

Volcanic forcing in CESM2



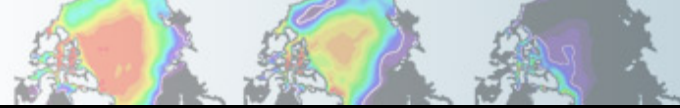
Sarychev Peak,
Kuril Islands
June 12, 2009
viewed from ISS

Mike Mills, WACCM Liaison

Ryan Neely & Anja Schmidt, University of Leeds

Dick Easter & Steve Ghan, PNNL

Andrew Conley, NCAR ...and many others!

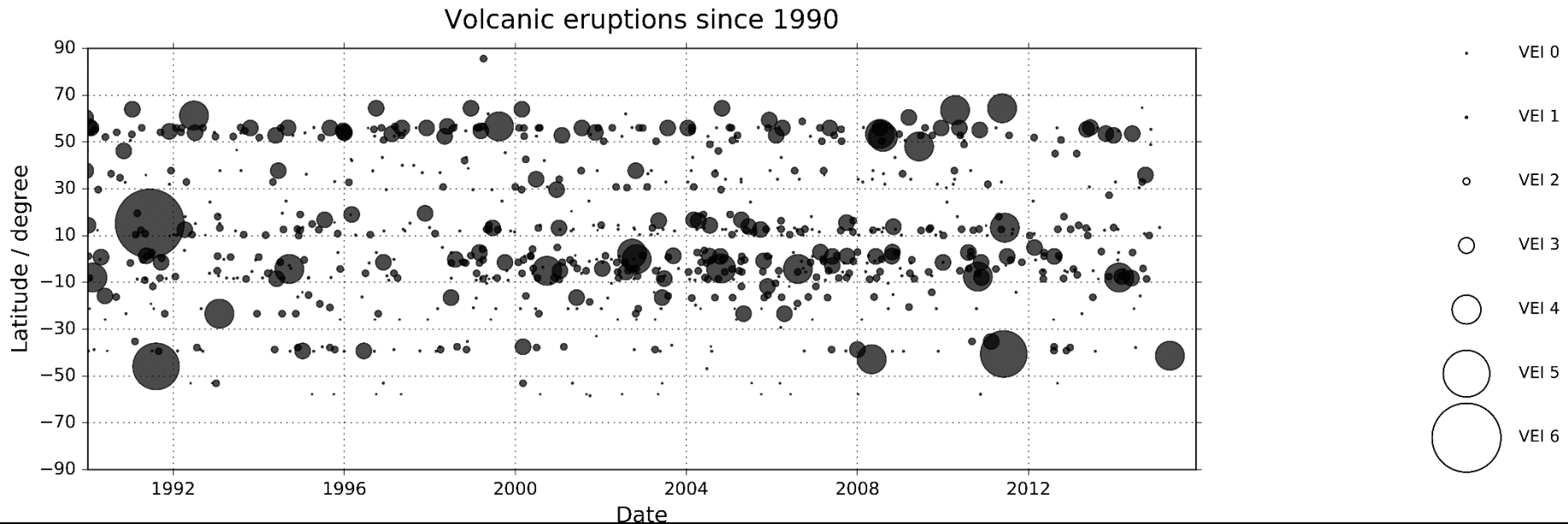


Volcanic forcing in CESM: a history

- **CESM1 (CMIP5, LENS):** prescribed single mode
 - **CAM5:** prescribed volcanic aerosol mass file (Ammann et al., 2003). Assumes 75% H₂SO₄/25% H₂O, wet effective radius = 0.426 μm, $\sigma(\ln(r)) = 1.8$
 - **WACCM4:** prescribed volcanic surface area density file (Kinnison et al., 2007). Composition varies with T & H₂O, $r_{\text{eff wet}} = 0.5 \mu\text{m}$, $\sigma(\ln(r)) = 1.25$
- **CESM2**
 - **WACCM6:** prognostic volcanic aerosol derived from SO₂ emissions (Mills et al., 2016)
 - **CAM6 Interim:** prescribed single mode based on obs, varying radius, mass, and SAD (Neely et al., 2016)
 - **CAM6 CMIP6:** 3 modes prescribed from WACCM6 output (Neely et al., in preparation)

Volcanic eruptions since 1990

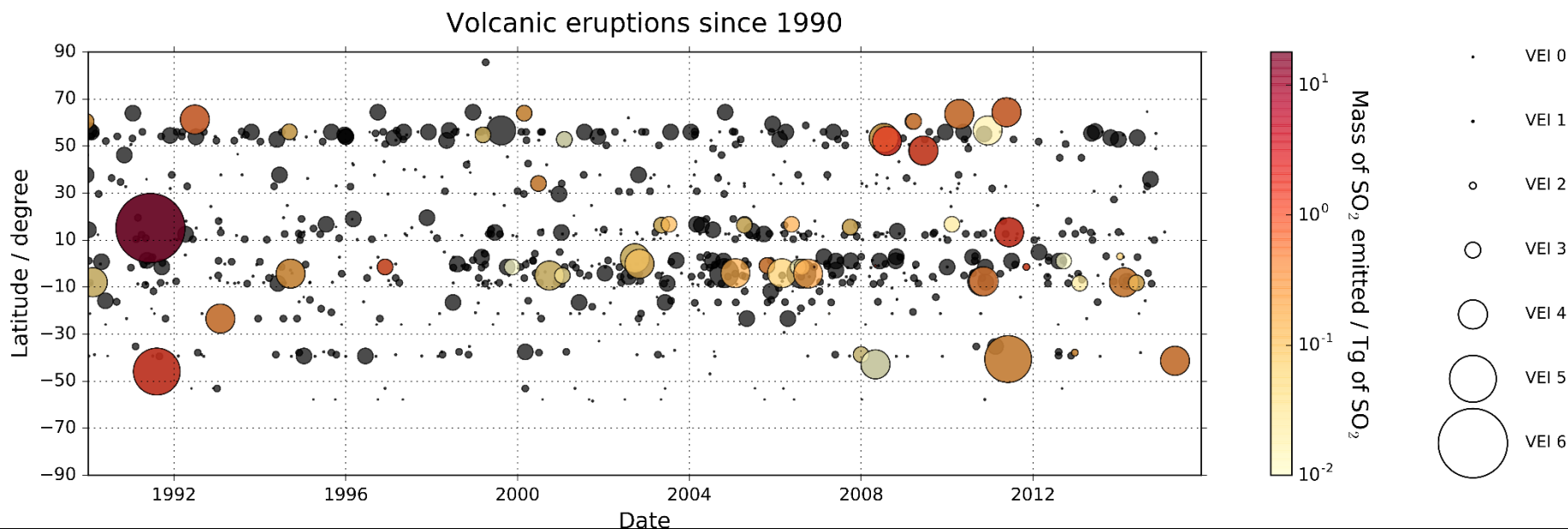
- Volcanic eruptions increasingly well characterized (Satellite retrievals, in-situ measurements, geochem. & geophys. monitoring)
- 1979 first TOMS volcanic SO₂ retrievals
- Compiled volcanic emission dataset for use in climate models



Reported eruptions, Smithsonian
Global Volcanism Program

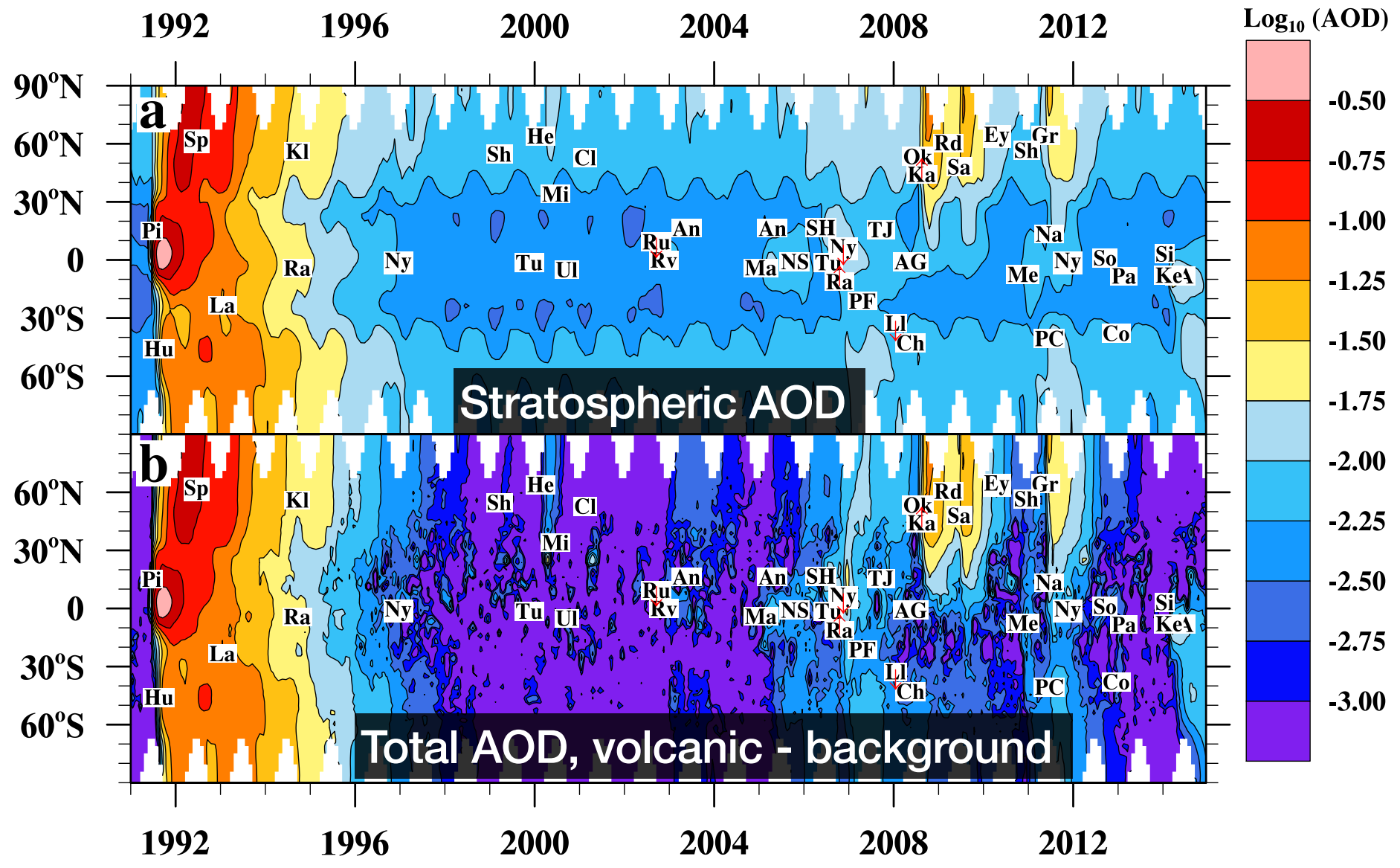
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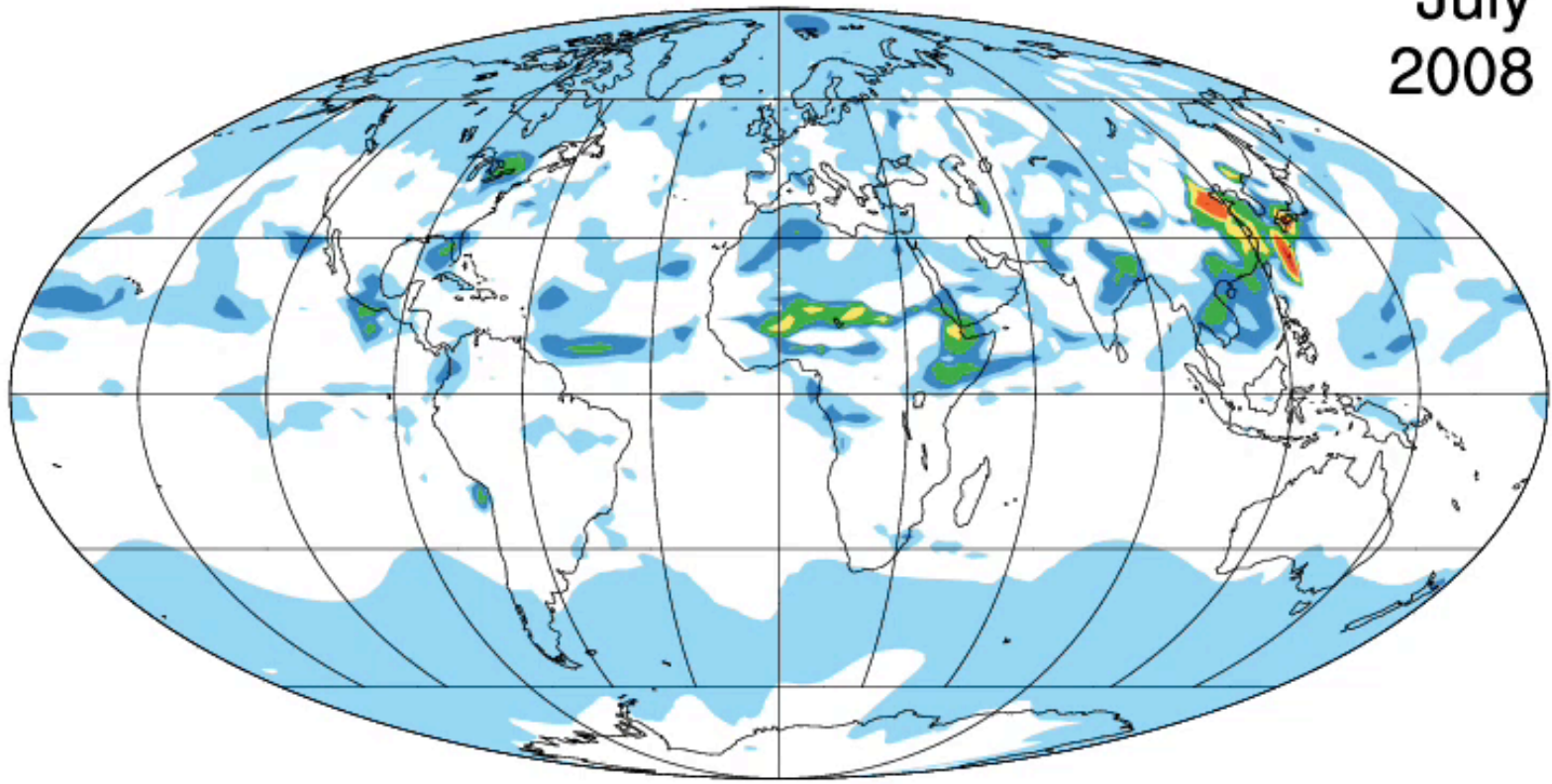


1990-1994	1995-1999	2000-2004	2005-2009	2010-2015
12.85 Tg of SO ₂	0.93 Tg of SO ₂	0.93 Tg of SO ₂	7.56 Tg of SO ₂	8.55 Tg of SO ₂

VolcanEESM SO₂ database: 1853-2016, 244 days of eruption



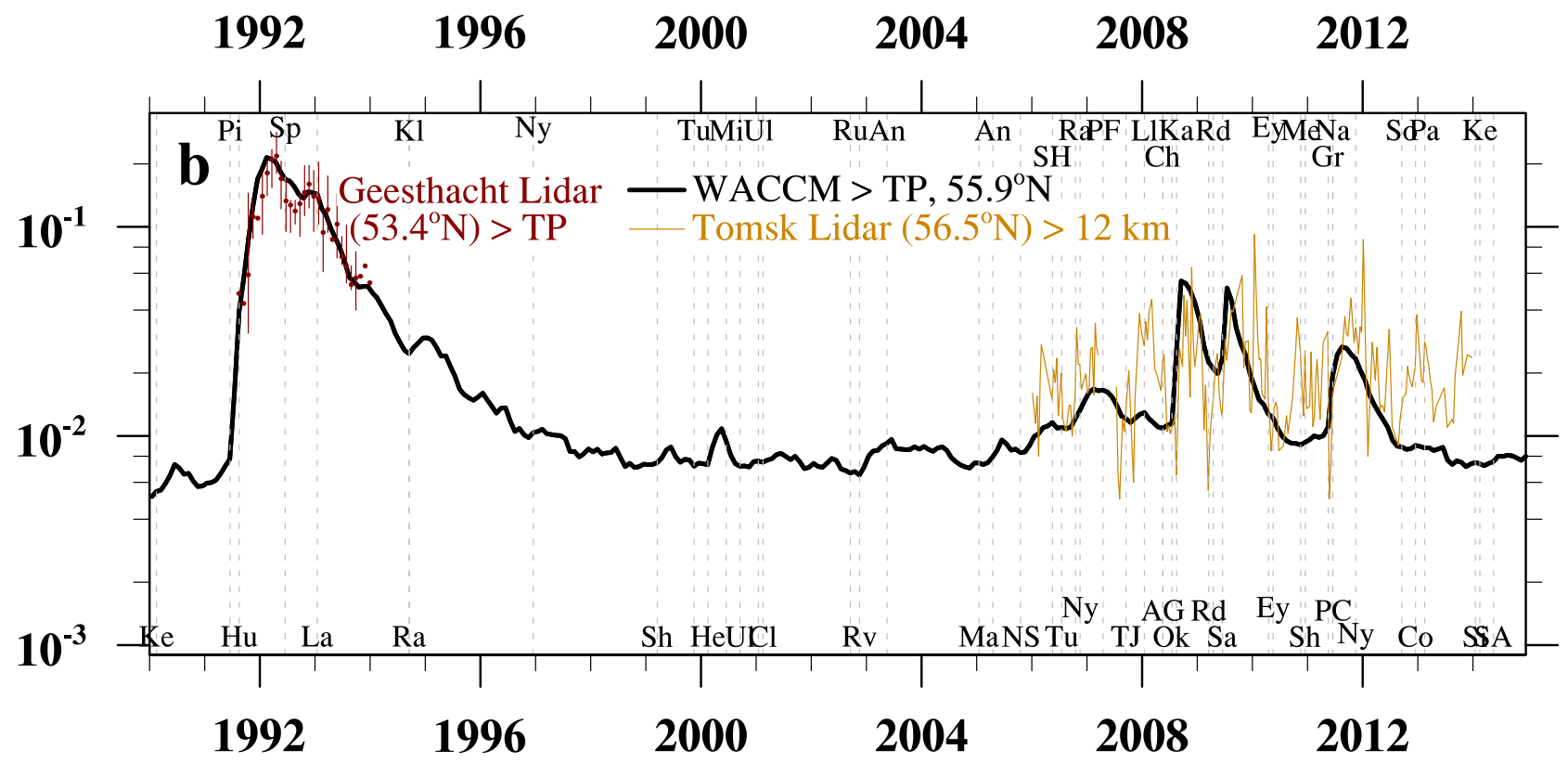
July
2008



Volcanic Aerosol Column Burden (kg S m^{-2})



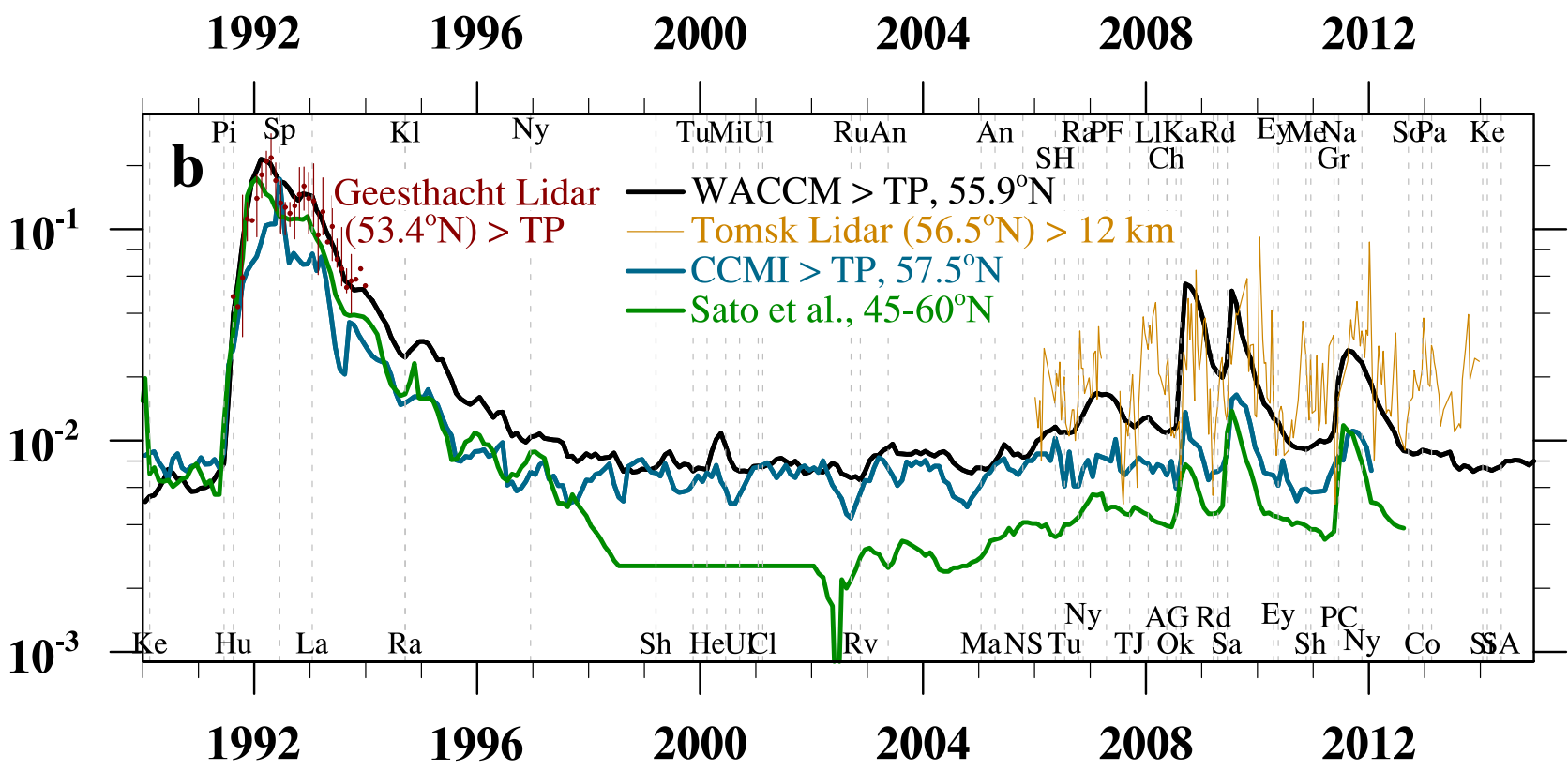
Aerosol Optical Depth, visible



Northern mid-latitudes

Mills et al. (JGR, 2016)

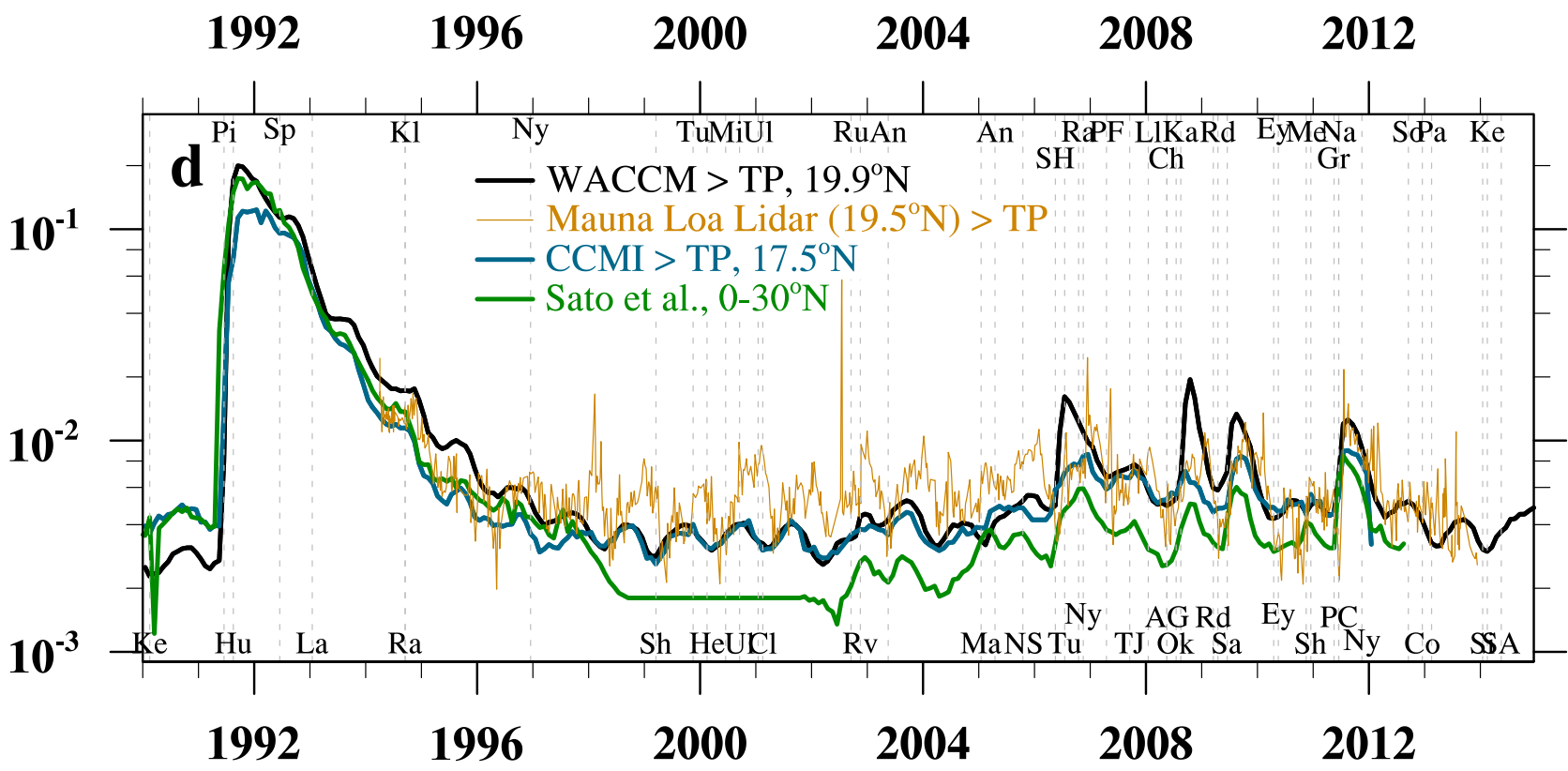
Aerosol Optical Depth, visible



Northern mid-latitudes

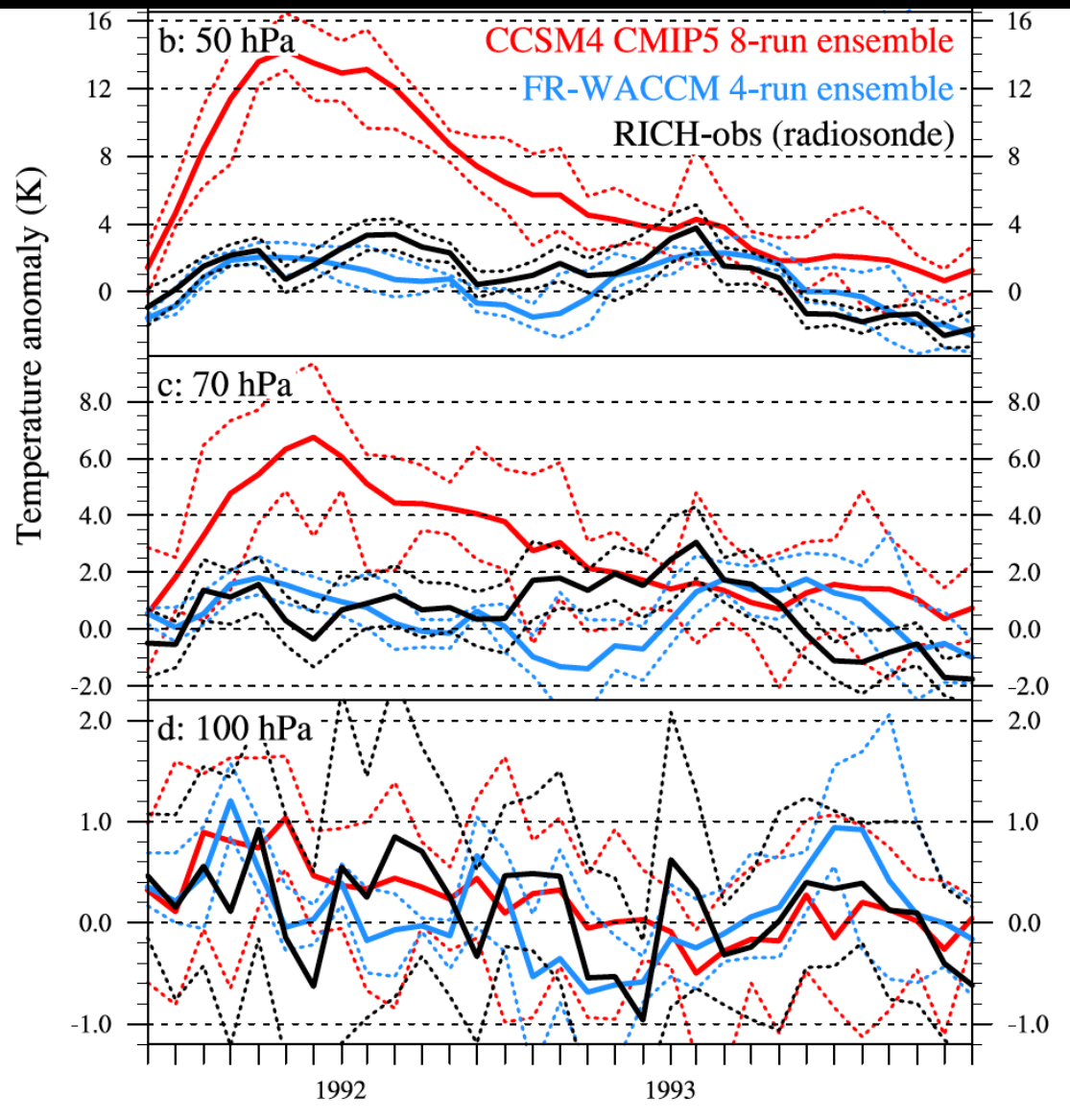
Mills et al. (JGR, 2016)

Aerosol Optical Depth, visible



Tropics

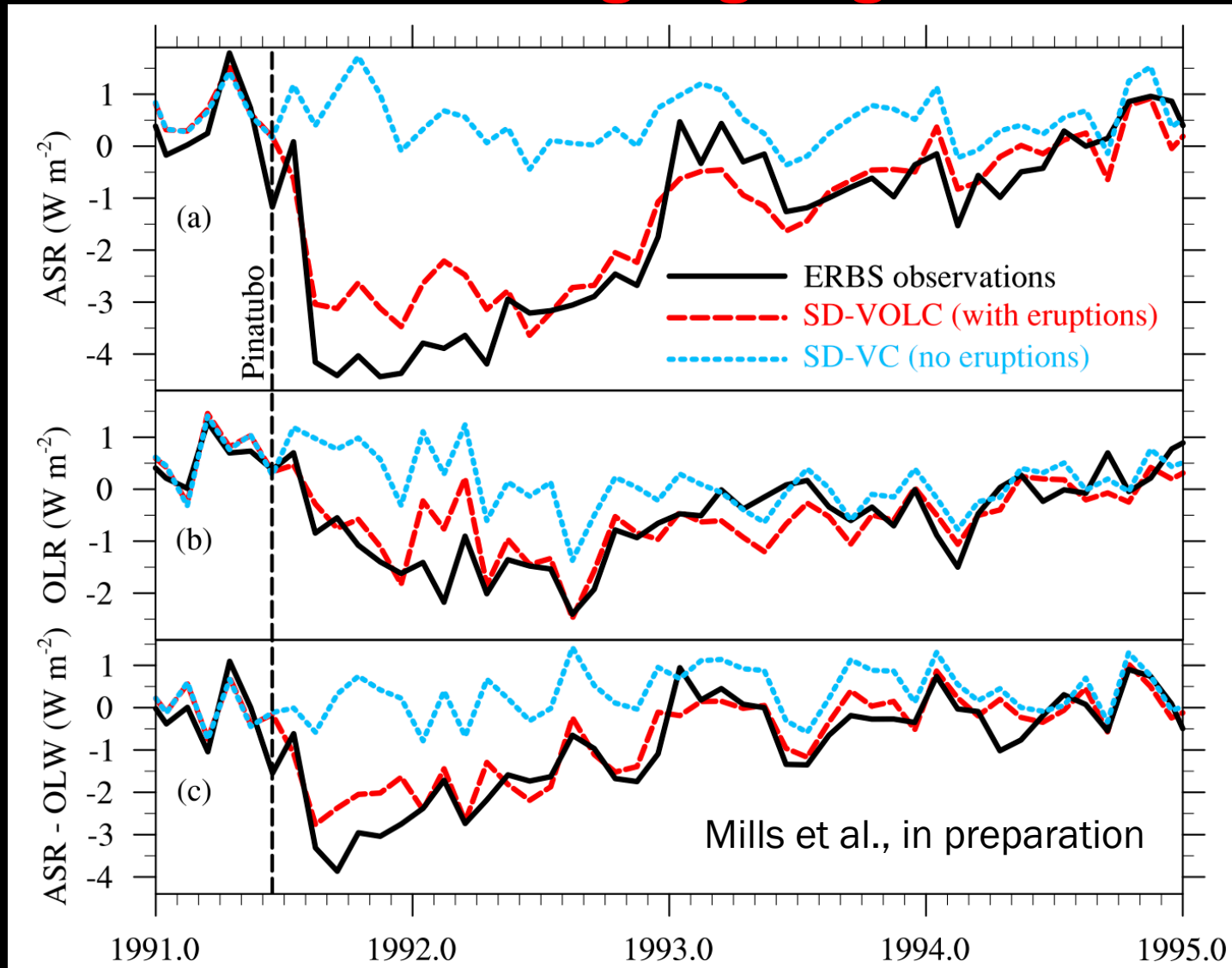
Mills et al. (JGR, 2016)

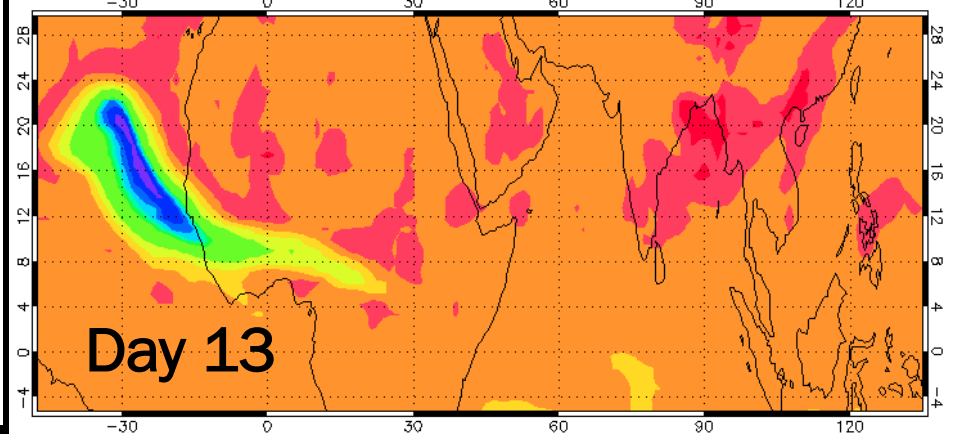
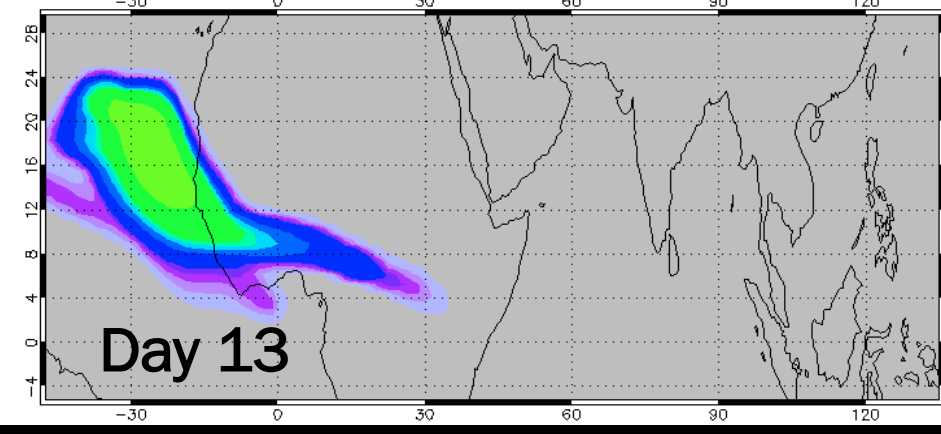
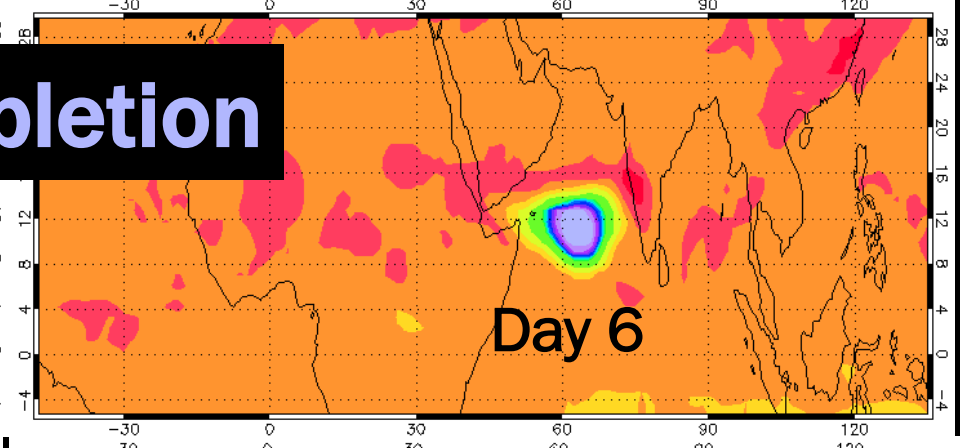
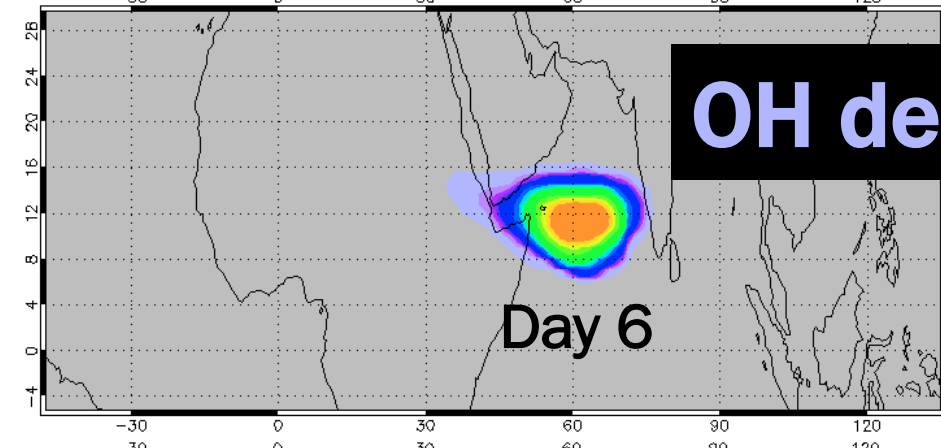
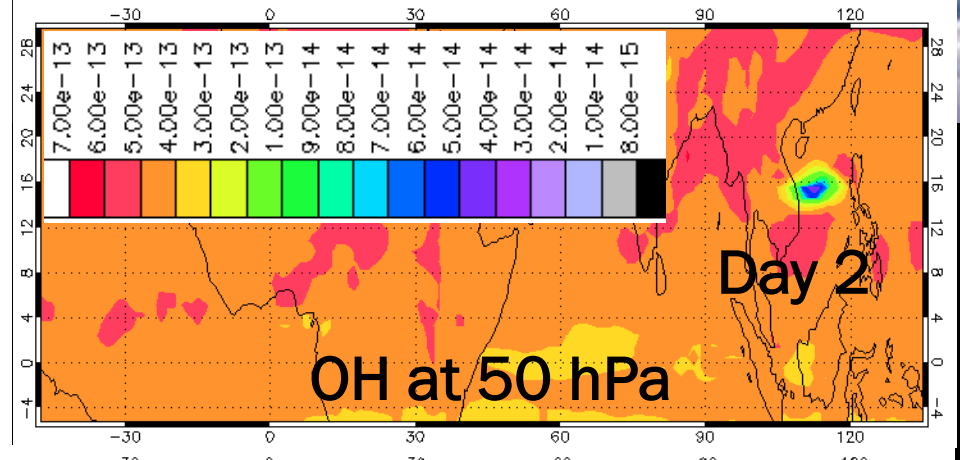
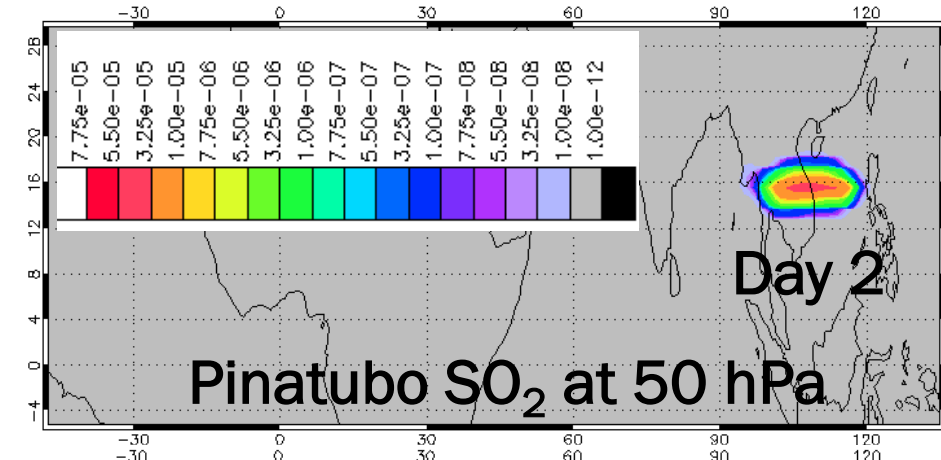


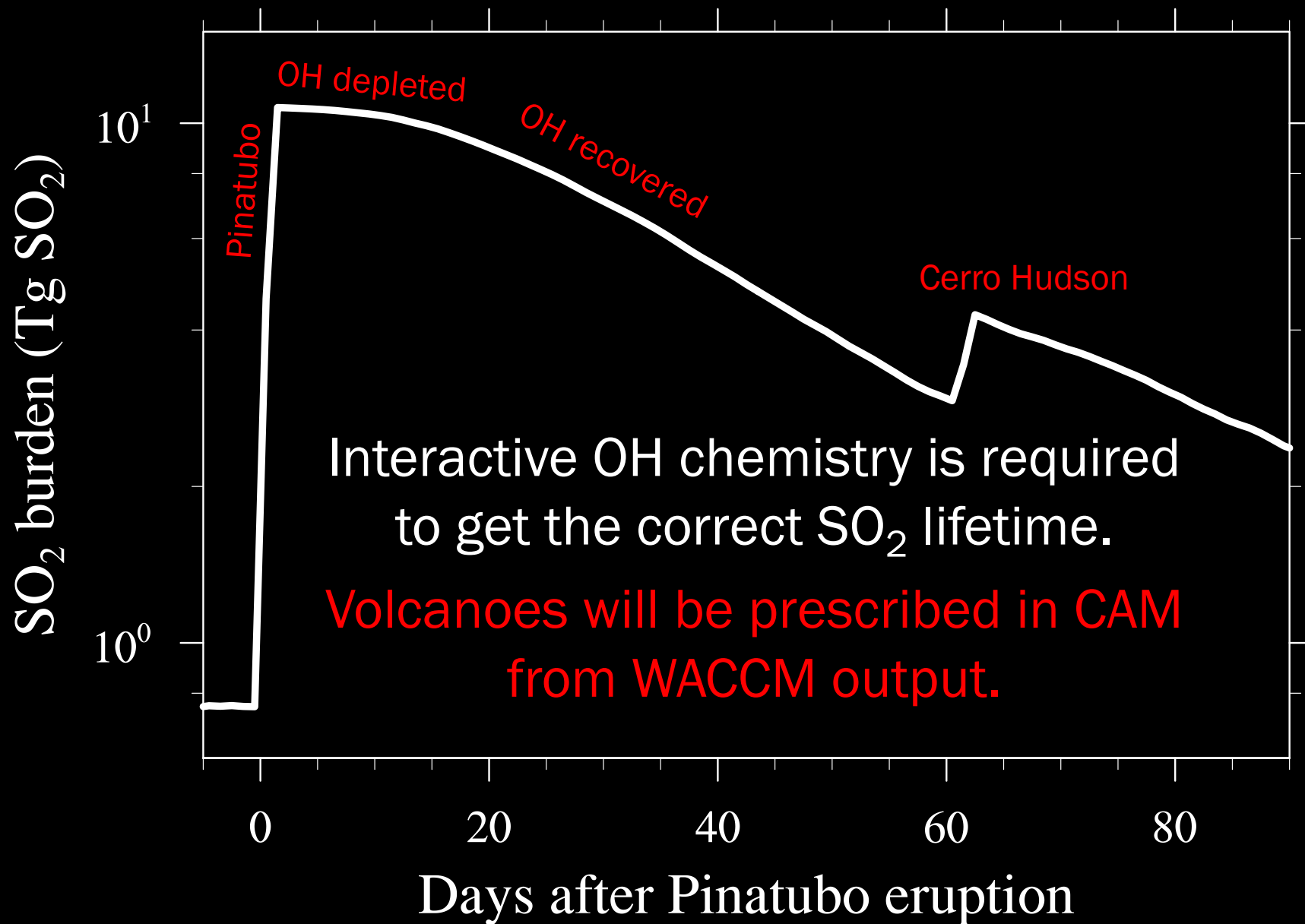
Temperature anomalies due to volcanoes are improved with **Prognostic Treatment** over **CCSM4/CESM1**

Mills et al. (JGR, 2016)

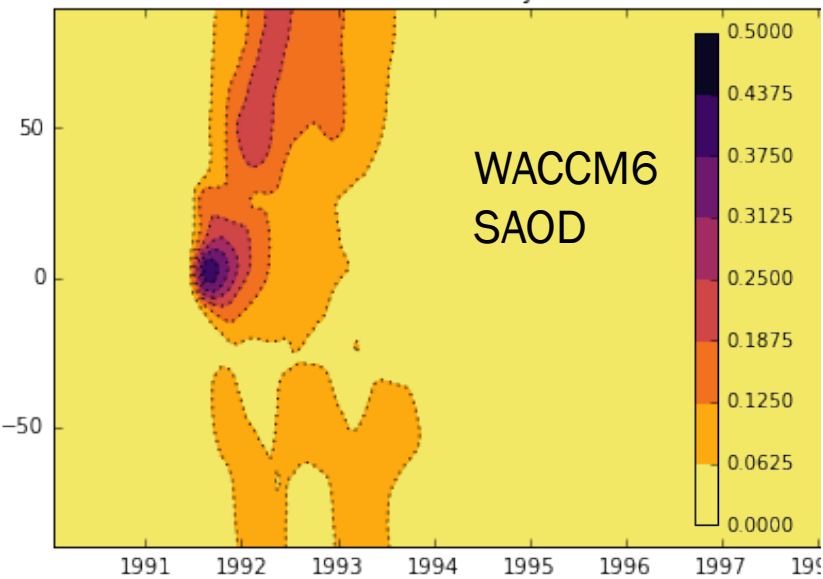
Absorbed solar and outgoing longwave radiation



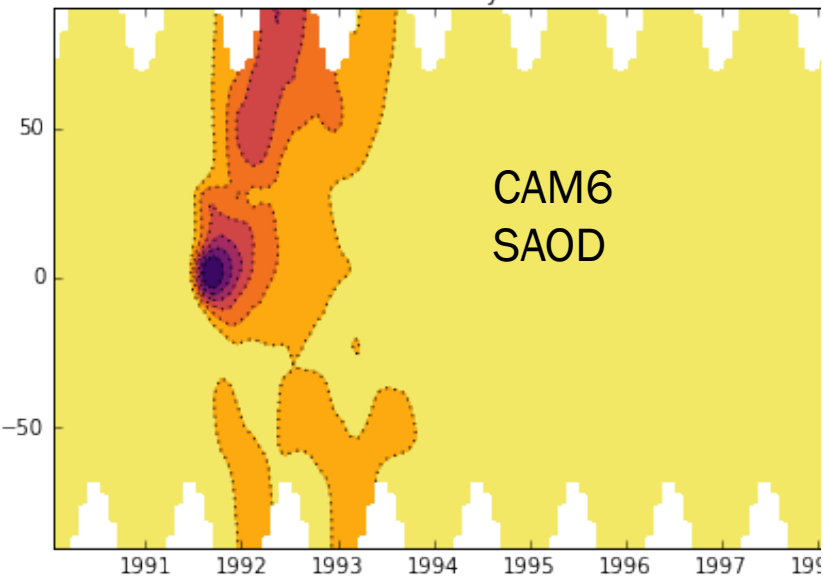




SD-WACCM Monthly Zonal Mean SAOD



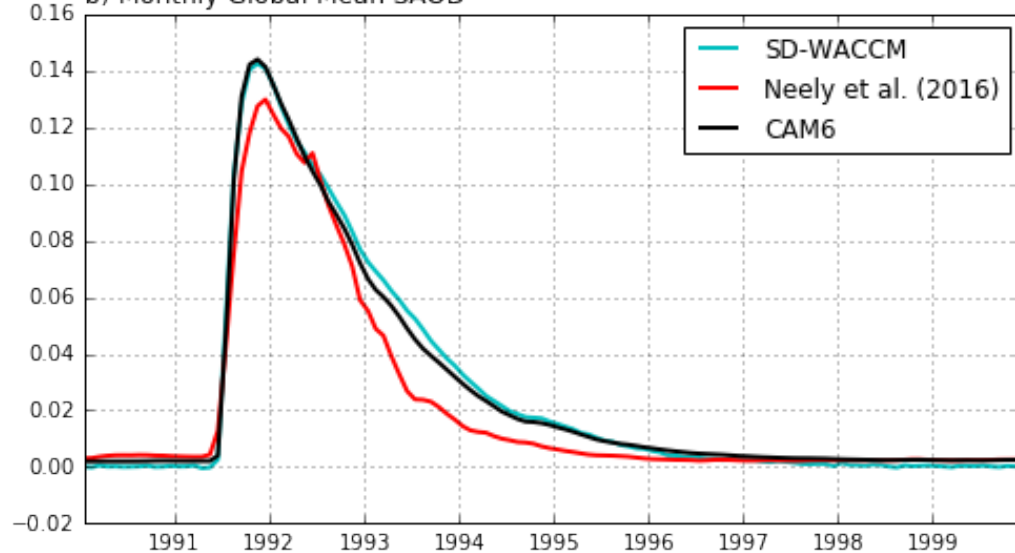
CAM6 Monthly Zonal Mean SAOD



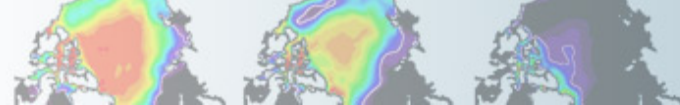
CAM volcanoes prescribed from WACCM output

Information from all 3 sulfate aerosol modes used.

b) Monthly Global Mean SAOD

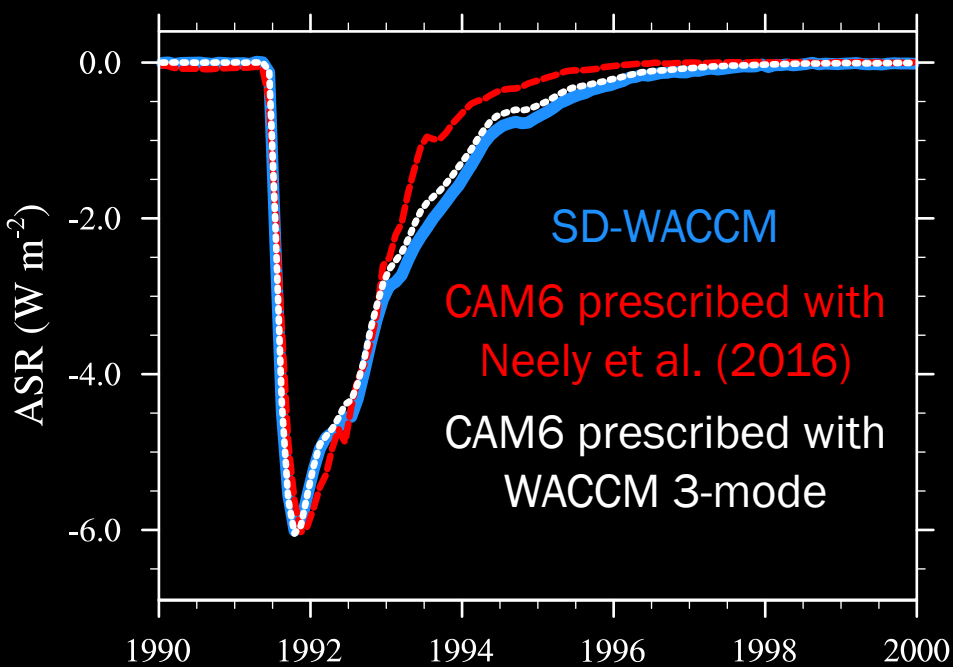


Figures courtesy Ryan Neely

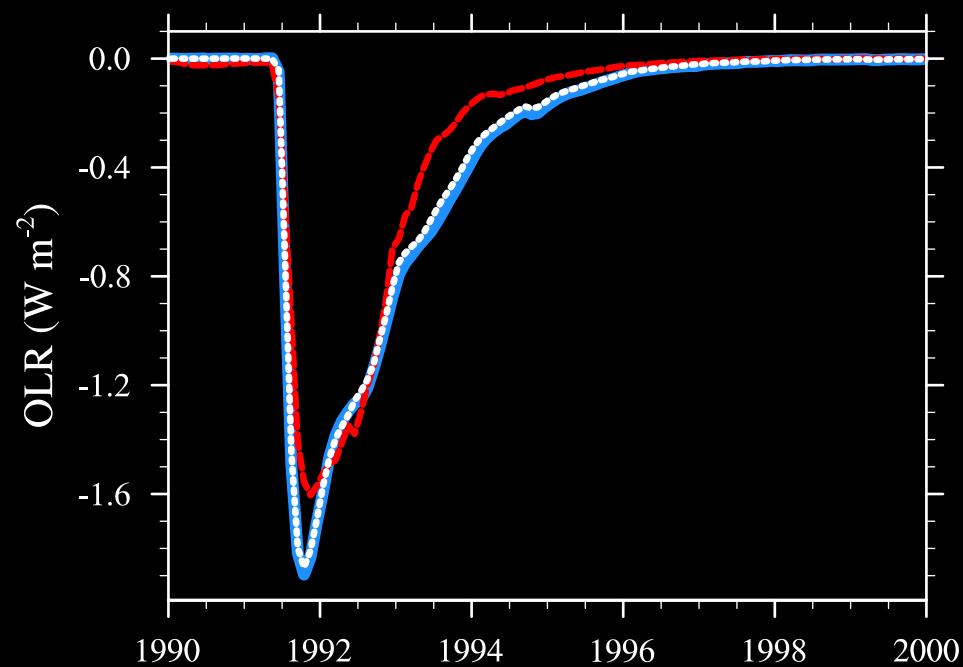


Monthly global mean clearsky volcanic flux anomalies

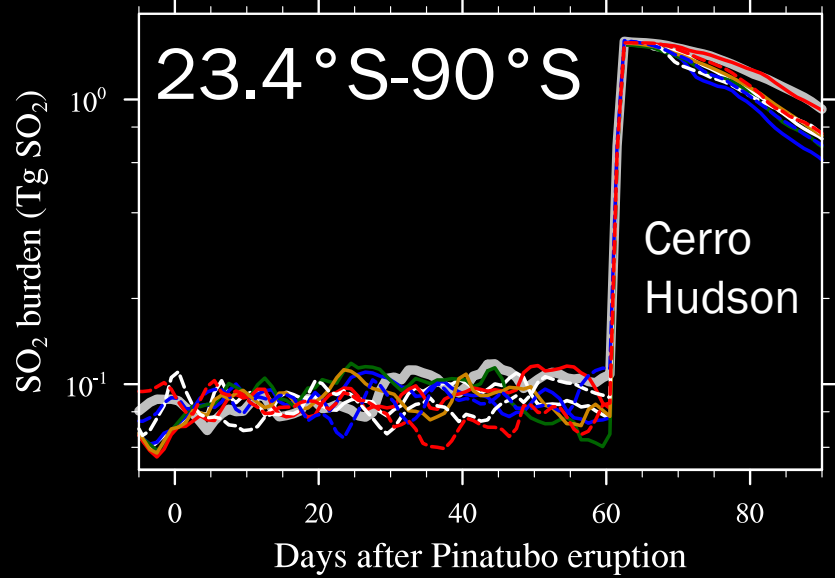
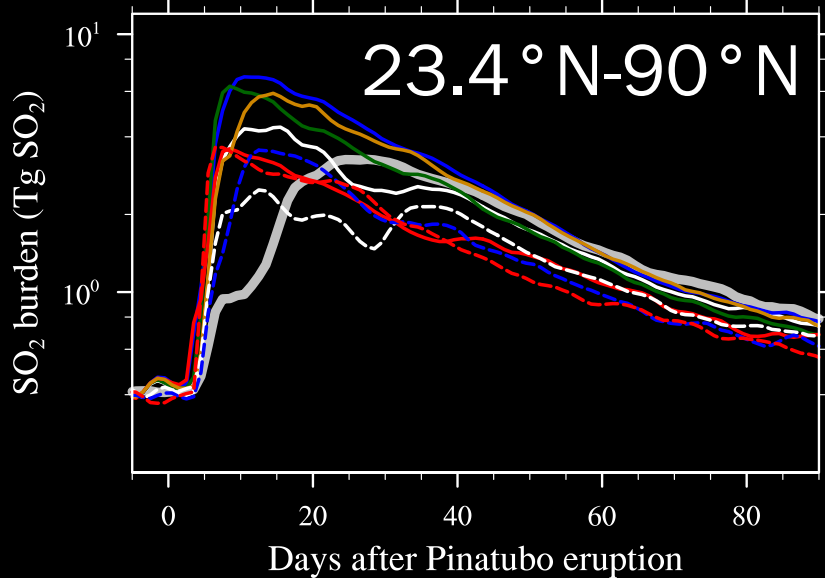
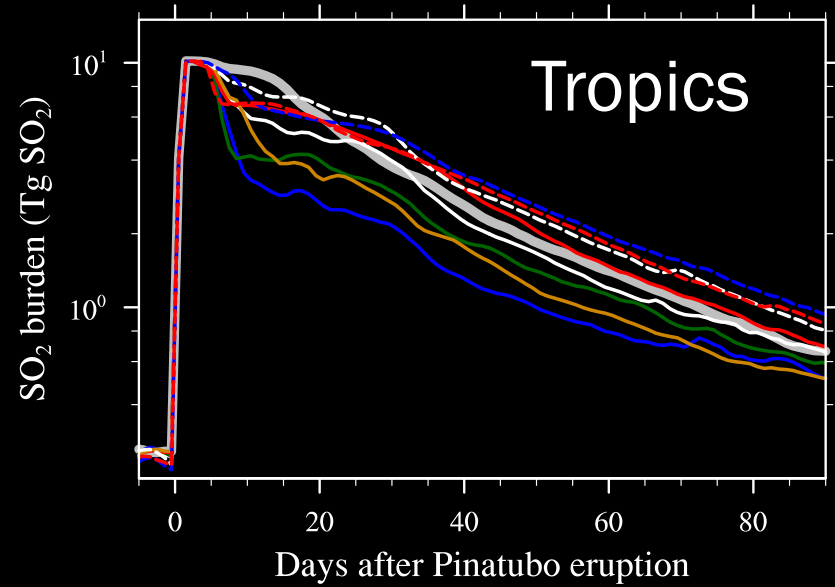
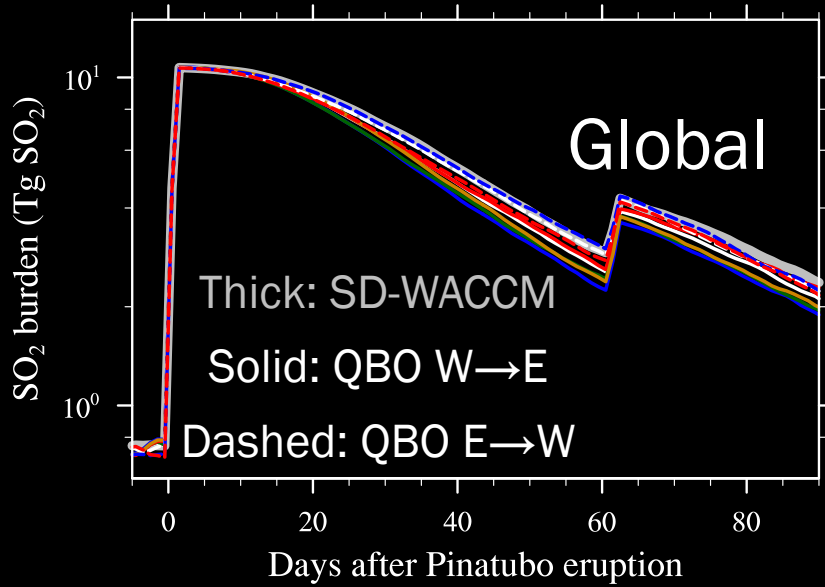
Absorbed solar



Outgoing longwave



WACCM Pinatubo ensemble variability

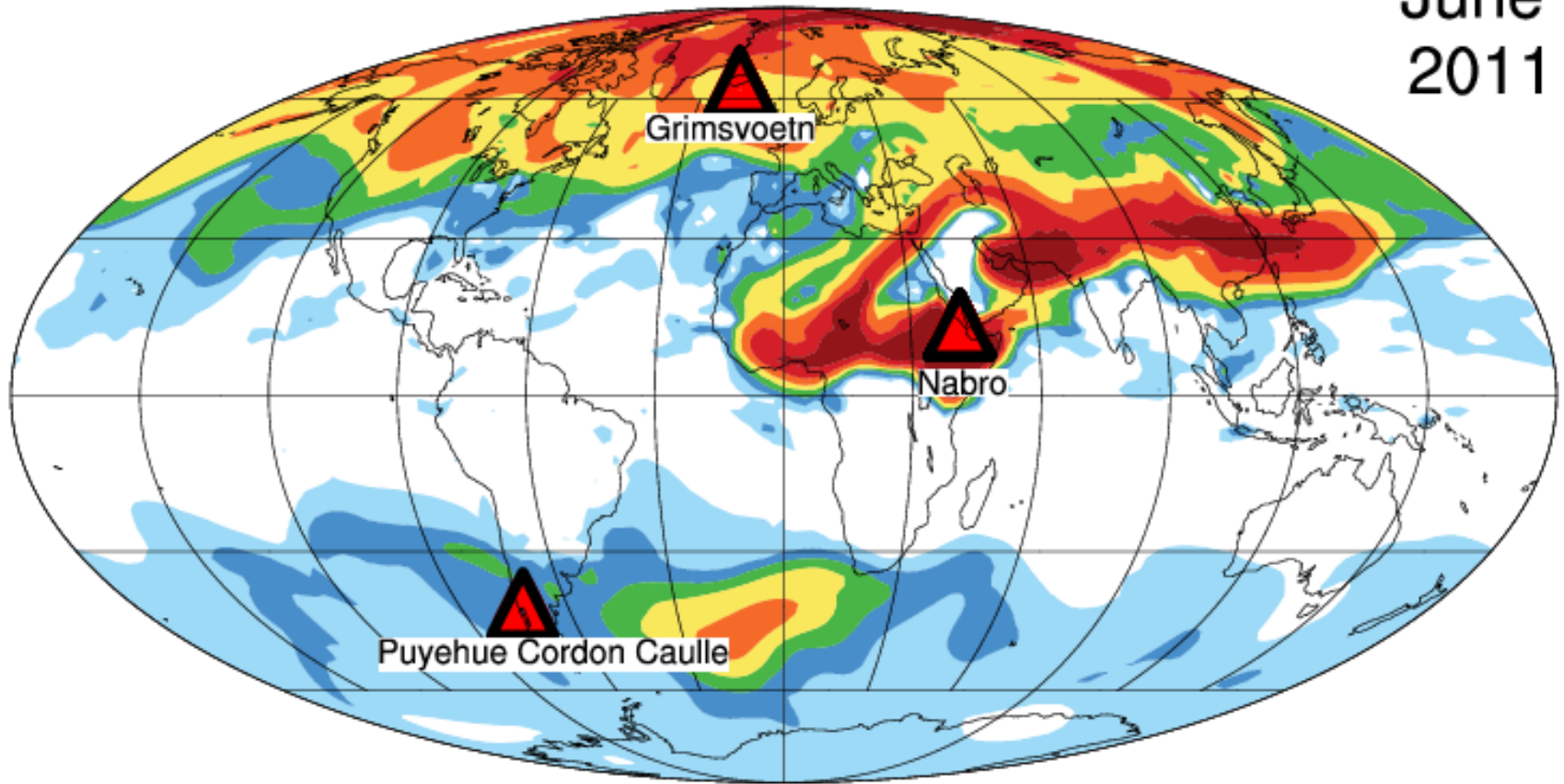


Summary

- Prognostic volcanic aerosol from SO₂ emissions has been validated in WACCM, with significant improvements over volcanoes prescribed from observations.
- Due to lack of interactive OH chemistry, volcanoes will be prescribed in CAM from WACCM output. Information from all aerosol modes is used, forcing with excellent agreement to WACCM.
- Due to significant ensemble variability in volcanic evolution in WACCM, output from different WACCM runs should be used to force different CESM2 realizations.

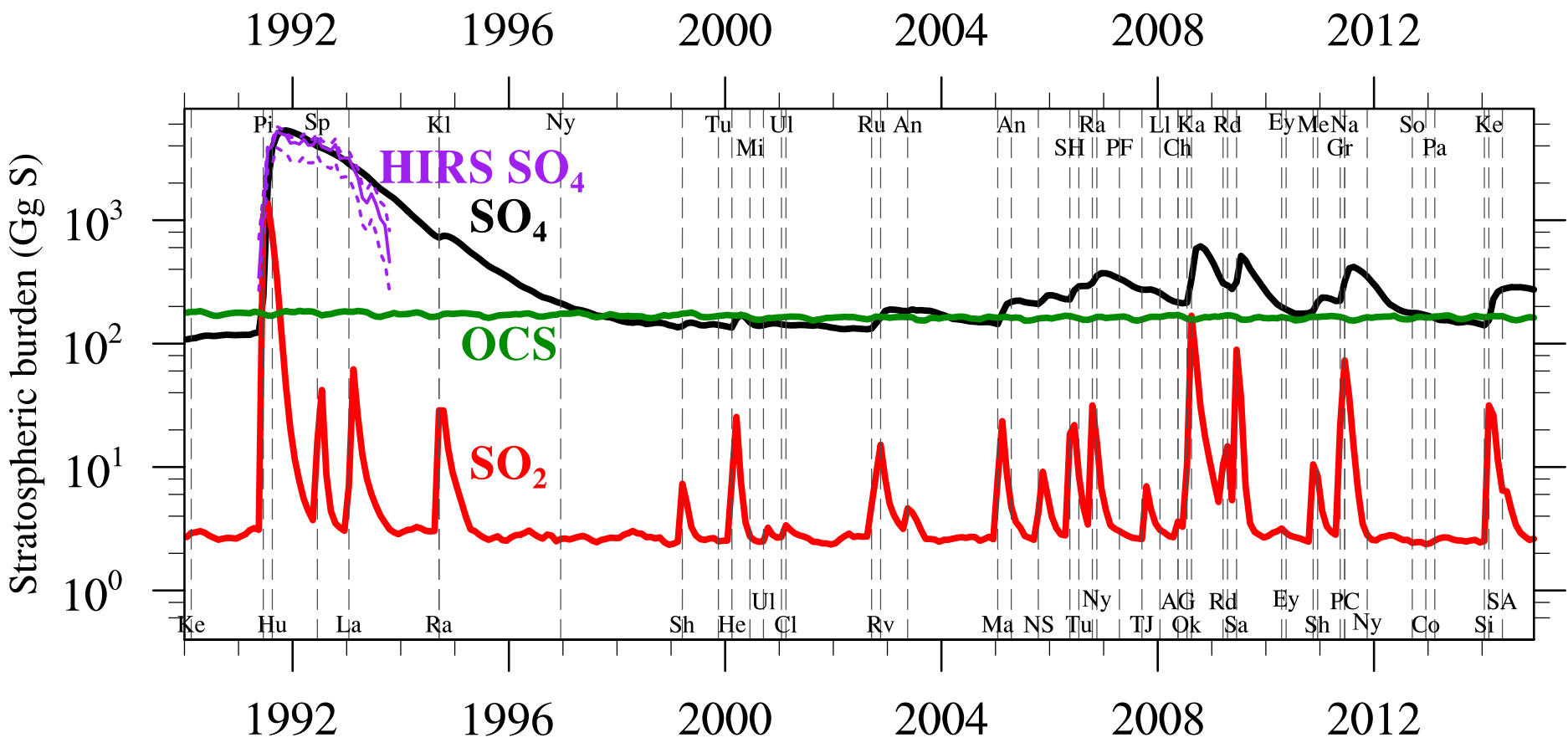
Thank you!

June
2011



Volcanic Aerosol Column Burden (kg S m^{-2})

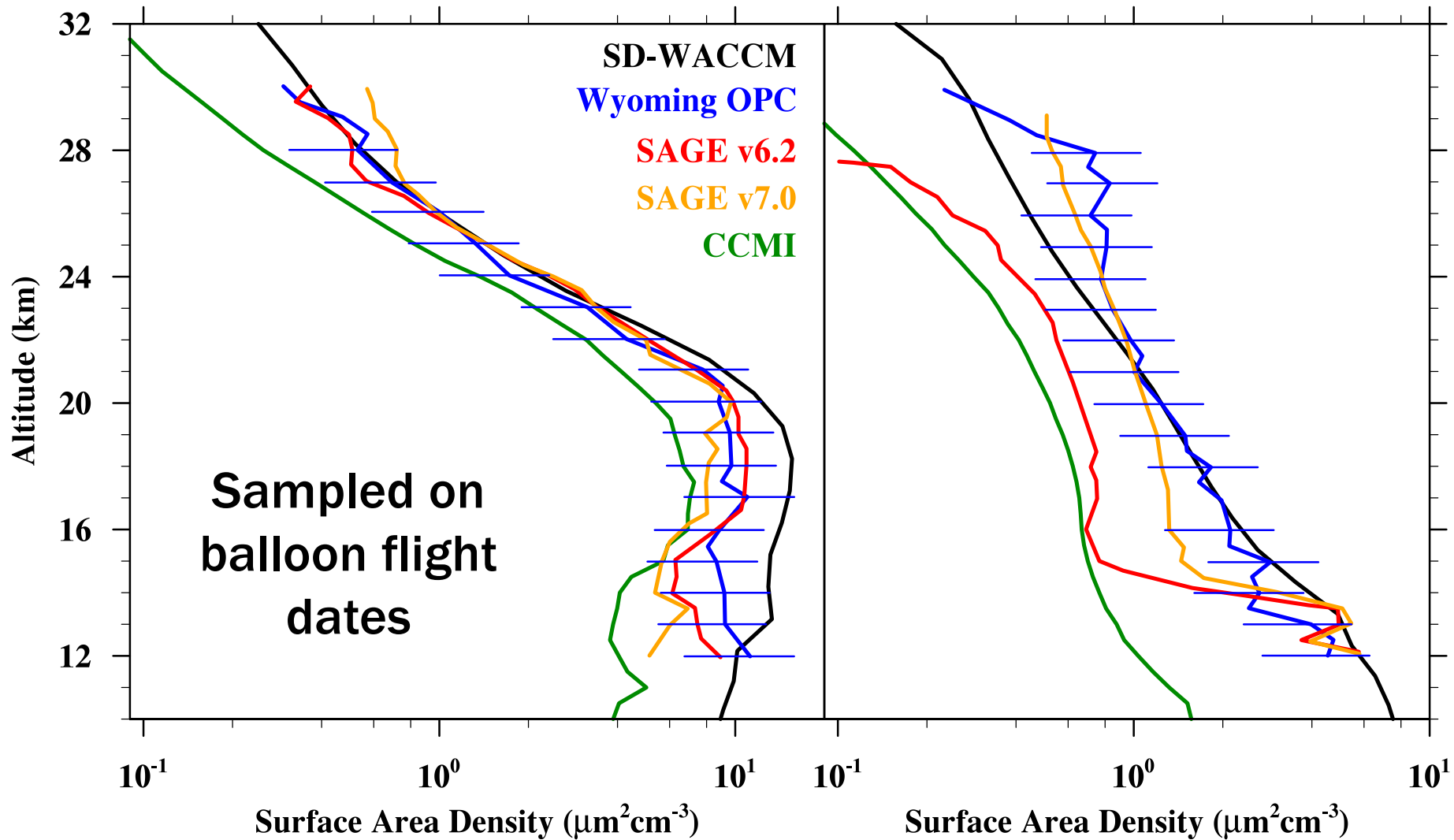


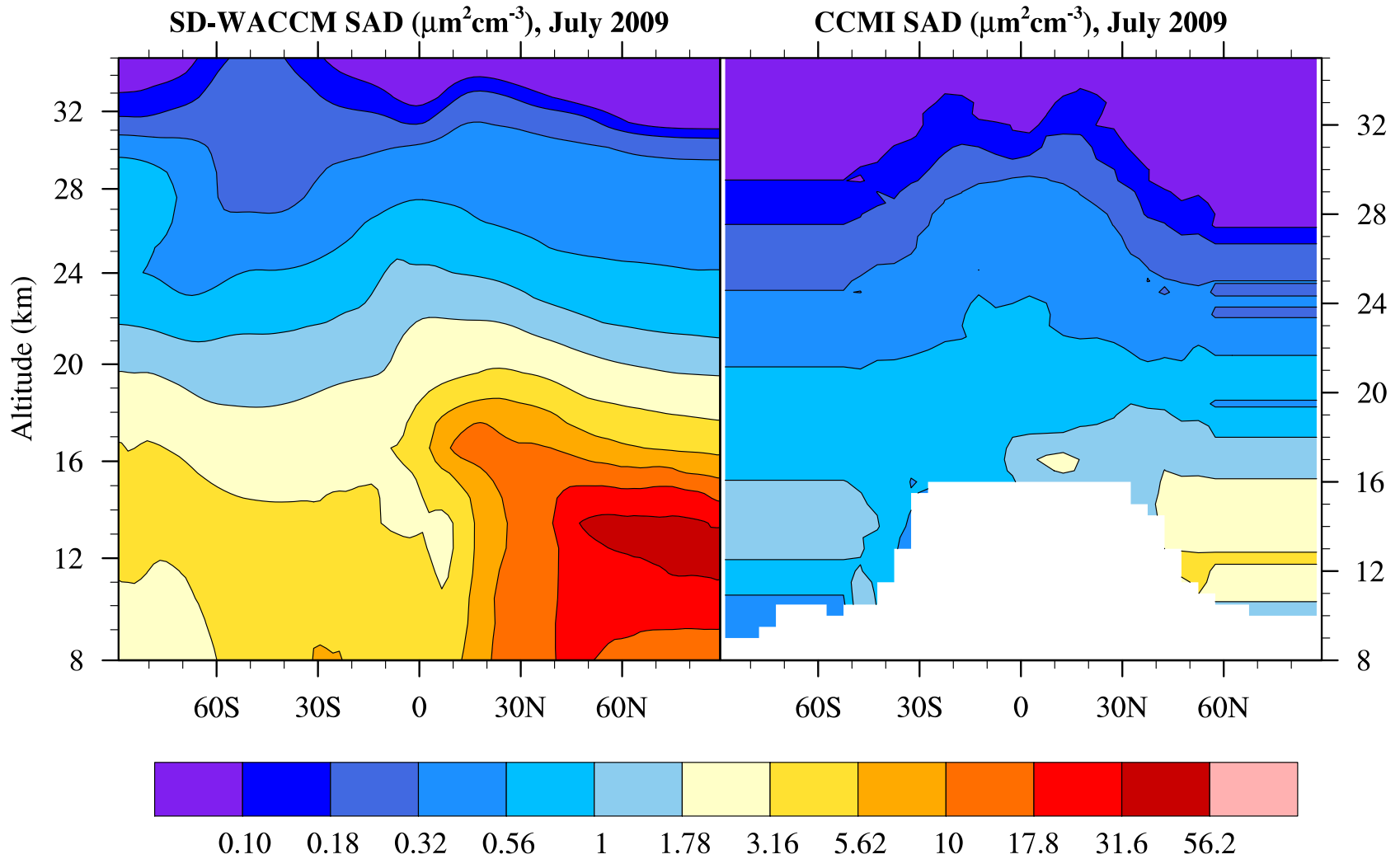


SD-WACCM simulations from "Global volcanic aerosol properties derived from emissions, 1990-2014, using CESM1(WACCM)," Mills et al. (JGR, 2016)

July 1991-December 1996

1997-2005





Post-Sarychev eruption: calculated SAD = 10x CCMI
 from Mills et al., JGR, 2016