

# Stratospheric Volcanic Aerosol Simulations using SD- WACCM/CARMA Model

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# Purpose of study

- Improve the WACCM/CARMA model by simulating more types of stratospheric aerosols
- Understand the effect of volcanic aerosols on stratospheric ozone
- Understand the transport of volcanic aerosols into the Polar Vortex
- Constrain the volcanic emissions of SO<sub>2</sub> and ash

# 2015 Calbuco



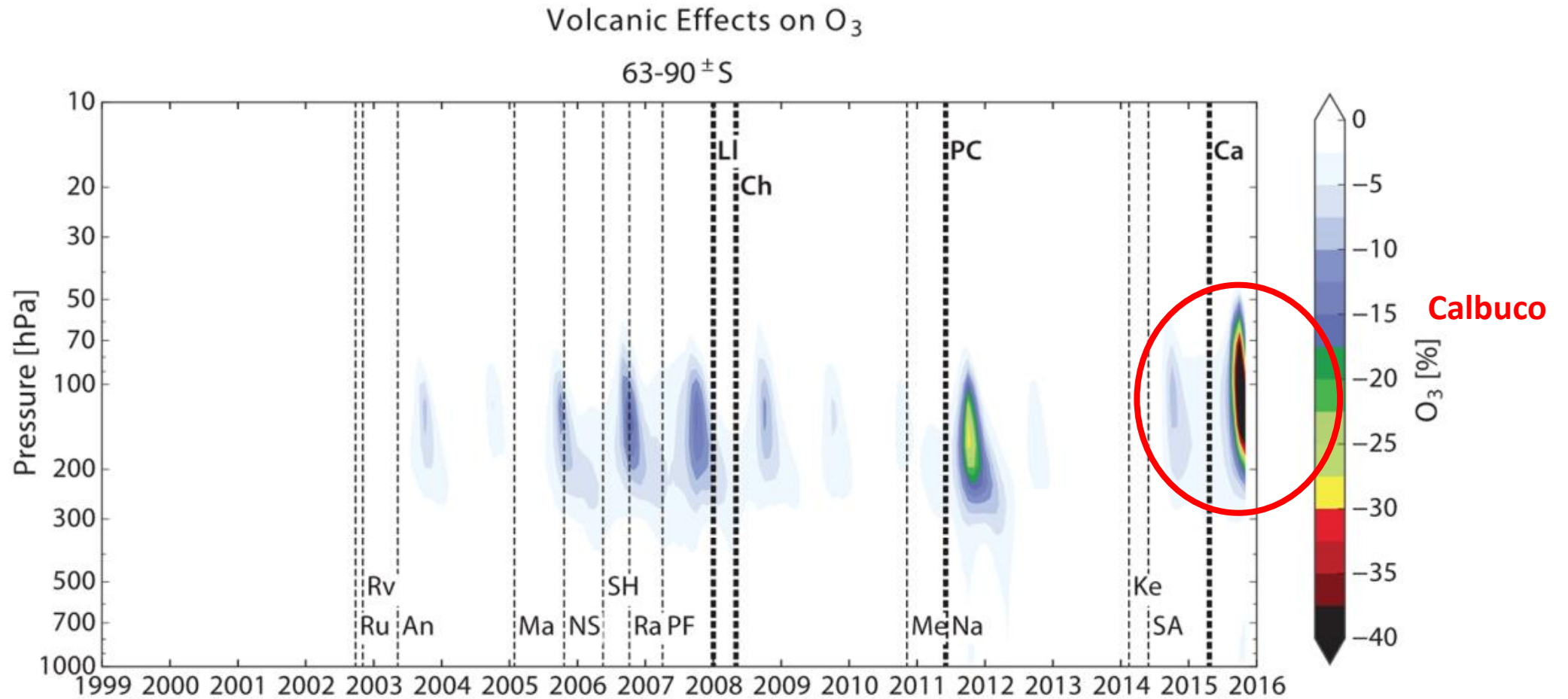
Injection date:  
April 23, 2015

[Mills et al., 2016]  
Injection amount:  
0.4 Tg of SO<sub>2</sub>

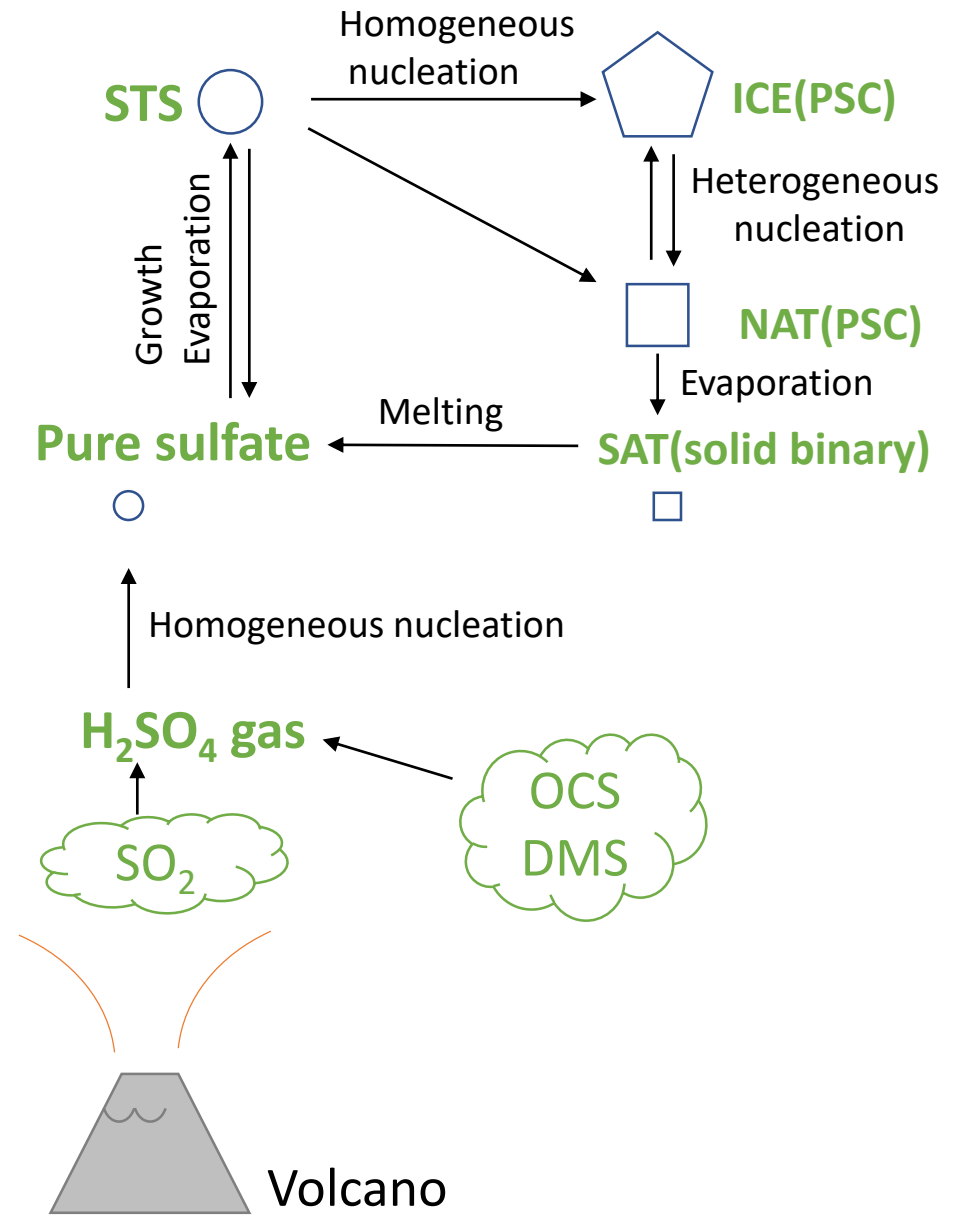
Injection height:  
~ 18-21km

[Zhu et al., 2018, JGR]

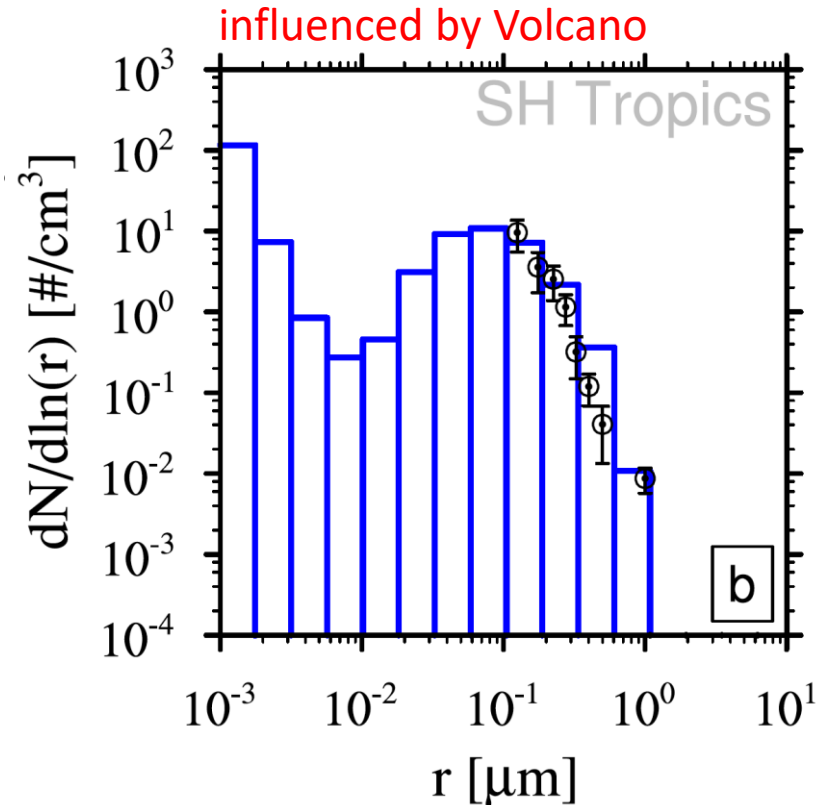
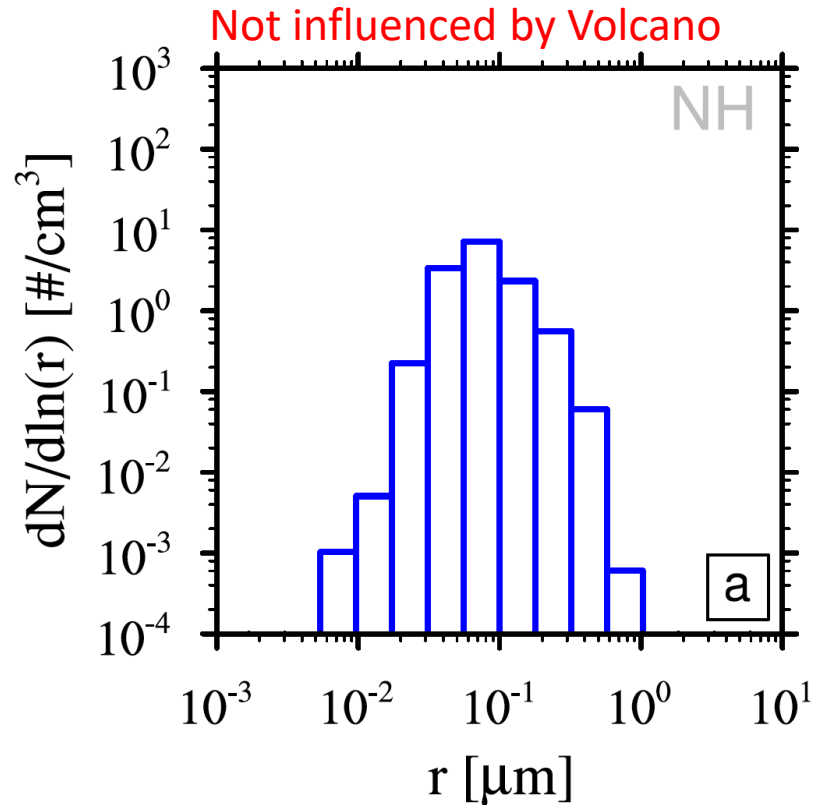
Solomon et al., [2016] found that small stratospheric volcanic aerosol injections enhance the Antarctic ozone depletion.



# WACCM/CARMA Physics for PSCs and sulfate aerosol

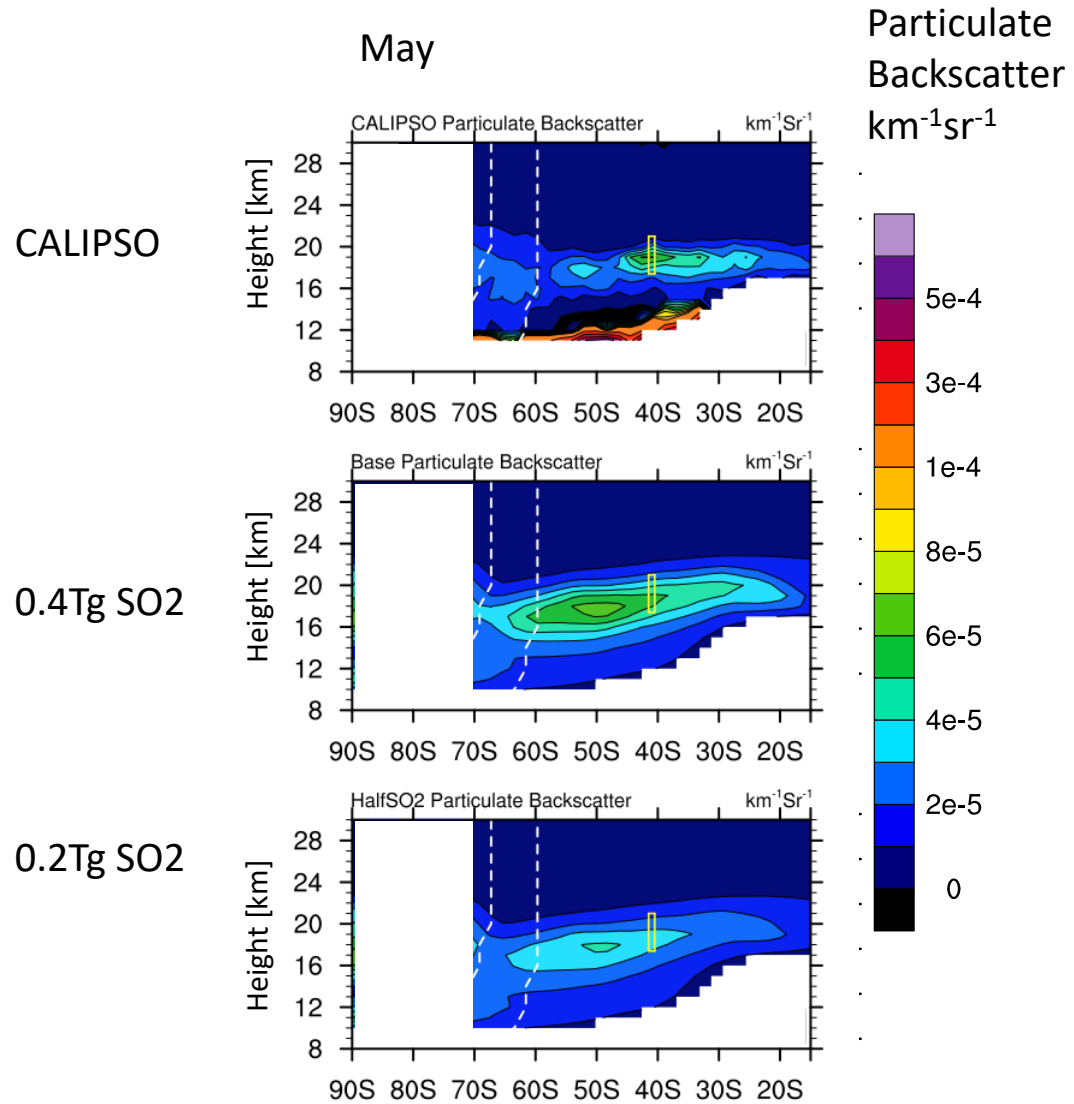


**WACCM/CARMA provides detailed volcanic sulfate aerosol size distribution and useful optical parameters for satellite retrieval.**

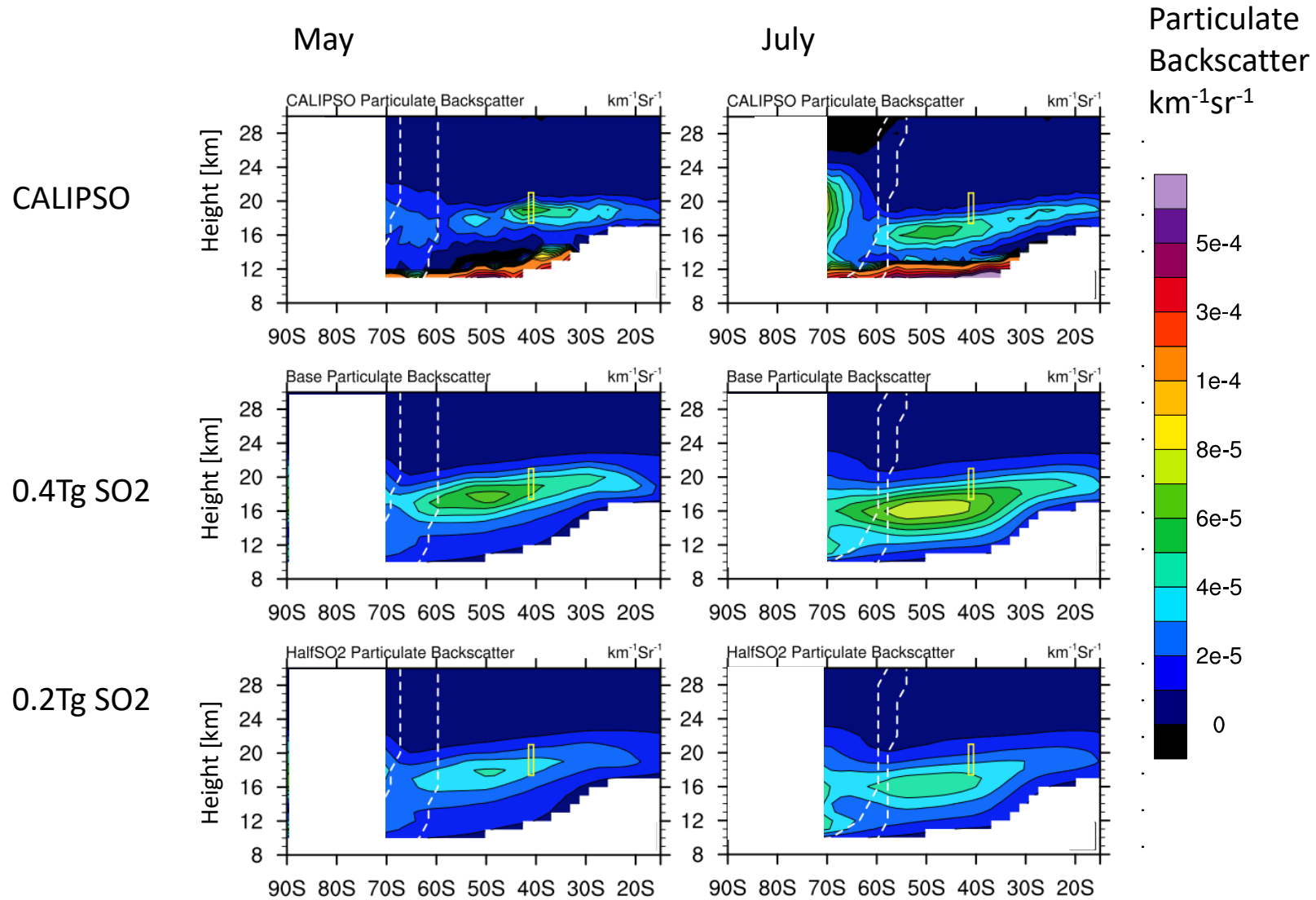


Ångström exponent	1.94	1.19
Effective radius (μm)	0.16	0.22
Optical effective radius (μm)	0.38	0.46

# Comparisons between the simulations and CALIPSO show the injection of SO<sub>2</sub> is between 0.2-0.4 Tg.

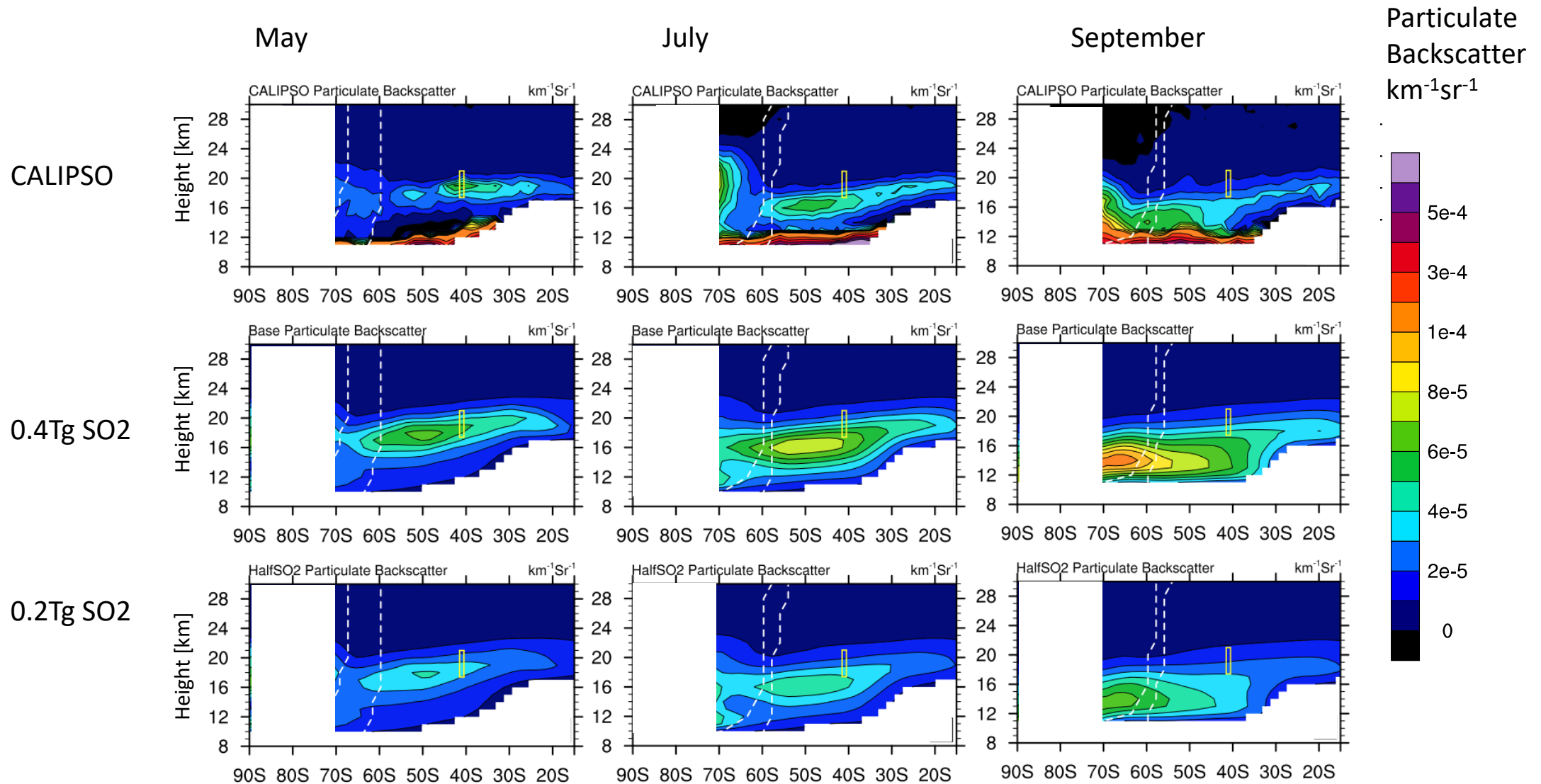


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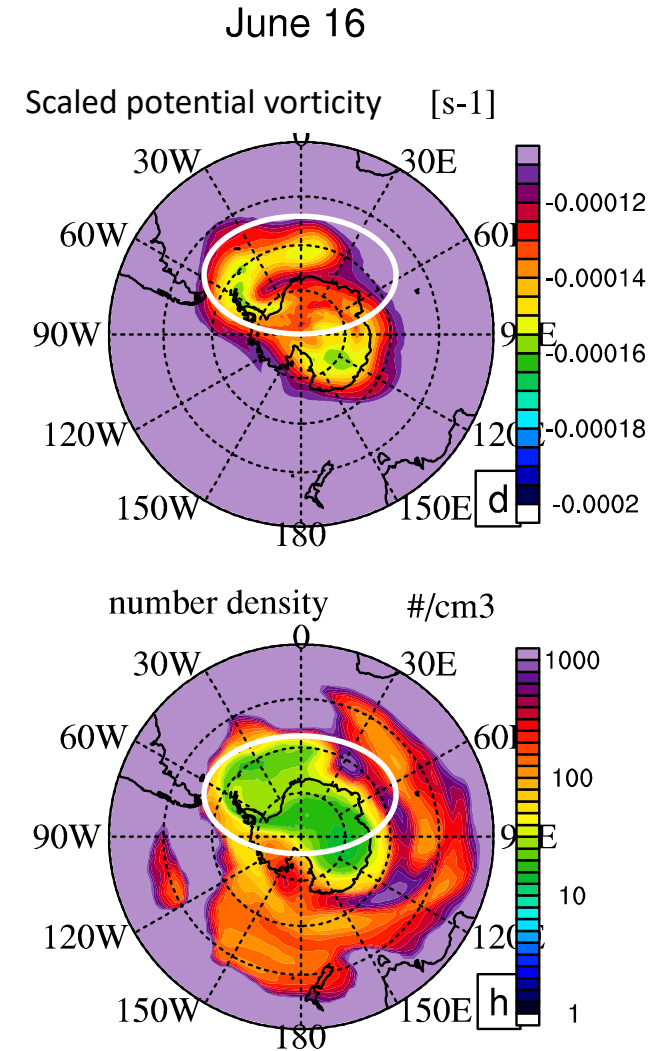
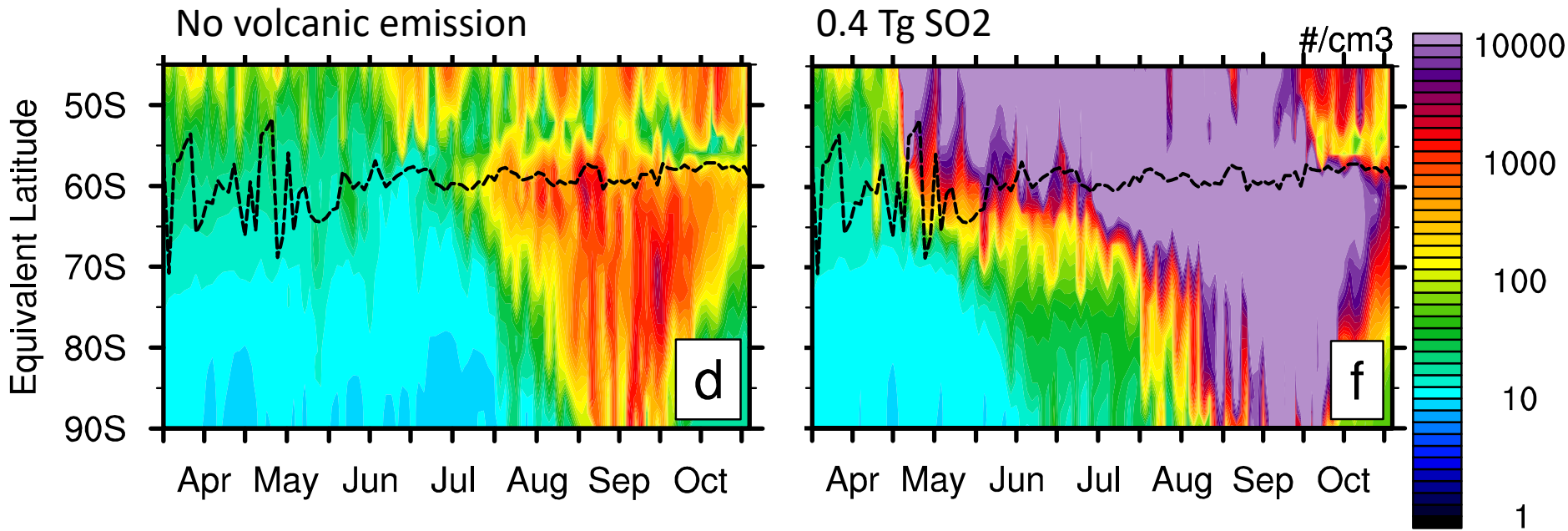


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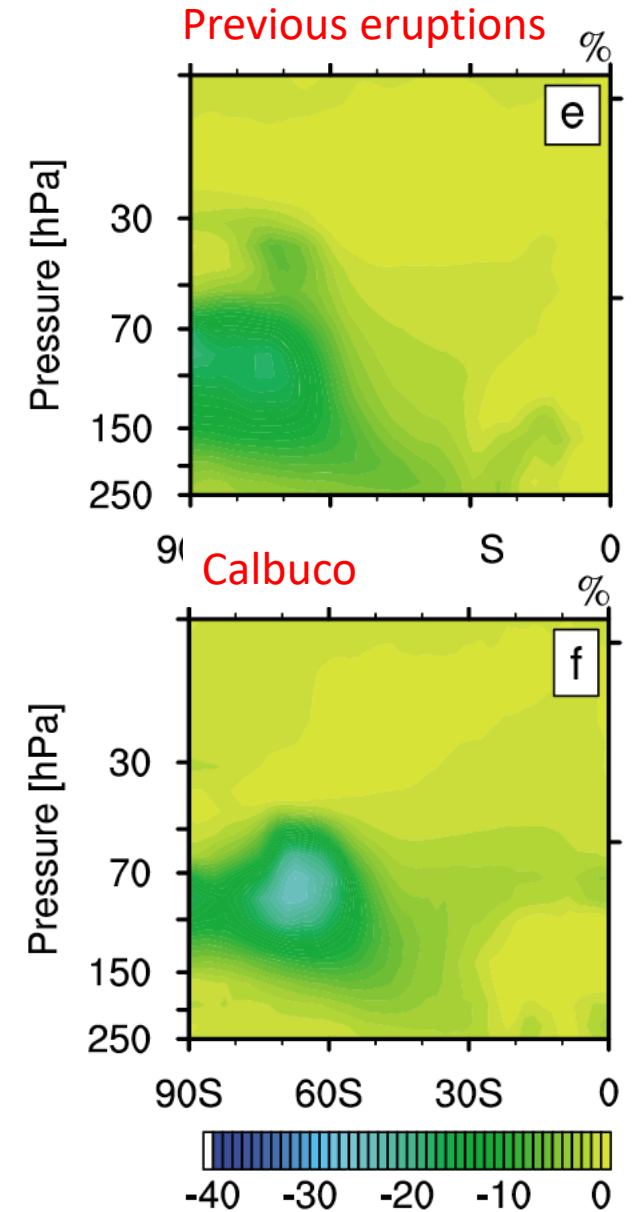
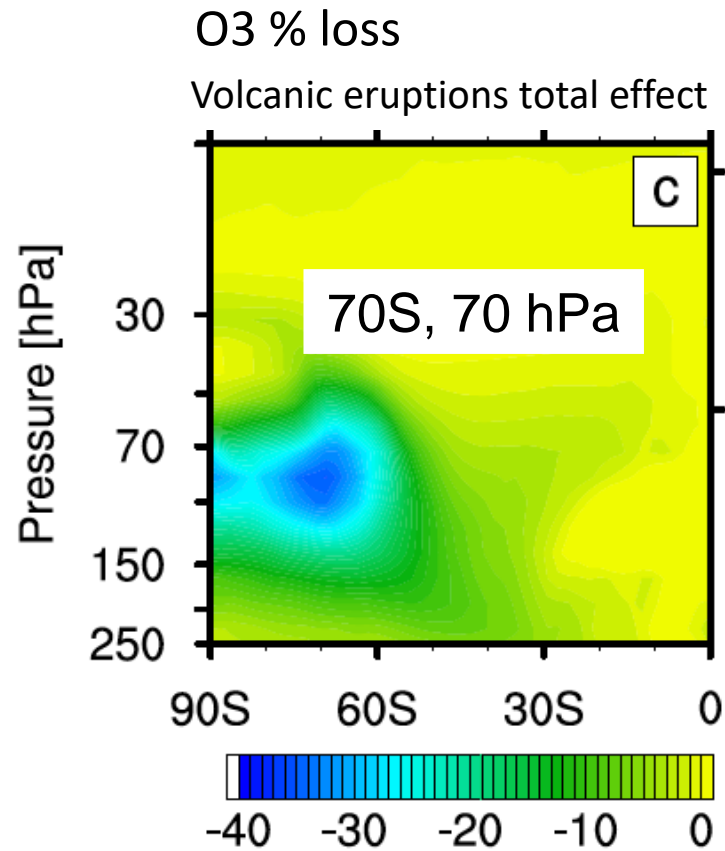
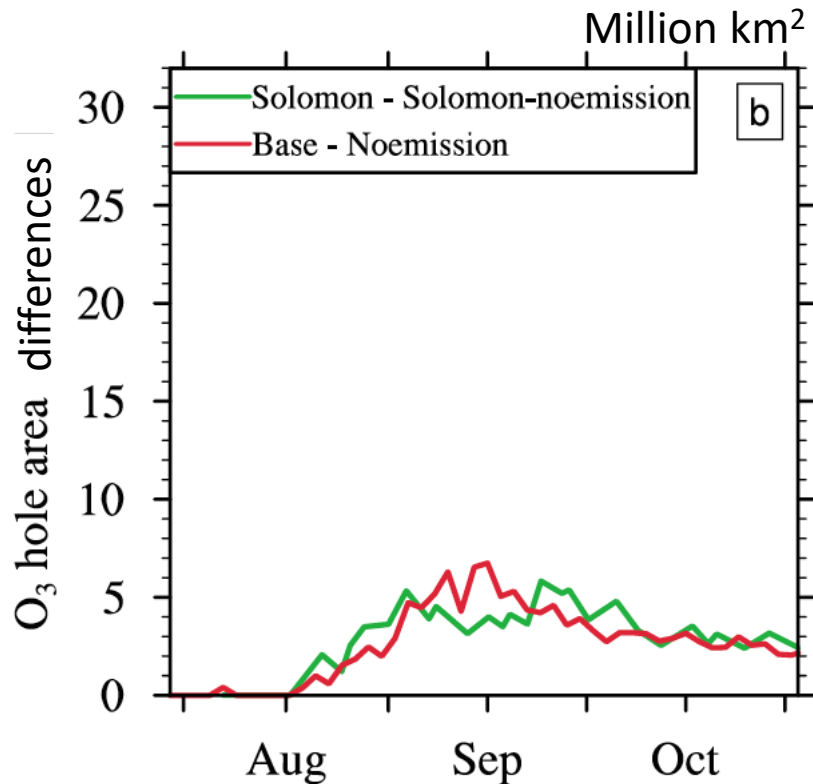


WACCM/CARMA shows a significant increase of sulfate number density inside the vortex after May.

The transport of sulfate into the vortex is caused by planetary waves.



- Our modeled  $O_3$  is consistent with CESM/MAM model simulation [Solomon et al., 2016].
- Due to the Calbuco and previous eruptions, the area of the ozone hole expands and ozone loss is greater.



# Part 1 Conclusions

1. WACCM/CARMA can compute satellite observed quantities because it provides size distribution.
2. Satellite can use CARMA results for their retrieval algorithms.
3. WACCM/CARMA constrains the SO<sub>2</sub> emission between 0.2 and 0.4 Tg.
4. There's a debate when the aerosols penetrating the vortex. WACCM/CARMA predicts the distortion of potential vorticity leading to volcanic aerosols penetrating the vortex as early as June.
5. we find volcanic aerosols from Mt. Calbuco impact ozone depletion as Solomon et al., 2016. Aged aerosols from previous years also contribute to the enhancement of ozone depletion.

# 2014 Kelut



Injection date:  
Feb 13, 2014

[Mills et al., 2016]  
Injection amount:  
0.3 Tg of SO<sub>2</sub>

Injection height:  
~ 17-26 km

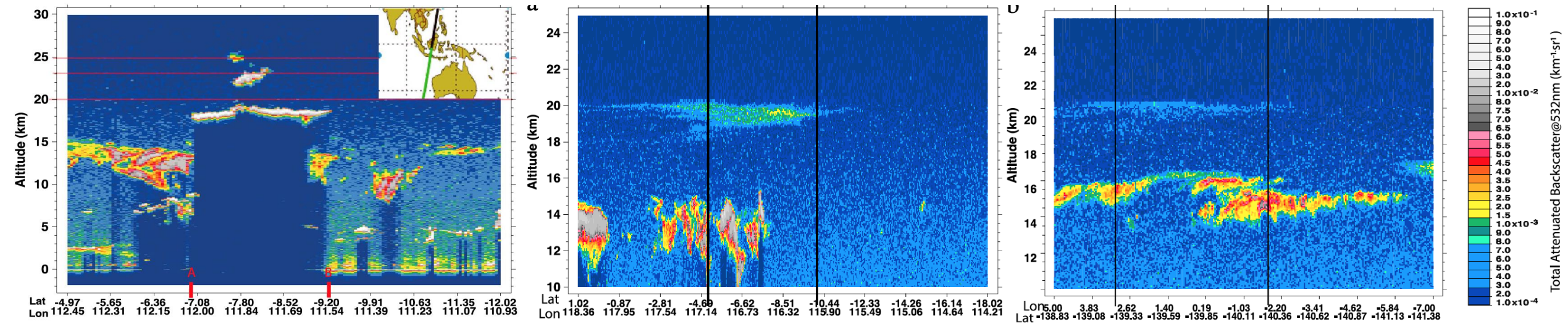
Dust injection:  
Unknown

# CALIPSO observations indicate Kelut aerosol layers persist more than a month.

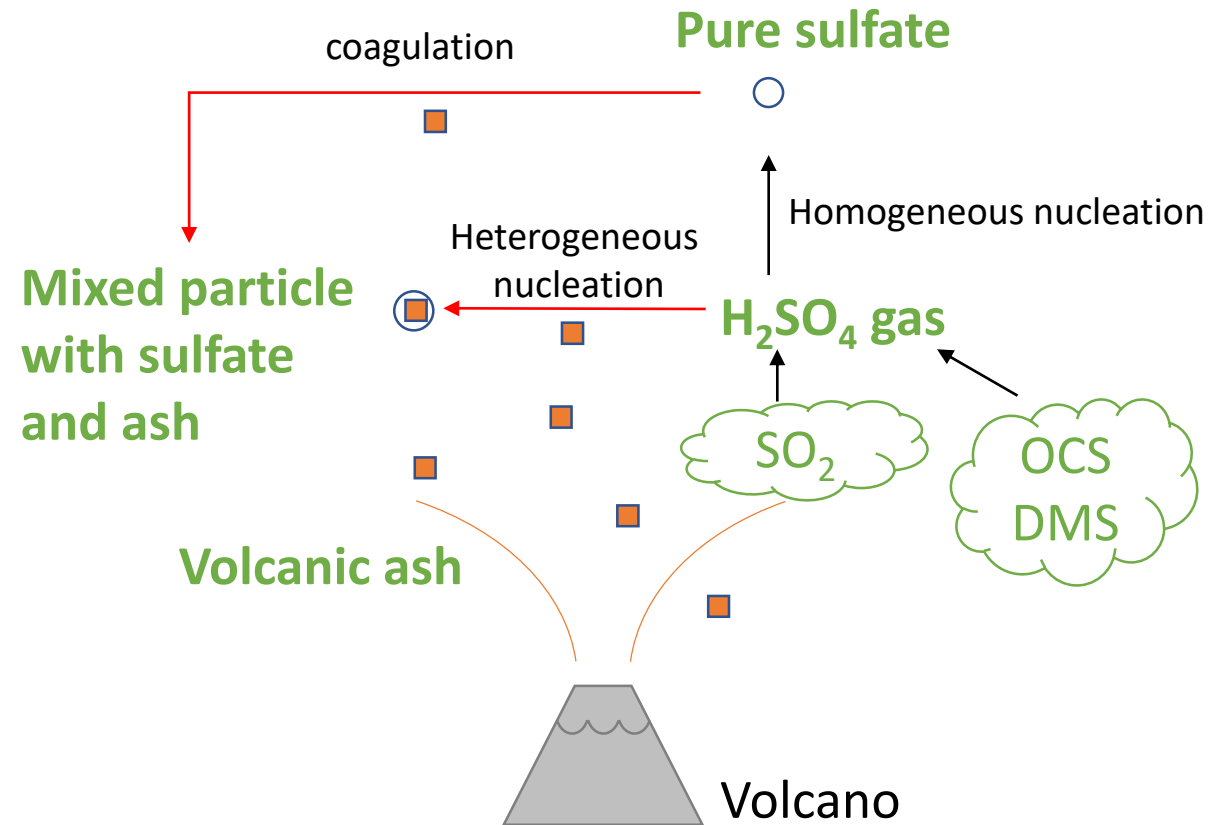
Day 1

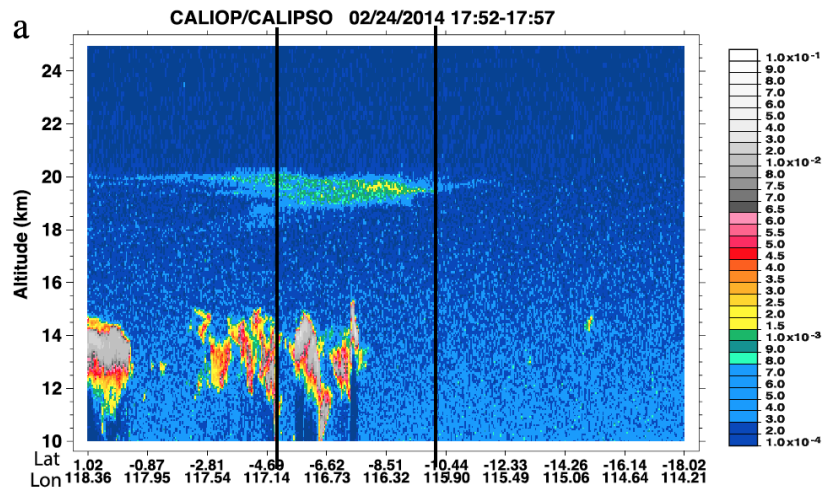
Day 11

Day 30



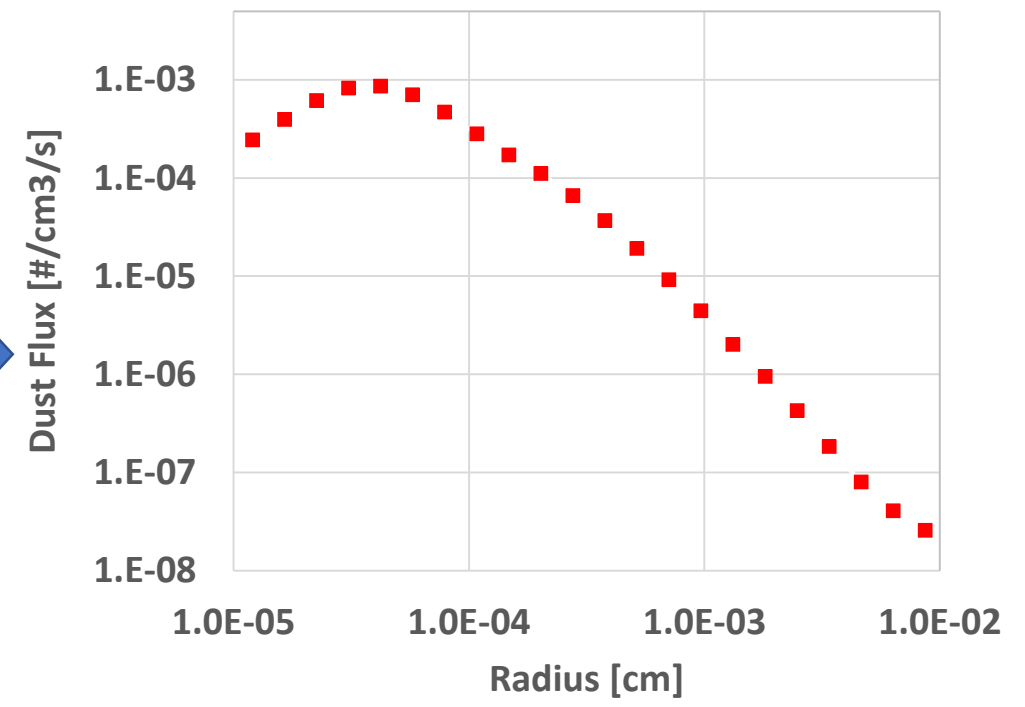
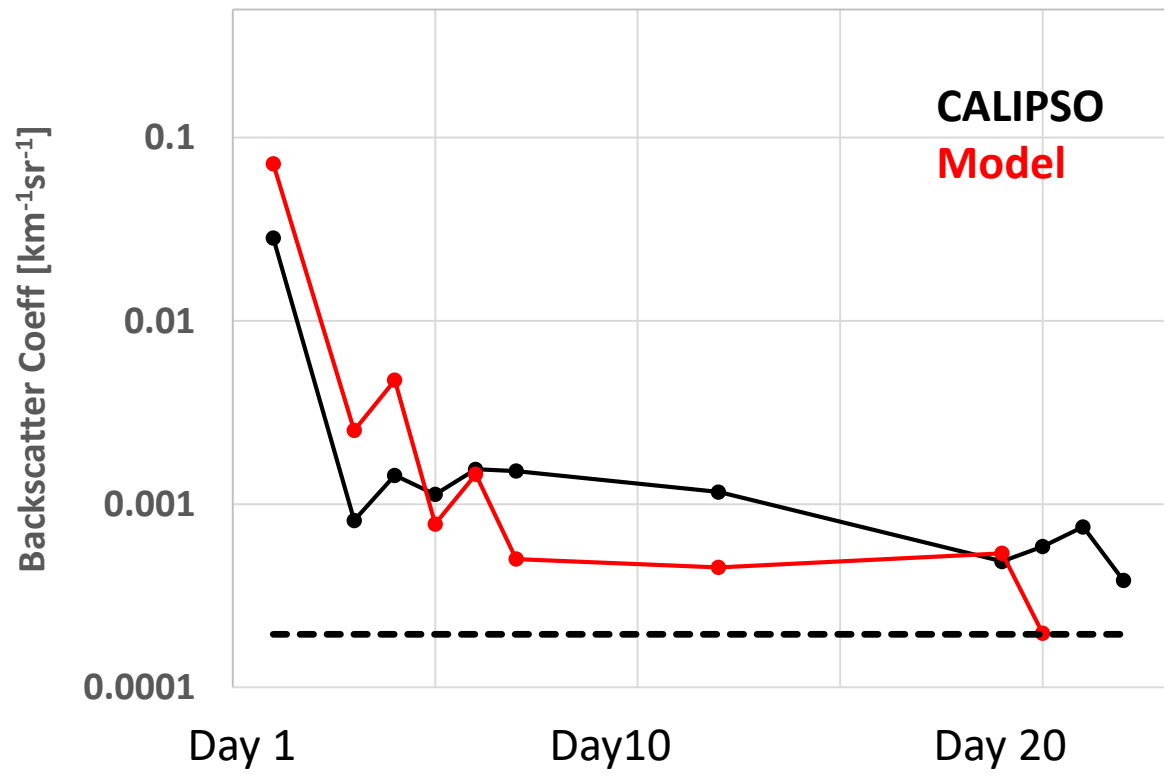
# WACCM/CARMA model physics for volcanic ash and sulfate





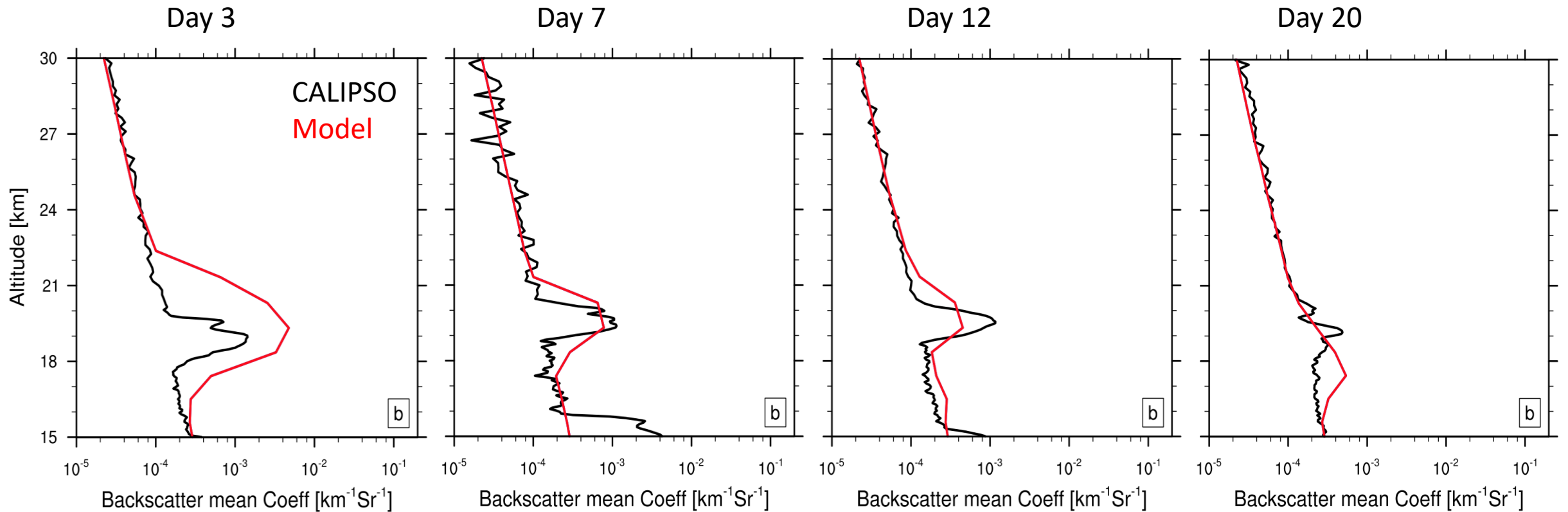
CALIPSO back scatter data helps to constrain the initial ash size distribution.

Dust initial size distribution

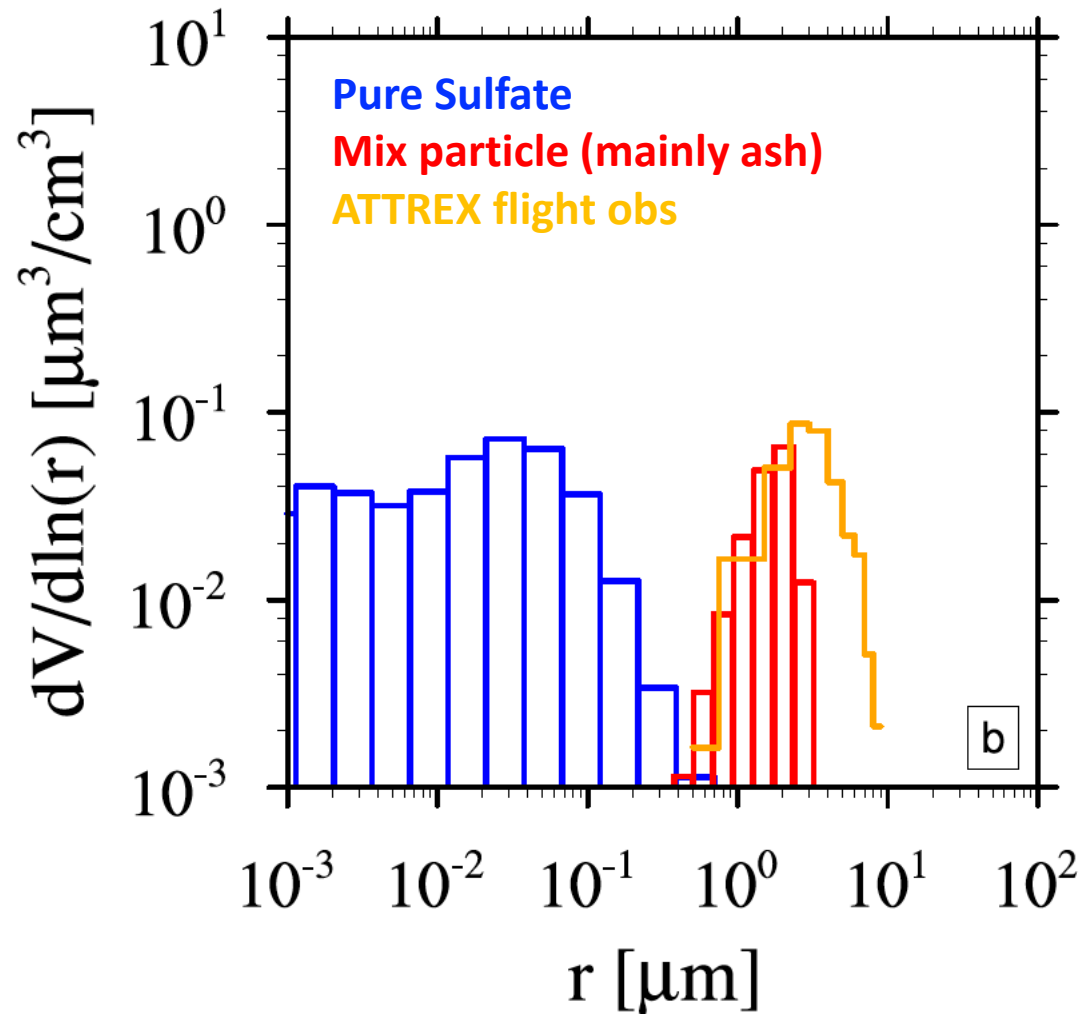
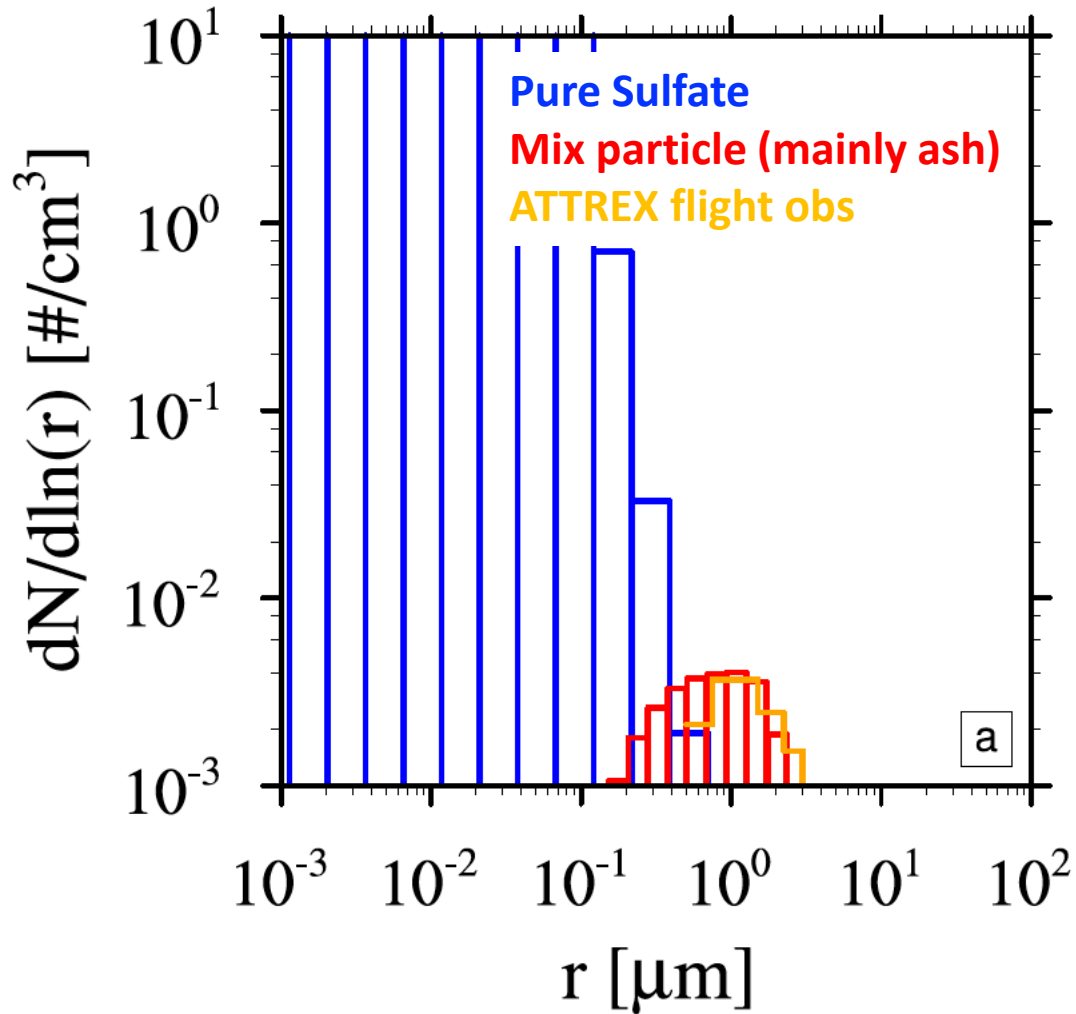




Simulated backscatter is close but not perfect, suggesting initial size distribution need more work.



Simulated particle size distribution misses particles larger than 5  $\mu\text{m}$  as observed by ATTREX on Day 22.



## Part 2 Conclusion and Future work

- We find simulated backscatter of volcanic ash is sensitive to the initial ash size distribution.
- The particle size distribution misses particles larger than 5  $\mu\text{m}$  as observed by the airplane.
- We find volcanic ash doesn't influence the volcanic sulfate burden for this eruption.
- We are currently computing the radiative effect of volcanic ash.

Thank you!

