Global volcanic aerosol properties derived from emissions, 1990-2015, using CESM1(WACCM)

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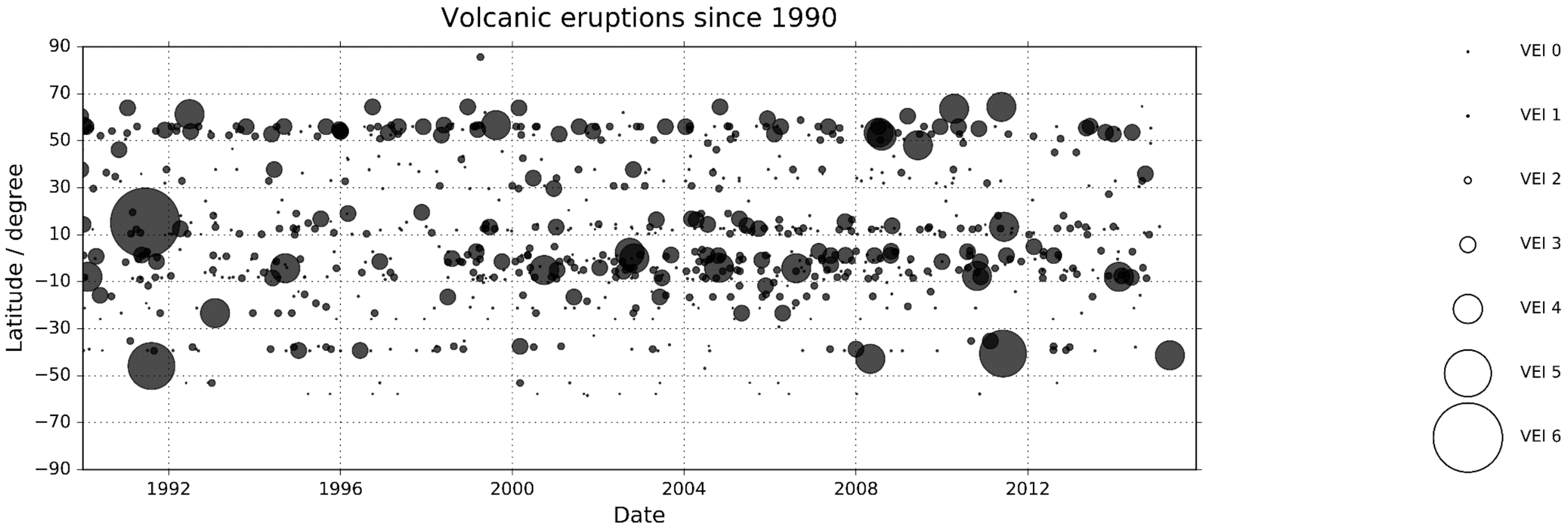
NCAR is funded by the National Science Foundation

Volcanic eruptions since 1990

- Volcanic eruptions increasingly well characterized
  (Satellite retrievals, in-situ measurements, geochem. & geophys. monitoring)
- 1979 first TOMS volcanic SO_2 retrievals
- Compiled volcanic emission dataset for use in climate models



Reported eruptions, Smithsonian Global Volcanism Program

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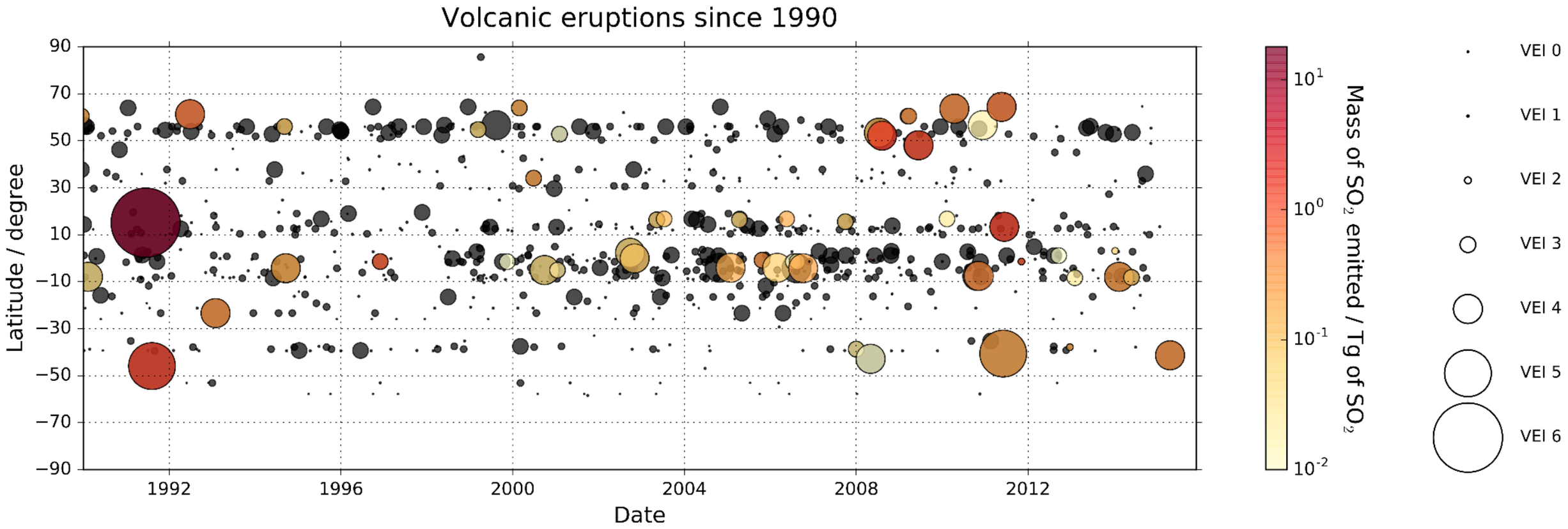
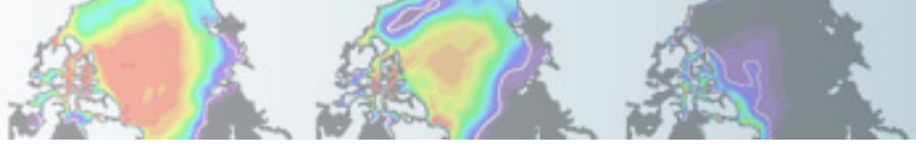


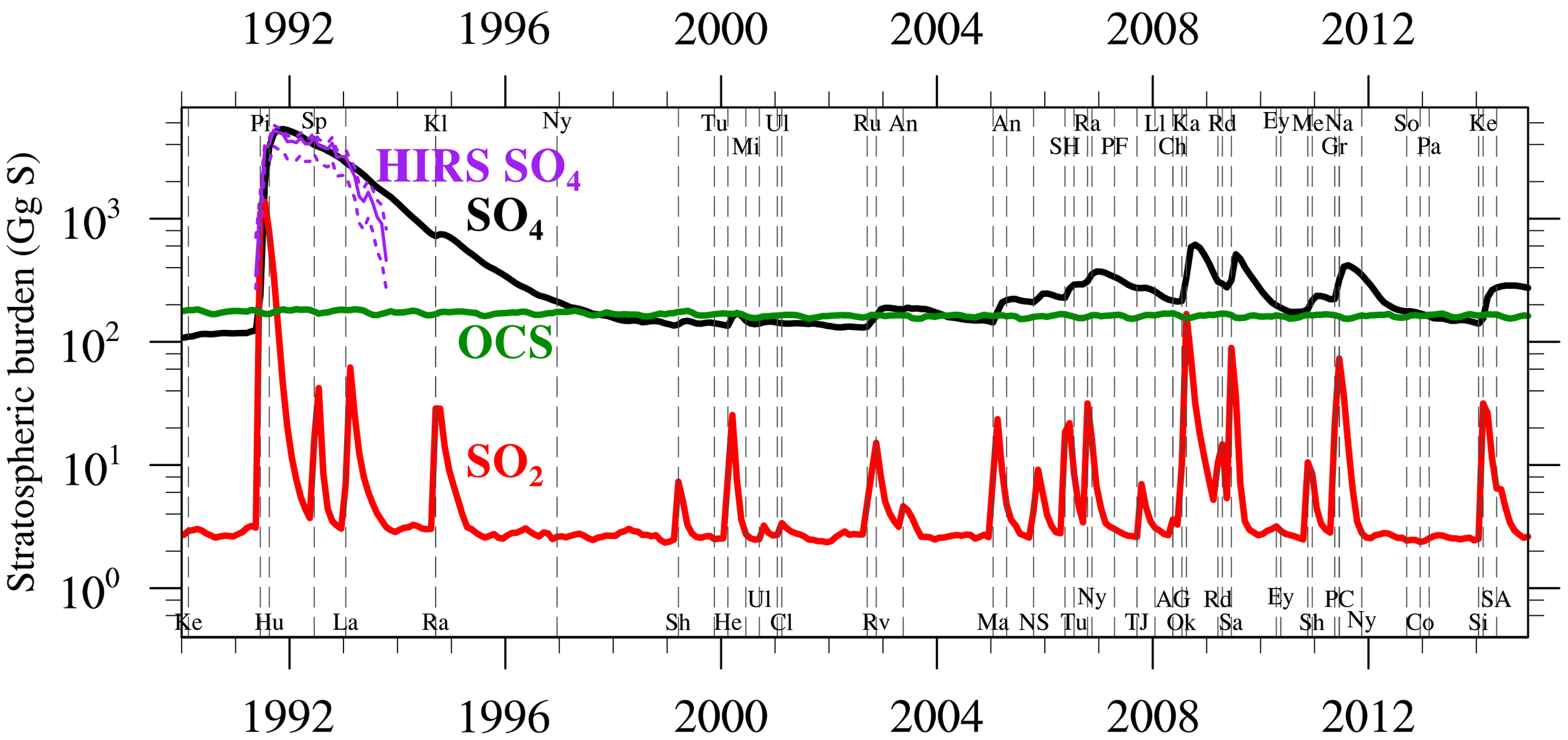
Database: 42 volcanoes, 52 eruptions, 171 days of eruption

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



New prognostic stratospheric aerosol capability in CESM(WACCM)

- CESM: Community Earth System Model (National Center for Atmospheric Research)
- WACCM: Whole Atmosphere Community Climate Model
  - Extends from the surface to the lower thermosphere (~145 km)
  - Full interactive chemistry and dynamics
  - May be nudged by specified dynamics (SD-WACCM)
- Modal Aerosol Model (MAM)
  - Sulfate in 3 modes: Aitken, accumulation, and coarse
  - Microphysics includes nucleation, condensation, evaporation, coagulation, and sedimentation
  - Stratospheric heterogeneous chemistry on sulfates and polar stratospheric clouds



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

June
2011

Grimsvoetn

Nabro

Puyehue Cordon Caulle

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

2e-07 3e-07 6e-07 1e-06 2e-06 3e-06 6e-06

July
2008

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

2e-07 3e-07 6e-07 1e-06 2e-06 3e-06 6e-06

Community Earth System Model

CESM

1992 1996 2000 2004 2008 2012

90°N 60°N 30°N 0 30°S 60°S

a

Sp Kl He Sh Cl Mi Rd Ey Gr Sh Ok Ka Sa Pi Ra Ny Tu Ul An Ru Rv An SH Ny TJ Ma NS Tu Ra AG PF Ll Ch Na Ny So Si Me Pa KeA La Hu PC Co

Stratospheric AOD

b

Sp Kl He Sh Cl Mi Rd Ey Gr Sh Ok Ka Sa Pi Ra Ny Tu Ul An Ru Rv An SH Ny TJ Ma NS Tu Ra AG PF Ll Ch Na Ny So Si Me Pa KeA La Hu PC Co

Total AOD, volcanic - background

1992 1996 2000 2004 2008 2012

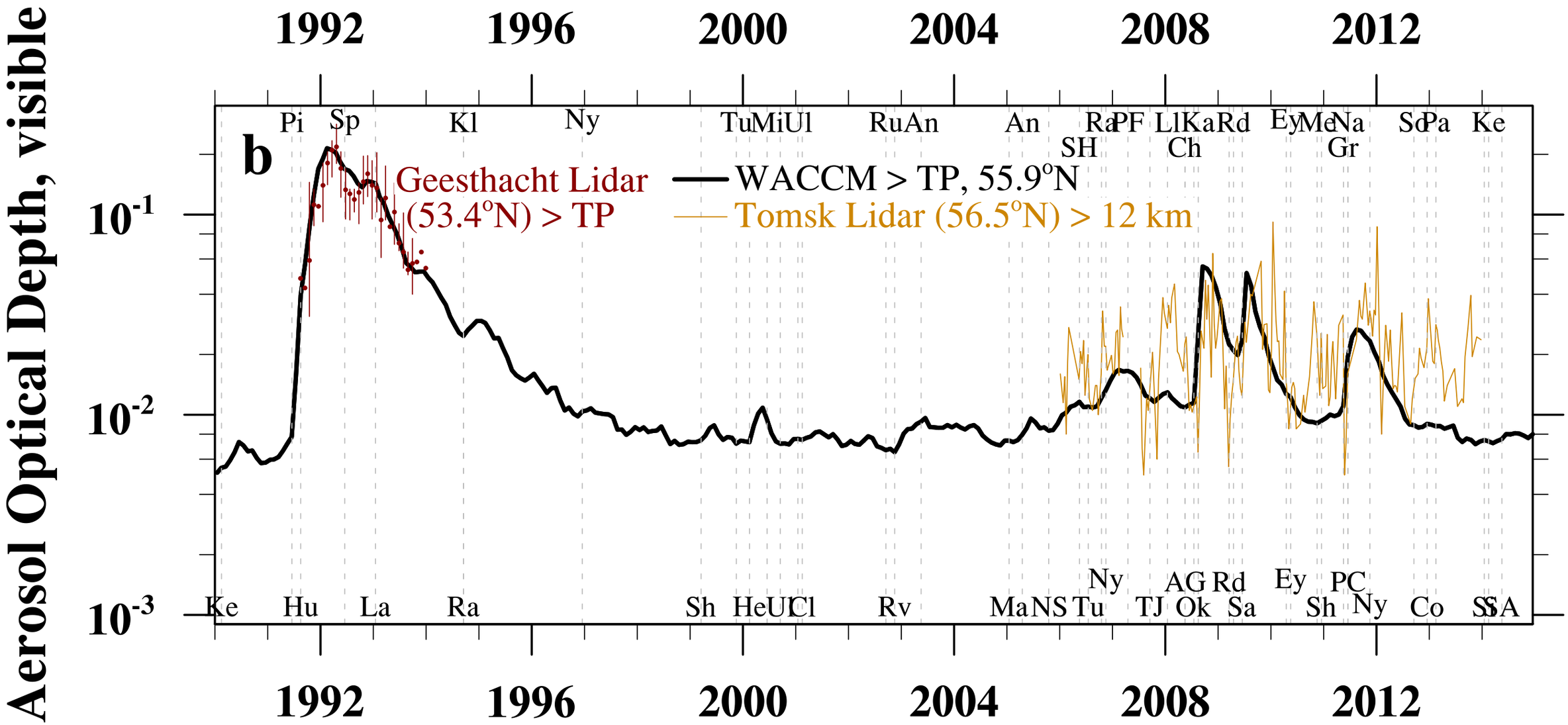
Log_{10} (AOD)

-0.50 -0.75 -1.00 -1.25 -1.50 -1.75 -2.00 -2.25 -2.50 -2.75 -3.00

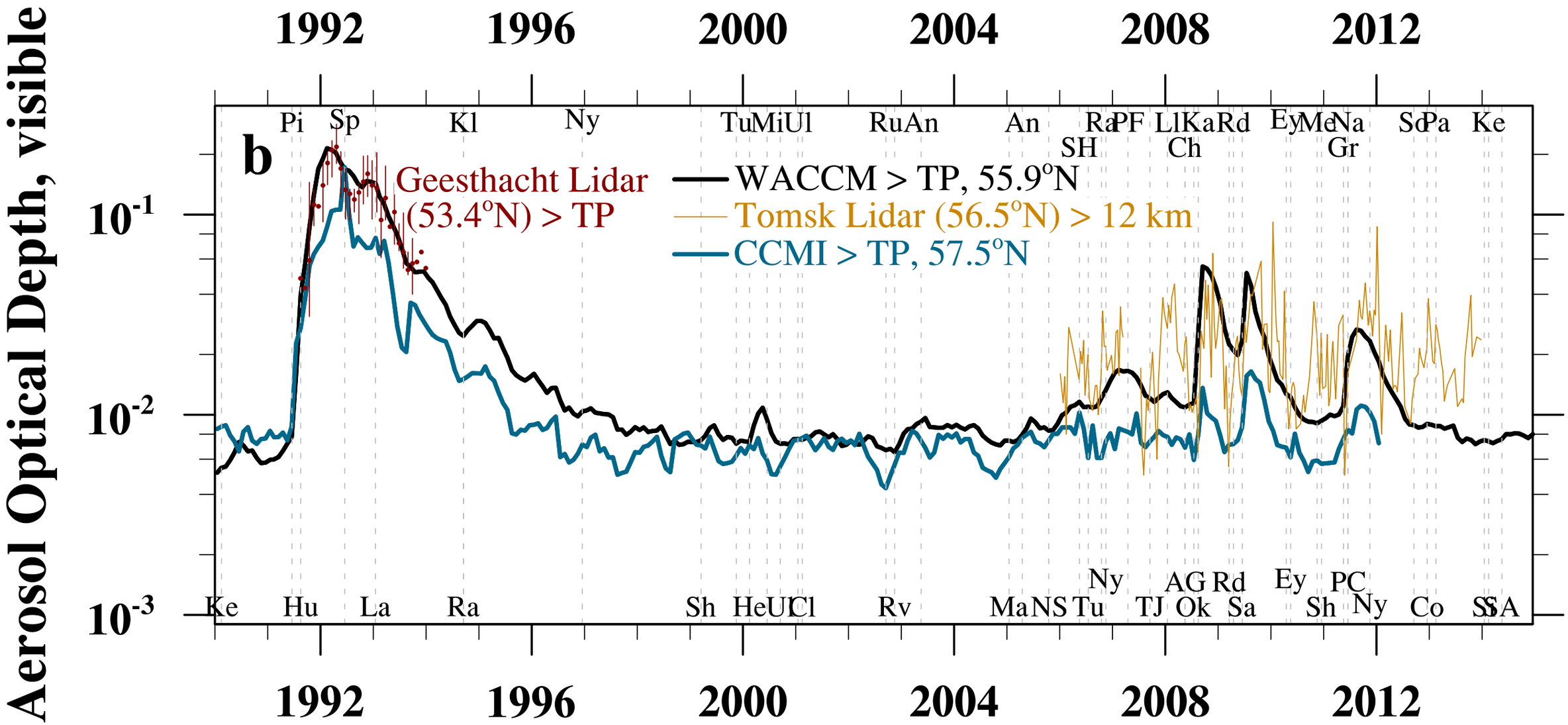
NCAR

WACCM

Whole Atmosphere Community Climate Model



Northern mid-latitudes



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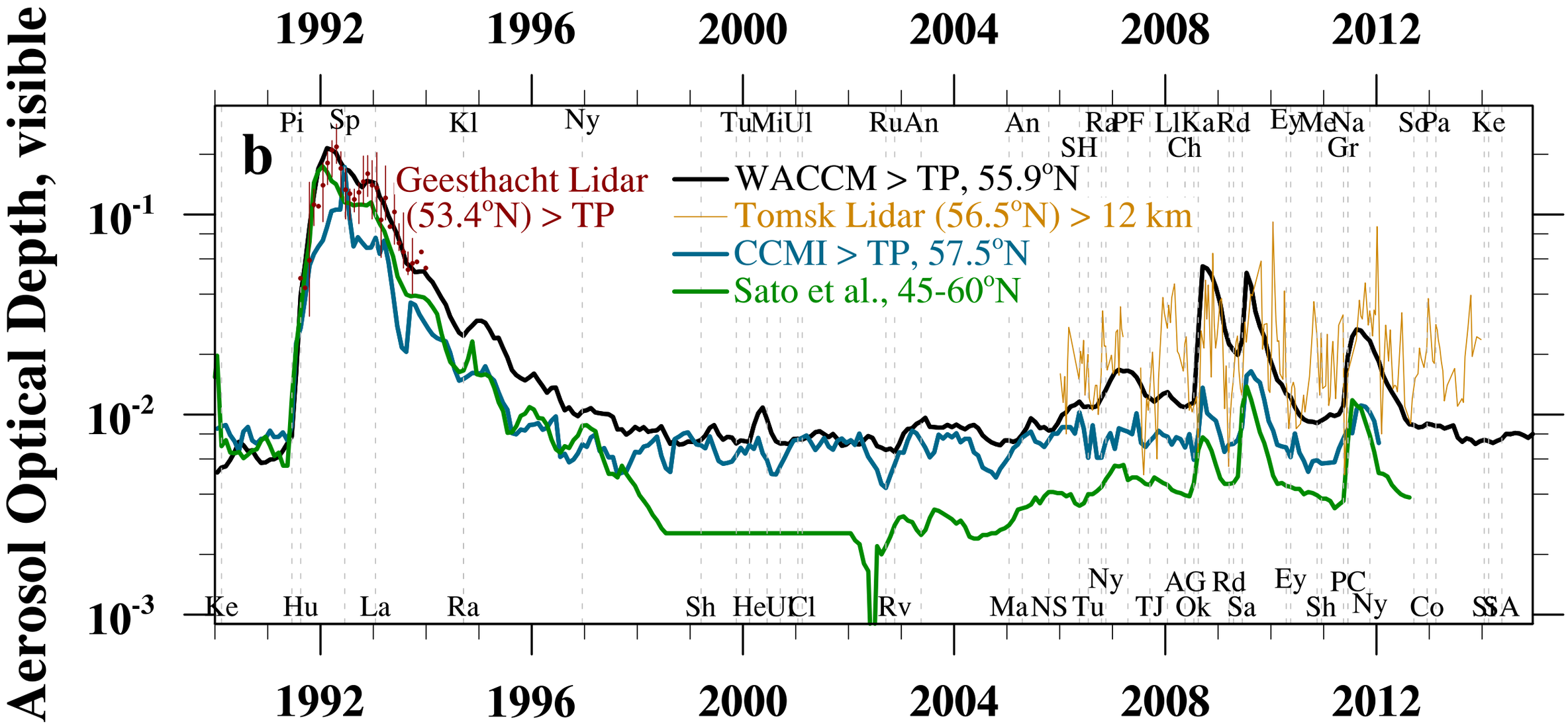

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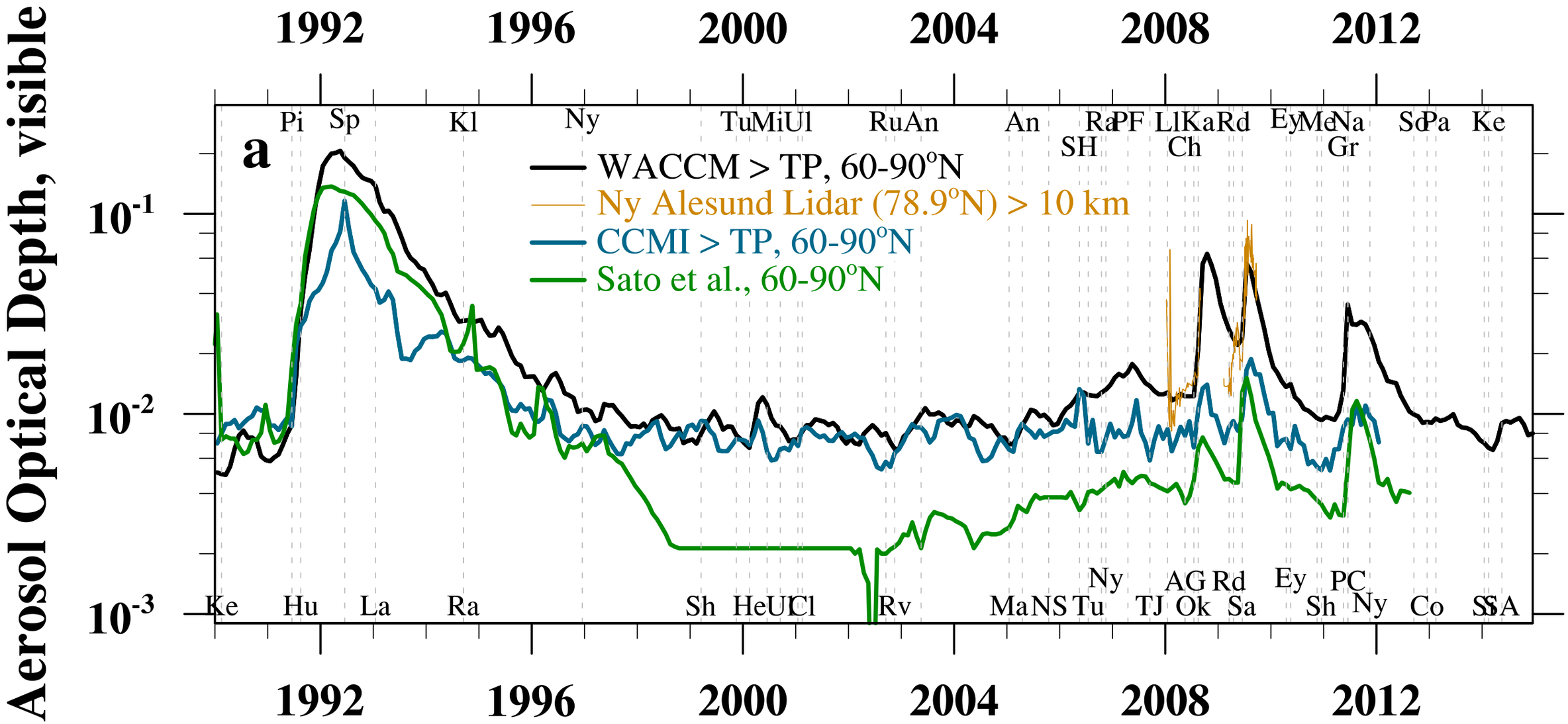
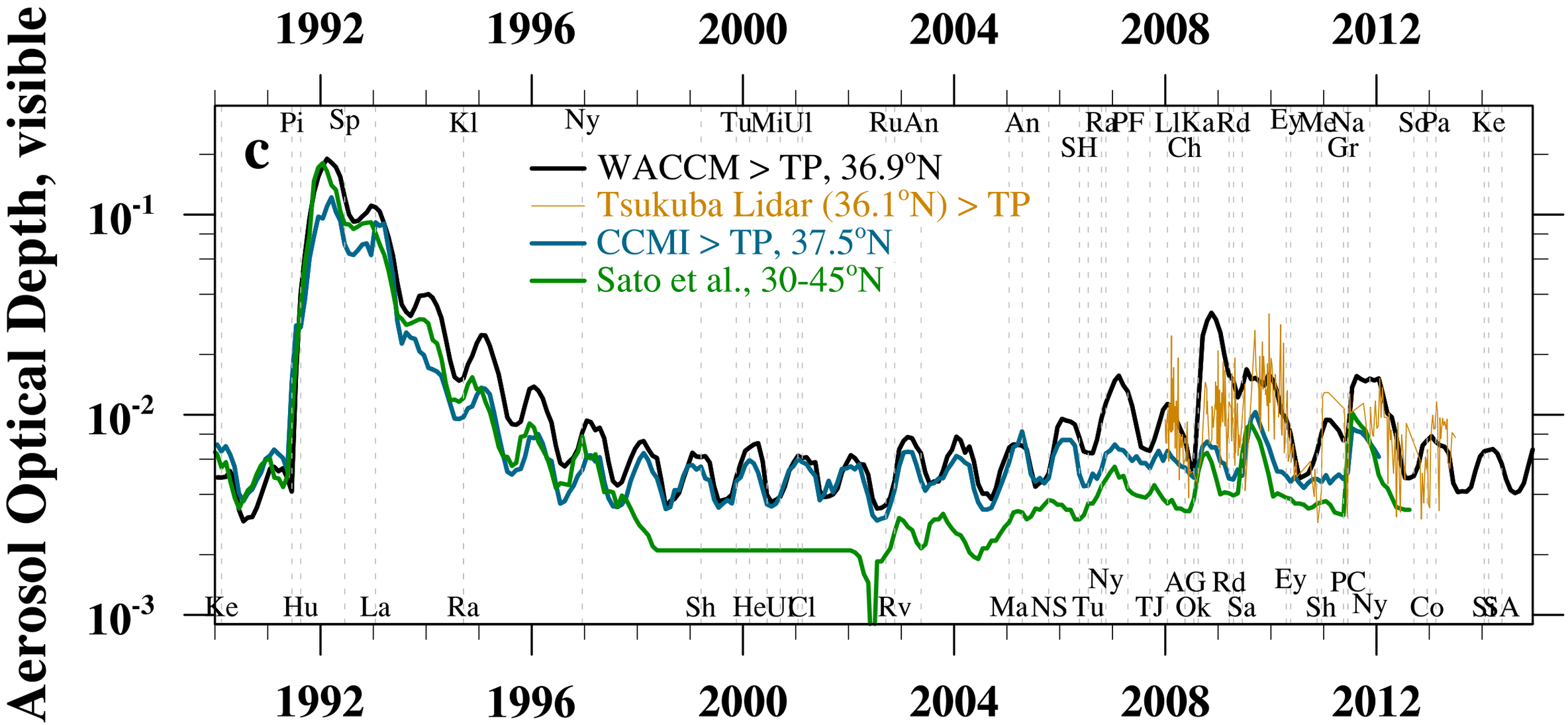
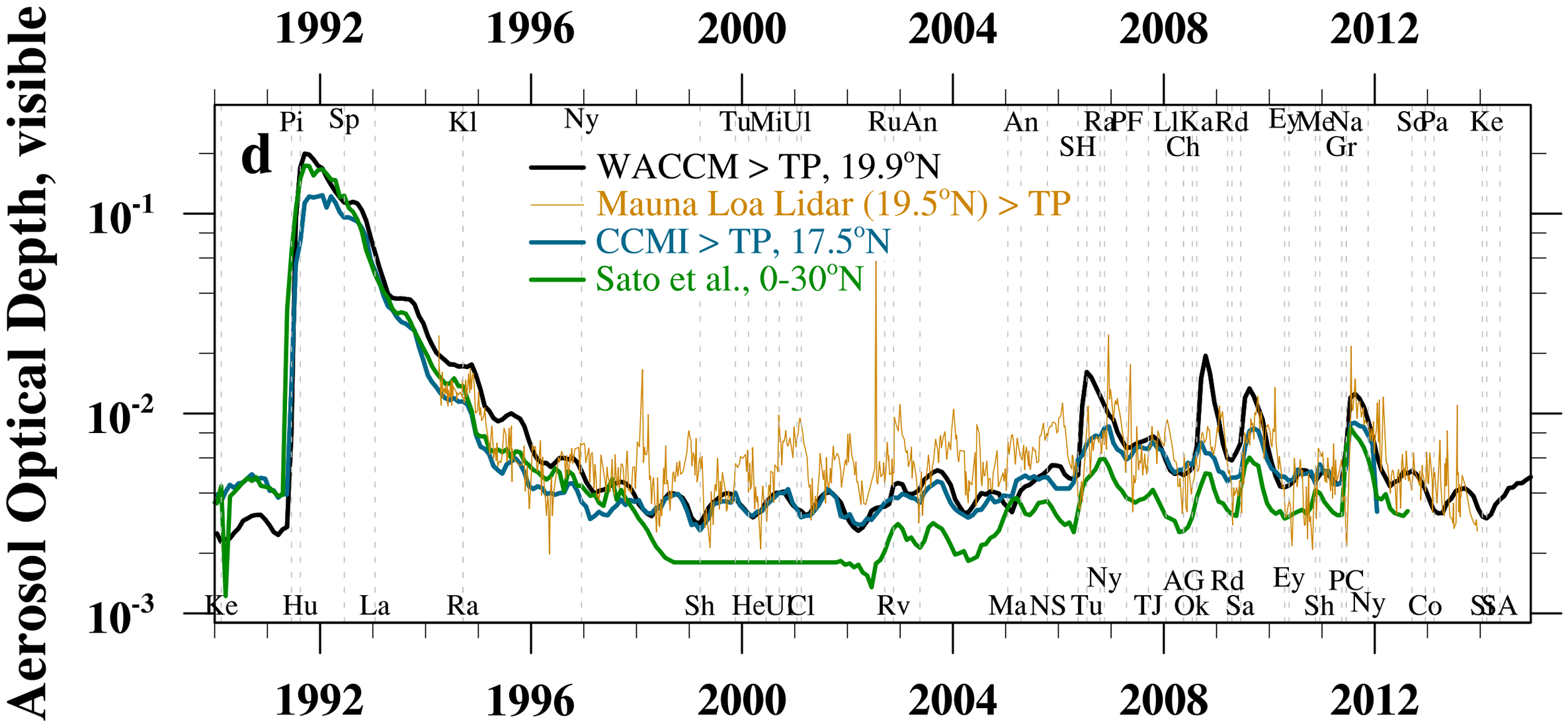


Northern high latitudes



Northern extra-tropics


1992
1996
2000
2004
2008
2012
d
WACCM > TP, 19.9°N
Mauna Loa Lidar (19.5°N) > TP
CCMI > TP, 17.5°N
Sato et al., 0-30°N
Aerosol Optical Depth, visible
10-1
10-2
10-3
Pi Sp Kl Ny TuMiUl RuAn An RaPF LlKaRd EyMeNa ScPa Ke
SH Ch Gr
Ke Hu La Ra Sh HeUCl Rv MaNS Tu Ny TJ AG Ok Rd Sa Ey Sh PC Ny Co SSA

Tropics

July 1991-December 1996

1997-2005

Wyoming OPC

SAGE v6.2

SAGE v7.0

Data from Kovilakam and Deshler (2015)

Altitude (km)

32

28

24

20

16

12

10^{-1} 10^{0} 10^{1}

Surface Area Density ($\mu m^2 cm^{-3}$)

10^{-1} 10^{0} 10^{1}

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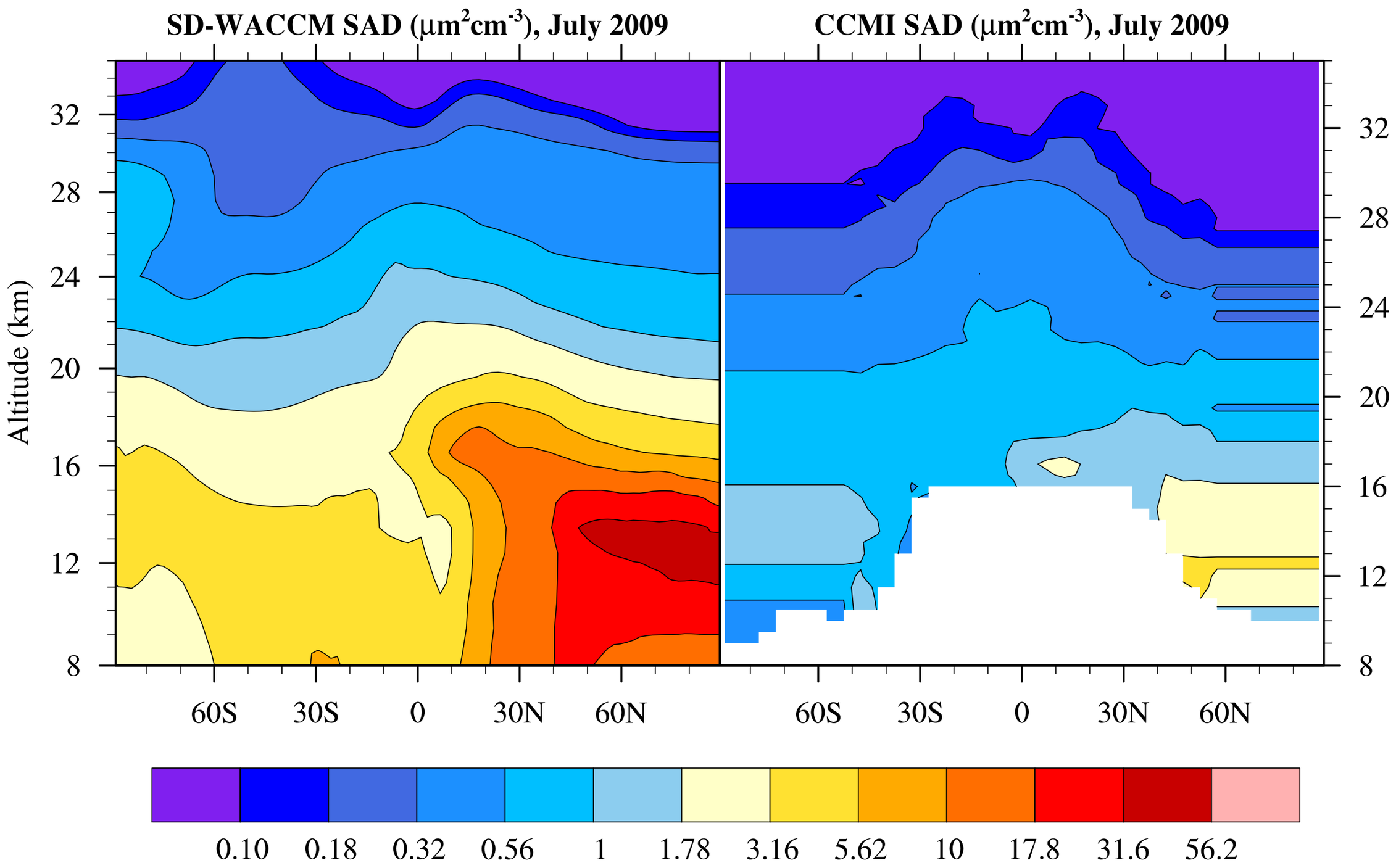

Post-Sarychev eruption: calculated SAD = 10x CCMI

from Mills et al., JGR, 2016

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- Prognostic modal volcanic aerosol is now available for use in CESM.
- Volcanic Emissions for Earth System Models (VolcanEESM) SO_2 available for 1850-2015 from CEDA at http://doi.org/10/f3kxt5
- Completed 1990-2015 runs with and without volcanoes. Comparisons to NH lidars and OPC show good agreement.
- CCMI and Sato climatologies are deficient in stratospheric AOD during 2005-2015 active period of moderate eruptions.
- Calculated aerosol climatology is publicly available on the Earth System Grid at http://dx.doi.org/10.5065/D6S180JM

Mills et al., "Global volcanic aerosol properties derived from emissions, 1990-2014, using CESM1(WACCM)," *JGR*, **121**, 2332-2348, doi:10.1002/2015JD024290, 2016.

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