1. Abstract

Aerosol interactions with water control the evolution of optical properties and their cloud condensation nuclei activity that affect the Earth’s radiative budget. Water uptake increases light scattering by aerosol growth, absorption by black carbon by lensing, cloud reflectivity, and lifetime and aerosol scavenging with competing effects on climate forcing. Model parameterizations must capture process details including composition of fresh emissions and the evolution of mixing state as they age. We report laboratory studies of fresh biomass burning smoke from Southwest US fuels. We measured a suite of aerosol properties with a focus on aerosol light extinction and their hygroscopic response. While optical properties were strongly dictated by the flaming versus smoldering nature of the burn, we find that aerosol hygroscopicity is intimately linked to fuel type and its ion content. We also analyzed the treatment of aerosols by the global CAMChem model. In particular, sensitivity of BC in MAM4 where it is transferred from the Aitken to the accumulation mode after accumulating 8 monolayers of material on aging is evaluated by varying this threshold from from 1 to 12 monolayers. We compare the timescales of this BC conversion in CAMChem that range from hours to several days to those in a more detailed BC mixing-state model PartMC MOZAIc. We examine the effects of parameters on global distributions of BC to assess their importance and develop a strategy to constrain them with field data.

2. Experimental Methods

Light scattering by particles was measured using a controlled RH nephelometry system (EcoTech Aurora, 450 nm). Smoke emissions were sampled under a fume hood through a cyclone into 9-gallon stainless steel mixing chambers with minimal dilution. Smoke emissions were sampled under a fume hood through a cyclone into 9-gallon stainless steel mixing chambers with minimal dilution. Light scattering by particles was measured using a Choke Chamber (Ecotech Aurora, 450 nm). Smoke emissions were sampled under a fume hood through a cyclone into 9-gallon stainless steel mixing chambers with minimal dilution.

3. Results: Scattering f(RH)

Evidence of particle collapse with RH: Pines, junipers, evergreens show low hygroscopicity.

4. Results: Fuel Chemistry

Hygroscopicity driven by large fuel inorganic content

5. Predictive Framework

Hygroscopicity is driven by:
1) Fuel inorganic content is key
2) Rules on smoke hygroscopicity:
   - More Inorganic > Less Inorganic
   - Flaming > Smoldering
   - Leaves > Woods and Barks
   - Deciduous > Evergreen
   - Invasives > Natives

6. Assess BC Aging Mechanism in CAMChem

Goal: Assess Aging in CAMChem & PartMC MOSAIC

CAMChem uses mechanistic aging rates, very sensitive to the choices of assumed parameters.

Particle resolved model (PartMC-MOSAIC) estimates BC aging timescales more precisely by tracing the mass and composition of individual particles.

PartMC-MOSAIC parameterization of BC’s aging can be applied to the output of CAMChem model to assess the accuracy of its aging criterion.

The equivalent of 8-monolayers of sulfate is needed to transfer material from the primary carbon mode (fresh) into the accumulation mode (aged).

7. Sensitivity to Monolayer Criterion

Fuel vs. hygroscopicity: Large Range

Relative difference in BC Burden: Invasives > Natives

Arctic Annual BC Direct Forcing

CAMChem vs PartMC aging timescale

8. Results: BC Models

- BC burden is most sensitive to aging criterion in the high-latitude regions.
- Aging timescales range from less than one hour to several days.
- Condensation of SOA and sulfate plays a dominating role in BC aging, compared to coagulation.
- MAM4 aging timescales are broadly consistent with PartMC-MOSAIC aging timescales.