Improving ozone modeling in the Southeast US: how it affects background ozone estimates

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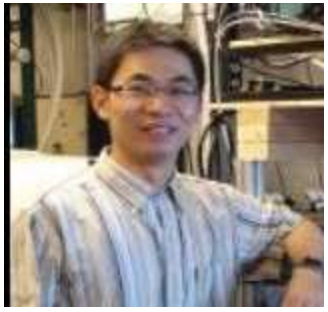
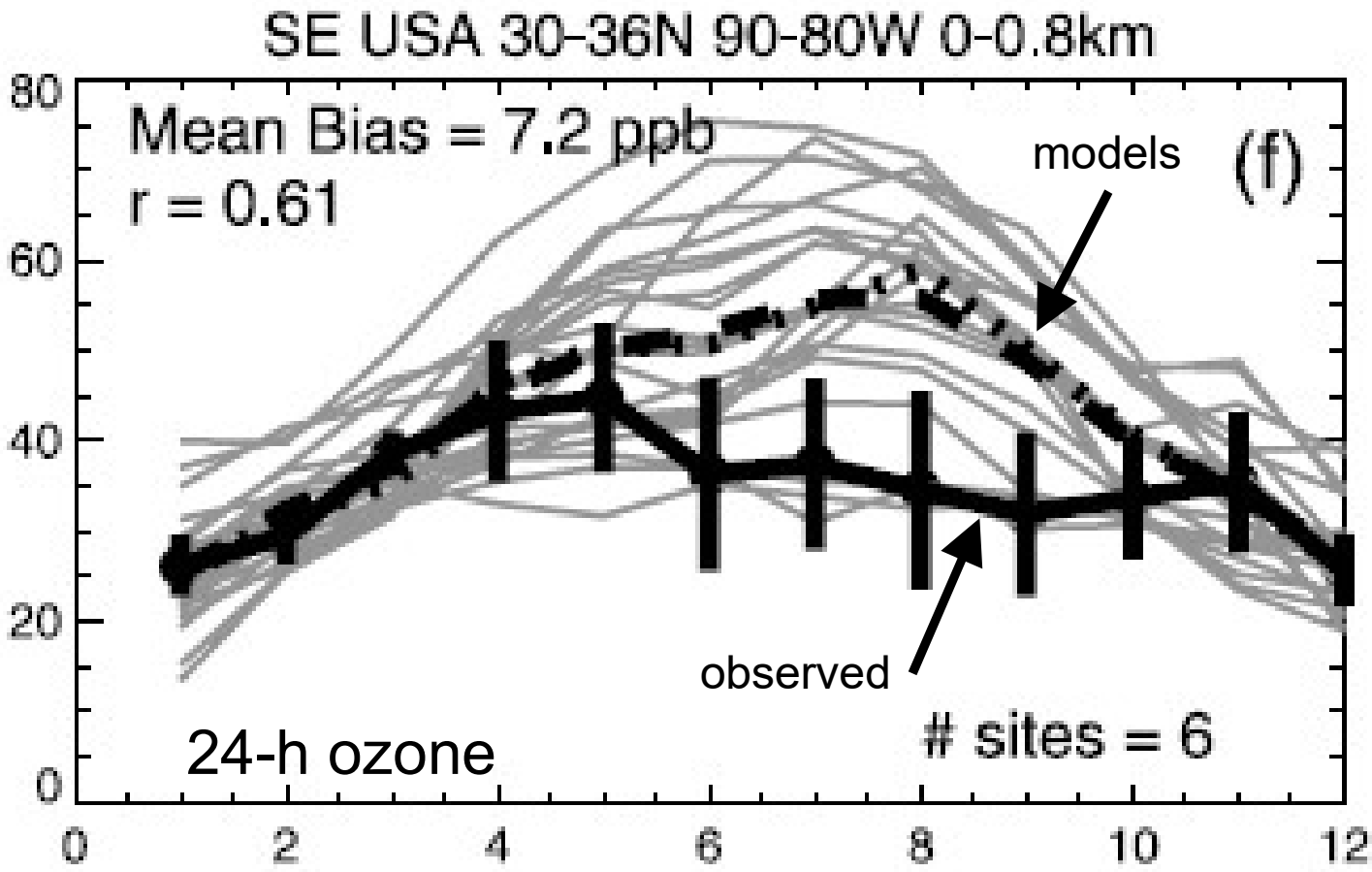


Models tend to overestimate surface ozone in the Southeast US in summer

HTAP model intercomparison:

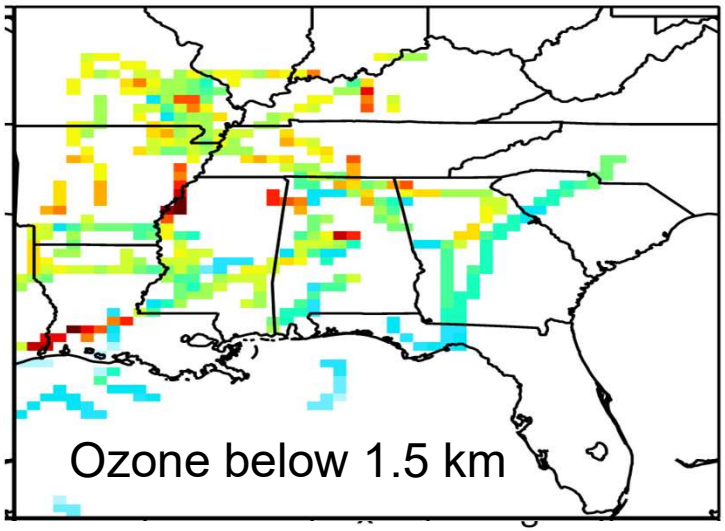


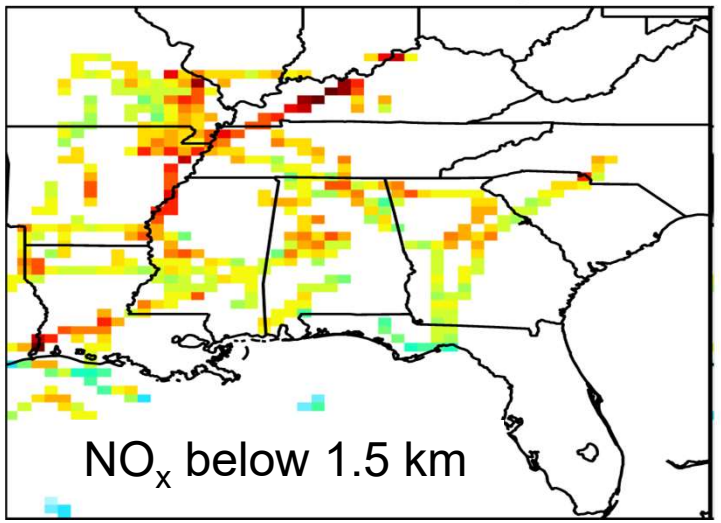
We need to understand this bias and the implications for ozone background estimates

Fiore et al. [2009]

SEAC^{4}RS campaign out of Houston (Aug-Sep 2013): NASA DC-8 aircraft with full chemical payload

T Ryerson, NOAA

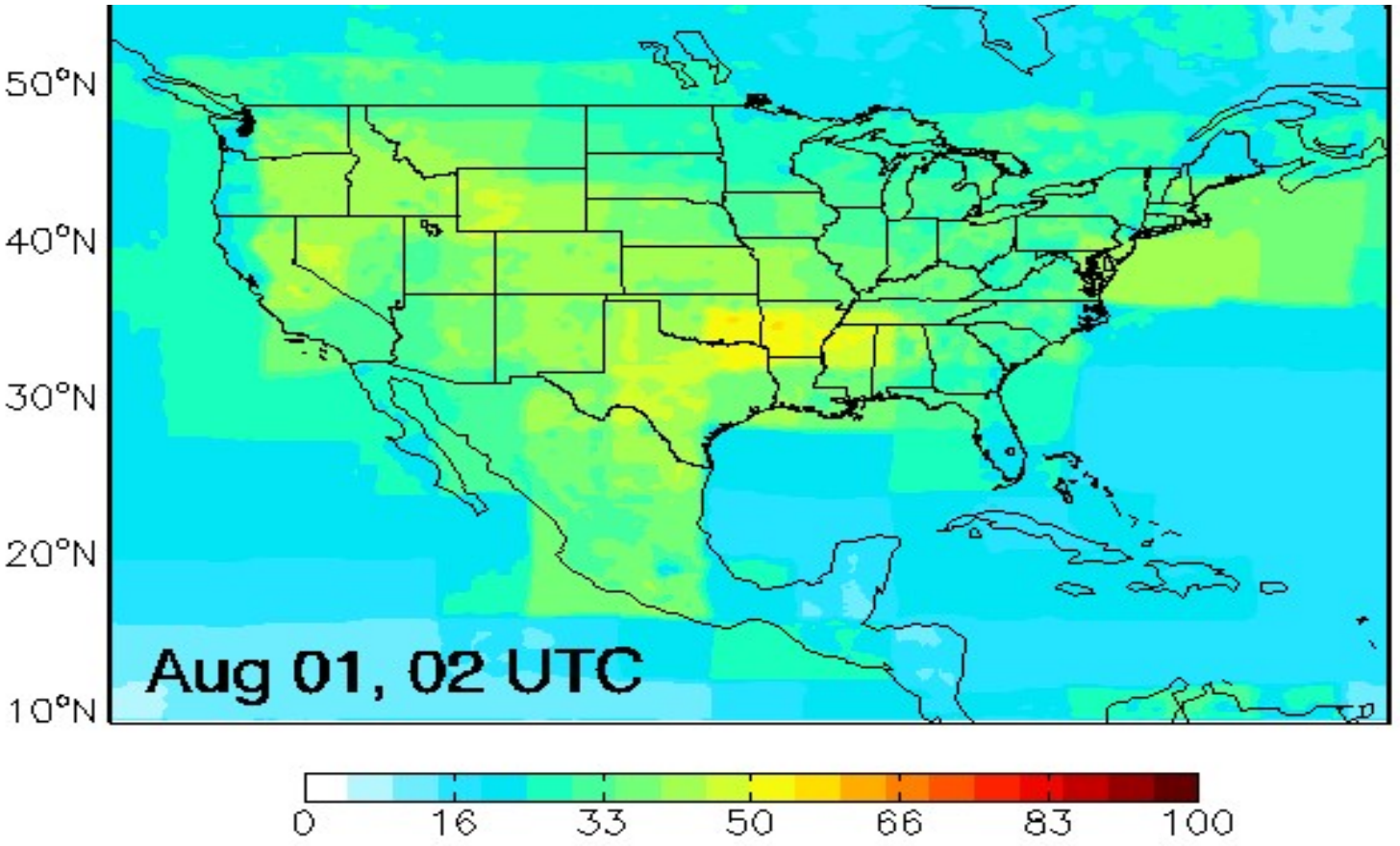




Near-real-time GEOS-Chem simulation during SEAC^{4}RS

GEOS-Chem with 0.25°x0.3125° resolution over North America
nested in global simulation with 2°x2.5° resolution
NASA GEOS-FP assimilated meteorological data
Anthropogenic US emissions from EPA NEI 2011

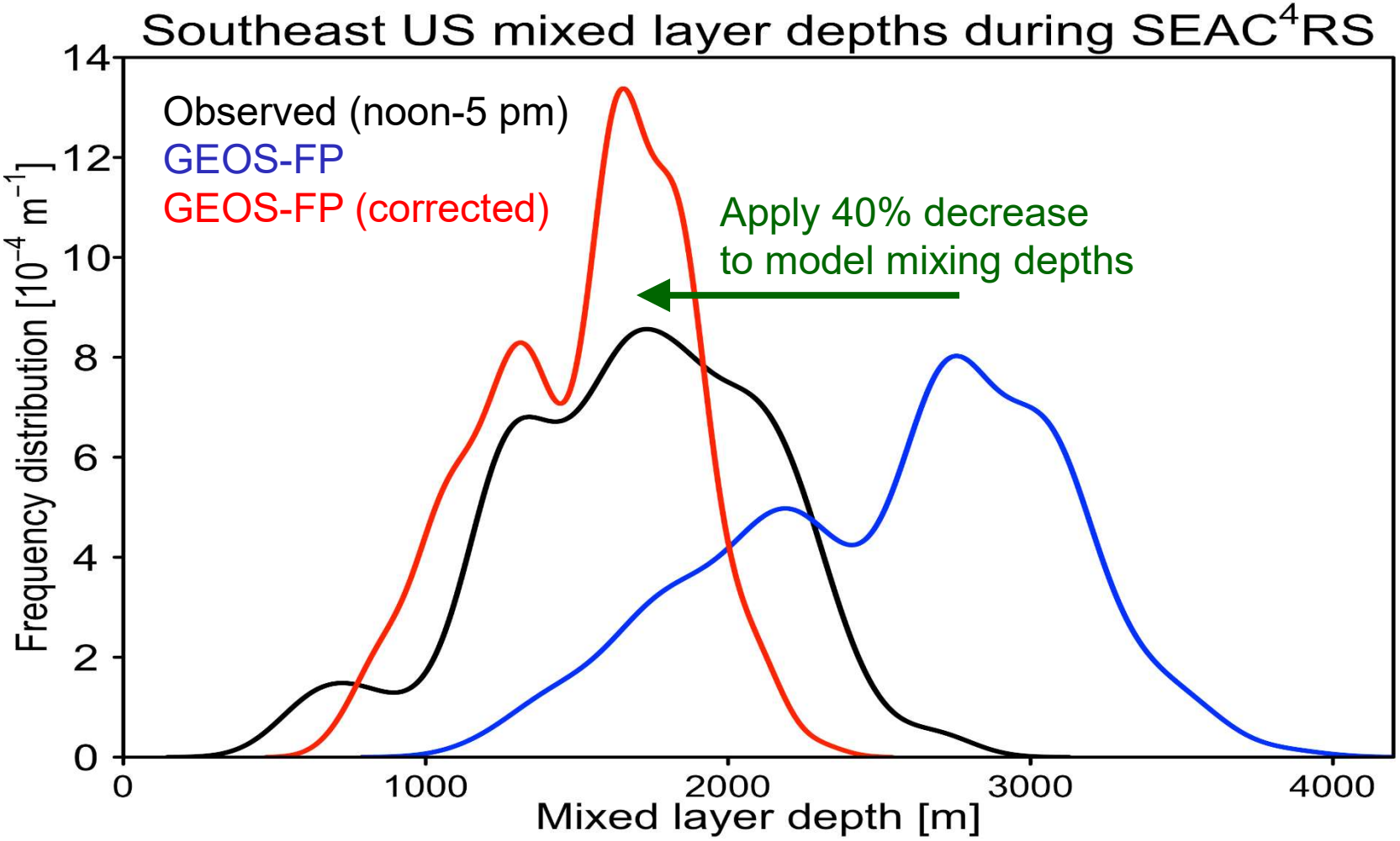
O_3 (ppb) in surface air - circles are aircraft data below 1 km



Karen Yu, Patrick Kim, Jenny Fisher, Katie Travis, Lei Zhu (Harvard)

Correcting model mixing depths

Model comparison to aircraft lidar observations (R. Ferrare, LaRC)



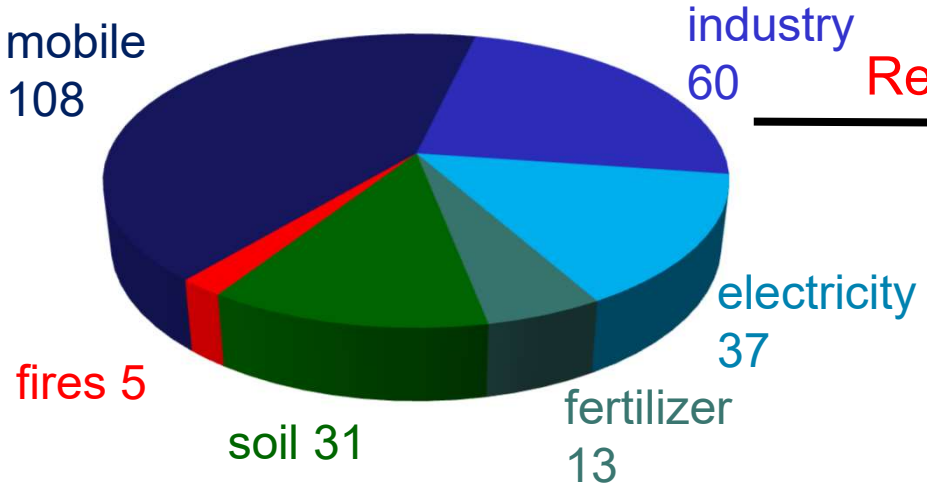
Summertime drying out in GEOS-FP causes excessive mixed layer depths

Zhu et al., submitted

Finding: NEI NO_x emissions are 2x too high

Aug-Sep 2013 surface NO_x emissions in Southeast US
NEI13 + soils + open fires [Gg]

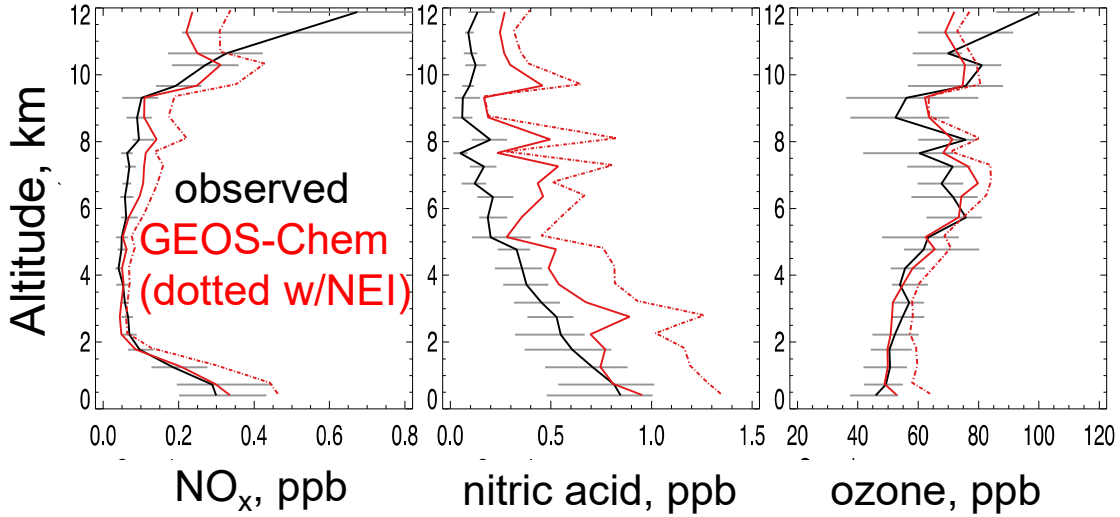
Travis et al., submitted



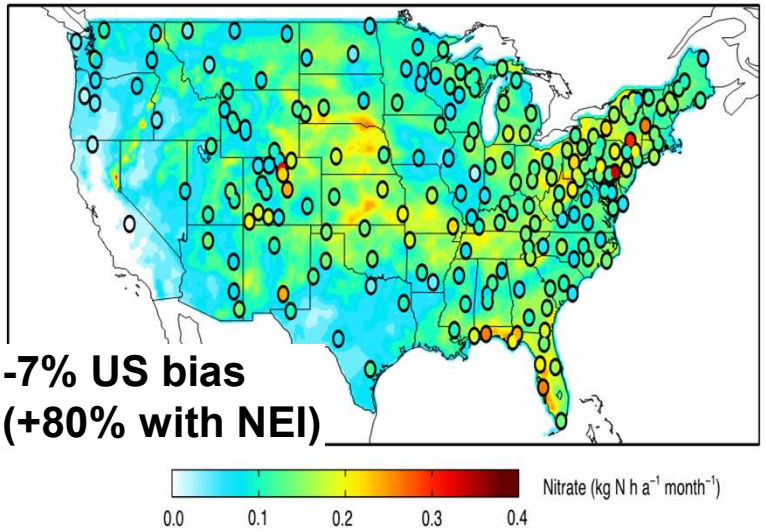
Reduce mobile+industry emissions by 60%

Observations by
G. Huey, J. Dibb,
T. Ryerson

SEAC⁴RS median vertical profiles



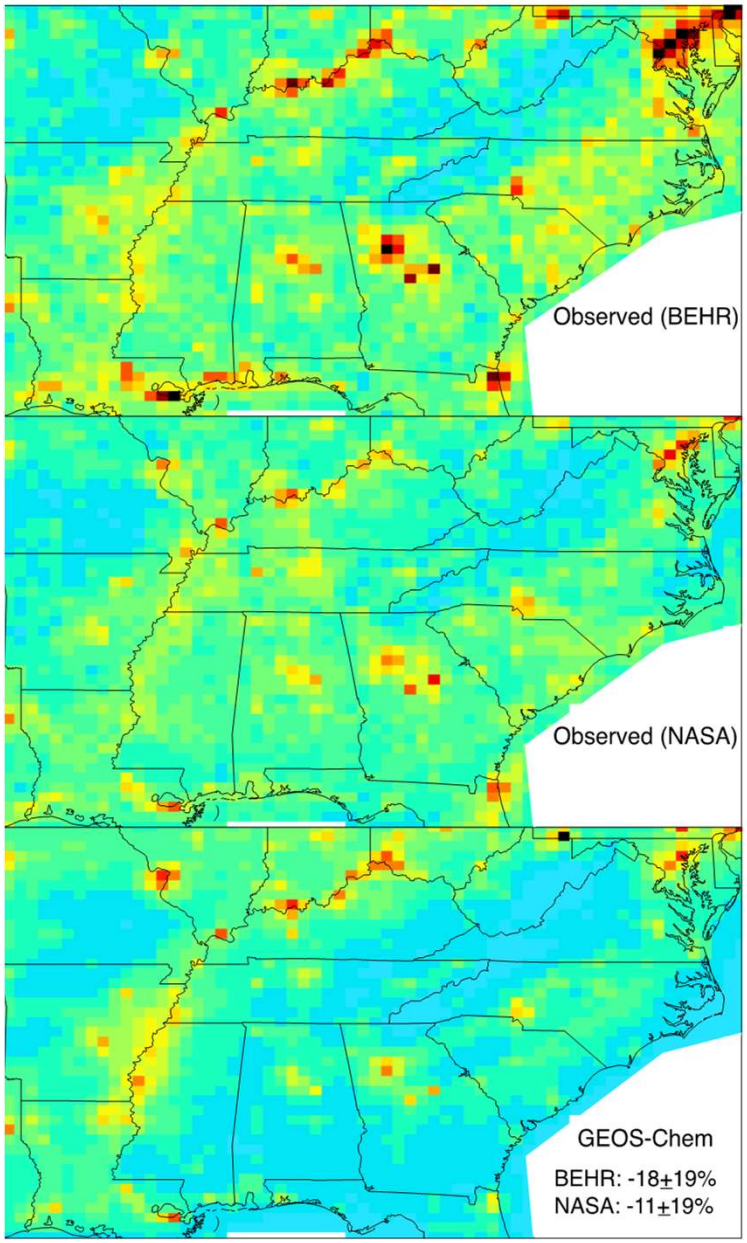
Nitrate wet deposition flux (obs in circles)

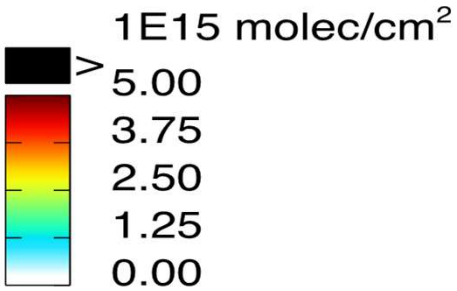


Comparison to OMI NO_2 tropospheric columns

OMI NO_2 (BEHR)

OMI NO_2 (NASA)





GEOS-Chem with reduced NO_x emissions

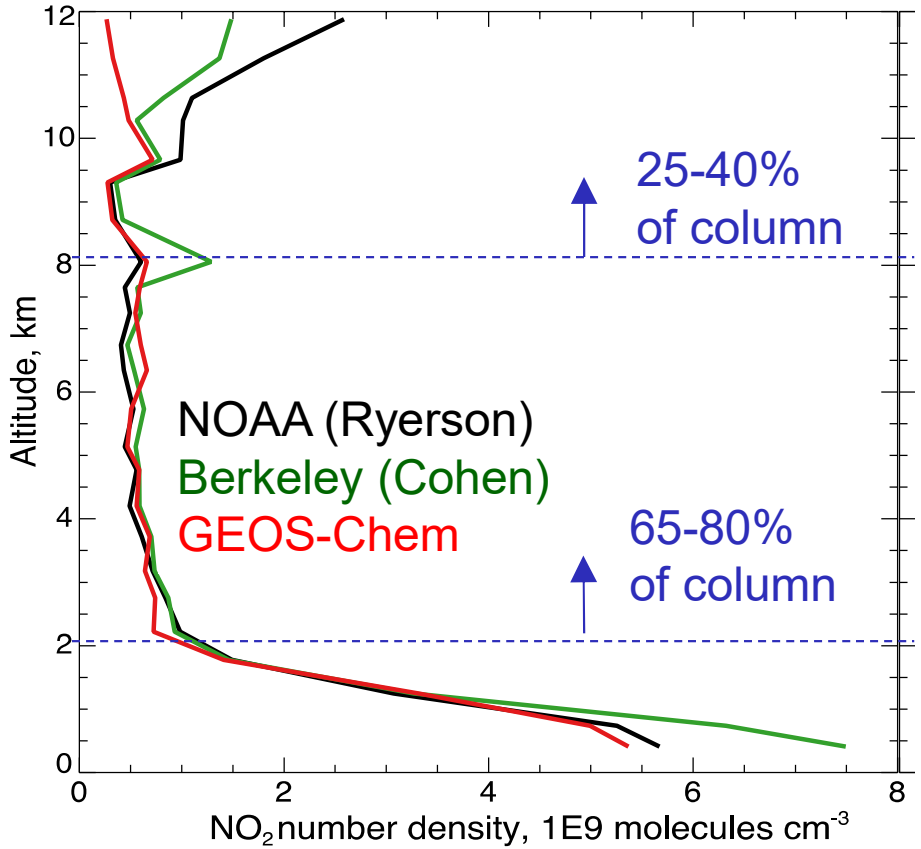
-18% vs. BEHR
-11% vs. NASA

Low bias in GEOS-Chem is due to lightning, not surface emissions

Travis et al., submitted

Lightning makes major contribution to OMI NO_2 tropospheric column in summer

Mean SEAC^{4}RS NO_2 profile over Southeast

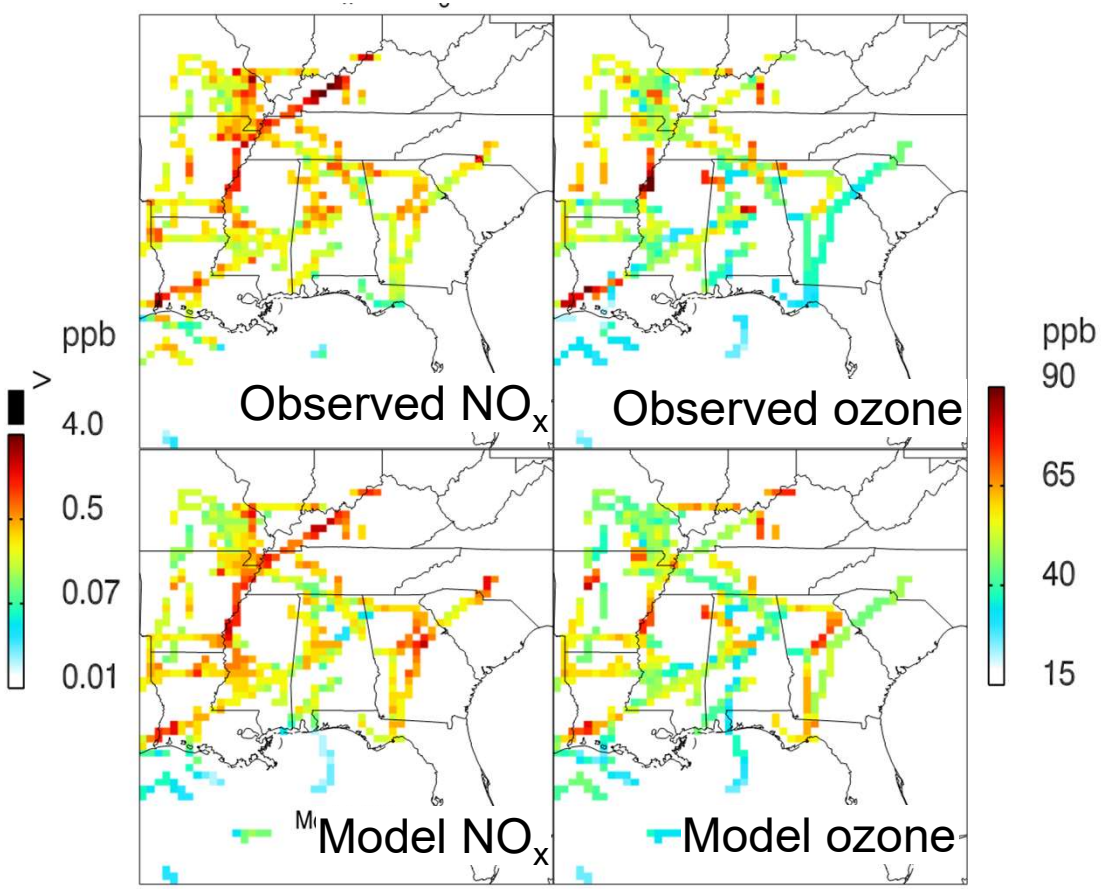


GEOS-Chem low bias in upper troposphere driven by NO/NO_2 chemistry

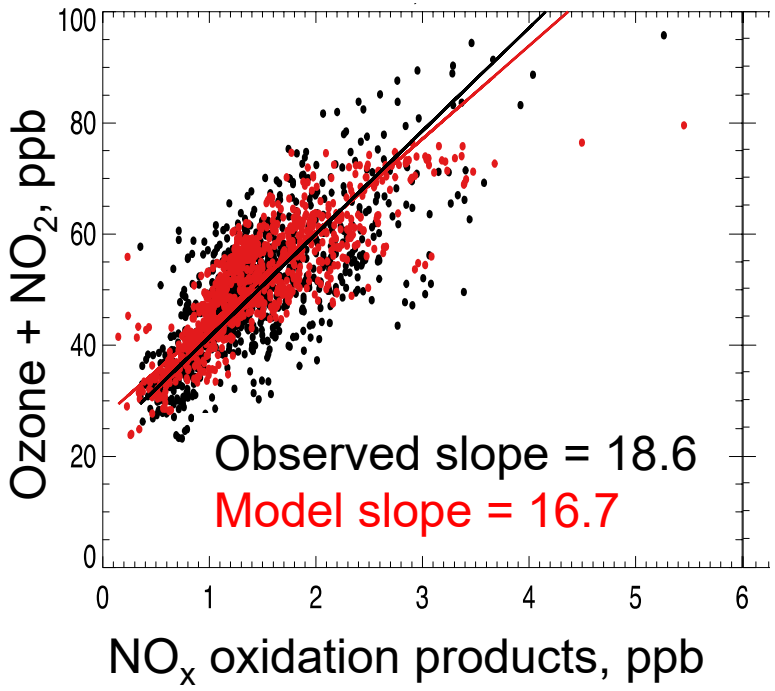
Travis et al., submitted

Boundary layer NO_x, ozone, ozone production efficiency are well simulated after NO_x emissions are decreased

Concentrations below 1.5 km



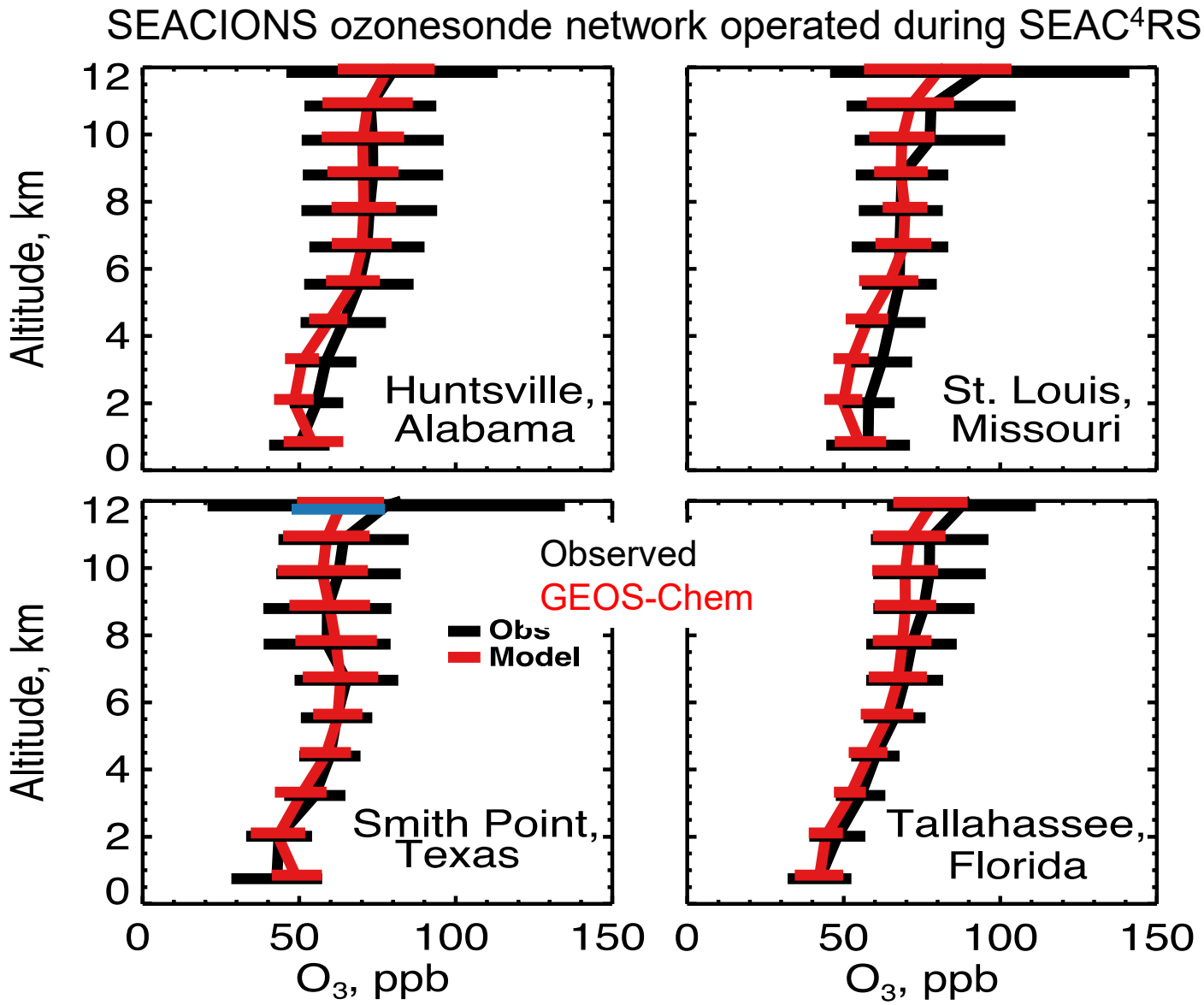
Ozone vs. NO_x oxidation products



Mean model bias for ozone is +2 ppb; before decreasing NO_x emissions it was +16 ppb

Travis et al., submitted

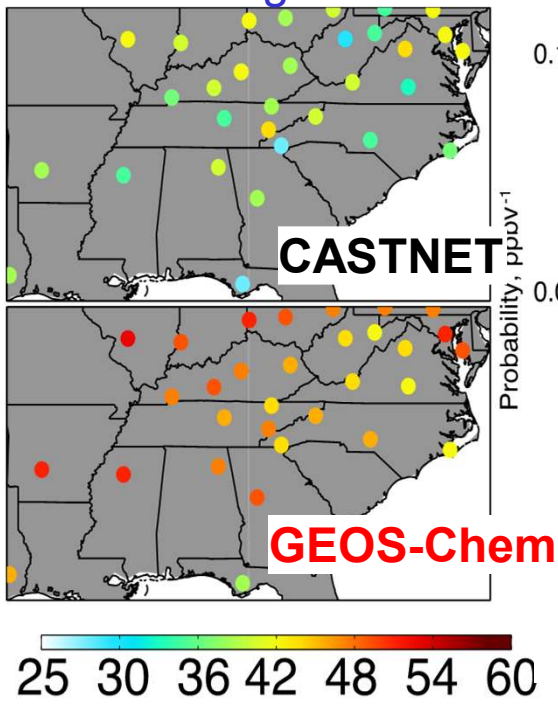
Ozonesonde data in Southeast US are also well simulated



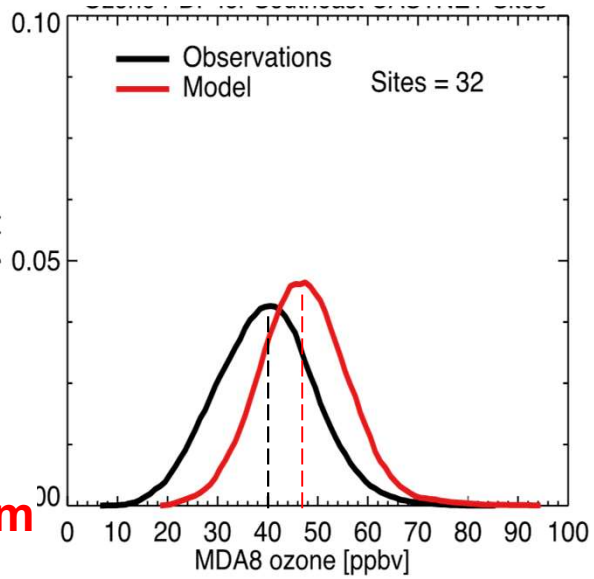
Travis et al., submitted

But model is still too high by 9 ppb for surface ozone: cause is excessive boundary layer mixing

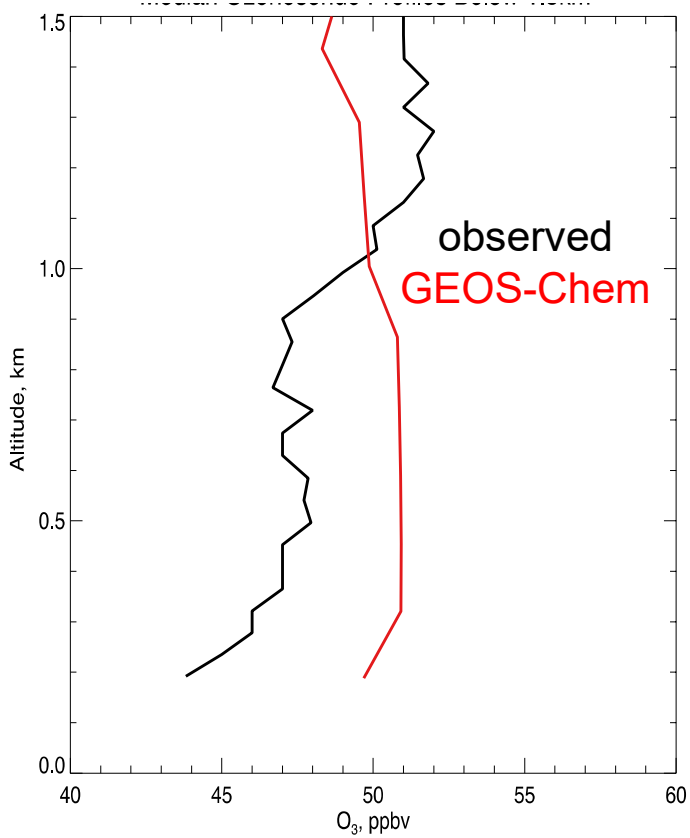
Mean MDA8 ozone (ppb)
Jun-Aug 2013



PDF of MDA8 ozone
Jun-Aug 2013



SEACIONS ozonesondes
11am-2pm below 1.5 km

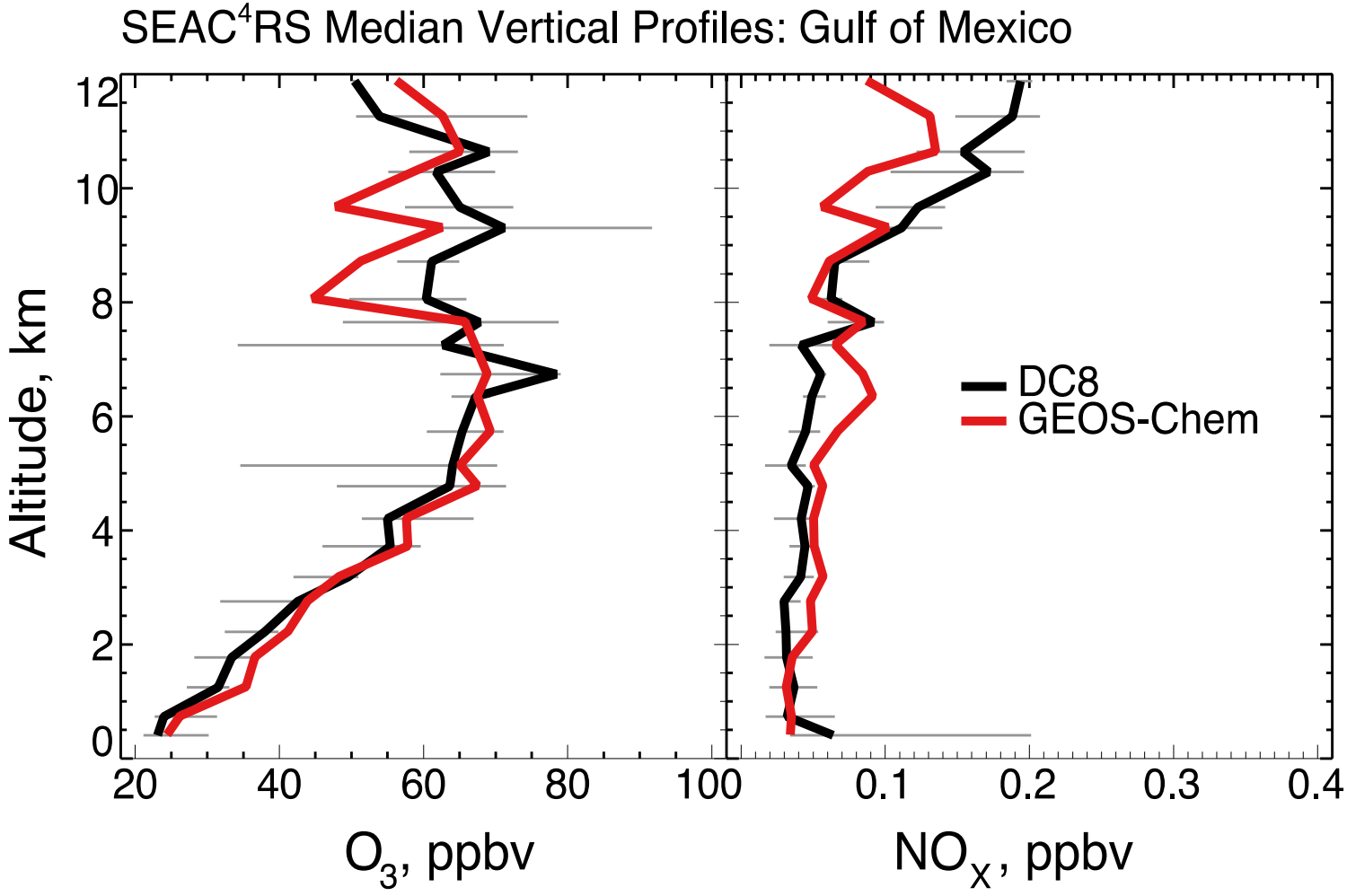


- Midday ozonesondes show 7 ppb decrease from 1.5 km to 0.2 km, not GEOS-Chem
- Excessive boundary layer mixing in GEOS-Chem caused by excessive dryness

Travis et al., submitted

Ozone background over Gulf of Mexico is well simulated

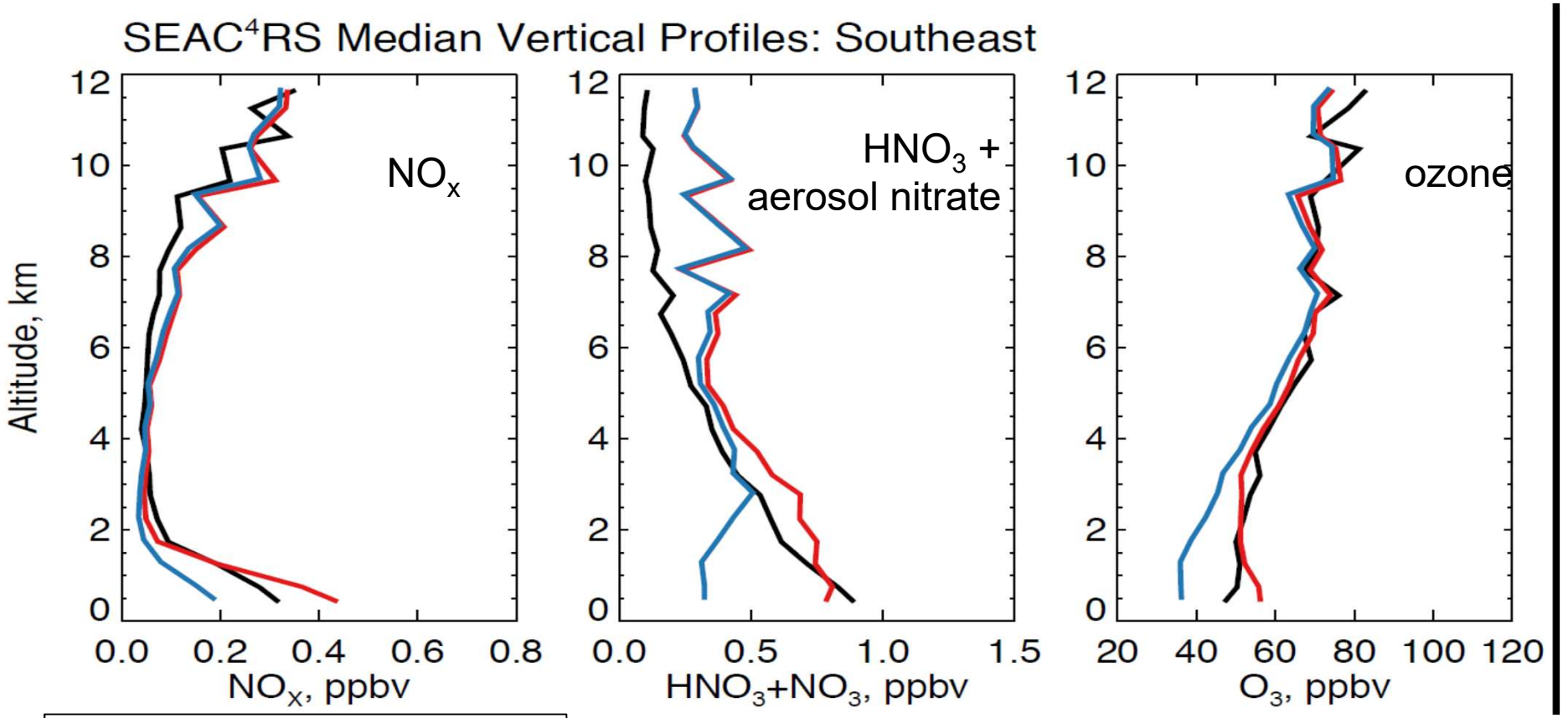
Excessive ozone over the Gulf is not the problem



Travis et al., submitted

N. American background ozone: comparison to SEAC^{4}RS

Background simulation shuts off all anthropogenic emissions in N America



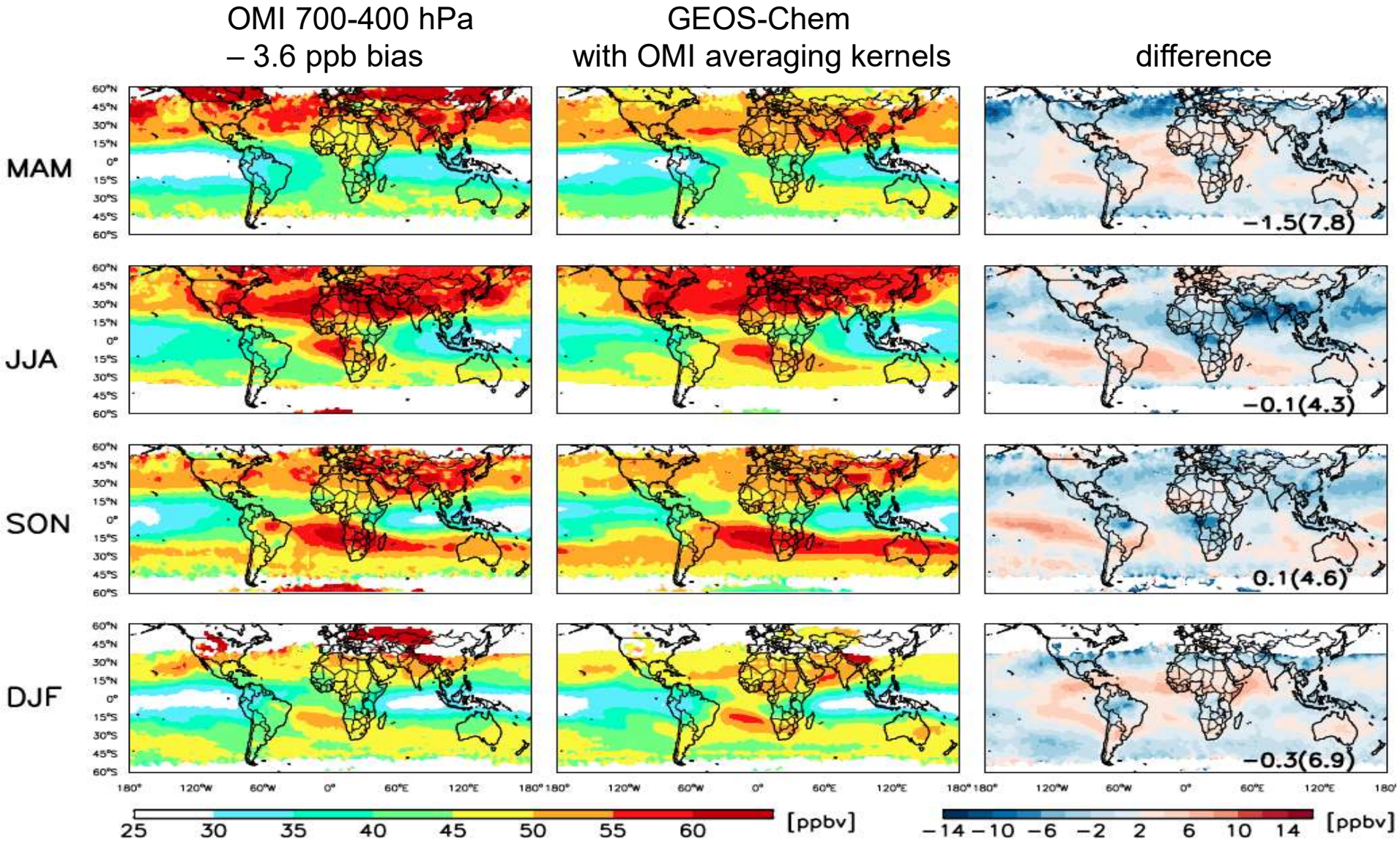
Observed
GEOS-Chem (standard)
GEOS-Chem (background)

Anthropogenic emissions increase NO_x only by factor 2, enough for 20 ppb increase in ozone

Travis et al., in prep.

Tropospheric ozone evaluation of current GEOS-Chem version

OMI satellite data validated with ozonesondes, reprocessed with uniform prior



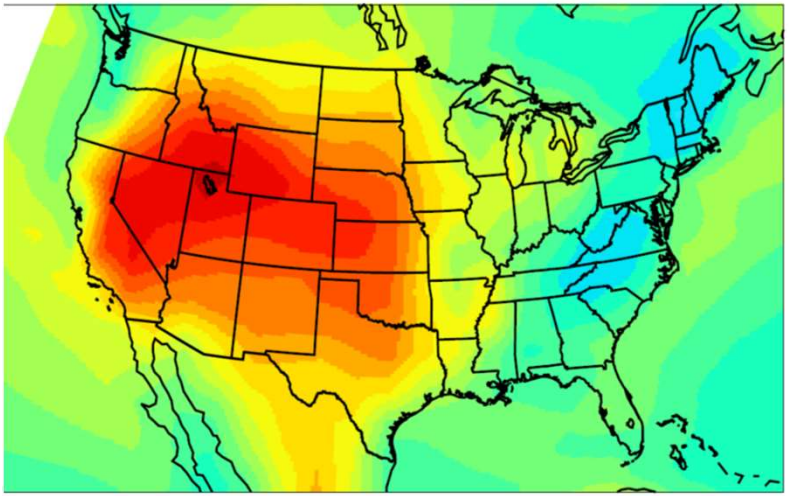
Hu et al., in prep.

N. American ozone background estimated with GEOS-Chem

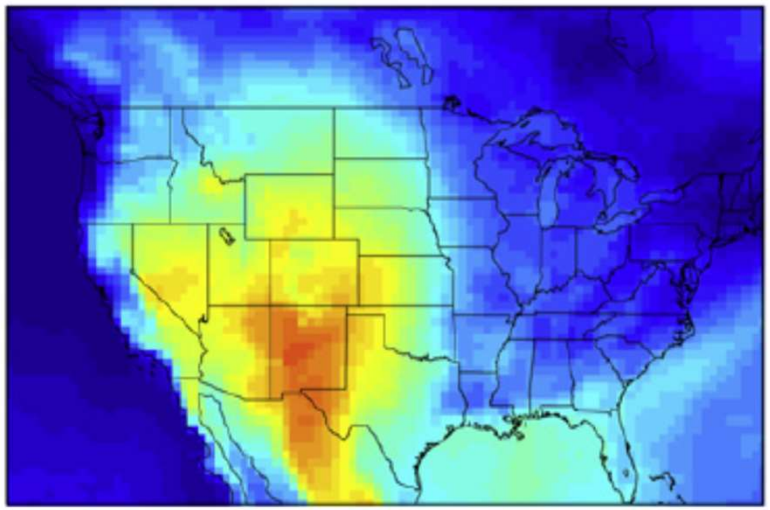
Simulation shutting off all anthropogenic N American emissions

Mean MDA8 ozone background for summer (JJA)

Current model



Zhang et al. [2011]

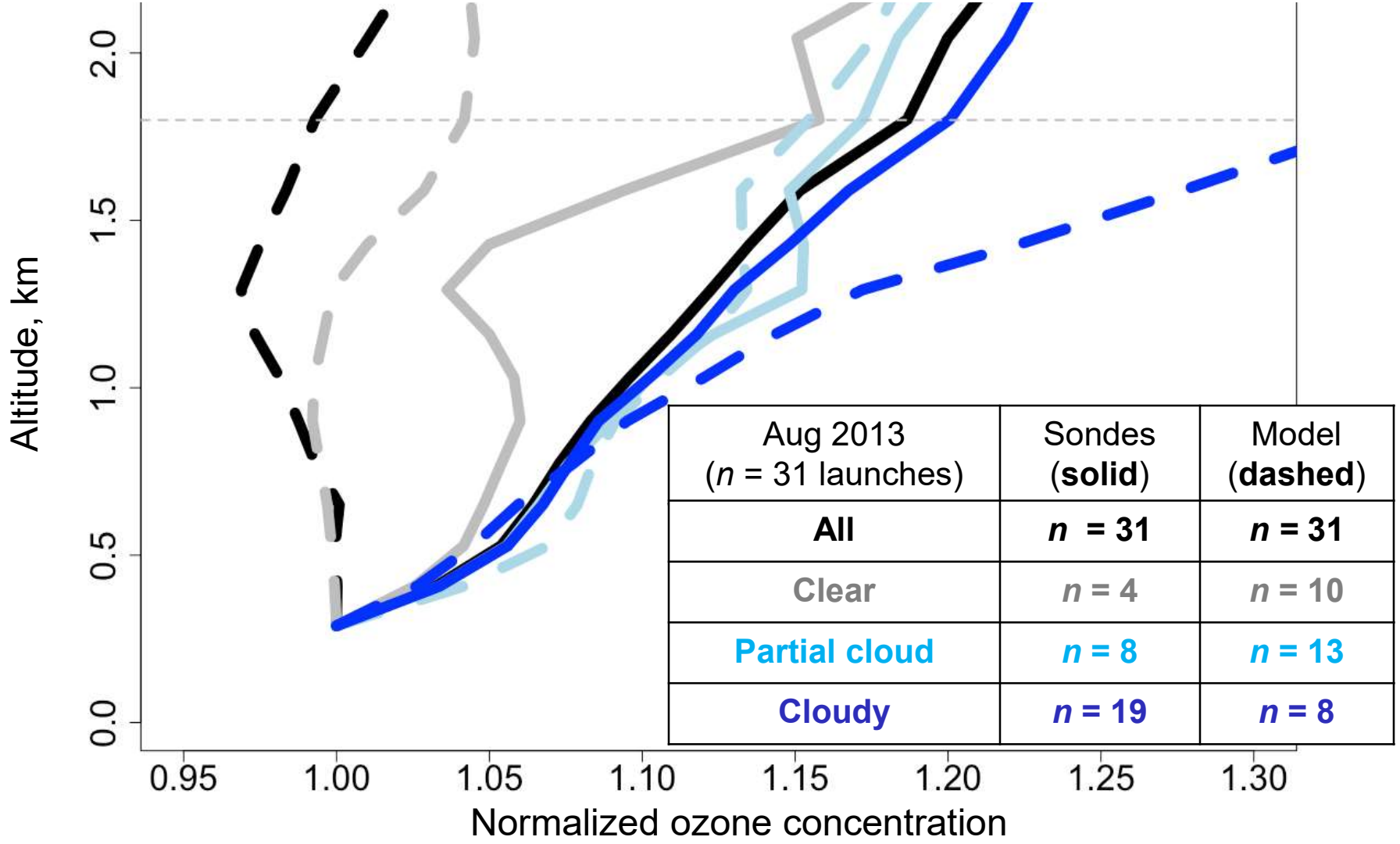


- Northward shift in western US maximum (updated lightning)
- Ring of elevated values along Gulf Coast is gone
- Otherwise not much difference – despite lots of change in model
- Need to worry about soil moisture!

Travis et al., in prep.

Why is PBL mxing excessive in GEOS-Chem?

Normalized ozone profiles at Huntsville, AL in August 2013

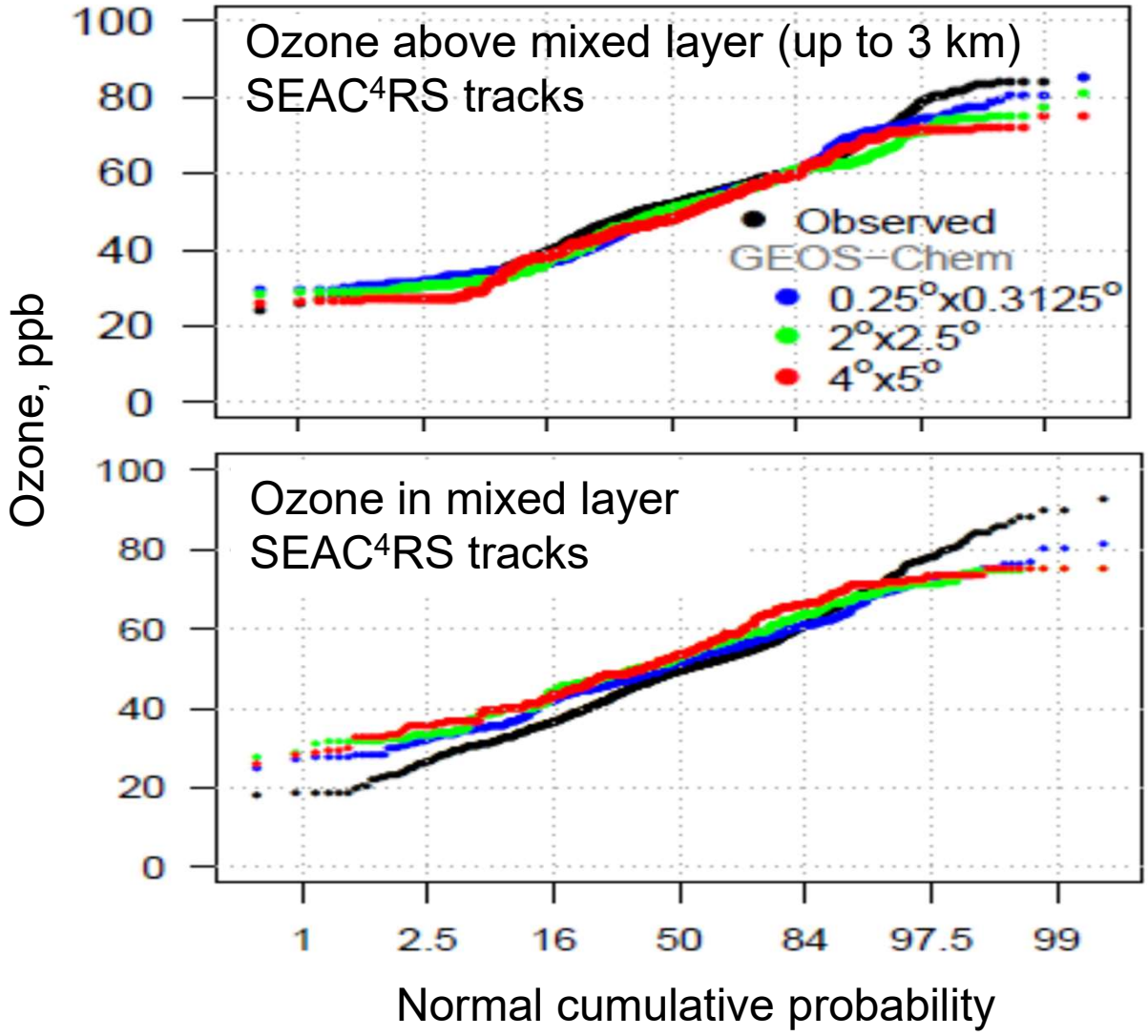


Aug 2013 (*n* = 31 launches)	Sondes (**solid**)	Model (**dashed**)
All	***n* = 31**	***n* = 31**
Clear	***n* = 4**	***n* = 10**
Partial cloud	***n* = 8**	***n* = 13**
Cloudy	***n* = 19**	***n* = 8**

Model underestimates cloudiness, probably due to soil drying out over summer

Katie Travis, in prep.

Model of SEAC^{4}RS period shows little sensitivity to grid resolution: implies that 2°x2.5° is acceptable for calculations of background ozone



Yu et al. [2016]