Quantifying the structural uncertainty of the aerosol mixing state representation in MAM4

Category

General topics – Aerosols

Authors

Zhonghua Zheng University of Illinois at Urbana-Champaign; Matthew West University of Illinois at Urbana-Champaign; Jeffrey Curtis University of Illinois at Urbana-Champaign; Po-Lun Ma Pacific Northwest National Laboratory; Xiaohong Liu Texas A&M Universi

Description

Aerosol mixing state is an important emergent property that affects the aerosol radiative forcing and aerosol-cloud interactions, but it has not been easy to constrain this property globally. Our study aims to verify the global distribution of aerosol mixing state represented by four-mode version of the modal aerosol module (MAM4) that is used in E3SM and CESM. We defined three aerosol mixing state indices that describe (1) the mixture of optically absorbing and non-absorbing species (χo), (2) the mixture of primary carbonaceous and non-primary carbonaceous species (χc), and (3) the mixture of hygroscopic and non-hygroscopic species (χh). These mixing state indices were used to assess CESM-MAM4 as compared with benchmark simulations from the particle-resolved stochastic aerosol model PartMC-MOSAIC. A machine learning surrogate model is used to emulate the PartMC-MOSAIC results. We show that CESM-MAM4 and PartMC-MOSAIC produce up to 70% different values of χ. The difference appears to be zonally structured, with the modal model predicting a more internally mixed aerosol at low latitudes, and a more externally mixed aerosol at high latitudes. Our study quantifies potential model bias in simulating mixing state in different regions, and provides insights into potential improvements to model process representation for a more realistic simulation of aerosols.