



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

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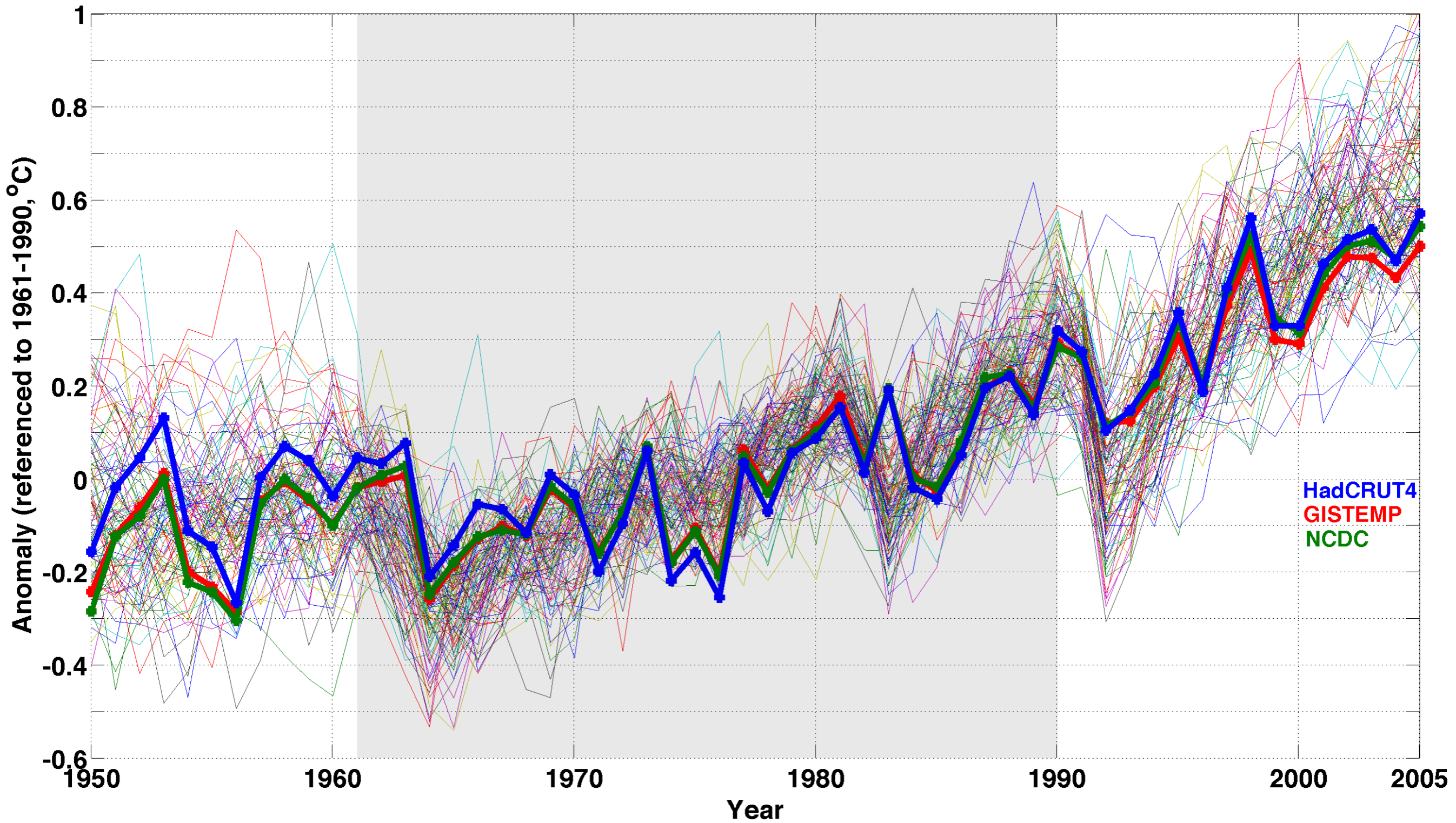
With J.F. Lamarque, A. Conley, F. Vitt, D. Kinnison, D. Marsh, M. Mills and S. Tilmes.

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



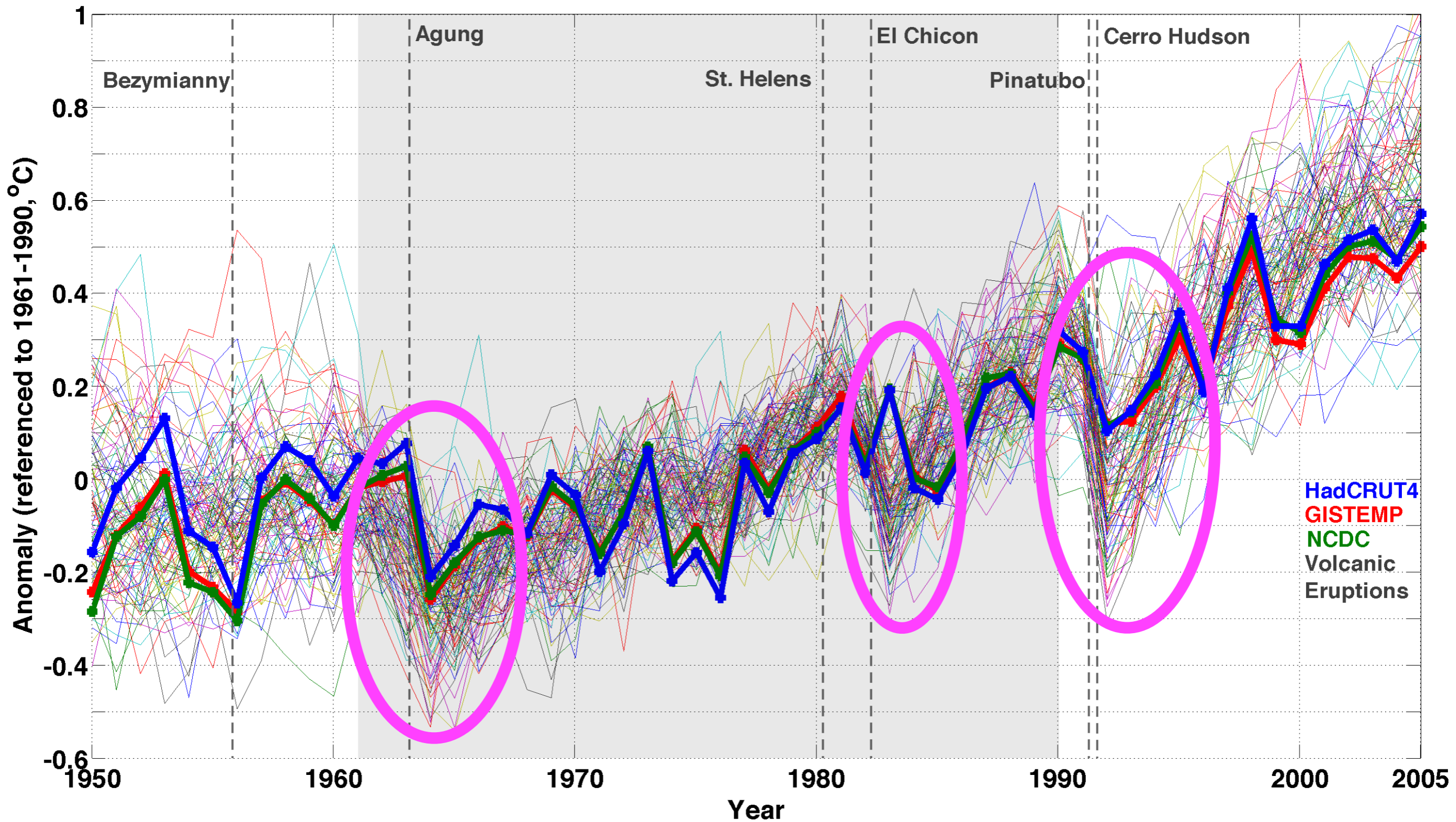
Motivation

CMIP5 Global Annual Mean Surface Temperature Anomaly



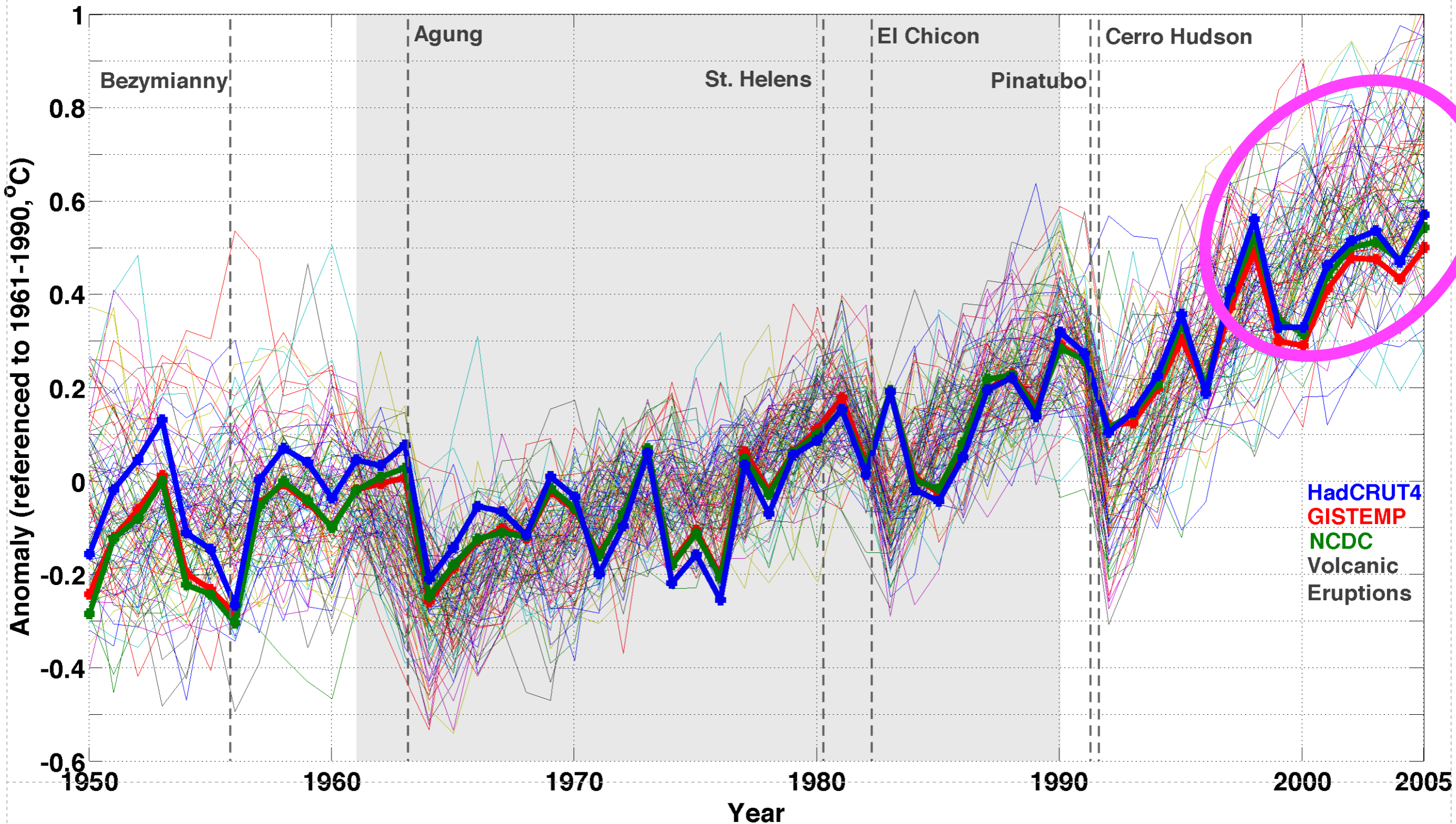
Motivation: Bad and Ugly Volcanoes

CMIP5 Global Annual Mean Surface Temperature Anomaly



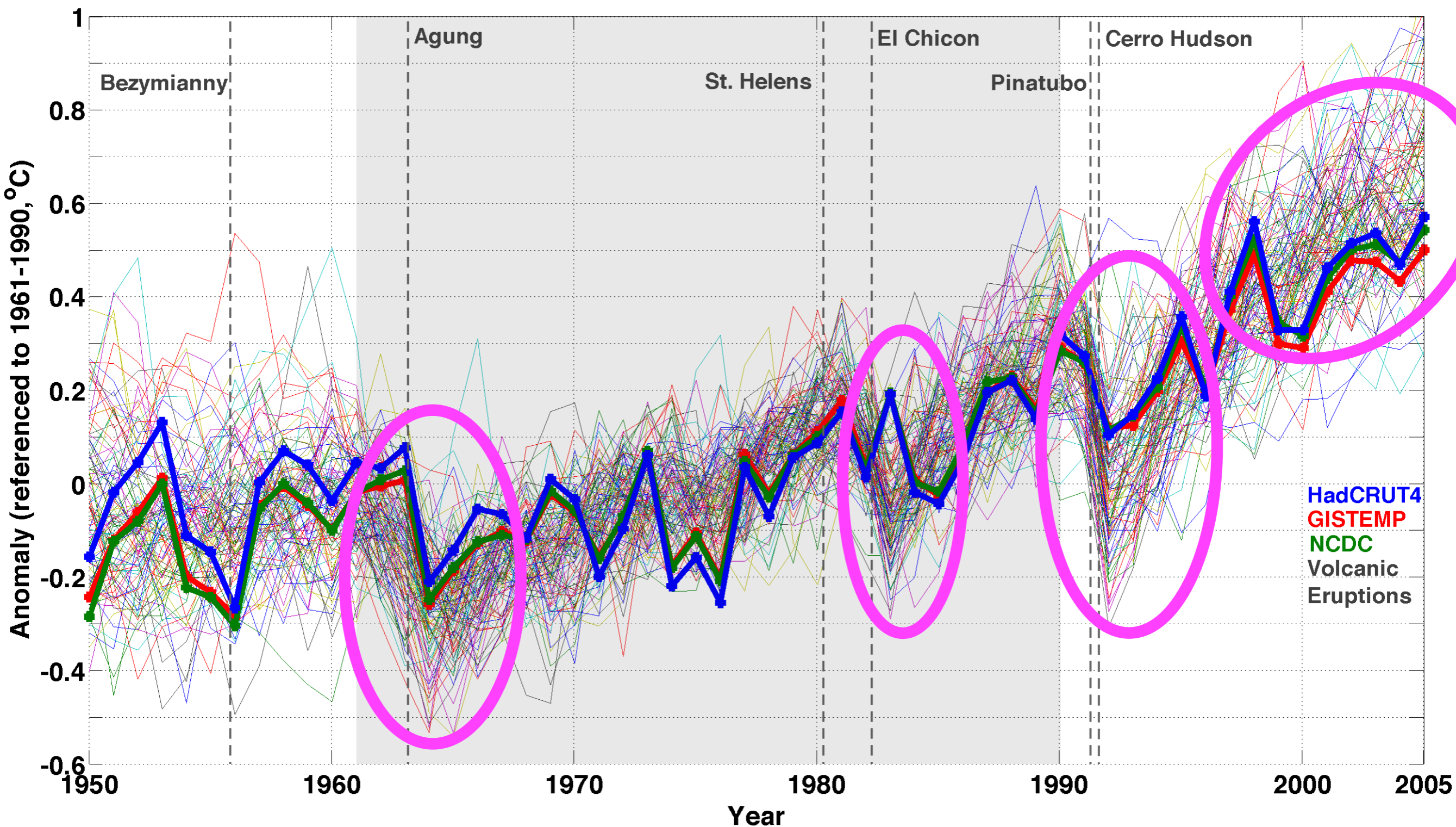
Motivation: "The Hiatus"

CMIP5 Global Annual Mean Surface Temperature Anomaly



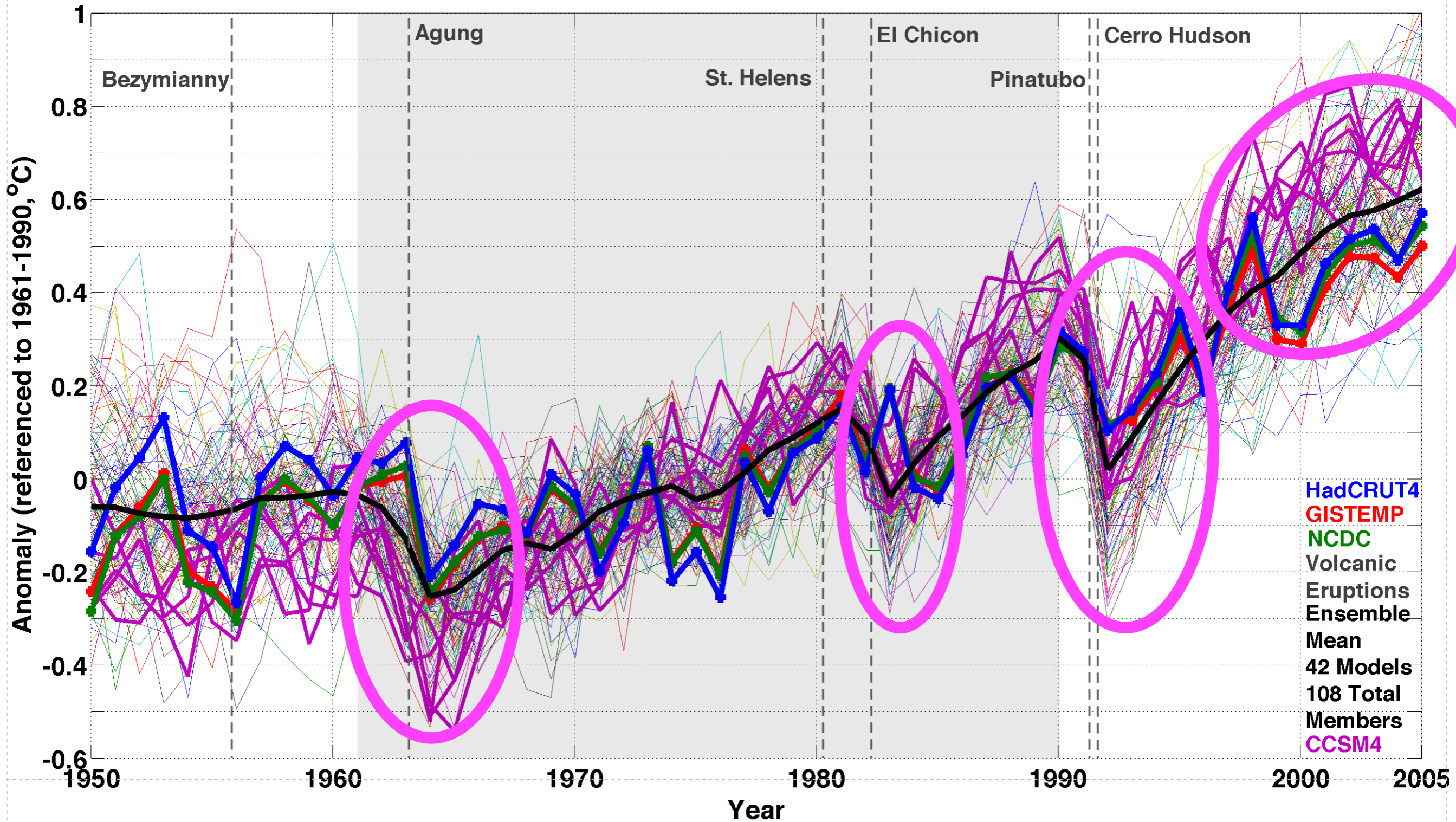
Motivation: Why are there Discrepancies?

CMIP5 Global Annual Mean Surface Temperature Anomaly



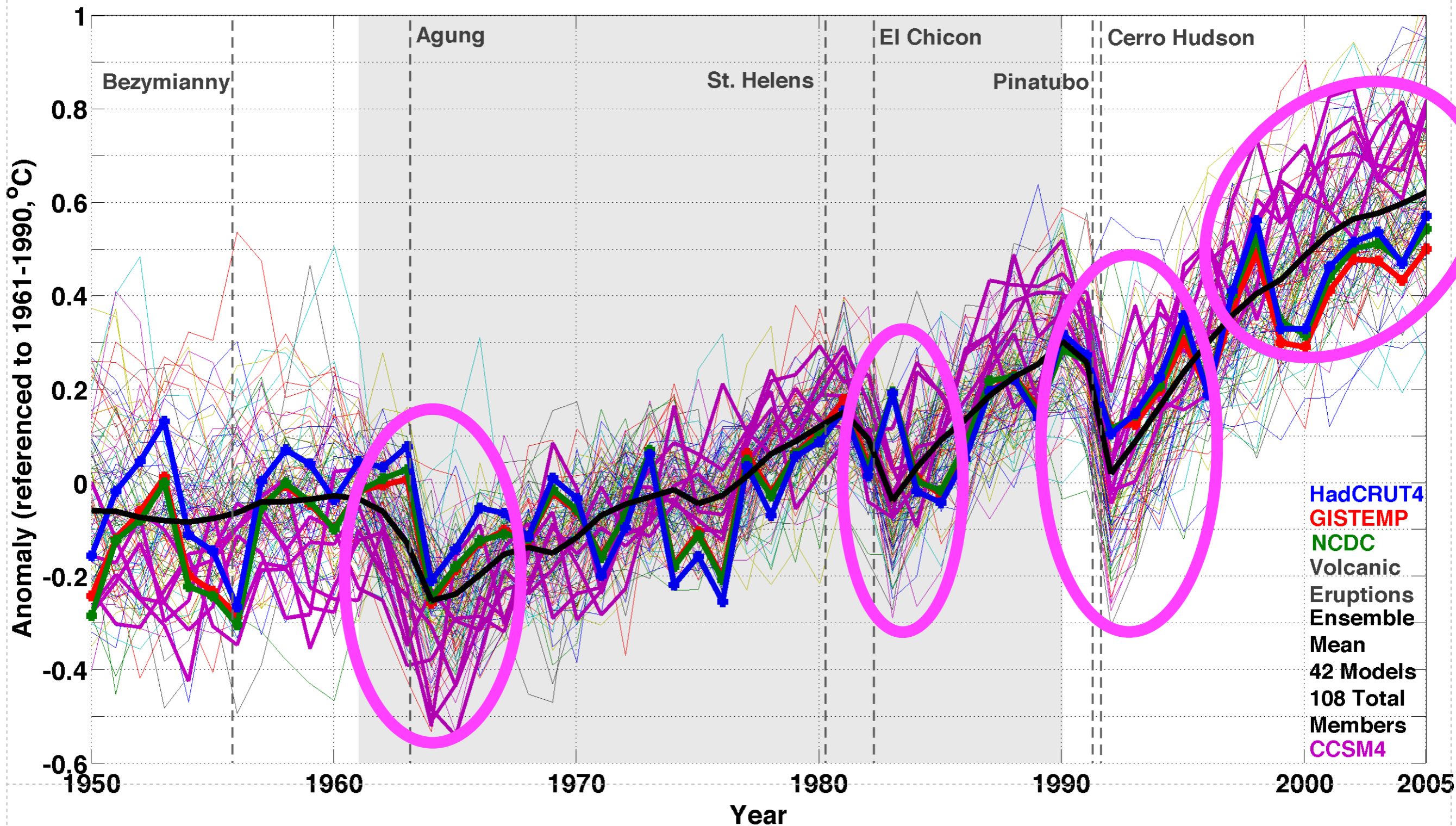
Motivation: Why are there Discrepancies?

CMIP5 Global Annual Mean Surface Temperature Anomaly



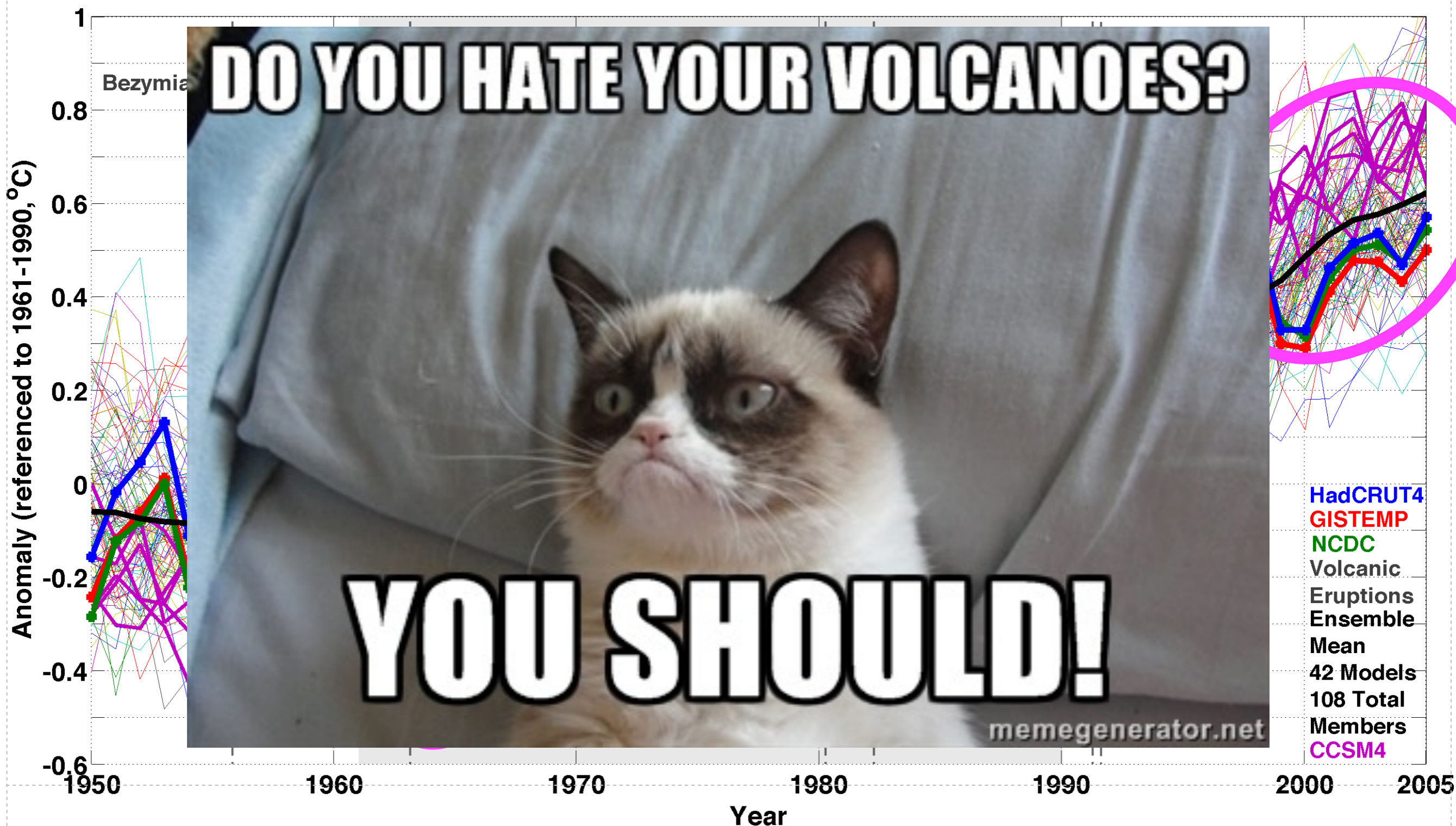
Motivation: Why are there Discrepancies?

CMIP5 Global Annual Mean Surface Temperature Anomaly

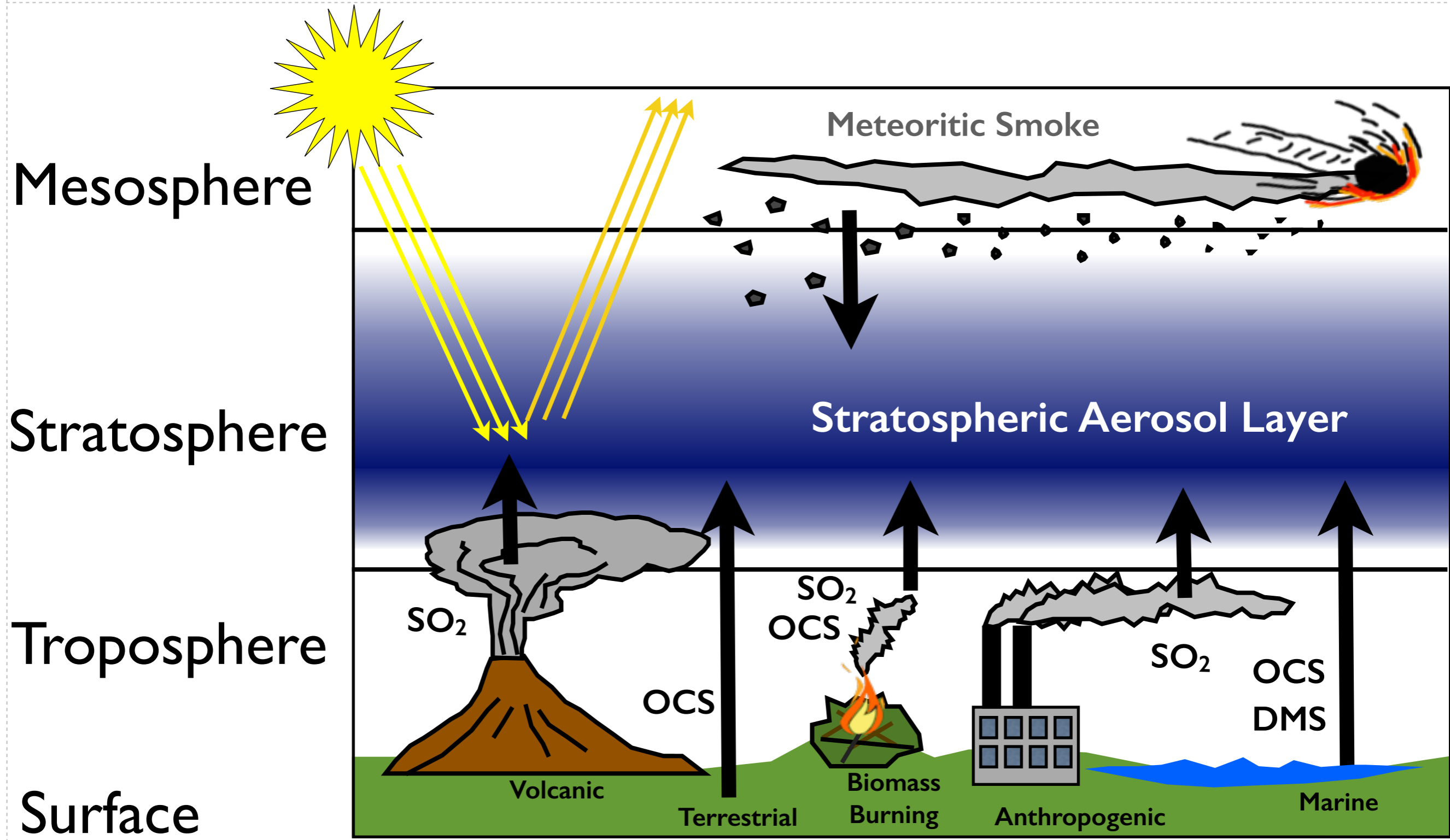


Motivation: Why are there Discrepancies?

CMIP5 Global Annual Mean Surface Temperature Anomaly



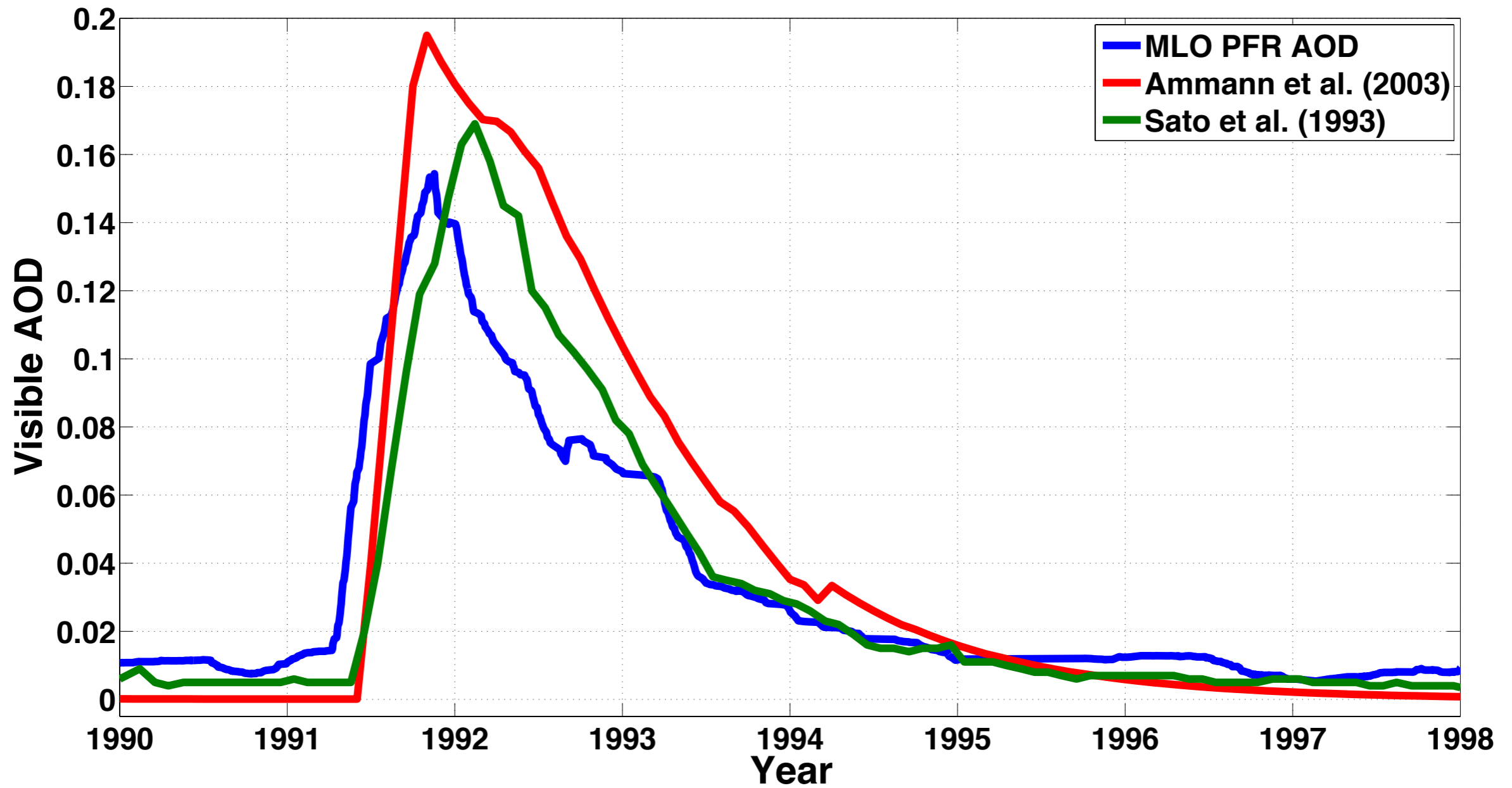
Overview of Stratospheric Aerosols





Problems with Stratospheric AOD Forcing

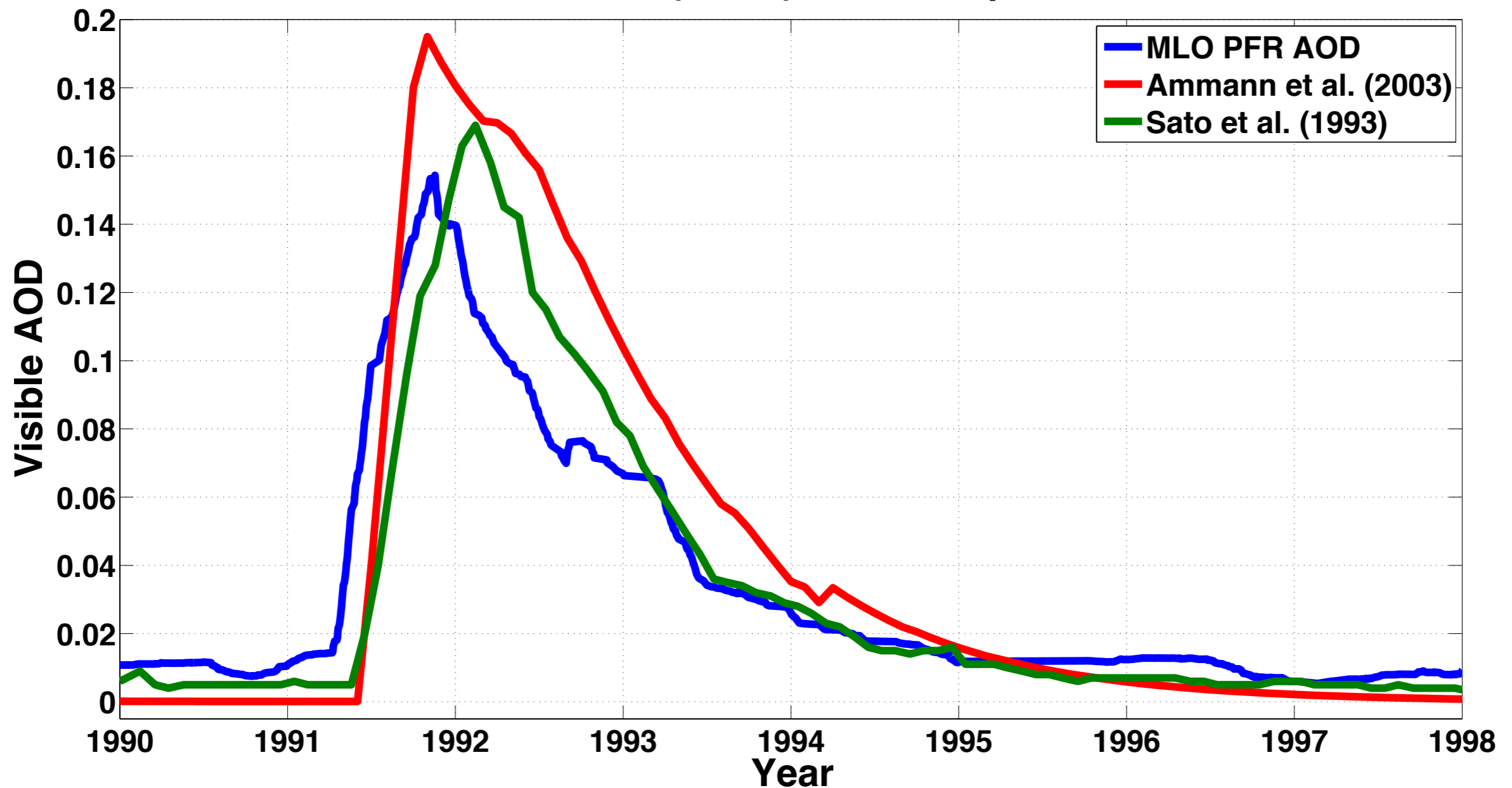
Mauna Loa (19.5N) AOD Comparison





Problems with Stratospheric AOD Forcing

Mauna Loa (19.5N) AOD Comparison



**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

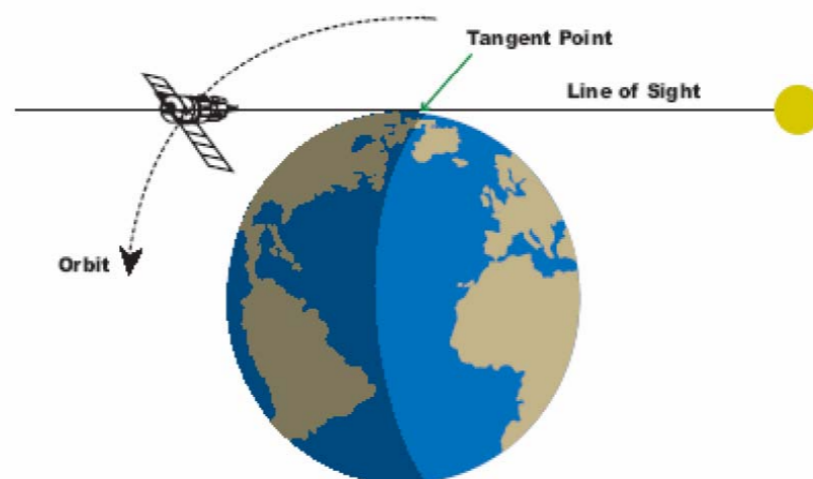
1960-1978



Photometer

Ground photometers:
Optical depths at 550 nm.

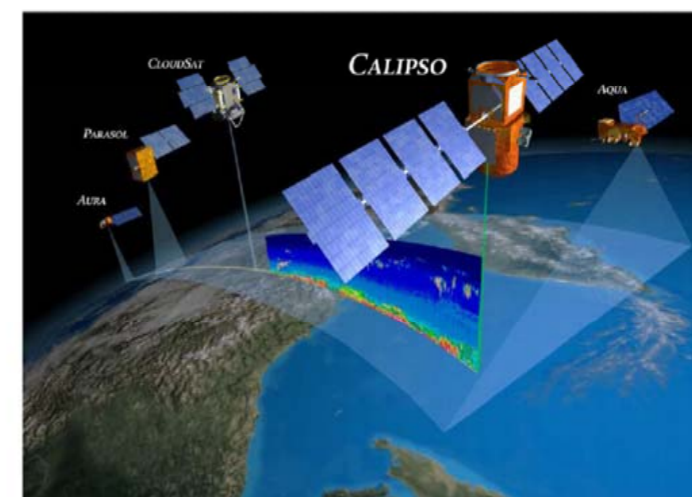
1979-2005



SAGE I, SAM II, SAGE II

- (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.

2006-2011



CALIOP

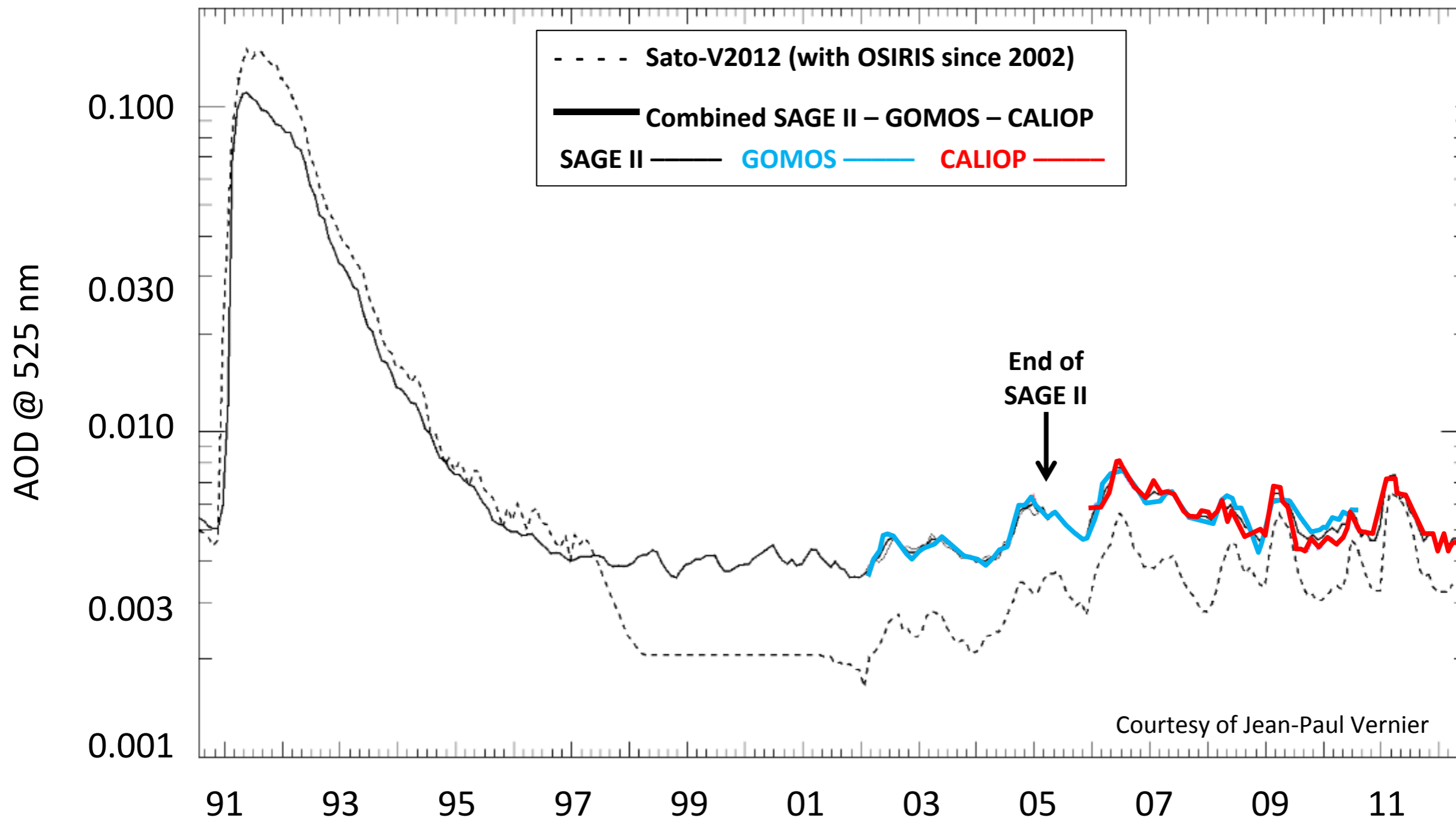
CALIOP: Backscatter and extinction coefficients at 532 nm.

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

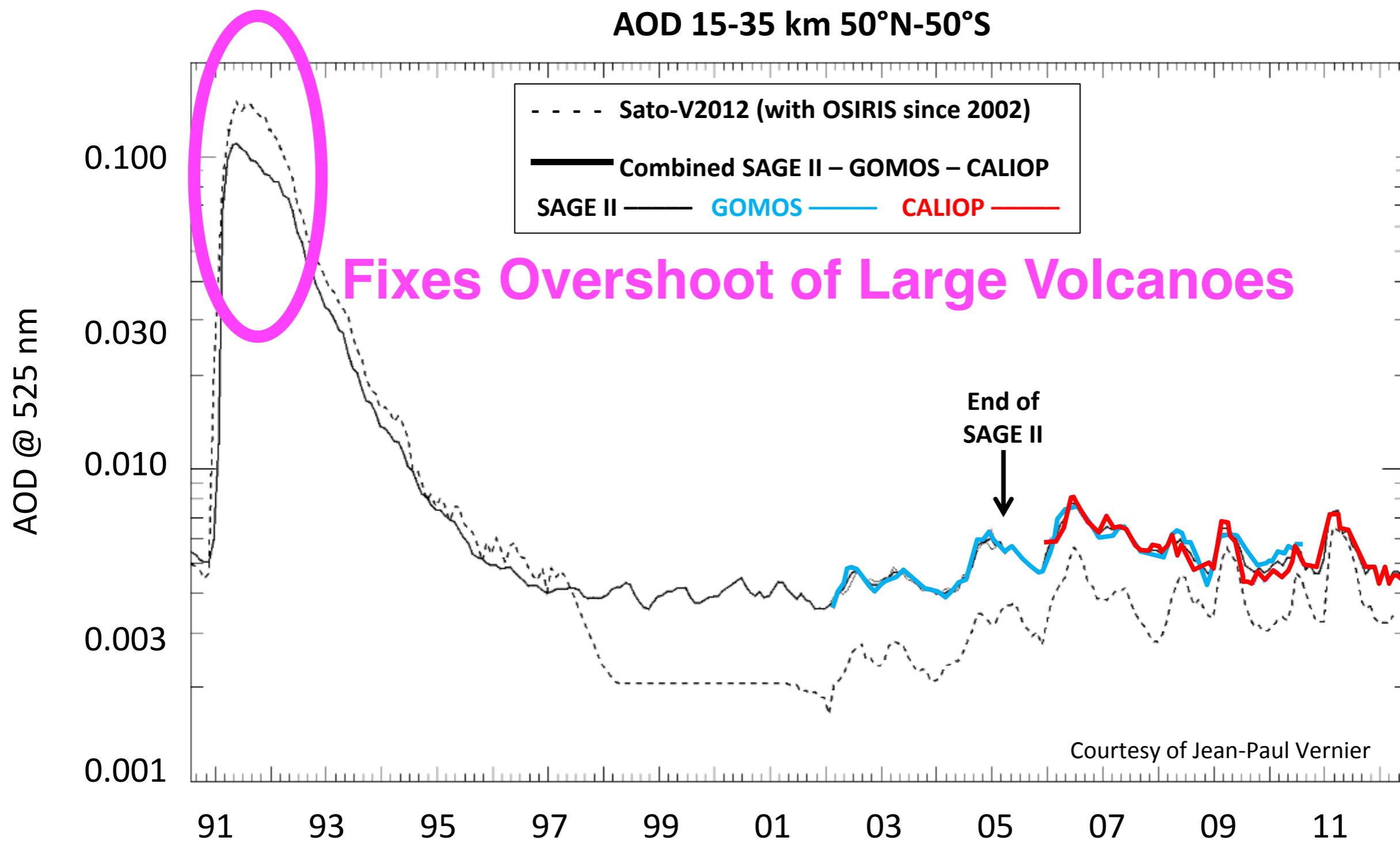
For more details see: Arfeuille, F., and B.-P. Luo (2013), Uncertainties in modeling the stratospheric warming following Mt. Pinatubo eruption, ACP

A New Dataset for CCMI: Strat. AOD

AOD 15-35 km 50°N-50°S

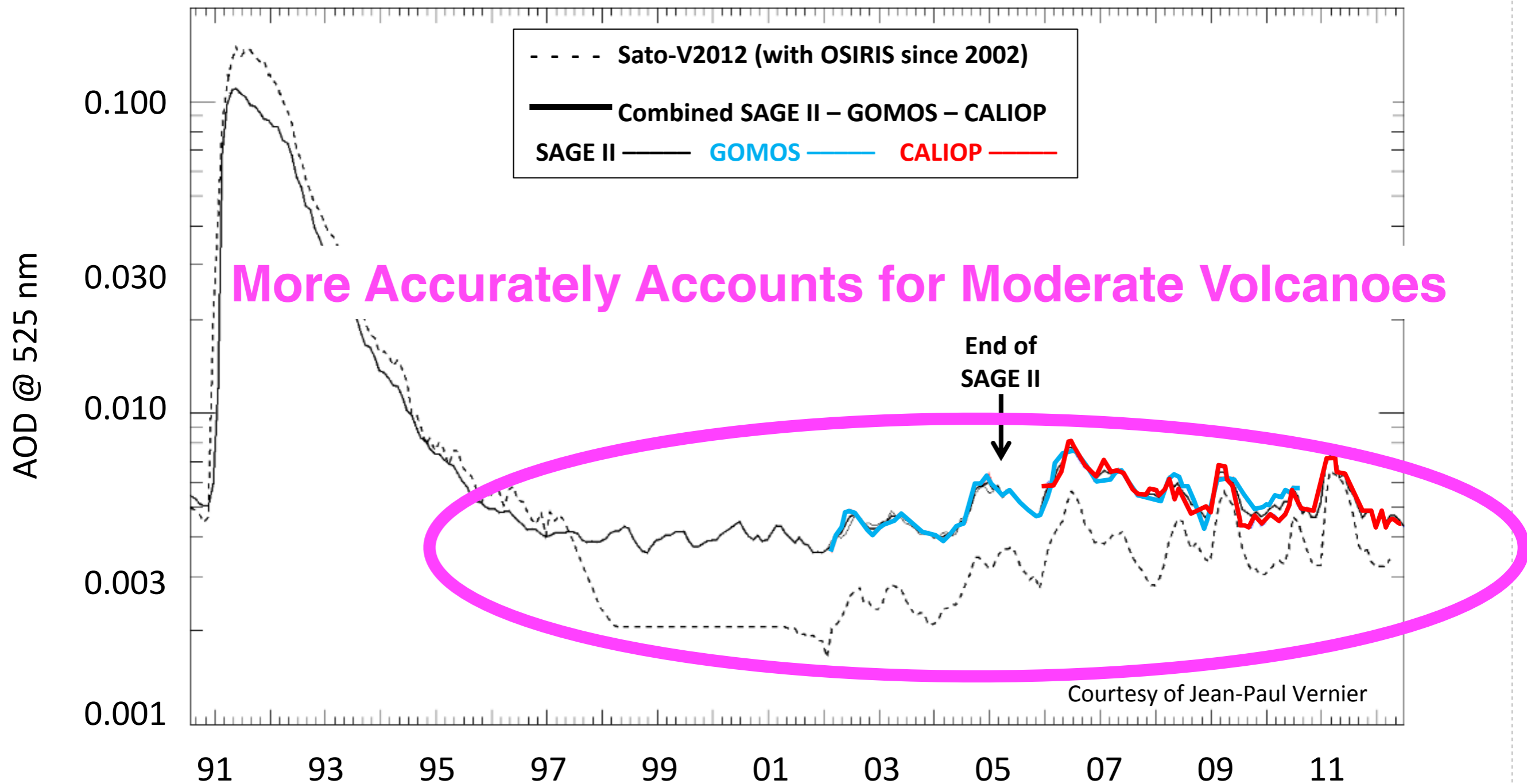


A New Dataset for CCMI: Strat. AOD



A New Dataset for CCMI: Strat. AOD

AOD 15-35 km 50°N-50°S



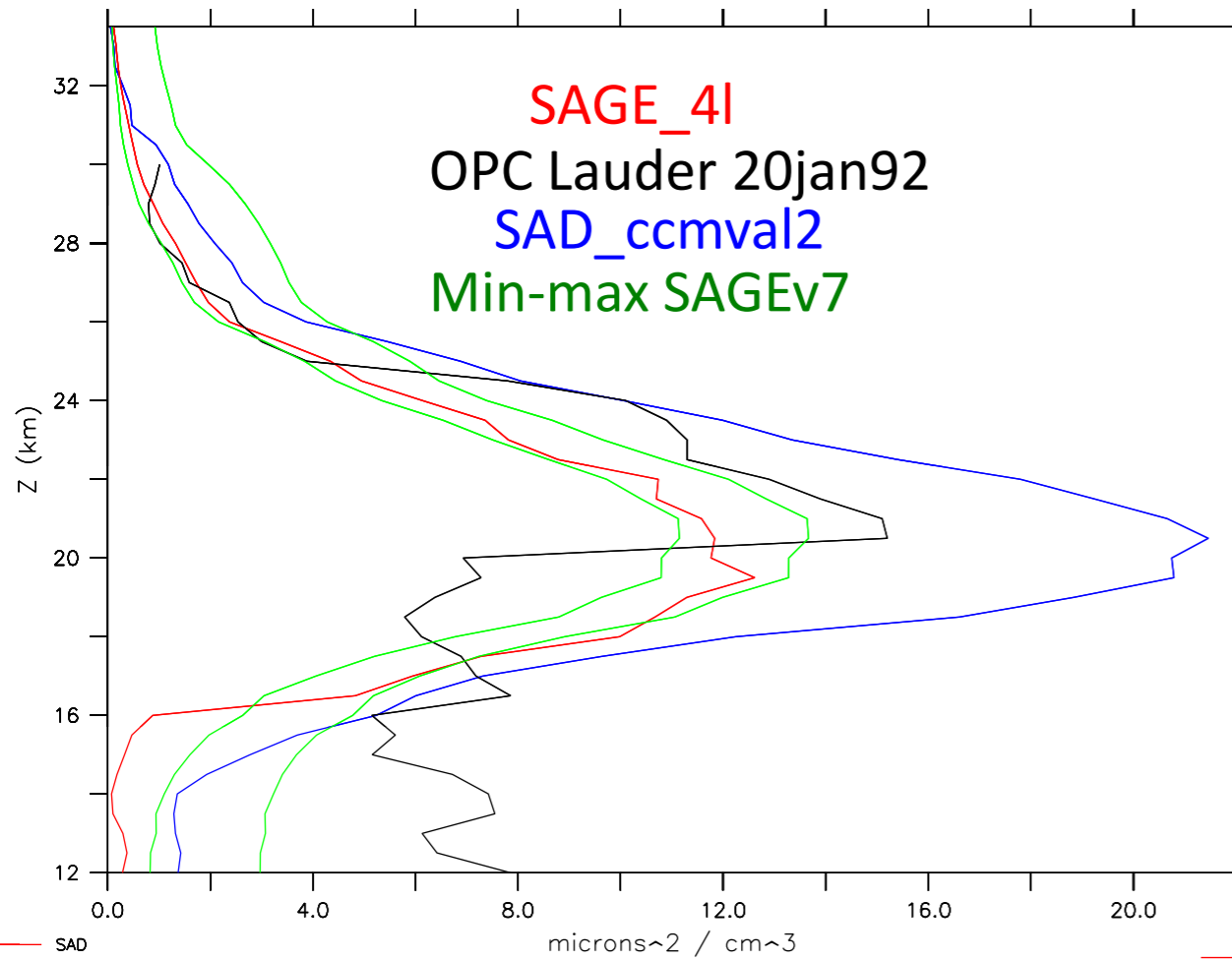
A New Dataset for CCMI: SAD

SAD

January 1992, 45°S

FERP

11

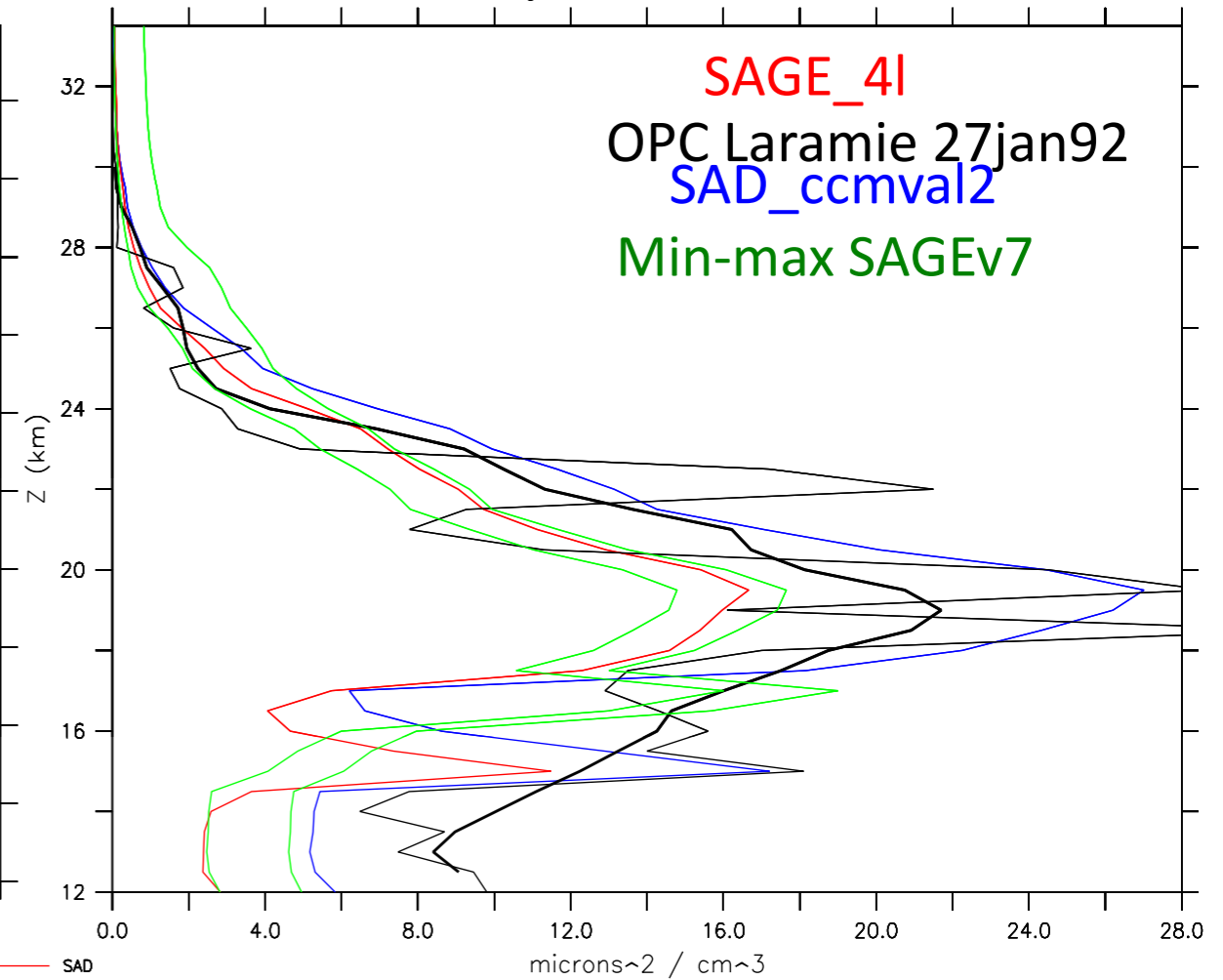


SAD

January 1992, 41°N

FERP

011



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**

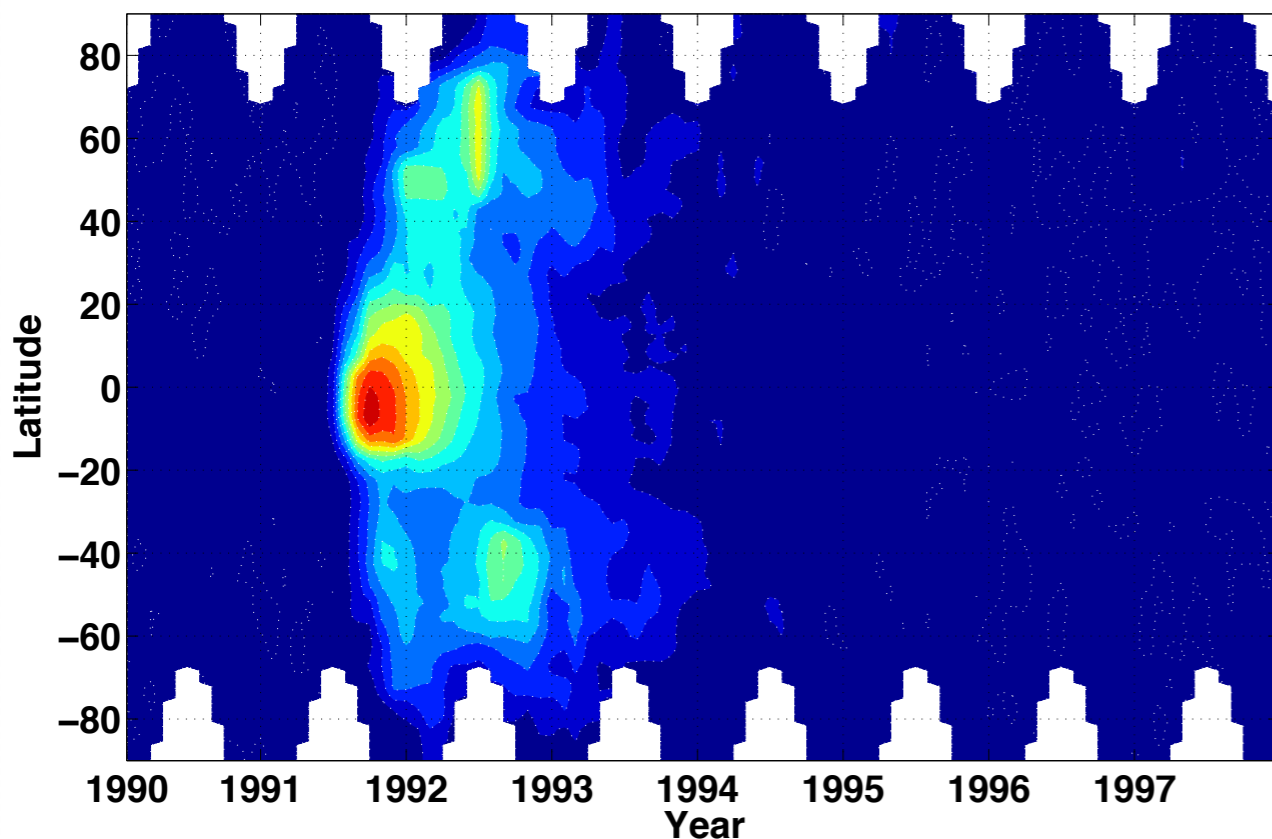


Mt. Pinatubo, June 12, 1991, USGS

Changes in Stratospheric AOD

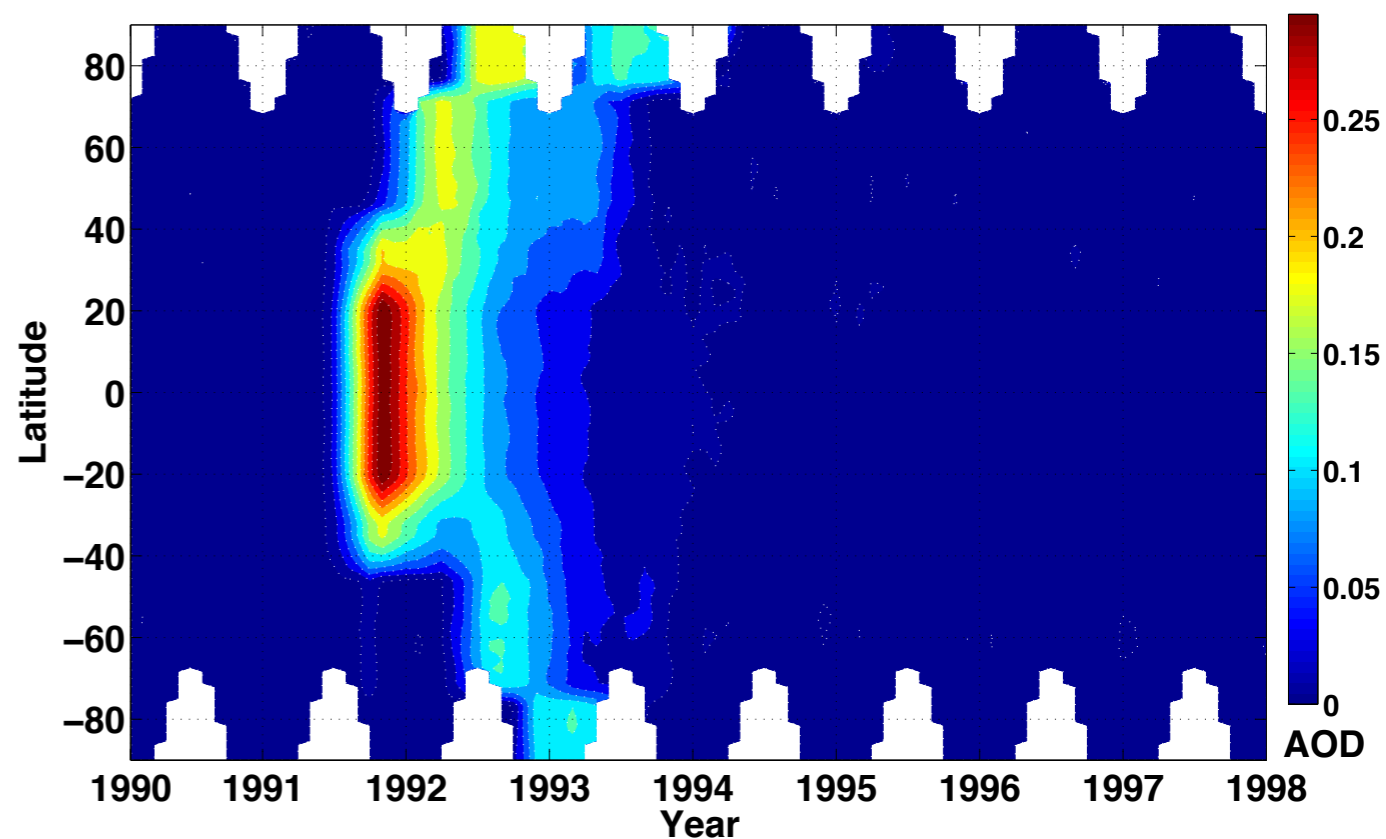
New/CCMI

CAM4: New Volcanoes – Background, AEROD_v



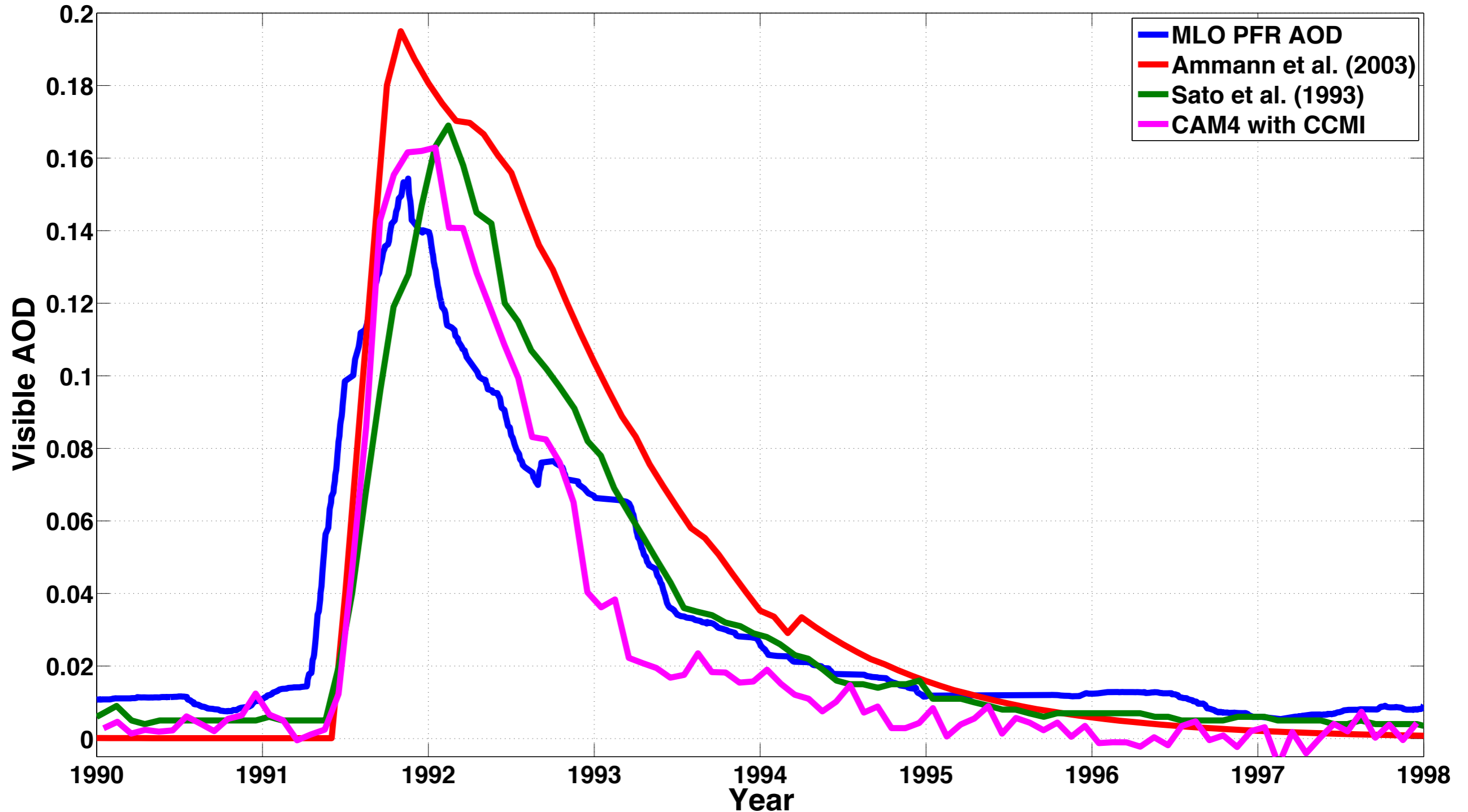
Old/CCSM4

CAM4: Old Volcanoes – Background, AEROD_v



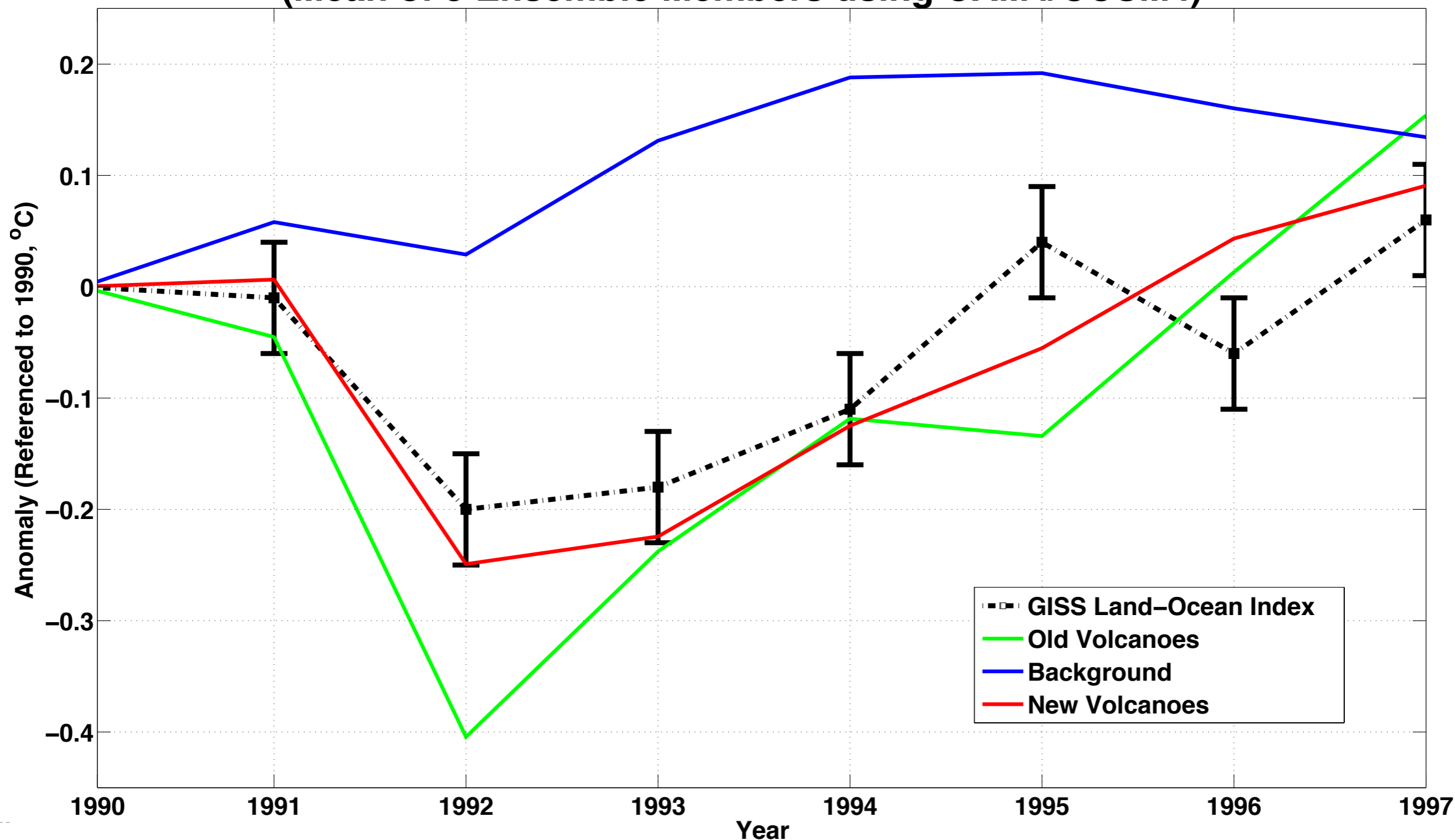
Changes in MLO Stratospheric AOD

Mauna Loa (19.5N) AOD Comparison



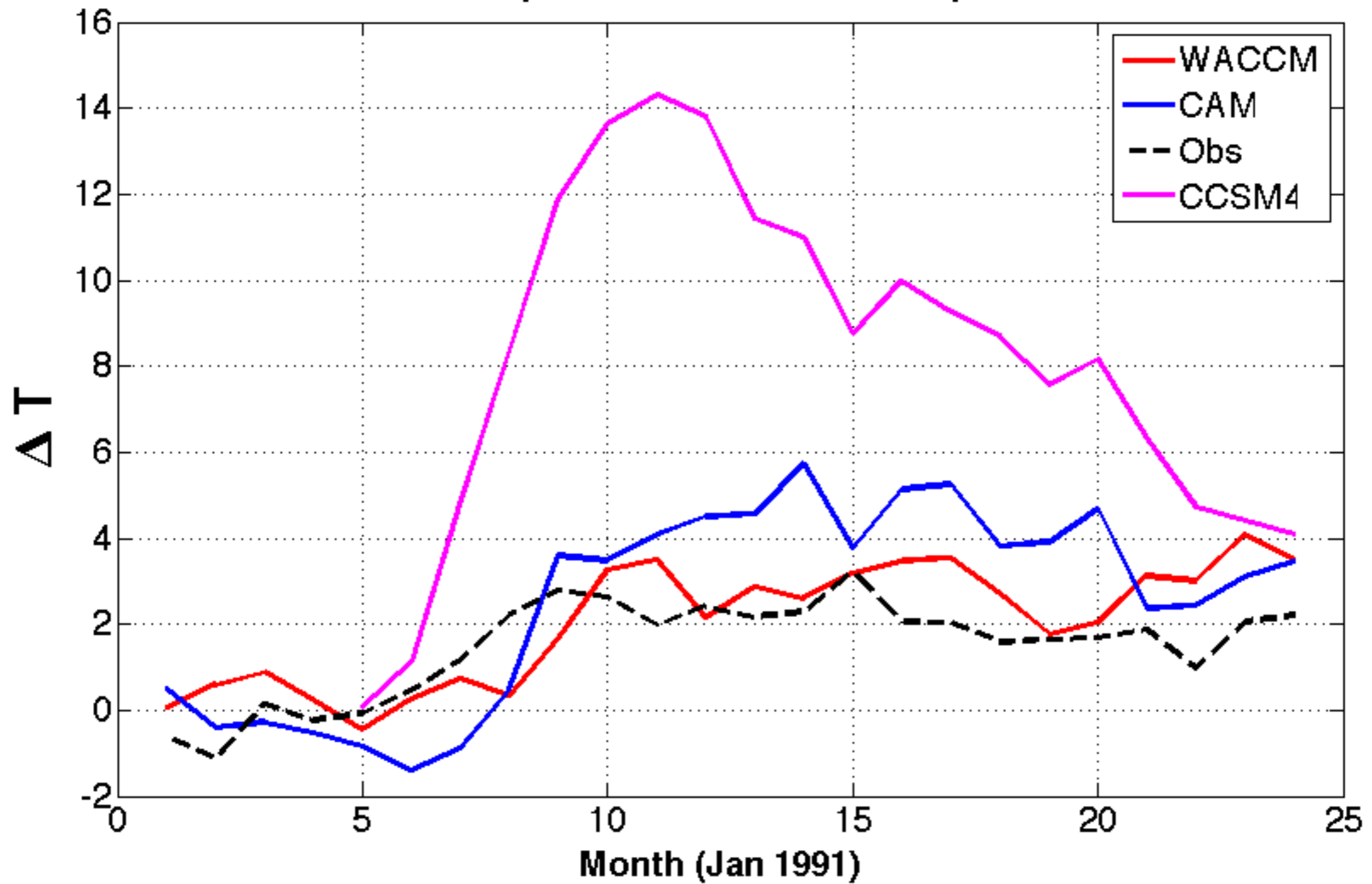
Implementation in CESM(All Flavors)

**Global Annual Mean Surface Temperature
(Mean of 5 Ensemble Members using CAM4/CCSM4)**



Upper Atmosphere Warming

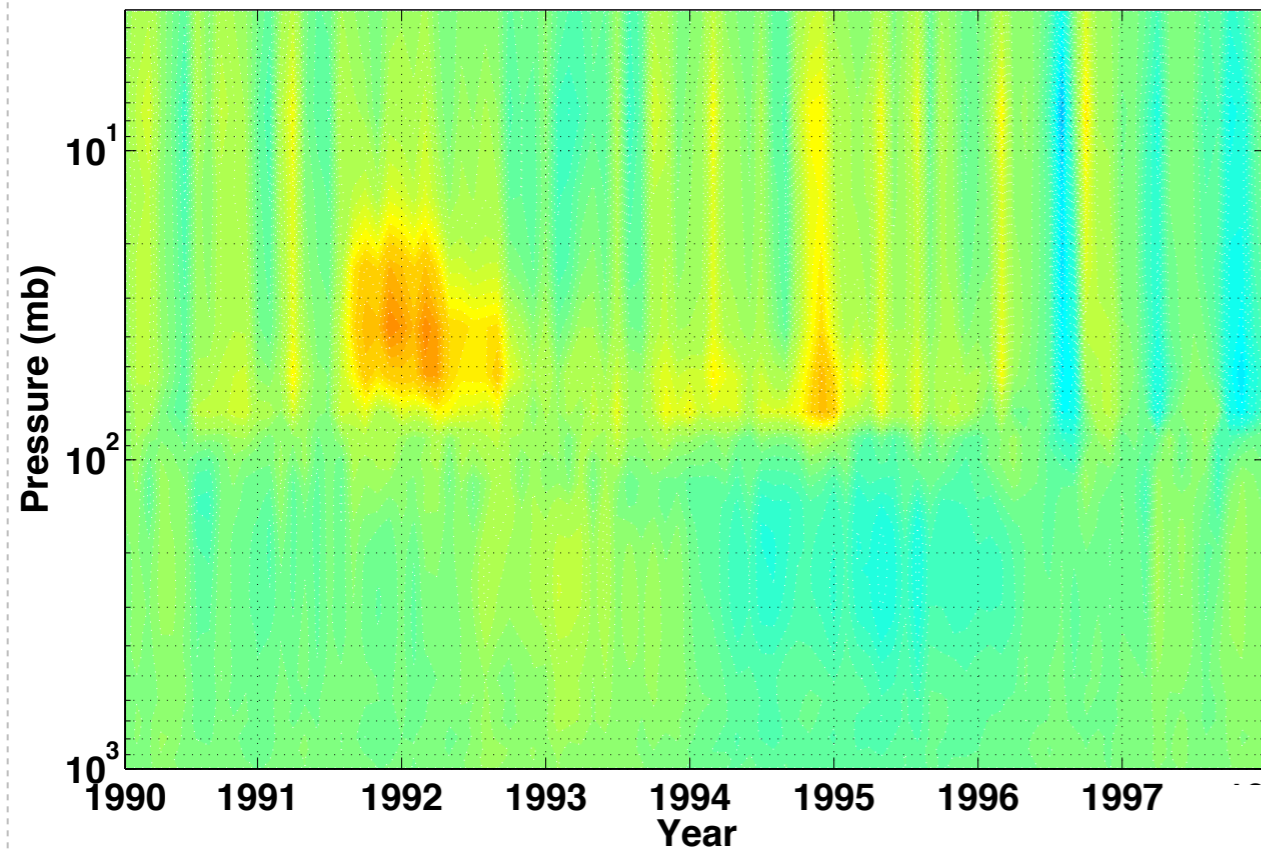
Temperature Difference at 50hpa



Changes in Stratospheric Heating

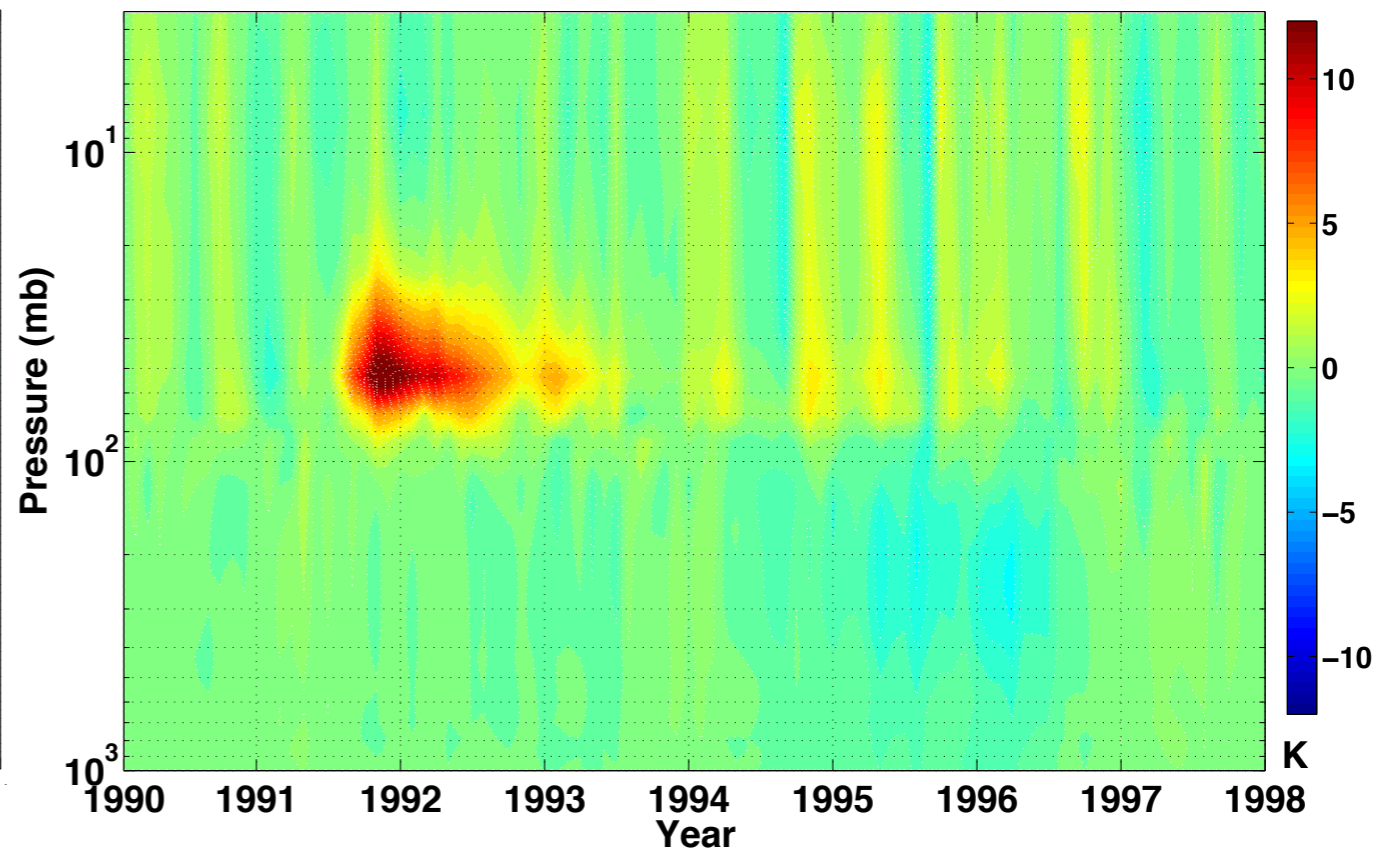
New/CCMI

CAM4: New Volcanoes – Background, Tropical T



Old/CCSM4

CAM4: Old Volcanoes – Background, Tropical T



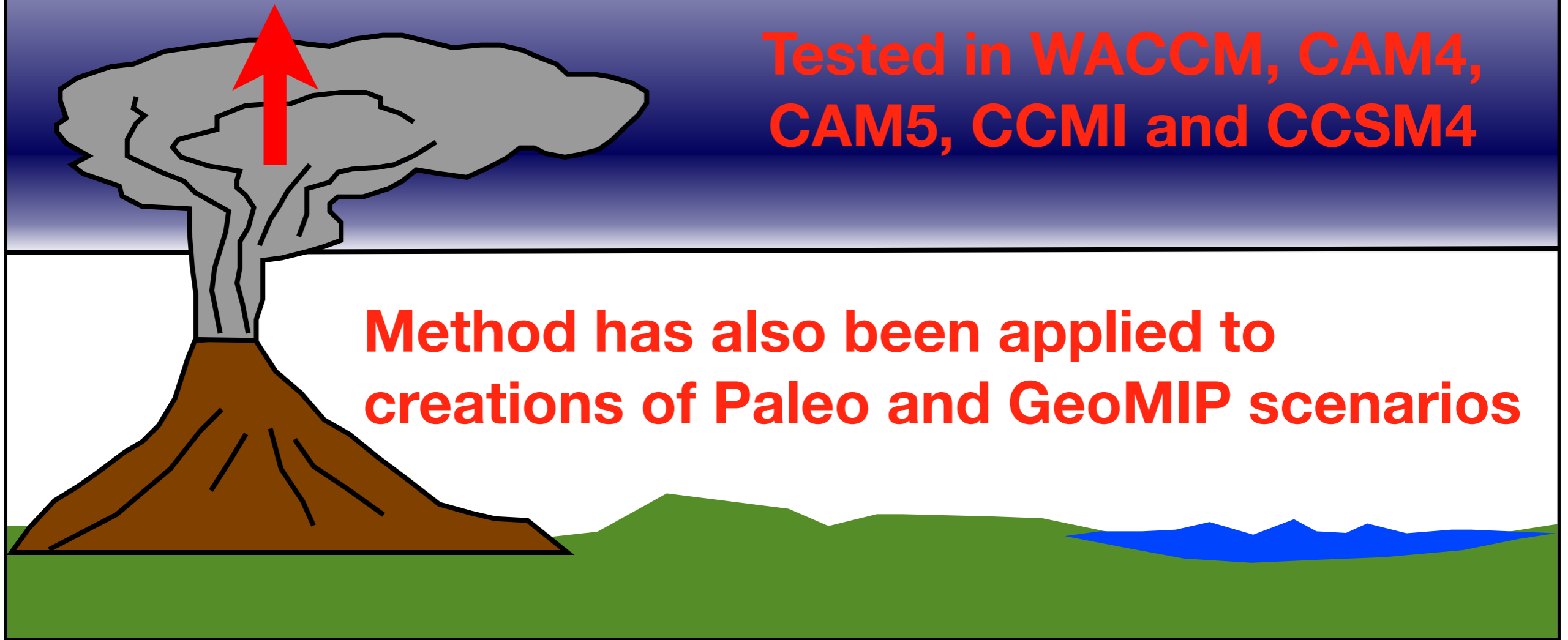


Conclusion

A New Parameterization of Stratospheric Aerosol has been implemented in CESM

Tested in WACCM, CAM4, CAM5, CCMI and CCSM4

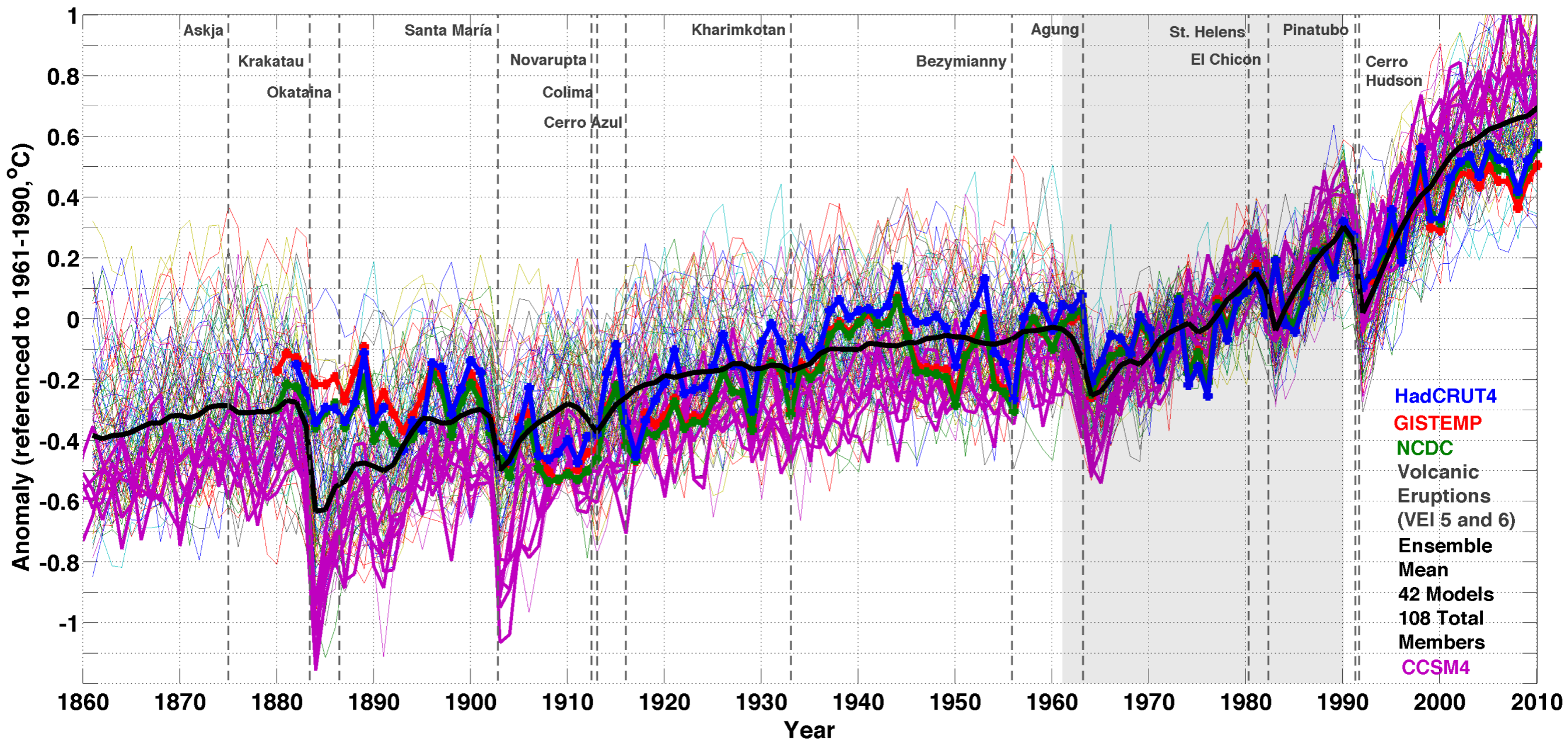
Method has also been applied to creations of Paleo and GeoMIP scenarios





Next Steps... What about Prior 1960?

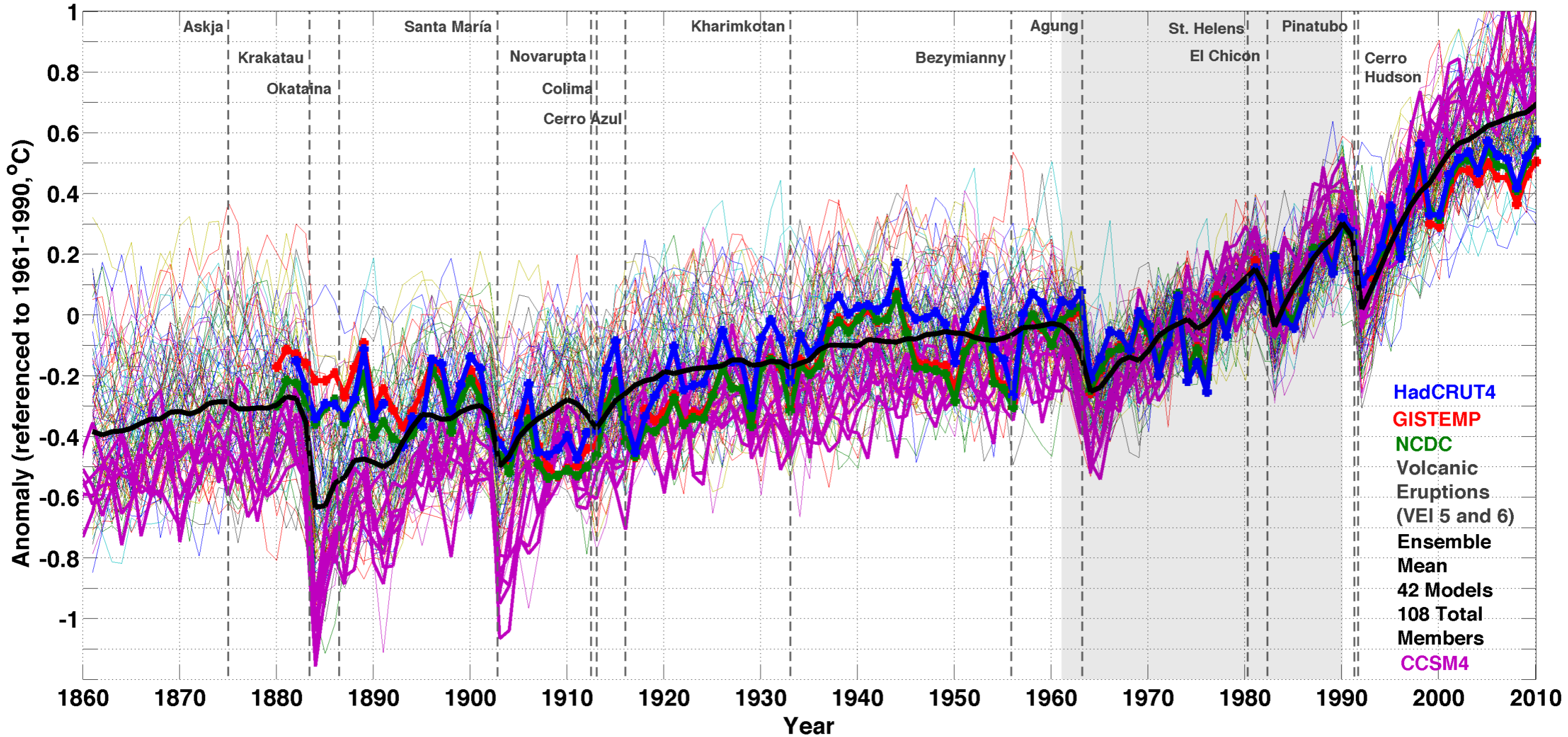
CMIP5 Global Annual Mean Surface Temperature Anomaly





What about Prognostics Stratospheric Aerosols?

CMIP5 Global Annual Mean Surface Temperature Anomaly

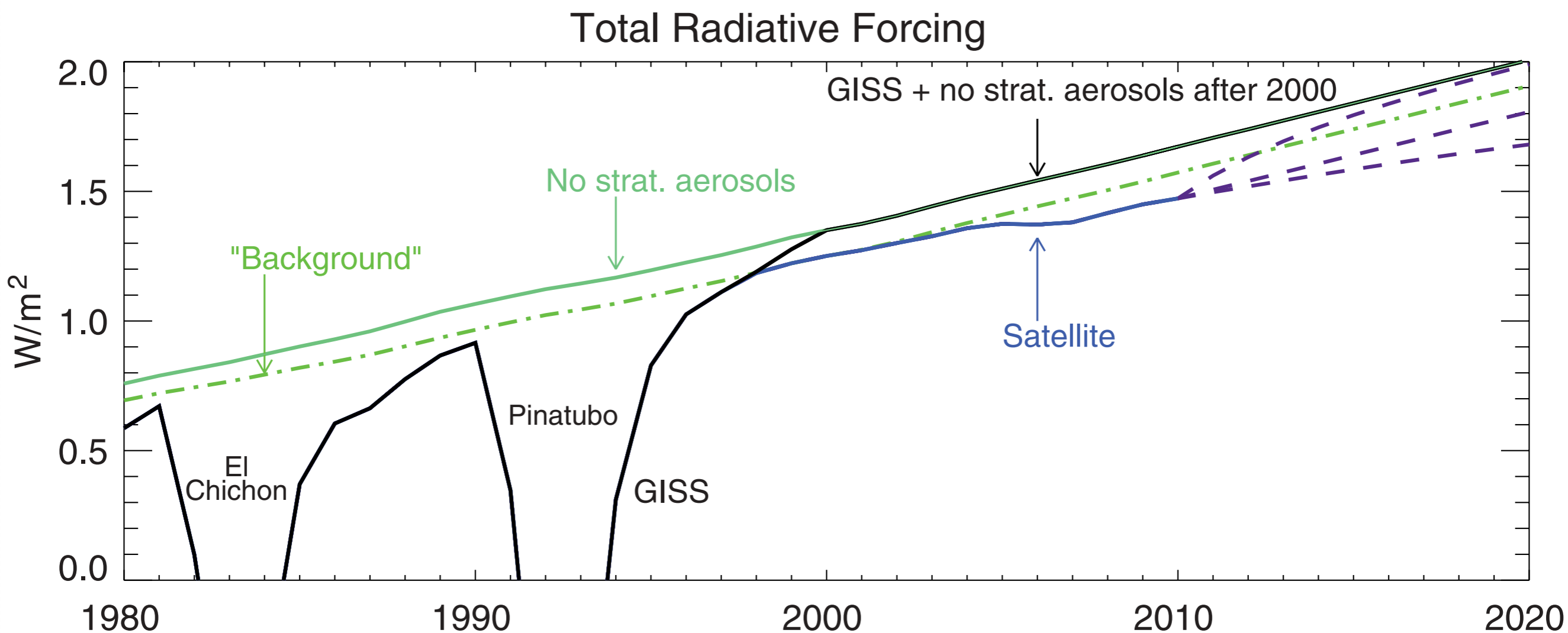




Questions?

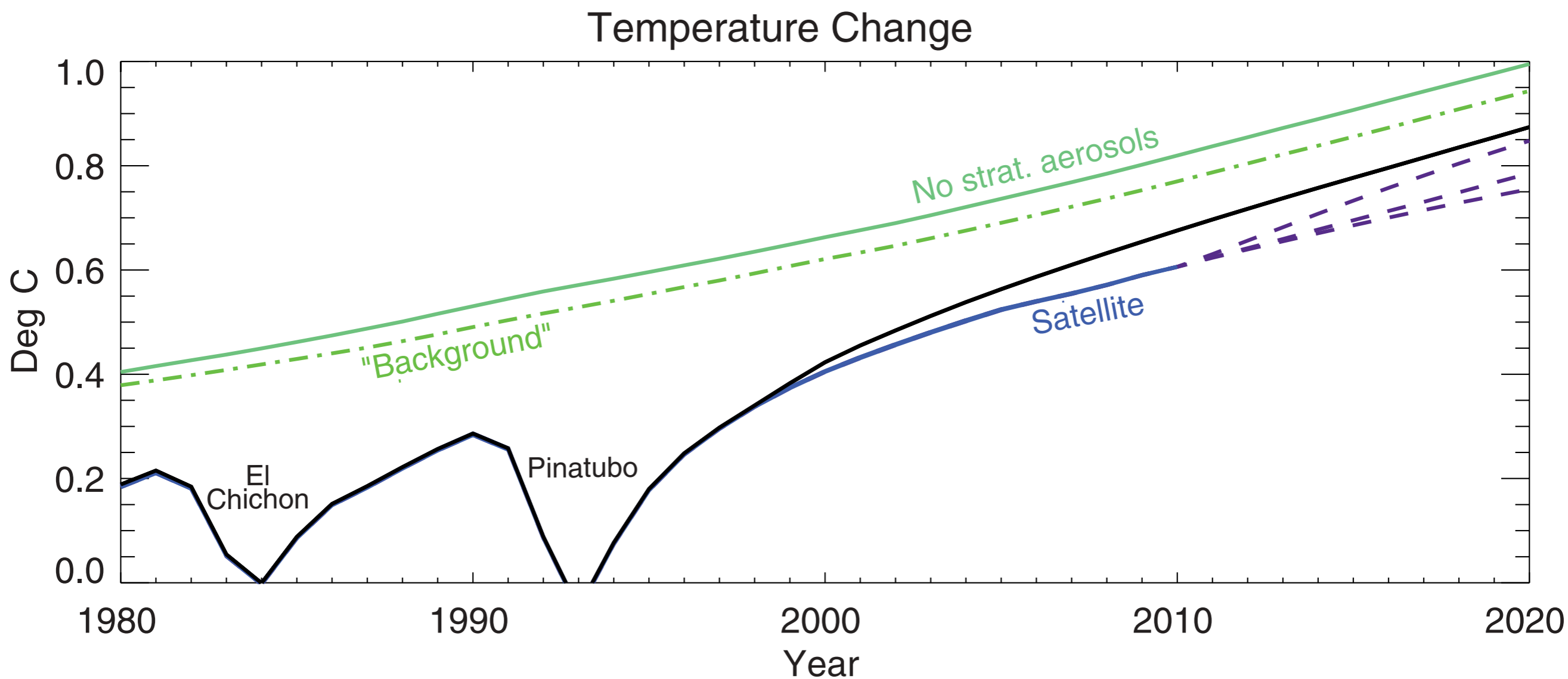


The Role of Moderate Volcanoes and the 'Hiatus'



Greenhouse gas forcing increased continuously throughout period.
 Stratospheric aerosol only slowed increase by $\sim 0.2 W/m^2$

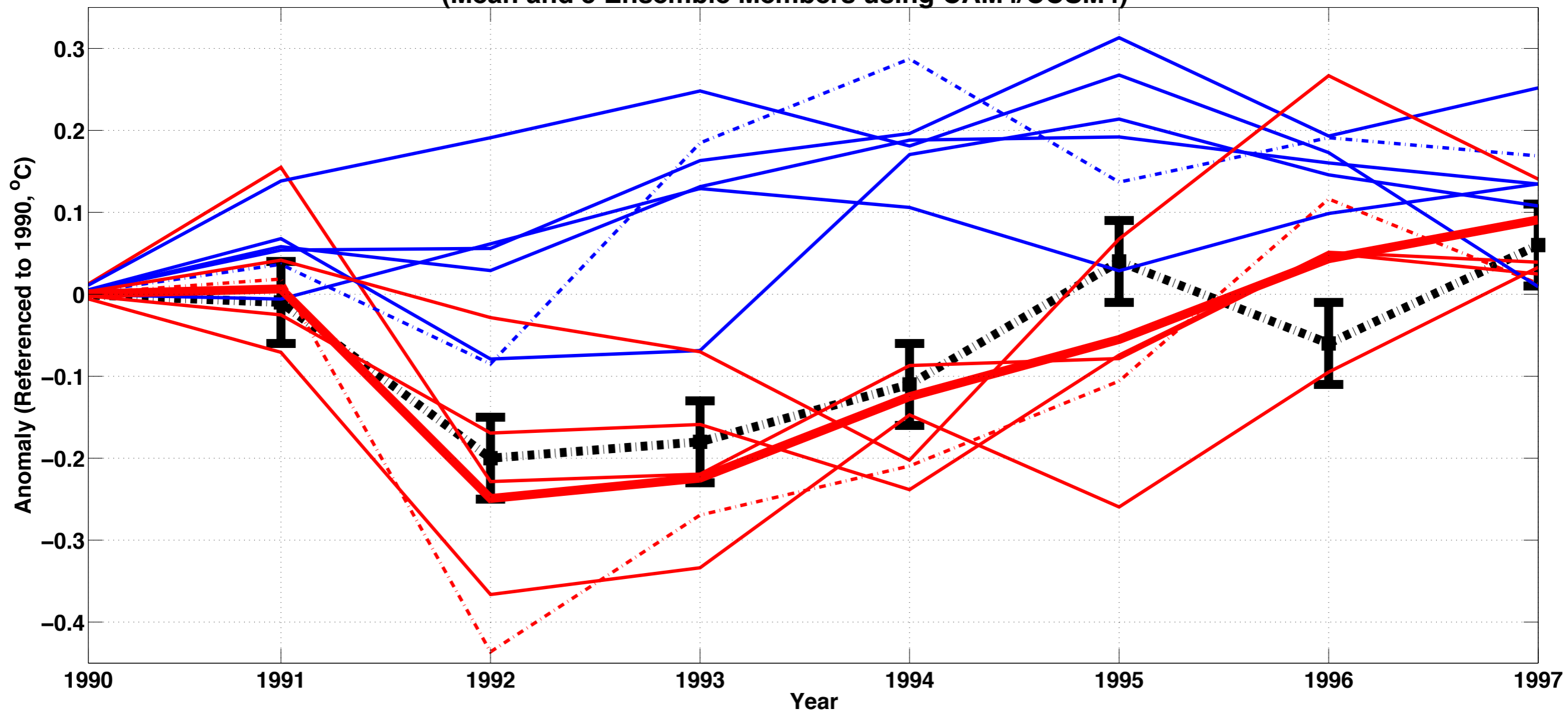
Impacts on global temperature



Ignoring the moderate volcanoes from 2000 to 2010 may lead to an underestimate of global temperature of $\sim 0.1^{\circ}\text{C}$ in 2010

Remaining Questions: Why is the Response so Variable?

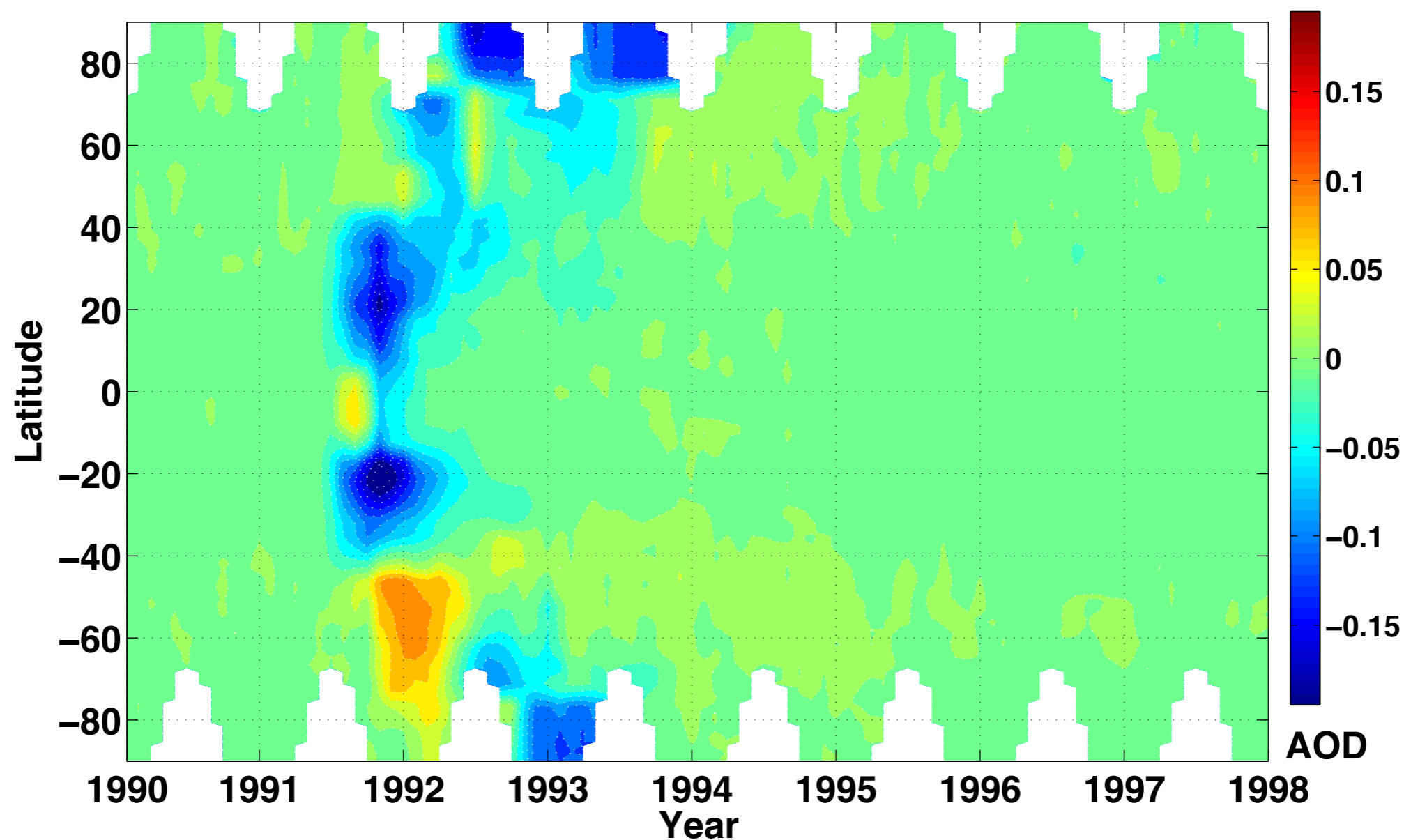
Global Annual Mean Surface Temperature
(Mean and 5 Ensemble Members using CAM4/CCSM4)



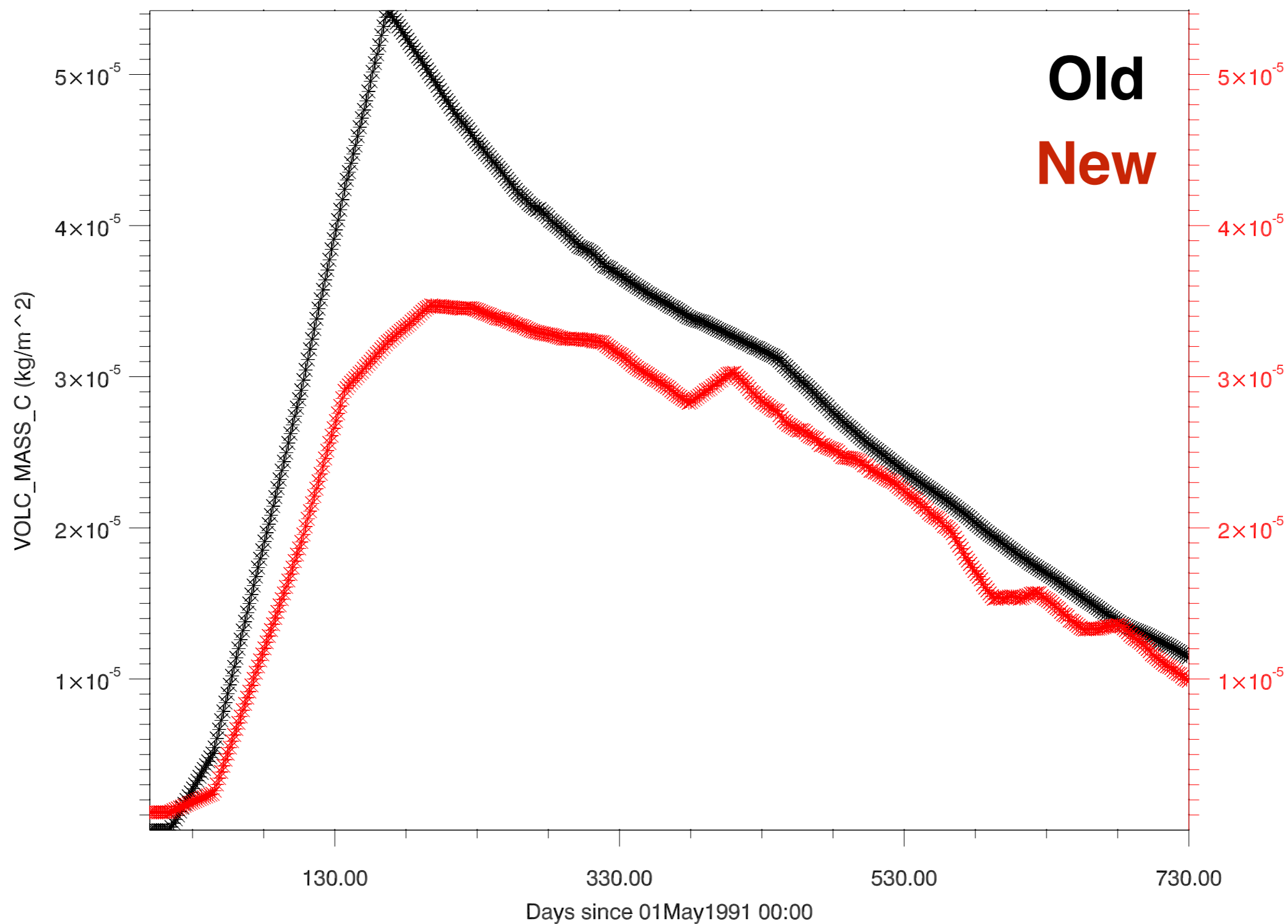
Changes in Stratospheric AOD

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

CAM4: New Volcanoes – Old Volcanoes, AEROD_v

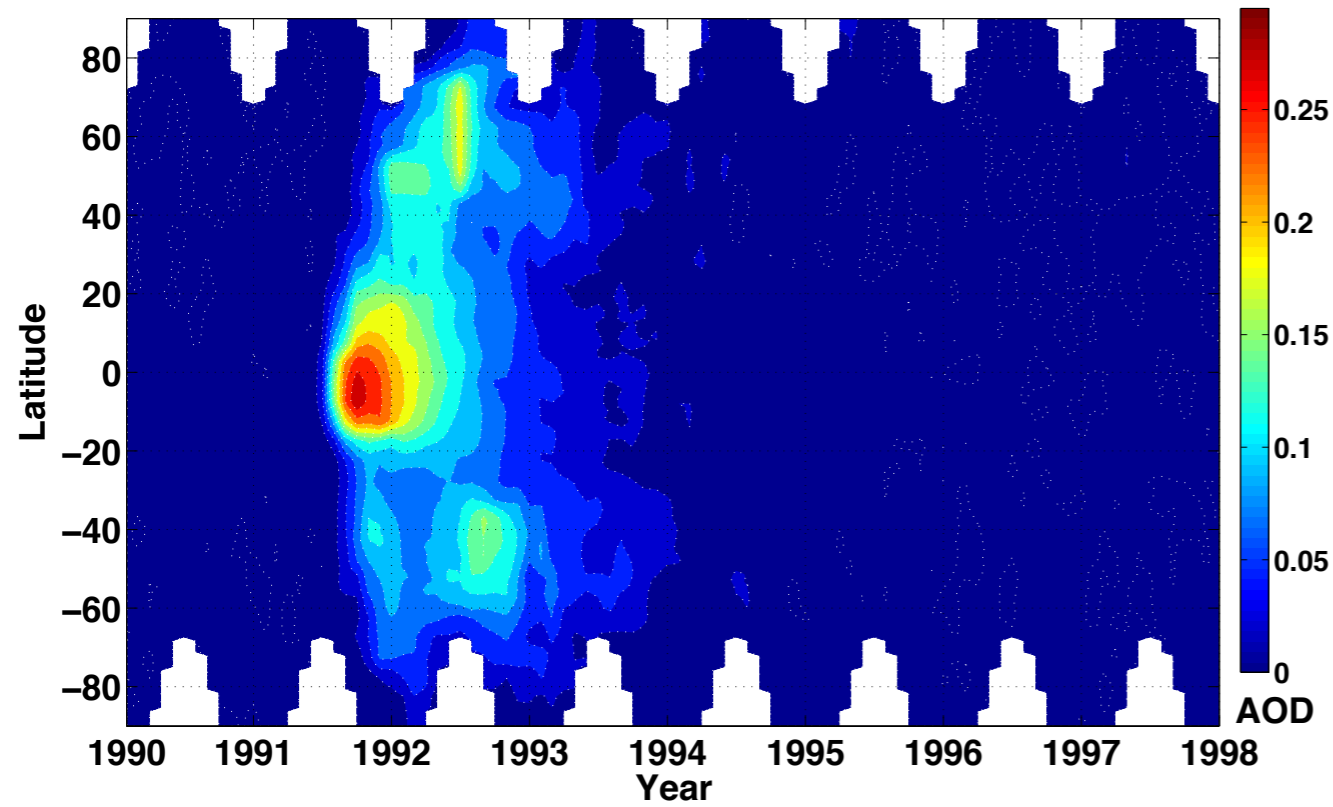


Where is the Change in AOD Coming From?

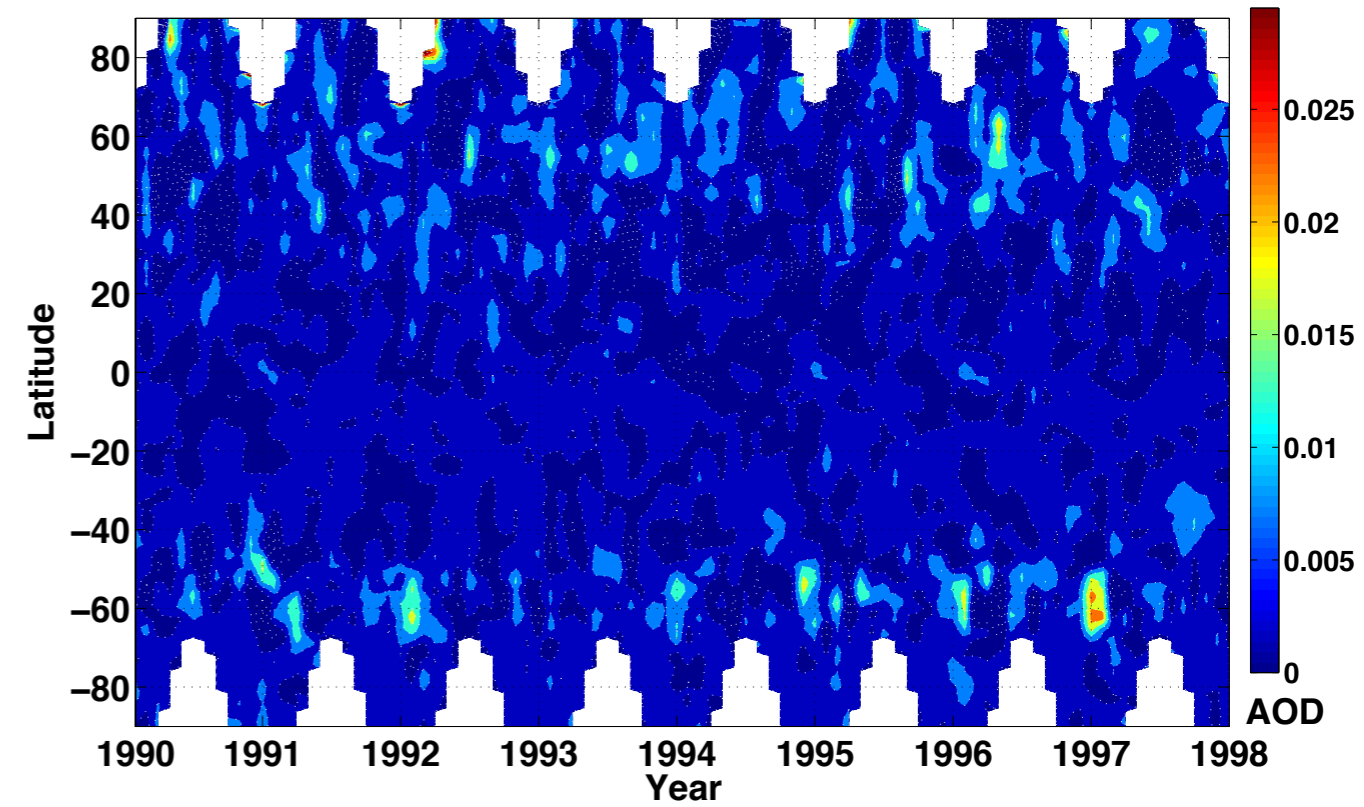


AOD

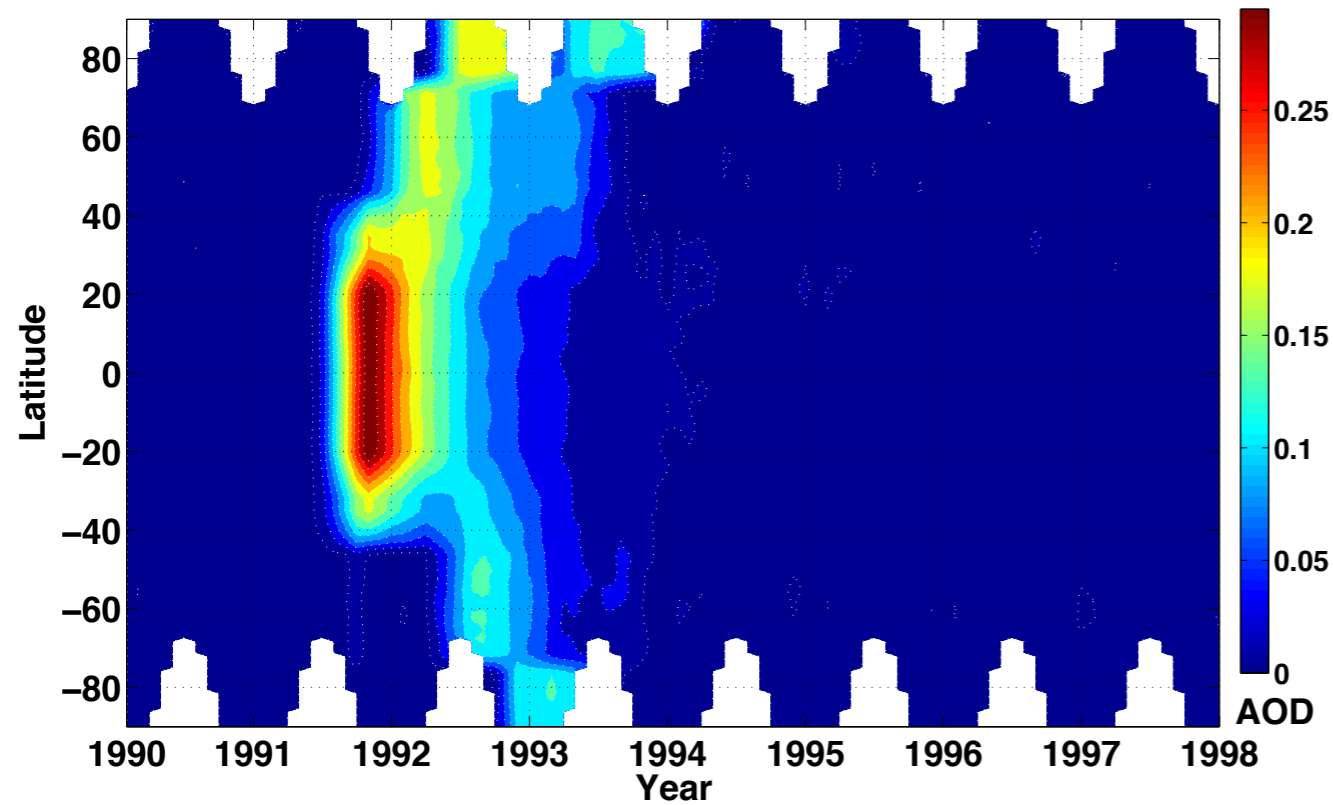
CAM4: New Volcanoes – Background, $AEROD_V$



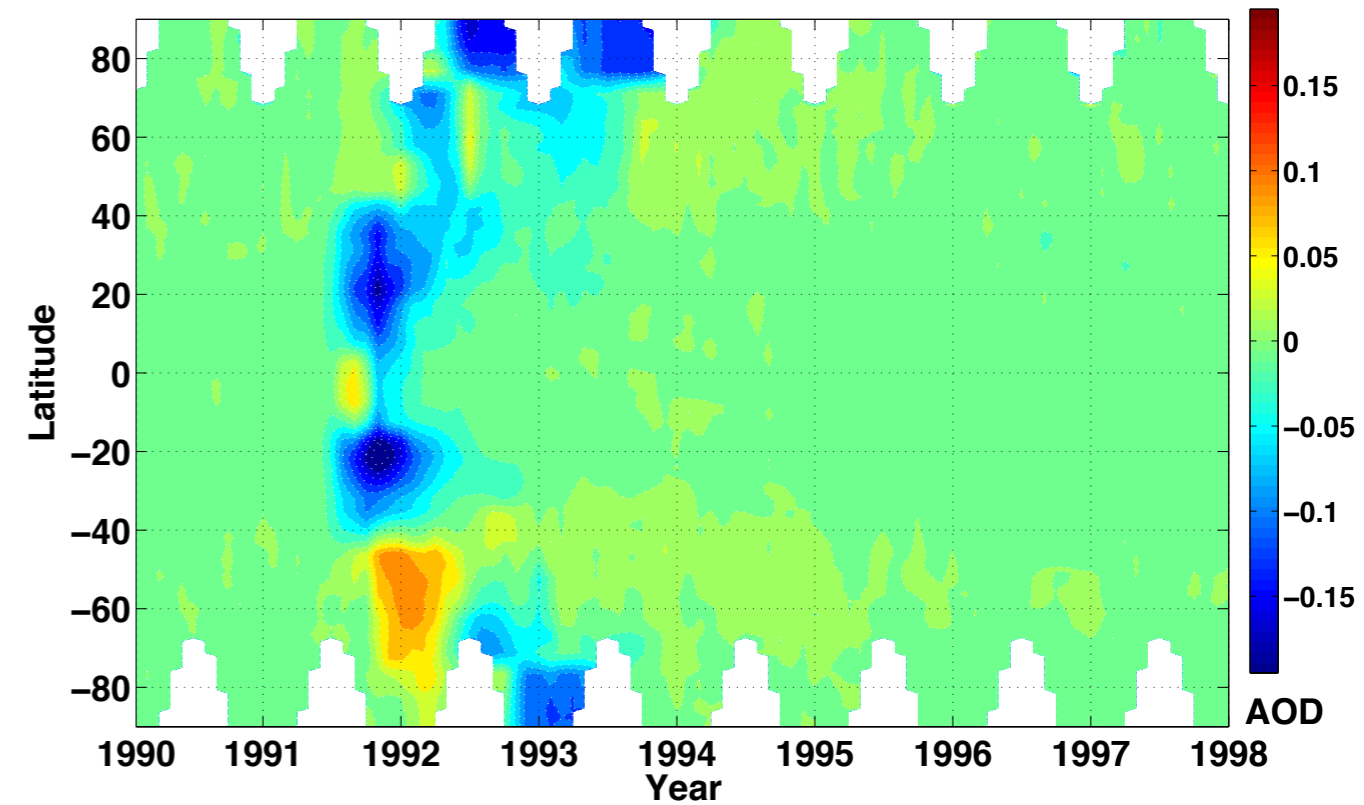
CAM4: Background – No Stratospheric Aerosol, $AEROD_V$



CAM4: Old Volcanoes – Background, $AEROD_V$

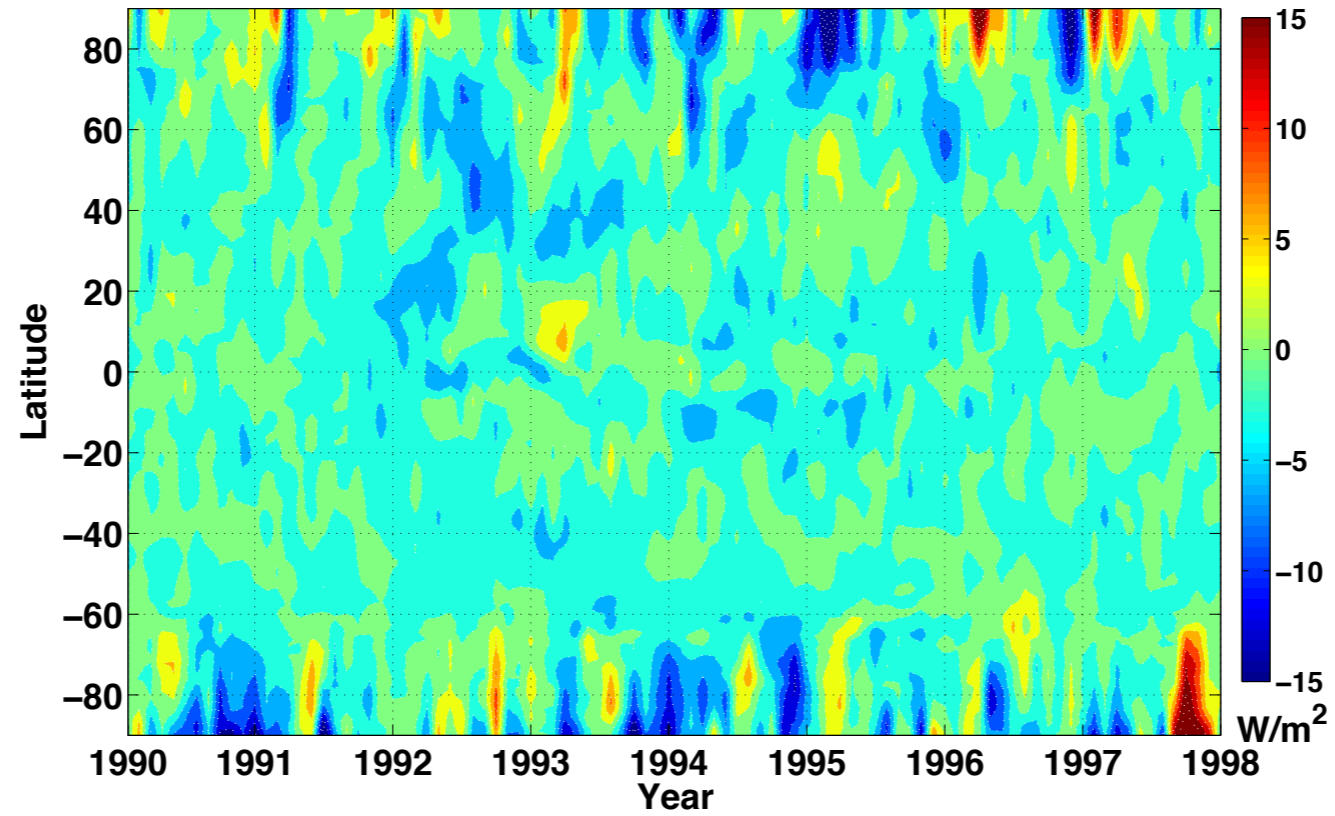


CAM4: New Volcanoes – Old Volcanoes, $AEROD_V$

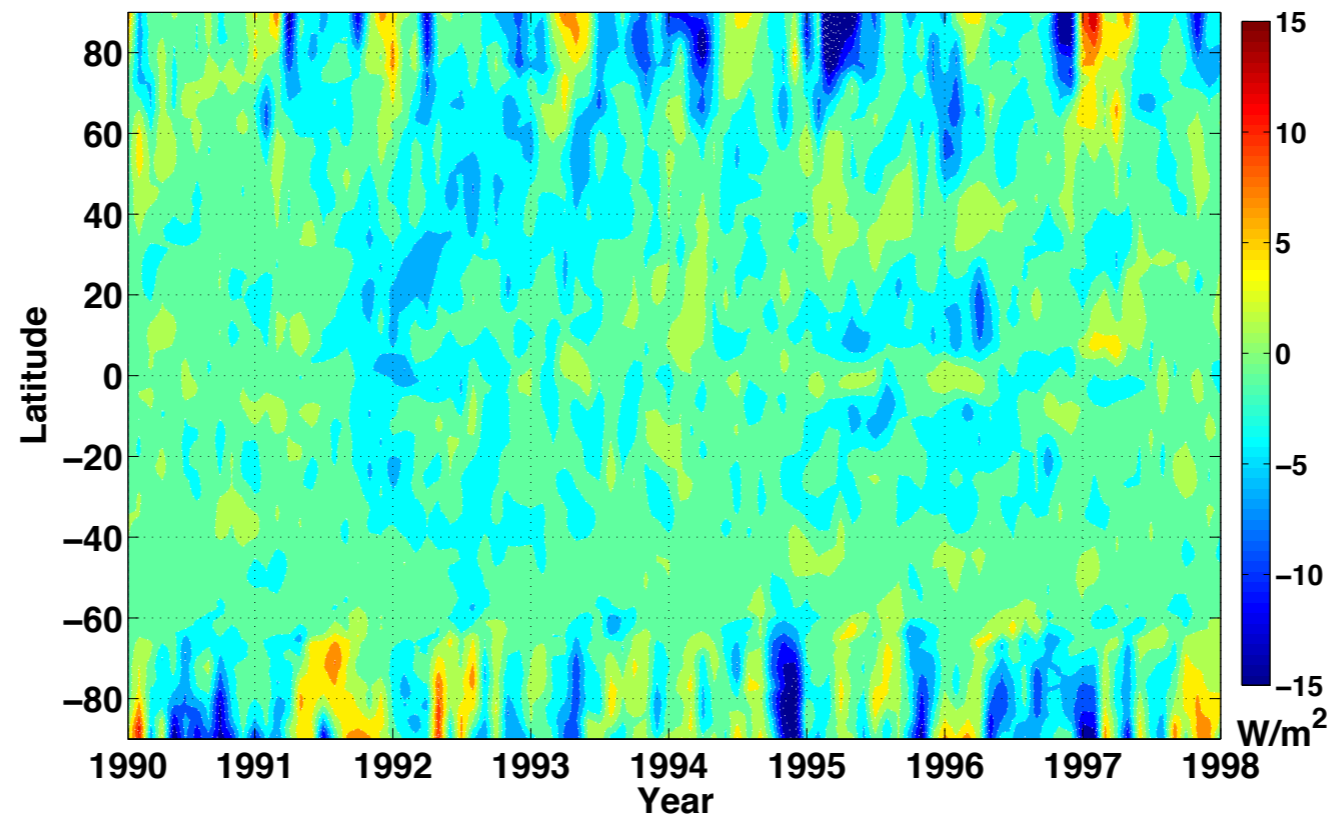


FLNTC

CAM4: New Volcanoes – Background, FLNTC

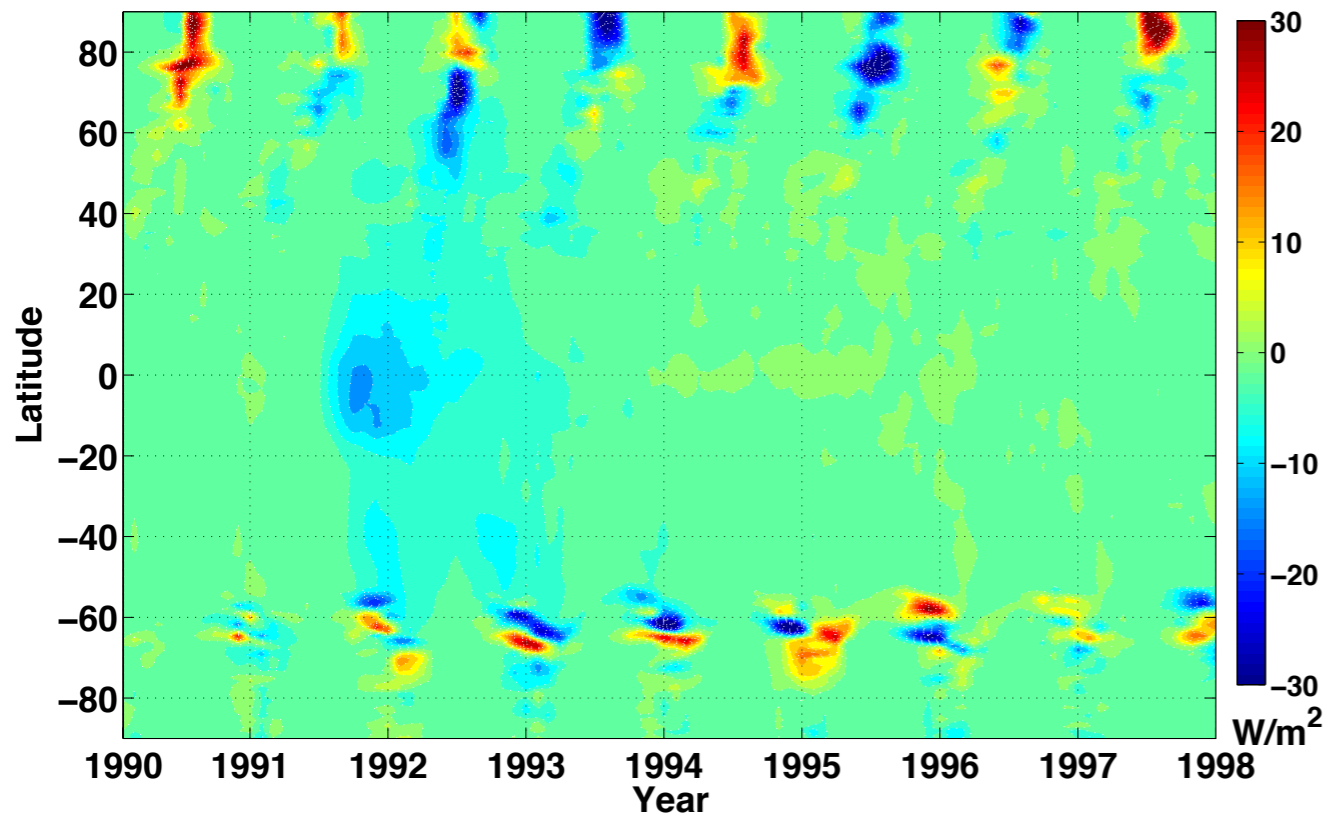


CAM4: Old Volcanoes – Background, FLNTC

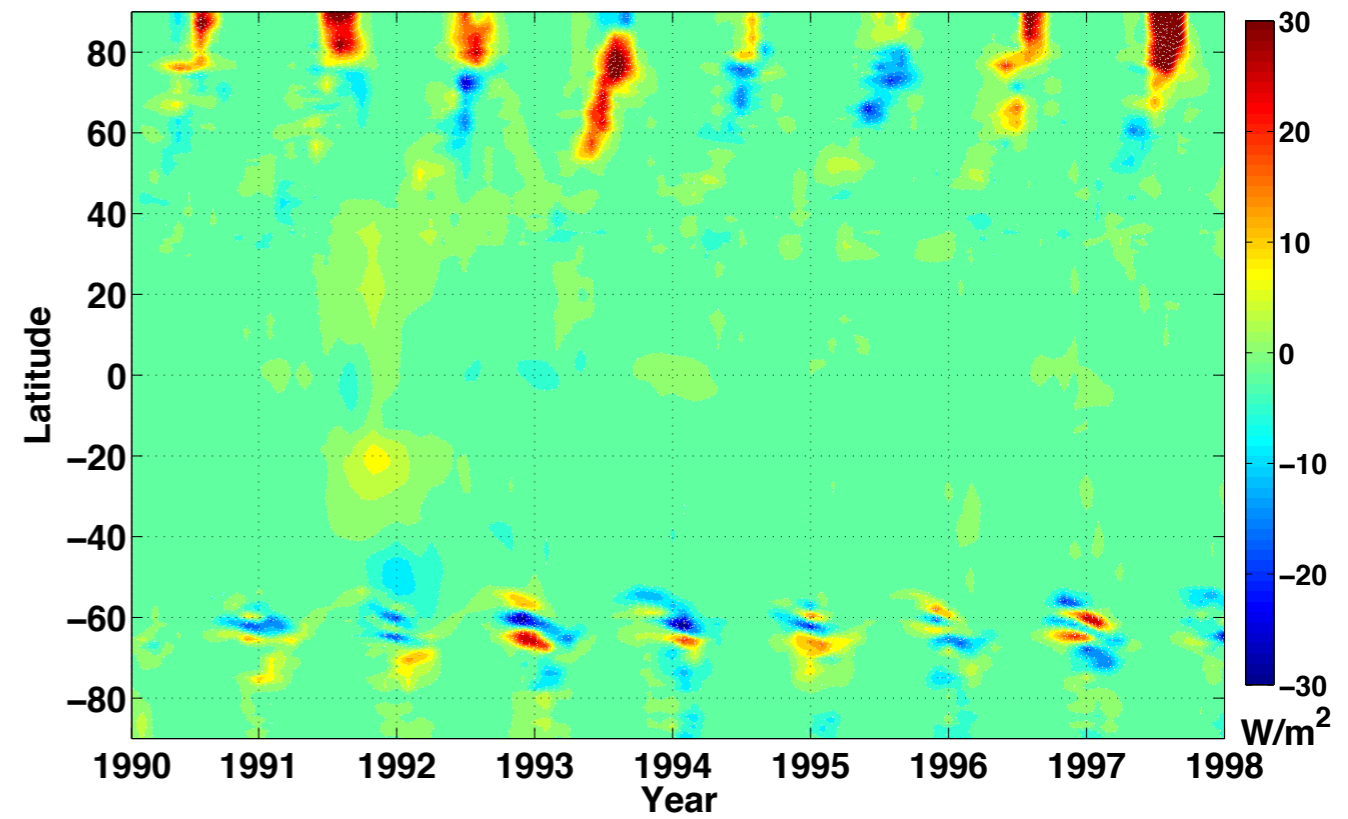


FSNSC

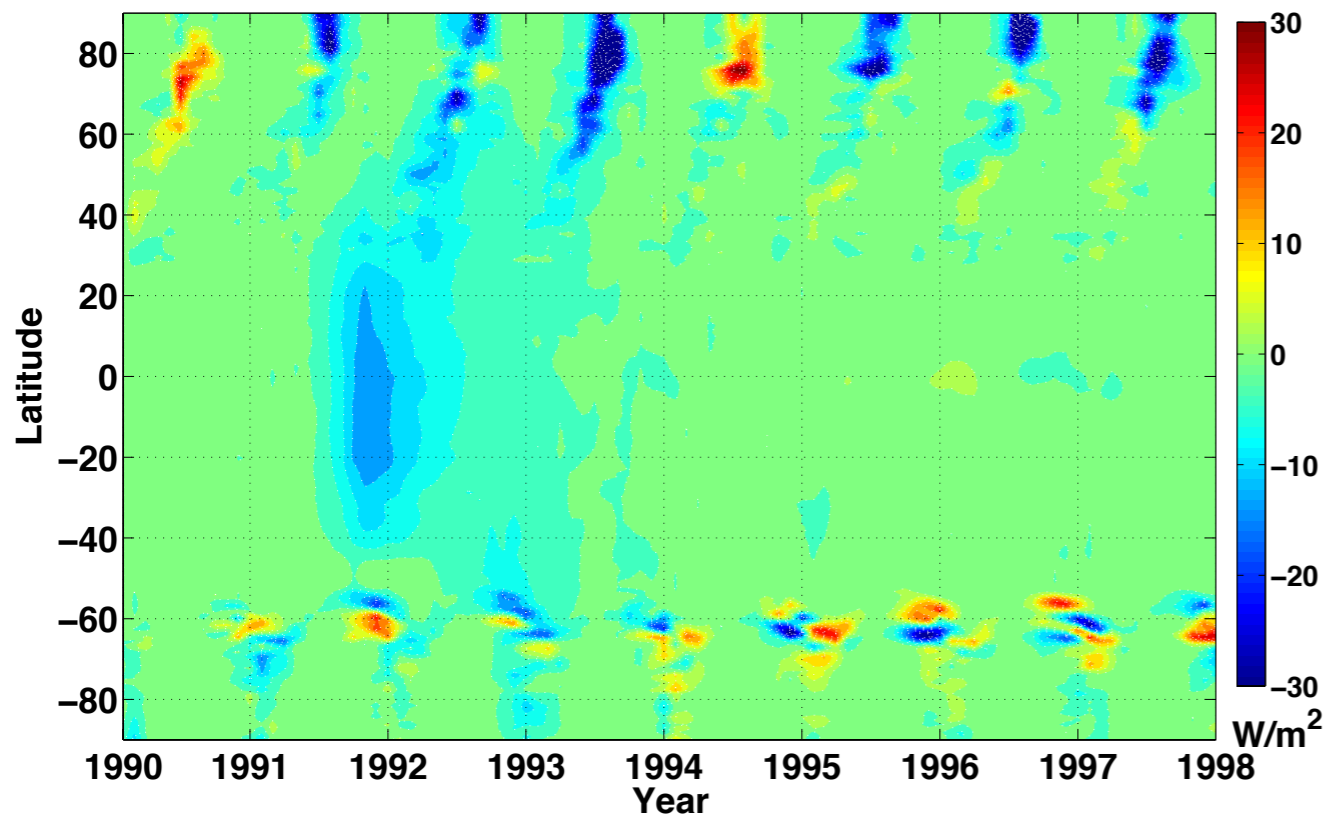
CAM4: New Volcanoes – Background, FSNSC



CAM4: New Volcanoes – Old Volcanoes, FSNSC

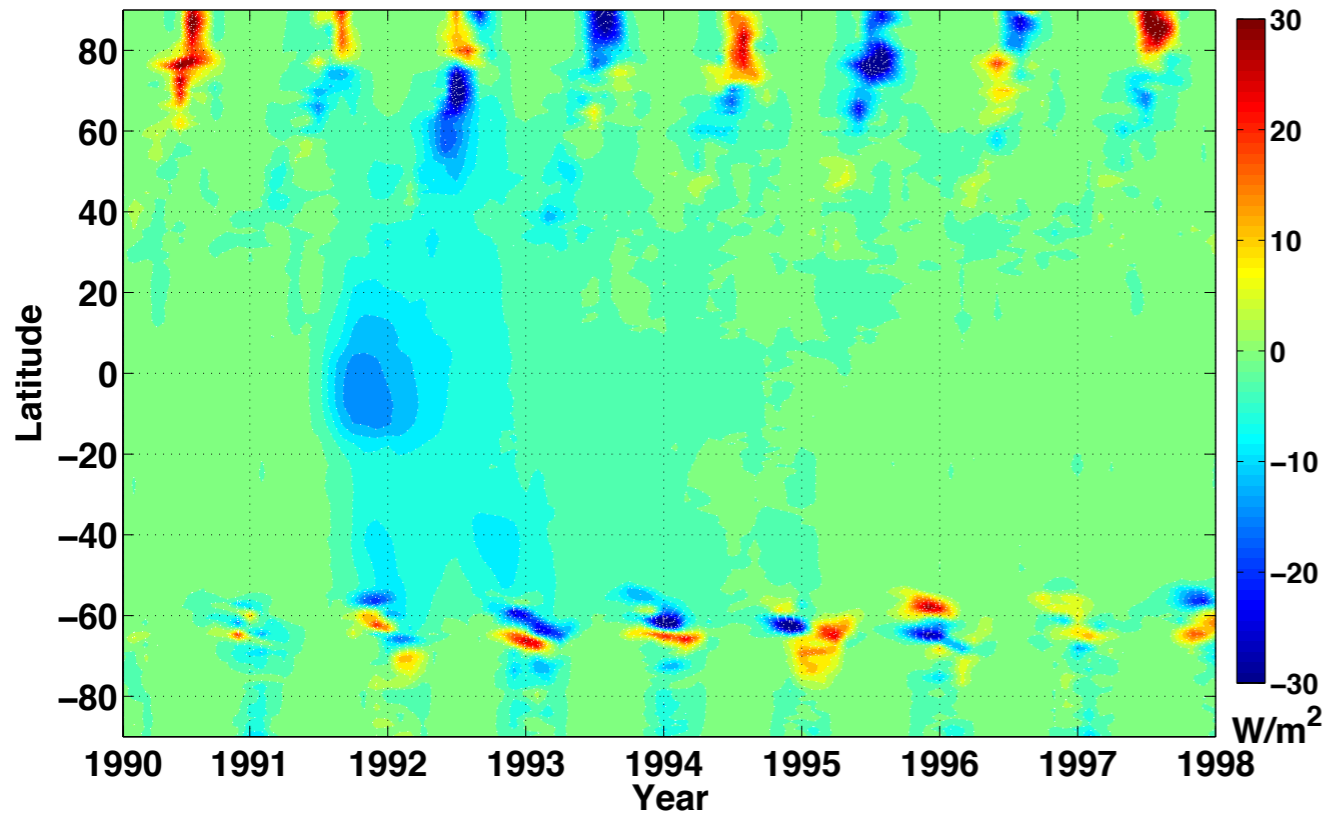


CAM4: Old Volcanoes – Background, FSNSC

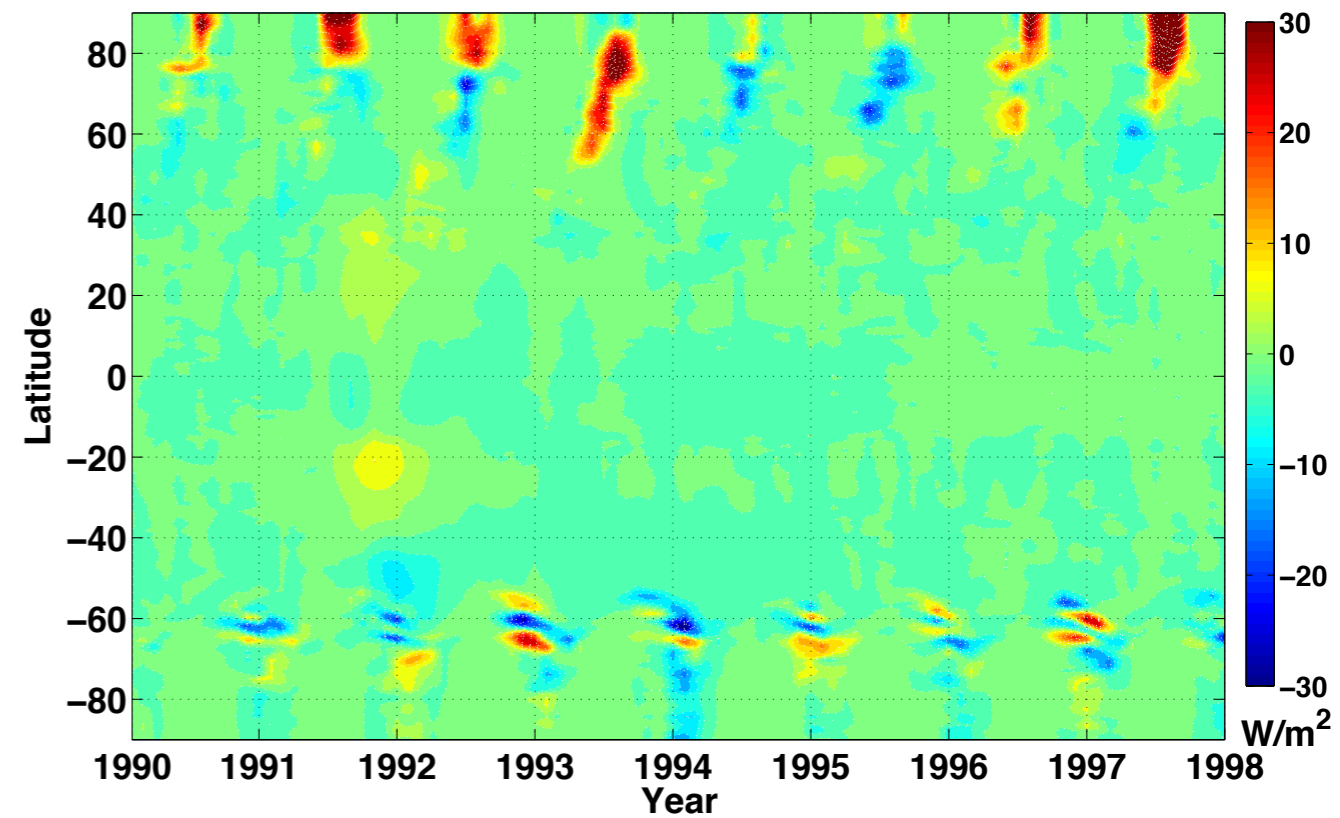


FSNTC

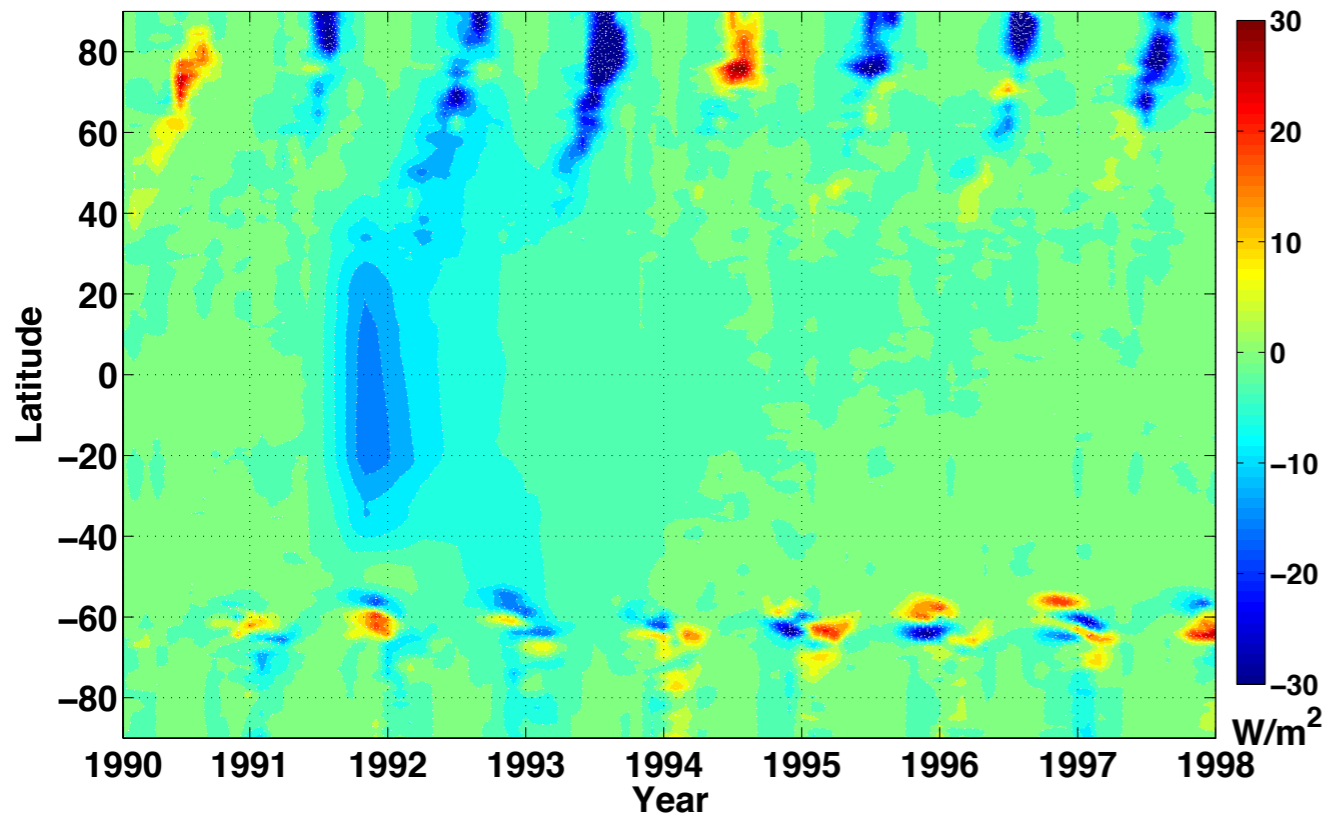
CAM4: New Volcanoes – Background, FSNTC



CAM4: New Volcanoes – Old Volcanoes, FSNTC

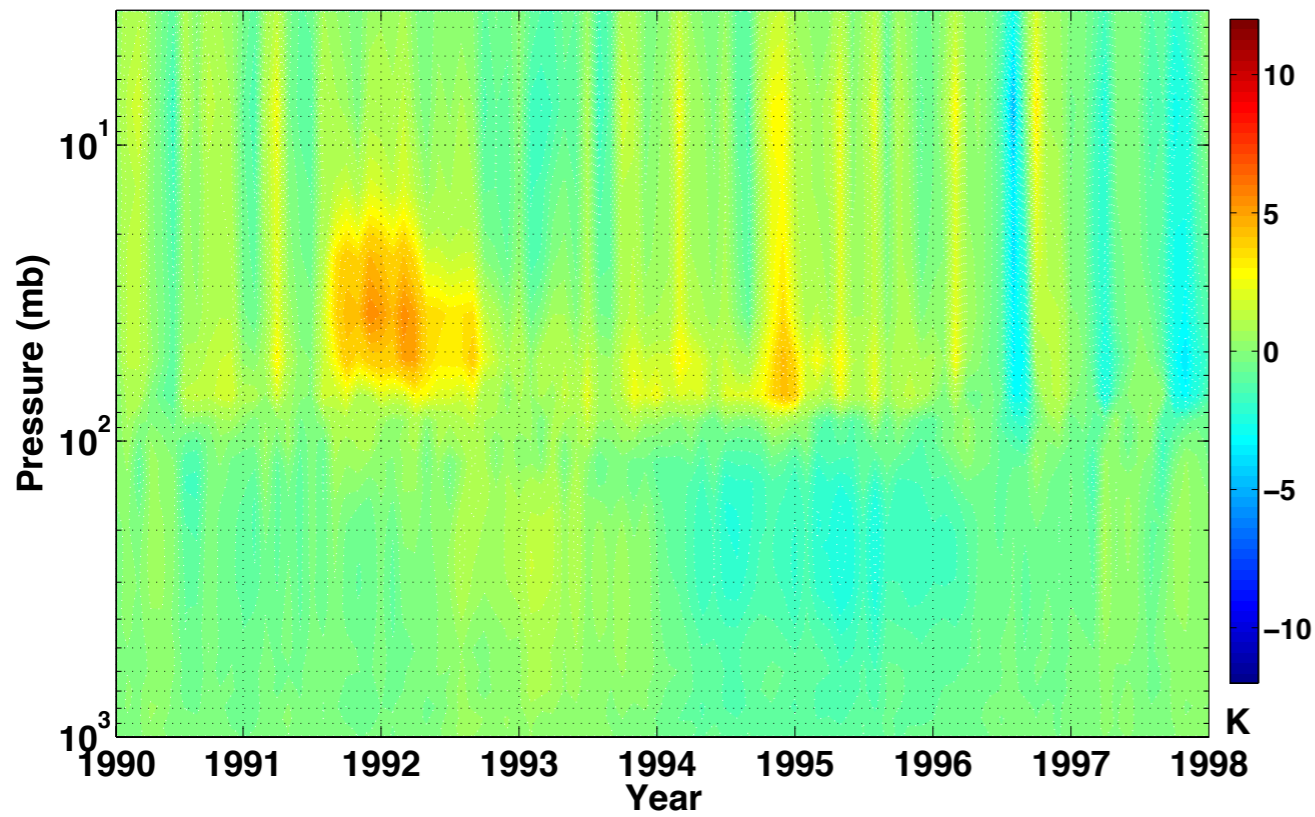


CAM4: Old Volcanoes – Background, FSNTC

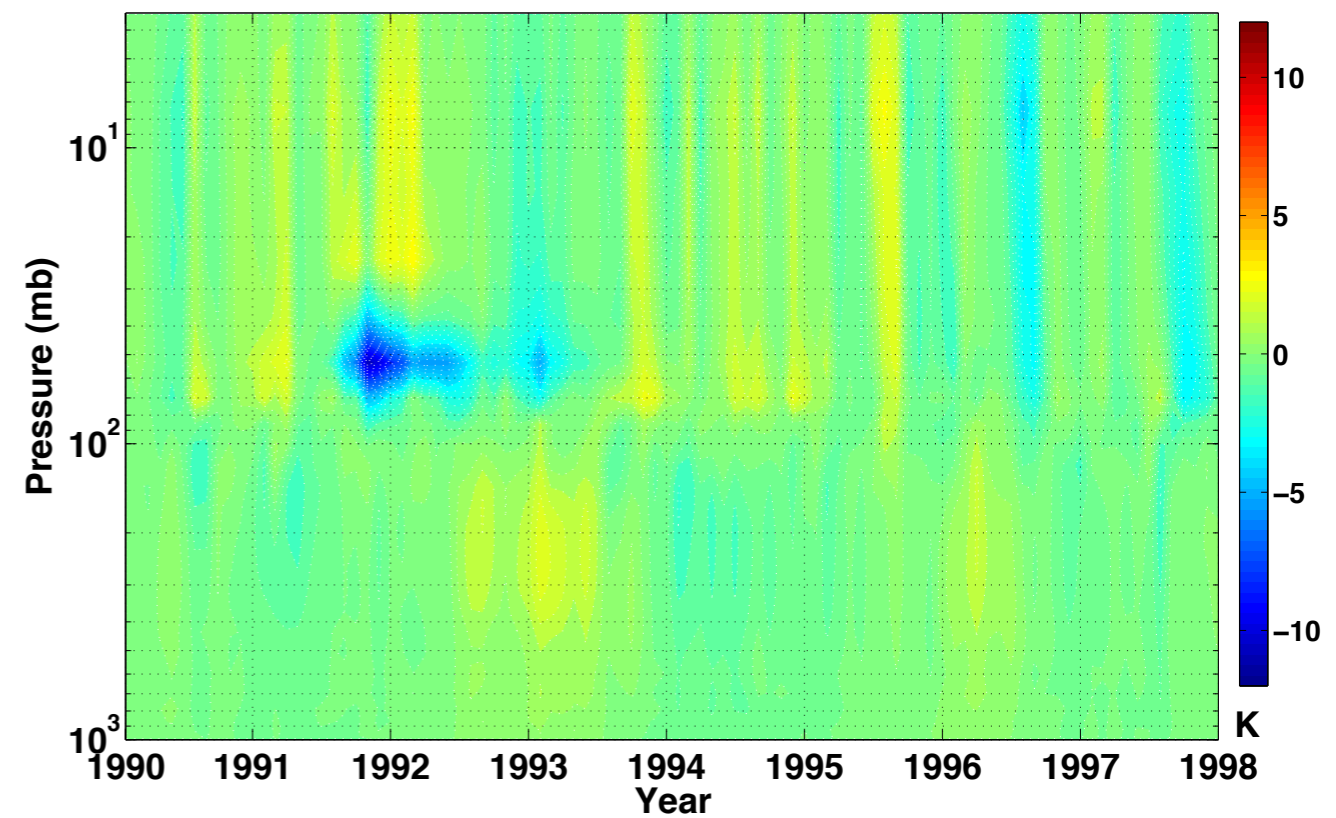


Tropical T (20S-20N)

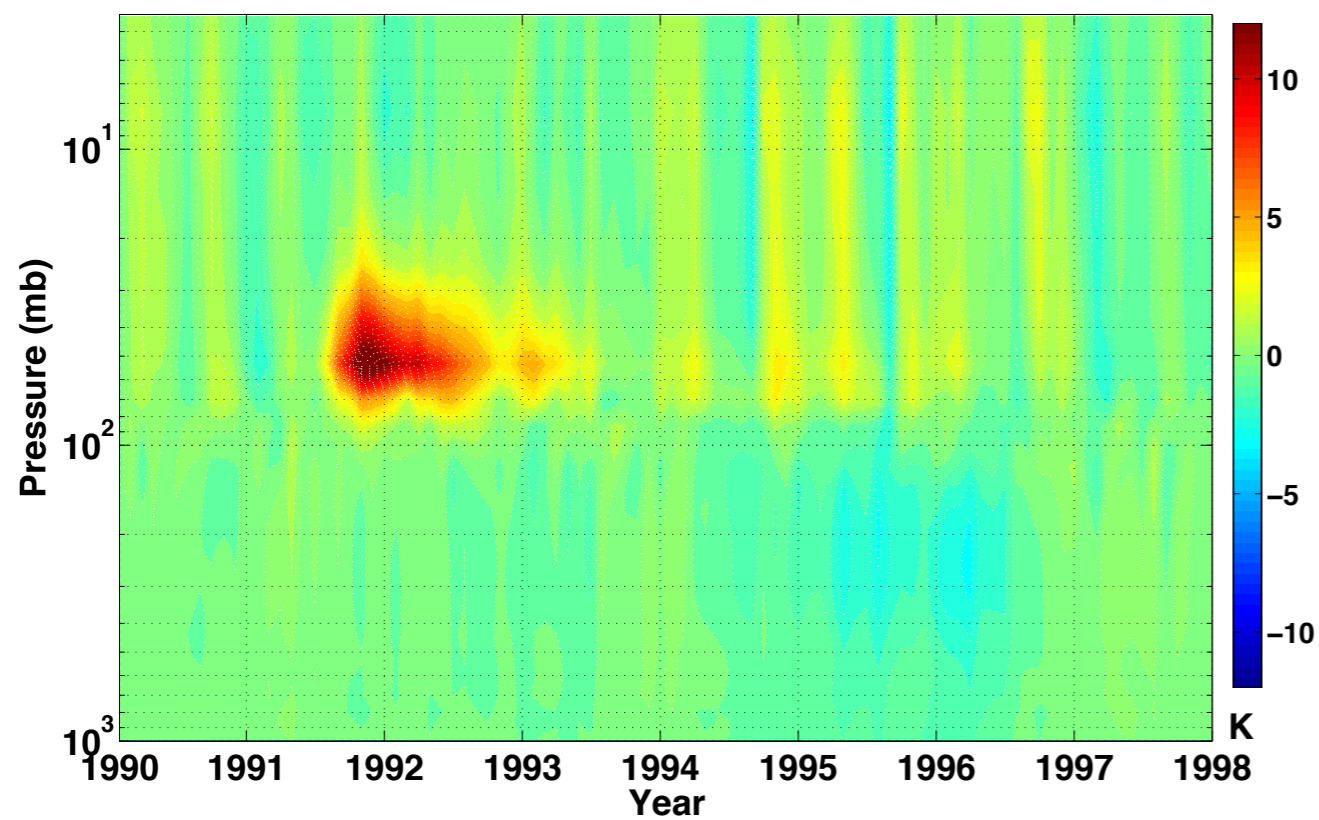
CAM4: New Volcanoes – Background, Tropical T



CAM4: New Volcanoes – Old Volcanoes, Tropical T

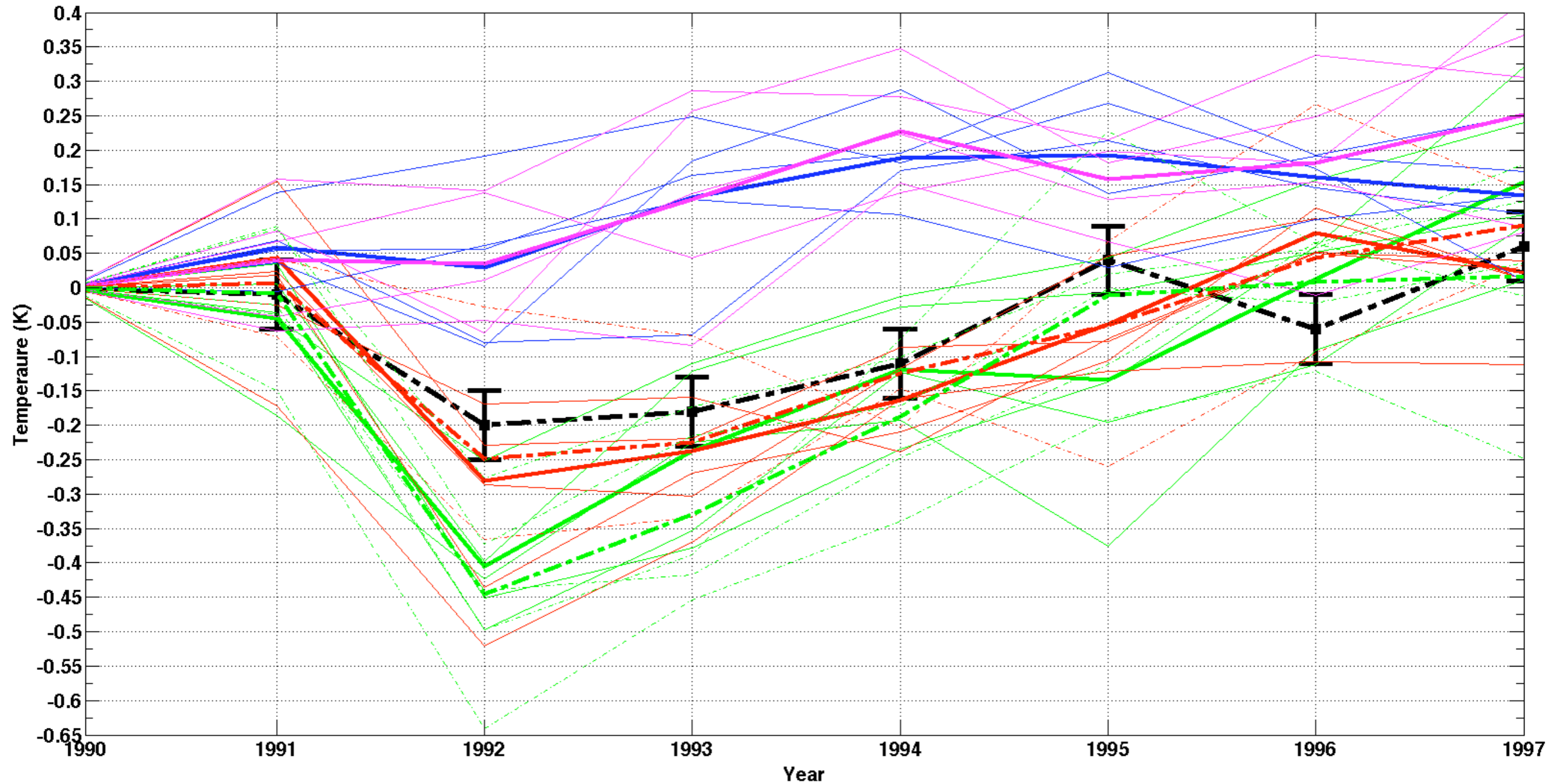


CAM4: Old Volcanoes – Background, Tropical T



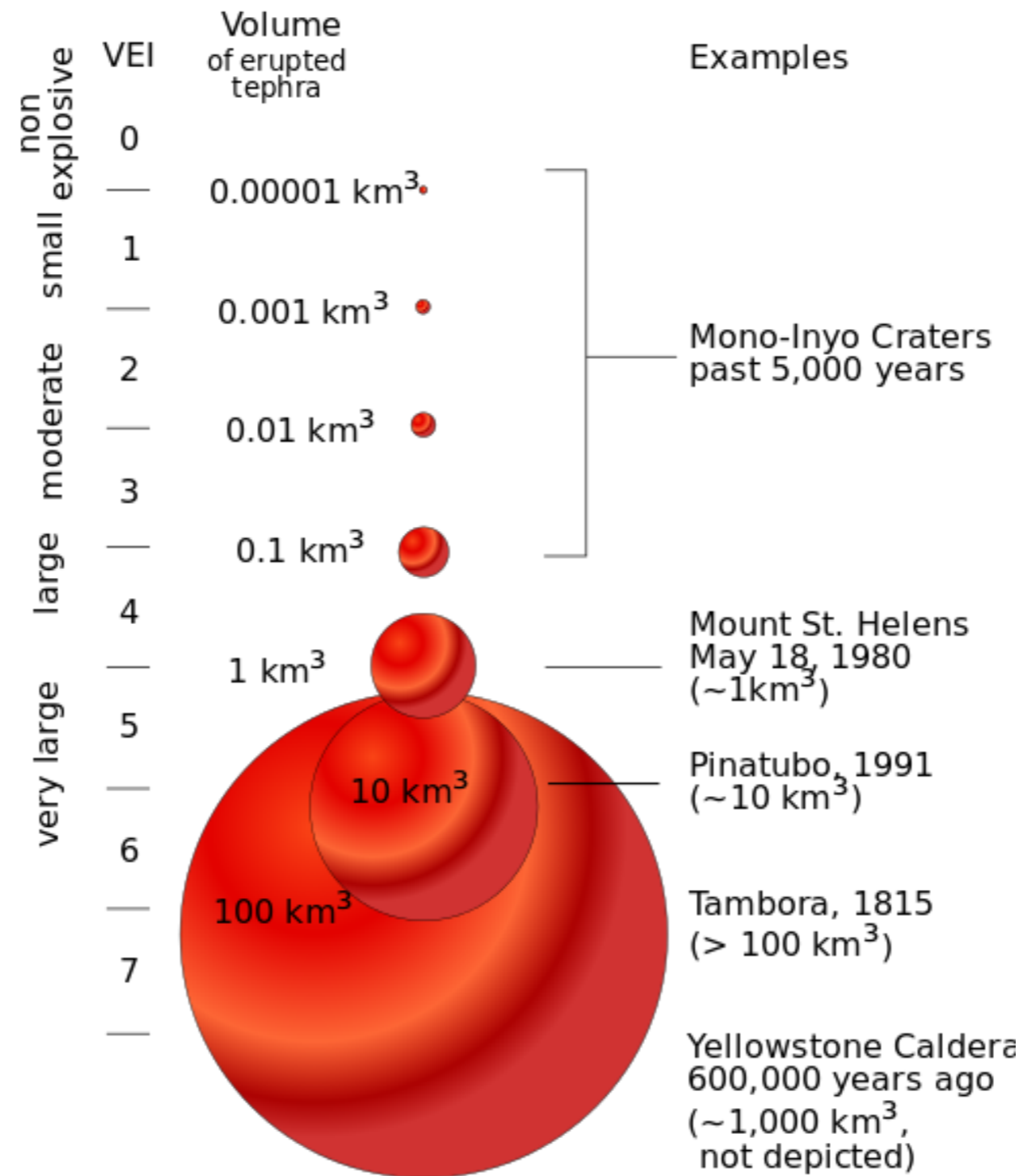
Old, New, Background, None, New Mass Old
Optics, Old Mass with New Optics, GISS

Global Annual Mean TREFHT



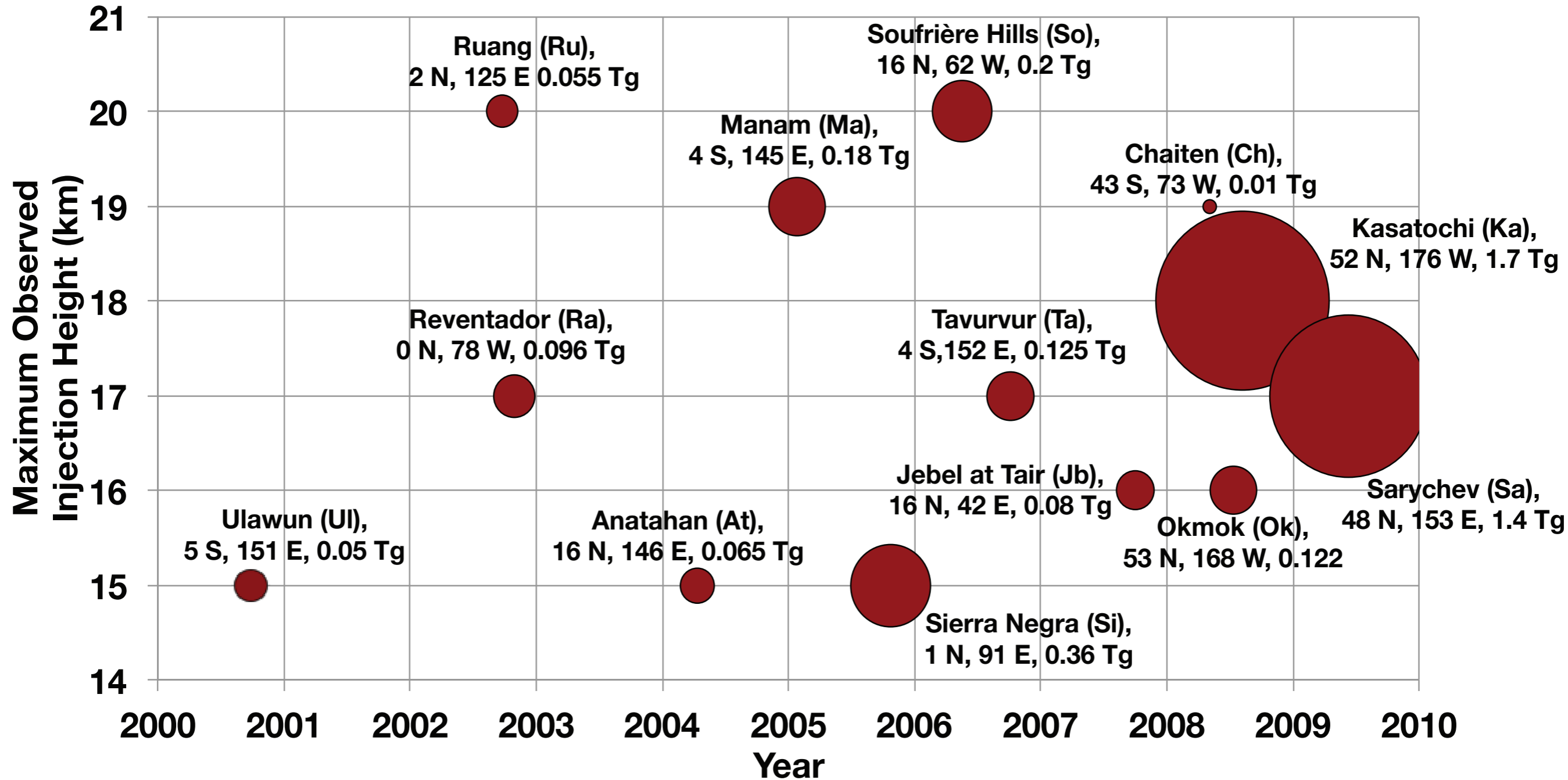


Scale



Volcanic Eruptions from 2000 to 2010

Maximum Observed Injection Height and Total Column SO₂



Circles represent relative amount of sulfur emitted.