**Improving the E3SMv1 Representation of the Stratospheric Aerosol Forcing Induced by Volcanic Eruptions**

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**Abstract**

An Earth system model (ESM) is desired to simulate the impact of volcanic eruptions and geoengineering injections on climate. To achieve this goal, the ESM needs to accurately simulate the stratospheric sulfur cycle and the evolution of sulfate aerosol with an affordable computational cost. We developed a 7-mode version of the Modal Aerosol Module for Stratosphere (MAM7S) and improved the MOZART gas chemistry in the Energy Exascale Earth System Model version 1 (E3SMv1). The MAM7S is based on the default E3SMv1MAM4 and is added with three new modes: stratospheric Aitken mode, stratospheric accumulation mode, and stratospheric coarse mode. In the MOZART gas chemistry, we altered the original two-step sulfur dioxide gas oxidation reaction to two single-step reactions to correct the bias in the OH-HO2 radical cycle. To test the model performance, E3SMv1 with MAM7S (E3SM-MAM7S) is used to simulate the stratospheric sulfate aerosol evolution after the Mt. Pinatubo eruption on June 15, 1991, which is the strongest volcano eruption in the satellite era. The model results are compared to satellite data and the NCAR Whole Atmosphere Community Climate Model version 6 (WACCM6) results. The simulated stratospheric sulfur dioxide and sulfate aerosol burdens agree well with satellite observations and WACCM results, while the E3SM-MAM7S model corrects the large dust bias in WACCM6 that is due to the use of a single coarse aerosol mode to represent both tropospheric coarse aerosols (e.g., dust) and stratospheric coarse sulfate aerosols. The impact of stratospheric sulfate aerosols on radiative budget in E3SM-MAM7S is also analyzed.