



Evaluating the E3SM and CESM simulations of aerosols and CCN with the ACE-ENA campaign and ARM ground-based observations

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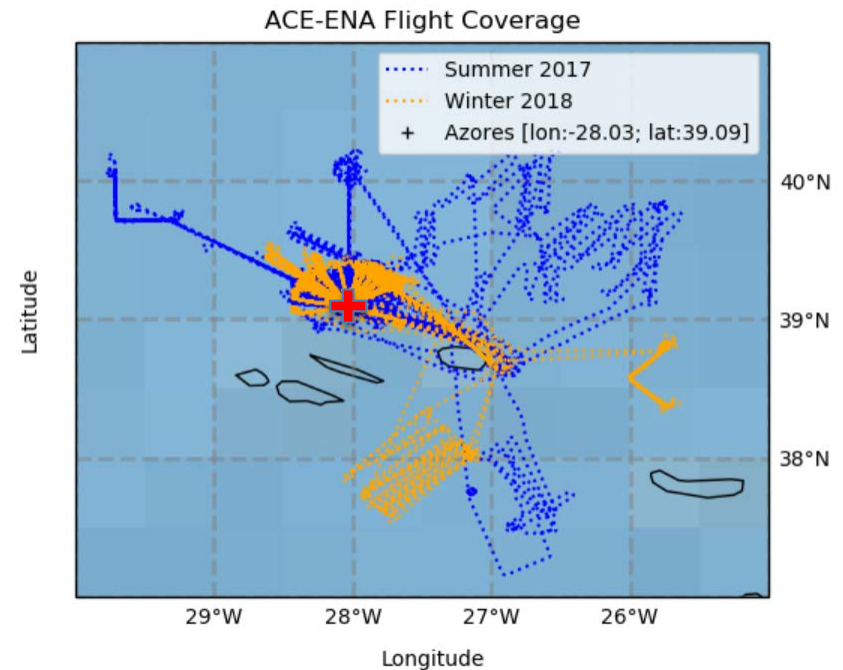
Objectives

Model Evaluation and Process Studies:

- Evaluating and improving the representation of MBL aerosol and CCN in GCMs using “nudged” or “specified” meteorology.
- Examining aerosol and CCN budget and processes driving the vertical structure and mesoscale variation of aerosol and CCN using validated/constrained GCM simulations.

Model and Data

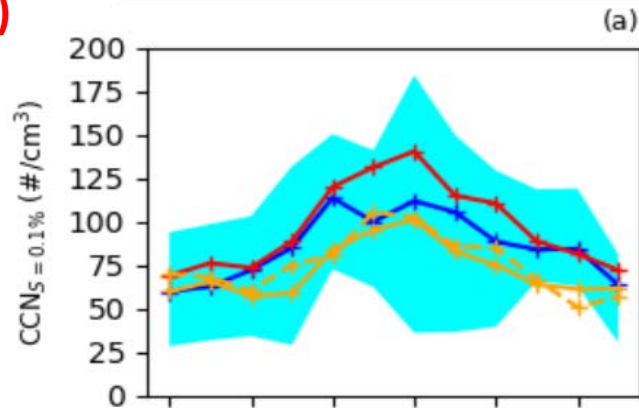
- DOE Energy Exascale Earth System Model version 1 (E3SM), using “nudged” meteorology from 2014-2017
- NCAR Community Earth System Model version 2 (CESM), using “nudged” meteorology from 2014-2017 and also “climatology”
- Surface observations at ENA: CCN (0.1% and 0.2%) from 2014 to present, and aerosol number and composition (e.g., sulfate and organics) from 2014-2016
- Aircraft observations during ACE-ENA field campaign: CCN and composition in 2017 June/July and 2018 January/February



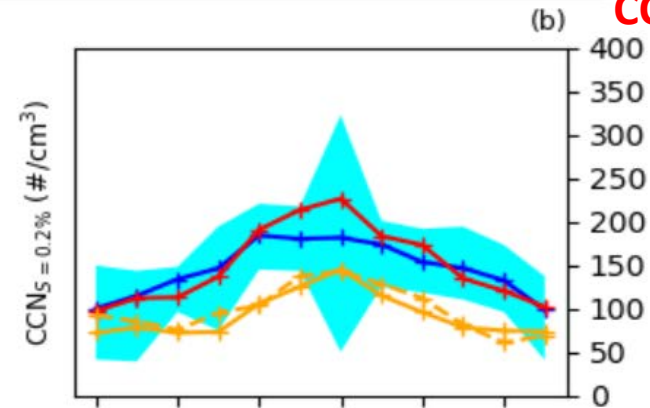
Seasonal variation of surface CCN and aerosol number

— Observation — E3SM nudging — CESM nudging — CESM climatology

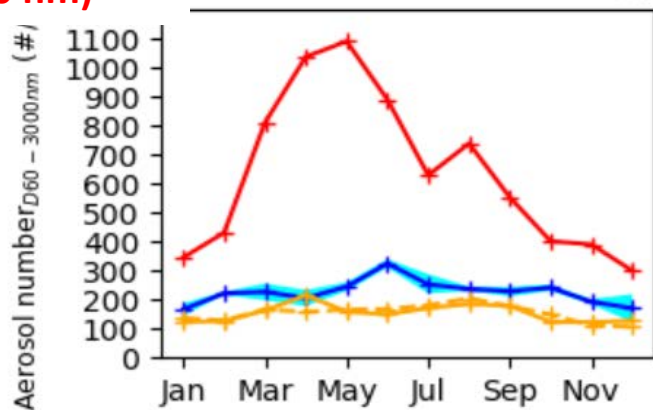
CCN (SS = 0.1%)



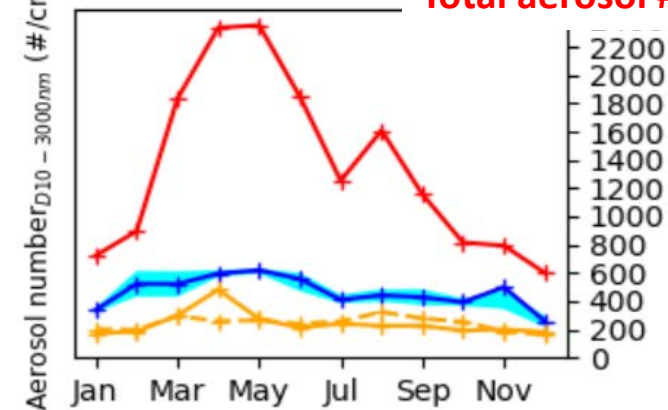
CCN (SS = 0.2%)



Aerosol # (D > 60 nm)

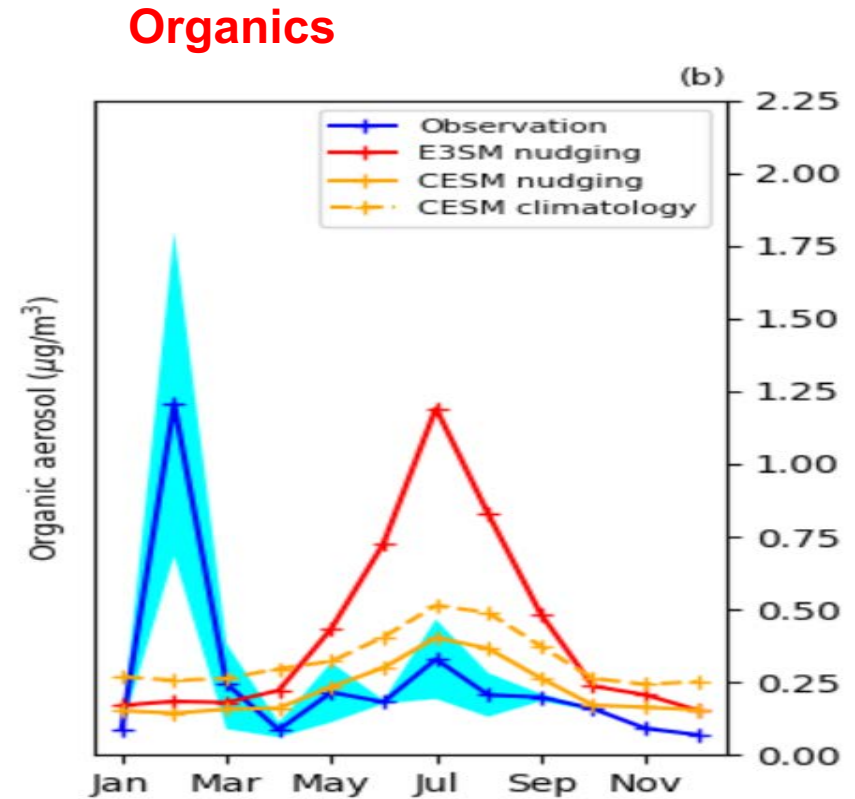
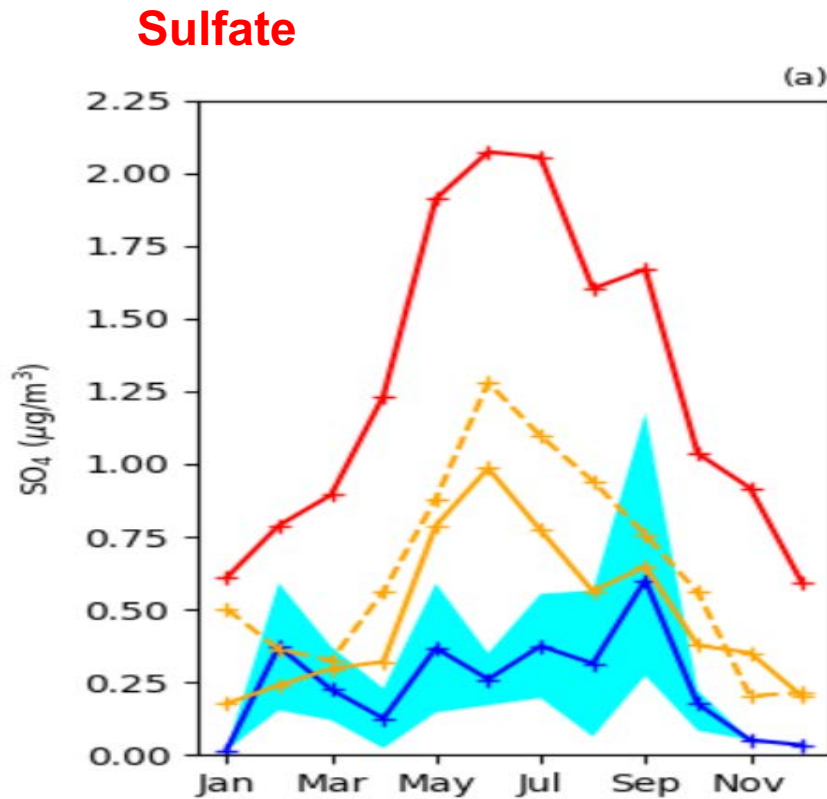


Total aerosol # (D > 10 nm)



- Models capture observed magnitudes and seasonal variations of CCNs (0.1% & 0.2%). E3SM has higher CCN concentrations than CESM
- Models have large biases in simulating number concentrations of smaller particles with E3SM strongly overestimating and CESM underestimating observations

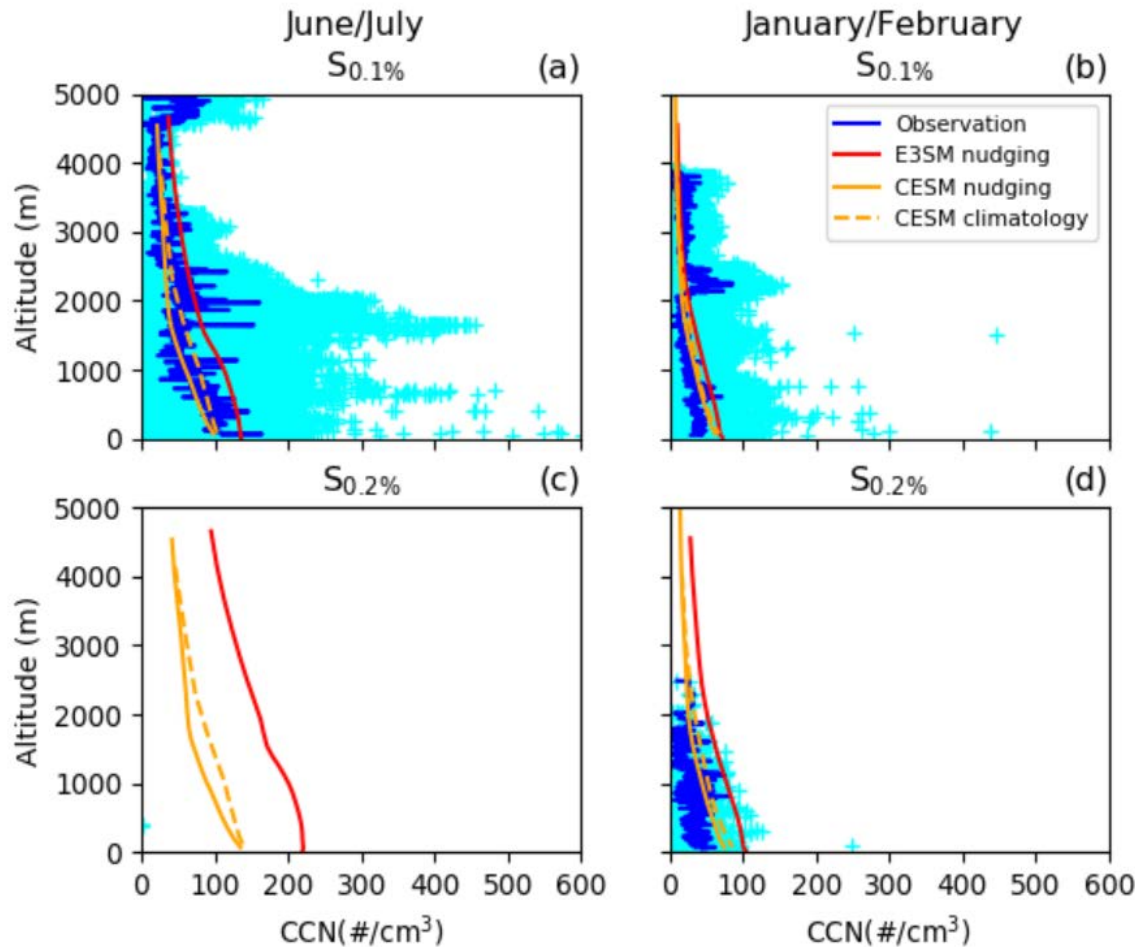
Seasonal variation of surface aerosol composition



- E3SM strongly overestimates and CEM3 slightly overestimates observed sulfate and organics

Comparison of CCN with aircraft observations during ACE-ENA

CCN (SS = 0.1%)

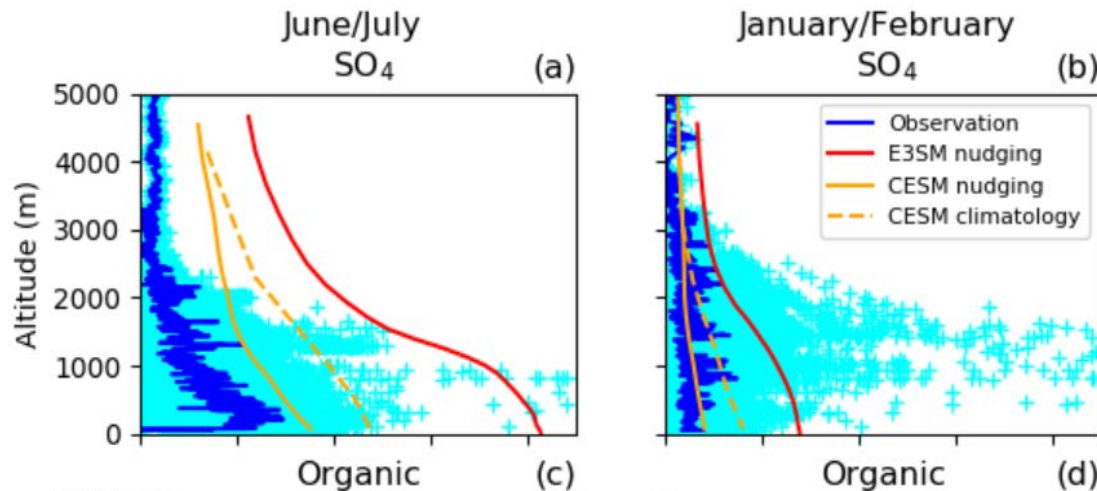


CCN (SS = 0.2%)

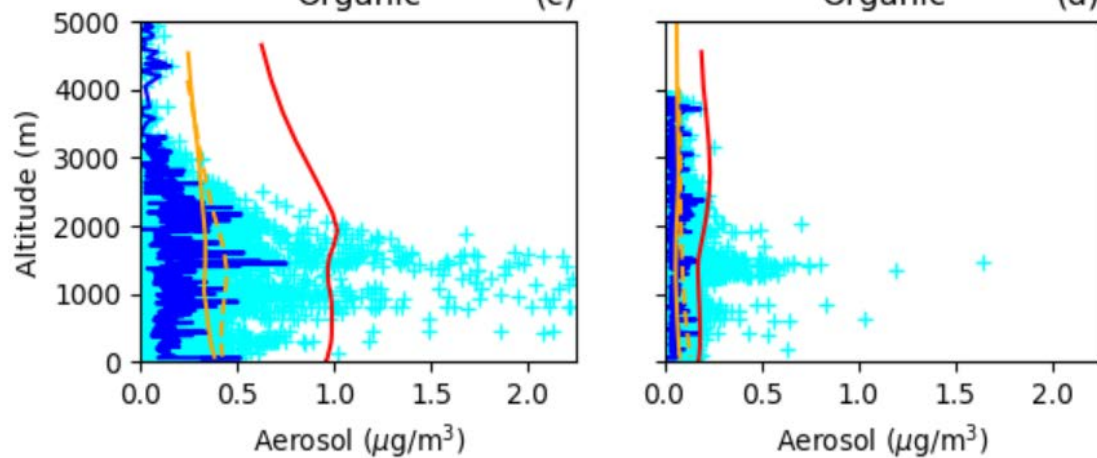
- Model captures the vertical profiles and seasonal variations of CCN (0.1%), consistent with surface site observations

Comparison of aerosol composition with aircraft observations during ACE-ENA

Sulfate



Organics



- Models overestimates observed vertical distributions of sulfate and organics with E3SM much higher than CESM, consistent with surface site observations

Summary

- Models capture observed magnitude, seasonality, and vertical profile of CCN (0.1% and 0.2%) based on comparison with surface site and aircraft observations.
- However, models have large biases in simulating number concentrations of smaller particles, and aerosol composition (sulfate and organics). E3SM significantly overestimates observations both at surface and high elevations.

Future work

- Understand aerosol processes responsible for large model biases (e.g., SO₂, organics, biomass burning emissions at surface for CESM2 while E3SM emits at high elevations)
- Conduct analysis of CCN budget over ENA site