

# New prescribed and prognostic volcanic and stratospheric aerosol options in CESM

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WACCM

Whole Atmosphere  
Community Climate Model

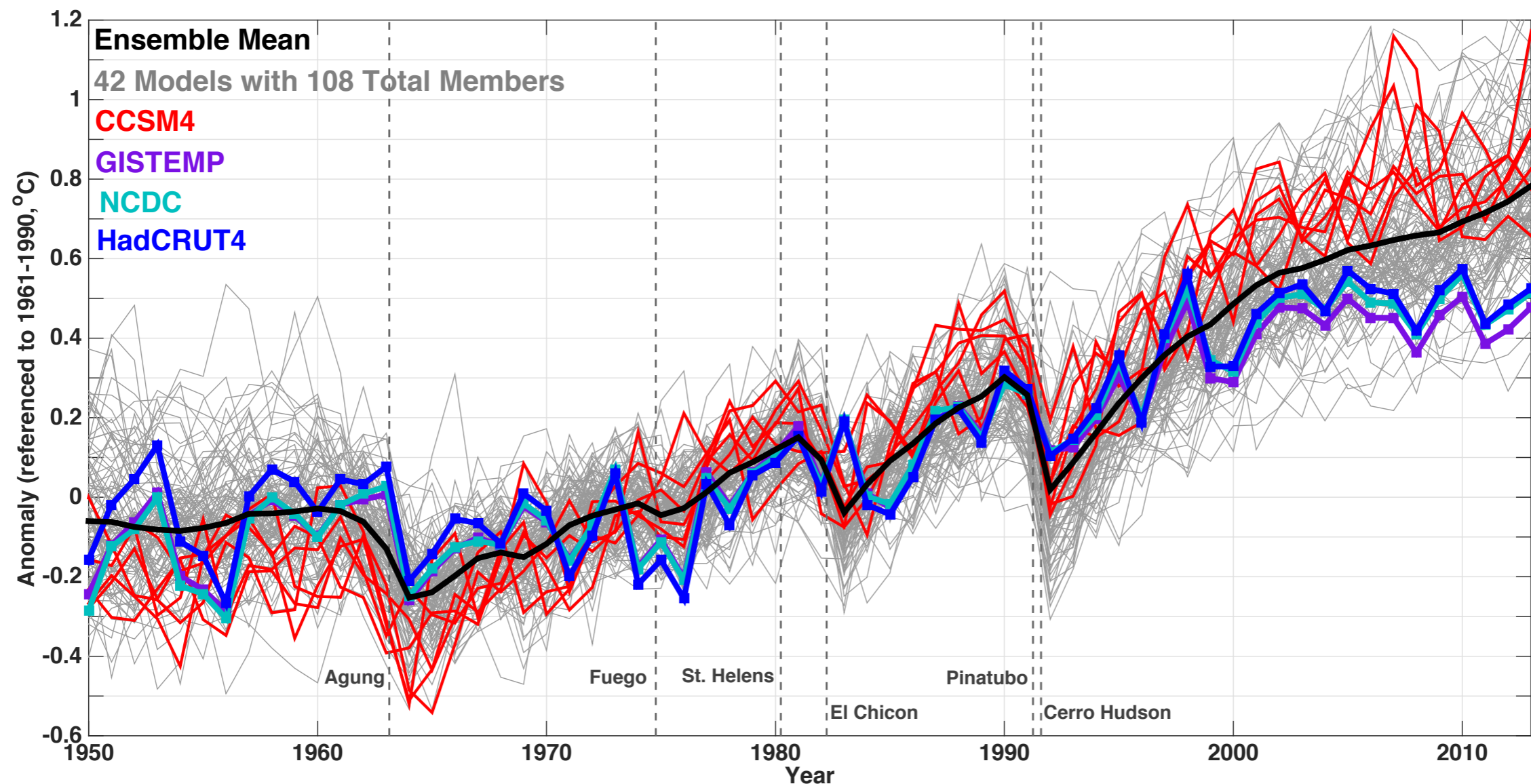


# A Consistent Prescription of Stratospheric Aerosol for Both Radiation and Chemistry in the Community Earth System Model (CESM1)

R. R. Neely III<sup>1,2</sup>, A. Conley<sup>2</sup>, F. Vitt<sup>2</sup>, and J. F. Lamarque<sup>2</sup>

Geosci. Model Dev. Discuss., 8, 10711–10734, 2015  
www.geosci-model-dev-discuss.net/8/10711/2015/  
doi:10.5194/gmdd-8-10711-2015

Motivation: poor global response of most models in CMIP5 to colossal volcanic perturbations to stratospheric aerosol



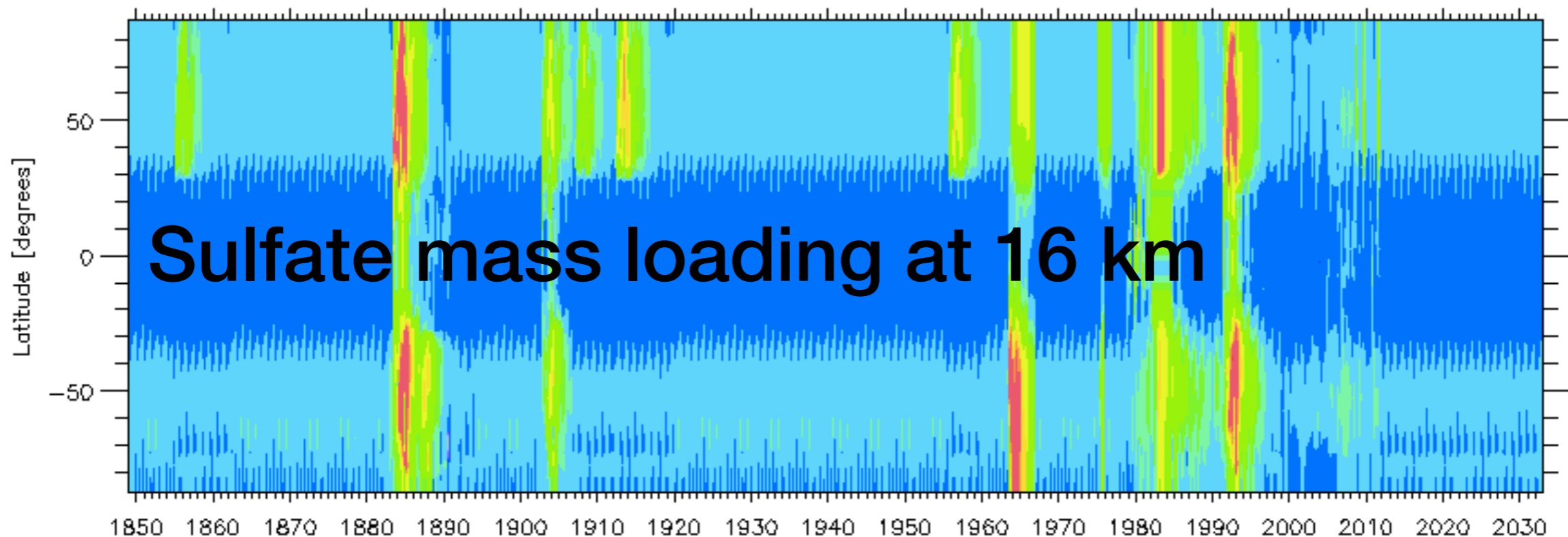
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New prognostic stratospheric aerosol scheme

- accounts for variation in *effective radius* in addition to mass loading
- improved historical volcanic database for 1850-2015 (reduced mass for large eruptions)
- non-volcanic background aerosol included during control simulations and volcanically quiescent periods, including 2016-2100

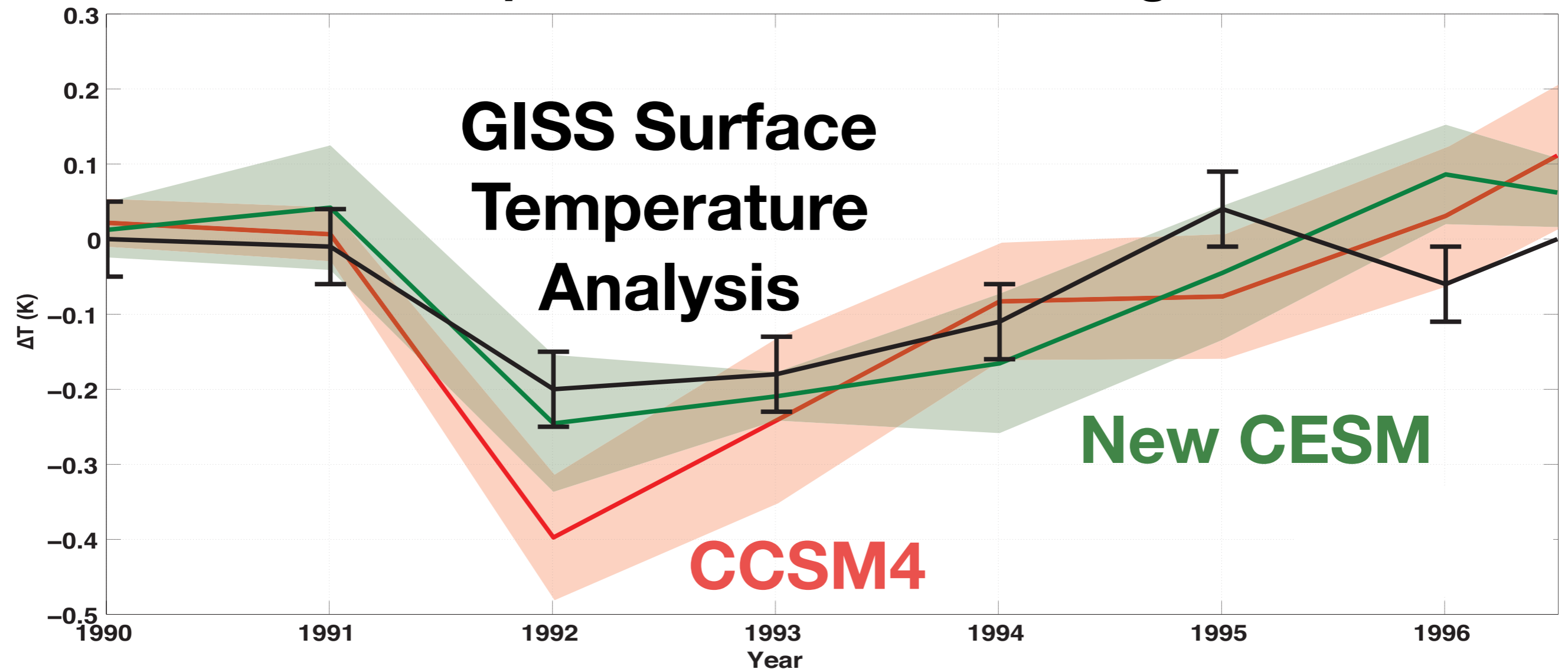


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## *Improved surface cooling*



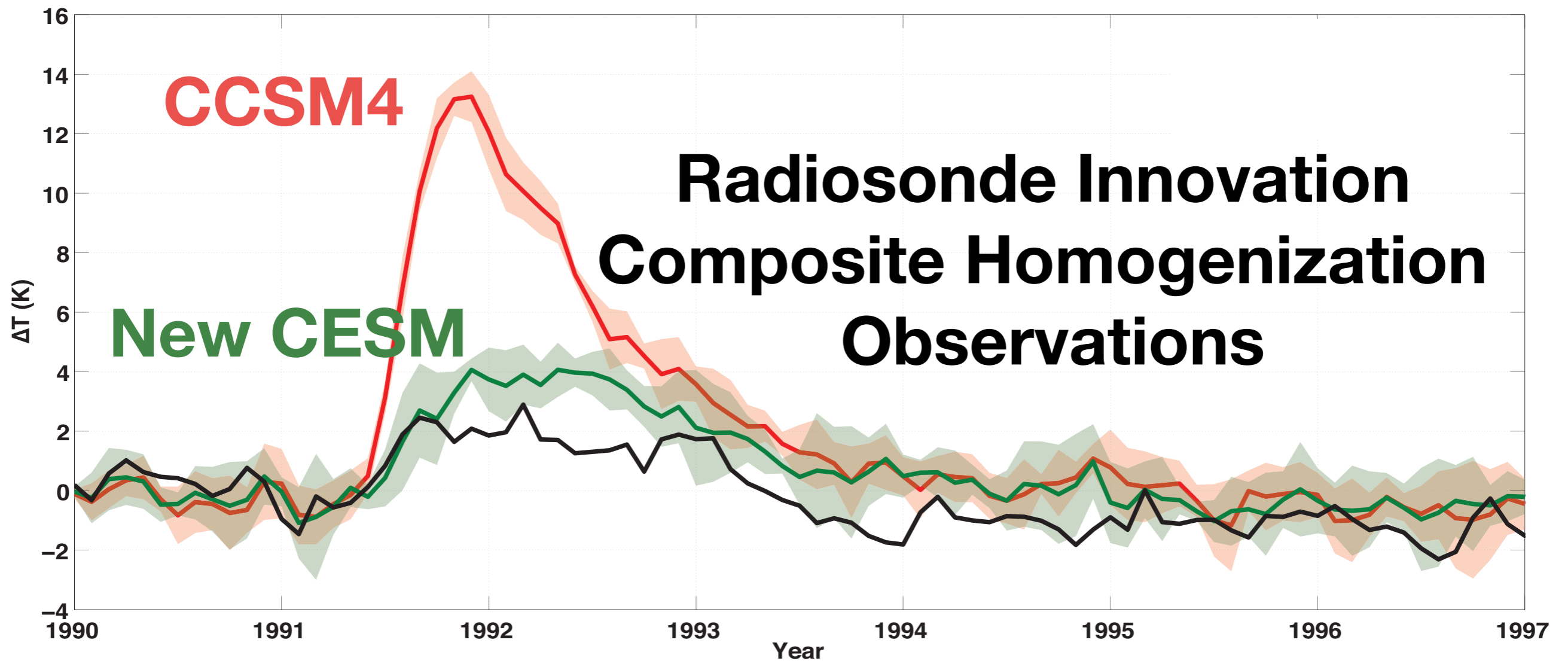
## Global annual average surface temperature anomaly

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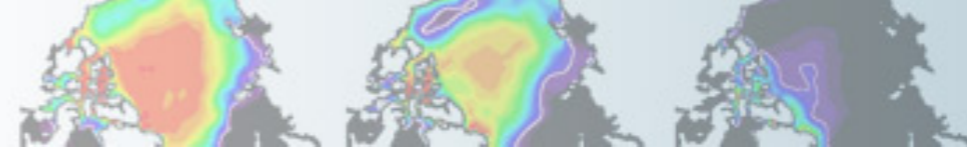
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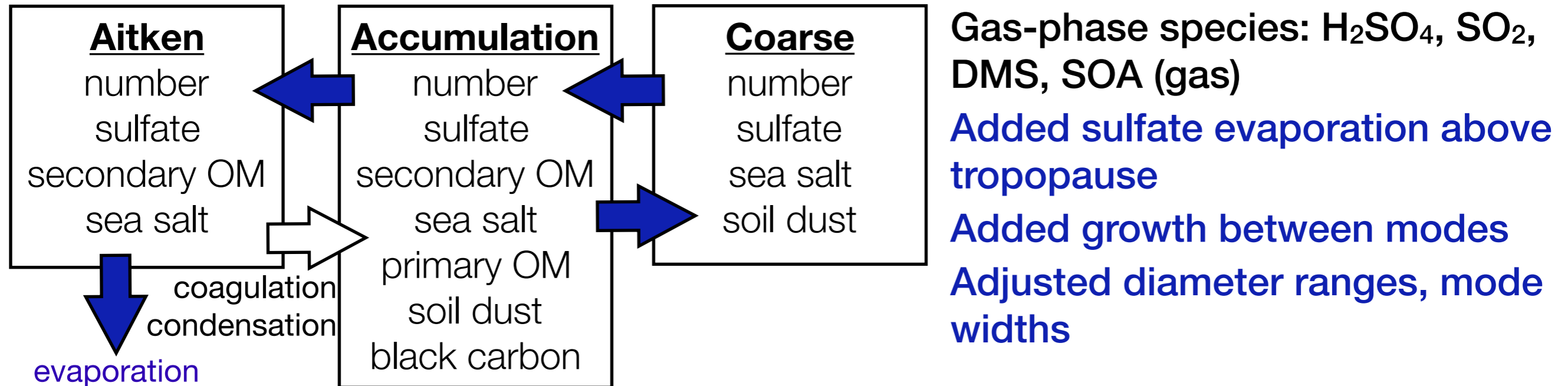
## *Improved stratospheric heating*



Tropical monthly mean temperature anomaly at 50 hPa



# Prognostic stratospheric aerosol option: Extend modal aerosol model (MAM3) for stratospheric aerosols



Mode	Aitken	Accumulation	Coarse
Standard MAM3 radius ( $\mu\text{m}$ )	0.00435 - 0.026	0.02675 - 0.22	0.5 -
geom. std. dev	1.6	1.8	2.0
Modified MAM3 radius ( $\mu\text{m}$ )	0.00435 - 0.026	0.02675 - 0.22	>0.22
geom. std. dev.	1.6	1.6	1.2

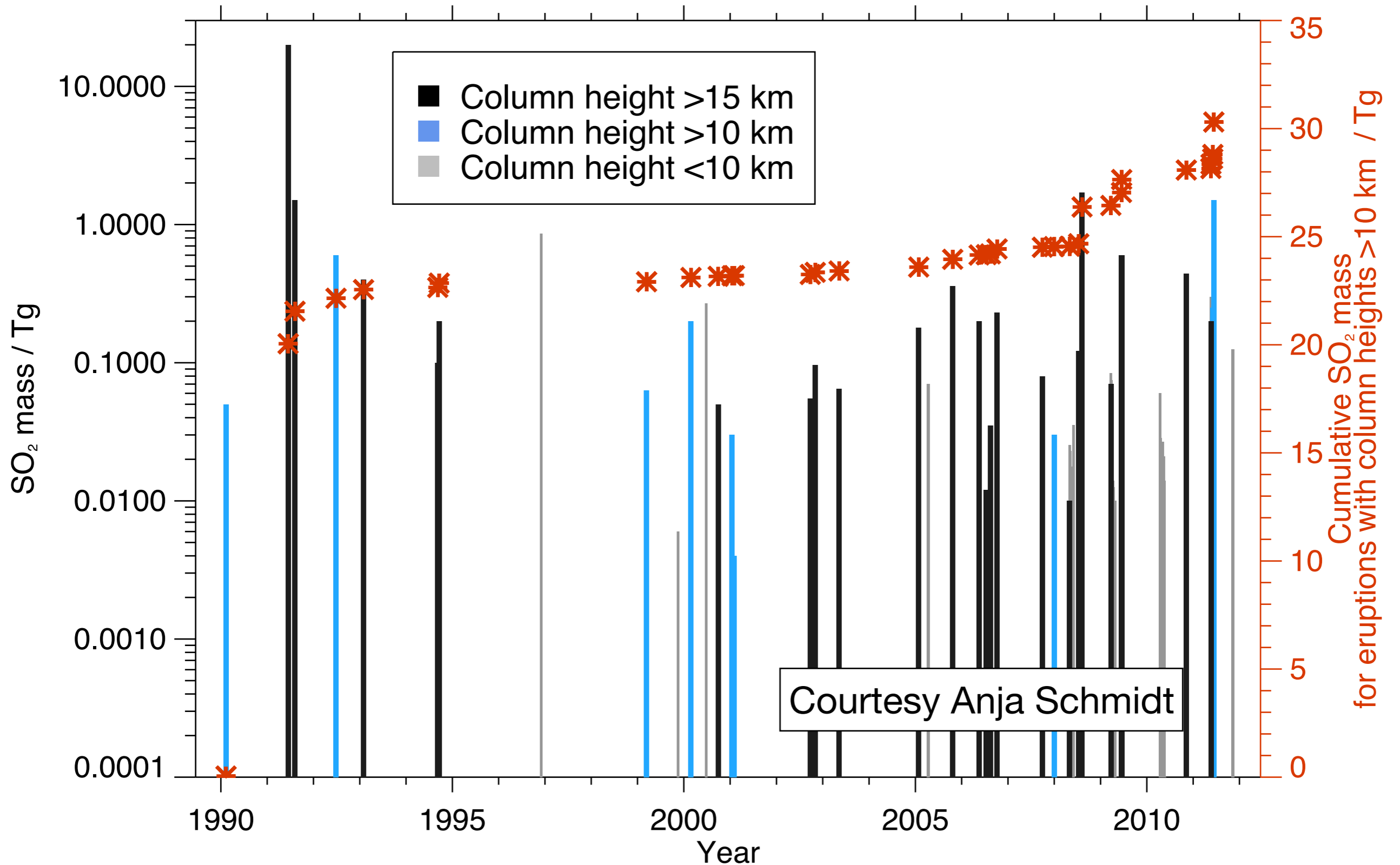
**With chemistry: added OCS, S, SO, SO<sub>3</sub>**

**Without chemistry:**

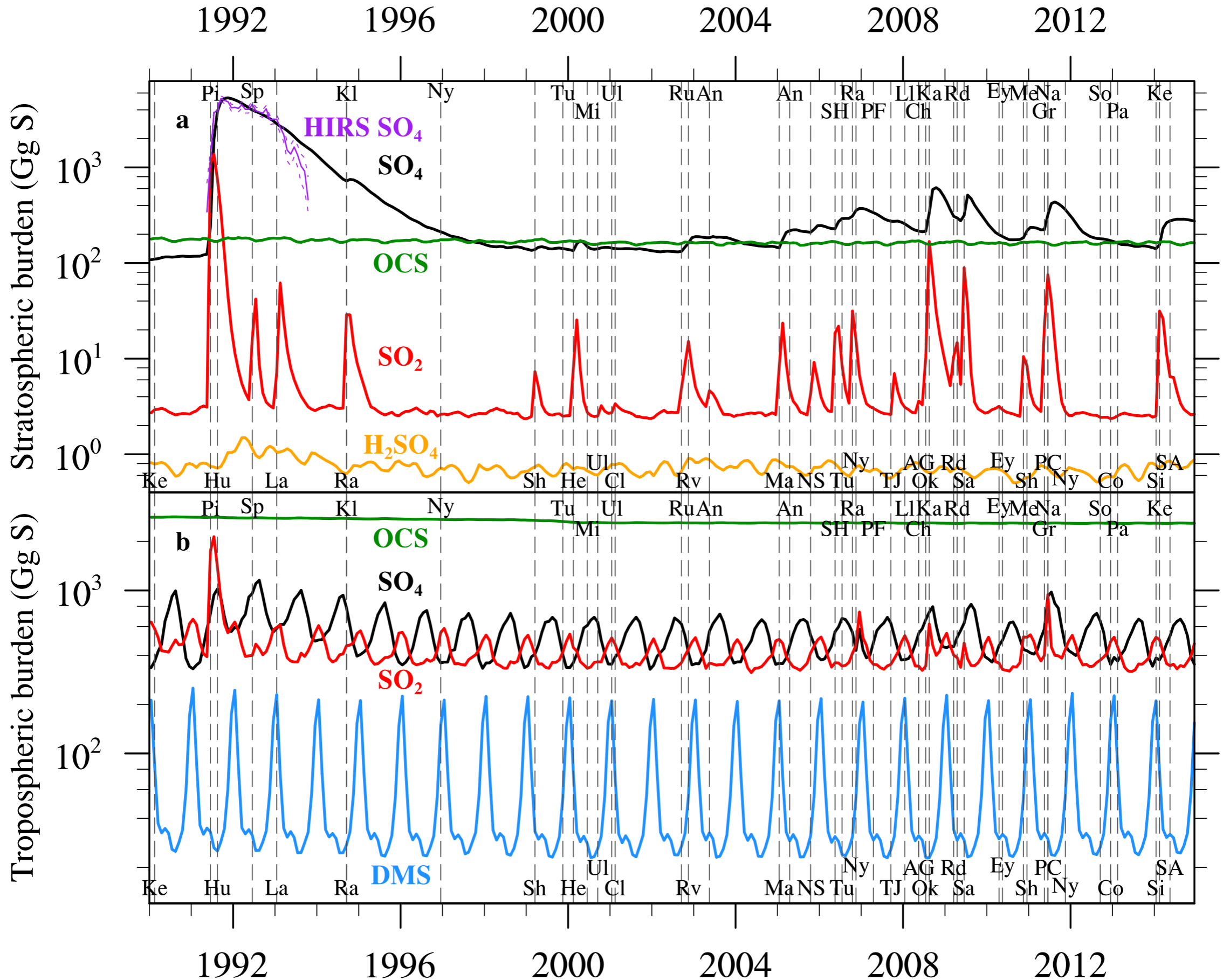
- added  $\text{SO}_2$  external forcing from OCS oxidation
- added  $\text{H}_2\text{O}$  external forcing from  $\text{CH}_4$  oxidation

# VolcanEESM 3D volcanic strat/trop SO<sub>2</sub> input file for 1850-2015 (Schmidt, Neely)

VEI > 2 eruptions since 1990 (with SO<sub>2</sub> reported)

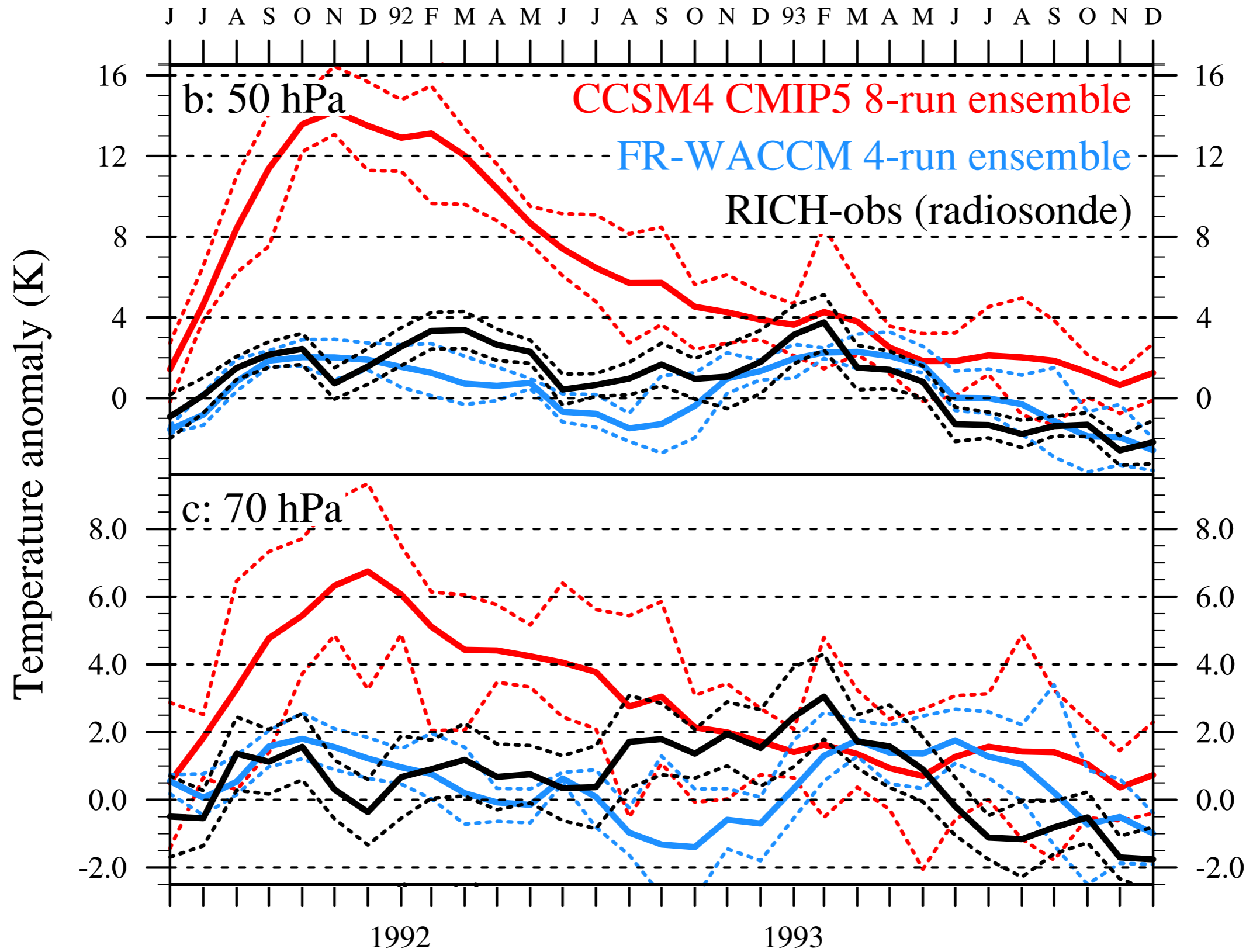


SD-WACCM simulations from "Global volcanic aerosol properties derived from emissions, 1990-2014, using CESM1(WACCM)," Mills et al., submitted to JGR.

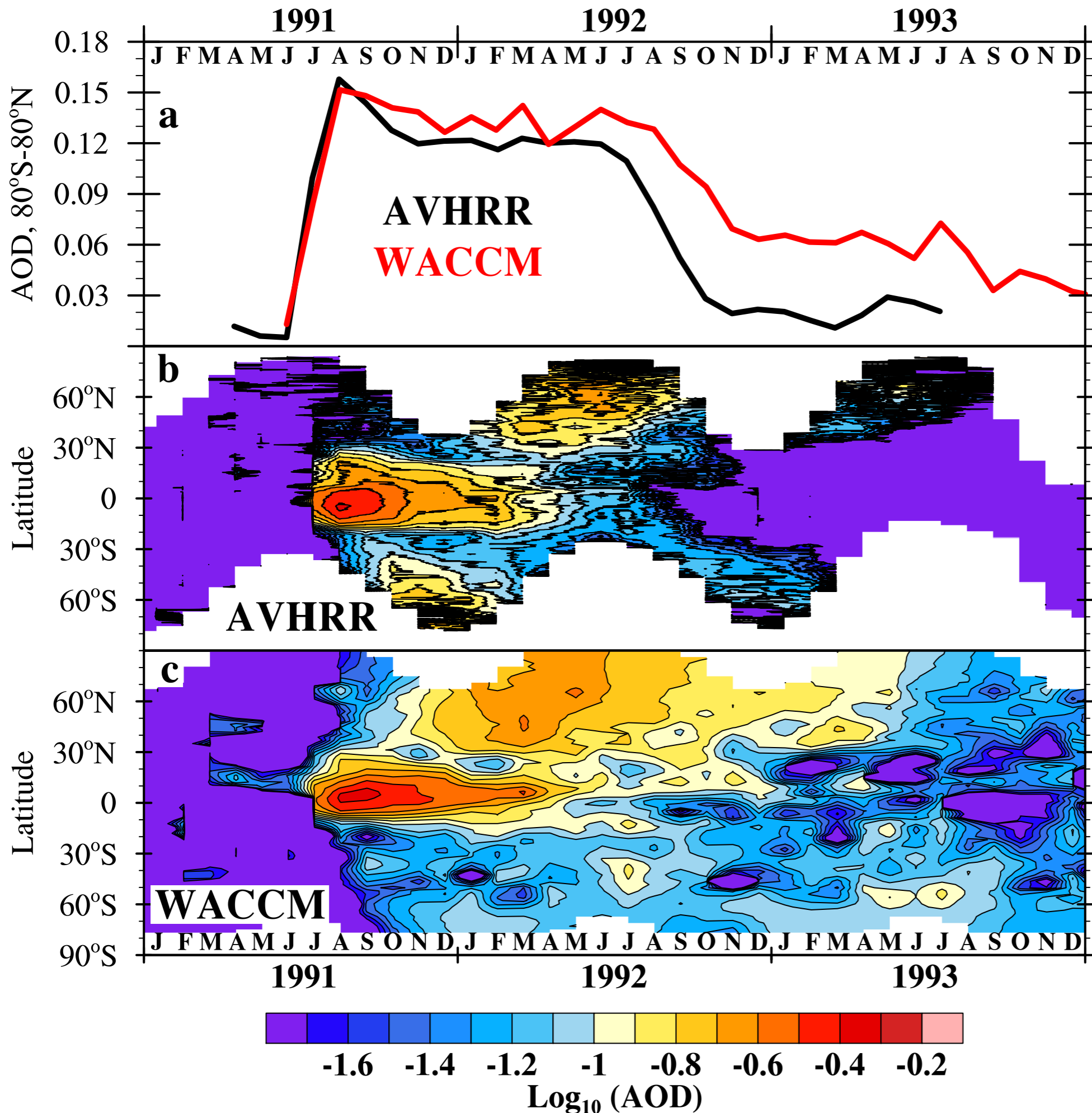




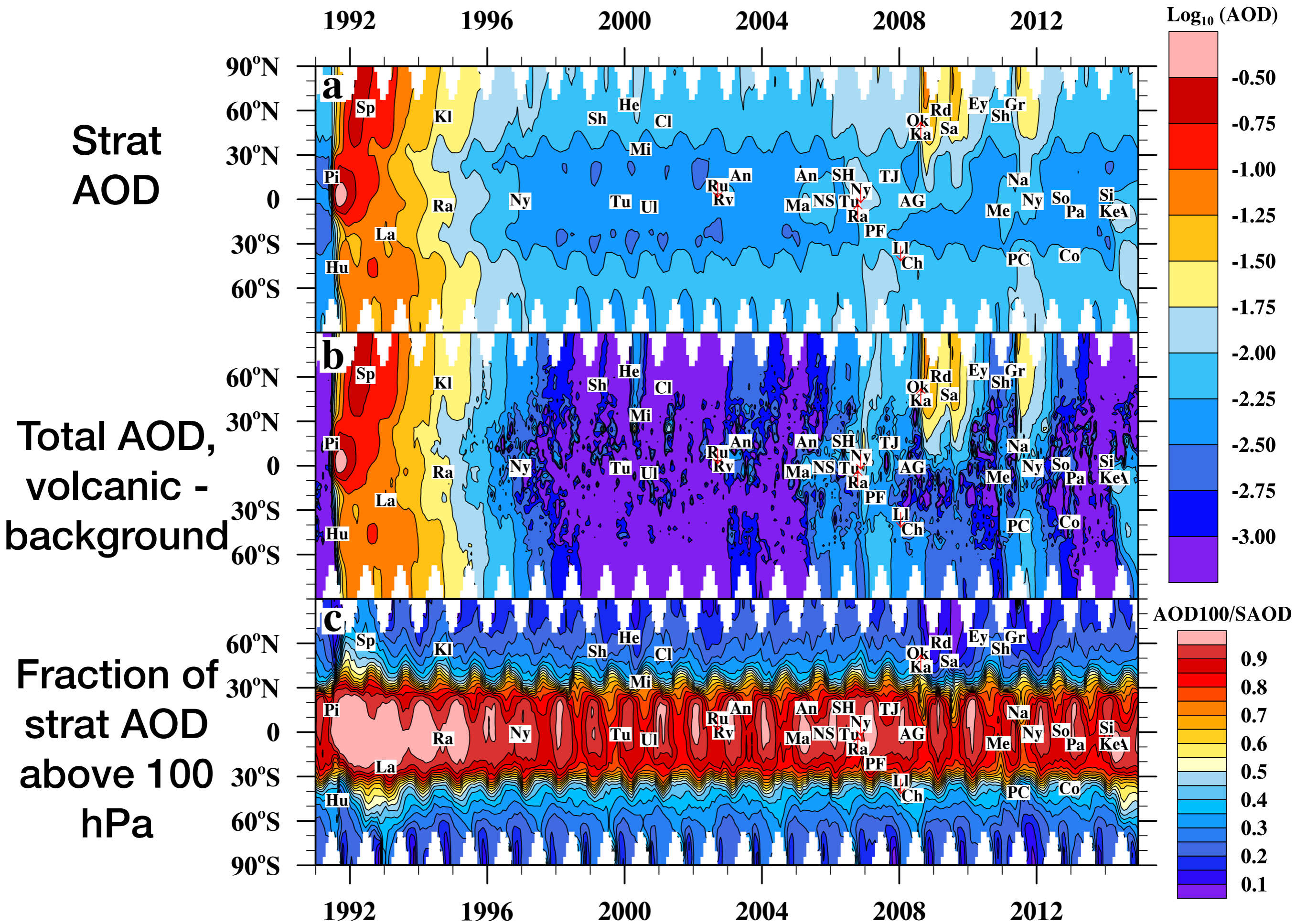
# Prognostic aerosols: *Improved stratospheric heating*

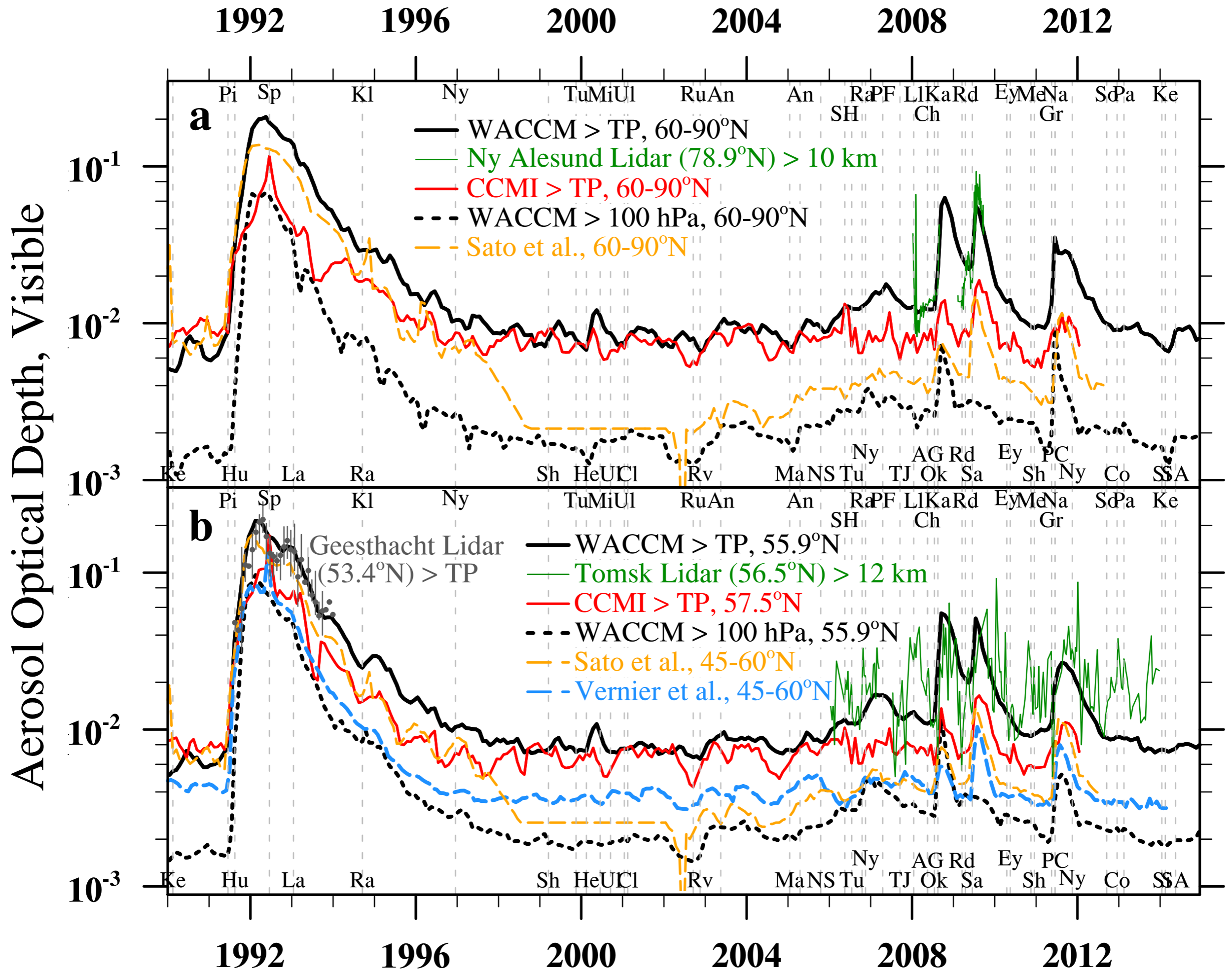


Tropical temperature anomalies  
from Mills et al., submitted to JGR.

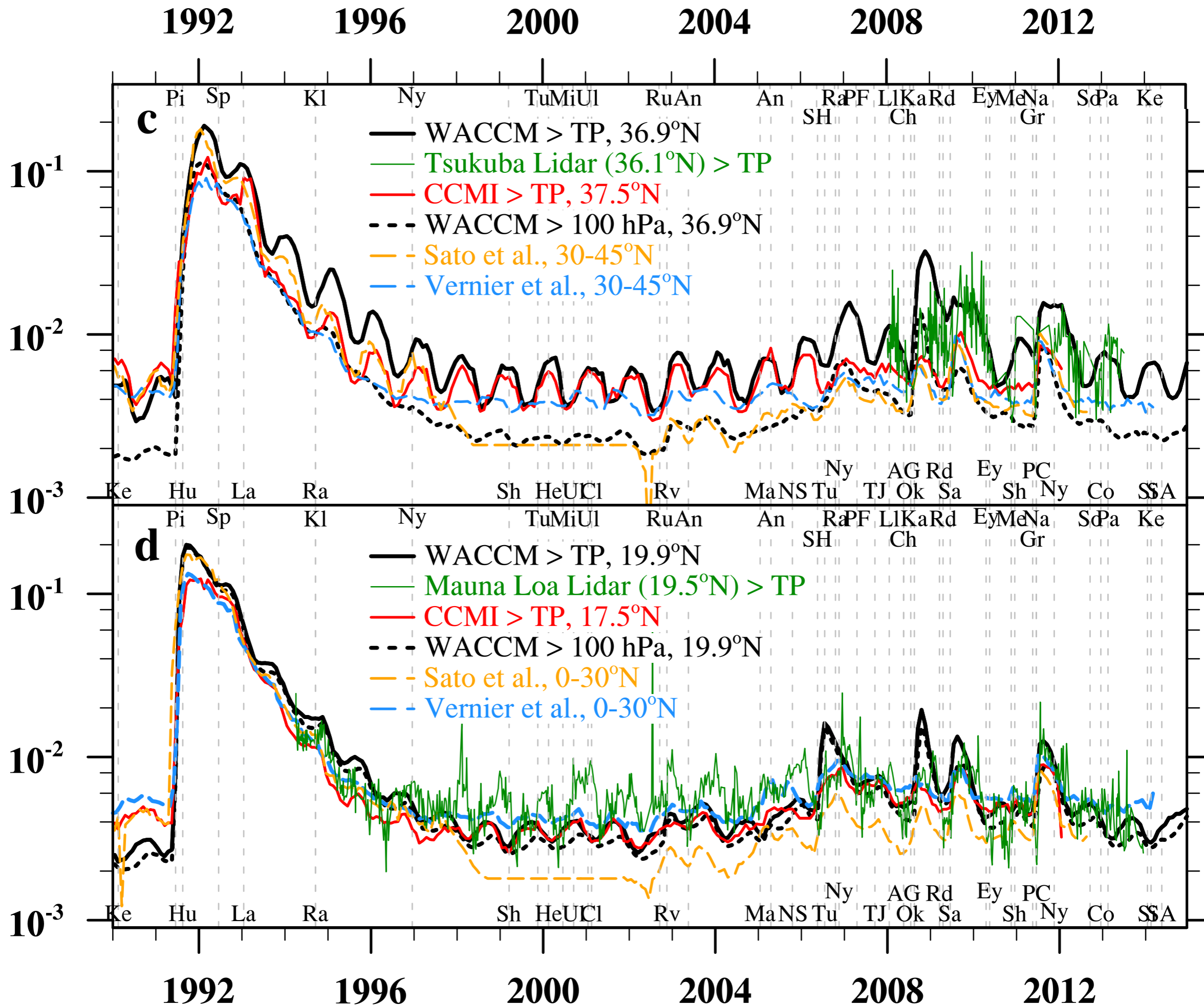


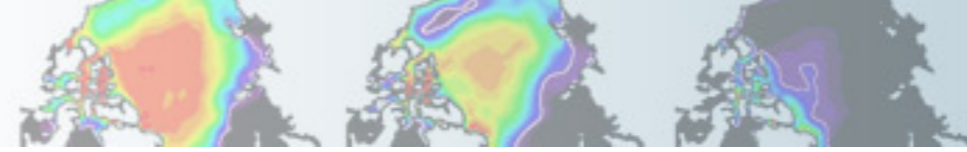
**Total AOD  
over ocean  
minus  
background  
from Mills et  
al., submitted  
to JGR.**





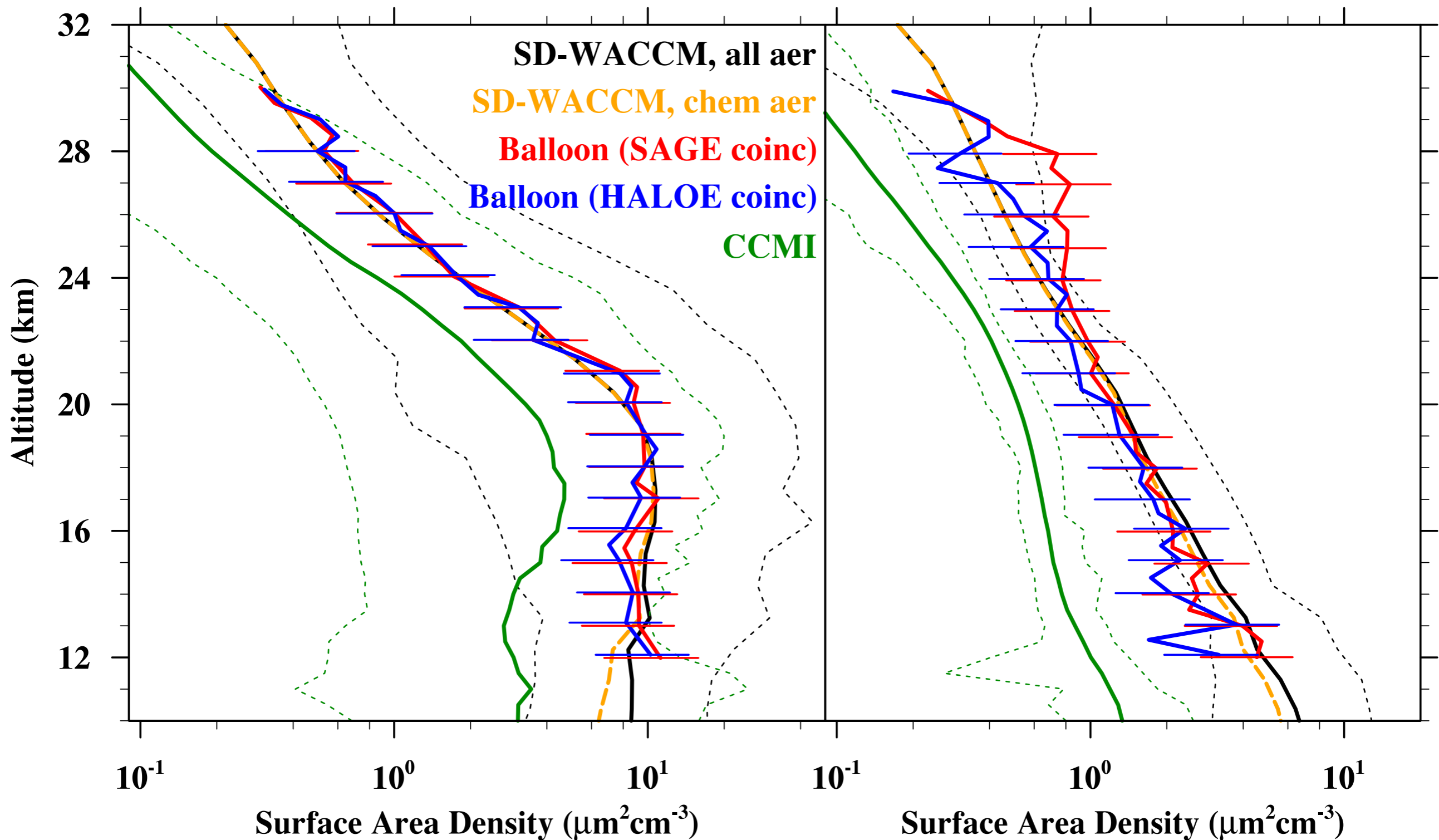
Aerosol Optical Depth, Visible



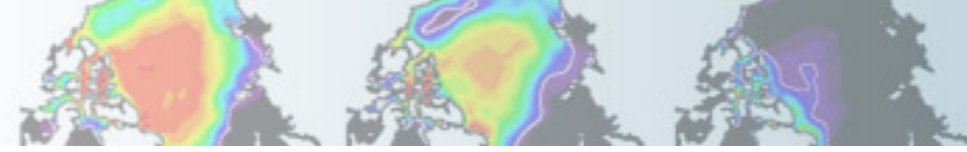


July 1991-December 1996

1997-2005

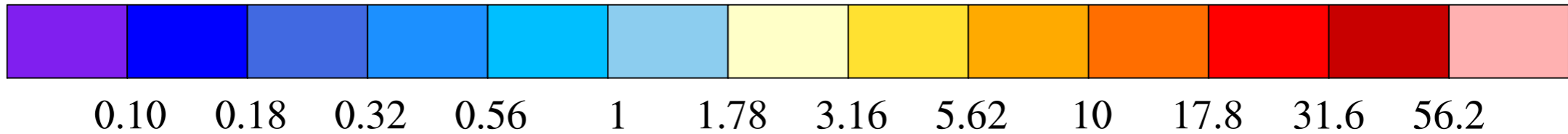
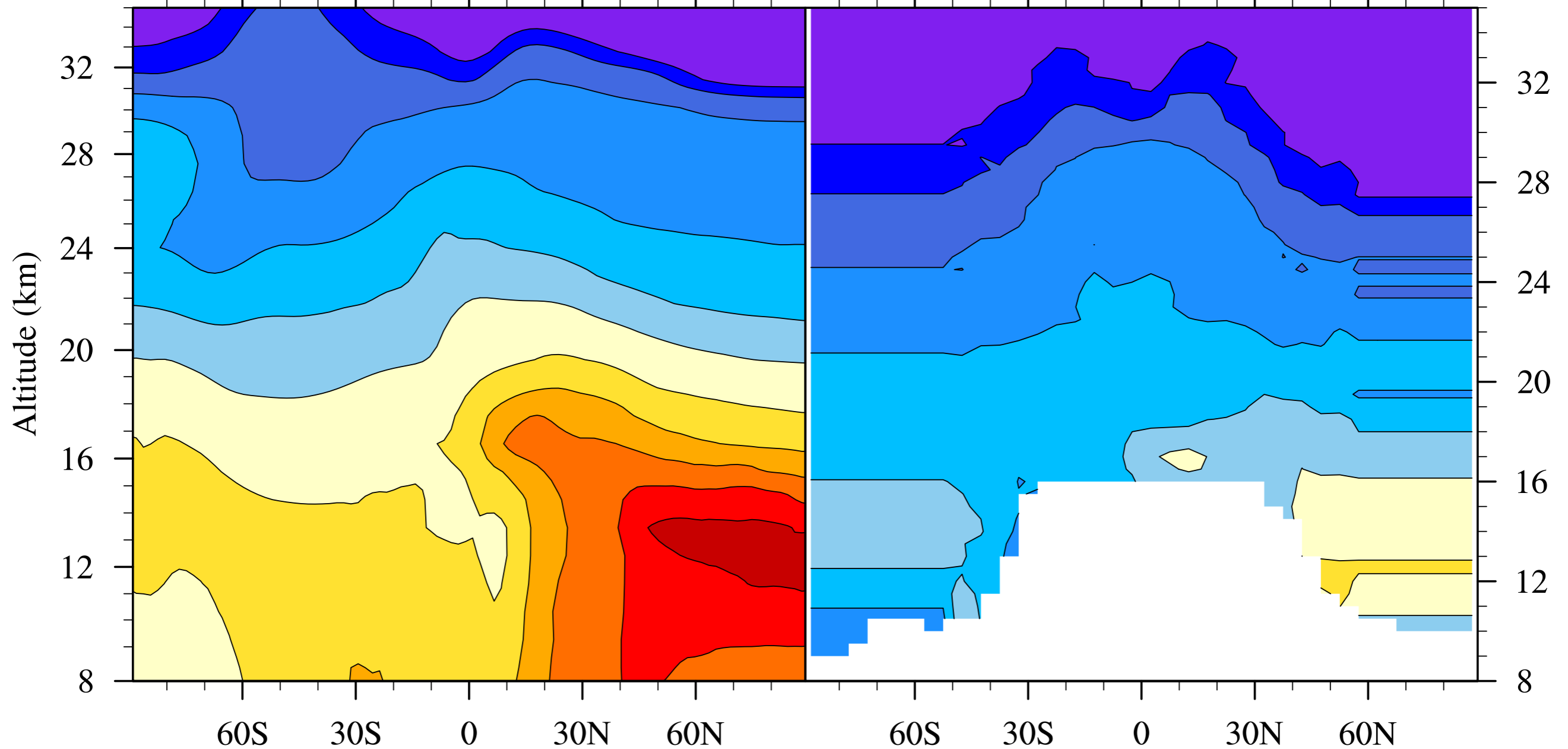


Calculated SAD matches obs. **CCMI SAD misses >60%.**  
from Mills et al., submitted to JGR.

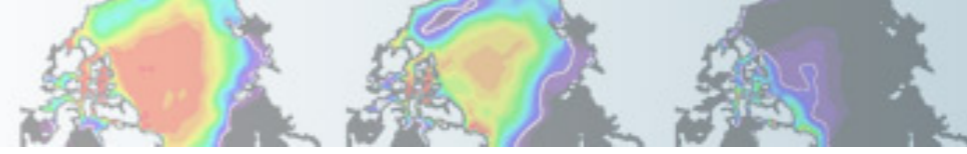


SD-WACCM SAD ( $\mu\text{m}^2\text{cm}^{-3}$ ), July 2009

CCMI SAD ( $\mu\text{m}^2\text{cm}^{-3}$ ), July 2009



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

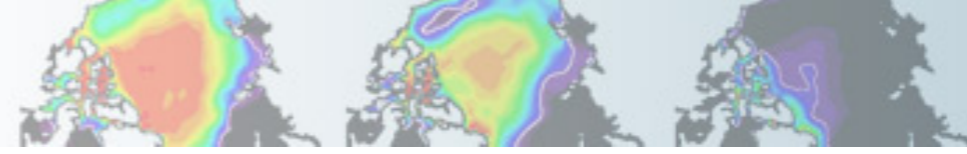


## New prescribed and prognostic volcanic and stratospheric aerosol options in CESM

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- Prescribed stratospheric aerosol based on effective radius, improved mass loading.
- Prognostic modal volcanic aerosol is now available for use in CESM.
- VolcanEESM SO<sub>2</sub> emissions available for 1850-2015.
- Completed 1990-2014 runs with and without volcanoes. Comparison to lidar shows excellent agreement, reveals limitations of satellite data in the lower stratosphere.
- Surface area densities from prognostic aerosols in excellent agreement with Laramie OPC data. In contrast, CCMI-recommended SAD misses 60% of observed SAD in both volcanic and quiescent periods.
- New prescribed and prognostic options greatly improve stratospheric heating after Pinatubo compared to CCSM4.
- CAM may be run with prognostic stratospheric aerosol, or prescribed based on WACCM prognostic run.





# Extra slides

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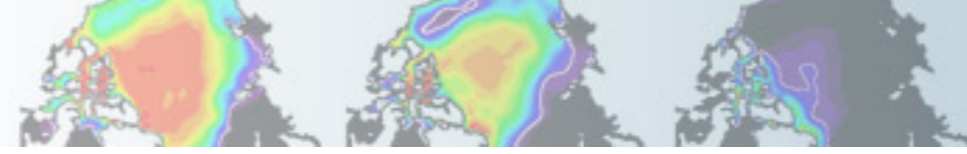
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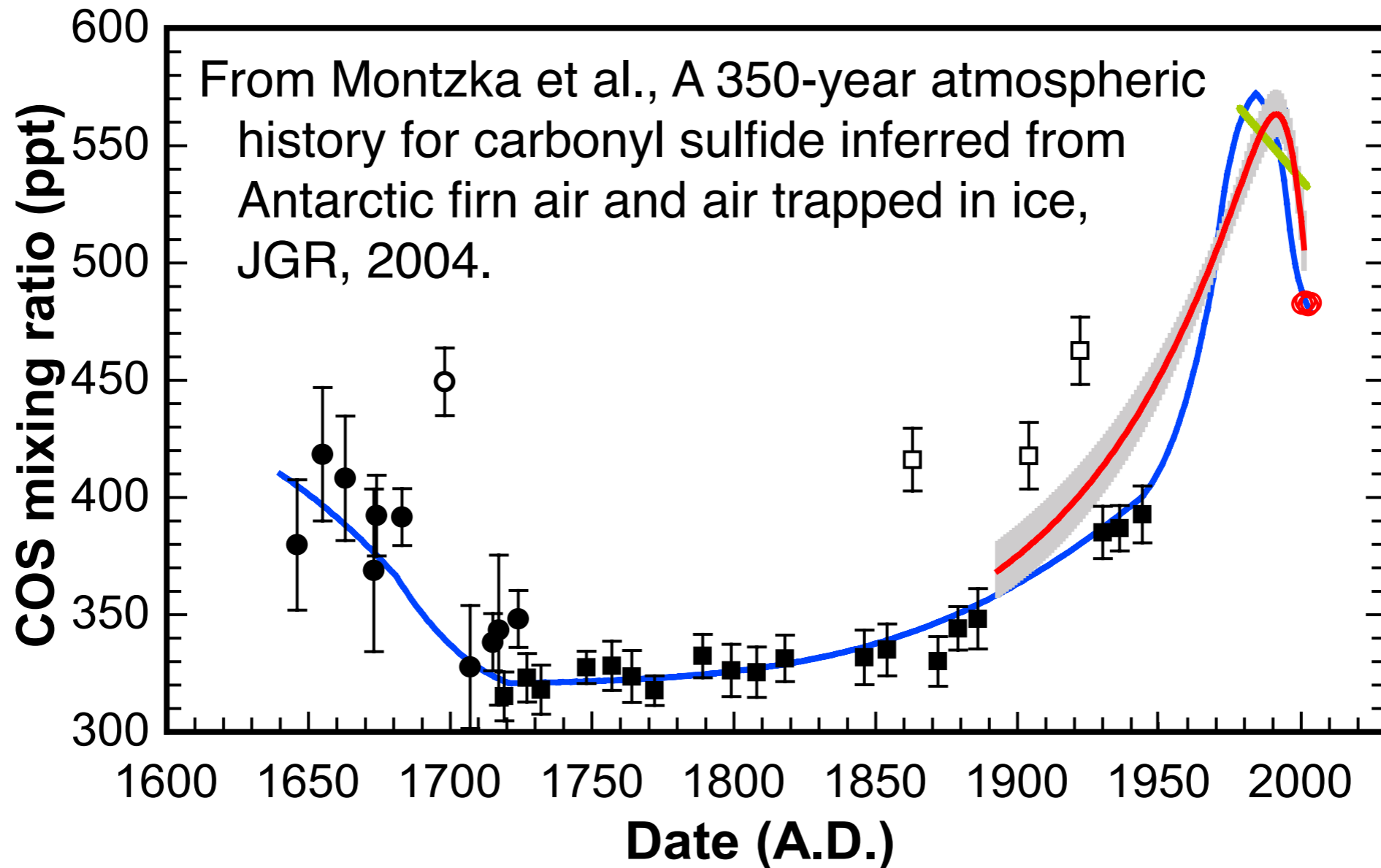
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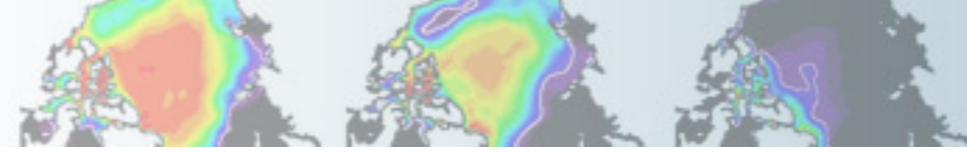




# Time-varying lower boundary condition for OCS



- New LBC file for runs with chemistry (WACCM, CAM-chem)
- External forcing files developed for  $\text{SO}_2$  produced from OCS oxidation in CAM without chemistry: 1850, 20th Century



# 3D volcanic strat/trop SO<sub>2</sub> input file for 1990-2011

No. of VEI > 2 eruptions with eruption column heights >10 km

