Impact of Meteorological Fields on Transport & Photochemistry:

Preliminary Thoughts & Results with Some Provocative Plots

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GMI Meeting: ***June 6-8, 2005***
Greenbelt, MD

Reminder of Important Changes: V1 _ V2

- **Synoz Flux: 475 Tg/yr _ 550 Tg/yr.**
- **Entrainment/detrainment and downdraft code for GISS convection was implemented.**
- **G4agcm (a.k.a. fvGCM) fields; replace CCM3.**
- **Radiative and heterogeneous chemical effects of sulfate, dust, sea-salt, organic carbon and black carbon aerosol:**
  - **3-D aerosol mass distributions from GOCART [*Chin et al.*, 2002].**
  - **Implemented following *Martin et al.* [2003].**

See summary report for details:

gmi.gsfc.nasa.gov/models/gmit-v2_summary.pdf

Confounding Issues

⇒ Vertical Resolutions

⇒ On-line Emissions (e.g., biogenic emissions)

⇒ Temperature

⇒ Clouds

⇒ Convection & Advection

⇒ Different Time Periods

⇒ etc.

Therefore, it may be difficult to:

⇒ isolate impact of a certain field

⇒ compare to/evaluate with observations

Differing Time Periods

⇒ Specific Time (*i.e.,* DAO & Observations)

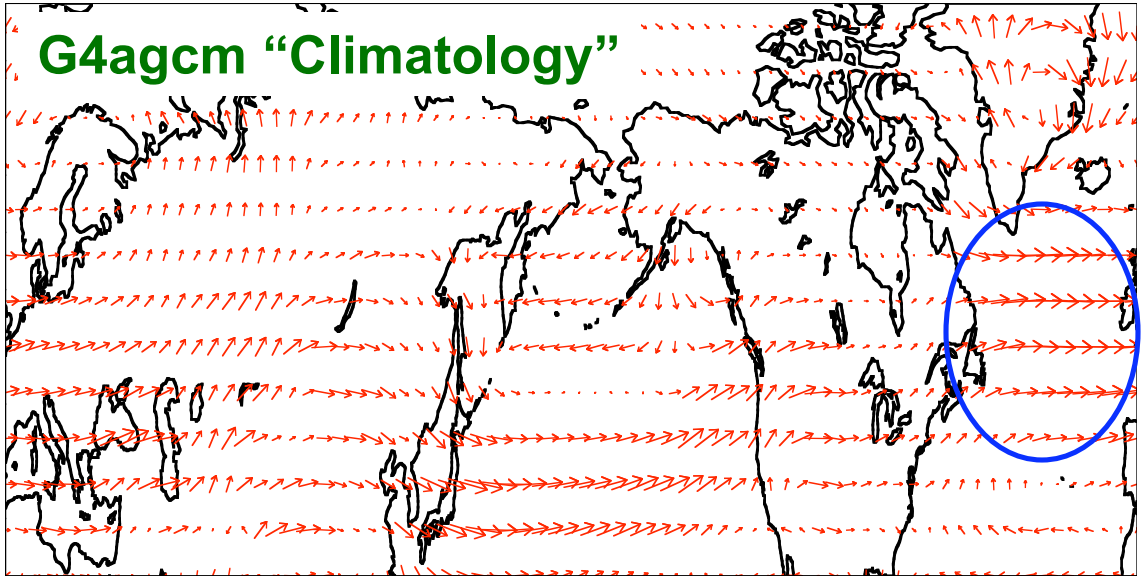
vs

Climatology (*i.e.,* G4agcm & GISS)

⇒ Significant Complications from Large-Scale Weather Phenomena:

e.g., El Niño-Southern Oscillation (ENSO)
North Atlantic Oscillation (NAO)

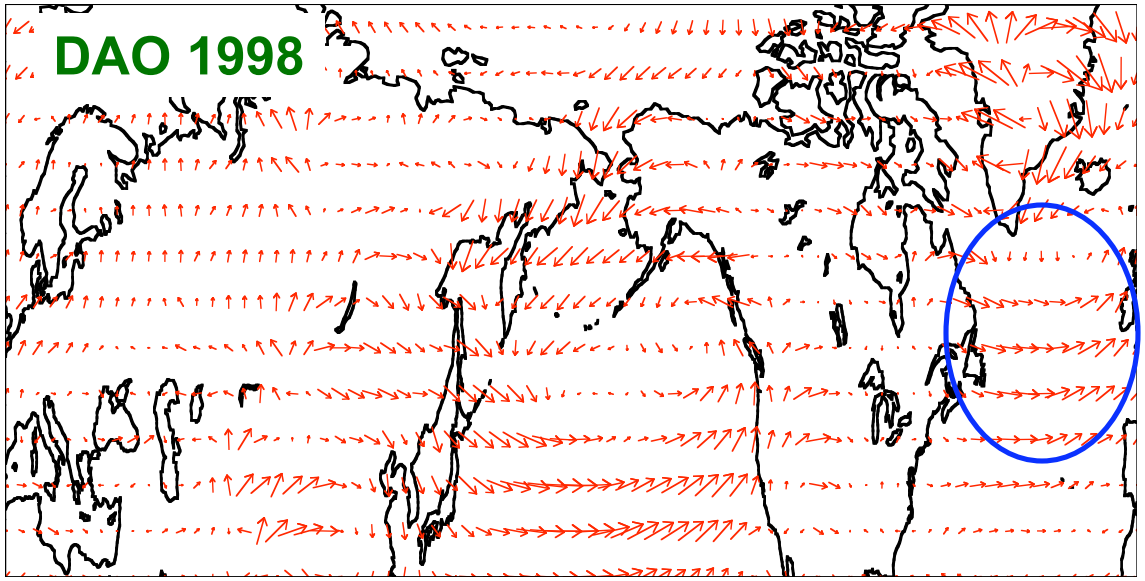
Advection



January Surface Winds

+ NAO

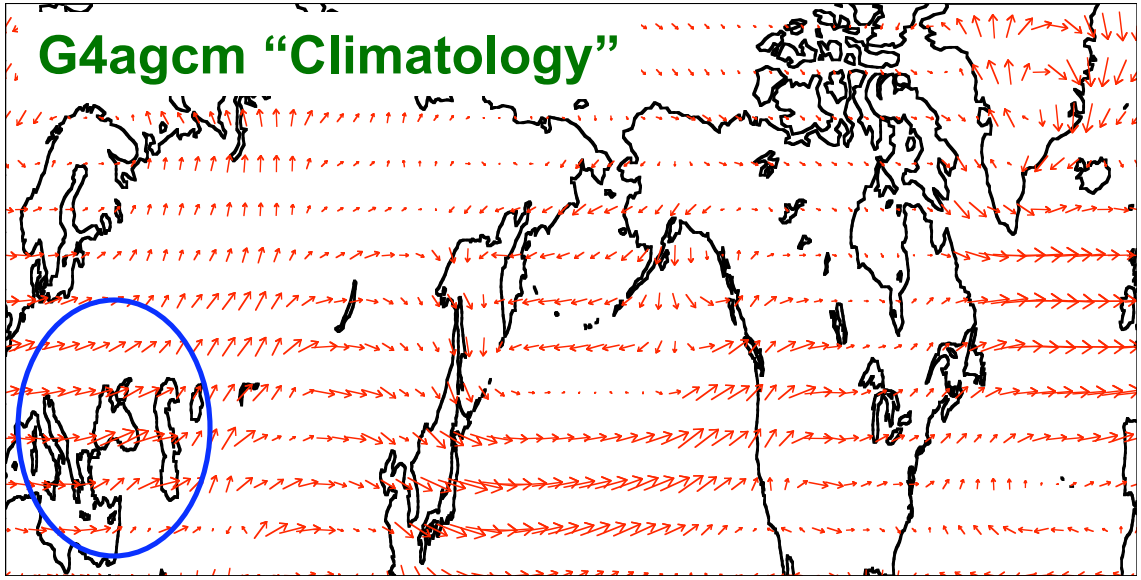
strong flow,
frequent storms



Weakly – NAO (–0.28)

somewhat weak flow,
frequent stagnation

Advection

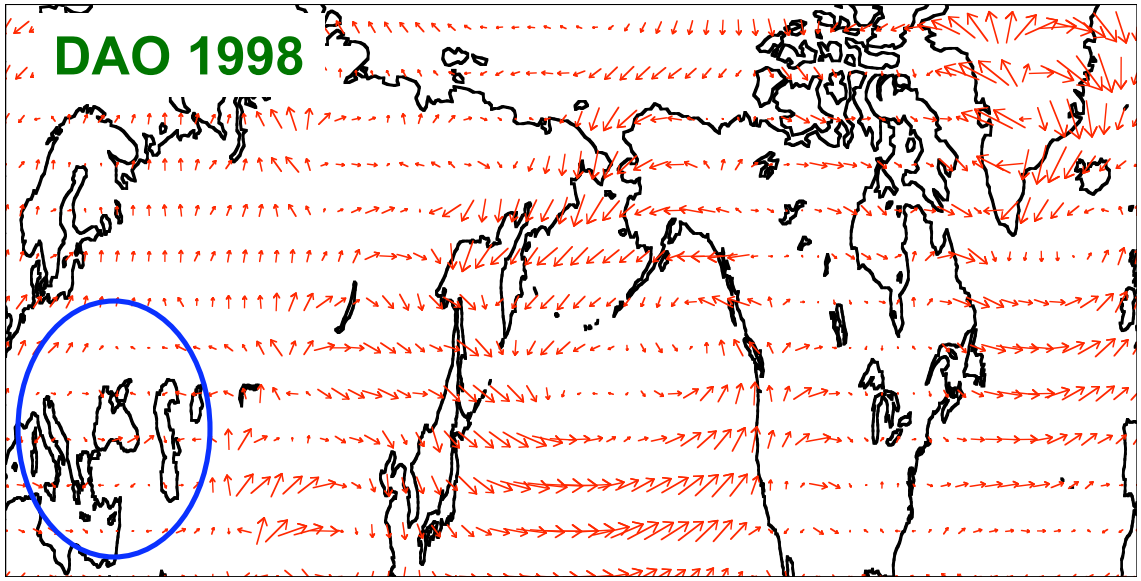


January Surface Winds

+ NAO

Lower Pollutant Concentrations

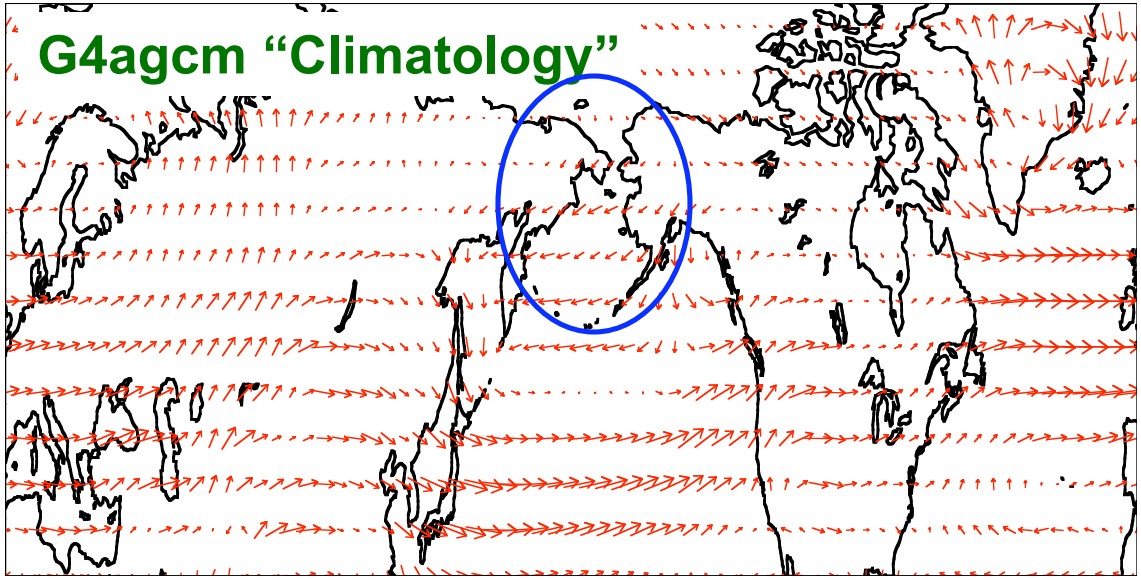
European observations sensitive to NAO phase.



– NAO

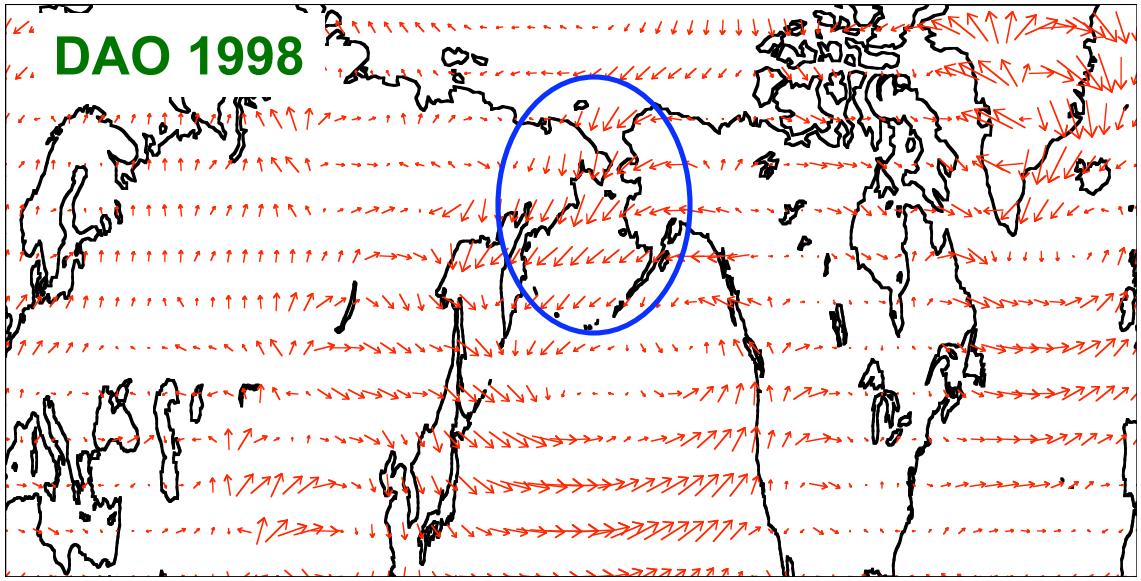
Higher Pollutant Concentrations

Advection



January Surface Winds

Pacific Decadal and/or Arctic Oscillations?

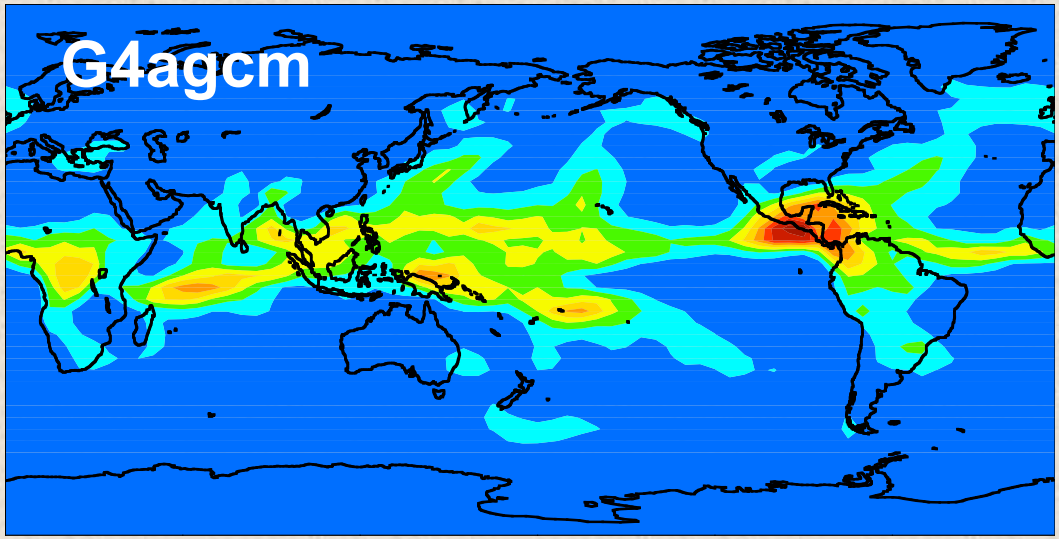


Convection

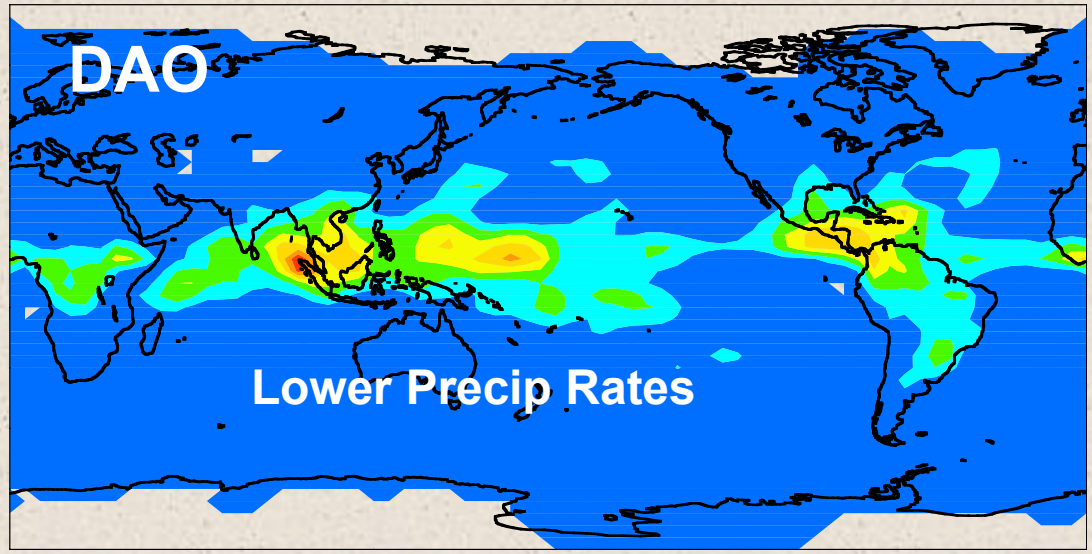
"October 1994"

El Niño

October 1997



"precon" = convective precipitation rate (mm/day)



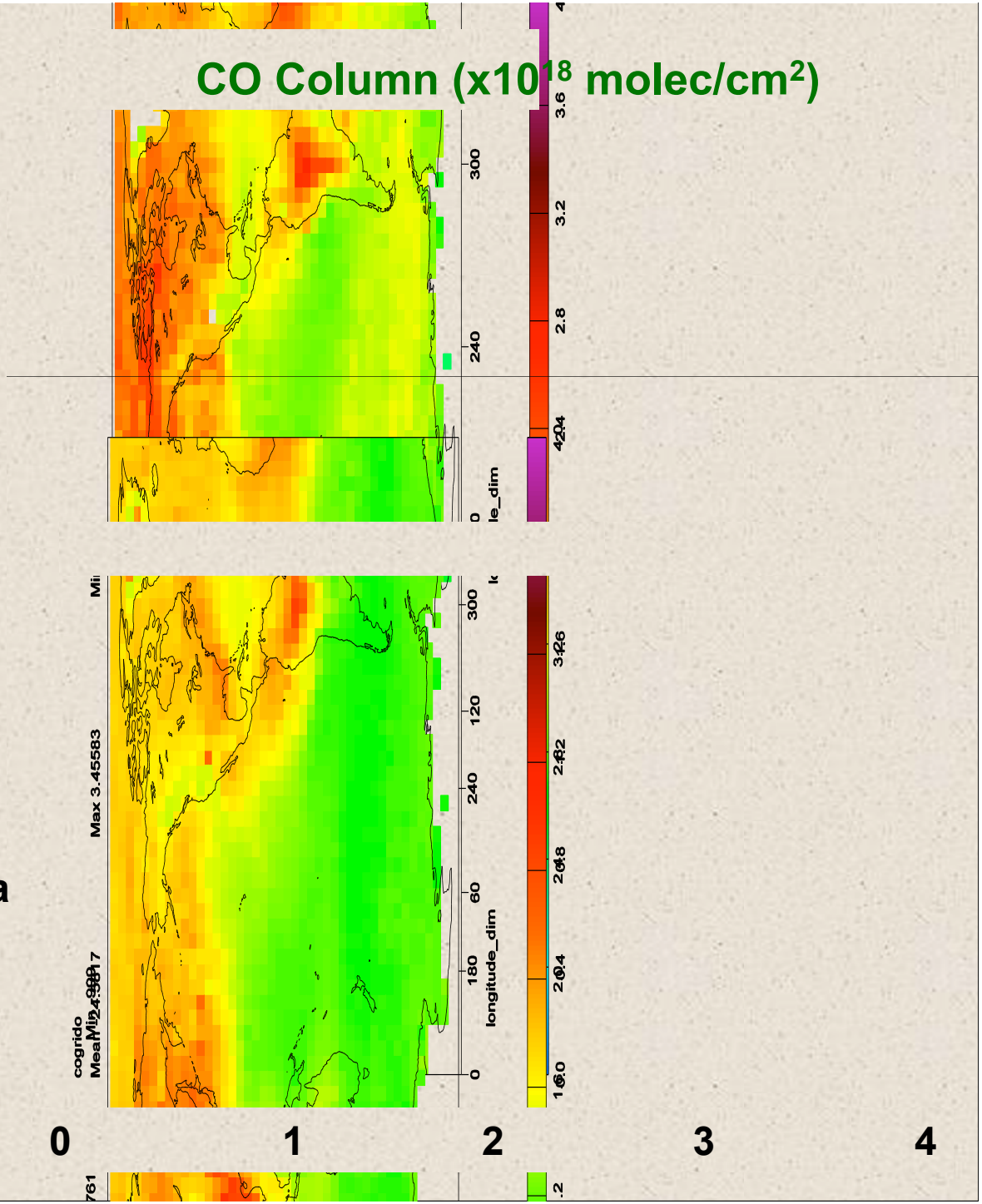
0 5 10 15 20 24

Time Period vs Physics in Parent GCM/Assimilated Data?

Comparison with Observations

MOPITT
August 2002

DAO
August 1997



*MOPITT CO: Prasad Kasibhatla

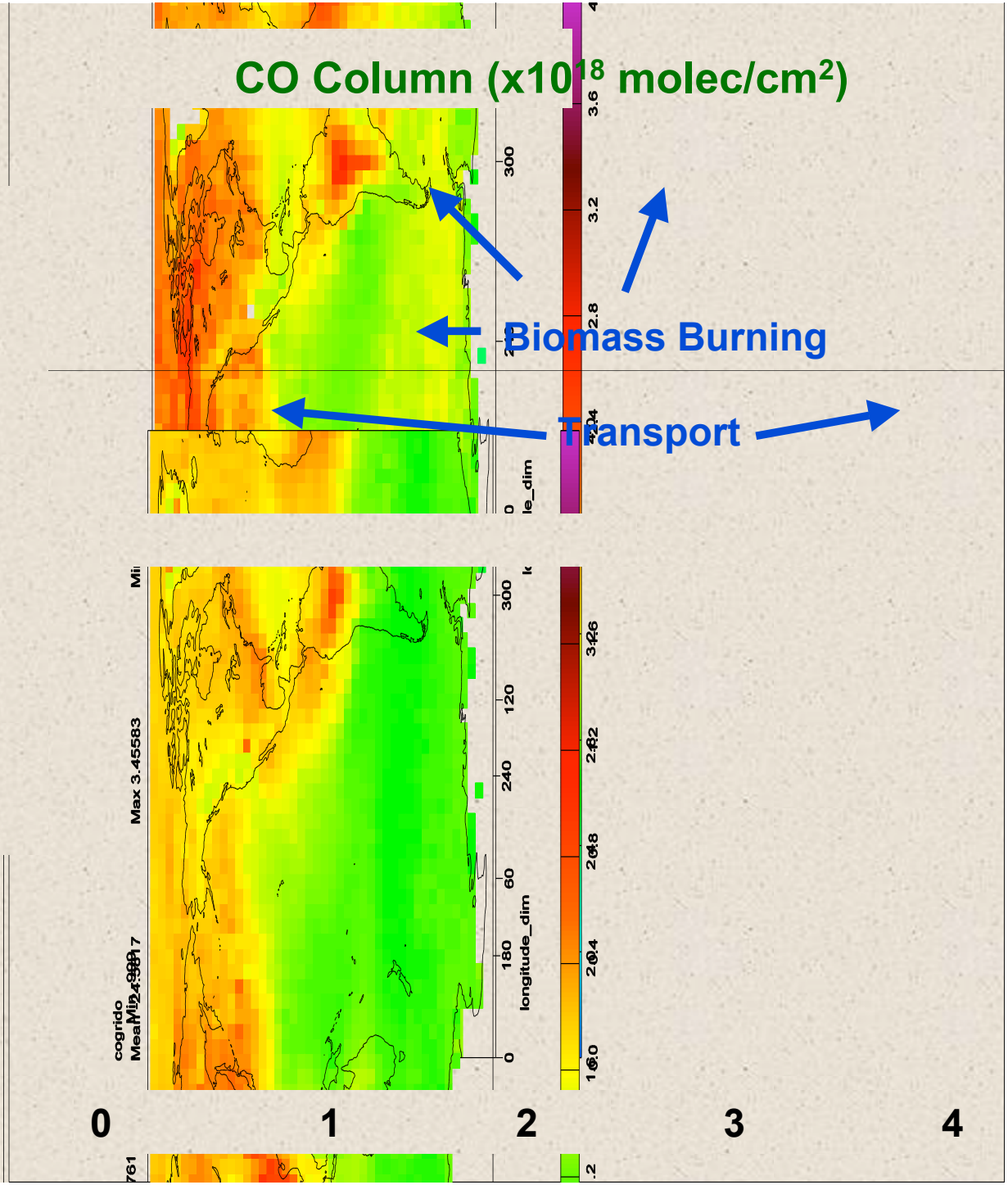
*GOME NO_2: Randall Martin

*AURA next.

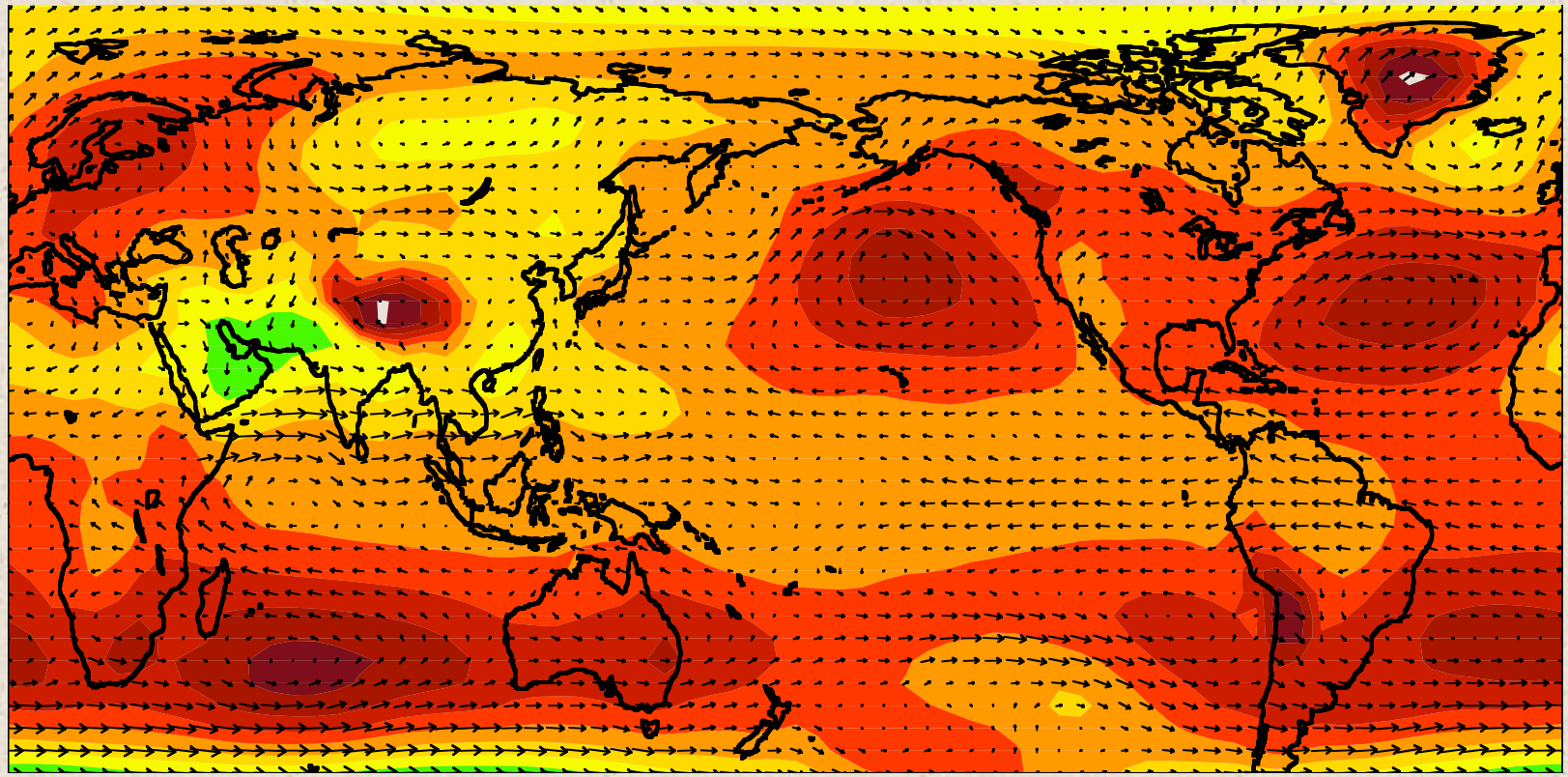
Comparison with Observations

MOPITT
August 2002

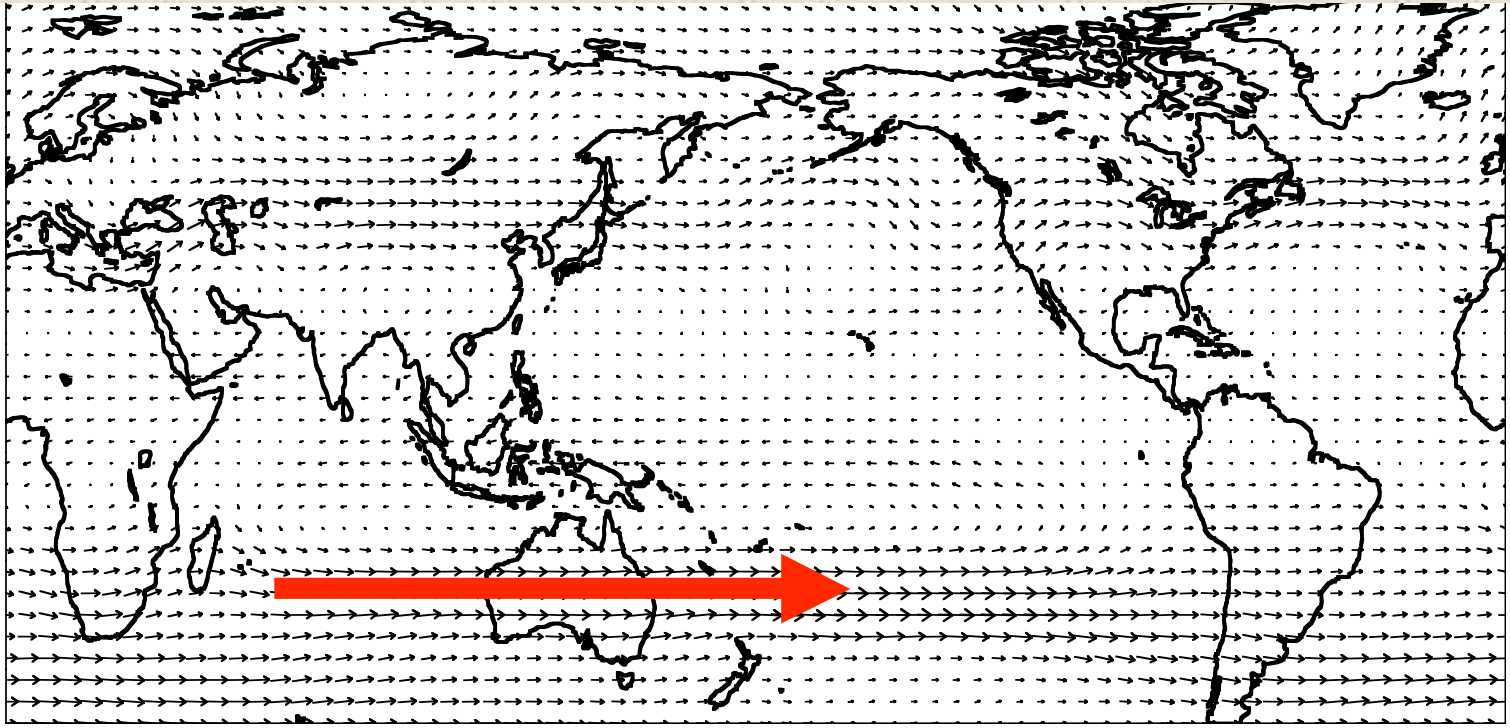
DAO
August 1997



Mean SLP (mb) and DAO Winds at 800 mb



DAO Winds at 300 mb



Transport in UT in Subtropical Jet, but CO needs to be Lofted to UT.

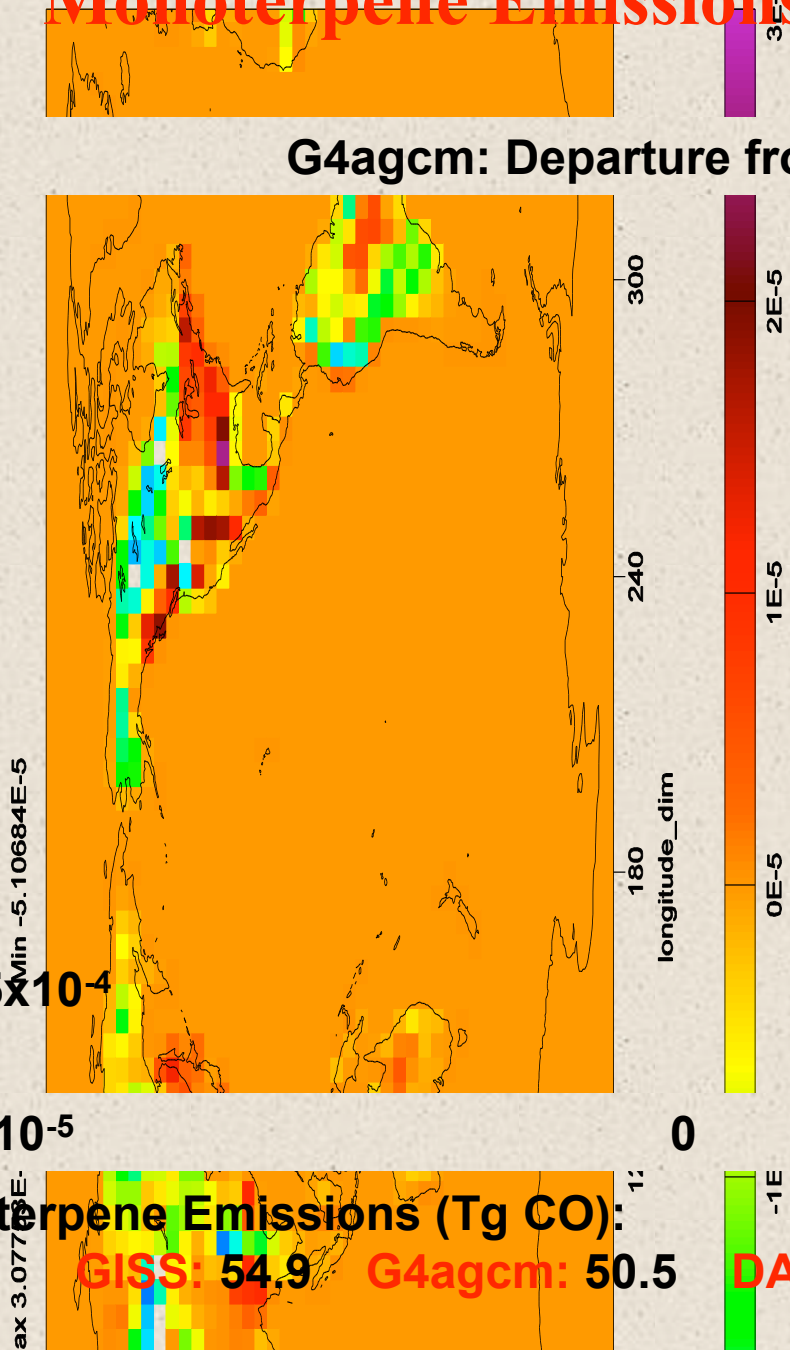
DAO Cldmas indicates no/minimal convection.

Emissions

Source	NO_y Tg N	CO Tg	MEK Tg C	PRPE Tg C	C_2H_6 Tg C	C_3H_8 Tg C	ALK4 Tg C	ALD2 Tg C	CH_2O Tg C	ISOP Tg C	VOC Tg C
Variable[a]											
Soils	6.6-6.8	--	--	--	--	--	--	--	--	--	--
Vegetation	--	150.5-155.4[b]	--	10.9	--	--	--	--	--	380.0[c]	390.9
Fixed											
Aircraft[d]	0.6	--	--	--	--	--	--	--	--	--	--
Lightning[d]	5.0	--	--	--	--	--	--	--	--	--	--
Fossil Fuel[e]	23.6	393.8	0.8	7.9	5.3	5.7	25.2	--	--	--	44.9
Biom. Burn[d]	6.5	439.3	3.6	3.9	1.9	0.7	0.6	2.6	1.9	--	15.3
Biofuel[e]	2.2	160.3	1.3	6.3	2.0	0.9	0.8	0.7	0.5	--	12.4
Total	44.8-45.0	1144-1149	5.8	29.0	9.3	7.3	26.6	3.3	2.4	380.0	463.5

[a]The spatial and temporal distribution of emissions are dependent on meteorological fields. [b]Emissions of CO from the oxidation of 1) biogenic methanol are fixed at 100 Tg and distributed spatially and temporally following isoprene emissions, and 2) monoterpenes range from 50.5-55.4 Tg CO. [c]Total annual emissions for the different meteorological fields are scaled to be equal, though the temporal and spatial distributions of emissions are not. [d]Monthly mean emissions. [e]Annual mean emissions.

Monoterpene Emissions (kg/m^2/July)



$E^{max} = 2.5 \times 10^{-4}$

-3×10^{-5} 0 3×10^{-5}

Annual Monoterpene Emissions (Tg CO):

GISS: 54.9 G4agcm: 50.5 DAO: 55.4

July Surface Temperature Departure (°C) from Average

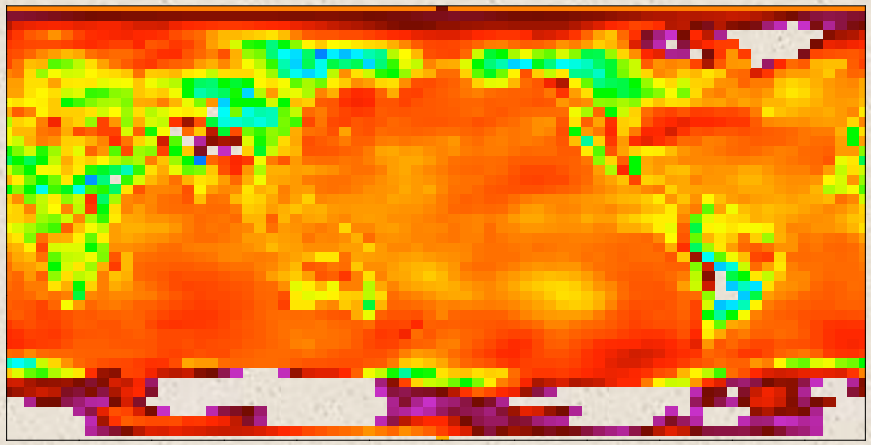
⇒ **G4agcm: No Ocean Bias ; Cooler Land**

⇒ **GISS: Ocean Bias ~ –1° ; Warmer Land**

⇒ **DAO: Ocean Bias ~ +1° ; Warmer Land**

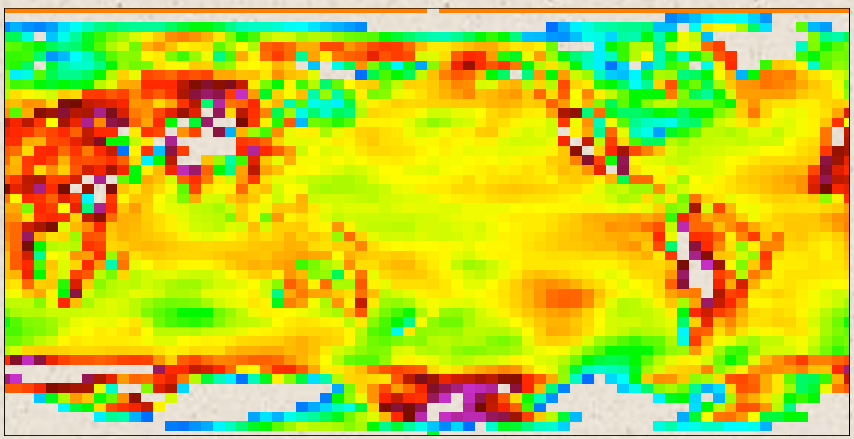
Which is right?

G4agcm

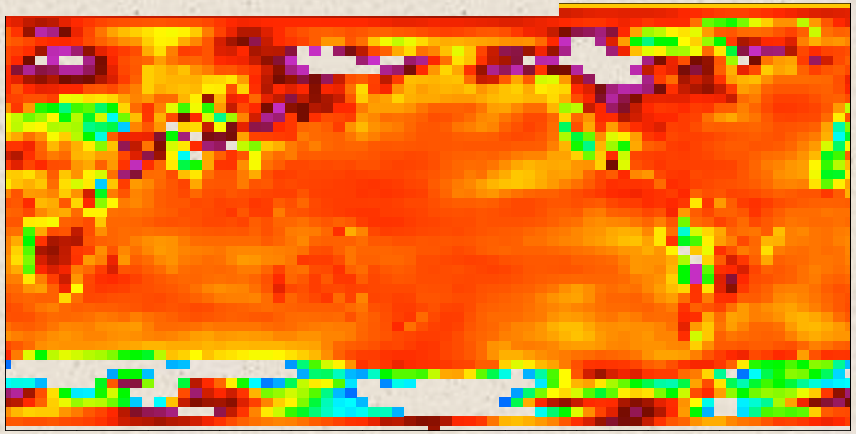


-5 -4 -3 -2 -1 0 1 2 3 4 5

GISS



DAO

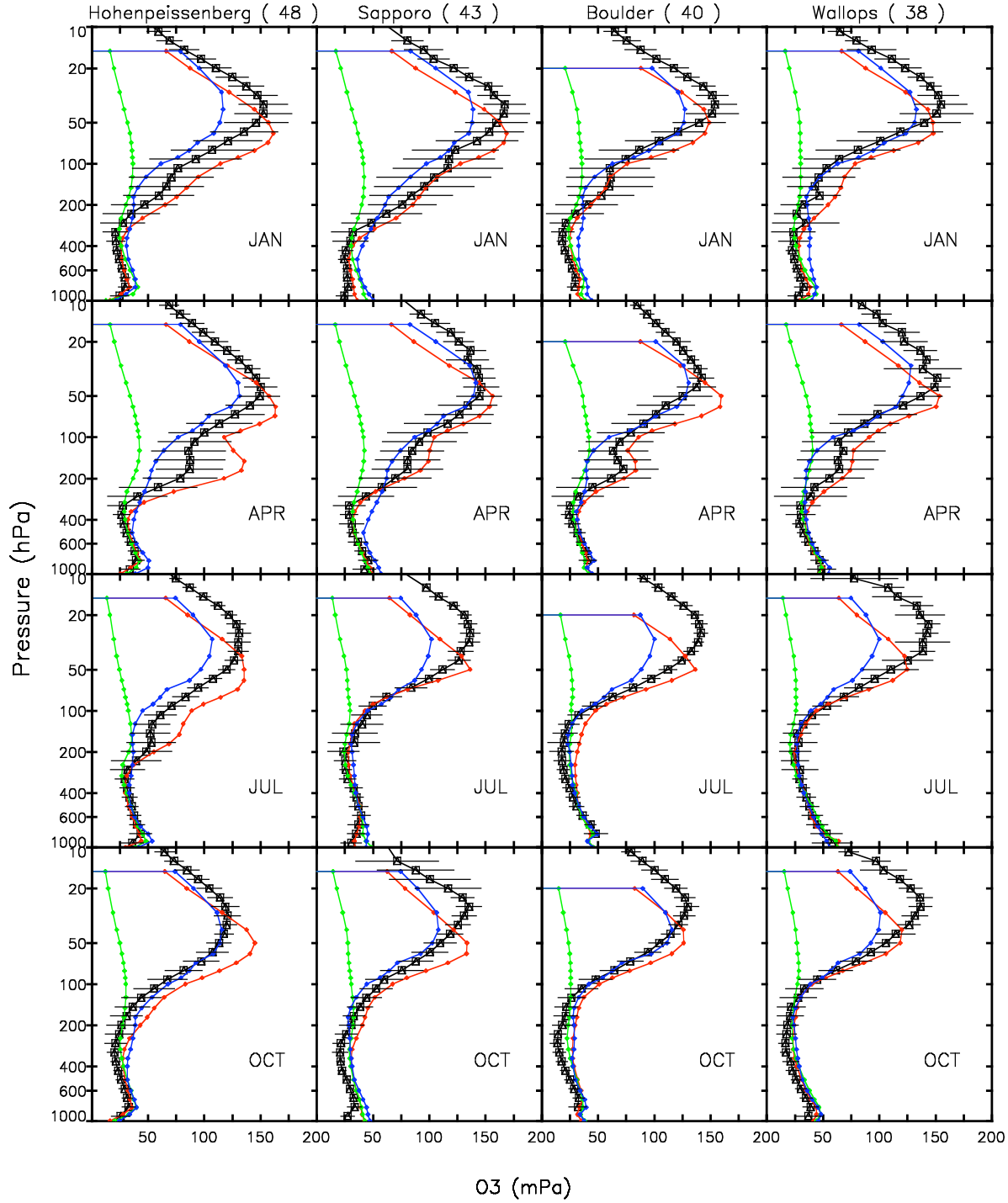


Stratosphere-Troposphere Exchange

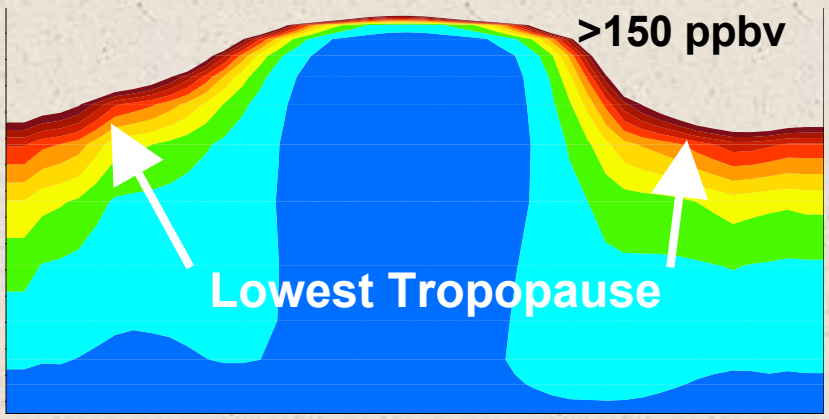
Ozone (mPa)

GISS
G4agcm
DAO: 3-4x excessive STE

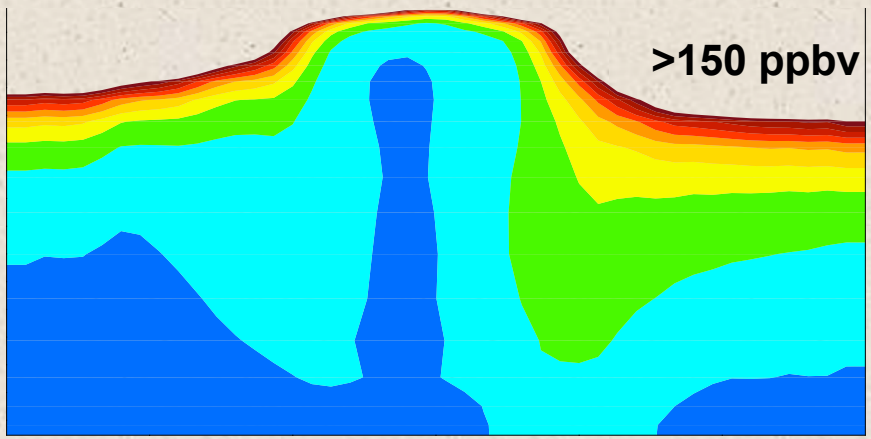
HNO_3 (Nodoz) behaves similarly.



GISS April Synoz (ppbv)

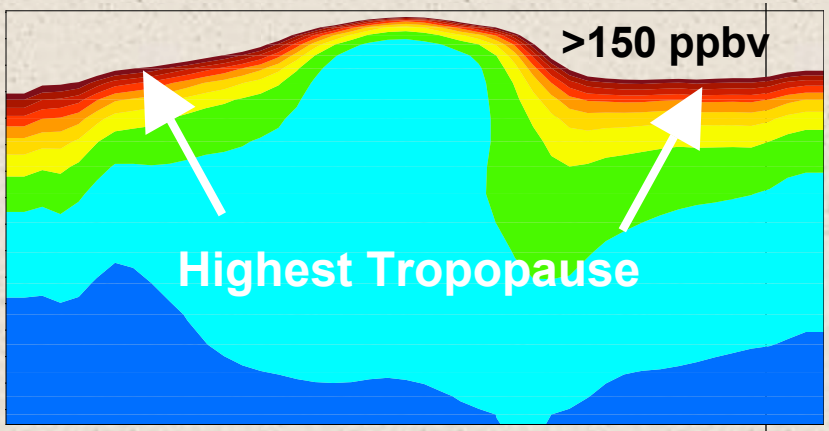


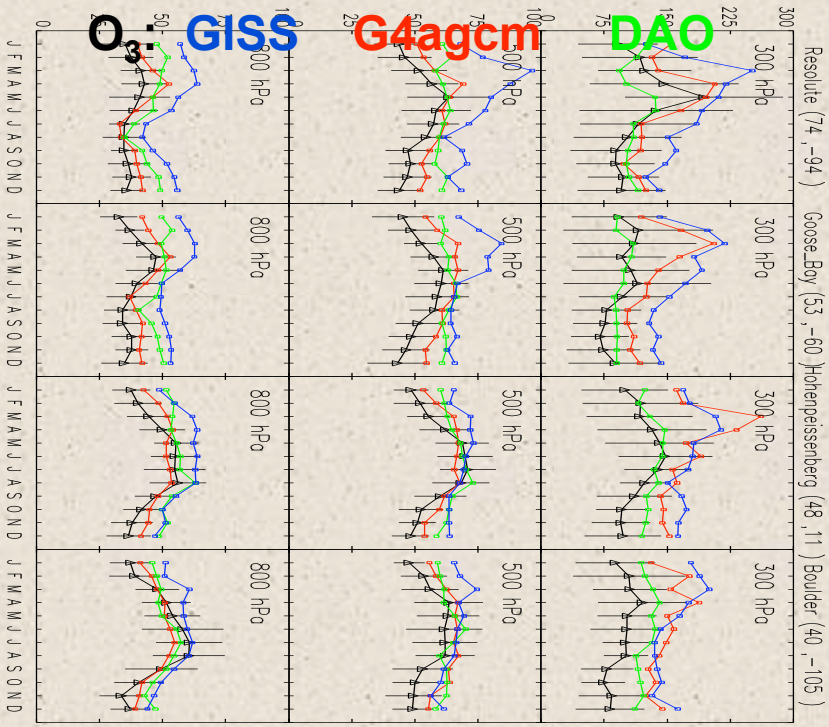
G4agcm



25 50 75 100 125 150

DAO



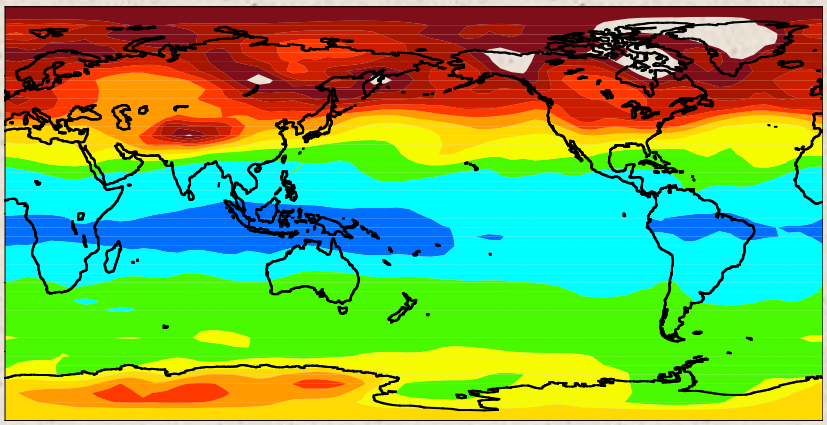


Synoz (ppbv) April ~300 mb

⇒ GISS: Strongest Horizontal Gradient

⇒ DAO: Weakest Horizontal Gradient

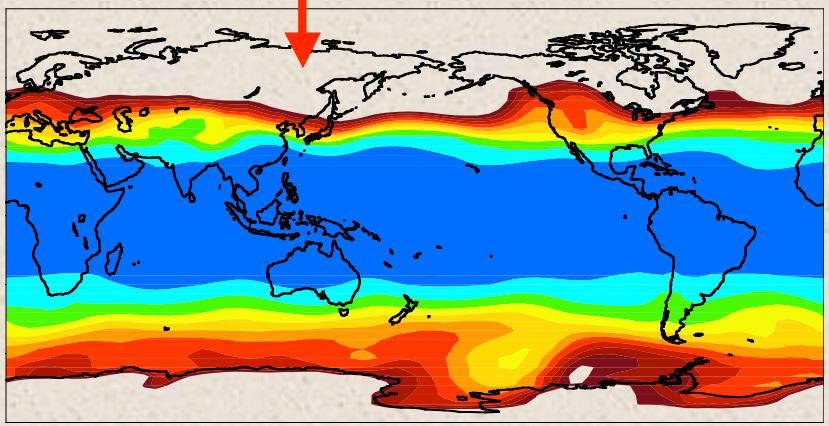
G4agcm



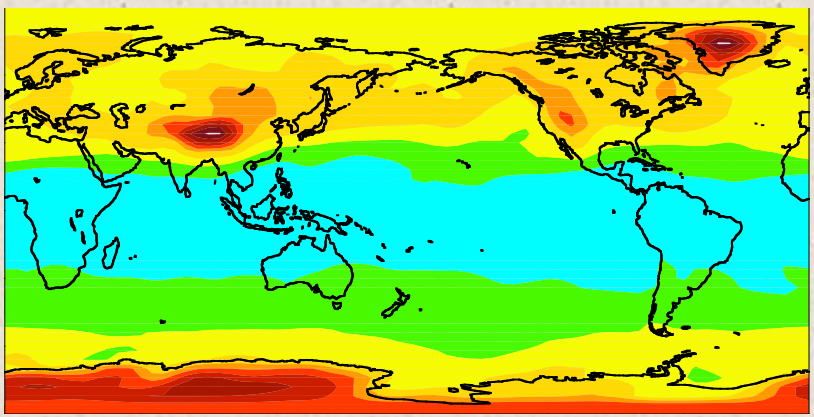
25 50 75 100 125 150

> 150 ppbv

GISS



DAO



Tropospheric Nitrogen Budget (Tg N)

Emission Sources (44.8-45.0 Tg N)

Aircraft	0.56	(1%)
Lightning	5.0	(11%)
Biofuels	2.2	(5%)
Fossil Fuels	23.4	(53%)
Biomass Burning	6.5	(15%)
Nodoz	0.5	(1%)
Soils	6.6-6.8	(15%)

Sinks (45.6-46.2 Tg N)

GISS: 46.2 G4agcm: 46.0 DAO: 45.6

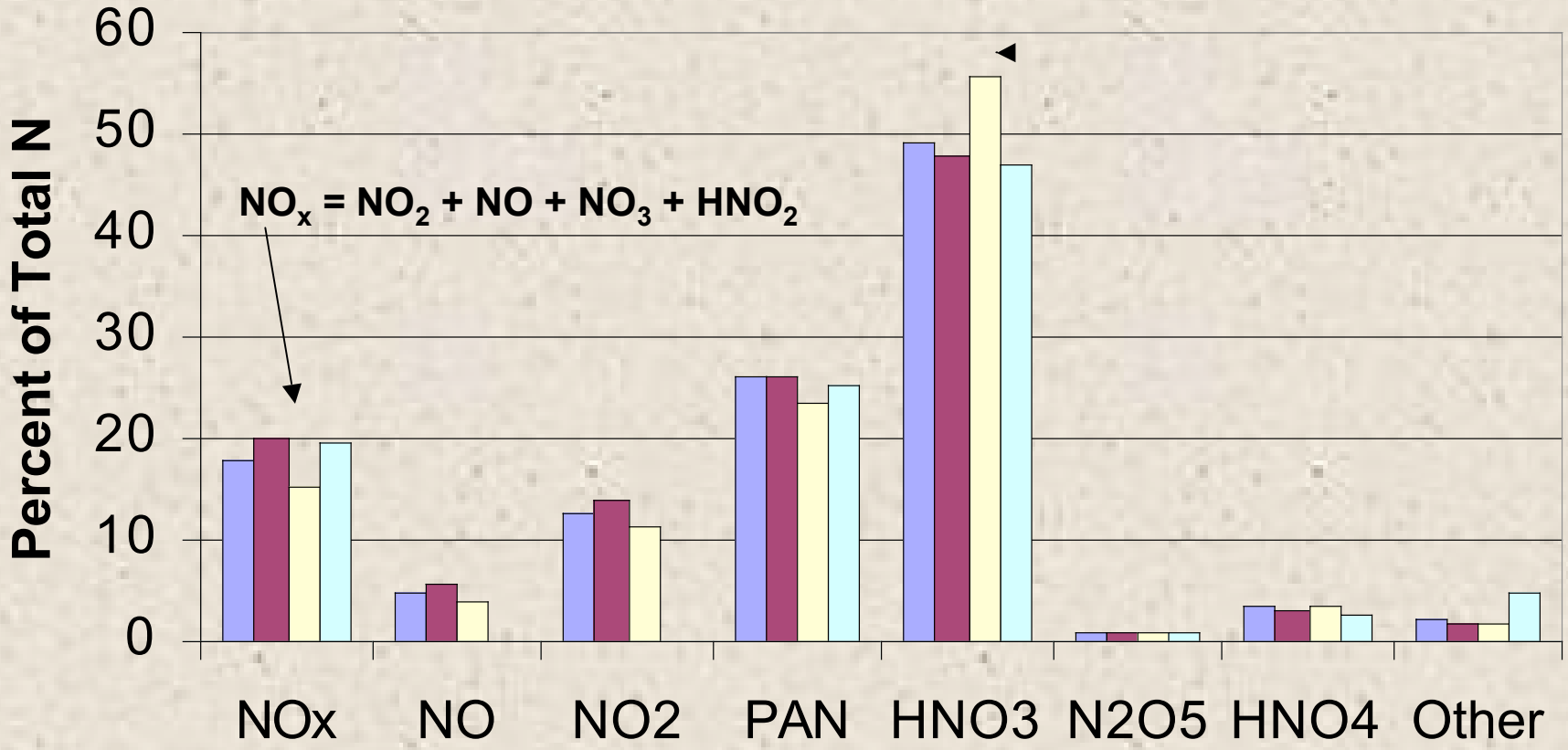
Wet Deposition : HNO_3

GISS: 25.6 G4agcm: 25.9 DAO: 27.7

Dry Deposition :

	GISS:	G4agcm:	DAO:
	20.6	20.1	17.9
NO_2	2.4	2.2	2.6
HNO_3	15.1	14.8	12.7
PAN	0.72	0.61	0.58
Other	2.4	2.5	2.0

Tropospheric NO_y Partition (%)

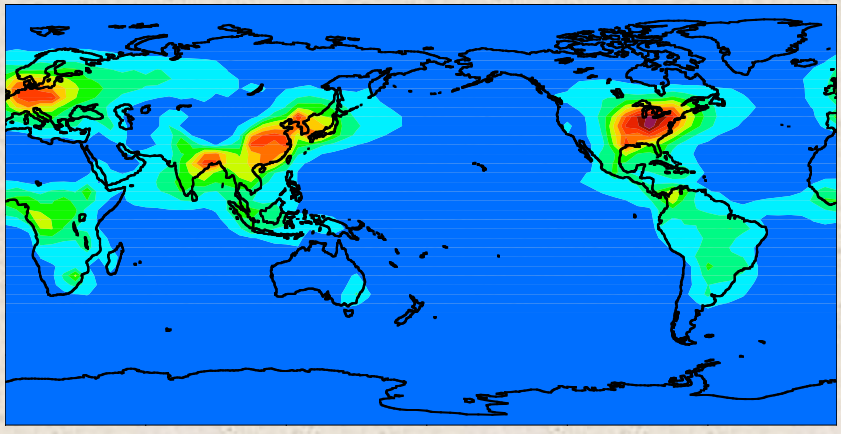


Burden (Tg N) : **10.0** **9.2** **10.2** **8.1**

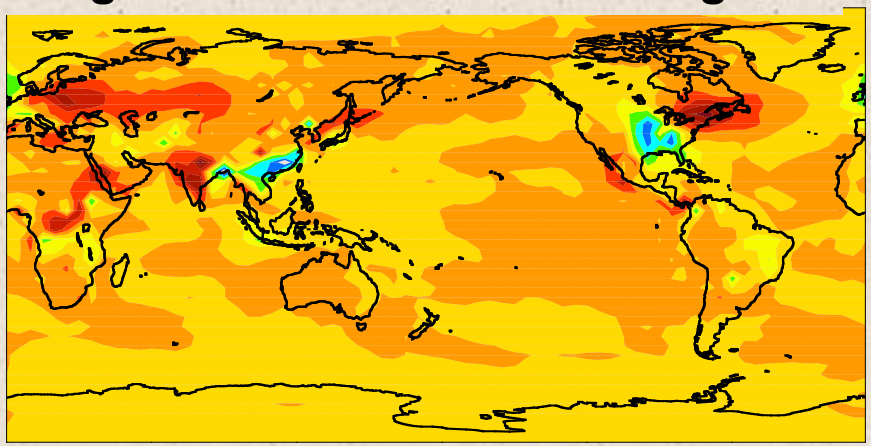
GISS G4agcm DAO-Strat GEOS-CHEM

NO_2/NO : **2.6** **2.5** **3.0**

Average HNO_3 Wet Deposition (kg/m^2)

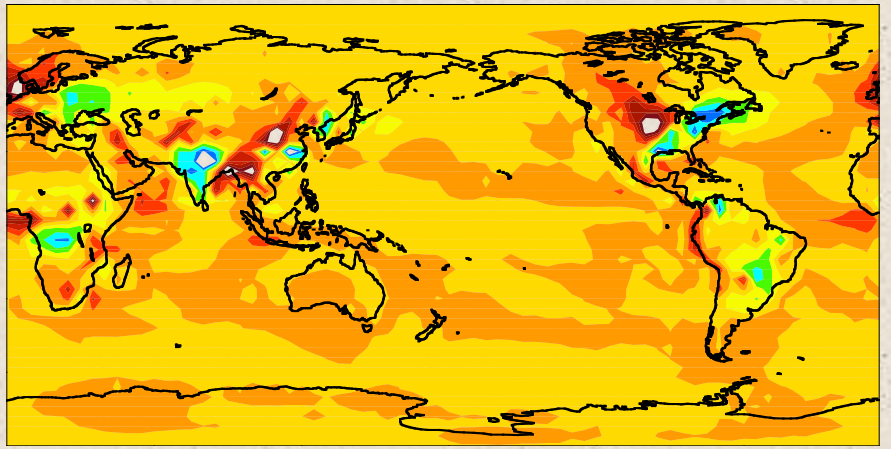


G4agcm: Deviation from Average

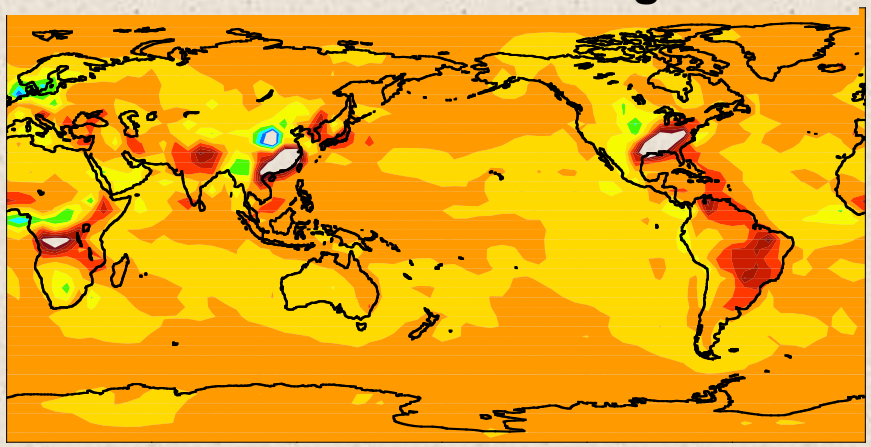


0 0.001 0.002 0.0025 -0.0005 0 0.0005

GISS: Deviation from Average



DAO: Deviation from Average



NO_y Budget

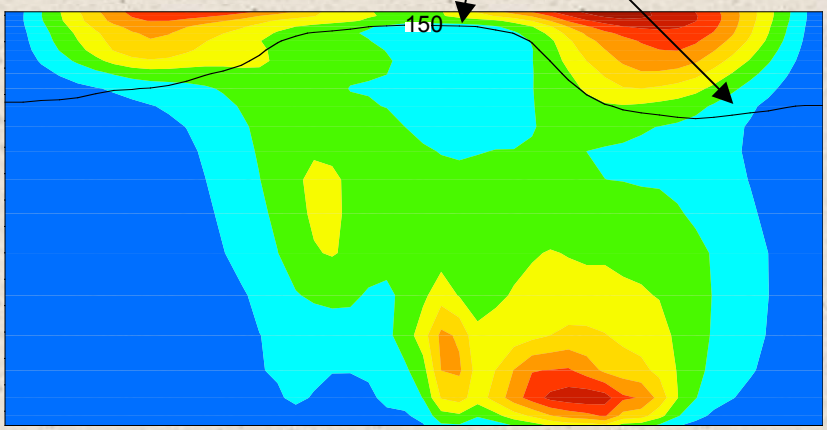
NO_y (kg N) January

⇒ DAO: low NO_y in LS/UT : Fast STE?

⇒ GISS: Excessive convection?

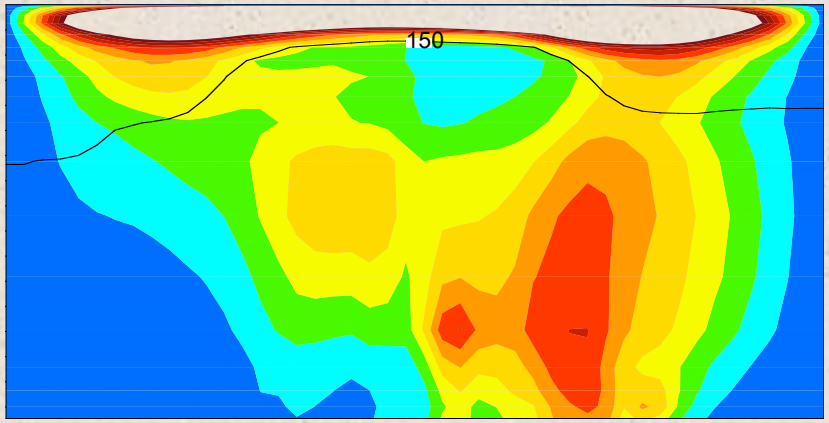
⇒ GISS: Realistic source from LS?

G4agcm

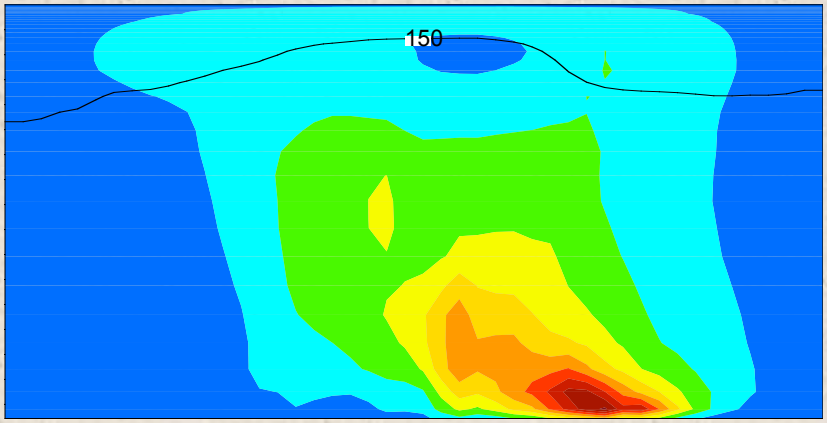


0 50000 100000

GISS



DAO



NO_y Budget

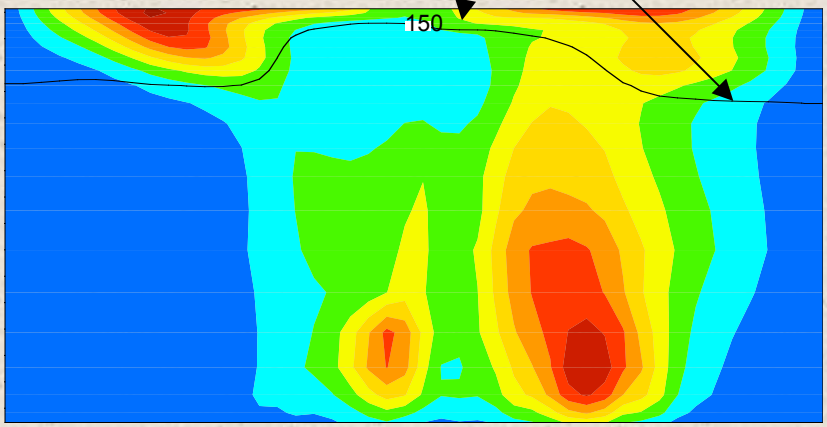
NO_y (kg N) July

⇒ DAO: low NO_y in LS : Excessive STE?

⇒ GISS: Excessive convection?

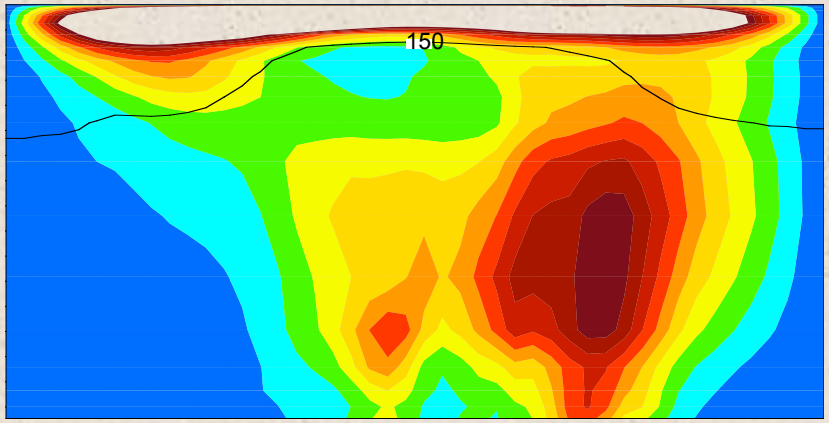
G4agcm

Synoz = 150 ppbv

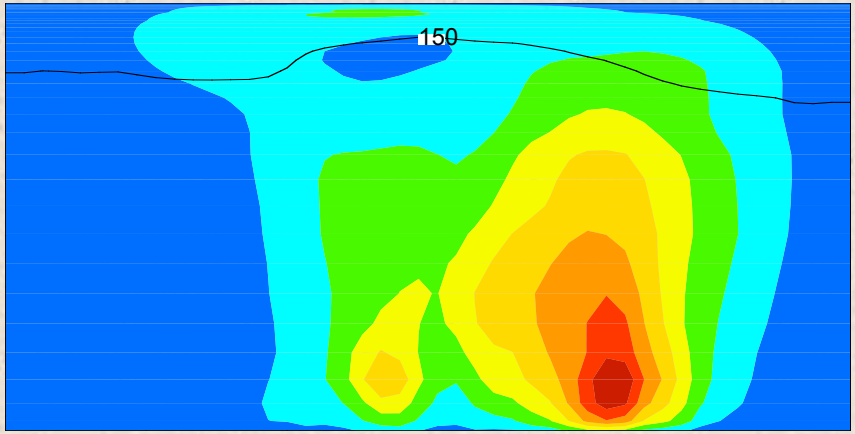


0 50000 100000

GISS



DAO

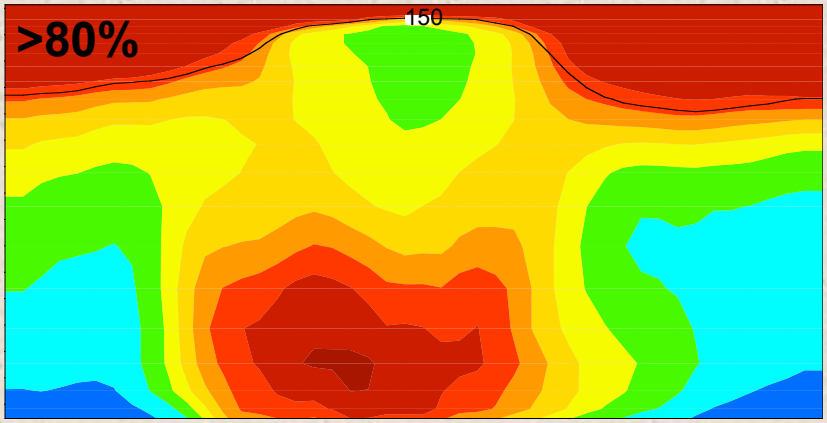


HNO_3/NO_y (% N) January

⇒ DAO: High in NH?

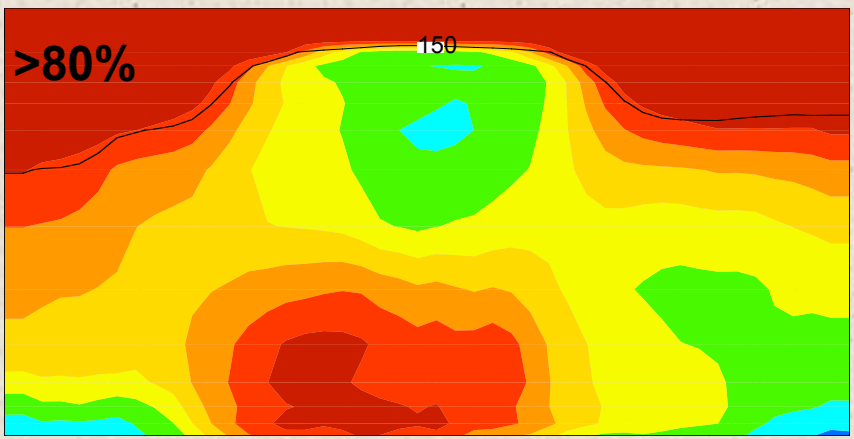
⇒ GISS: Realistic source from LS in SH?

G4agcm

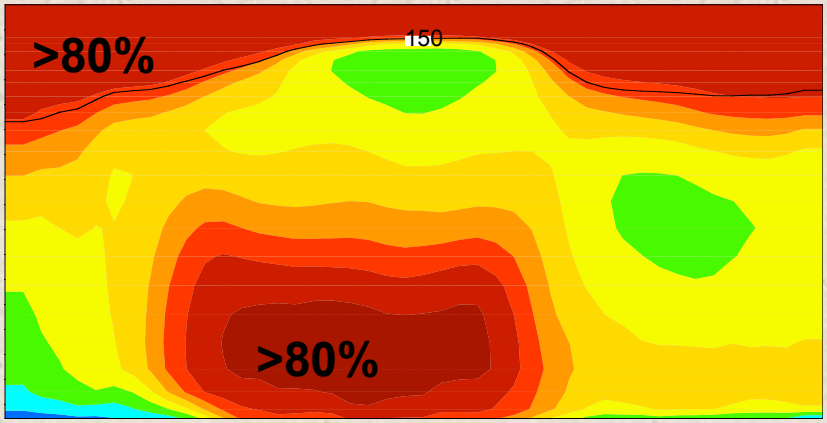


0 20 40 60 80 100

GISS



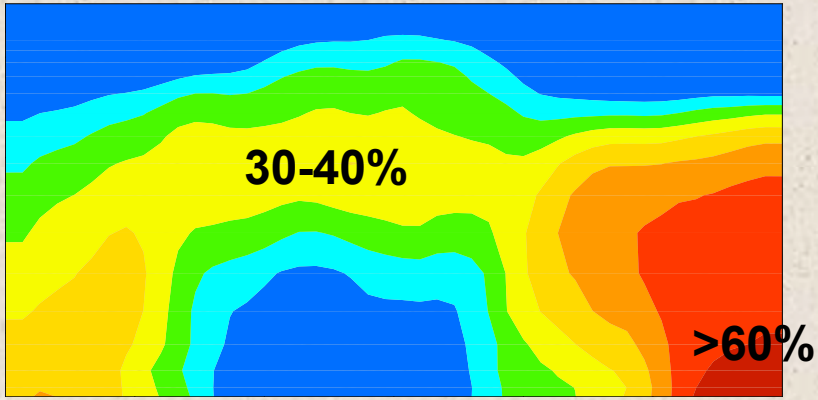
DAO



PAN/NO_y (% N) January

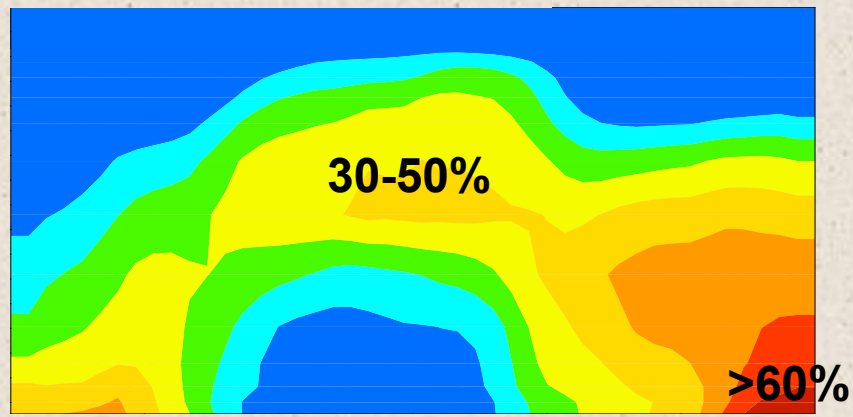
⇒ DAO: Low in NH?

G4agcm

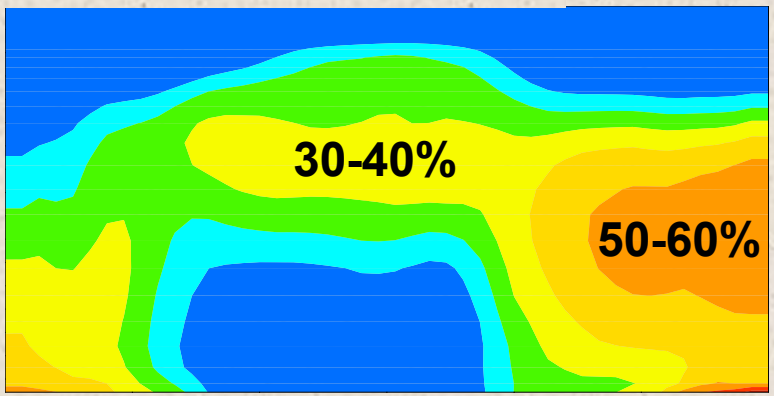


0 20 40 60 80 100

GISS



DAO

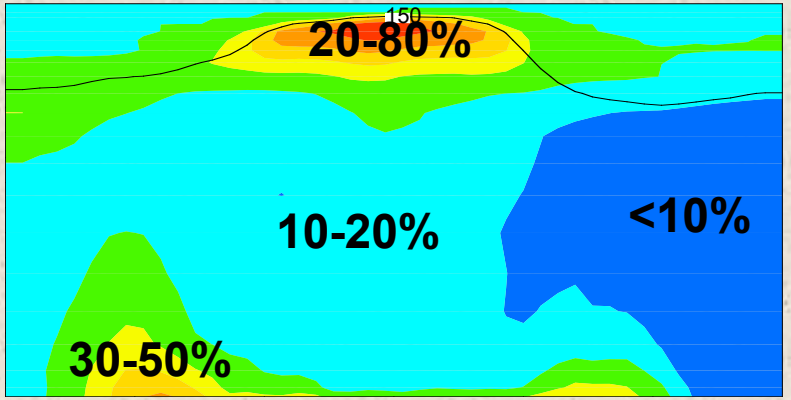


NO_x/NO_y (% N) January

⇒ Why NO fraction high in UT?

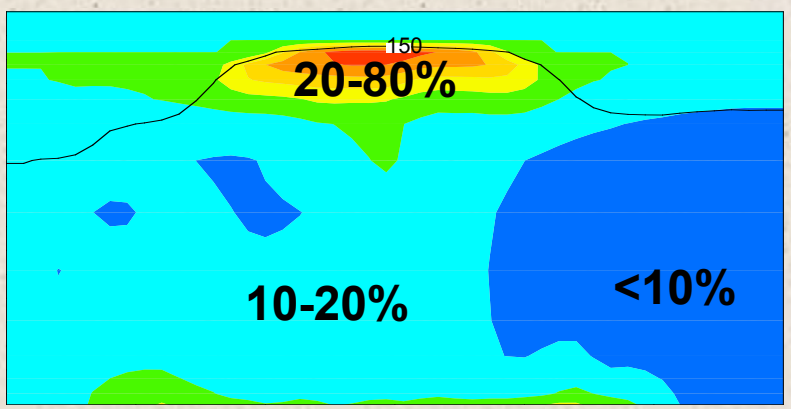
1. Convection removes HNO_3.
2. Lightning NO.

G4agcm

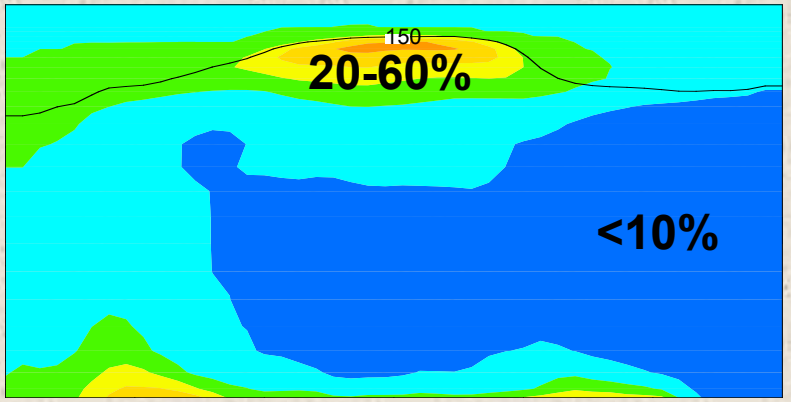


0 20 40 60 80 100

GISS



DAO



Tropical UT OH :
GISS @ 171 mb

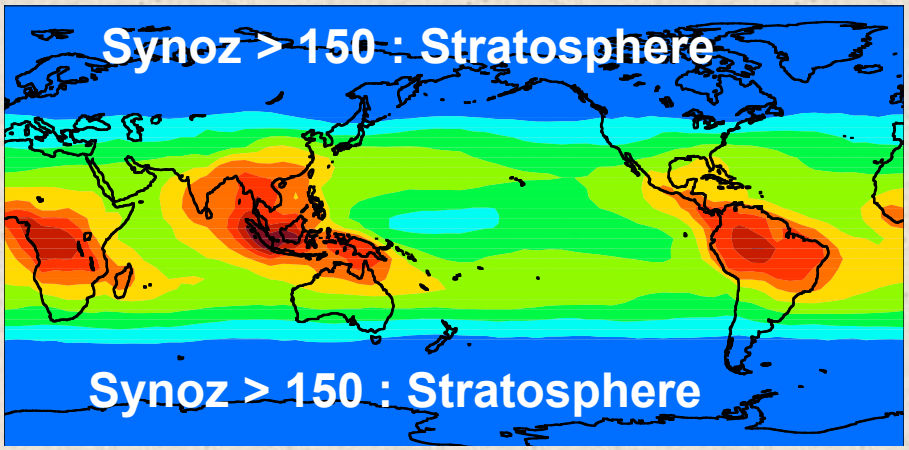
⇒ Lightning NO repartitions HOx

$NO + HO_2 \rightarrow OH + NO_2$

⇒ NO_x from other sources (e.g., stratosphere, surface sources)

⇒ OH produced via $j*O_3 \rightarrow 2OH$ (~10%)

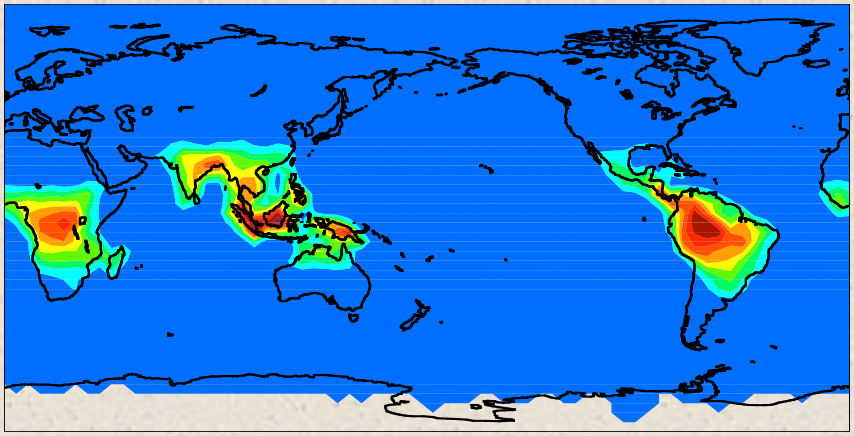
OH (molec/cm^{3}x10^6)



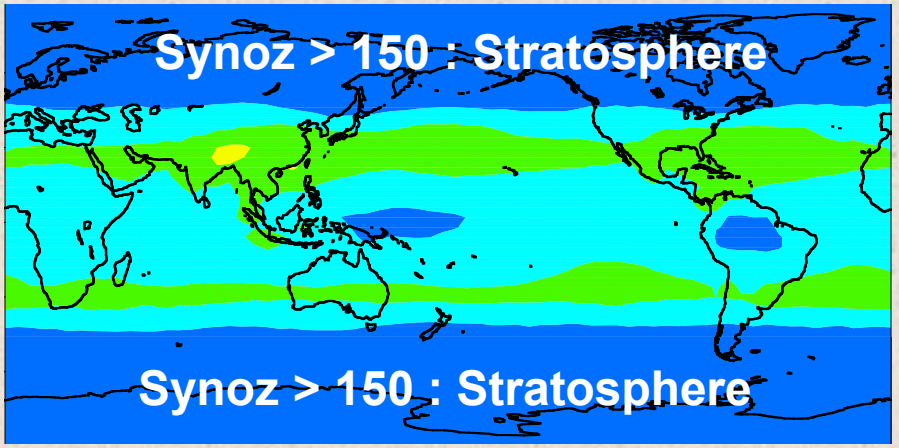
0 60°E 120°E 180 120°W 60°W

0 0.8 1.6 2.4 3.2

Lightning NO Emissions (kg/yr)



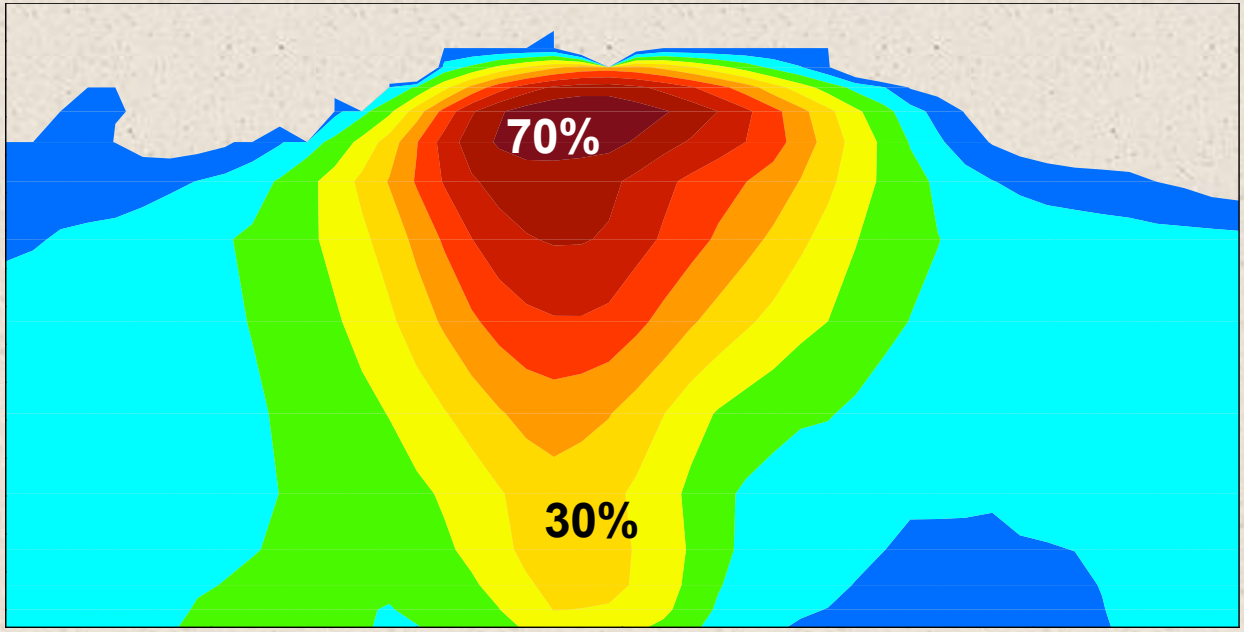
OH (molec/cm^{3}x10^6) – w/o Lightning



0 60°E 120°E 180 120°W 60°W

Impact of Met Fields: Tropical OH

Annual OH (% difference) w/ & w/o Lightning Emissions (GISS)



⇒ **Ken & Dale's Lightning Parameterization**

Convection & Lightning will be Co-Located!

Tropospheric OH

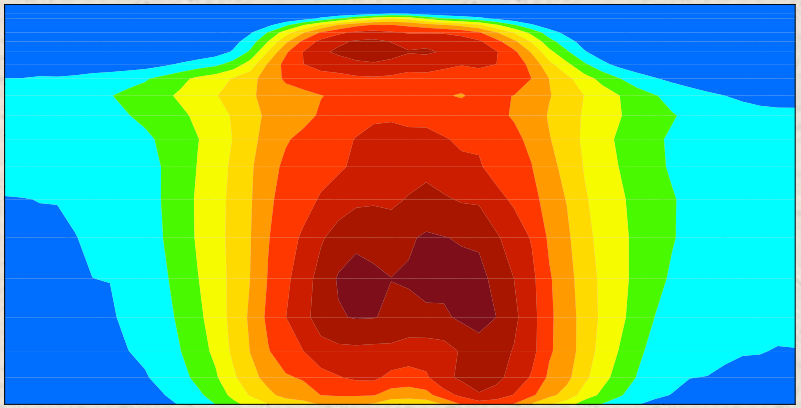
	GISS	G4agcm	DAO-Strat
Mean OH ($x10^6$ molec/cm^3)	0.93	1.02	0.96
MC Lifetime (yr) wrt Trop OH	6.54	5.75	5.94
MC Lifetime (yr) wrt All Sinks	5.13	4.63	4.75
CO Lifetime (months)	2.01	1.84	1.95
H_2O_2 Wet Deposition (Tg/yr)	302	297	270

Annual OH ($x10^6$ molec/cm^3)

⇒ DAO & G4agcm: Mid-trop Max OH

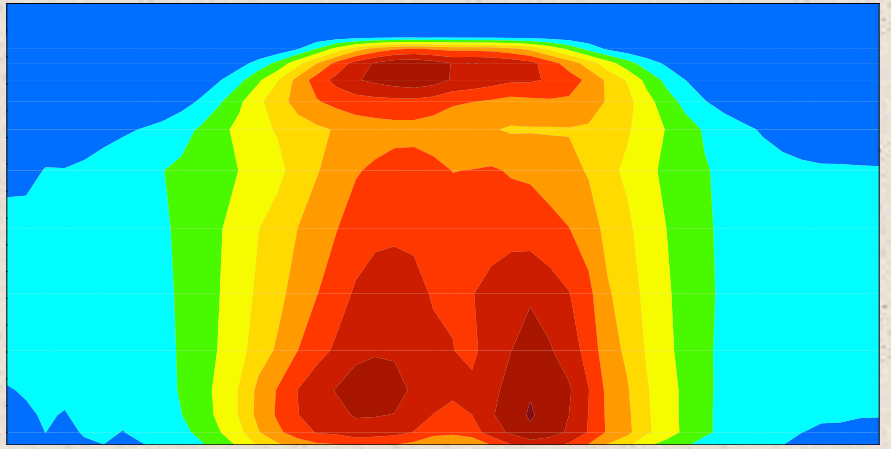
⇒ GISS: Low-trop Max OH : Horse Lats

G4agcm

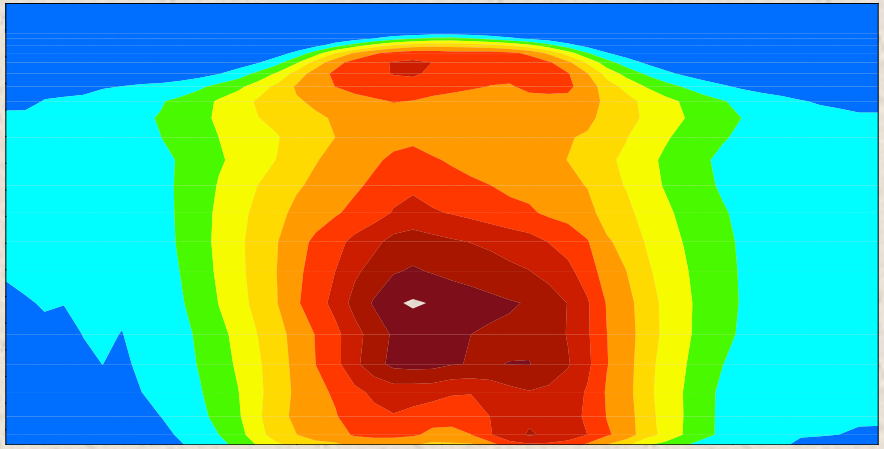


0 0.5 1.0 1.5 2.0

GISS



DAO



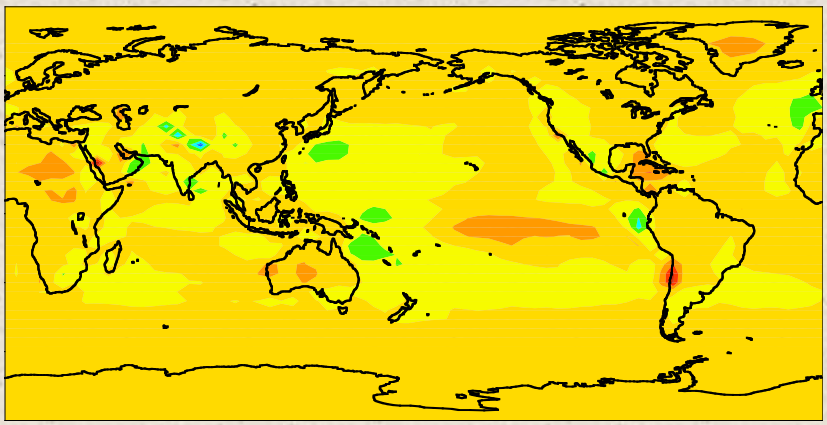
Annual Surface OH (molec/cm^3): Departure from Average

⇒ DAO: Higher over Land

⇒ G4agcm: Lower in Horse Lats over Ocean

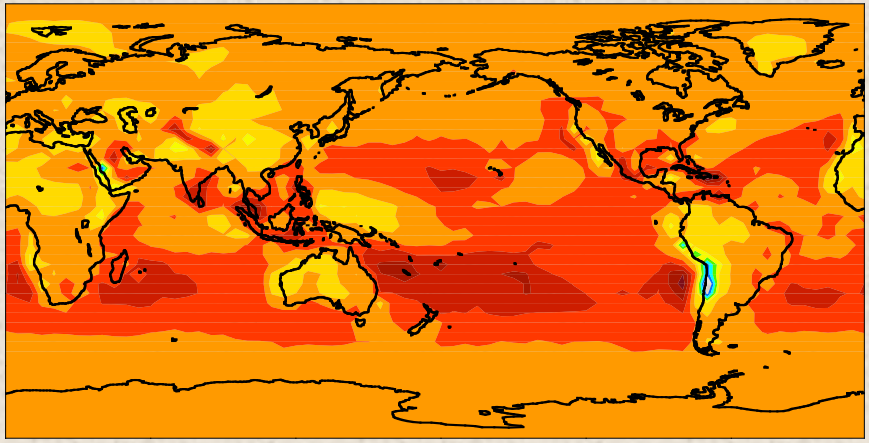
⇒ GISS: Higher in Horse Lats over Ocean

G4agcm

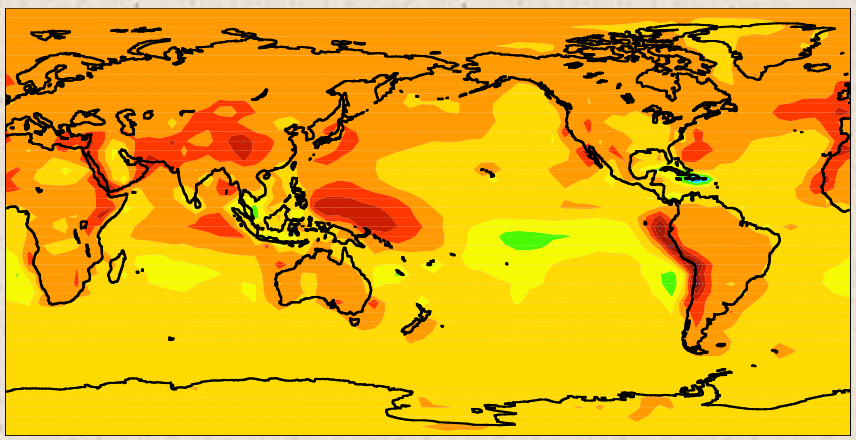


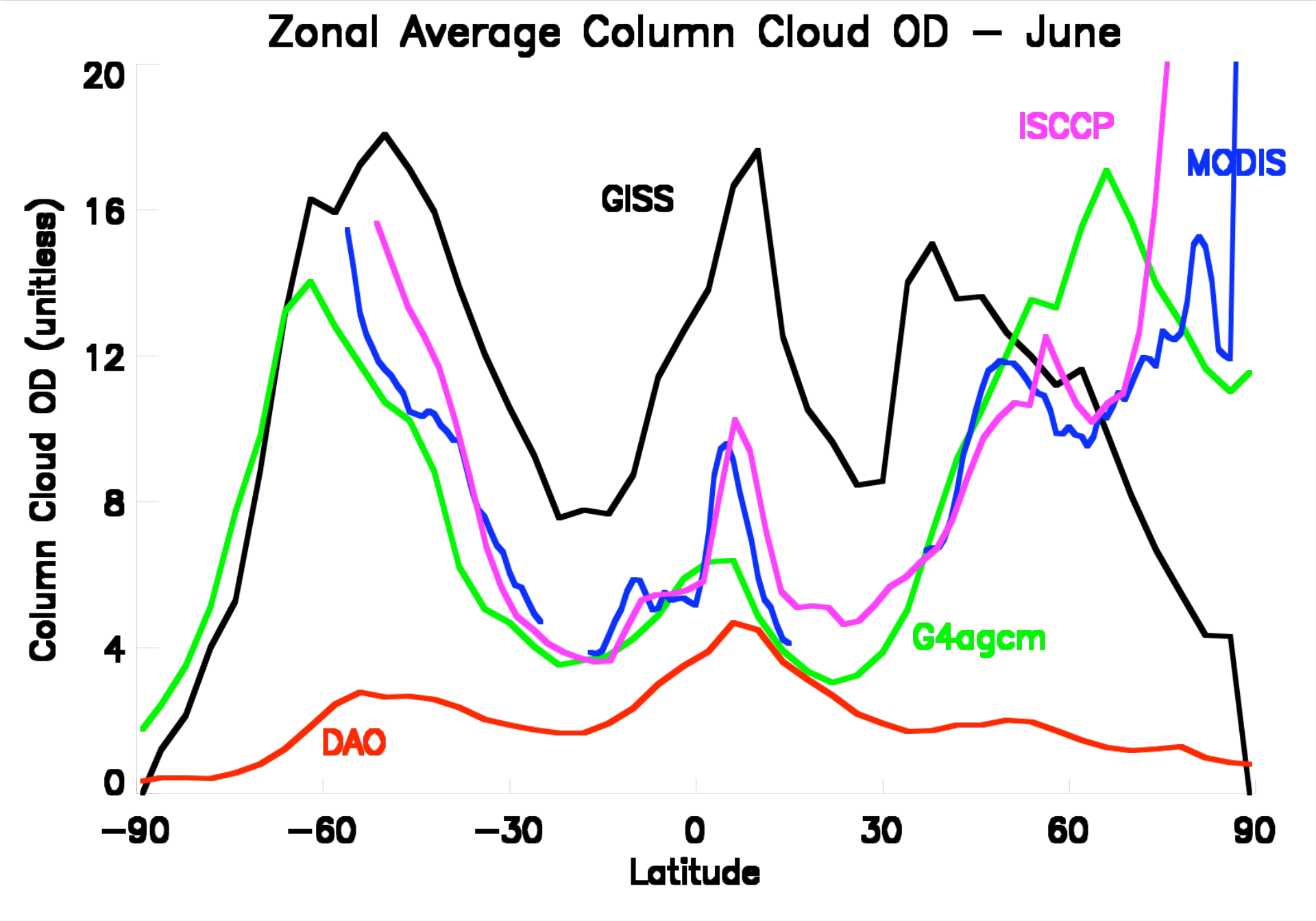
$-6x10^5$ 0 $6x10^5$

GISS



DAO

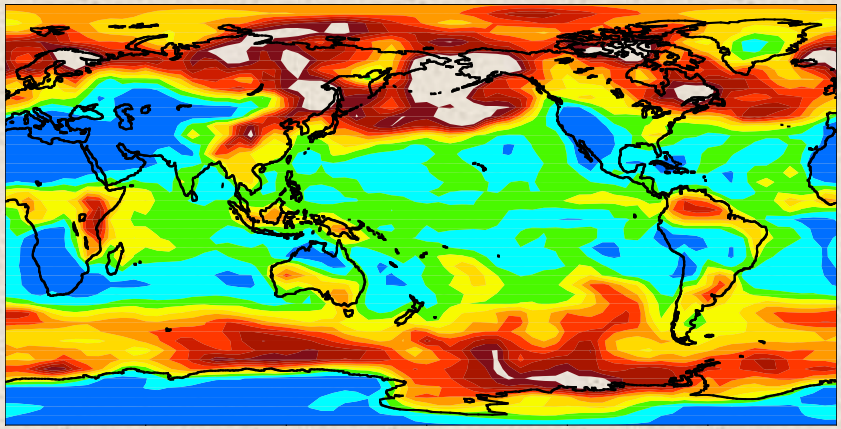



Zonal Average Column Cloud OD – June
Column Cloud OD (unitless)
20
16
12
8
4
0
−90
−60
−30
0
30
60
90
Latitude
GISS
ISCCP
MODIS
G4agcm
DAO

Column Cloud Optical Depth (unitless) In June

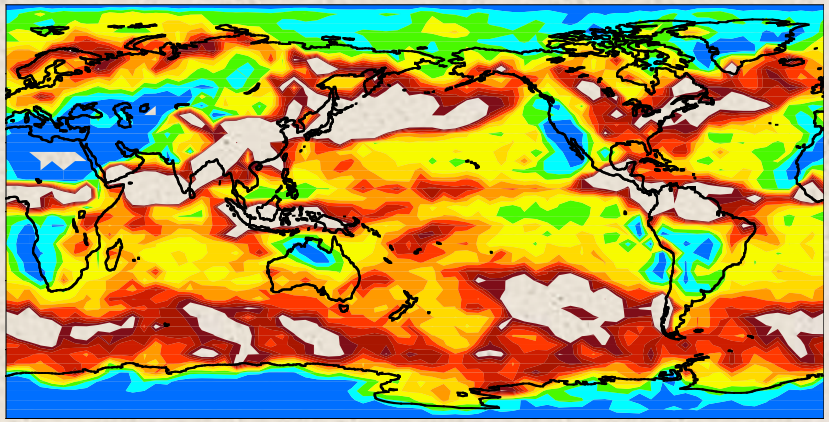
⇒ What can I say?

G4agcm

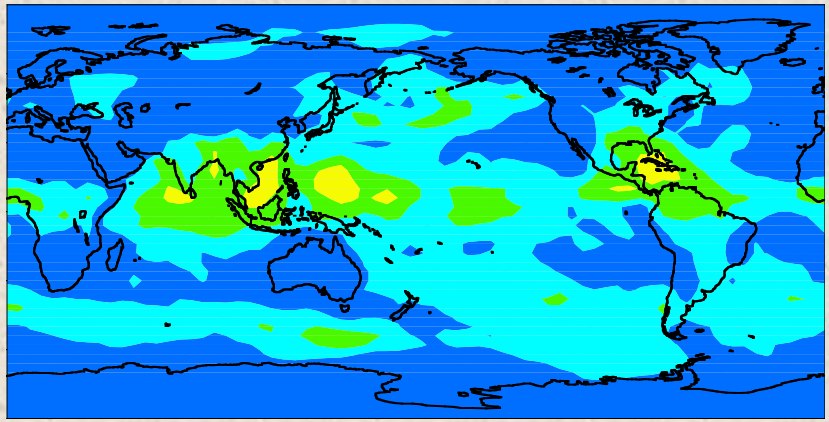


0 4 8 12 16 20

GISS



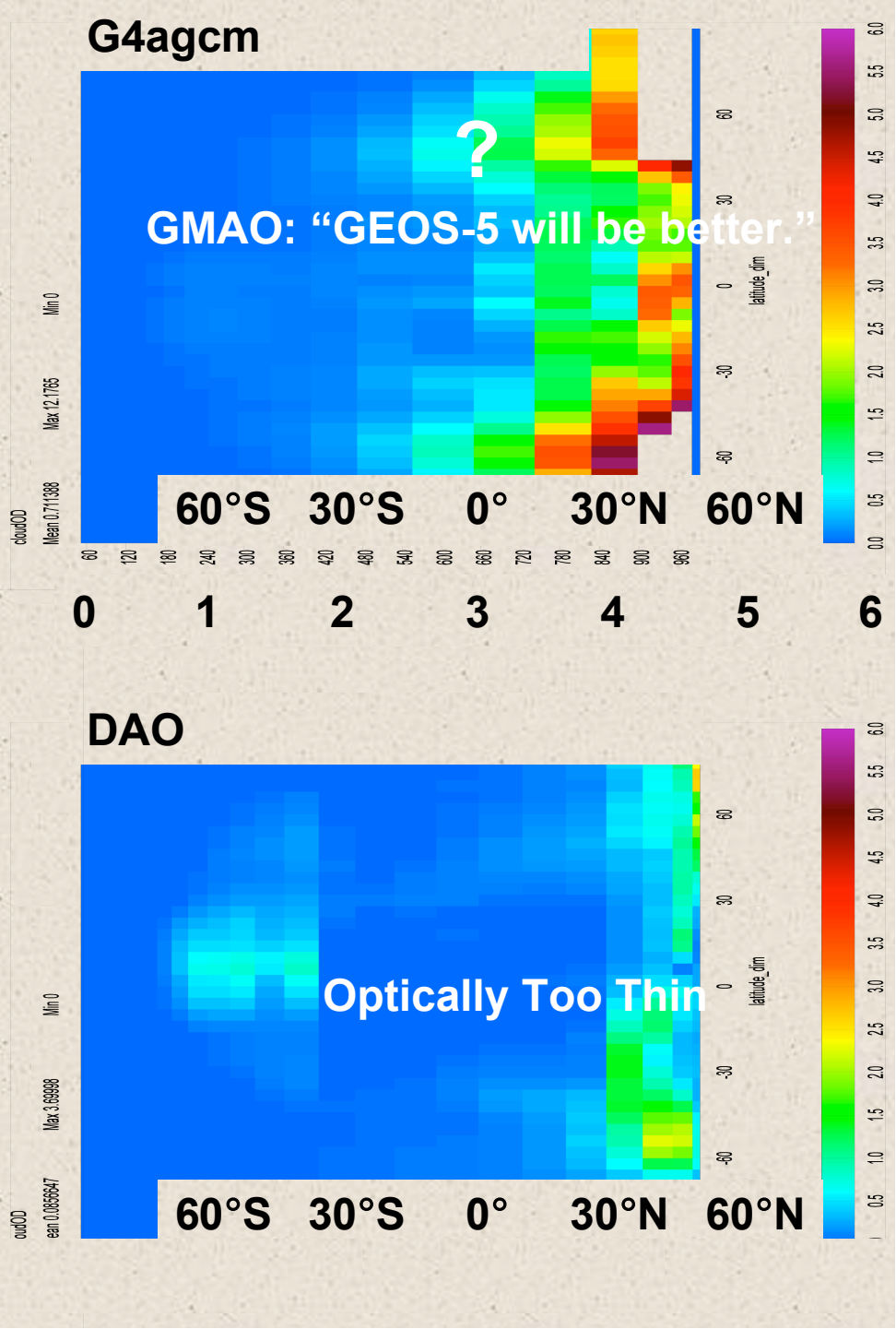
DAO



Cloud Optical Depth (OD/km) In June

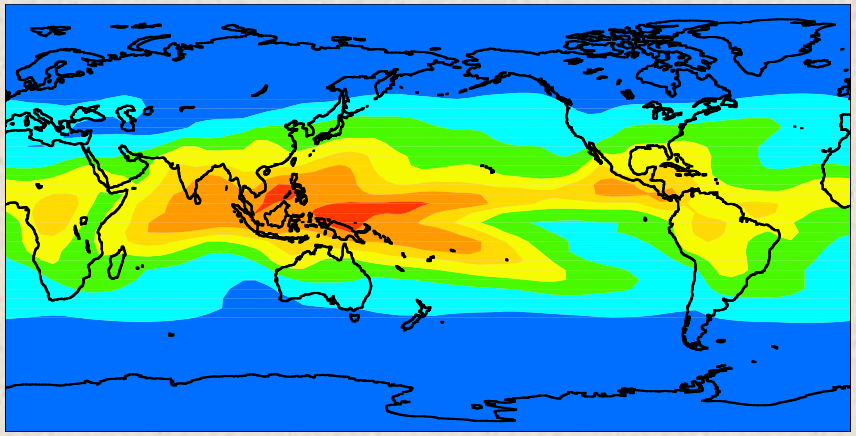
⇒ Can we salvage G4agcm with a cloud OD parameterization?

⇒ DAO is Mars, GISS is Venus?



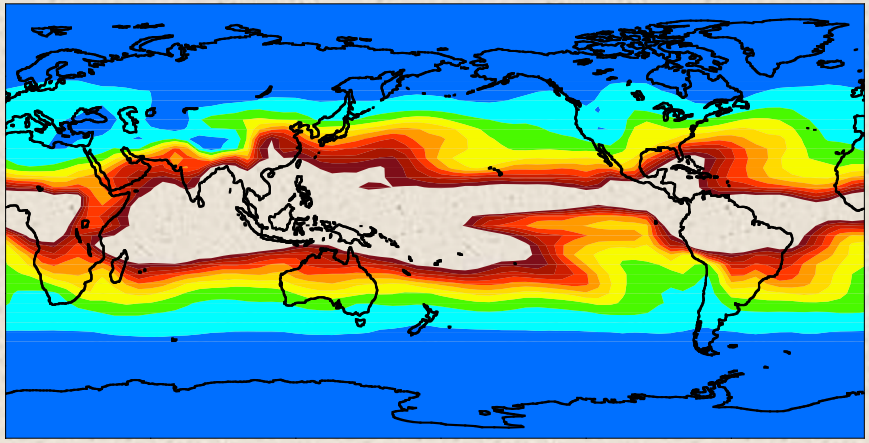
Annual Average (100-300 mb)
Metwater (ppmv)

G4agcm

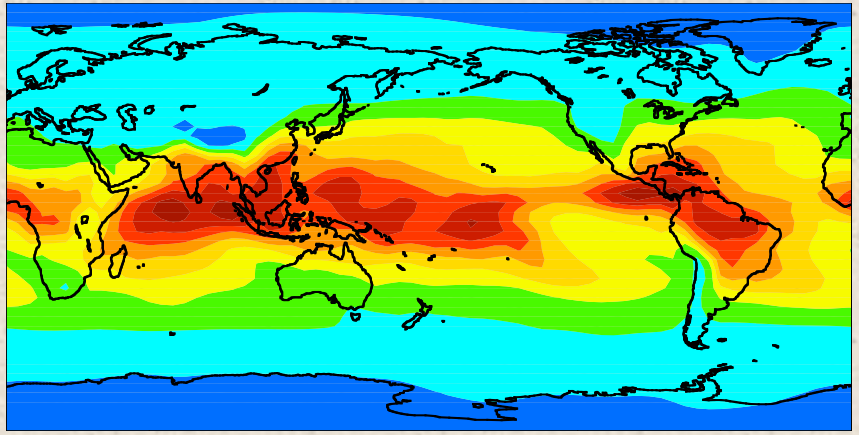


0 80 160 240 320 400

GISS

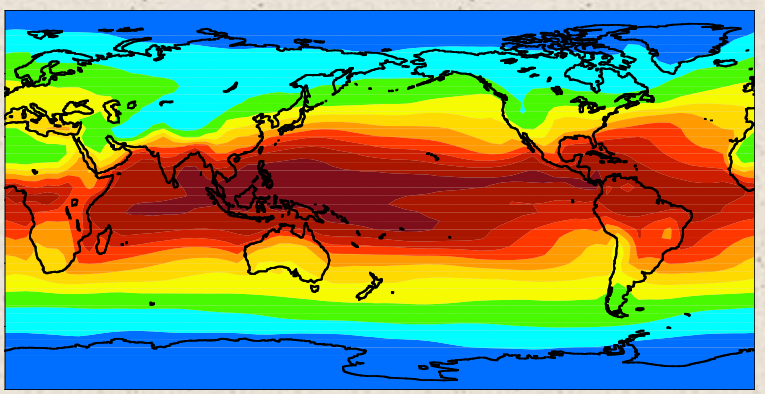


DAO



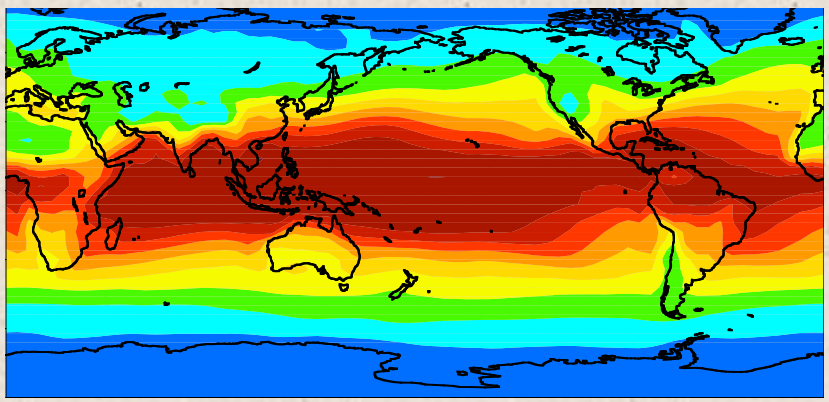
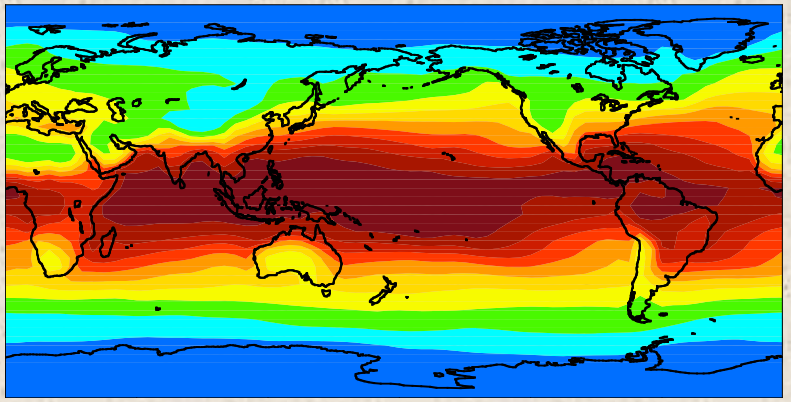
Annual Average (Surface) Metwater (ppmv)

G4agcm



0 9000 18000 27000

GISS



DAO