Introduction

Marine aerosols contribute considerably to the global aerosol load, are emitted from a large surface area, and have the ability to strongly influence reflective properties and lifetime of marine stratus/stratocumulus clouds. As cloud properties are most sensitive to the addition of particles when the background is low (Platnick and Twomey, 1994), marine aerosols play a crucial role in our understanding of the cloud-mediated effects of aerosols on climate. Hoese et al. (2009) suggest that marine aerosol number concentration prescribed/diagnosed in global climate models (GCMs) could be the single most important parameter affecting model prediction magnitude of indirect forcing. Since model predictions are used for developing the planet’s energy economy strategies, marine aerosols, their number, size distribution and chemical composition need to be better constrained.

Despite the crucial role, the source strength, emission mechanism and chemical composition of marine aerosols remain poorly understood. Sea-salt and dimethyl sulfide (DMS) have been established as the main contributors to marine aerosol number, recent studies suggest that emissions of primary organic matter (POM) of marine origin, and secondary organic aerosol (SOA) from phytoplankton-produced volatile organic compounds can also lead to considerable changes in marine aerosol composition and size distribution.

Today there is no agreement on relative contribution of marine organic carbon (OC) aerosols to total aerosol mass and number distribution over the oceans and POM are often tuned with the existing marine aerosol model to represent current climate. Therefore, instead of the attempt to reproduce Earth’s contemporary climate, we will examine the range of uncertainty in radiative forcing associated with marine organic aerosols. Here we consider:

i) Effect of marine organic aerosols on coastal air quality

ii) Effect of marine organic aerosols on cloud radiative forcing

Summary

- New marine primary organic aerosol emission function based on [DOC] and wind speed has been developed.
- Addition of marine OC aerosols increases coastal PM$_{2.5}$ mass by 0.1-0.3 g/m$^3$ (up to 5%) and coastal OC$_{2.5}$ concentration up to 15%.
- Small changes (0.2 ppb, 0.5%) are predicted in O$_3$ concentration over coastal oceanic areas in the Top-down approach; changes in Bottom-up approach was trivial.

[DOC] number simulation compared to Default:
- Increased shallow cloud CDNC by 6.5% over the global oceans and by 10% over the Southern Ocean (SO).
- Increased LWP by 1.5% over the global ocean and by 1.7% over the SO.
- Decreased cloud top $t_c$ by 0.20 µm over the global ocean.
- Increased global mean SWCF by -0.24 W/m$^2$.

[DOC] number simulation compared to Default:
- Increased shallow cloud CDNC by 8.5% over the global oceans and by 23% over the equatorial waters (EW).
- Increased LWP by 1.8% over the global ocean and by 4.4% over the EW.
- Decreased cloud top $t_c$ by 0.19 µm over the global ocean.
- Increased global mean SWCF by -0.62 W/m$^2$.

Simulated CDNC in Different Ocean Parts

- Over the ocean (global basis), the ice water path (IWP) is

Future Work

- Finish implementation of new SOA production mechanism for terrestrial isoprene
- Conduct long-term climate simulations for 2001-2010 and 2020-2050 (IPCC A1)
- Conduct different model configurations

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References

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The Impact of Marine Organic Emissions on Global Climate and Coastal Air Quality

[Diagram of Marine Emissions (Primary Organic Aerosols)]

- Sub-micron Marine POM Emmission (unit: C molecules/cm$^3$/s)
- [Chl-a] number simulation
- [DOC] number simulation

Effect of Marine Emissions on Coastal Aerosol

- Contribution of marine organics to OC$_{2.5}$
- Contribution of marine organics to PM$_{2.5}$

A Shortwave Cloud Forcing (SWCF) (with marine OC - without DOC) Wm$^{-2}$

- Default: global mean = -0.81 W/m$^2$
- [DOC] number: global mean = -0.35 W/m$^2$
- [Chl-a] number: global mean = -0.44 W/m$^2$

Indirect Effect (present - preindustrial SWCF) Wm$^{-2}$

- Default: global mean = -0.81 W/m$^2$
- [DOC] number: global mean = -0.35 W/m$^2$
- [Chl-a] number: global mean = -0.44 W/m$^2$

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