Recovered measurements of the 1960s stratospheric aerosol layer for new constraints for the volcanic forcing in the years after 1963 Agung

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1960s was highly volcanically active after 4 quiescent decades

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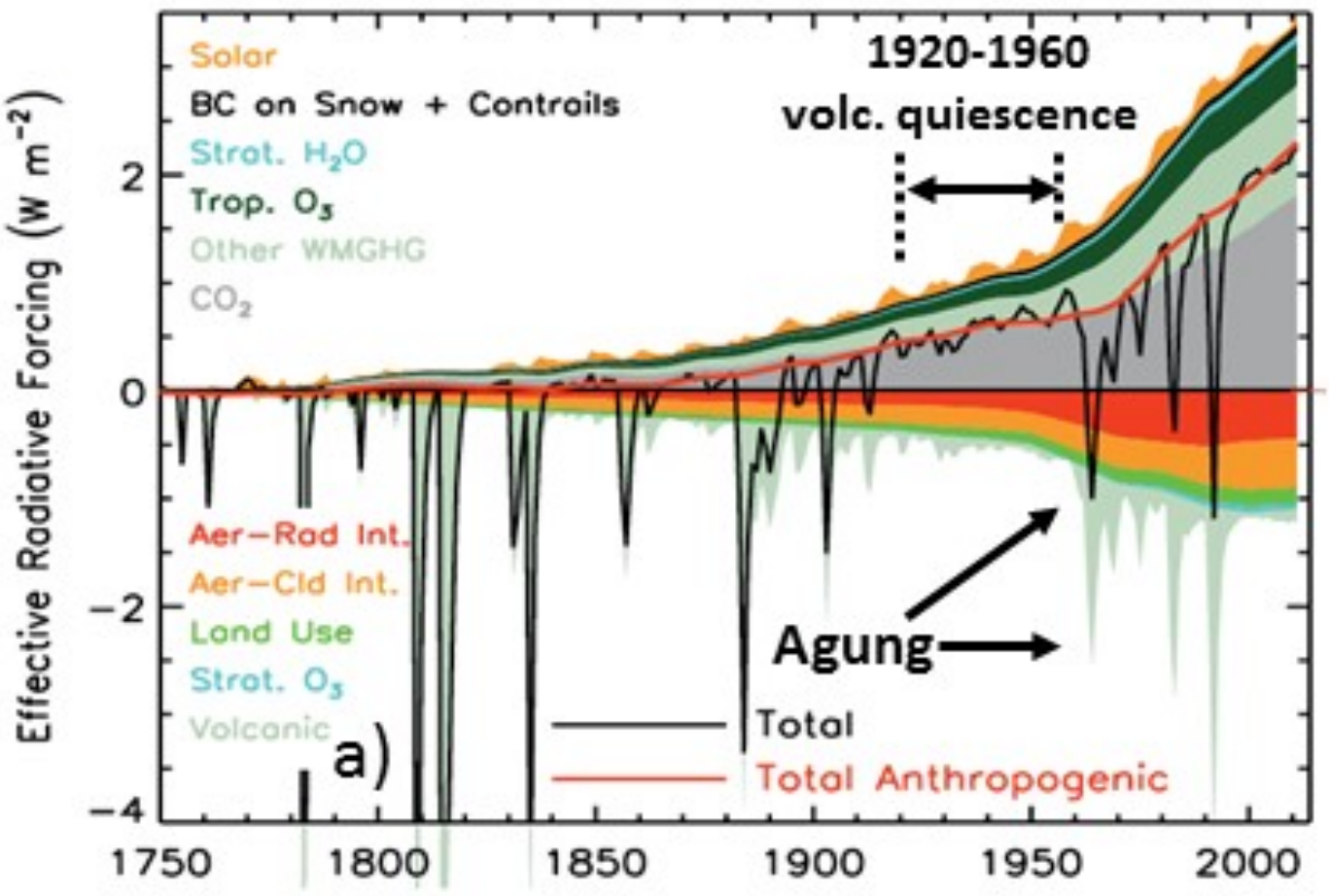
- Major volcanic eruptions are dominant forcing signatures within historical climate change.



- The 1963 Agung eruption (Bali) occurred after 40 years (1920-1960) with very little volcanic activity
- 1960s strongly volcanic decade with tropical strat-injecting eruptions in
  -- September 1965 (Taal, Philippines)
  -- August 1966 (Awu, Indonesia)
  -- June 1968 (Fernandina, Ecuador)
- First in-situ measurements of the stratospheric aerosol layer from balloon (Junge et al., 1961) and the U-2 aircraft (Junge and Manson, 1961)

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Stronger and earlier Agung cooling in CMIP6 than in CMIP5

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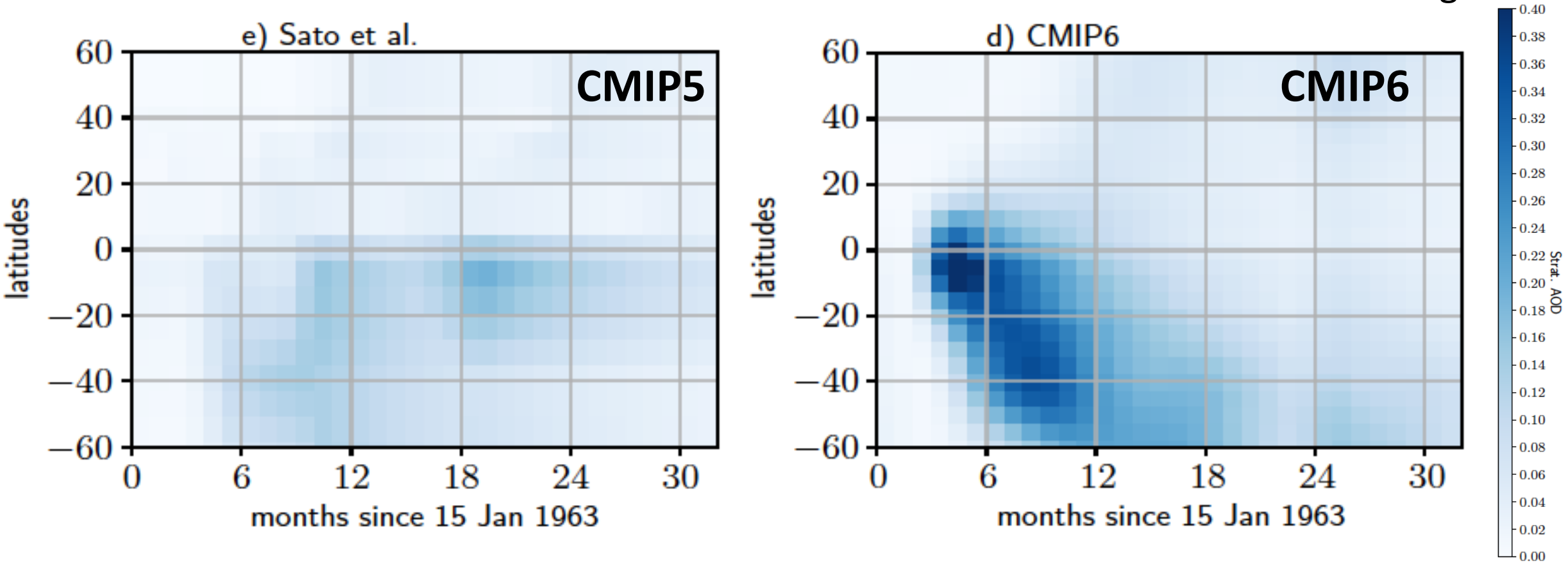
- In CMIP5, most climate models used the Sato et al. (1993) volcanic aerosol dataset, which enacted Agung cooling based on surface radiation measurements (Dyer & Hicks, 1968)
- CMIP6 volcanic aerosol dataset based on ETH 2D-AER interactive strat-aerosol integrations



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“1960s hiatus” in 15-year global surface temperature trends

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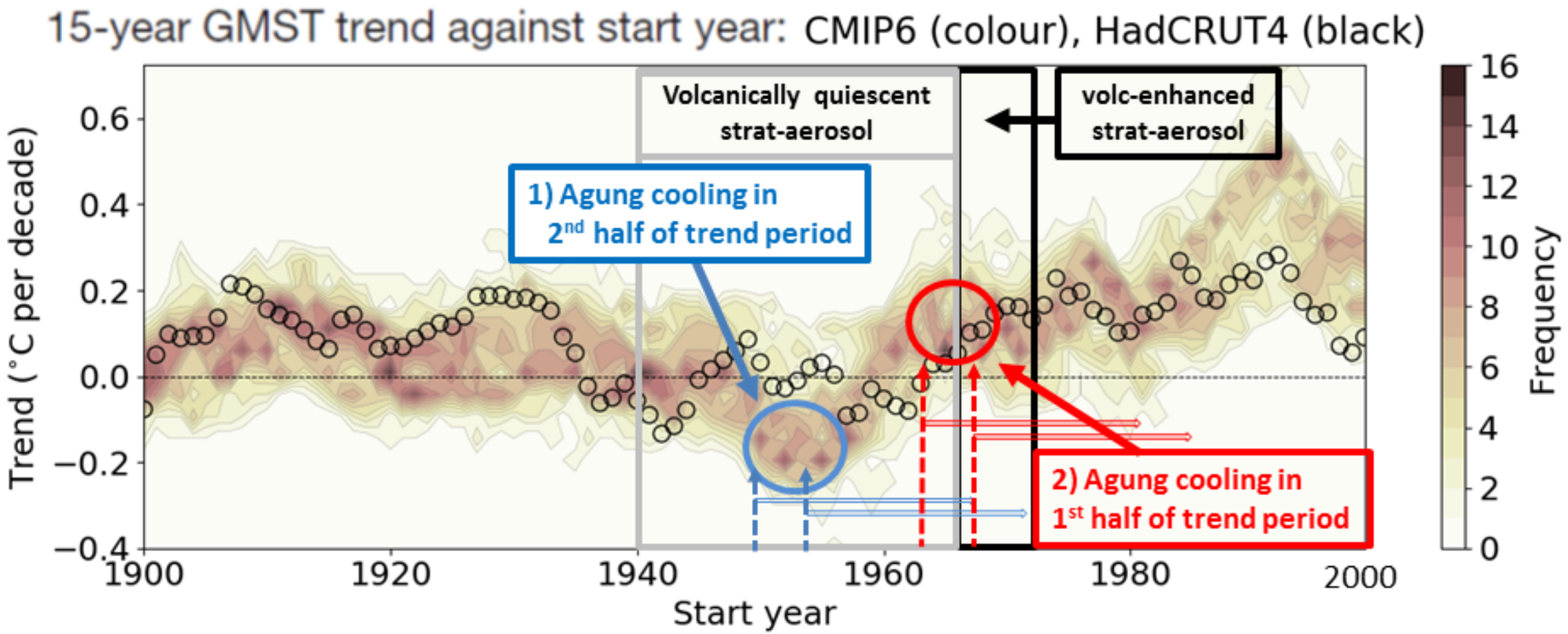

- Marotzke and Forster (Nature, 2015) showed CMIP5 models failed to capture flat 15-year Global-Mean-Surface-Temperature (GMST) trends through 1950-1980 period –potential errors in Agung forcing identified as possible cause or major contributor
- Initial analysis of CMIP6 15-year GMST trends shows problem has got worse for 1950s start years → Agung cooling too strong?

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1960s data recovery within WCRP stratospheric sulphur activity "SSiRC"

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- Current 2nd phase of Stratospheric Sulphur and its Role in Climate (SSiRC) has begun a data rescue of stratospheric aerosol measurements focused on periods after major eruptions. (see http://www.sparc-ssirc.org/data/datarescueactivity.html).
- Initial focus on gap period after 1991 Pinatubo and 1960s in-situ and active remote sensing obs
  -- **Pinatubo** -- ship-borne lidar measurements of tropical Pinatubo plume **July-Sep 1991** from transect of North Atlantic on Russian vessels (Avdyushin et al., 1993)
  -- ground-based lidar from Melbourne, Australia **Jul91 to Mar92** (Young et al., 1994)
  -- airborne lidar from NASA Electra flights in July 1991 (Winker and Osborne, 1992)
  -- **post-Agung** -- 10 dust-sonde flights from Minneapolis in 1963-66 (Rosen, 1964; Rosen, 1968)
  -- ground-based lidar, Lexington, 66 profiles: Jan64- Jul65 (Grams & Fiocco, 1967)
  -- aircraft impactor samples from U-2 global surveys (Mossop, 1964; Friend, 1966)
  -- ground-based searchlight, New Mexico, 99 profiles Dec63-Dec64 (Elterman, 1966)
- Pinatubo ship-borne lidar submitted for doi on PANGAEA archive (https://www.pangaea.de), a paper with data and recovery methodology in review on ESSD (Antuna Marrero et al., 2020)

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1960s measurements: potential to improve Agung forcing and link with ISA-MIP activity for interactive stratospheric aerosol models

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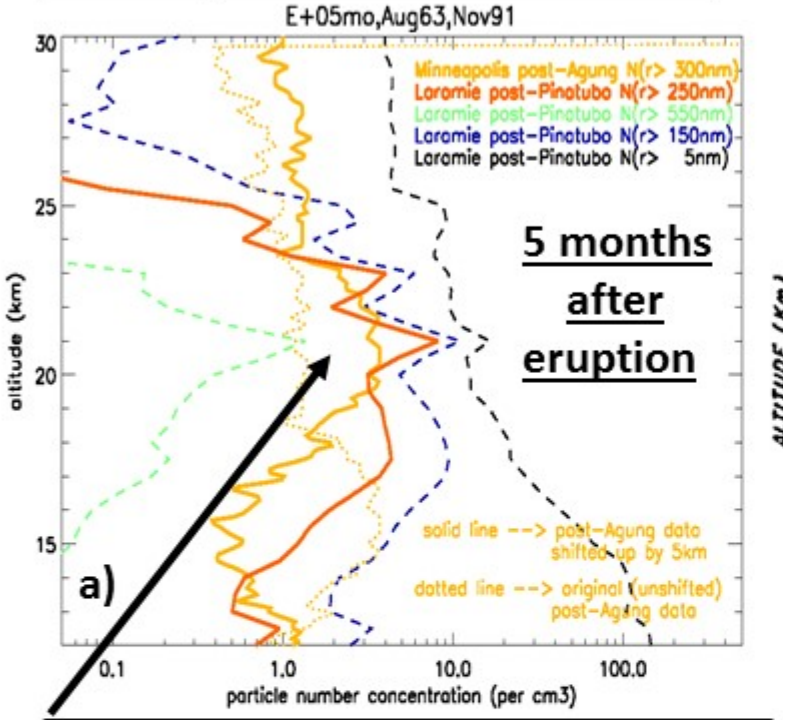
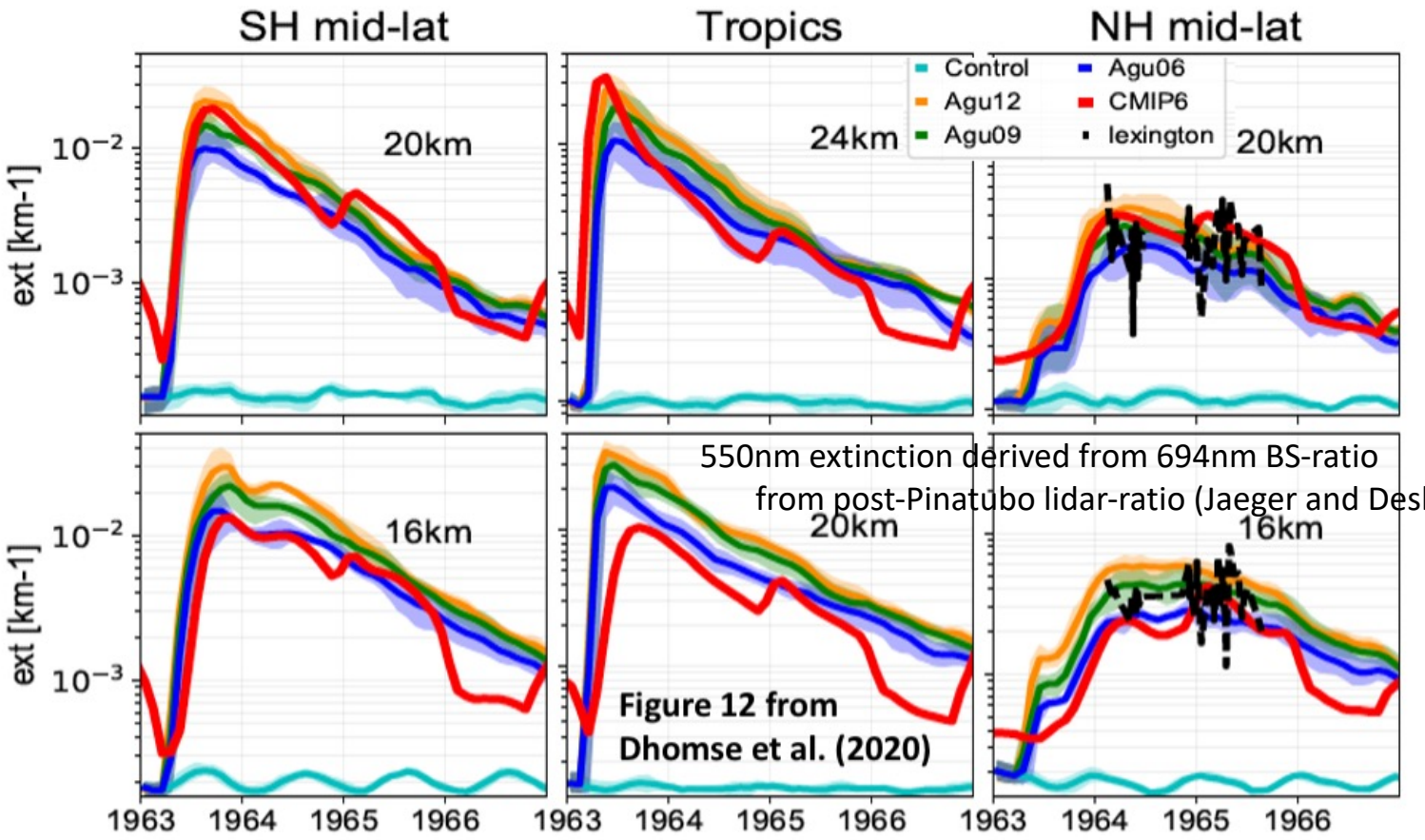
10 balloon particle counter soundings (Minneapolis, 1963-65): enhancement as strong as Pinatubo but shallower



Pinatubo N(r>250nm) from Wyoming (Deshler et al., 1993) and Rosen (1964) **Agung N(r>300nm)** at Minneapolis.



- Already compared CMIP6 dataset and UM-UKCA simulations to Lexington lidar.
- Currently discussing with Jim Rosen re: uncertainty for Minneapolis size cuts, initial calibration, e.g. Aug 1963 for N(r>300nm) and later re-calibration (Pinnick et al., 1973)
- Terry Deshler will also contribute re: size re-calibration and comparisons to model

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