Evaluation of the GMI Tropospheric Simulations, Including FVGCM Results.

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with thanks to the GSFC core team and
Inna Megretskaia

GMI Science Team meeting, June 6-8, 2005.

Data used for model evaluation - review

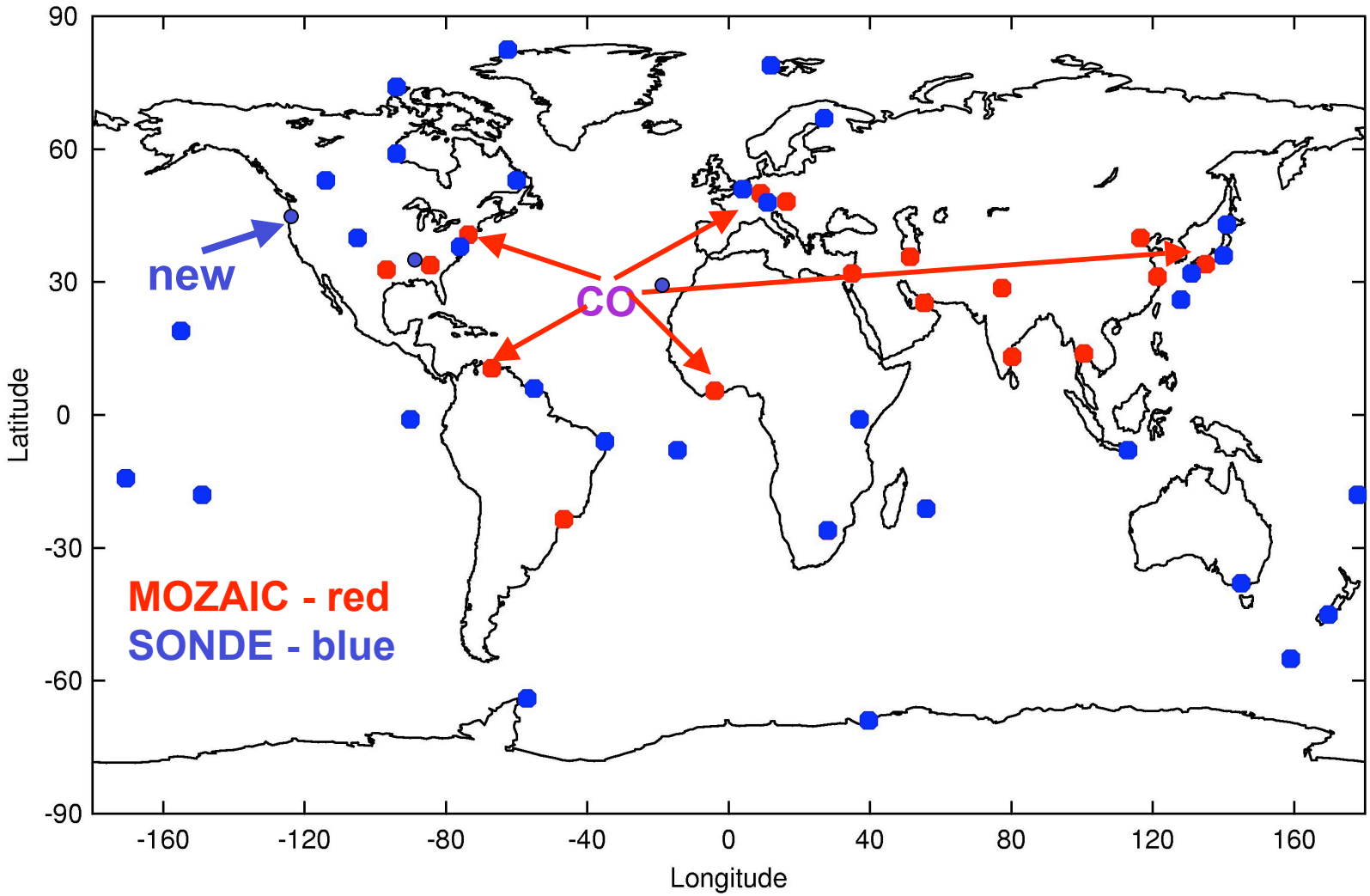
- Ozonesondes – 35 sites - 3 new sites
- MOZAIC ozone - 18 locations - some updates
- Surface CO from CMDL, 1992-1997
- MOZAIC CO profiles - 7 locations - updates
- Column CO data
- Aircraft data for CO, NO, HNO_3, PAN, H_2O_2, HCs, from field campaigns (e.g., NASA GTE)

MOZAIC data available up to April, 2004.

Basic evaluation uses "climatological" data, to examine general characteristics of model, and compare simulations with different met. fields

Locations of ozone profiles used for model evaluation

MOZAIC provides data for 20º-40ºN, in the U.S., the Middle East, south and east Asia. Also Africa, S. America.



How to best evaluate model performance, given the large number of model-data comparisons - 50 sites for ozone?

Apply objective criteria

These are used here to

- Evaluate different sets of dynamics (GMI)

Other applications

- Quantify improvement in model performance (GMI, GEOS-CHEM)

For ozone and CO, we examined:

- Mean bias
- Absolute bias
- Amplitude of the seasonal cycle
- The phase of the seasonal cycle

Recent Progress

- Comparison of V2 vs. V1 for DAO and GISS results, with observations.
- Very small changes found, even with changes in convection for GISS.

Presented here:

- Evaluation of V2 full chemistry runs (May, 2005), including FVGCM for the first time
- Focus on ozone and CO here
- Very preliminary analysis of tracer runs

Tracer runs and diagnostics

- CO - fossil fuel/industry, 60 day lifetime
- CO - biomass burning, 60 day lifetime
- CO_2 - fossil fuel

- CH_3I - marine source, 5 day lifetime
- Marine tracer - uniform source, 5 day lifetime ★

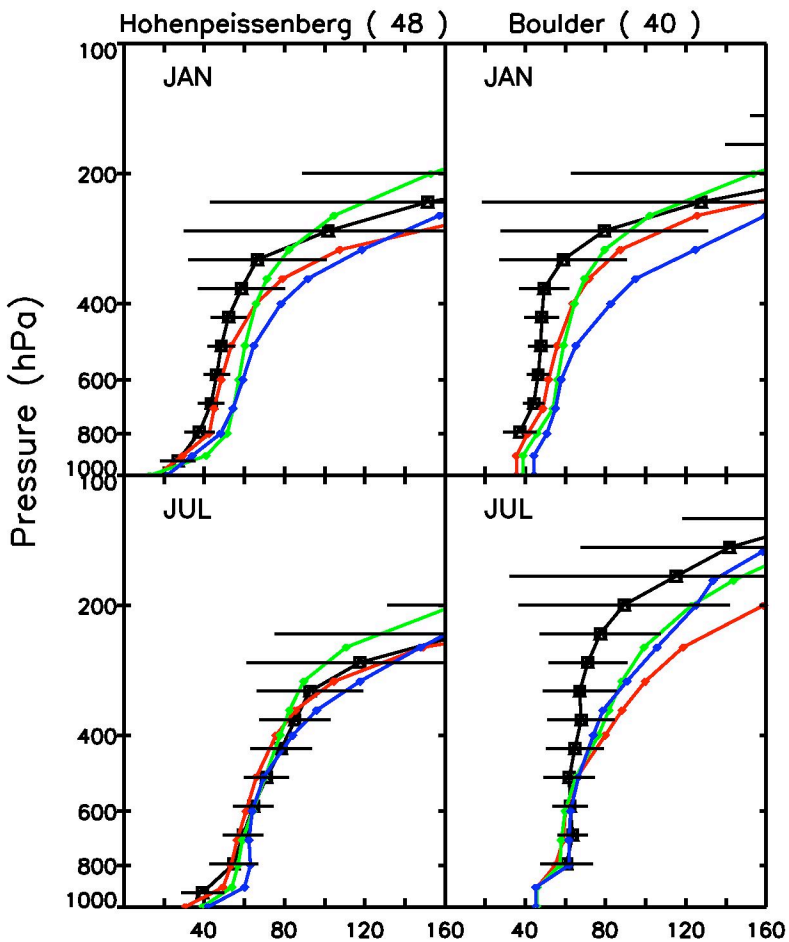
- Rn

Diagnostics include monthly vertical fluxes, and monthly cumulative tendencies for:

- Emissions, convection, advection, diffusion, dry deposition, wet deposition, chemistry
- No term for accumulation of tracer (can be calc. from restart files), or for loss (simple tracer runs).

FVGCM
DAO
GISS

Ozone at mid-latitudes, Jan., July



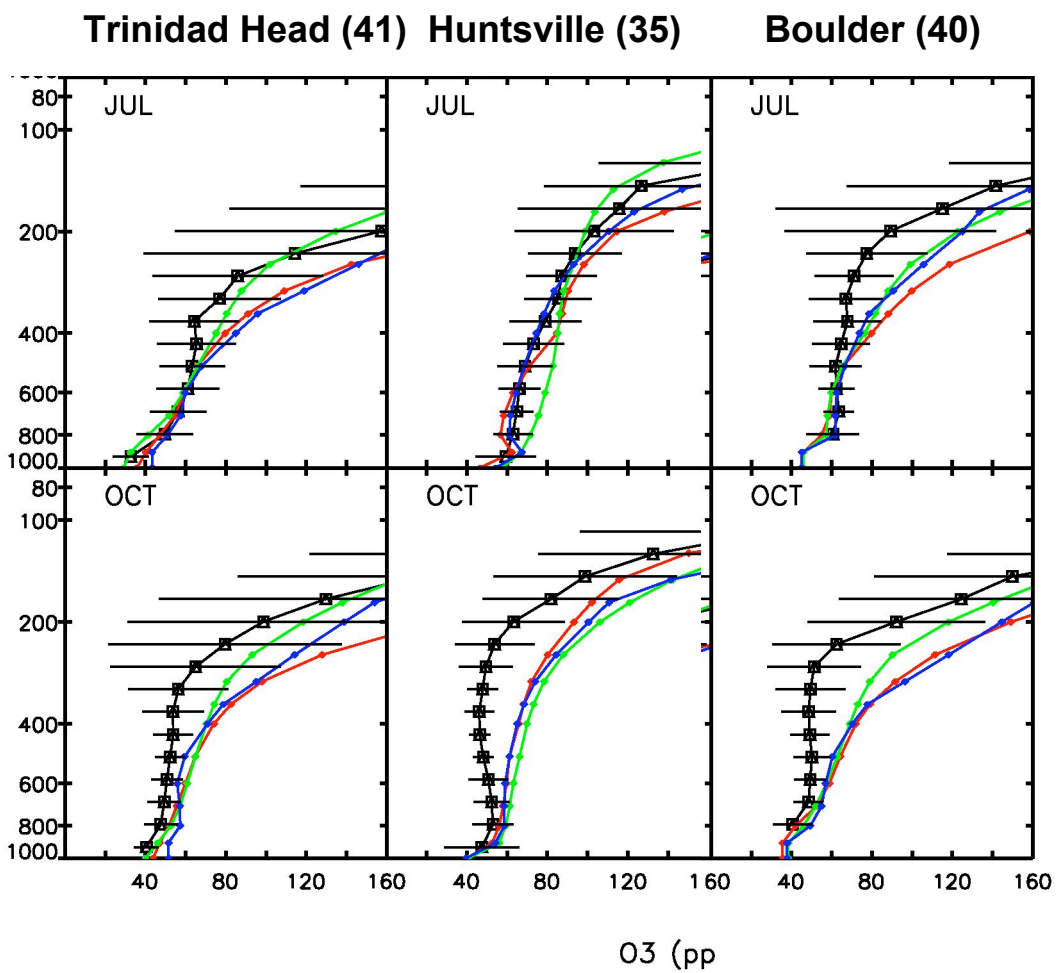
GISS to high in winter
DAO also a bit high in winter

??

Vertical gradient OK most mid-lat. locations.

FVGCM
DAO
GISS

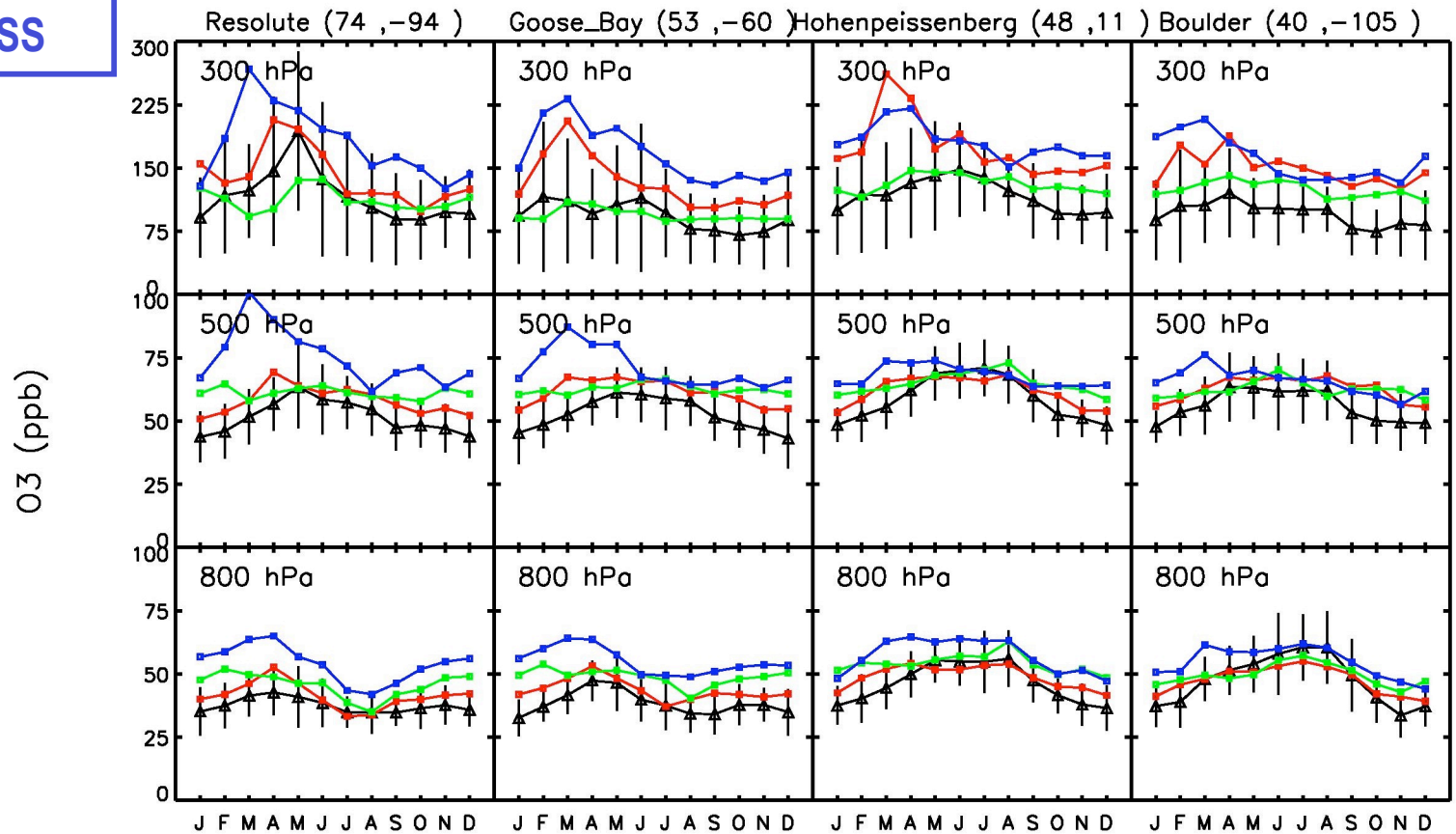
Vertical profiles over the U.S.



Models do not capture uniform profiles in autumn over the southern U.S. - issue with vertical mixing?

Ozone at mid-high latitudes

FVGCM
DAO
GISS

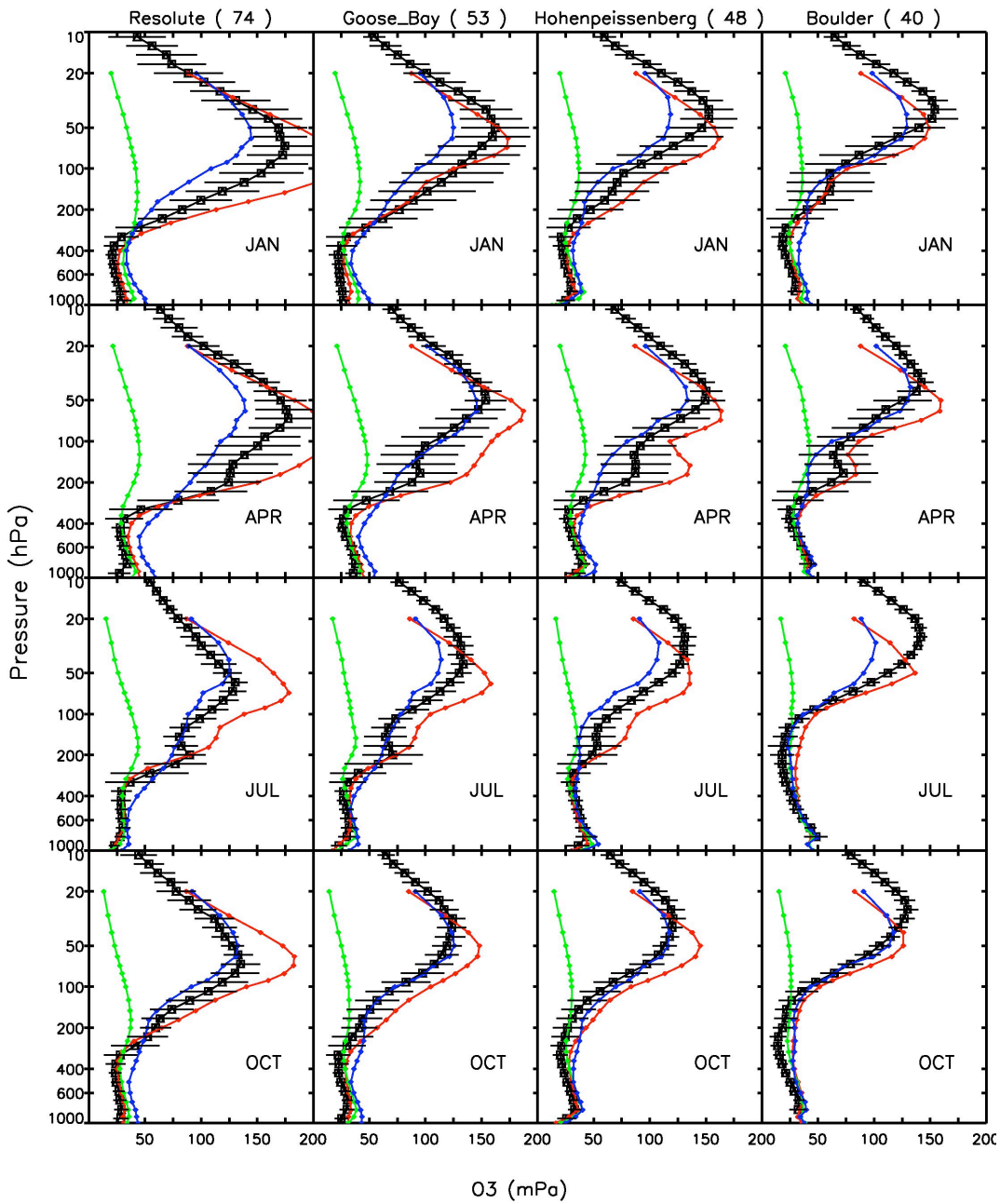


GISS: too much ozone from the strat. at high latitudes, affecting ozone at 500 hPa as well as 300 hPa.

FVGCM: too much ozone at 300 hPa at mid-latitudes, but 500 hPa is reasonable

DAO: damped seasonal cycle at 500 hPa.

SYNOZ in the lower stratosphere



FVGCM
DAO
GISS

Residual circulation is much too strong in GEOS-STRAT (DAO), so SYNOZ tracer is much too low is LS.

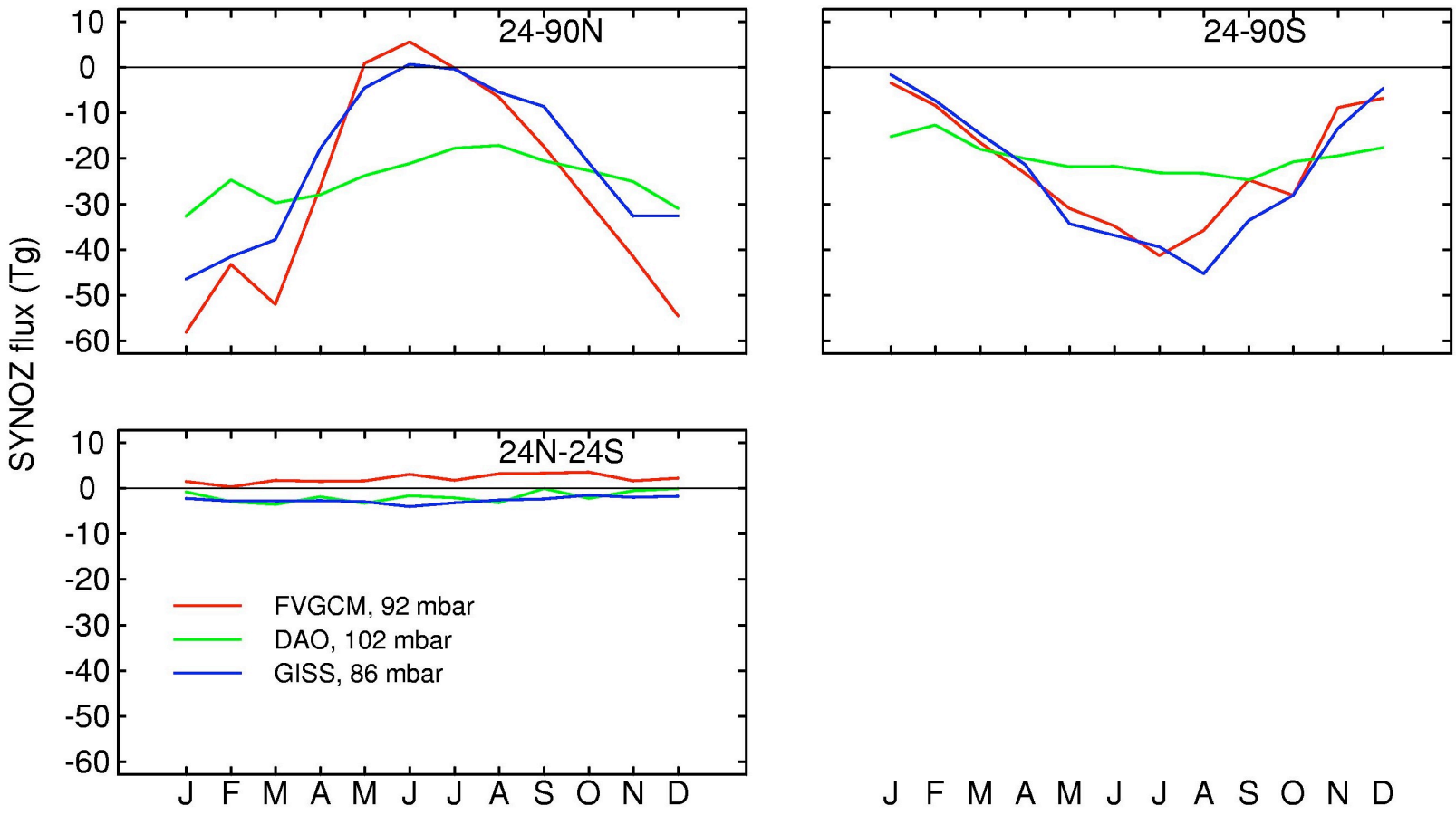
Air mass flux too high by a factor of 3-4 - old news.

FVGCM has the most realistic gradients in the UTLS - new to trop. community maybe but not to strat. community.

FVGCM
DAO
GISS

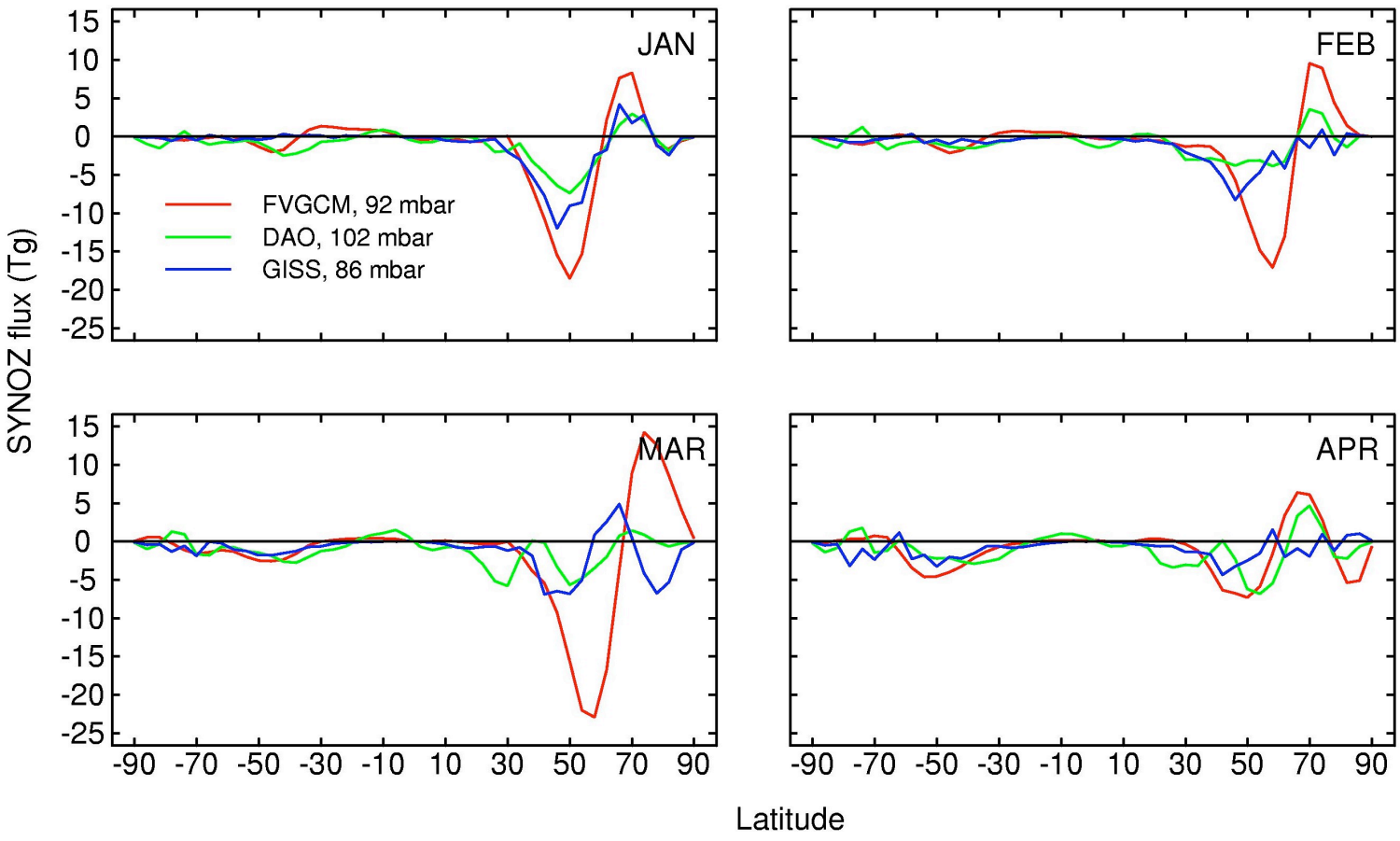
SYNOZ vertical FLUX near 100 hPa vs. month

Amplitude of the seasonal cycle for DAO is much less than for FVGCM and GISS.
This contributes to problem of damped seasonal cycle at 500 hPa in DAO run.



SYNOZ vertical FLUX near 100 hPa

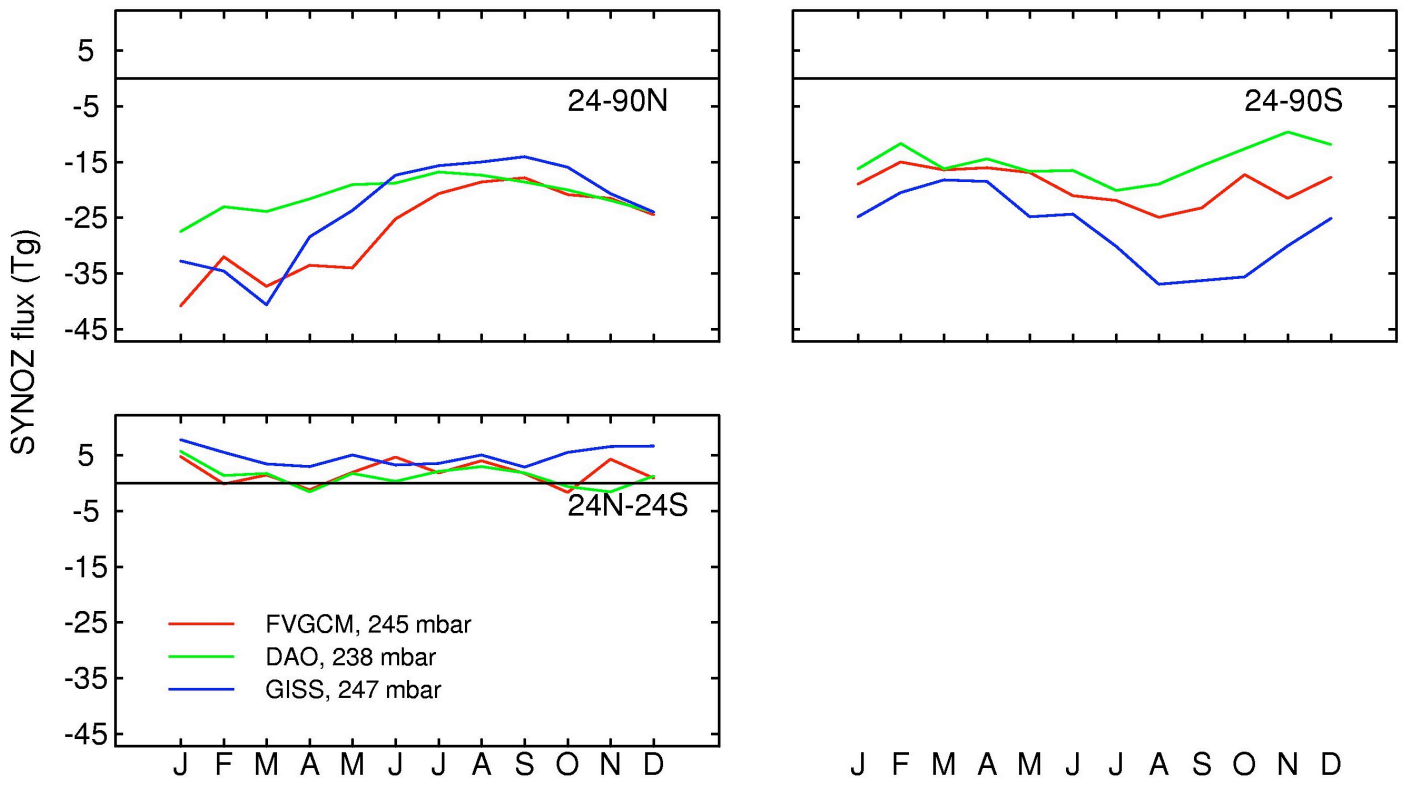
FVGCM
DAO
GISS



Downward flux largest in NH winter/spring near 50°N in FVGCM

SYNOZ vertical flux near 250 hPa

FVGCM
DAO
GISS

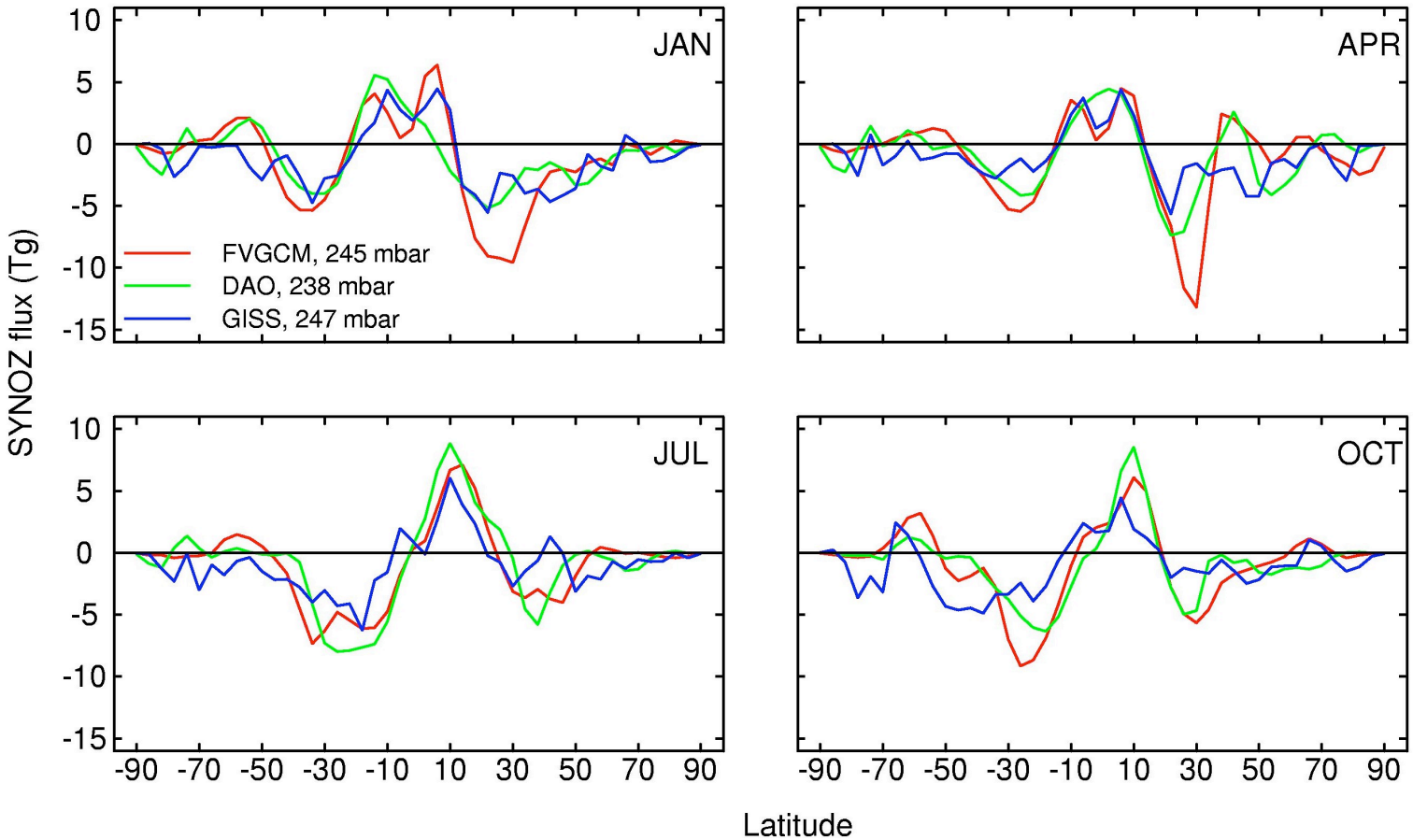


GISS has highest flux in Jan-Mar,
FVGCM flux stays high Jan-May in NH.

FVGCM
DAO
GISS

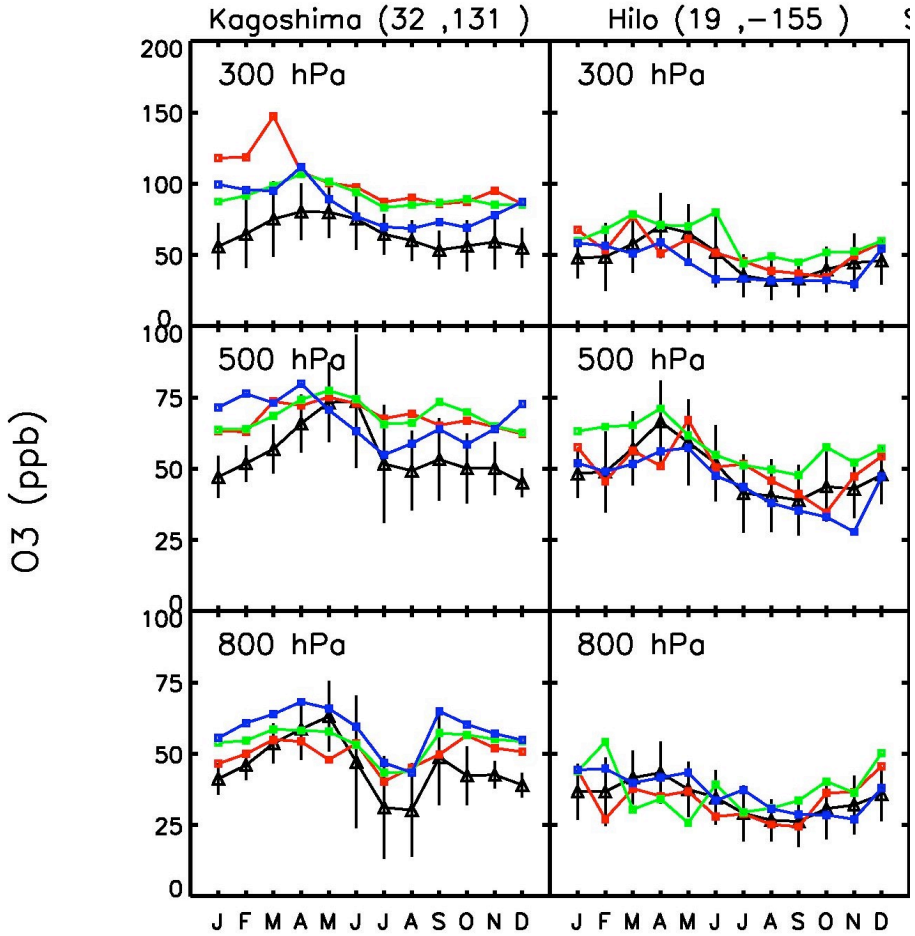
SYNOZ vertical FLUX near 250 hPa

Note largest downward flux in sub-tropics - largest in FVGCM in NH.



Ozone in the sub-tropics: SE Asia to Hilo

FVGCM
DAO
GISS



1. FVGCM has too much ozone over Japan in Jan-Mar. - from strat. (see Kagoshima, 30 N)

2. Observations show a steep drop from June to July at all sonde and MOZAIC sites in E. Asia.

None of the models do this very well.

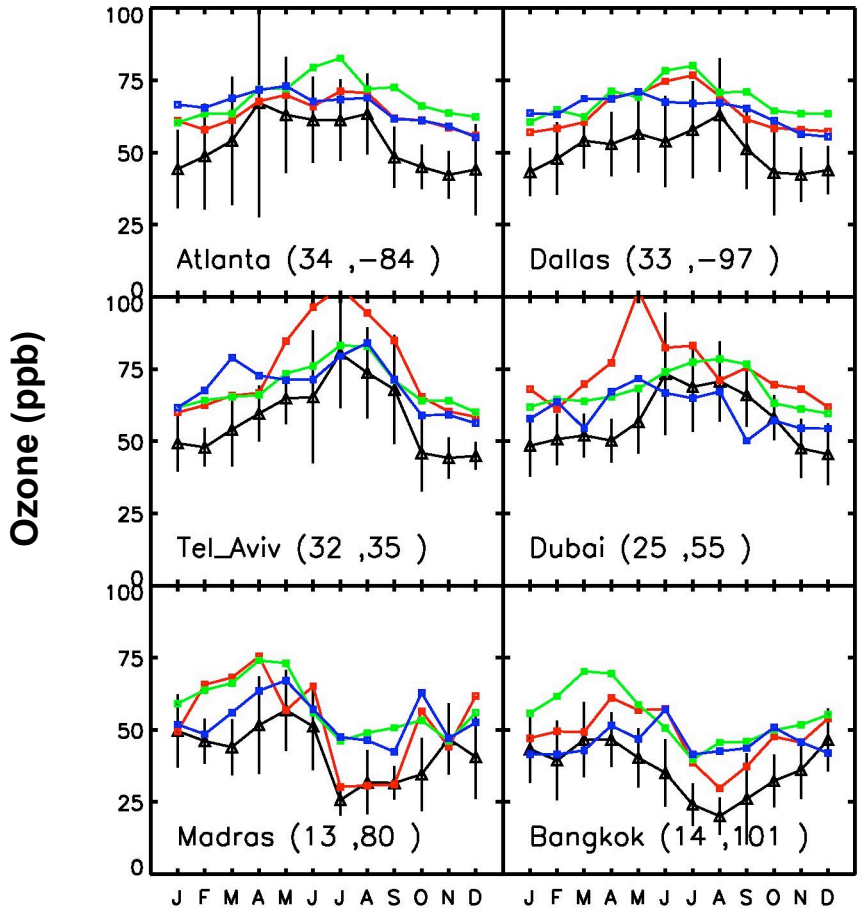
FVGCM looks good at Hilo (unlike CCM3).

FVGCM
DAO
GISS

Ozone in the sub-tropical US and Middle East, and S. Asia

Ozone at 500 hPa

MOZAIC data



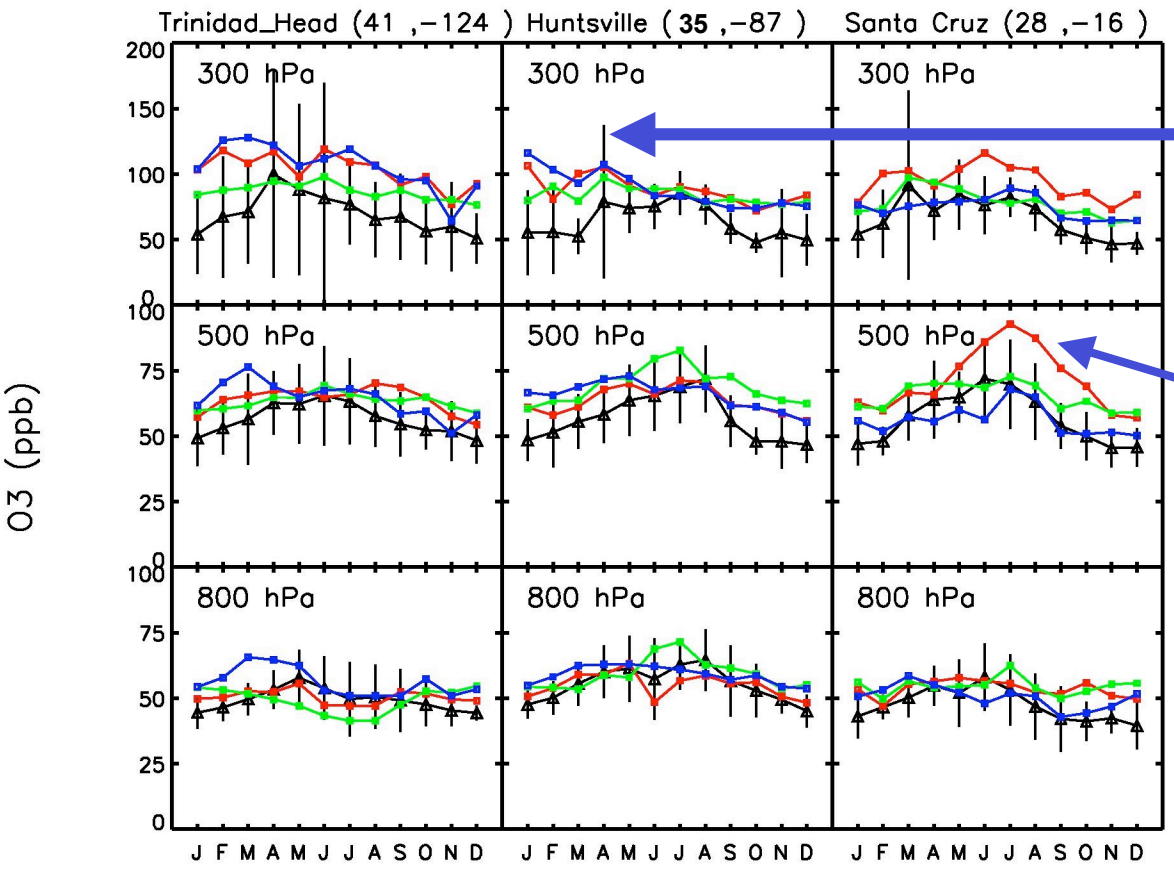
All too high in summer over southern US

FVGCM much too high for Middle East summer maximum.

FVGCM best in S. Asia during the monsoon, but too high in N. spring (along with DAO)

Note: problem with Middle East ozone not seen using GEOS-4 data GEOS-CHEM.

New sonde stations - the U.S. and Canary Islands

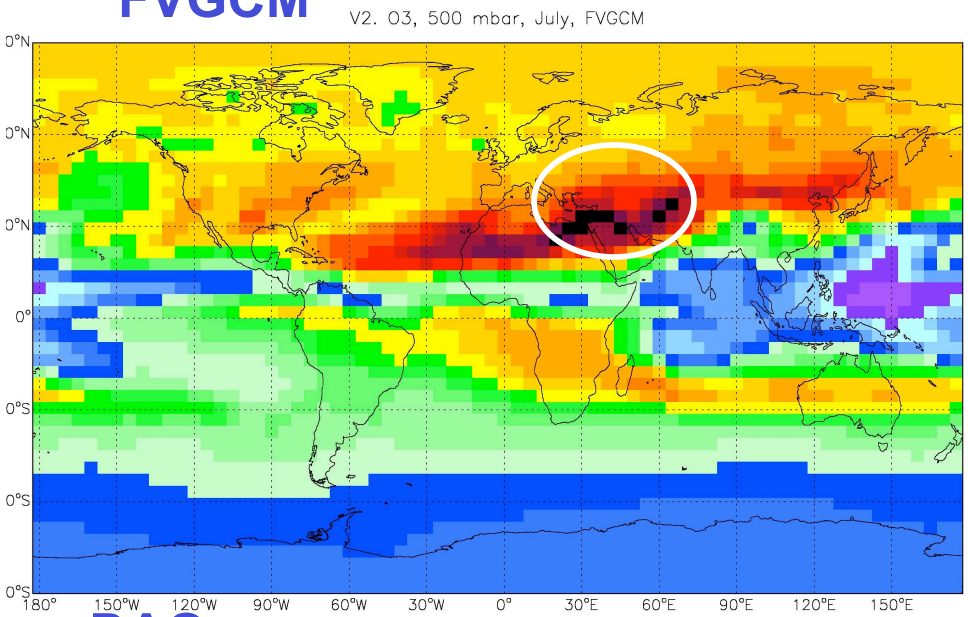


Note that 300 hPa is not yet completely "tropospheric" in simulations at 300 hPa at 35 N.

Excessive summer max. in FVGCM extends to E. Atlantic.

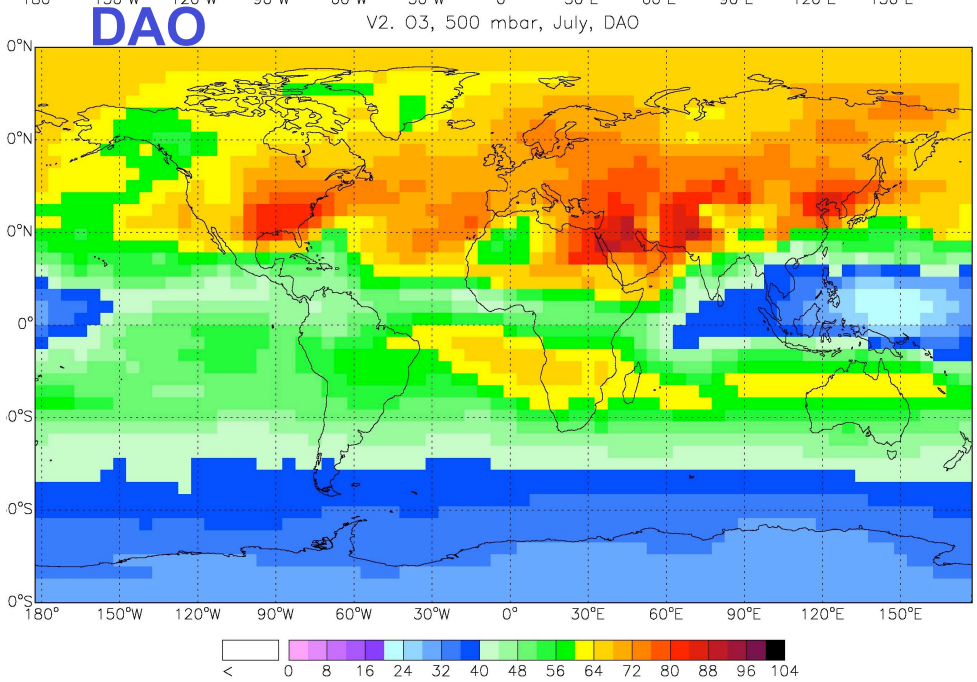
Ozone at 500 hPa in July

FVGCM

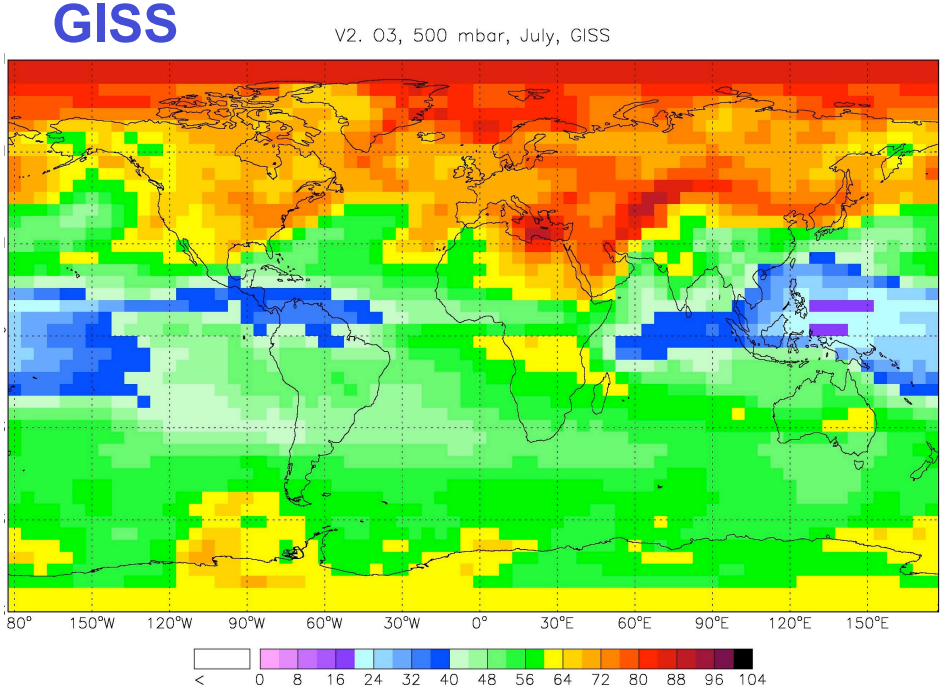


Note extended region of enhanced ozone in the sub-tropics in FVGCM - not just in the Middle East

DAO



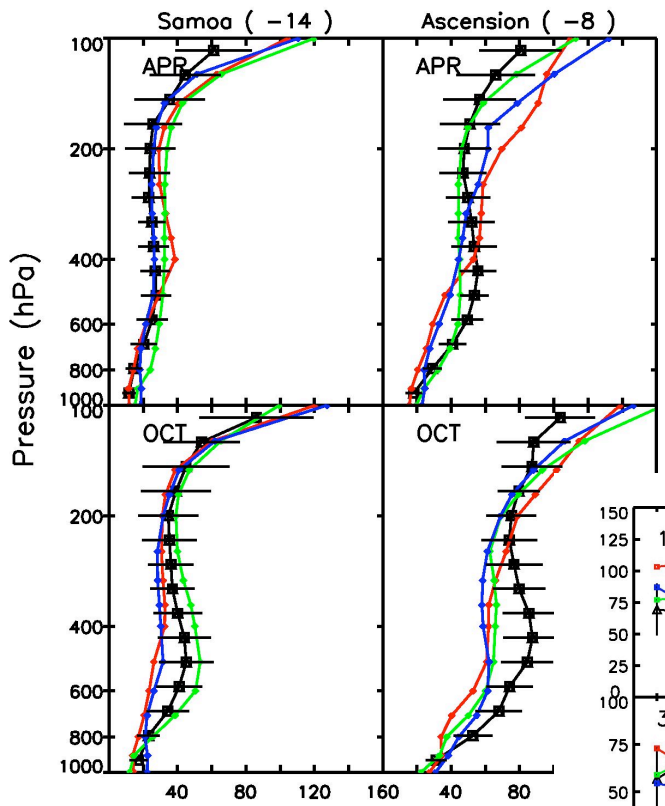
GISS



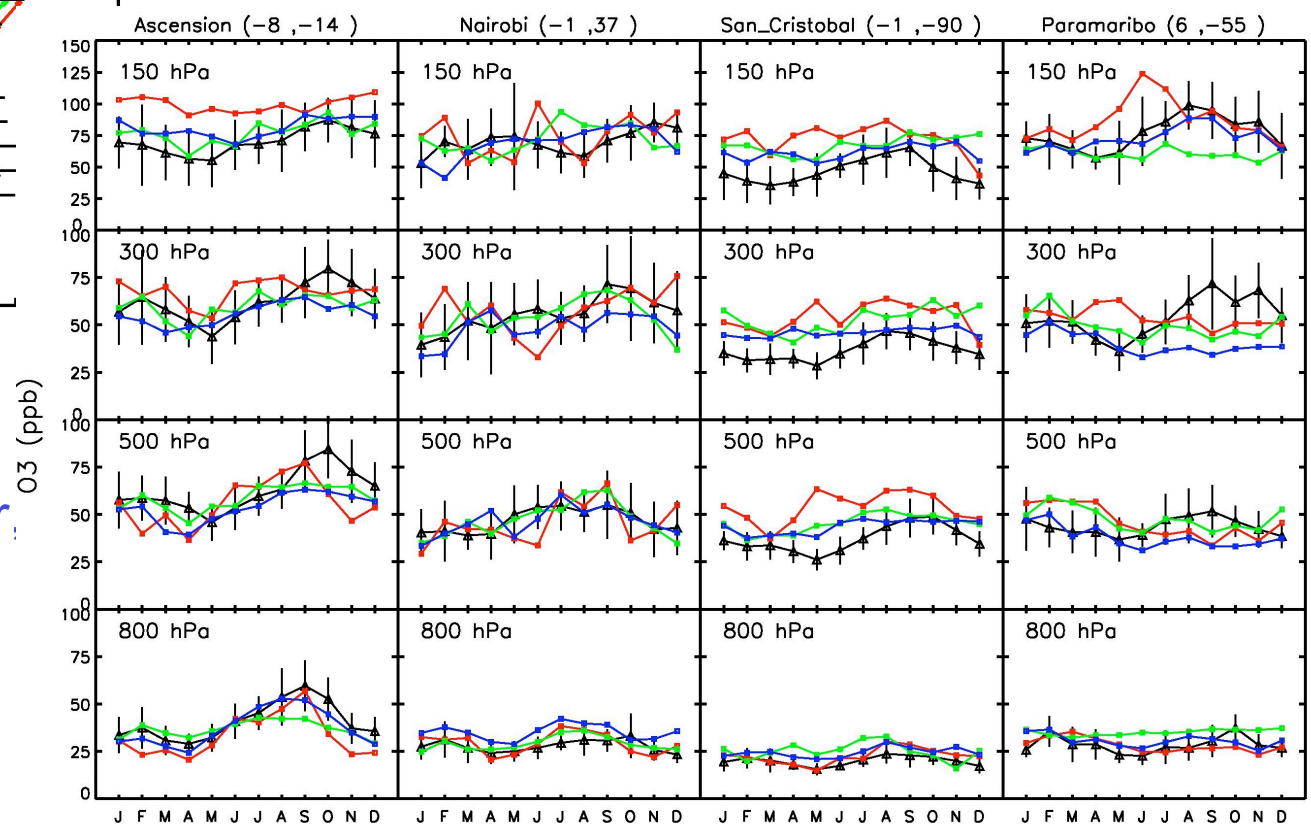
Ozone in the Tropics

FVGCM
DAO
GISS

FVGCM: ozone too high at 150 hPa compared to observations and DAO, GISS, except for sites in the W. Pacific, and Nairobi. Not a problem for GEOS-4 in GEOS-CHEM



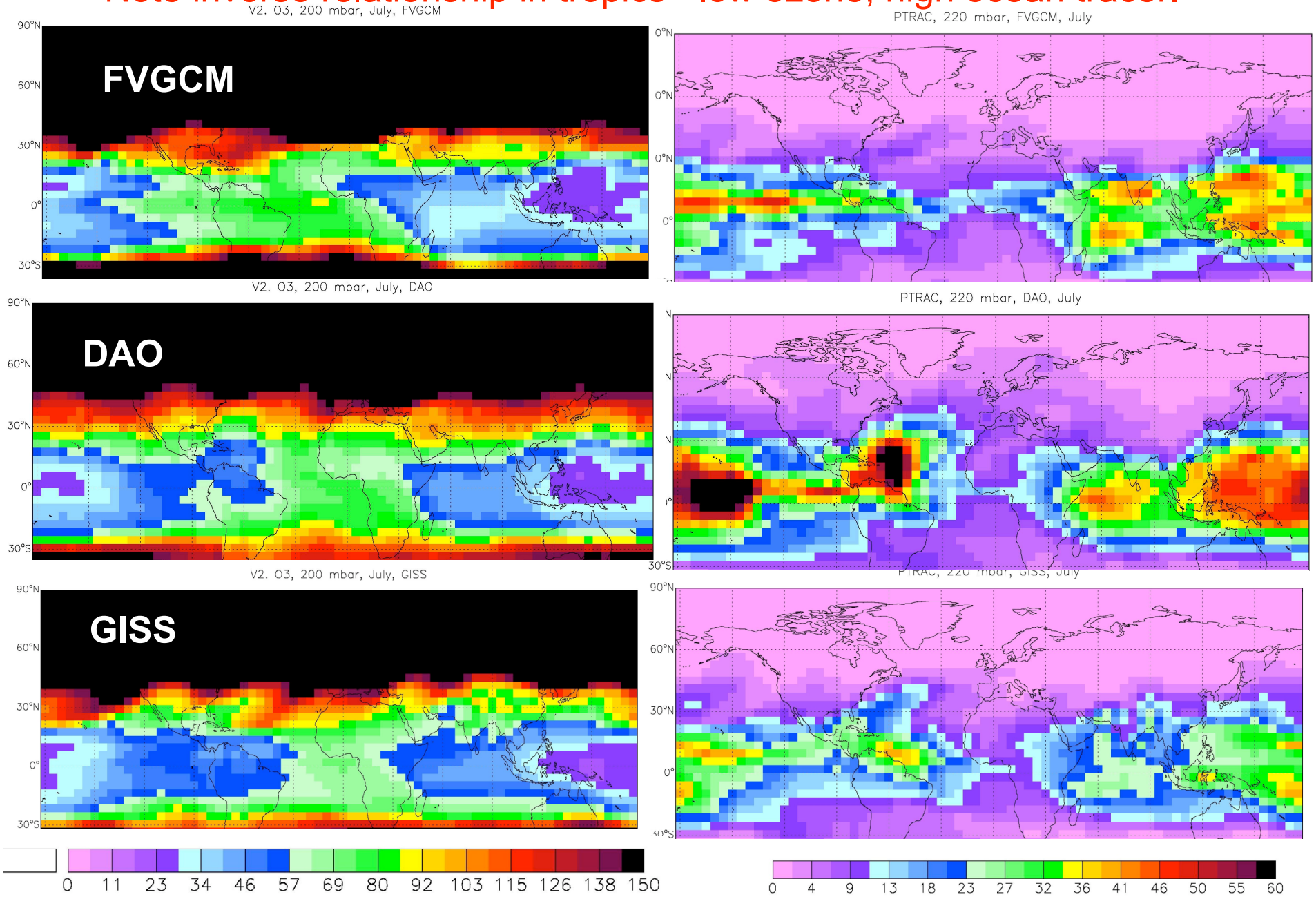
Convective heights reached over the oceans seem similar, based on ozone profiles.



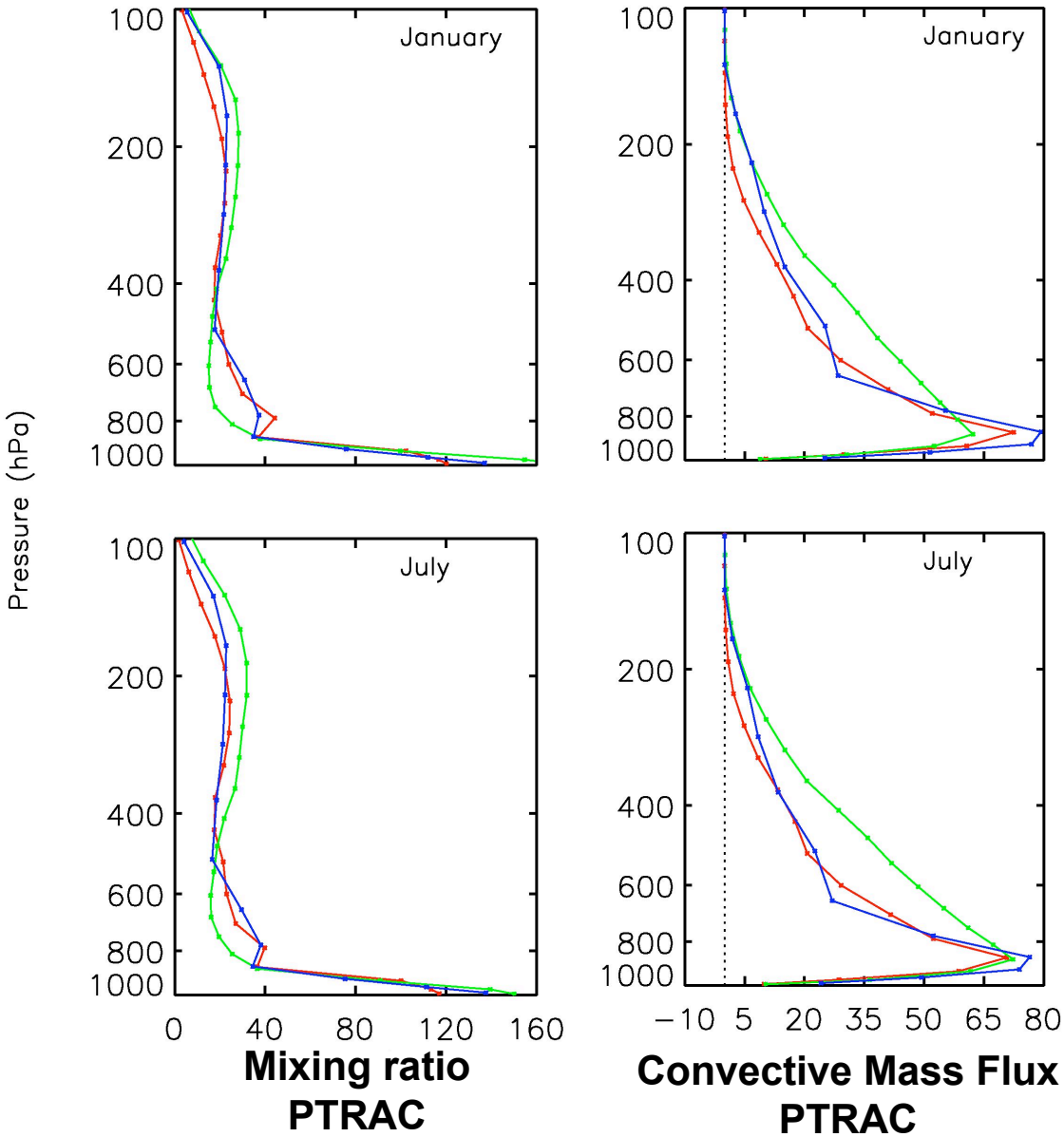
Ozone at 200 hPa

Oceanic tracer at 200 hPa

Note inverse relationship in tropics - low ozone, high ocean tracer.



Ocean tracer, 5 day lifetime - mean profiles for 16 N - 16 S

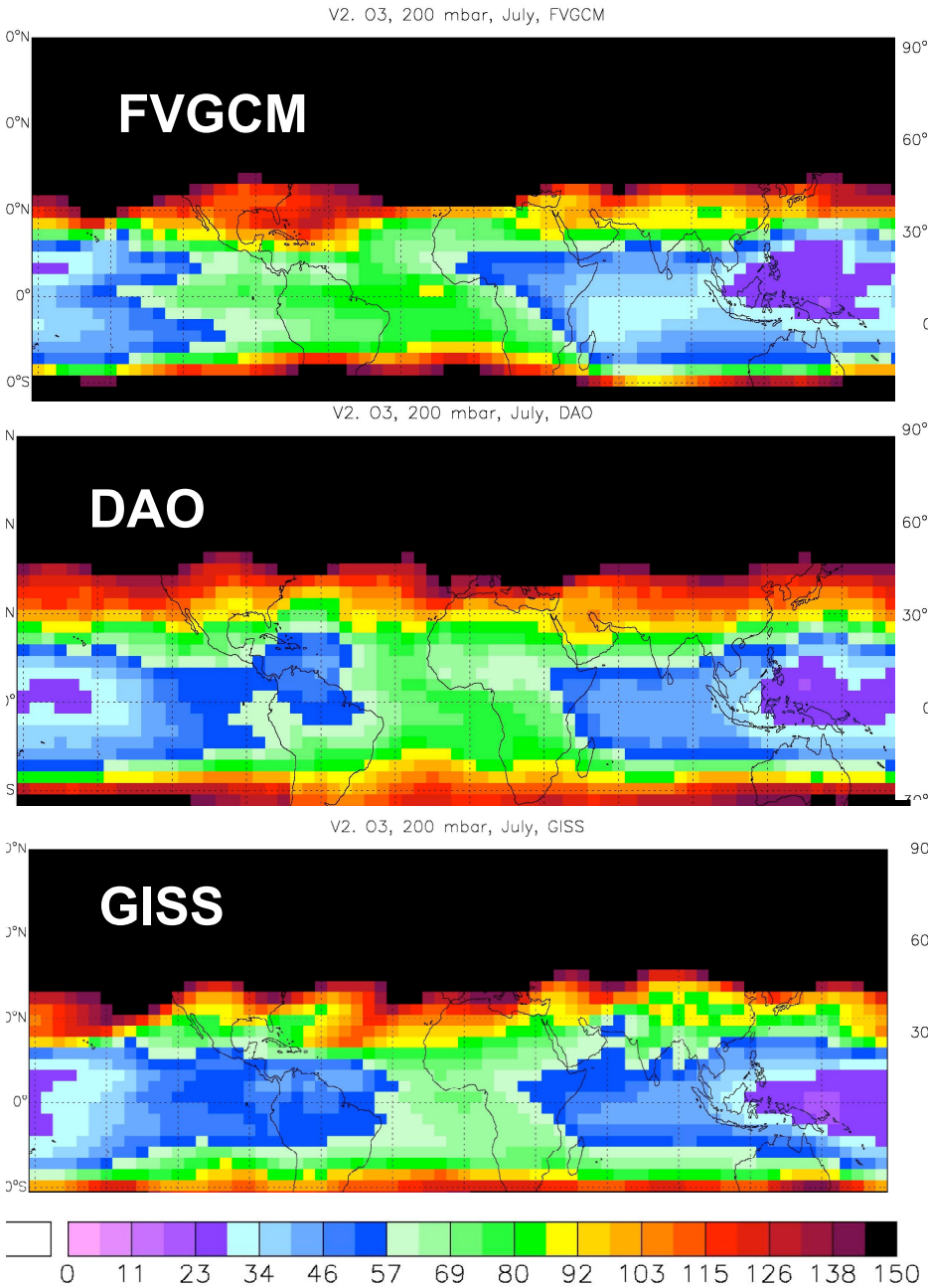


DAO has most tracer in the UT, FVGCM has the least

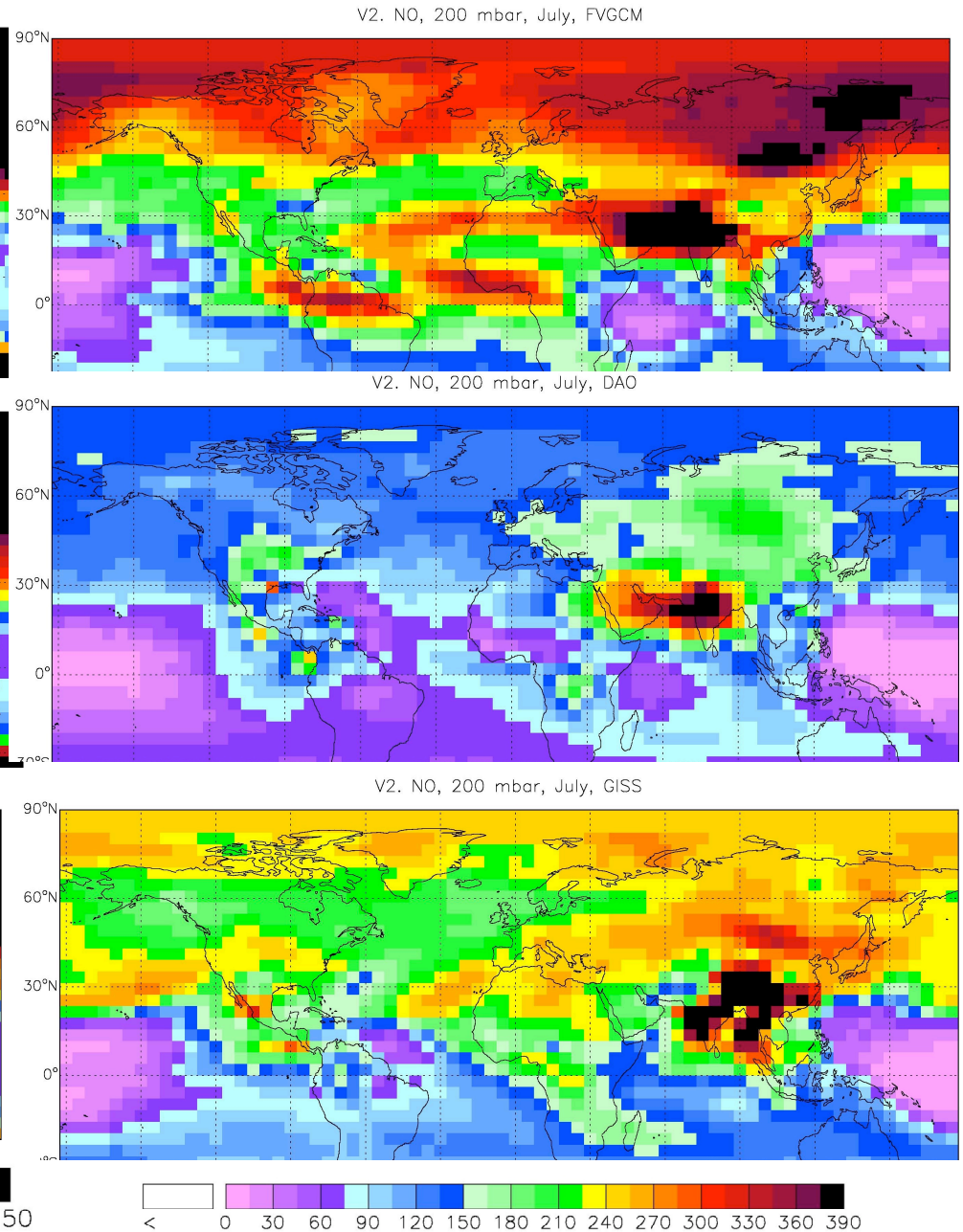
UT maximum mixing ratio is at a higher altitude for DAO than for FVGCM

Convective mass flux of PTRAC is similar to results for cloud mass flux, the latter showed a much higher flux at low altitudes for FVGCM compared to DAO, GISS.

Ozone at 200 hPa in July

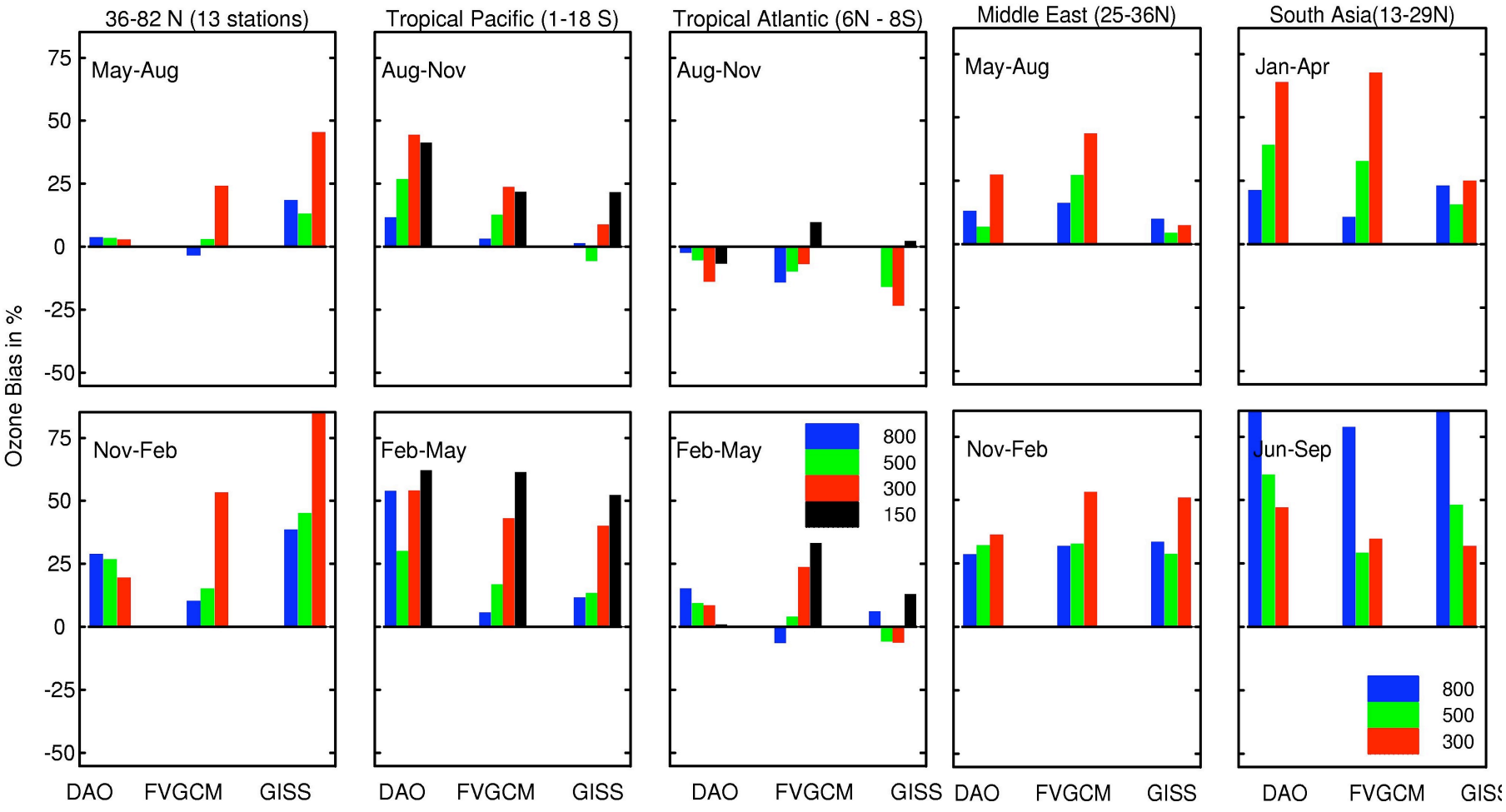


NO at 200 hPa

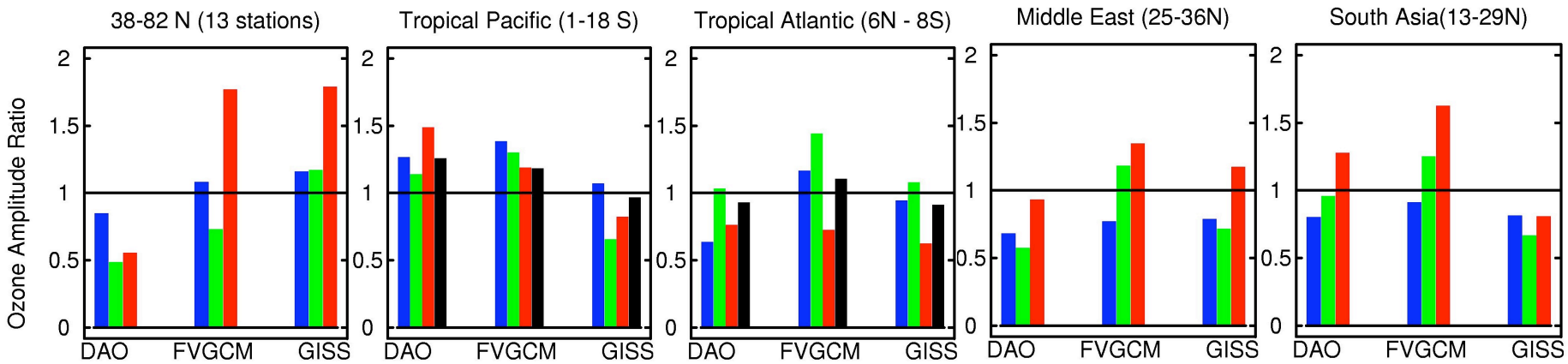


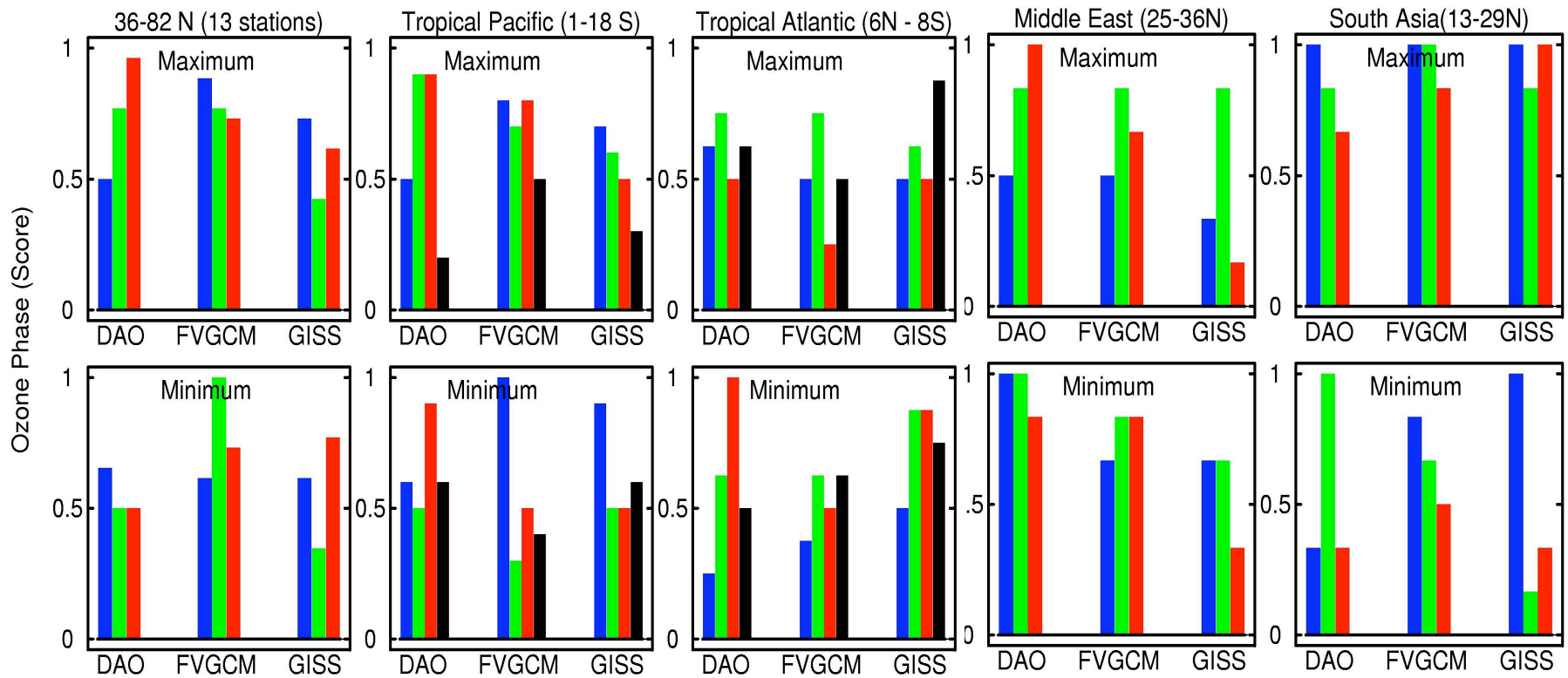
Ozone Bias by region

Note: biases are almost always positive except in tropical Atlantic



Amplitude





Phase

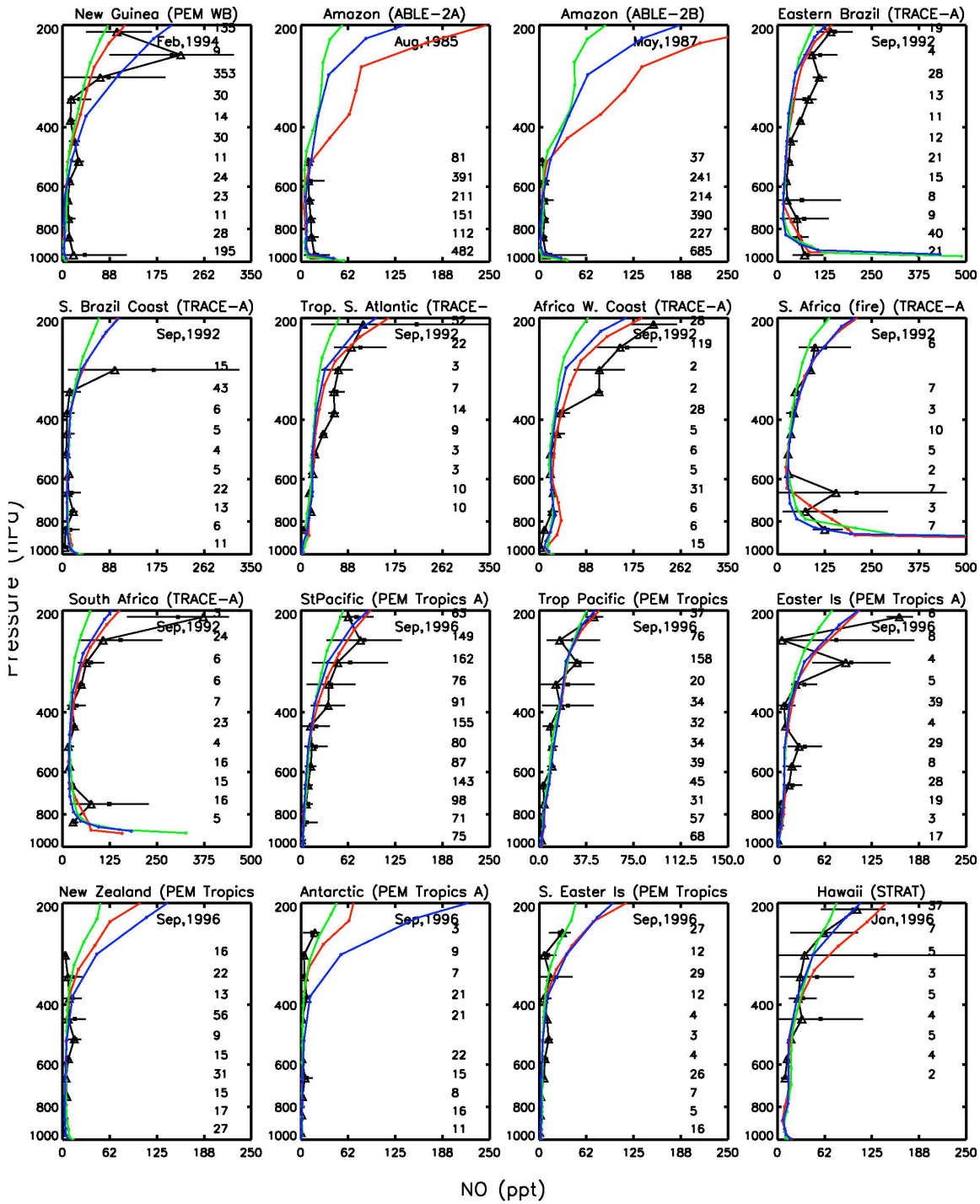
Ozone Scores

Table 1. Scores for ozone evaluation

	DAO	FVGCM	GISS	DAO	FVGCM	GISS
	Ozonesonde Locations			MOZAIC Locations		
	High N. Lat., 800, 500 hPa			N. Mid. Lat, 800, 500 hPa		
Bias Score	0.85	0.91	0.52	0.79	0.85	0.74
Total Score	0.51	0.77	0.49	0.74	0.80	0.65
	Mid N. Lat., 800, 500 hPa			Middle East, 800, 500, 300 hPa		
Bias Score	0.82	0.87	0.69	0.71	0.61	0.72
Total Score	0.66	0.78	0.60	0.73	0.69	0.69
	Tropics, 800, 500, 300, 150 hPa			South Asia, 800, 500, 300 hPa		
Bias Score	0.66	0.72	0.77	0.40	0.48	0.59
Total Score	0.62	0.60	0.66	0.63	0.66	0.69
	S. Mid-high Lat., 800, 500 hPa					
Bias Score	0.88	0.90	0.44			
Total Score	0.63	0.72	0.65			

FVGCM has highest scores in mid-high latitudes.
DAO is a close second for bias score only

GISS has highest scores in the tropics



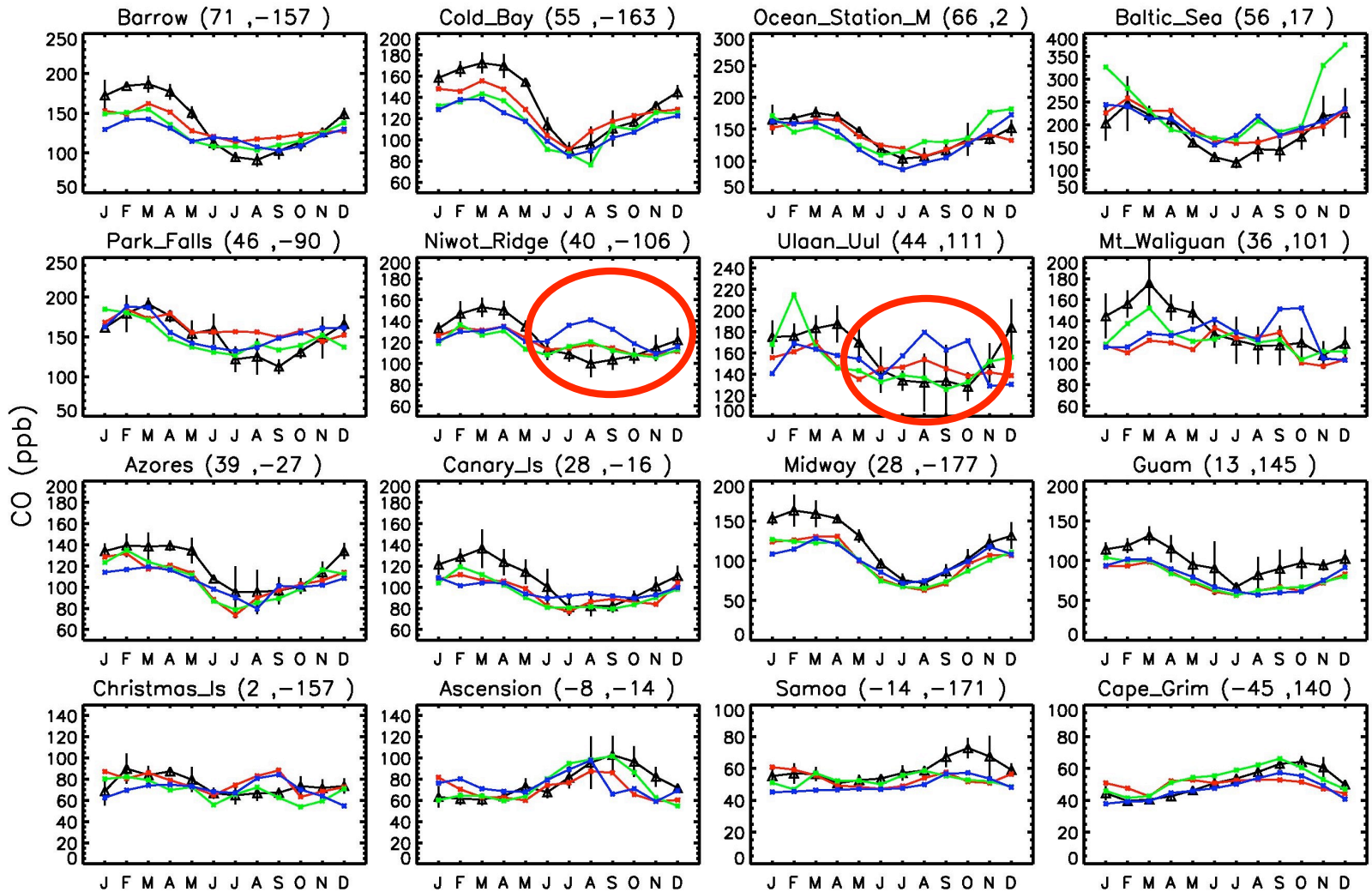
NO vs. aircraft obs

Bob Chatfield finds HNO3/NOx is much better in V2 than in older runs

FVGCM
DAO
GISS

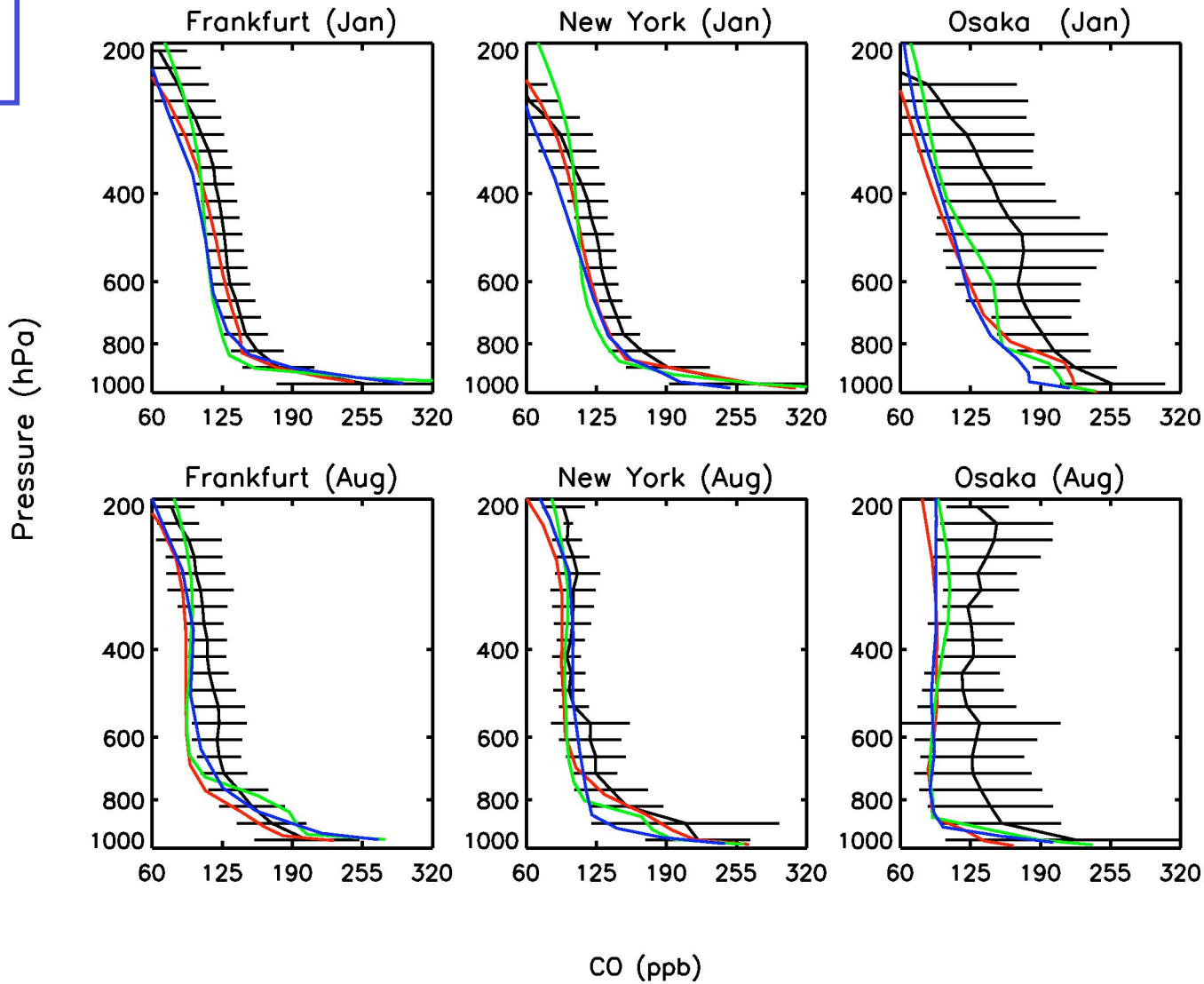
CO at CMDL surface sites

FVGCM looks more normal than CCM3 did over the continents



FVGCM
DAO
GISS

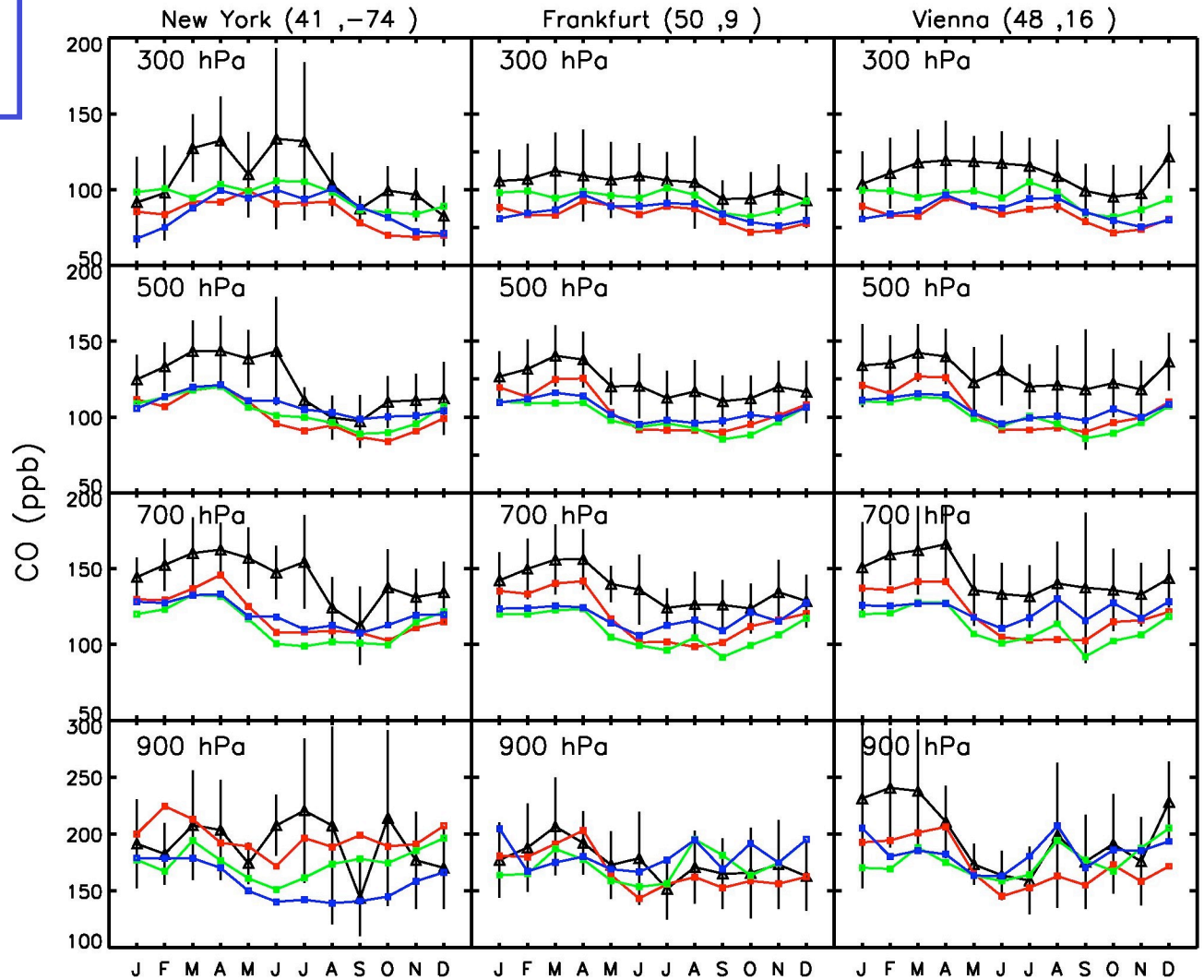
MOZAIC CO profile data



GISS drops off too quickly in the BL compared to observations.

Seasonal cycle in CO - MOZAIC data

FVGCM
DAO
GISS

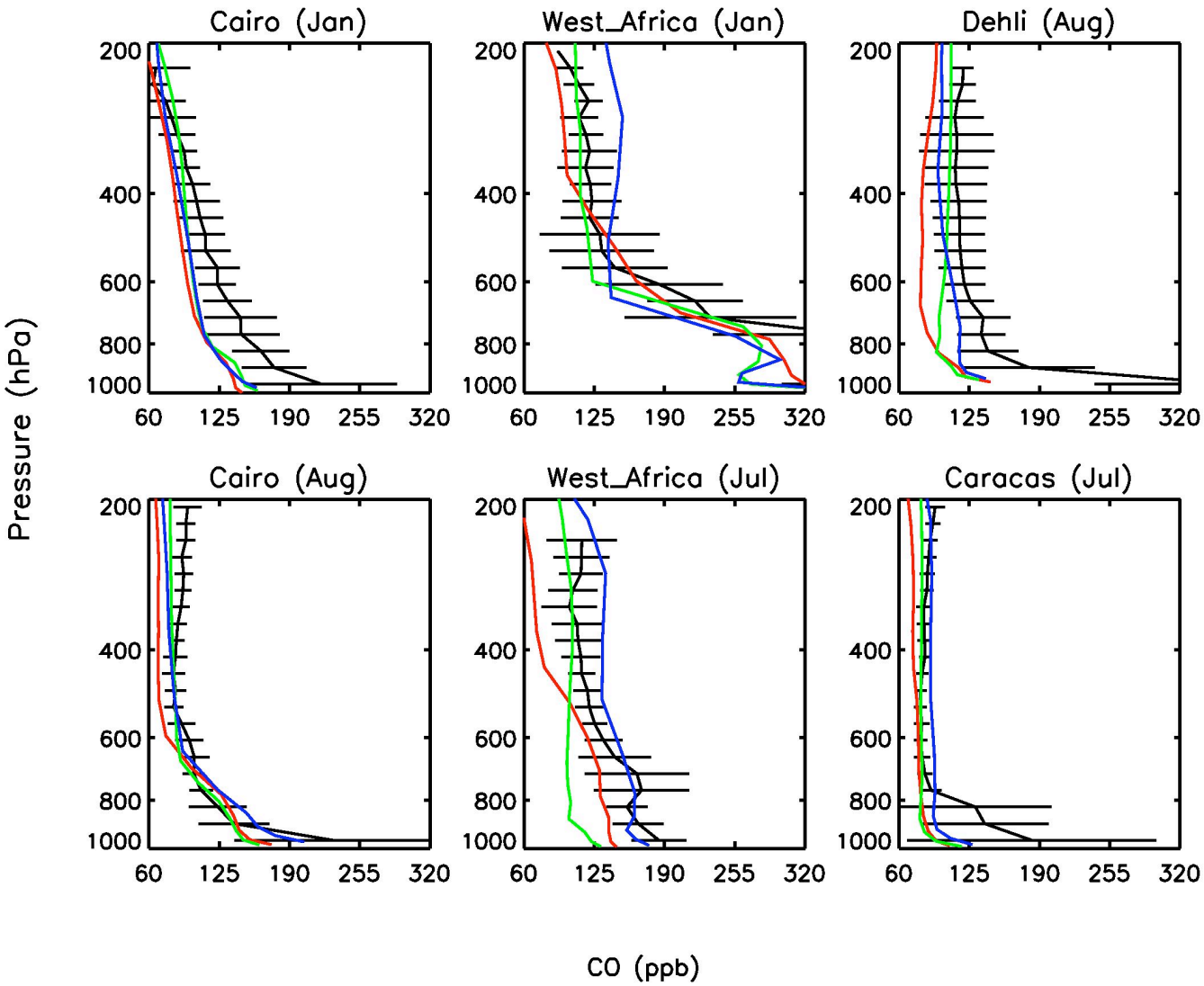


All simulations too low above the BL. CMDL data suggest surface data are OK over the US and Europe.

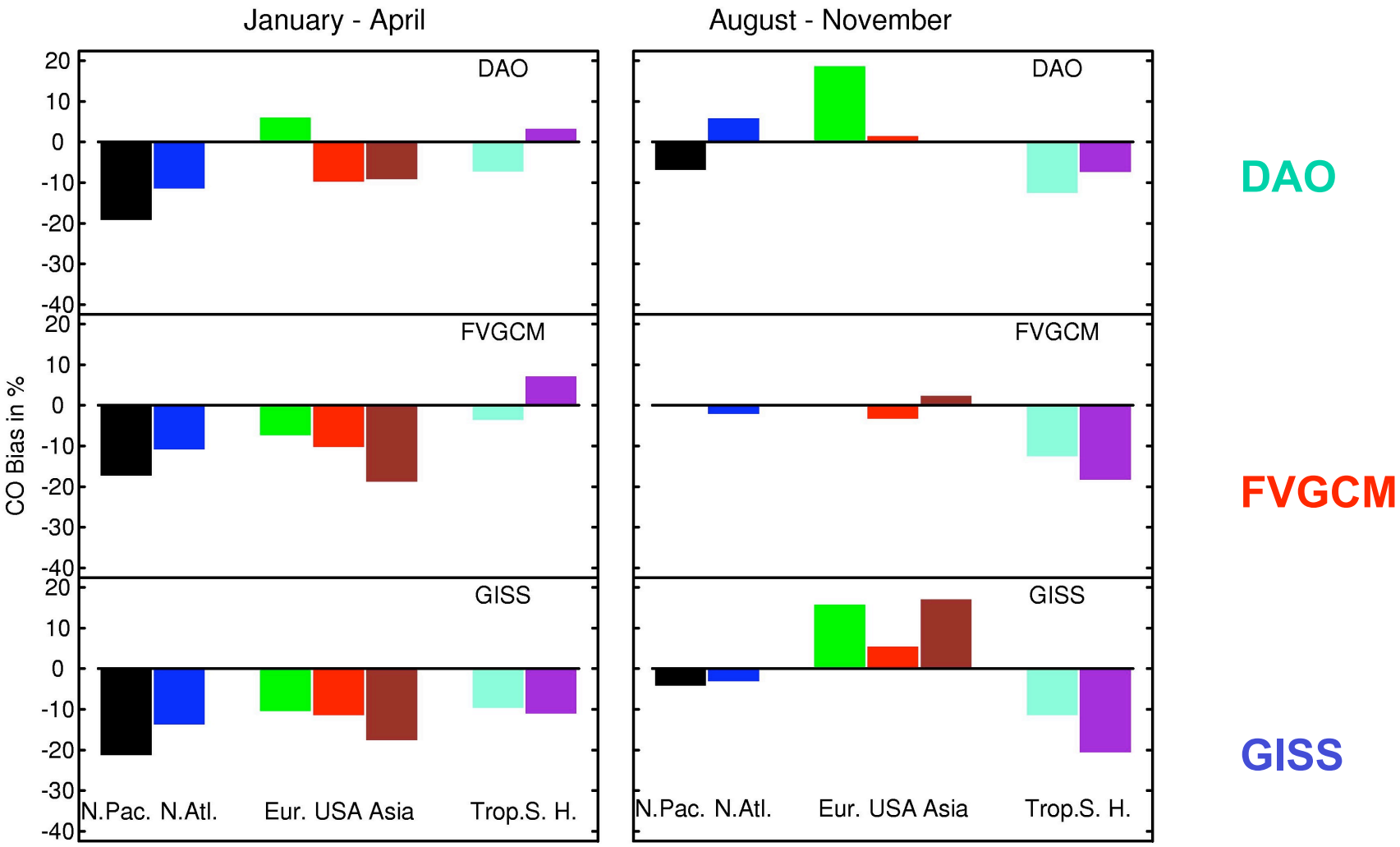
CO profiles in the tropics

FVGCM
DAO
GISS

- Months selected with the most profiles.
- Not enough data to define seasonal cycle.
- Largest differences near tropical sources.



CO Bias at CMDL sites



Systematic negative bias for all in N.H.

Summer max. over continents for GISSS

Conclusions from preliminary analysis of V2

- FVGCM looks pretty good with respect to observations in general, with fewer problems that CCM3
- Need to investigate causes of discrepancies such as Middle East max. and high ozone in tropical UT: convection. NO_x distribution, etc
- Need to examine budgets
- Analysis of tracer runs is just beginning