Climate Intervention with Stratospheric Aerosols: The growing complexity of the Stratosphere

9 February 2010

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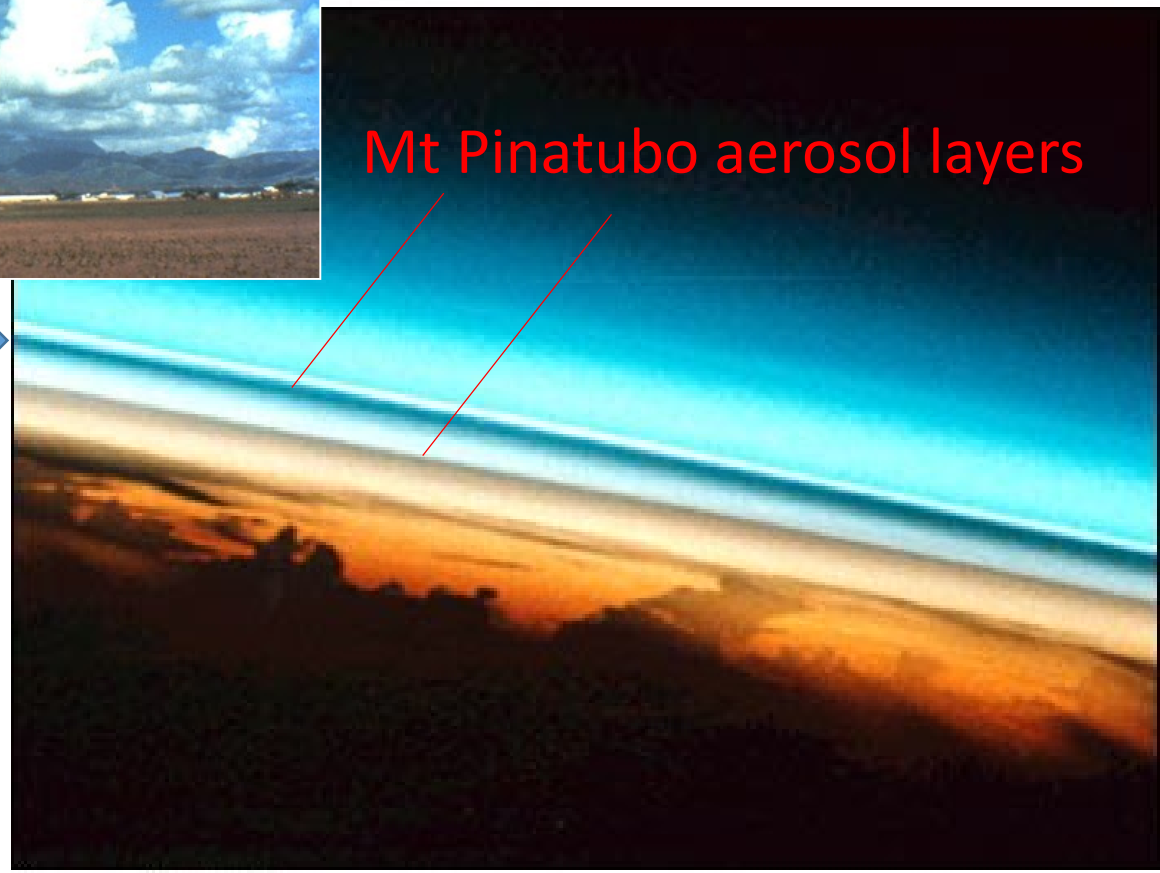
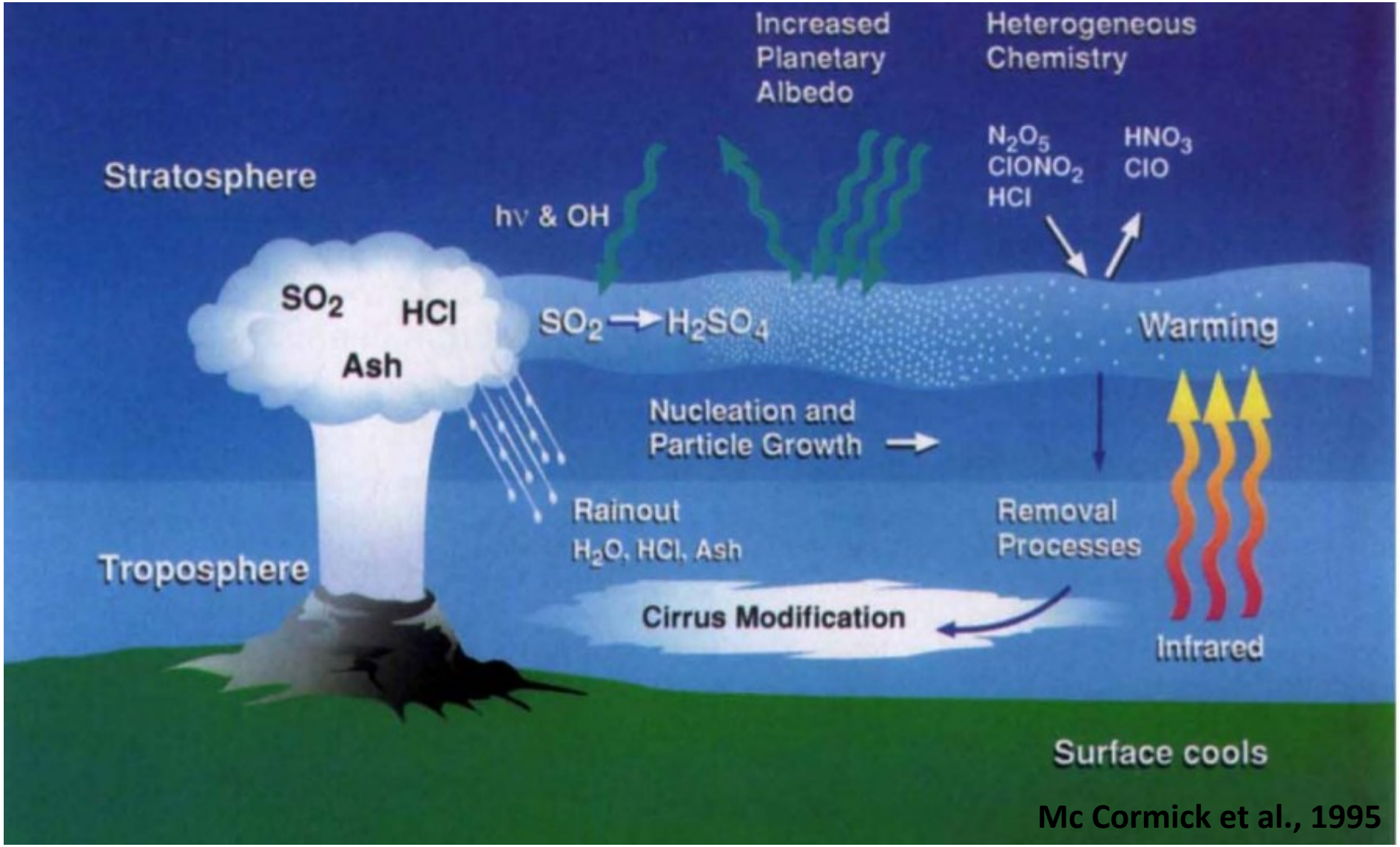
Impact of Mt Pinatubo eruption on Stratospheric Aerosols

August 30, 1984

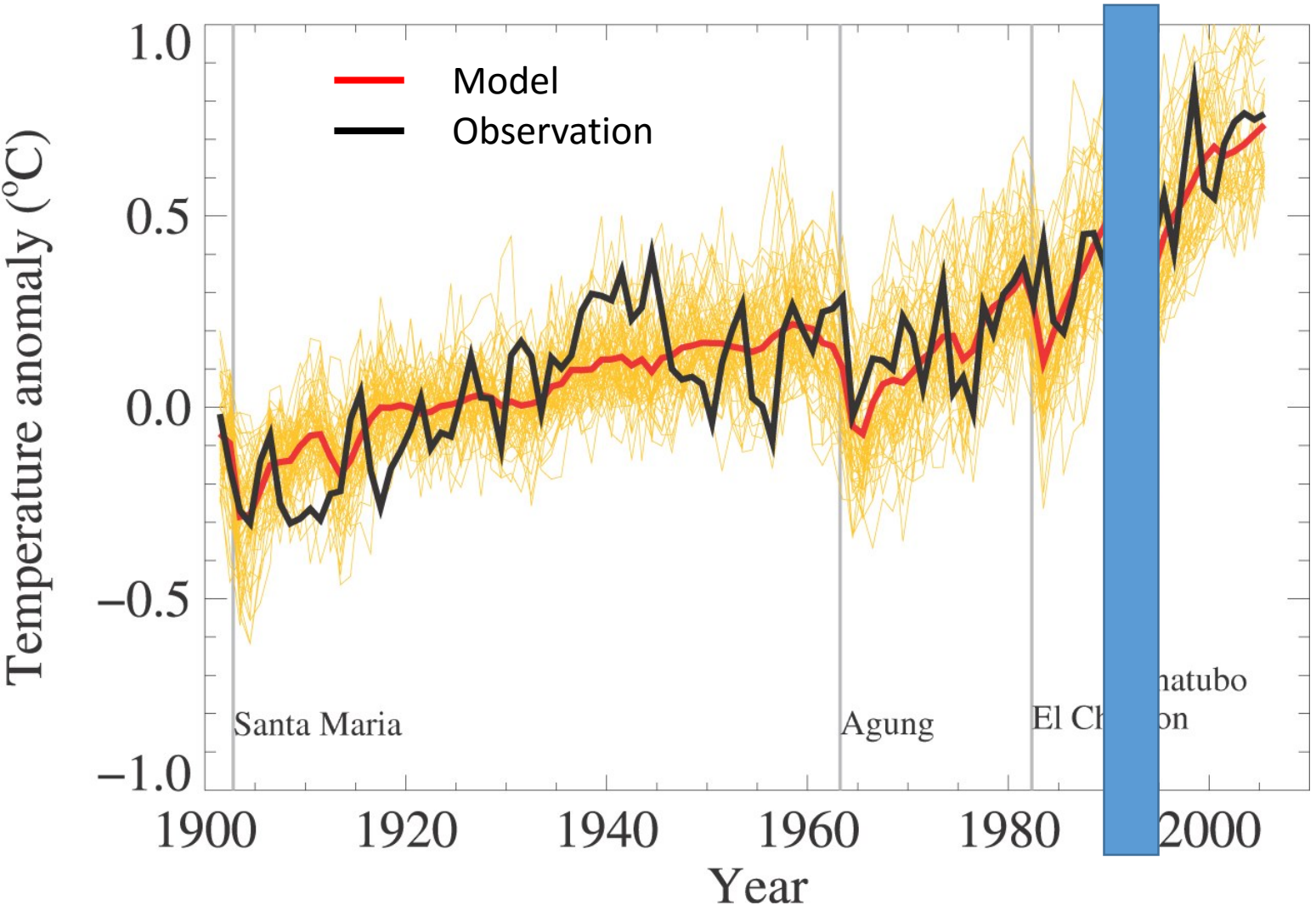


August 8, 1991

The atmospheric impacts of Mt Pinatubo eruption



Temporary Cooling after Major Volcanic Eruptions



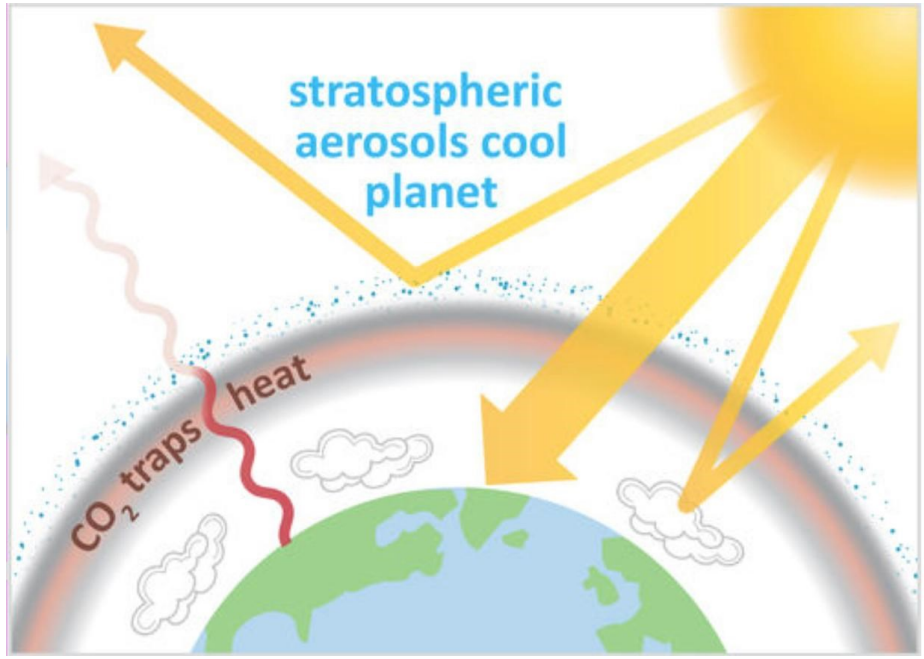


Figure 8, IPCC/AR4/Chap 8

How well do we understand stratospheric aerosols ?

The Discovery of the Stratospheric Aerosol Layer: 1961

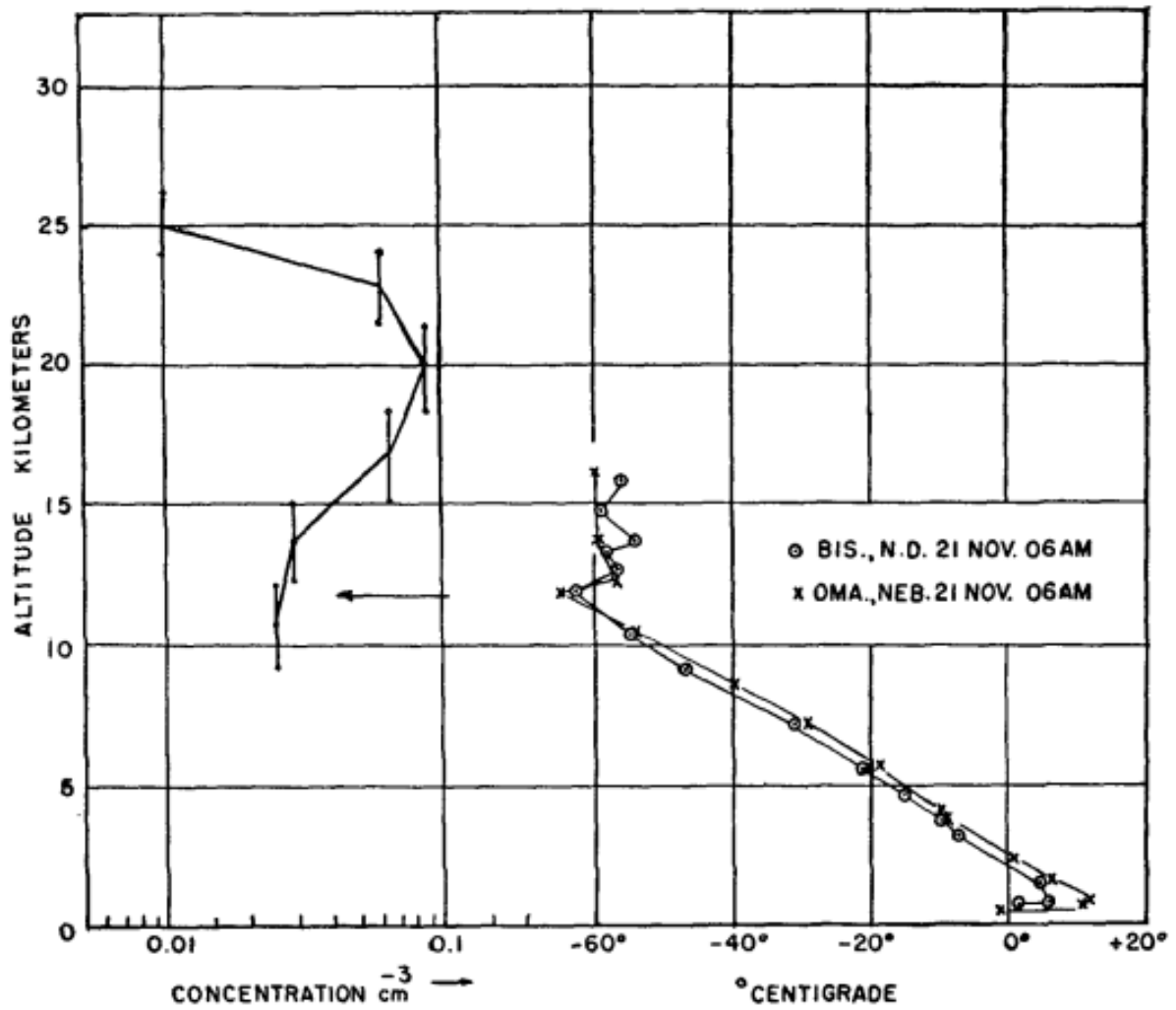
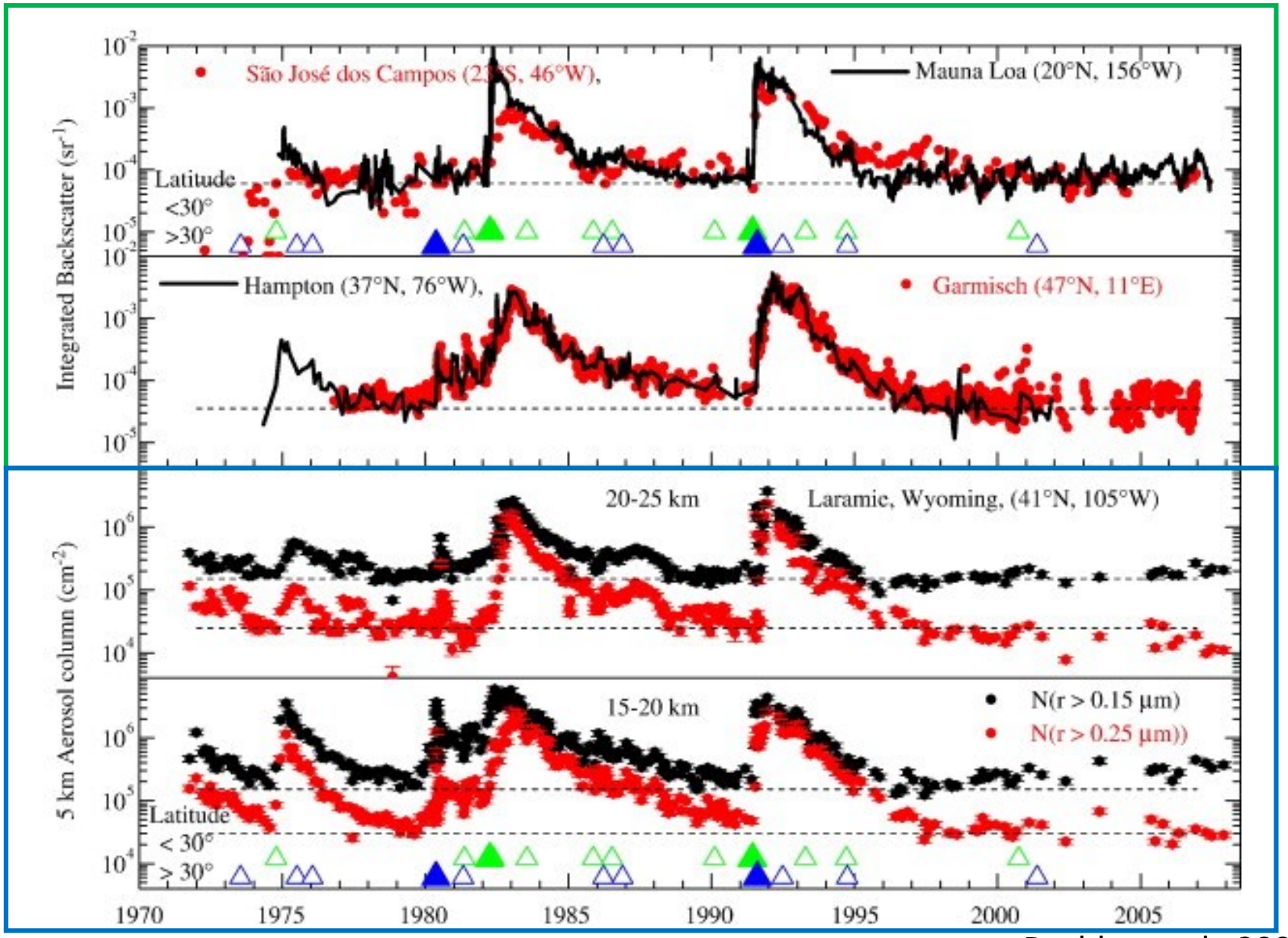


FIG. 17. Vertical profile of particles collected with the General Mills impactors on 21 November 1959, and the available temperature soundings closest in time and space. The vertical bars indicate the altitude interval over which the sample was collected.

Junge et al., 1961

Long-term measurements of stratospheric aerosols

Balloon

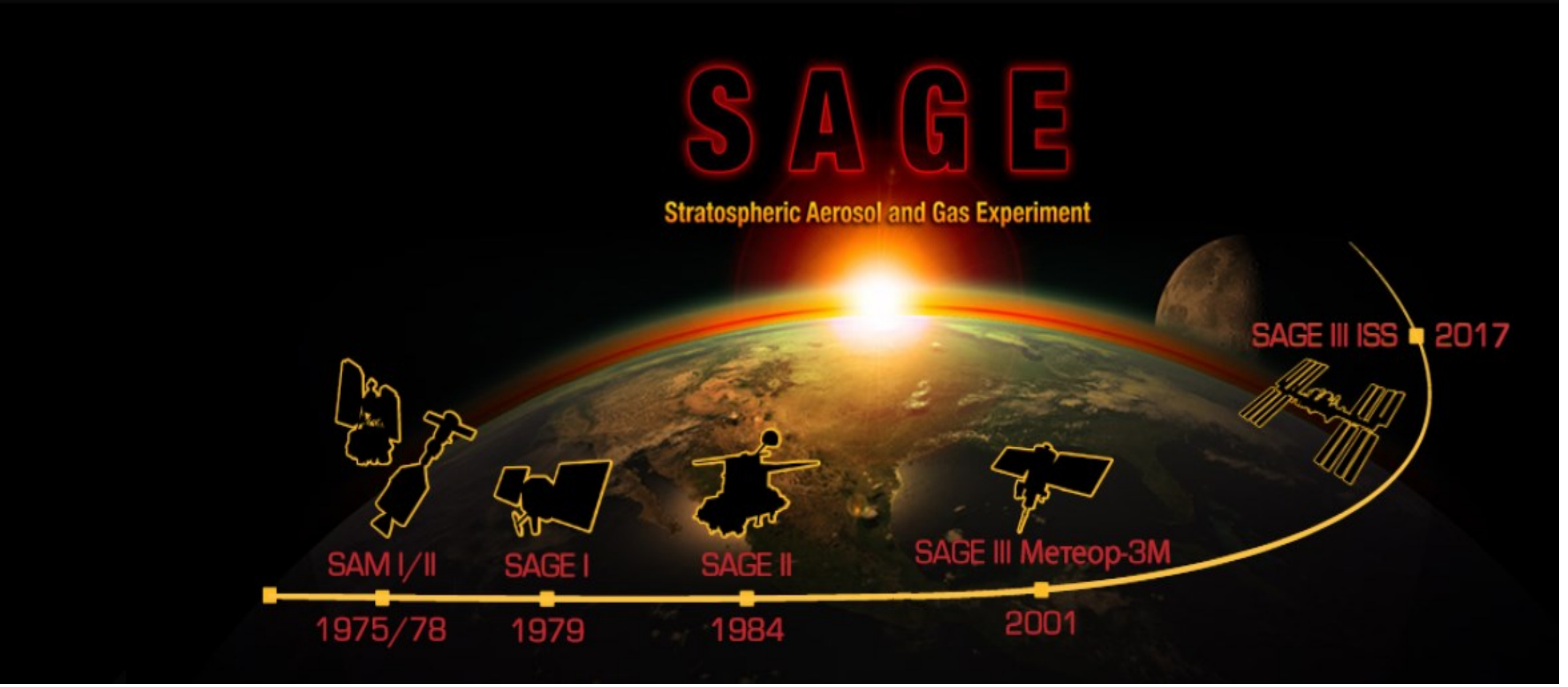


Lidar

Deshler et al., 2008

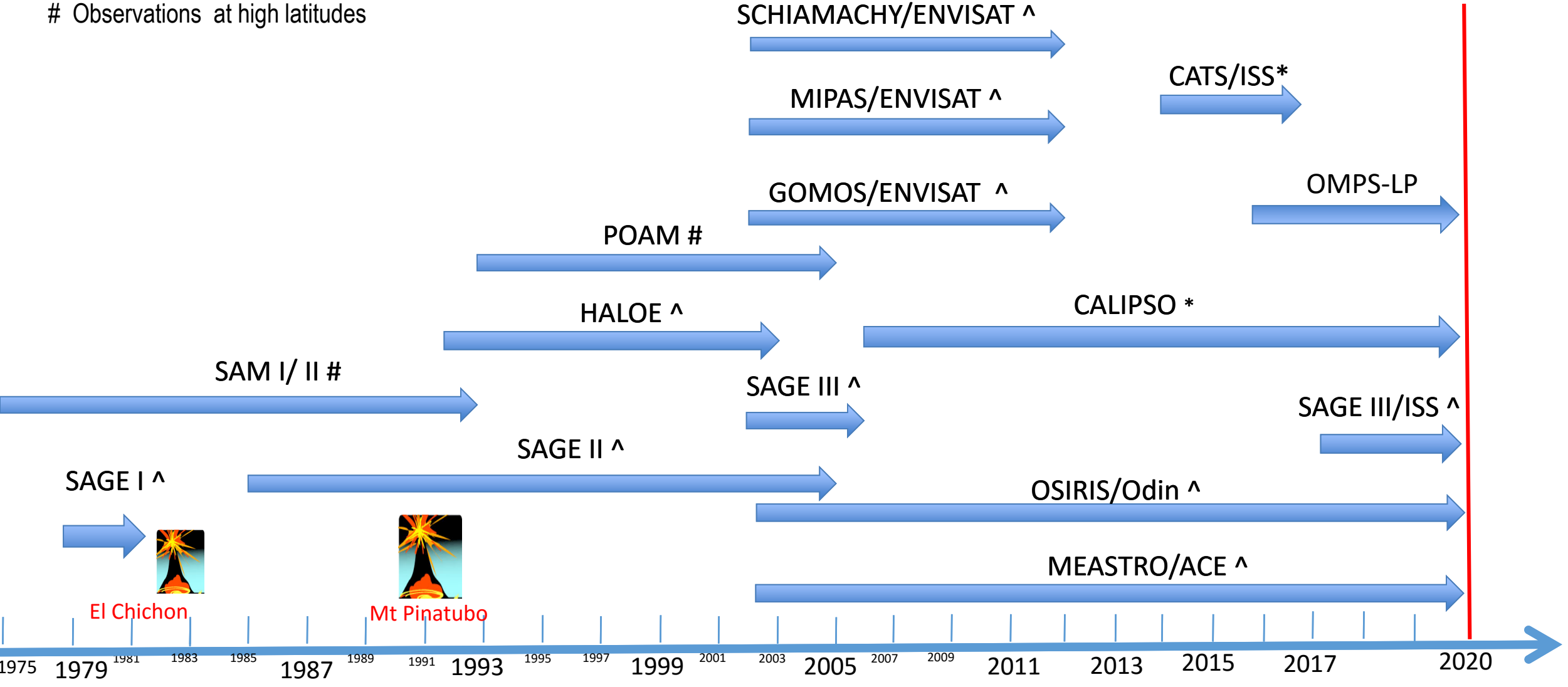
National Aeronautics and Space Administration

Home Missions News & Outreach Validation

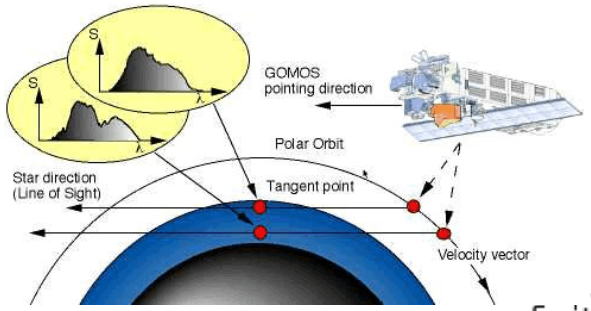


Stratospheric aerosol observations by satellites since late 70's

* Active Lidar
^ Passive Limb (scatter-emission)/Occultation (UV-Vis-IR)
# Observations at high latitudes

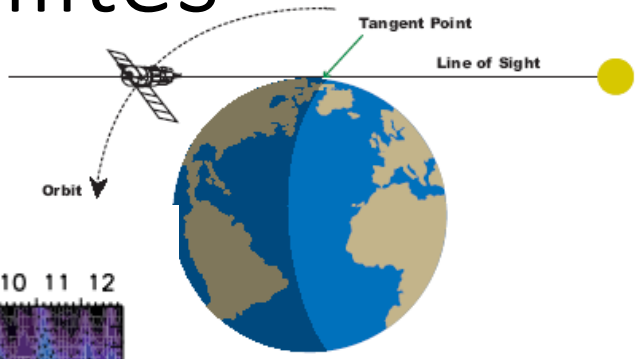


Stratospheric Aerosols from Satellites



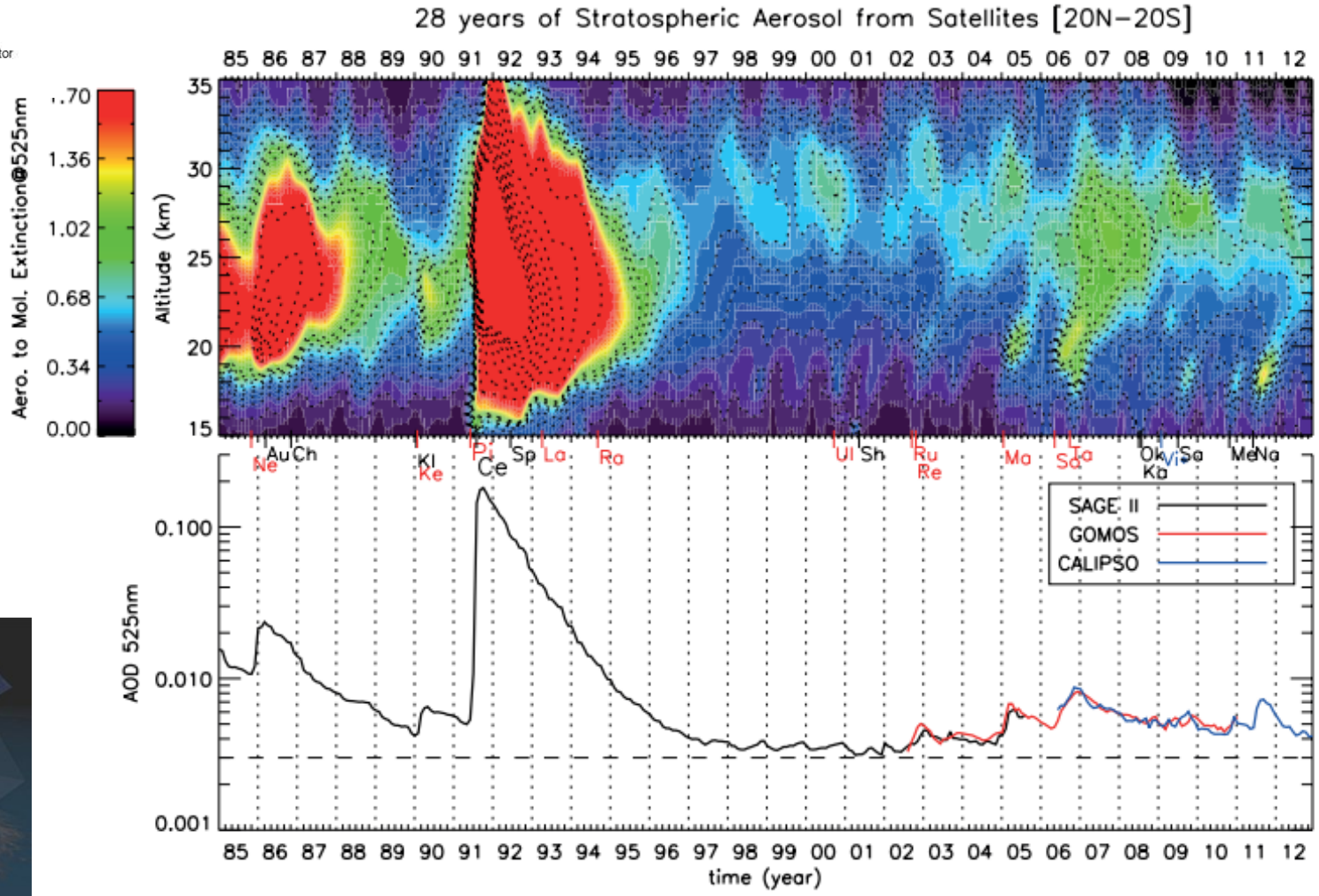
GOMOS/ENVISAT

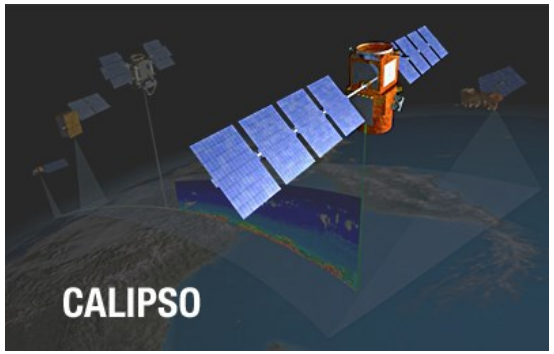
2002-2014



SAGE I/II/III

1979-2005

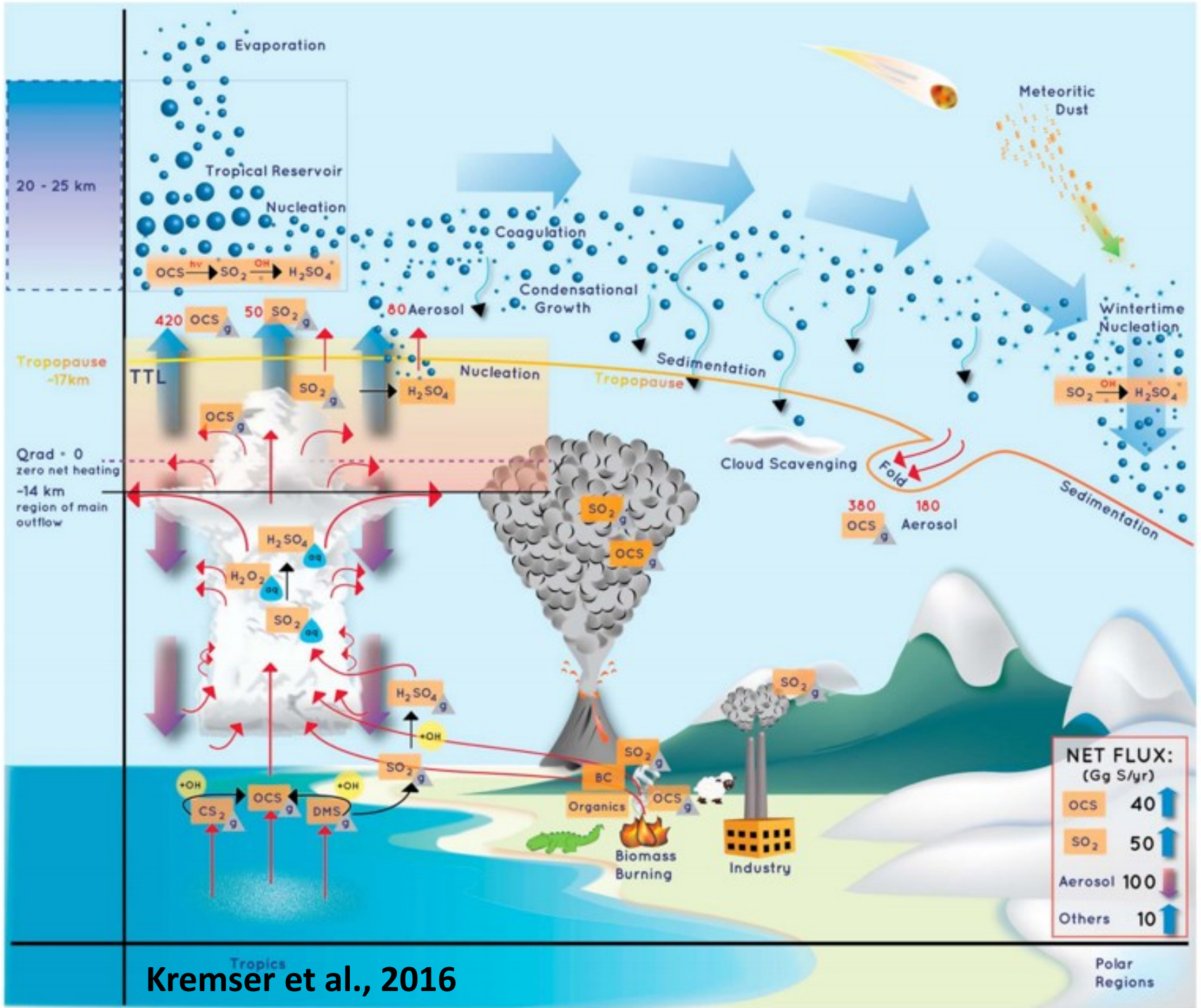




2006-now

IPCC, Chap8, AR5

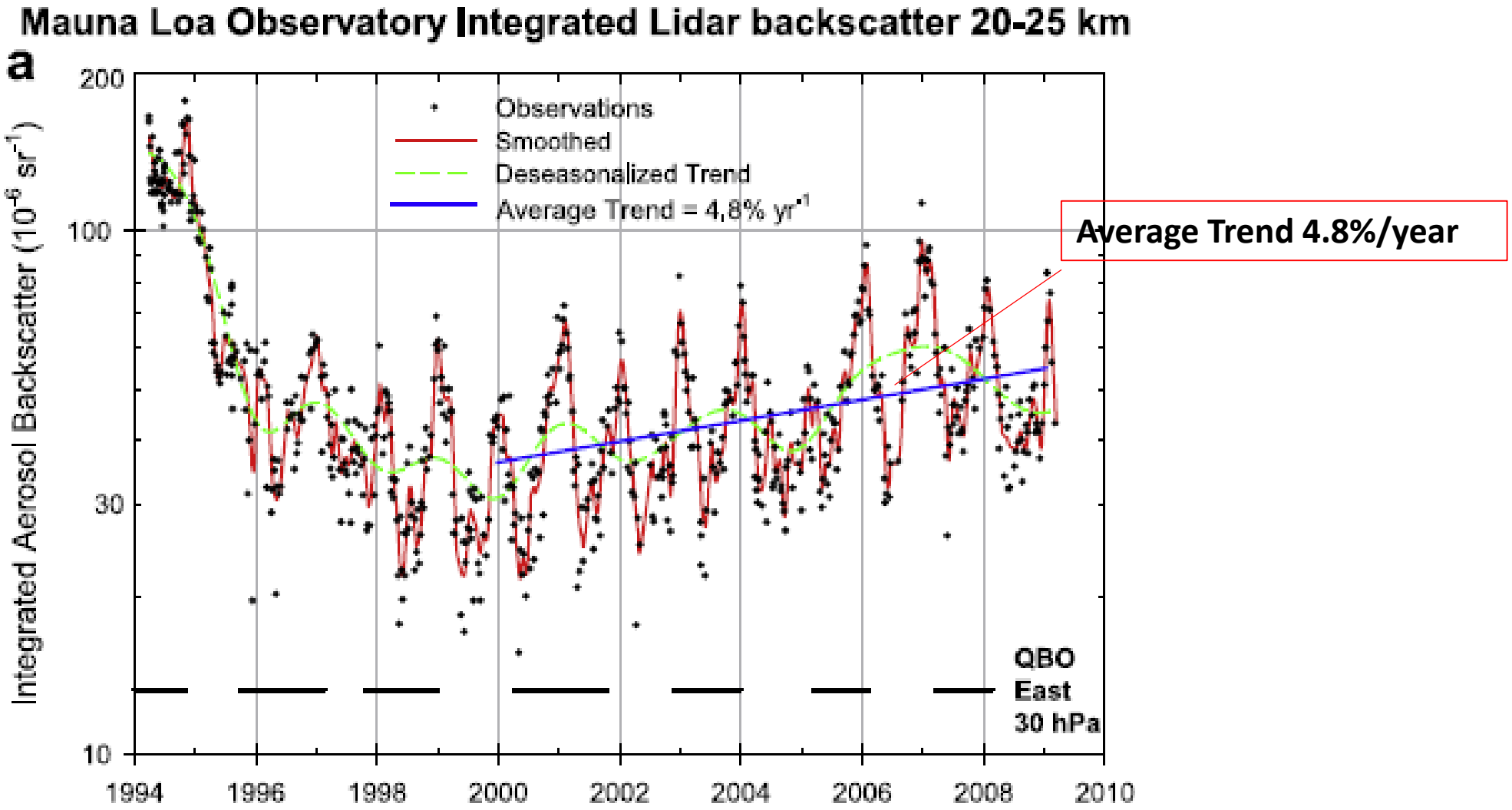
Stratospheric Sulfur and Its Role in Climate (SSiRC)



Kremser et al., 2016

The Growing Complexity of Stratospheric Aerosols

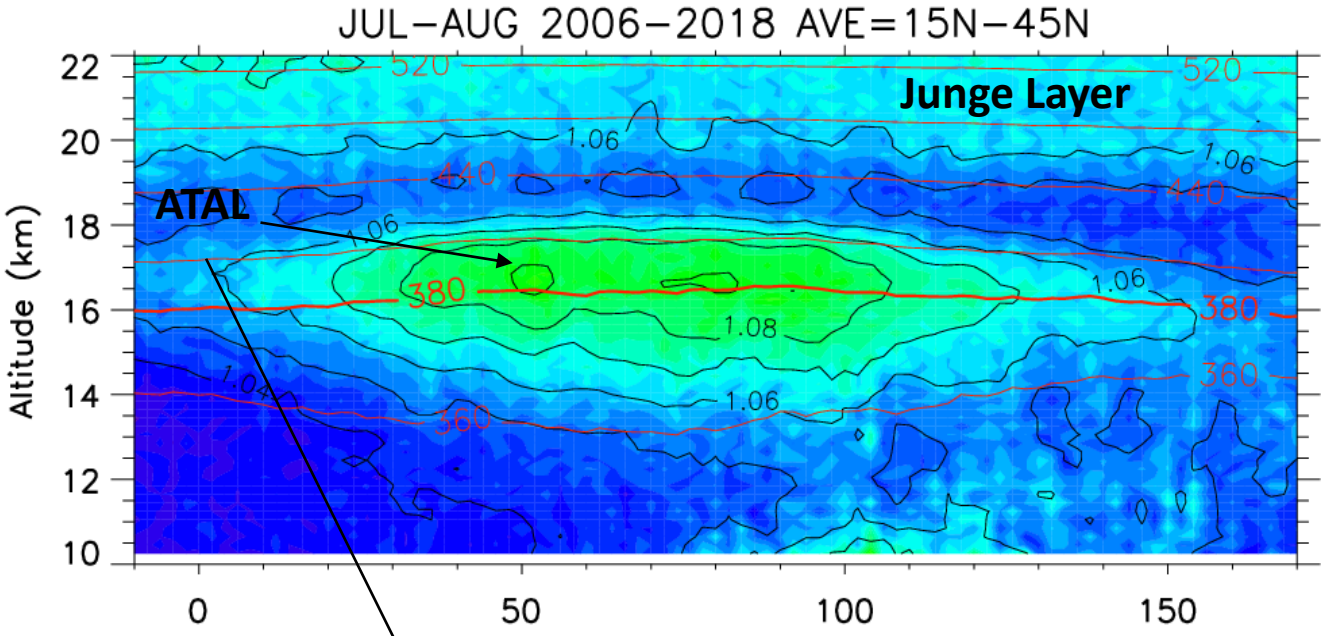
Increase of background stratospheric aerosol loadings observed at Mauna Loa

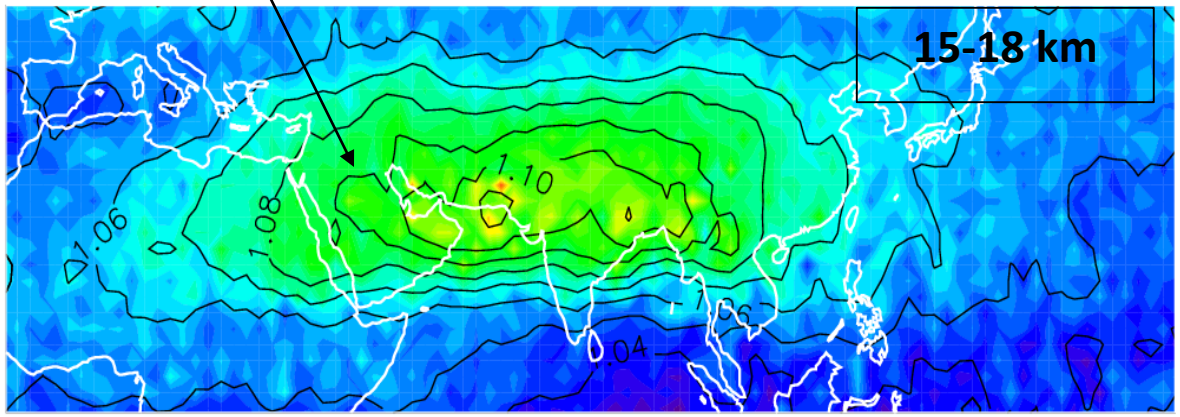


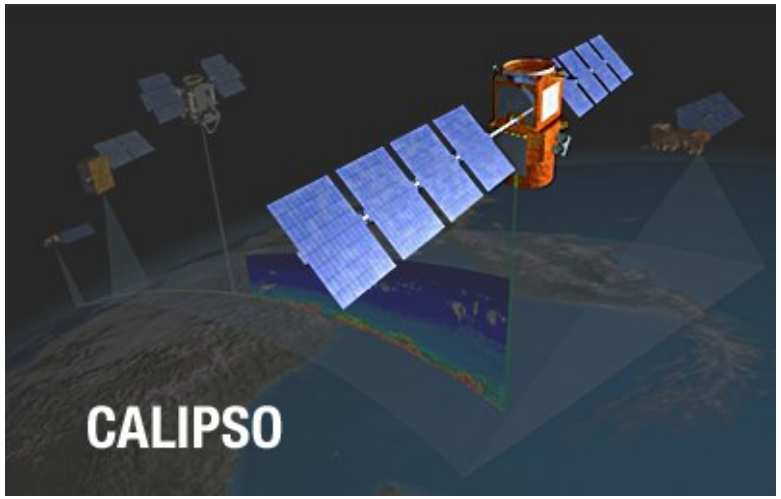
Hoffman et al., 2009, GRL

Origin: “Increase in anthropogenic sulfur gas emissions in the troposphere…. coal burning since 2002, mainly in China”

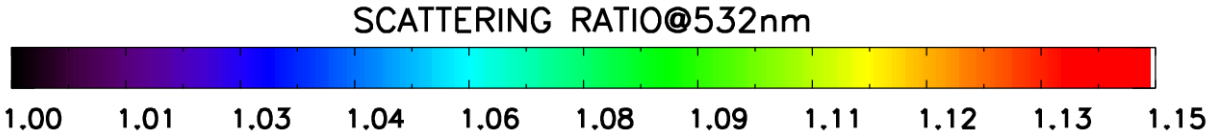
Asian Pollution into the Stratosphere



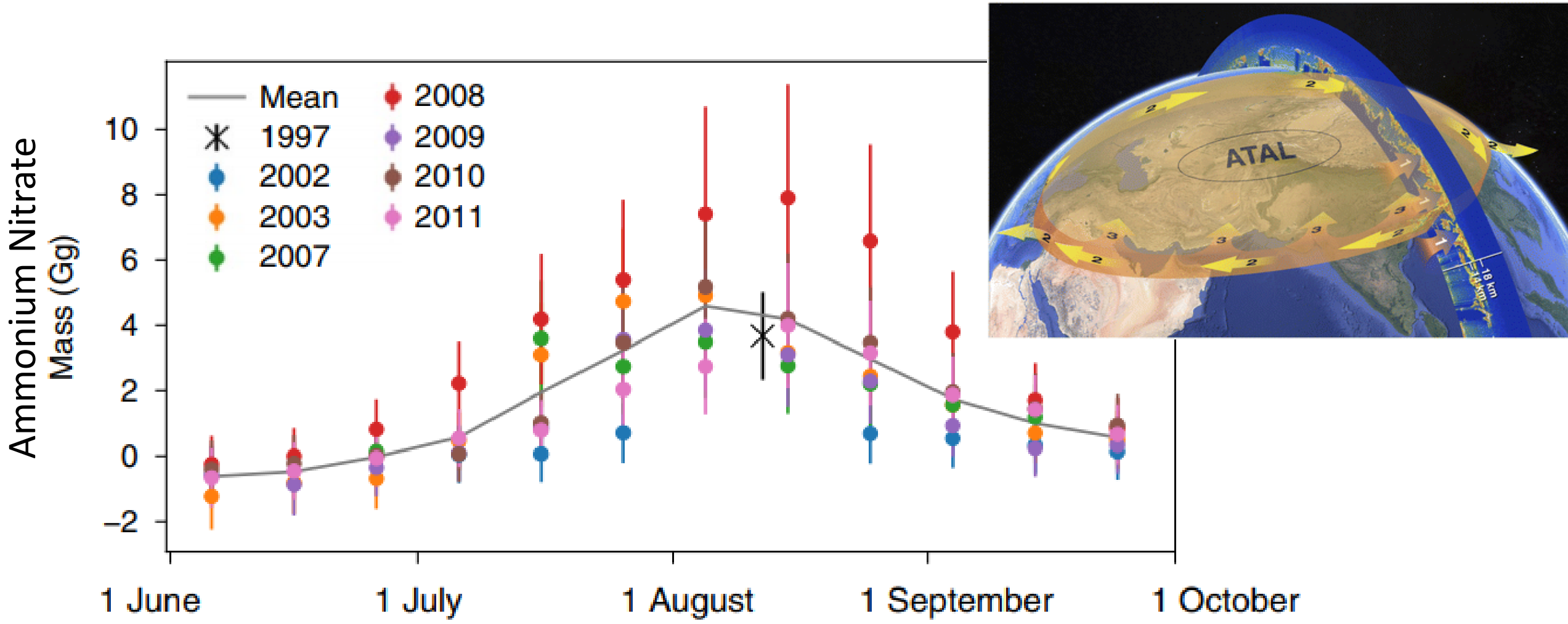




Vernier et al., 2017, BAMS

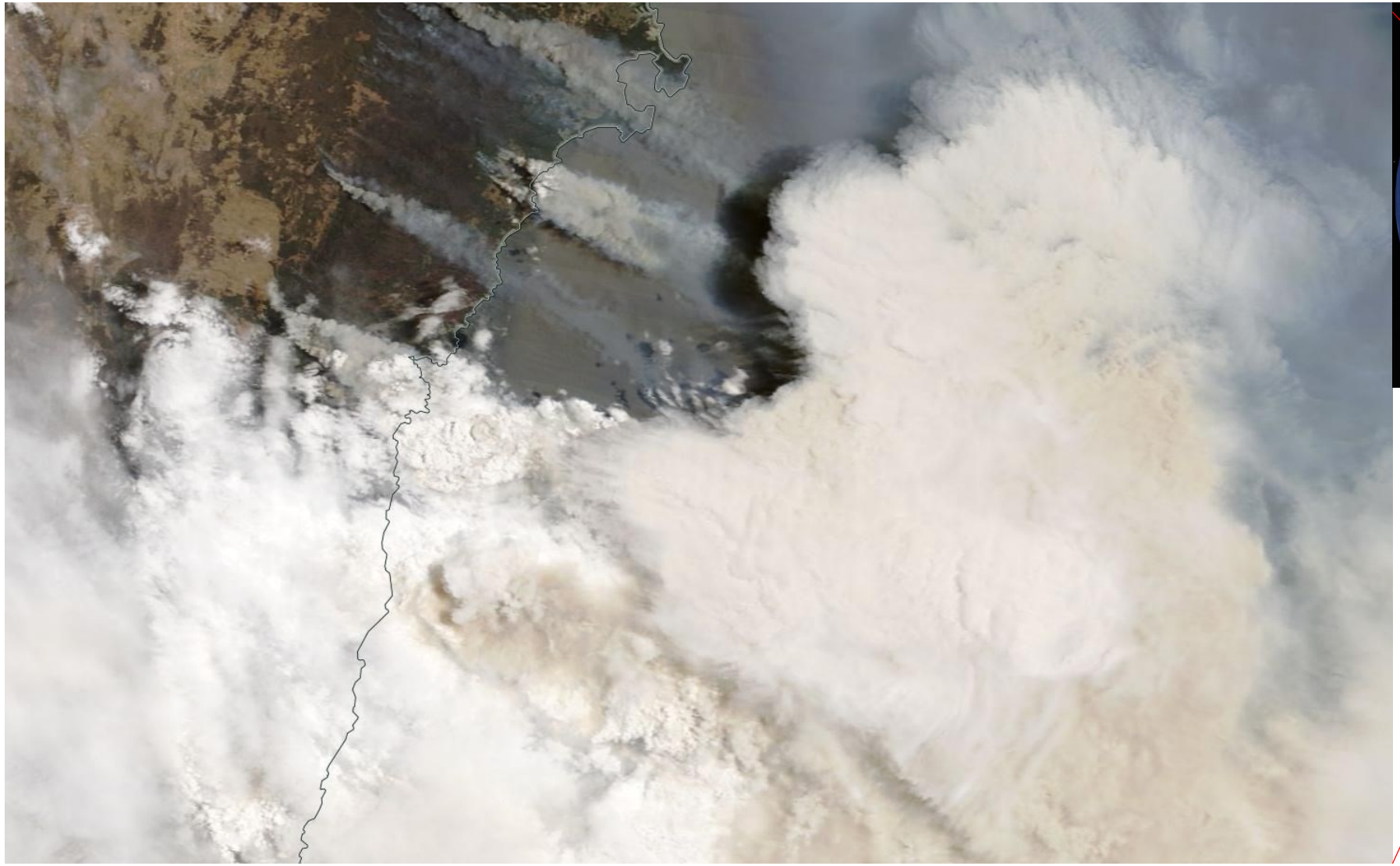


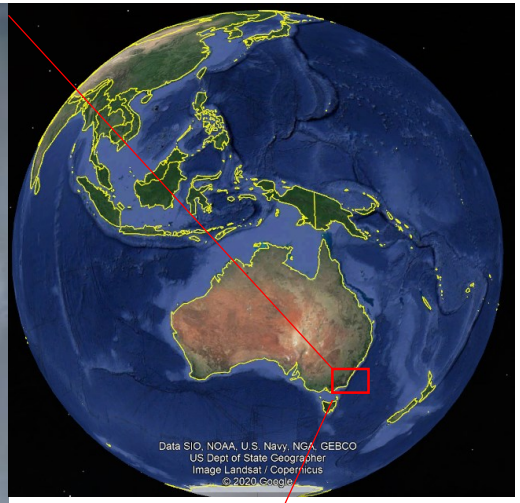
Ammonium Nitrate in the stratosphere during the Summer Asian Monsoon



Hopfner et al.,2019, Nat. Geo.

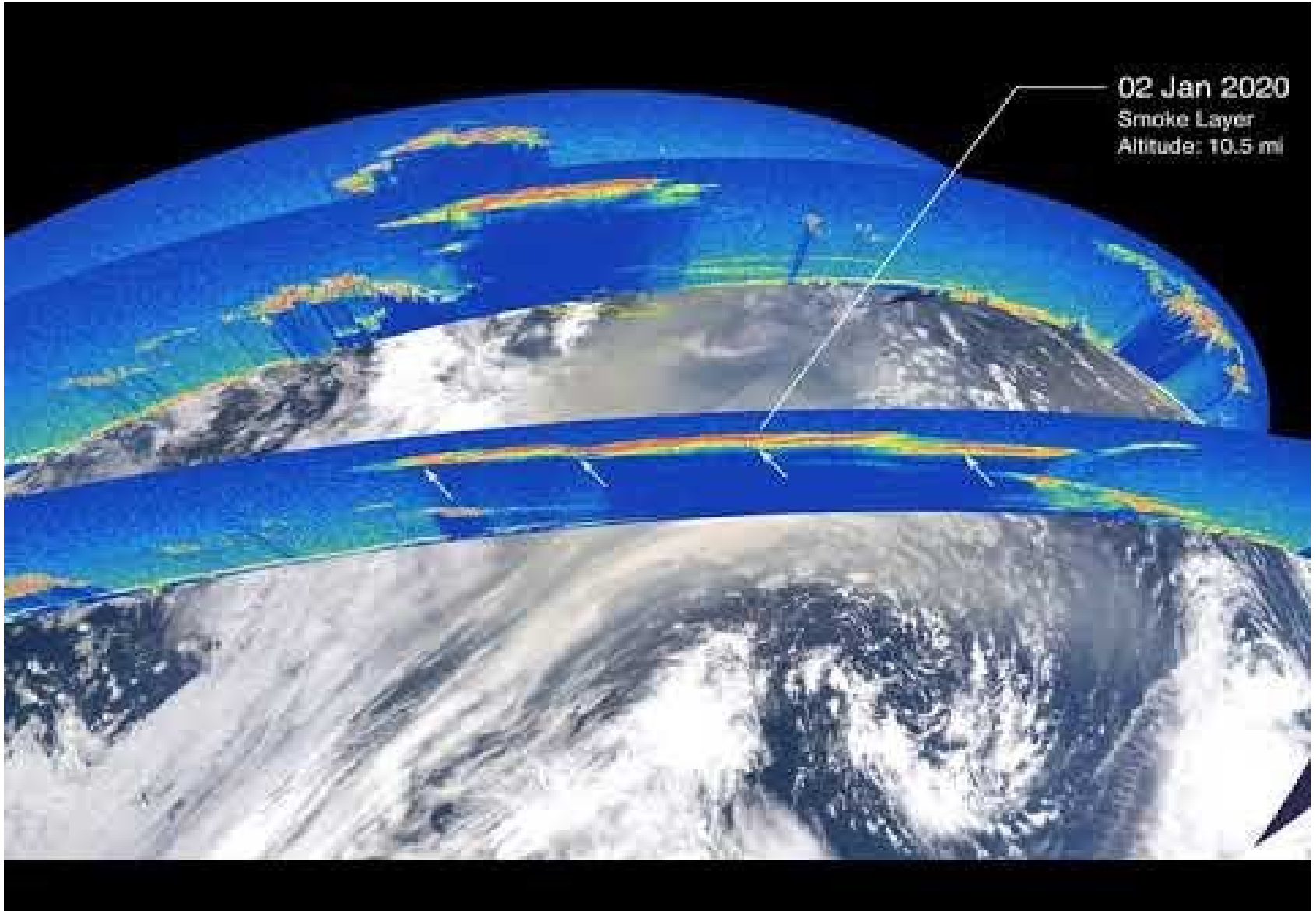
Australian 2019-2020 Bushfires



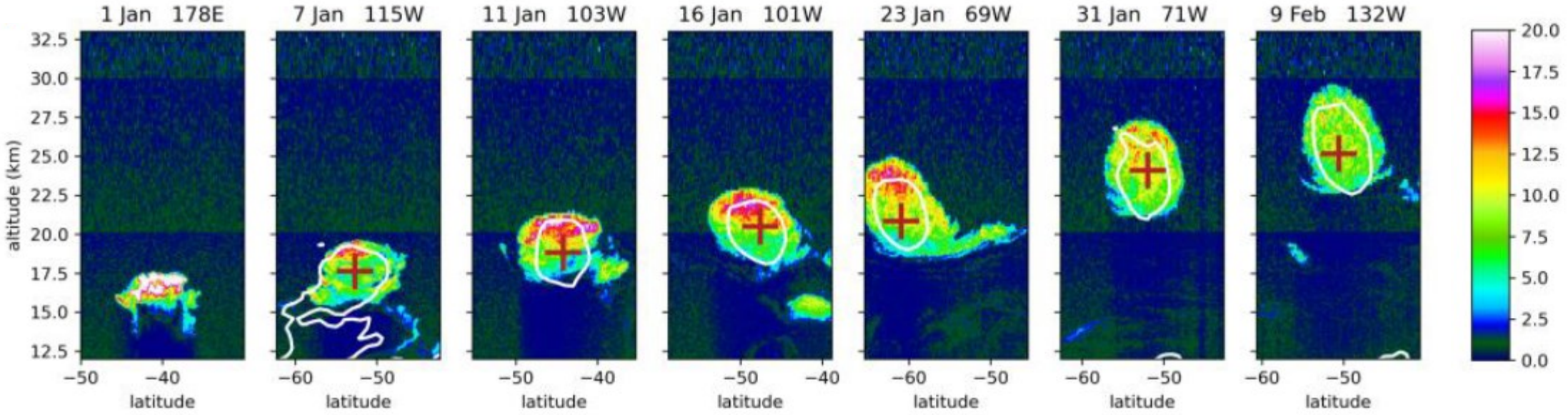


MODIS/Terra/ 1 January 2020

Smoke transport into the stratosphere



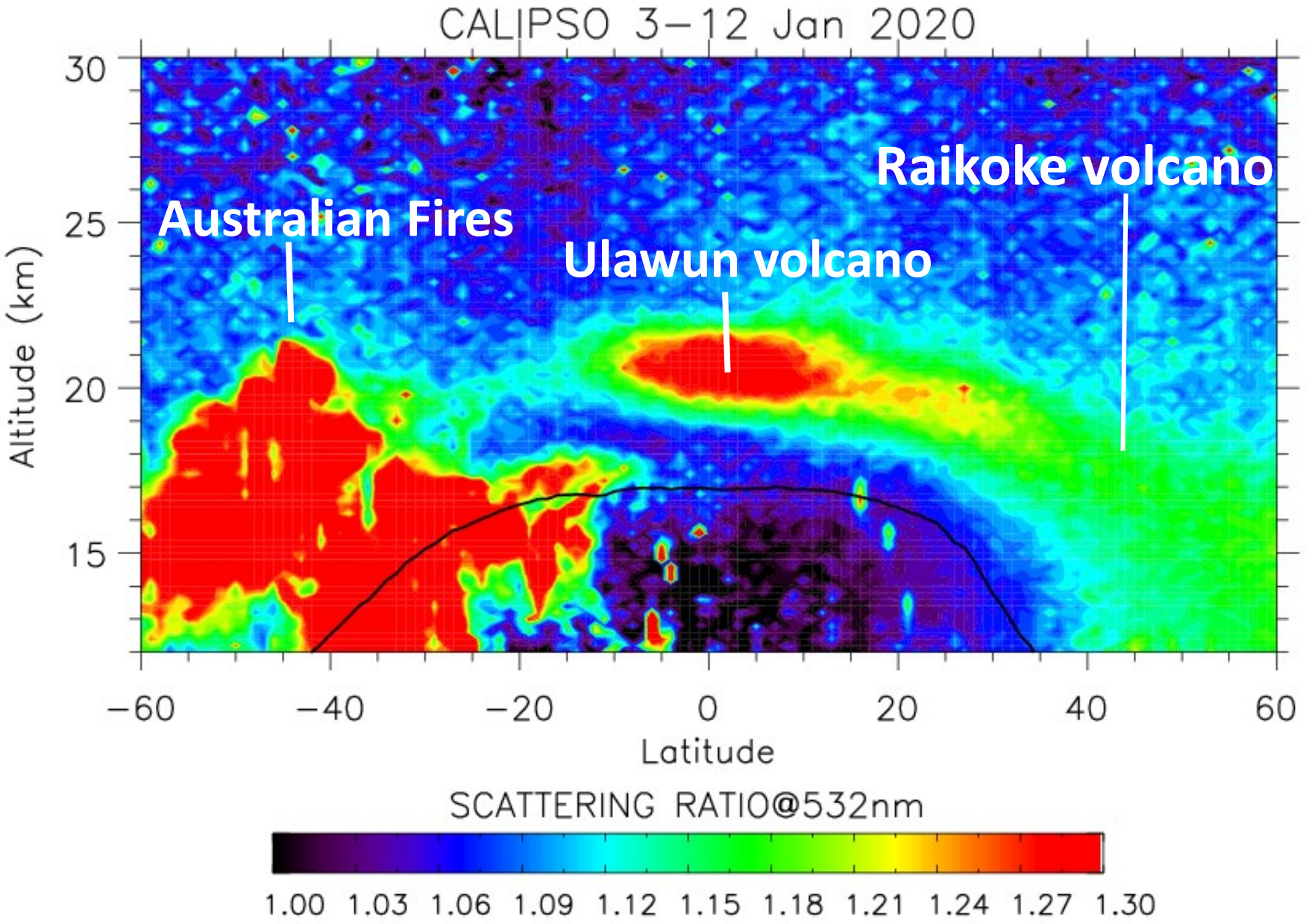
Smoke Rising into the stratosphere after the 2019/2020 Australian Busfires



Preprint/ Khaykin et al., 2020

https://www.researchgate.net/publication/342168784_Australian_wildfires_cause_major_perturbation_of_the_stratosphere_and_generate_a_self-maintained_smoke-charged_vortex_rising_up_to_35_km

The Complexity of Stratosphere Aerosols



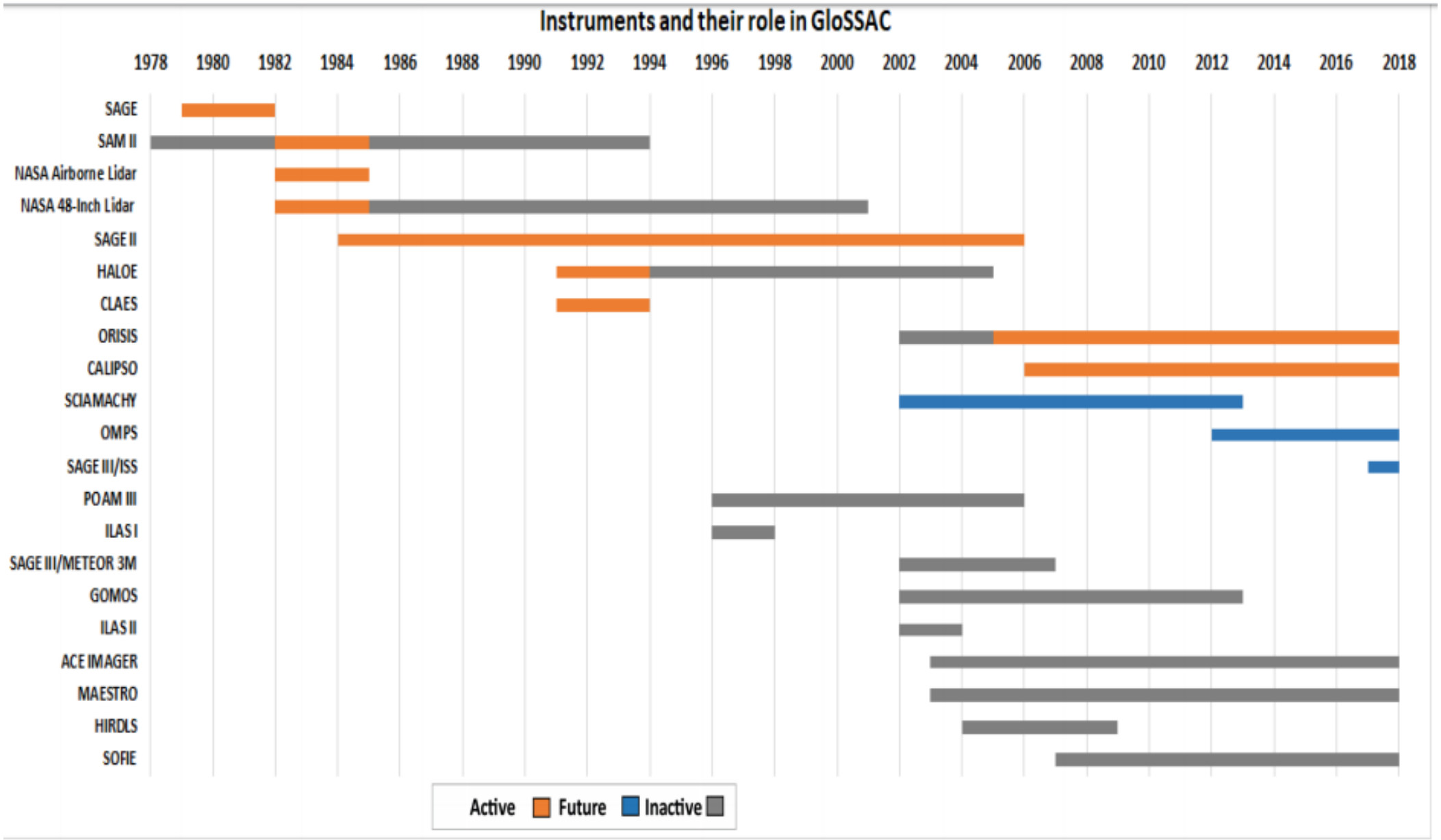
Conclusion

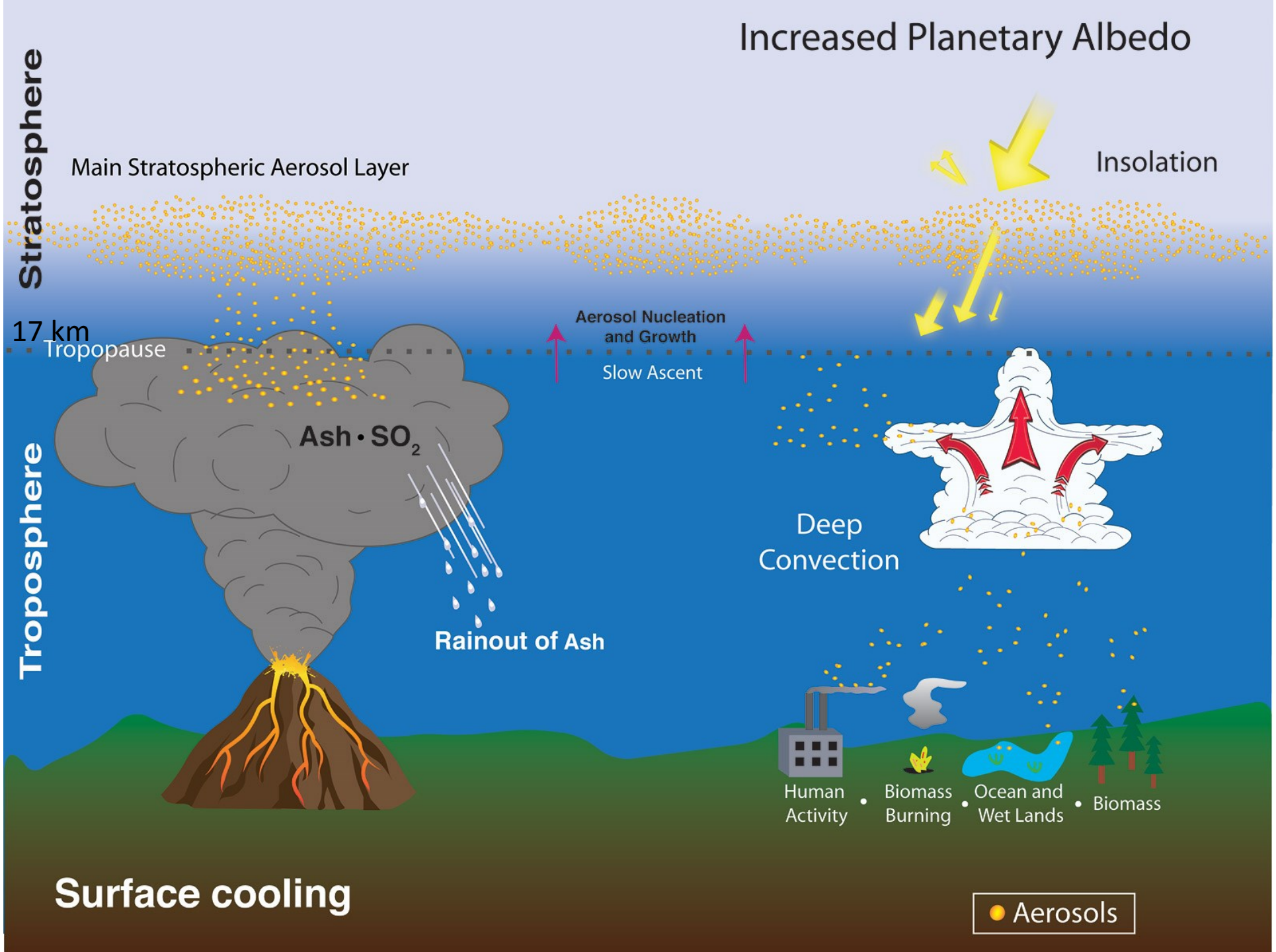
- Stratospheric aerosols have been monitored since the late 70’s
- Climate cooling after major volcanic eruption is relatively well documented and thus an apparent analogue for Climate Intervention with stratospheric aerosols
- Recent satellite obs. and field campaigns show that Asian Pollution represents a significant source of aerosols for the UTLS
- Major wildfires over the past few years have reached the stratosphere and with mass injection comparable to volcanic eruptions
- Increasing complexity of stratospheric aerosols makes climate intervention more risky

Thank you !

Will the stratosphere look like this after Climate Intervention with stratospheric aerosols ?…I hope not

Extra slides




Increased Planetary Albedo
Stratosphere
Main Stratospheric Aerosol Layer
Insolation
17 km
Tropopause
Aerosol Nucleation
and Growth
Slow Ascent
Troposphere
Ash • SO_2
Rainout of Ash
Deep
Convection
Human
Activity
Biomass
Burning
Ocean and
Wet Lands
Biomass
Surface cooling
Aerosols

The source of Ammonia in the world