



Evaluating GEOS-CF with TEMPO data

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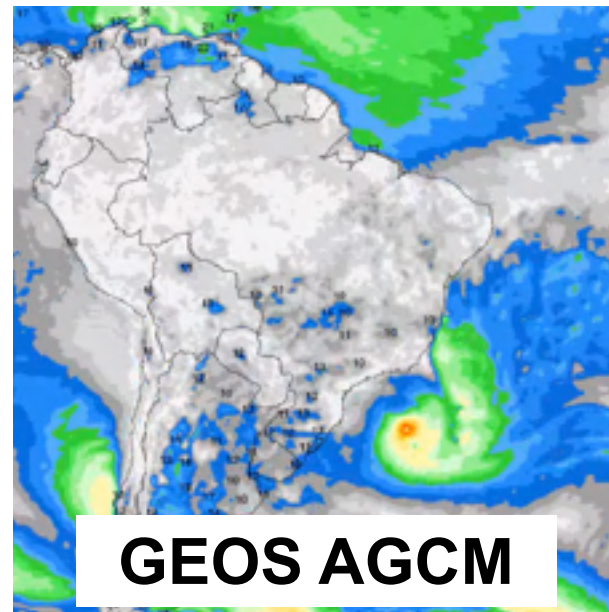
Emma Knowland, Christoph Keller, Pam Wales,
Kris Wargan, Brad Weir & Steven Pawson

GEOS-CF is widely used for research and NASA mission support



GEOS-CF is NASA GMAO's composition forecasting system,
combining GEOS-Chem with the GEOS model

GEOS-CF



+ **GEOS**
Chem

Keller et al., 2021, JAMES;
Knowland et al., 2022, JAMES

- Daily near real time estimates and 5-day forecasts since 2019
- Global coverage at ~25 km resolution
- Number of applications, including:
 - NASA mission support (TEMPO, ToINet, field campaigns)
 - Atmospheric chemistry research
 - Air quality management

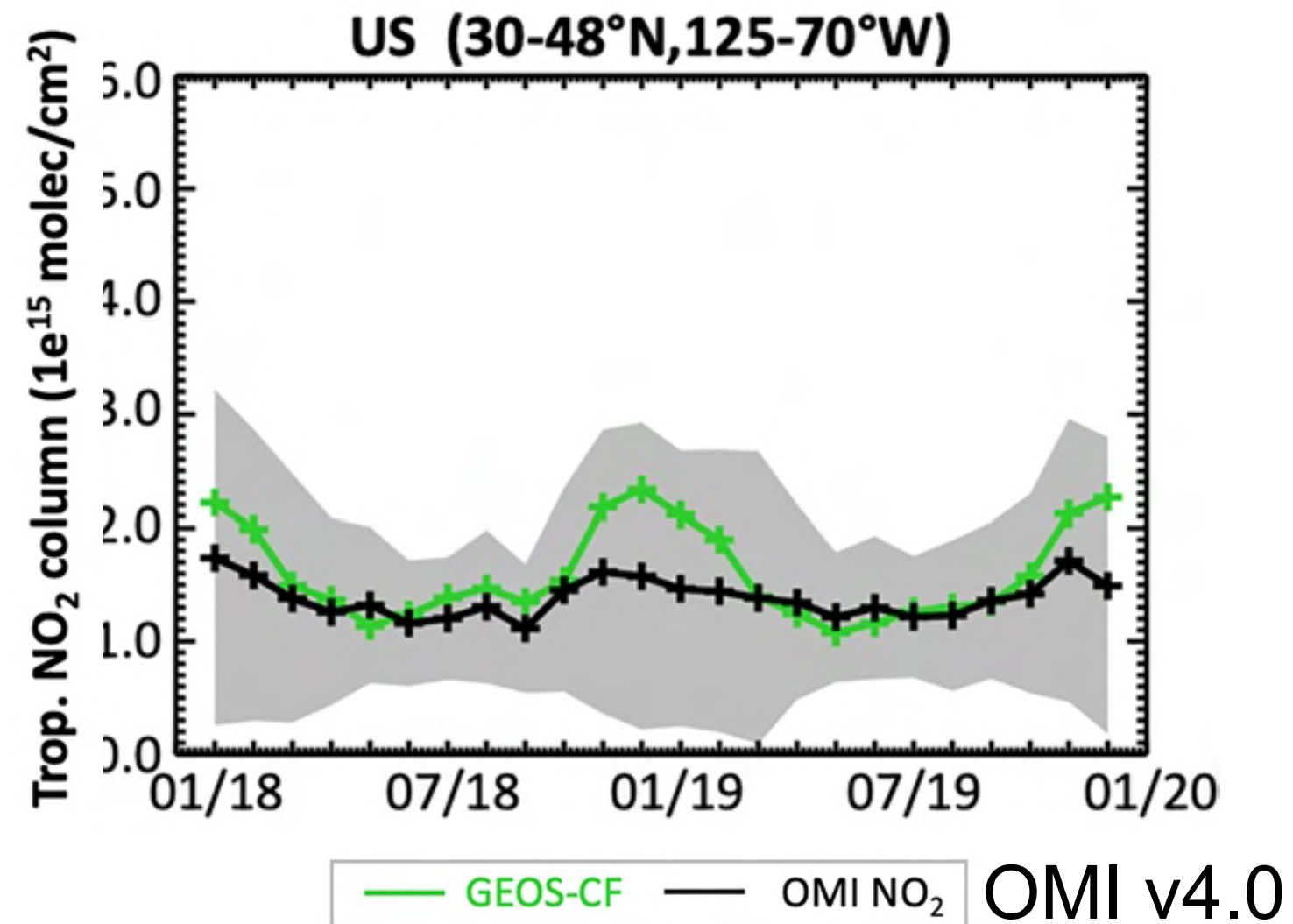
CF-2 coming soon!

GEOS-CF NO₂ is consistent with OMI and surface observations



Tropospheric NO₂ columns

Surface NO₂



Results for 2018-19

GEOS-CF trop NO₂ spatially correlated with TEMPO NO₂

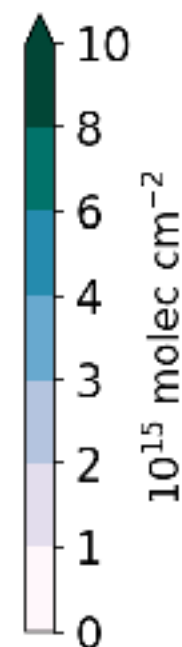
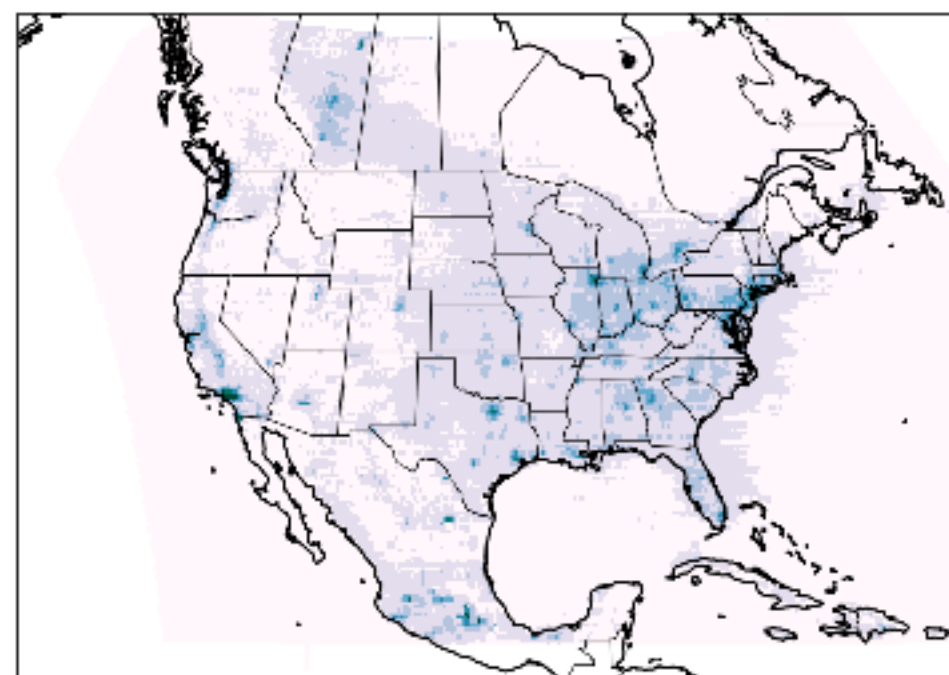
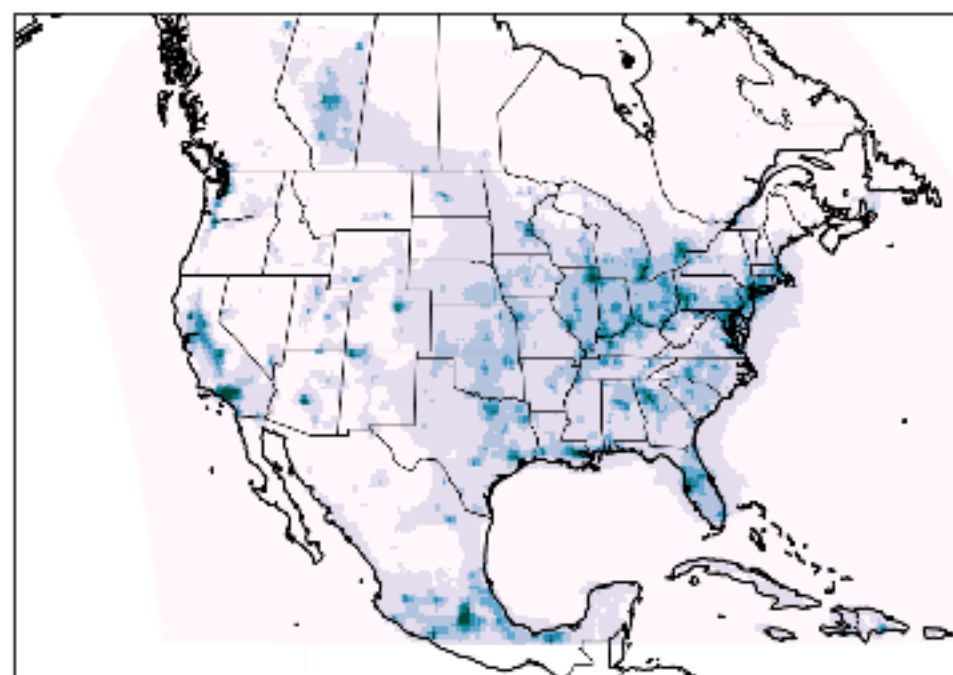


Tropospheric NO₂ columns

GEOS-CF-1

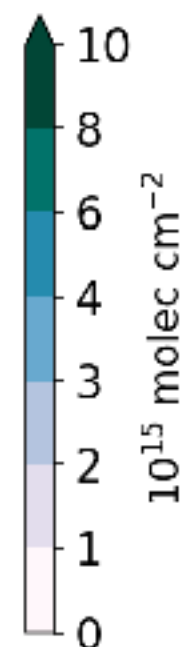
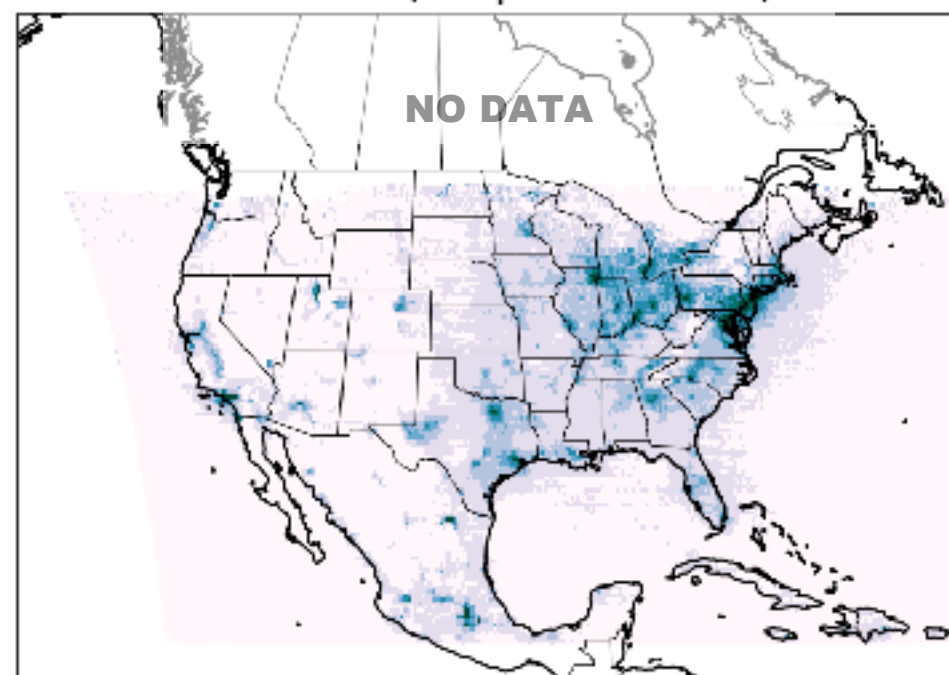
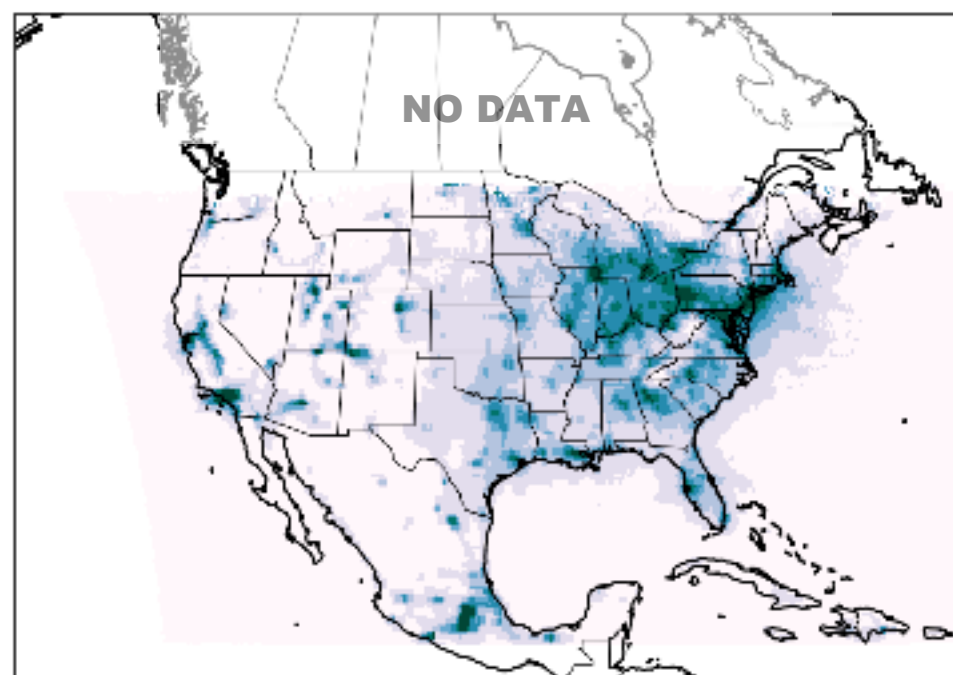
TEMPO (V03)

June '24



- ◆ High correlation between GEOS-CF and TEMPO
- ◆ GEOS-CF 40% higher because of older emissions

Dec '23



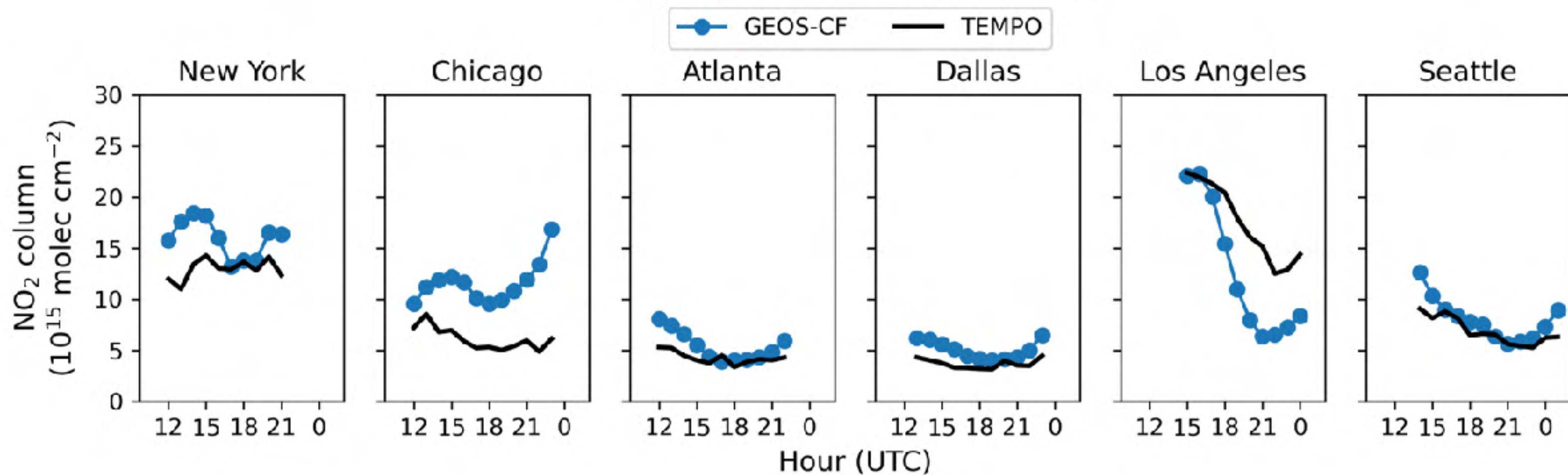
- ◆ TEMPO shows high NO₂ over the Permian Basin, not seen in the model

TEMPO data gridded to GEOS-CF grid with recommended quality filters

GEOS-CF NO₂ diurnal profiles stronger than in the TEMPO data



Tropospheric NO₂ columns June '24



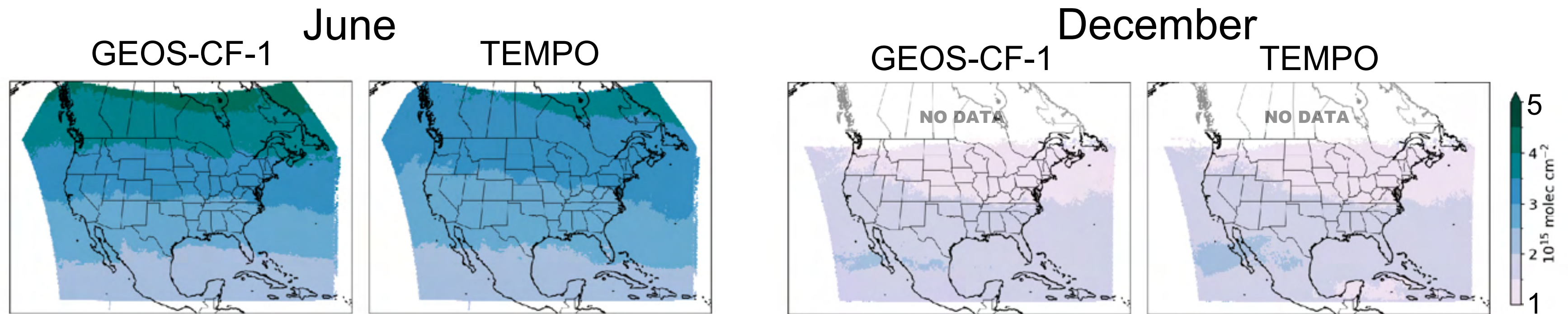
Diurnal variation in the model driven by oxidation (mid-day peak)
and emissions (morning & evening peaks)

GEOS-CF shows larger diurnal variation than the TEMPO data

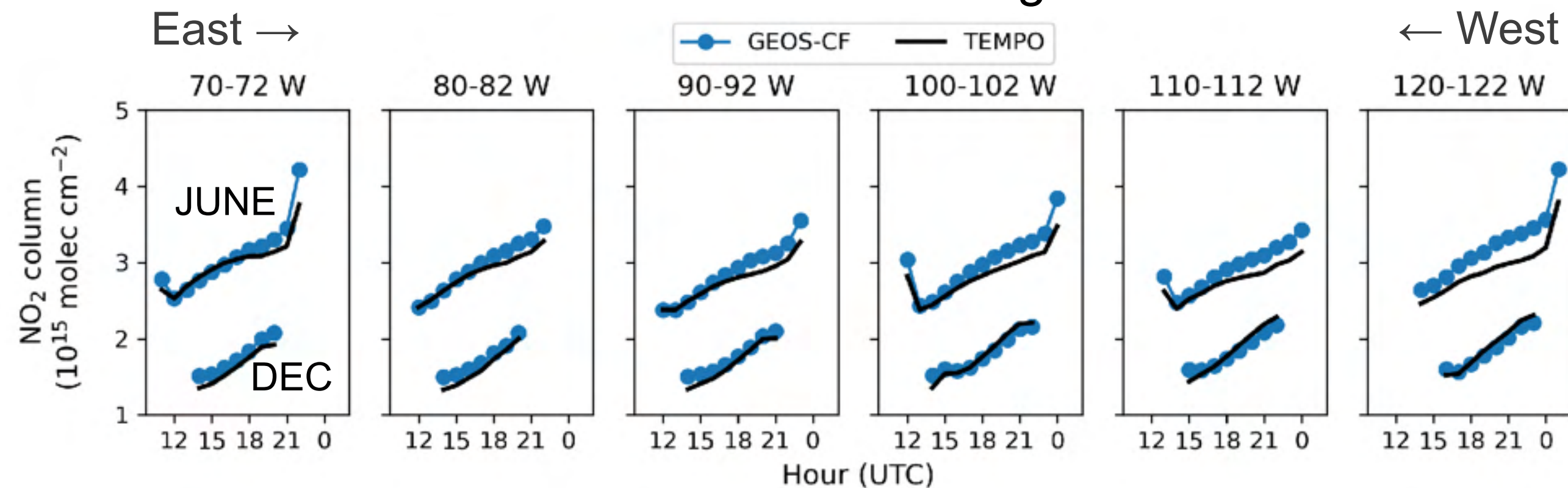
GEOS-CF stratospheric NO₂ matches the TEMPO data



Stratospheric NO₂ columns



Diurnal variation for 2° longitude slices

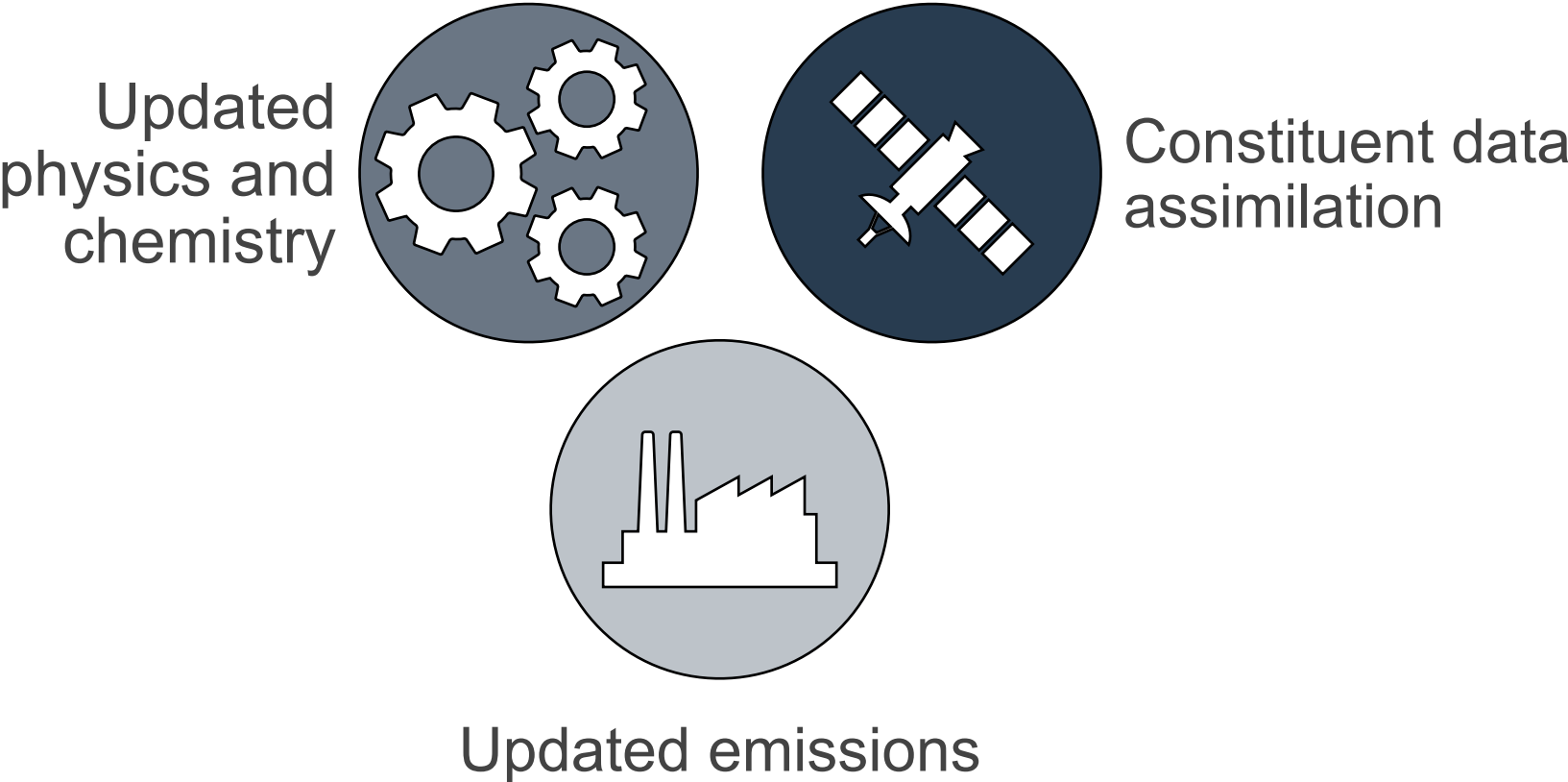


◆ Diurnal and seasonal variation driven by chemistry

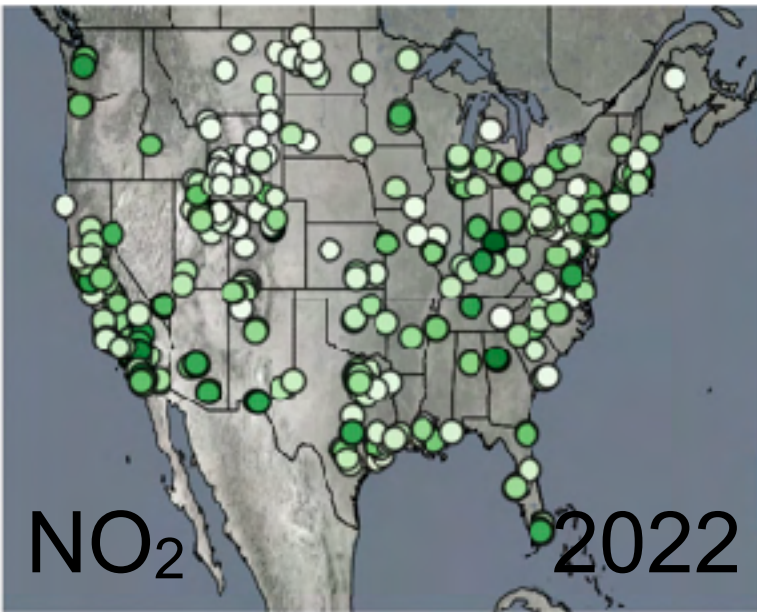
Surface NO₂ much lower in GEOS-CF-2



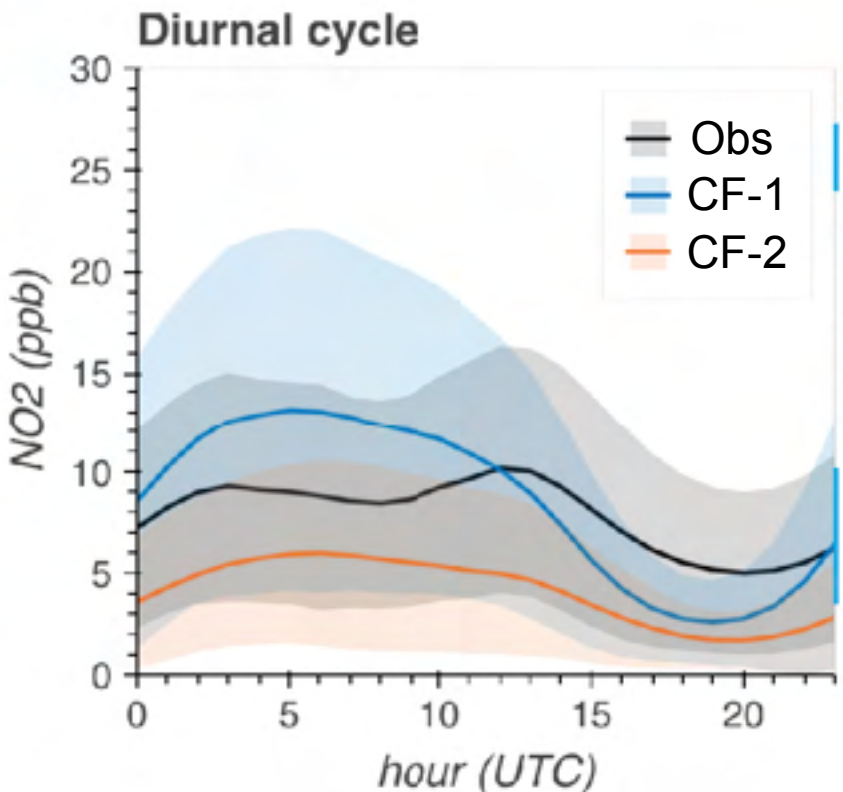
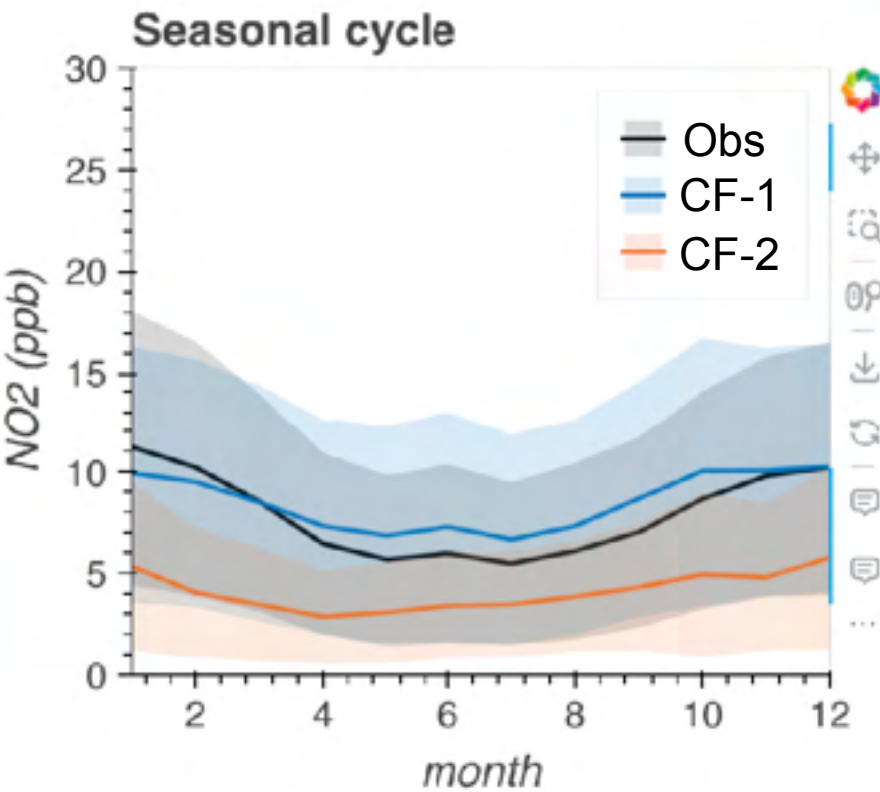
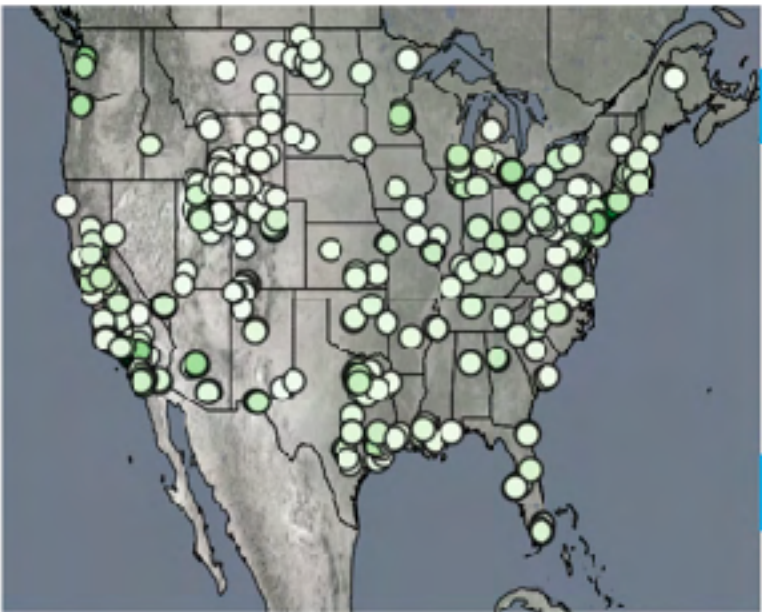
GEOS-CF-2 includes major updates



EPA AQS observations



GEOS-CF-2



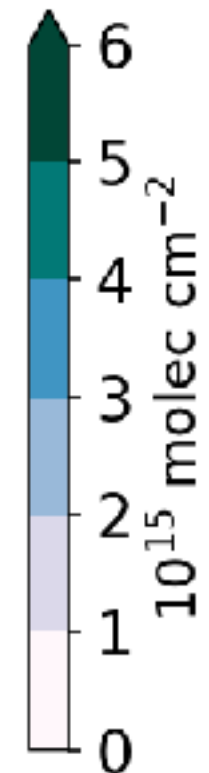
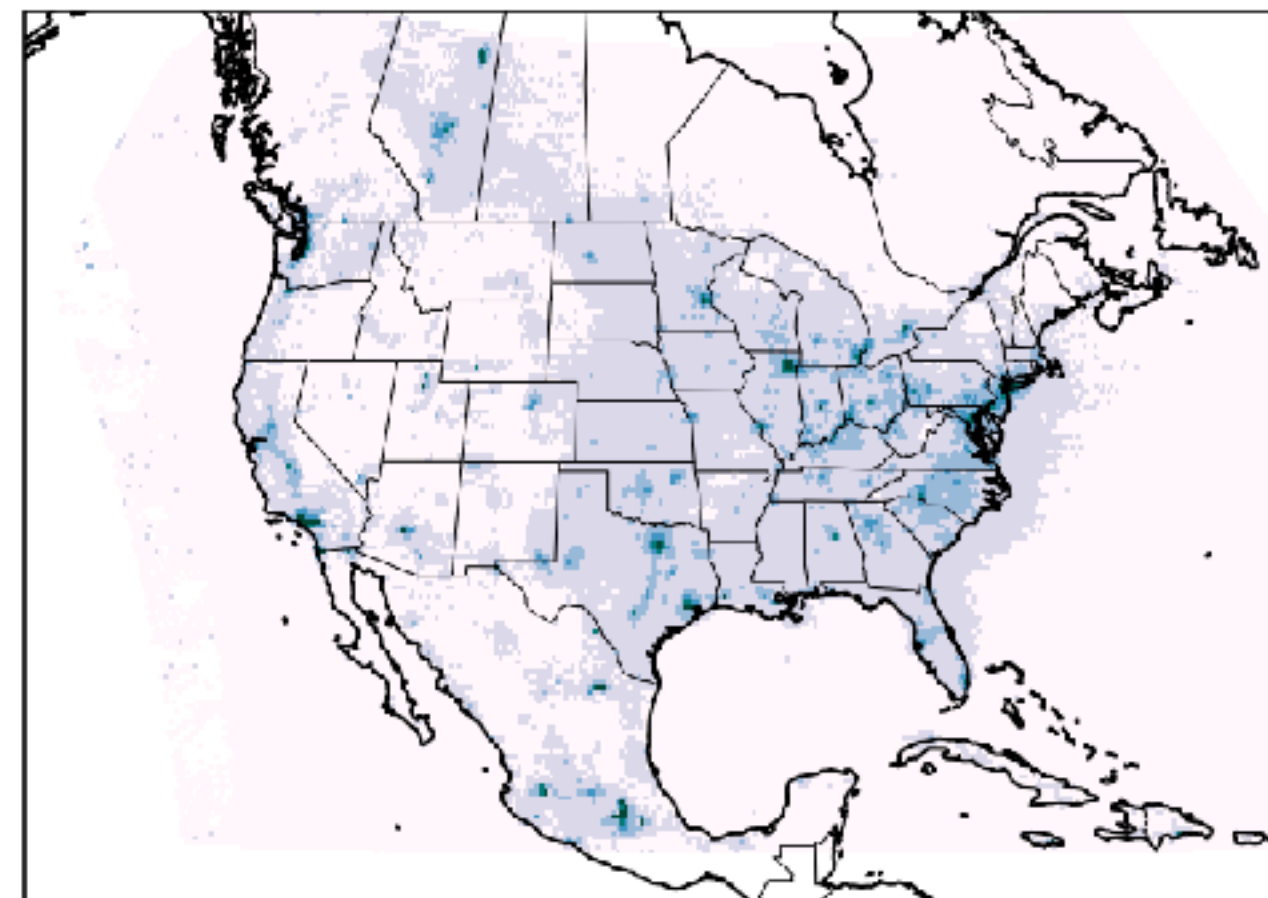
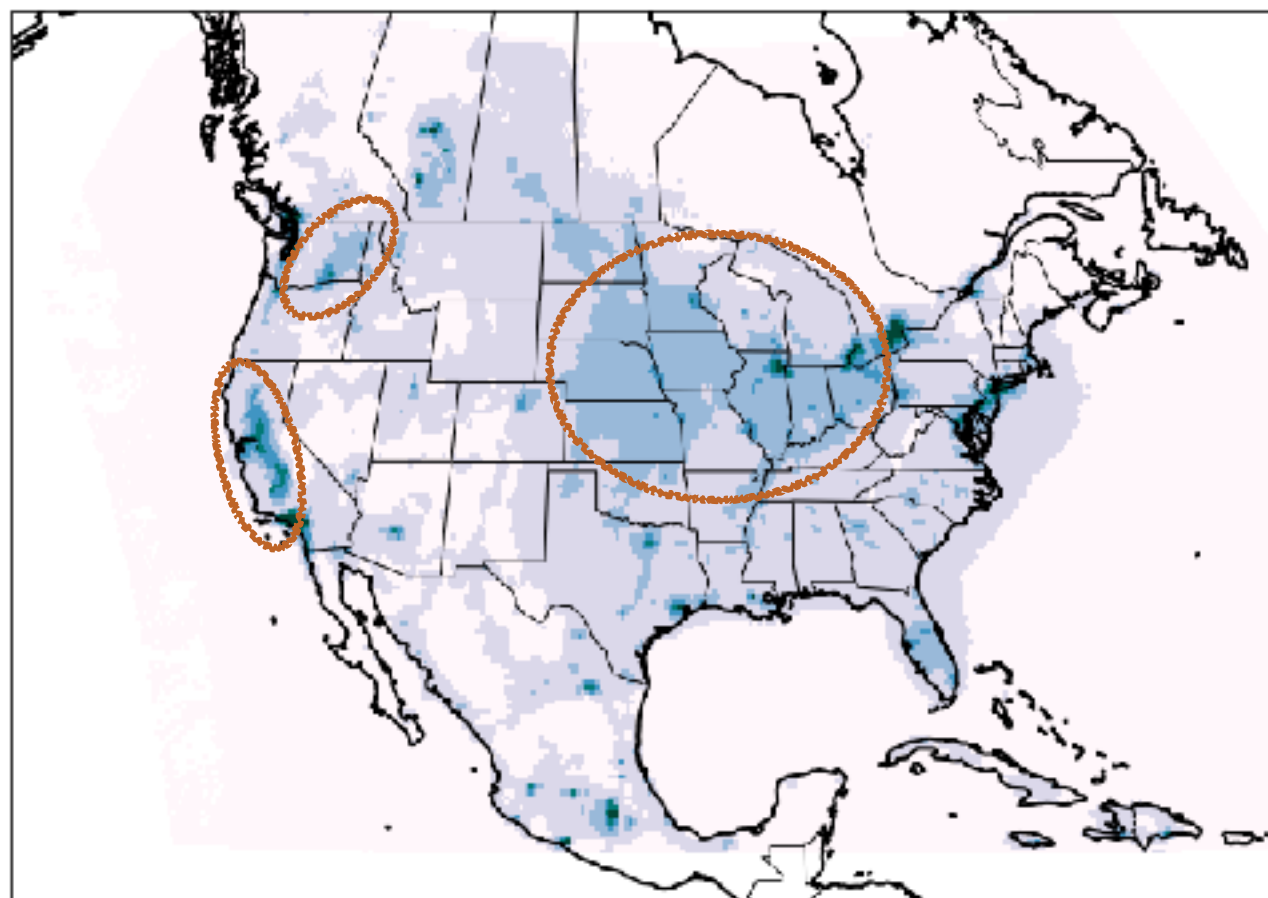


But NO₂ columns in CF-2 closer to the TEMPO data

Tropospheric NO₂ columns Aug '23

GEOS-CF-2

TEMPO



Preliminary; TEMPO averaging kernel not applied

- > GEOS-CF-2 is consistent TEMPO data over cities, improvement over GEOS-CF-1
- > Background NO₂ too high in CF-2

Conclusions



- ❖ GEOS-CF-1 tropospheric NO₂ is spatially similar to the TEMPO data; stratospheric NO₂ columns match each other well
- ❖ High bias in tropospheric NO₂ in GEOS-CF-1, but GEOS-CF-2 is better
- ❖ Need to better understand
 - the diurnal variation of NO₂ over cities,
 - the inconsistency between column and surface comparisons, and
 - and the higher background NO₂ in the new model