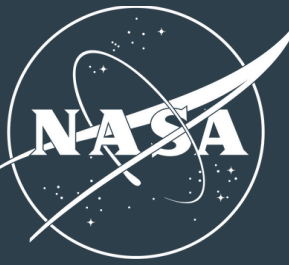


New Developments to the NASA GEOS Composition Forecasting System (GEOS-CF)

Viral Shah (NASA GMAO & Morgan State University)

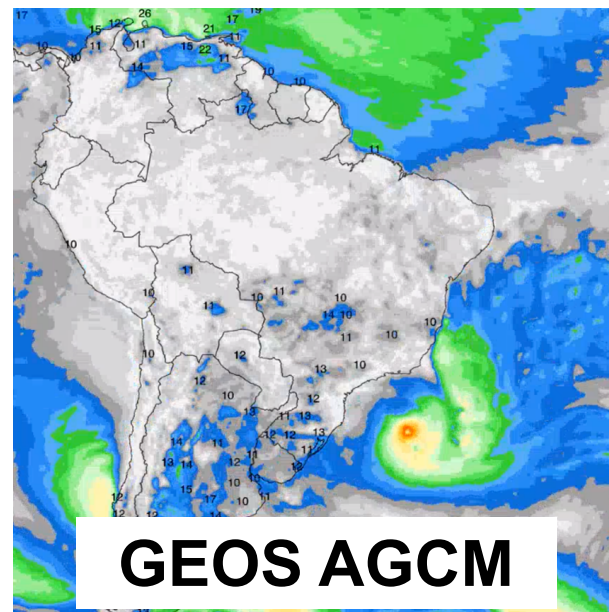
Emma Knowland, Christoph Keller, Pam Wales,
Carl Malings, Kris Wargan, Brad Weir & Steven Pawson



GEOS-CF is widely used for research and mission support

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

GEOS-CF



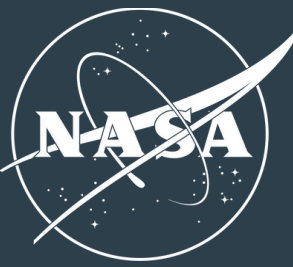
+ **GEOS**
Chem

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

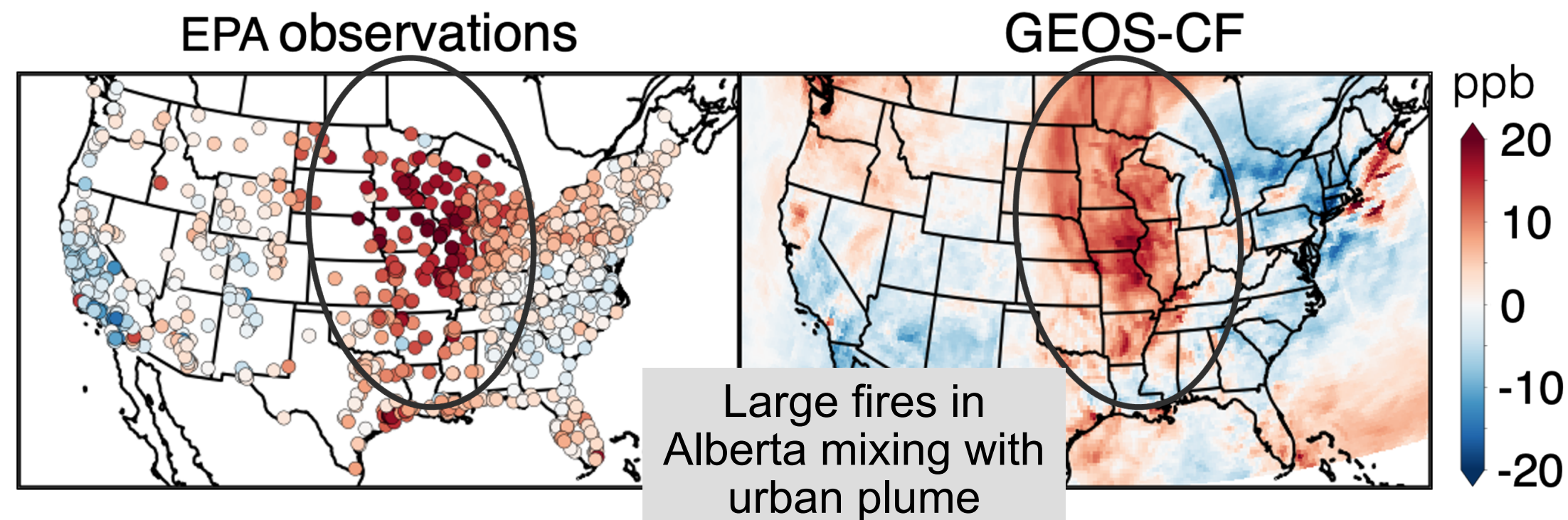
- Daily near real time estimates and 5-day forecasts since 2019
- Global coverage at ~25 km resolution
- Number of applications, including:
 - NASA mission support (TEMPO, ToINet, field campaigns)
 - Atmospheric chemistry research
 - Air quality monitoring

GEOS-CF-2 coming soon

GEOS-CF reproduces surface ozone anomalies linked to wildfires and weather patterns

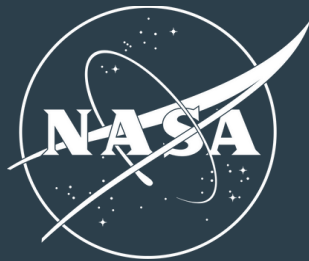


Surface ozone anomaly in May 2023
Highest surface ozone over Midwest in decades



Monthly anomalies for the 90th percentile MDA8 ozone for 2019-23

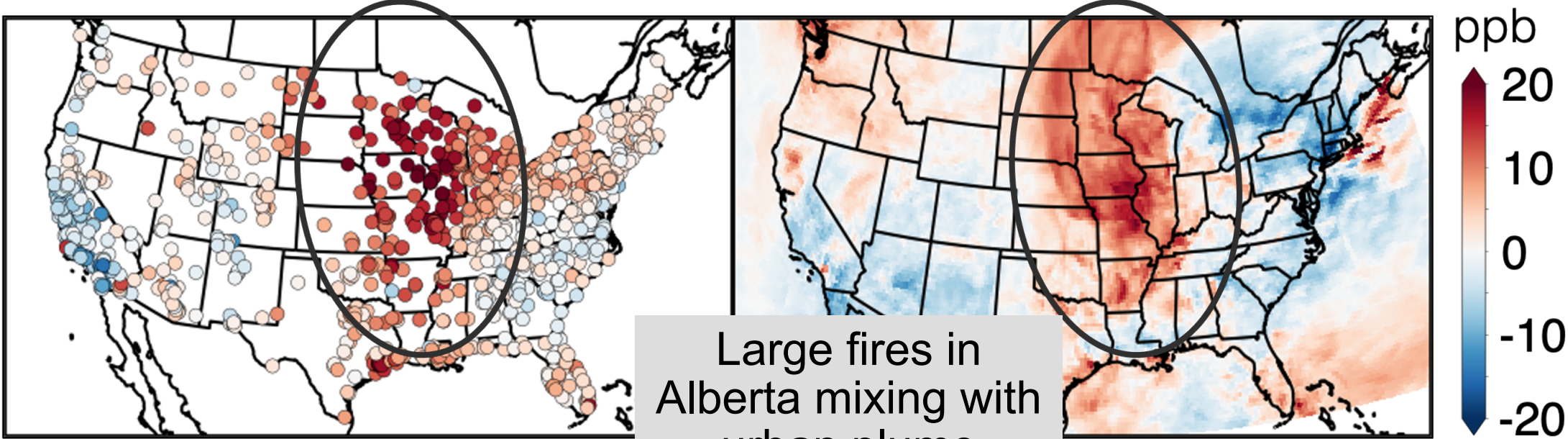
GEOS-CF reproduces surface ozone anomalies linked to weather patterns and fires



Surface ozone anomaly in May 2023
Highest surface ozone over Midwest in decades

EPA observations

GEOS-CF



Large fires in
Alberta mixing with
urban plume

July 2021

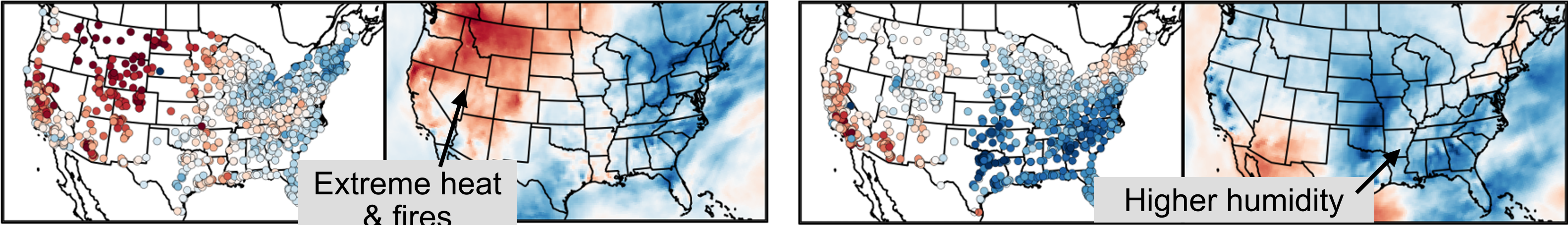
Sept 2020

Observations

GEOS-CF

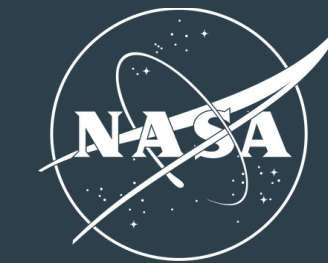
Observations

GEOS-CF

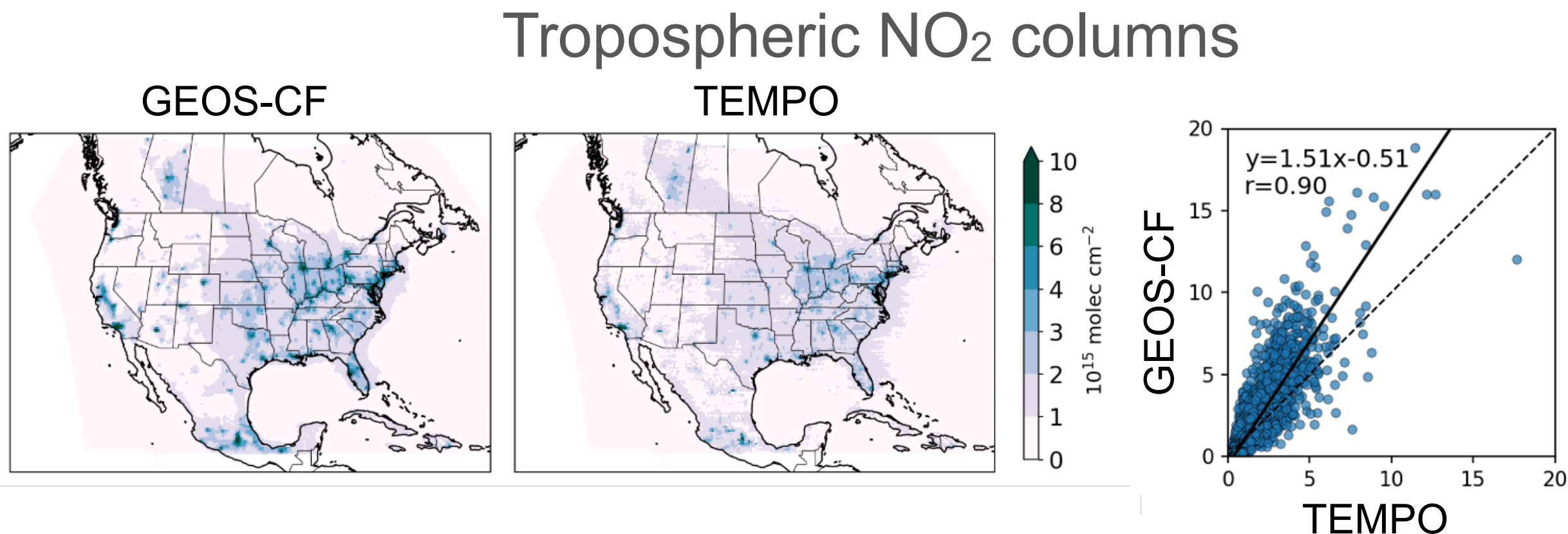


Monthly anomalies for the 90th percentile MDA8 ozone

Indirectly validating TEMPO retrievals using GEOS-CF

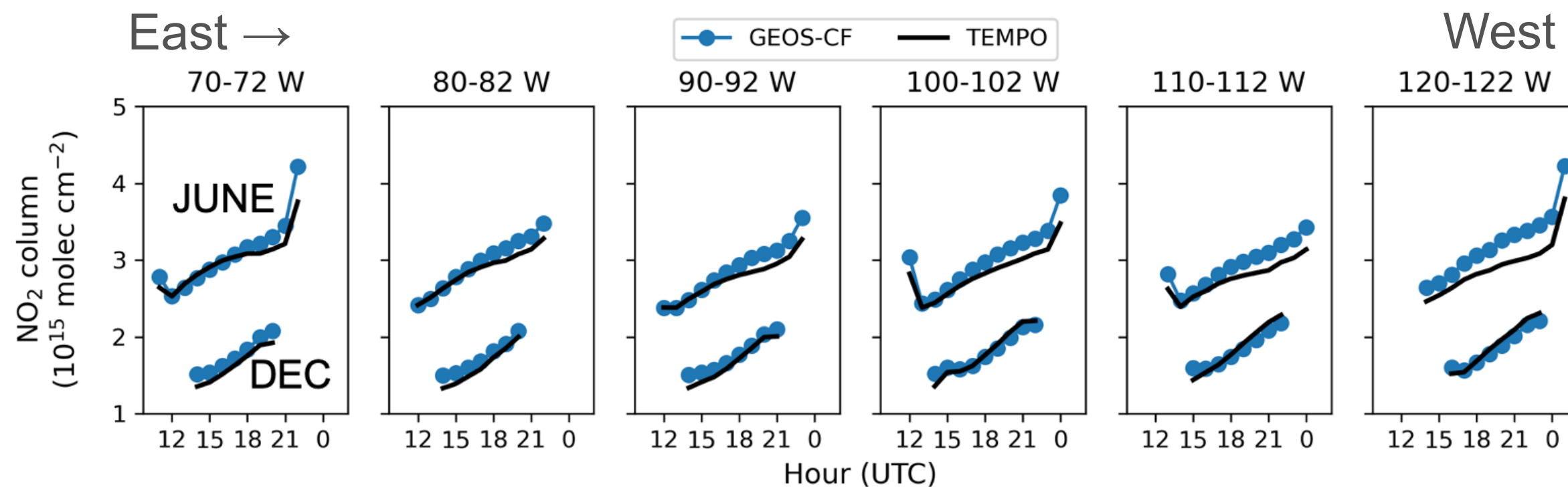


June 2024



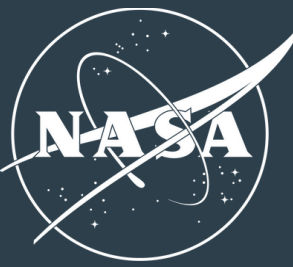
High correlation; but
GEOS-CF 50% higher

Stratospheric NO₂ columns (diurnal variation)

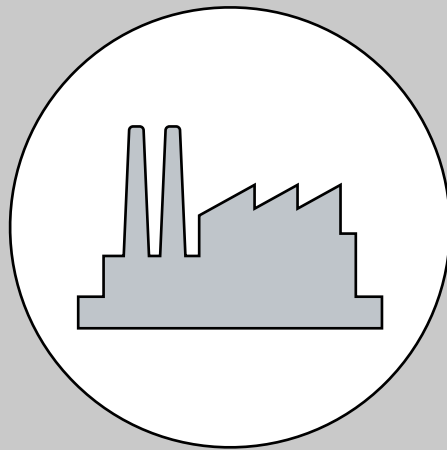


Consistent daytime
gradient

GEOS-CF-2 will be a major update to the system



Emissions

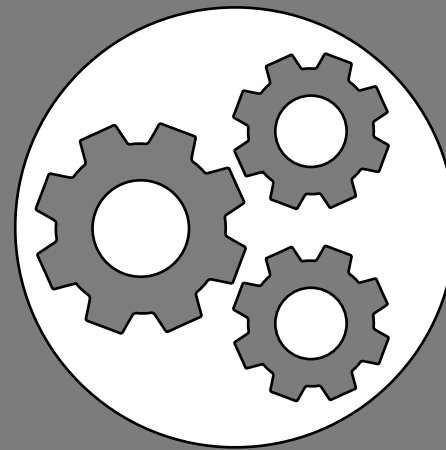


CEDS (2021)

Updated fire
emission factors

Redistributed
lightning NO_x
emissions

Model components

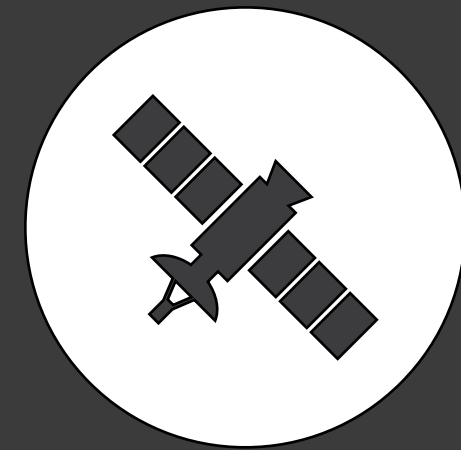


GEOS-Chem 14.0

Updated model
physics

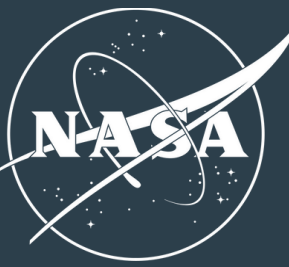
Online convective
transport

Data assimilation

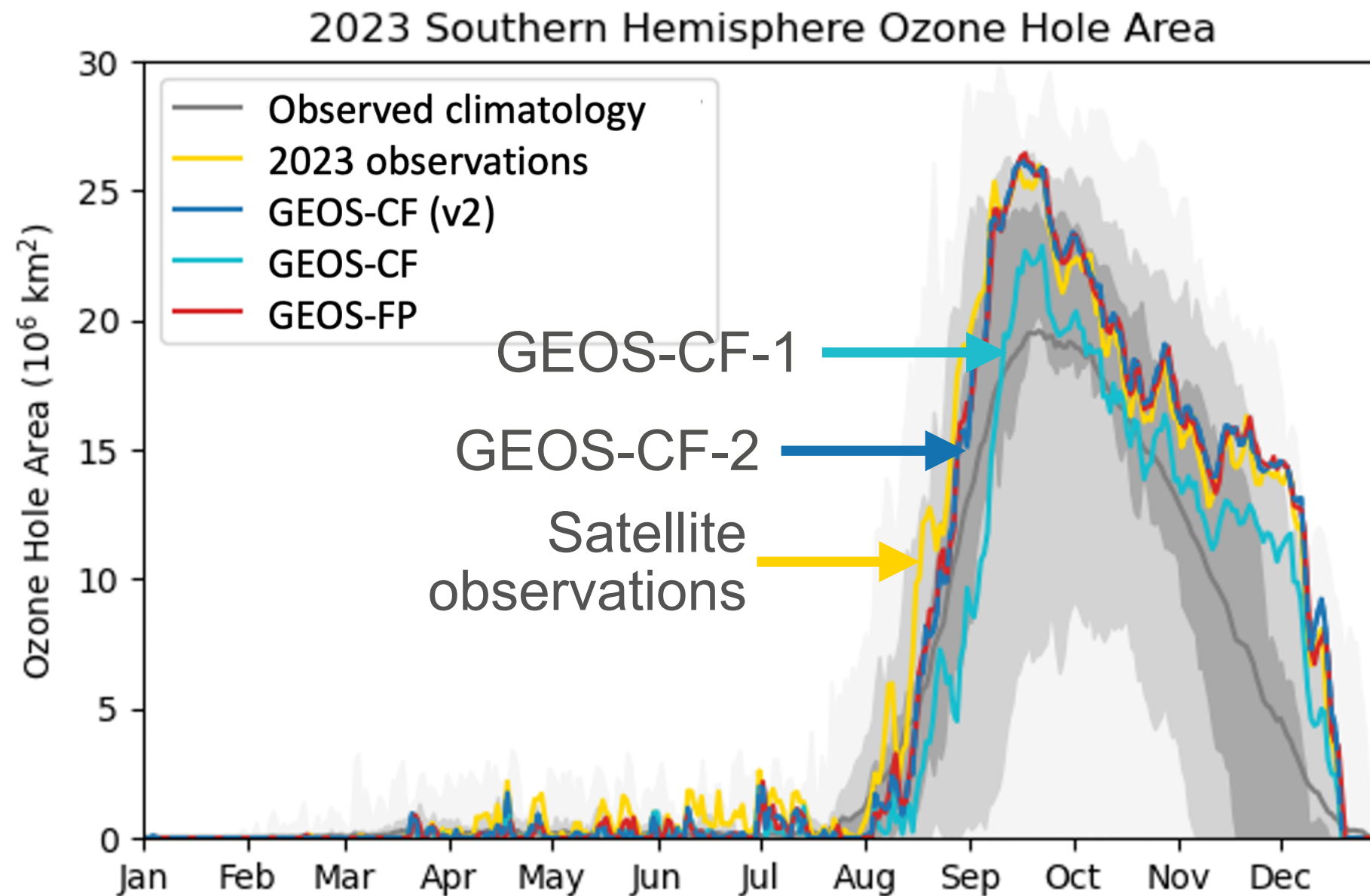


Assimilation of
ozone, NO₂ and
SO₂ satellite
data from MLS
and OMI

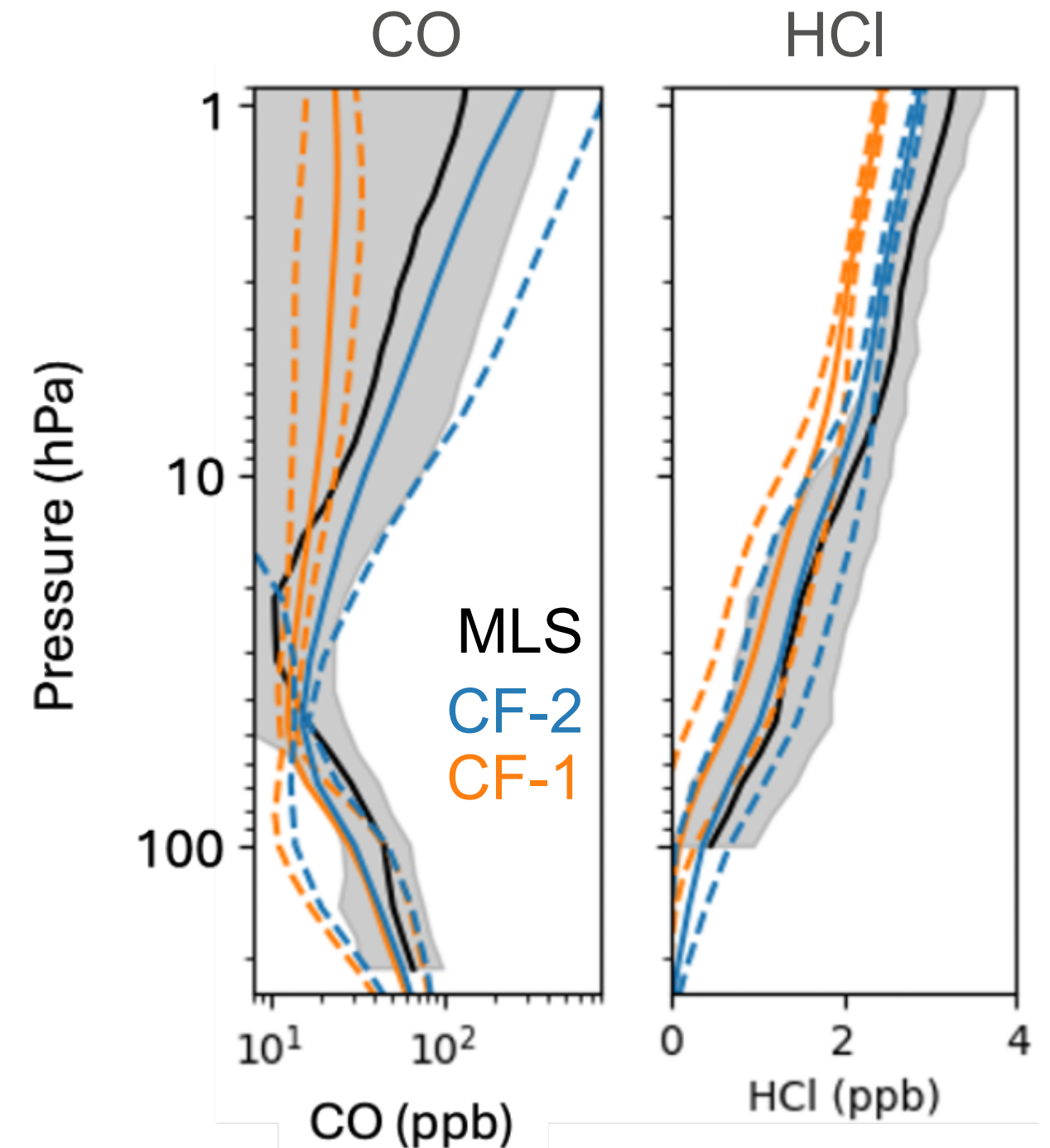
GEOS-CF-2 better represents stratospheric species



Data assimilation improves stratospheric ozone in GEOS-CF-2

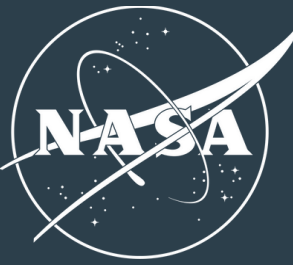


Effect of mesospheric CO source and Cl chemistry updates



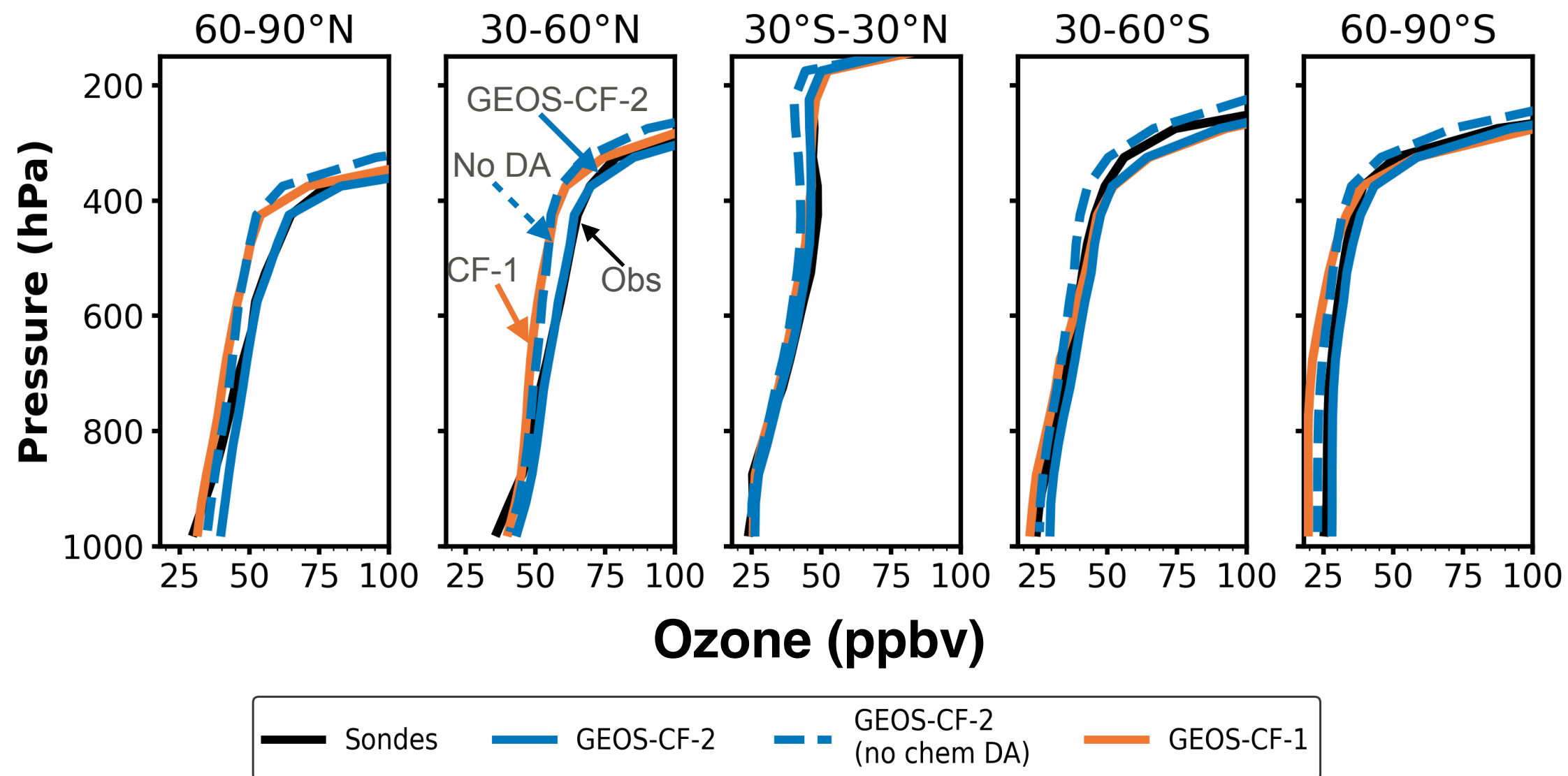
Results for 2023

Tropospheric ozone and surface PM_{2.5} improve in GEOS-CF-2



Tropospheric ozone profiles

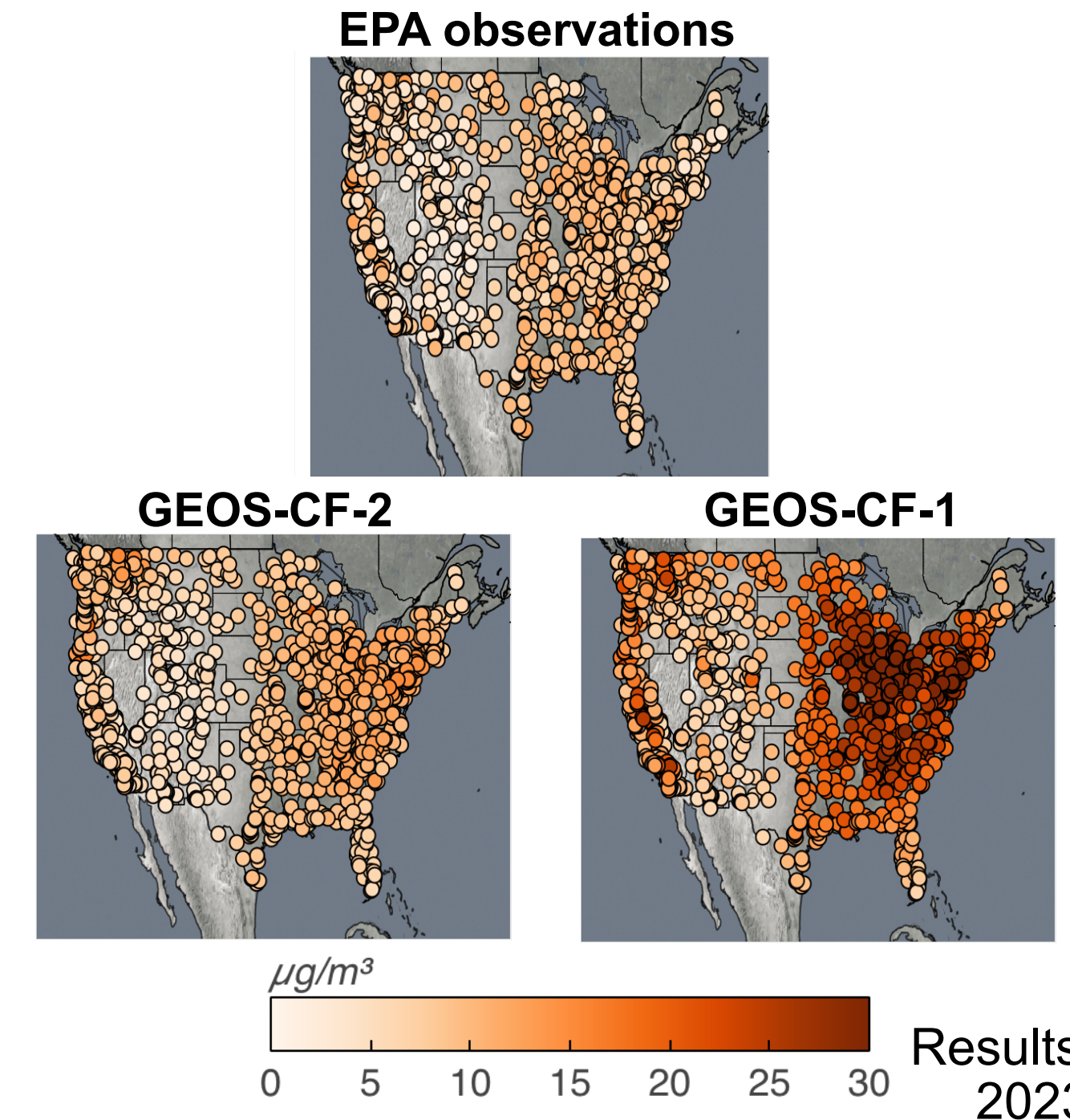
Data assimilation improves tropospheric ozone simulation in GEOS-CF-2



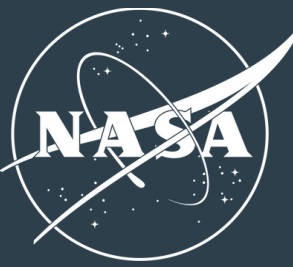
Sonde observations are from the WOUDC, SHADOZ, and NOAA ozonesonde networks

PM_{2.5}

Updated emissions and chemistry improve PM_{2.5}

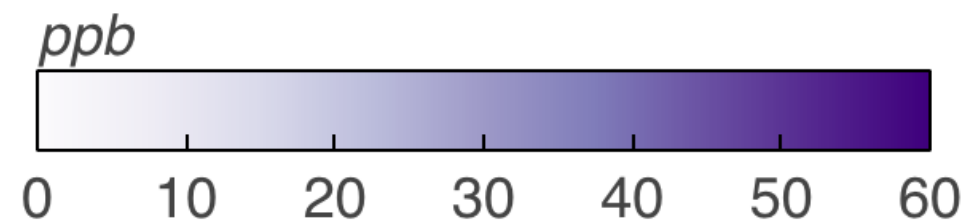
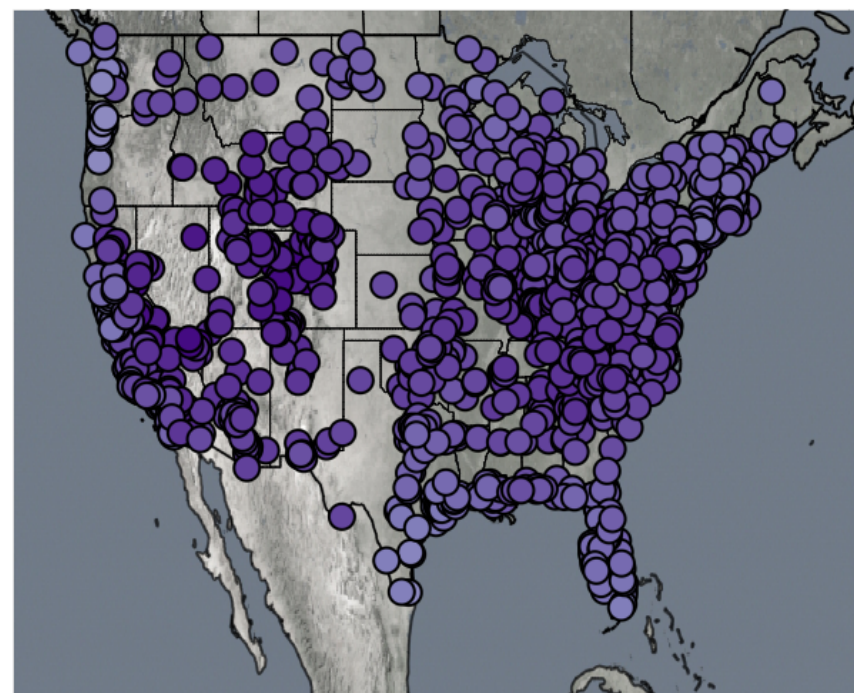
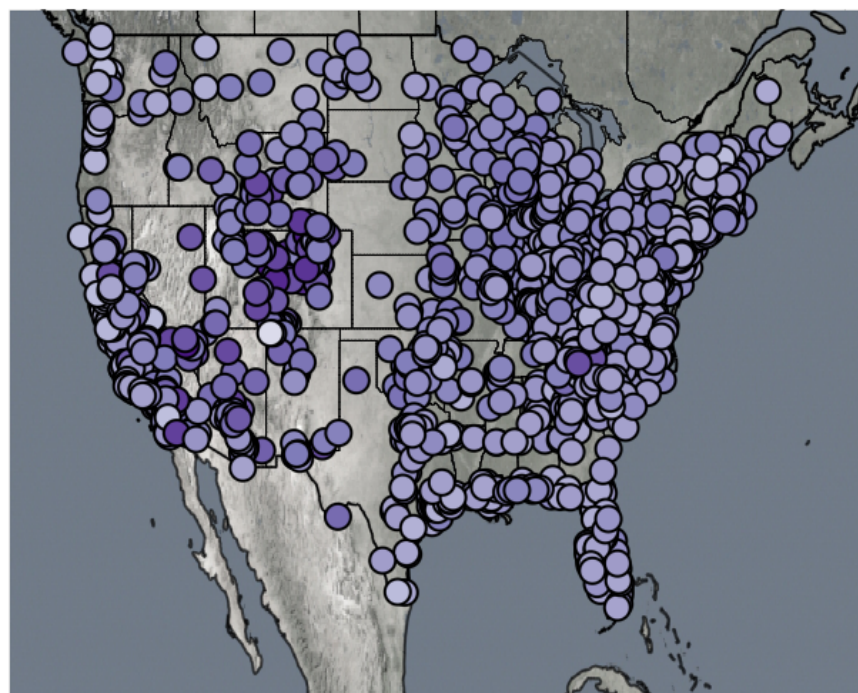


But there is a high bias in surface ozone

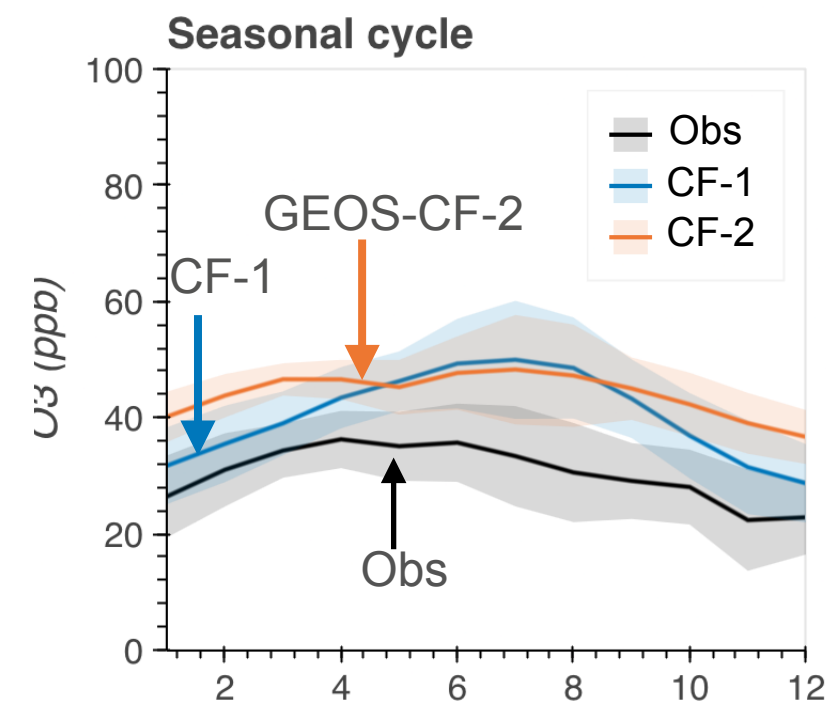


Surface ozone is biased high – a persistent problem in global models

Annual mean surface ozone
EPA observations GEOS-CF-2

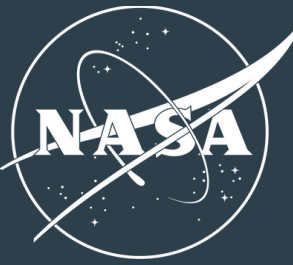


Ozone



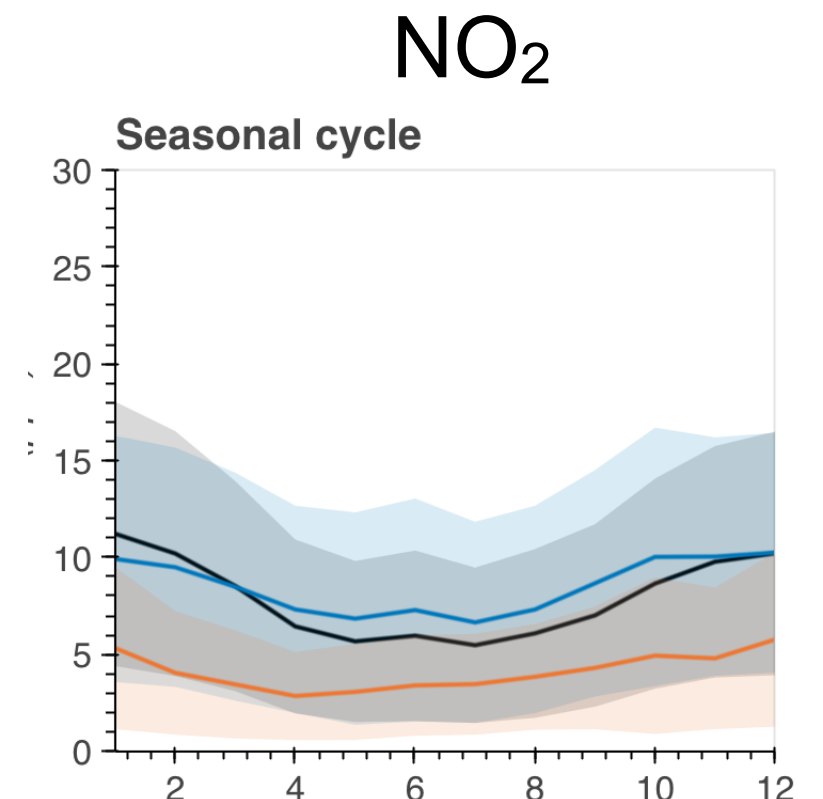
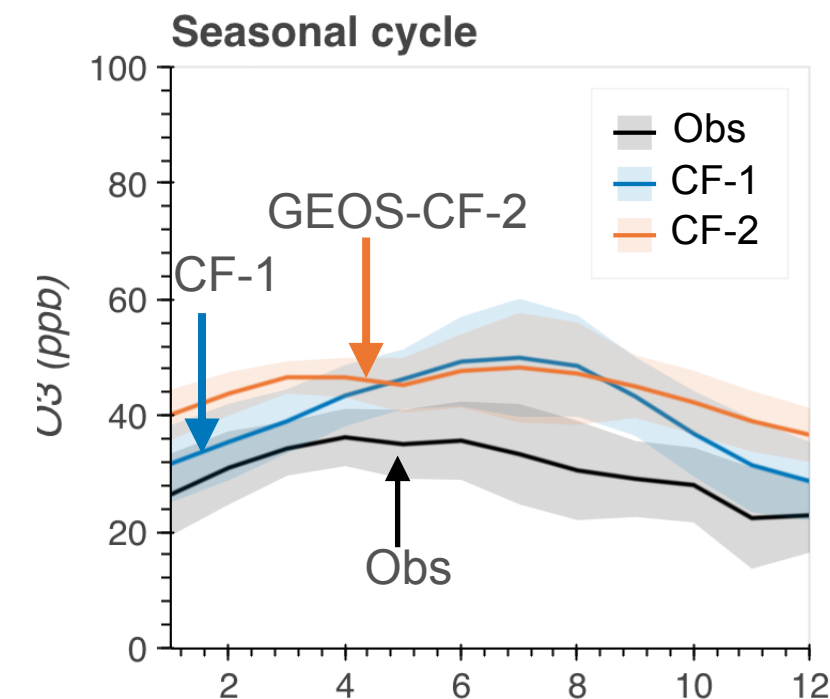
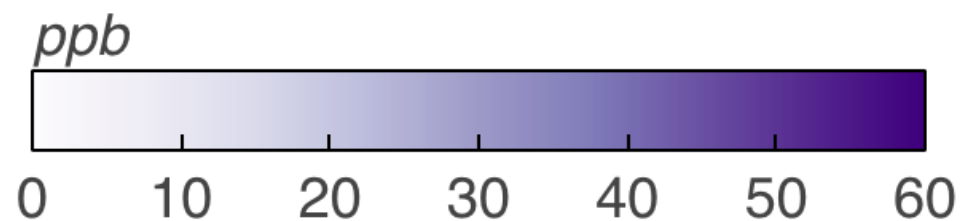
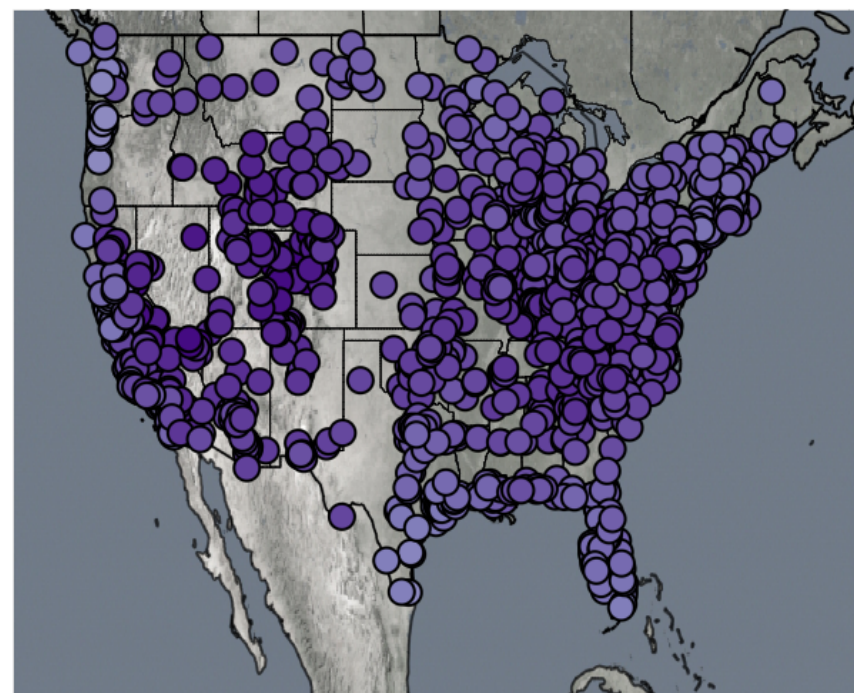
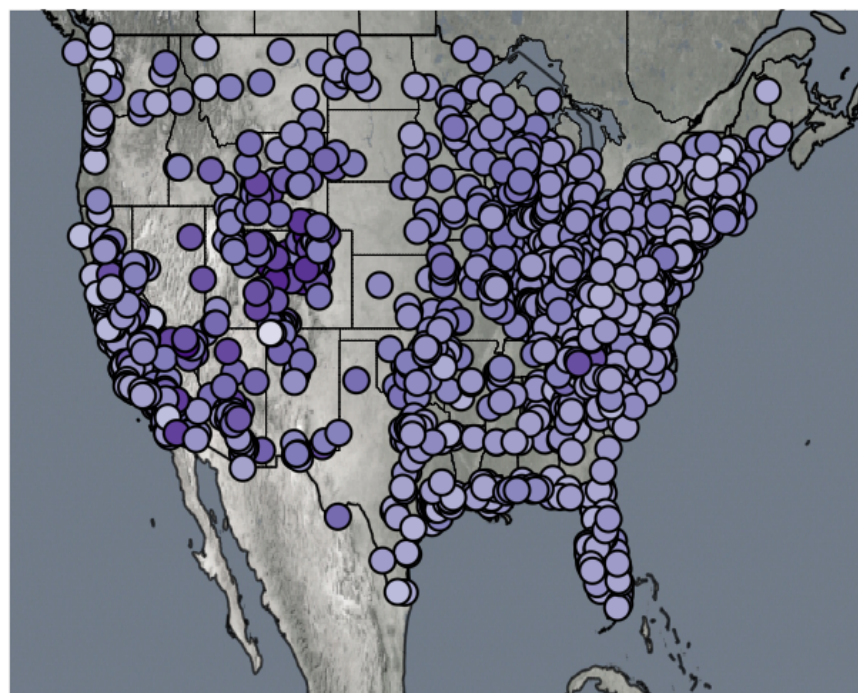
Results for 2023

But there is a high bias in surface ozone



Surface ozone is biased high – a persistent problem in global models

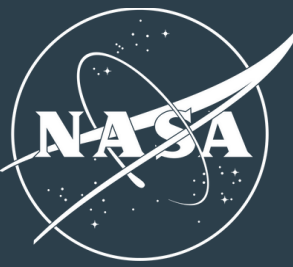
Seasonal cycle more consistent with observations



Less NO_x, insufficient ozone titration

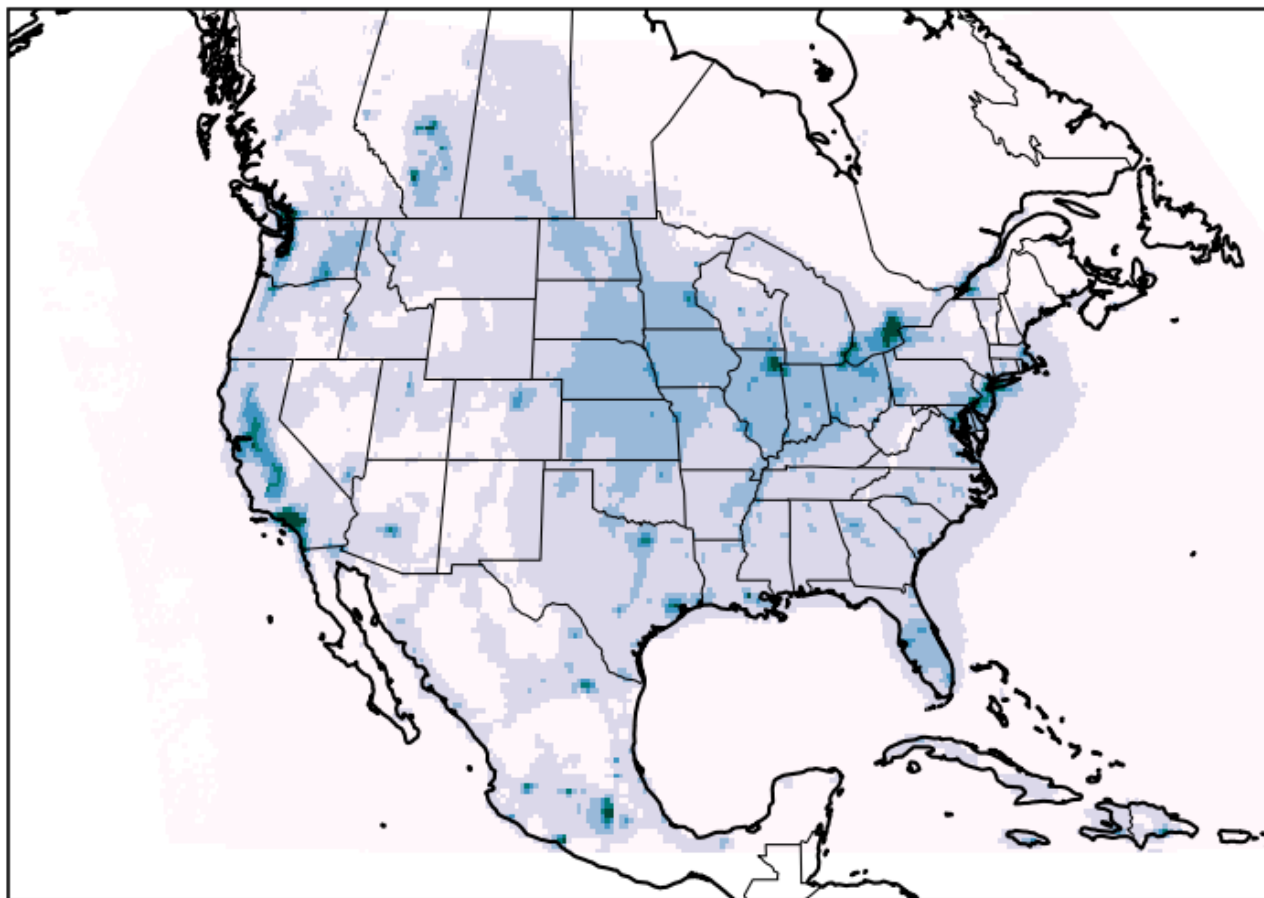
Results for 2023

But daytime NO_2 columns in GEOS-CF-2 are not low

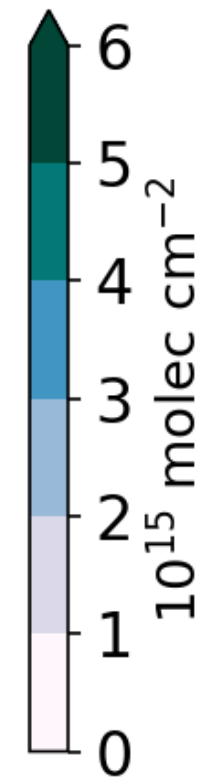
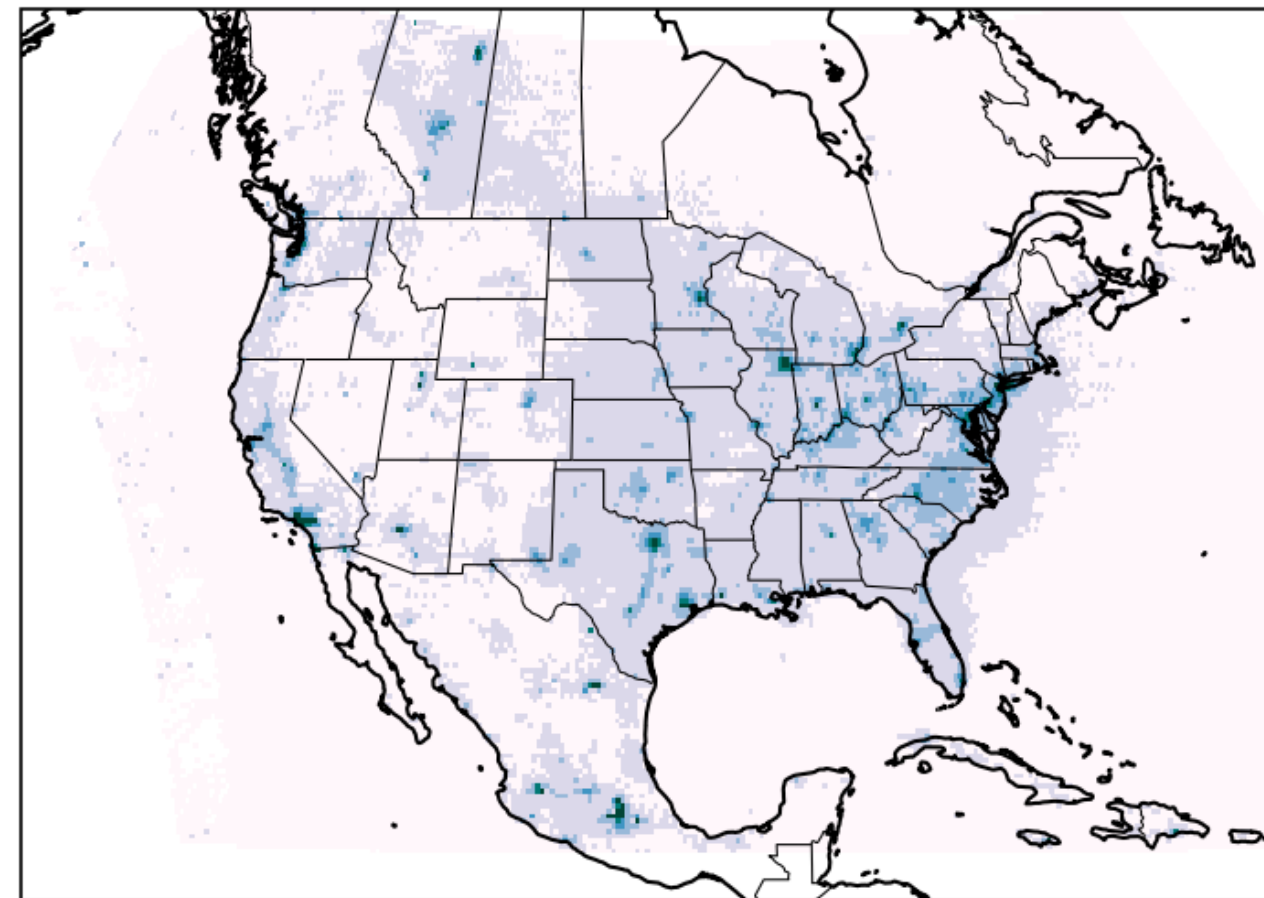


Tropospheric NO_2 columns Aug '23

GEOS-CF-2



TEMPO



**GEOS-CF-2 is consistent TEMPO data over cities,
but high over agricultural areas**

GEOS-CF is a state-of-the-science, versatile tool for atmospheric chemistry research and applications

Version 2 will include major updates and improvements, but some aspects need attention

Other developments on the horizon

Better vertical resolution and stretched-grid over CONUS

Transition to data assimilation with JEDI and include TEMPO data



Link to GEOS-CF
webpage and data