# SUPPLEMENTAL

**Table S1:** Assigned values of κ and density (ρ) for compounds used in the hygroscopicity analysis of CAM-chem model outputs and AMS and SP2 observations. (a: Peng et al. (2017); b: Bond et al. (2013); c: Rose et al. (2010); d: Laborde et al. (2012); e: Fan et al., (2020); f: Sullivan et al. (2009); g: Almeida et al. (2019) and references therein; h: Hersey et al. (2013); i: Pöschl et al. (2019); j: Dusek et al. (2010); k: Aldaif et al. (2018); l: Schulze et al. (2020); m: Chang et al. (2010); n: Kawana et al. (2016); o: Petters and Kreidenweis (2007); and p: Ren et al. (2022).

| Species | κ | ρ (g cm$^{-3}$) |
|---|---|---|
| **Black Carbon (Aged)** | 0.035 [a] | 1.8 [b] |
| **Black Carbon (Primary)** | 0.00 [c,d] | 0.45 [e] |
| **Dust ($AlSiO_3$)** | 0.001 [f] | 3.8 |
| **NaCl** | 1.24 [g] | 2.16 |
| **Organics (Aged)** | 0.10 [h,i,j] | 1 [k] |
| **Organics (Primary)** | 0 [l] | 1 [k] |
| **Secondary Organic Aerosol ($C_{15}H_{38}O_2$)** | 0.15 [m,n] | 1.4 |
| **Sulfate as Ammonium Sulfate ($(NH_4)_2SO_4$)** | 0.61[o] | 1.77 |
| **Sulfate as Ammonium Bisulfate ($NH_4HSO_4$)** | 0.56 [p] | 1.78 |

## S1. CAM-chem Model Configuration

The Community Atmosphere Model coupled with chemistry (CAM-chem) is a component of the Community Earth System Model (CESM2.2) that represents the dynamics, physics, and chemistry of the atmosphere. The Multi-Scale Infrastructure for Chemistry and Aerosols (MUSICA) is a configuration of CAM-chem, it is a next generation unified infrastructure to study atmospheric chemistry at different horizontal grid resolutions. It is community-built, open-source, flexible, and computationally efficient. MUSICA uses a modular approach within a unified framework to represent aerosol and gaseous chemistry at smaller scales, where exposures are significant, while being able to simulate their effects at a larger scale, such as on radiation which is important for climate.

For the simulations performed here, CAM-chem is fully coupled to the land and prescribes observed sea-surface temperatures and sea-ice. CAM-chem includes comprehensive tropospheric and stratospheric chemistry (Emmons et al., 2020). CAM-chem includes the Modal Aerosol Model (MAM4) and a Volatility Basis Set description with gas-phase SOA precursors (VBS-SOA) to simulate secondary organic aerosols (Tilmes et al., 2019; Emmons et al., 2020; and references therein).

MAM4 has four aerosol modes: Aitken, accumulation, coarse, and primary carbon which considers elemental and organic carbon aging (Liu et al., 2016). Köhler theory is used to determine water uptake and wet diameter in the troposphere from the relative humidity and volume mean hygroscopicity per mode, and through which, with altitude information, the gravitational settling velocities can be calculated. Information on how MAM4 treats nucleation, coagulation, condensation, and evaporation in general, as well as water uptake and settling velocity calculations from are described by Liu et al., (2016) and Liu et al., (2012).

The Volatility Basis Set (VBS) models organic aerosol evolution by categorizing organic aerosol particles by their volatilities, which affects their partitioning and condensation characteristics (Hodzic et al., 2016). VBS-SOA includes a comprehensive parameterization which includes updated removal mechanisms and the interaction of SOA with biogenics. This enables the identification of SOA precursors from biomass burning, anthropogenic sources, and biogenic emissions. Details about VBS-SOA can be found in Tilmes et al. (2019).

Here, we are evaluating different horizontal resolutions of CAM-chem and MUSICA version 0 where both employ a spectral element (SE) dynamical core that allows regional refinement for up to 0.0625º from its default 1º (~111 km) resolution in a specified region of the world. The available regional refined grids were created by users for a variety of applications. We used a 1º base grid resolution (ne30) and a 0.25º (ne30x4) regionally refined output grid (which we label MUSICA) for East Asia that was developed at the NSF National Center for Atmospheric Research (NCAR)/Atmospheric Chemistry Observations and Modeling Laboratory (ACOM).

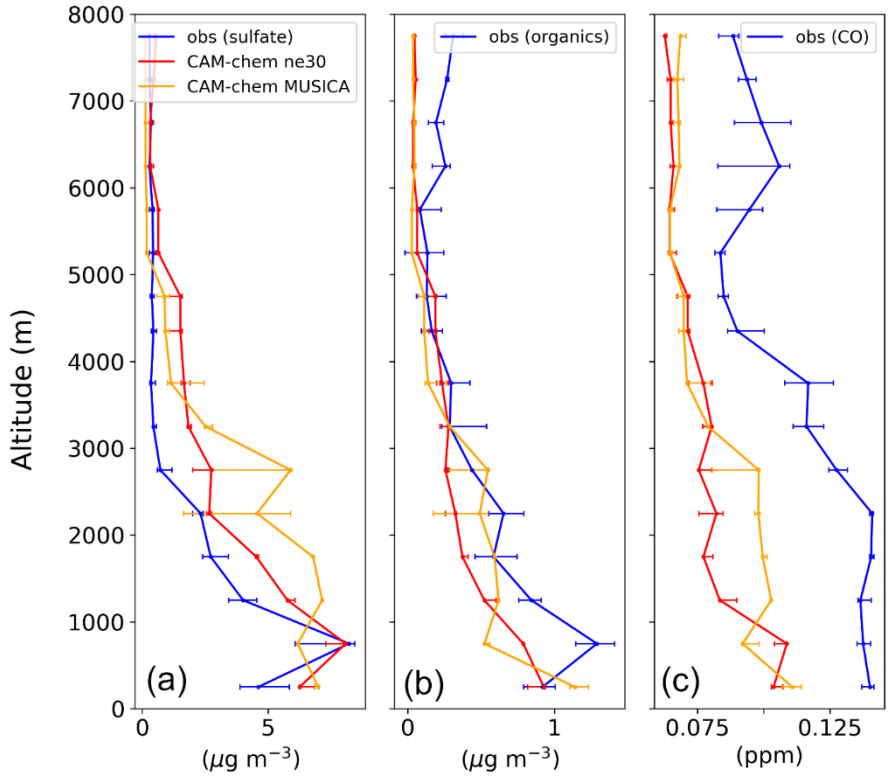


**Figure S1.** Vertical profiles of observed data (01:53 to 06:20 UTC) and CAM-chem model outputs (06:00 UTC) for ne30 ~1° and MUSICA 0.25° grids for the tropical cyclone-induced convection case on 20 September 2019 at 500 m intervals. (a) Submicron aerosol mass concentration for $SO_4^{2-}$ and $NH_4^+$ from AMS data and CAM-chem output sulfate ($NH_4HSO_4$), (b) submicron aerosol mass concentration for organics from AMS data and CAM-chem, and (c) total CO concentration from observations and CAM-chem. The lines correspond to the median values of data in the given altitude intervals and the bars correspond to the 25$^{th}$ and 75$^{th}$ percentile values.

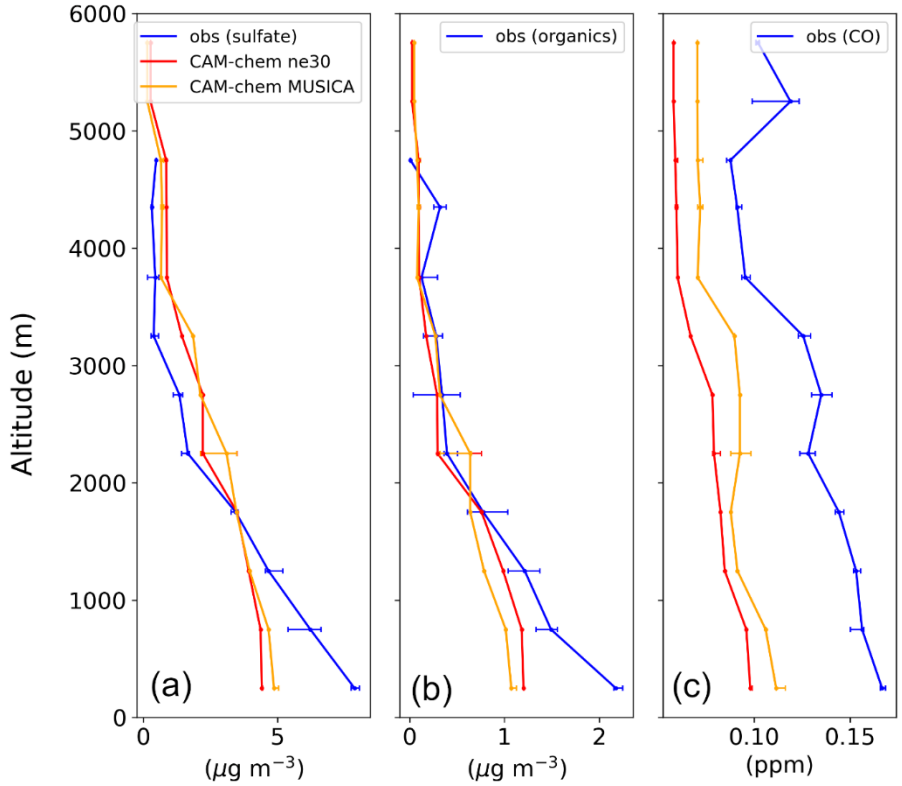


**Figure S2.** Vertical profiles of observed data (02:55 to 06:02 UTC) and CAM-chem model outputs (06:00 UTC) for ne30 ~1° and MUSICA 0.25° grids for the shallow convection case on 24 September 2019. (a) Submicron aerosol mass concentration for $SO_4^{2-}$ and $NH_4^+$ from AMS data and CAM-chem output sulfate ($NH_4HSO_4$), (b) submicron aerosol mass concentration for organics from AMS data and CAM-chem, and (c) total CO concentration from observations and CAM-chem. The lines correspond to the median values of data in the given altitude intervals and the bars correspond to the 25$^{th}$ and 75$^{th}$ percentile values.