The Goddard Chemistry Climate Model (GEOS CCM)

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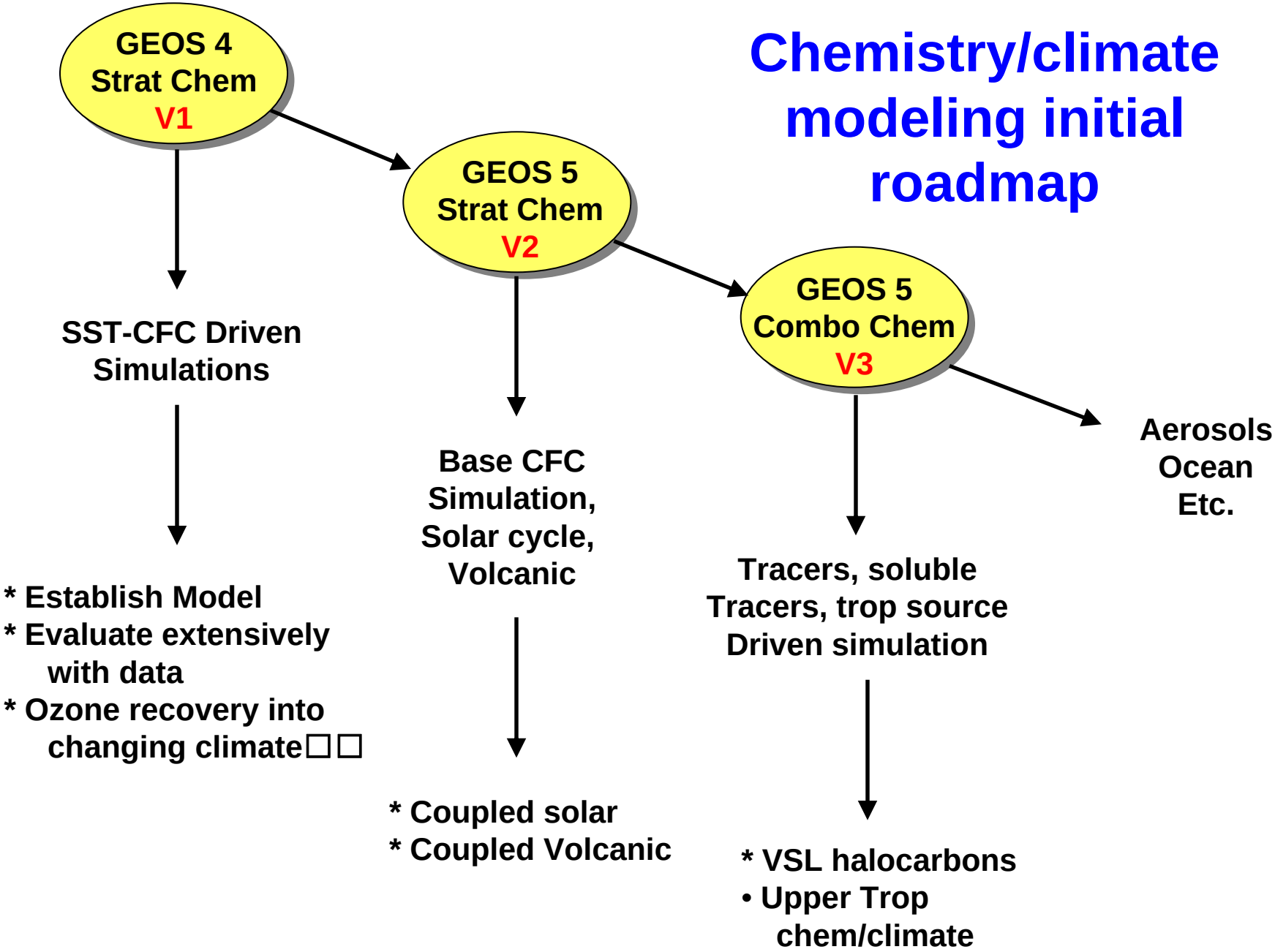
A joint project of the Goddard Atmospheric Chemistry and Dynamics Branch (ACDB) and the Global Modeling and Assimilation Office (GMAO)

We combine the atmospheric chemistry of the Goddard CTM and the GMI CTM with the atmospheric general circulation model of GMAO into a coupled chemistry climate model

Funded by the NASA Modeling and Analysis Program (MAP)

Chemistry/climate modeling initial roadmap



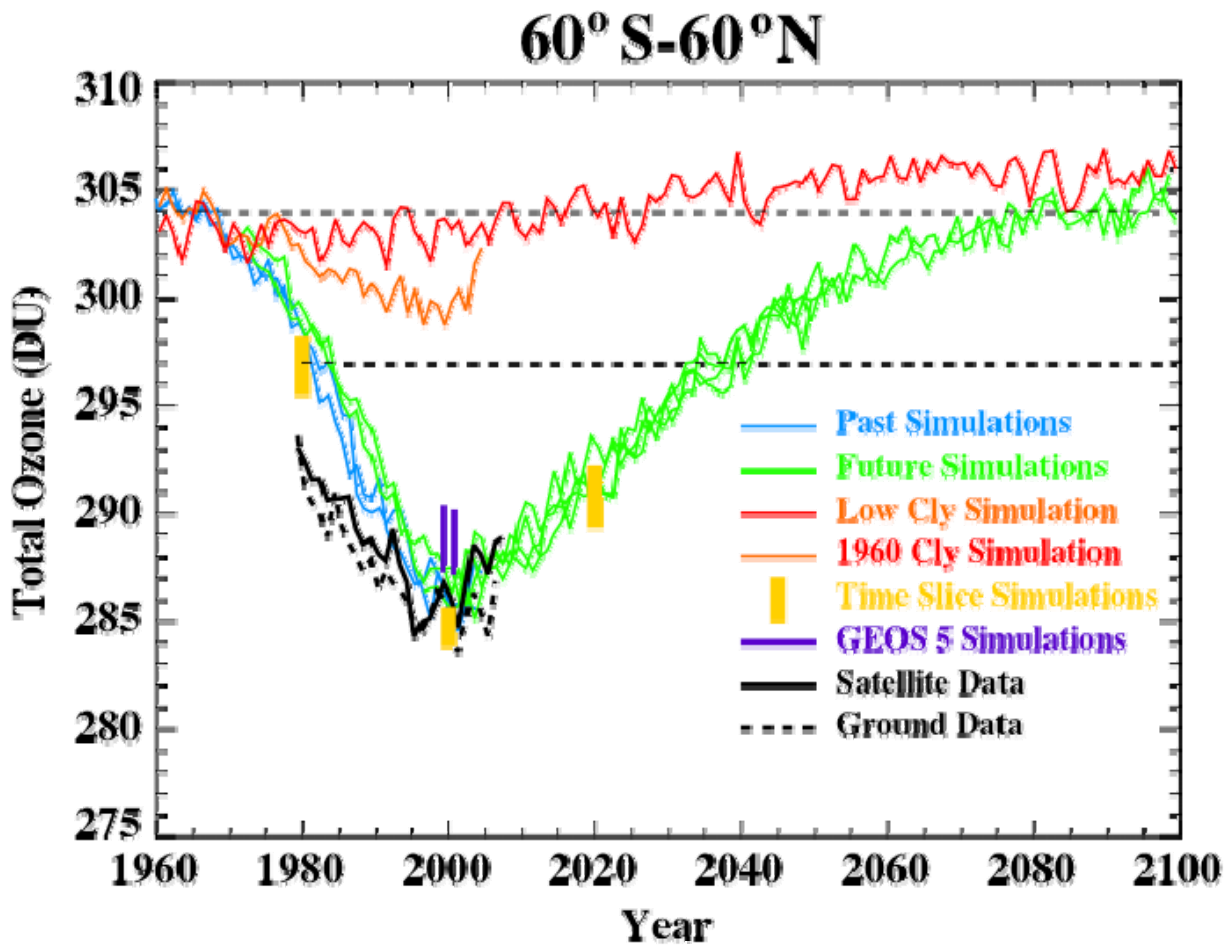
Completed Simulations

V1-GEOS 4 AGCM coupled with stratospheric chemistry

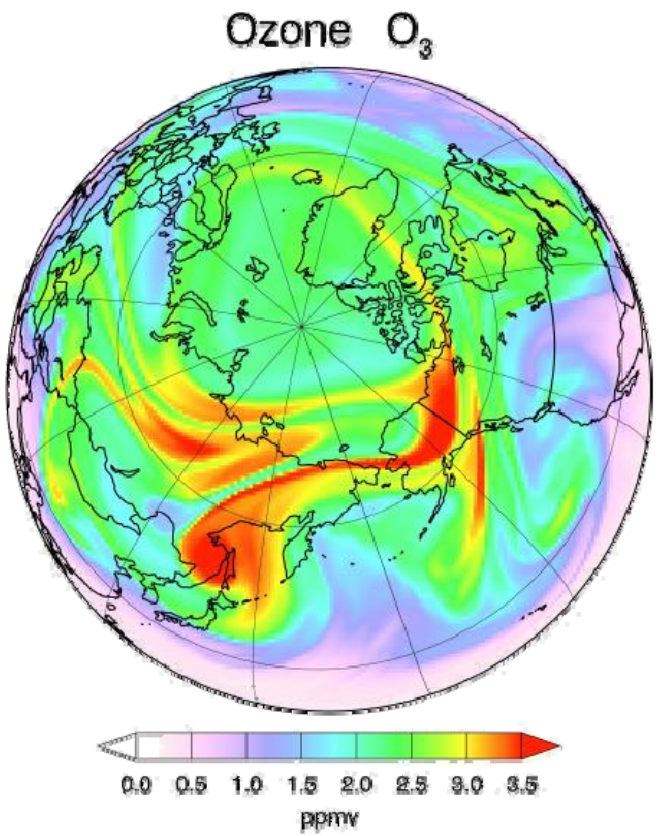
- Time slice 1980 (26 years) Hadley SSTs 1979-2004
- Time slice 2000 (26 years) Hadley SSTs 1979-2004
- Time slice 2020 (26 years) Hadley SSTs 1979-2004
- Time dependent past (1950-2005) Hadley SSTs
- Time dependent past (1950-2005) Hadley SSTs, 2nd ensemble member
- Time dependent future (1996-2099) HadGEM SSTs
- Time dependent future (1971-2050) HadGEM SSTs
- Time dependent future (1971-2053) NCAR SSTs
- Time dependent future (2000-2099) NCAR SSTs
- Time slice 2000 (26 years) repeated 2002 Hadley SSTs
- Time slice 2000 (26 years) repeated 2000 Hadley SSTs
- Time dependent past: low chlorine (1960-2004)
- Time dependent past and future: 1960 chlorine (1960-2099)
- Time dependent repeated mean Hadley SSTs (1960-2004)
- Time dependent future NCAR SSTs A2 GHG scenario (2000-2073)
- Time slice 2020 World avoided NCAR SSTs
- Time dependent World avoided NCAR SSTs (1974-2065)

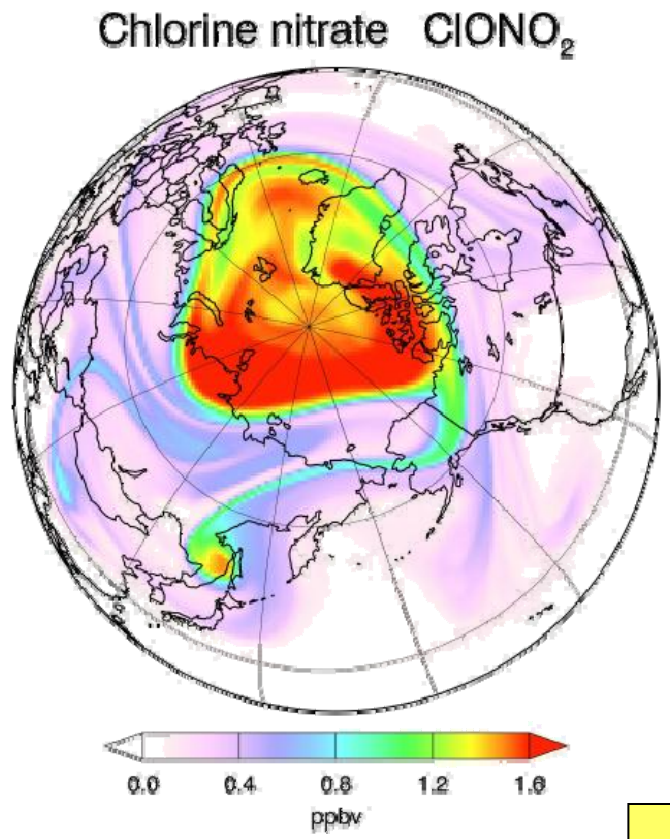
Version Used in CCMVal comparisons (Eyring et al. papers) and 2006 Ozone Assessment

Quasi-Global Average Total Ozone Summary: GEOS CCM V1 Simulations



High-Resolution GEOS 5 Transport with Stratospheric Chemistry

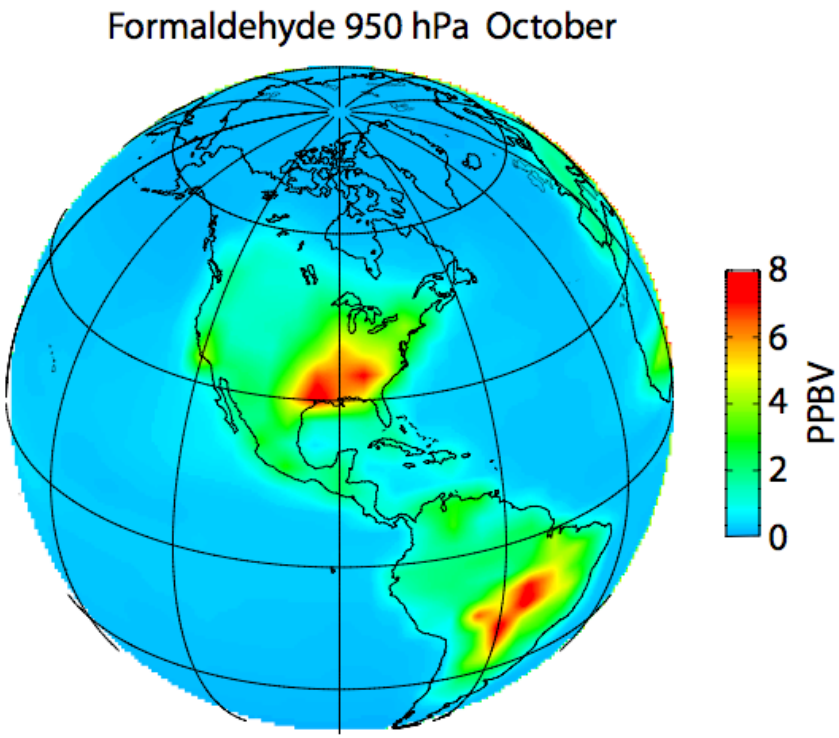


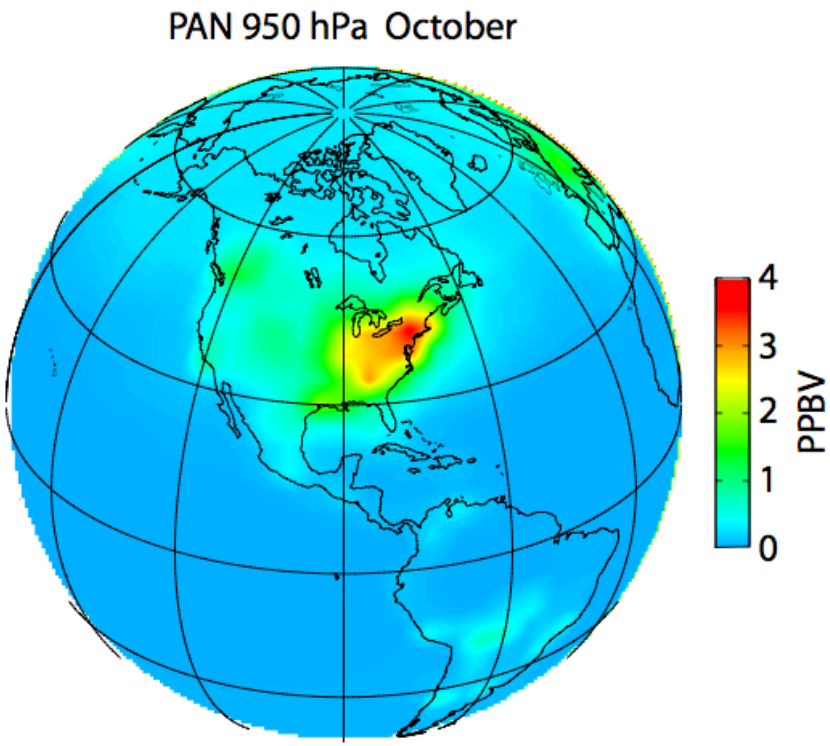


P=70 hPa
1 April 2004
2/3° x 1/2°

From Eric Nielsen

Formaldehyde and PAN at 950 hPa from GEOS CCM Simulation with Combo Chemistry



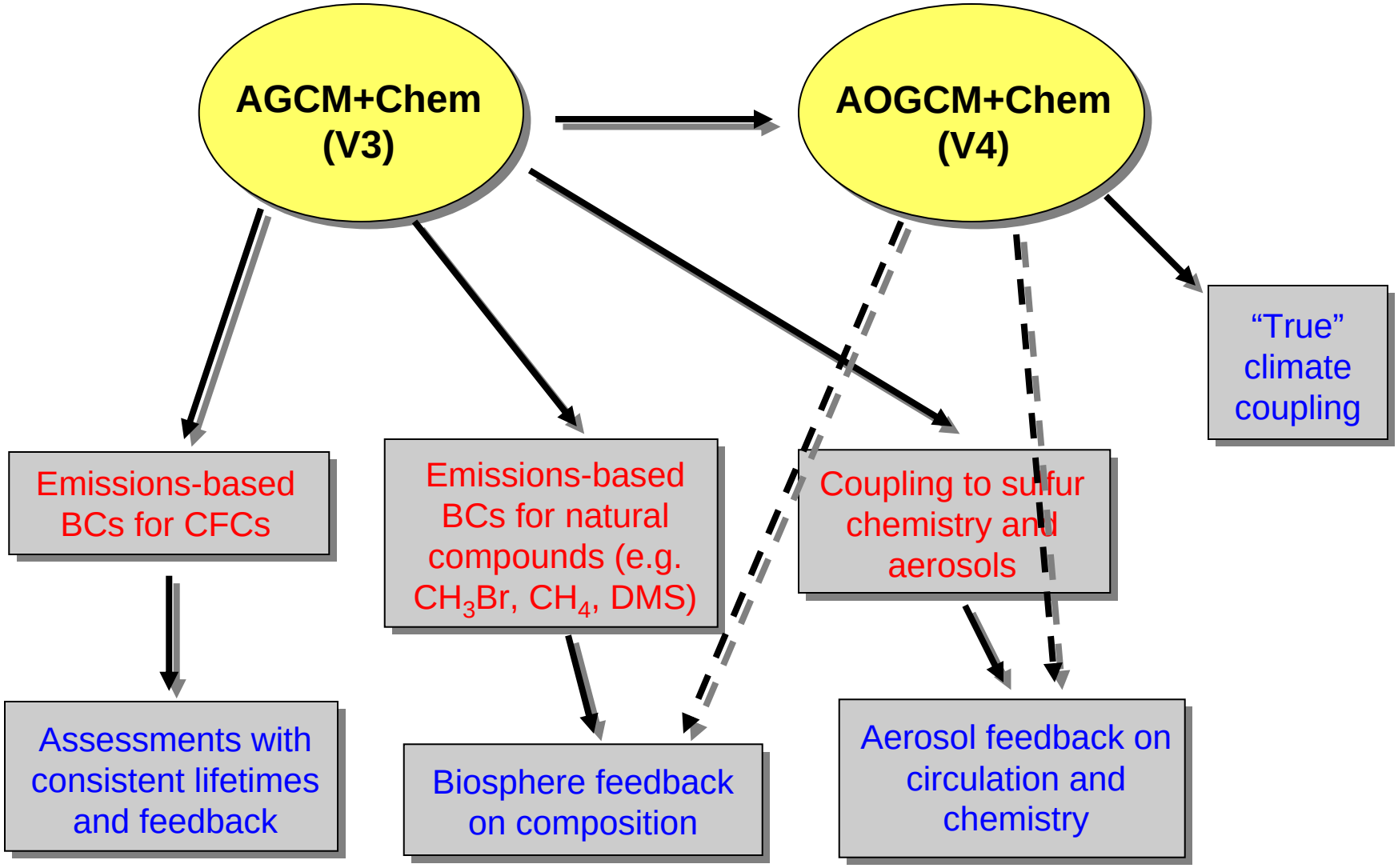


Future CCM Development
Working Toward Earth-System Model

- **Extensions of Model**
  - Coupled to Ocean-Atmosphere Model
  - Coupled to Aerosols
  - Interactive Emissions from Land and Ocean
- **Improvements of Underlying Model**
  - Vortex Breakup Timing
  - Issues with Convective Transport and Washout
- **Directions and Priorities Driven by Science Issues**

GEOS CCM Development:

A collaborative effort



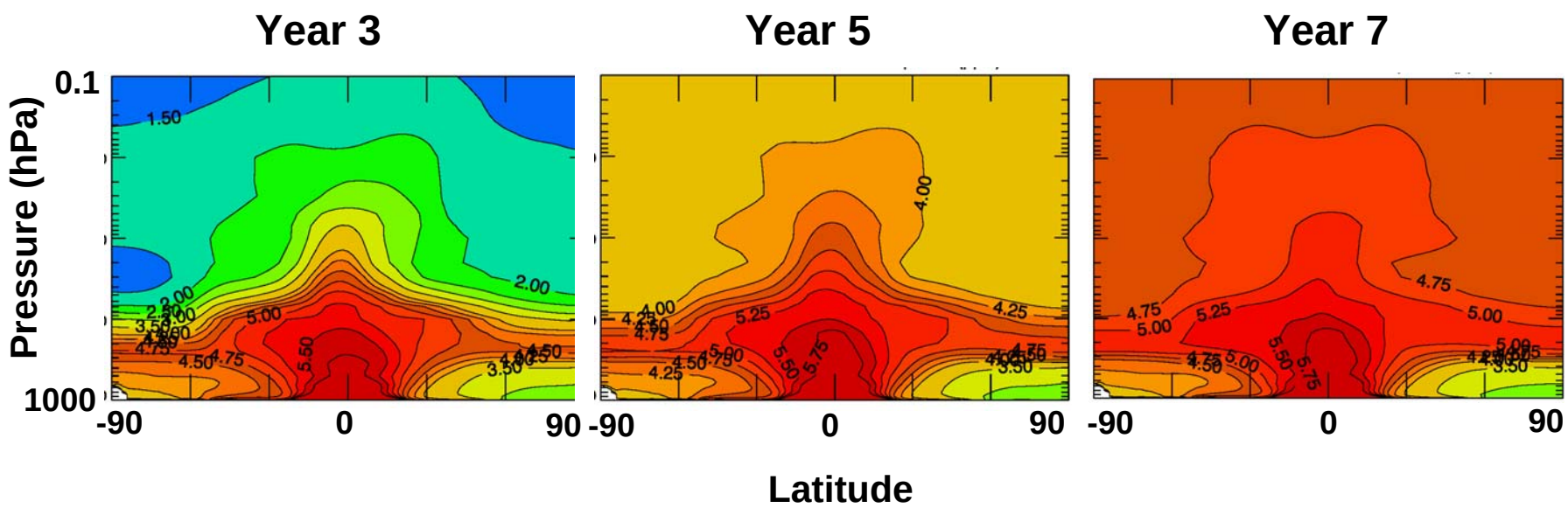
Experiments in progress

- **Ensemble of runs (V2) with a variety of assumptions on GWD (orographic and non-orographic)**
- **Resolution tests (1x1.25; 0.5x0.67)**
- **New tracer module (pulse tracers for age spectrum-eventually stratified tracers)**
- **Alternative scenarios (e.g. A2)**
- **Photolysis test (fast J with albedo .3 and no clouds) to evaluate ozone bias**
- **Reduced tropical convection**
- **Bromine from $CHBr_3$ and $CH2Br_2$ to evaluate VSL contributions**

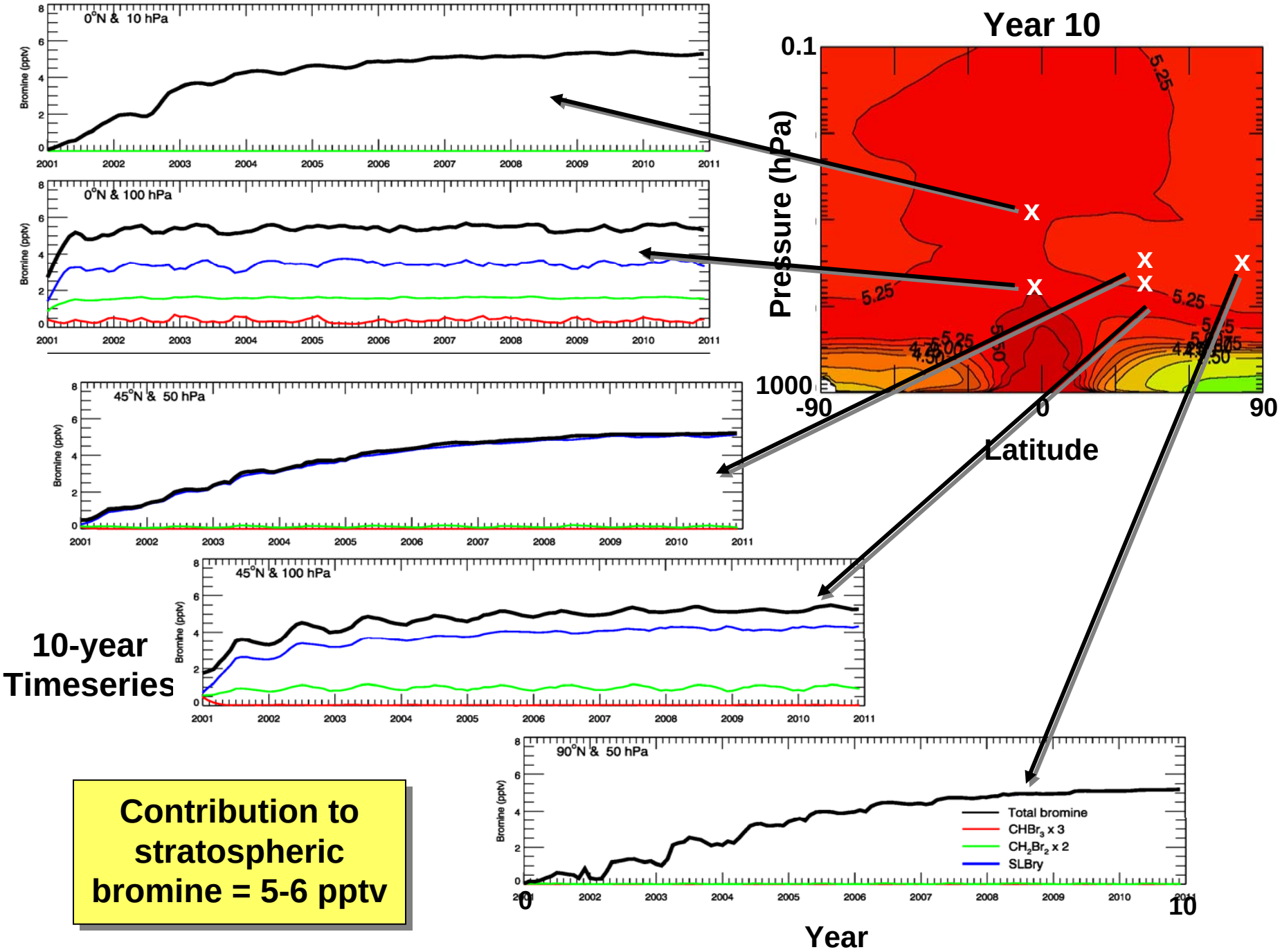
Short-lived Bromine Calculation

Bromoform ($CHBr_3$) + Dibromomethane (CH_2Br_2)

Released at the surface with open ocean and coastal sources:
OH reaction + photolysis gives active bromine,
Bry (calculated as a tracer with washout).



Qing Liang; unpublished work



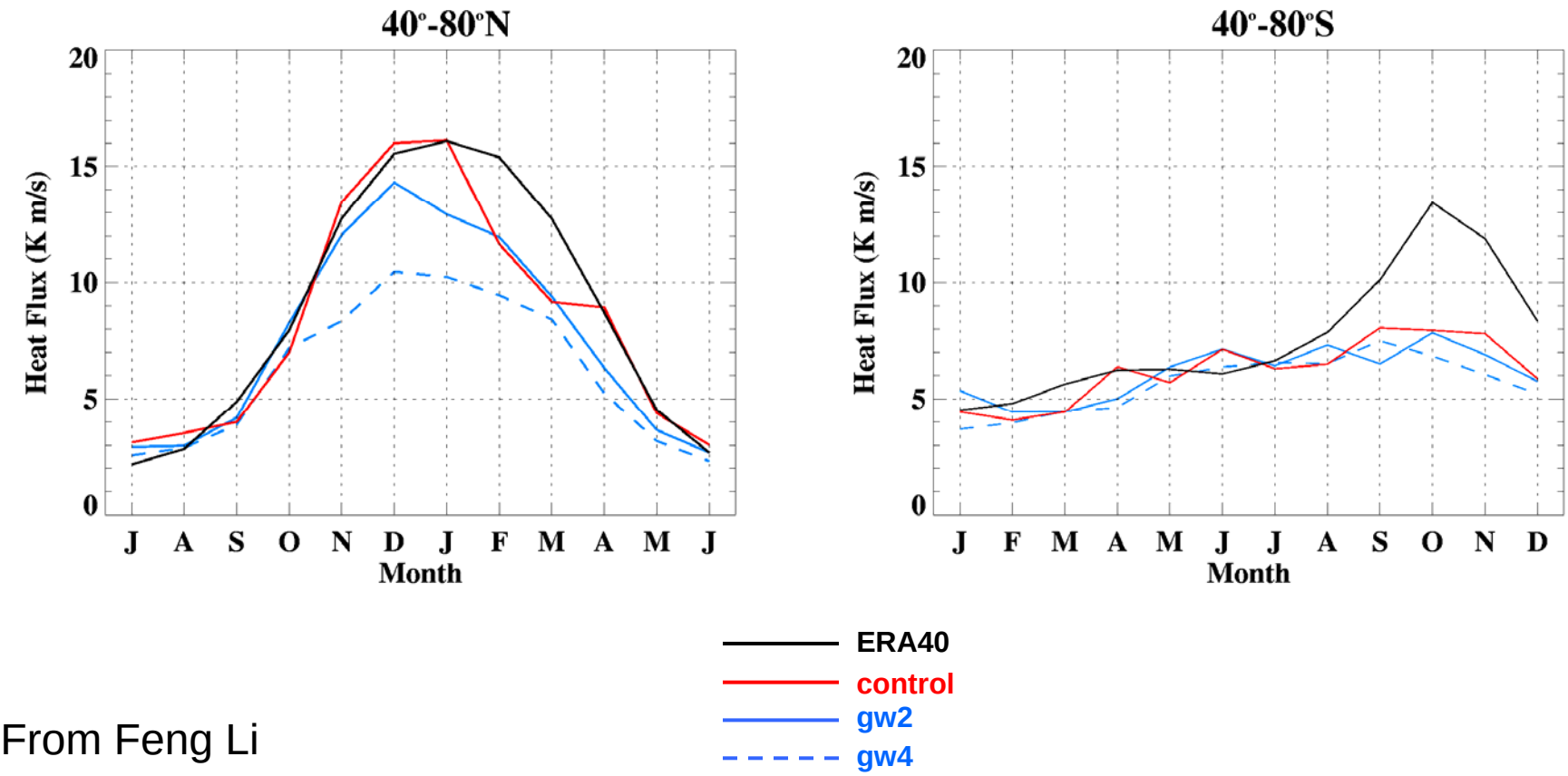
Contribution to stratospheric bromine = 5-6 pptv

Model is highly rated in CCMVal 2 comparison

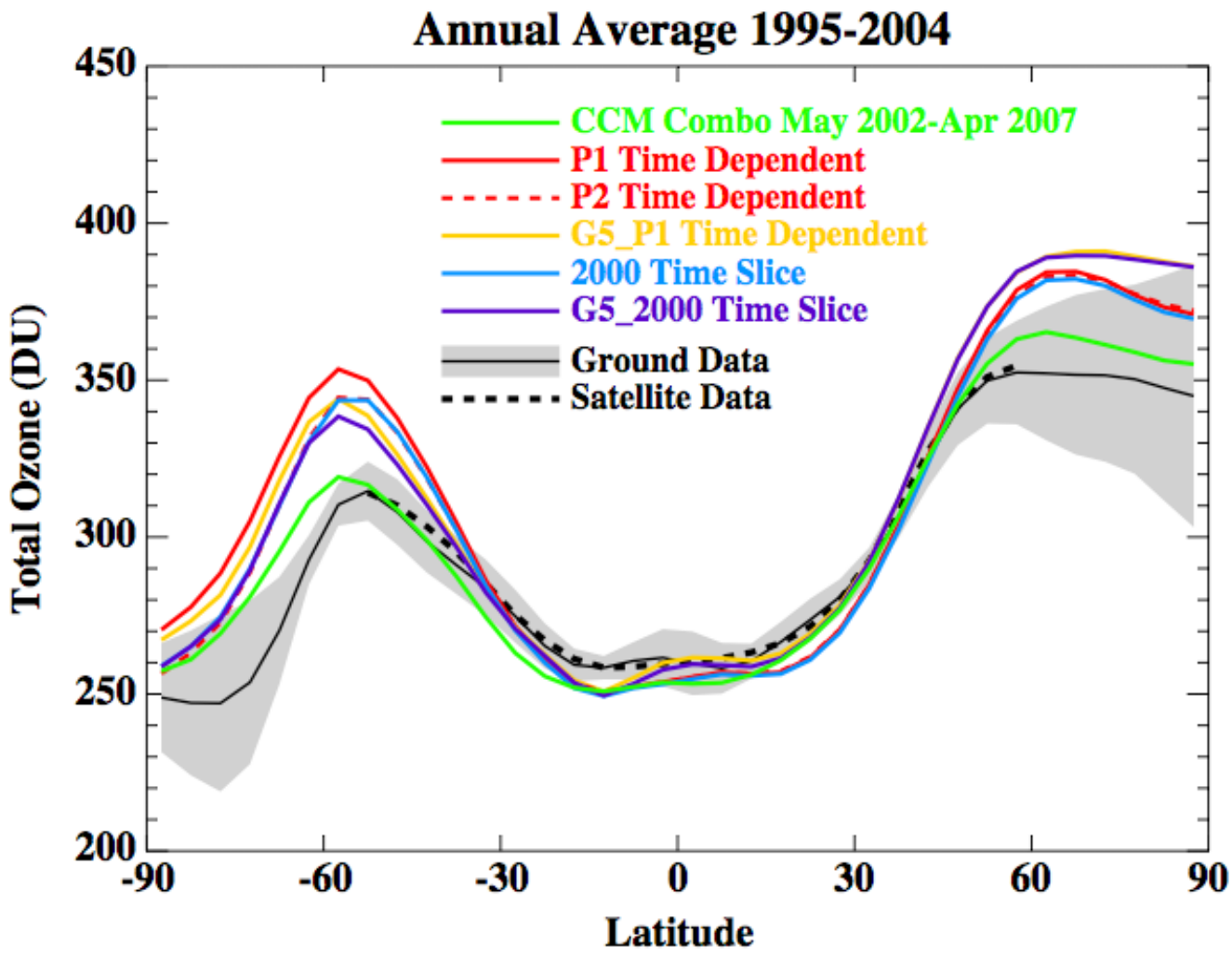
but still has deficiencies that we want to understand

- **Antarctic vortex breakup 2-3 weeks late; lack of seasonal peak in planetary wave flux into stratosphere in southern hemisphere**
- **Total ozone bias high in stratchem version; much less in Combo version; why?**
- **Tropics still too isolated based on N_2O gradients, etc.**
- **Lots of issues with convection, washout, etc.**

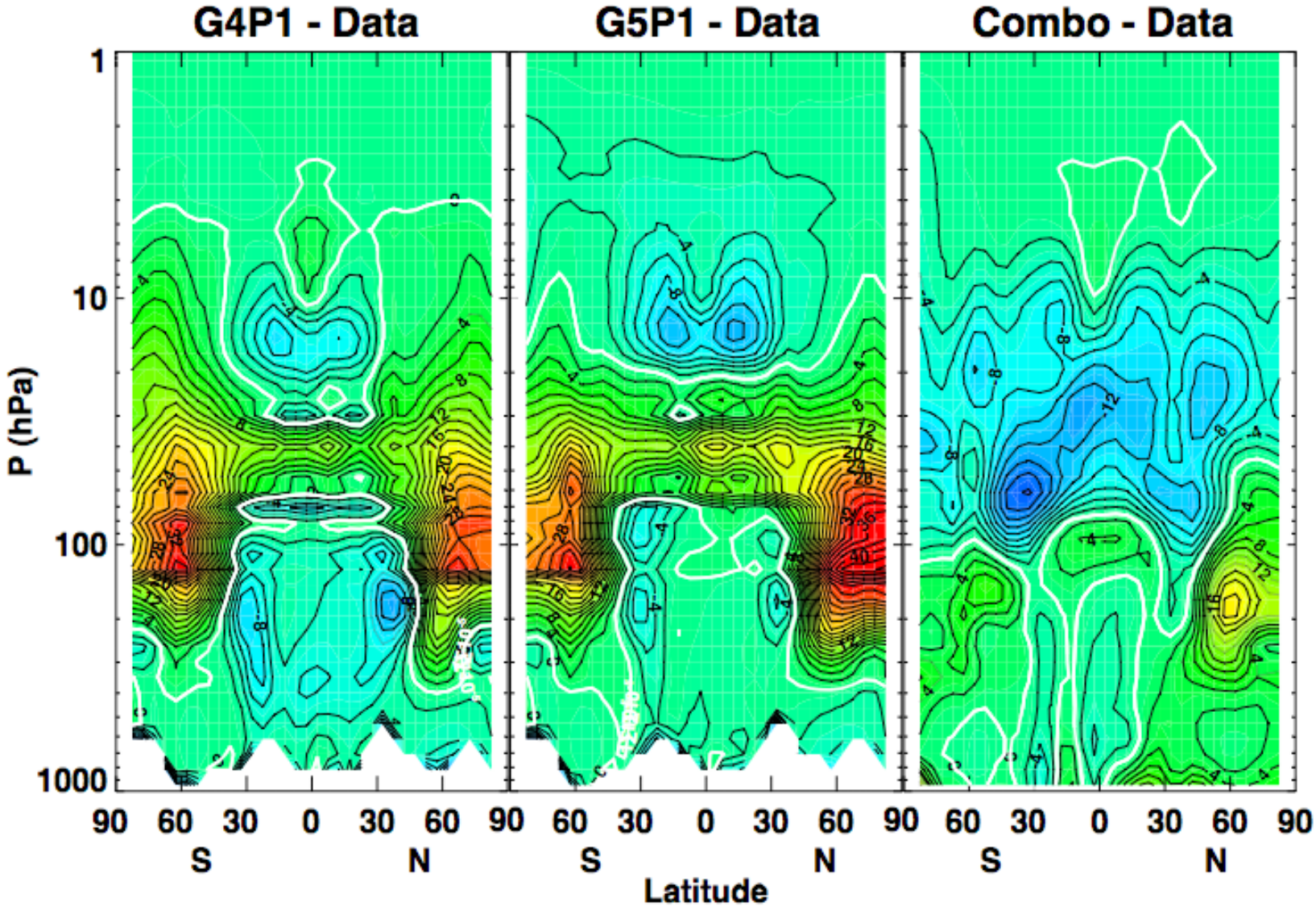
100 hPa Heat Flux

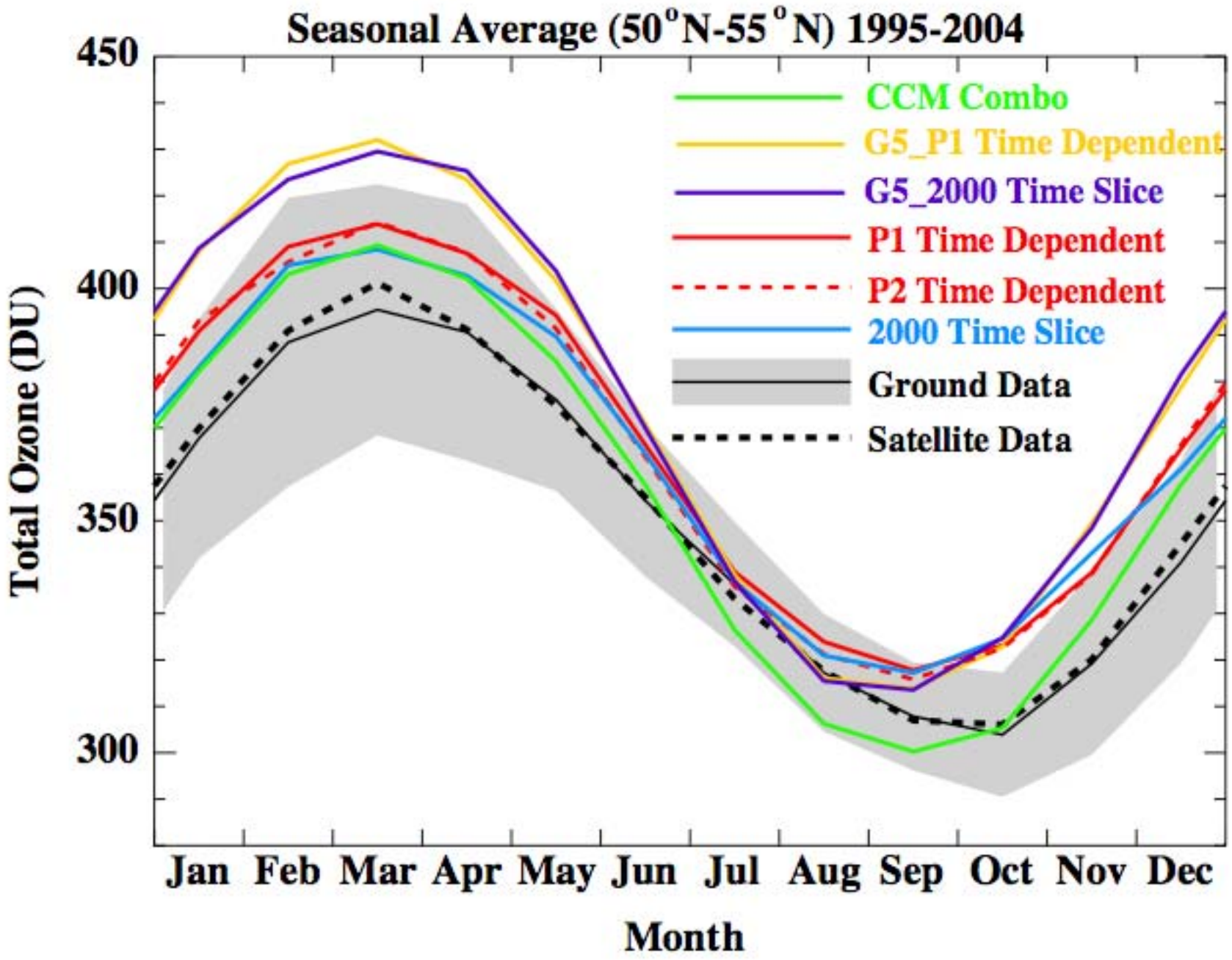


From Feng Li


Annual Average 1995-2004
CCM Combo May 2002-Apr 2007
P1 Time Dependent
P2 Time Dependent
G5_P1 Time Dependent
2000 Time Slice
G5_2000 Time Slice
Ground Data
Satellite Data
Total Ozone (DU)
450
400
350
300
250
200
-90
-60
-30
0
30
60
90
Latitude

Annual Average Difference between GEOS CCM and Logan, Labow, McPeters Ozone Climatology (nbar)




Seasonal Average (50°N-55°N) 1995-2004
450
400
350
300
Total Ozone (DU)
CCM Combo
G5_P1 Time Dependent
G5_2000 Time Slice
P1 Time Dependent
P2 Time Dependent
2000 Time Slice
Ground Data
Satellite Data
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Interaction with GMI

- **We think that GMI can be the best place to develop chemical modules (e.g. sulfur chemistry/aerosols)**

- **We think that we can benefit GMI scientists by providing an opportunity to put together a more comprehensive model of the Earth system with relevant feedbacks for multi-decadal scale scientific studies**