Tropospheric Ozone: The Role of Stratospheric Variability

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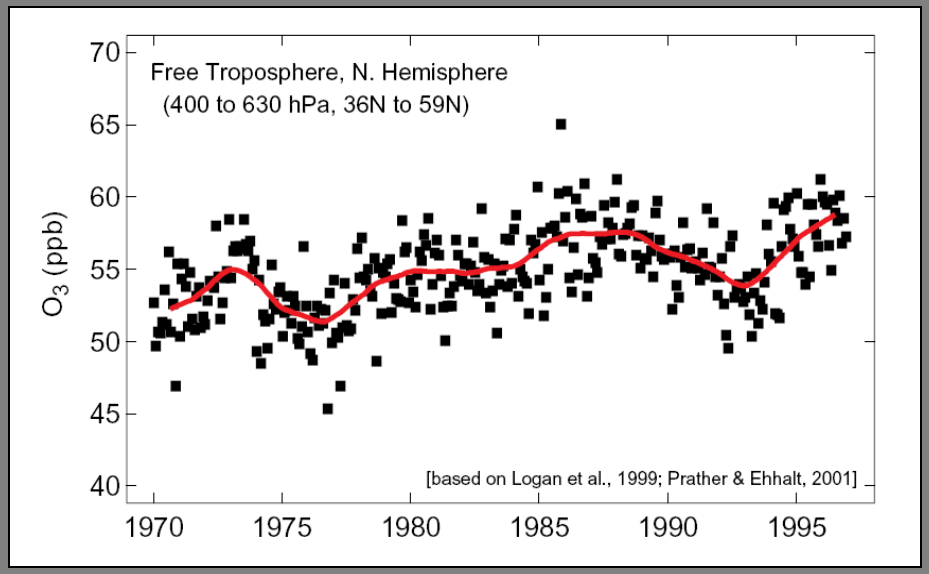
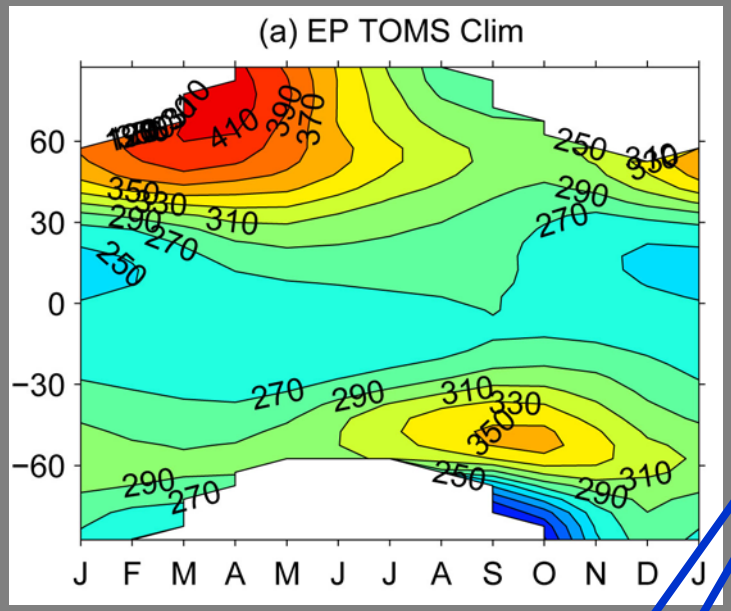
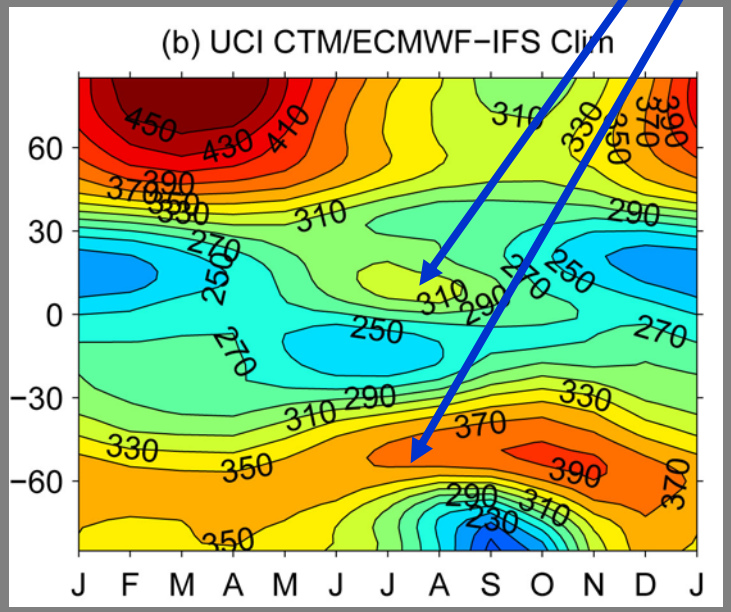


SPARC GA, 2008 Bologna, Italy





UCI CTM

2001-2005 ECMWF/OSLO Met Fields: T42L40 (0.6 km in trop, top at 2 hPa)
New IFS cycle – STE too large (~600 Tg/year), clear problems in L40 Total Column O3

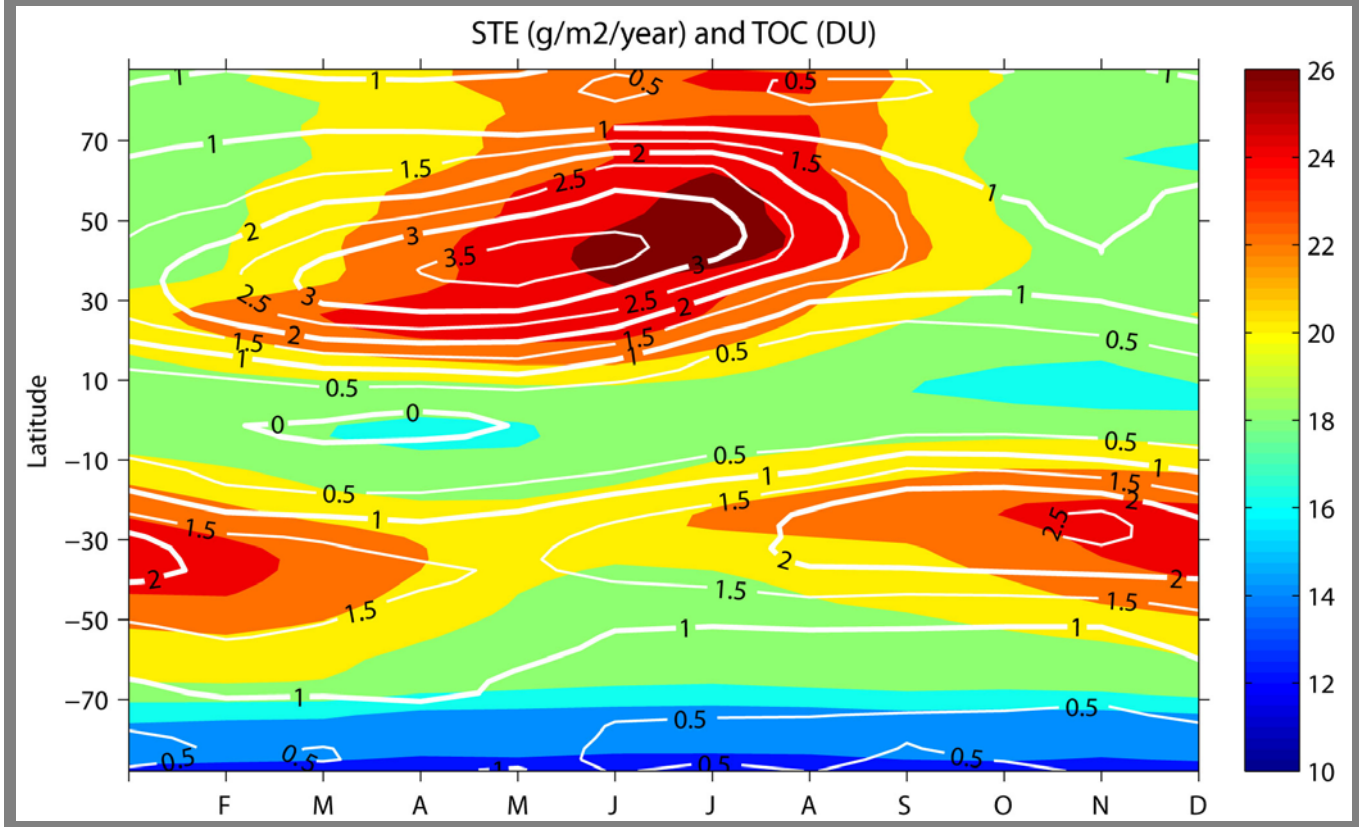
Linoz = Linearized stratospheric O3 P-L as function of O3, T, column-O3. Updated version described in Hsu and Prather, JGR 2008 (TBS)
New climatologies, kinetics, solar fluxes, and parameterized PSC O3 loss (Cariolle et al.,1990)
Corrects biases and STE flux is unchanged

Hsu and Prather: Runs with stratospheric ozone tracer only. Relaxation with 2-day e-fold to 20 (30) ppb in lowest 600m

These runs: constant emissions, full tropospheric chemistry (30 reactive species, ~100 reactions) Lightning horizontal distribution from Price and Rind, scaled to 5 Tg N/year for 2000

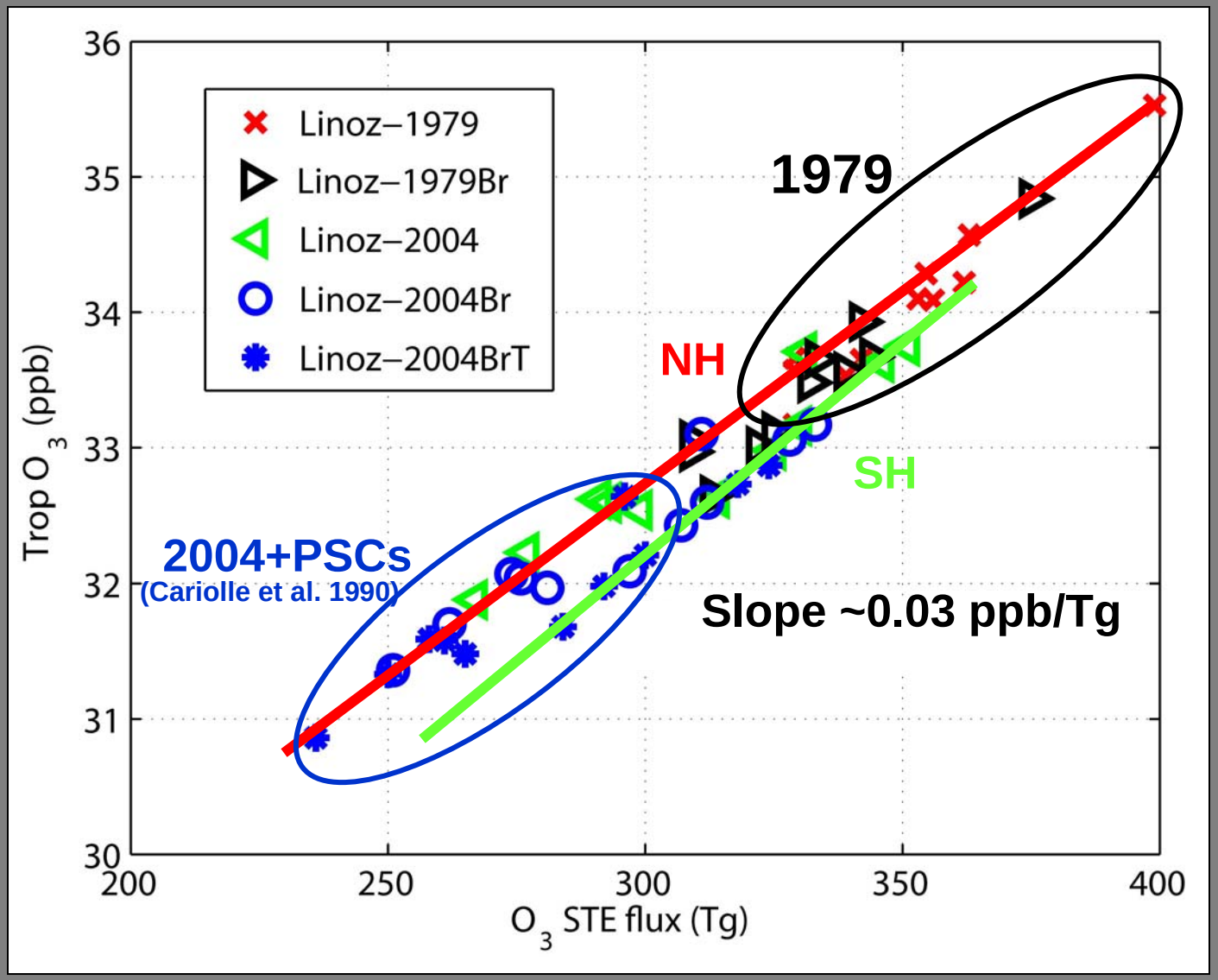
STE Flux Diagnostic

Deduce column STE O3 flux (F_{S-T}) from
(1) change in mass <100 ppb (dM/dt),
(2) flux divergence in troposphere (F_{T-T}), and
(3) chemistry (S). *(Hsu et al., 2005)*

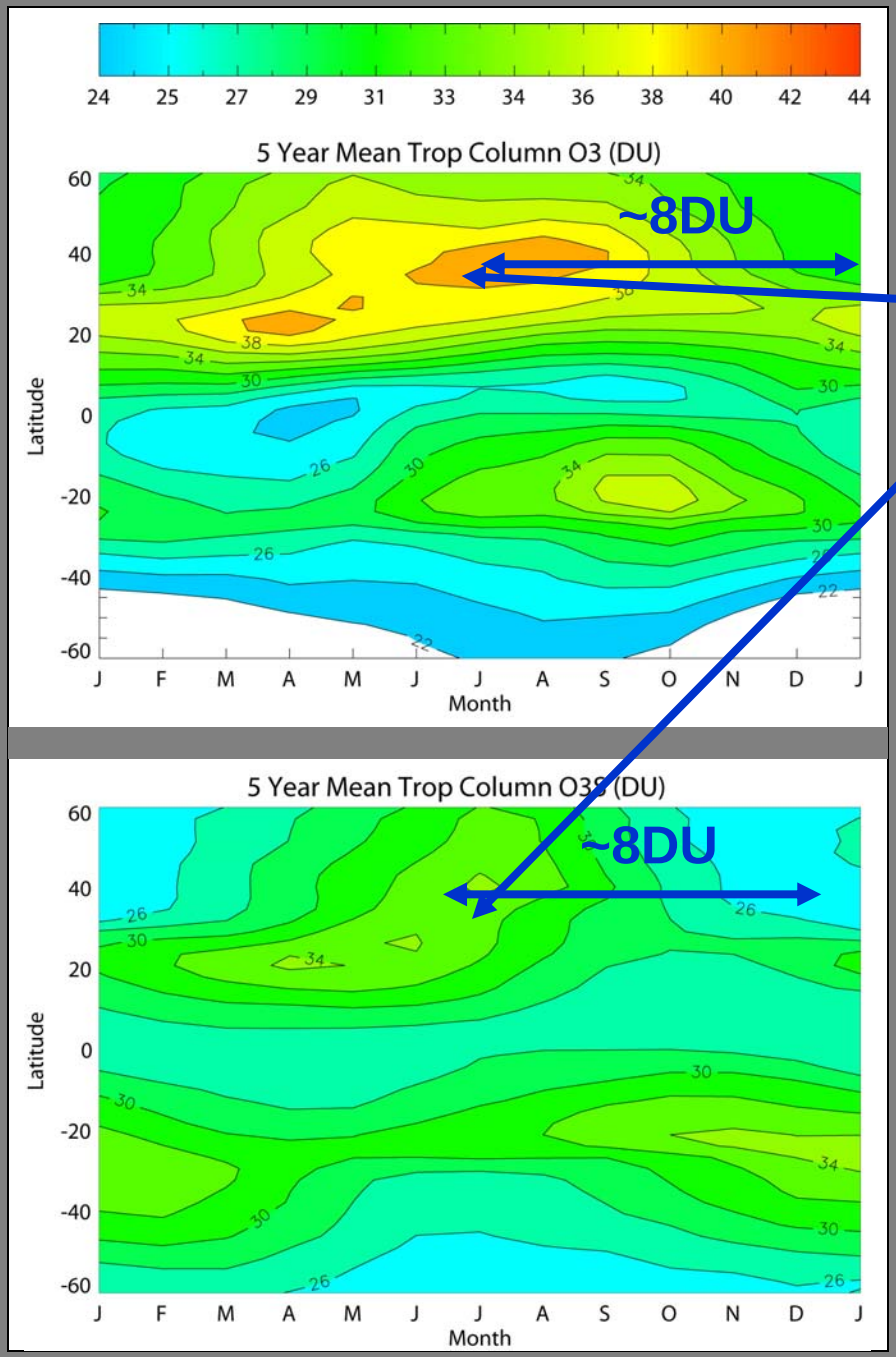


Now uses 2nd Order Moments for calculating flux divergence – noise is much reduced.

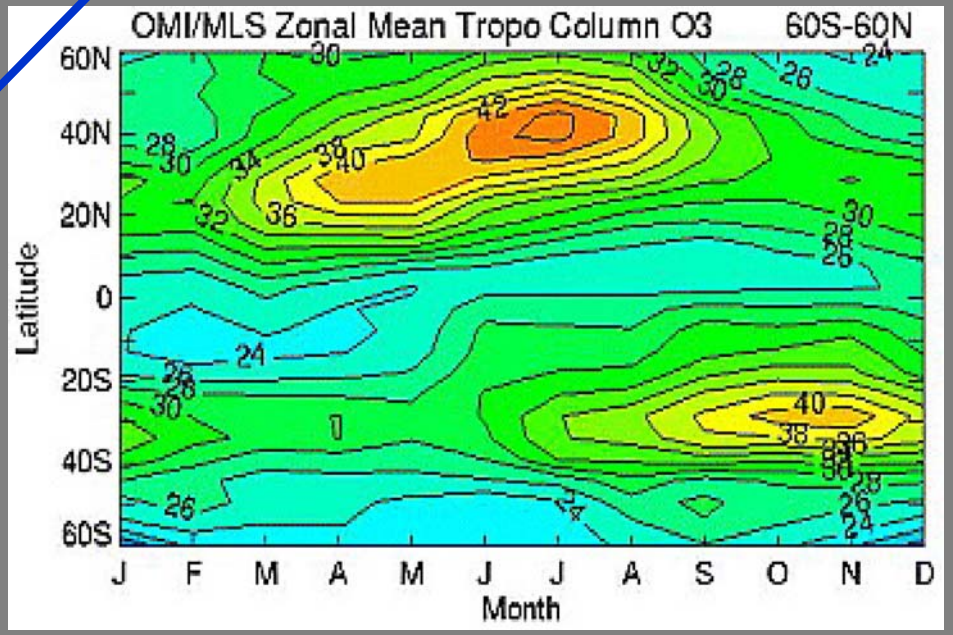
STE-only changes in Tropospheric Ozone



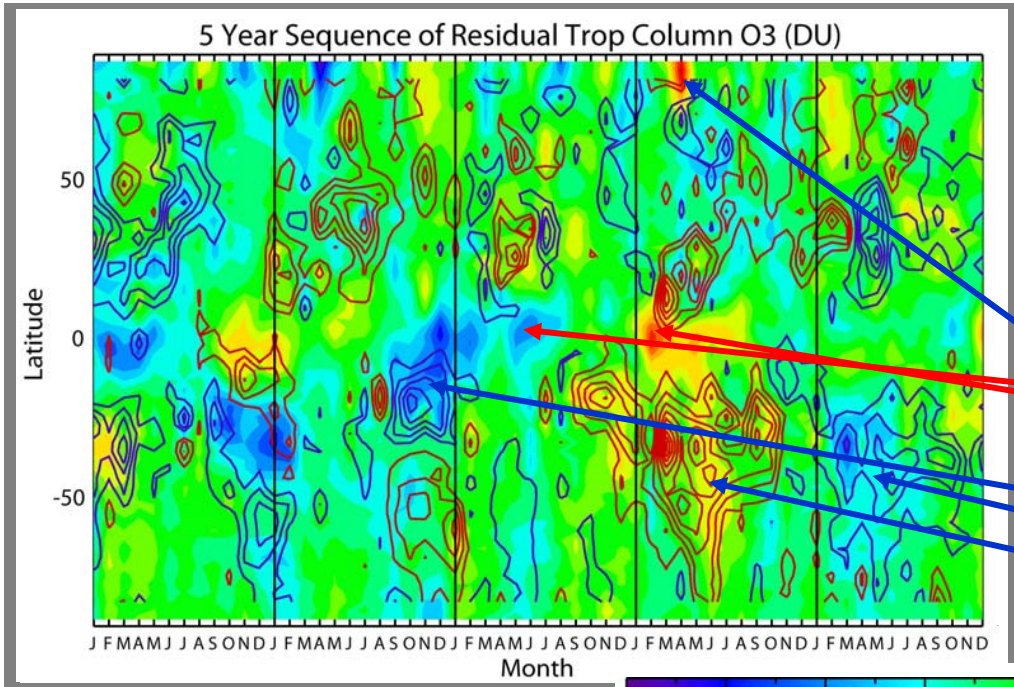
Mean Tropospheric Ozone Columns



STE pattern mimics photochemical buildup



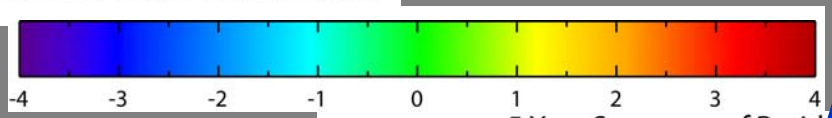
From Ziemke, et al. JGR, 2006

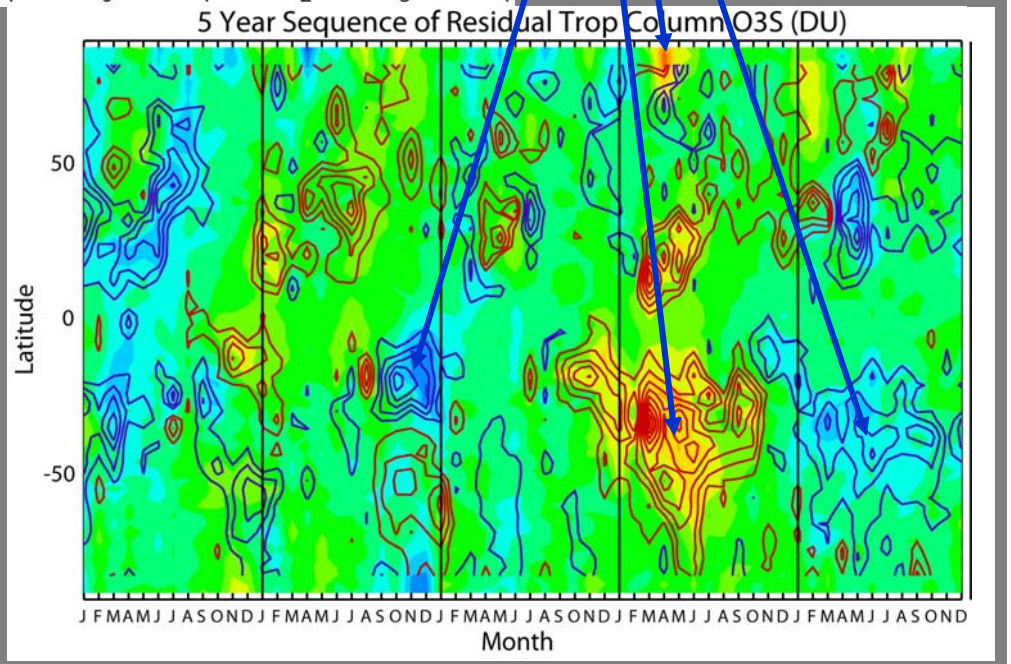


5-Year Sequence of Tropospheric Column Ozone Residuals

Only chemically active O3

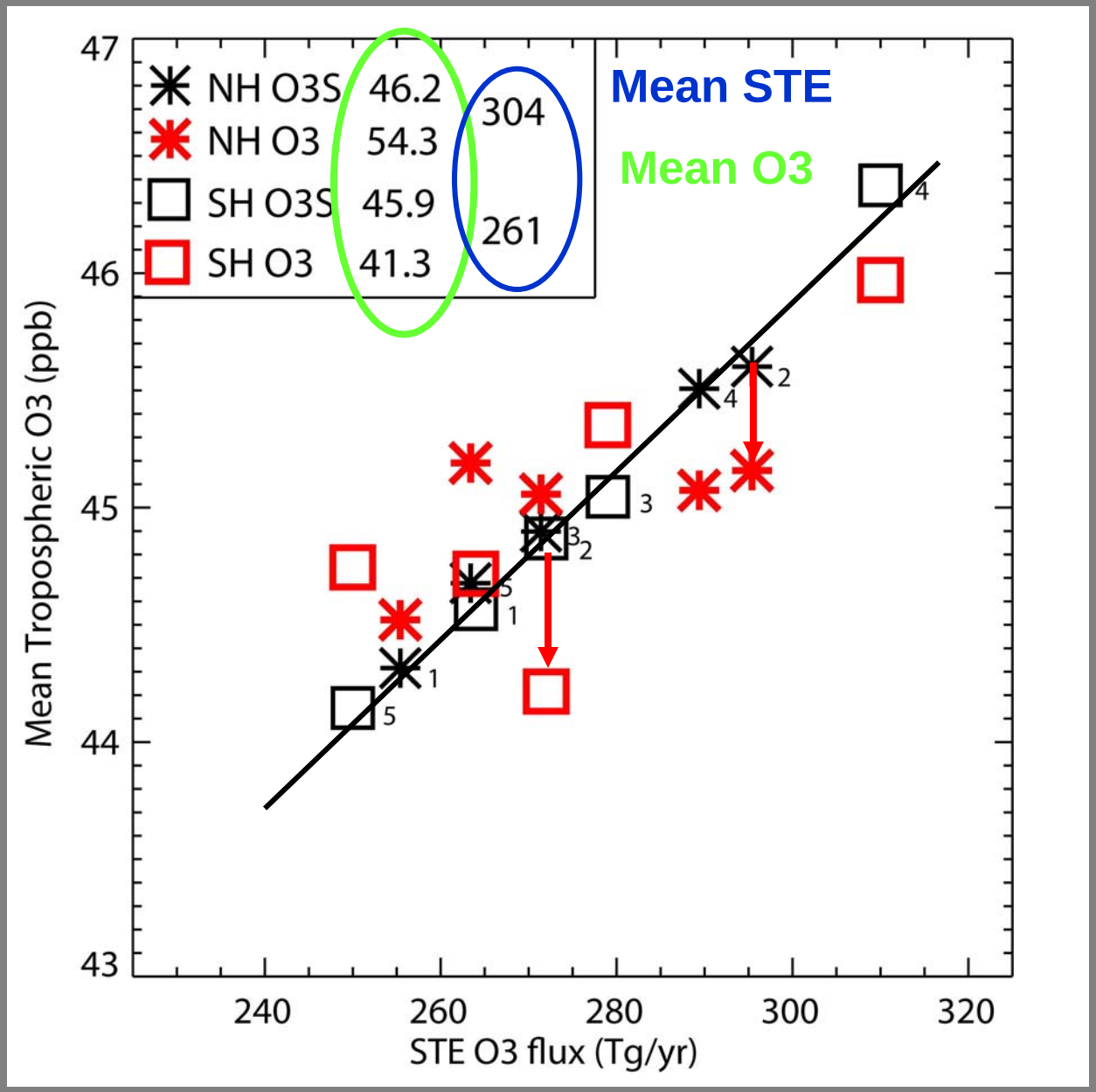
Common Features





QBO contribution to interannual variability in STE: ~20% NH, ~45% SH

Interannual Variability: O3S vs Chemically Active O3



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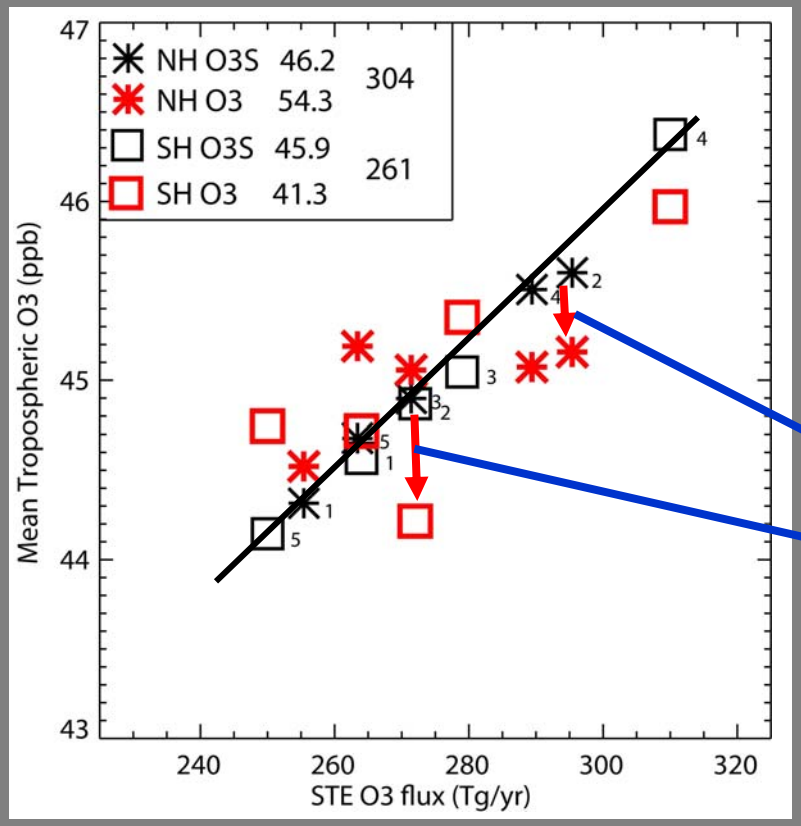
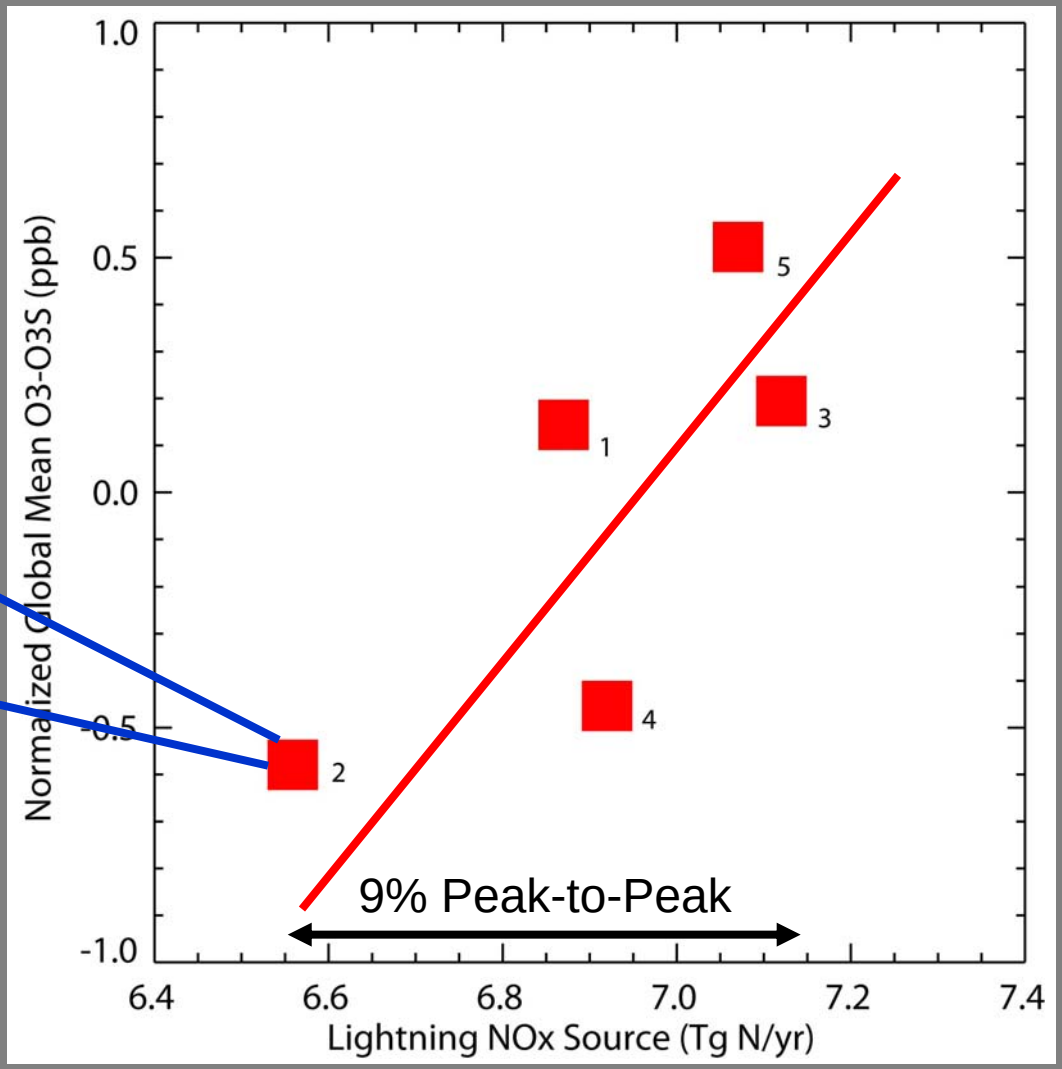
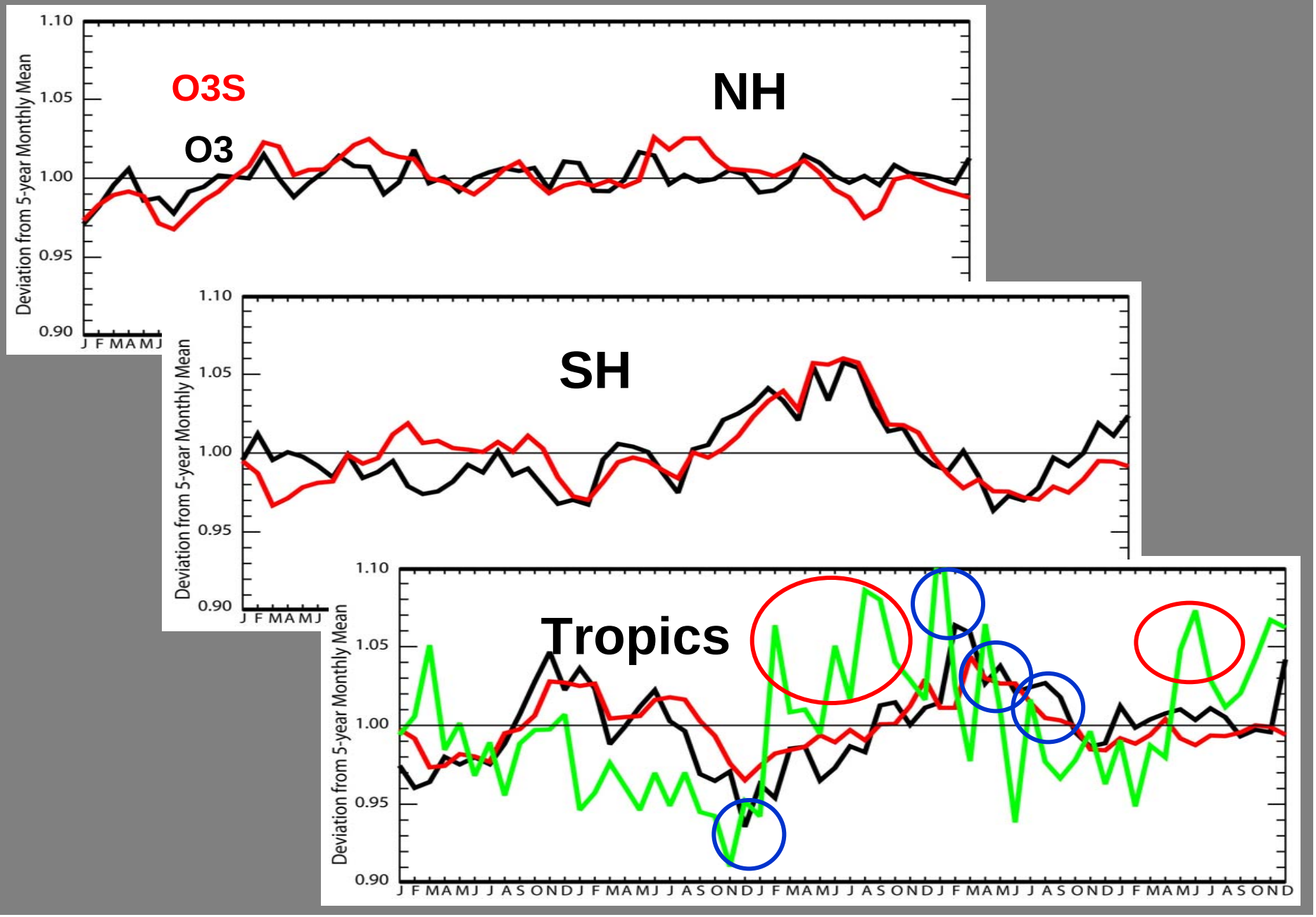


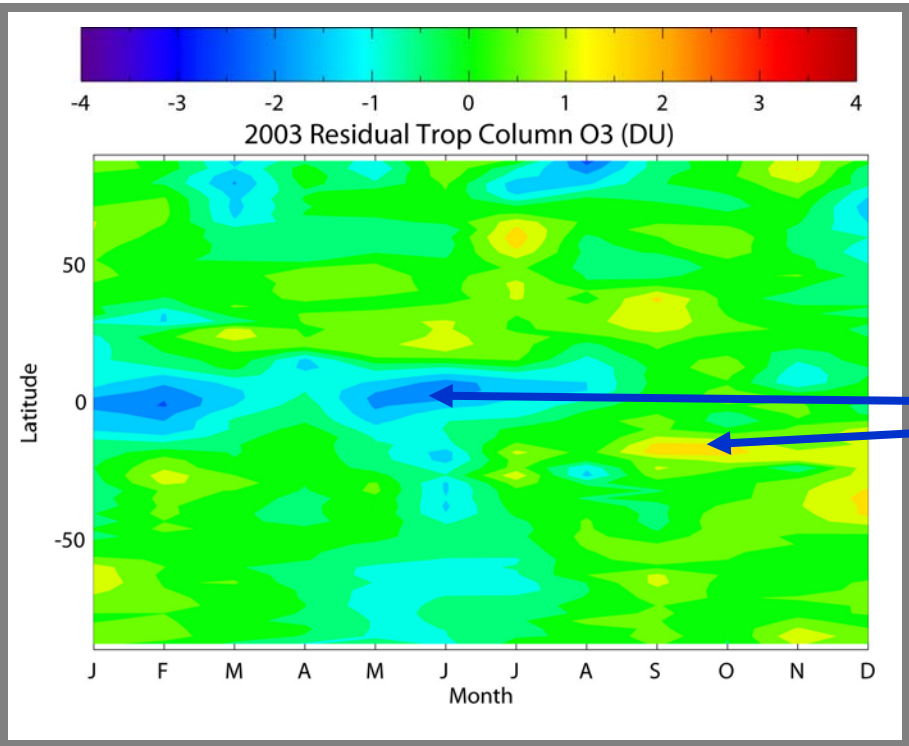


2000 = 5 Tg/year !

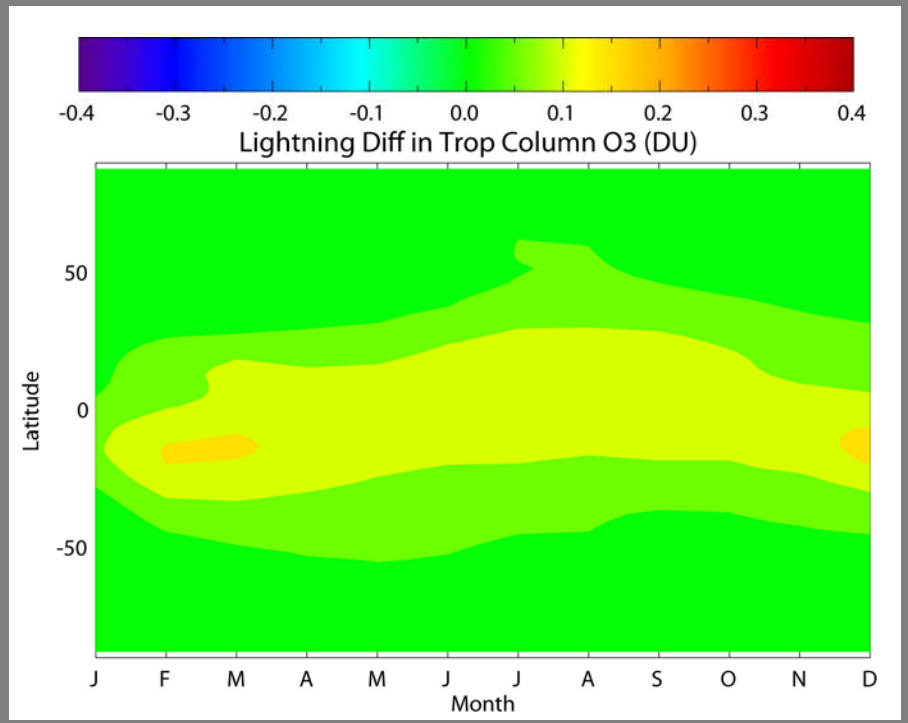
Deviations From Monthly “Climatology”



Comparing Sources of Natural Variability



Variability +/- 2-3 DU



3.5% Difference in lightning gives 0.1- 0.2 DU variability

For 2-3 DU, need 5 +/- 2 Tg N/year

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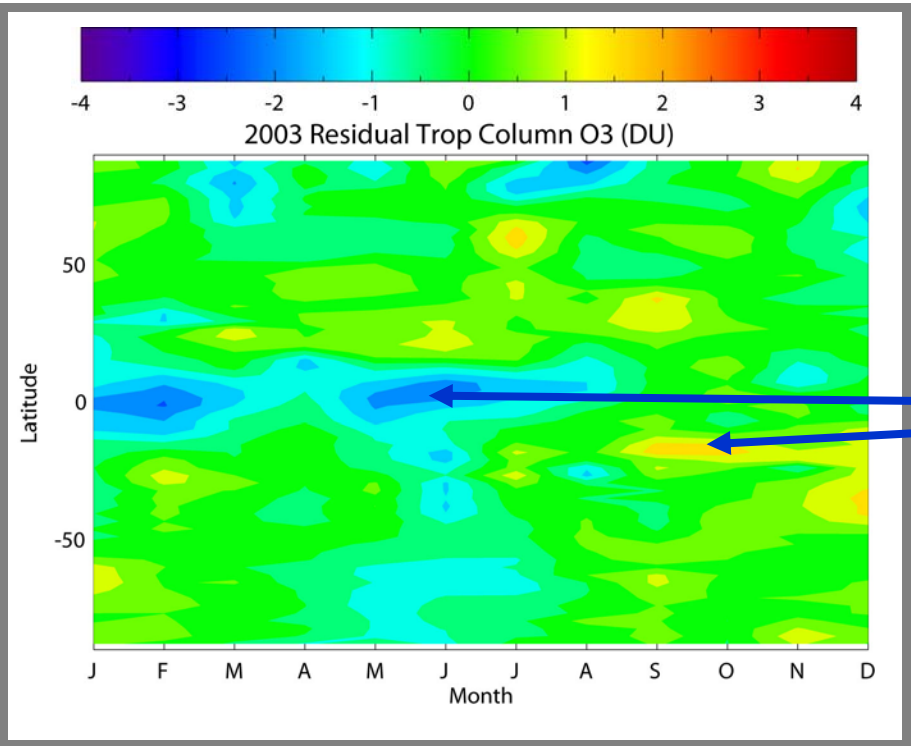

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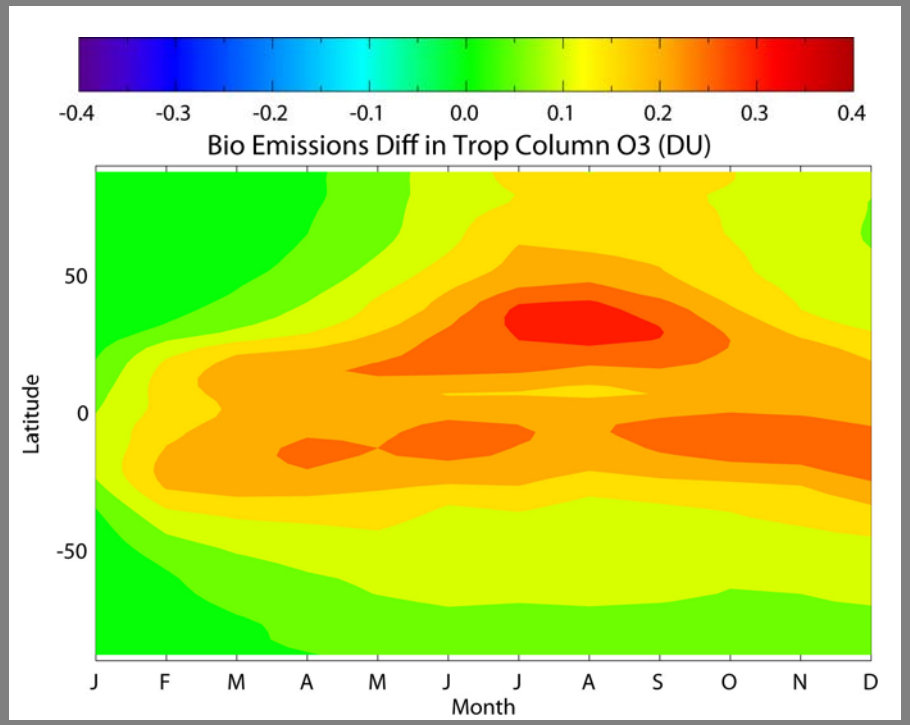
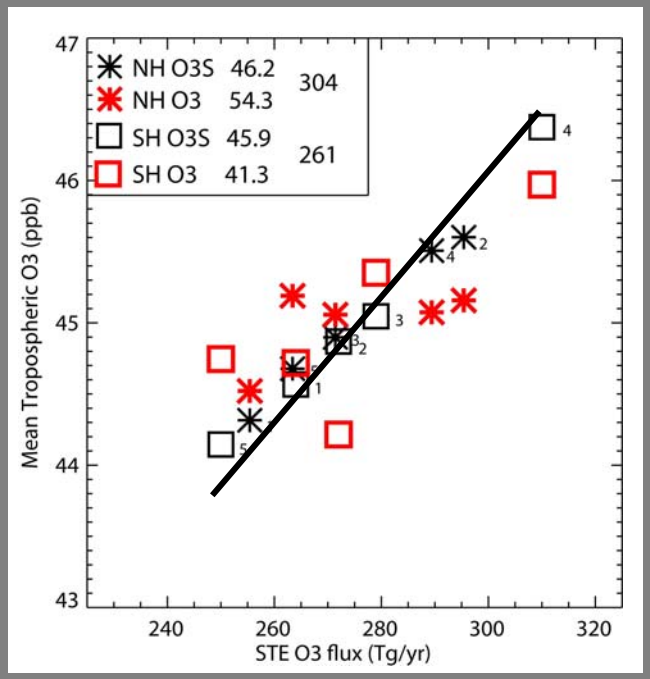


5% Change in biogenic emissions gives 0.2 – 0.4 DU variability

Biomass Burning – still need to quantify

Summary

STE is a major source of natural variability in tropospheric O3



In our model, other meteorological sources of variability are small compared to STE – What is the interannual variability in lightning NOx?

There are other undetermined sources of variability not related to emissions – Stratospheric modulation of photolysis rates? Convection? H2O?

Variability due to changes in emissions (both biogenic and anthropogenic) are still to be determined. These highly constrained runs give us a basis for doing so.