R: Updates on treatments of aerosol, cloud, and light-absorbing particles in snow/ice

Hailong Wang, Richard Easter, Kai Zhang, Balwinder Singh, Yun Qian, Phil Rasch
Pacific Northwest National Laboratory

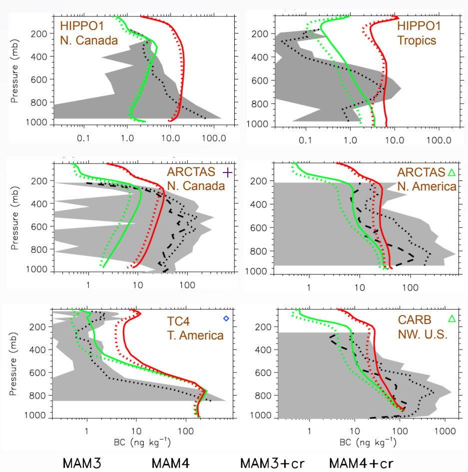
Aerosol resuspension

Objective:
Improve the MAM treatment of the release of scavenged aerosol material from evaporating raindrops

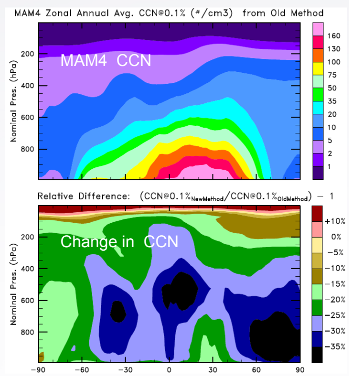
Approach:
Raindrops contain many cloud drops and their CCN, and release a single large (coarse mode) particle when evaporating. The original MAM treatment that releases particles back to their originating mode was revised to this more physically-based treatment.

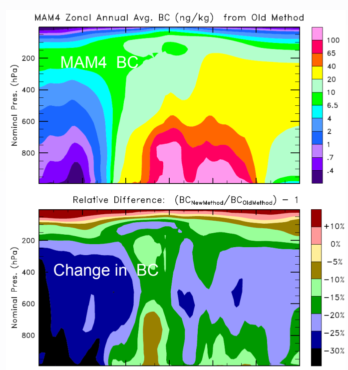
Impact:

- When particles are released to the coarse mode,
  1) the number is much less, leading to a 25% reduction in CCN and cloud drop number concentrations globally
  2) the released aerosols have a shorter lifetime, leading to a 20% reduction in sulfate, BC, POA and SOA burdens globally
  3) the relative impact on BC, POA, and SOA is highest in the mid troposphere, and larger in MAM3 than MAM4
- The impact on cloud liquid water path and shortwave cloud forcing is much smaller



BC profiles from field measurements (black lines for the mean or median and shaded area for one standard deviation) at various locations and model simulations that use MAM3 vs. MAM4 with or without coarse-mode resuspension (+cr)





Cloud ice to snow conversion

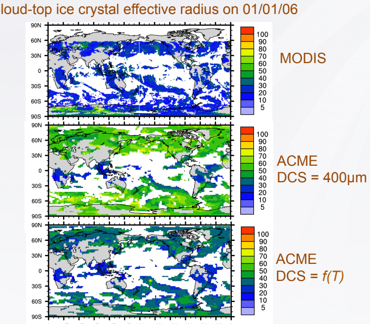
Objective:
Improve the ACME treatment of the threshold ice crystal size for conversion of cloud ice to snow (i.e., the DCS parameter)

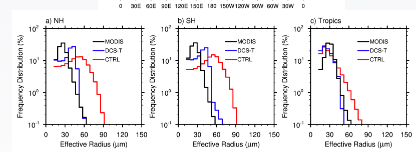
Approach:
A temperature dependent treatment of DCS (Field, 2000; Eidhammer et al., 2014) has been implemented in ACME, to replace the constant parameter that is often tuned to a larger value (400 or 600μm) than the best estimate (200−250μm)

Impact:

- A too large DCS can lead to positive biases in effective radius of cloud ice, IWP and TOA net radiative flux.
- The temperature dependent parameterization of DCS gives improved agreement with satellite retrievals

Cloud-top ice crystal effective radius on 01/01/06





Light-absorbing particles in snow and ice

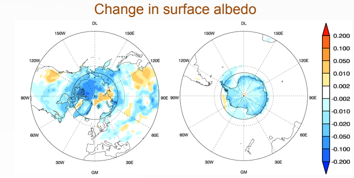
Objective:
Improve the treatment of light-absorbing particles (LAPs) in snow/ice and the simulation of their impact on radiative fluxes at the surface

Approach:
The ACME model has been modified to

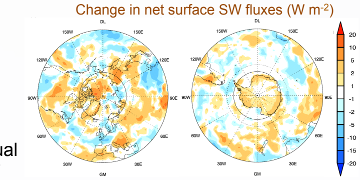
- treat both interstitial and within-hydrometeor (i.e., snow/ice grains) BC
- utilize new estimates of BC-in-snow optical properties that depend on snow grain size and BC particle size
- integrate other aerosol improvements in CAM with LAPs treatment in CLM4.5/CICE

Impact:
The new treatments reduce the Arctic (Antarctic) annual mean albedo by 0.02 (0.01), leading to an increase of 1.6 (1.3) W m^{-2} in surface net SW flux, mostly due to the enhanced solar absorption by internally-mixed BC in snow/ice grains (Flanner et al.,2012).

Change in surface albedo



Change in net surface SW fluxes (W m^{-2})



Based on 5-year simulations using the default ACME (with the MAM4 aerosol) vs. the modified model

ACME Accelerated Climate Modeling for Energy

For additional information, contact Hailong.Wang@pnnl.gov, or visit the ACME Confluence / Atmosphere Group Space / Atmosphere Tasks (P3,P4, M1)

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