How much can we learn about nitrous oxide emissions from background sites and simple box models?

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NOAA HATS is cooperating network of NDACC.
NOAA's Mauna Loa Observatory shown.

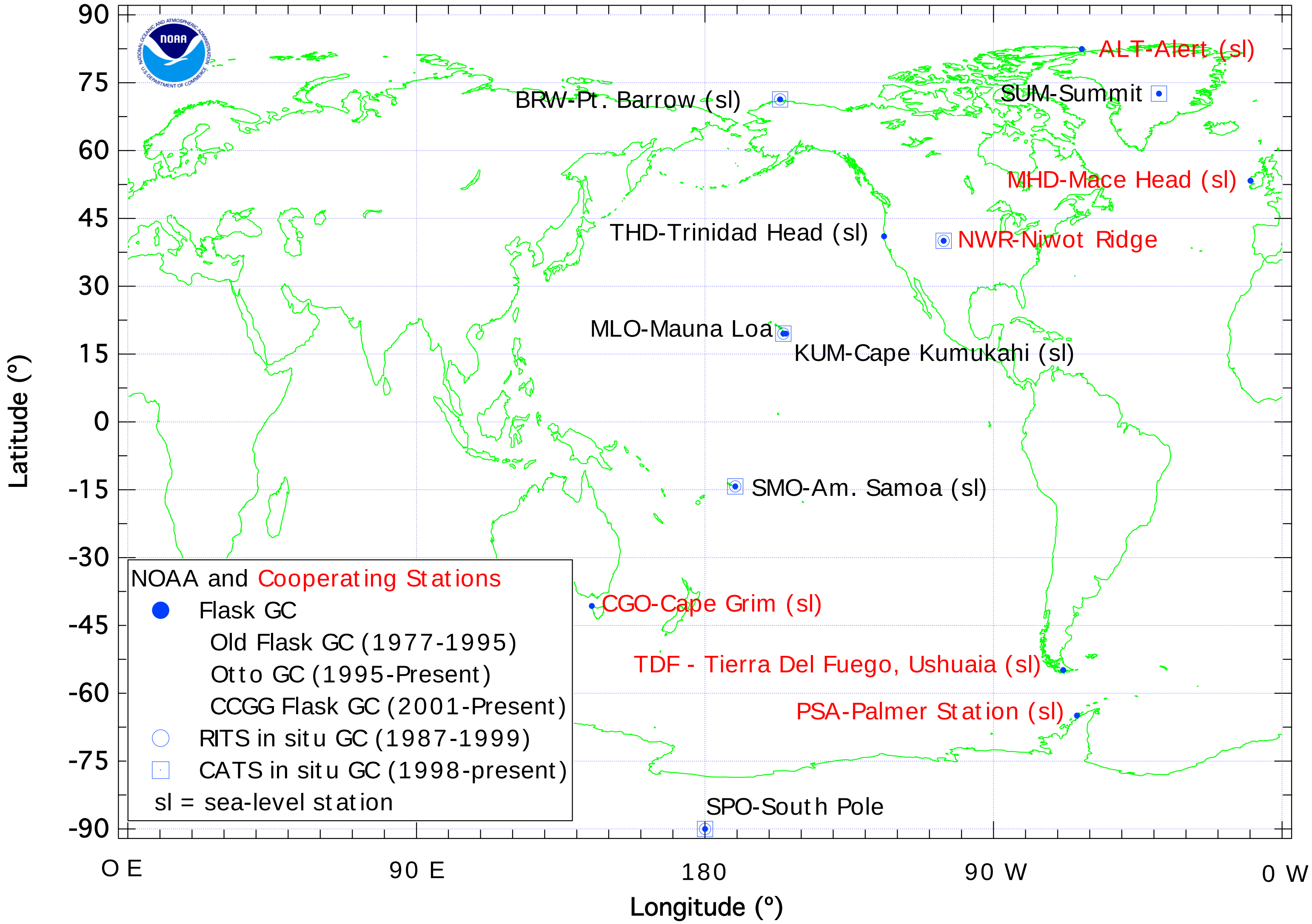
Motivation for studying N_2O

- Atmospheric N_2O is the third strongest greenhouse gas.
- Since the CFCs are in decline, N_2O is the largest ozone-depleting gas based on future emissions.
- Isopleths of N_2O are used as an proxy for altitude (tracer-tracer plots for determining ozone depletion).
- The atmospheric budget of N_2O is ~30% out of balance, because of man-made emissions.

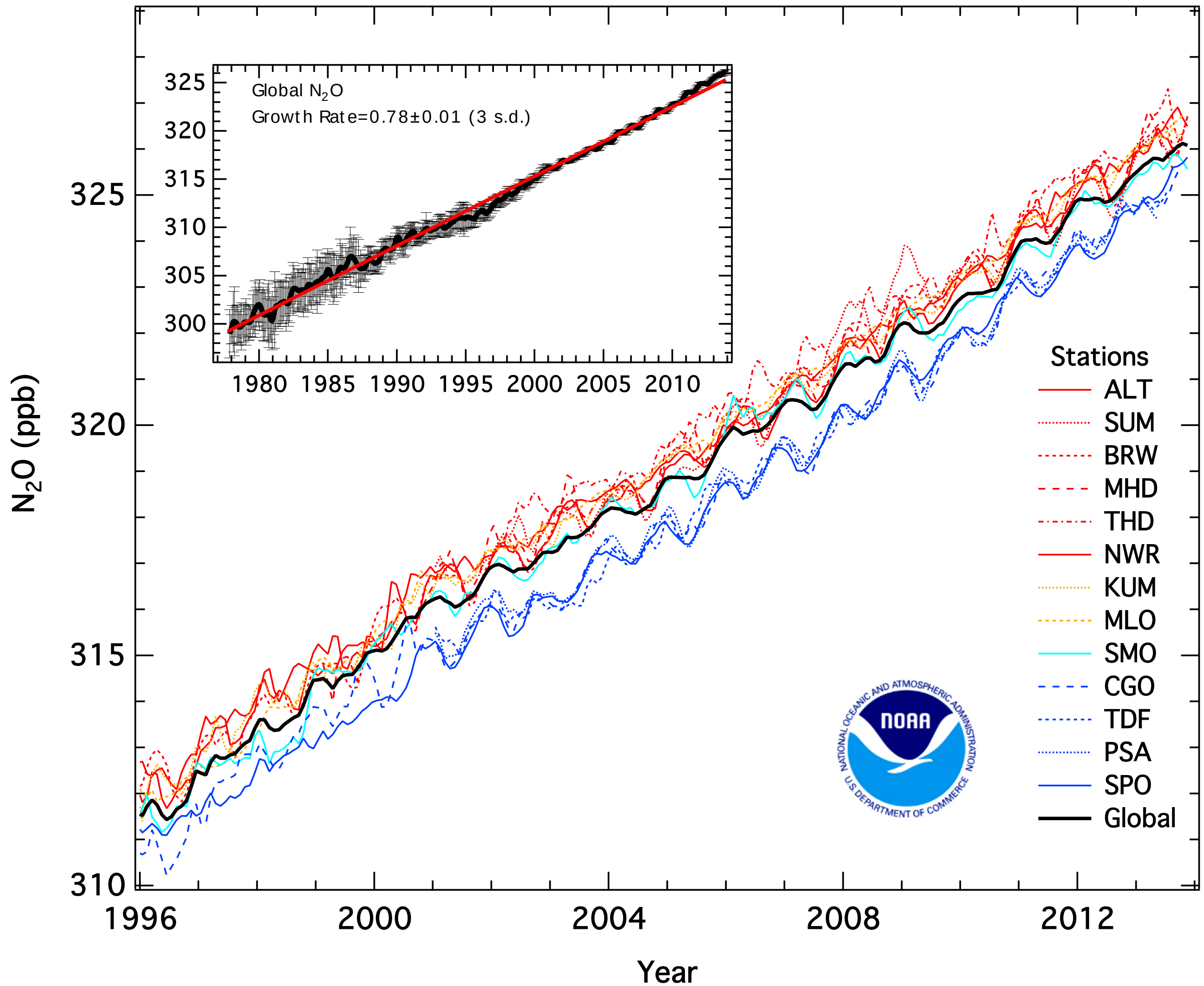
Location of major emissions of N_2O?

- Natural sinks of N_2O are in the stratosphere (atmospheric lifetime = 120 years).
- N_2O produced by natural decay in soils and ocean. Man-made sources include additional decay from fertilizers (inorganic and organic), catalytic converters (NO_x to N_2O), and various types of chemical production.
- Small differences in concentrations can amount to large differences in emissions.
- Previous studies have used Global Climate Models with combined data sets (AGAGE+NOAA+others). Our approach is different, use simple boxes with data from one network (consistent scale & methods).

Location of flask and in situ measurements



Background N_2O ground based-observations

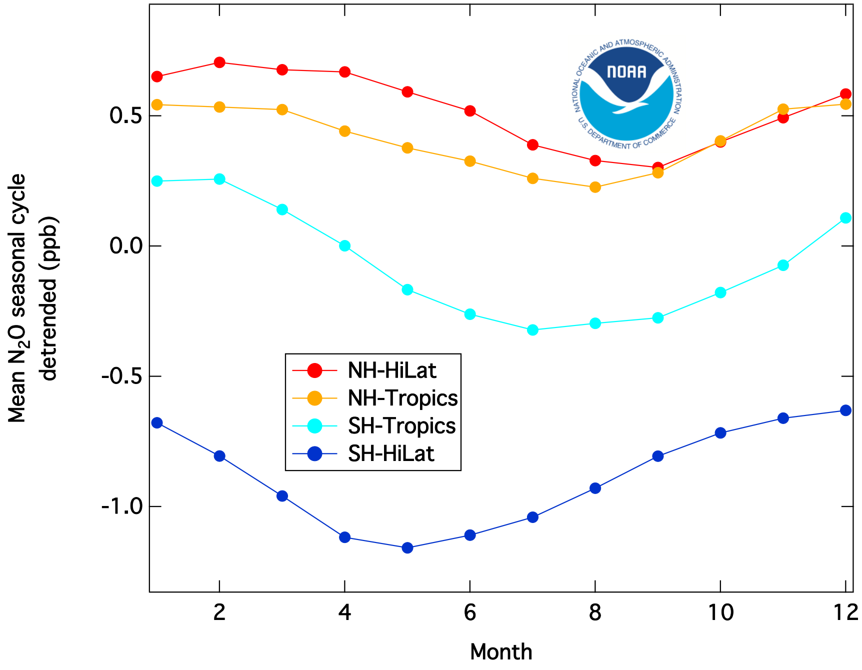


Growth rate is Constant at 0.78 ± 0.01 ppb/yr ~4.5 Tg N/yr

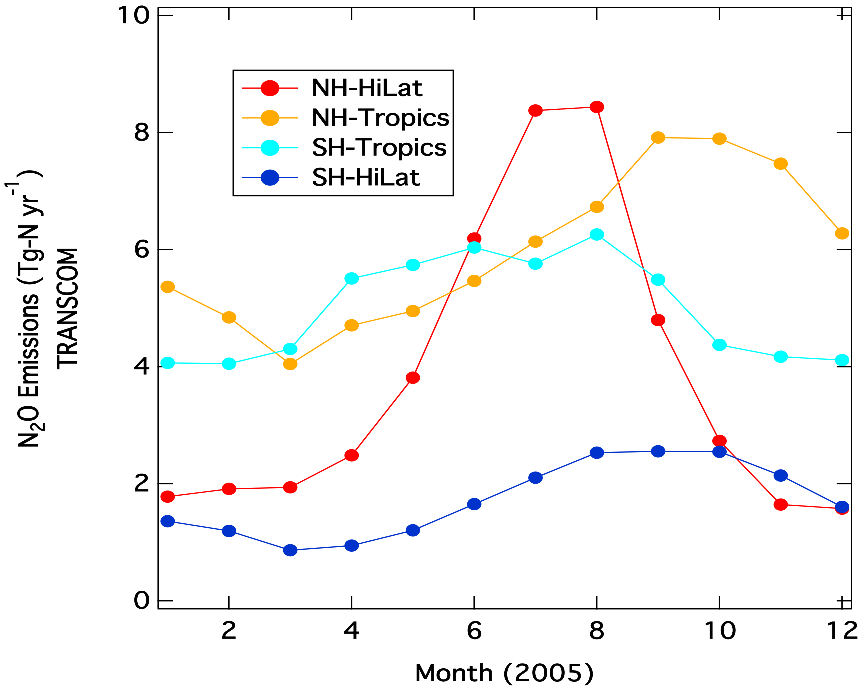
Interhemispheric Gradient is 0.96 ± 0.04 ppb

Seasonal Cycle from Observations and Prior Emissions

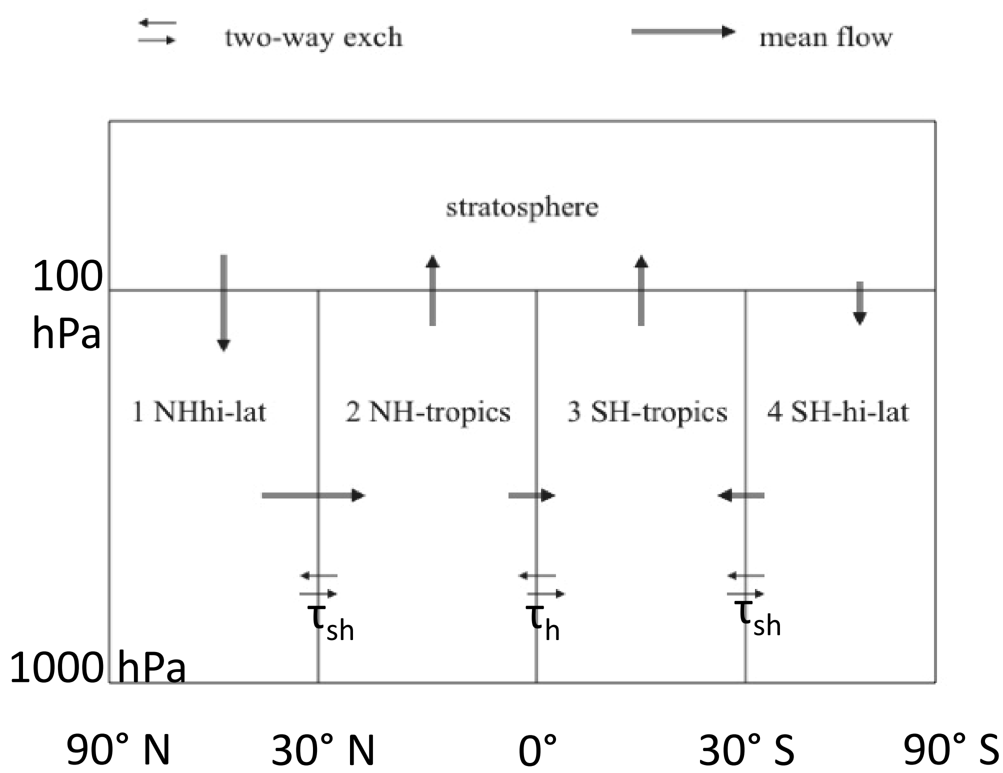
NOAA



TRANSCOM

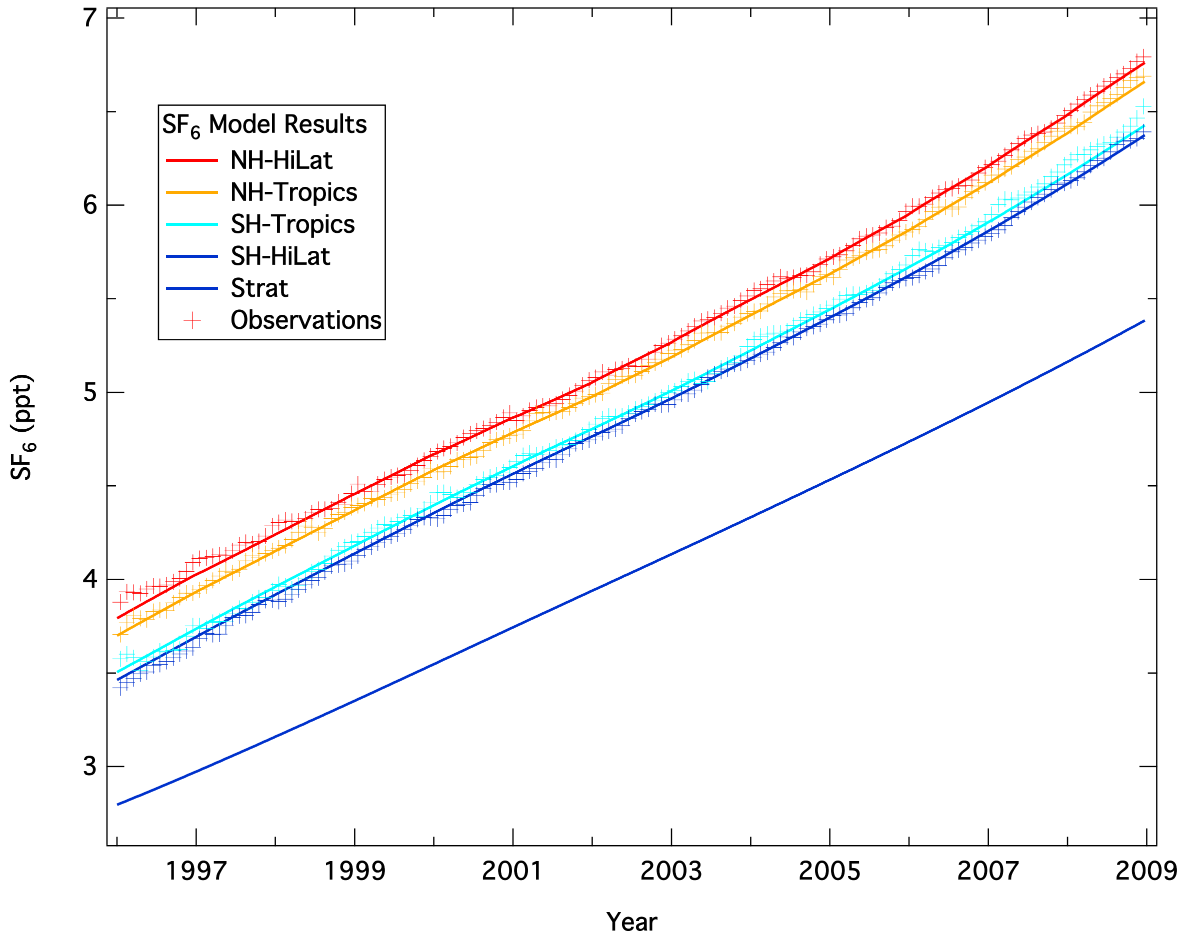


Harvard 5 box model: four semi-hemispheres and one stratospheric box

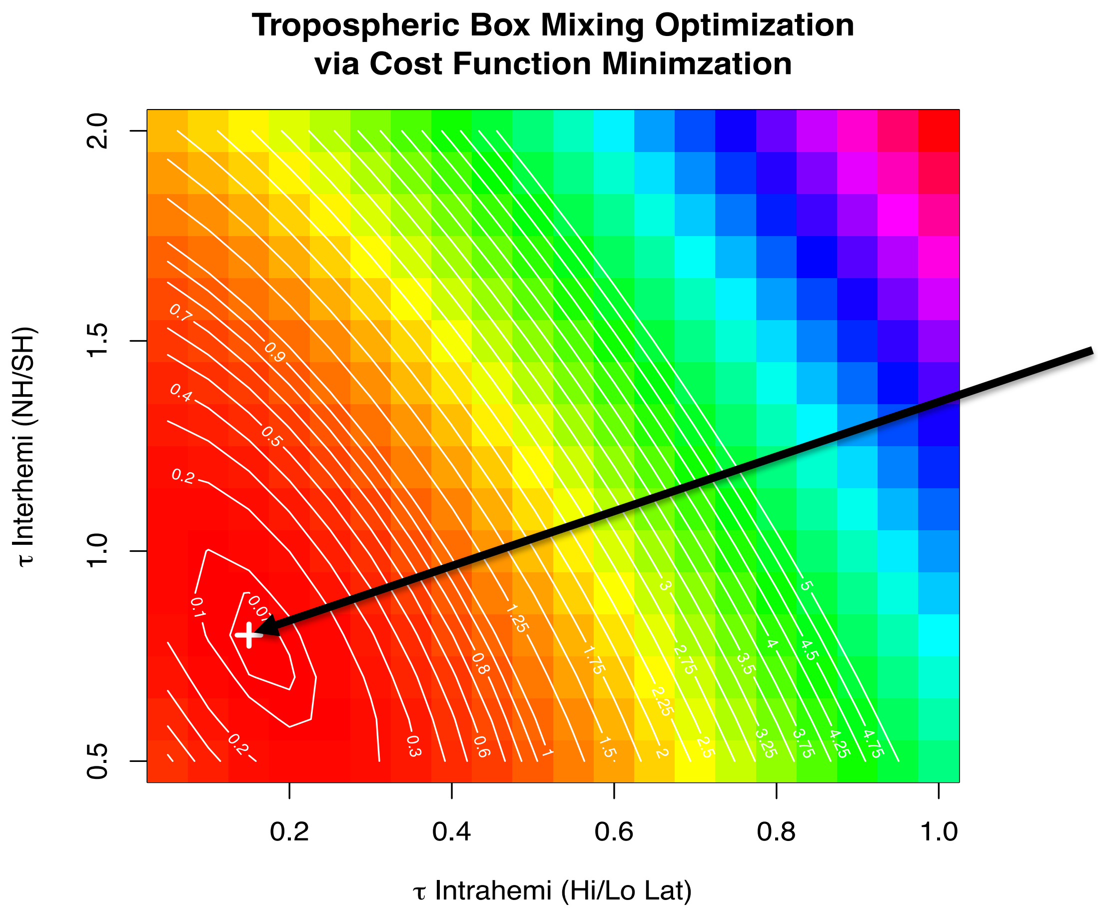


- Parameters
  - Atmospheric lifetime, 120 yr.
  - Stratospheric turnover time, 4 yr.
  - Advection rates are derived from Brewer-Dobson asymmetry in circulation, 55% NH, 45% SH
  - Initial guess for stratospheric value

Obtaining atmospheric parameters from NOAA SF_6 using 5-box model

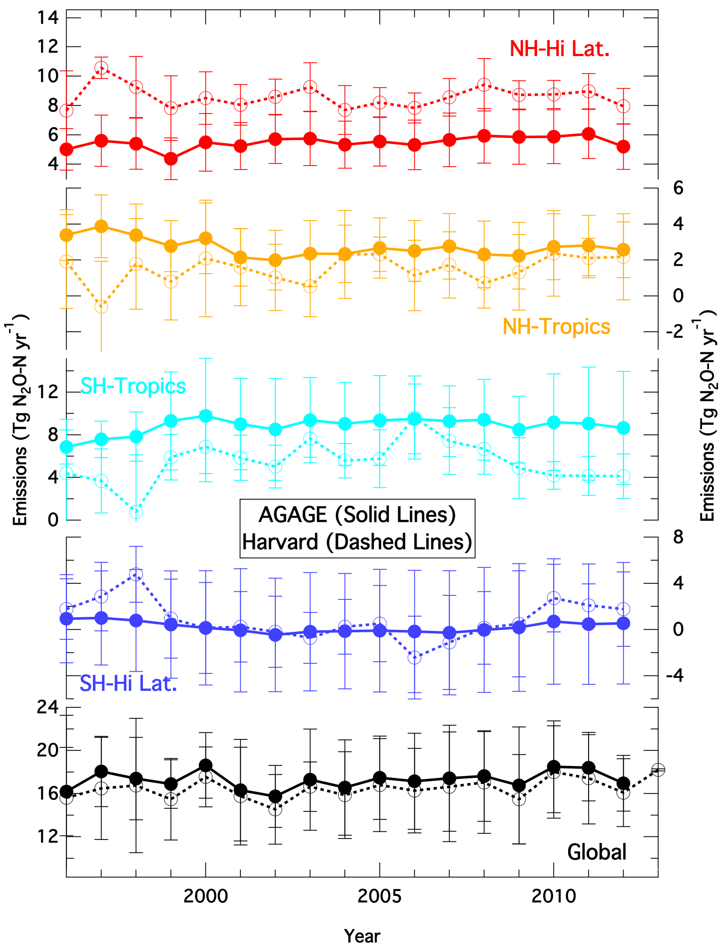


Cost function for finding interhemispheric (τ_h) and intrahemispheric (τ_{sh})



τ_h=0.8 yr.
τ_{sh}=0.15 yr.

5-box Harvard vs 12-box AGAGE Model



- NH-HiLatitudes: 5-box model predicts higher %
- NH-Tropics: Both models similar results
- SH-Tropics: 12-box model predicts higher %
- SH-HiLatitudes: Almost no emissions here.
- Emissions = 17 Tg N/yr

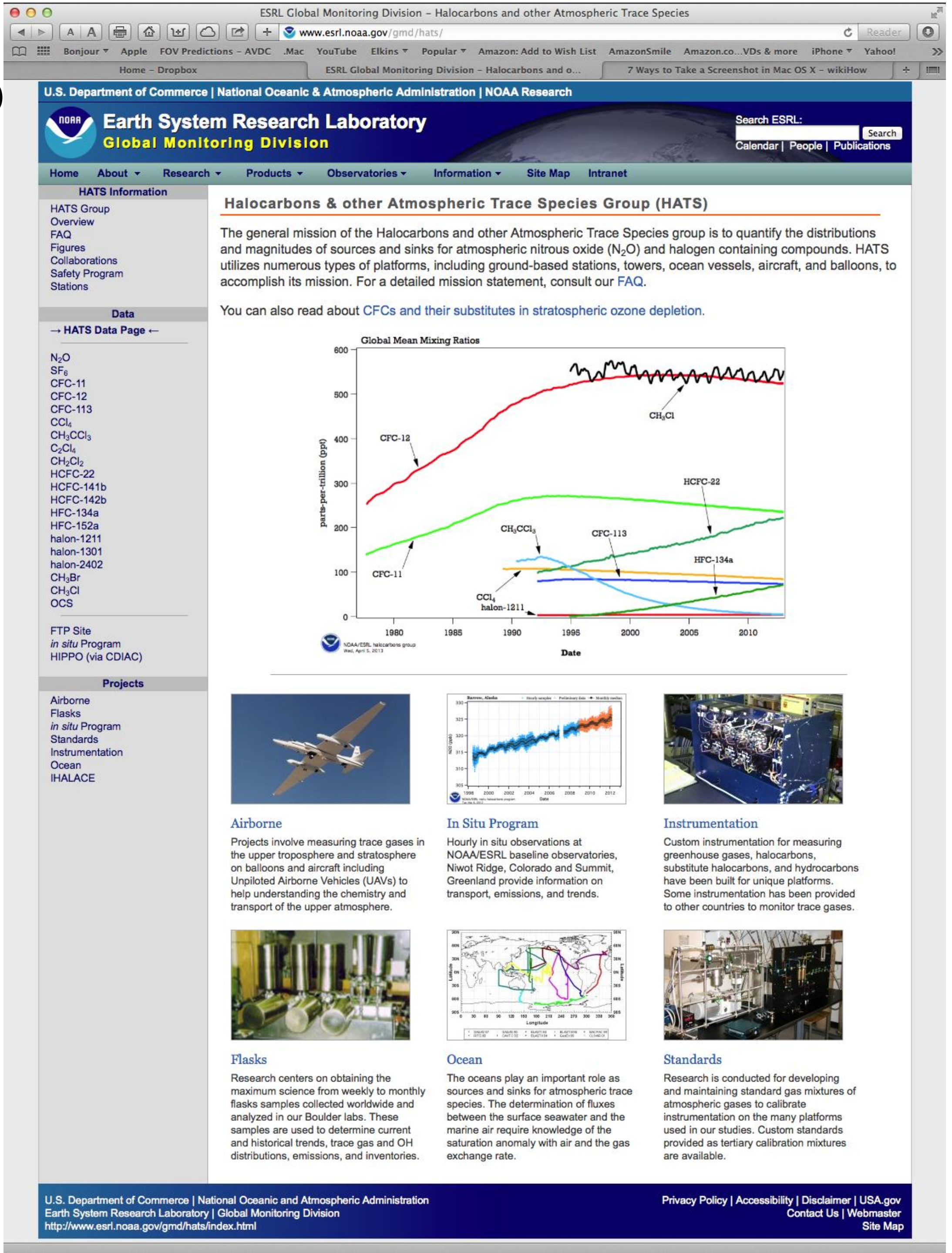
Conclusions

- 5-box model doesn't need prior emissions, only a starting stratospheric value.
- 12-box AGAGE model requires priors, but different priors only give slightly different results.
- Largest emissions in the NH-HiLatitudes (95% of population) in the 5 box model. 12 box model pushes more emissions in the SH-Tropics than NH-HiLatitudes.
- 12-box AGAGE model uses transport from long-lived gases, and older vs newer transport parameters give different greatly different results for the CFCs. We will use airborne and ground based SF_6 observations to calibrate transport in the 12-box model in the future.

Any Questions?

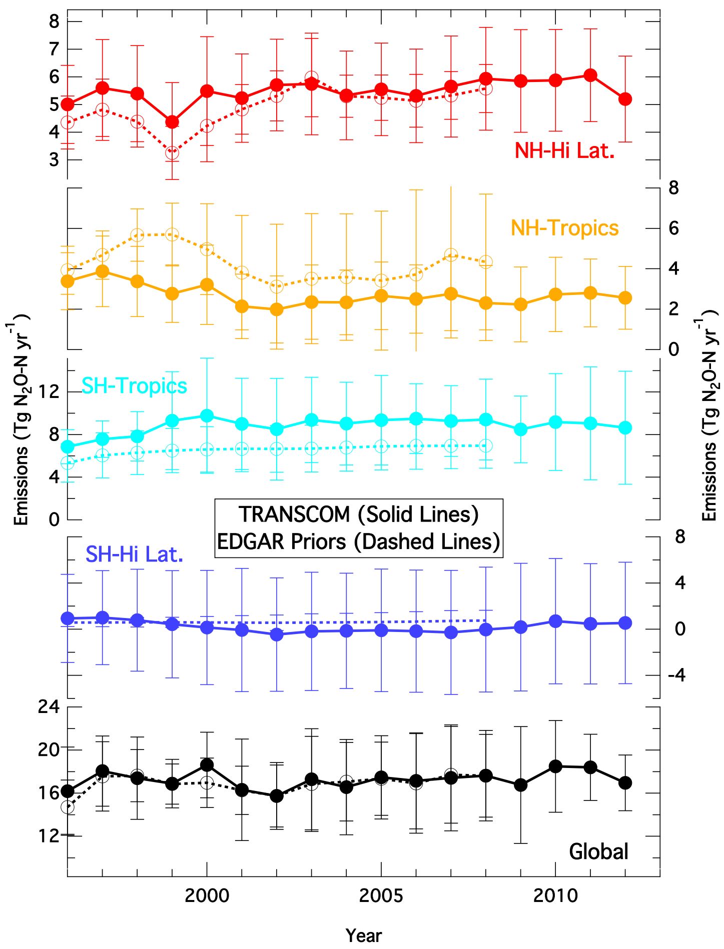
Thanks for listening!

For more information, see web:
http://www.esrl.noaa.gov/gmd/hats

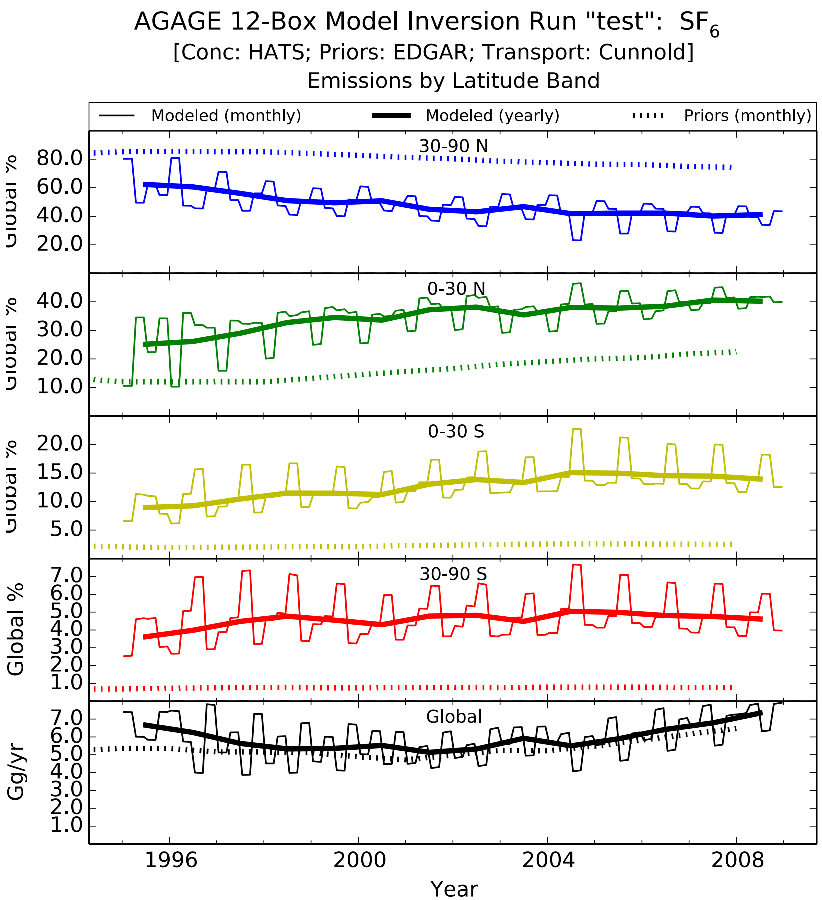


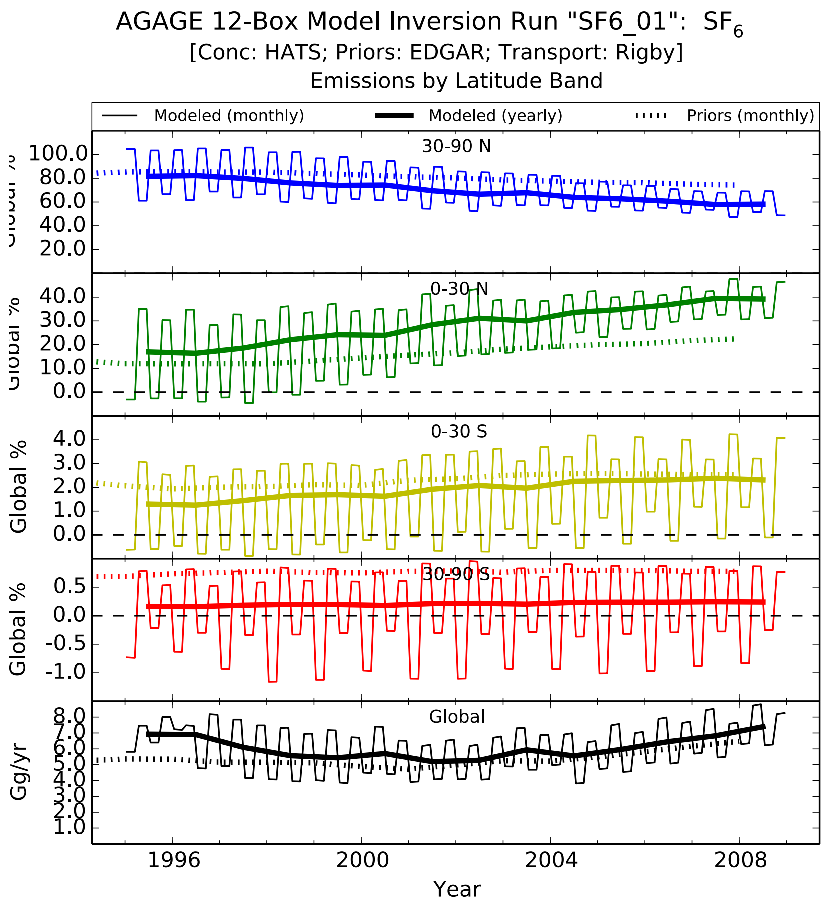
Extra slides

Test of different priors on AGAGE 12 box model



Different Transport 12 Box





Puts 20% of total emissions in the SH

Puts 2.5% of total emissions in the SH