Moving towards a Global GHG Constellation: Flux Constraints in the Presence of Intercalibration and Transport Uncertainty

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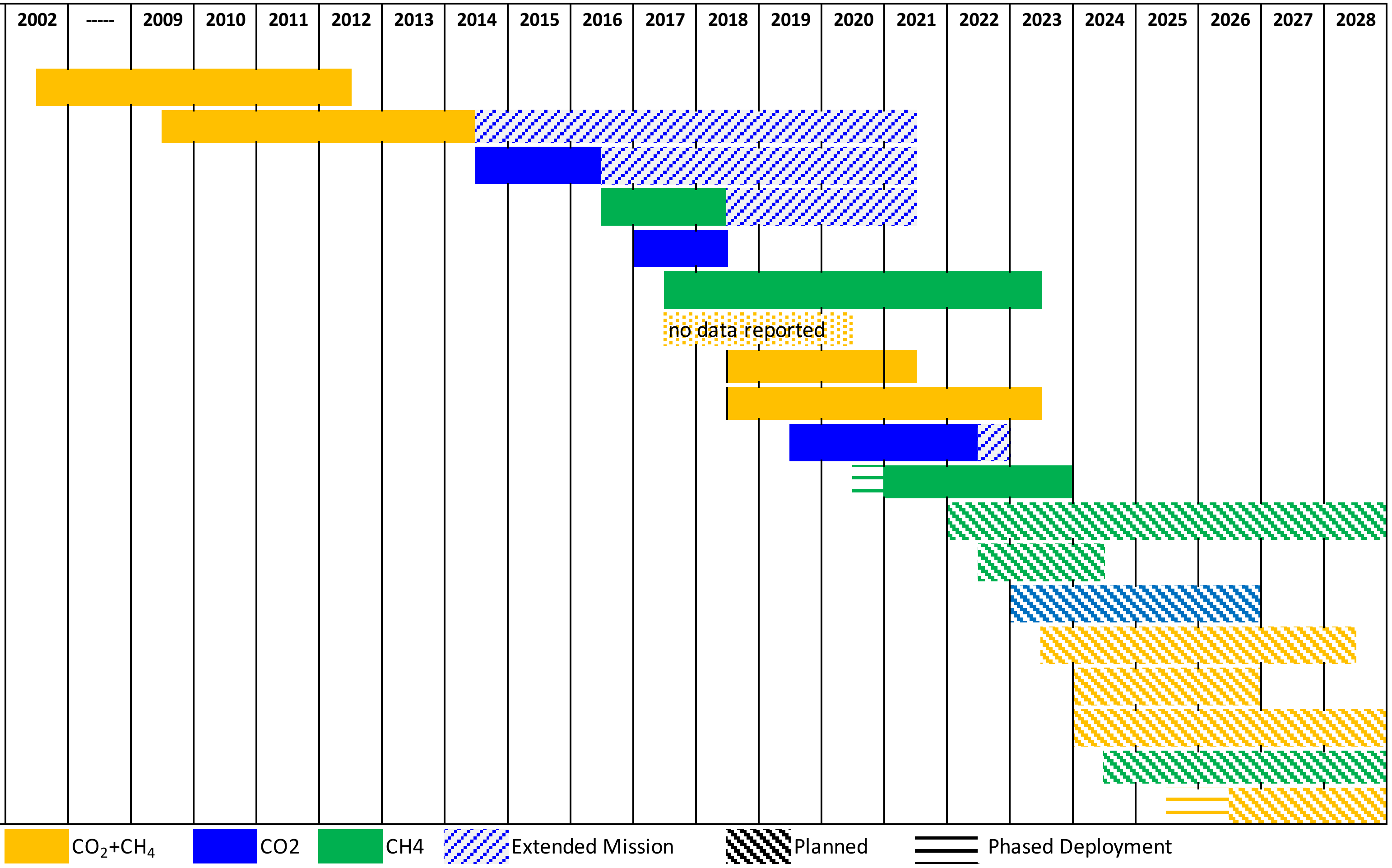
Upcoming missions

Satellite, Instrument (Agencies)	CO_2	CH_4	Swath/FOV	Sample
ENVISAT SCIAMACHY (ESA)	●	●	960 km	30x60 km^2
GOSAT TANSO-FTS (JAXA-NIES-MOE)	●	●	3 pts	10.5 km (d)
OCO-2 (NASA)	●		10.6 km	1.3x2.3 km^2
GHGSat-D - Claire (GHGSat)		●	12kmx12 km	0.0004 km^2
TanSAT (CAS-MOST-CMA)	●		20 km	1x2 km^2
Sentinel 5P TROPOMI (ESA)		●	2600 km	7x7 km^2
Feng Yun 3D GAS (CMA)	●	●	7 pts	10 km (d)
GaoFen-5 GMI	●	●	5-9 pts	10 km (d)
GOSAT-2 TANSO-FTS (JAXA-MOE-NIES)	●	●	5 pts	10.5 km (d)
OCO-3 (NASA)	●		11 km	4 km^2
GHGSat C1/C2 - Iris, Hugo (GHGSat)		●	12x12 km	33mx33m
MetOp Sentinel-5 series (Copernicus)		●	2670 km	50 km^2
MethaneSAT (EDF)		●	200 km	1 km^2
MicroCarb (CNES)	●		13.5 km	40 km^2
Feng Yun 3G (CMA)	●	●	100 km	< 3 km^2
GeoCarb (NASA)	●	●	2800 km	20 km^2
GOSAT GW (JAXA-MOE-NIES)	●	●	400 km	4 km^2
MERLIN (DLR-CNES)		●	100 m	0.14 km (w)
CO2M (Copernicus)	●	●	3x250 km	2x2 km^2



Crisp et al., 2018 CEOS White Paper

Using models to plan future missions

Nature Run

- Community assessment of science priorities
- Assume a set of fluxes and create CO_2 simulation
- Simulate multiple process-based flux scenarios

Synthetic Data

- Sample at measurement locations and times, screen for clouds
- Add in random errors | and biases!
- ...or simulate retrievals

Metrics

- Use inversion model to assimilate synthetic data and compare estimated fluxes to nature run
- Evaluate ability to detect process changes

Greater confidence in results, community consensus

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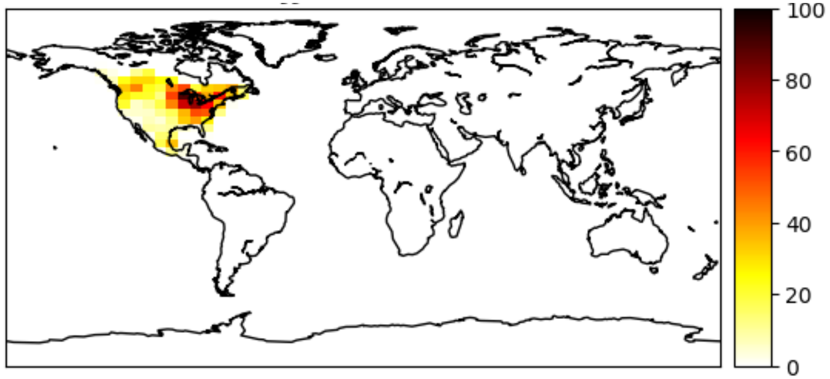
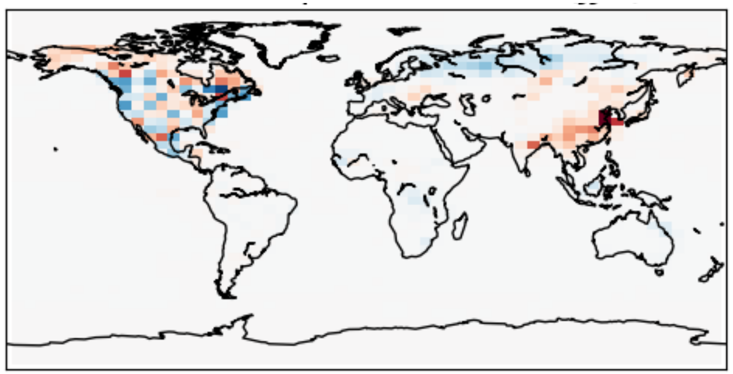
Experimental Design – Last Time

- Simulate CO_2 at 0.5º assuming different flux perturbations with GEOS-5
- Sample as GeoCarb and OCO-2
- Assimilate pseudo-data with TM5-4DVAR to recover flux perturbations
- Previously:
  - Perfect transport (using TM5 simulated pseudo-data)
  - Random observational error only
  - **Main result: flux error resulting from sampling bias mitigated with multiple sensors**

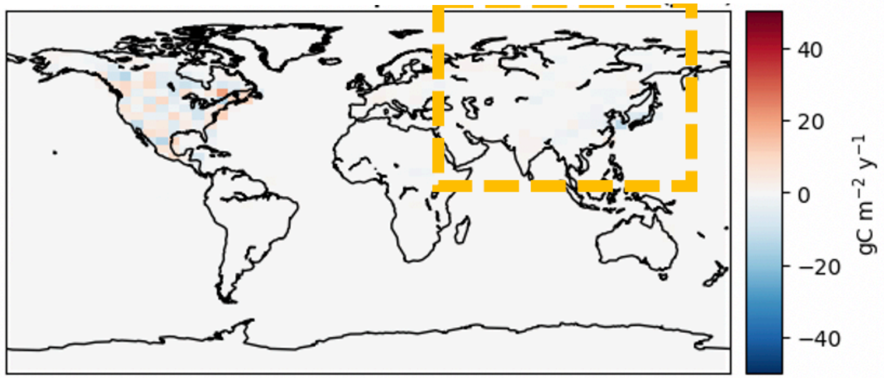
North America Perturbation – 'Truth'



Change in flux after GeoCarb inversion (JJA)



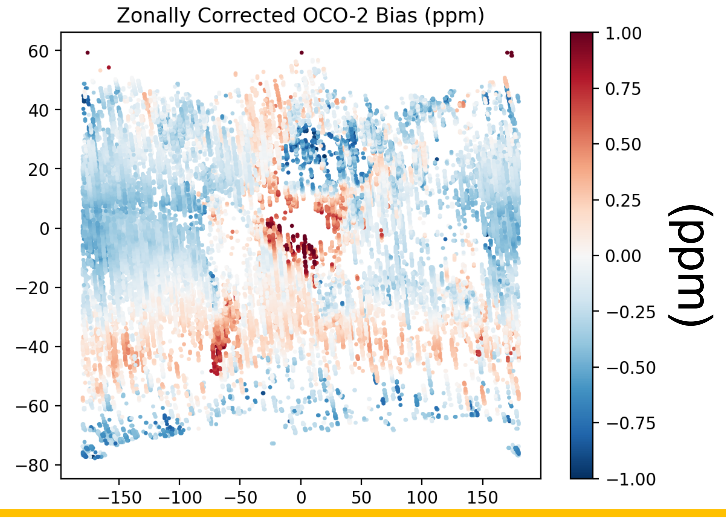
Error in flux after GeoCarb+OCO inversion



Experimental Design - Update

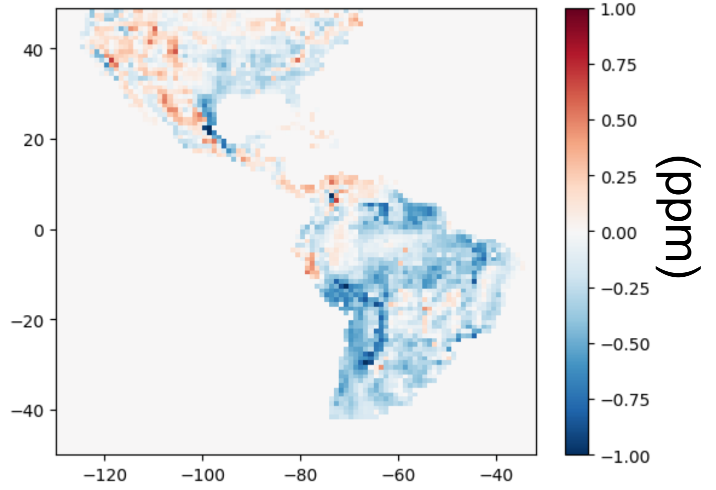
Systematic Errors: OCO-2 differences from in situ constrained models as a multilinear regression with

- Surface Albedo
- Aerosol loading
- Viewing/solar geometry
- Surface altitude
- Surface pressure Variations



Atmospheric Transport Errors

- simulated CO_2 comes from GEOS-5 at 0.5º
- assimilated by 6ºx4º TM5 system



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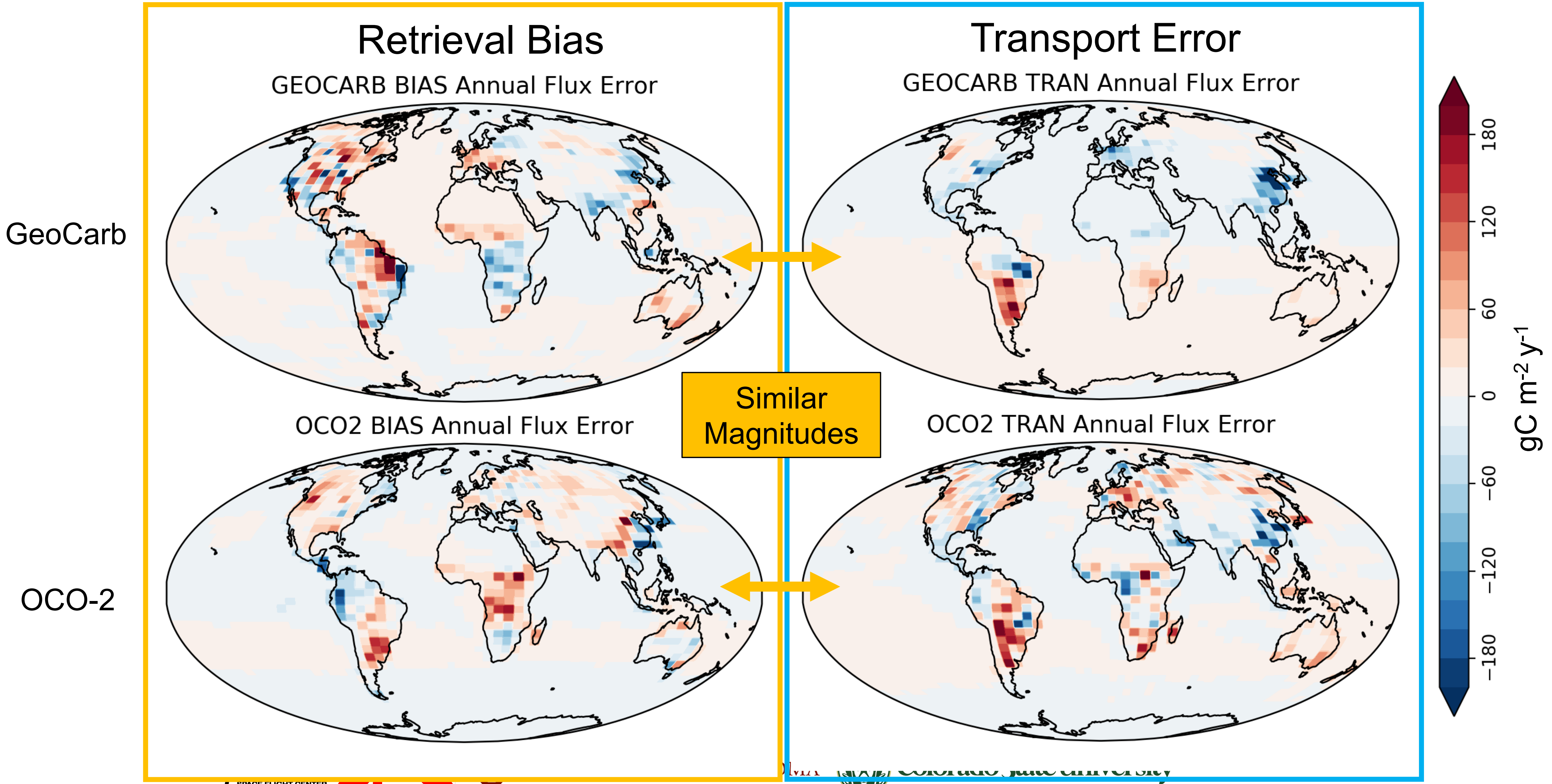
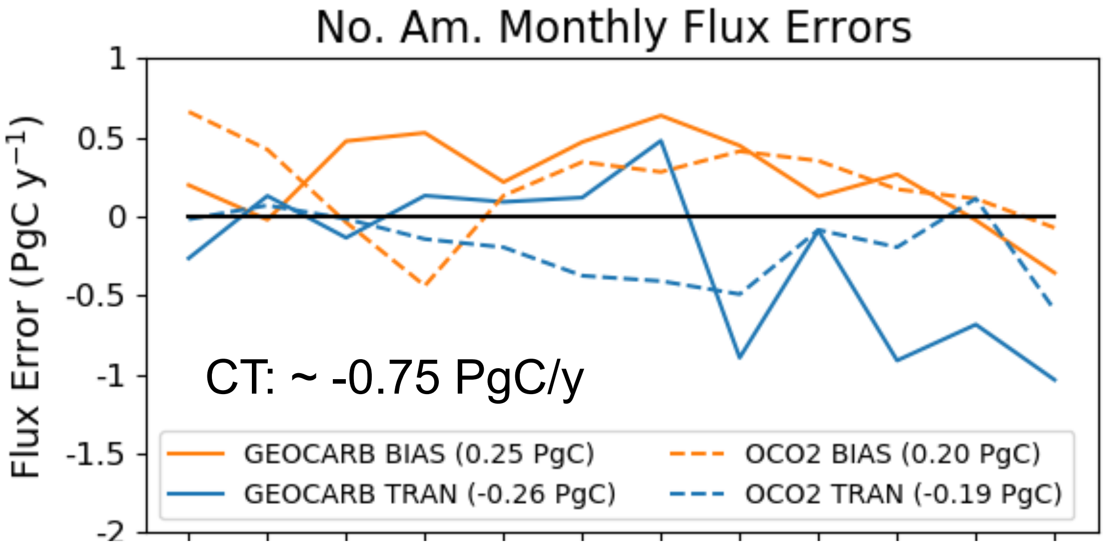
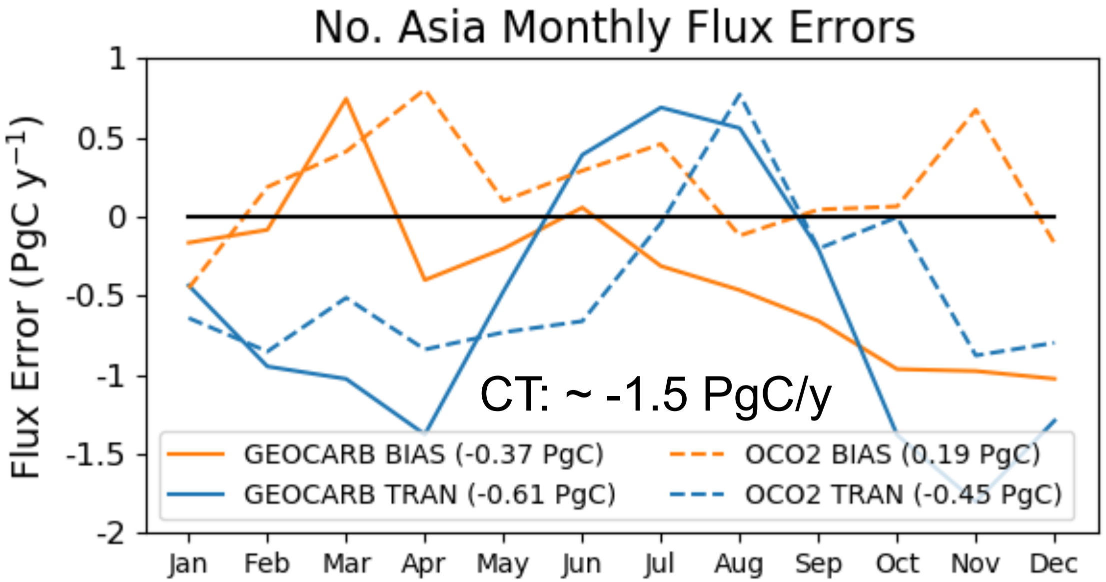
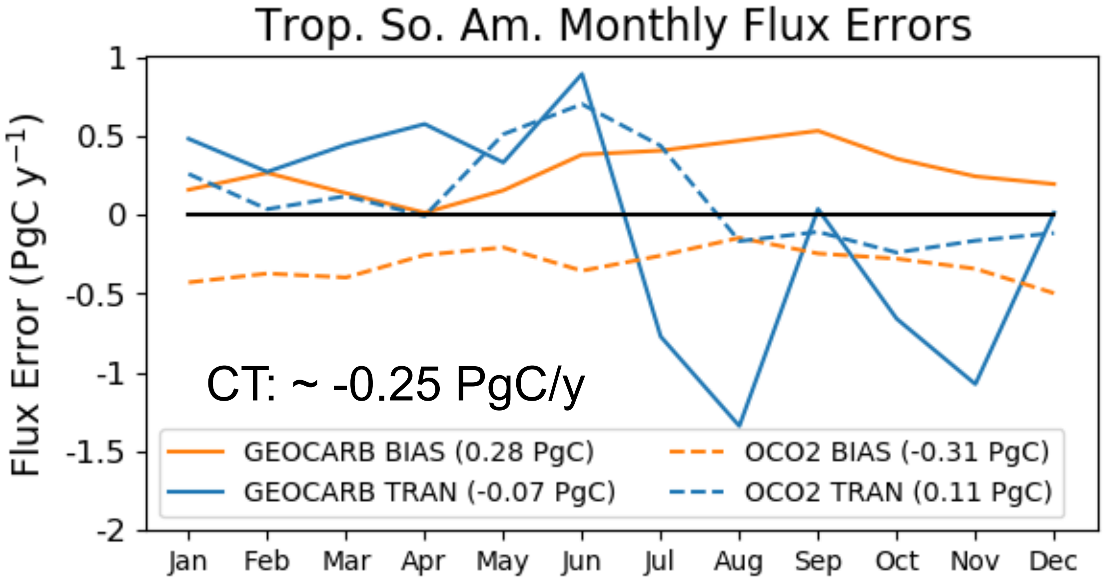
Flux Inversion Results: Gridded Annual Flux Errors



Flux Inversion Results: Regional Scales by Month







- Retrieval bias and transport effects vary significantly across regions and seasons
- Simulated biases have a pronounced regional and temporal structure
- Tropical retrieval bias induced flux errors are correlated with sampling time (airmass/SZA)
- Upstream effects of retrieval and transport errors are likely to be significant

Summary and Next Steps

- Random error OSSEs are an important first step, but they miss the effects of large sources of errors – retrieval biases and atmospheric transport errors
- Resulting flux errors from retrieval biases and transport errors are about the same size
- This (preliminary) analysis suggests that the small perturbations we examined previously (0.2 PgC for a Transcom region) would not be distinguishable from these error sources
- Next steps
  - Assimilate GeoCarb and OCO-2 simultaneously to see how the errors interact
  - Optimize GeoCarb sampling to minimize the effects of transport/retrieval errors
  - Include an unbiased instrument with a biased one to see how much posterior errors are mitigated