Assessing the Ability of Instantaneous Aircraft and Sonde Measurements to Characterize Climatological Means and Long-Term Trends in Tropospheric Composition

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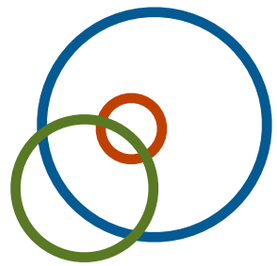
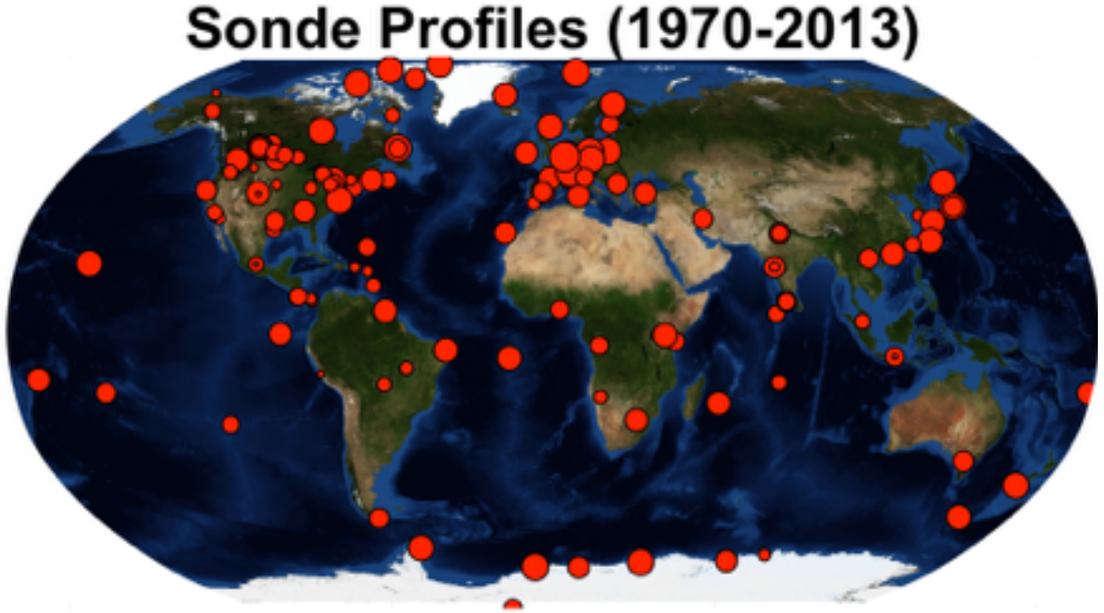


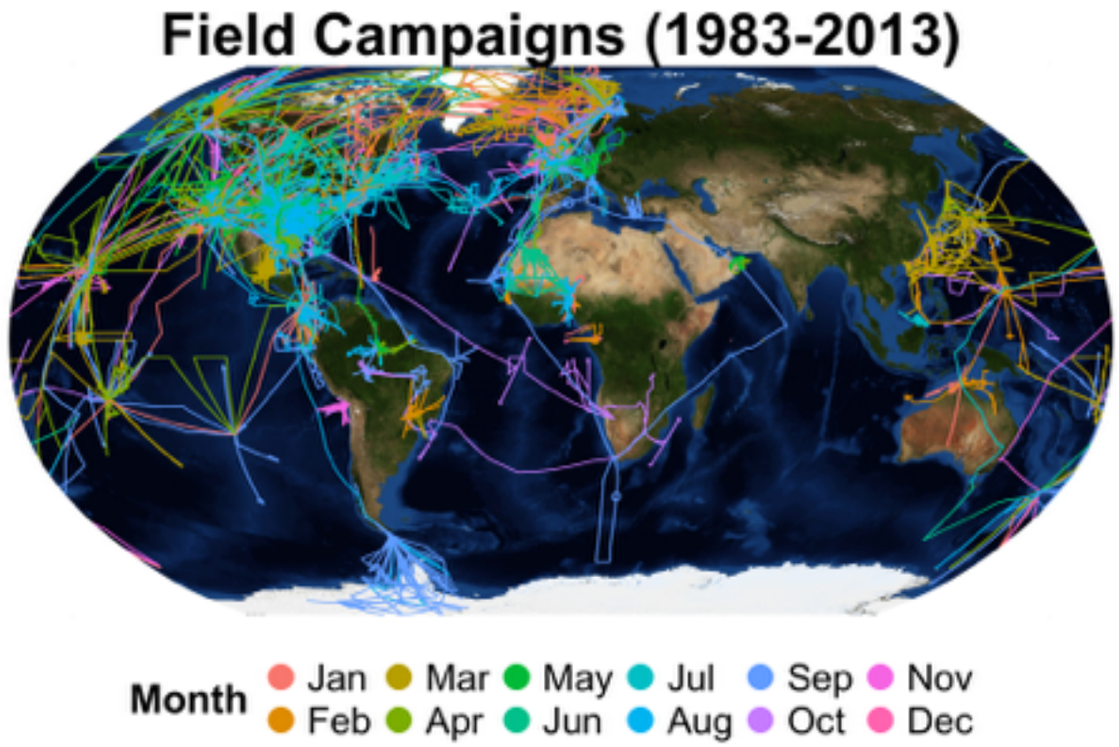
#A54E-05

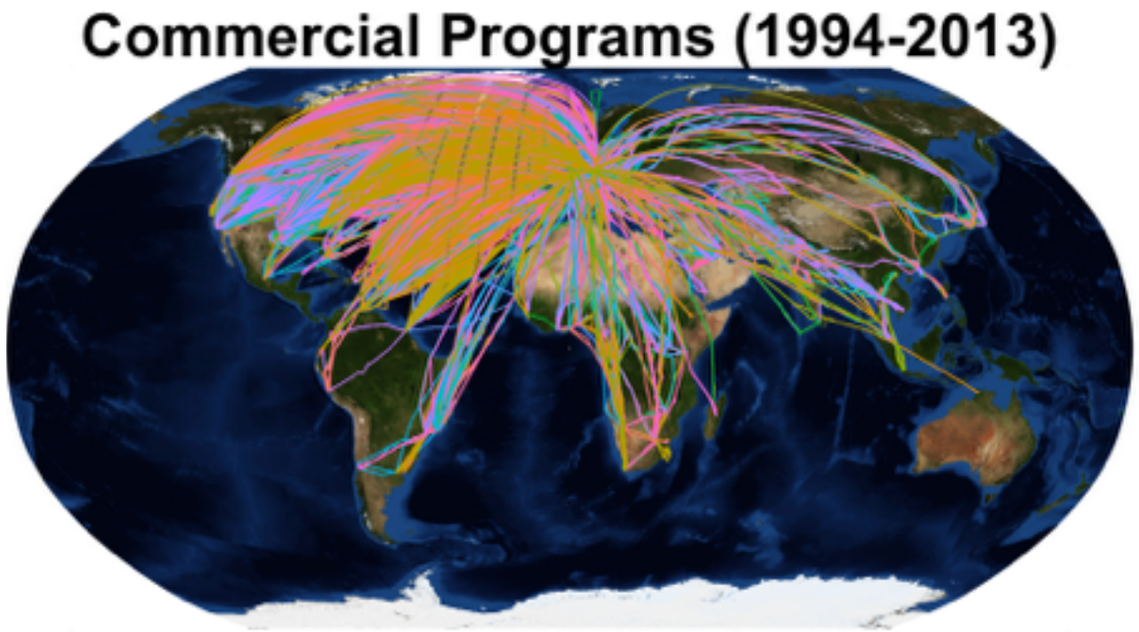
Over 40 yrs of 3-D *in situ* sampling of the troposphere



WOUDC (http://www.woudc.org)

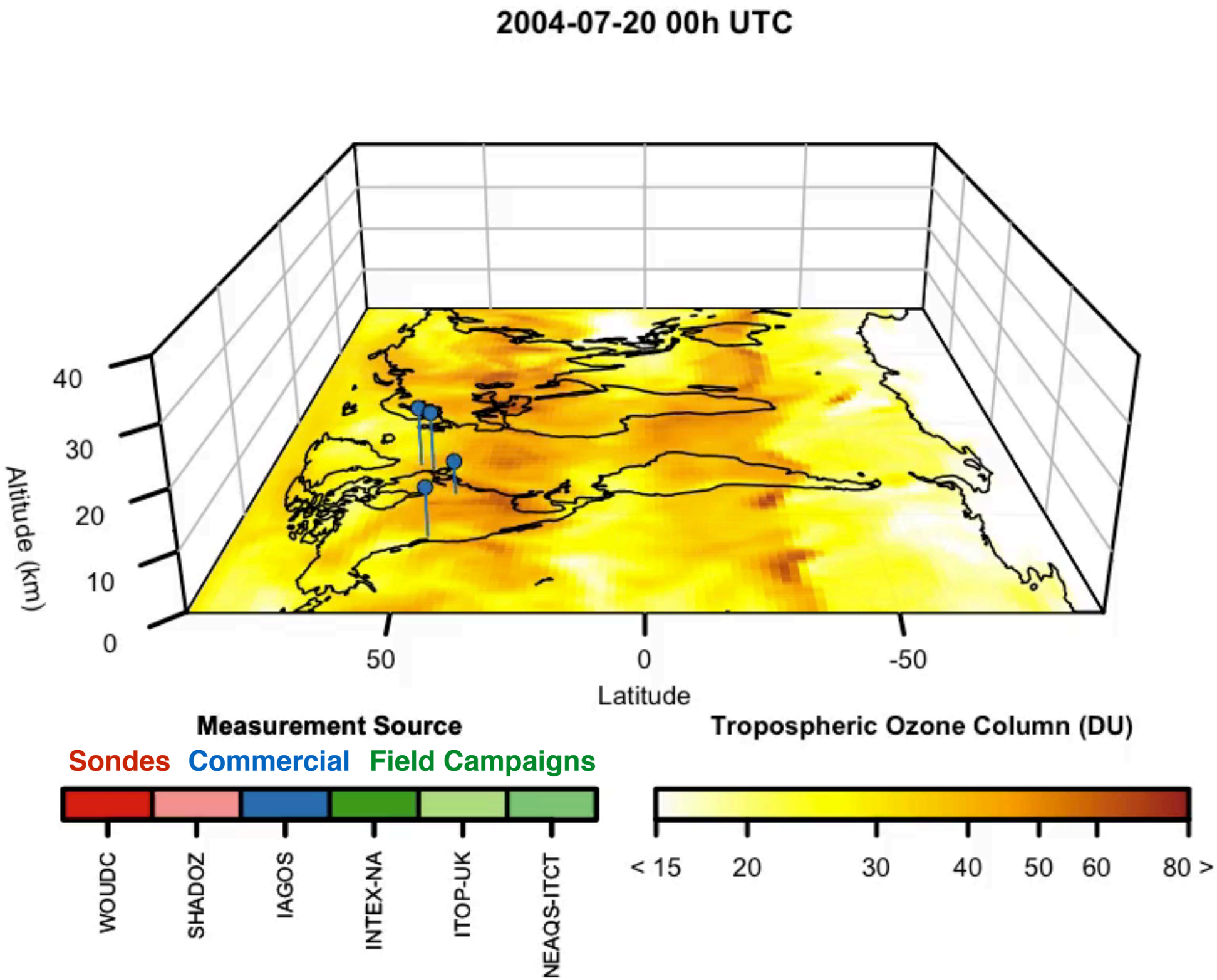
NASA, NOAA, NSF/NCAR,
NERC, DLR, *et. al*





IAGOS (http://iagos.org)
MOZAIC/CARIBIC

Observations discretely sample a dynamic 4-D system



Can we use these observations to constrain CCMs?

- Chemistry transport models (CTMs) may be evaluated by exact space-time matching
- Chemistry-climate models (CCMs) generate their own weather so cannot match observations exactly in space and time
- CCMs are typically evaluated with observed climatologies

Questions

- Are aggregated *in situ* observations indicative of background mean conditions?
- Where can these observations be used to constrain processes in CCMs?
- Can discrete sampling be used to constrain long-term trends?

Approach: Use CTM to compare *in situ* and "CCM" output

GEOS-Chem CTM
v9_02; 2°x2.5°; 47L; MERRA
Jan 2003-Dec 2012

Decadal Monthly Mean Climatology

Sample location at exact time of flight/sonde track

Sample location's clim. monthly mean for each observation

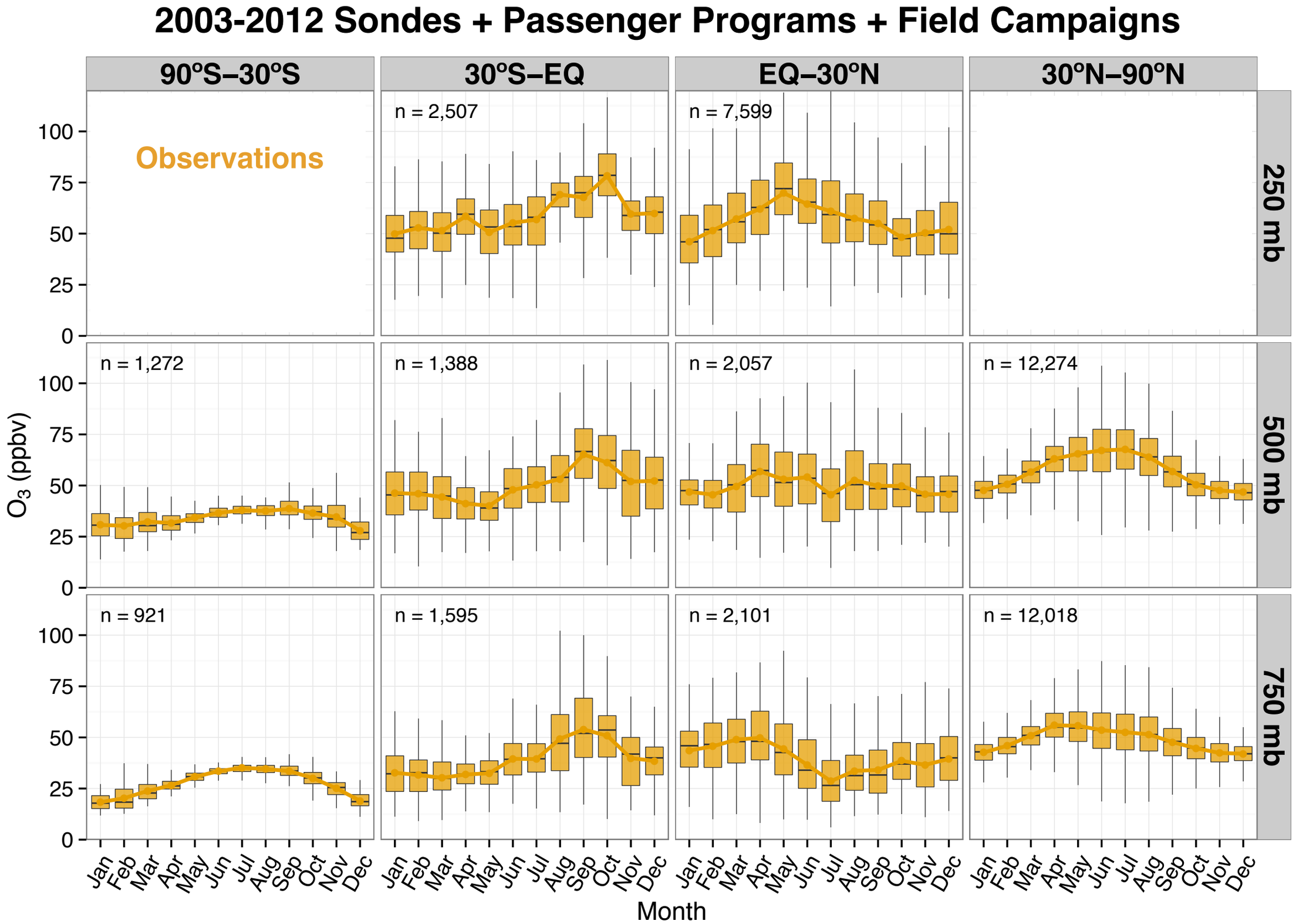
"CTM-like sampling"

"CCM-like sampling"

Simulated global "true" background concentrations

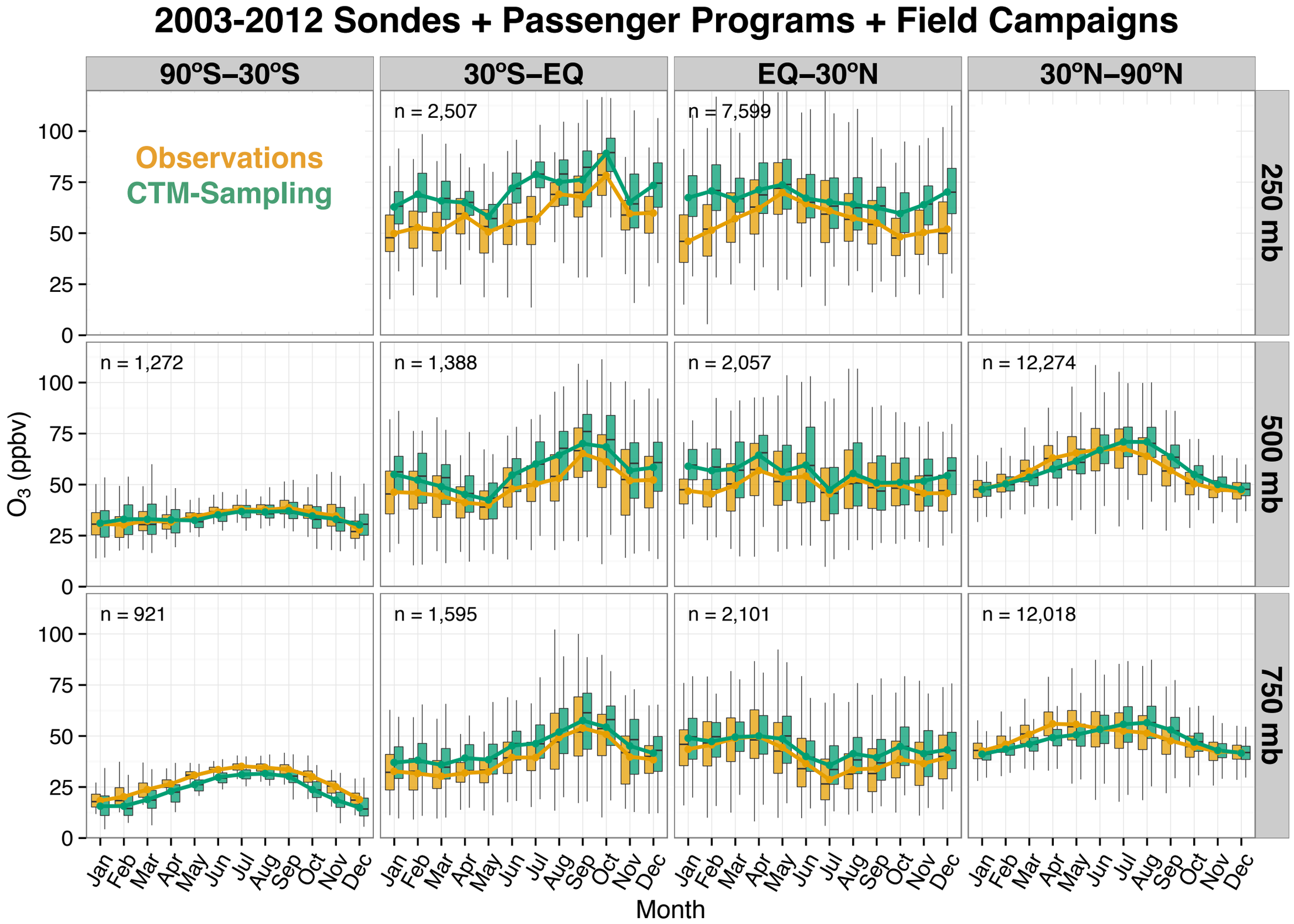
Compare all three to assess suitability of observations to characterize mean atmospheric composition

Ozone most-sampled tropospheric trace gas distribution



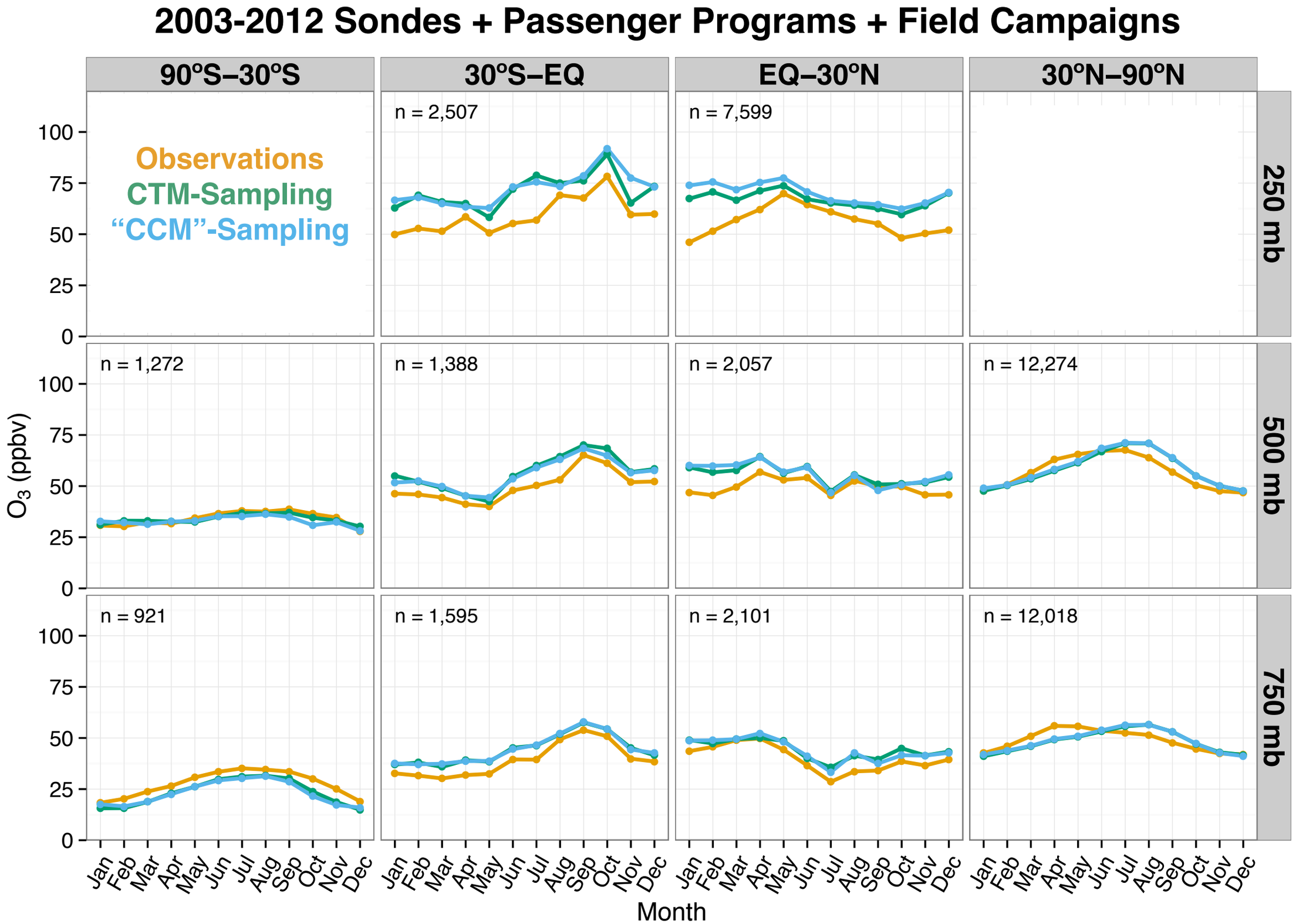
Ozone increases w/ latitude and altitude; large variability in FT; spring surface maxima

CTM sampled in space and time captures salient features



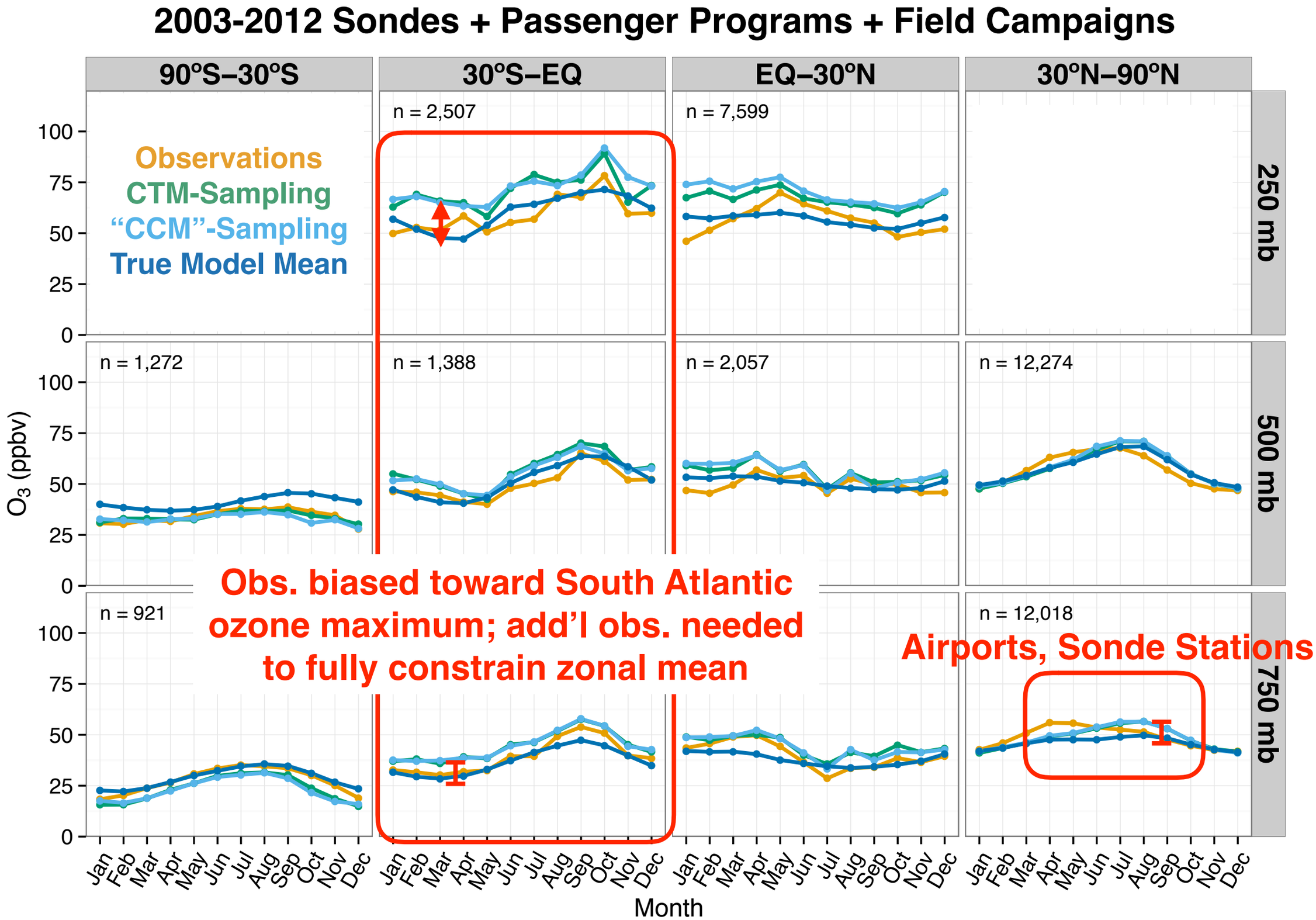
GEOS-Chem biased high ~7%; captures 87% of meridional, vertical, seas. variability (*n*=10 reg. x 12 mon.)

Sampling ozone decadal monthly means reproduces mean of direct sampling



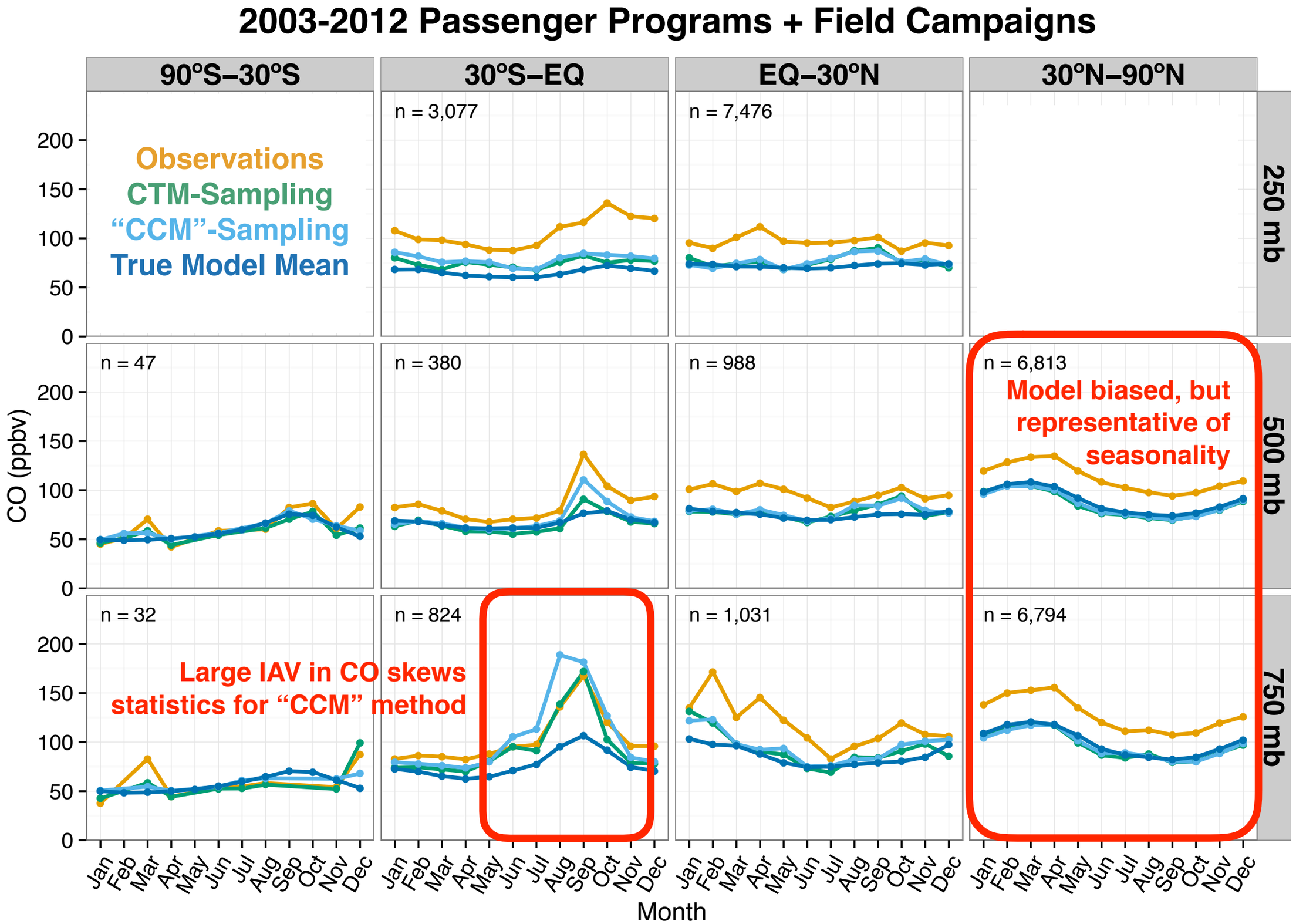
CCM decadal mean ozone patterns can be constrained with aggregated climatological observations

O_3 clim. fairly representative of "true" background mean & seasonality

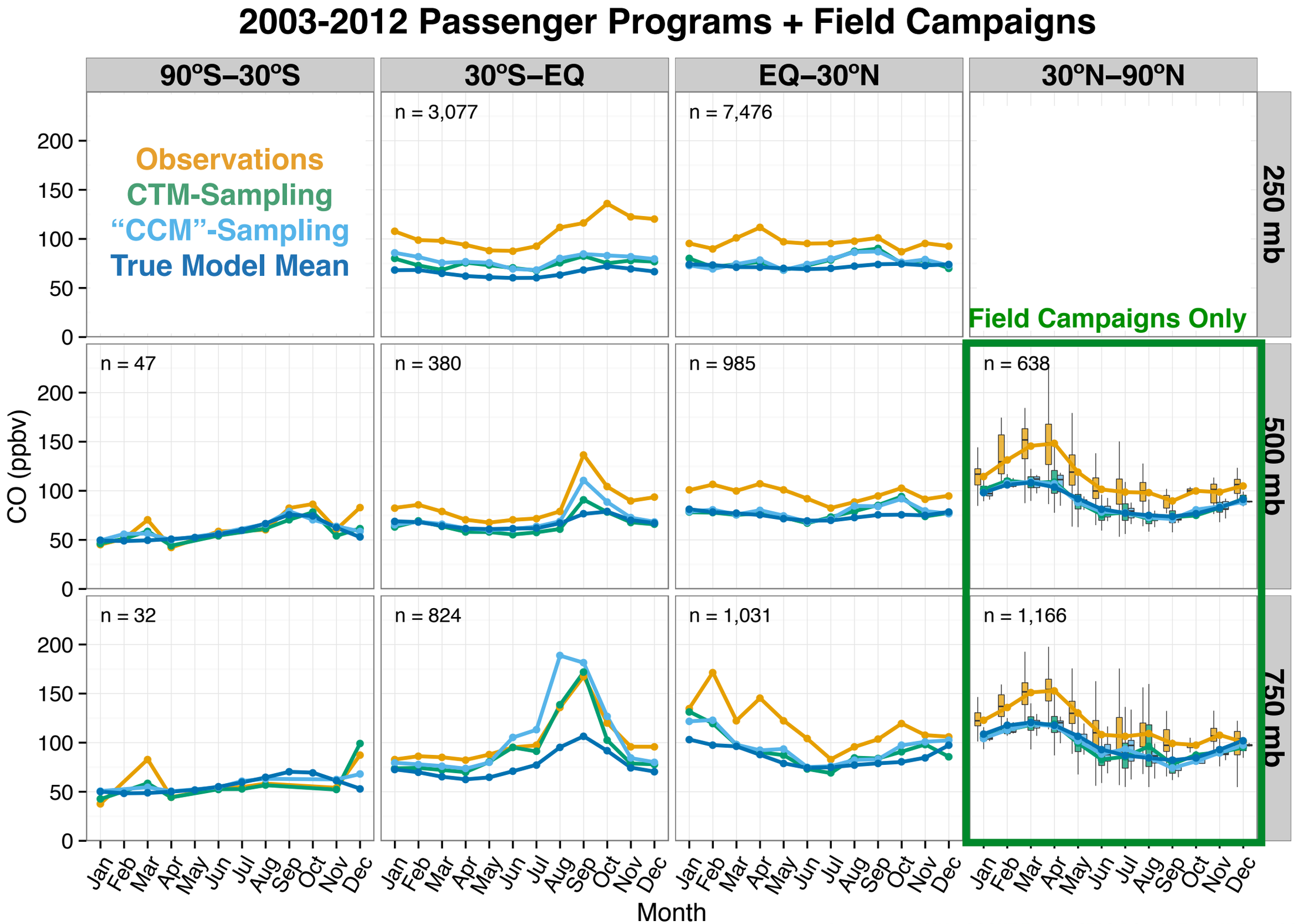


CCM/CTM sampling biased 6% higher than "true" mean; captures 84% of spat./seas. monthly variability

CO reasonably represented by climatology, except in SH

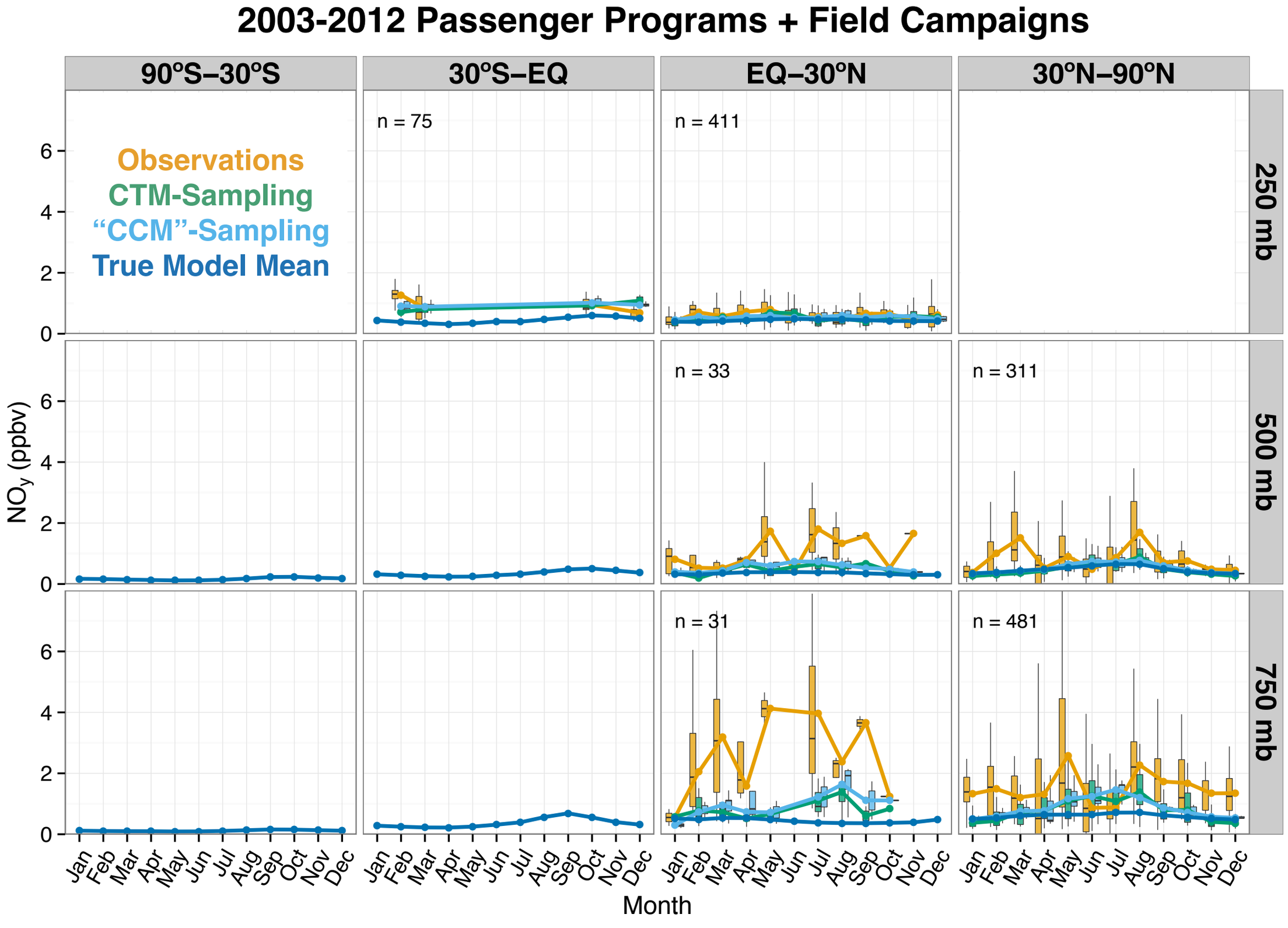


Field campaign aggregation mitigates “plume chasing”



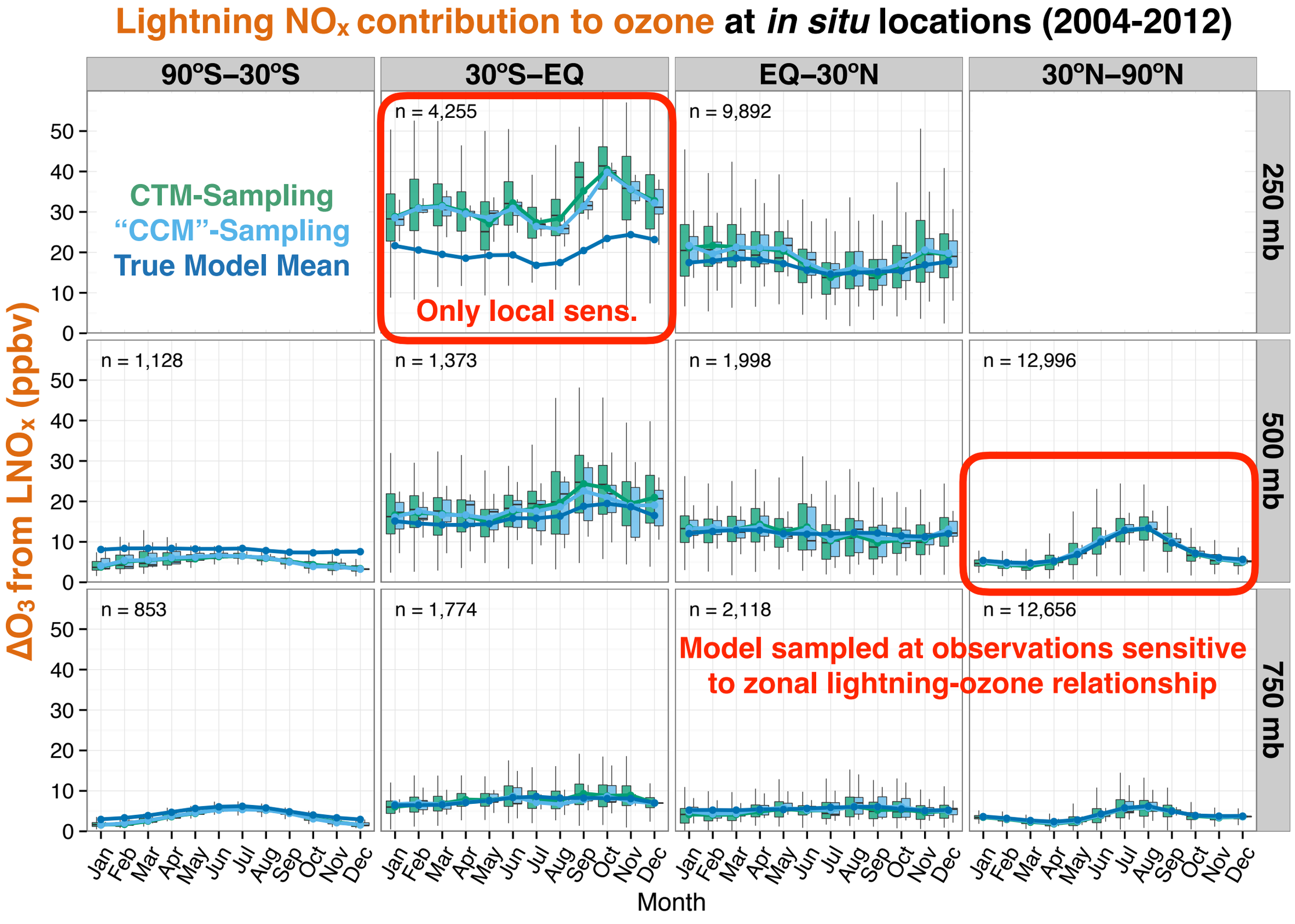
Campaigns; AMMA-SCOUT-F20; ARCTAS-DC8; AVE-04; AVE-05; COBRA-04; CR-AVE; DC3-GV; DISCOVER-AQ-DC-WP3B; FAAM; HIPPO; INTEX-B-C130; INTEX-B-DUCHESS; INTEX-B-DC8; INTEX-NA; ITOP-UK; MAXMex-GV; NEAQS-ITCT; Polar-AVE; Pre-AVE; START-08; VOCALS-C130; VOCALS-G1

Short-lived, infrequently sampled species poorly characterized



Additional observations required for characterizing reactive nitrogen budgets

Can observations constrain processes in CCMs?



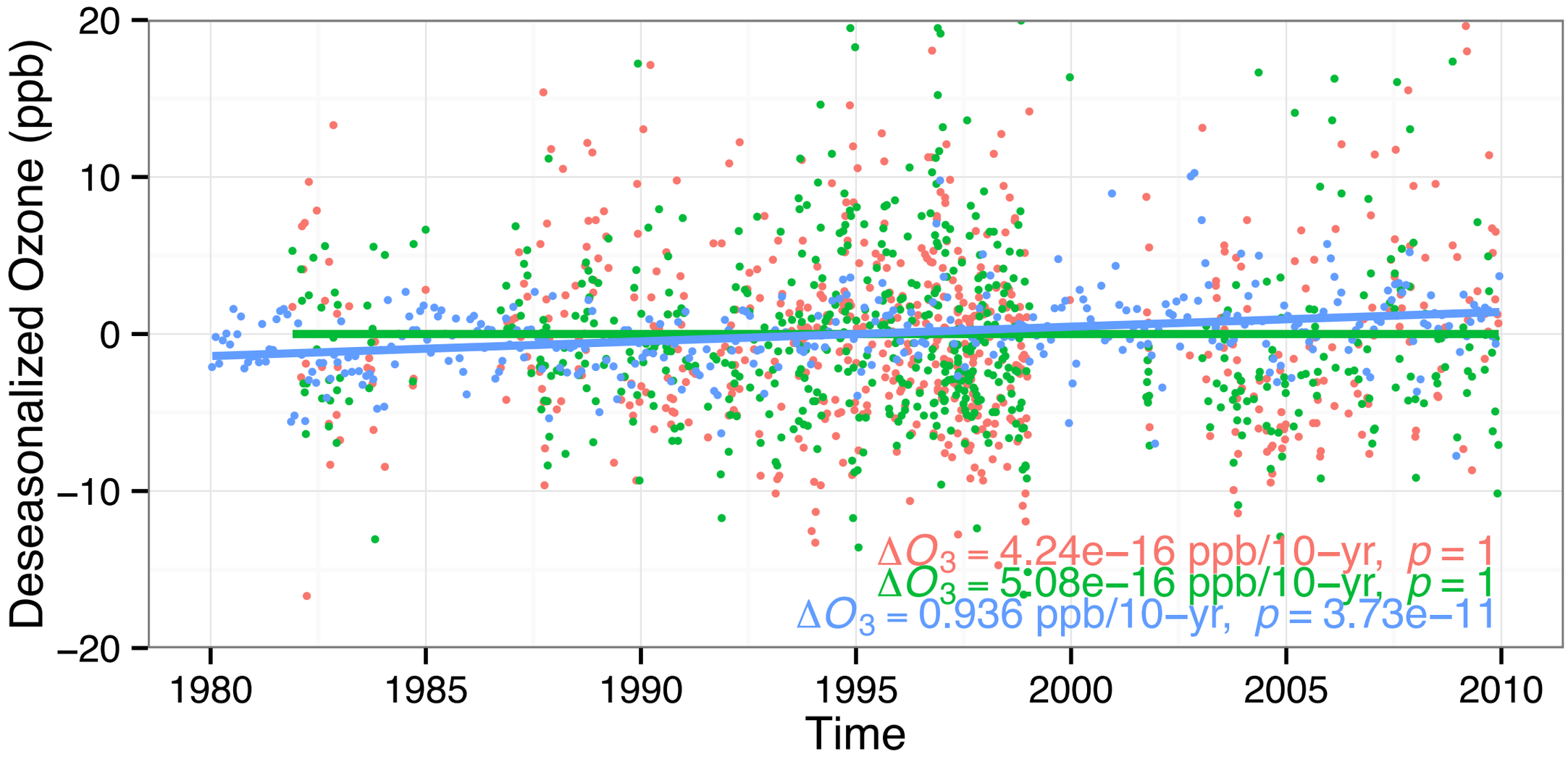
NH *in situ* clim. evenly sample zonal emission-ozone sensitivities (incl. Soil, FF, BB, BVOC); SH does not

Ongoing Work: Assessing Long-Term Trends

Currently assessing whether aggregated sonde + aircraft data
may constrain multi-decadal trends in vertical structure

GEOS-Chem v9.01.03; 4°x5°; MERRA + MACCity; Jan 1980-Dec 2010

Deseasonalized Ozone @ 500 mb above Hohenpeißenberg, Germany



Statistically significant trend in **simulated monthly mean ozone**…

..but not in **observations** or **model sampled at observations**

Conclusions

- Northern hemispheric sampling mostly indicative of background mean O_3 and CO conditions; some biases toward polluted regions
- Southern hemisphere needs additional constraints on zonal asymmetries in O_3 and CO and/or longer averaging intervals
- Reactive nitrogen species poorly characterized
- **Sampling dense enough in northern hemisphere to constrain zonal emission-ozone/CO relationships; less so in the southern hemisphere**
- Ongoing work will assess the suitability of the aggregated *in situ* data to characterize long-term trends

Acknowledgements

The ***many*** individuals and groups that collected and archived data through the years

WMO/GAW/WOUDC, SHADOZ, MOZAIC, CARIBIC, IAGOS, *Pre-AVE, TROCCINOX-2004, COBRA04, INTEX-NA, NEAQS-ITCT, ITOP-DLR, ITOP-UK, FAAM, AVE-04, Polar-AVE, TROCCINOX-2005, AVE-05, AMMA-SCOUT-F20, CR-AVE, INTEX-B-J31, MAXMex-GV, INTEX-B-DC8, INTEX-B-C130, INTEX-B-DUCHESS, INTEX-B-CESSNA, TexAQS-P3B, TC4-DC8, TC4-WB57, ARCPAC, ARCTAS-WP3B, ARCTAS-DC8, START-08, VOCALS-G1, VOCALS-C130, VOCALS-TwinOtter, VOCALS-Dornier, HIPPO-1, HIPPO-2, HIPPO-3, HIPPO-4, DISCOVER-AQ-DC-WP3B, DISCOVER-AQ-DC-UMD, HIPPO-5, DC3-DC8, DC3-GV, DC3-F20, TACTS, ESMVal