

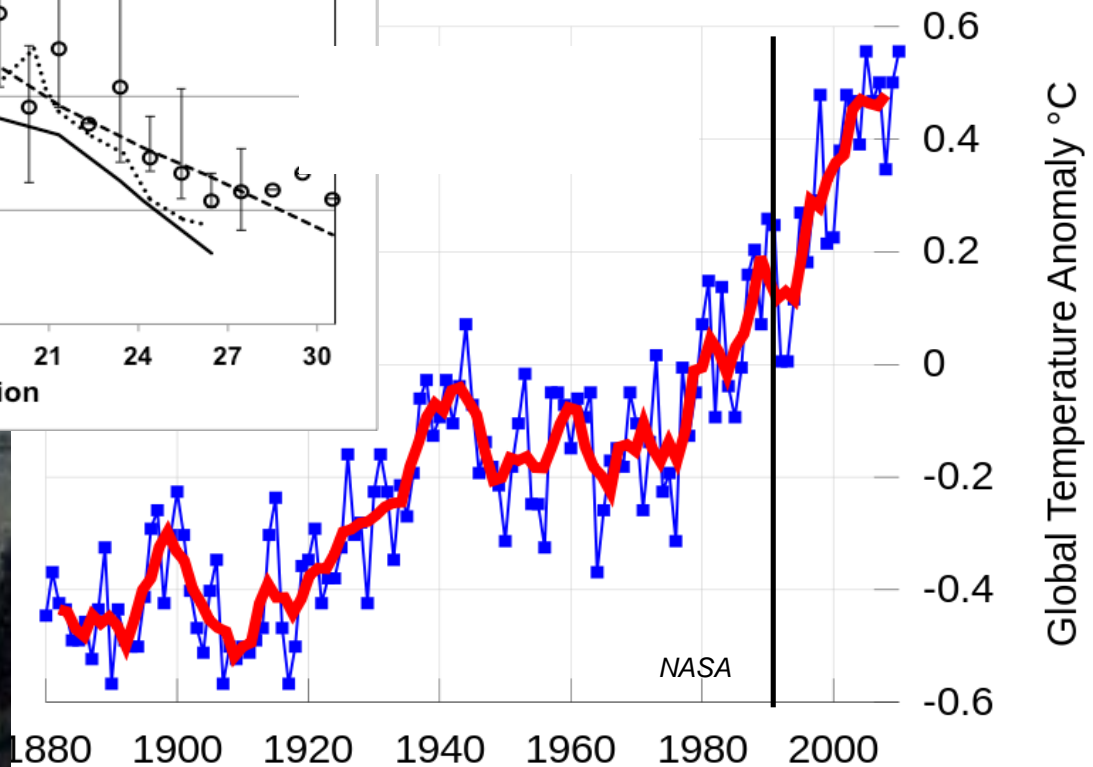
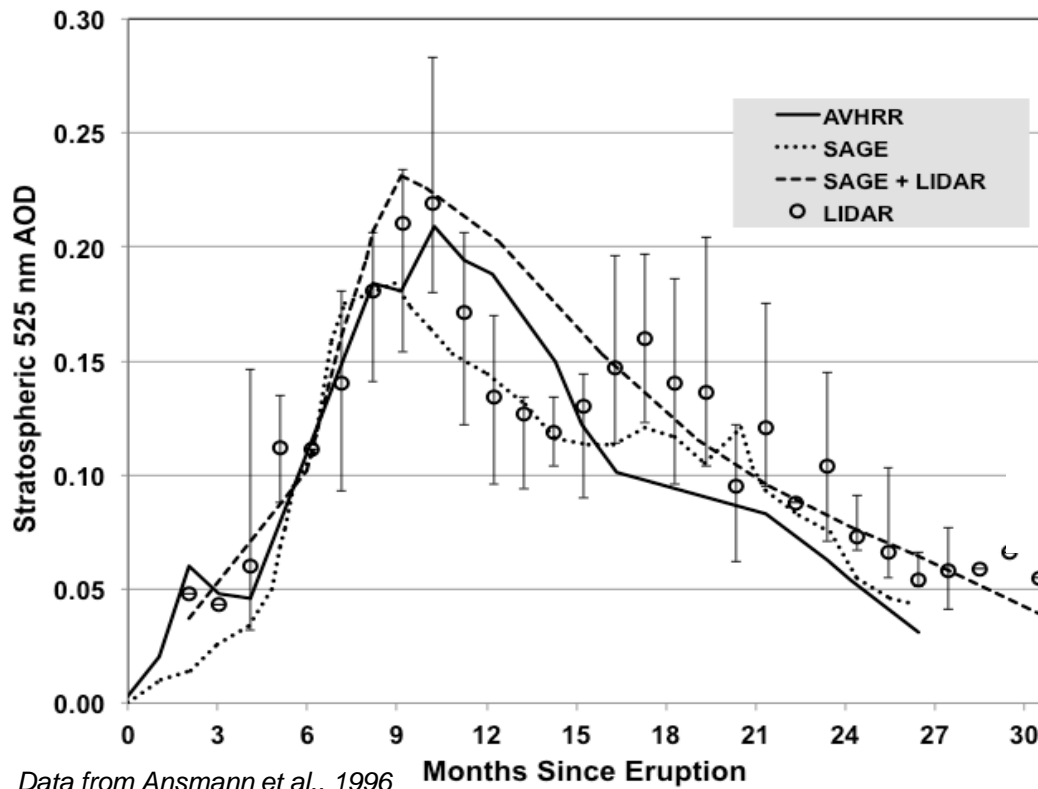


Aerosol size distributions after large volcanic eruptions evolve in a complex manner

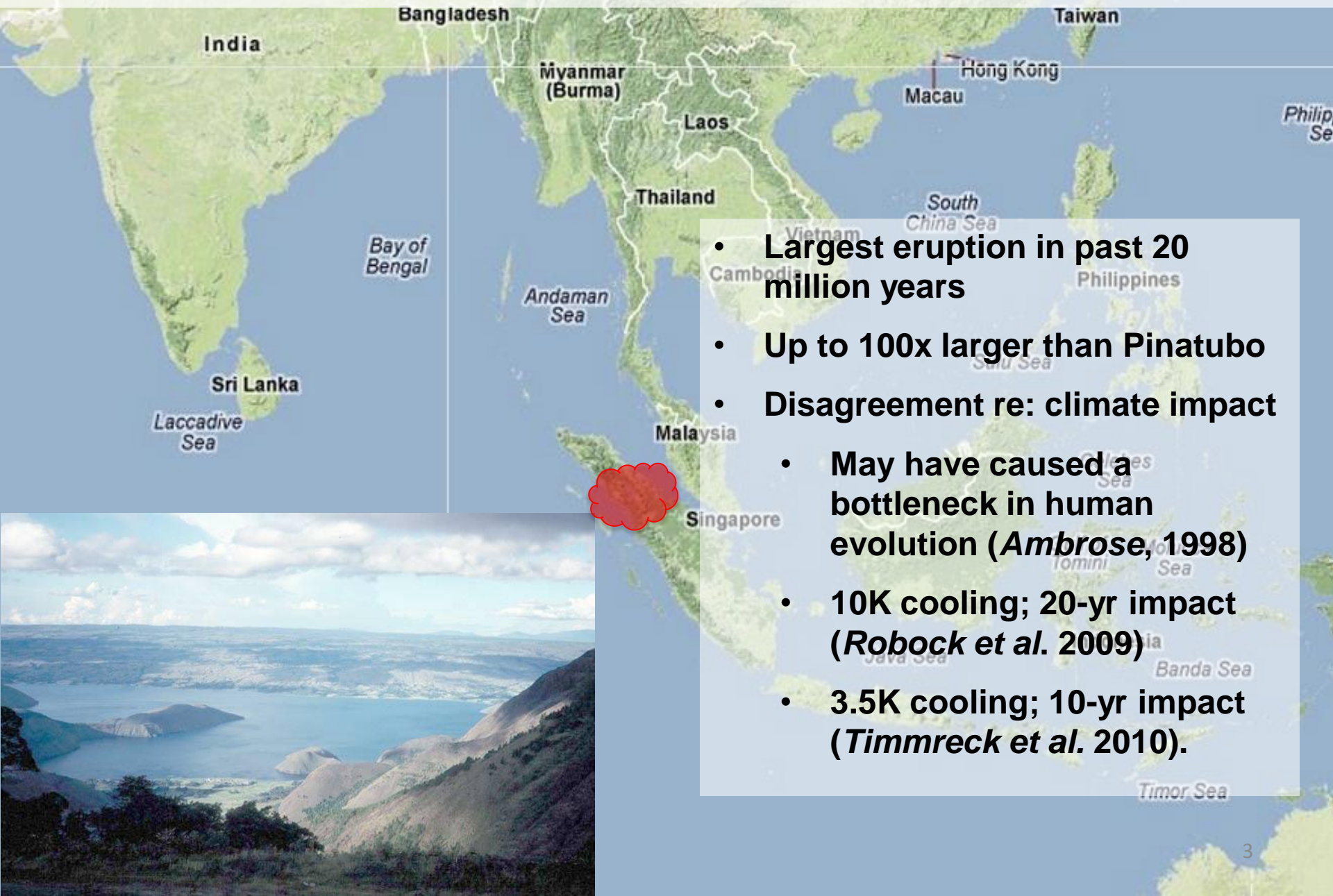
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Thanks to collaborators
Brian Toon and Michael Mills

The 1991 eruption of Mt. Pinatubo



The Toba super-eruption 74,000 years ago

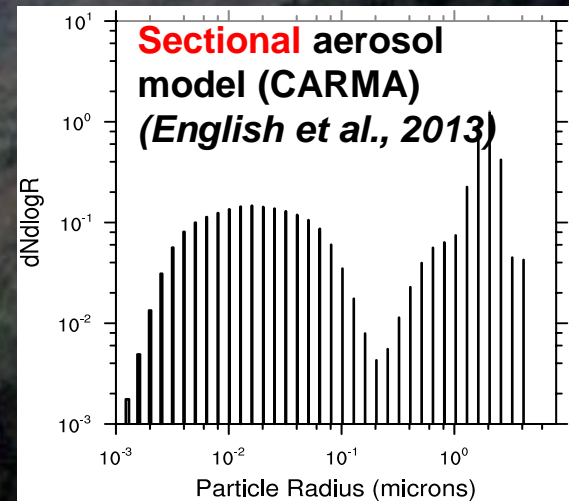
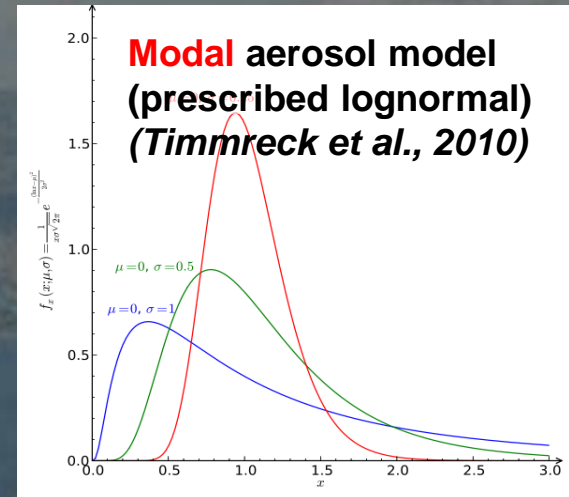
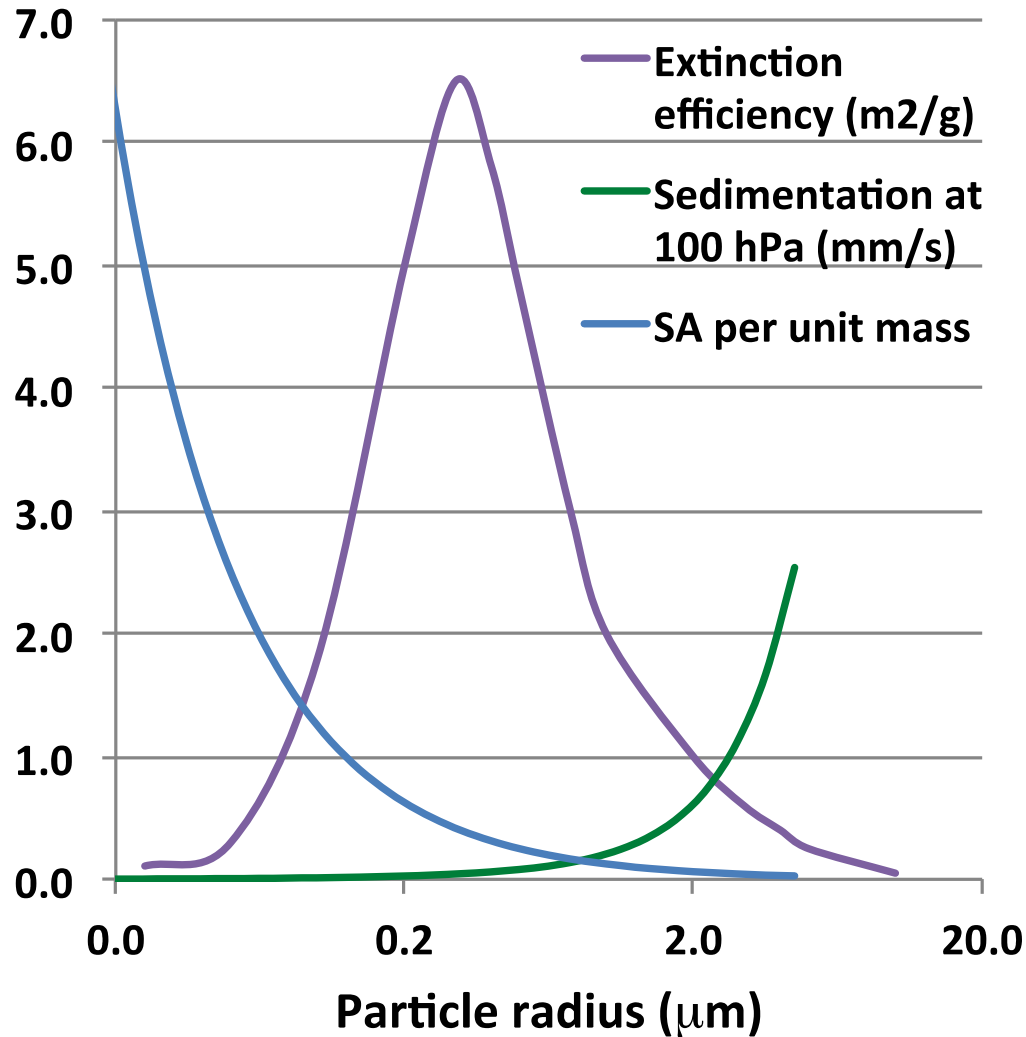


- Largest eruption in past 20 million years
- Up to 100x larger than Pinatubo
- Disagreement re: climate impact
 - May have caused a bottleneck in human evolution (*Ambrose, 1998*)
 - 10K cooling; 20-yr impact (*Robock et al. 2009*)
 - 3.5K cooling; 10-yr impact (*Timmreck et al. 2010*).

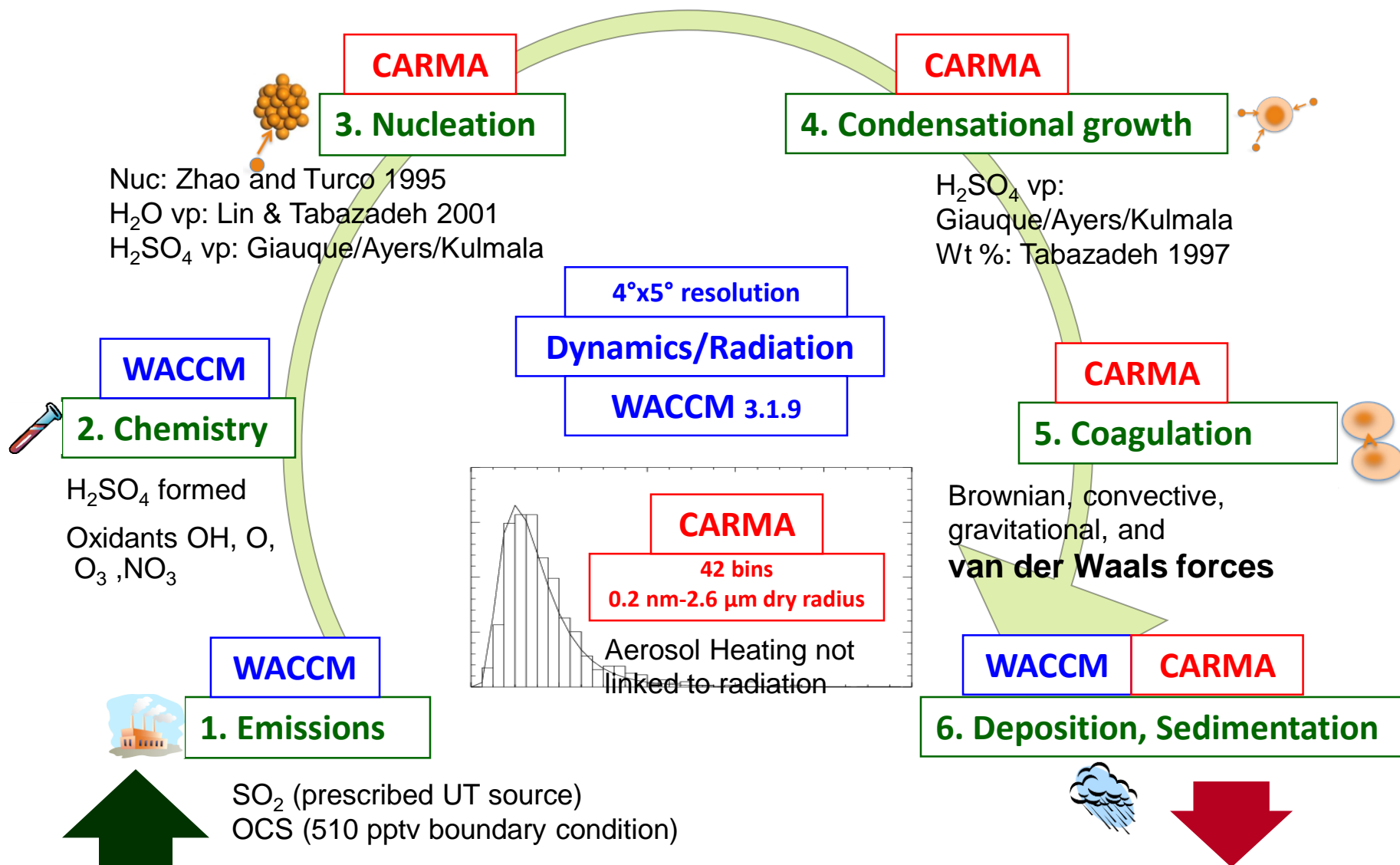


Accurate aerosol representation is critical

Bulk aerosol model:
predict mass,
prescribes size.



WACCM/CARMA Model

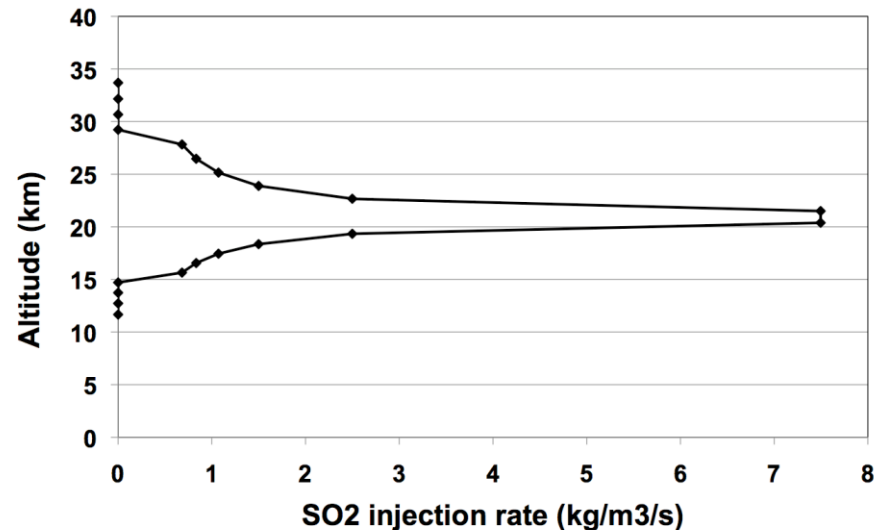
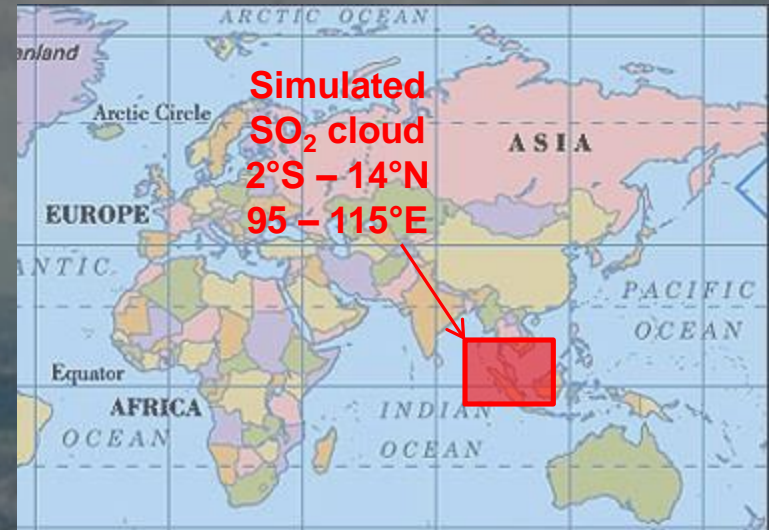


Three eruptions; with and without van der Waals

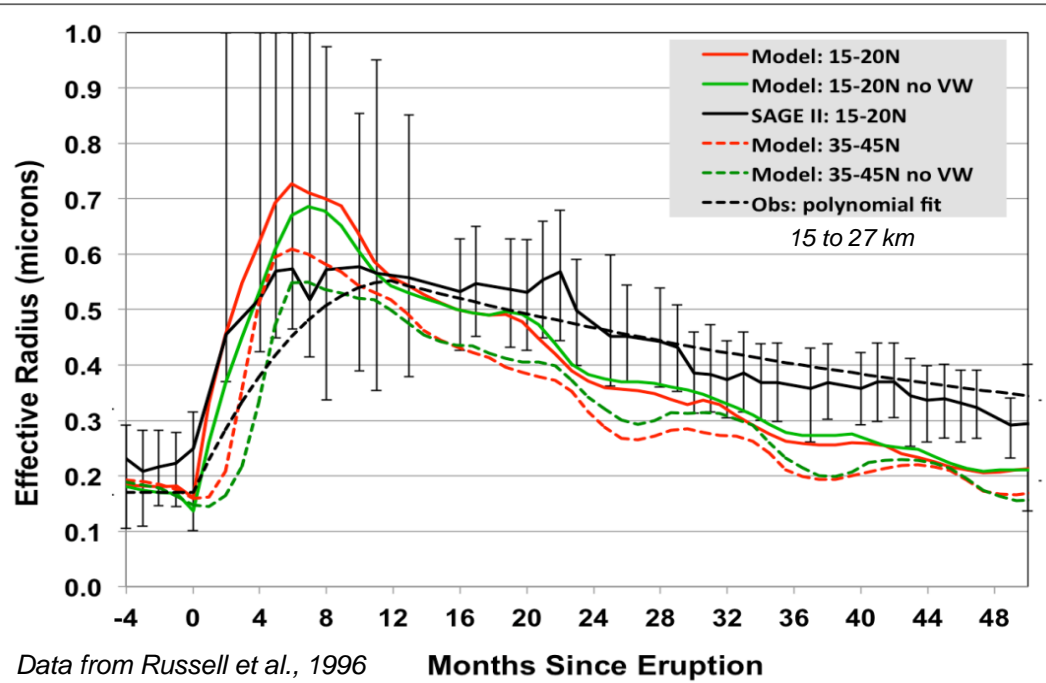
Three eruptions simulated

Pinatubo	10 Tg S
Pinatubo x 10	100 Tg S
Toba	1000 Tg S

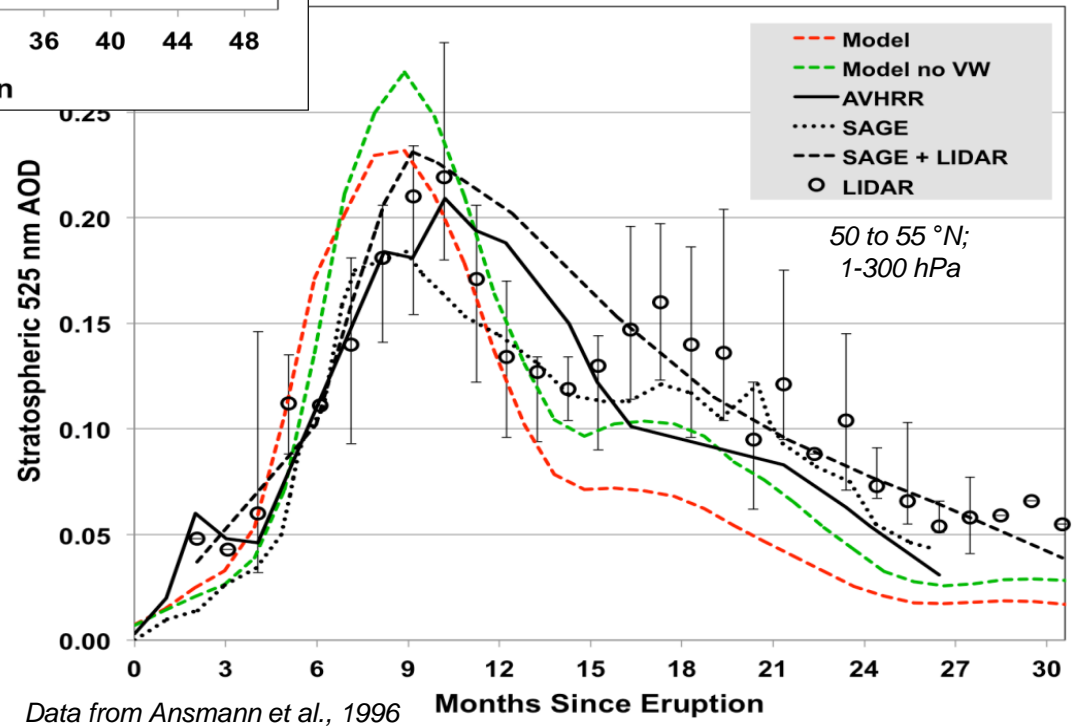
- 10-year simulations
- SO₂ gas injected continuously over 48 hours on June 14-15 of first year



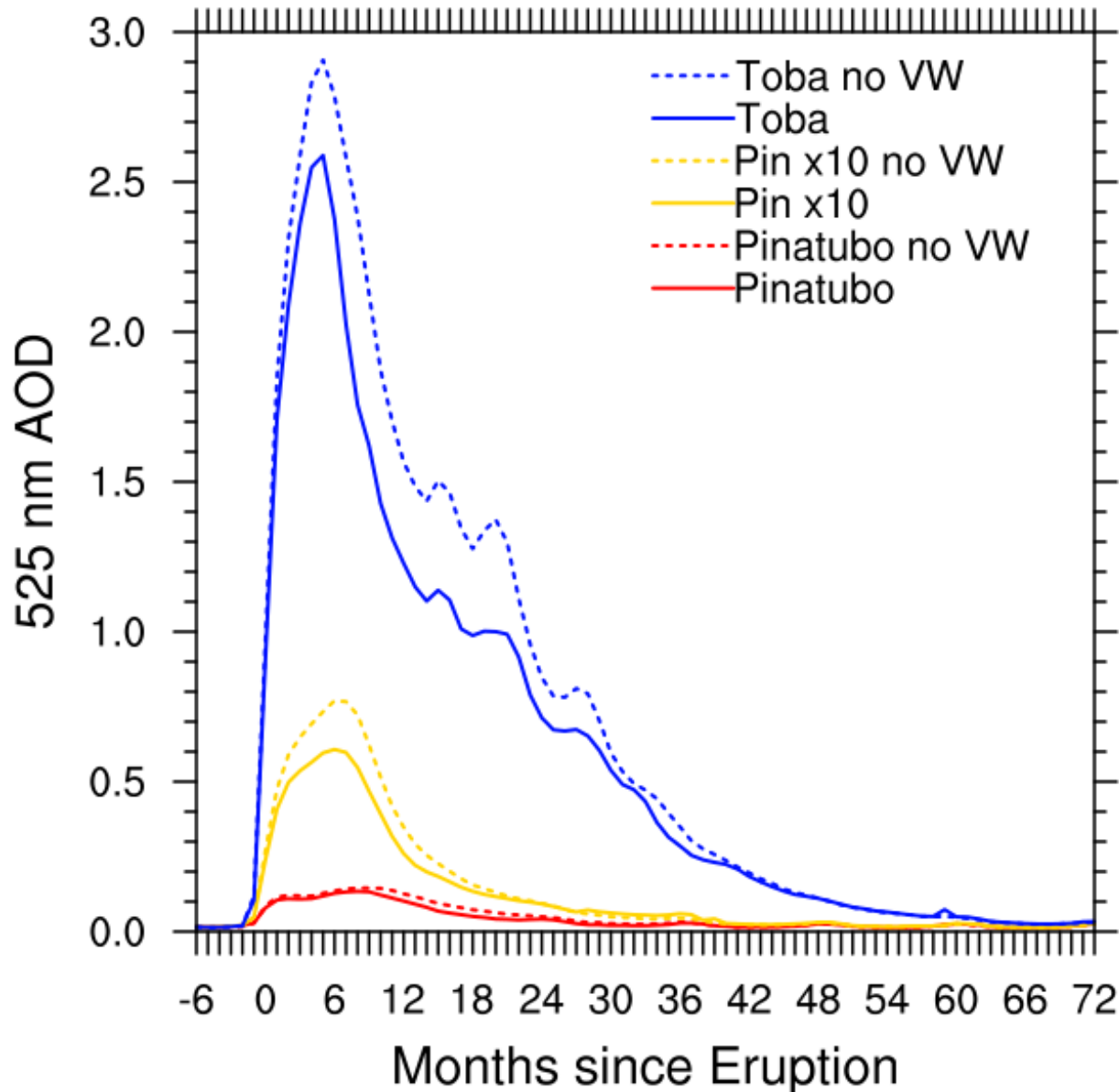
Pinatubo: Model captures peak but declines too quickly



- Model is mostly within error bars but declines too quickly (need aerosol heating, QBO)
- Including van der Waals forces increases effective radius and reduces AOD

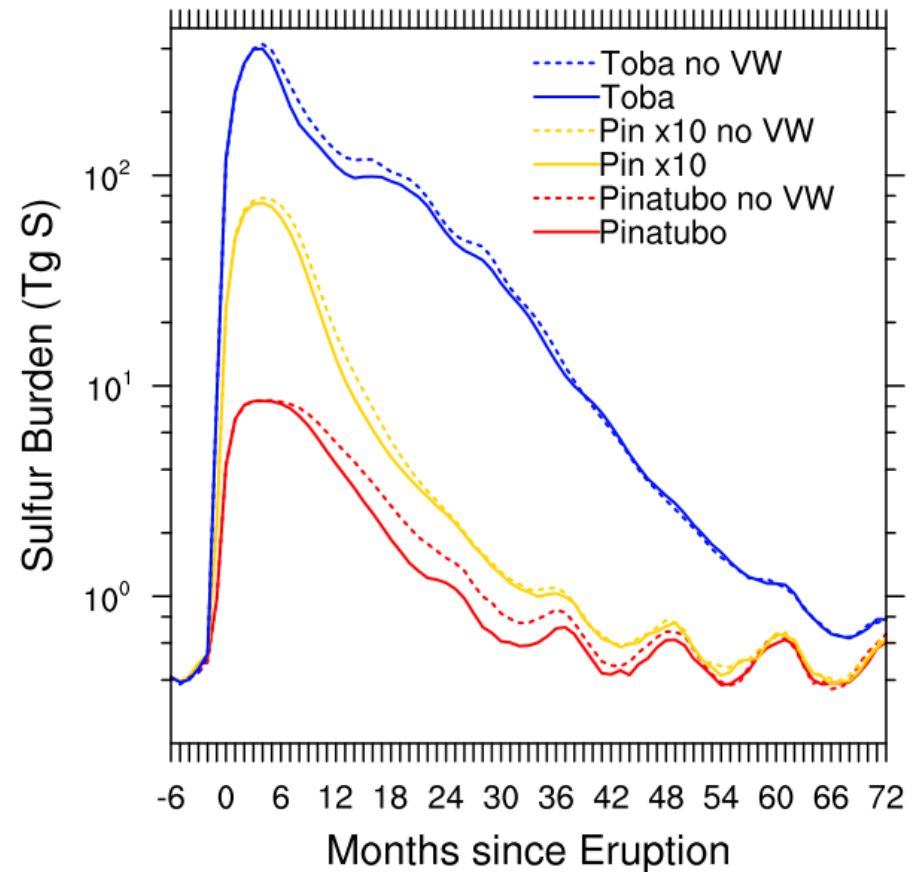
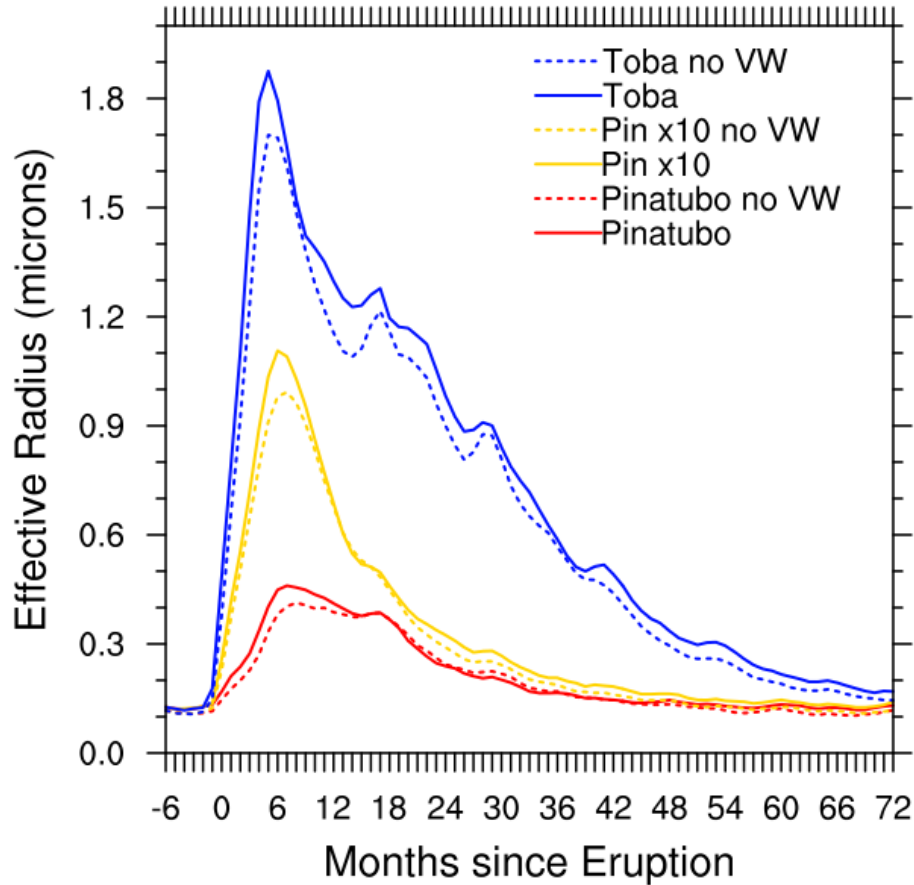


AOD is limited in larger eruptions, esp. when van der Waals forces are included (100x emissions = 20x AOD). Why?



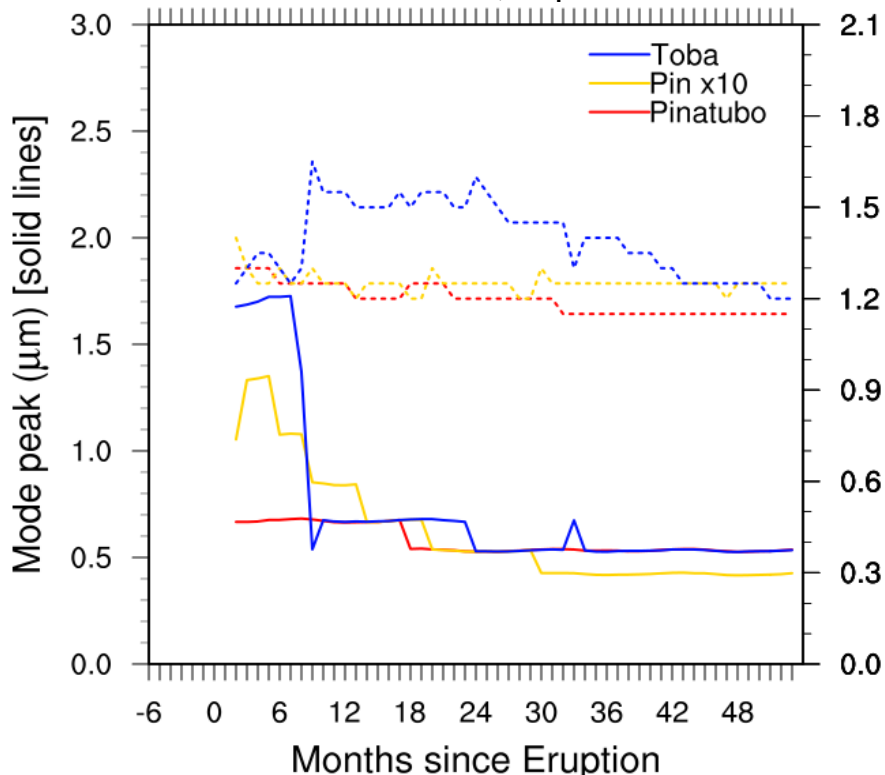
Larger Eruptions have larger particles, limited burdens

Van der Waals forces increases R_{eff}

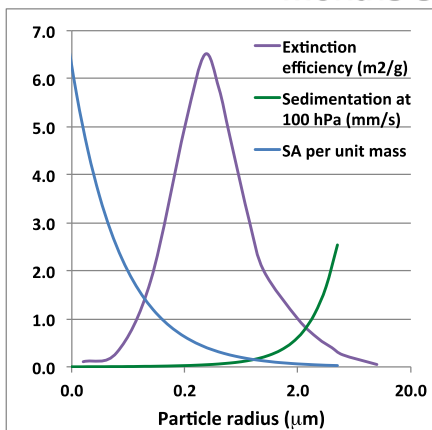
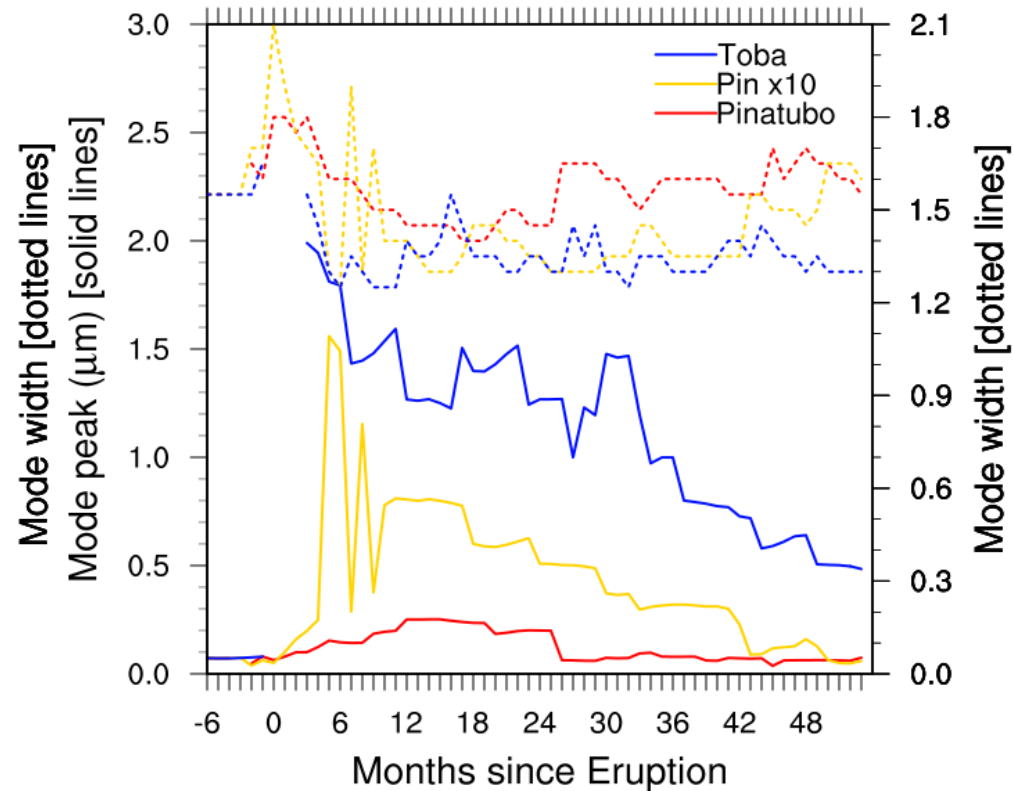


Mode peak size and widths evolve

20-200 hPa; Equator



50-990 hPa; 80-90°S



Comparing Toba Studies	R_{eff}	Mode width
<i>Robock et al., 2009</i> (Bulk)	~0.6 μm (0.45 dry)	1.25
<i>Timmreck et al., 2010</i> (Modal)	0.8 – 1.1 μm	1.2
<i>English et al., 2013</i> (Sectional)	1.1 – 2.2 μm	1.2 - 2.1

Summary

- **Large eruptions have self-limiting radiative effects due to increased particle size***
 - Toba (100x Pinatubo) has only 50x burden; 20x AOD; 5-yr AOD
 - Particle size grows to 2.0 μm ! Contributions from growth vs coag TBD (Van der Waals forces increases size by 25%)
 - Mode widths vary from 1.2 to 2.1; modal models don't allow this to evolve
- **Accurate representation of aerosol processes is critically important to constrain volcanic contribution to:**
 - 20th century temperature trends
 - “Hiatus” over the past 10 years
 - Devastation from super-eruptions

** English, J. M., O. B. Toon, and M. J. Mills (2013), Microphysical simulations of large volcanic eruptions: Pinatubo and Toba, JGR.*