The OCO-2 Model Intercomparison Project Reveals Systematic Transport Model Effects on Inverse Model CO_2 Fluxes

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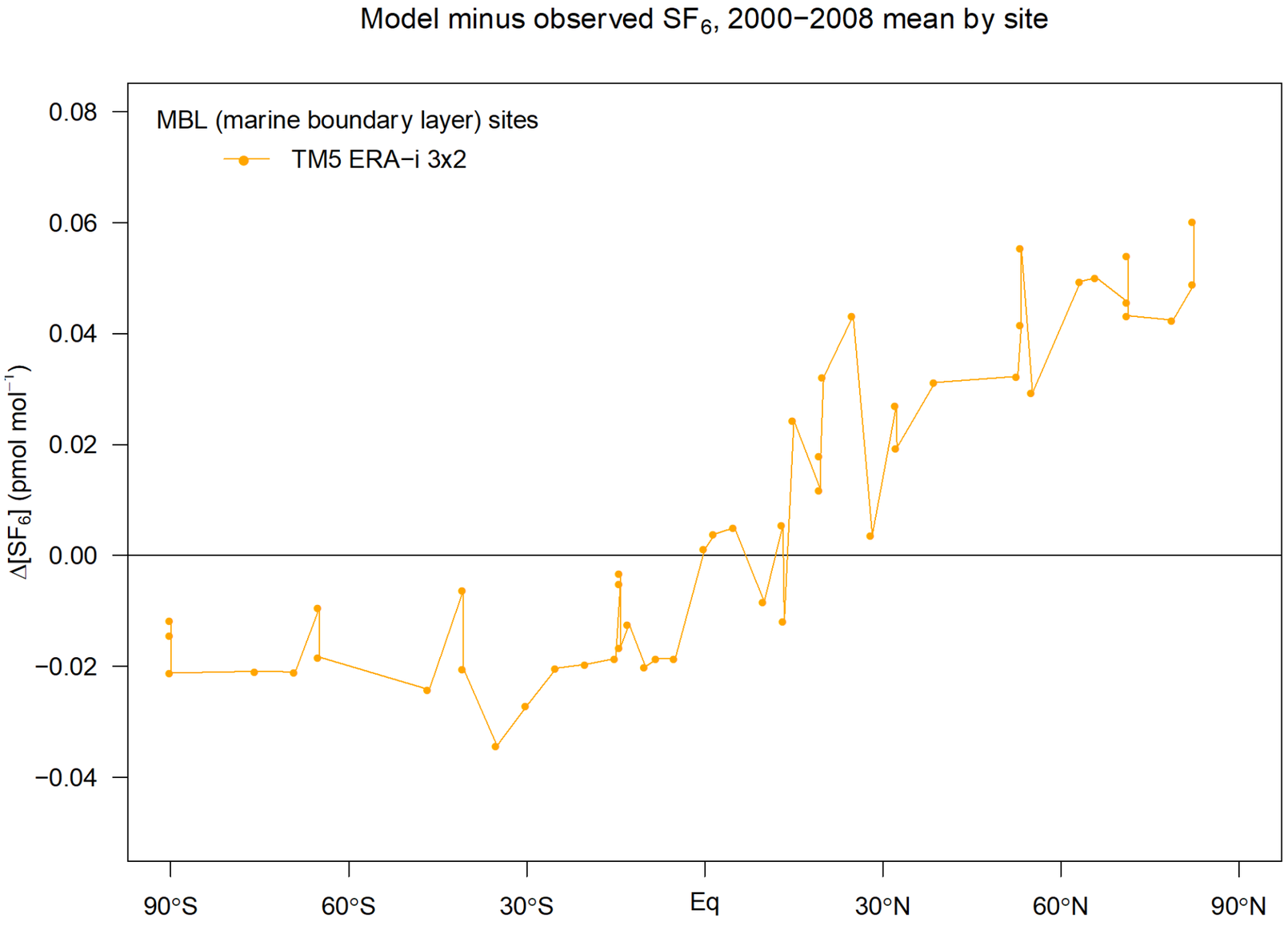
Sulfur Hexafluoride

Long-term mean model residuals at surface SF_6 sites.

TM5 performance circa 2012 (gold) showed sluggish interhemispheric transport.



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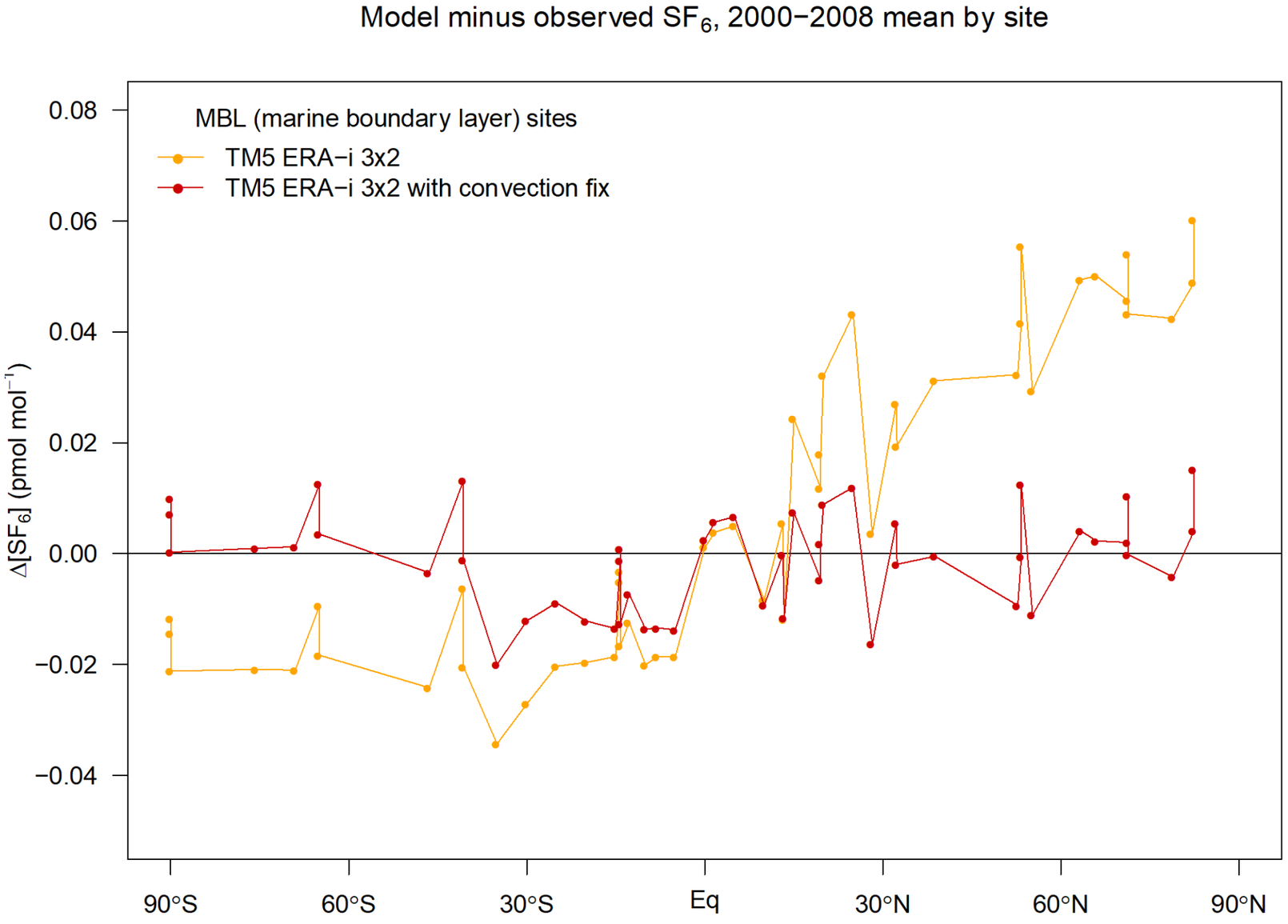

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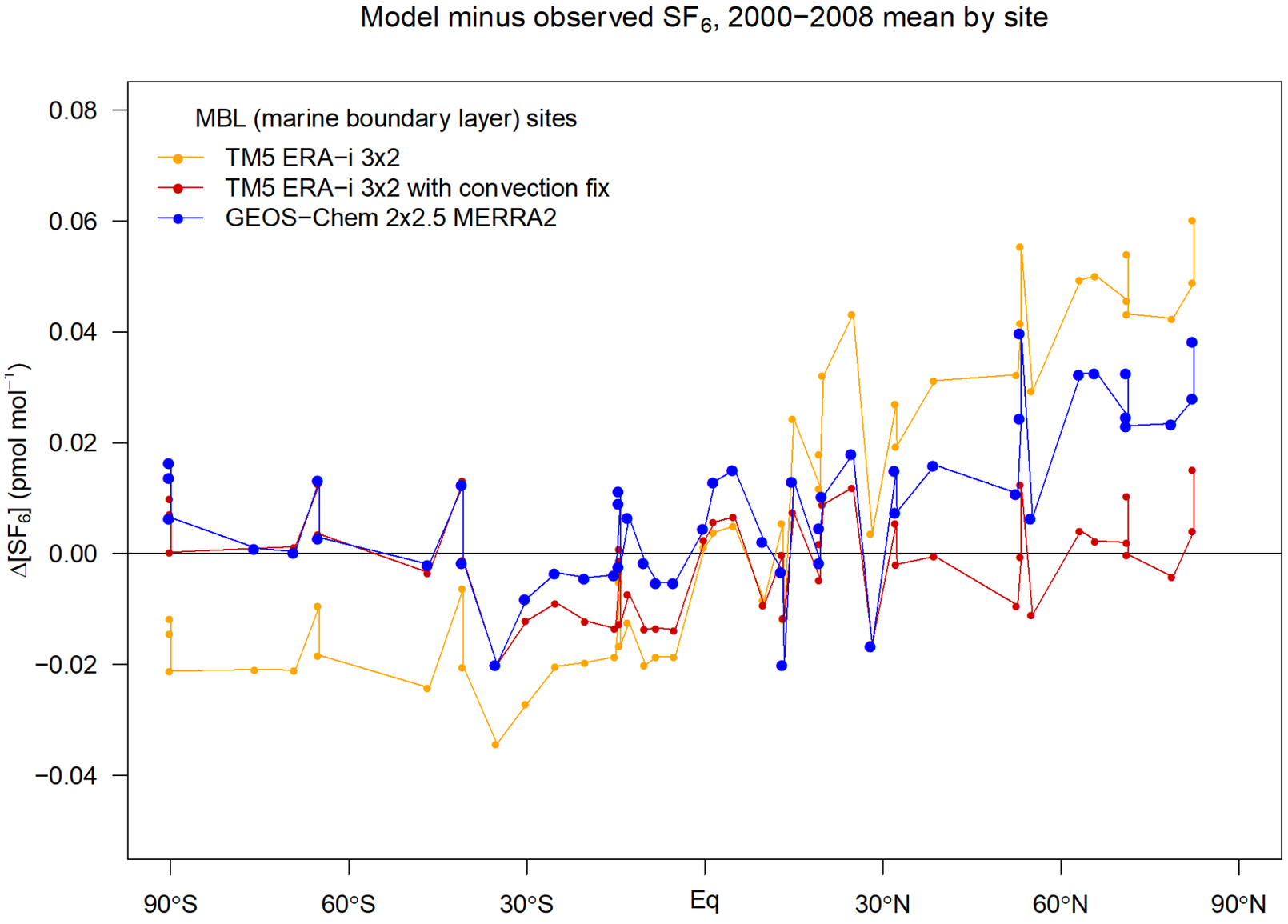
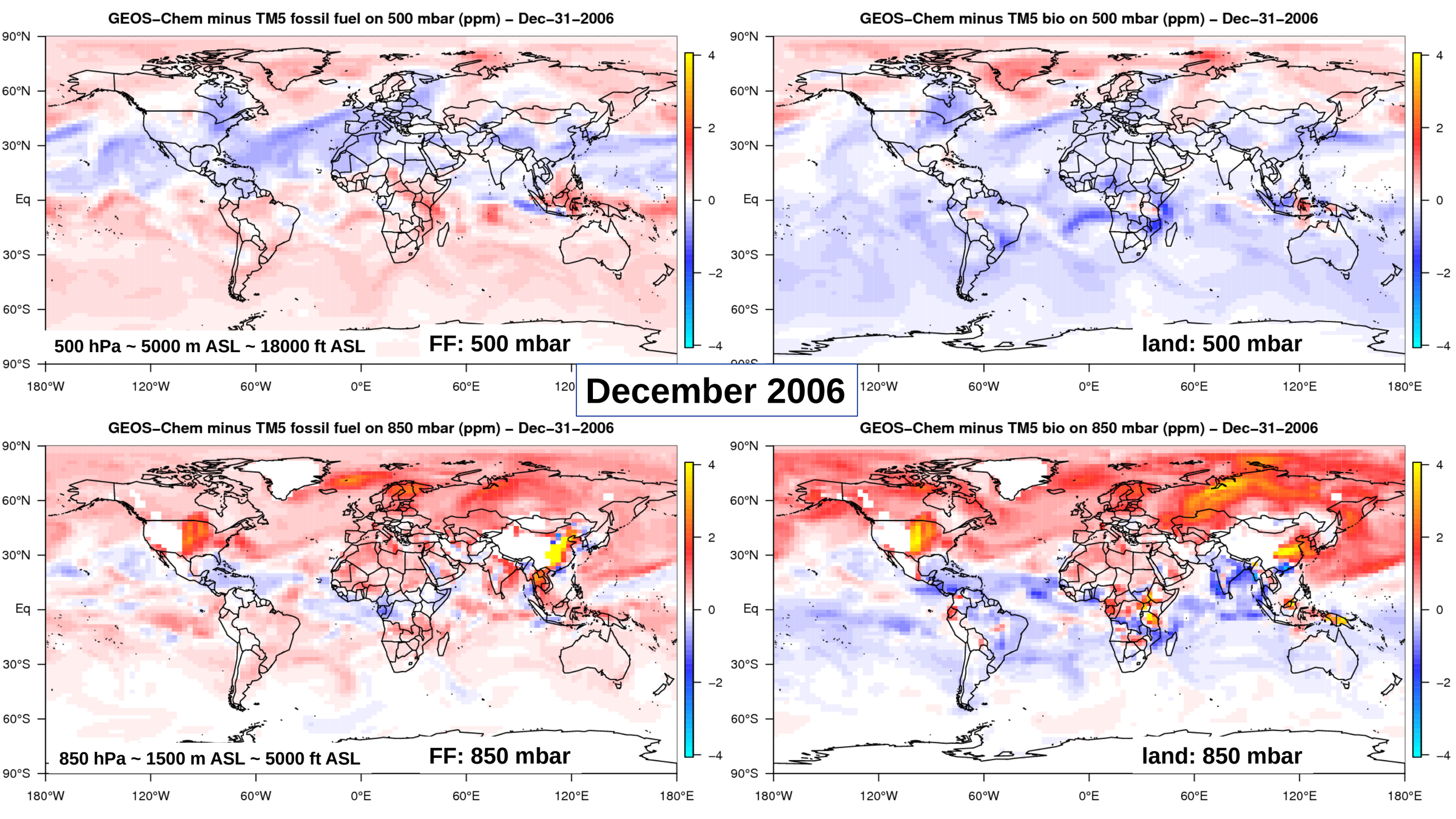
GEOS-Chem (blue) has surface excess north of about 30°N.




GEOS–Chem minus TM5 fossil fuel on 500 mbar (ppm) – Dec–31–2006
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500 hPa ~ 5000 m ASL ~ 18000 ft ASL
FF: 500 mbar
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60°N
30°N
Eq
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90°S
180°W
120°W
60°W
0°E
60°E
120°E
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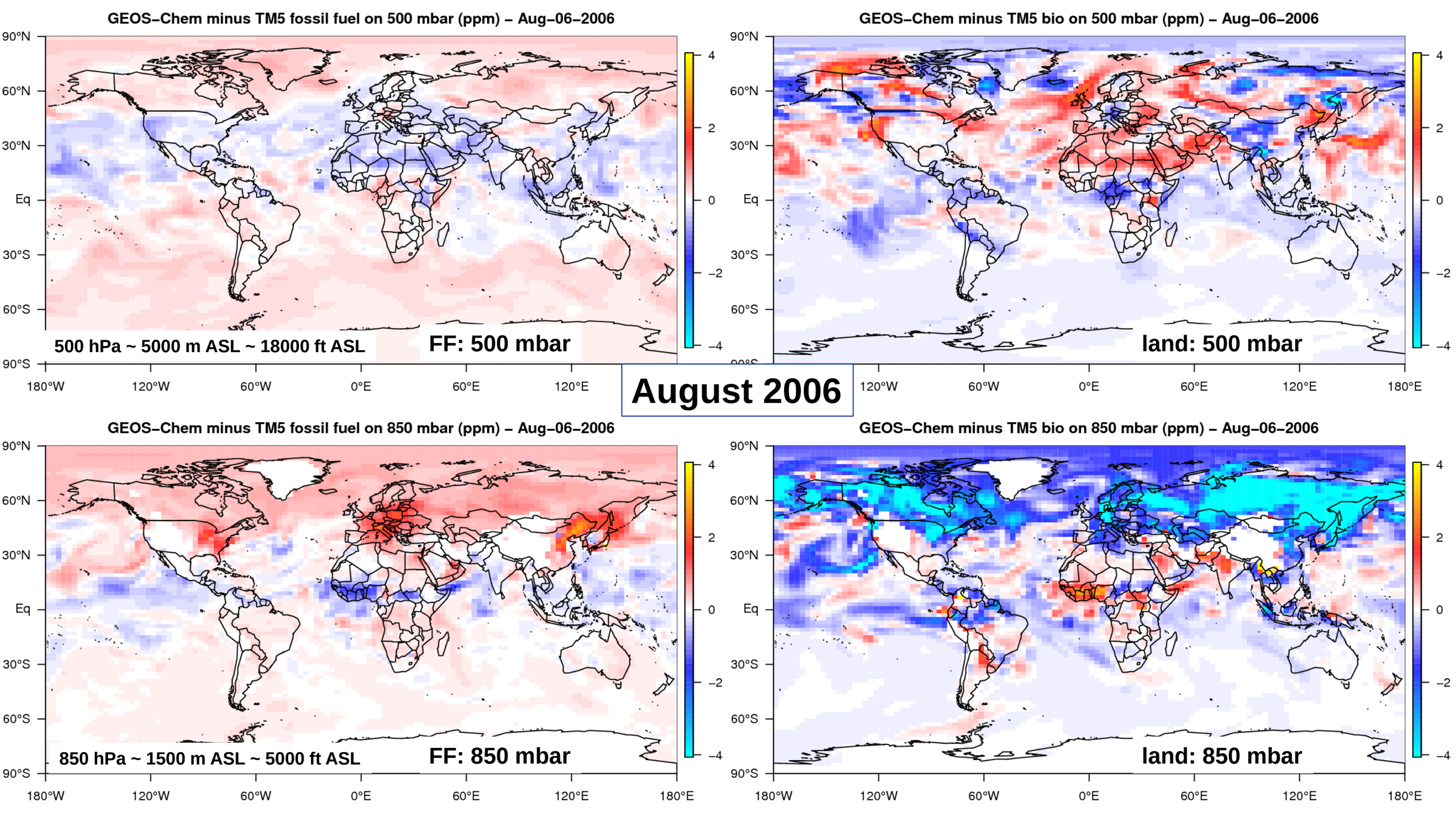
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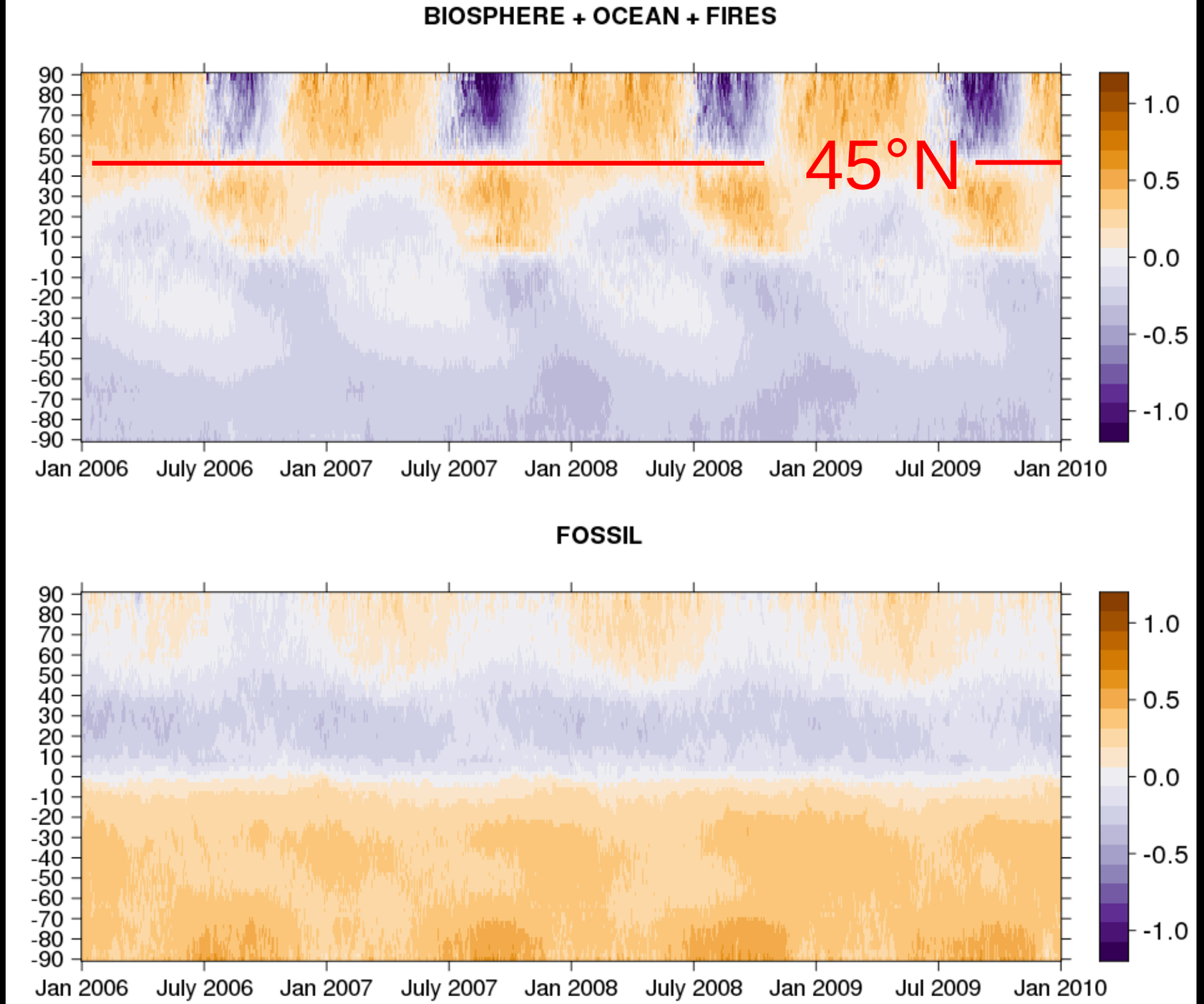
CT2016 CO_2 tracers

Zonal-mean xCO_2, so varies in latitude and time.

Portrayed is the difference (GEOS-Chem minus TM5)

GEOS-Chem appears to transport signals out of the northern midlatitudes more quickly than does TM5.

Figure courtesy of Andrew Schuh



The OCO-2 Model Intercomparison Project

Experiment	Data Assimilated
IS	Traditional *in situ* CO_2 measurements
LN	OCO-2 xCO_2 retrievals – land nadir mode
LG	OCO-2 xCO_2 retrievals – land glint mode
OG	OCO-2 xCO_2 retrievals – ocean glint mode
LNi	Traditional *in situ* CO_2 measurements and OCO-2 xCO_2 retrievals – land nadir mode

Experiments from Sept 2014 to near present

V7 of OCO-2 retrievals, using empirical bias correction (including S31 albedo fix)

In situ measurements from GLOBALVIEW+ and NRT ObsPack

1. CT-NRT (Jacobson)
2. OU (Crowell)
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4. CSU (Schuh)
5. CMS-Flux (Liu, Bowman)
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TM5/ERA-i

GEOS-Chem/ MERRA

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EnKF

other

variational

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OCO-2 MIP flux results - seasonality

Annual cycle amplitude

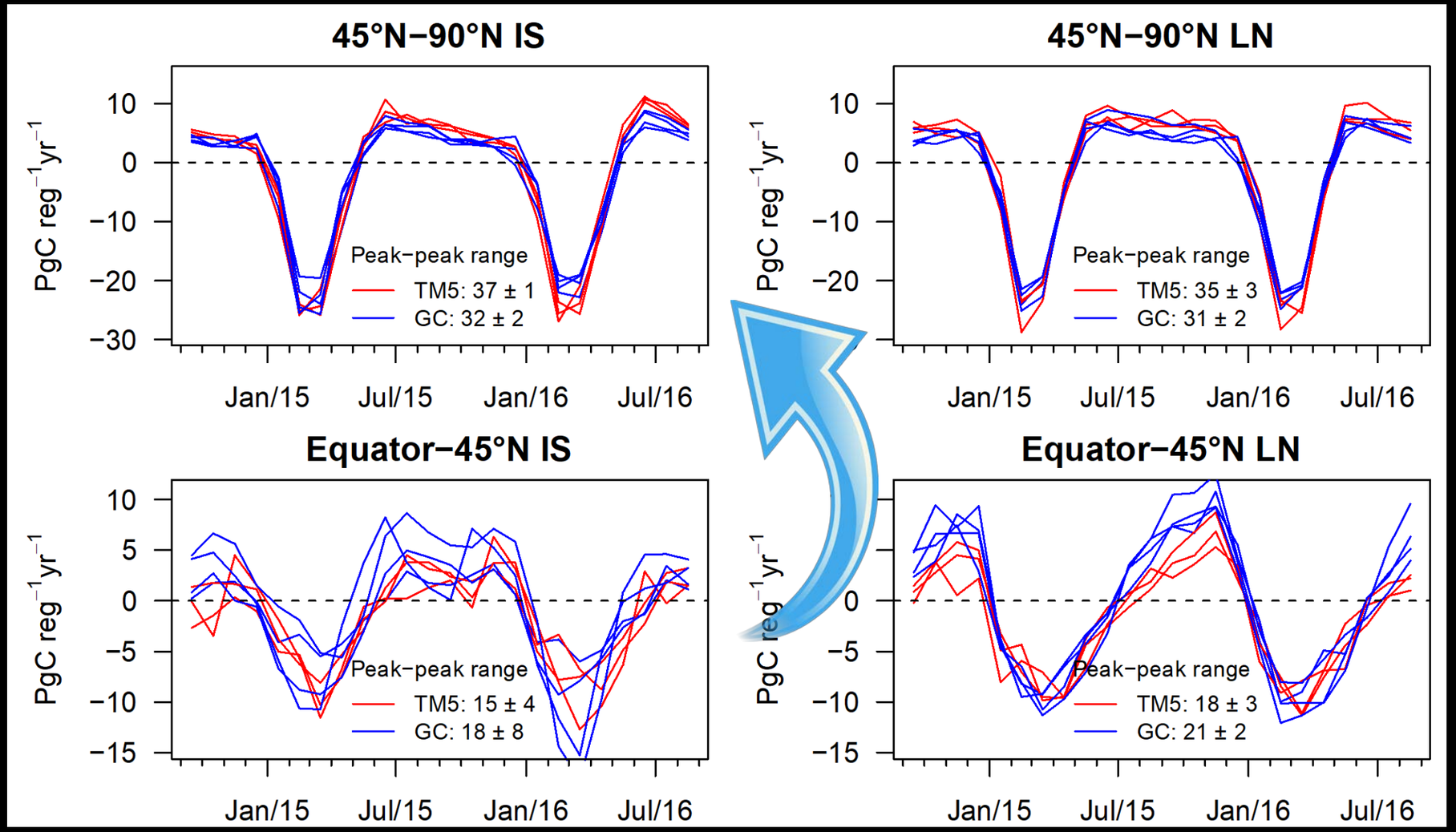
0-45°N: GEOS-Chem (blue) has greater seasonality, TM5 (red) lesser.

45°N-90°N: GEOS-Chem (blue) has lesser seasonality, TM5 (red) greater.

More diversity in GEOS-Chem results than in TM5.

Scatter precludes statistical significance.

Consistent with GEOS-Chem more actively sweeping signals out of mid-latitudes.



OCO-2 MIP flux results – long-term mean

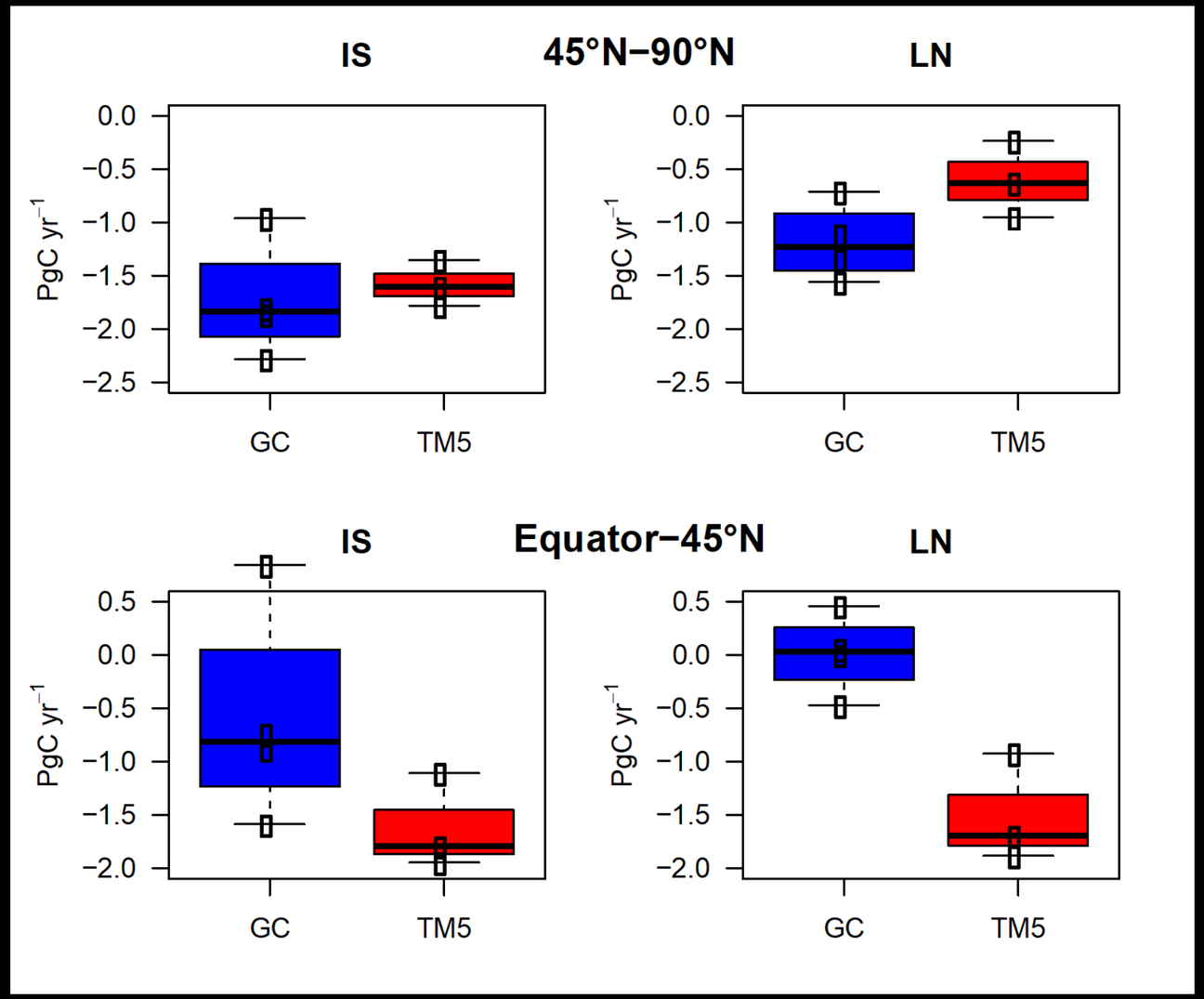
Optimized flux – 2-year mean

0-45°N: GEOS-Chem (blue) has smaller sink, TM5 (red) greater.

45°N-90°N: GEOS-Chem (blue) has greater sink, TM5 (red) smaller.

Evidence is anecdotal more than statistical. Thankfully, it is backed up by a mechanistic interpretation.

Despite increased seasonality in low latitudes, GEOS-Chem sink is smaller…because of the fossil fuel signal.



Conclusions

- Large-scale transport differences between GEOS-Chem and TM5 are revealed by forward simulations of SF_6 and CO_2.
- Mechanism requires that GEOS-Chem ventilate mid-latitudes more quickly than TM5, so enhanced meridional transport…but also trapping closer to surface.
- An collection of inversions from the OCO-2 MIP appears to show optimized flux artifacts consistent with those transport differences.
- Next step: Reynolds decomposition of the zonal-mean meridional CO_2 flux. Contributions from mean flow, stationary eddies, transient eddies.