GFDL AM3 Meteorological Fields with GMI: an Update

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Acknowledgements:
S. Strahan, J. Rodriguez, J. Kouatchou (NASA GSFC)
R. Hemler, L. Donner, S. Maleyshev, M. Zhao, A. Fiore (NOAA GFDL)
D. Considine, J. Crawford (NASA LaRC)
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GMI meeting, GSFC, Aug.4-5, 2011

Objectives

- To improve our understanding of uncertainties in model predictions due to the use of different input meteorological fields by incorporating output from GFDL AM3 GCM into the GMI modeling framework.

- To assess the AM3 meteorological fields through inter-comparison with those from other major global climate models or data assimilation systems.

- Eventually, to study the effects of climate change on Asian pollution outflow with GMI CTM driven by output from GFDL AM3.

GFDL AM3

- Donner et al., *J. Climate*, 2011
- The atmospheric component of the GFDL coupled GCM (CM3) for atmosphere, oceans, land, and sea ice.
- Employs a **cubed-sphere** implementation (Putman and Lin, 2007) of a finite-volume dynamical core (Lin, 2004)
- Most basic circulation features in AM3 are simulated as realistically, or more so, than in AM2.1.
- Being used for the IPCC 5th Assessment Report (AR5)

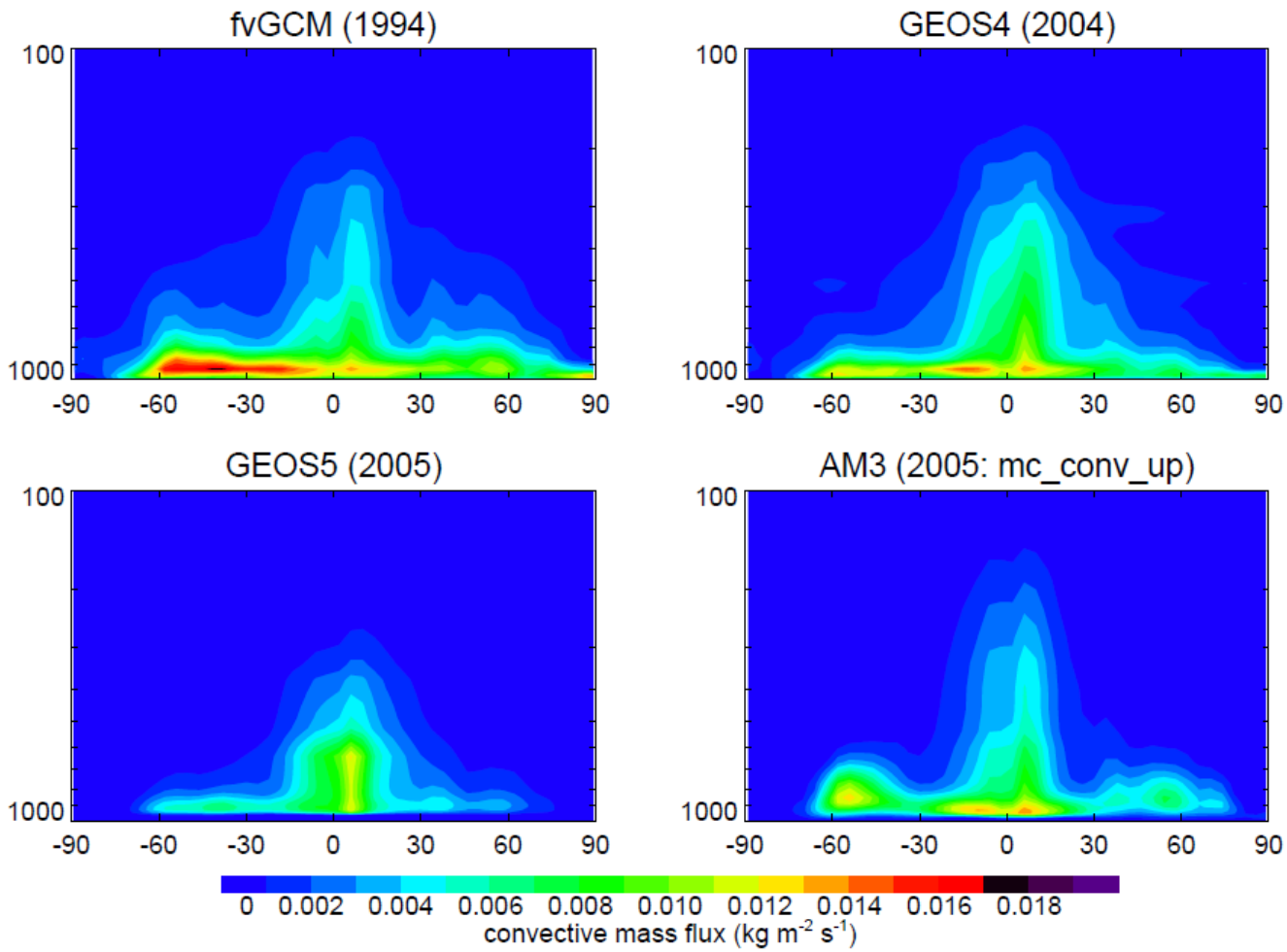
GFDL AM3 (cont'd)

- **deep convection**: Donner scheme (Donner, 1993)
- **shallow convection**: Univ of Washington shallow convection scheme (Bretherton et al., 2004)
- **planetary boundary layer**: Louis (1979), Lock et al. (2000)
- **stratiformclouds**: Tiedke(1993)
- **cloud droplet numbers**: prognostic equation (Ming et al., 2007) of Nd
- **chemistry**:
  - Gas phase - MOZART (Horowitz et al, 2003)
  - Aerosols - GOCART (Chin et al., 2000; Ginoux et al. 2001)
  - stratospheric chemistry: Austin & Wilson (2006).
- **radiation**:
  - SW (Freidenreichand Ramaswamy, 1999);
  - LW (Schwarzkopf and Ramaswamy, 1999)
  - on-line gas species and aerosols
  - stochastic overlap of stratiform, shallow and deep conv clouds
- **advection**: C48 cubed-sphere implementation of the FV dynamical core (Putman and Lin, 2007; Lin, 2004)
- **vertical levels**: 48 (additional levels in the stratosphere relative to AM2)

Incorporation of AM3 Met Fields Into GMI - Status

- Integrated AM3 forced with observed SST to generate present-day climate
  - One year (2005) for now; 4x5 and 2x2.5
- Re-gridded model output from the cubed-sphere grid (AM3) to regular lat/lon grids (GMI).
- Verified the re-griddings
- AM3 met fields available on Discover (20GB/mon for 2x2.5)
- Interfaced AM3 met fields with GMI CTM
- Conducted radionuclide (222Rn-210Pb-7Be) simulations
  - Examined the characteristics of transport in AM3 in comparison with other met. data sets
- GMI/AM3 Combo runs (4x5 & 2x2.5) – ongoing

convective mass flux (annual average)



mc_conv_up = total upward mass flux (cell up + meso up + shallow up)

AM3 convective mass fluxes

Total cumulus

Cell updraft

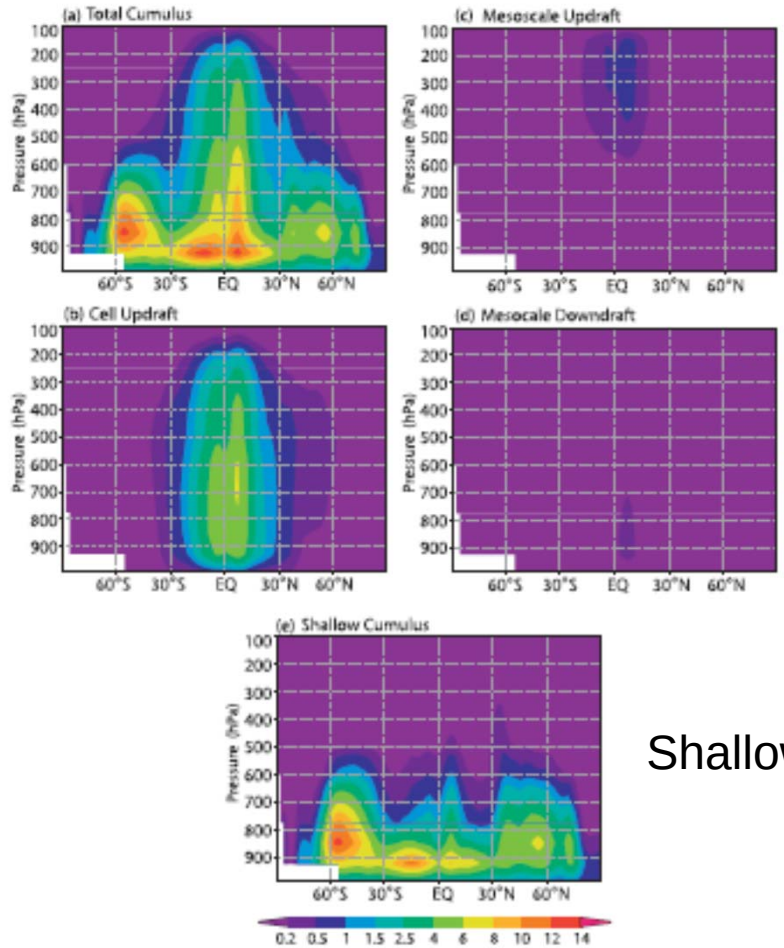


FIG. 1. AM3 annual-mean, zonally averaged cumulus mass fluxes (g m^{-2} s^{-1}) for (a) all convection (except MAA), (b) cell updrafts, (c) mesoscale updrafts, (d) mesoscale downdrafts, and (e) shallow cumulus.

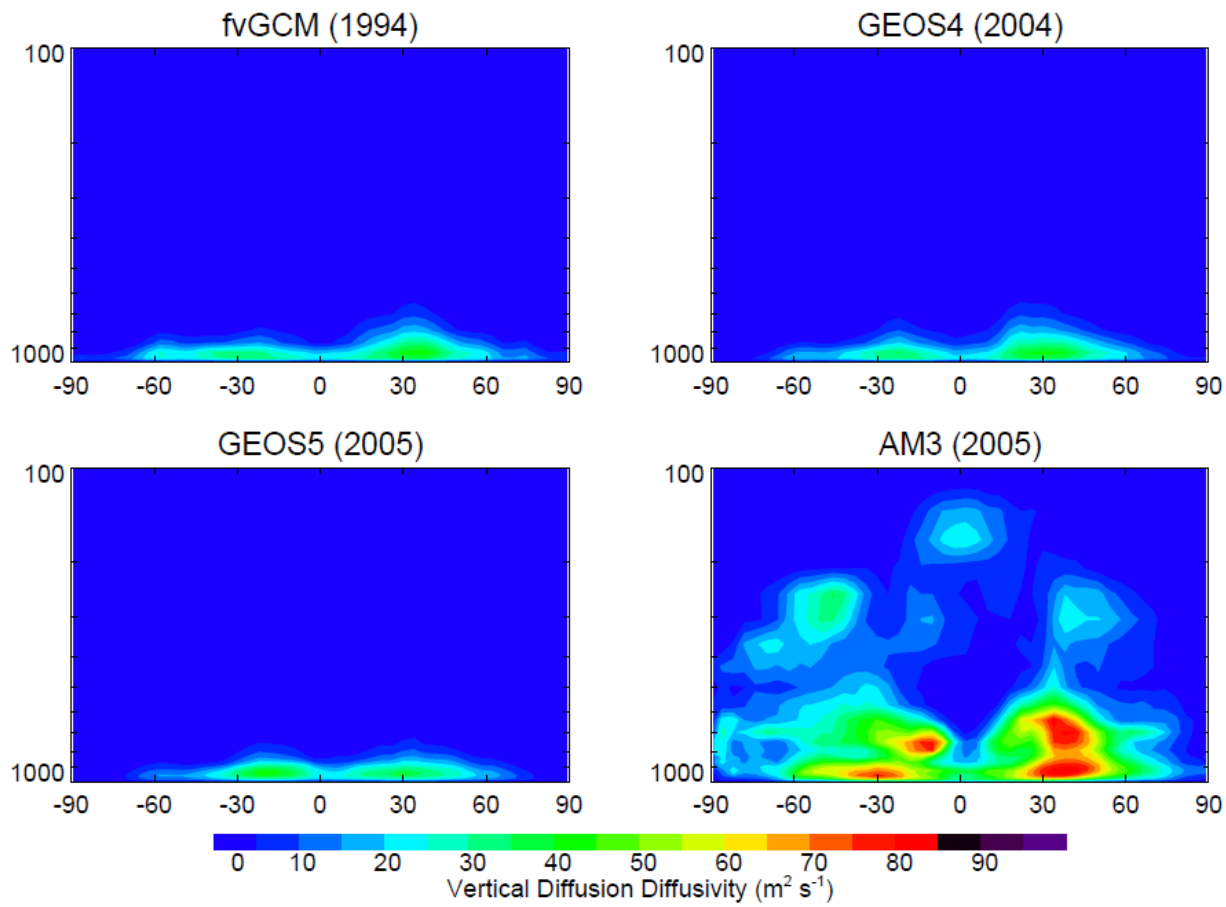
Mesocale updraft

Mesoscale downdraft

Shallow cumulus

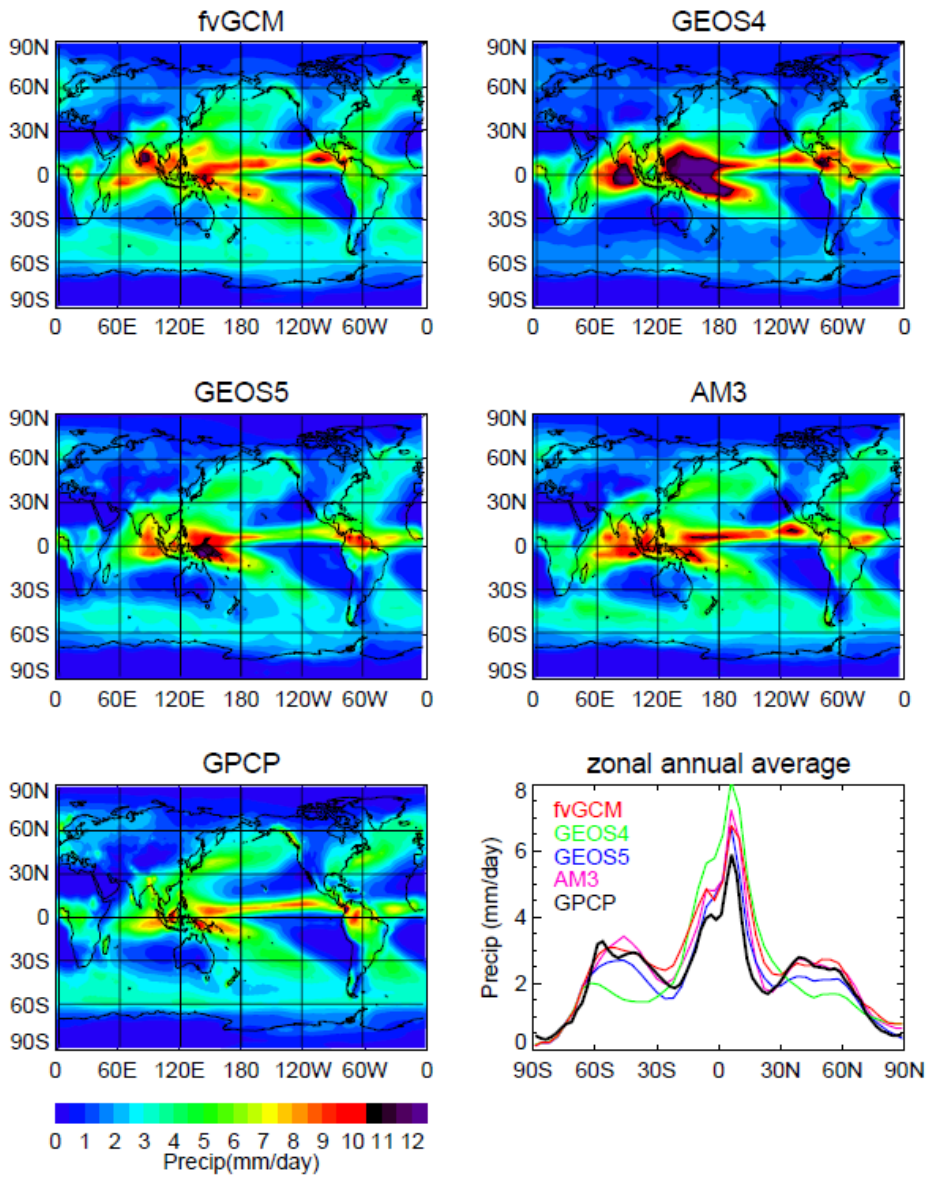
Donner et al., J. Climate, 2011

Vertical Diffusivity (annual average)

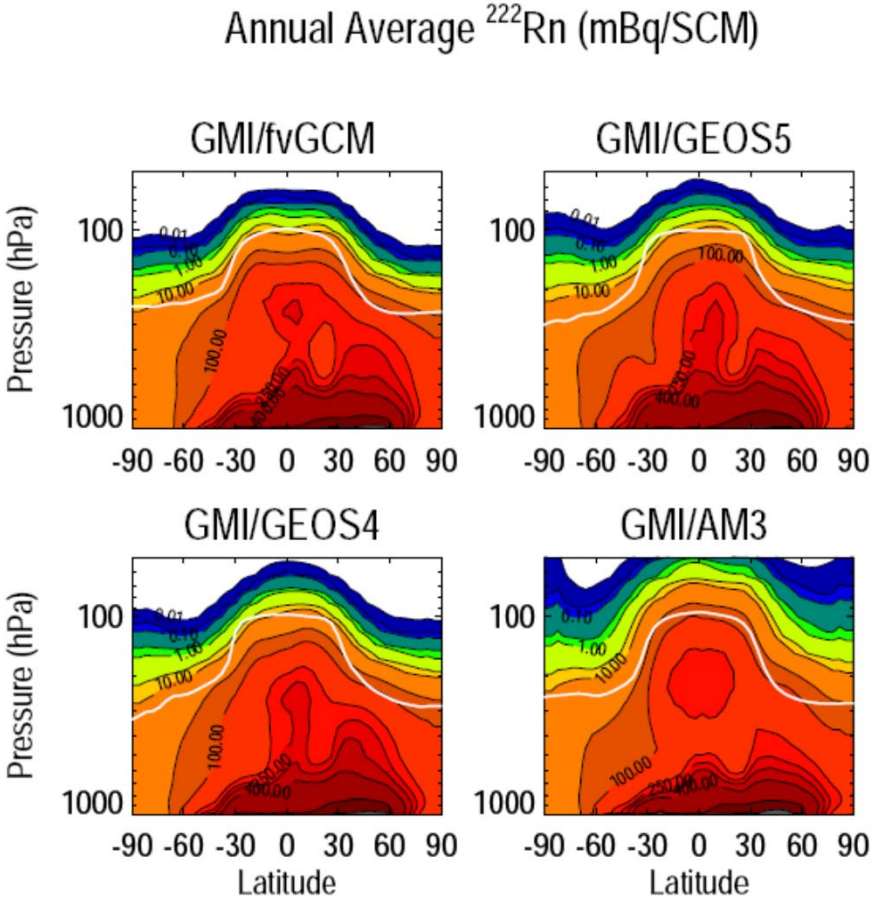


GEOS-5: K_H (m^2/s), total scalar diffusivity (defined at layer edges)
AM3: diff_t (m^2/s), vertical diff coeff for heat, moisture, tracers

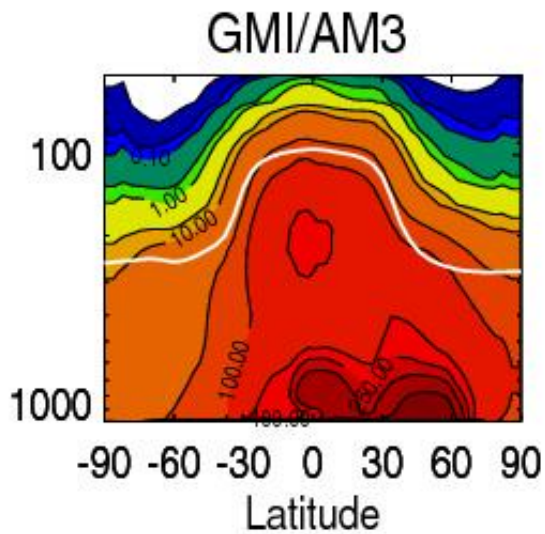
Total precipitation and evaluation with GPCP data set



Effect of diff met fields on GMI 222Rn



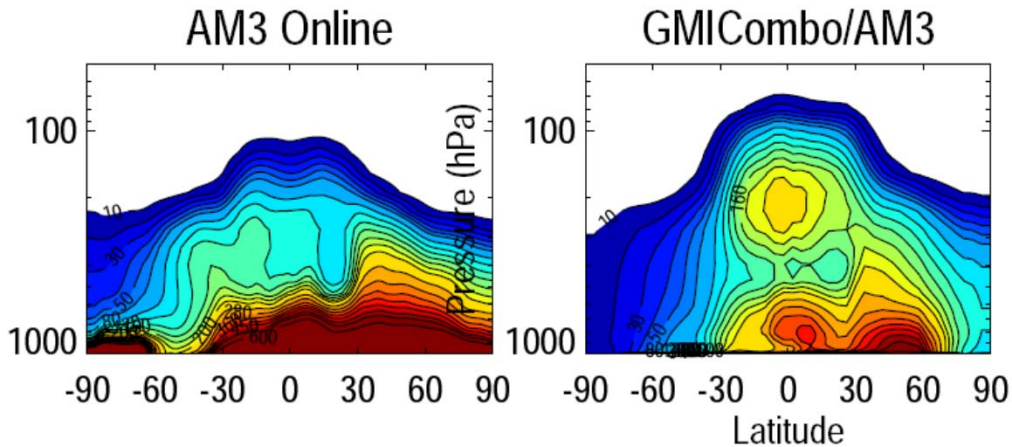
GMI/AM3: Gridboxes within PBL were mixed with a relaxation time of 3h (standard run)



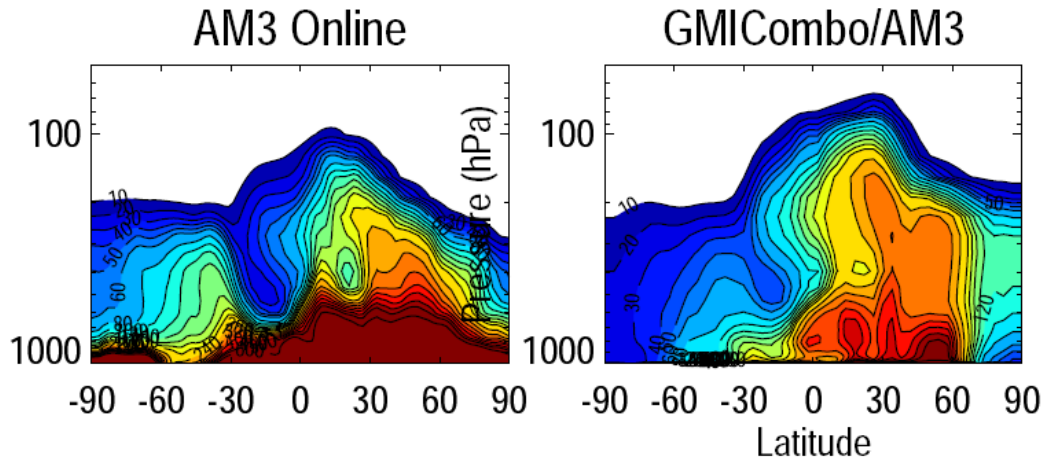
AM3 vertical diffusion coefficients were used.

Comparison between online and offline 222Rn

Annual average

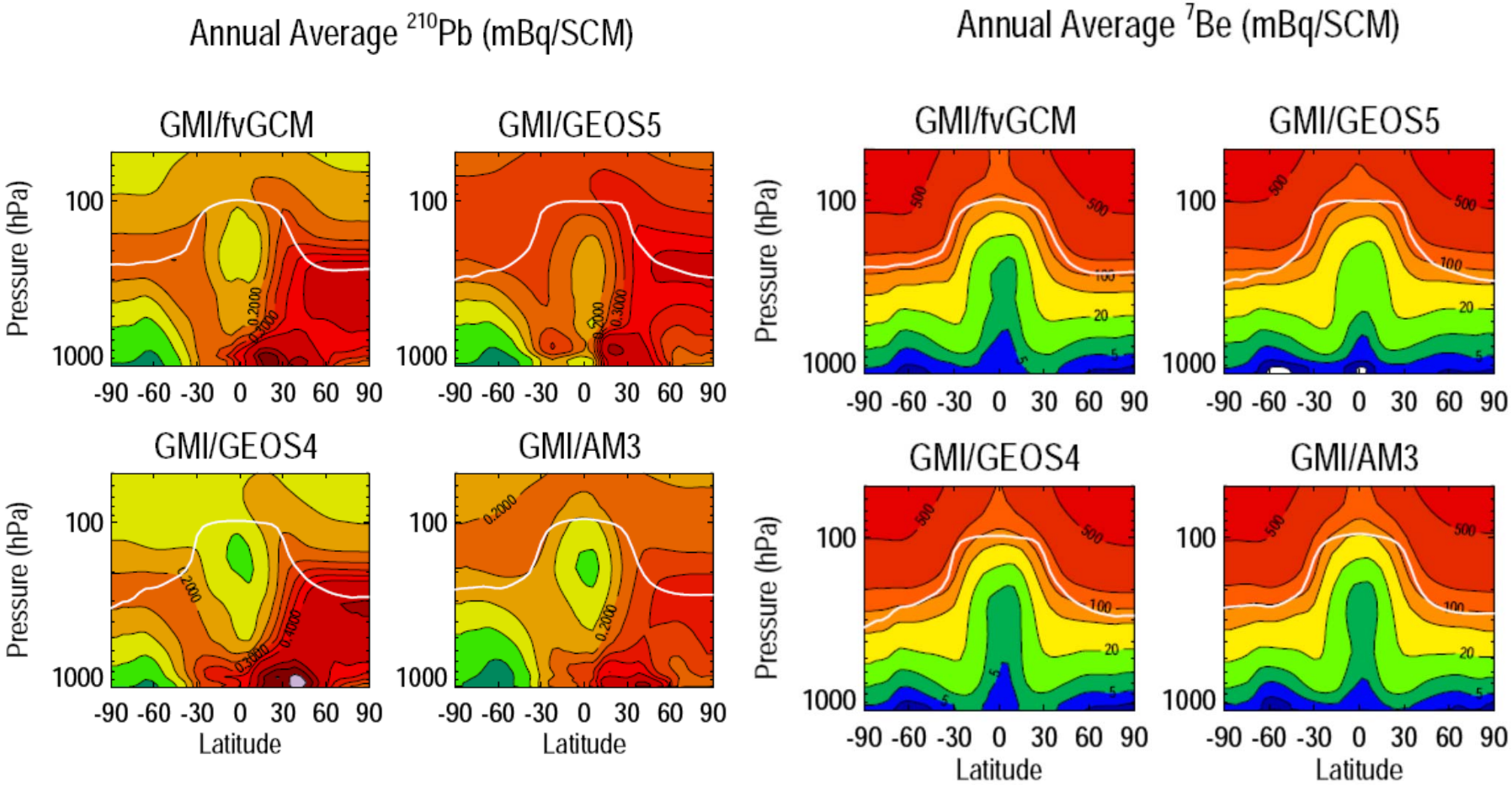


July



- Online run needs to be updated and corrected for 222Rn emissions.

Effect of diff met fields on GMI 210Pb-7Be



GMI/AM3 210Pb-7Be budget analysis

Annual Average Global Budgets of 210Pb and 7Be in the GMI/AM3 Trop+Strat

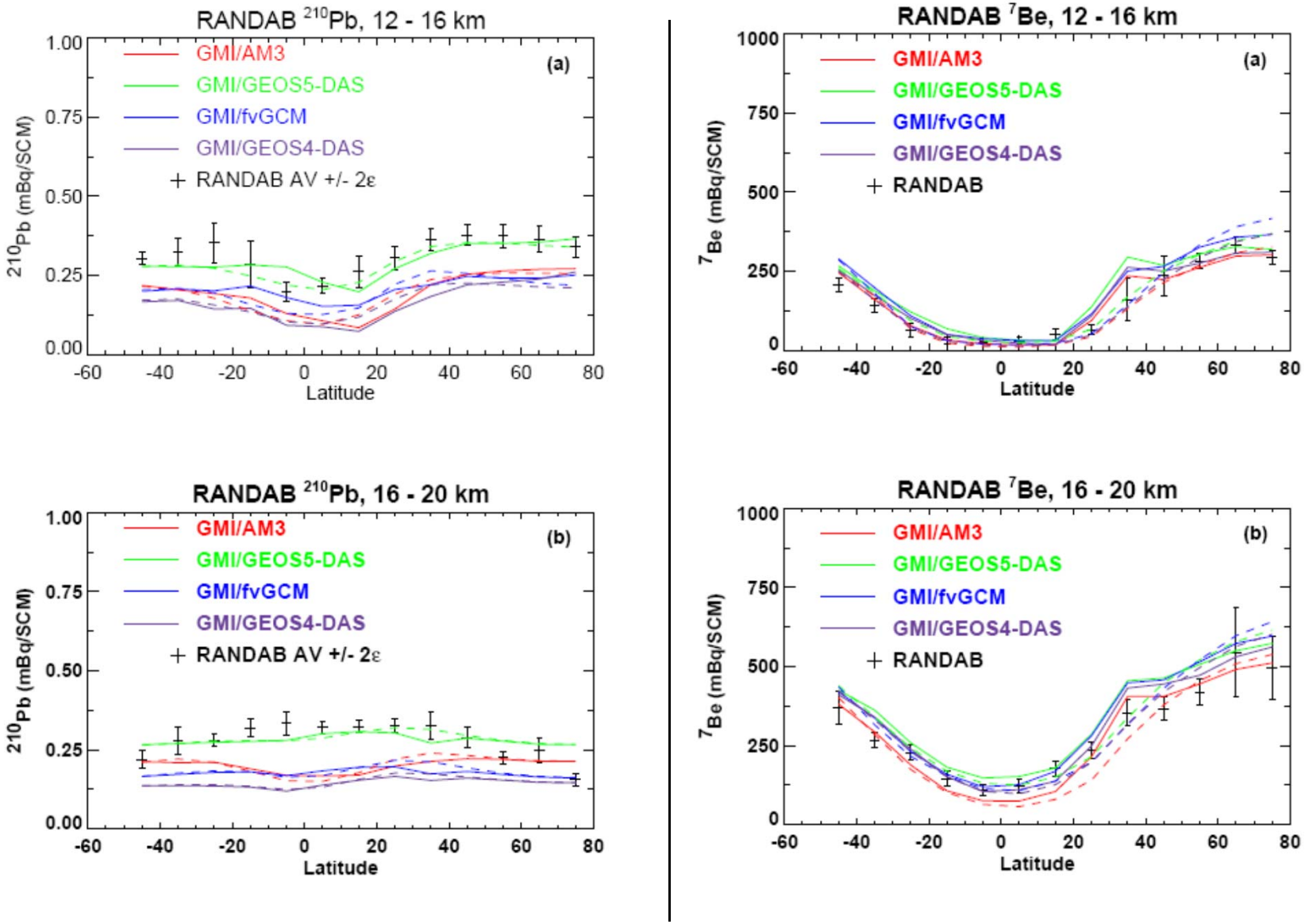
	210Pb	7Be
Burden, g	256.931	20.8560
Sources, g d-1	26.2126	0.405564
stratosphere	0.111374	0.271914
troposphere	26.1012	0.133650
Sinks, g d-1	26.2033	0.405560
dry deposition	6.66628	0.00396098
wet deposition	19.5151	0.130416
radioactive decay	0.0218889	0.271183

Annual Average Global Budgets of 210Pb and 7Be in the GMI/AM3
Troposphere

	210Pb	7Be
Burden, g	210.865	4.18436
Residence time, days	8.06779	31.0990
Sources, g d-1	26.1993	0.188758
from stratosphere	0.0981522	0.0551080
within troposphere	26.1012	0.133650
Sinks, g d-1		
dry deposition	6.66628	0.00396098
wet deposition	19.5151	0.130416
radioactive decay	0.0179648	0.0543813

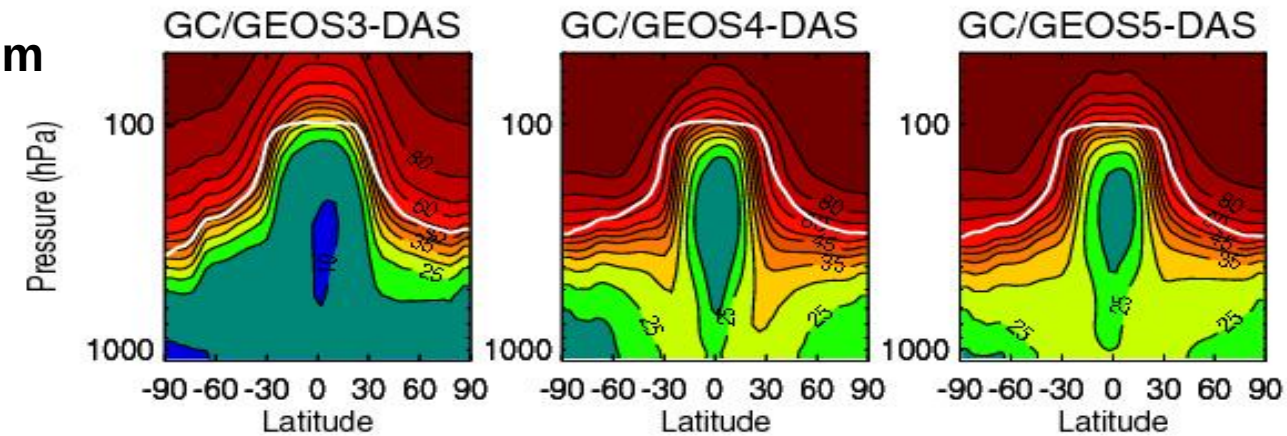
reasonable residence times

Comparison of GMI 210Pb-7Be with RANDAB dataset (UT/LS)

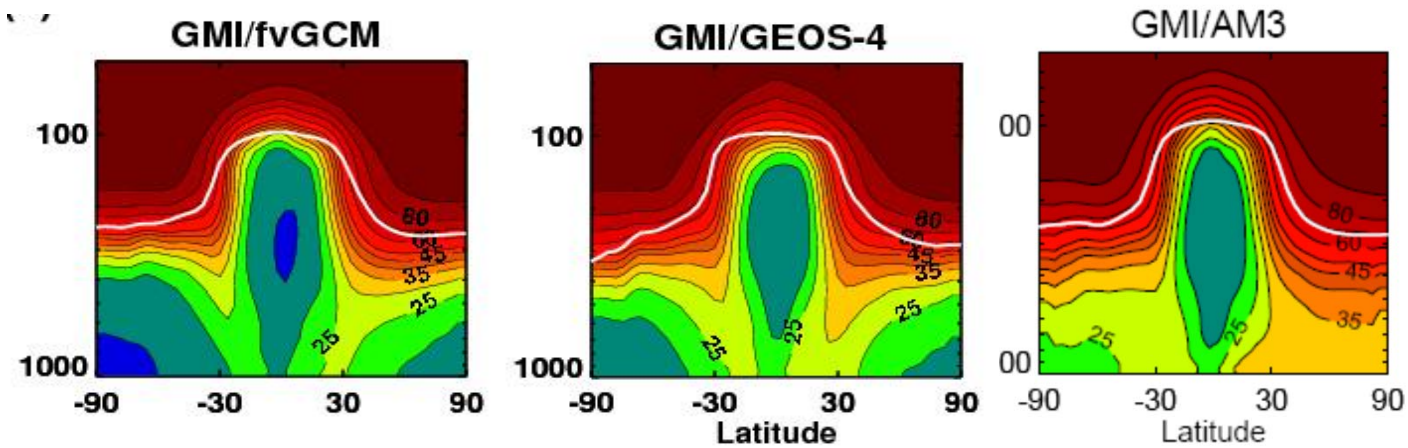


Stratospheric fraction (%) of 7Be in the troposphere (annual average)

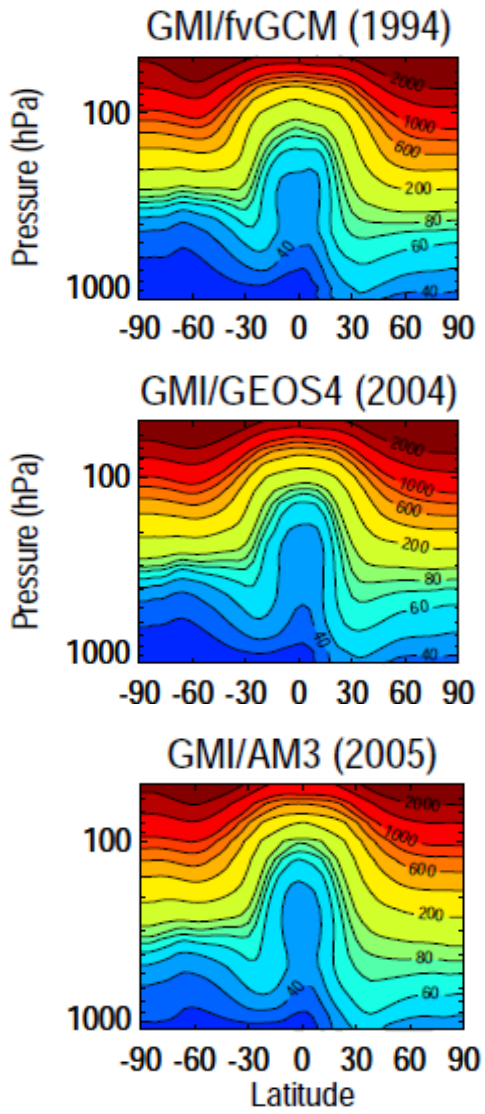
GEOS-Chem



GMI

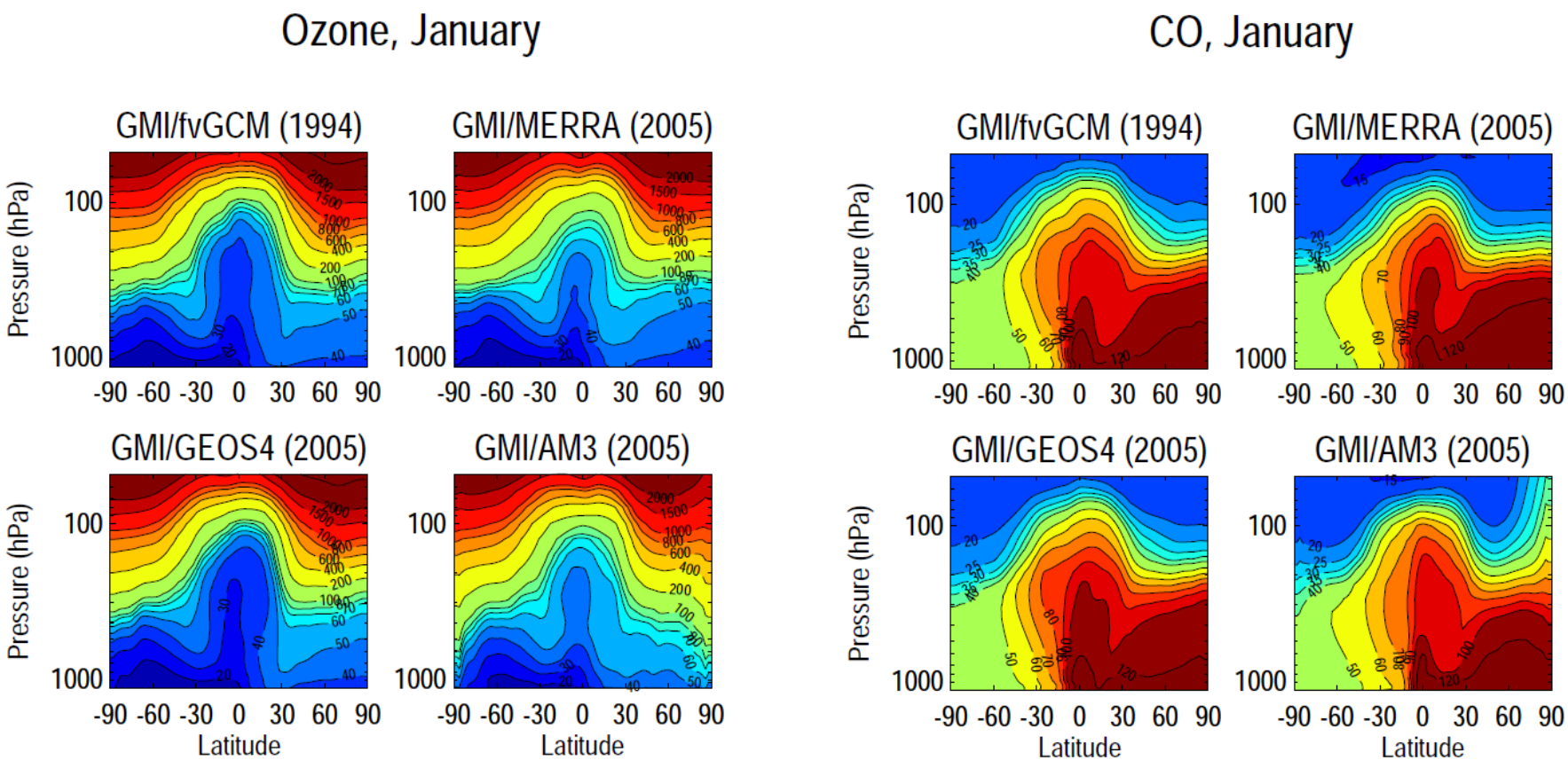


Annual zonal mean ozone concentrations (GMI Combo, 4x5)



- preliminary GMI/AM3 Combo 4x5 run
- Need to update fvGCM and GEOS-4 4x5 Combo runs

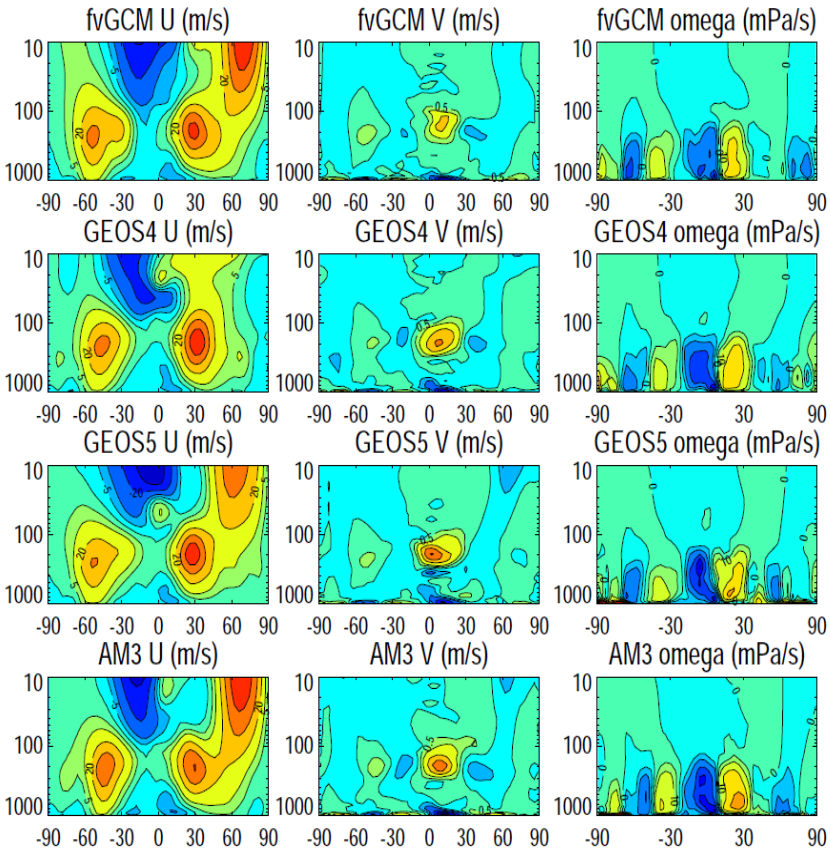
Combo, 2x2.5



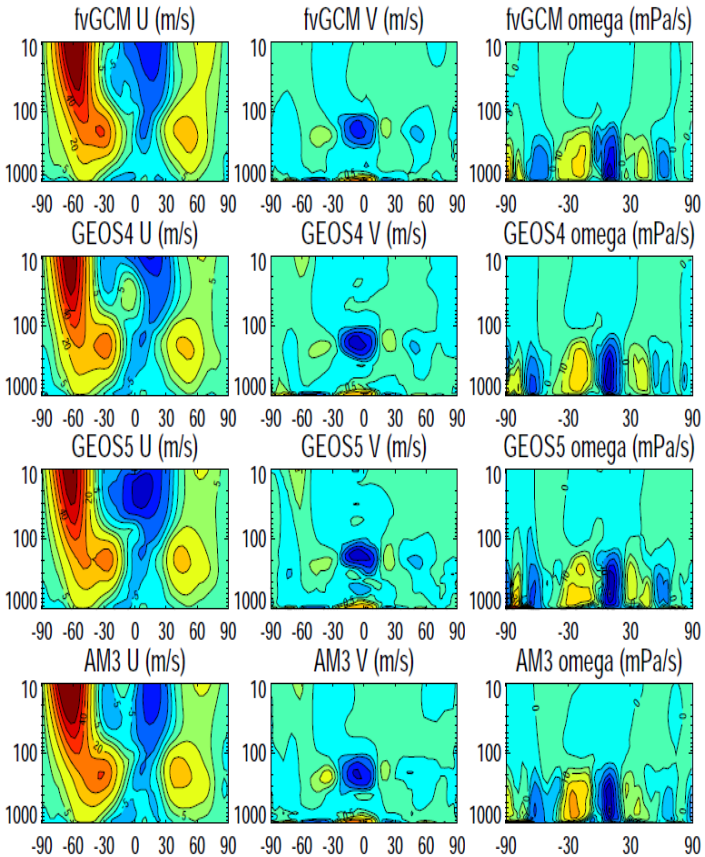
- For debugging - what's going on over the poles in GMI/AM3 Combo (2x2.5)?

U, V, and omega (vertical velocity) in fvGCM, GEOS-4, GEOS-5, and AM3

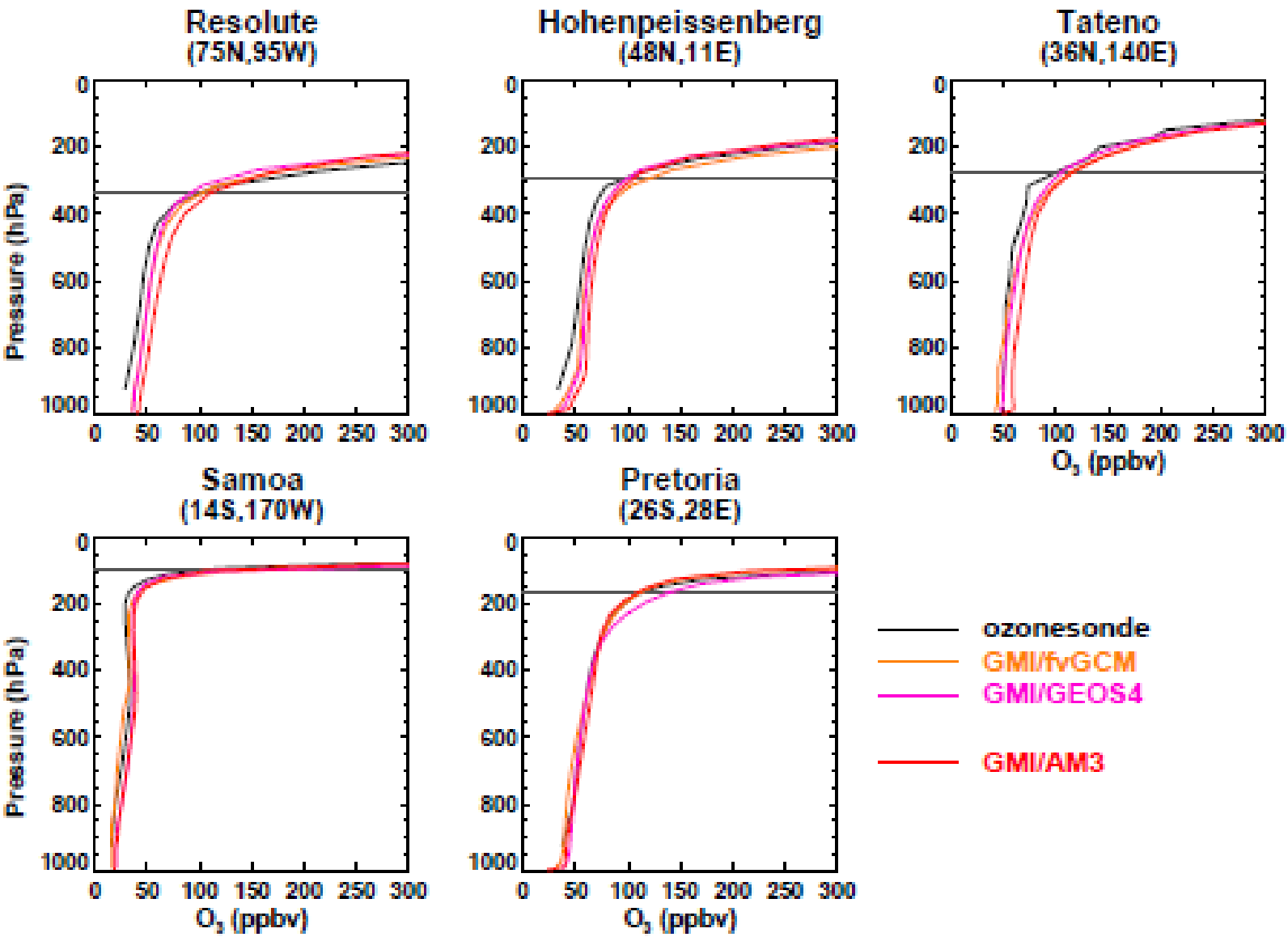
FEB



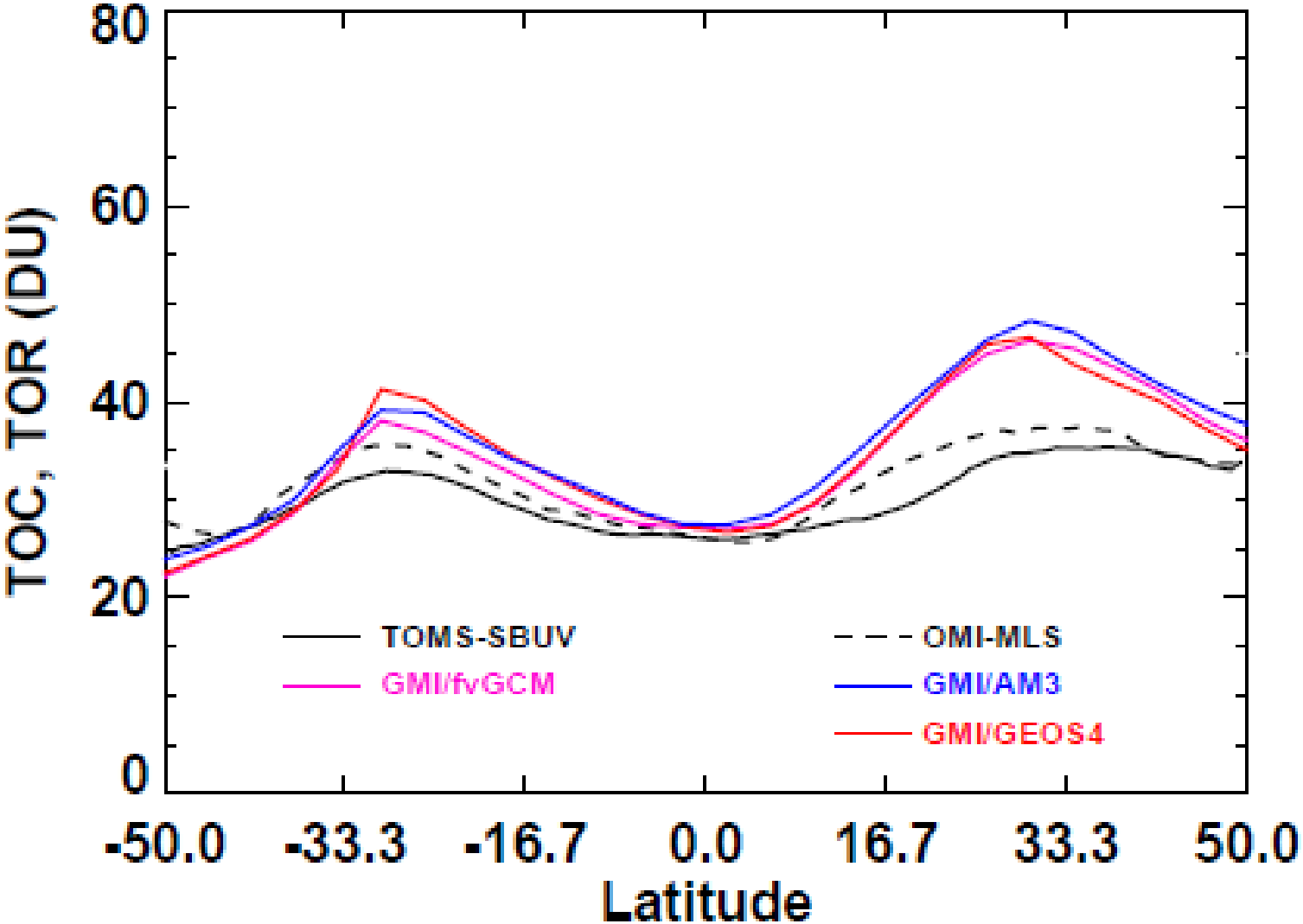
SEP



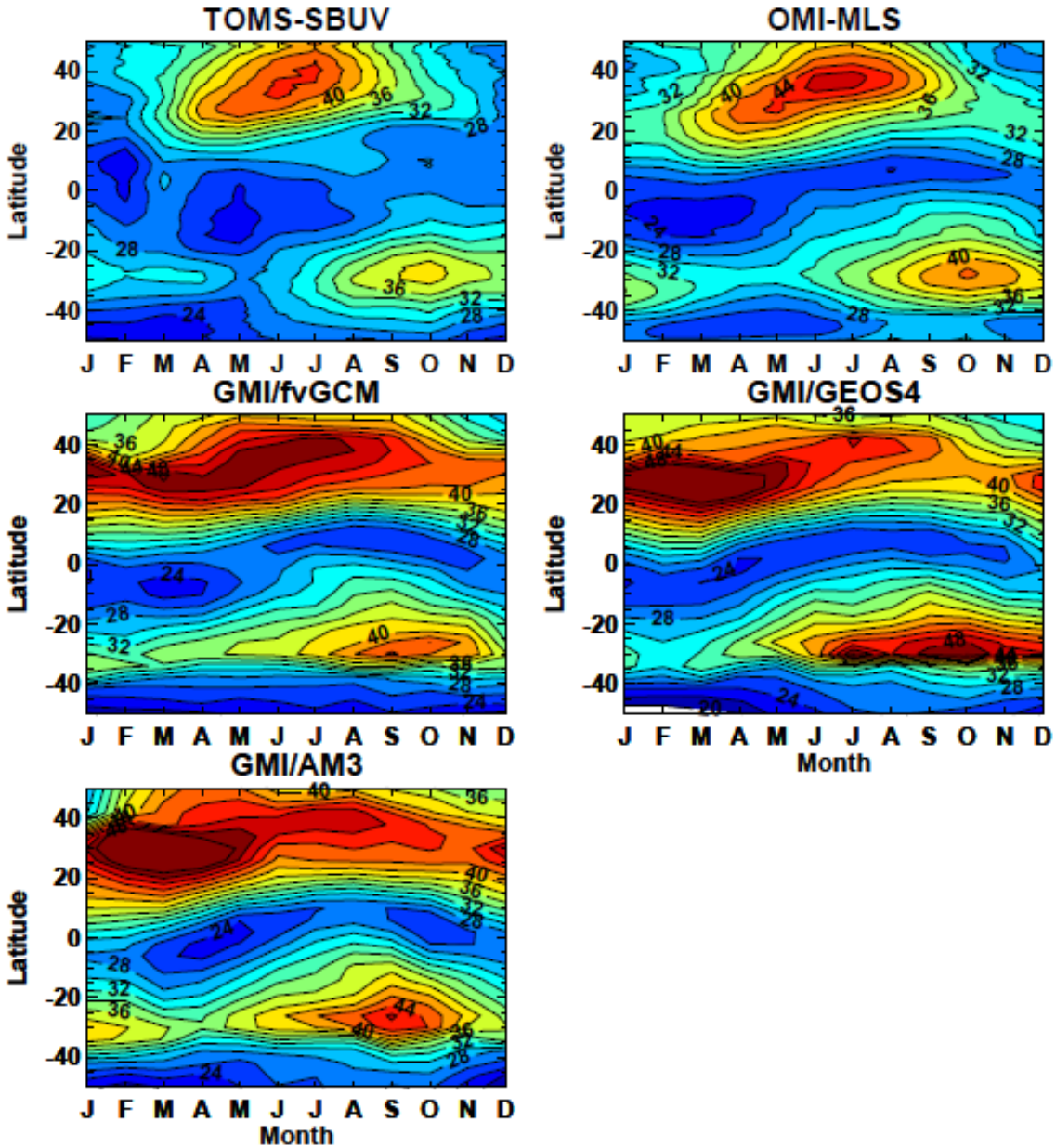
Comparison with ozonesonde profiles



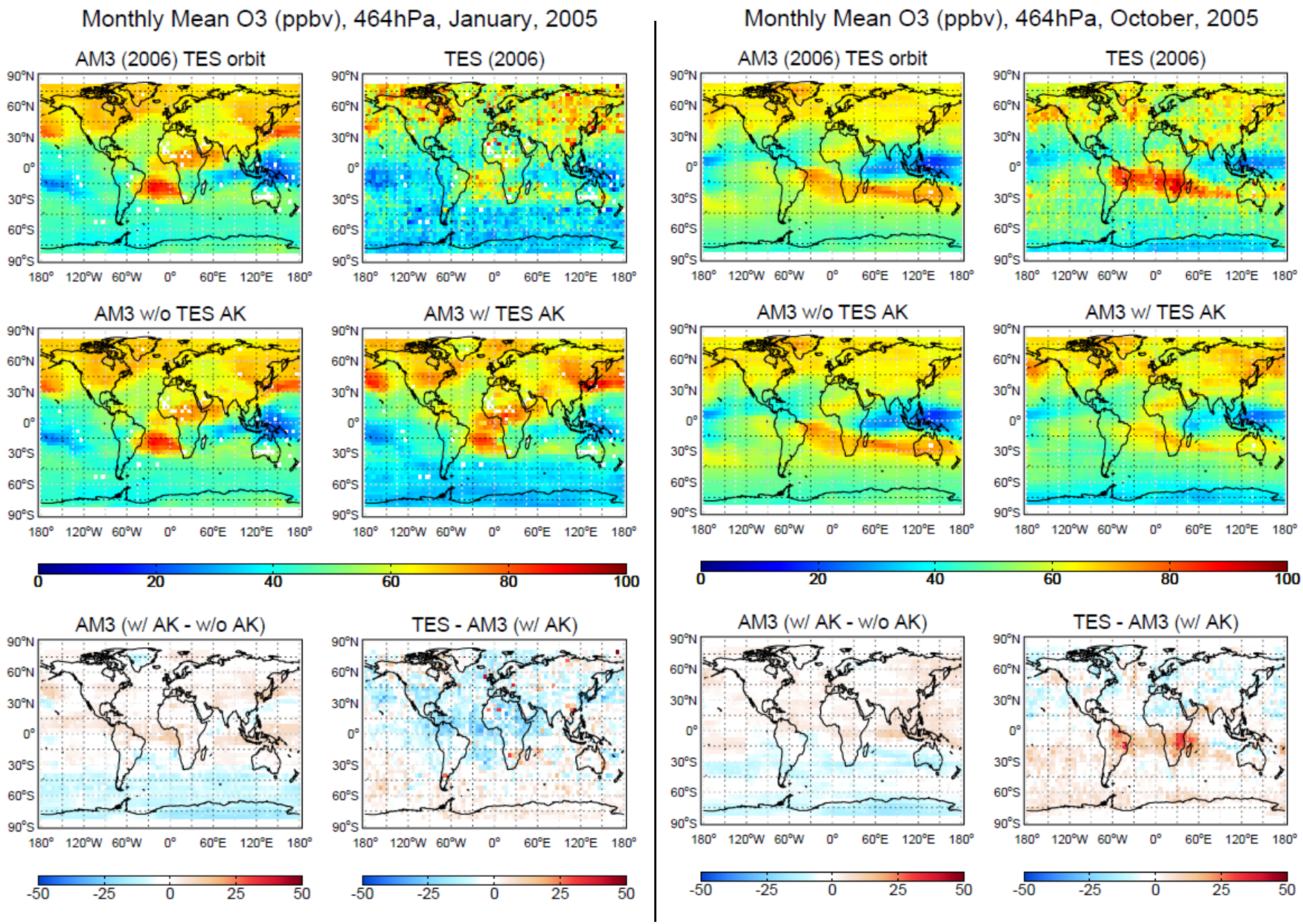
Annual zonal mean trop ozone column



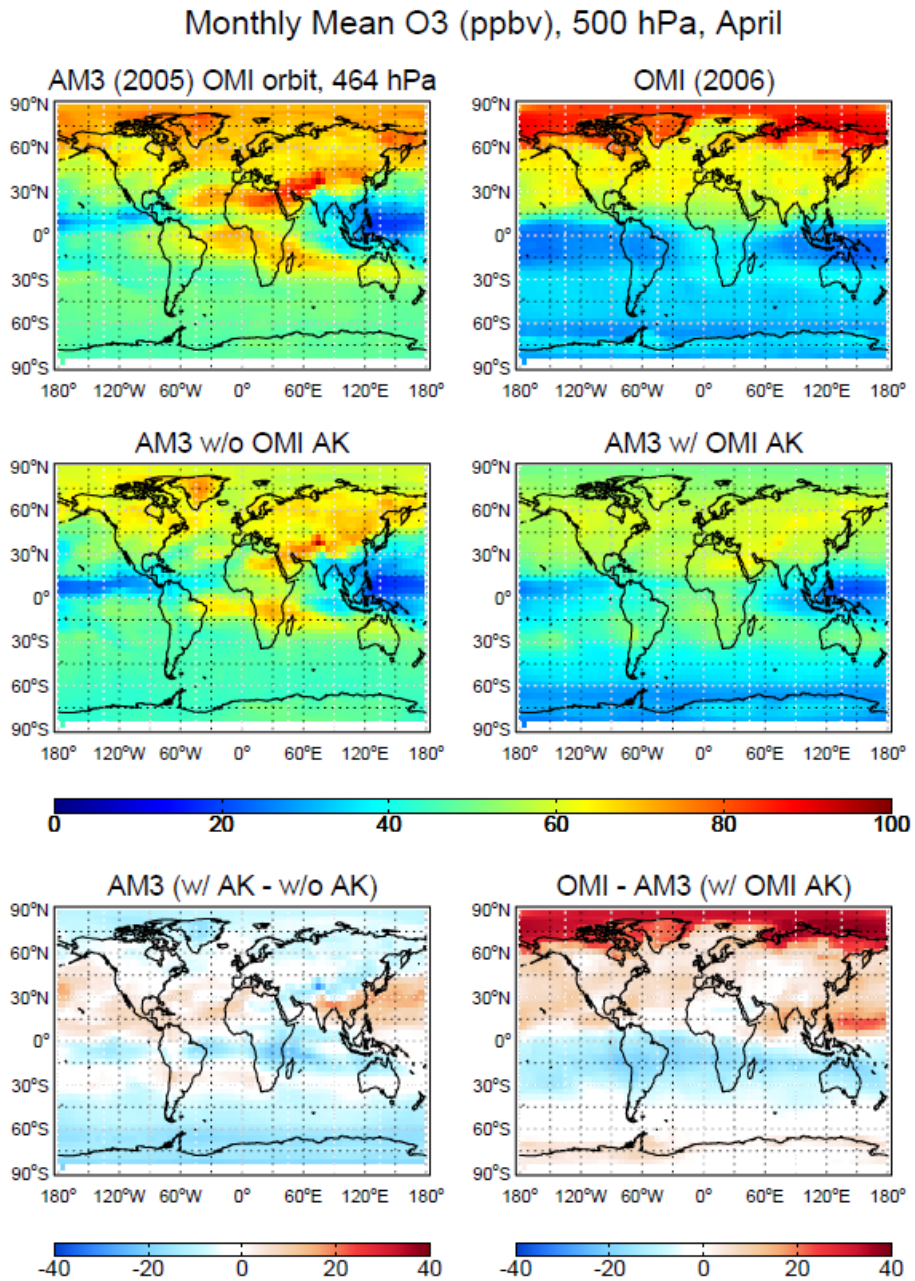
Time-latitude x-section of trop ozone column

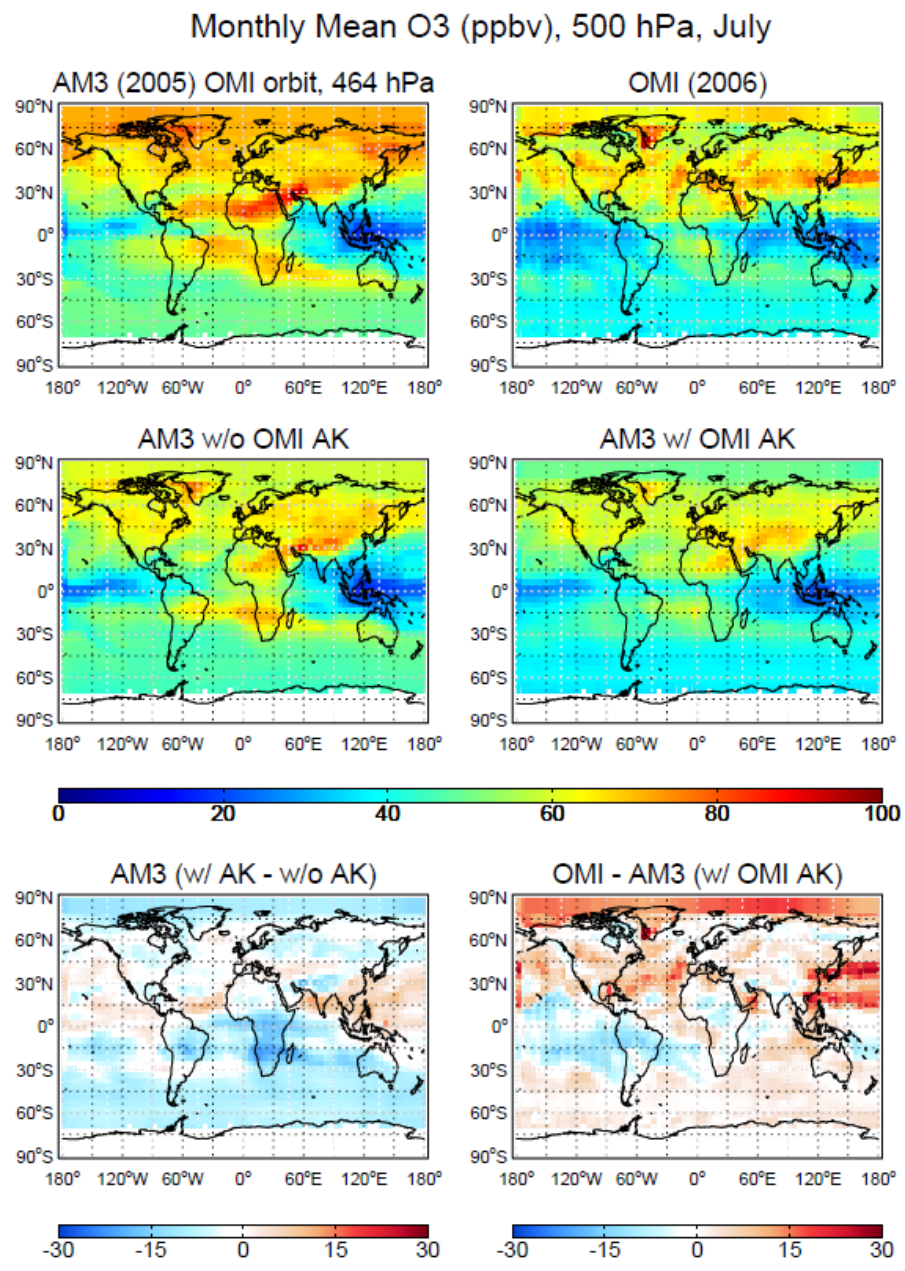


Comparison of AM3 CCM O3 with TES measurements (464 hPa)



Comparison of AM3 CCM O3 (2005) with OMI (2006) measurements





Summary

- **Generated one year (2005) of GFDL/AM3 meteorological fields (2x2.5 & 4x5) for use with GMI (available on Discover)**

- **Interfaced AM3 met fields with GMI CTM**

- **GMI/AM3 CTM tested with radionuclide simulations**
  - **Strong mixing near tropopause region over the poles?**
  - **AM3: STE appears a bit too fast (especially in the NH)**
  - **Convection; PBL mixing**
  - **Reasonable 210Pb and 7Be residence times in the troposphere**

- **GMI/AM3 Combo (4x5 & 2x2.5, 2005)**
  - **Preliminary runs**
  - **2x2.5 debugging is ongoing**

Future Work

- **Look into issues wrt AM3 convection, PBL mixing, and mixing over the poles etc.**
- **Compare GMI/AM3 radionuclide simulations with AM3 online runs**
- **Update GMI/AM3 Combo runs & evaluations**
  - **Lightning NO emissions**
  - **Evaluate with TES (O3, CO) & OMI (O3) measurements**
  - **Explore O3-CO correlations (fvGCM, GEOS-4, MERRA, AM3)**
- **Generate AM3 met fields for multi-years & under future climate**
- **Effects of climate change**

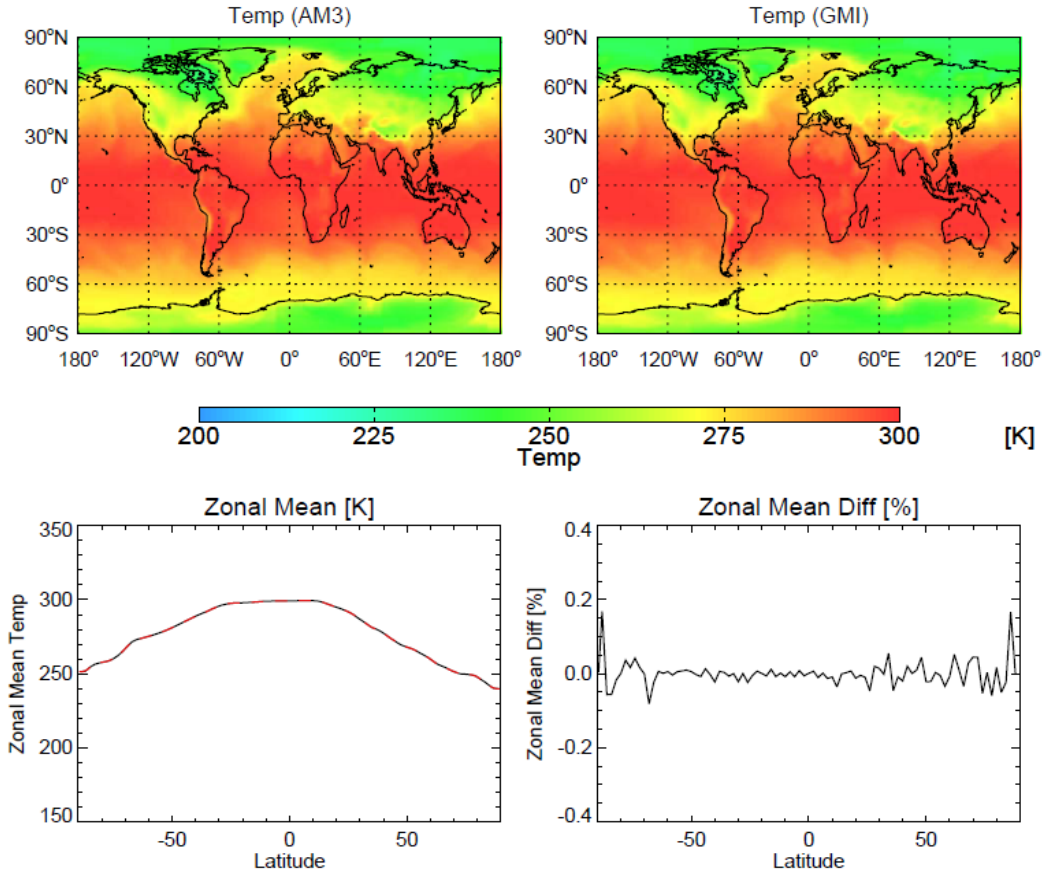
EXTRA SLIDES

RE-GRIDDING OF AM3 MET. FIELDS

- **AM3**
  - Longitude: [1.25, 3.75, 6.25, ……, 353.75, 356.25, 358.75]
  - Latitude: [-89, -87, -85, ……, 85, 87, 89]
  - Pressure: 48 vertical levels
- **GMI**
  - Longitude: [0, 2.5, 5, ……, 325.5, 355, 357.5]
  - Latitude: -89.5, -88, -86, ……, 86, 88, 89.5]
- A re-gridding scheme developed at GFDL (based on Jones, 1999) was applied to re-grid the output from the cubed-sphere grid (AM3) to GMI 2°×2.5° and 4°×5° latitude/longitude grids
  - Reference: Jones, P.W., **First- and second-order conservative remapping schemes for grids in spherical coordinates**, MWR, vol.127, 2204-2210, 1999.

GFDL Grid VS. GMI Grid: Temperature

- 996 hPa
- 01/15/1980, 12-15hr average

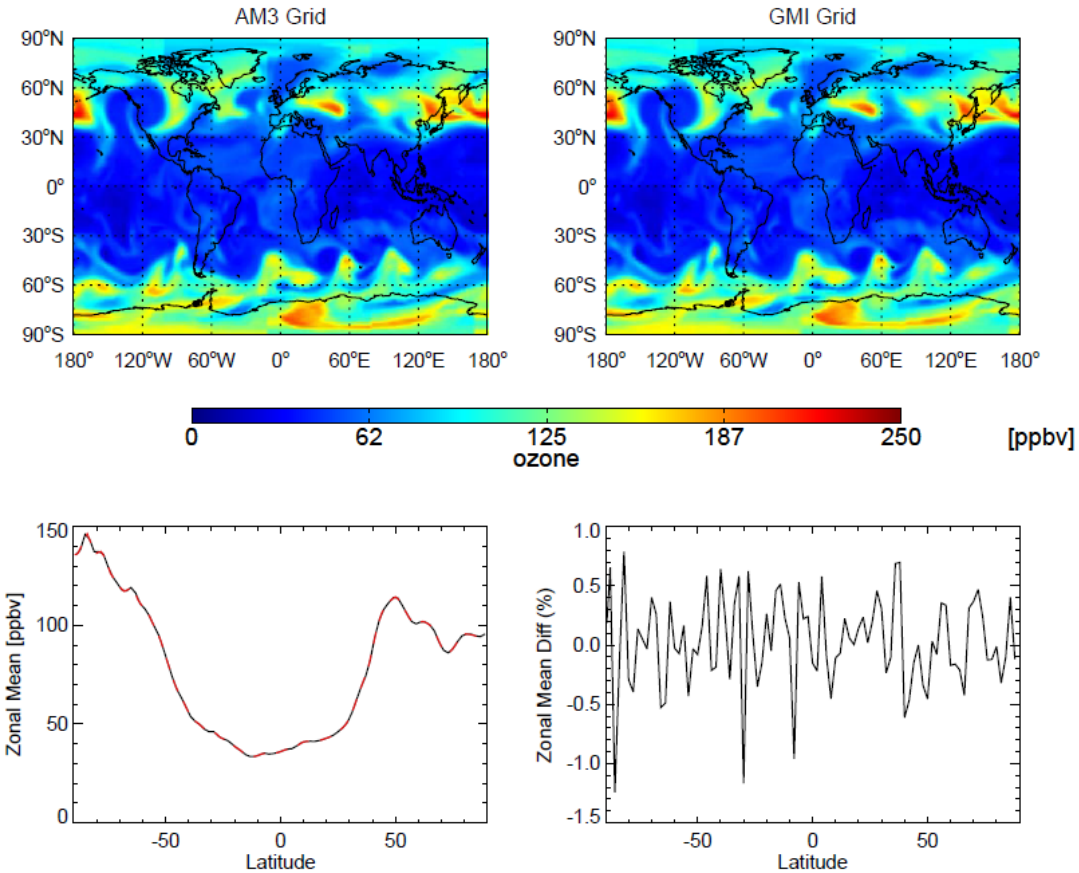


- **AM3 Temp.**
  - Min: 232.869
  - Max: 310.788
  - Median: 280.232
  - Mean: 277.338
- **GMI Temp.**
  - Min: 232.273
  - Max: 311.420
  - Median: 279.850
  - Mean: 276.990

The re-gridded AM3 fields on GMI lat/lon grids were verified against the same fields on GFDL lat/lon grids. (GFDL regularly re-grids AM3 output from cubed-sphere grids to lat/lon grids for analysis.)

GFDL Grid VS. GMI Grid: Ozone

- 277 hPa
- 01/15/1980, 12-15hr average



- **AM3 Ozone**
  - Min: 17.2397
  - Max: 224.611
  - Median: 65.9896
  - Mean: 78.2020
- **GMI Ozone**
  - Min: 16.0329
  - Max: 233.639
  - Median: 66.8829
  - Mean: 78.6155