Seasonal & Interannual Variability in Tropospheric CO: Global-Scale Analysis of GEOS-CHEM using MOPITT CO Measurements

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Questions

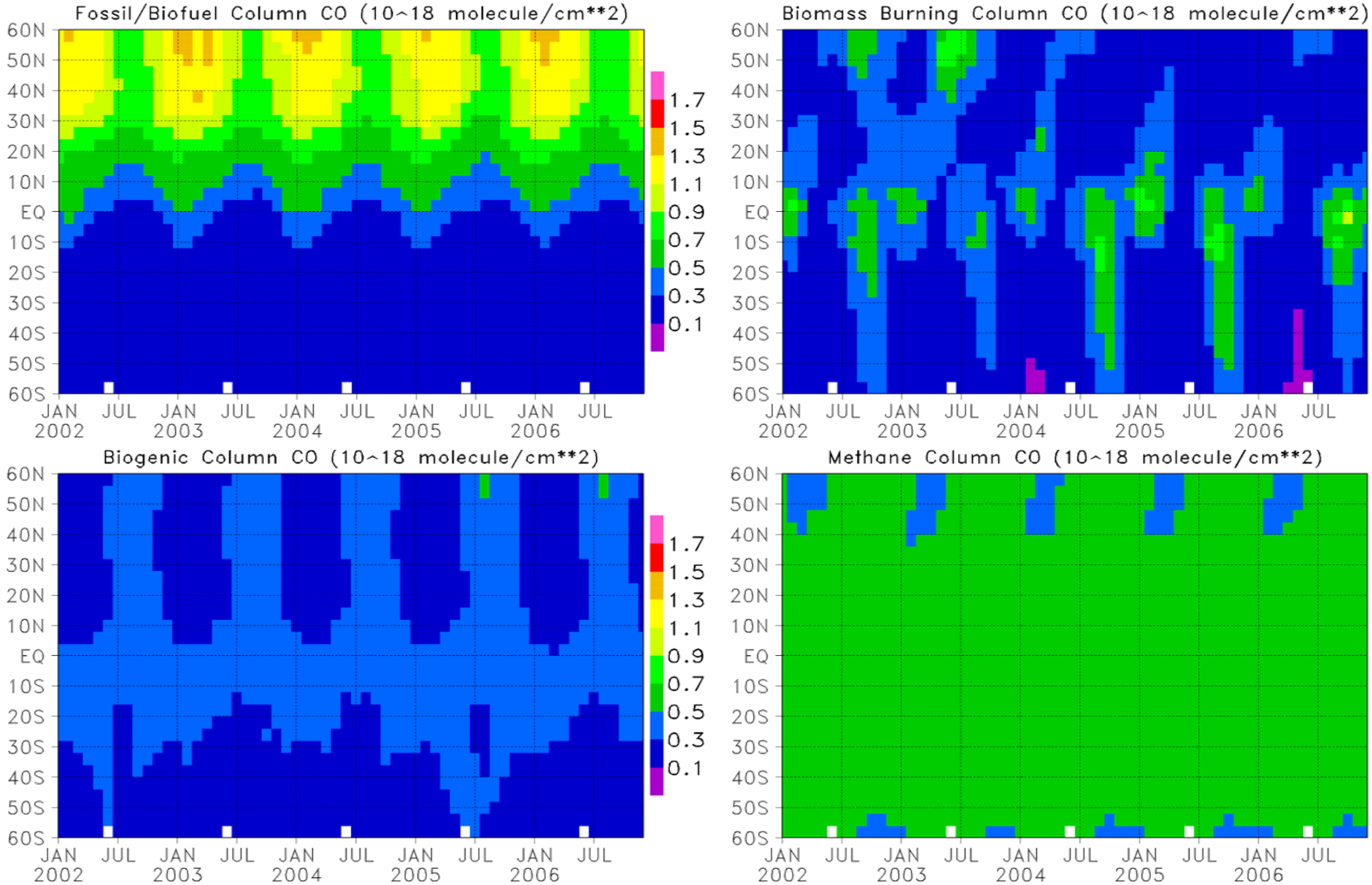
- Can seasonal and interannual variations in MOPITT CO provide constraints on biomass-burning emissions?

- Are there persistent biases in GEOS-CHEM simulations of CO relative to MOPITT measurements?

Simulation Set-up

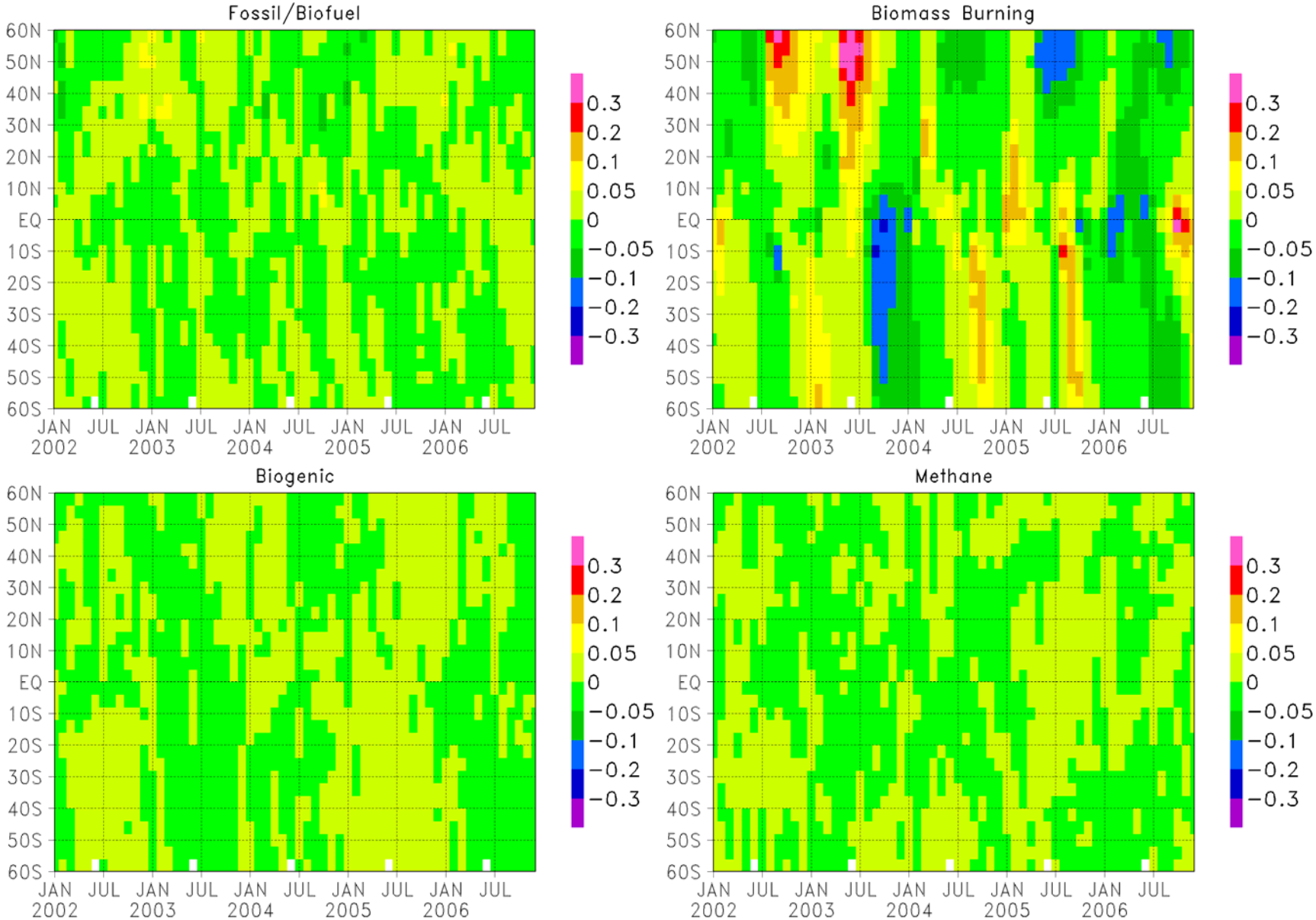
- 1996-2006 with GEOS-CHEM v7-04-06 driven by GEOS-4 4x5 met fields (*sensitivity runs at 2x2.5 resolution*)
- Tagged CO with prescribed monthly-mean OH from v5-07-08 (*sensitivity runs with OH from GMI-Combo and Isabelle Bey's simulation*)
- Sources
  - Fossil-fuel: GEIA 1985 CO emissions scaled to 1998 (Logan) and scaled up by 18.5% to account for VOC oxidation (Duncan) (*sensitivity runs with EGDAR/Streets/EMEP/NEI/BRAVO inventory*)
  - Biofuel: Yevich and Logan
  - Biogenic VOC oxidation: GEIA isoprene & monoterpene emissions with CO yields of 0.3 and 0.2; CO from methanol = 0.36 CO from isoprene; acetone emissions with CO yield of 0.67 (Duncan) (*sensitivity runs with MEGAN isoprene and monoterpene emissions*)
  - Methane oxidation: Calculated on-line using prescribed OH
  - Biomass burning: GFED2 (with preliminary 2006 product) and scaled up by 11% to account for VOC oxidation (Duncan)
- Focus here on 2002-2006 – Phase-2 MOPITT & MODIS fire counts

MOPITT-equivalent Model Column CO



Seasonal cycle dominated by fossil/biofuel combustion in NH – need to simulate this correctly to extract information on NH biomass burning fluxes

MOPITT-equivalent Model De-seasonalized Column CO

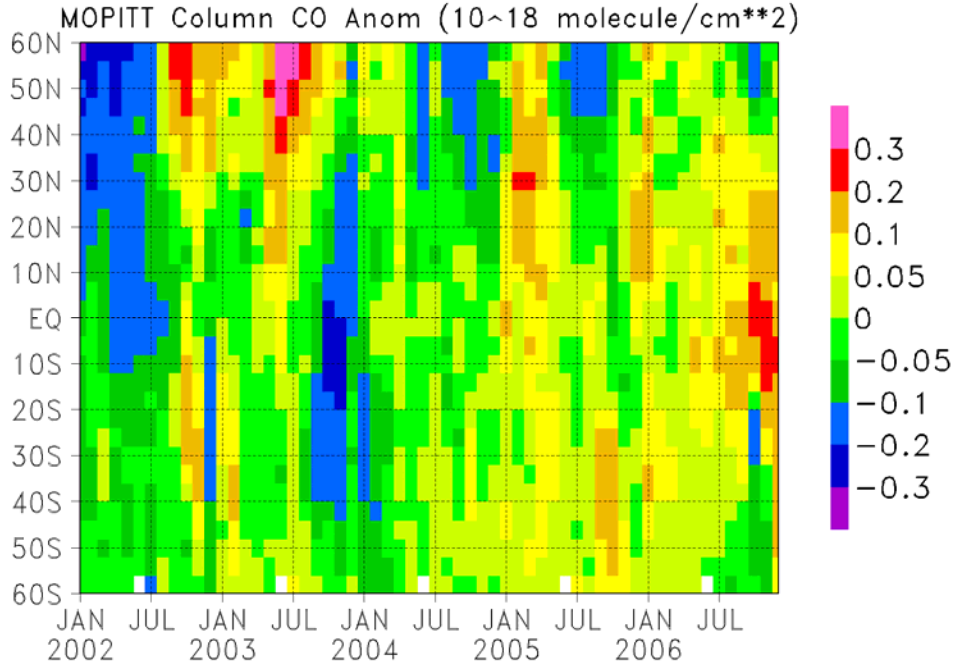


Interannual variations dominated by biomass burning in NH and SH – can provide information on regional biomass burning fluxes

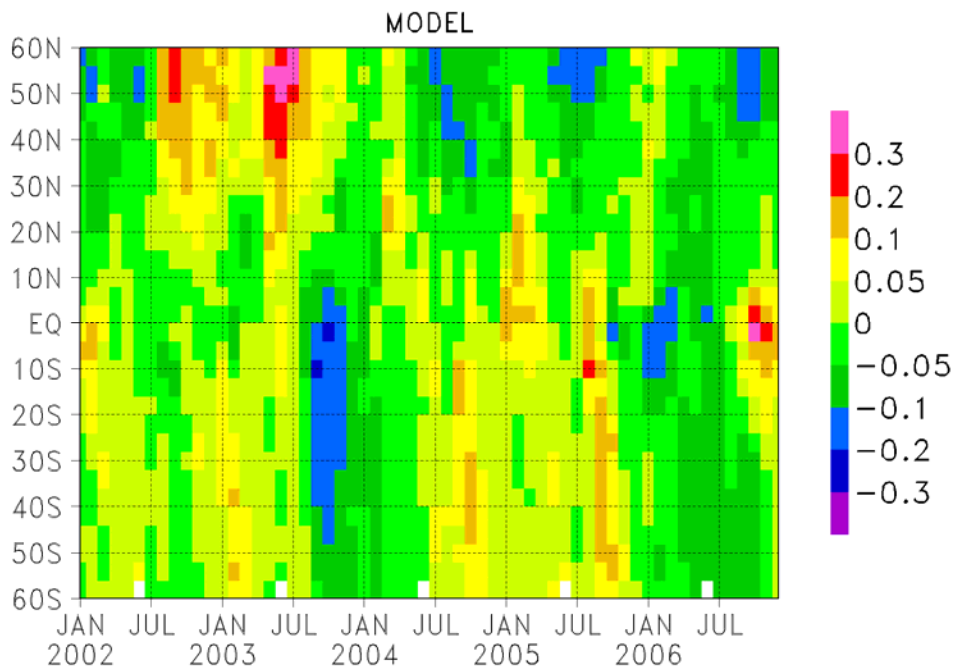
Let’s look at interannual variation first …

Model vs MOPITT De-seasonalized Column CO

MOPITT



MODEL

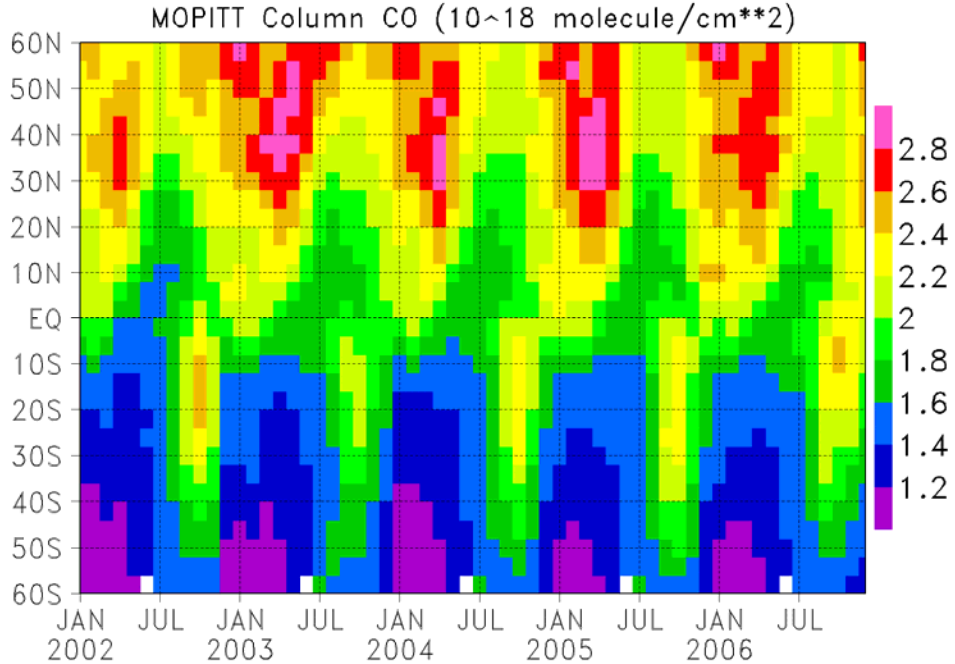


Model is relatively successful in reproducing observed anomaly patterns, with some notable exceptions → we are currently using anomaly contributions from basis regions to derive scaling factors for GFED2

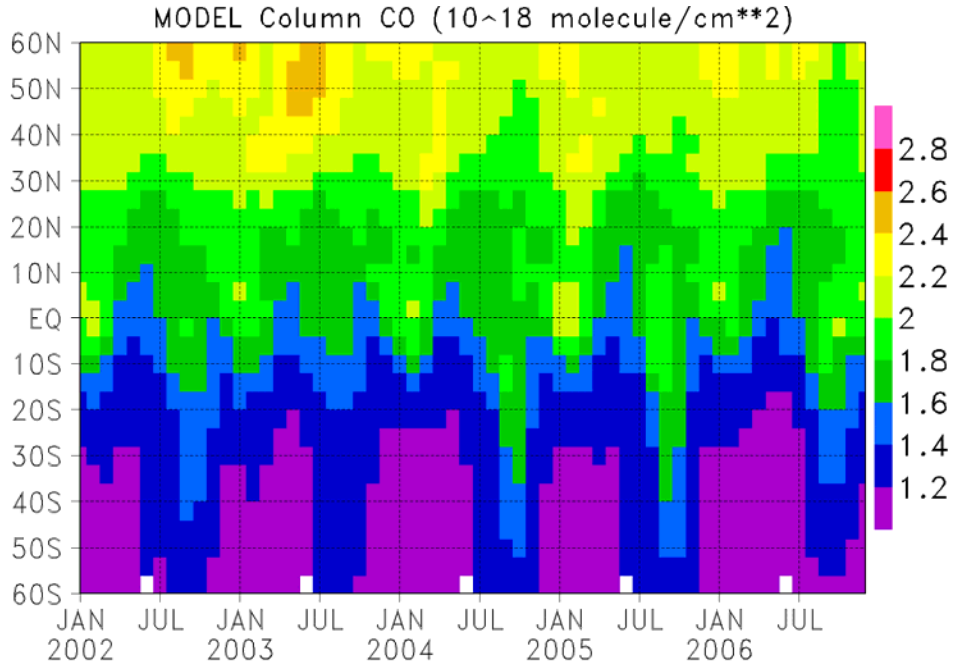
Now let’s get back to the seasonal cycle question …

Model vs MOPITT Column CO

MOPITT

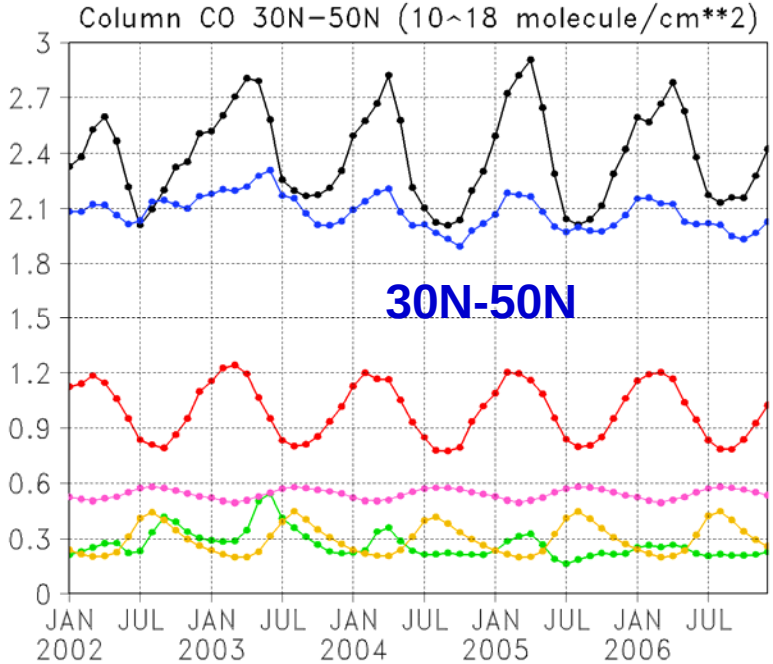


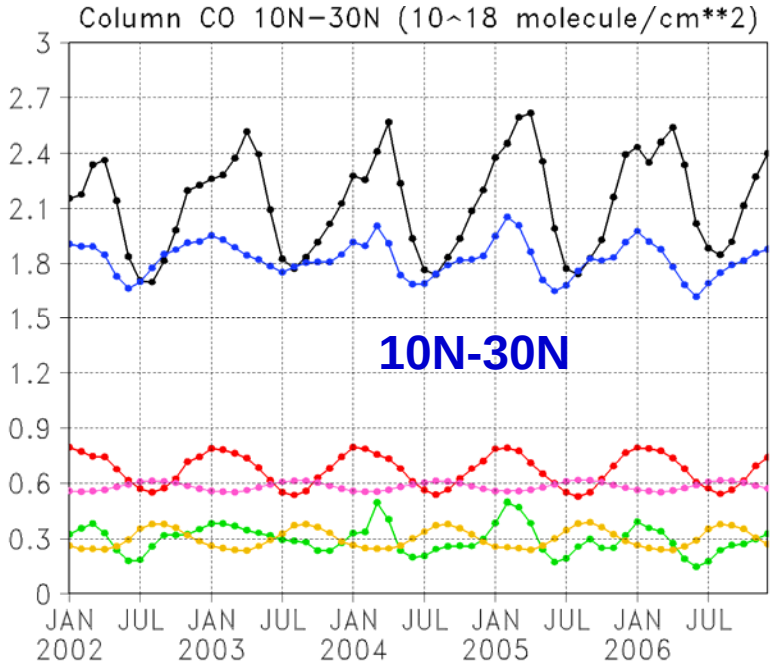
MODEL



Model underestimates tropospheric column CO in both hemispheres – and as the next few slides show does not capture the observed seasonal cycle.

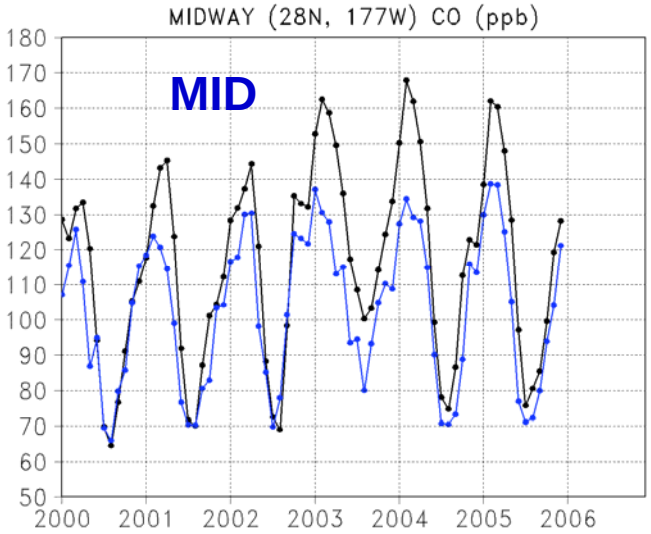
NH Model vs MOPITT Column

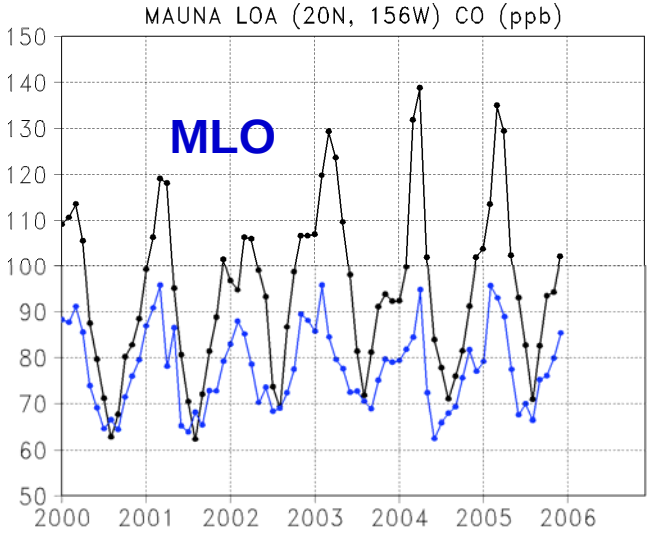




Obs
Model
Model FFBF
Model BB
Model BG
Model METH

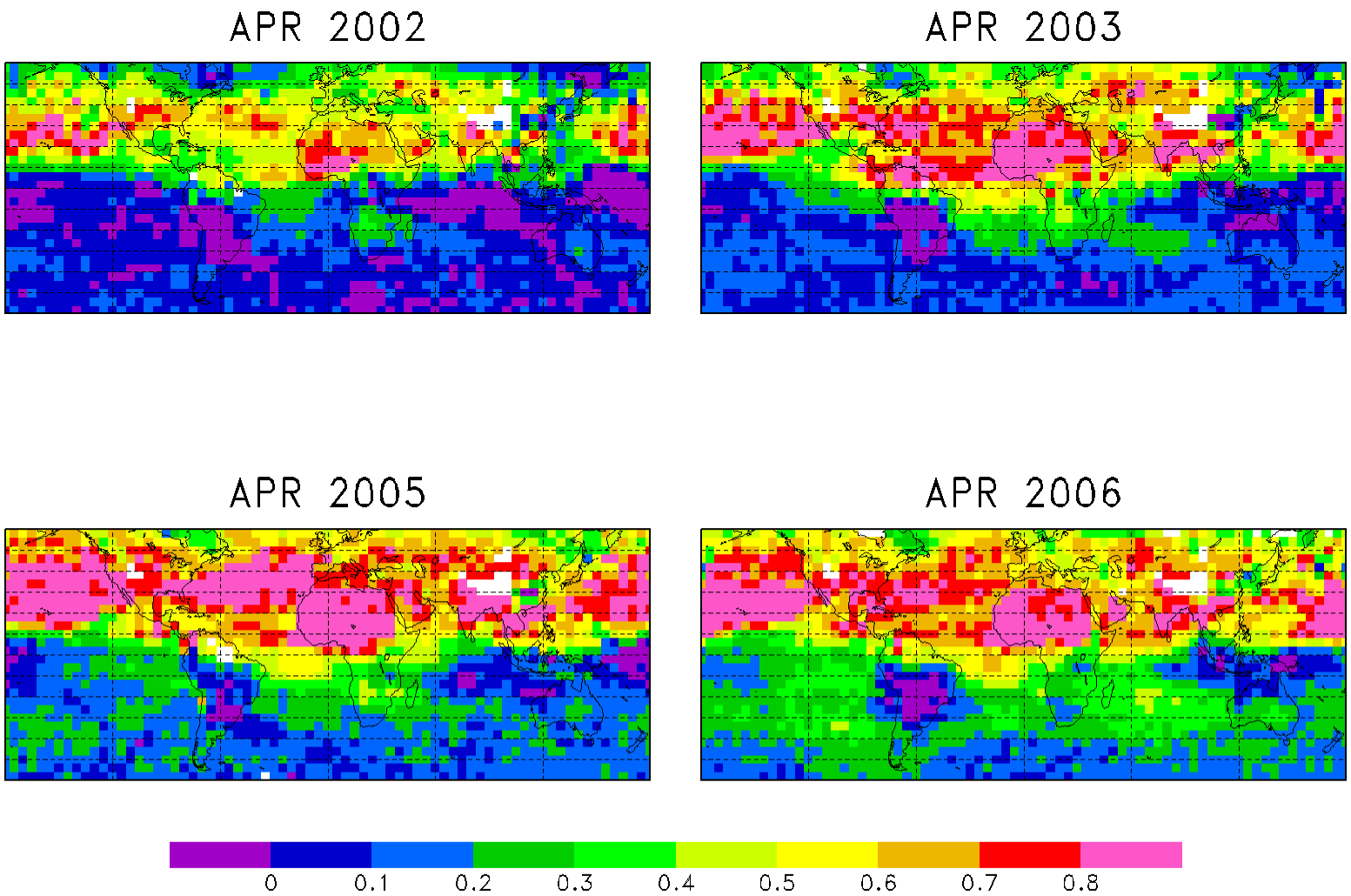
Model vs GMD Surface





Surface sites also show a similar problem

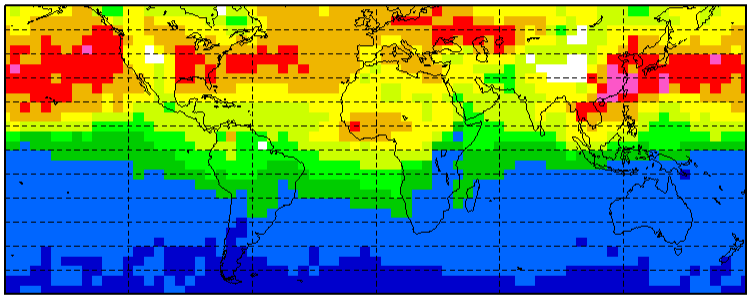
Difference Between MOPITT and Model Column CO in April



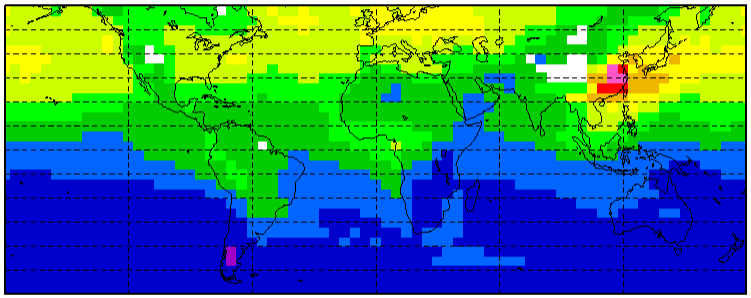
MOPITT-Model Column CO (10^{18} molecules cm^{-2})

MOPITT vs Column CO for Different Model Configurations in April 2004

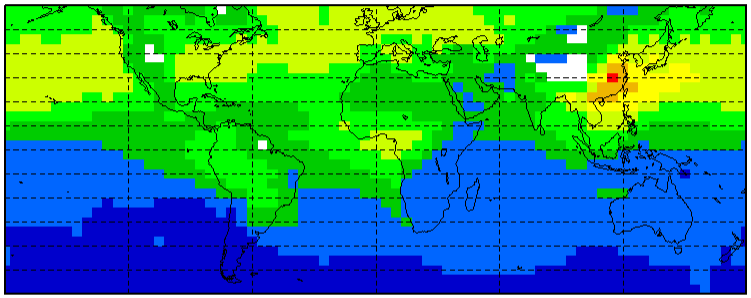
APR 2004 MOPITT Column CO



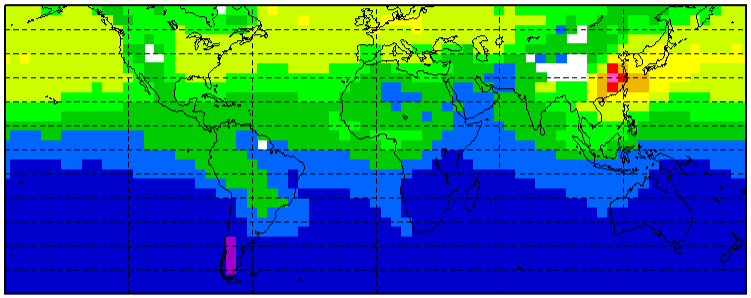
Model



GMI



Bey



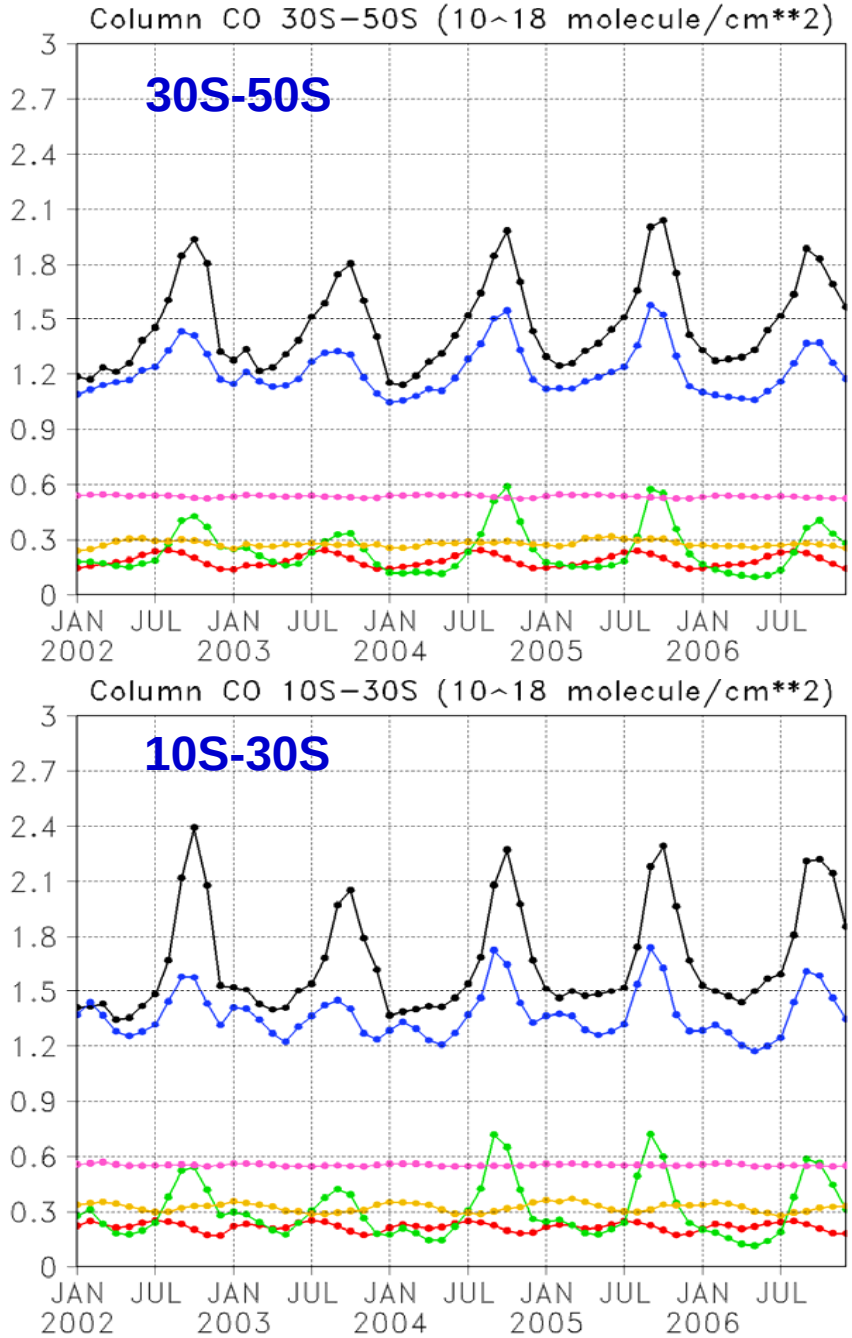
Model results from Susan Strahan

Model results from Isabelle Bey

Column CO (10^{18} molecules cm^{-2})

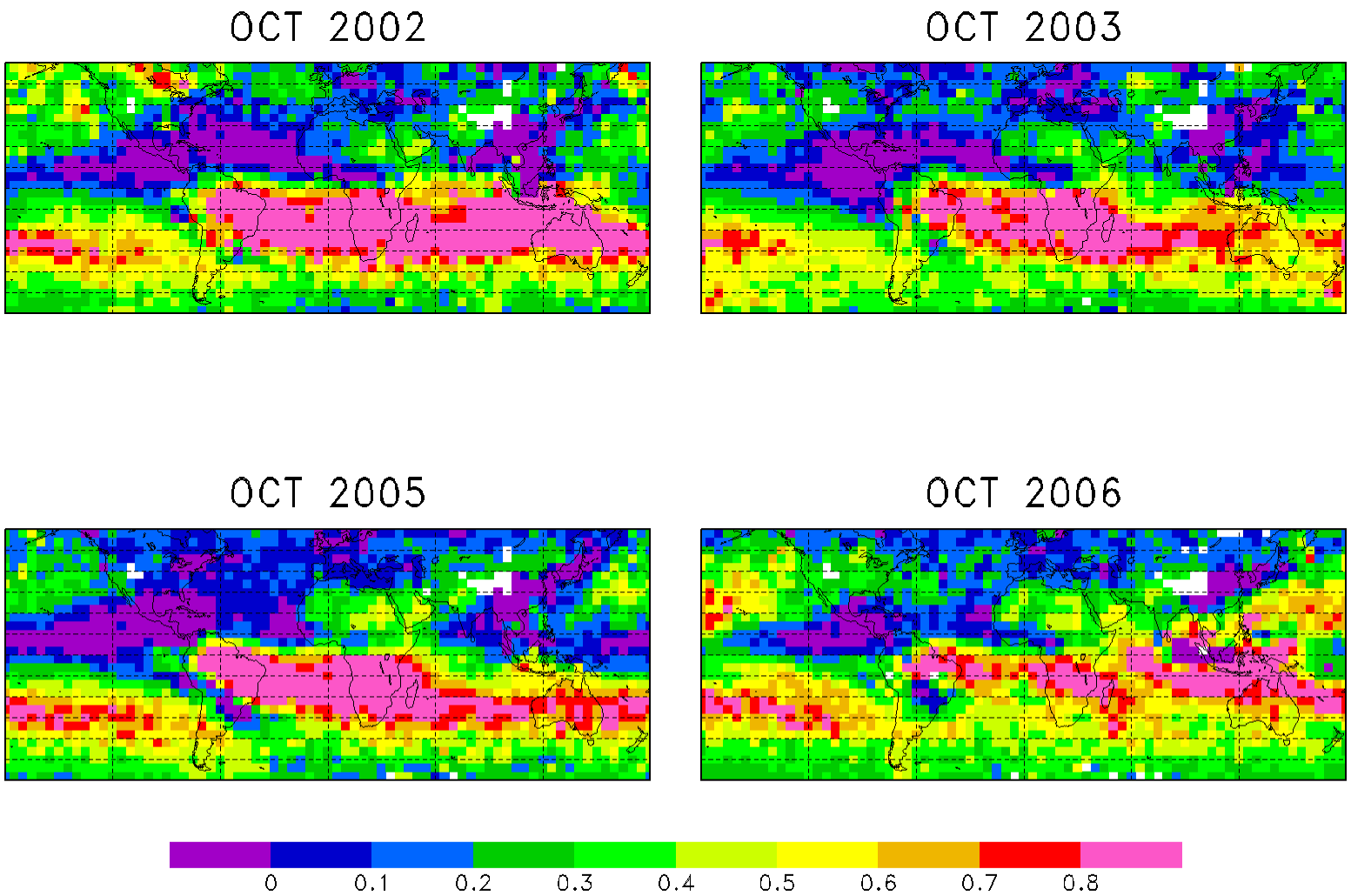
What is going on in Spring in the NH?????

SH Model vs MOPITT Column CO



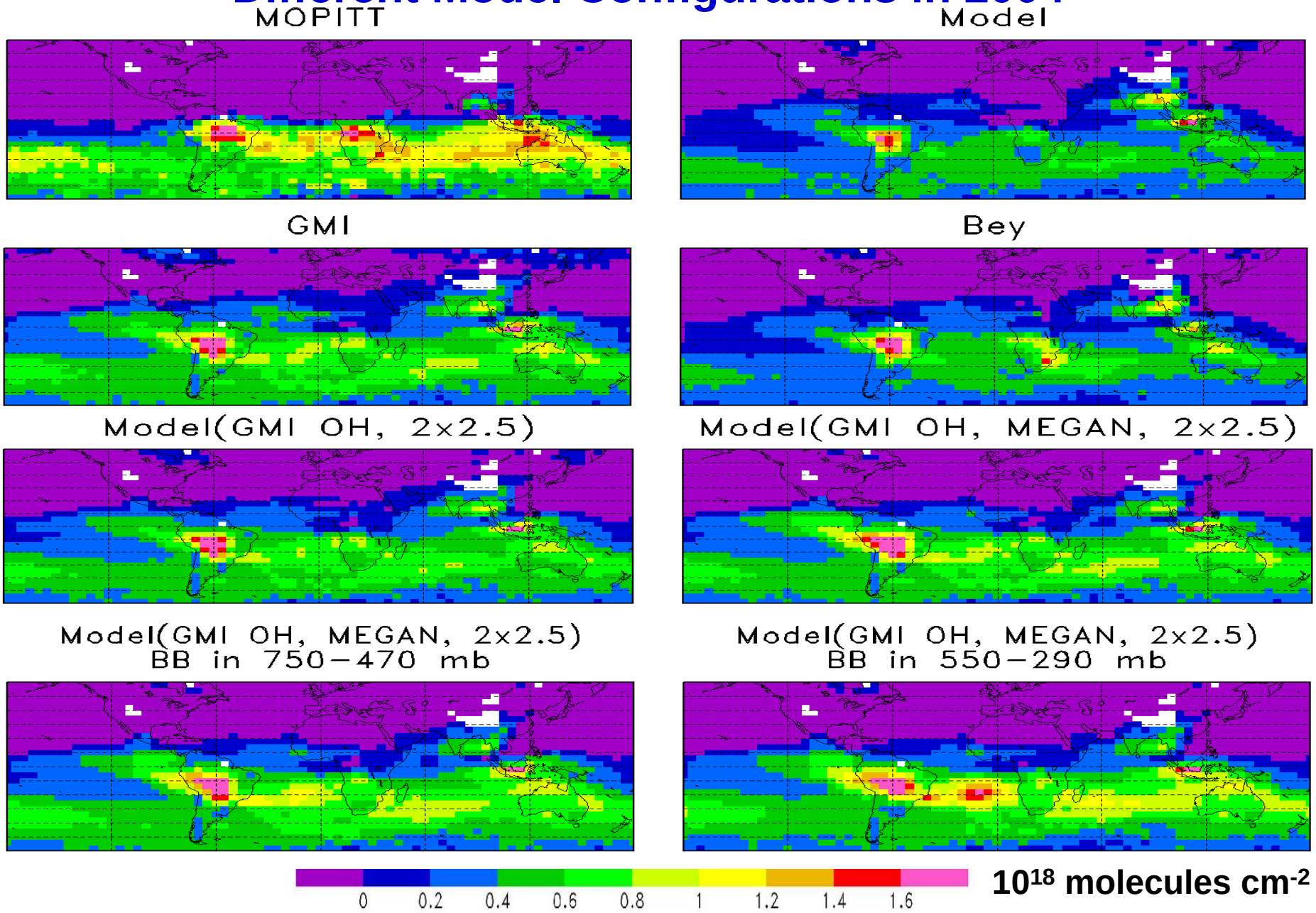
Obs
Model
Model FFBF
Model BB
Model BG
Model METH

Difference Between MOPITT and Model Column CO in October



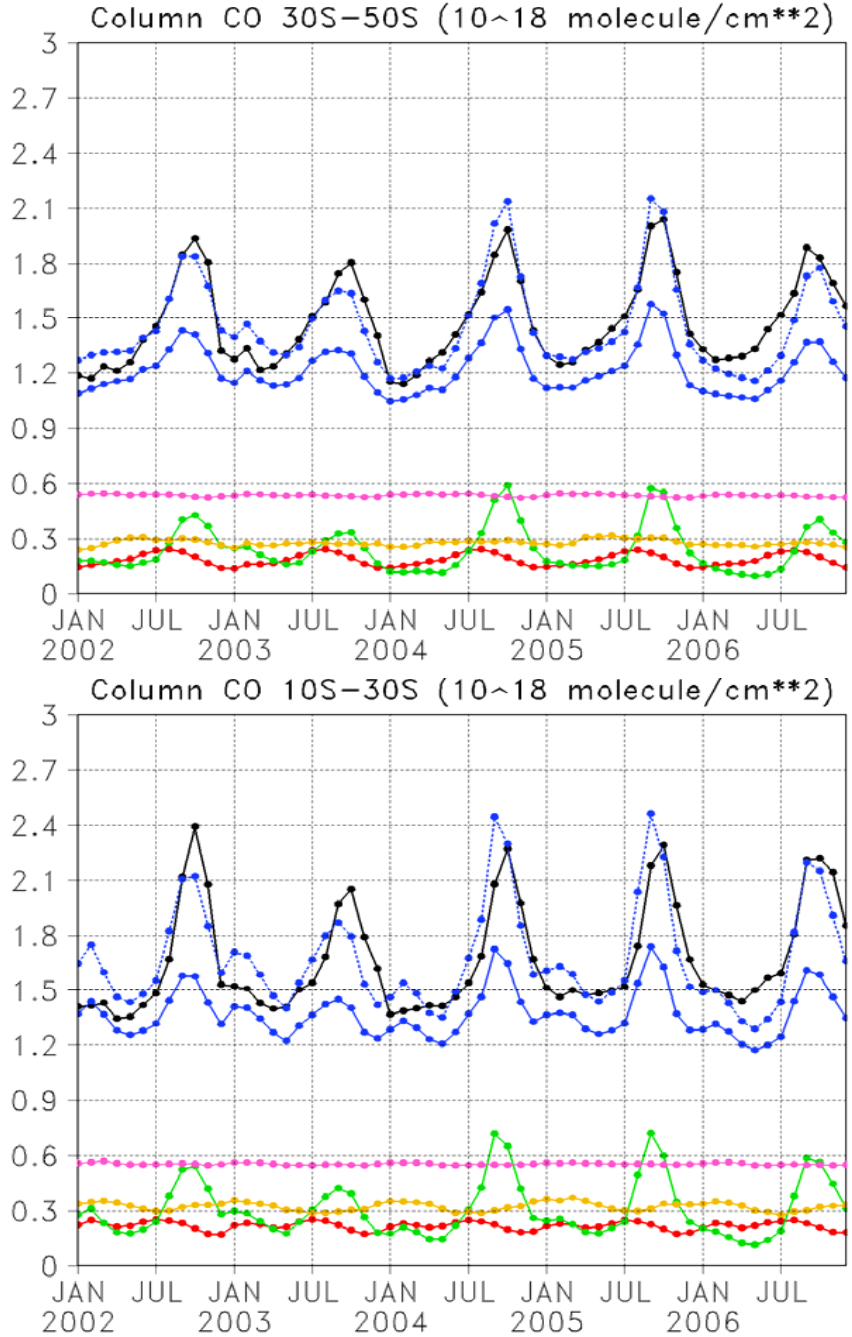
MOPITT-Model Column CO (10^{18} molecules cm^{-2})

MOPITT vs Column October-April Column CO for Different Model Configurations in 2004



10^{18} molecules cm^{-2}

SH Model vs MOPITT Column CO



Obs

Model

Model FFBF

Model BB

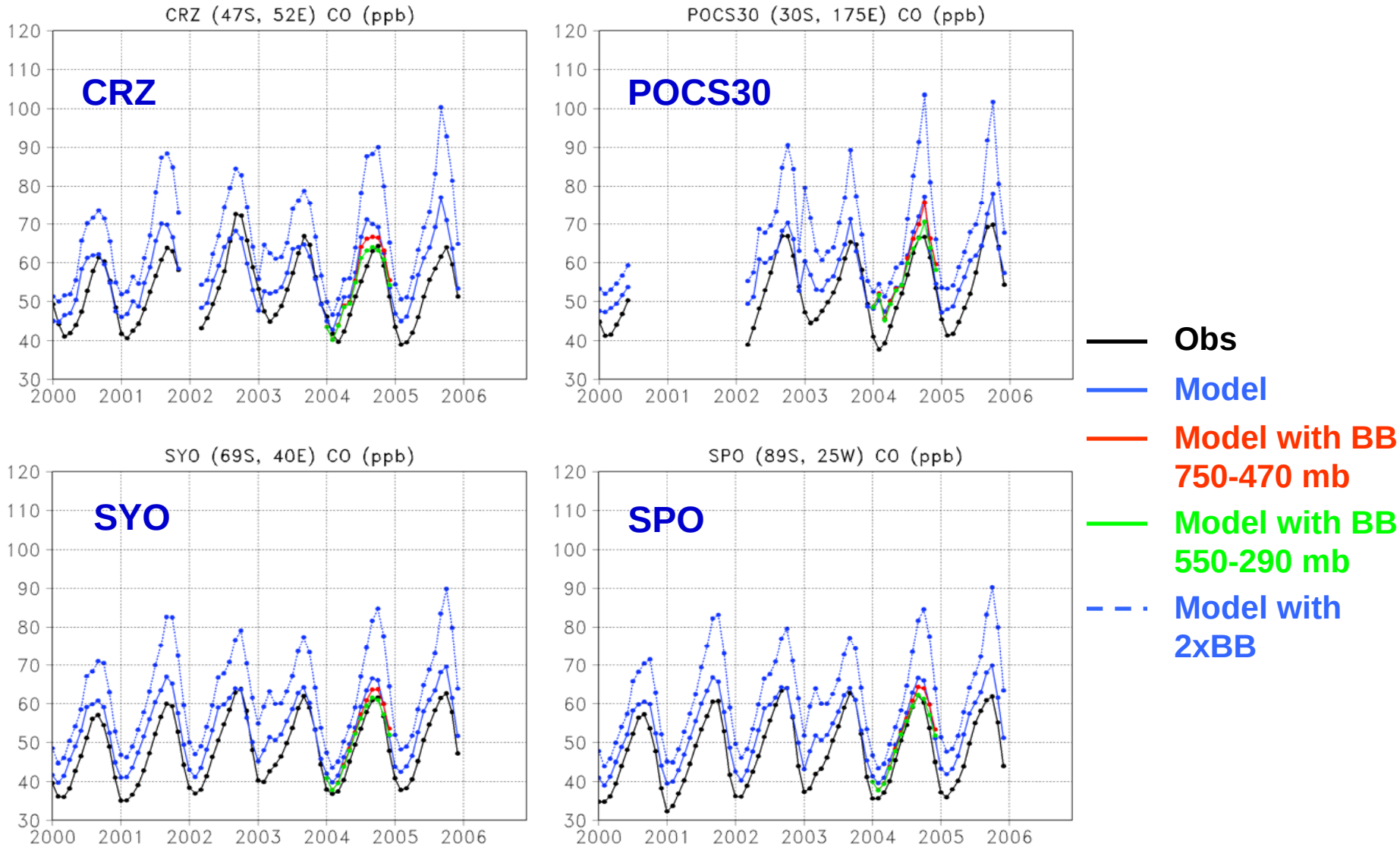
Model BG

Model METH

Model with 2xBB

Model with 2xBB captures seasonal amplitude of tropospheric column CO in SH,
but …

Model vs GMD Surface CO



- Model with 2xBB overestimates seasonal amplitude at surface in SH
- Injection of BB emissions into upper free trop appears to improve model agreement with MOPITT and surface sites in SH

Summary

- Patterns of interannual variability in tropospheric column CO relatively well simulated

- There are significant biases in modeled CO relative to MOPITT in both hemispheres (conclusion partly different from Shindell et al., 2006)

- NH bias
  - Likely not significantly tied to biomass burning emissions
  - Difficult to reconcile → can analysis of aircraft+TES+MOPITT+GMD CO measurements provide insights?
  - Other potential factors to consider → seasonality and trends of NH anthropogenic emissions, state-dependent MOPITT biases?
  - Transport biases???

- SH bias
  - Also seen with respect to TES (Logan)
  - Likely tied to biomass burning emissions
  - Difficult to reconcile MOPITT measurements relative to surface measurements → can limited aircraft measurements provide a clue?
  - Transport biases?

Acknowledgements

- NASA (funding)
- Daniel Jacob, Bob Yantosca, and GEOS-CHEM core team (model)
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- Isabelle Bey (model results)
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