# Global LIDAR Remote Sensing of Stratospheric Aerosols and Comparison with WACCM/CARMA:

# The Need For Meteoritic Dust In The Stratosphere

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**Acknowledge: Dr. Michael Mills and Jason English for basis of current working model.**

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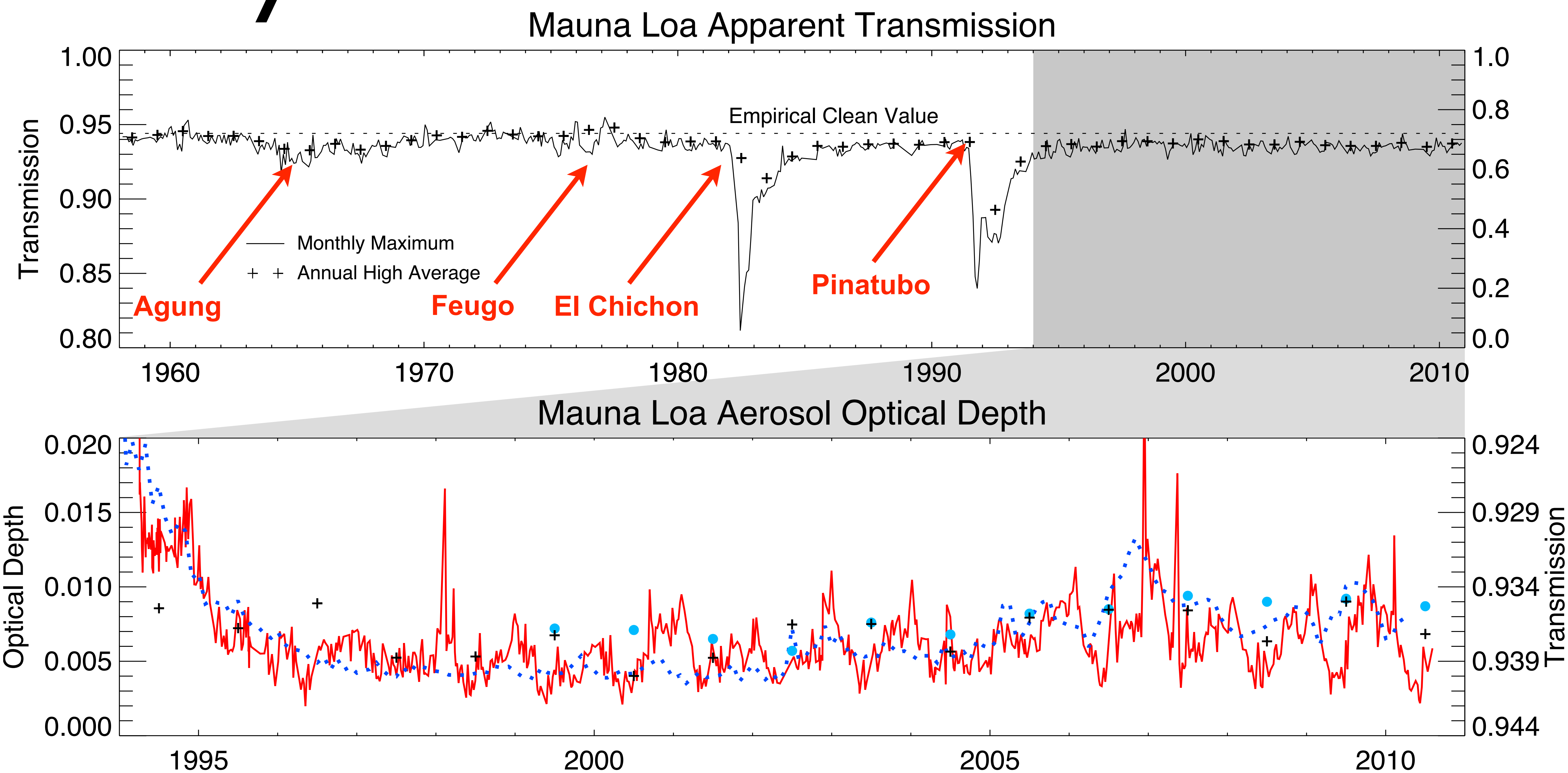
Advisors: Susan Solomon, Brian Toon, Jeff Thayer, Karen Rosenlof and Michael Hardesty

# Why?




**Mauna Loa Lidar**
**Transmission**
**Satellite (Tropics, >15km)**
**PFR**

Variability of stratospheric aerosol has an impact on the global radiation budget

# Research Questions

## Goal: Understand Variability in Stratospheric Aerosol

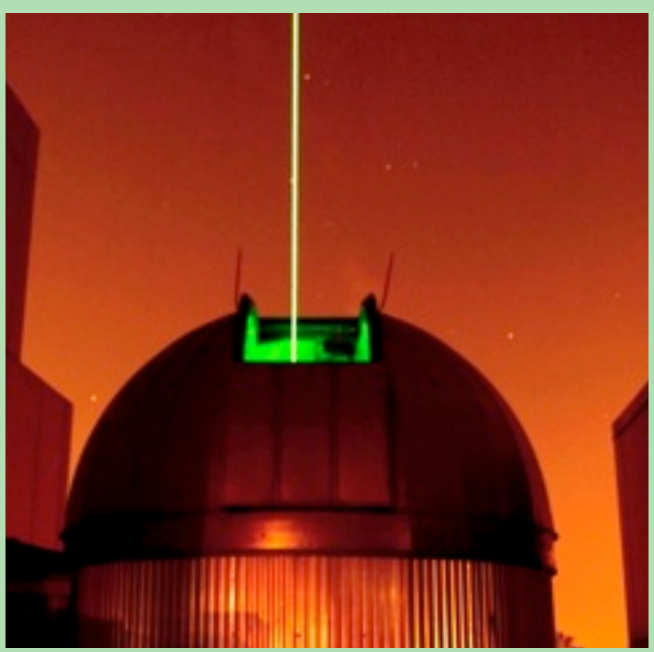
Seasonal cycles? Long-term trends?

How will I answer these:

**Observations**

Lidar ⟷ WACCM/CARMA

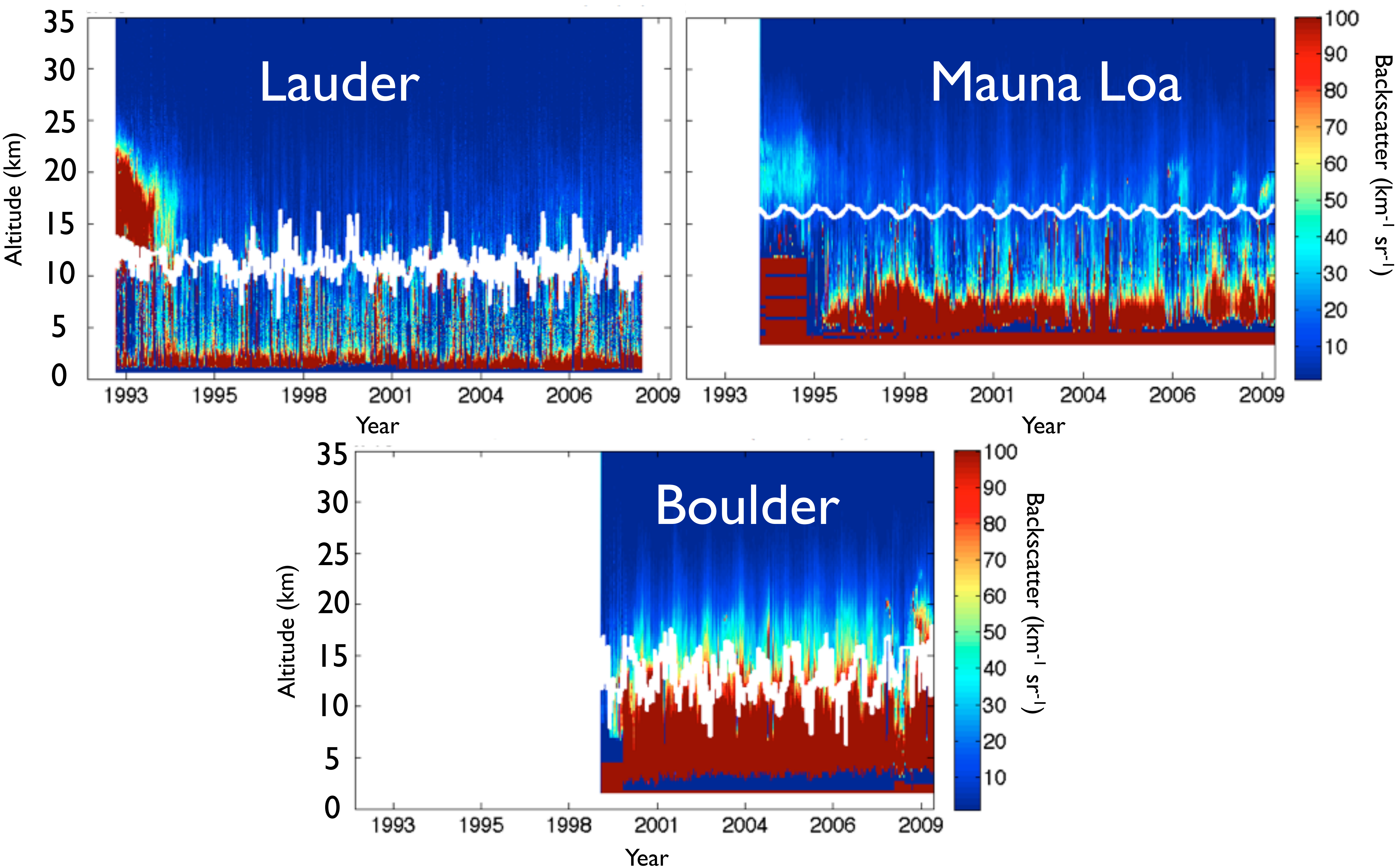
**Modeling**



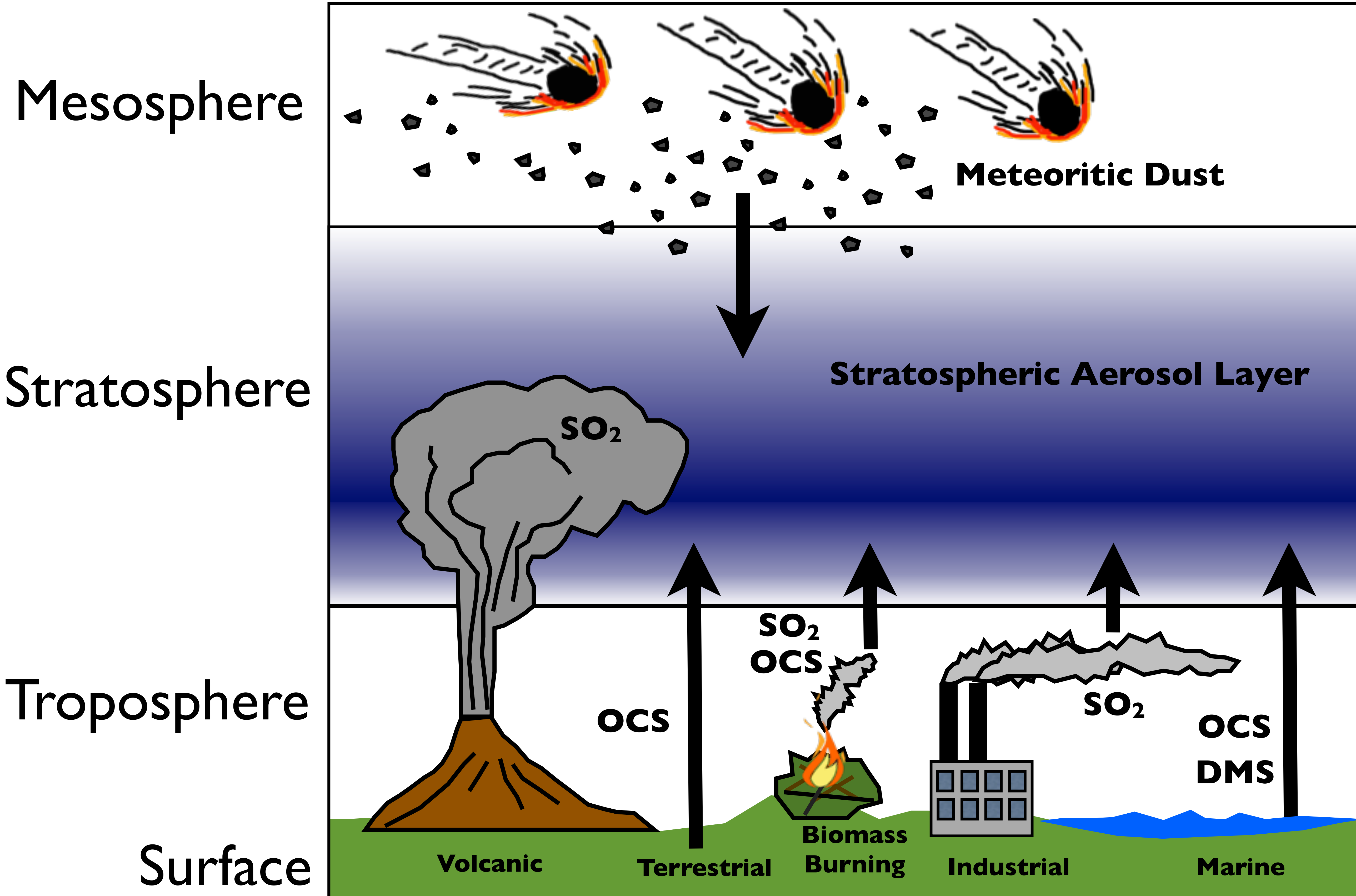
Boulder Lidar
(R. Neely III)

Pleiades Supercomputer
(NASA AMES)

# Lidar Datasets

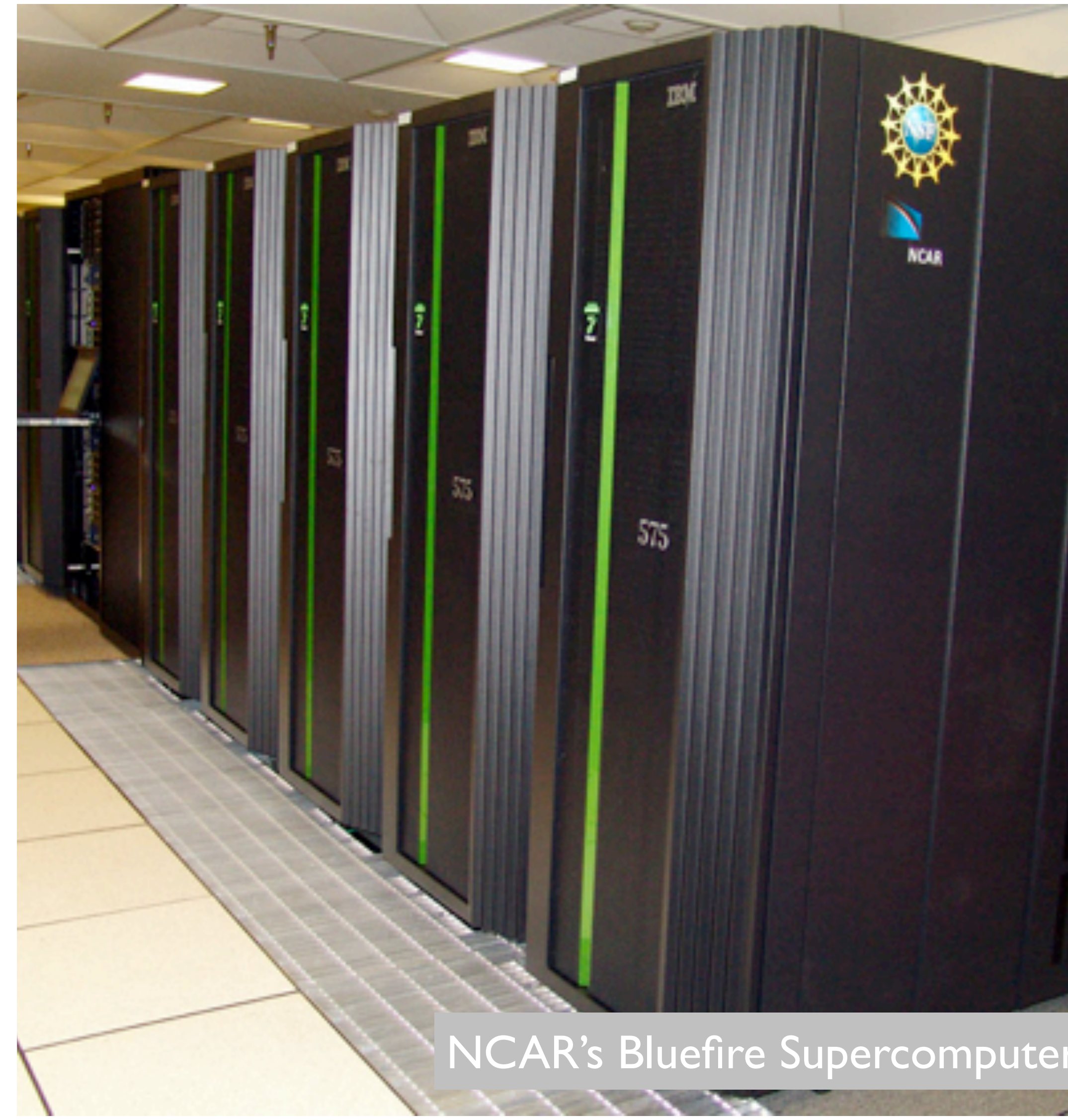


# Sources of Stratospheric Aerosols



# WACCM Setup

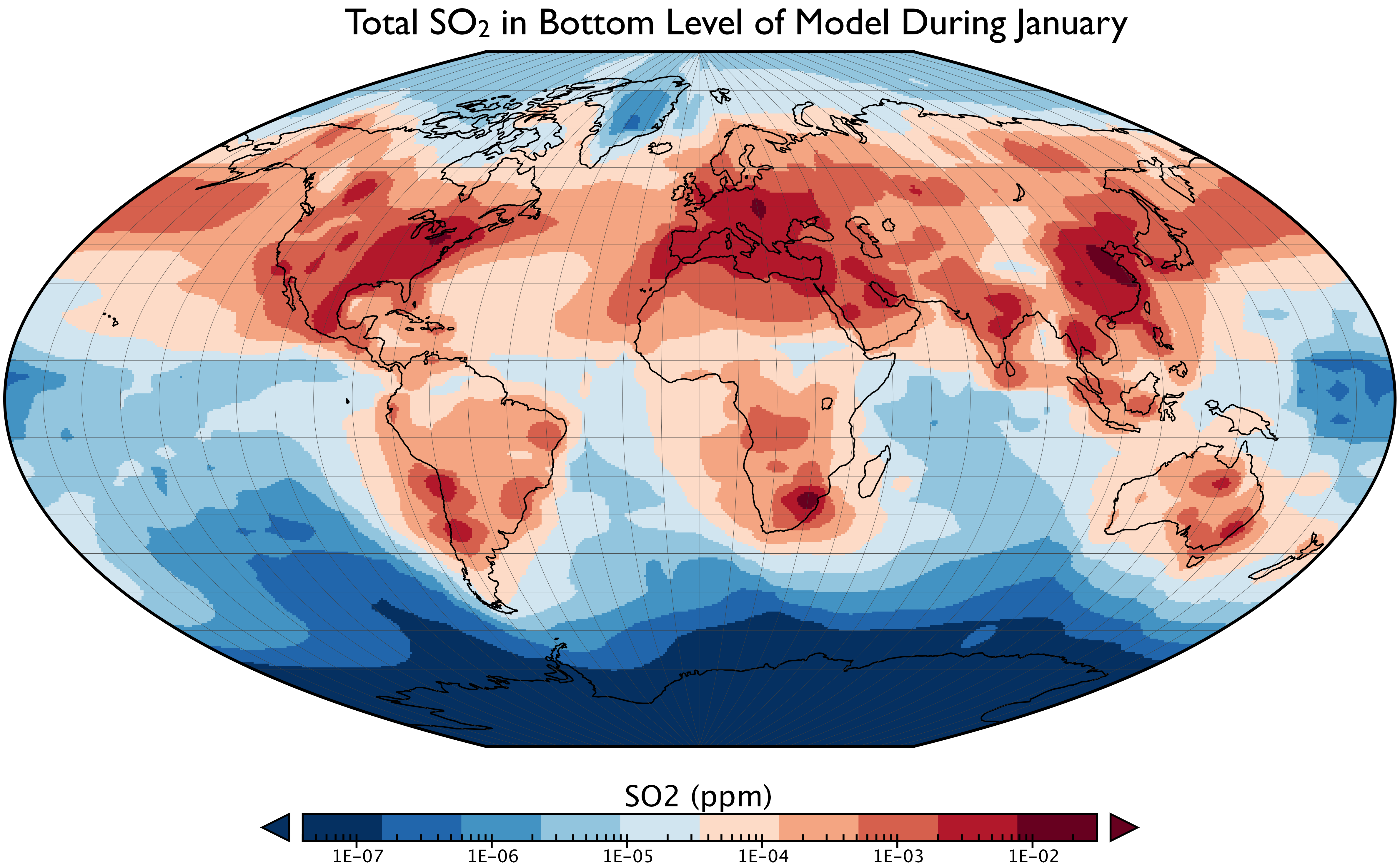
- NCAR's WACCM version 3.1.9
- 4x5 degree resolution
- 66 vertical levels
- Model top near 140 km
- Vertical spacing of 1-1.75 km in the stratosphere
- 3D chemical transport Model for OZone And Related chemical Tracers (MOZART)(Horowitz et al. 2003)



NCAR's Bluefire Supercomputer

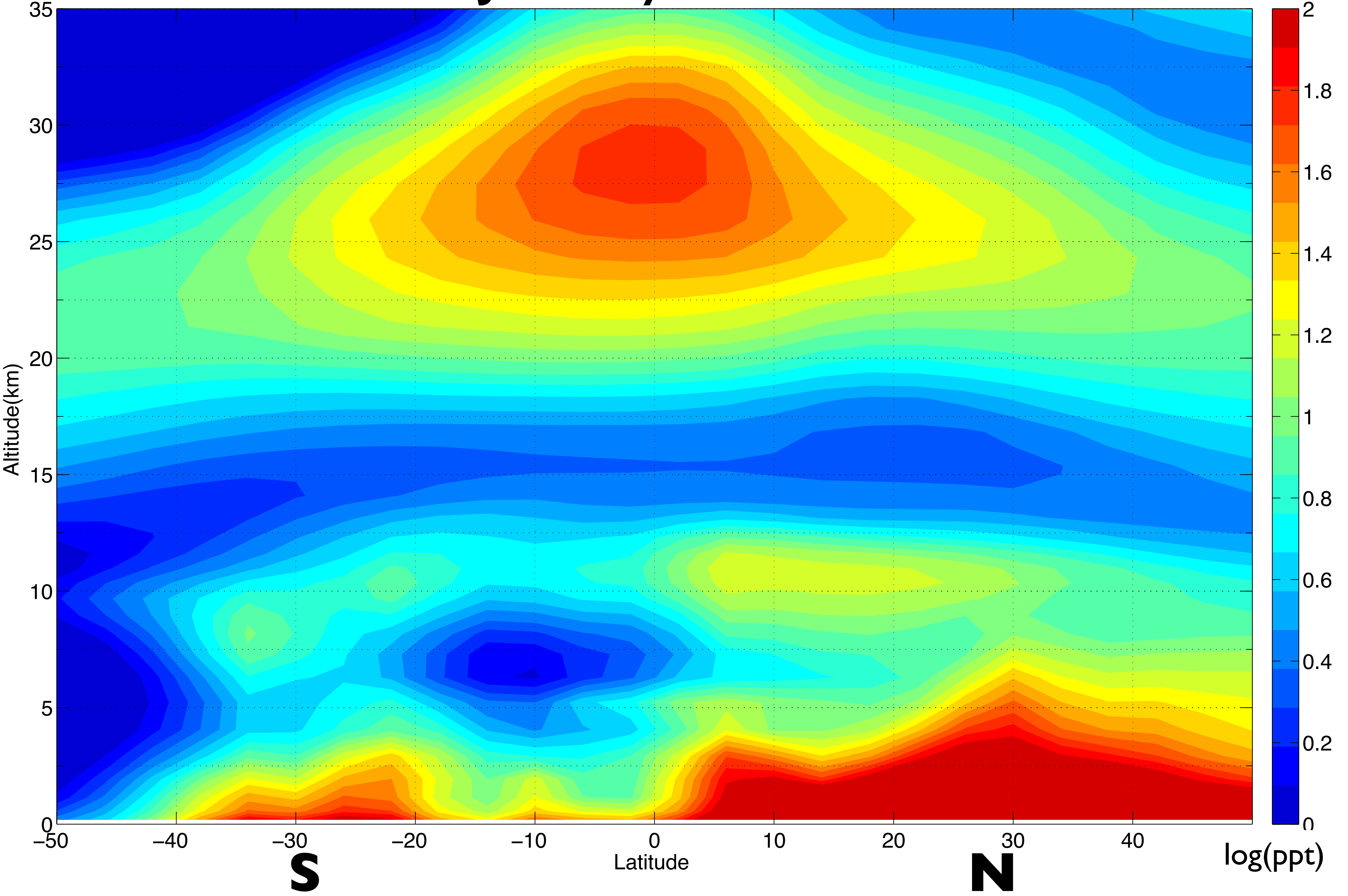
- Sulfur chemistry includes seven sulfur species: $SO_2$, $SO_3$, SO, $H_2SO_4$, $CS_2$ and OCS (English et al., 2011(ACPD))
- 25 year run, using last 10 years for comparison to observations.

# Sulfur Emissions Setup




- $SO_2$ Emission data representative of background aerosol period(Smith et al. (2010) and English et al., 2011(ACPD)).
- OCS field is a lower boundary condition of 510 pptv.

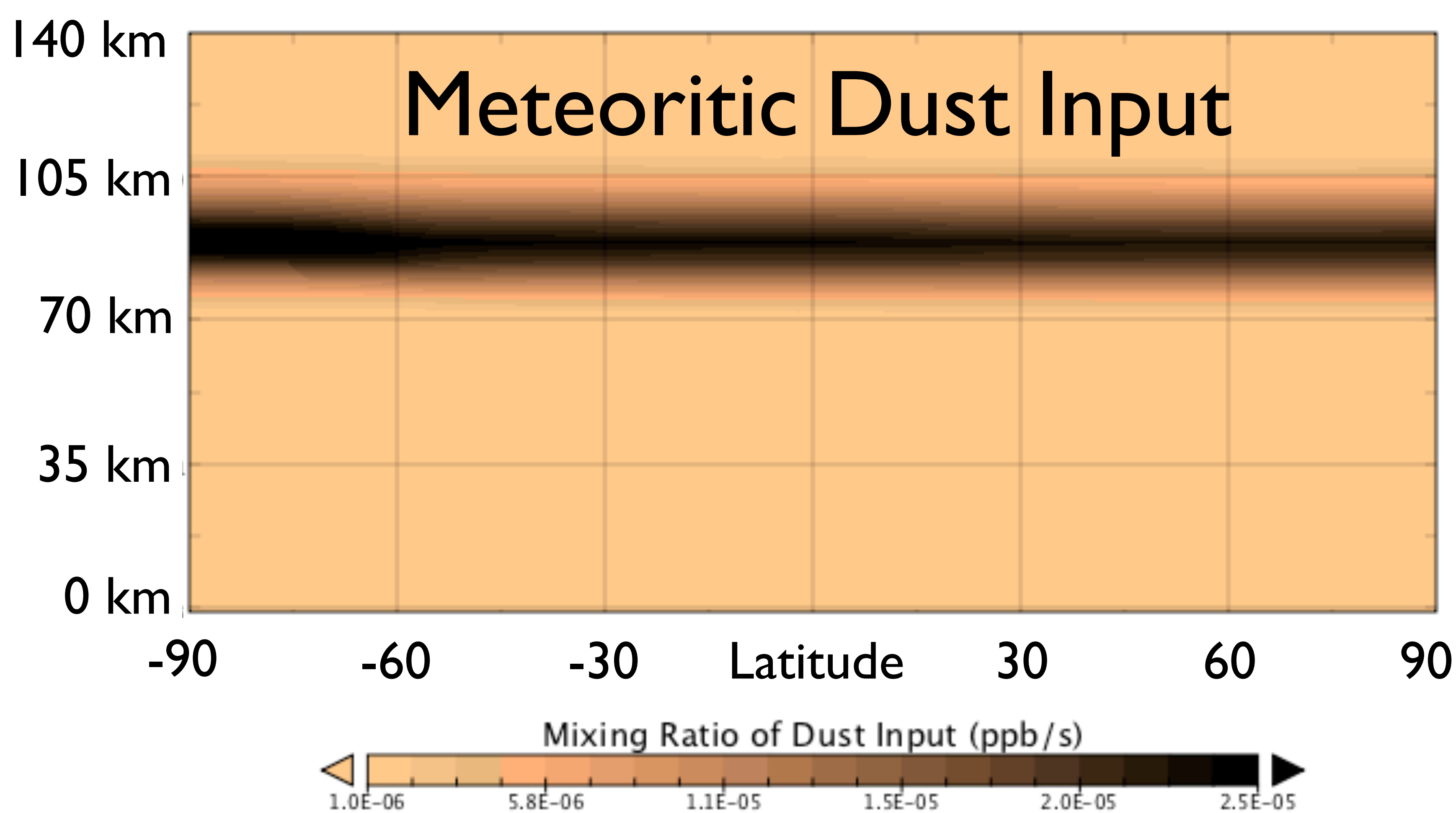
# WACCM January Zonal Mean $SO_2$



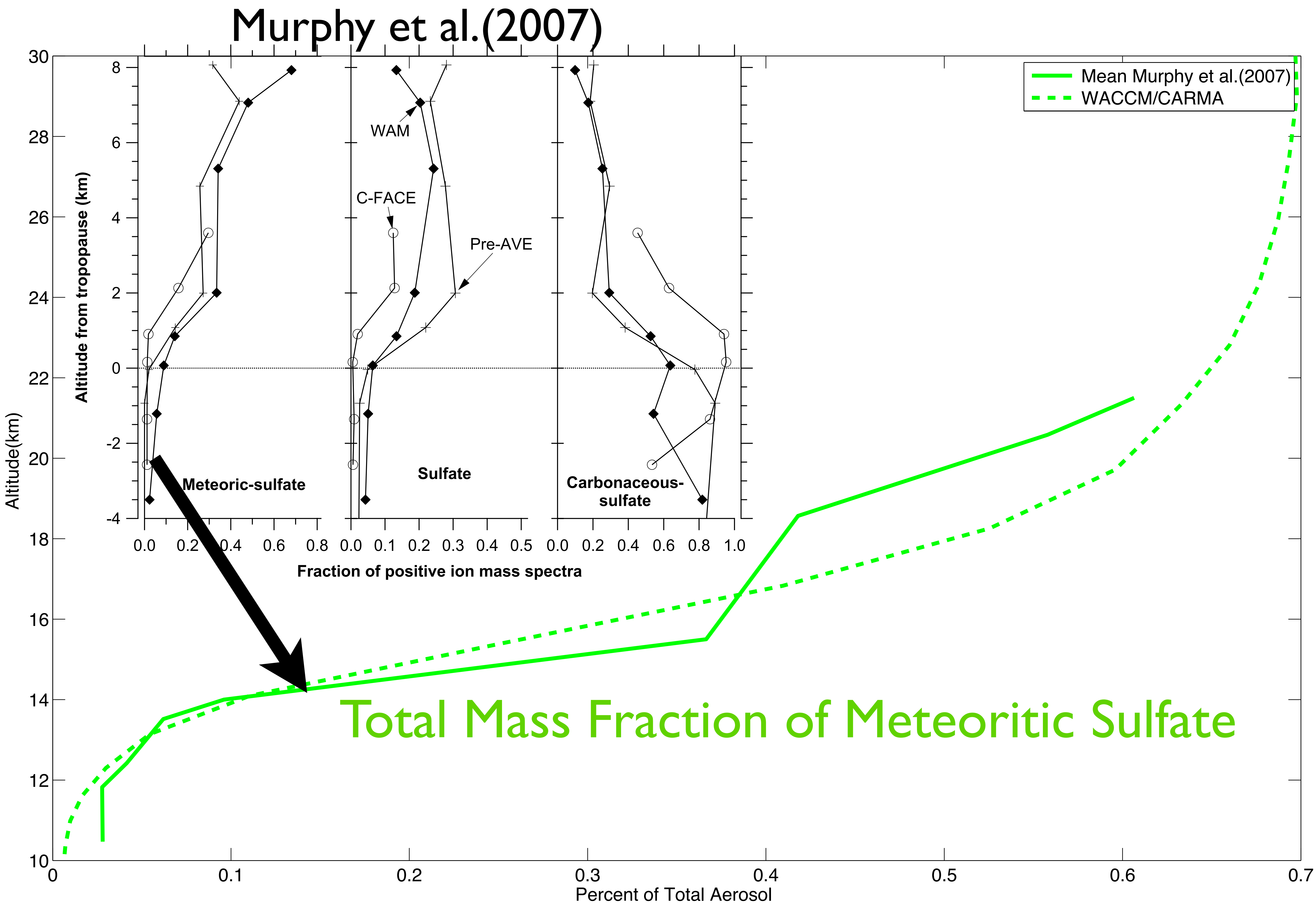
# CARMA Setup

**C**ommunity **A**erosol and **R**adiation **M**odel for **A**tmospheres

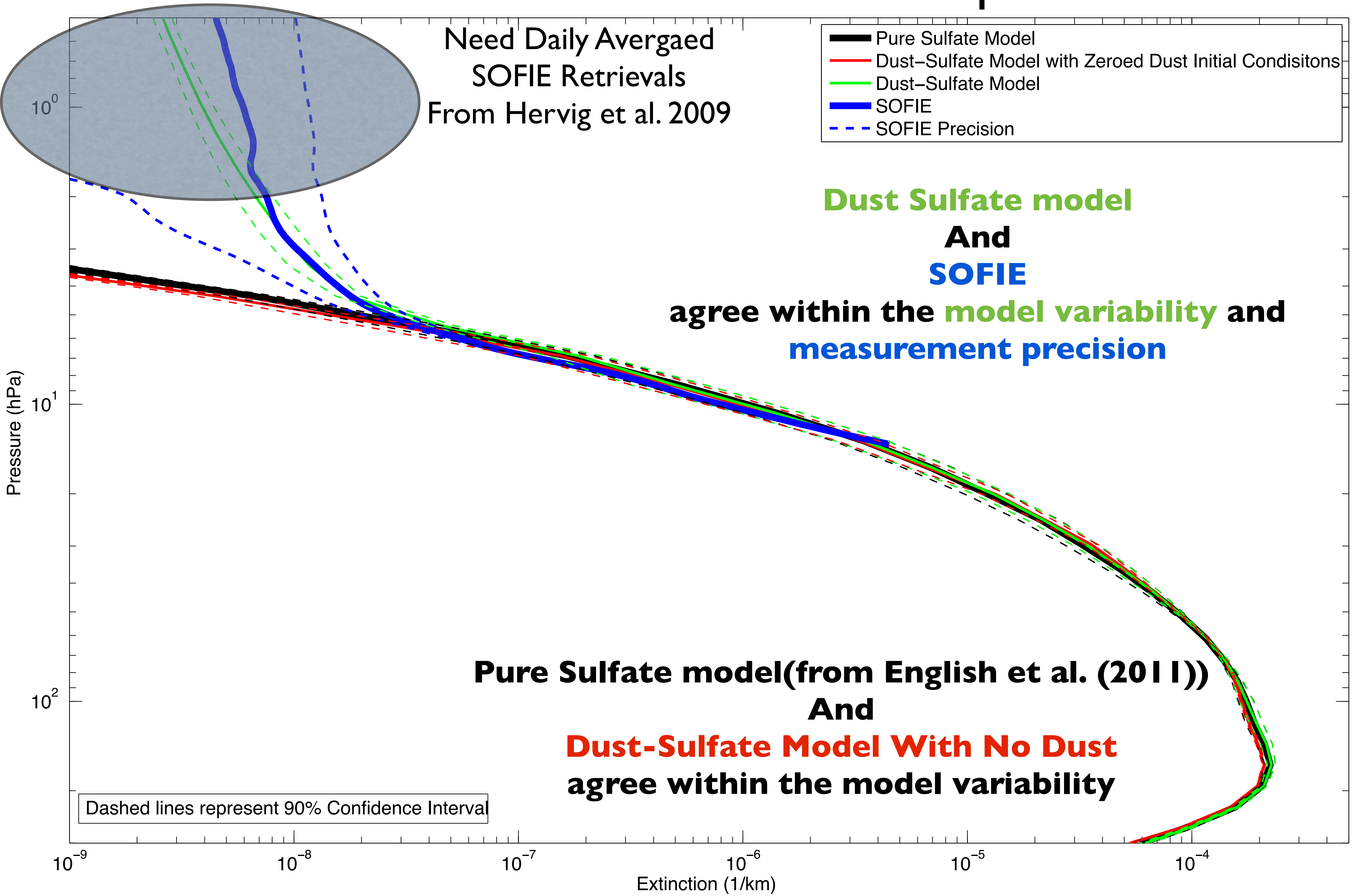
- Aerosol Size Distributions created by thirty-six bins (dry radii from 0.2 nm to 1100 nm) each for:
  - Pure sulfates (English et al., in prep, 2011)
  - Meteoritic dust (Bardeen et al. 2008)
  - Mixed sulfates (sulfate aerosols with dust cores)



# Comparison With In Situ Observations



# SOFIE and Pure Sulfate Model Comparison



# Lidar Comparison

## Lauder, NZ

**Model With Dust**

$\beta_{total}=\beta_{Pure\ \ Sulfate}+\beta_{ixed\ \ Sulfate}+\beta_{Dust}$

WACCM

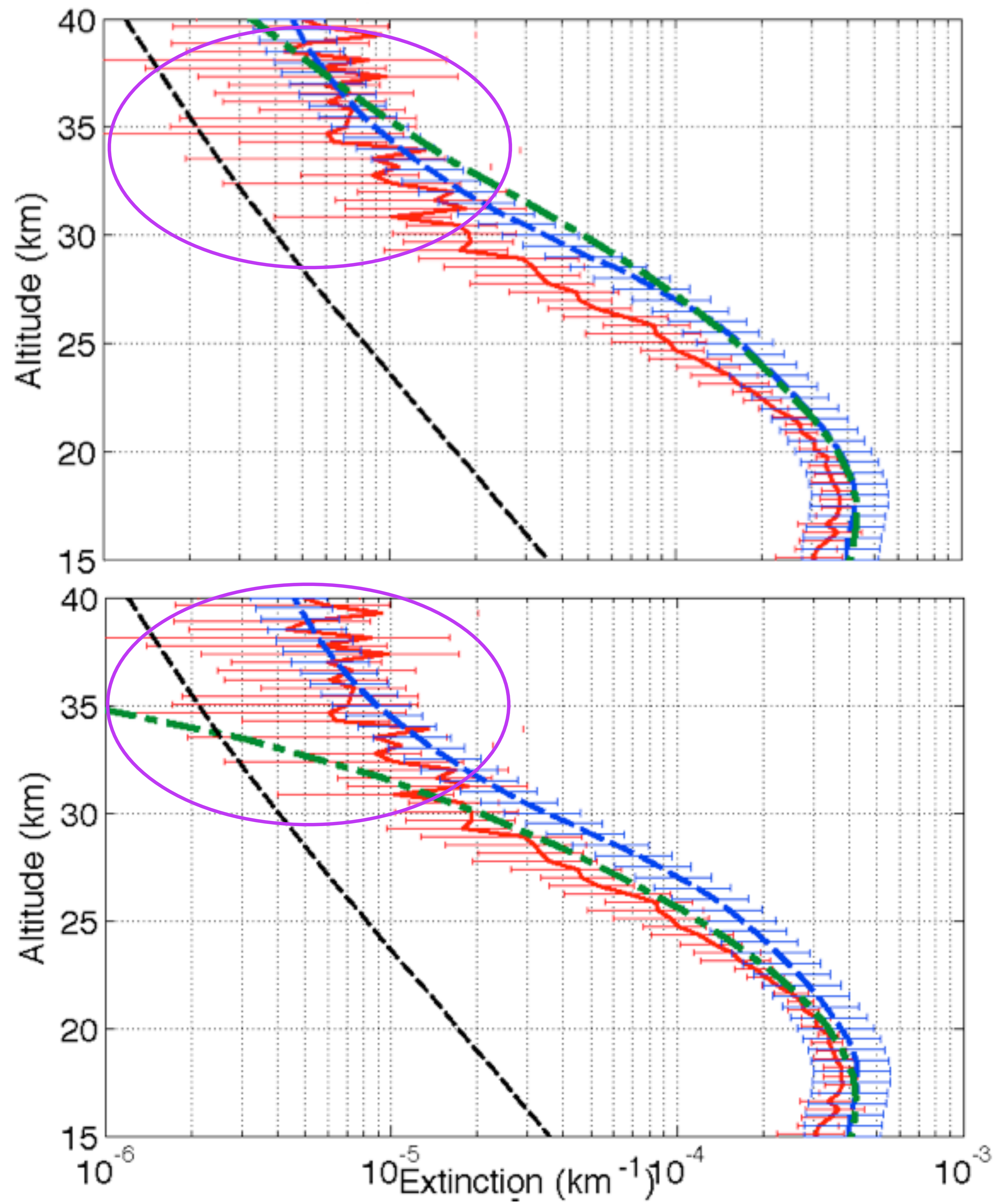
Lidar

SAGE II

Rayleigh

**Model Without Dust**

$\beta_{total}=\beta_{Pure\ \ Sulfate}+\beta_{ixed\ \ Sulfate}$



# Lidar Comparison

## Boulder, CO

### Model With Dust

$\beta_{total} = \beta_{Pure\ \ Sulfate} + \beta_{ixed\ \ Sulfate} + \beta_{Dust}$

(Same as Results Shown Previously)

WACCM

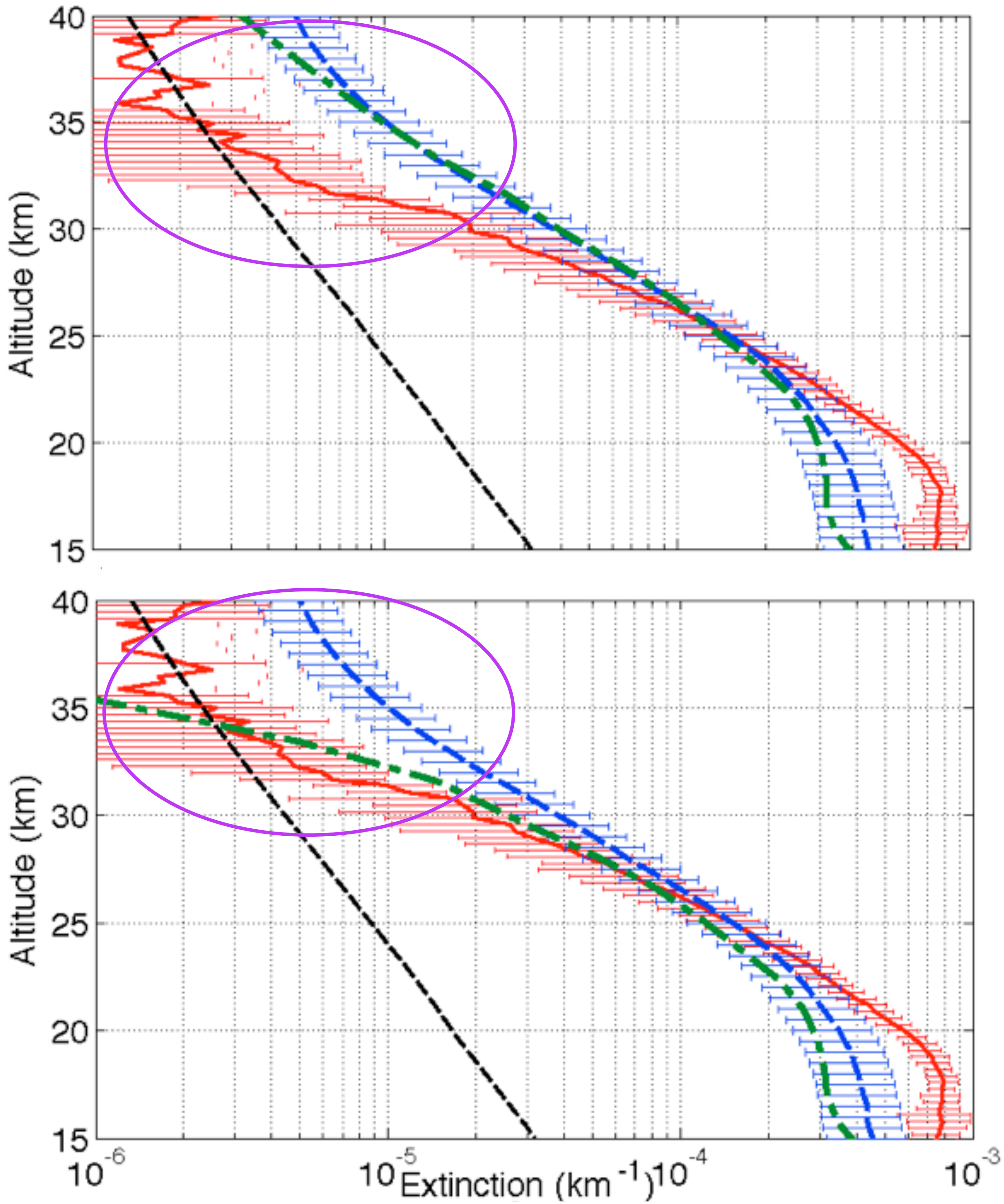
Lidar

SAGE II

Rayleigh

### Model Without Dust

$\beta_{total} = \beta_{Pure\ \ Sulfate} + \beta_{ixed\ \ Sulfate}$



# Summary

- First global microphysical model of stratospheric aerosols to include current sulfur emissions and meteoritic dust
- Comparison to observations show:

1. Agreement within the natural variation of the observations in the lower aerosol layer that is dominated by sulfate aerosols.
2. Meteoritic dust is needed to fully characterize the upper aerosol layer.
3. Inclusion of meteoritic dust is needed within lidar retrievals

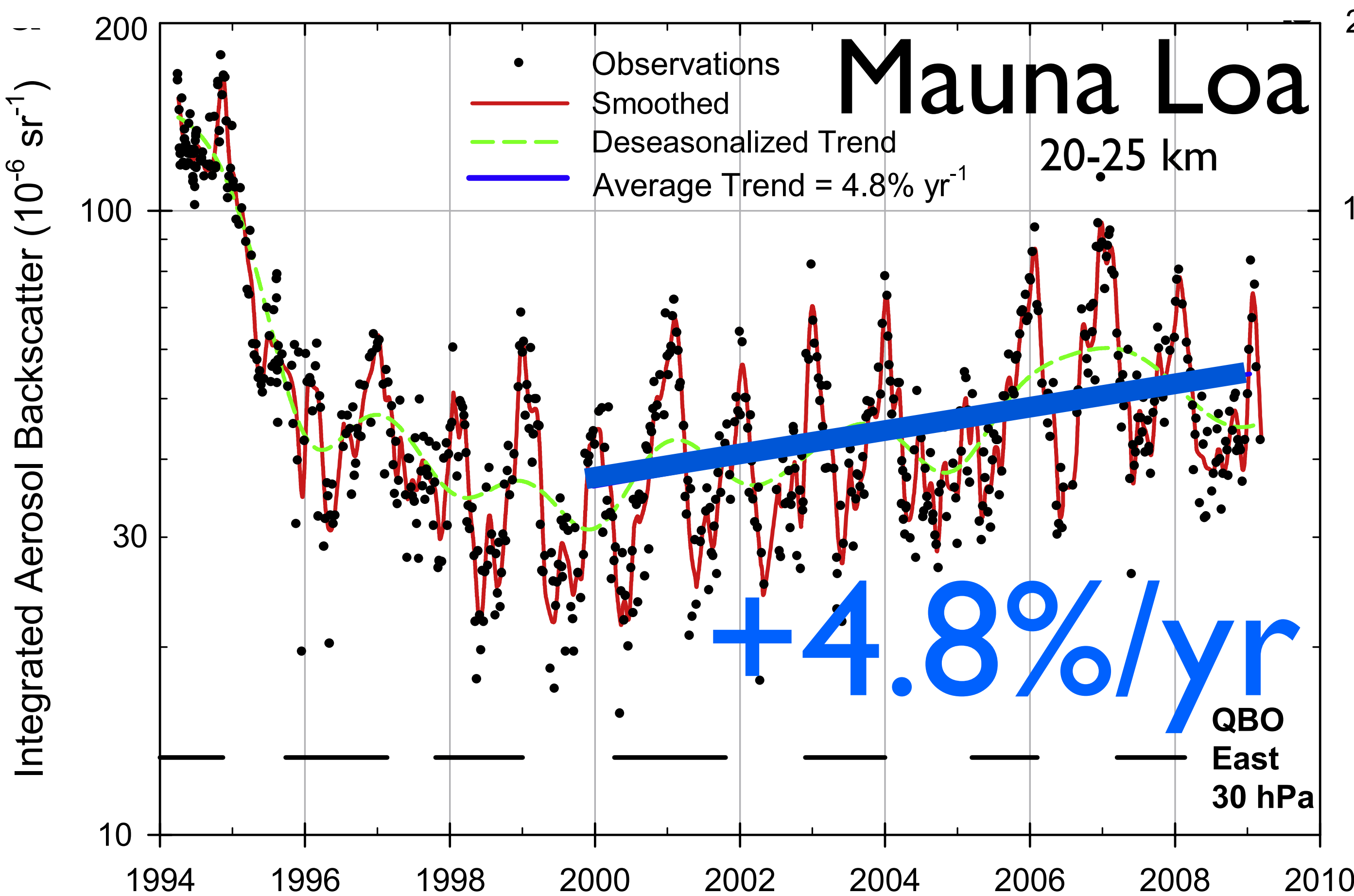
- Errors associated with the lidar retrievals need to be addressed before further comparison and analysis of trends can be made.

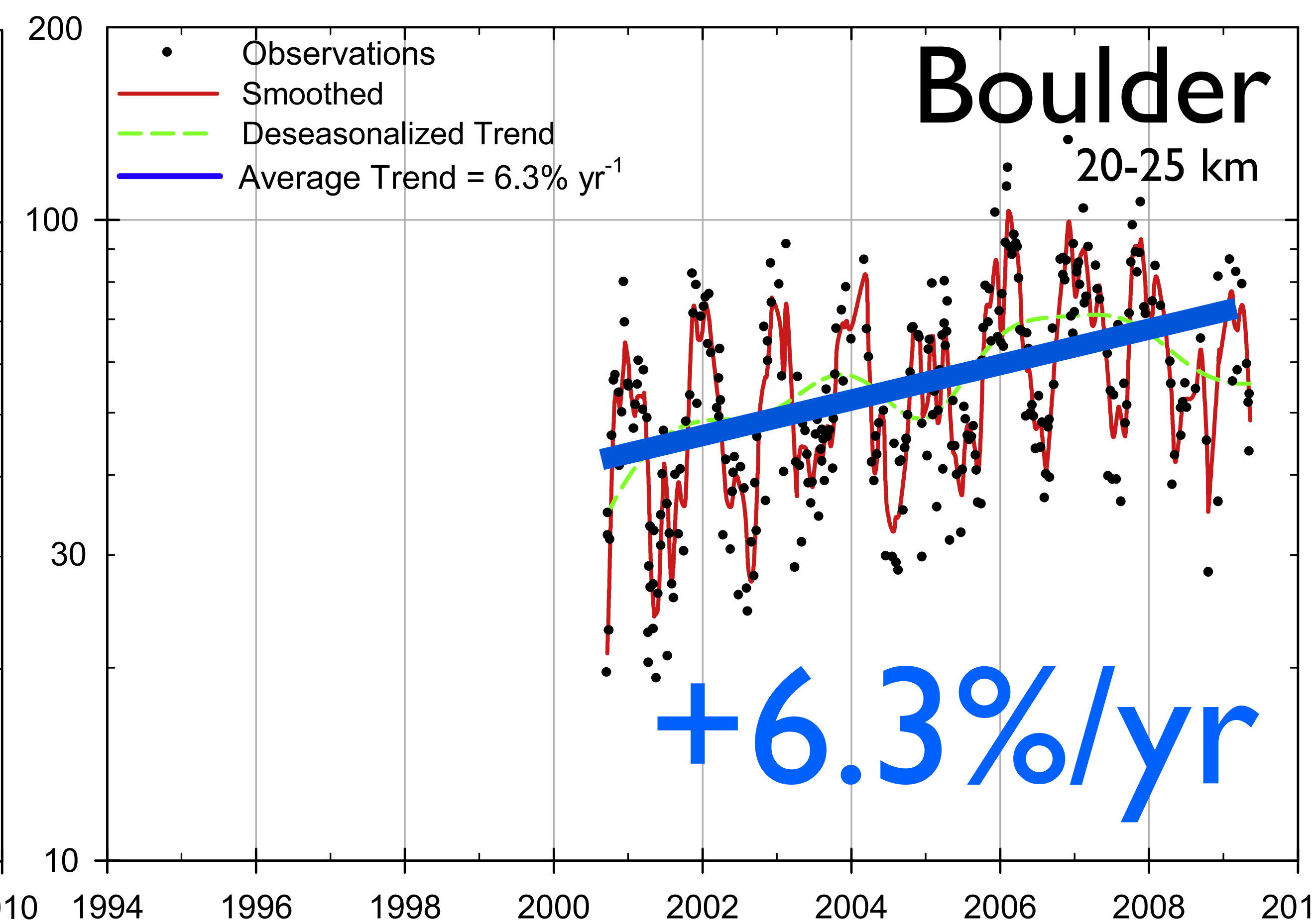
**Observations⇒Modeling⇒Observations**

# Future Work: Trends?

Possible theories:

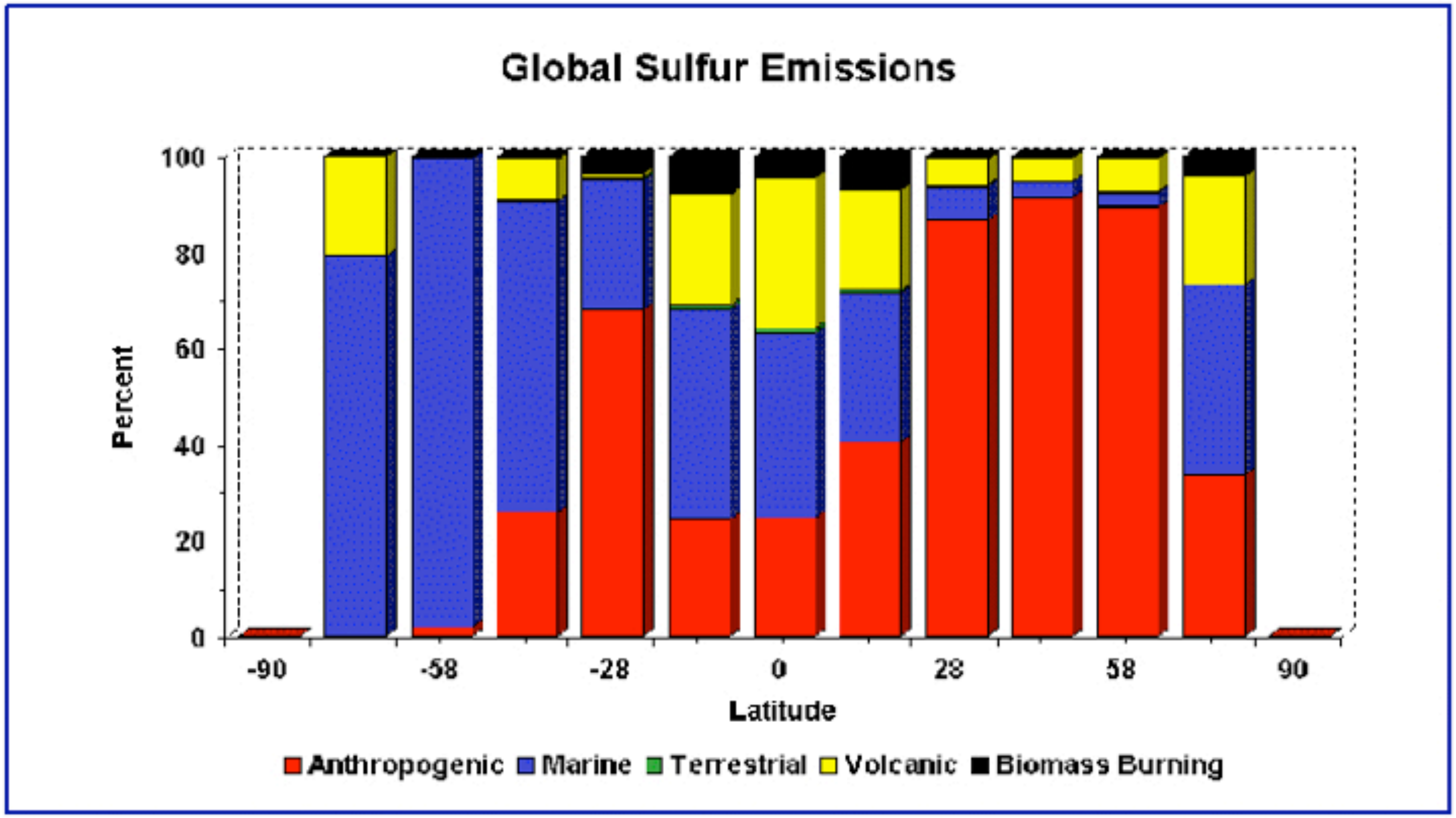
1. Anthropogenic emissions (Hofmann et al. 2009)?
2. Small episodic volcanic injections (Vernier et al. 2009)?
3. Strengthening of stratospheric circulation (Butchart et al., 2006; Niwano et al., 2009)?




Adapted from Hofmann at al. (2009)

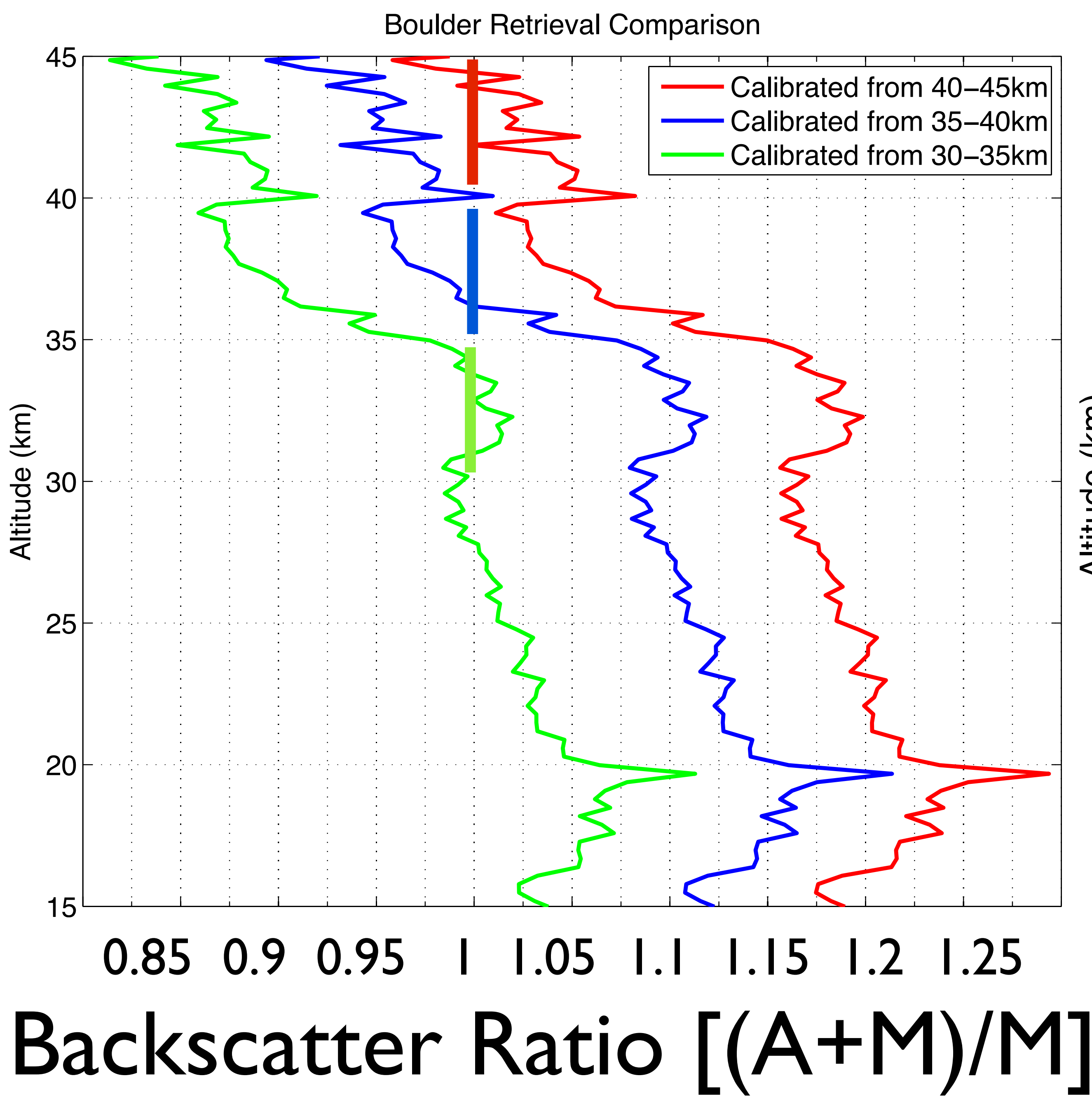

Thank You
David Oonk



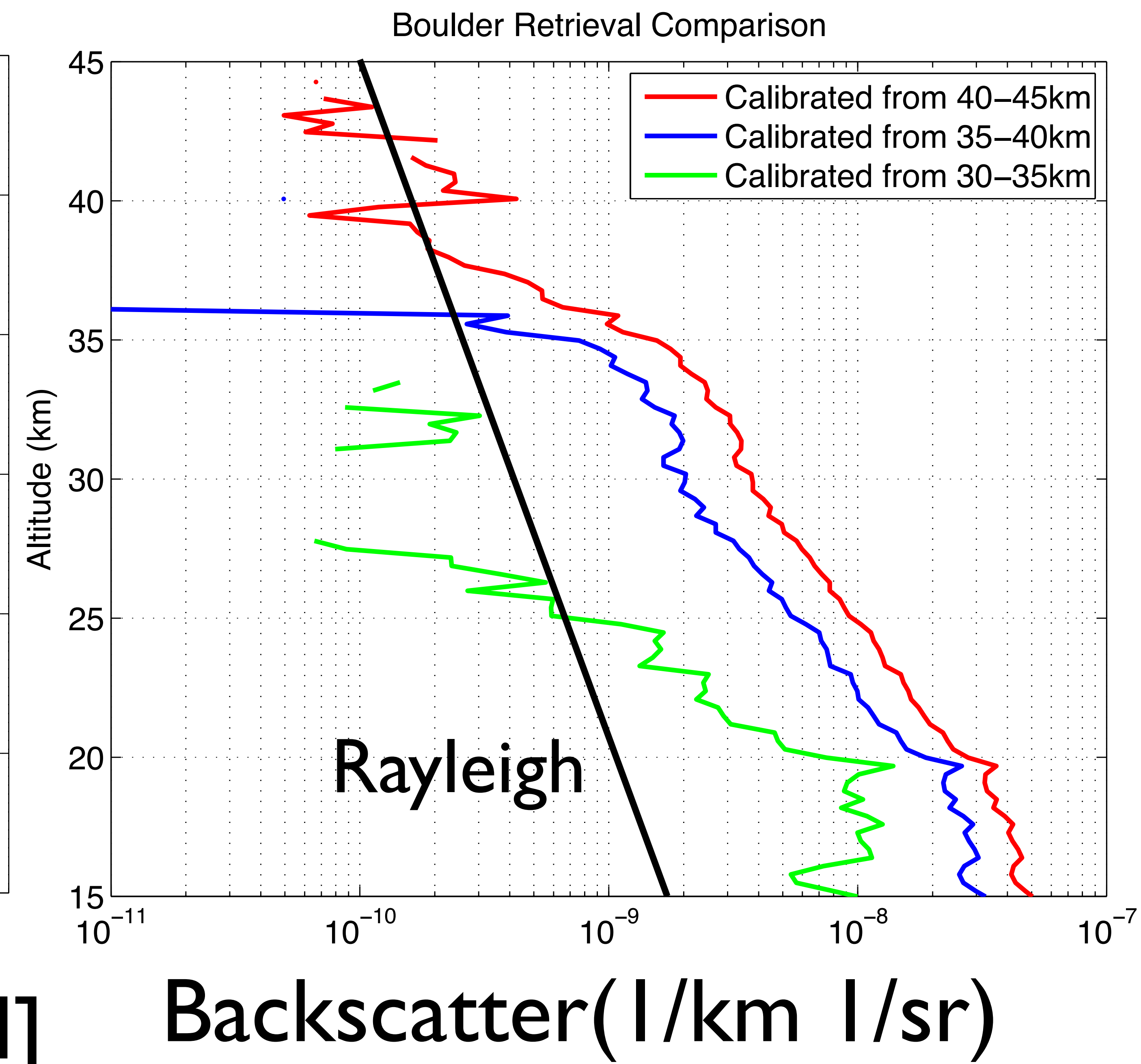

Adapted from Bates et al. 1992

# Lidar Retrieval Error

## Derivable




## Backscatter



- Osiris =alt omi=how much
- Then put in if then logic in mo sad
- Get kathrine to do emission stuff
- Compiler switch
- Intro models
- Show comparison of models
- Show from ells calc that is is 1-2% and not radiatively that important
- Show sofie
- Show lidar and show how this small error can propagate using russel math