**Improving the representation of ultra-fine aerosols in the E3SM atmosphere model**

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**Abstract**

New particle formation happens frequently in the troposphere. It can directly affect the aerosol lifecycle and has the potential to change the cloud and precipitation properties indirectly. The newly formed particles are often very small, so including a nanometer-scale size bin or nucleation mode is critical to better represent these ultra-fine particles and their impact on aerosol lifecycle and radiative forcing in global aerosol models. In this work, we add a nucleation mode to the Modal Aerosol Module (MAM) used in the atmospheric component of the Energy Exascale Earth System Model (E3SM). The lower bound of geometric mean dry diameter of aerosols is extended from 8.7 nm in the default model to 1 nm. The condensational growth (including the impact of secondary organic aerosols), coagulation, and other important physical processes of ultra-fine particles are now explicitly simulated. Nudged hindcast simulations are carried out for years 2016-2018 to compare with aerosol size distribution data from recent Atmospheric Radiation Measurement (ARM) campaigns as well as conventional datasets. Preliminary evaluations show that with the new nucleation mode, E3SM can better simulate the aerosol number and size distribution below 10 nm, which is largely underestimated in the default model. The impact of this new feature on the anthropogenic aerosol forcing will also be discussed.