IMPLICATIONS OF CO BIAS FOR OZONE AND METHANE LIFETIME IN A CCM

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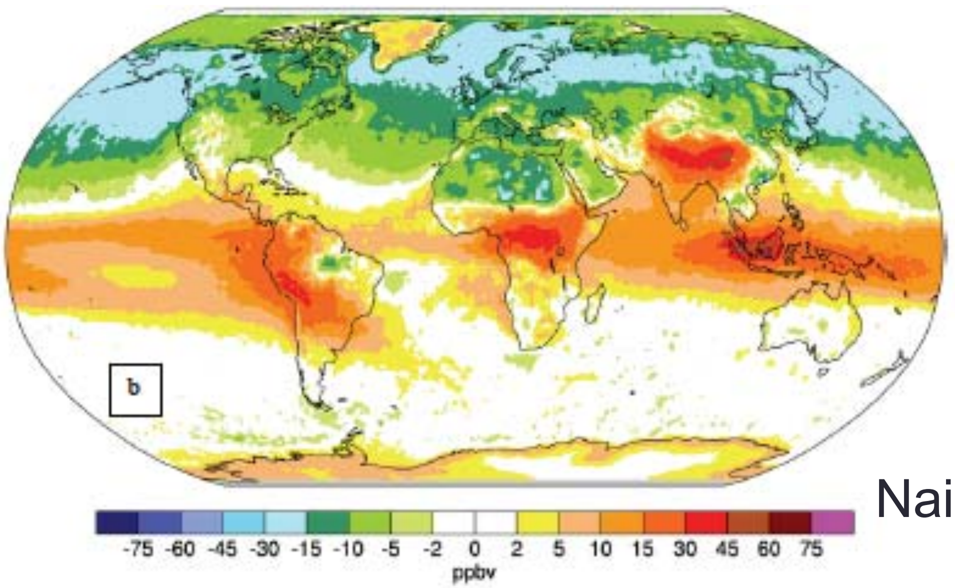
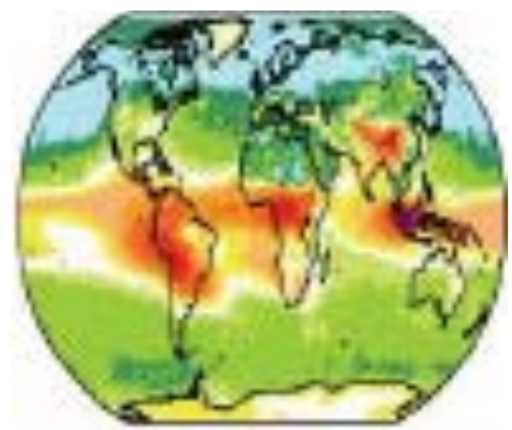
CO bias: what does it tell us?

- Low bias in CO at high latitudes is a common CCM feature: consistent with CH_4 lifetime underestimate

ACCMIP mean vs. MOPITT



GEOSCCM



Examine drivers of CO bias in the GEOSCCM ACCMIP 2000 simulation

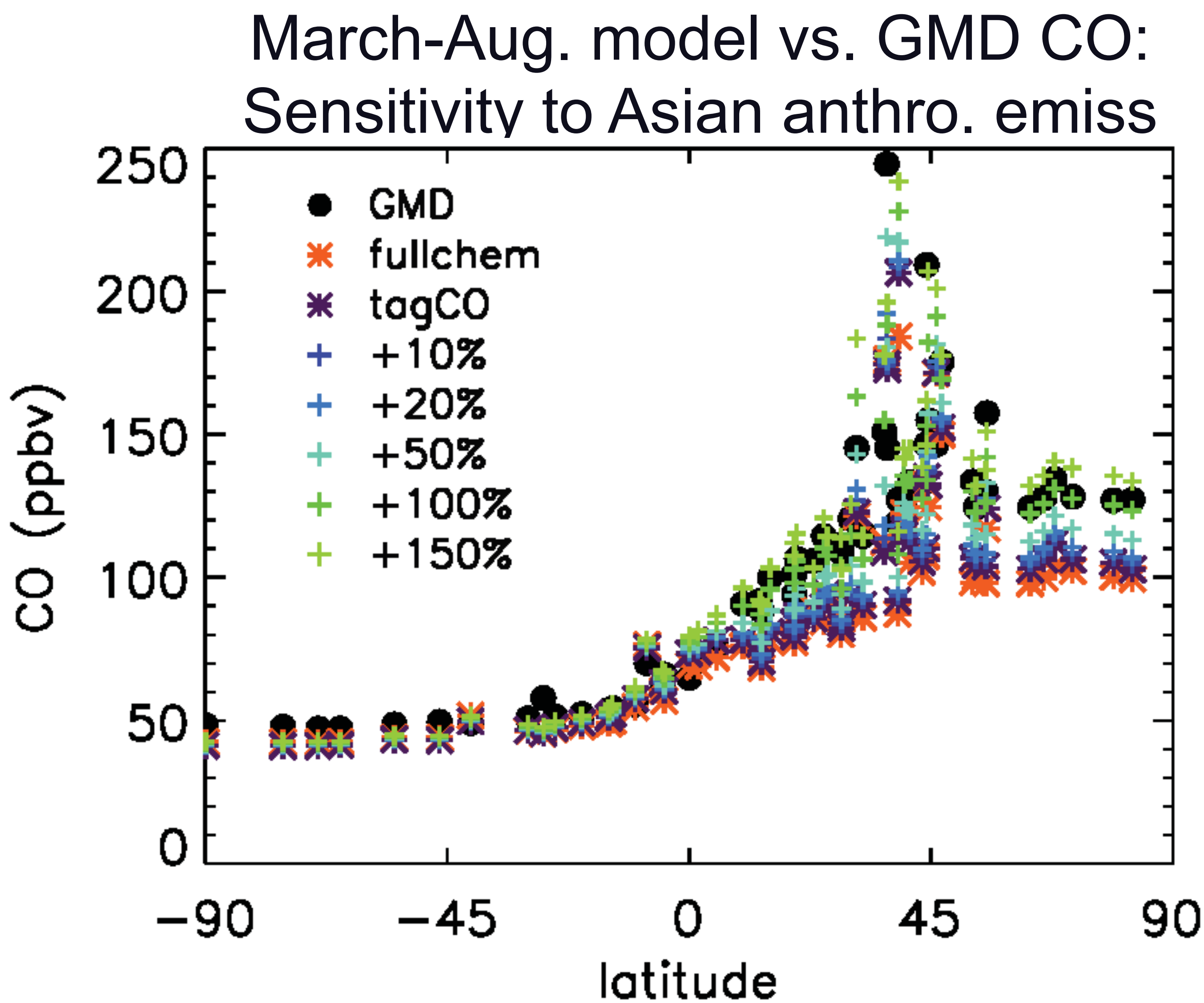
Naik et al. (2013)

- To what extent is low CO a symptom or cause of low OH?
  - Low CO emissions driving low CO, high OH? or
  - Other biases driving high OH driving low CO?
- What are the implications for ozone and methane?

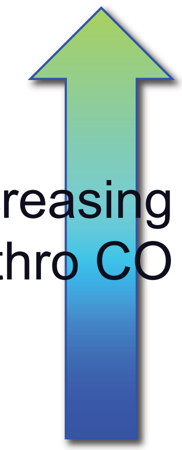
Models and Methods

- Use chemistry options of varying complexity in GEOS-5 to quantify impact of specific CO drivers:
  - Full Chemistry:
    - radiatively coupled stratospheric and tropospheric chemistry
    - >100 species
  - Tagged CO:
    - Computationally efficient
    - CO tracers tagged by source type
    - specified OH, CH_4, biogenic hydrocarbon oxidation
    - Isolate impact of specific source and OH adjustments
  - CH_4-OH-CO parameterization
    - Feedback between OH, CH_4, and CO
    - Specify methane, ozone, NOt, etc.
    - examine sensitivity of CO and OH to biases in these inputs

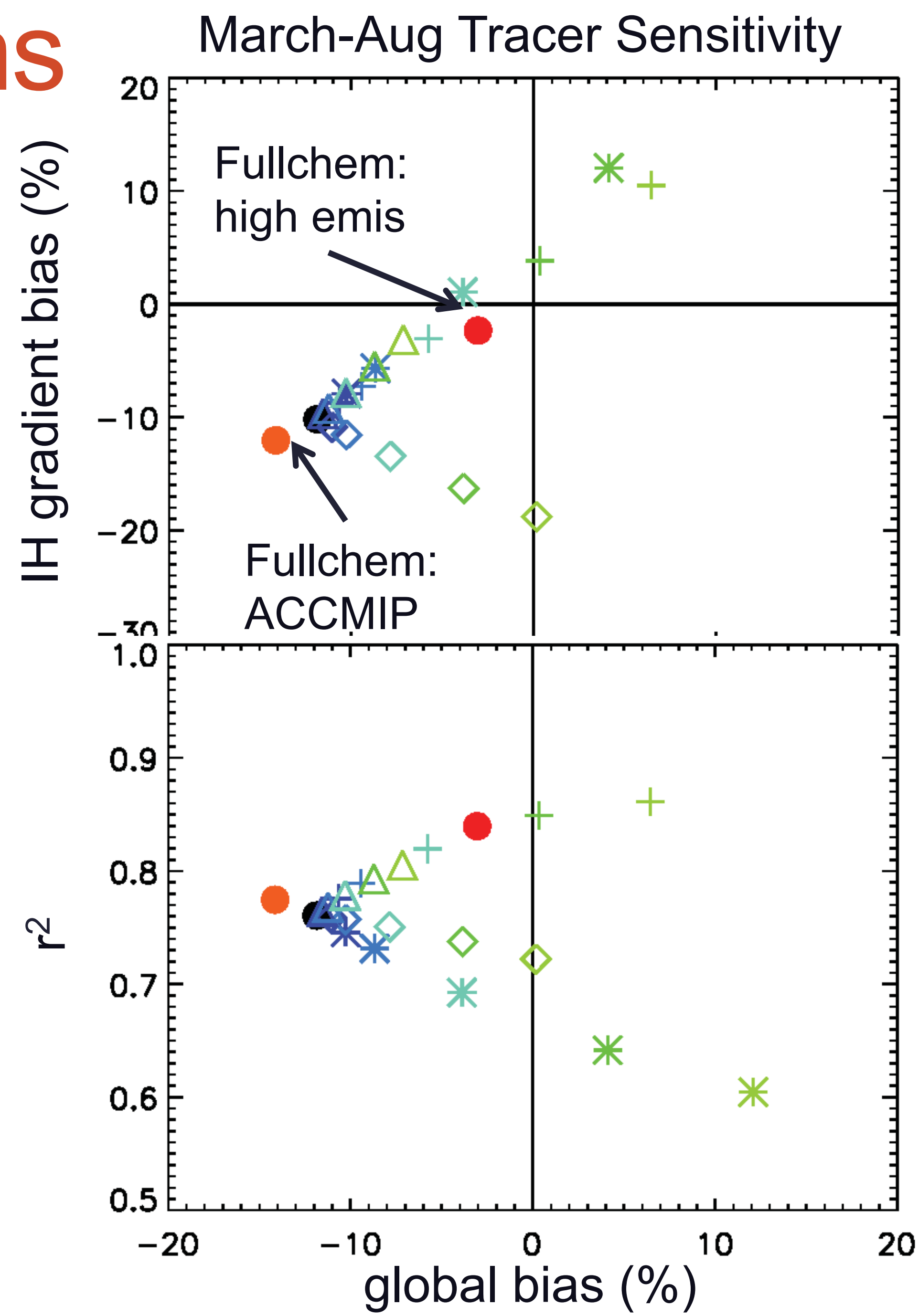
Latitudinal gradient of CO



- largest absolute bias in NH Spring/ Summer
- increasing mid-high latitude emissions reduces NH bias w/ little impact on SH



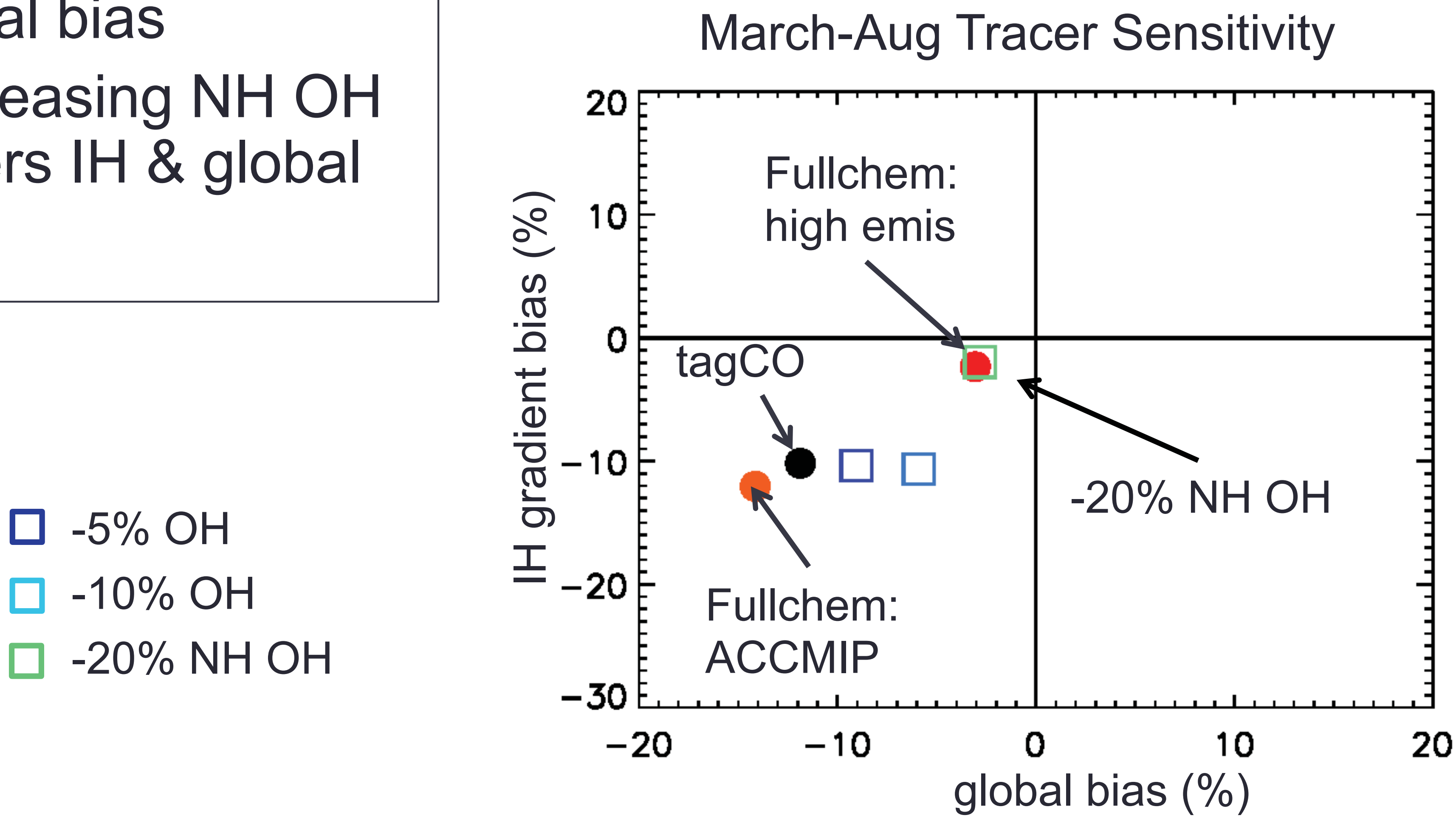
Source Contributions



- increasing NH emissions reduces total and interhemispheric (IH) gradient biases

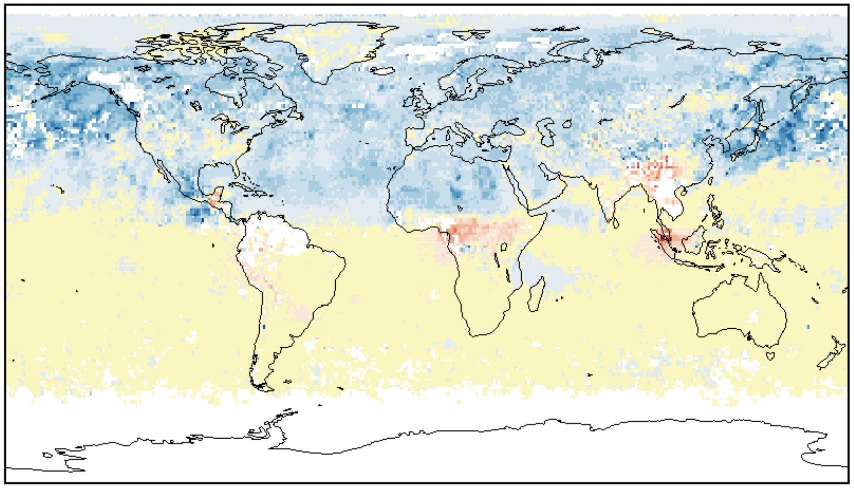
Source Contributions

- Global OH decrease reduces global bias
- decreasing NH OH lowers IH & global bias

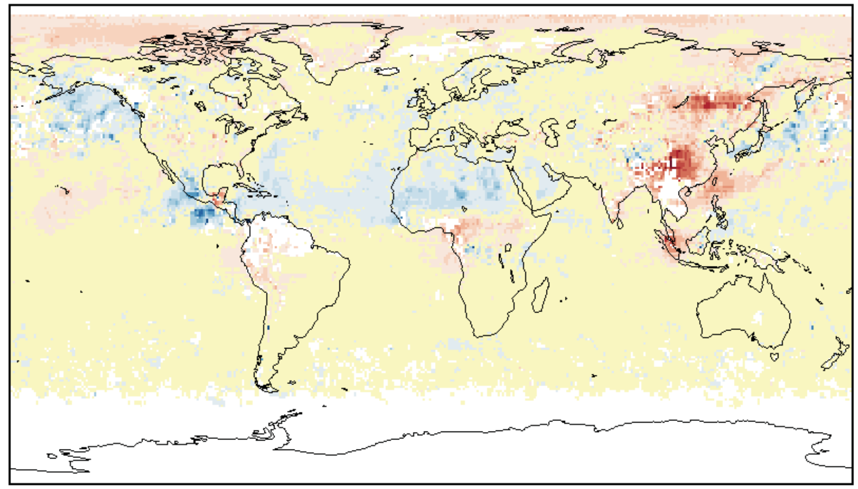


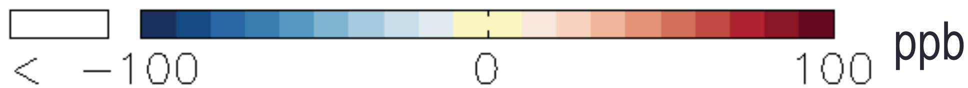
500mb CO Comparison to MOPITT

GEOSCCM – MOPITT, May 2000

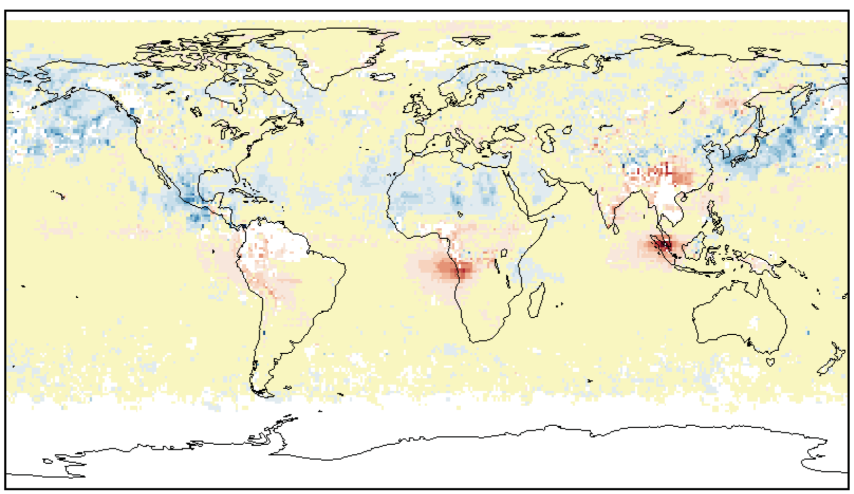


GEOSCCM w/ high emiss. - MOPITT





tagCO w/ -20% NH OH - MOPITT



- Increasing Asian anthro & boreal BB emission, or decreasing NH OH both reduce negative NH bias
- Positive bias over Asian source regions for Asian and boreal emissions increase

Impacts of CO emission increase

- Ran GEOSCCM full chemistry with increased Asian anthropogenic & boreal biomass burning emissions
- reduces CO bias compared to surface obs
- ~3% increase in CH_4 lifetime against OH: OH decreases 5% in NH, 1% in SH
  - small compared to the 20% reduction in N. hemisphere OH needed to correct CO bias for base emission case

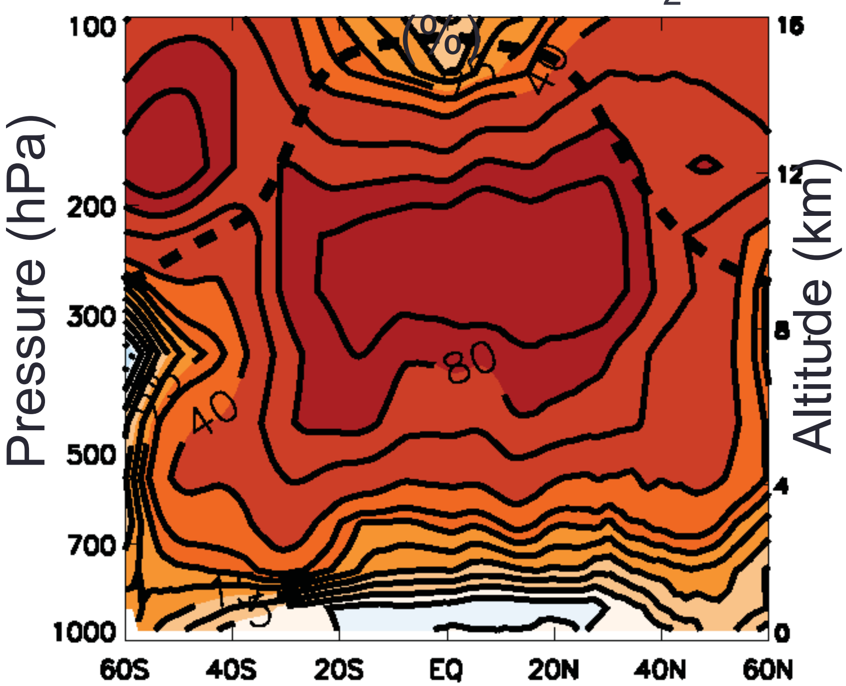
Next step: examine other model biases

- Can they drive CO bias via OH?

Impact of Water Vapor Bias

- high bias in water vapor
- Adjust H_2O in CH_4-OH-CO parameterization to better match AIRS
- Lower H_2O →lower OH →12% increase in CH_4 lifetime

GEOSCCM – AIRS H_2O

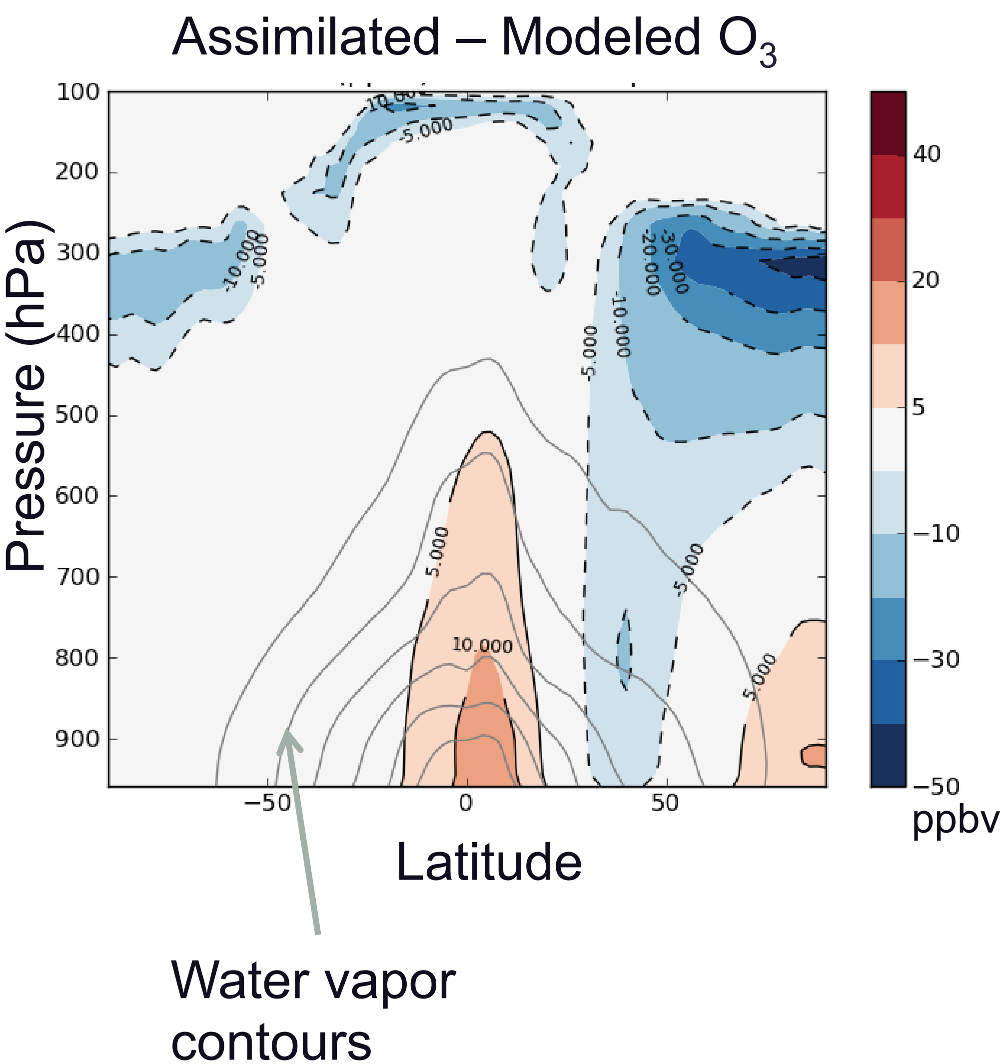


Surf. CO & trop OH changes from ΔH_2O

Annual, (Mar-Aug)	S. Hemisphere	N. Hemisphere
ΔOH (%)	-11 (-9)	-13 (-14)
ΔCO (%)	+9 (+9)	+6 (+6)

Impact of Tropospheric O_3 Bias

- Replace modeled O_3 w/ GMAO O_3 assimilation in the troposphere in CO-OH-CH_4 parameterization
- largest O_3 decrease in the upper troposphere; increase in tropical lower troposphere → net increase in OH
- 9% decrease in methane lifetime; small impact on CO



Conclusions & Future Work

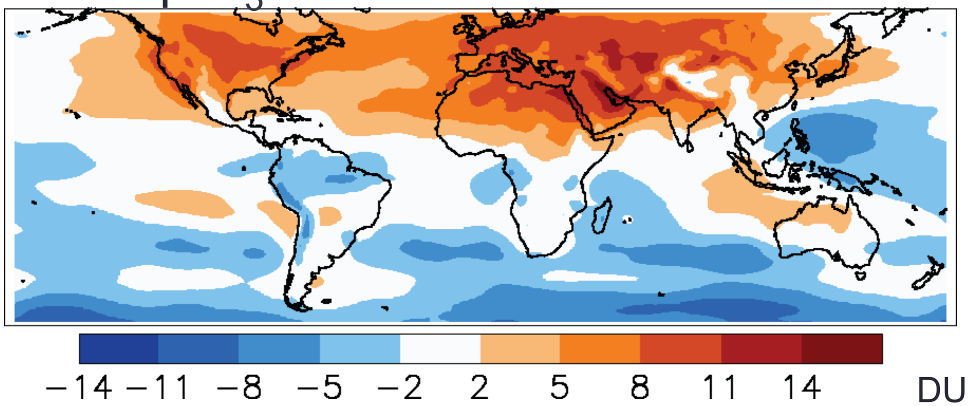
- Effects of removing NH CO bias:
  - w/ increasing high latitude emissions has small impact on methane lifetime
  - w/ decreased OH requires shift in inter-hemispheric gradient of OH
- H_2O bias increases global mean OH, while tropospheric O_3 bias decreases it
  - Neither bias alone explains CO gradient bias
- Combination of H_2O bias reduction and emissions could explain CO bias

- Future work
  - CO sensitivity to overhead ozone, NO_x, isoprene, convection
  - Quantify radiative forcing associated with each possible correction to CO bias

Impact of Tropospheric O_3 on OH & CO

- GEOSCCM tropospheric O_3 column compared to OMI/MLS climatology [*Ziemke et al.*, 2011]: high bias in NH, low bias in SH
- Bias also seen in ACCMIP multi-model mean [*Young et al.*, 2013]
- GMAO ozone assimilation incorporates OMI total O_3 column and MLS stratospheric O_3 profiles into GEOS-5
- Run CO-CH4-OH parameterization with GEOSCCM ozone, then rerun replacing tropospheric ozone with assimilated ozone
- 9% decrease in methane lifetime

Trop O_3 column bias vs. OMI/MLS



Surf. CO & trop OH changes from ΔO_3

Annual, (Mar-Aug)	S. Hemisphere	N. Hemisphere
ΔOH (%)	+10 (8)	+5 (5)
ΔCO (%)	-3 (-3)	-1 (-1)