Physicochemical properties of stratospheric sulfate aerosols from the 2022 Hunga Tonga-Hunga volcanic eruption

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Overview

- The eruption of Tonga volcano in 2022 injected about 150Tg of water vapor directly into the stratosphere(Carr et al., 2022; Proud et al. 2022), accounting for **about 10% of the global** water vapor(Millán et al., 2022; Santee et al., 2022; Xu et al., 2022).
- About 0.4-0.5Tg of sulfur dioxide (SO_2) gas was injected into the stratosphere at the same time(Taylor et al., 2022), equivalent to about 1/3 of the emissions of low-latitude volcano Nabro (2011).(Clarisse et al., 2013)
- In this study, we evaluate the microphysical properties of the HTHH aerosols.

Model: CESM/CARMA

- Modeling: CESM coupled with CAMAR

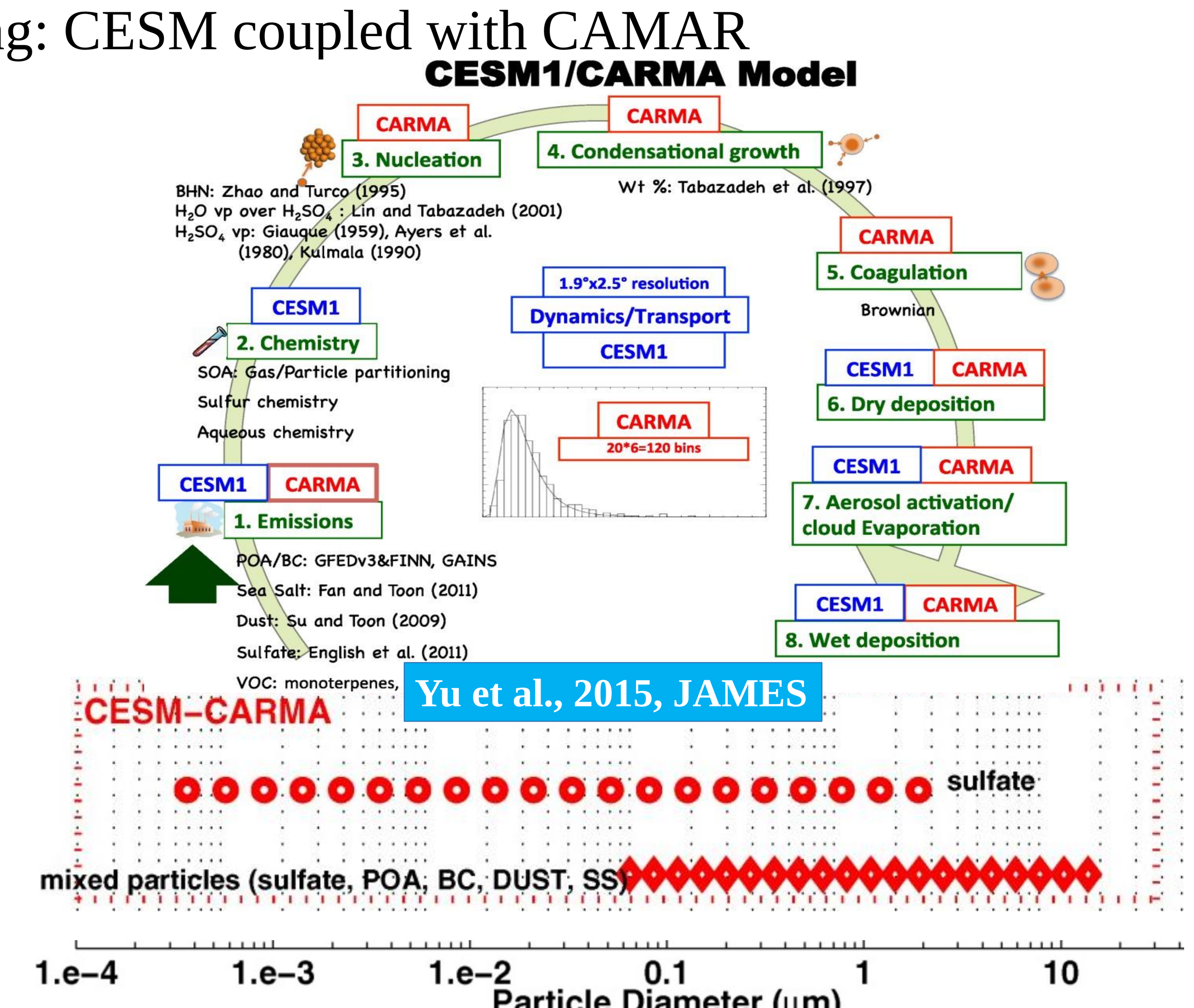

Figure1. CARMA tracks two type of aerosol: pure sulfate and mixed particles (mixed sulfate, organics, dust, sea salt, nitrate) 20 size bins from 0.05 μm to 8.7 μm

- Experiments: 1.Control run ($0TgH_2O$, $0TgSO_2$); 2.Tonga simulation ($150TgH_2O$, $0.42TgSO_2$); 3.SO_2 only ($0TgH_2O$, $0.42TgSO_2$).

Validation of stratospheric aerosol and water vapor

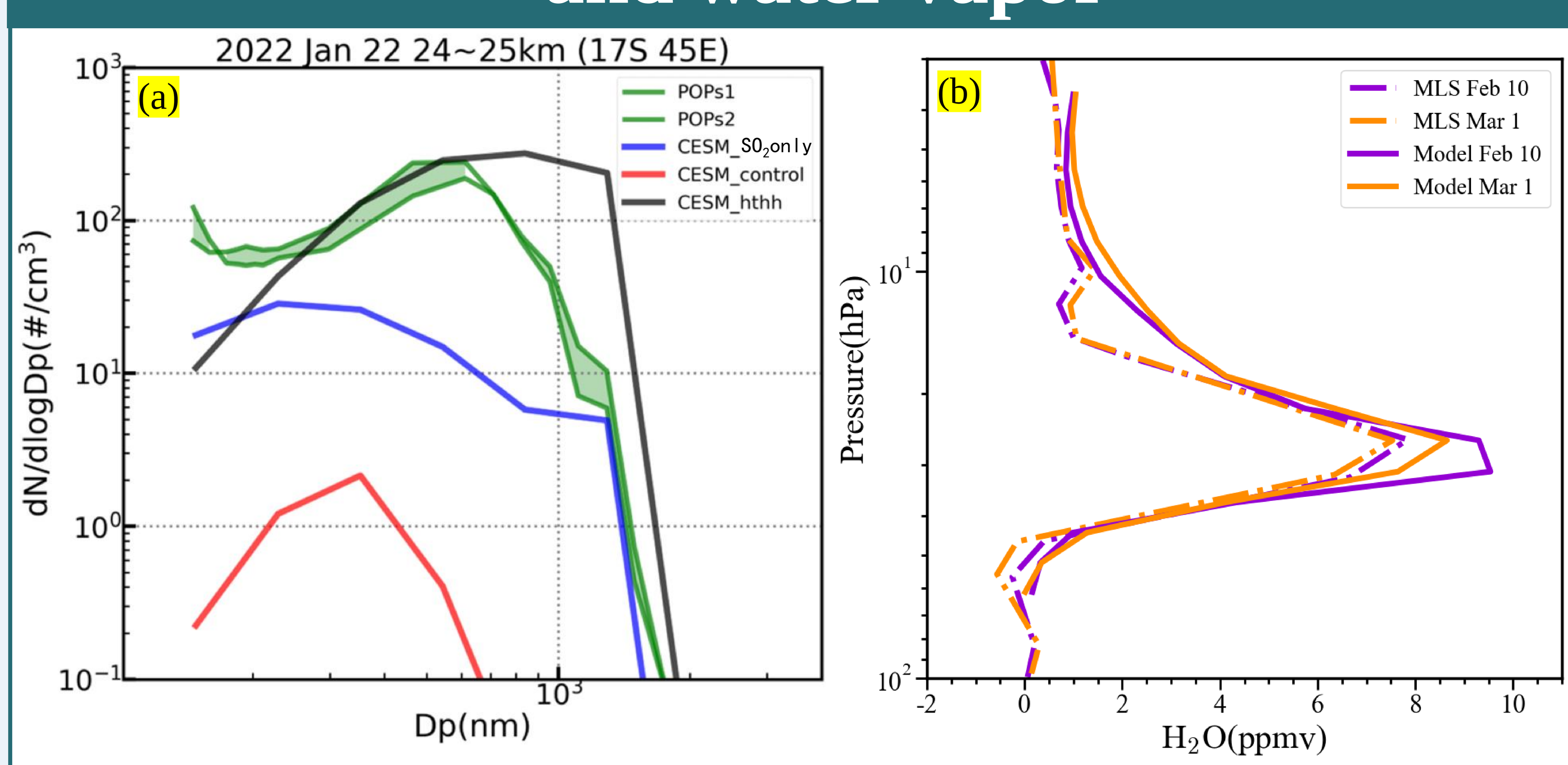

Figure2. (a) The sulfate particle volume size distribution around 24~25km at 17S 45E compared with POPs from La Réunion (21S, 55E) ; (b) The H_2O (water) profile and evolutions after the Hunga Tonga-Hunga Ha'apai eruption. The zonal average H_2O anomaly profiles between 30S–0 on February 10 and March 1, 2022. The solid lines are simulations and the dashed lines are the MLS observations (Zhu et al.,2022).

The impact of enhanced water vapor on sulfate aerosol effective radius

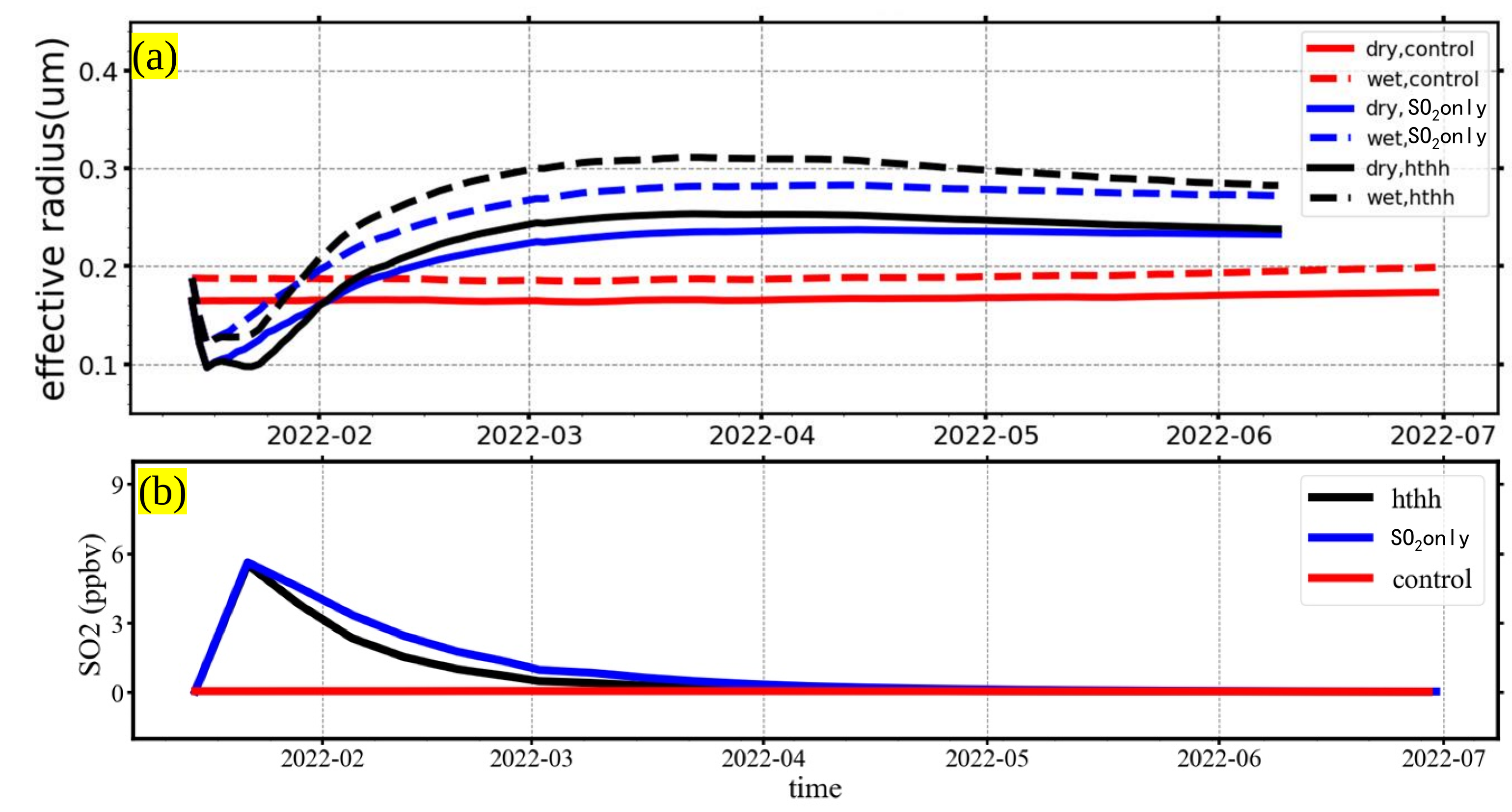

Figure3. (a) The effective particle size of sulfate aerosol in the Tongan volcano increased from 0.4um to 0.6um, consistent with the conclusions Bian et al.,(2023) reached. (b) The water injection significantly shortens the SO_2 lifetime by providing abundant OH (Zhu et al.,2022).

Estimation of particle size from model

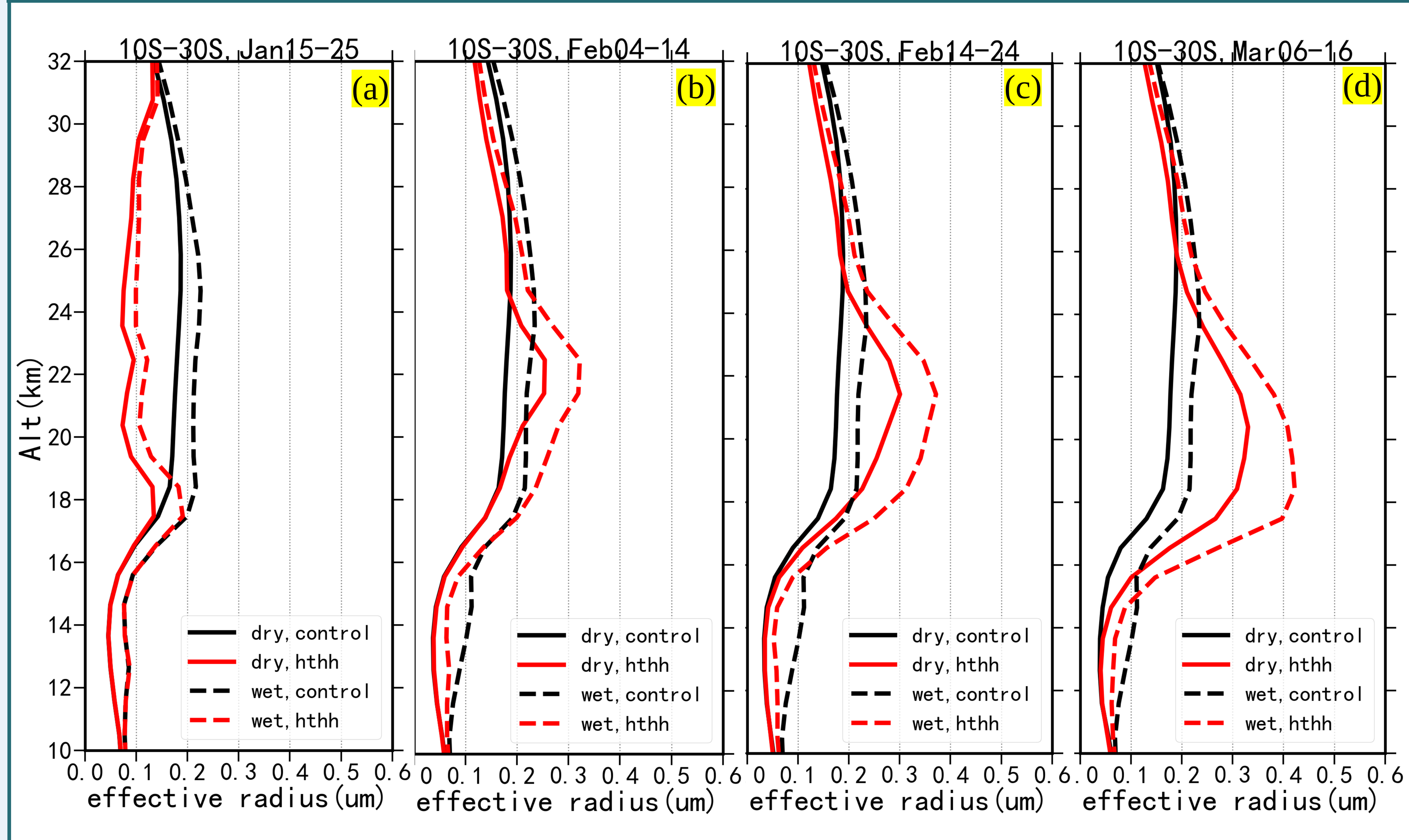

Figure4. Size distributions reveal an abundance of larger particles (0.4um to 0.6um) in parts of the plume above 25 km. This growth is contained primarily between 20 and 26 km, which contains the bulk of the enhanced aerosol. By mid-March the particles have reached their maximum size.

Summary

- Simulated anomalies of sulfate aerosols and H_2O following the HTHH eruption are compared and validated against the satellites and balloon-borne in-situ measurements.
- Science the eruption of the Tonga eruption, the effective particle size of sulfate aerosol increased from 0.4um to 0.6um between 20 and 26 km.
- The physicochemical mechanisms responsible for this phenomenon will be further evaluated.

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