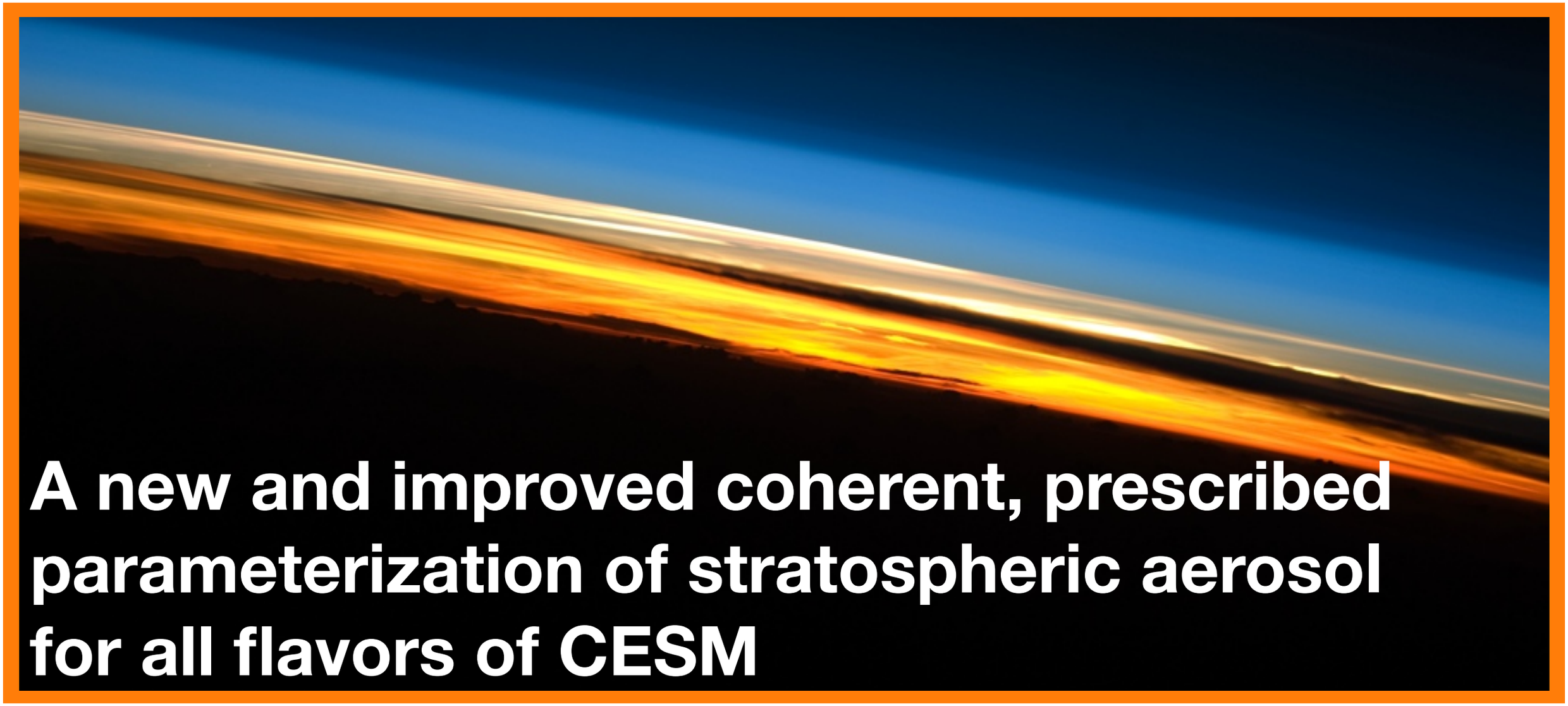


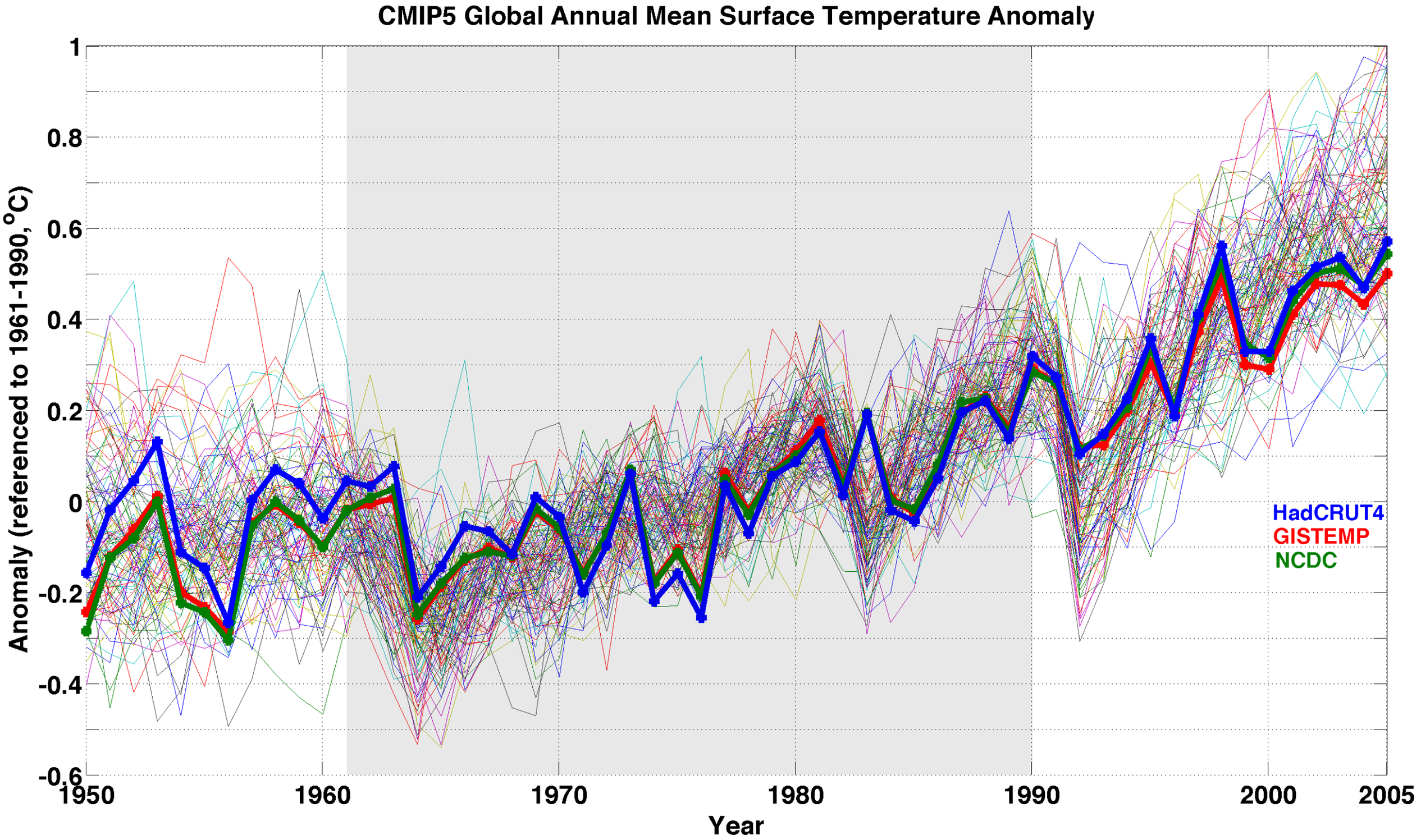
A new and improved coherent, prescribed parameterization of stratospheric aerosol for all flavors of CESM

Ryan R. Neely III, Post-Doctoral Fellow, NCAR's ASP and ACD

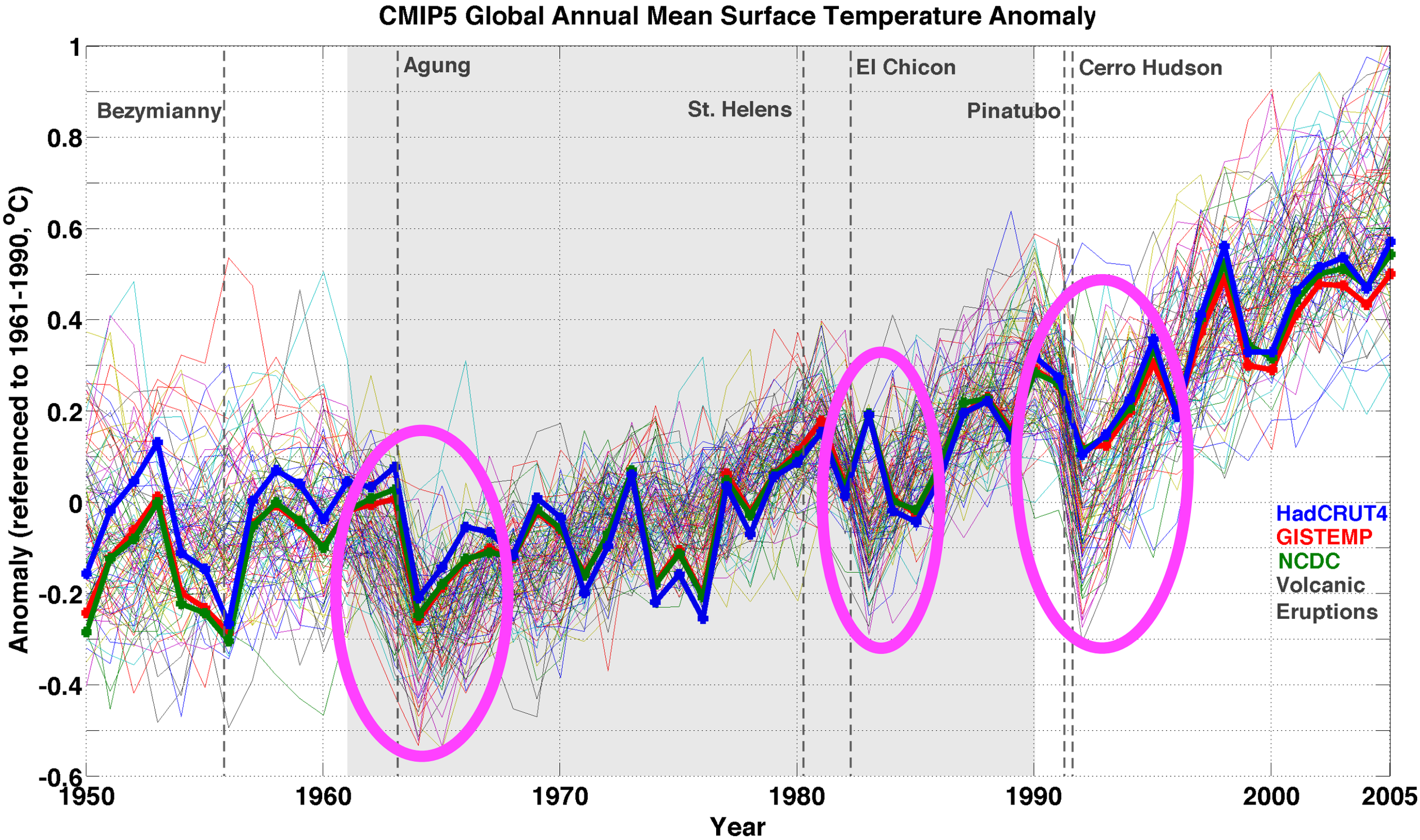
With J.F. Lamarque, A. Conley, F. Vitt, D. Kinnison, D. Marsh, M. Mills and S. Tilmes.

and thanks to L. Thomason, J.P. Vernier, B. Luo, F. Arfeuille and T. Peter

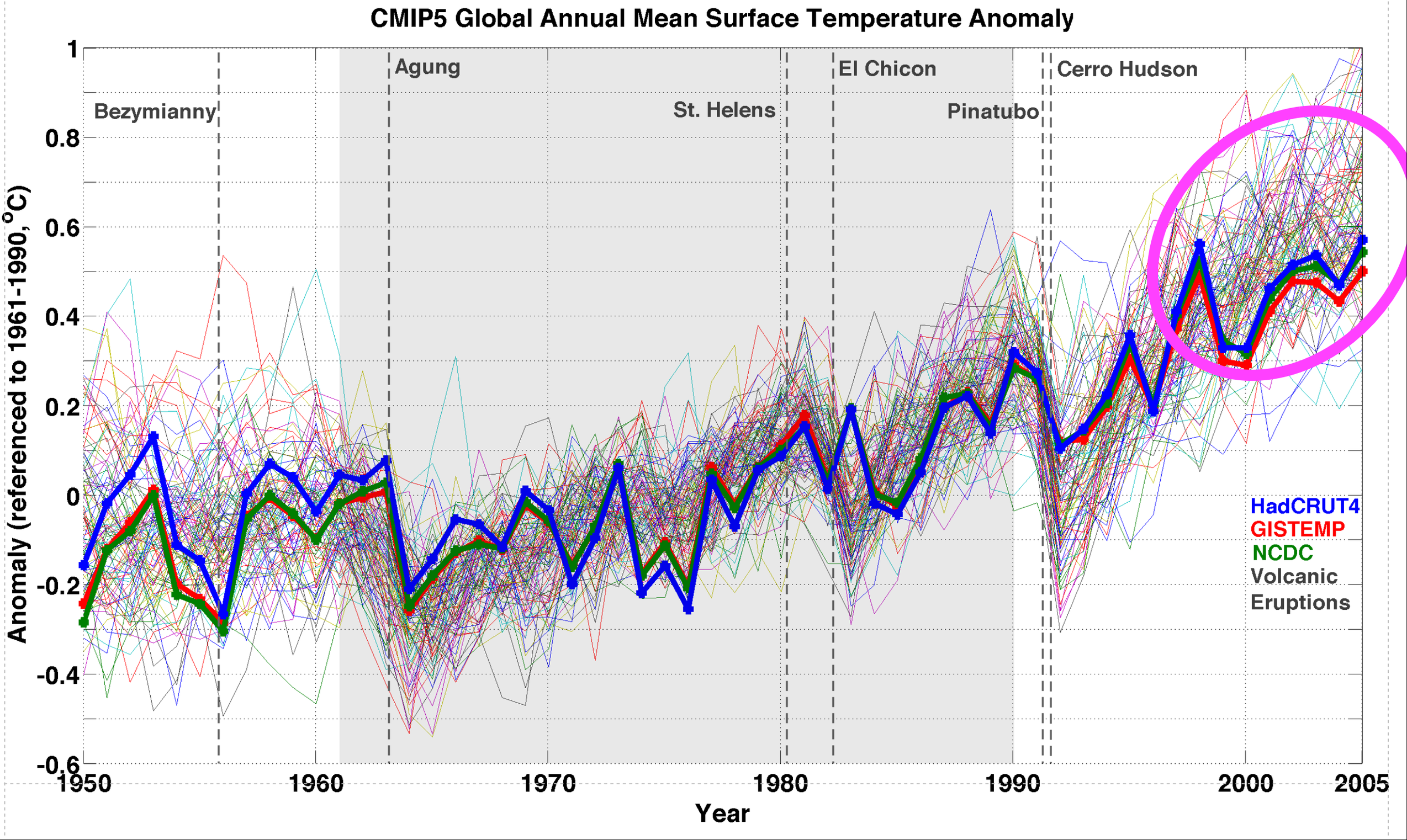
Motivation


CMIP5 Global Annual Mean Surface Temperature Anomaly
Anomaly (referenced to 1961-1990, °C)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
1950
1960
1970
1980
1990
2000
2005
Year
HadCRUT4
GISTEMP
NCDC

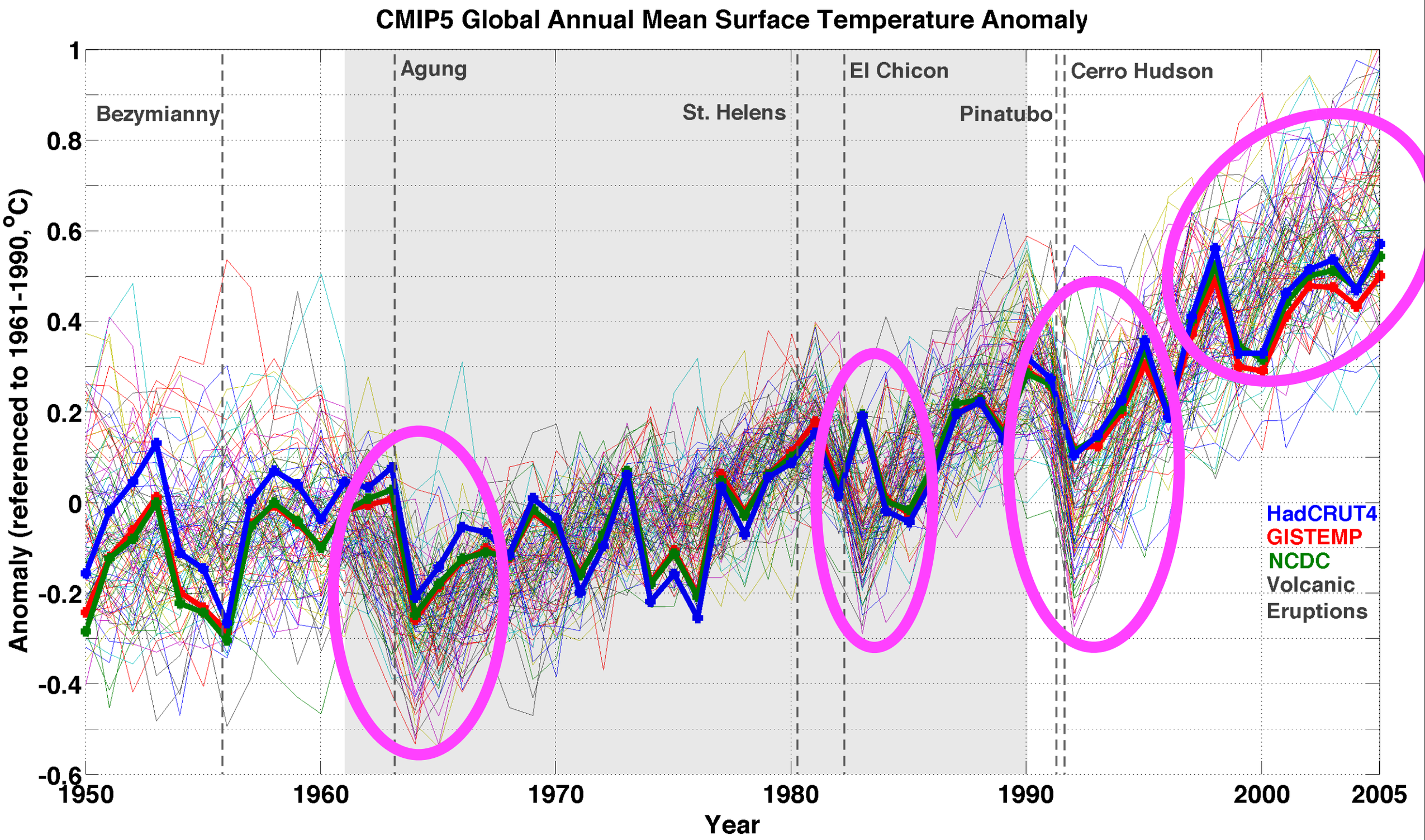
Motivation: Bad and Ugly Volcanoes



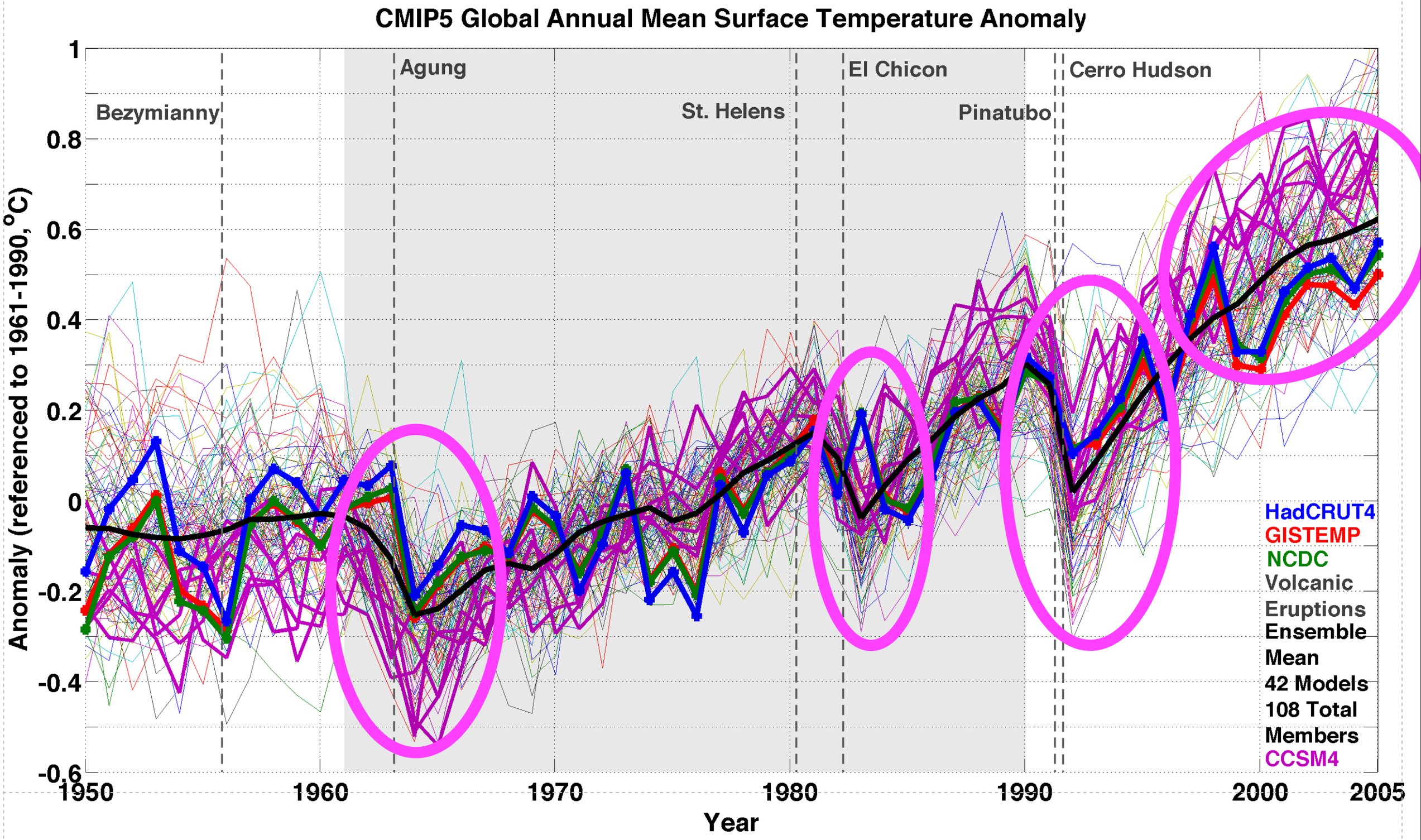
Motivation: “The Hiatus”



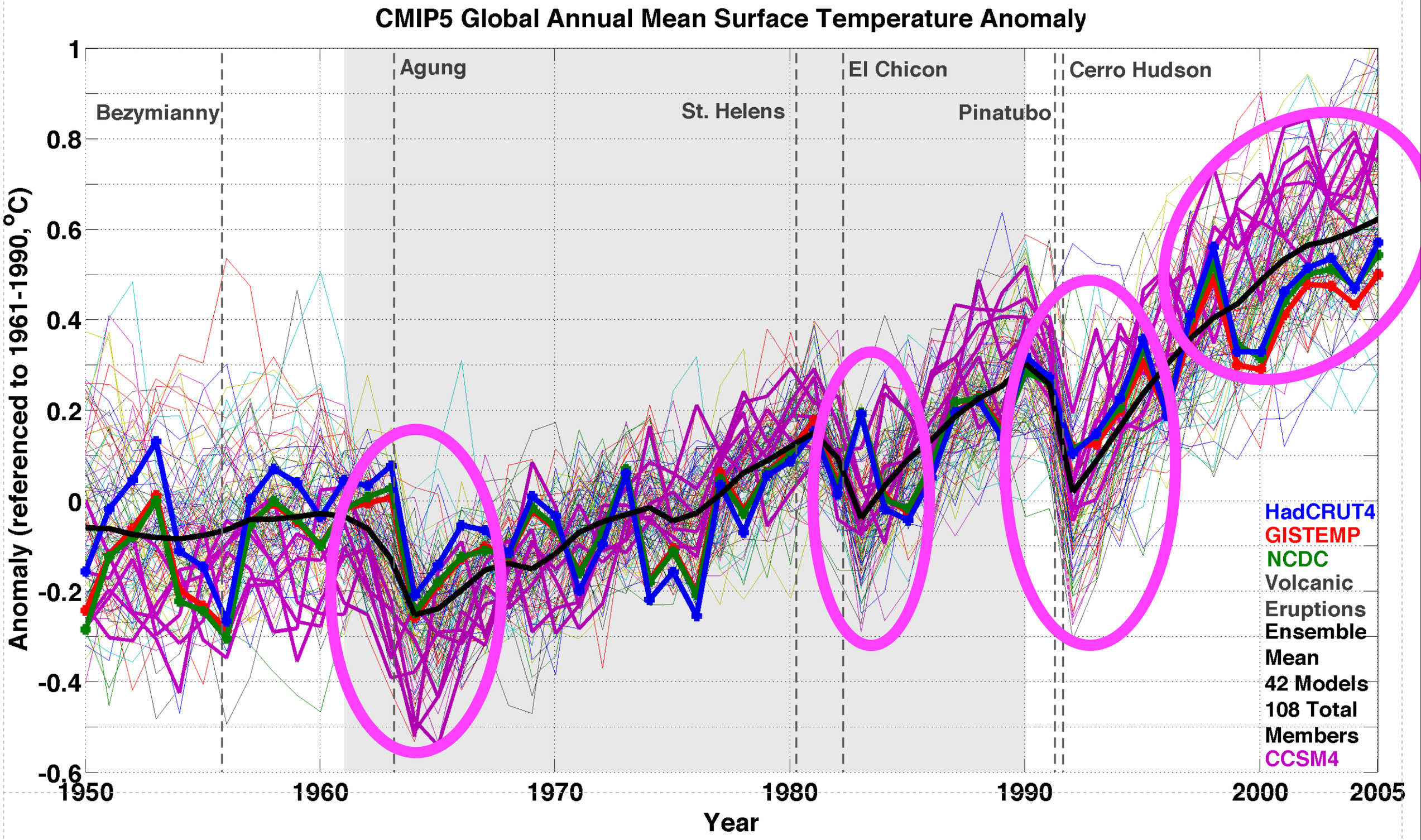
Motivation: Why are there Discrepancies?



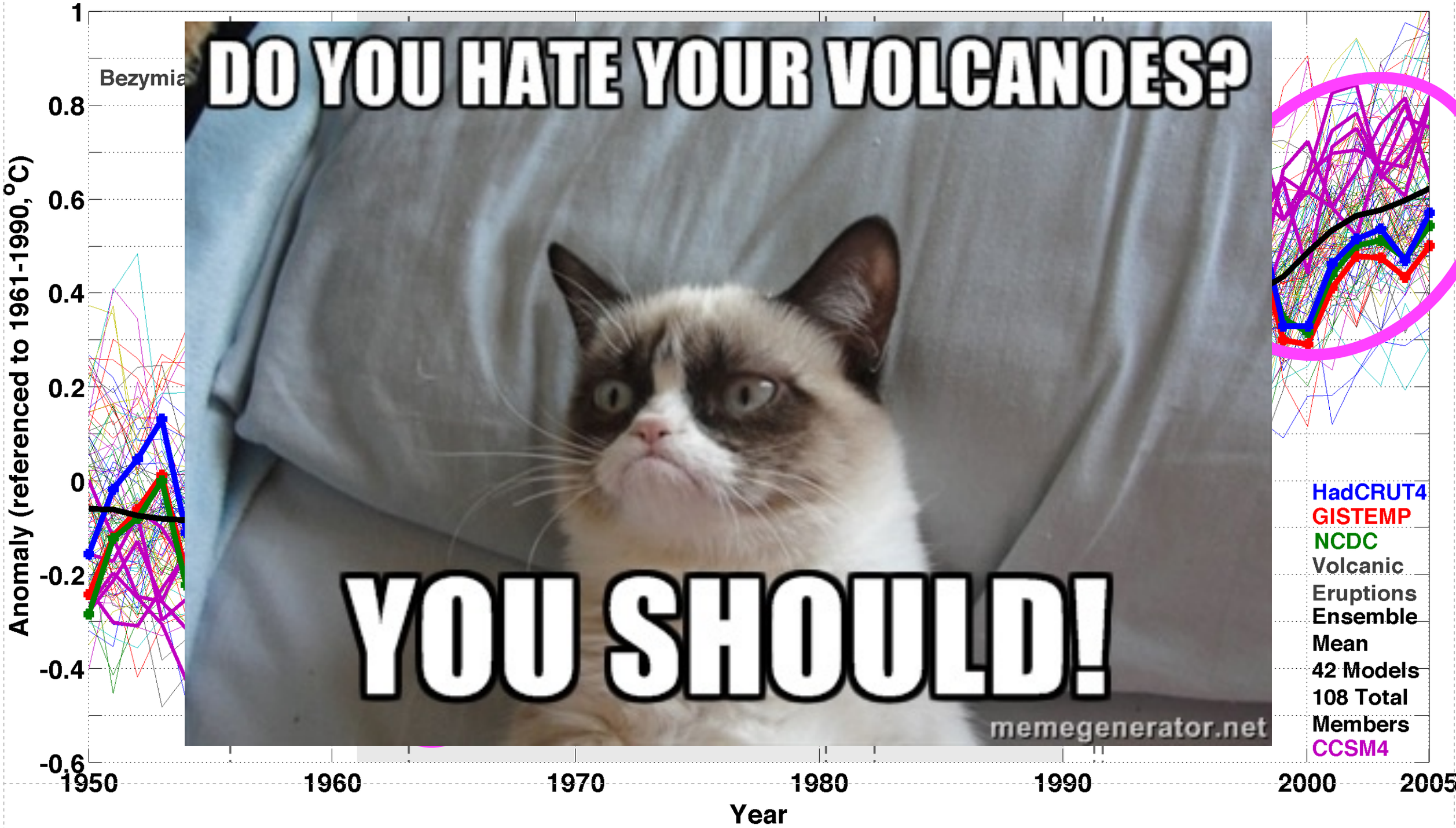
Motivation: Why are there Discrepancies?



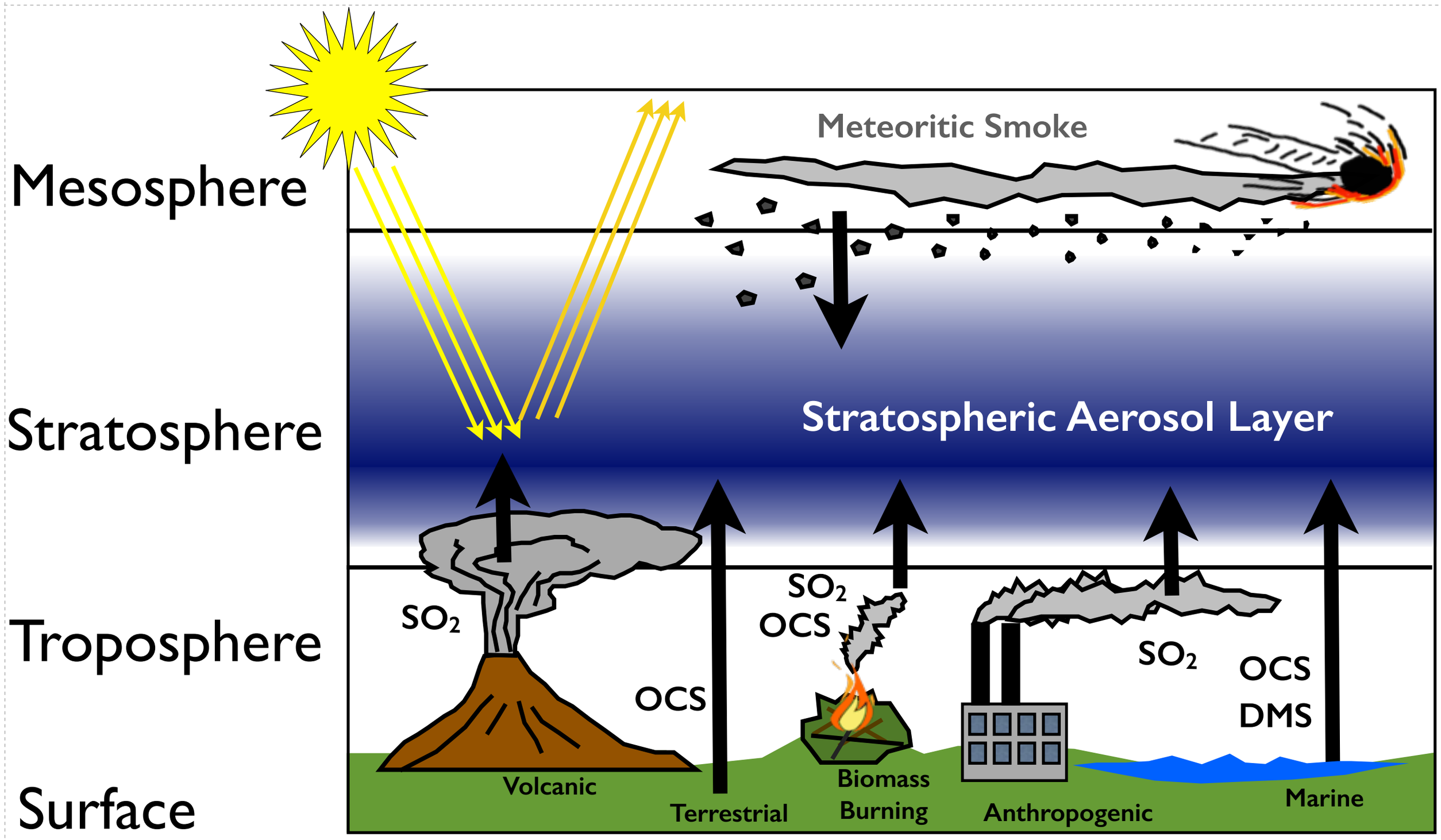
Motivation: Why are there Discrepancies?



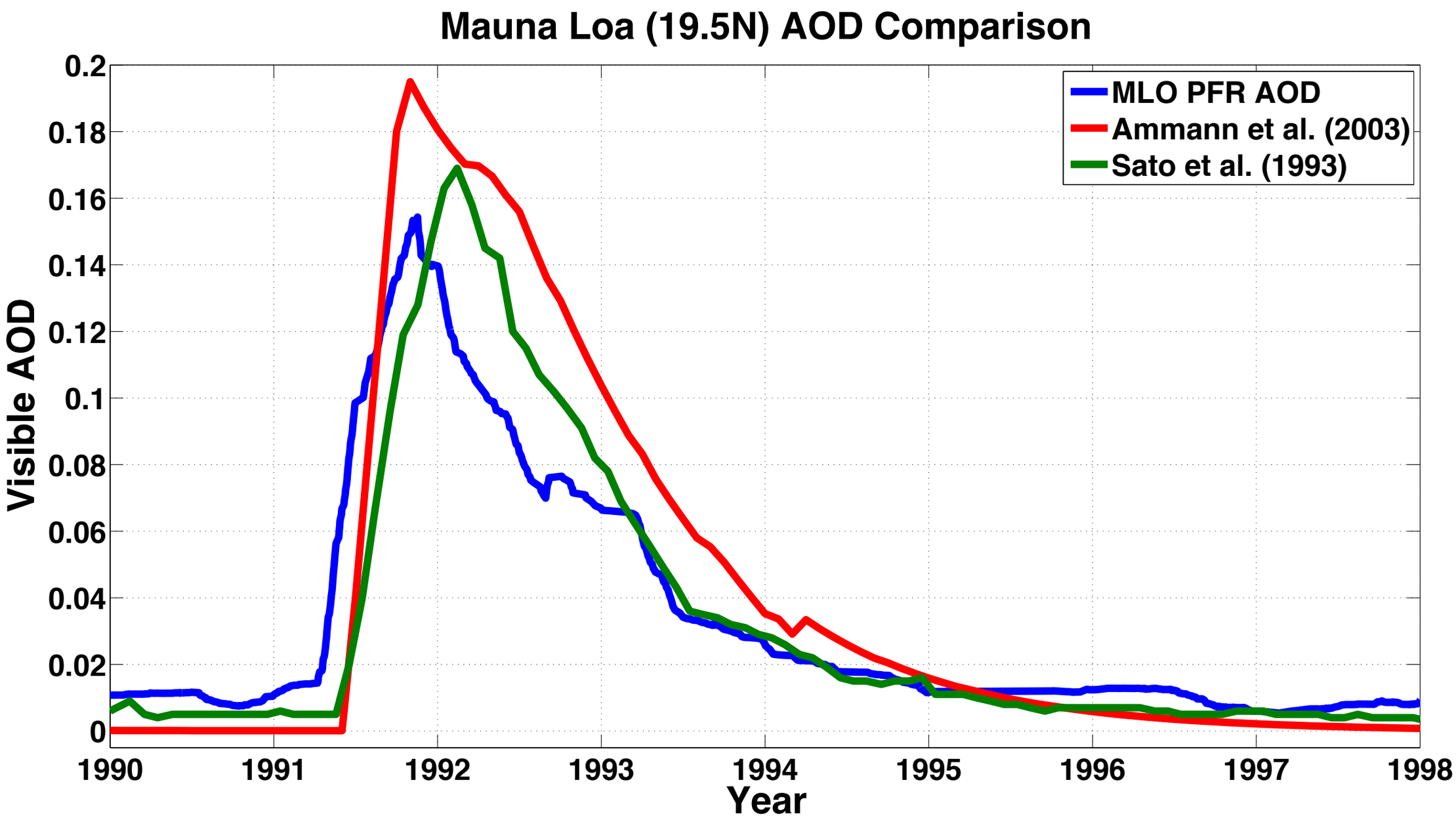
Motivation: Why are there Discrepancies?



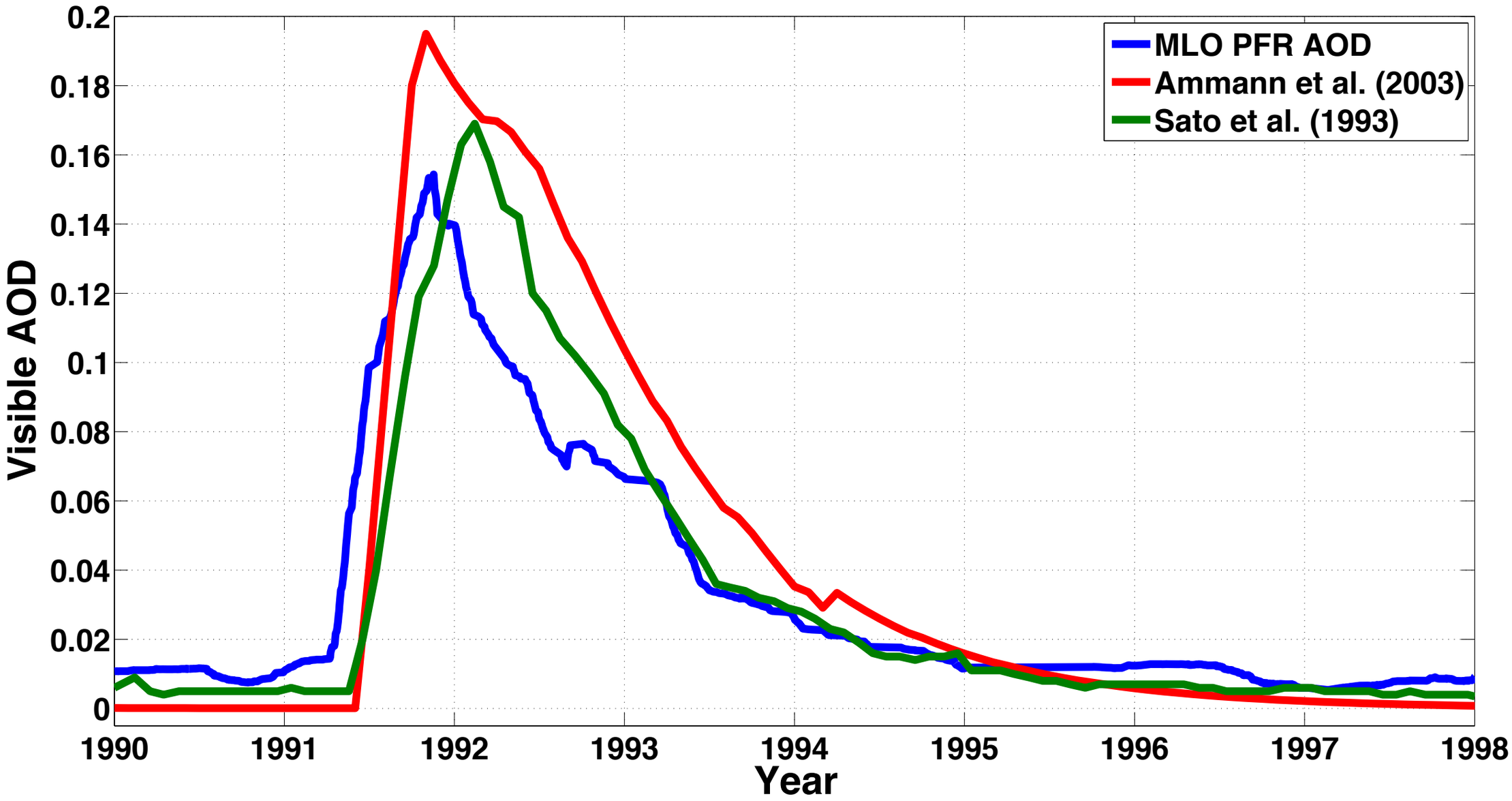
Overview of Stratospheric Aerosols



Problems with Stratospheric AOD Forcing



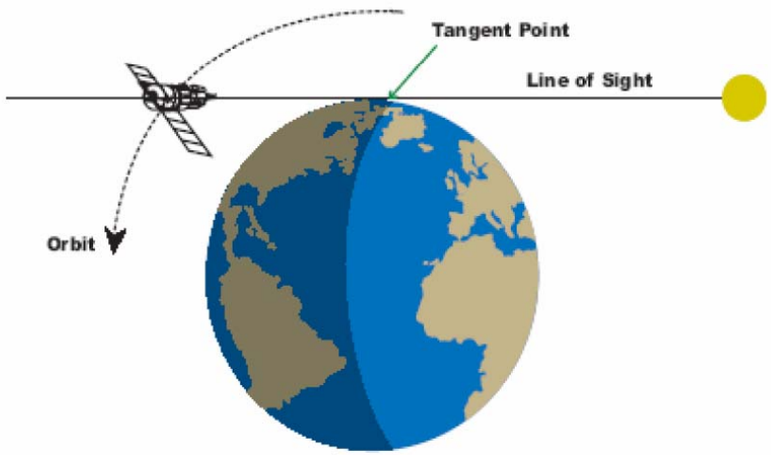
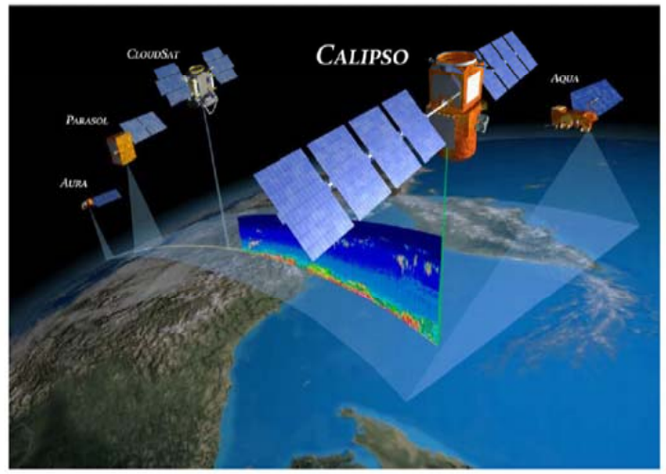
Problems with Stratospheric AOD Forcing



What are the best constraints for volcanic aerosol forcing?

How can we make a better forcing file?

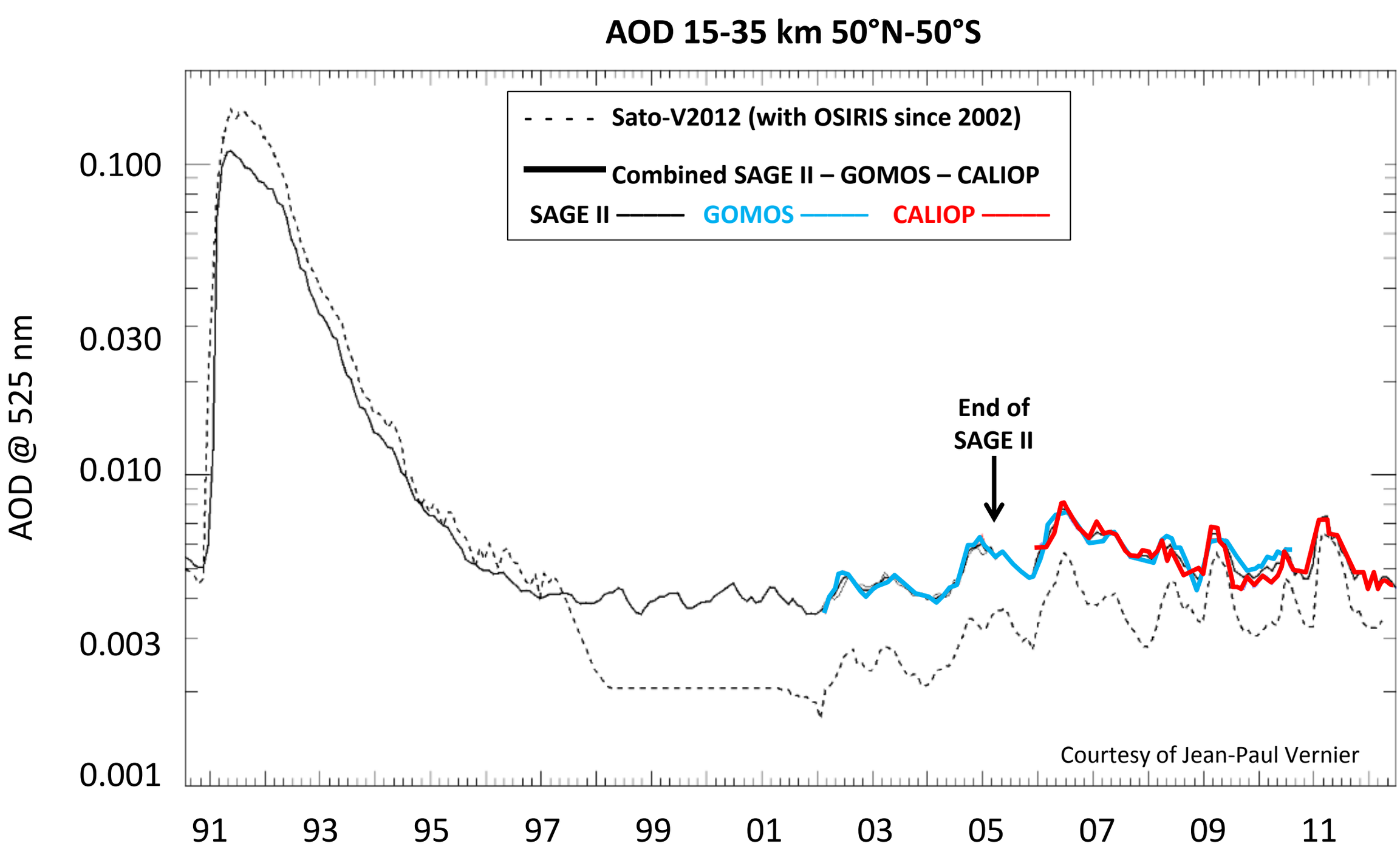
A New Dataset for CCMI for 1960-2013

1960-1978	1979-2005	2006-2011
		
Photometer	SAGE I, SAM II, SAGE II	CALIOP
Ground photometers: Optical depths at 550 nm.	(1) SAGE I: 1979-1980, extinction coefficients at 1020 nm (2) SAM II: 1981-1984, extinction coefficients at 1020 nm (3) SAGE II: 1984-2005, extinction coefficients at 1020, 525, 452 and 386 nm.	CALIOP: Backscatter and extinction coefficients at 532 nm.

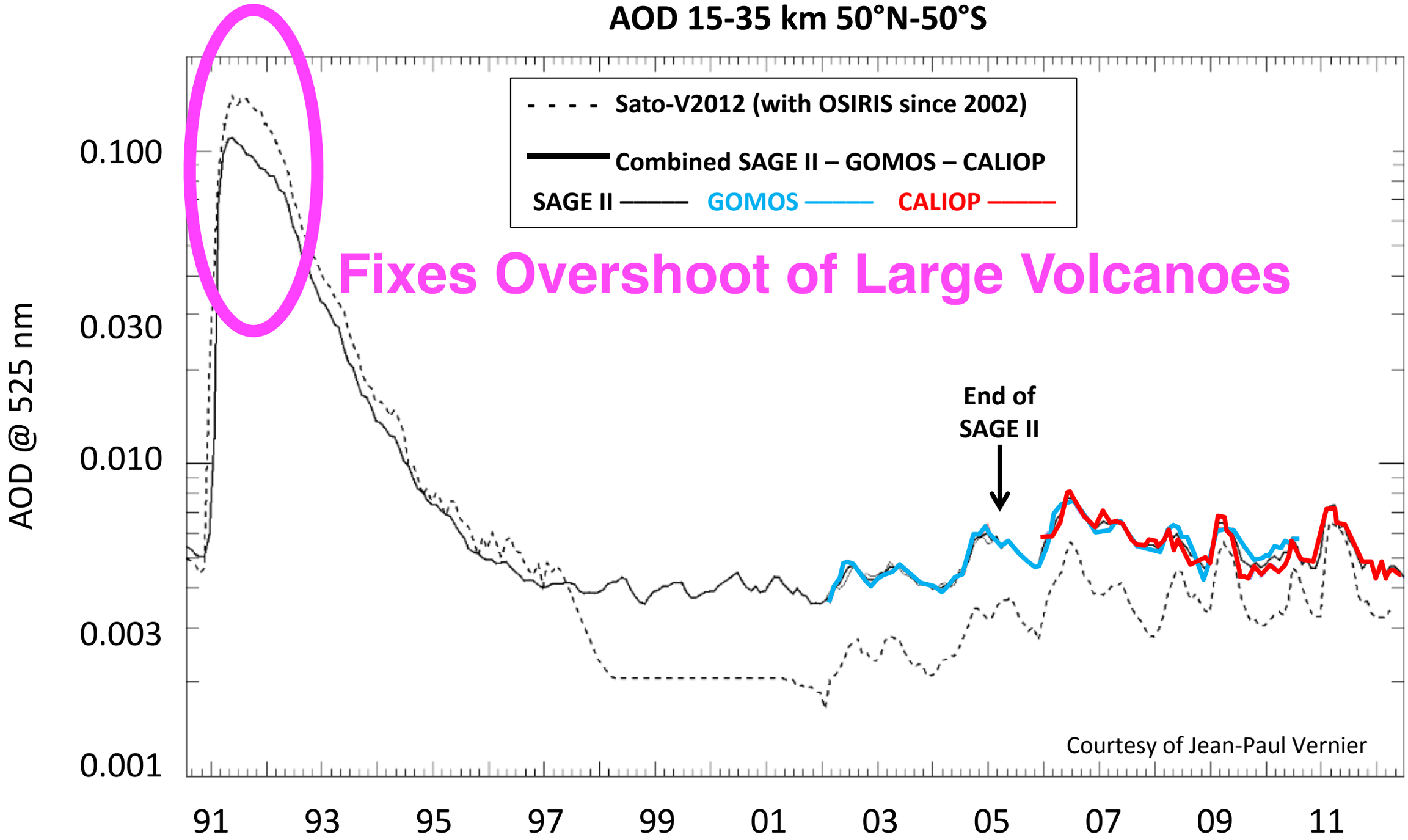
Chemistry-Climate Model Initiative (CCMI, http://www.igacproject.org/CCMI)

For more details see: Arfeuille, F., and B.-P. Luo (2013), Uncertainties in modeling the stratospheric warming following Mt. Pinatubo eruption,ACP

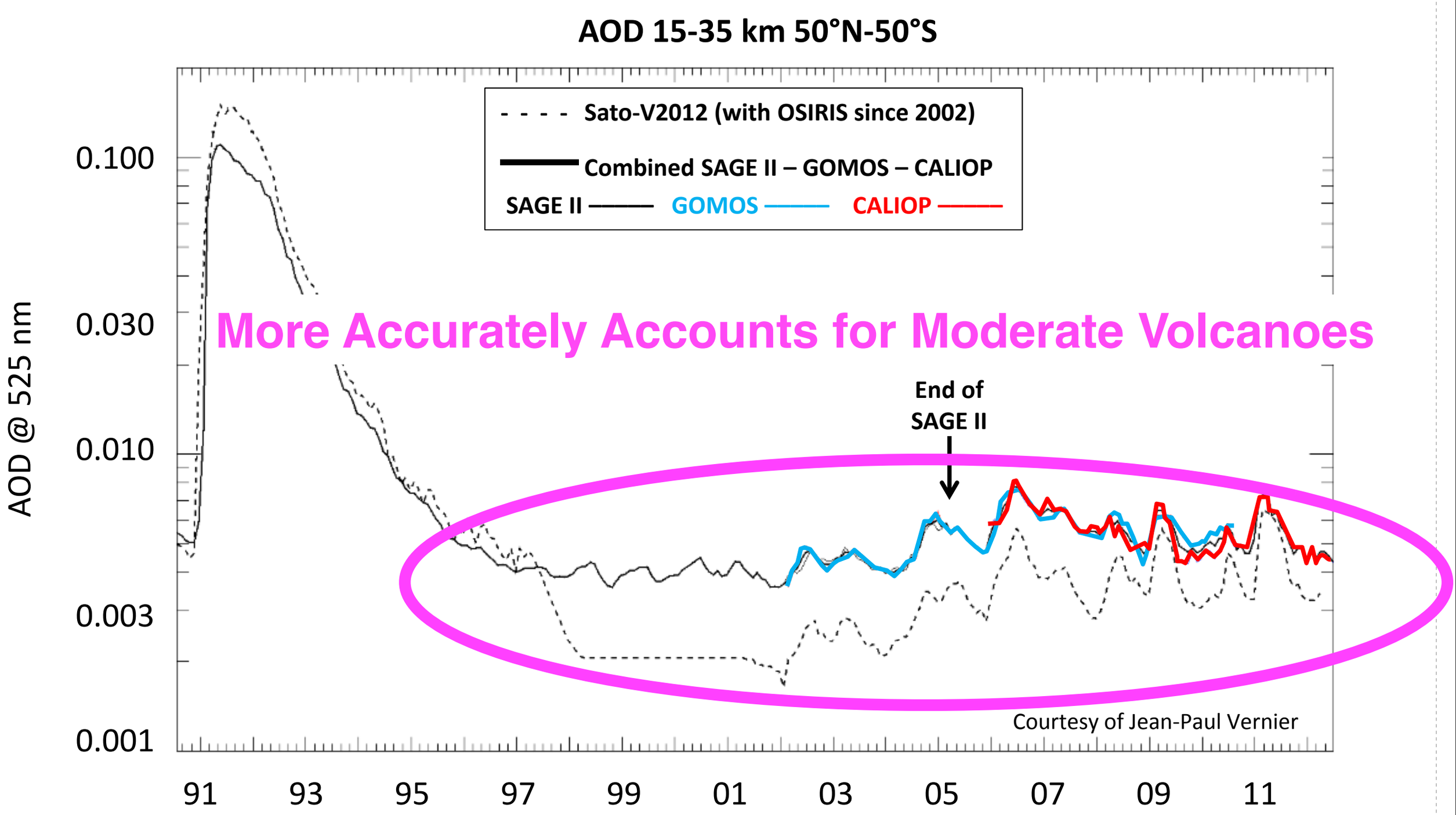
A New Dataset for CCMI: Strat. AOD



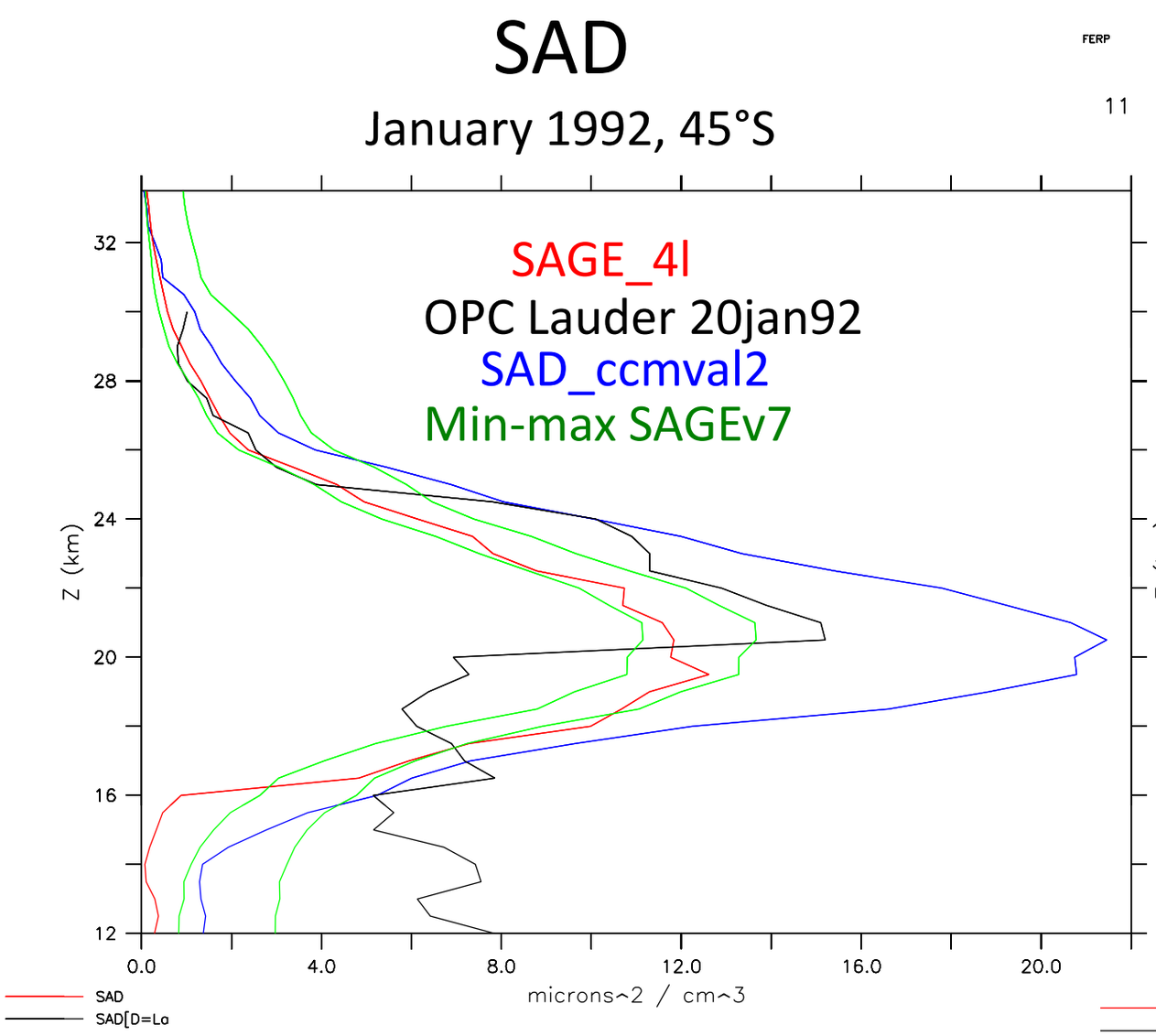
A New Dataset for CCMI: Strat. AOD

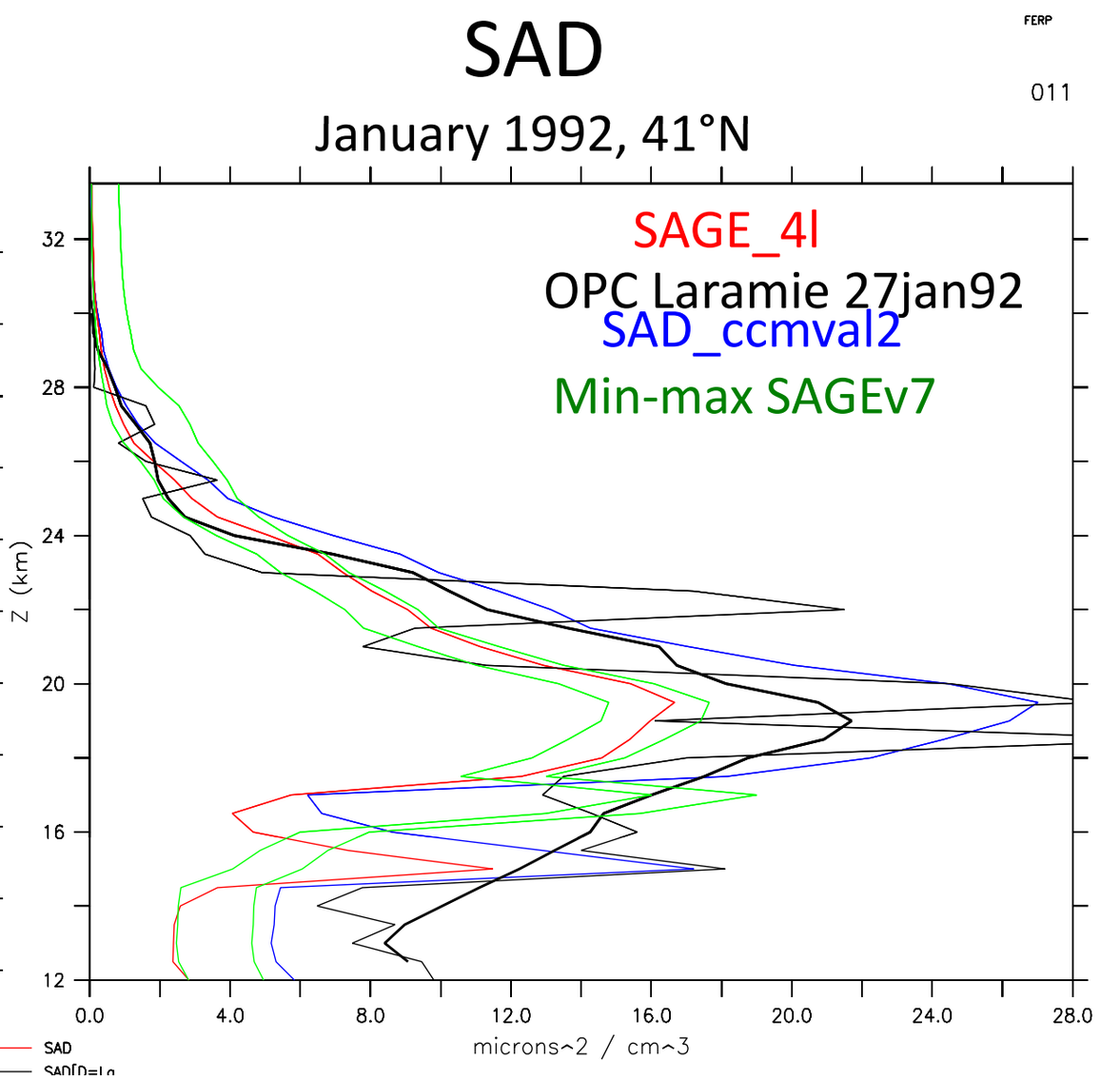


A New Dataset for CCMI: Strat. AOD



A New Dataset for CCMI: SAD





Courtesy of Arfeuille, F., and B.-P. Luo (2013, CCMI Meeting)

Implementation in CESM(All Flavors)

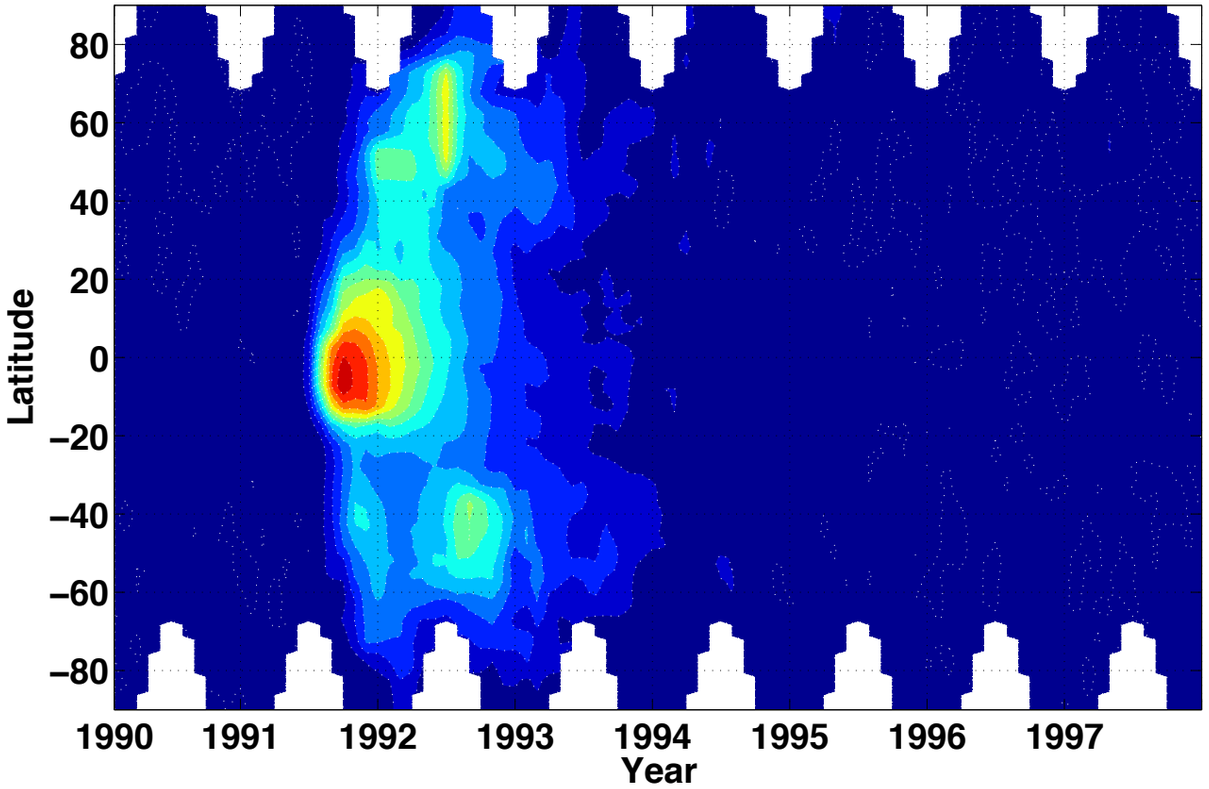
- **New mass, radius and SAD inputs** based on CCMI reanalysis
- **Improved** optical lookup **tables** for **CAMRT and RRTMG**
- **Coherent** treatment of input for **radiation** and **chemistry** parameterizations
- Test Setup:
  - Focus on Pinatubo (June, 1991)
  - Ensemble of 5 each for the

Old, New, and Background

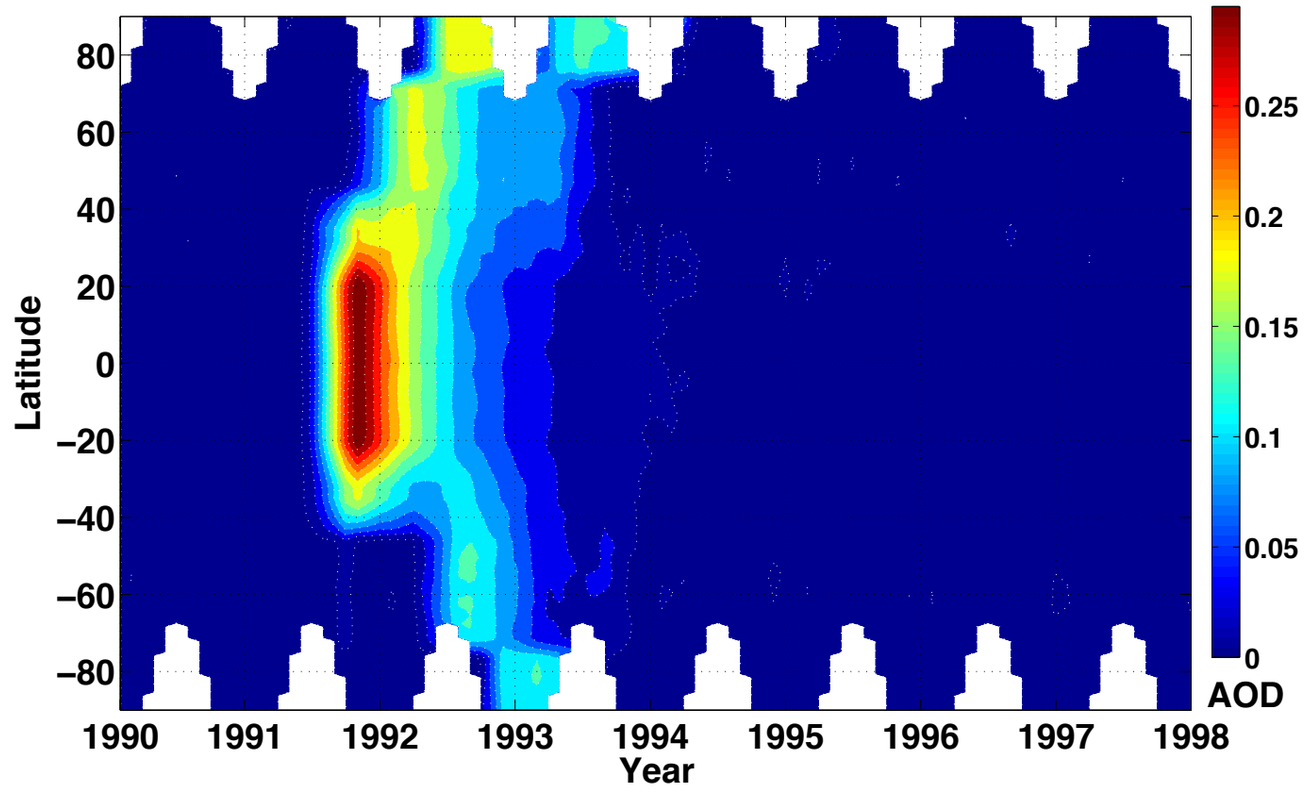
Mt. Pinatubo, June 12, 1991, USGS

Changes in Stratospheric AOD

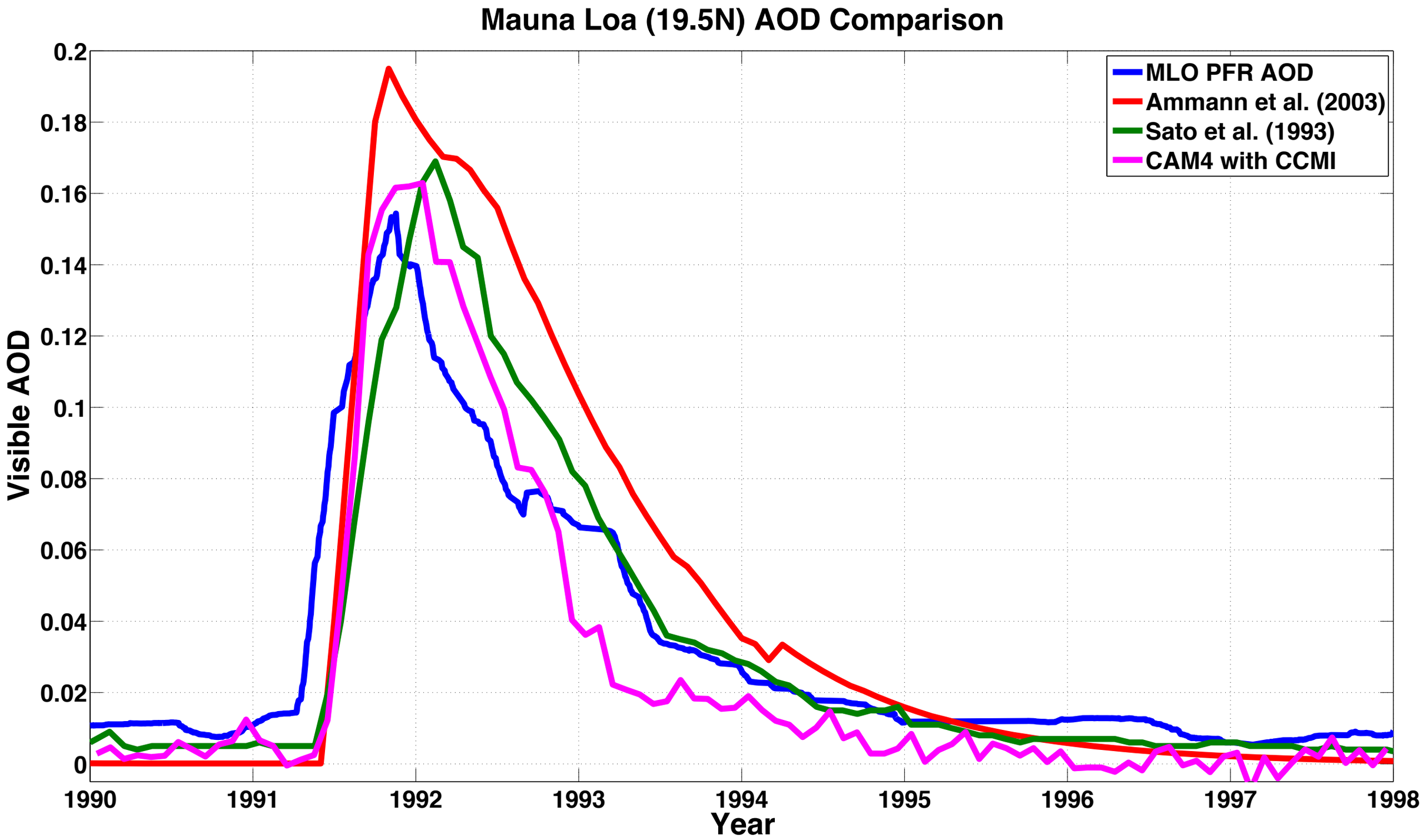
New/CCMI



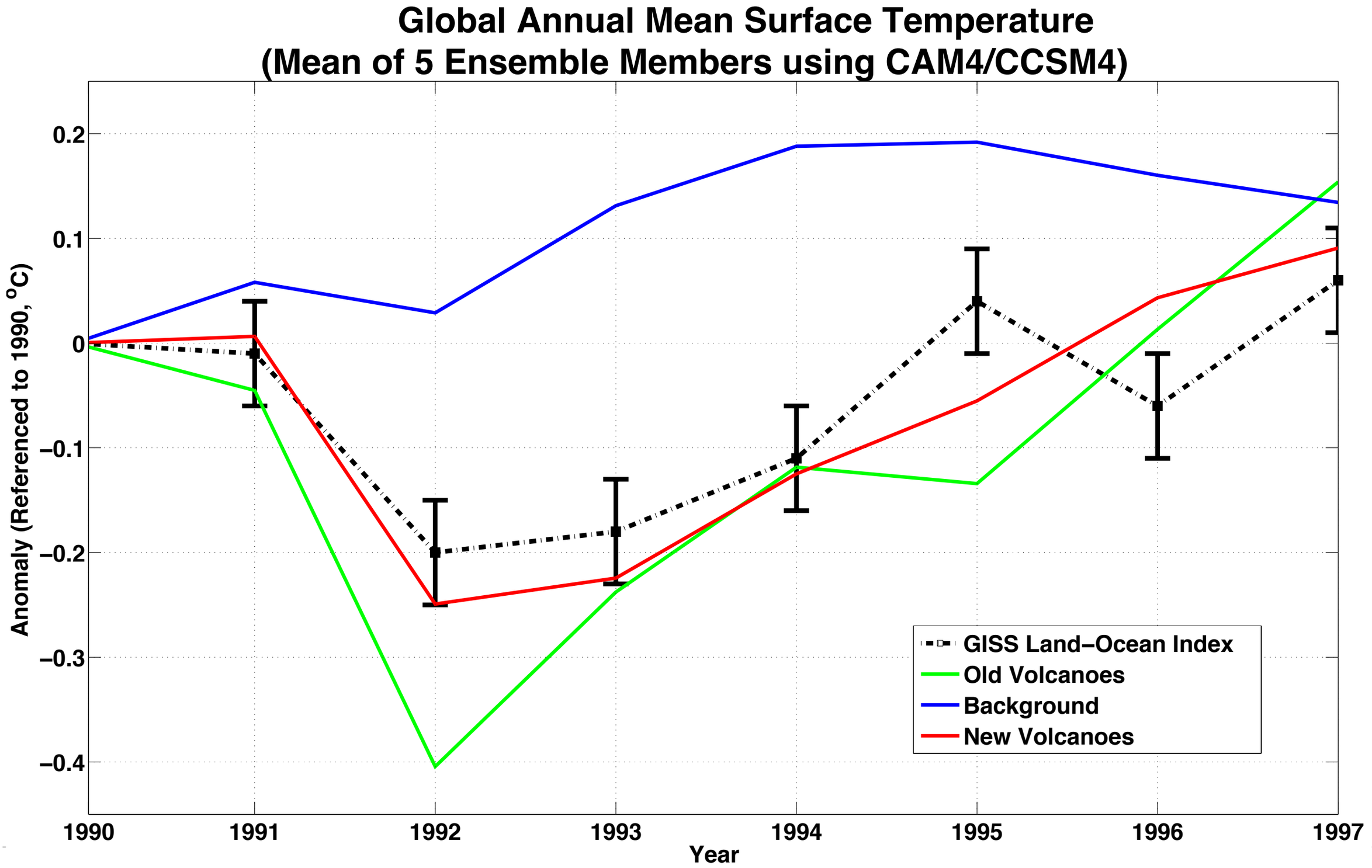
Old/CCSM4



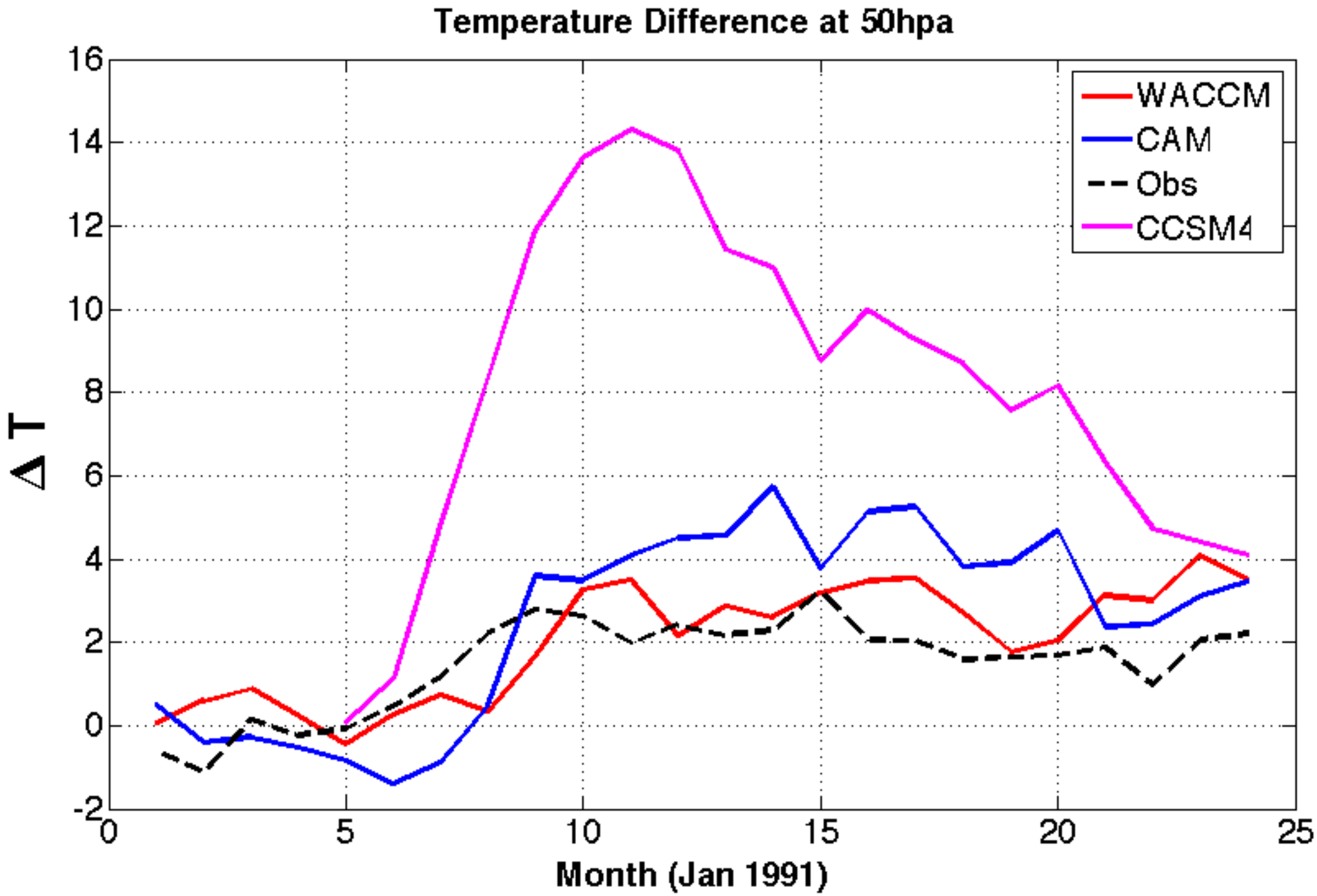
Changes in MLO Stratospheric AOD



Implementation in CESM(All Flavors)

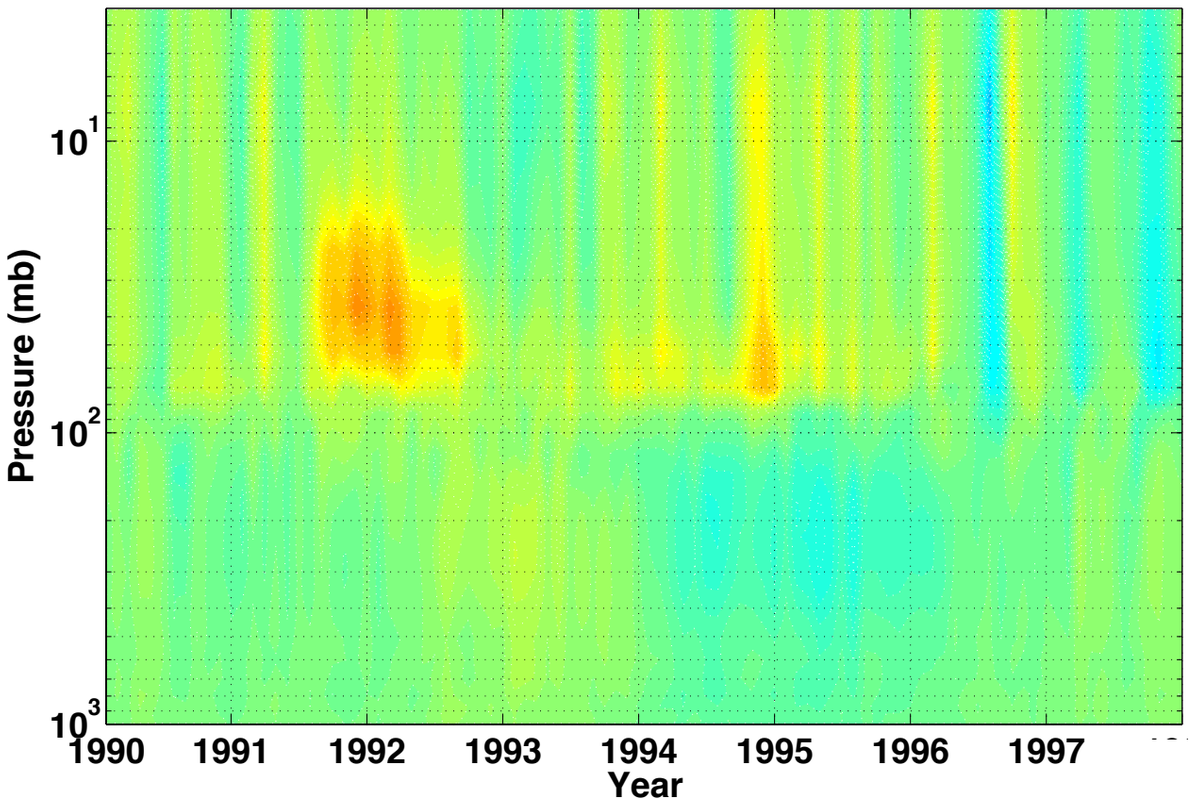


Upper Atmosphere Warming

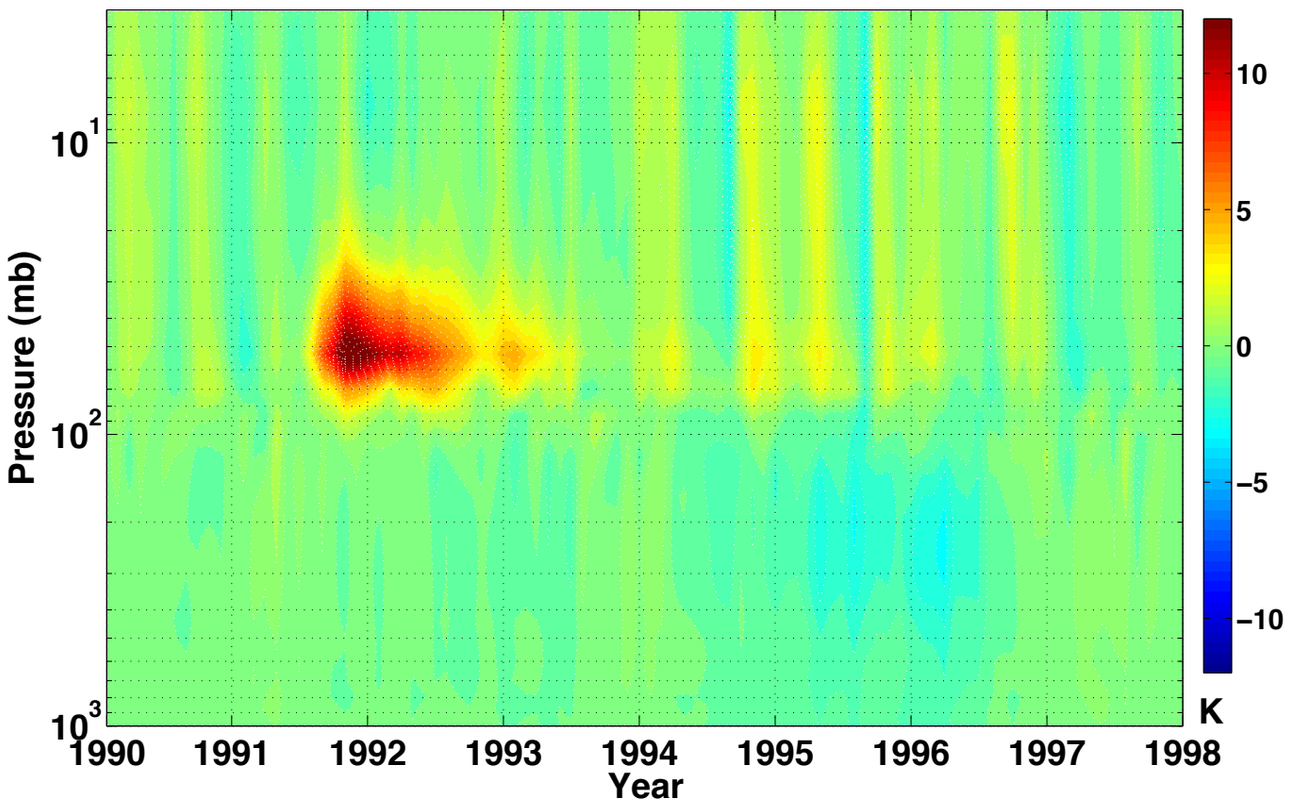


Changes in Stratospheric Heating

New/CCMI

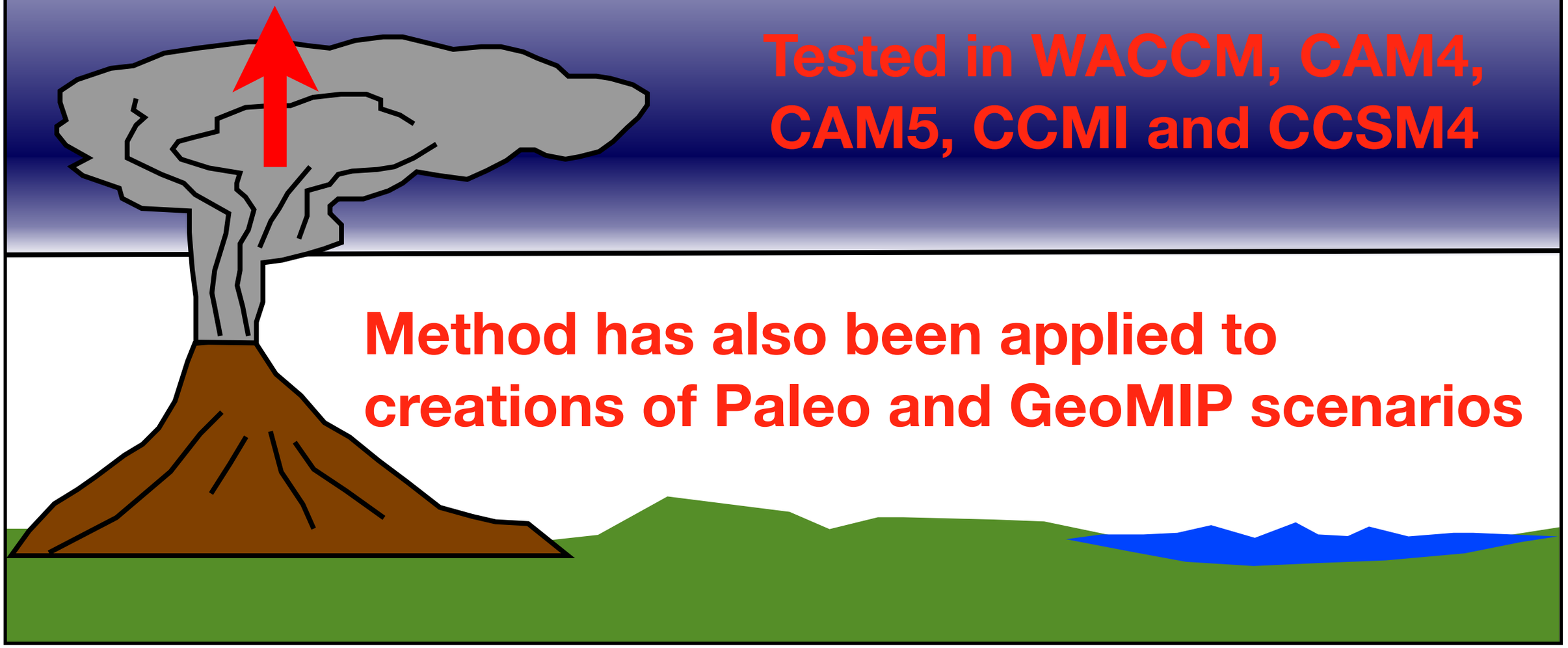


Old/CCSM4

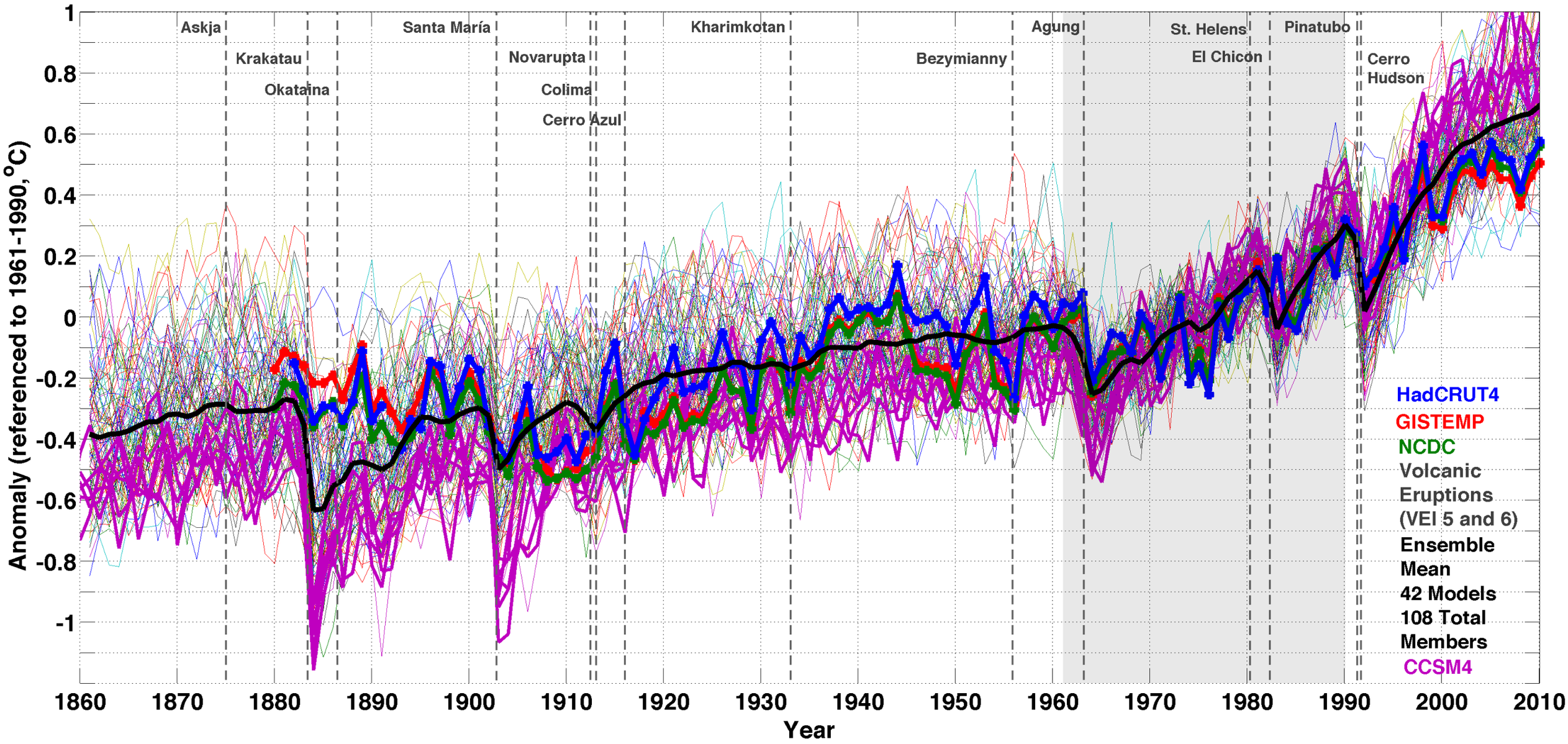


Conclusion

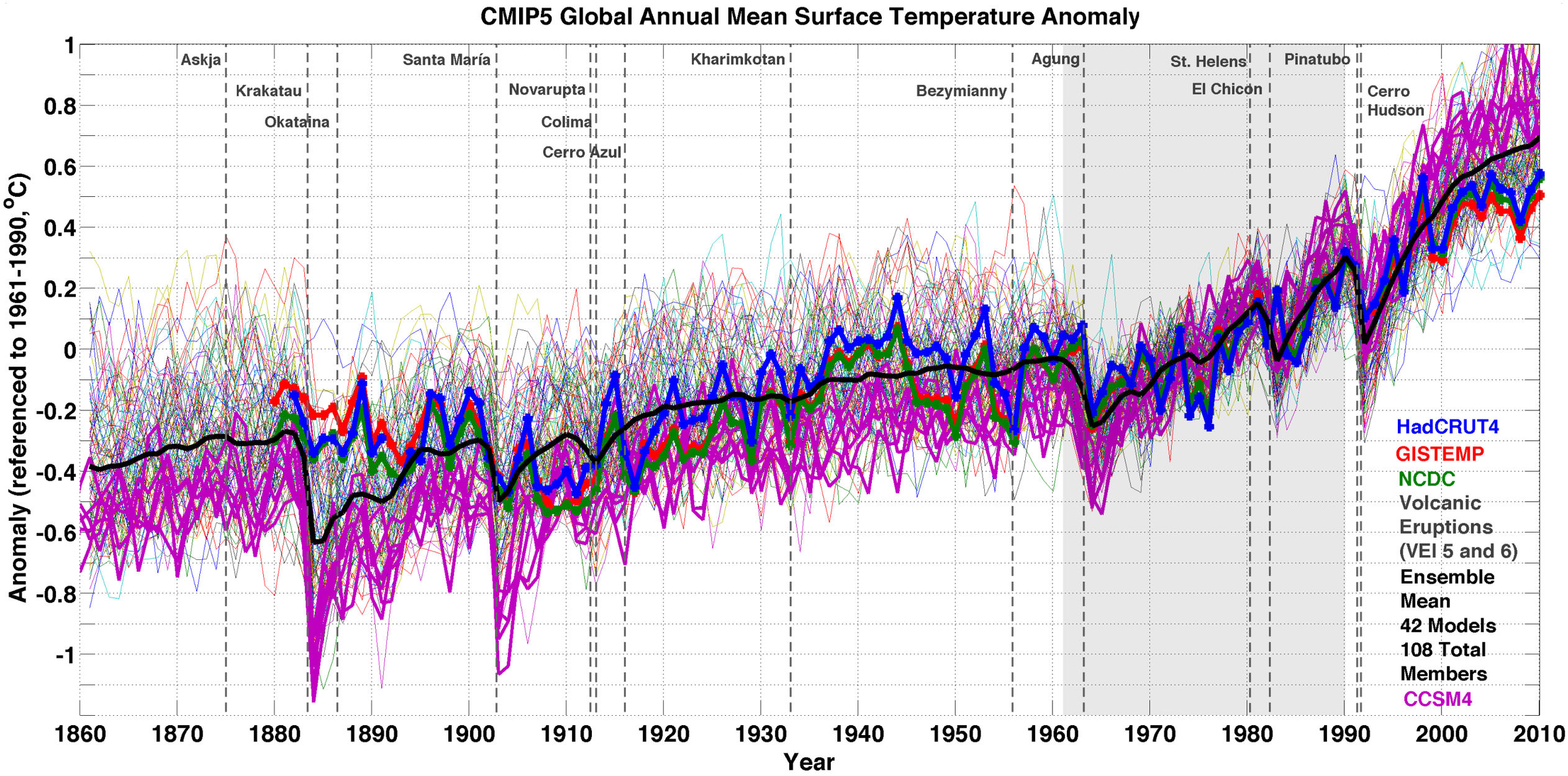
A New Parameterization of Stratospheric Aerosol has been implemented in CESM



Next Steps…What about Prior 1960?

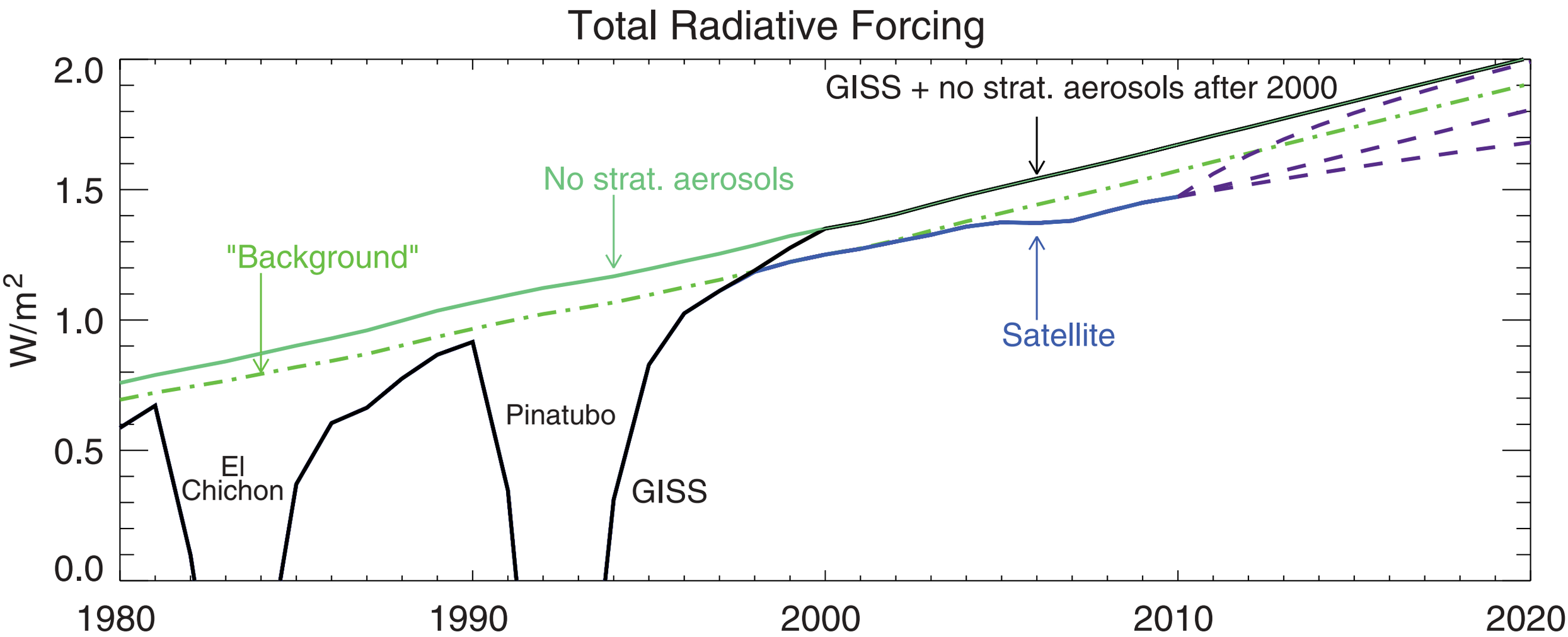


What about Prognostics Stratospheric Aerosols?



Questions?

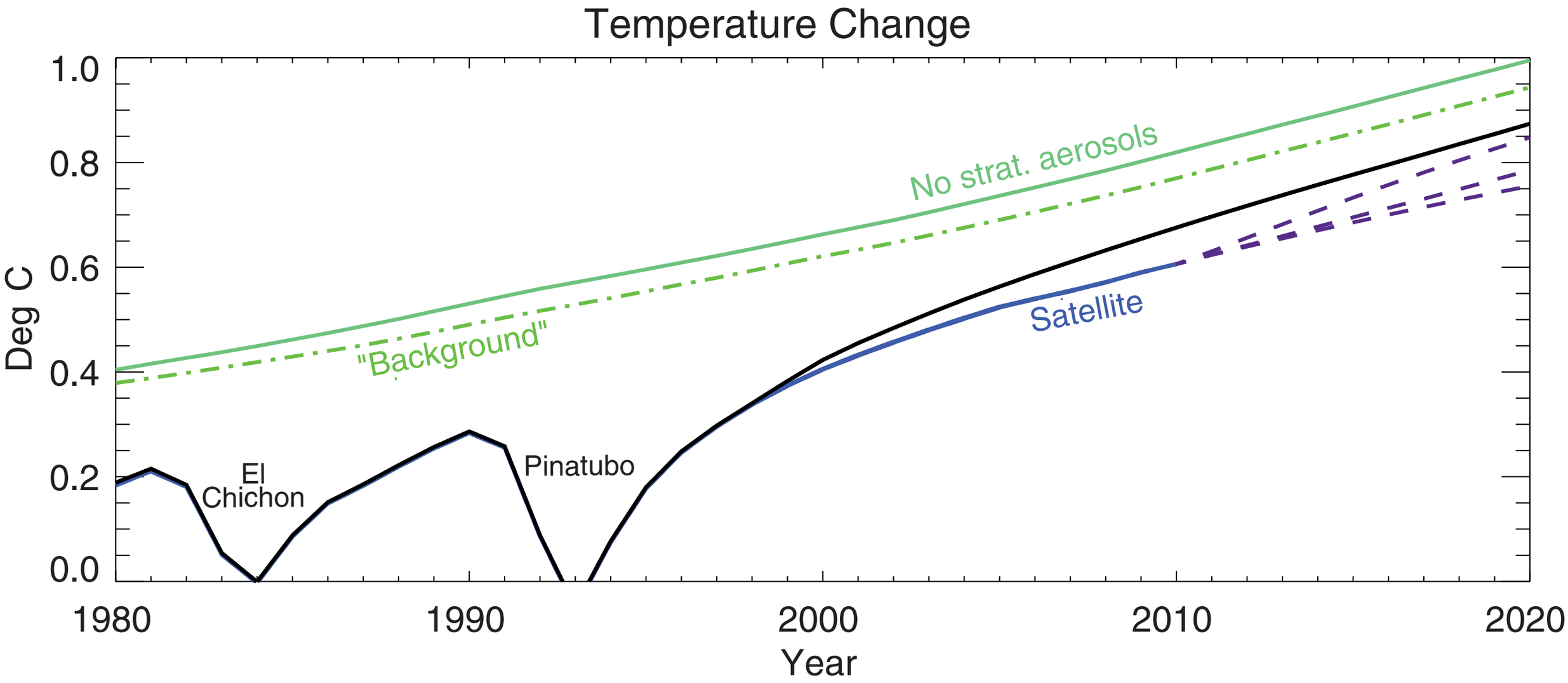
The Role of Moderate Volcanoes and the ‘Hiatus’



Greenhouse gas forcing increased continuously throughout period.
Stratospheric aerosol only slowed increase by ~0.2W/m²

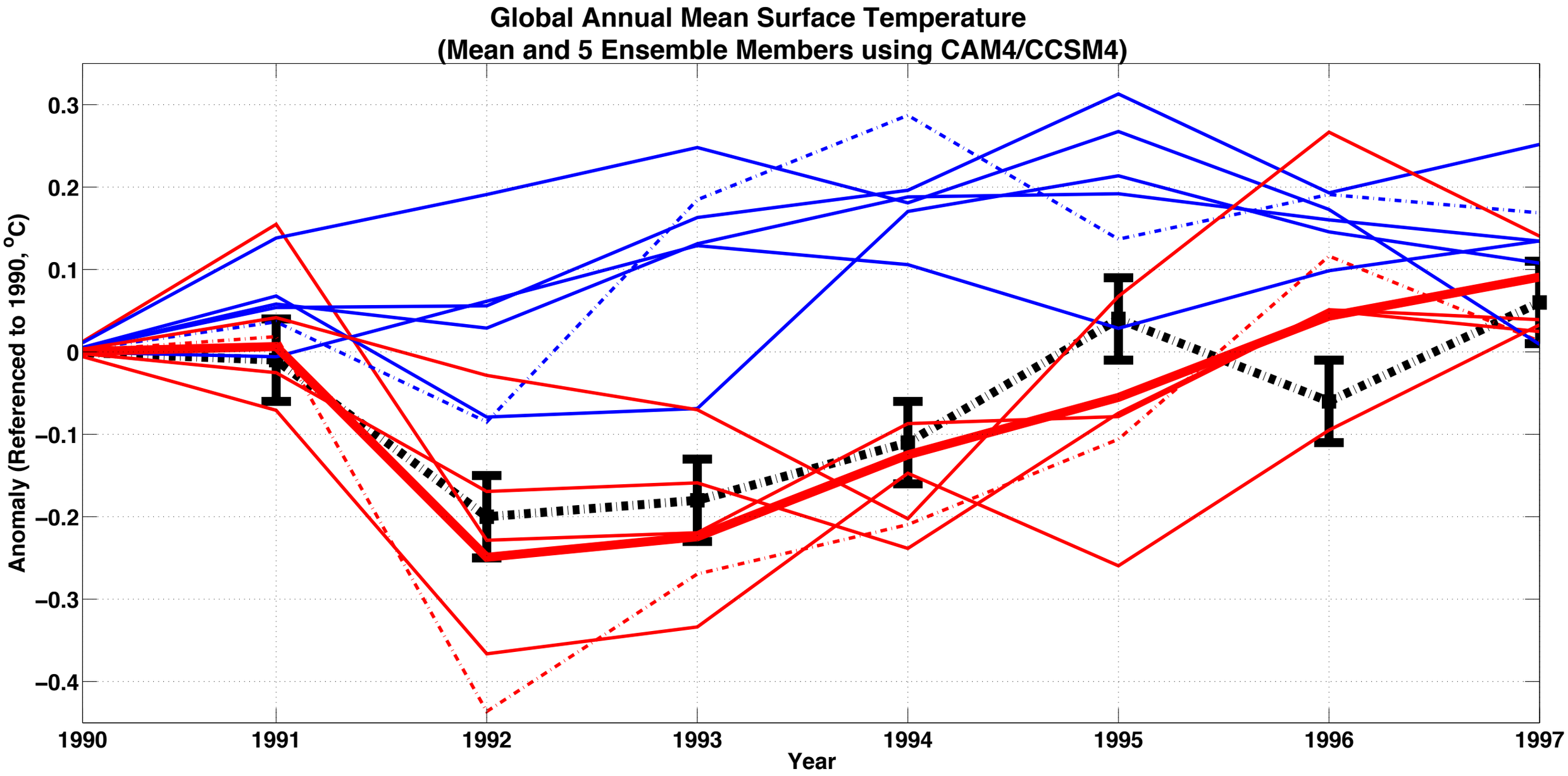
Adapted from Solomon et al. (2011), The Persistently Variable “Background” Stratospheric Aerosol Layer and Global Climate Change, *Science*.

Impacts on global temperature



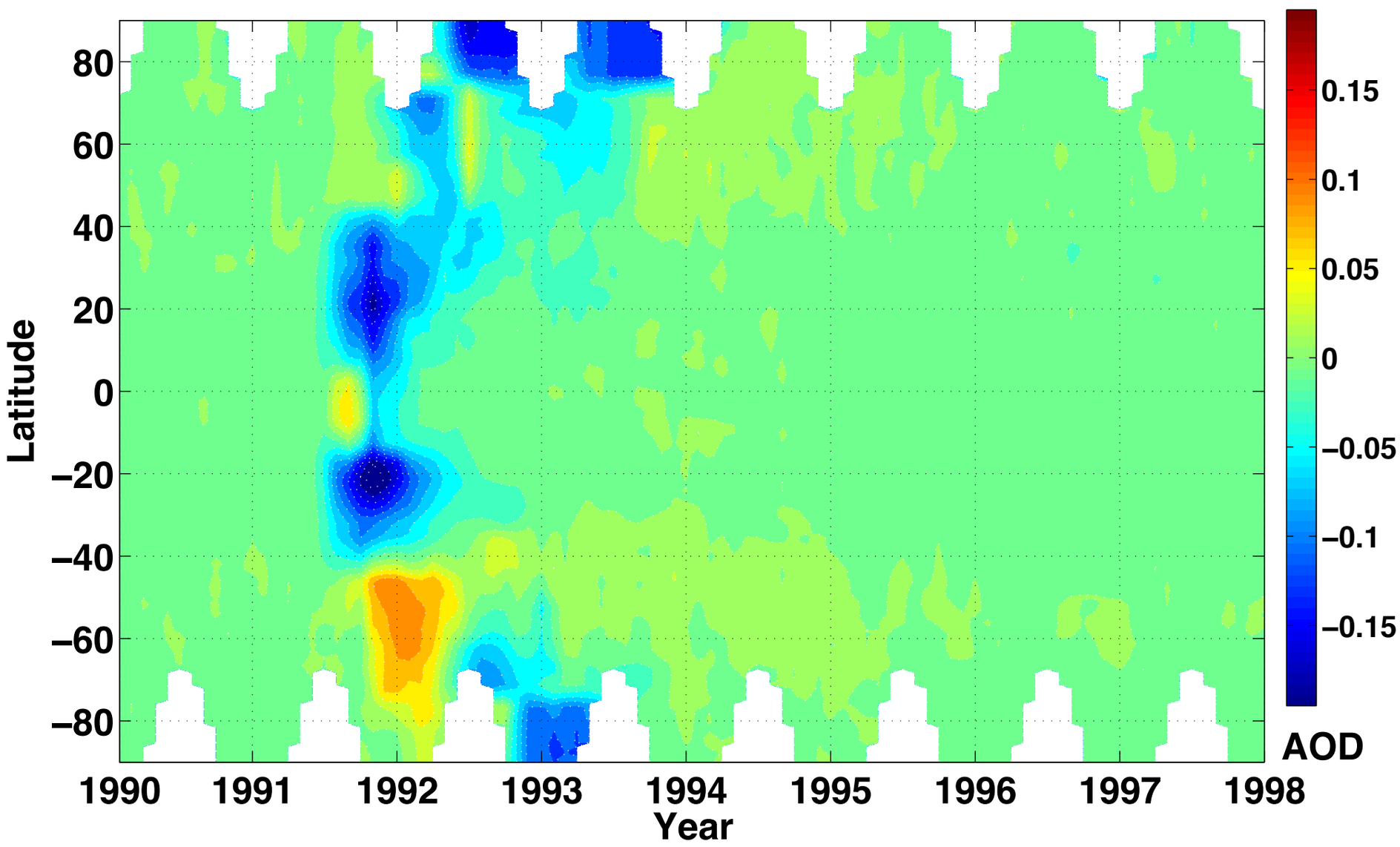
Ignoring the moderate volcanoes from 2000 to 2010 may lead to an underestimate of global temperature of ~0.1°C in 2010

Remaining Questions: Why is the Response so Variable?

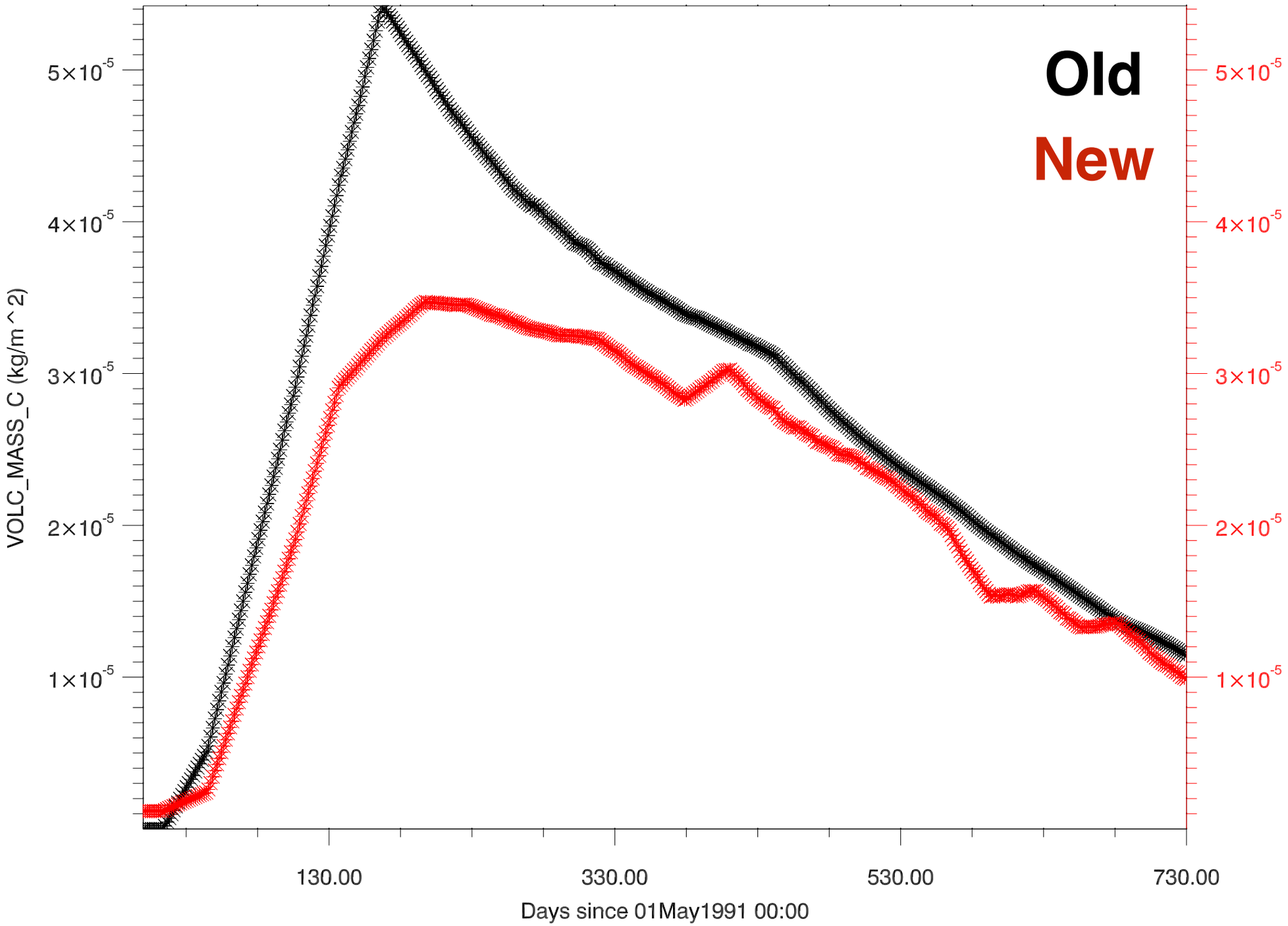


Changes in Stratospheric AOD

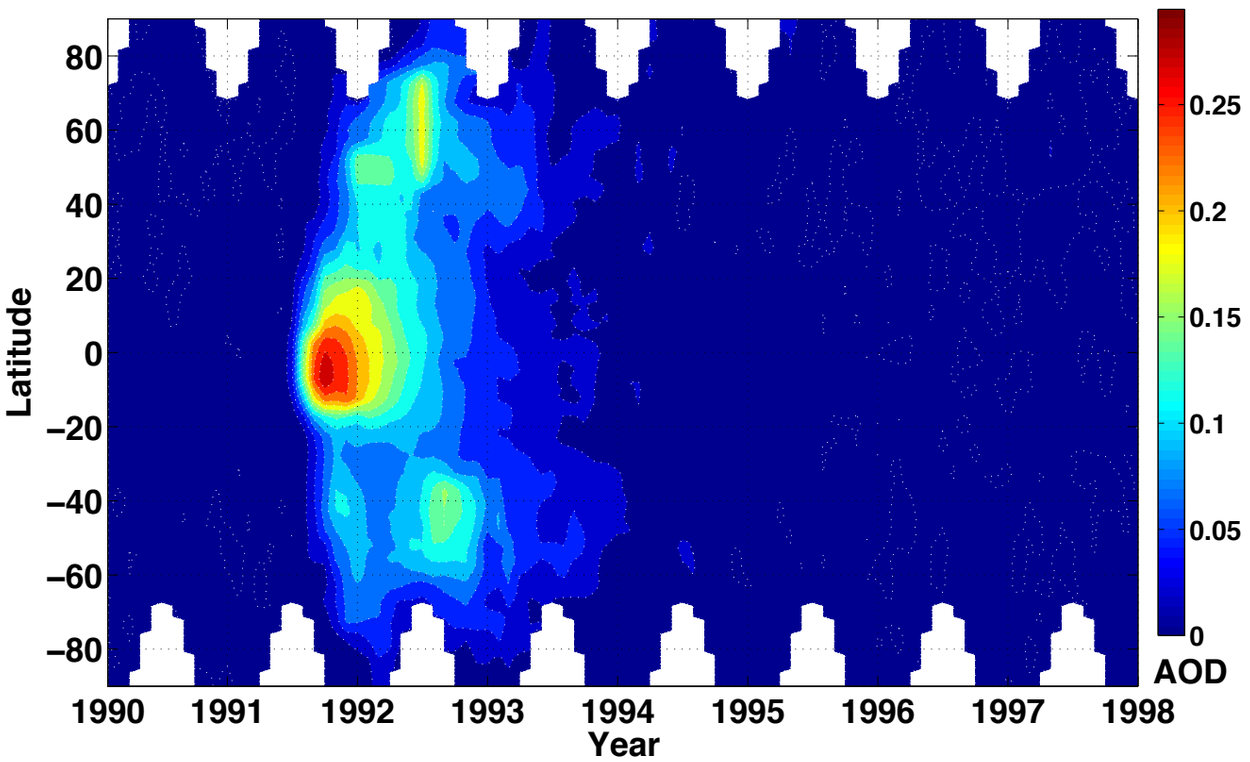
New/CCMI **minus** **Old/CCSM4**

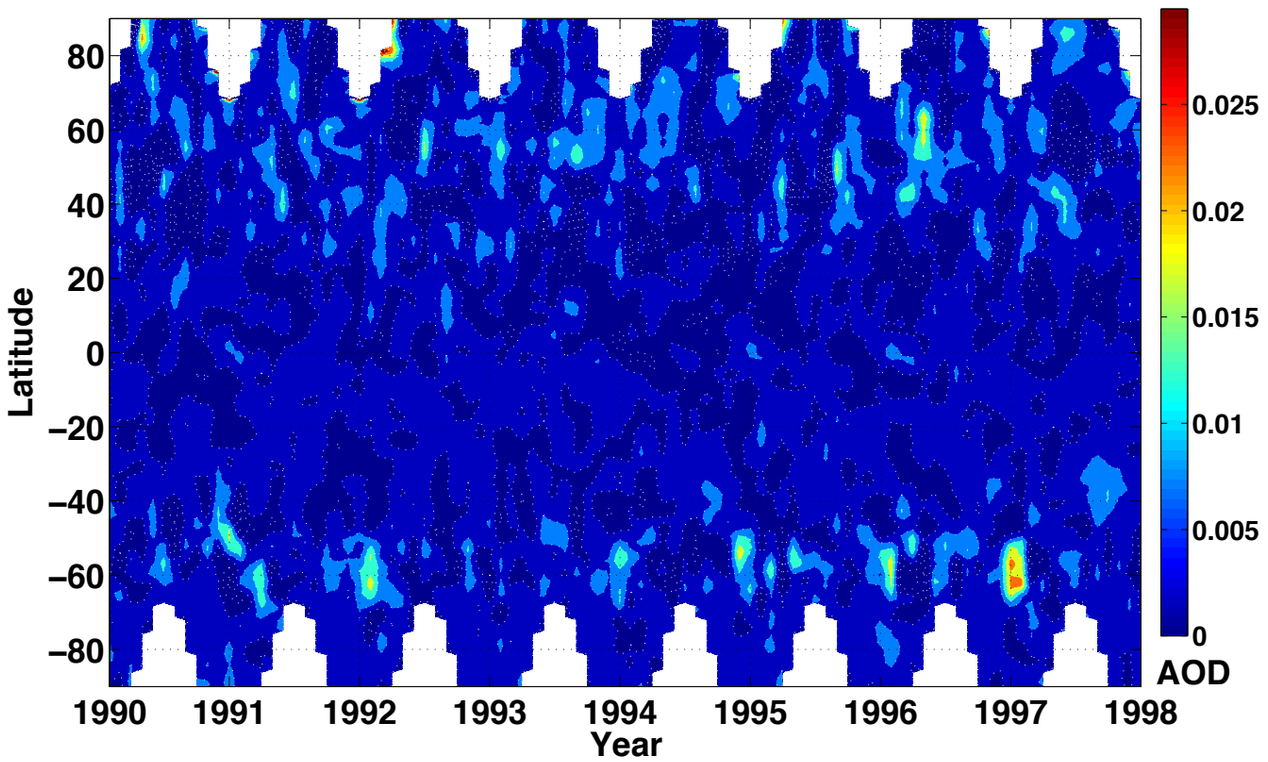


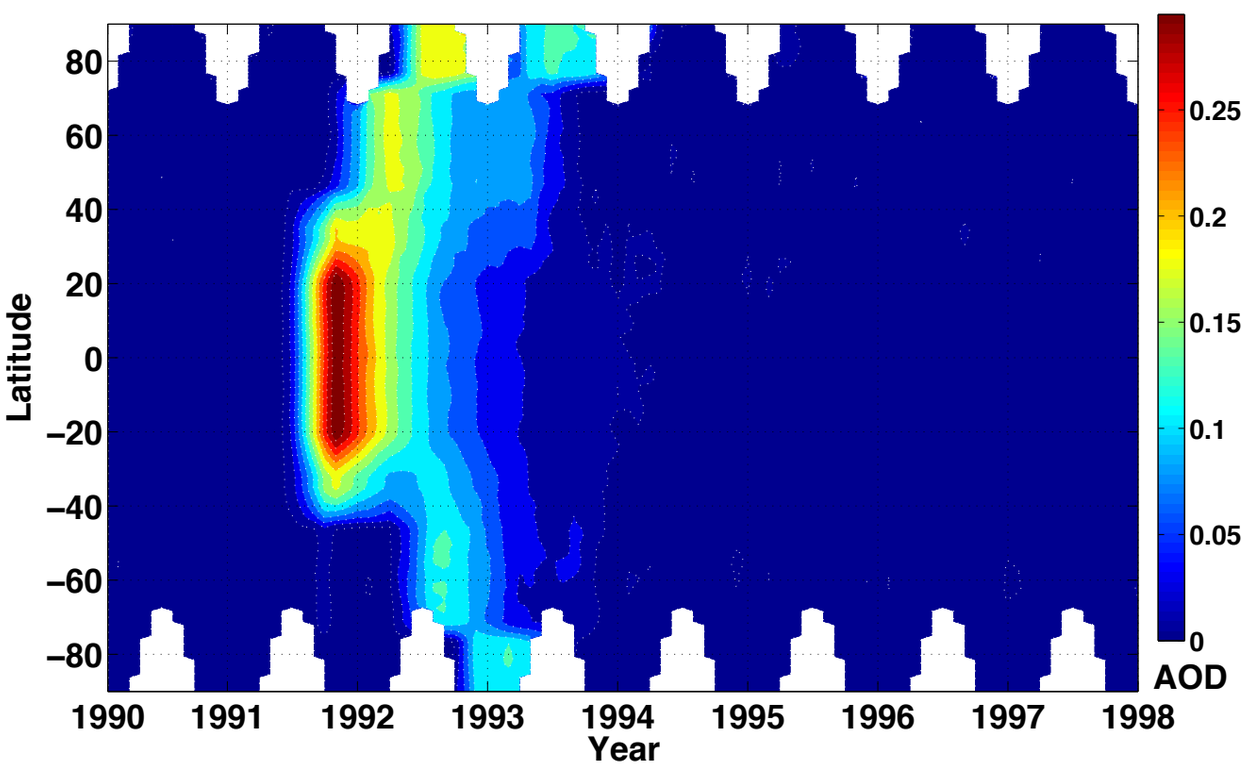
Where is the Change in AOD Coming From?

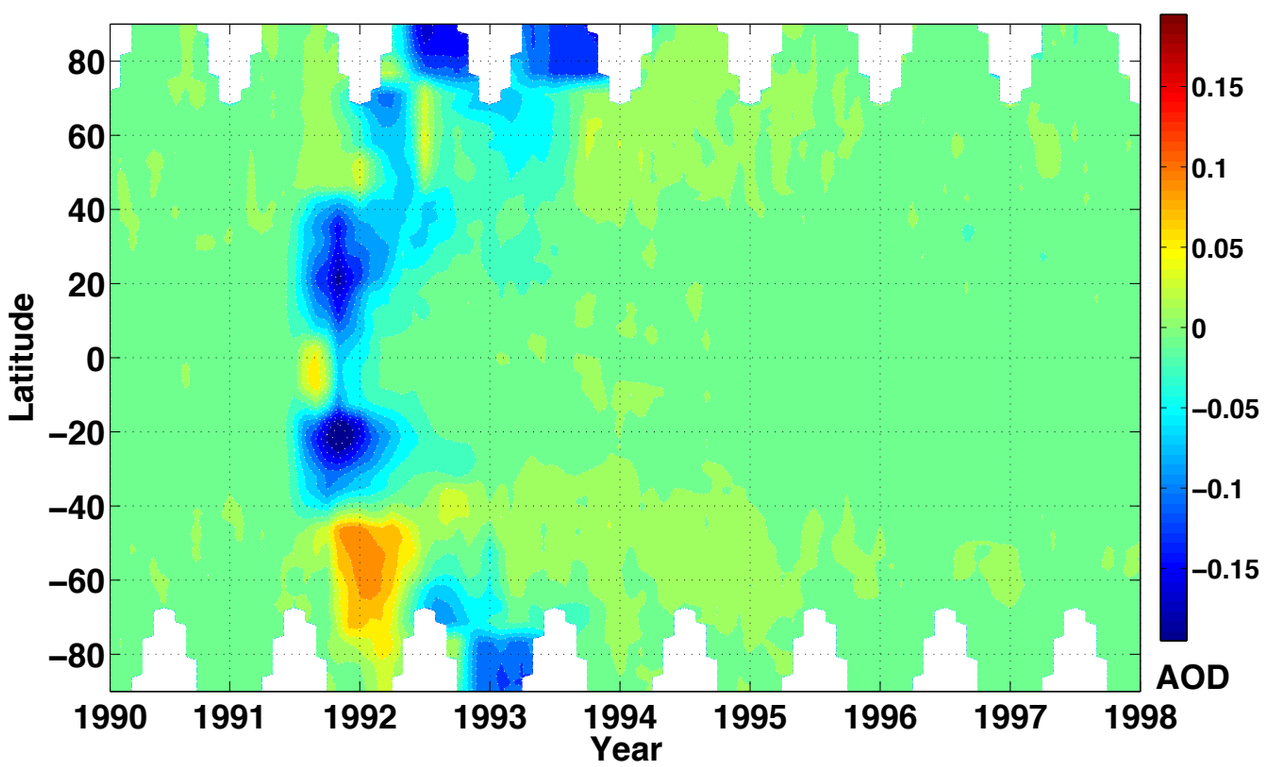


AOD

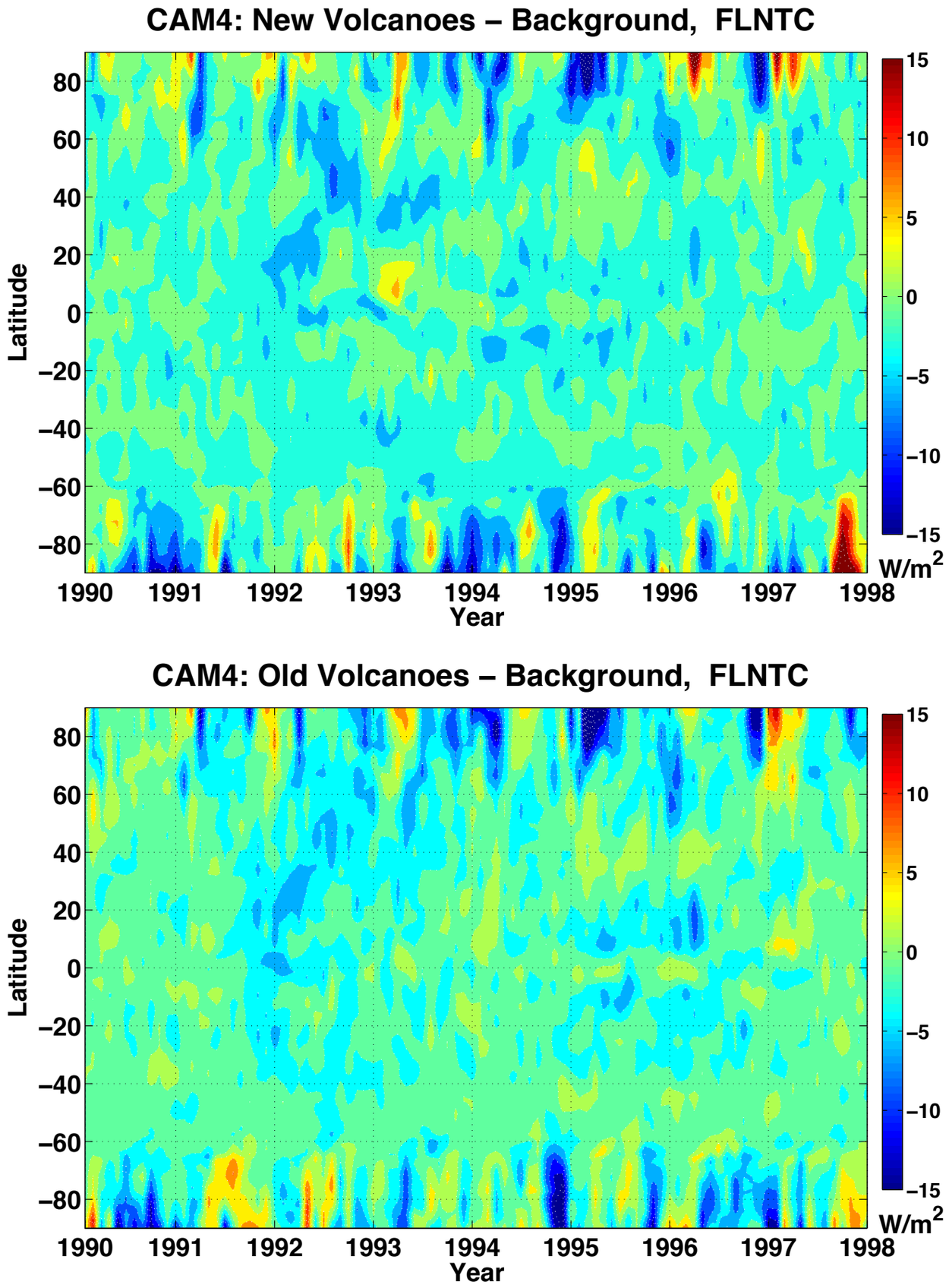

CAM4: New Volcanoes – Background, AEROD$_V$
Latitude
80
60
40
20
0
−20
−40
−60
−80
1990
1991
1992
1993
1994
1995
1996
1997
1998
Year
0.25
0.2
0.15
0.1
0.05
0
AOD


CAM4: Background – No Stratospheric Aerosol, AEROD$_V$
Latitude
80
60
40
20
0
−20
−40
−60
−80
1990
1991
1992
1993
1994
1995
1996
1997
1998
Year
0.025
0.02
0.015
0.01
0.005
0
AOD

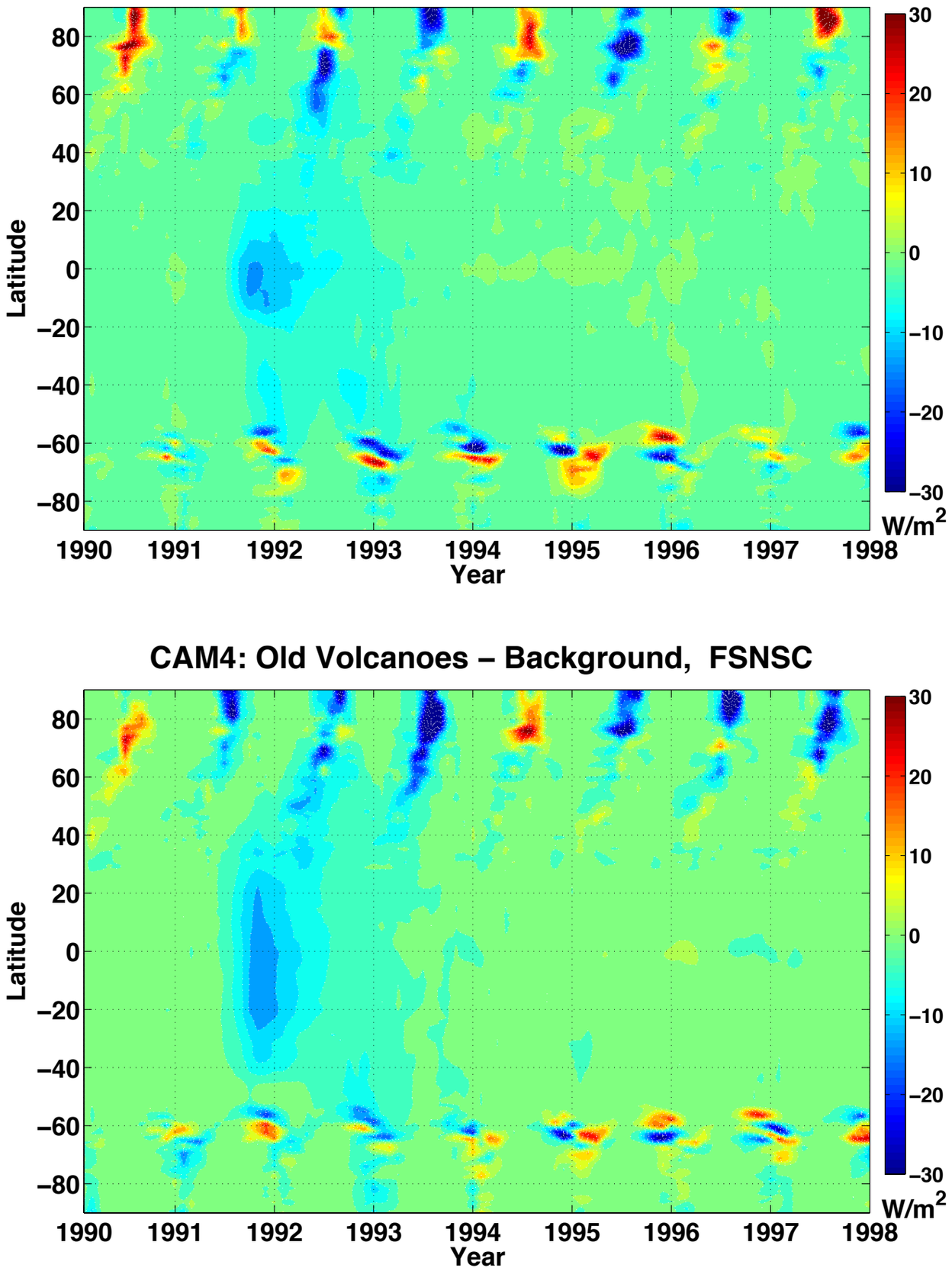

CAM4: Old Volcanoes – Background, AEROD$_V$
Latitude
80
60
40
20
0
−20
−40
−60
−80
1990
1991
1992
1993
1994
1995
1996
1997
1998
Year
0.25
0.2
0.15
0.1
0.05
0
AOD

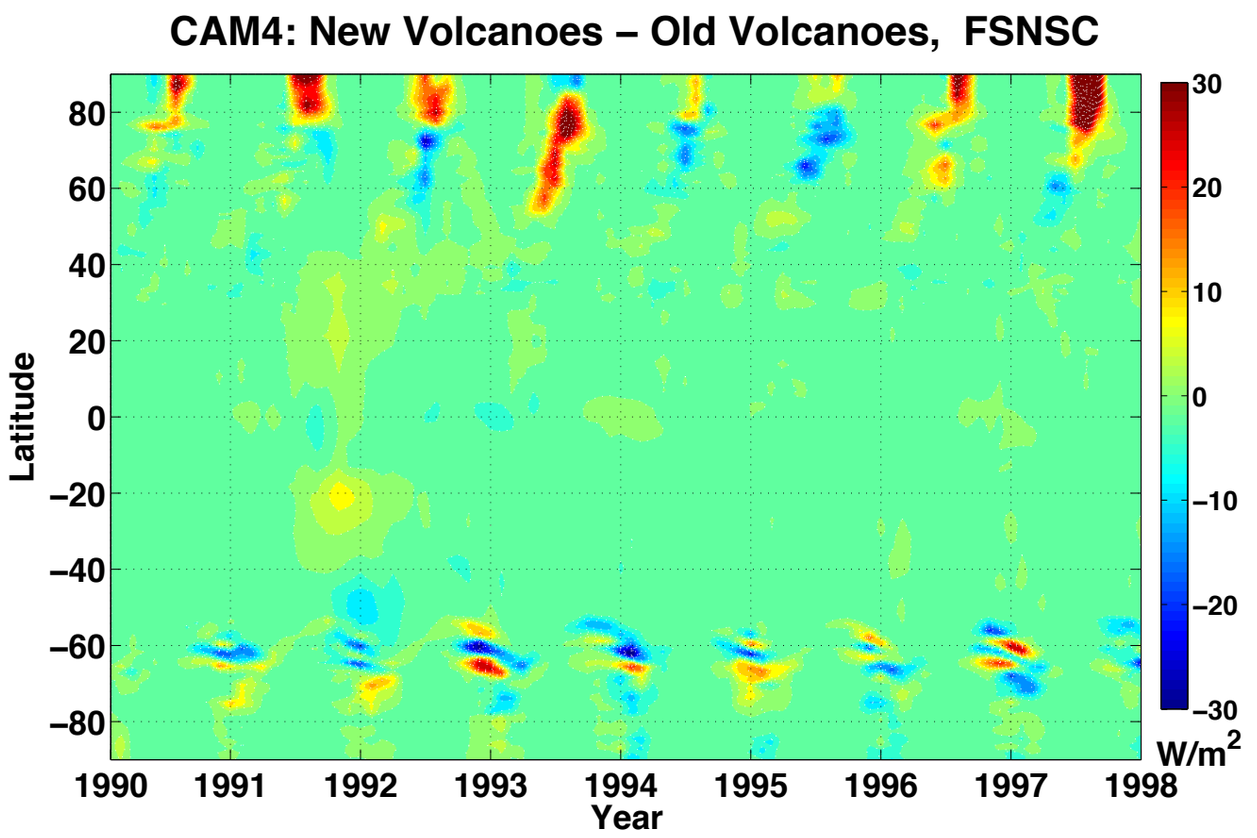

CAM4: New Volcanoes – Old Volcanoes, AEROD$_V$
Latitude
80
60
40
20
0
−20
−40
−60
−80
1990
1991
1992
1993
1994
1995
1996
1997
1998
Year
0.15
0.1
0.05
0
−0.05
−0.1
−0.15
AOD

FLNTC


CAM4: New Volcanoes – Background, FLNTC
Latitude
80
60
40
20
0
−20
−40
−60
−80
1990
1991
1992
1993
1994
1995
1996
1997
1998
Year
15
10
5
0
−5
−10
−15
W/m2
CAM4: Old Volcanoes – Background, FLNTC
Latitude
80
60
40
20
0
−20
−40
−60
−80
1990
1991
1992
1993
1994
1995
1996
1997
1998
Year
15
10
5
0
−5
−10
−15
W/m2

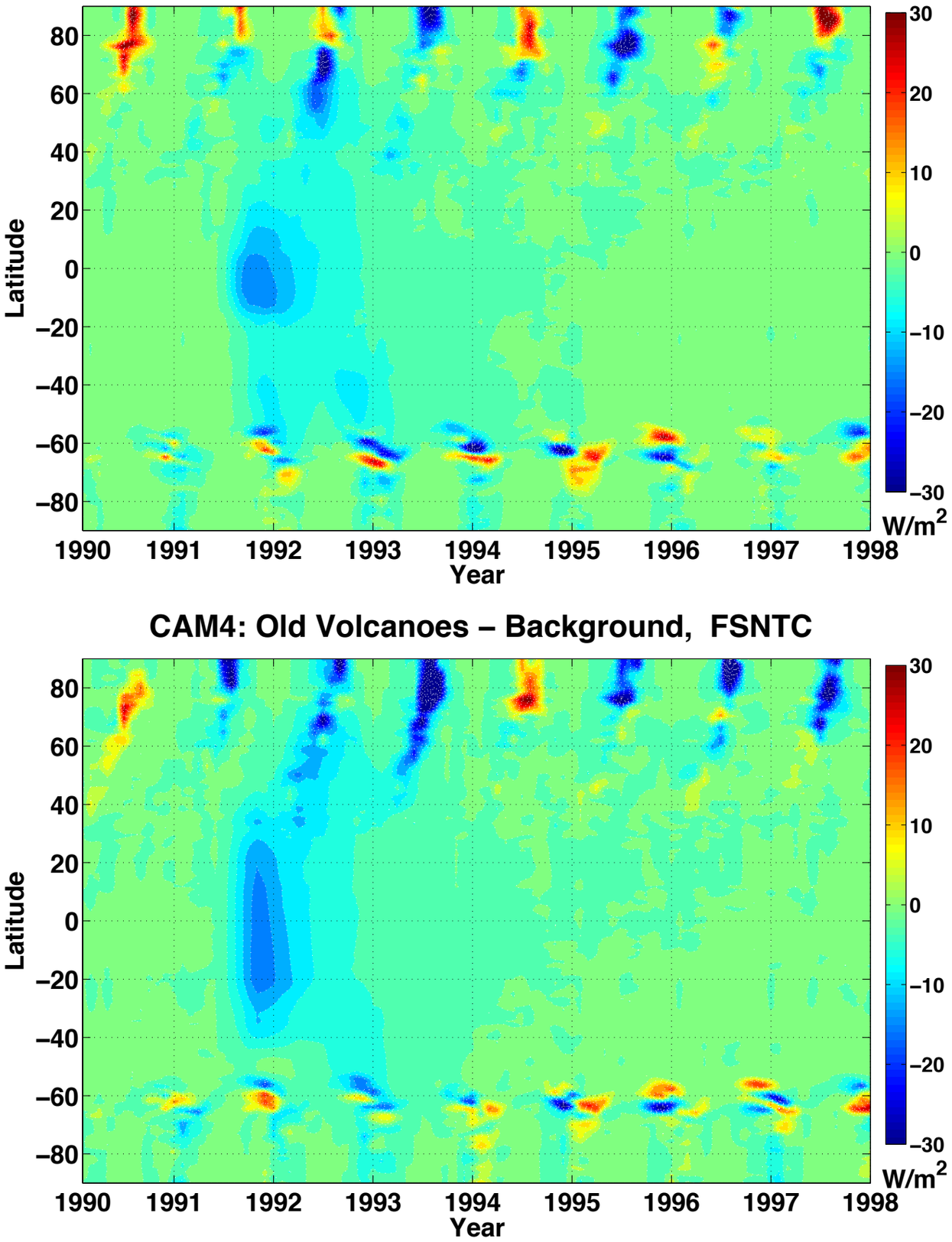
FSNSC

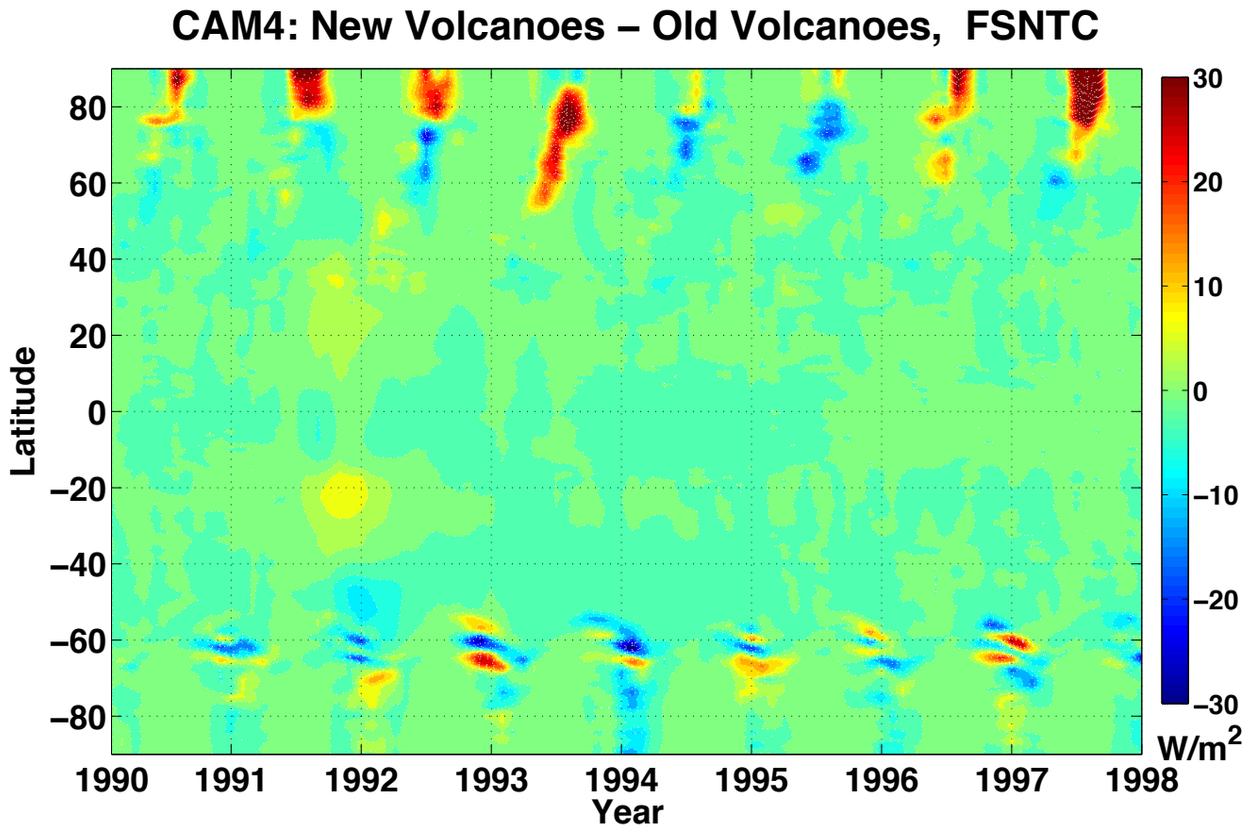

CAM4: New Volcanoes – Background, FSNSC
Latitude
80
60
40
20
0
−20
−40
−60
−80
1990
1991
1992
1993
1994
1995
1996
1997
1998
Year
30
20
10
0
−10
−20
−30
W/m2


CAM4: New Volcanoes – Old Volcanoes, FSNSC
Latitude
80
60
40
20
0
−20
−40
−60
−80
1990
1991
1992
1993
1994
1995
1996
1997
1998
Year
30
20
10
0
−10
−20
−30
W/m2

CAM4: Old Volcanoes – Background, FSNSC
Latitude
80
60
40
20
0
−20
−40
−60
−80
1990
1991
1992
1993
1994
1995
1996
1997
1998
Year
30
20
10
0
−10
−20
−30
W/m2

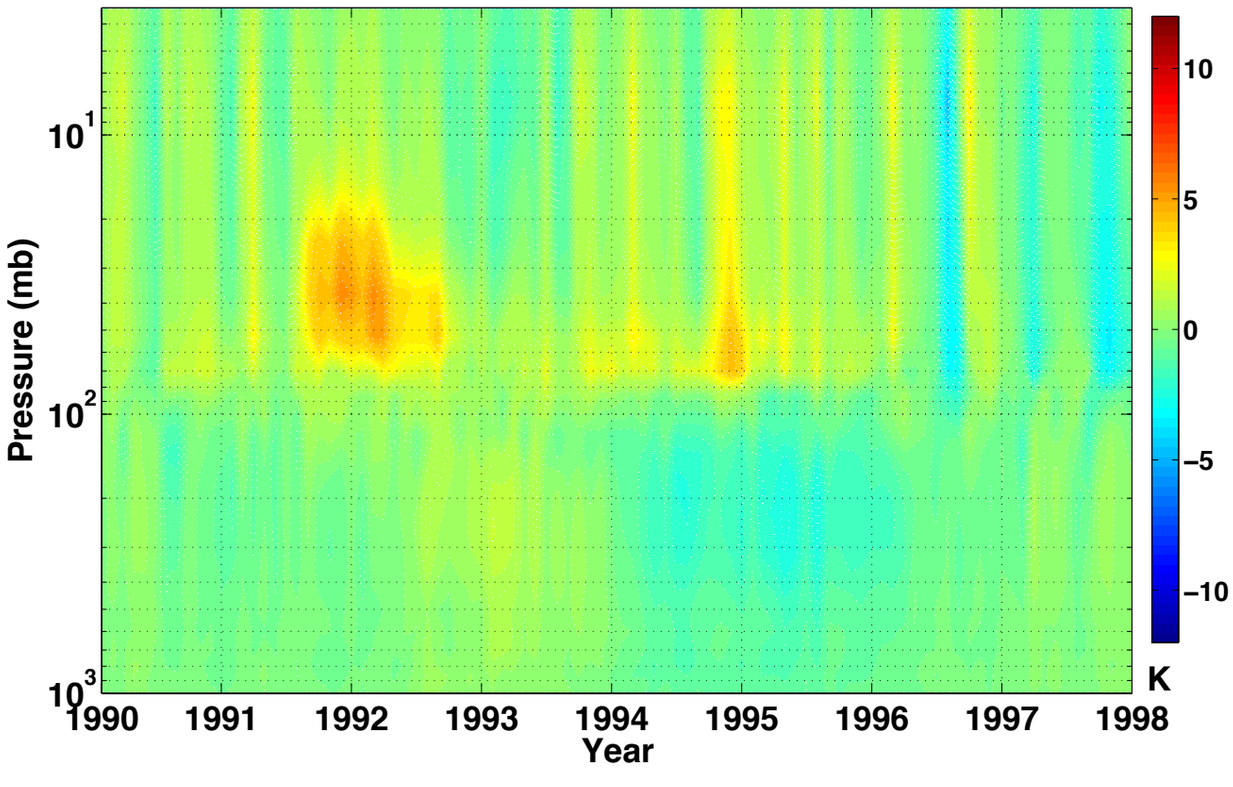
FSNTC

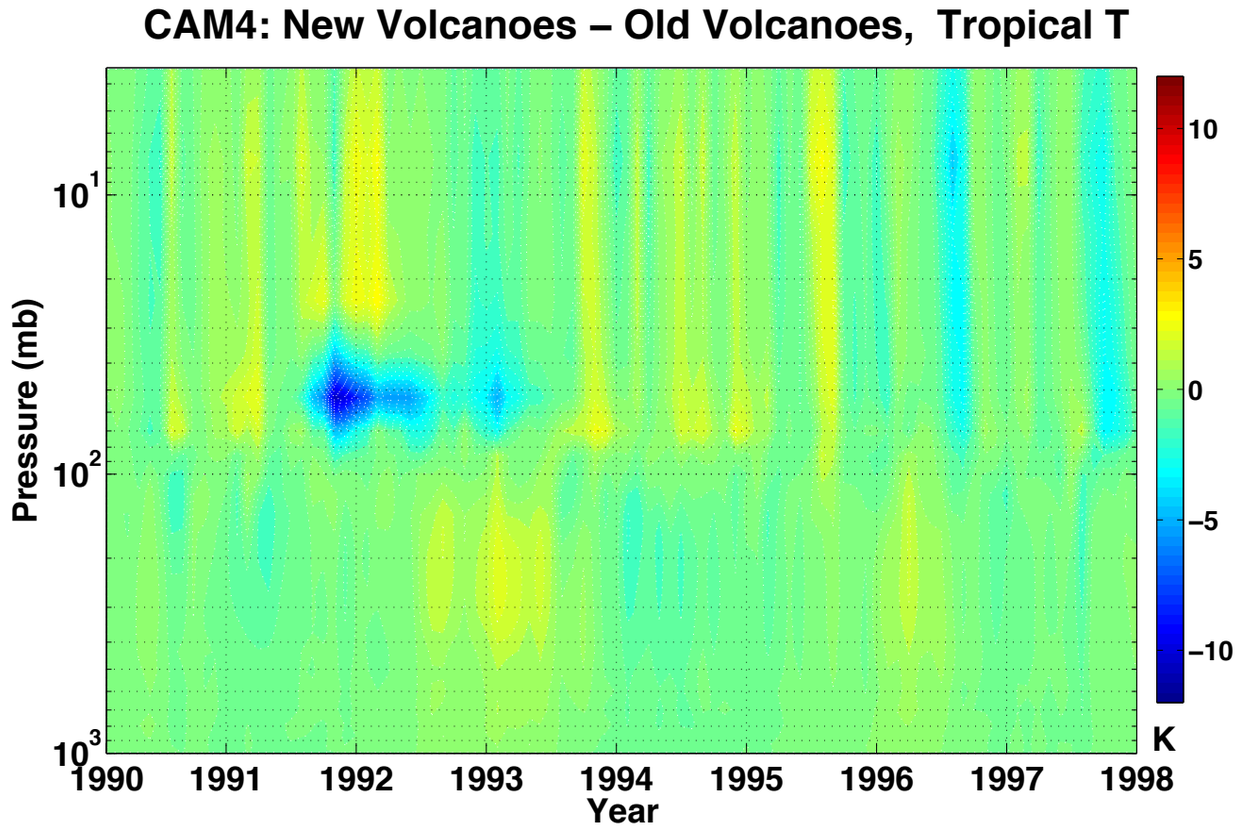

CAM4: New Volcanoes – Background, FSNTC
Latitude
80
60
40
20
0
−20
−40
−60
−80
1990
1991
1992
1993
1994
1995
1996
1997
1998
Year
30
20
10
0
−10
−20
−30
W/m2

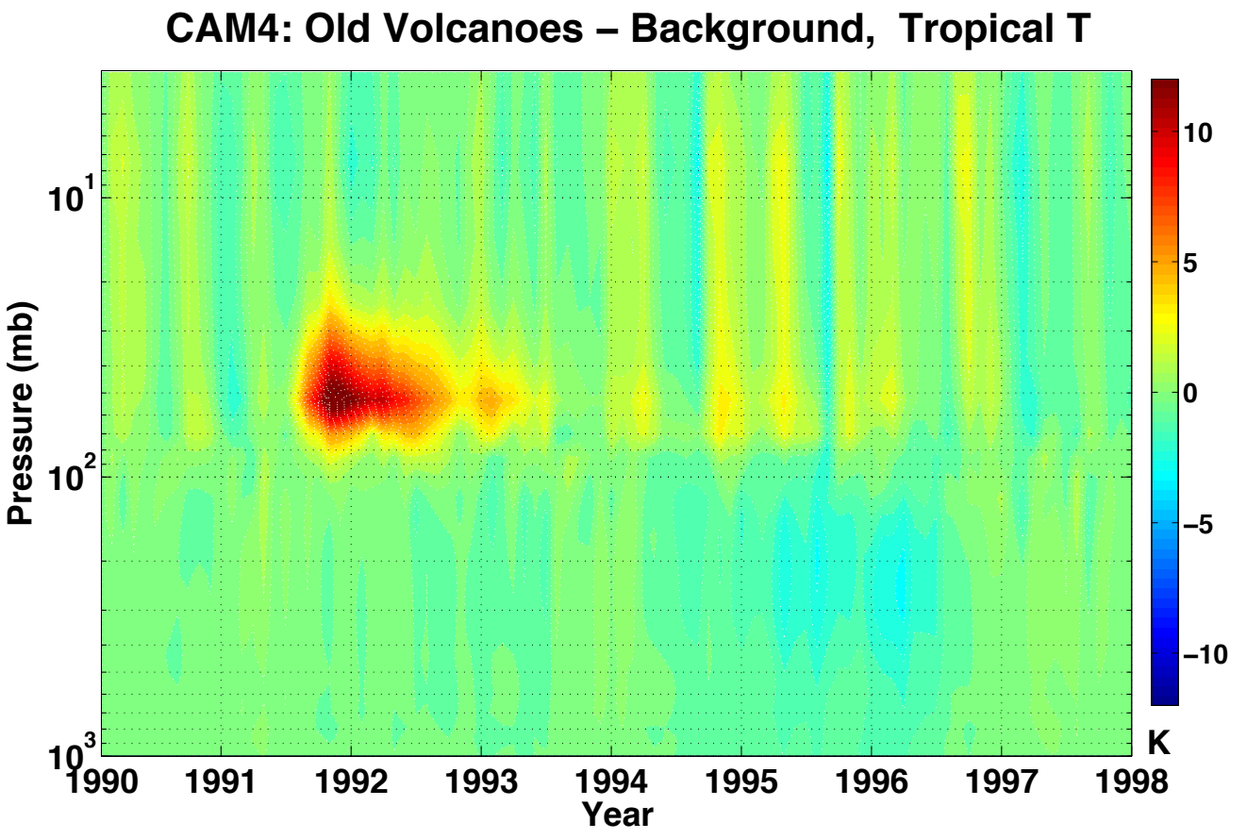

CAM4: New Volcanoes – Old Volcanoes, FSNTC
Latitude
80
60
40
20
0
−20
−40
−60
−80
1990
1991
1992
1993
1994
1995
1996
1997
1998
Year
30
20
10
0
−10
−20
−30
W/m2

CAM4: Old Volcanoes – Background, FSNTC
Latitude
80
60
40
20
0
−20
−40
−60
−80
1990
1991
1992
1993
1994
1995
1996
1997
1998
Year
30
20
10
0
−10
−20
−30
W/m2

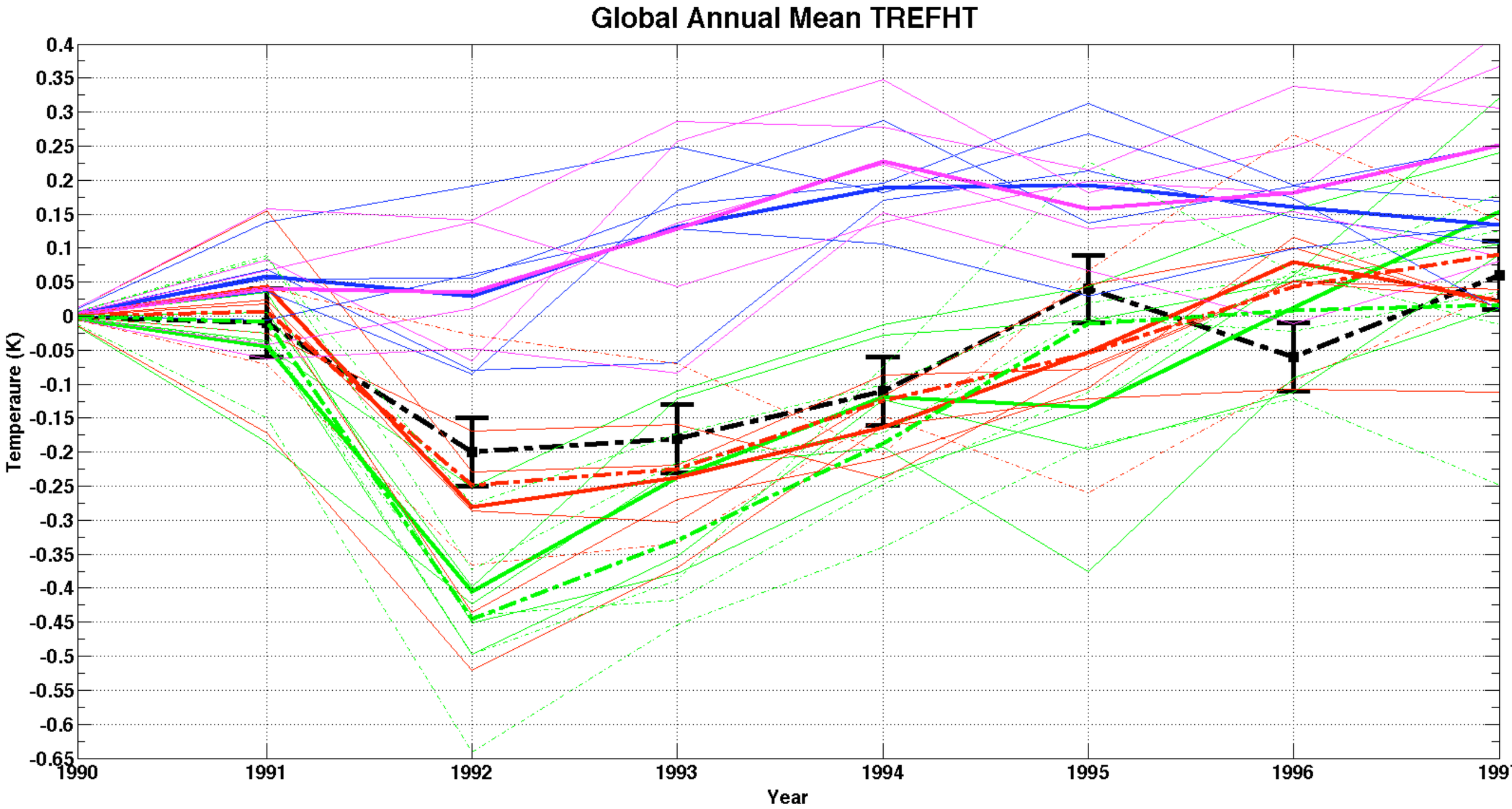
Tropical T (20S-20N)



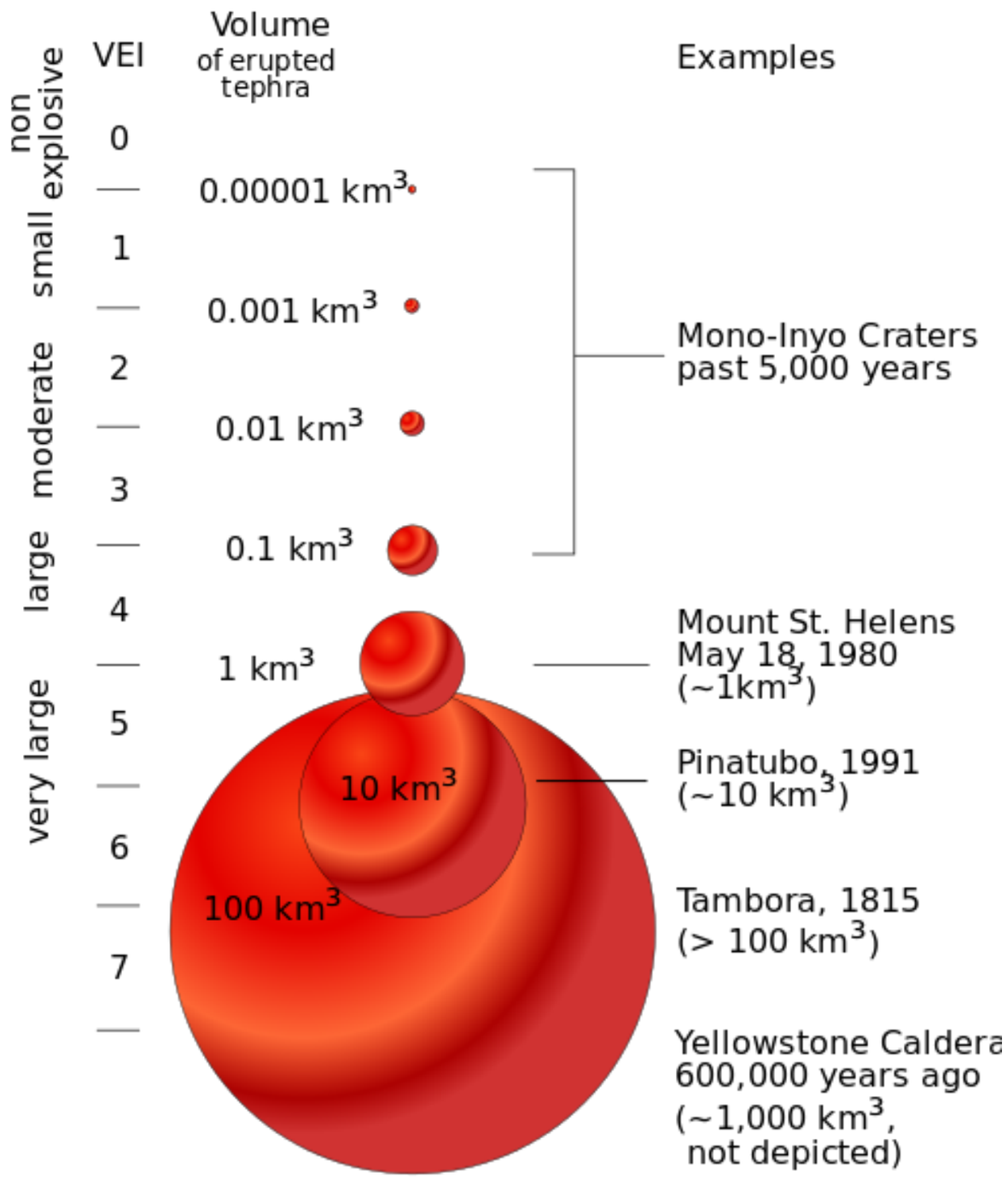




Old, New, Background, None, New Mass Old Optics, Old Mass with New Optics, GISS

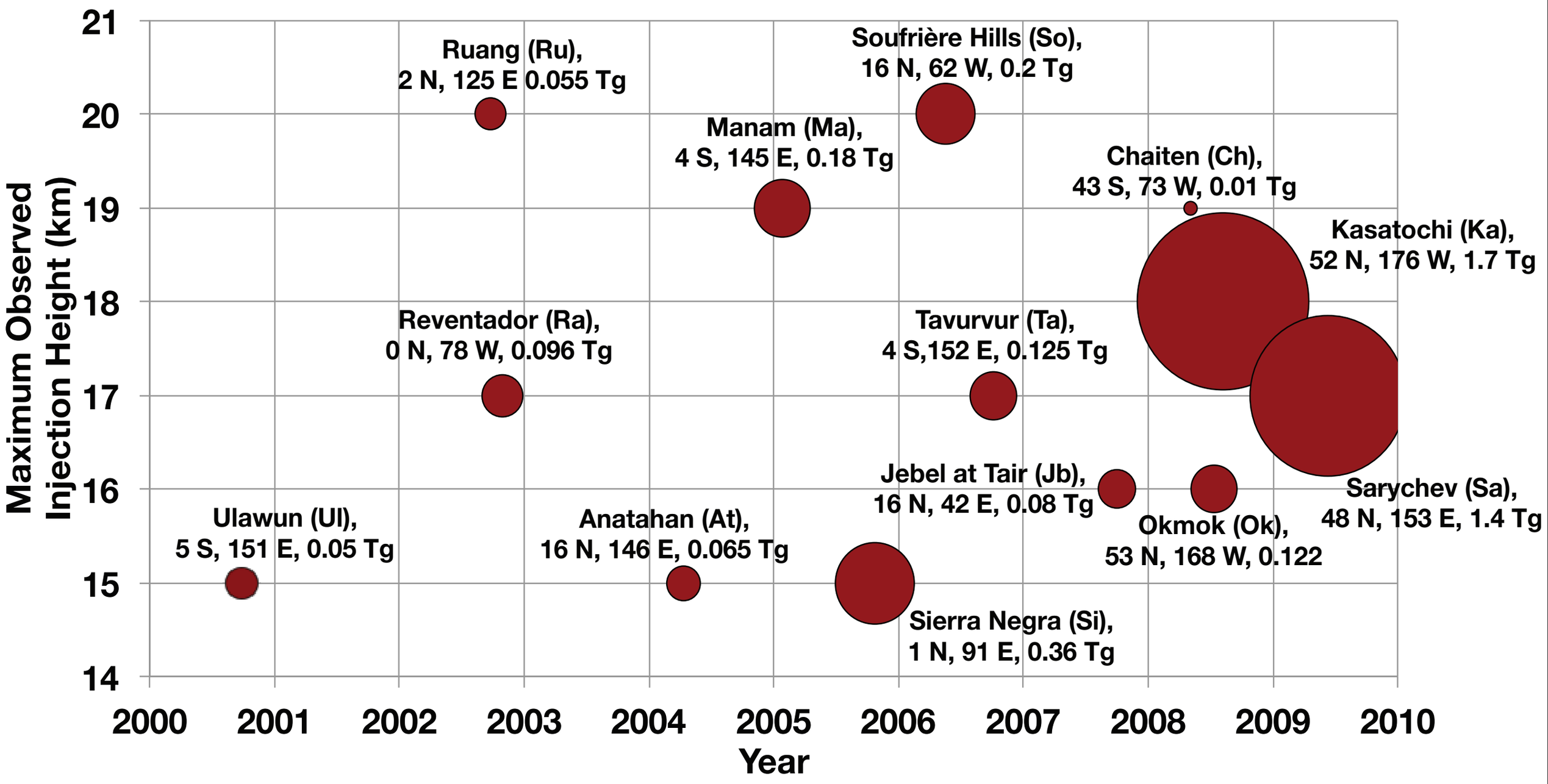


Scale


Volume
of erupted
tephra
Examples
non explosive
small
moderate
large
very large
VEI
0
1
2
3
4
5
6
7
0.00001 km3
0.001 km3
0.01 km3
0.1 km3
1 km3
10 km3
100 km3
Mono-Inyo Craters
past 5,000 years
Mount St. Helens
May 18, 1980
(~1km3)
Pinatubo, 1991
(~10 km3)
Tambora, 1815
(> 100 km3)
Yellowstone Caldera
600,000 years ago
(~1,000 km3,
not depicted)

Volcanic Eruptions from 2000 to 2010

Maximum Observed Injection Height and Total Column SO_2



Circles represent relative amount of sulfur emitted.