Ozone-hole experiments with the GISS V2 coupled model

Figures assembled by John Marshall
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Notes for
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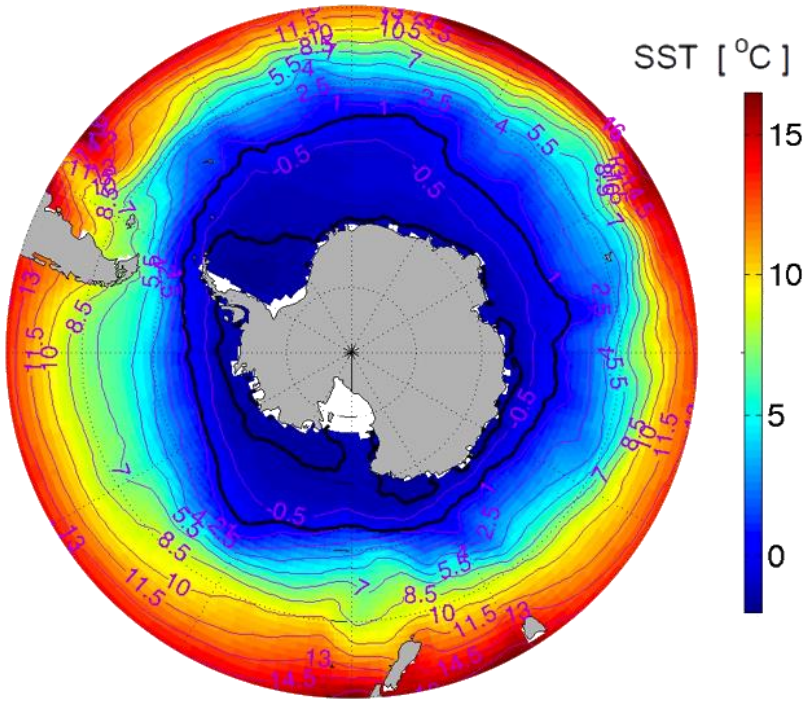
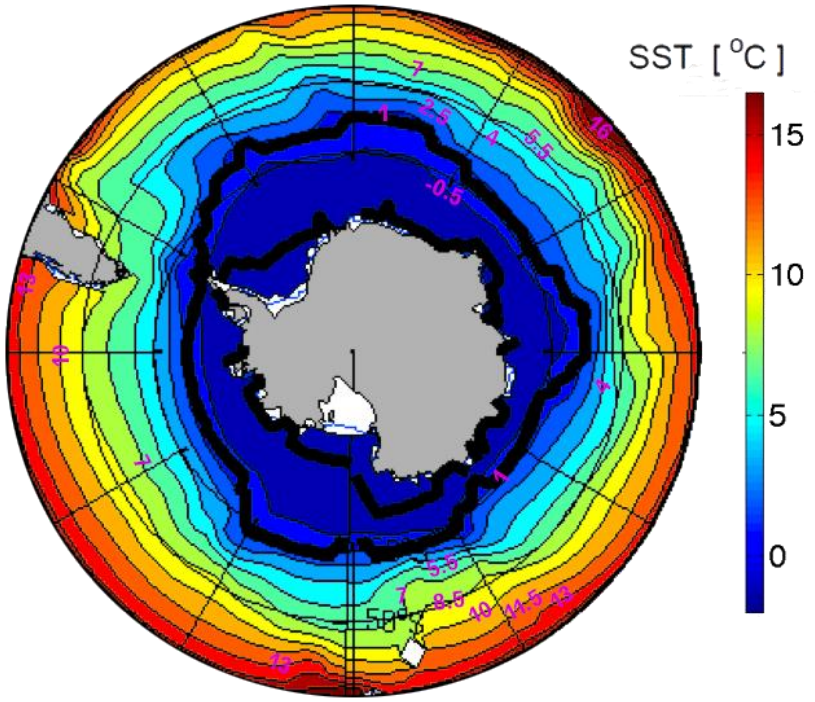
Larissa Nazarenko
Natassa Romanou

Climatology

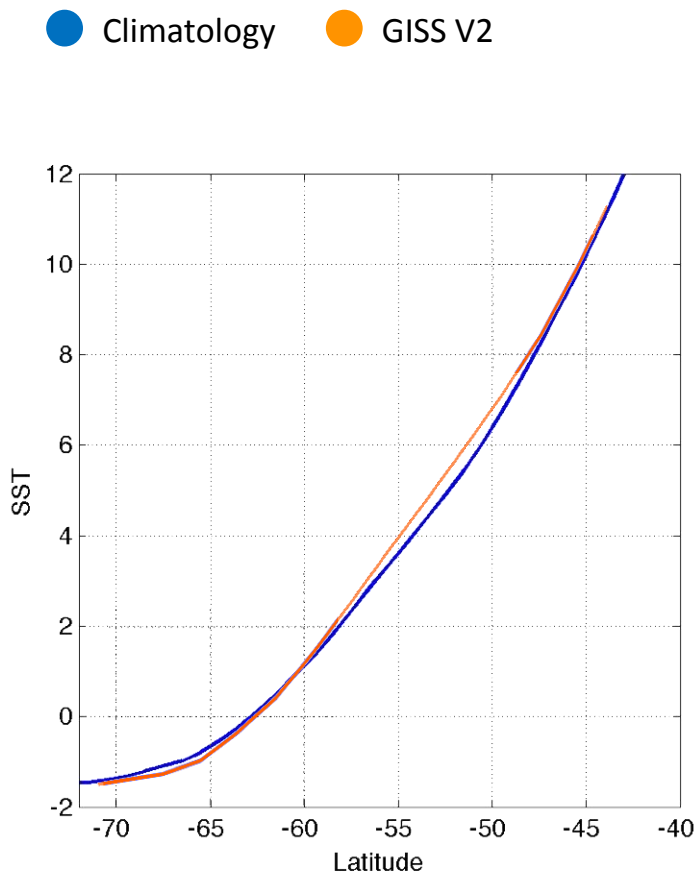
GISS V2

Max Kelley



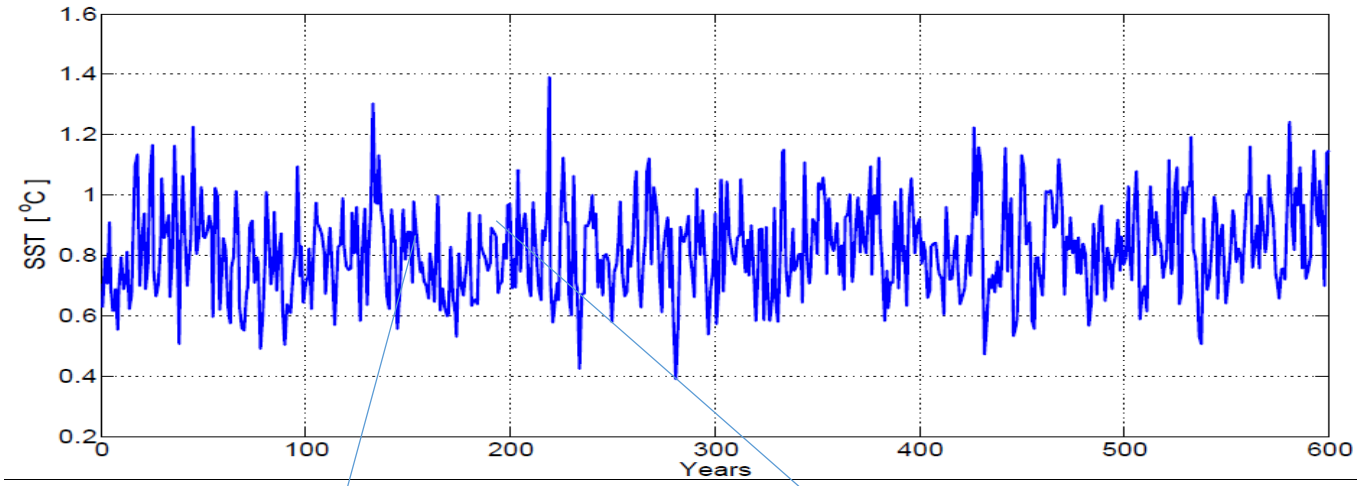


Annual-mean SST and
summer and winter
sea-ice extent



Zonally-averaged SST

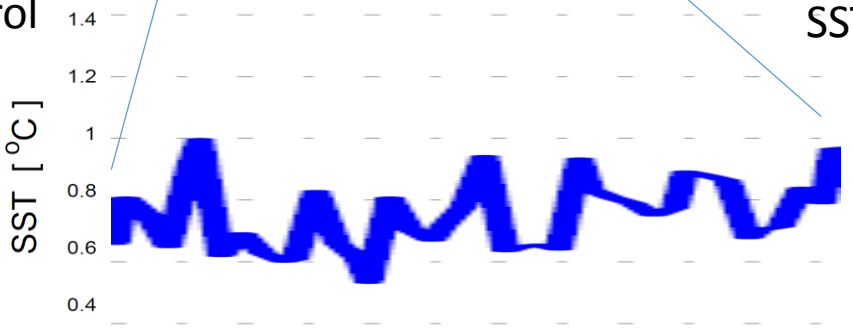
GISS V2



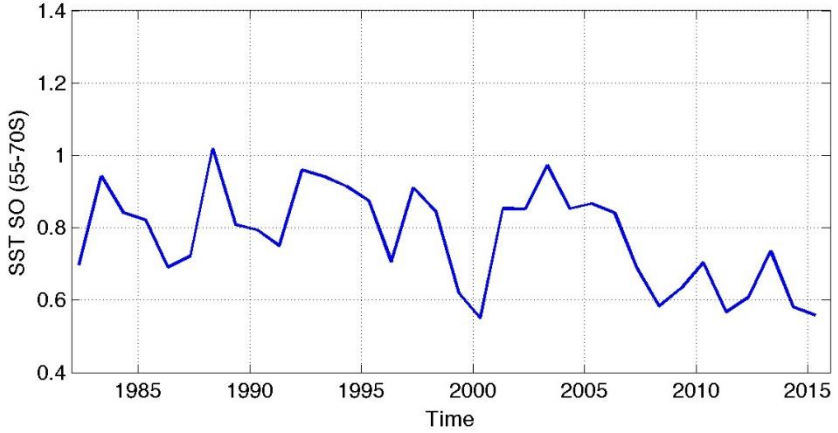
Time-series from control

SST between 55 and 70S

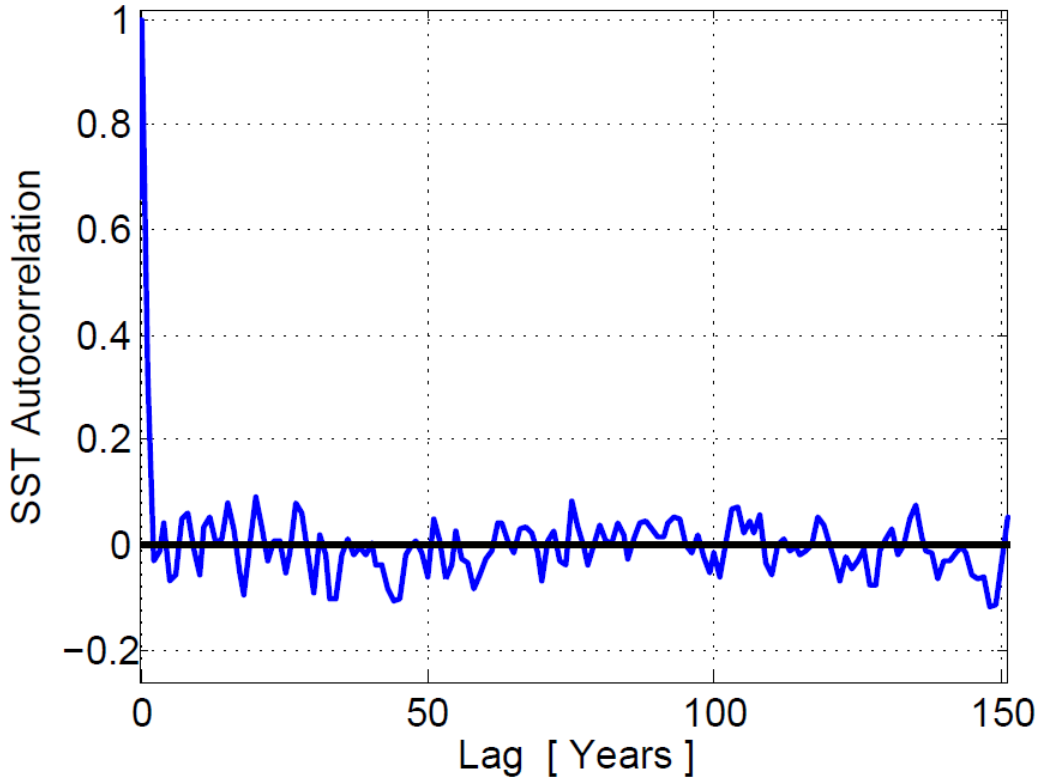
GISS V2



Observed

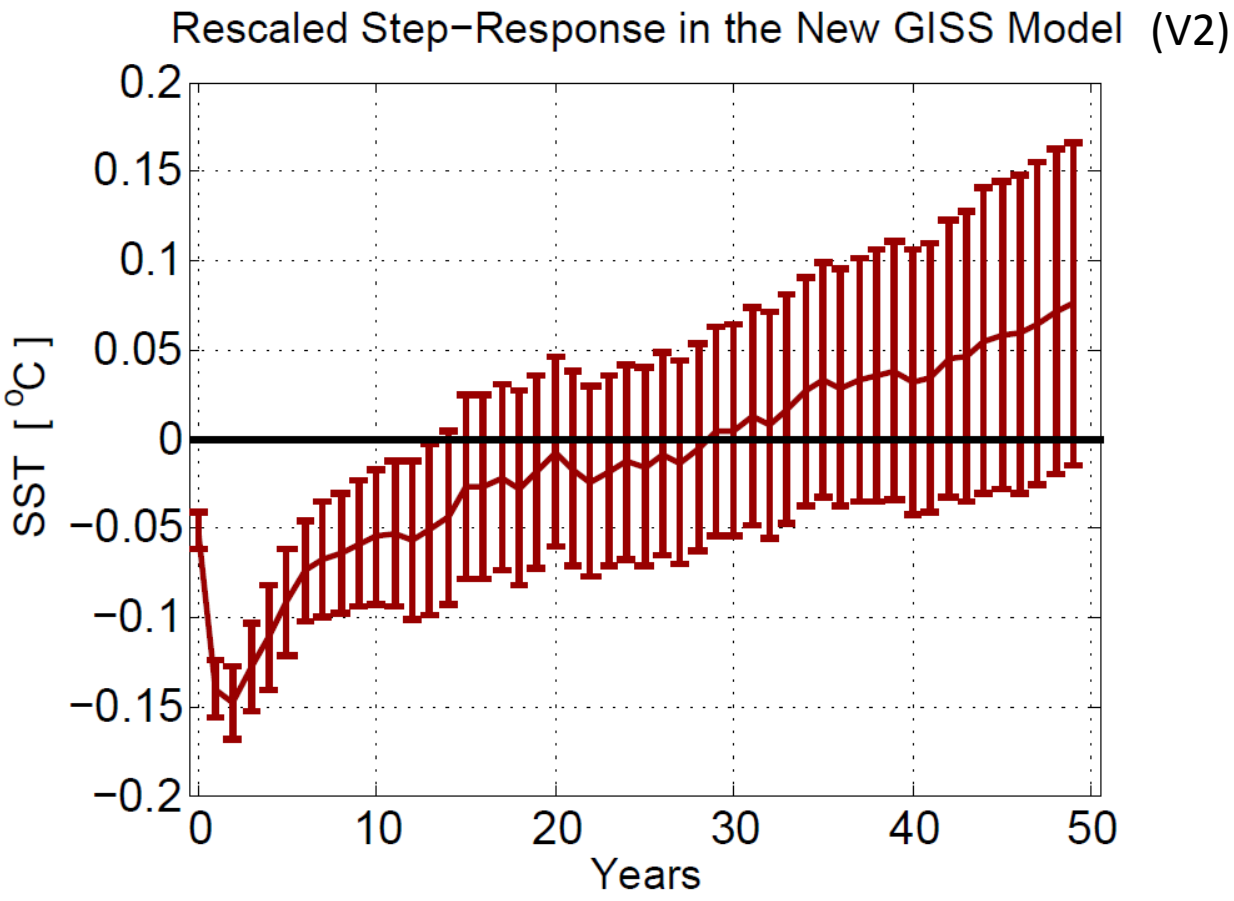


Auto-correlation of SST



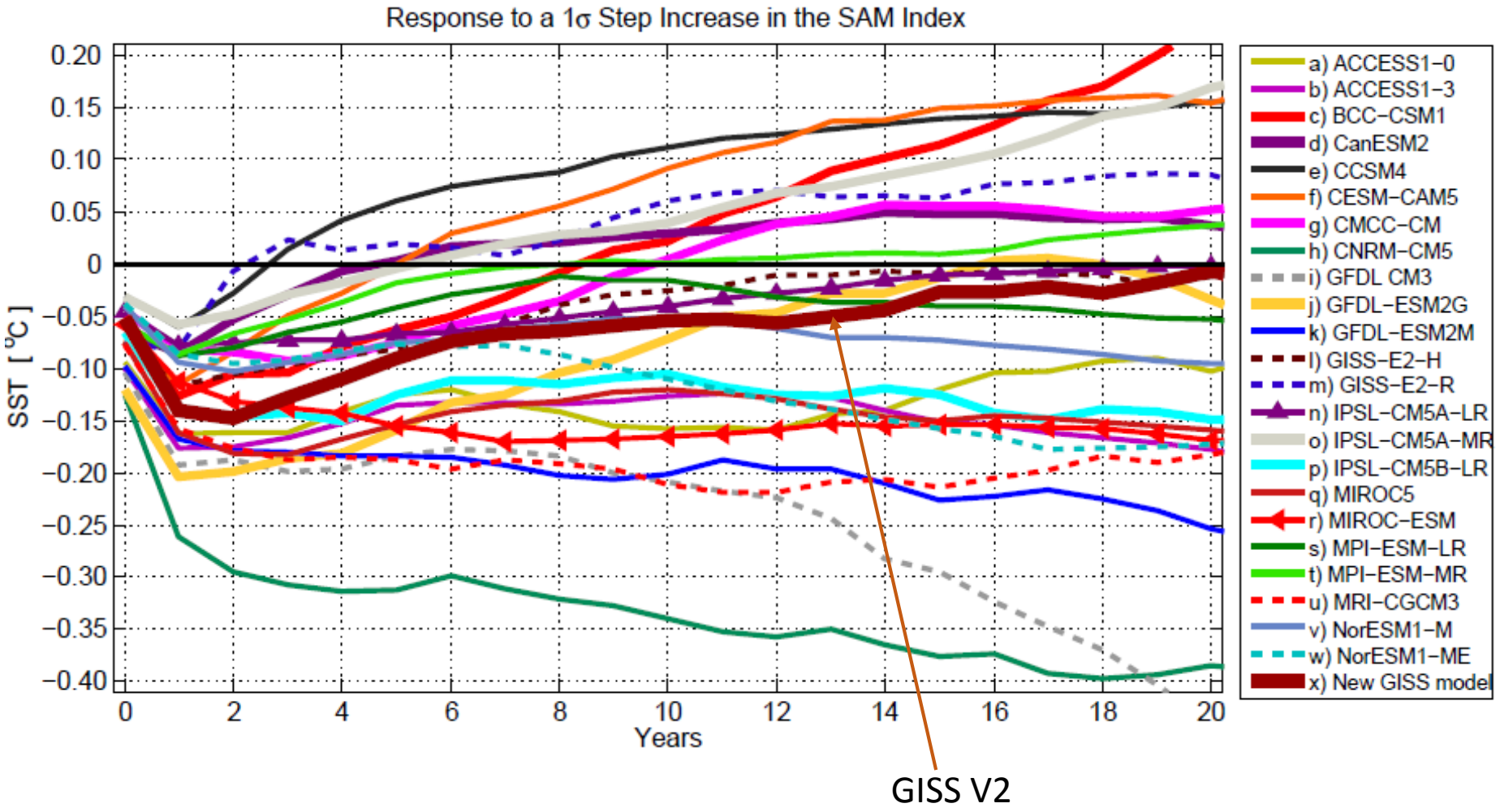
No low-frequency oscillations - good

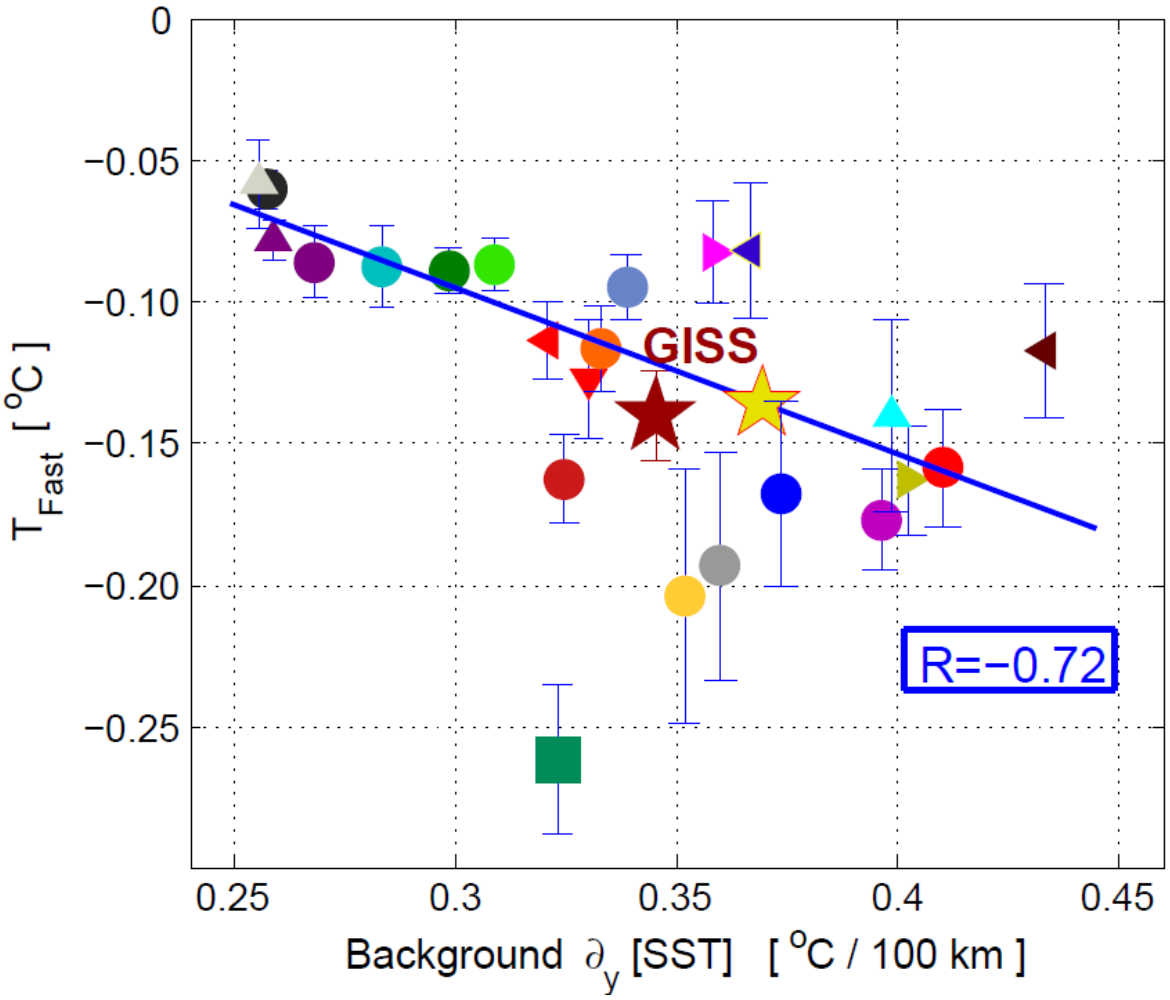
step_SAM-SST Response function for GISS v2



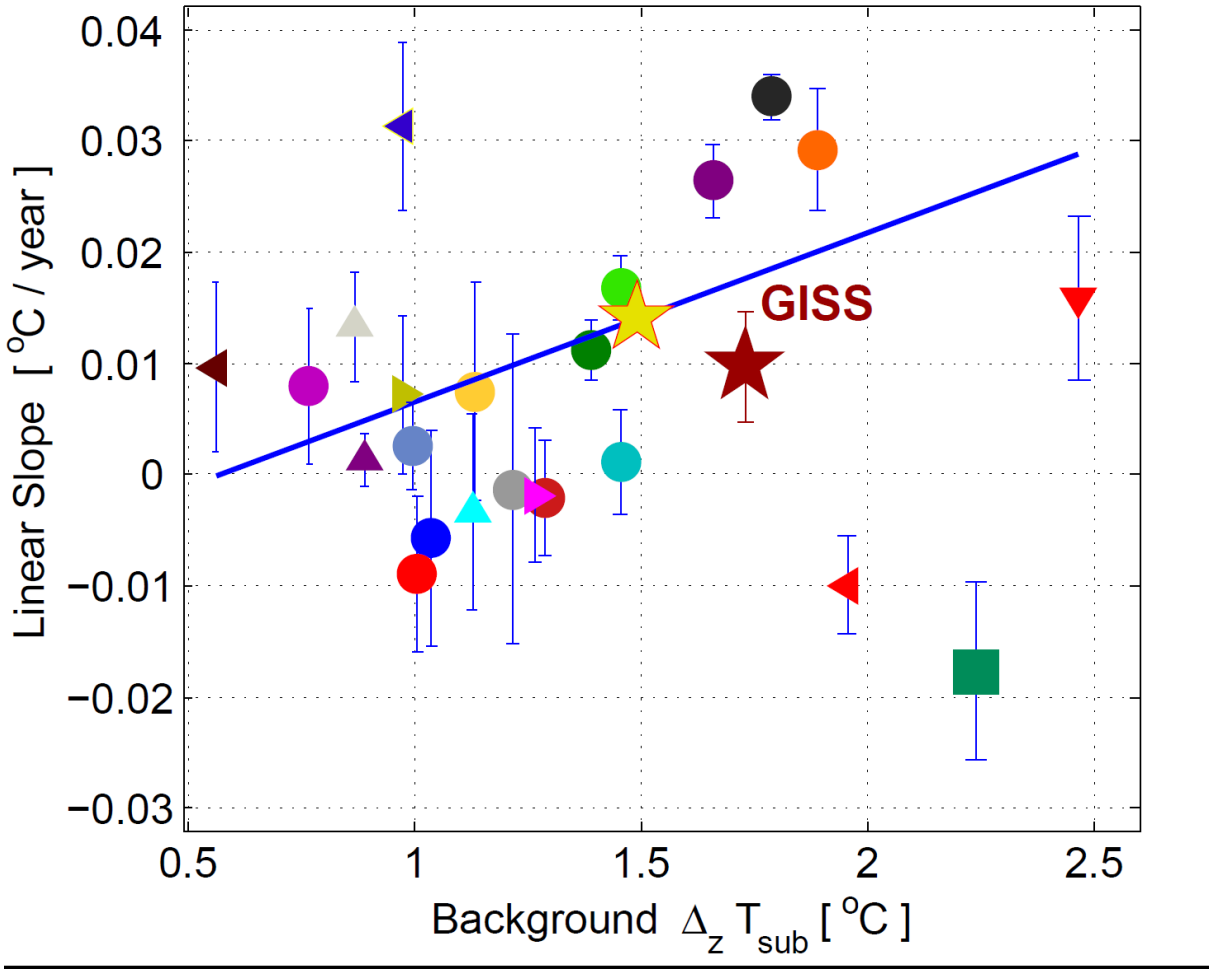
Yavor Kostov

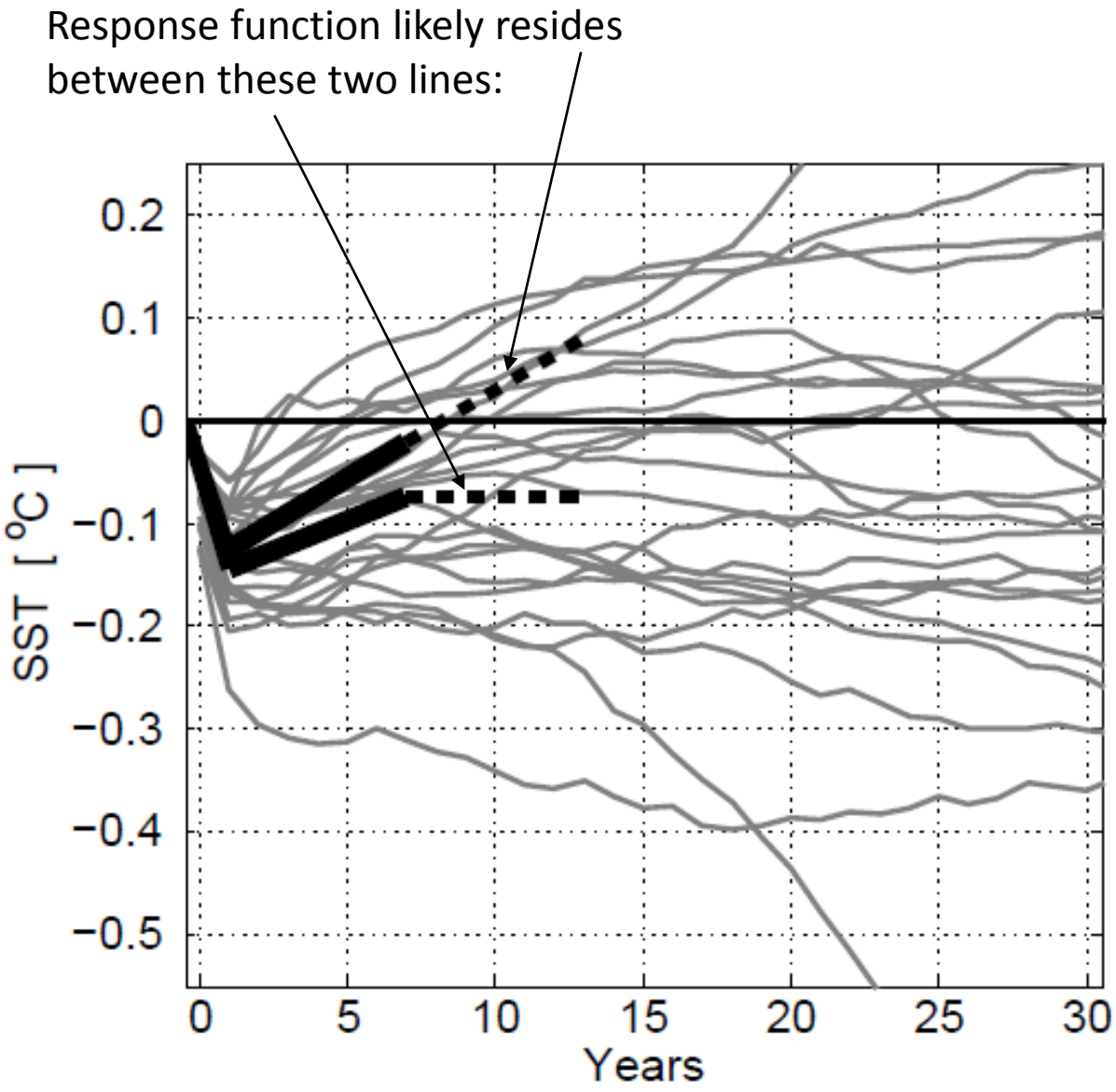
Other models



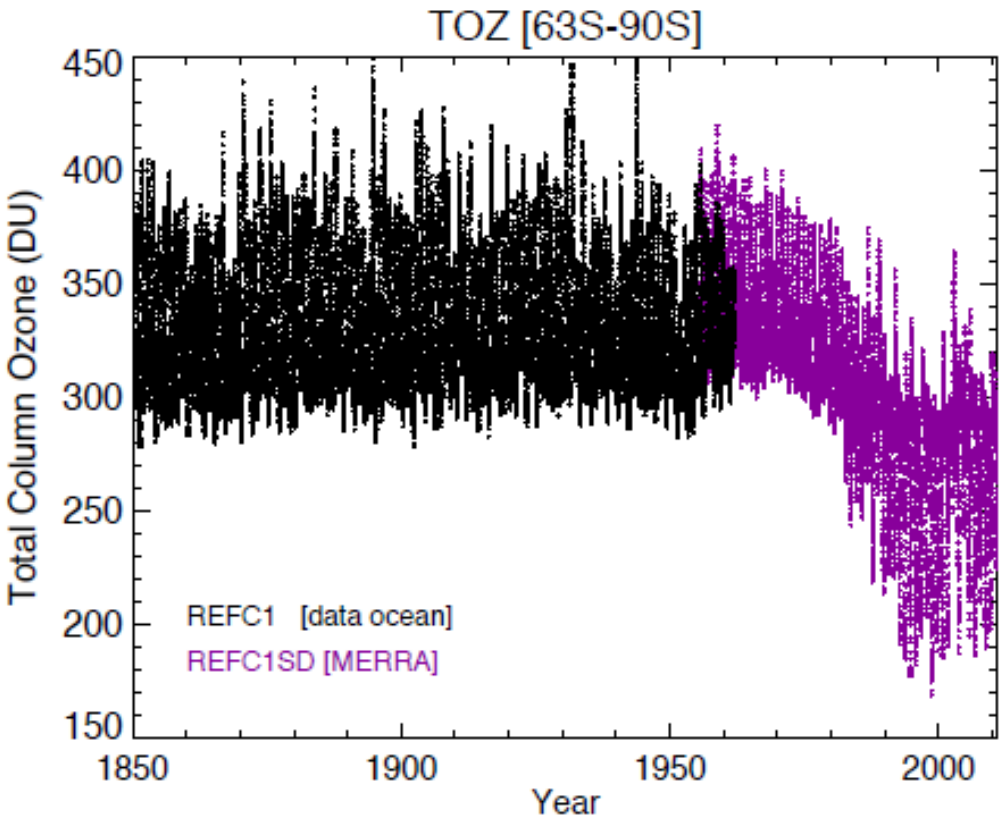


V2 seems to be getting pretty close to the climatology – one of the best models in the CMIP-5 'pack'!

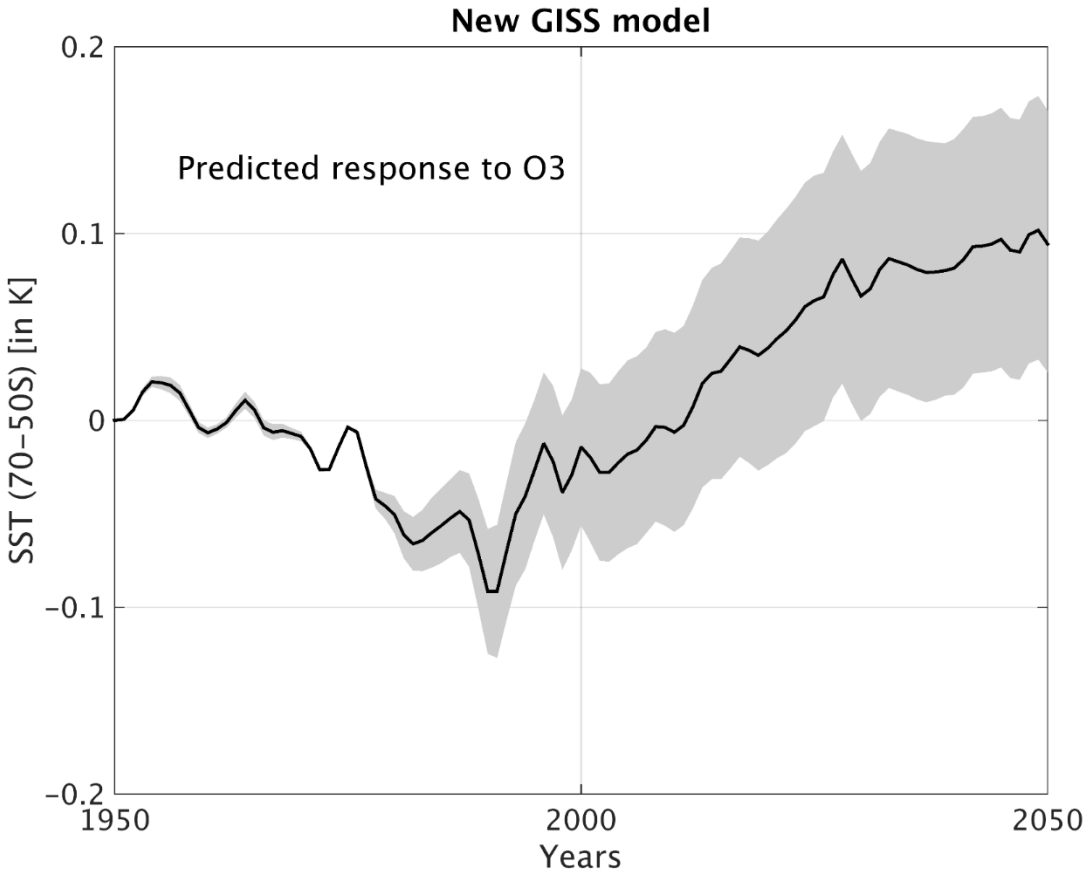

0.04
0.03
0.02
0.01
0
−0.01
−0.02
−0.03
0.5
1
1.5
2
2.5
Linear Slope [°C / year]
Background Δz Tsub [°C]
GISS


Response function likely resides
between these two lines:
0.2
0.1
0
−0.1
−0.2
−0.3
−0.4
−0.5
SST [°C]
0
5
10
15
20
25
30
Years

Time-history of total
column ozone over time



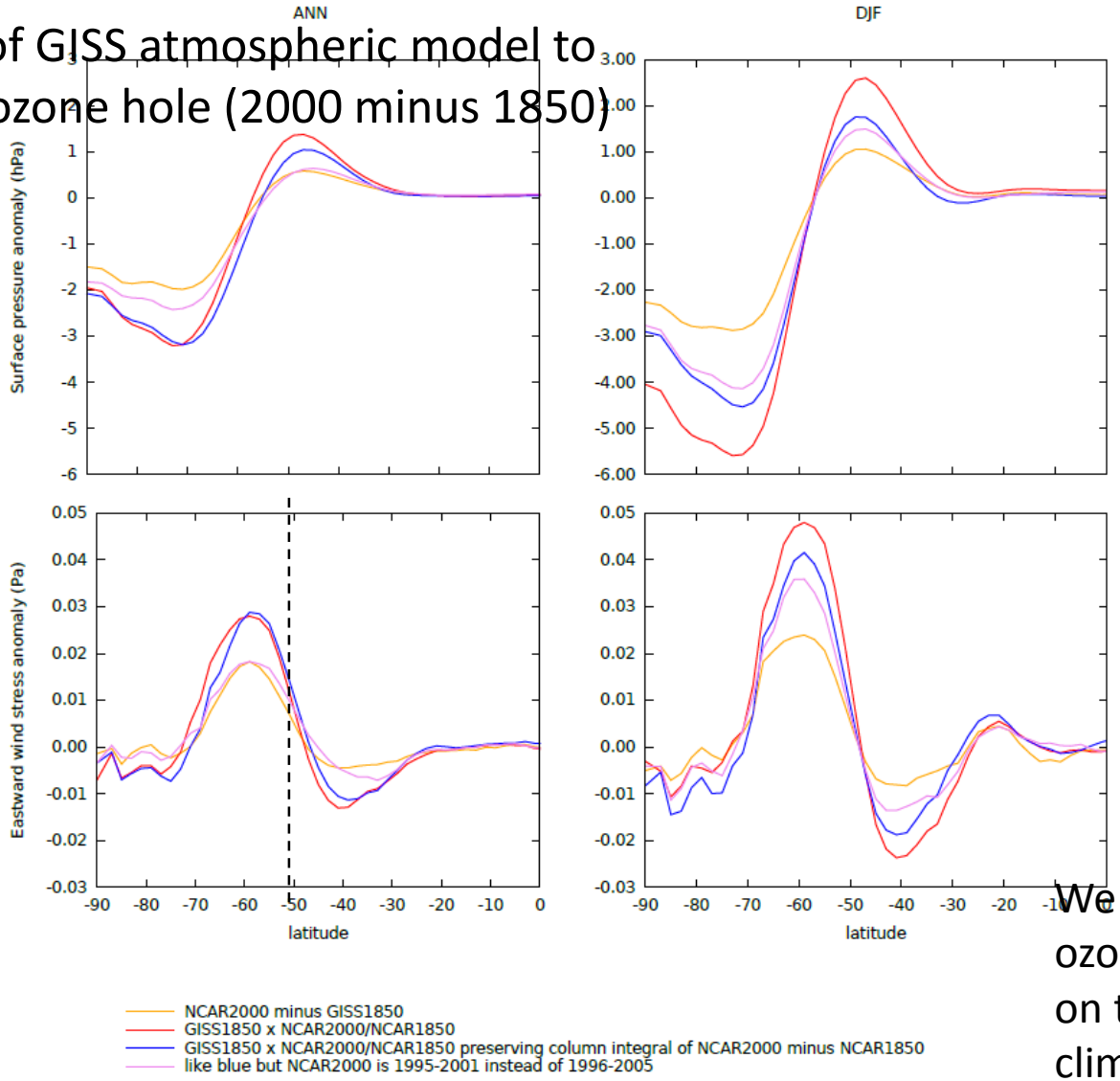
Predicted SST response to ozone forcing by convolving time-history of forcing with SAM-SST CRF



David Ferreira

Response of GISS atmospheric model to perpetual ozone hole (2000 minus 1850)

Max Kelley

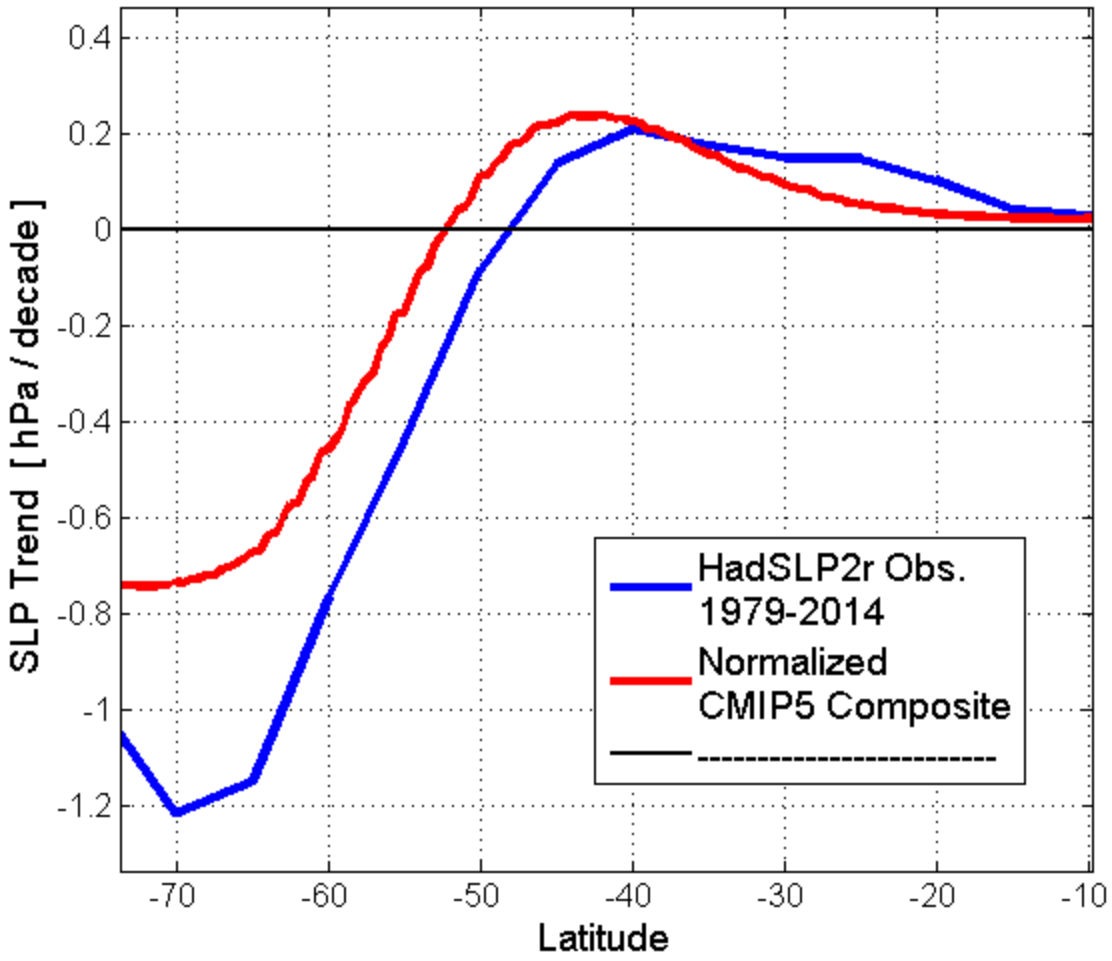


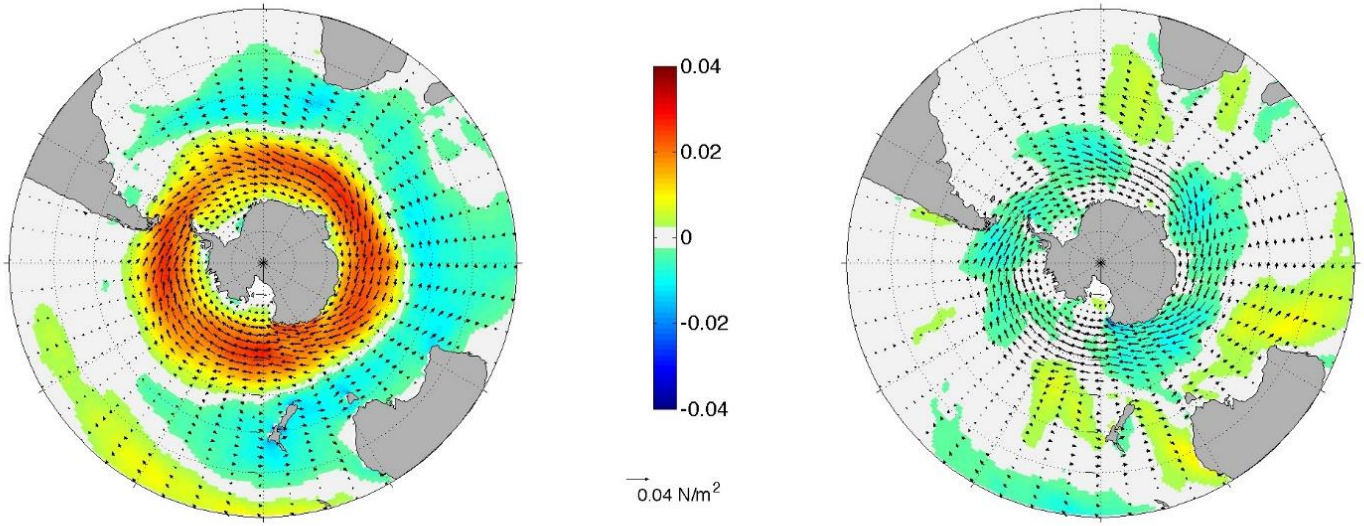
We will likely use an ozone-hole based on the 1995-2001 climatology

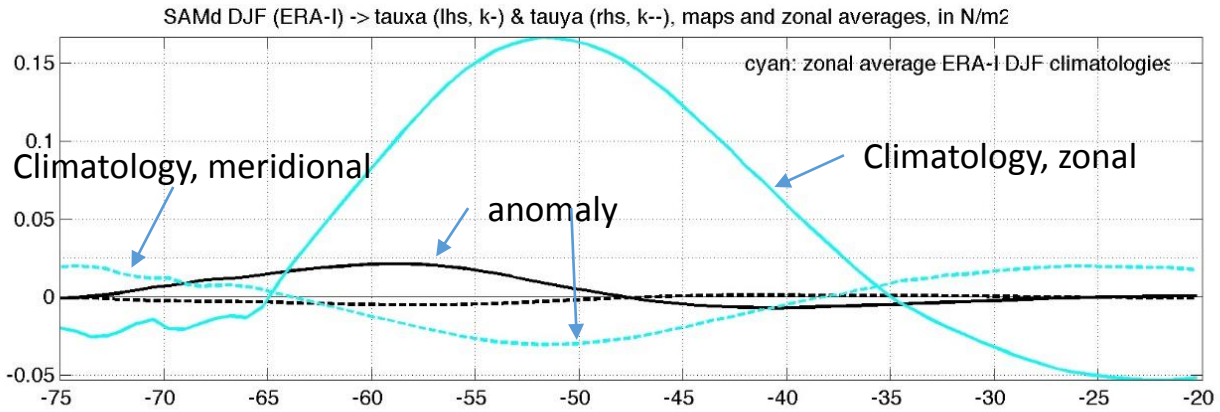
Attached are zonal means of the 2000 minus 1850 AGCM-only response of surface pressure (top row) and zonal wind stress (bottom row) resulting from applying “2000” ozone forcing. Focus on the blue curves which constrain the column-integral of ozone to be close to that of observations.

The DJF response (right column) is larger in magnitude than the annual mean (left column), as one expects,

These are 9-year averages - need to do some longer runs for better stats at the seasonal timescale.


0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
SLP Trend [hPa / decade]
-70
-60
-50
-40
-30
-20
-10
Latitude
HadSLP2r Obs.
1979-2014
Normalized
CMIP5 Composite

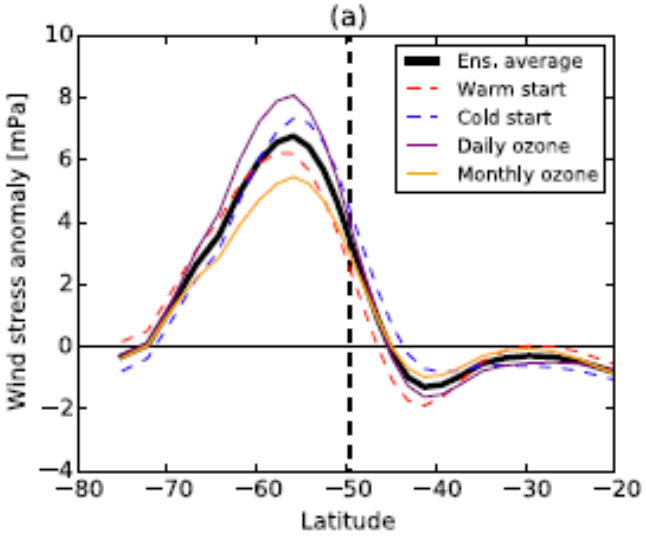

0.04
0.02
0
-0.02
-0.04
0.04 N/m2

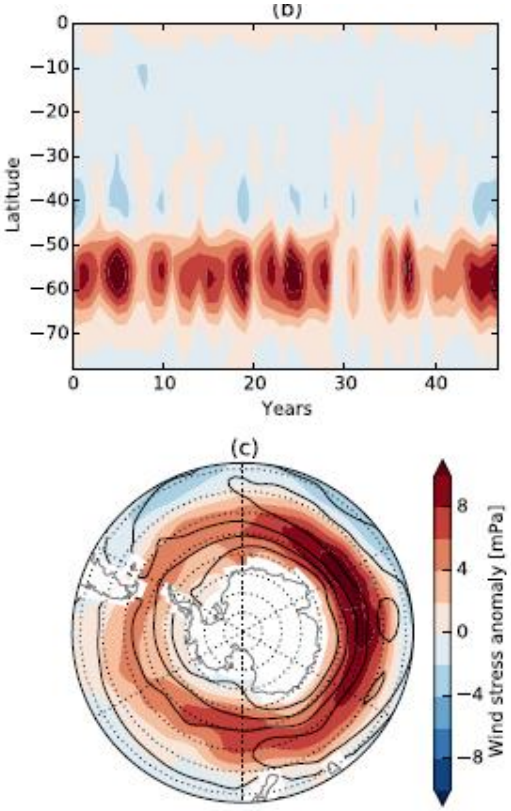

SAMd DJF (ERA-I) -> tauxa (lhs, k-) & tauya (rhs, k--), maps and zonal averages, in N/m2
cyan: zonal average ERA-I DJF climatologies
Climatology, meridional
anomaly
Climatology, zonal
0.15
0.1
0.05
0
-0.05
-75
-70
-65
-60
-55
-50
-45
-40
-35
-30
-25
-20

Compare response to some other models

GFDL, MITgcm and CCSM

GFDL model (run at JHU)

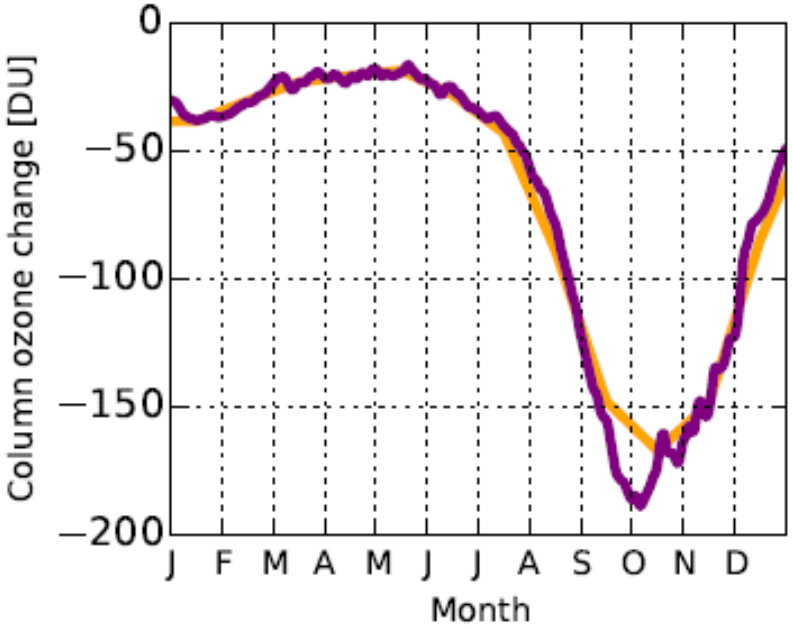


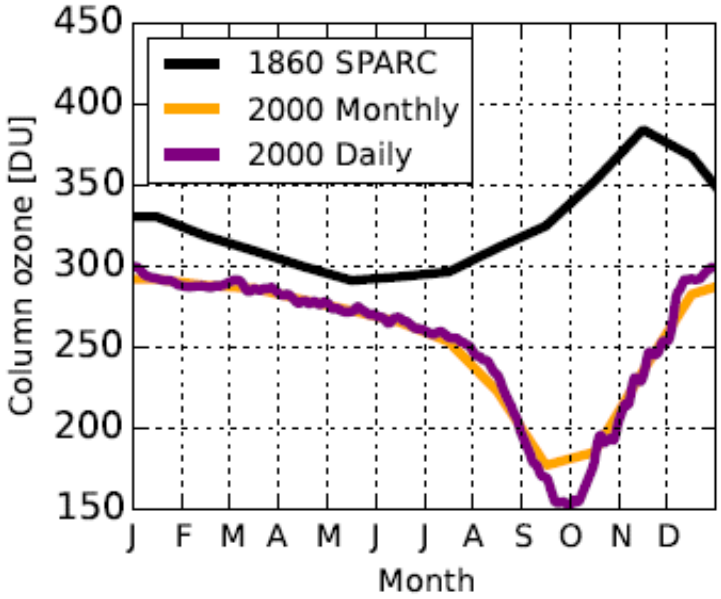


Peak wind stress anomaly polewards of the climatological maximum of magnitude 7mPa = 0.007Pa

FIG. 3. (a) Annual average zonal-mean zonal wind stress anomalies, averaged over the 48 years of the ozone perturbation simulations, for the ensemble mean, cold and warm start ensembles, and daily and monthly mean ozone ensembles. Vertical dashed line shows the location of maximum wind stress in the control simulation. (b) Variation of zonal-mean zonal windstress with time for the ensemble mean. (c) Zonal wind stress anomalies (colors) and climatology from the control simulation (black contours). The contour interval is 50 mPa, and anomalies are calculated relative to the control simulation.

Ozone forcing used in GFDL model





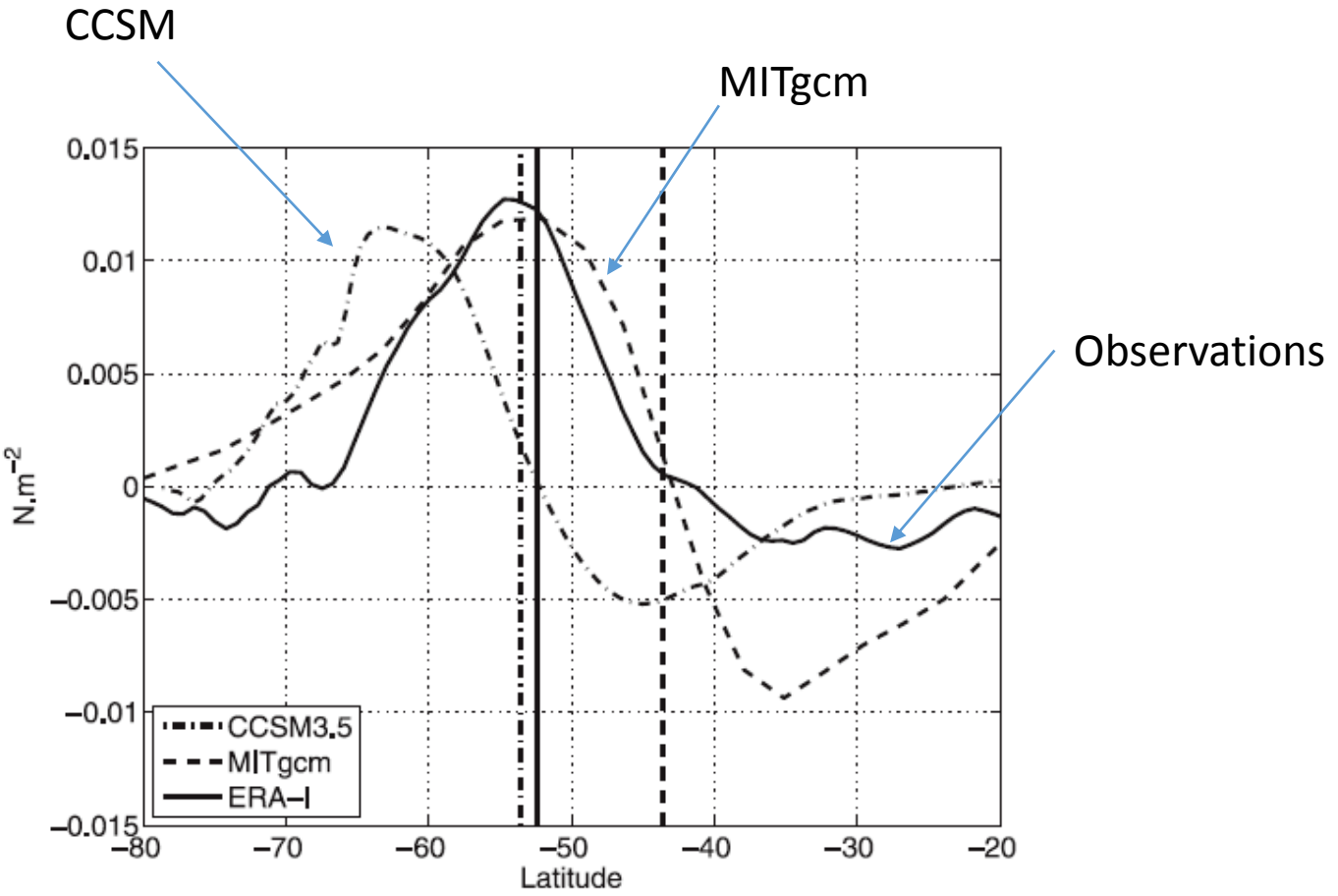
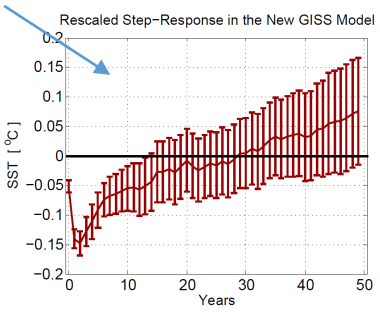


FIG. 3. Annual- and zonal-mean response of the surface wind stress (N m^{-2}) to an abrupt ozone depletion in the MITgcm (dashed) and in CCSM3.5 (dashed–dotted). The time average is over the first 20 yr. For comparison, the difference in surface wind stress between pre–ozone hole conditions (1980–89) and peak ozone hole conditions (1995–2004) is shown from the ERA-Interim reanalysis (solid). The vertical lines indicate the locations of the peak mean surface wind stress.

Bottom line is that V2 has a nice, healthy response to an ozone hole when compared to other models.

Next step is to compute the actual response of the GISS coupled V2 model driven by a perpetual ozone hole.

This can then be compared to the response inferred from lagged-correlations between SAM and SST, reproduced here.



Finally, we will drive the model with the ozone forcing time history ('historical') and see if we get something like this, which is the convolution of the time-history with the response function.