Preliminary results from implementation of a new marine organic matter parameterization

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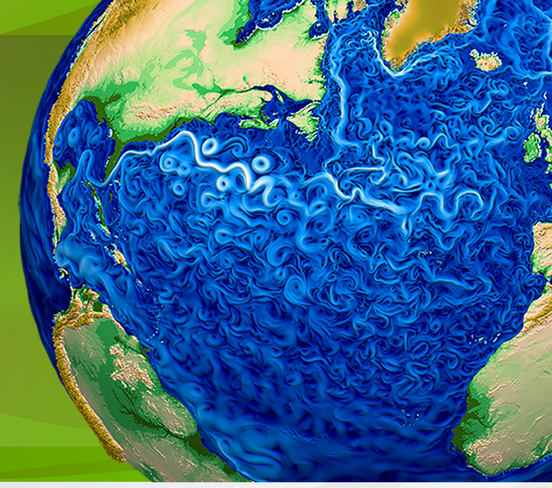
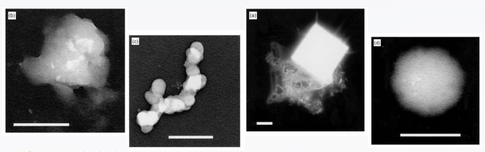


Why study marine organic aerosol

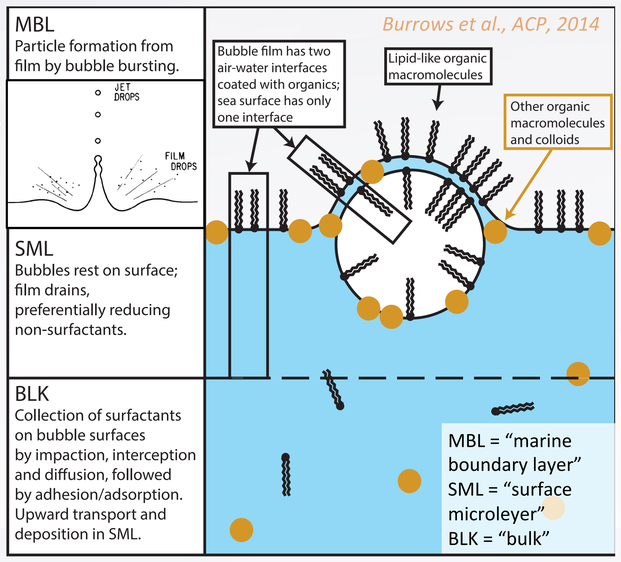
Marine organic matter: missing aerosol source affecting marine cloud forcing

Natural aerosol emissions are a major source of uncertainty in climate models, particularly in remote marine areas such as the Southern Ocean and Arctic. Because they impact cloud radiative properties, deficiencies in the representations of natural aerosol sources may contribute to cloud biases in these regions. Marine organic matter, which enters sea spray by adsorbing to ocean bubbles, is a missing source in regions where clouds are very sensitive to aerosol.

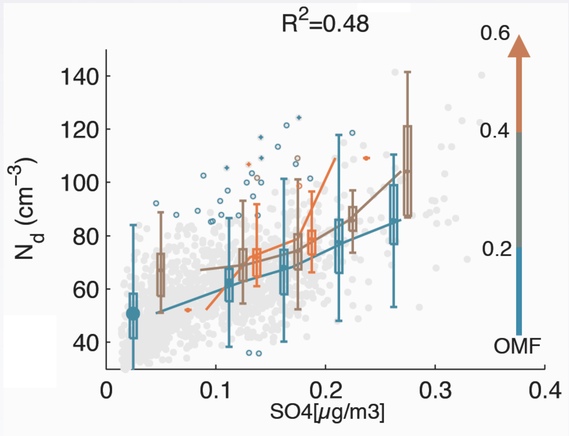


Bigg, 2007

Marine particles collected at Cape Grim

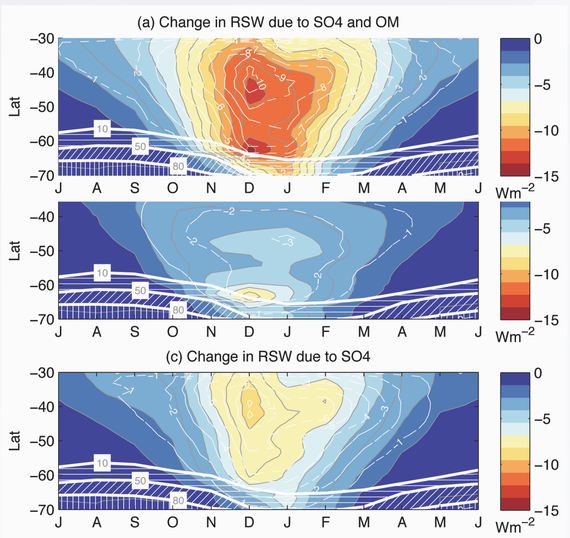


Analysis of real-world radiative impact



Cloud droplet number (Nd) vs. sulfate aerosol over Southern Ocean, binned into low-OMF, intermediate-OMF, and high-OMF groups.

(McCoy, Burrows, et al. 2015, subm.)



Sulfate and marine organic aerosol over Southern Ocean alter cloud droplet number, impacting cloud albedo and reflected shortwave radiation (RSW)

New parameterization

Impact of ocean biogeochemistry on aerosol composition:

OCEANFILMS emission model: Driven by representations of the distribution of five classes of marine dissolved organics compounds of varying adsorptivity and distributions, and an idealized adsorption model for these classes of compounds (Burrows et al., 2014).

Organic mass fraction (OMF) dependence on particle size:

Empirical parameterization of Gantt et al. (2011); adapted to Modal Aerosol Model (MAM).

Introduction of new aerosol modes and tracers for marine organic matter (MOM):

Added 2 new Modal Aerosol Model (MAM) modes into CESM for MOM (X. Liu, R. Easter), enabling fully external mixing with both soluble aerosols (such as sea salt and sulfates) and insoluble aerosols, such as continental particulate organic matter (POM).

Mixing state and number of emitted aerosol

The model is most sensitive to the mixing state and number of emitted particles. In situ and laboratory observations do not yet provide clear information on how the number of particles emitted depends on marine organics, but there are hints that emitted number may increase in the presence of freshly-derived surfactants (Long et al., 2014). We have implemented four sensitivity cases for mixing state and number of emitted particles.

Current status and next steps

Completed in Y1Q1-Y1Q3:

- Implemented OCEANFILMS emission mechanism into CESM with several options to choose different mixing state assumptions.
- Publication describing emissions parameterization (Burrows et al., ACP; Dec 2014)
- Analysis of sulfate and (McCoy Burrows et al., 2015, subm.)

Planned / in progress for Q4-Q6:

- Integration of code into ACME codebase (requires adaptation to the new sea spray code, which underwent major refactoring between CESM1.2 and CESM1.3beta10)
- Evaluation against in situ observations
- Testing (and refinement / debugging if needed)

References:

Burrows et al. (2014, ACP): A physically-based framework for modelling the organic fractionation of sea spray aerosol from bubble film Langmuir equilibria.

McCoy, Burrows et al. (2015, subm.): Natural aerosols explain seasonal and spatial patterns of Southern Ocean cloud droplet number concentration.

Long et al. (2014, GRL): Light-enhanced primary marine aerosol production from biologically productive seawater.

ACME Accelerated Climate Modeling for Energy

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