - CO2_pred

→ The inversion adjusts fluxes (and background) to minimize ΔCO2

CO_2 INVERSION FRAMEWORK

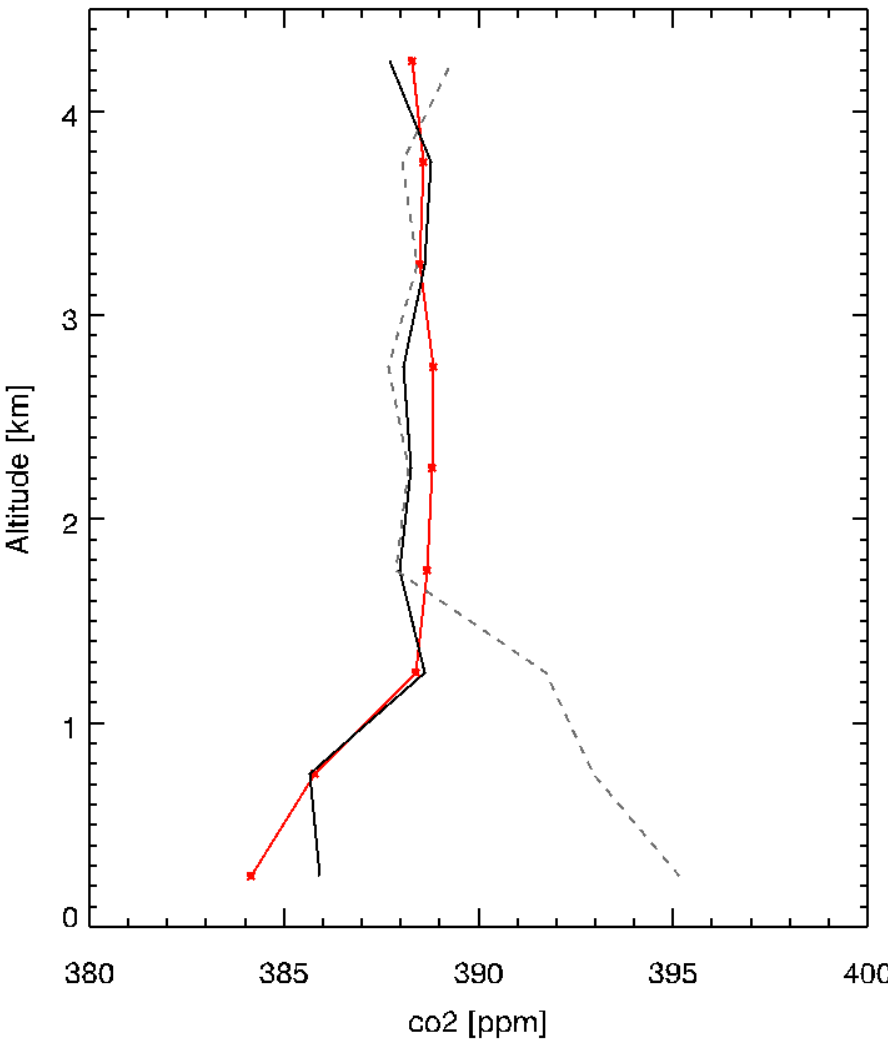
- 1 year batch inversions, covering 2010-2011
- ~1000 Observations/year from 4 sites: ALF, RBA, SAN, TAB
- Flux vector includes: (Covariance Matrix ~ 10^14 elements!!)
  - 1) Land Biosphere Fluxes (NEE) + Fire Fluxes
  - 2) Background mole fractions (background will be optimized!)
- Inversion resolution: 3-hourly, 1°x1°
- Aggregate fluxes to sub-Basin regions by month

RBA 2010 Wet Season (jan-may)

* Observations

-- Prior Estimate

– Posterior Estimate

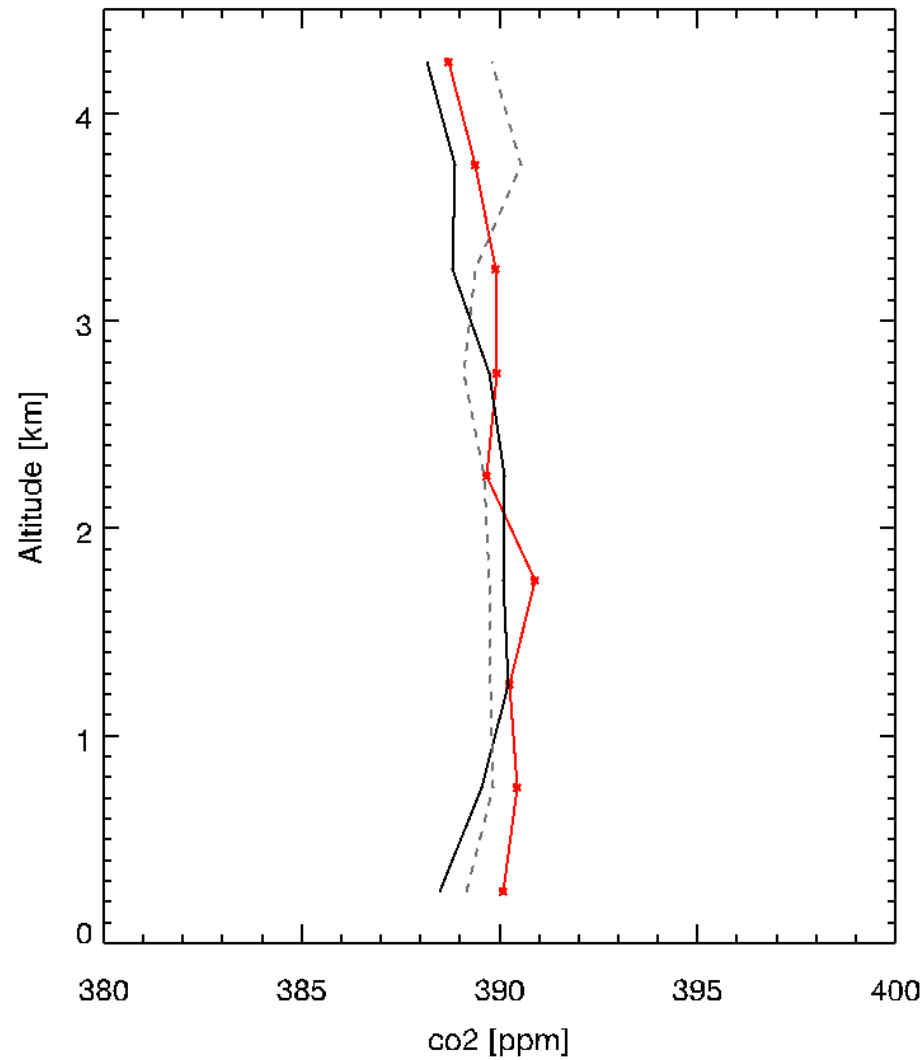


RBA 2010 Dry Season (july-oct)

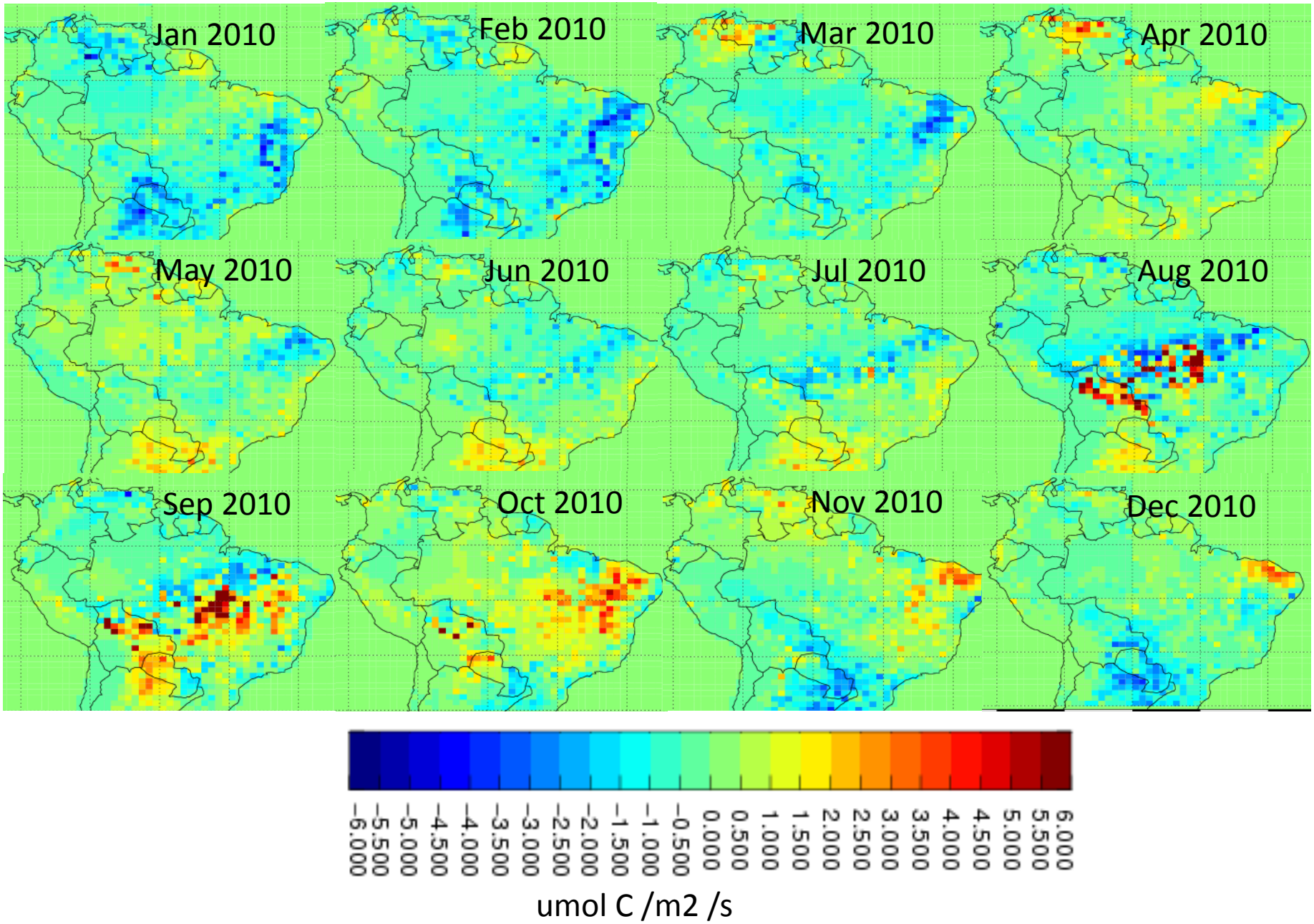
* Observations

-- Prior Estimate

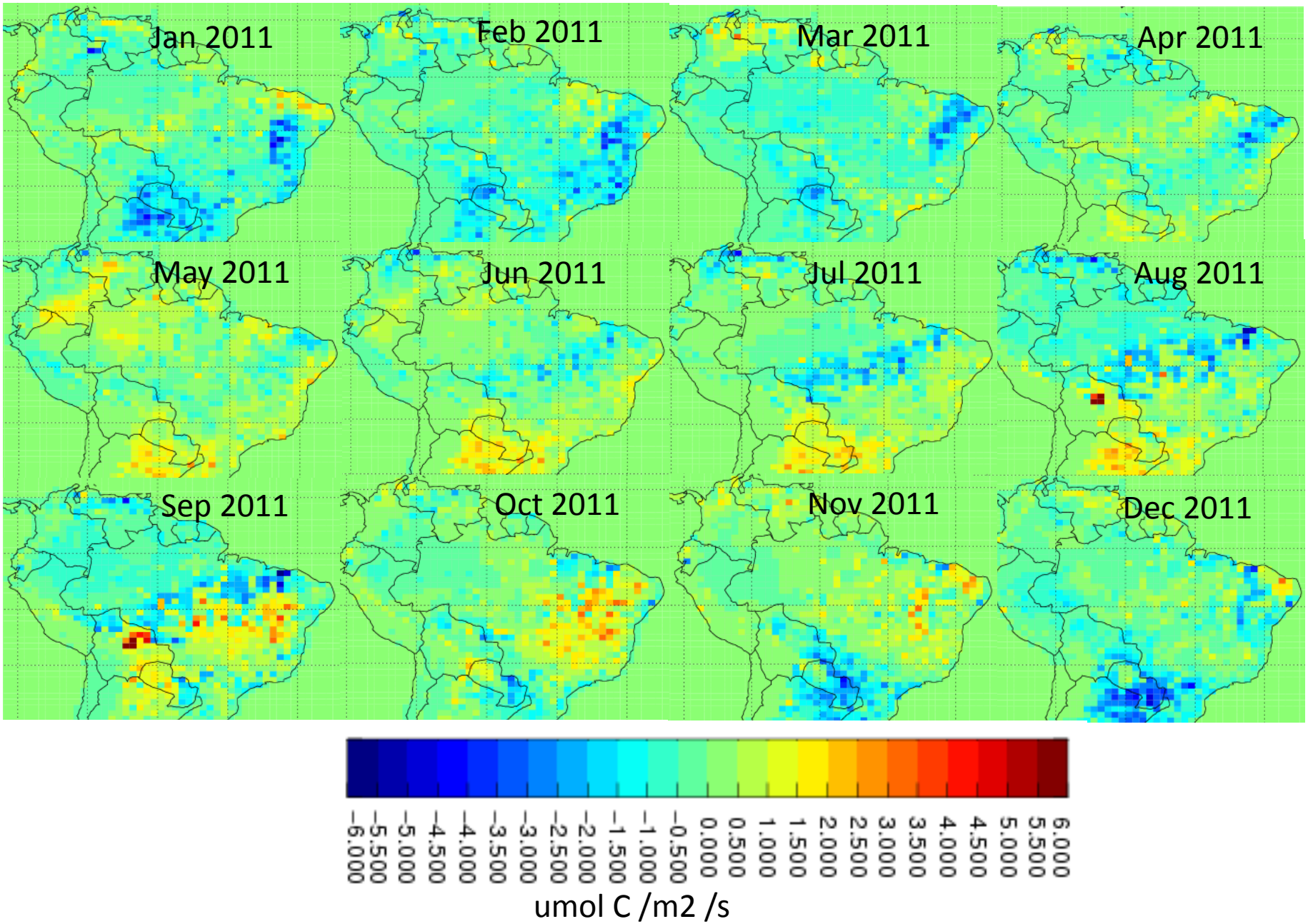
– Posterior Estimate



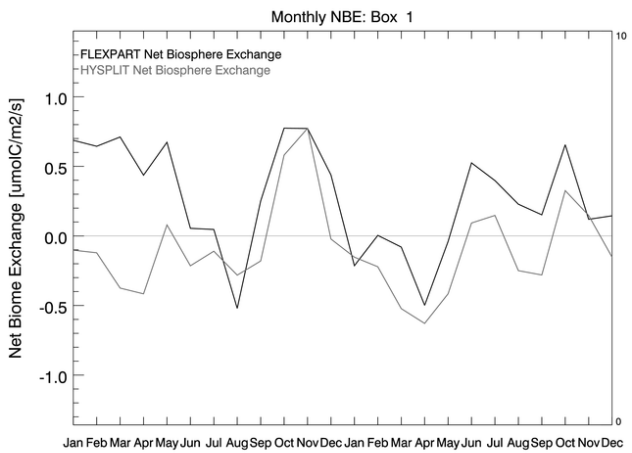
Monthly Mean Fluxes 2010 (Transport from Hysplit)

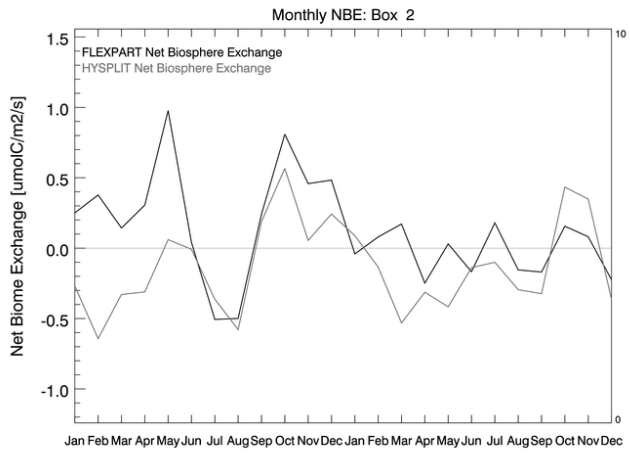


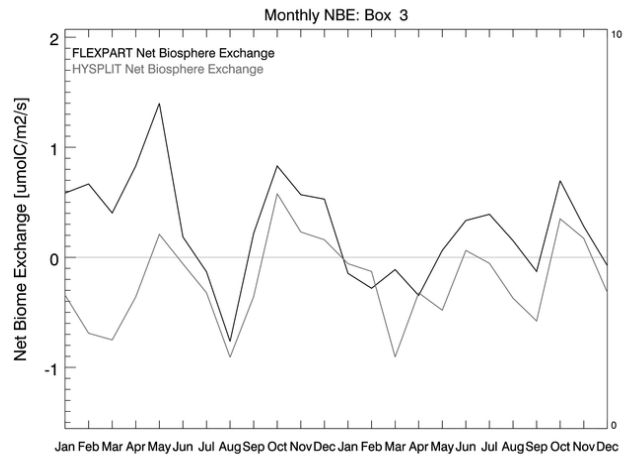
Monthly Mean Fluxes 2011 (Transport from Hysplit)

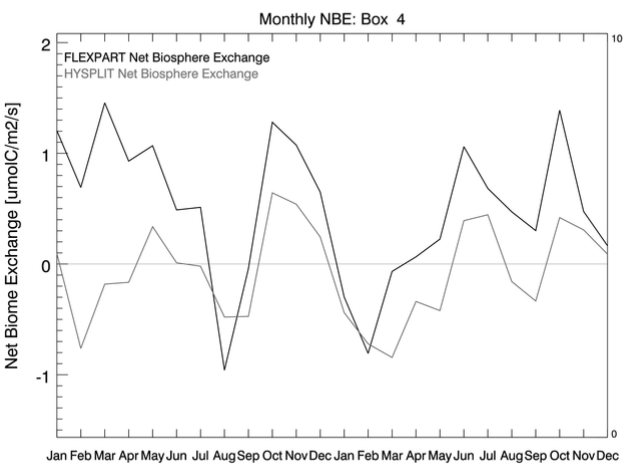


Aggregated Basin Flux Totals by Month: 2010 and 2011

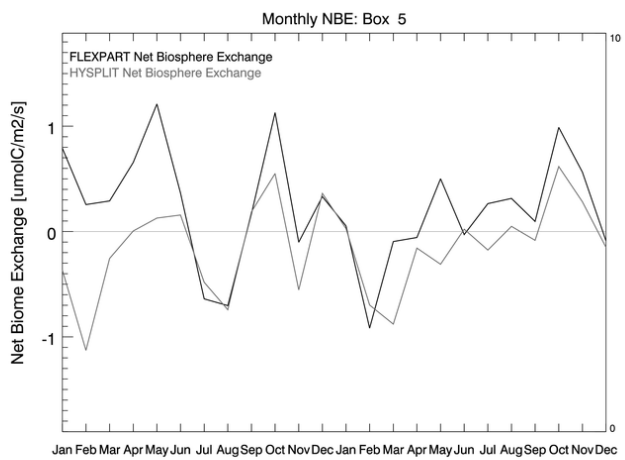




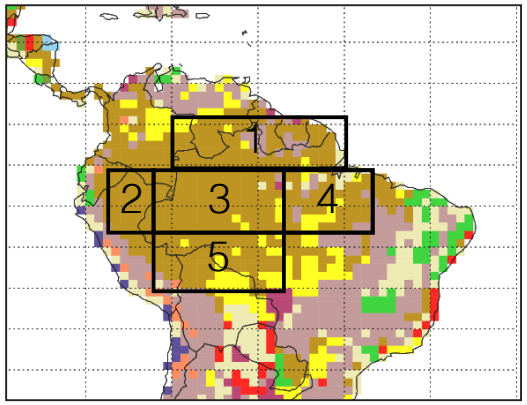




2010 2011



2010 2011



Basinwide Flux Totals

Total C Flux (NBE + Fire) [PgC/yr]

	2010	2011	Difference
HYSPLIT	-0.09	-0.34	0.25
FLEXPART	0.96	0.27	0.69
Gatti, 2014, Nature	0.48	0.06	0.42 +/- 0.2

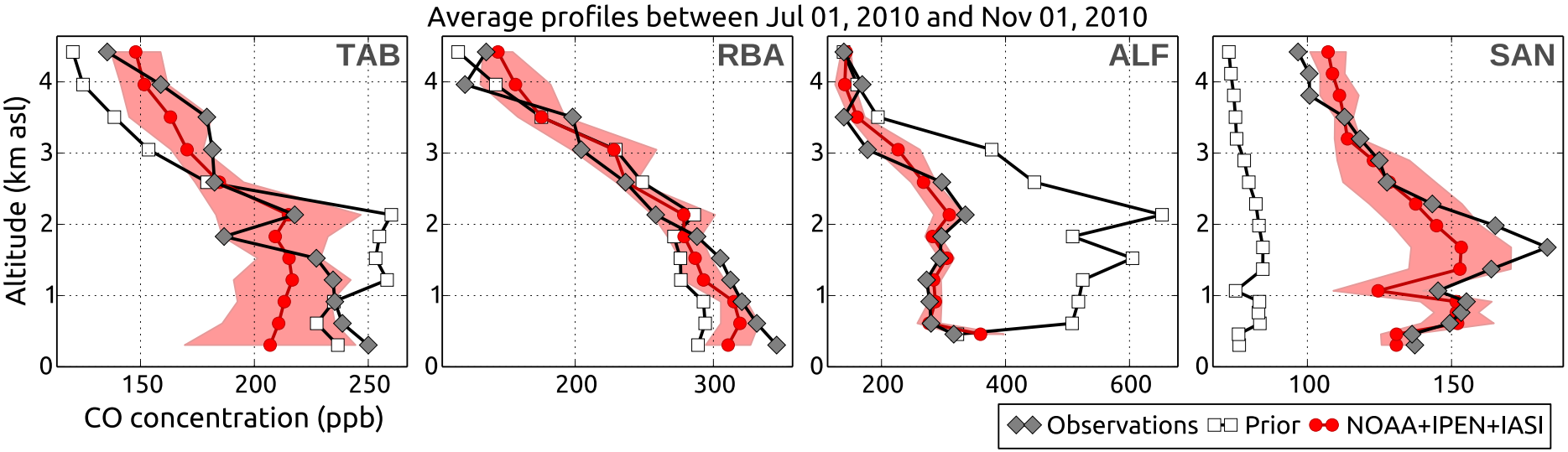
To Be Done…

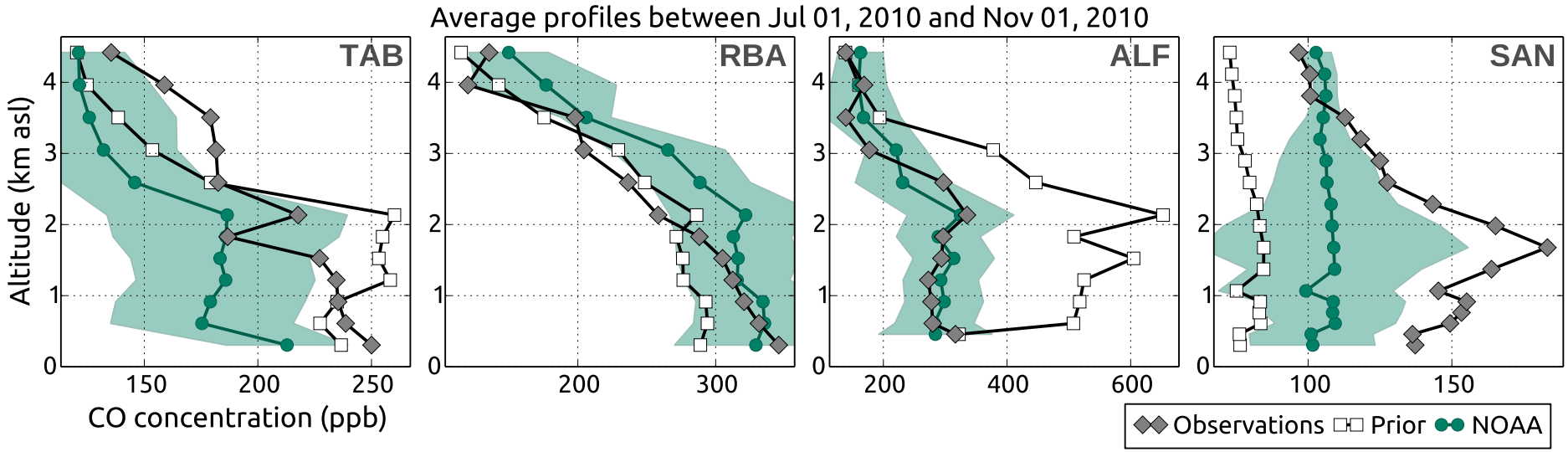
- ~~Regional CO Inversions~~ ☑ (not shown here)
- ~~Sub-basin and Seasonal Aggregation~~
- 2012-2013 Inversions (2014 Project)
- Use BRAMS/STILT Footprints for 2010-2011
- Compare results with CMS Flux product

CO Inversion Setup

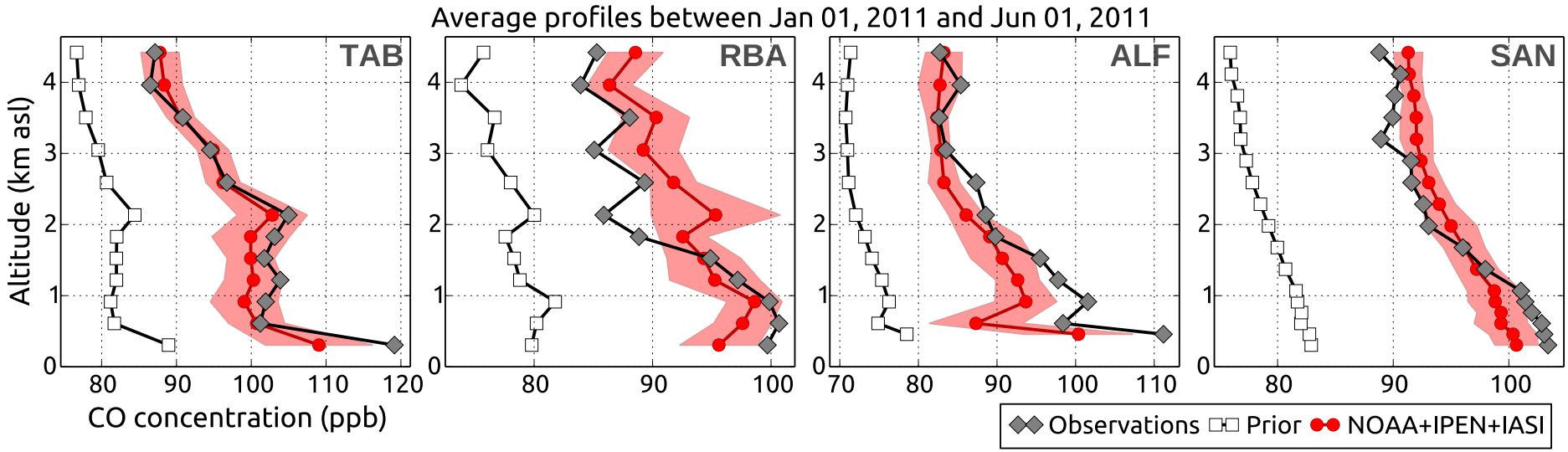
1. Global CO inversion using TM5 with S. American zoom region.
2. Prior fire flux from GFED3.1 with diurnal cycle and climatological injection heights.
3. Fluxes from CH4 and VOC oxidation and OH sink included, but not optimized.
4. Adjustments are weekly at the grid (1x1) scale.
5. Data inputs are combinations of:
   1. Aircraft CO profiles
   2. NOAA background data
   3. IASI

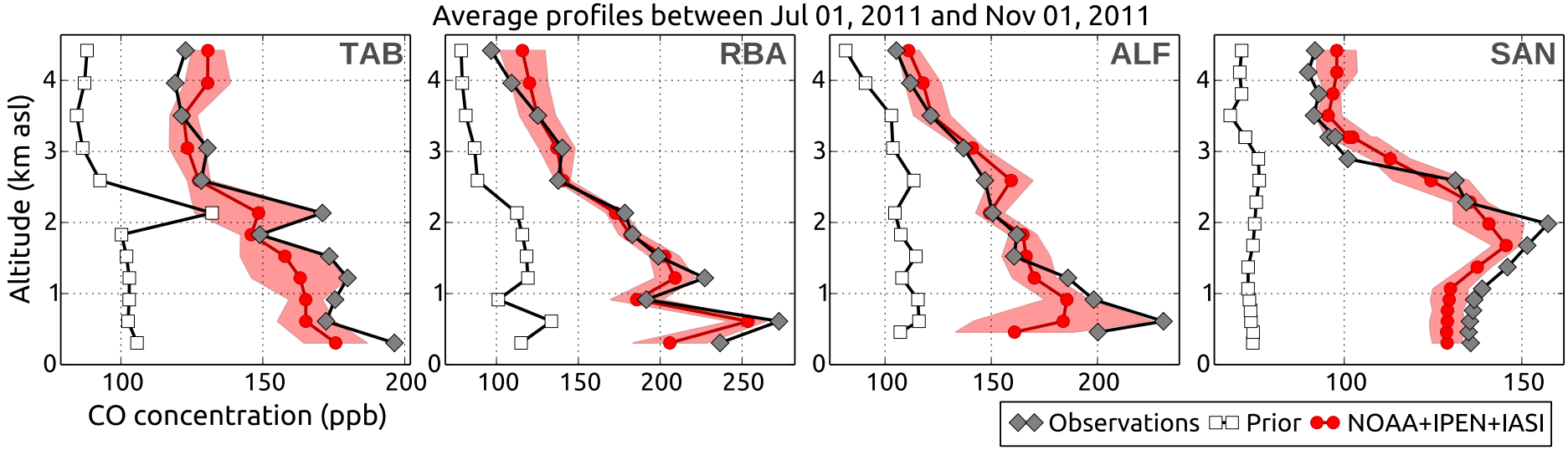
CO Inversion Results - 2010



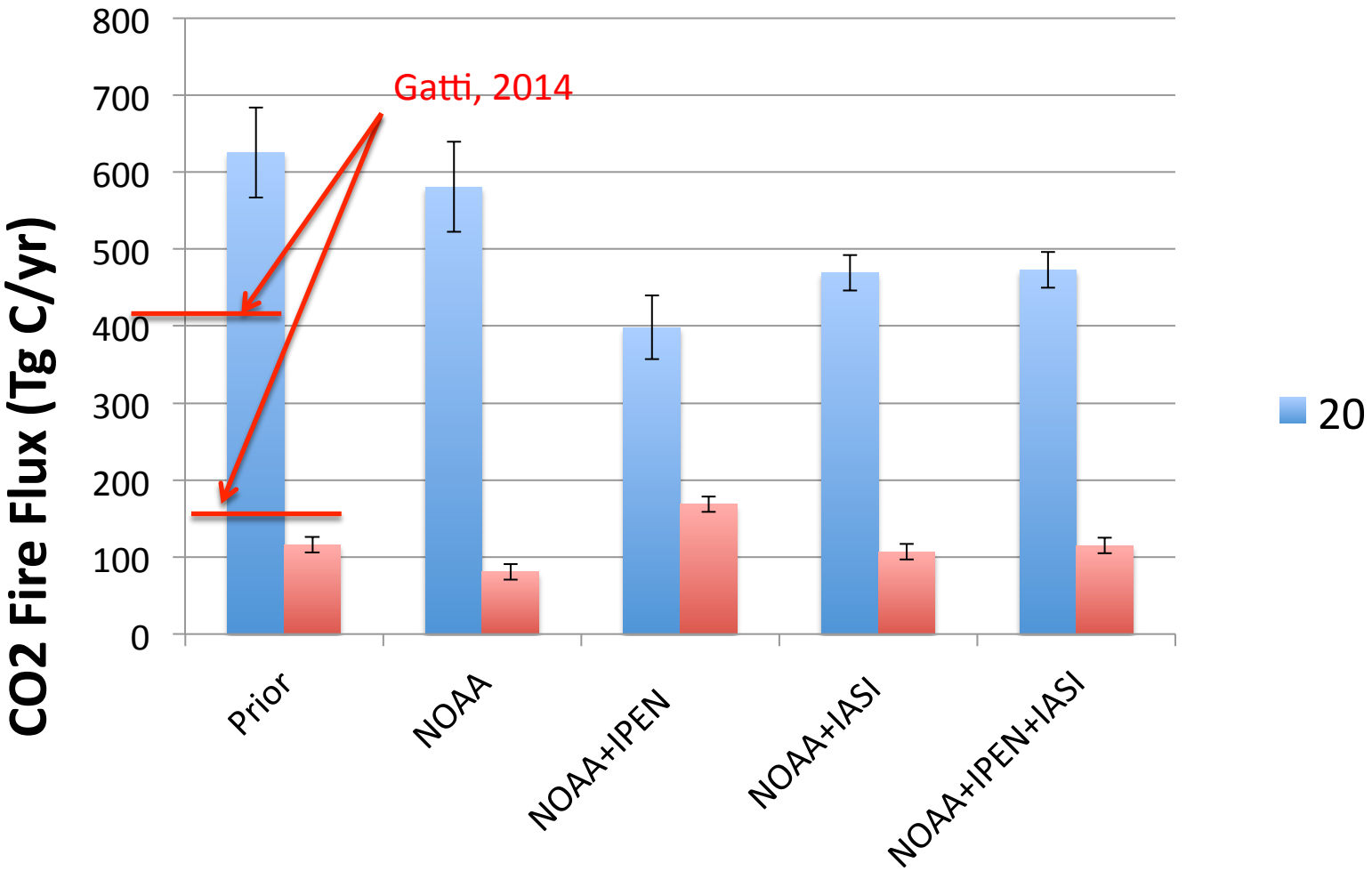


CO Inversion Results - 2011





CO Inversion Results: 2010 – 2011
Basinwide Fire Flux for CO2



Assume 75 ppb/ppm fire emission ratio