**New development and evaluation of E3SM-MOSAIC: Spatial distributions and radiative effects of nitrate aerosol**

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Nitrate aerosol plays an important role in regional air quality as well as the Earth’s climate system. We incorporate the Model for Simulating Aerosol Interactions and Chemistry (MOSAIC) module in the Energy Exascale Earth System Model version 1 (E3SMv1) to treat nitrate aerosol and its environmental and climatic effects. We first enable the Model for Ozone and Related chemical Tracers (MOZART) family of chemical mechanisms, originally developed for the Community Atmosphere Model version 5 with chemistry (CAM5-Chem), in the E3SMv1 Atmosphere Model (EAMv1). We then couple MOSAIC with the four-mode modal aerosol module (MAM4) and atmospheric chemistry in EAMv1. By comparing against ground observations and corresponding results from the Community Earth System Model version 2 (CESM2), we find that E3SM-MOSAIC performs reasonably well in simulating spatiotemporal distributions of nitrate aerosol with a relatively large global annual mean burden (0.38 Tg). However, E3SM-MOSAIC (using the default MAM4) produces a strong cloud radiative effect of -1.13 W m-2 associated with nitrate aerosol. After we add a treatment of Aitken-mode dust in the model, the cloud radiative effect significantly drops to -0.36 W m-2 and agrees well with CESM2 (-0.33 W m-2). Inclusion of Aitken-mode dust substantially reduces the gas-aerosol exchange of nitrate within the Aitken mode, which then changes the mass fraction of nitrate in both accumulation and coarse modes and reduces the total number of cloud condensation nuclei. The global annual mean burden of nitrate decreases to 0.27 Tg in the new simulation.