Modeling Status

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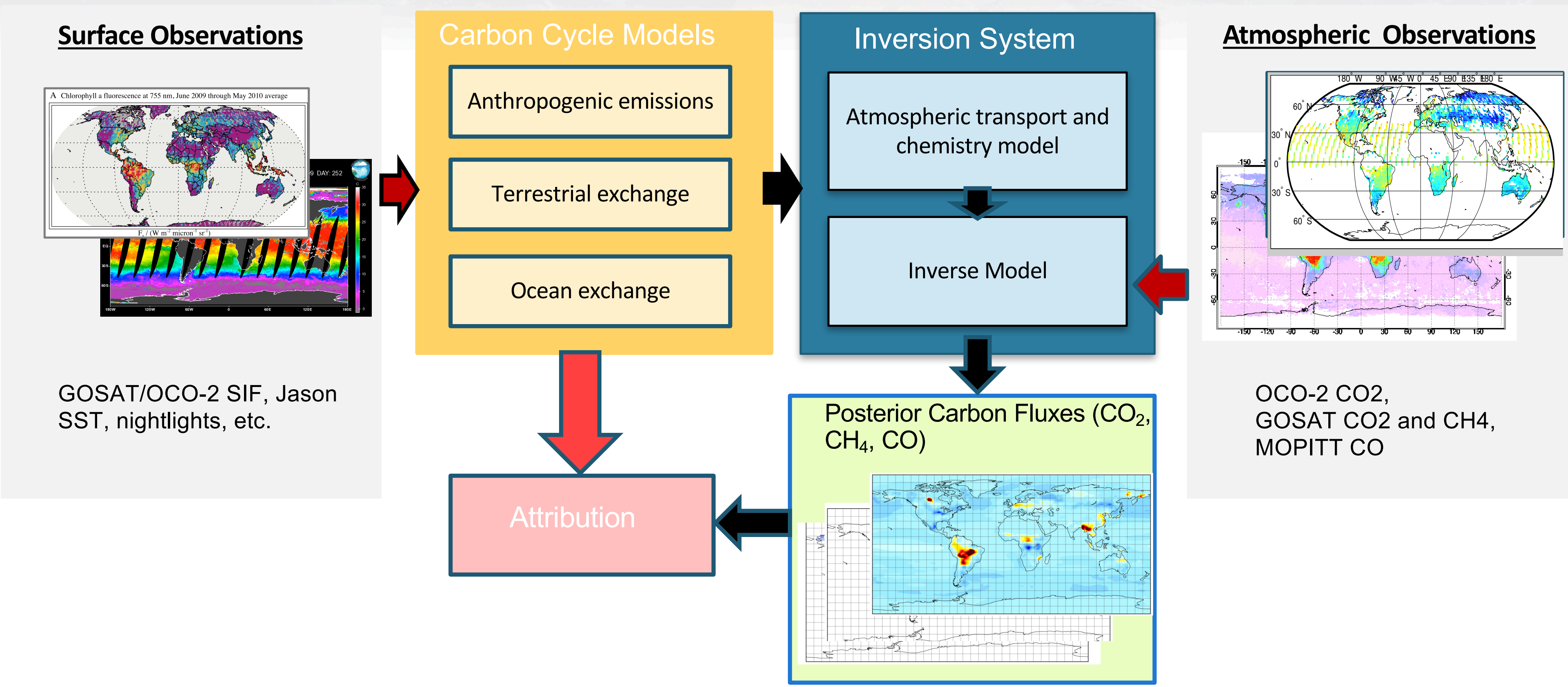
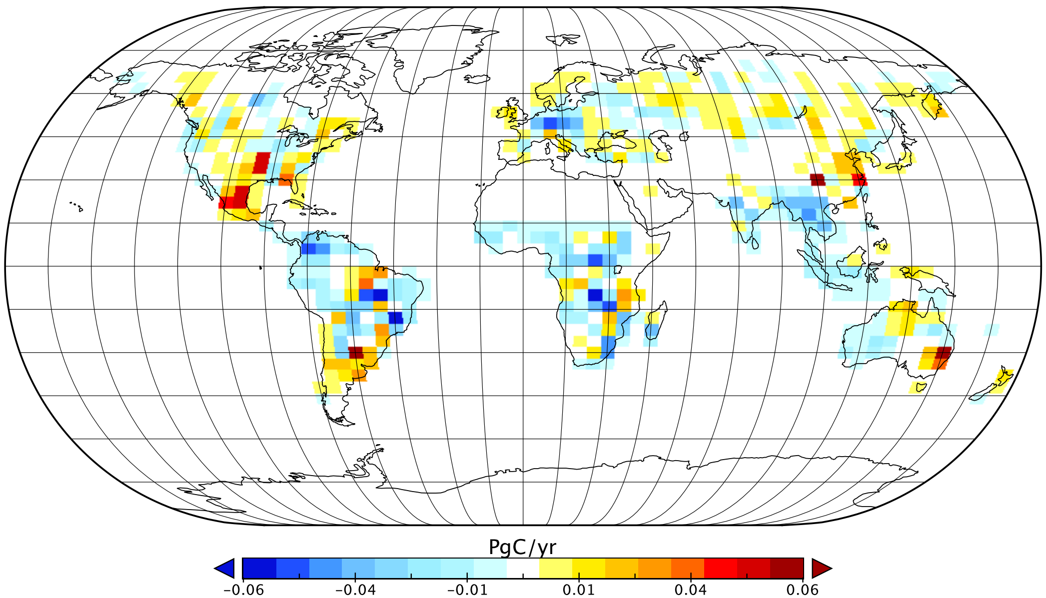
CMS-Flux Framework

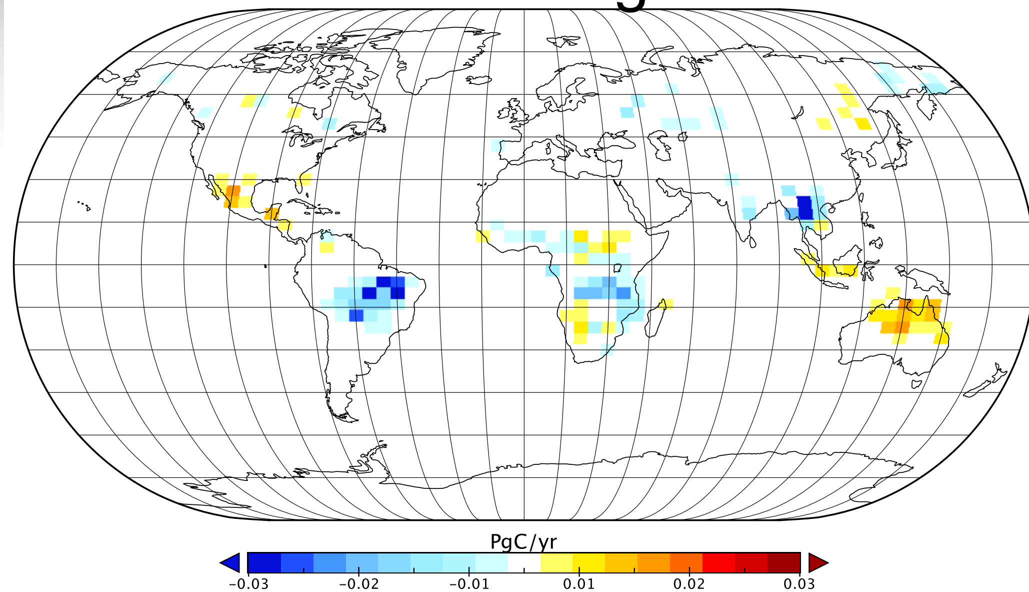


Global Analysis (2011-2010)

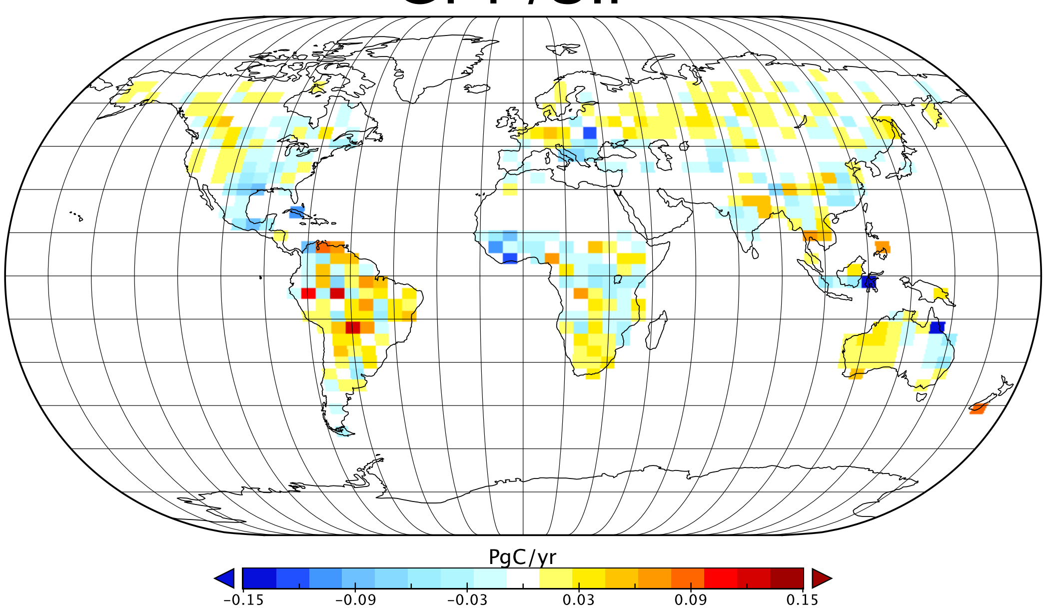
Total/GOSAT



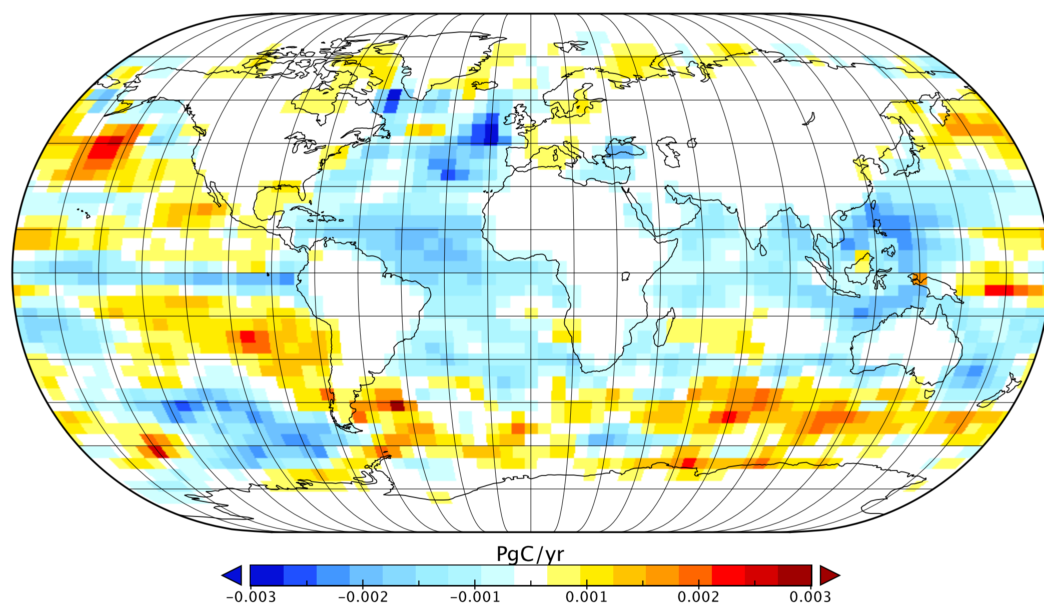
Biomass Burning/MOPITT



GPP/SIF

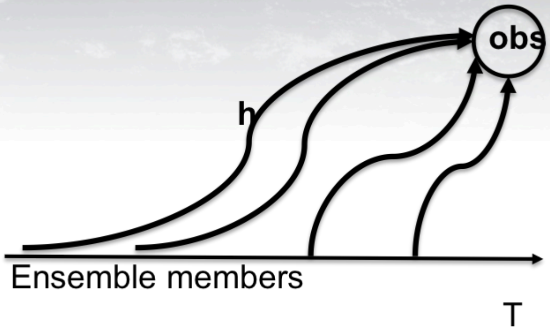


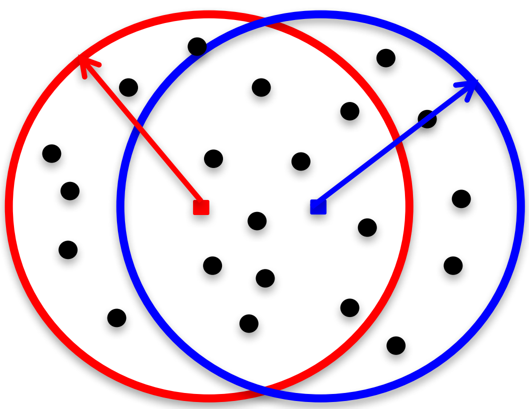
Ocean/ECCO-2

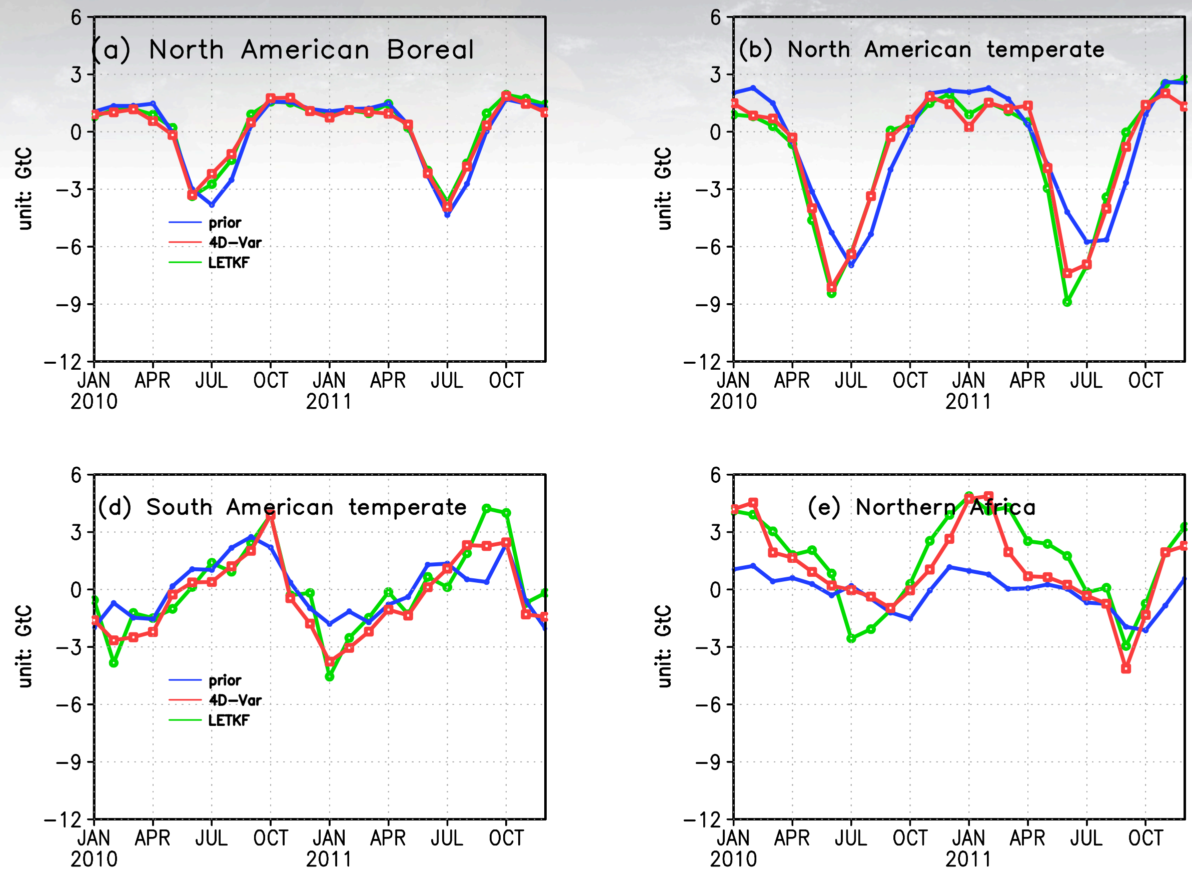


Bowman et al, *submitted*

CMS-Flux extension-LETKF





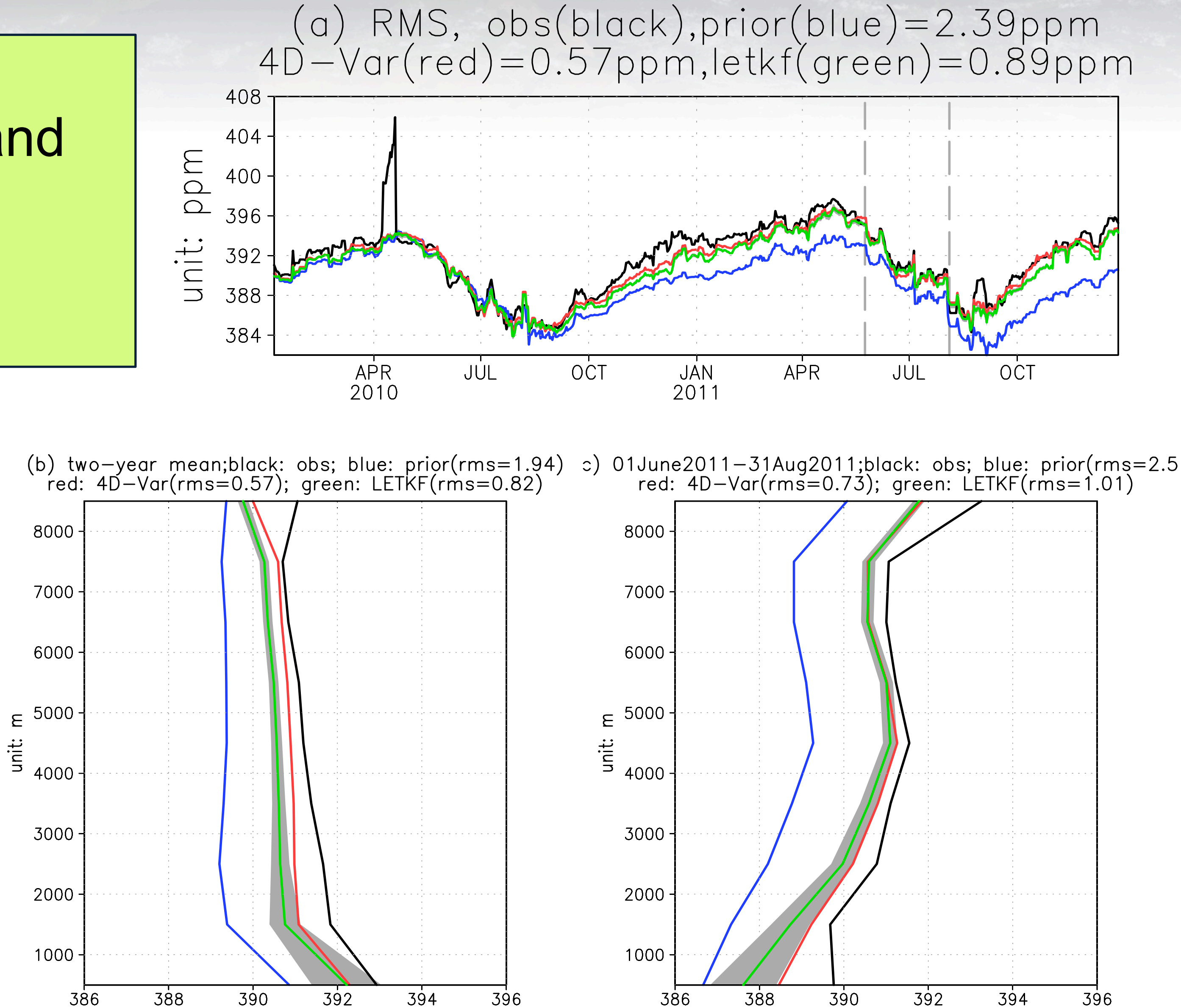


Liu, Bowman, and Lee, *in press*

- CMS-Flux now incorporates a Local Ensemble Transform Kalman Filter (LETKF) (Liu, Bowman, and Lee, JGR, *in press*)
- Good agreement overall between 4D-var and LETKF
- OCO-2 constrained fluxes can be rapidly updated in LETKF
- LETKF incorporates advanced diagnostics, e.g., observation impact

Boundary Conditions

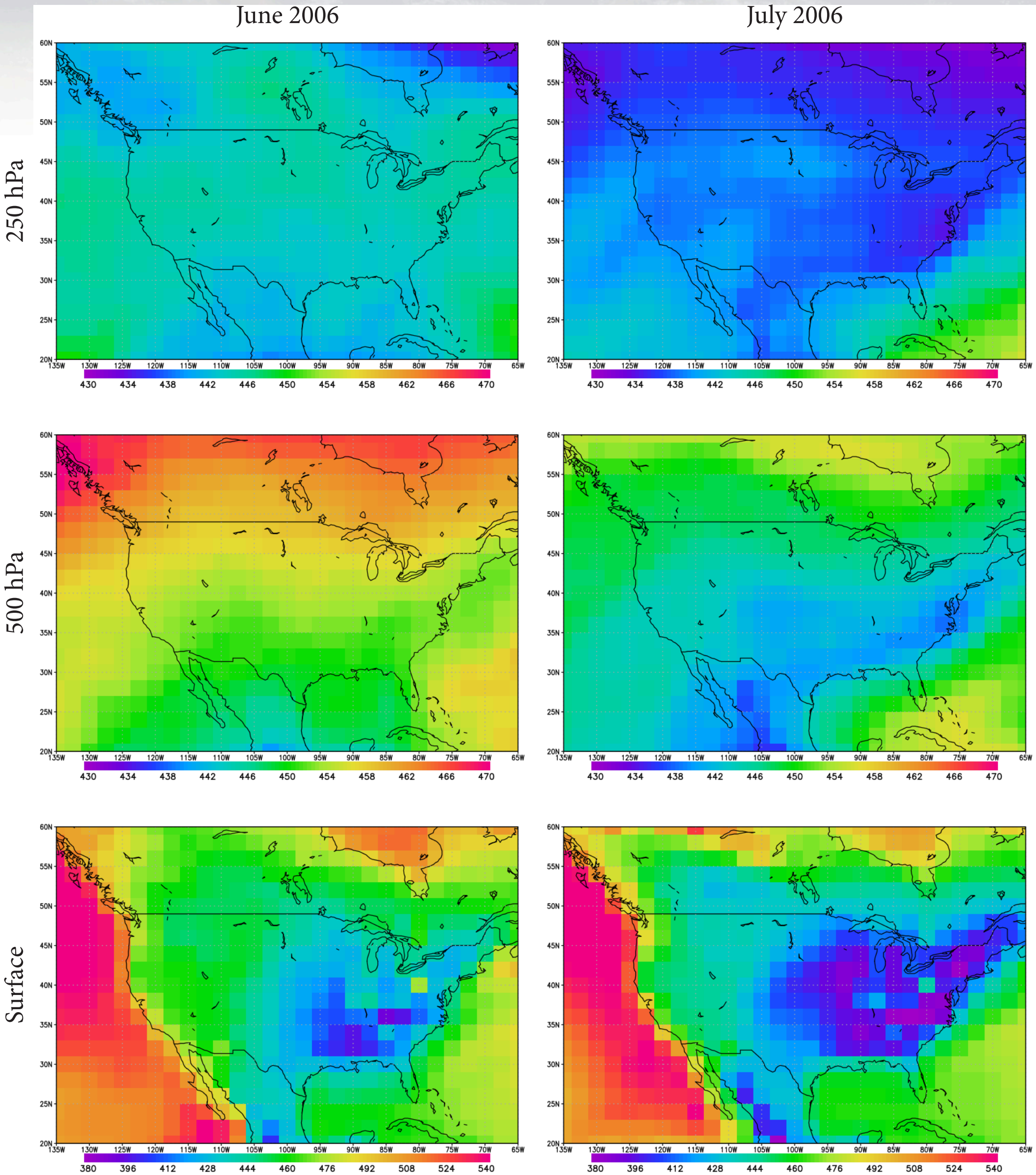
LETKF can provide boundary conditions and concentration uncertainties to force regional models.



Liu, Bowman, and Lee, *in press*

Carbonyl Sulfide

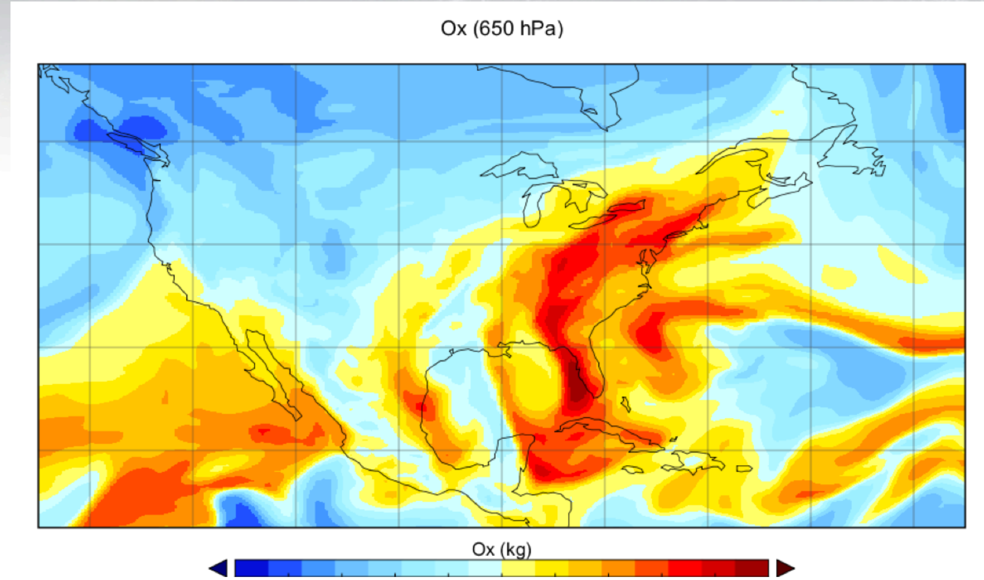
CMS-Flux has integrated COS fluxes building off of Kuai *et al*, 2014, 2015 using TES OCS measurements.

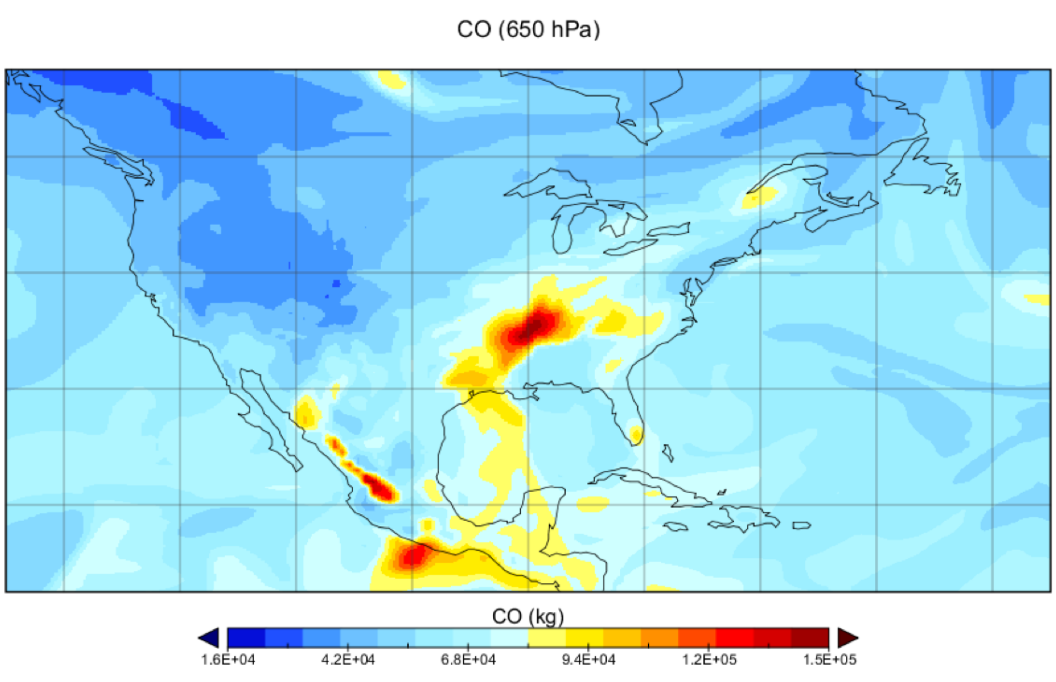


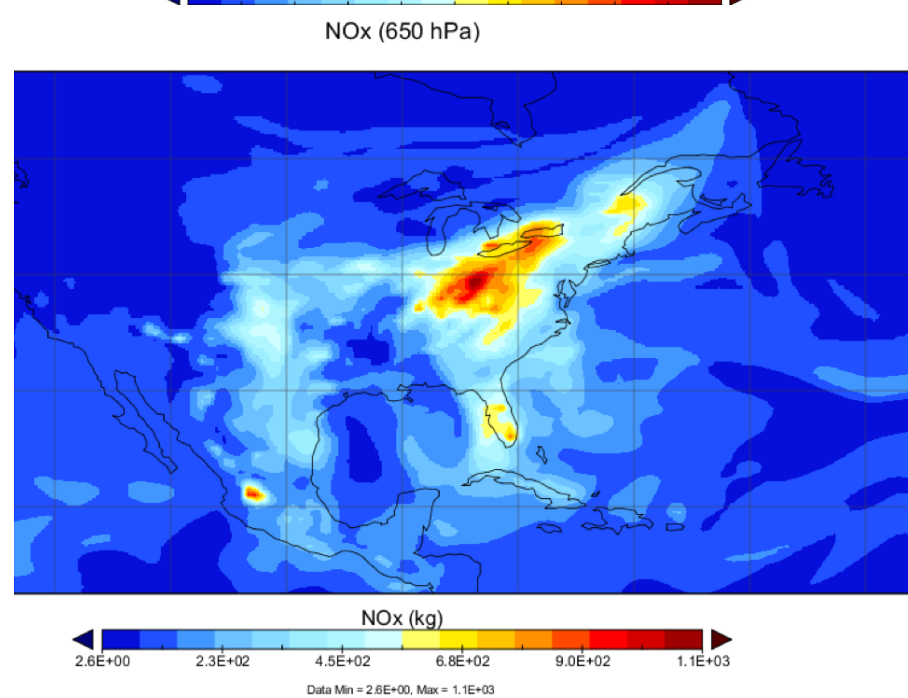
Active Species

CMS-Flux is based upon GEOS-Chem, which is a full chemistry and transport model.

Developed a North America "nested" forward and adjoint mode (0.5x0.667) for both carbon and active species.





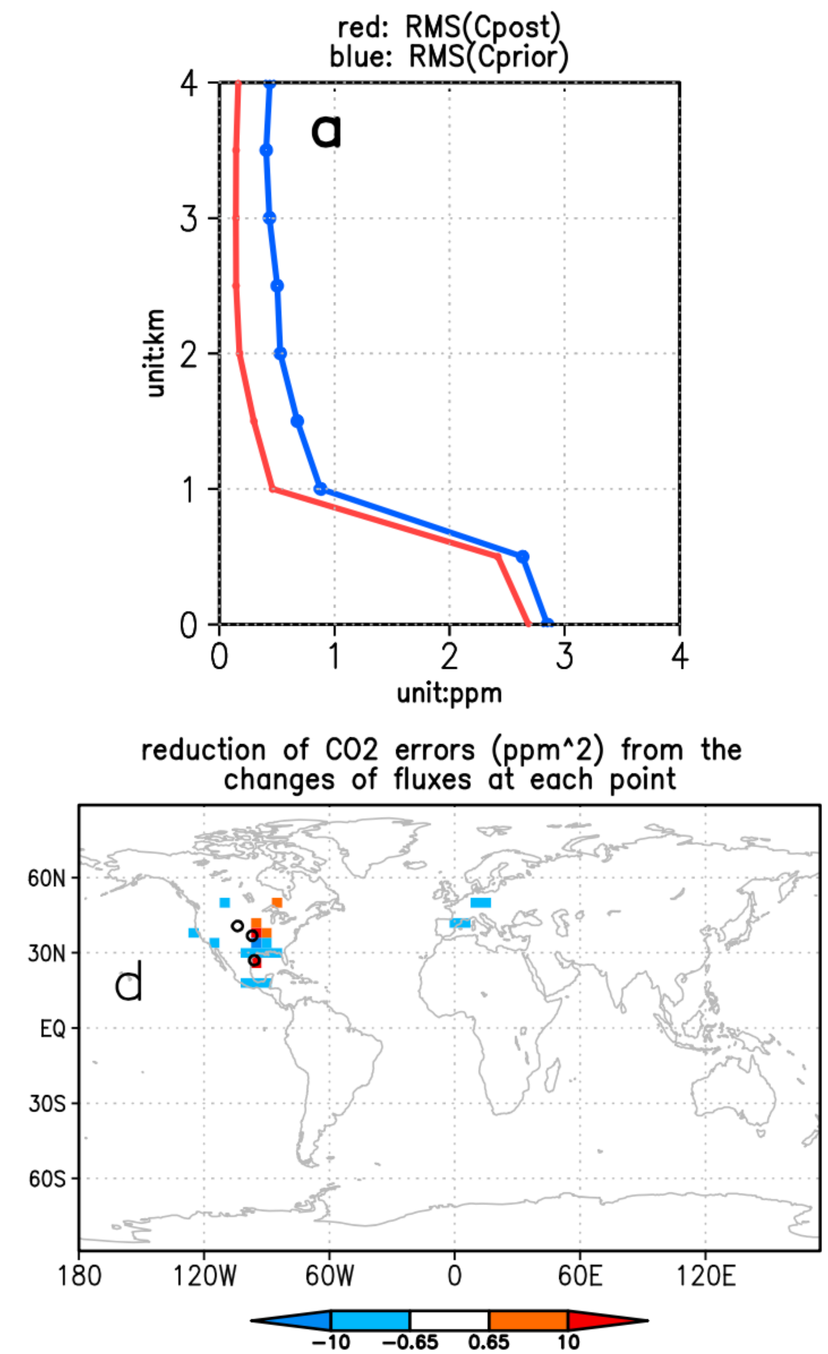


Attribution of improved fluxes

If predicted concentrations, e.g., CO_2, CO, are different from observed, what fluxes are implicated?

Liu and Bowman, GRL (2016) developed an adjoint methodology to attribute model-data differences to surface fluxes.

This approach can be applied to both Eulerian and Lagrangian techniques.



Liu and Bowman, GRL, 2016

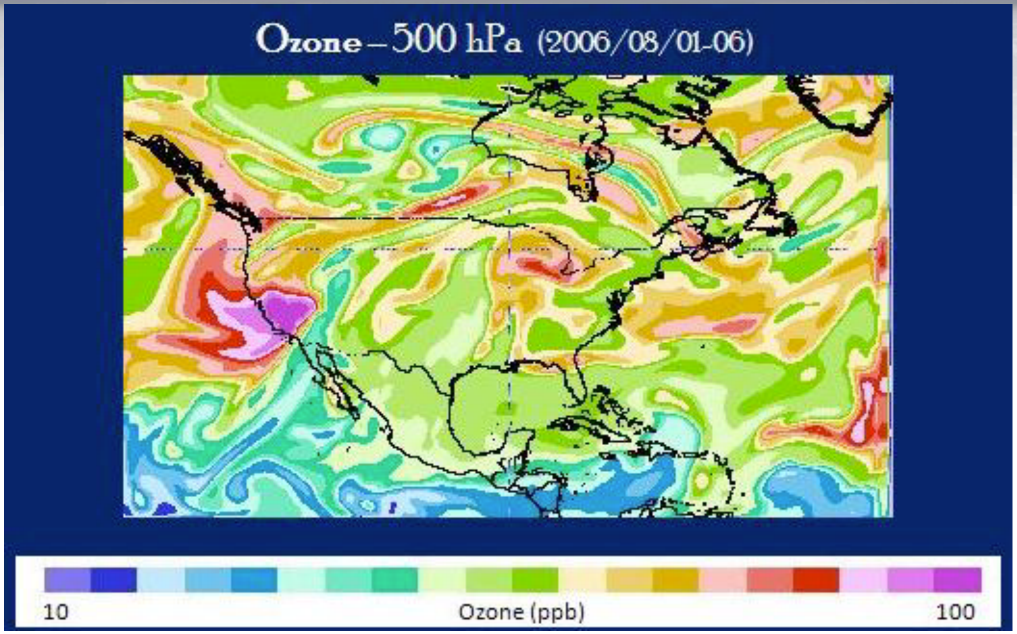
Summary

- CMS-Flux can simulate CO_2, CO, COS, (CH_4), and active chemistry (O_3, NO_2, etc.)
- LETKF can produce boundary conditions faster than our 4D-var approach.
  - Current driver is OCO-2 and MOPITT (1-2 month latency)
  - Working with Penn State (Lauvaux et al)
- Developing a NA nested forward and adjoint mode (0.25x0.325 or 0.5x0.667) for CO_2, CO, COS, and SIF.
  - Interested in using multi-constituents to separate flux and meteorological drivers of carbon variability using Liu and Bowman methodology.
  - Like to partner with CSU (Denning, Baker), Stanford (Berry)-–Others?
- Active species, e.g., ozone, could be valuable to interpret CO_2 transport, e.g., Deng *et al*, 2015, and are interesting in their own right.
  - Not planning to pursue yet, depends on group interest.

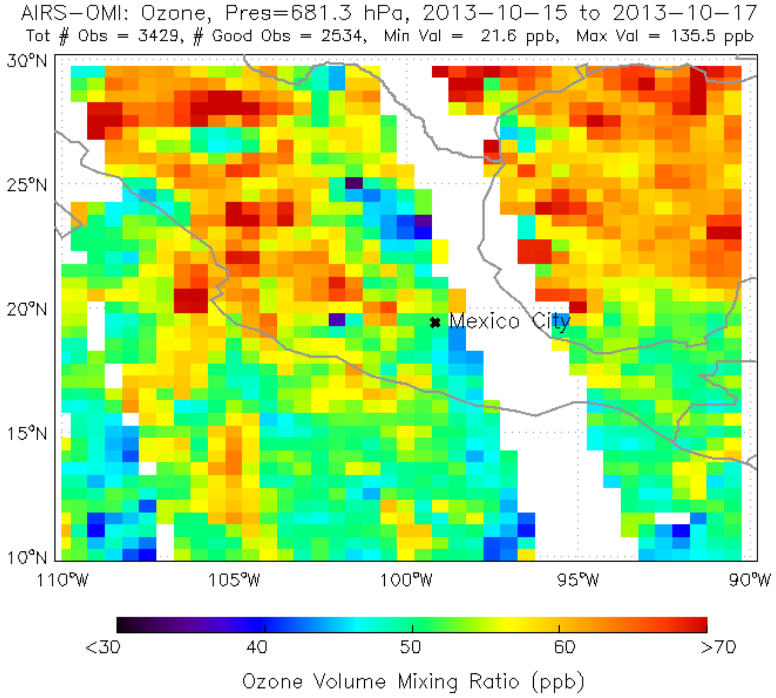
BACKUP

Tropospheric ozone

CMS-Flux is based upon GEOS-Chem, which is a full chemistry and transport model.



New AIRS/OMI ozone products from the TES team could provide a synoptic satellite observations



	truth	prior	4D-Var (land)	LETKF (land)	4D-Var (land+ocean)	LETKF (land+ocean)
North American Boreal	0.085	0.085±0.10	-0.08±0.09	-0.23±0.07	-0.08	-0.24±0.07
North American temperate	-0.88	-1.10±0.25	-0.75±0.19	-0.75±0.12	-0.79	-0.72±0.11
South American tropical	0.69	0.68±0.33	0.59±0.21	0.69±0.25	0.60	0.64±0.17
South American temperate	-0.37	-0.71±0.31	-0.31±0.21	-0.37±0.15	-0.32	-0.36±0.12
Northern Africa	-0.43	-0.20±0.21	-0.61±0.13	-0.39±0.16	-0.45	-0.36±0.12
Southern Africa	-1.73	-1.29±0.23	-1.62±0.18	-1.66±0.08	-1.63	-1.72±0.06
Eurasian Boreal	-0.38	-0.41±0.12	-0.55±0.09	-0.60±0.13	-0.58	-0.61±0.13
Eurasian Temperate	-0.63	-0.69±0.18	-0.41±0.22	-0.41±0.13	-0.33	-0.39±0.13
Tropical Aisa	-0.26	-0.29±0.29	-0.39±0.23	-0.41±0.18	-0.36	-0.30±0.14
Australia	-0.27	-0.24±0.13	-0.15±0.09	-0.14±0.12	-0.20	-0.18±0.09
Europe	-0.86	-1.02±0.21	-1.12±0.13	-1.08±0.11	-1.20	-1.14±0.11