The Impact of Dimethyl Sulfide Emissions on the Earth System

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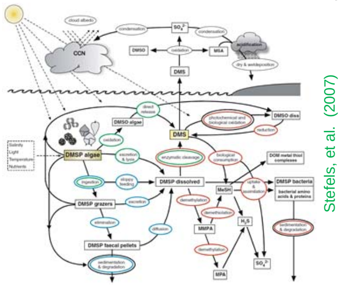
Ocean biological emissions of DMS change with climate

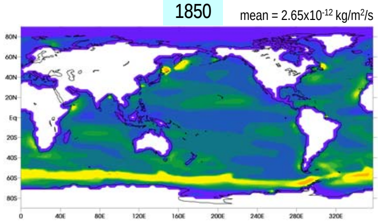
Ocean ecosystem produces dimethyl sulfide (DMS), which oxidizes to form sulfate aerosols in the atmosphere.



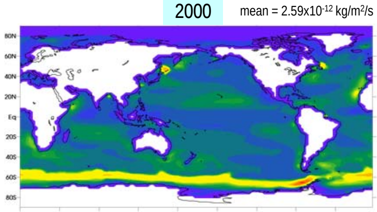
Stefels, et al. (2007)

DMS emissions predicted to change as oceans warms

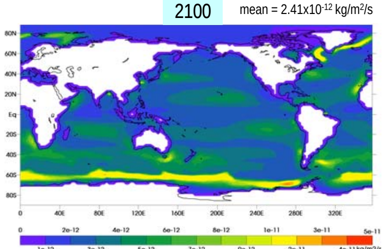
1850 mean = 2.65×10^{-12} kg/m^2/s



2000 mean = 2.59×10^{-12} kg/m^2/s



2100 mean = 2.41×10^{-12} kg/m^2/s



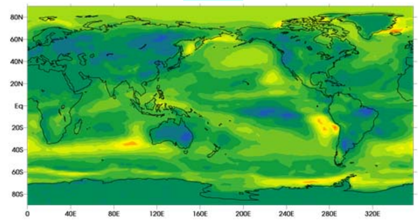
These are simulation results run using the CESM v1.2.2 model, with the Elliott (2009) ocean ecosystem for sulfur, the Cameron-Smith (2006) super-fast atmospheric chemistry, and Liu (2012) model aerosol model (MAM3), for the RCP 8.5 scenario.

Effect of aerosols from DMS shifts poleward

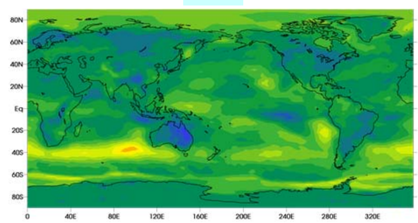
The solar radiation reflected to space is derived from the difference between simulations with and without DMS.

Aerosols from DMS oxidation to sulfate reflect sunlight directly and indirectly via clouds. The impact on radiation depends on the preexisting cloudiness, and the abundance of other aerosols that compete to be cloud condensation nuclei (CCN).

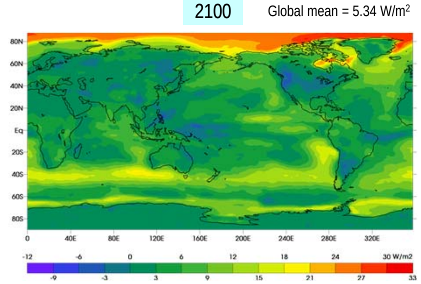
1850 Global mean = 5.94 W/m^2



2000 Global mean = 4.19 W/m^2



2100 Global mean = 5.34 W/m^2



The contribution to the global radiative balance is large (~5W/m^2). However, for climate change, what is important is how this term changes with time. As anthropogenic aerosols increase through the 20th century, and then are assumed to decrease for the RCP 8.5 scenario, the effect of DMS decreases then increases. This partially offsets the cooling effect of the anthropogenic aerosols.

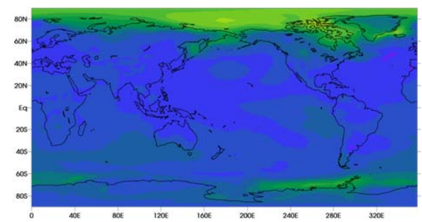
However, this simulation indicates that the spatial distribution does not revert to pre-industrial pattern. Specifically, note that the patterns shift poleward, following the shift of the cold loving *Phaeocystis,* which produces abundantly the DMS precursor DMSP.

Cooling from the aerosols has Arctic amplification

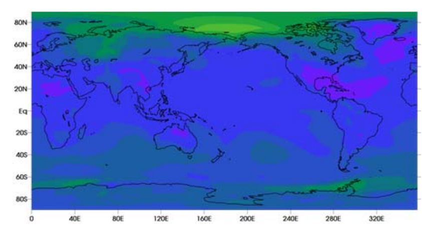
The cooling due to the aerosols from DMS is derived from the difference between simulations with and without DMS.

The cooling broadly follows the radiative forcing, with amplification in regions with sea-ice, due to the ice-albedo feedback (ice reflects sunlight, so if it melts more sunlight is absorbed by the darker surface below.

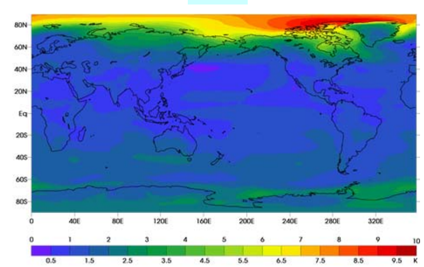
1850 Global mean = 1.28 K



2000 Global mean = 1.10 K



2100 Global mean = 1.48 K



The large Arctic cooling is presumably a combination of three effects:

1. The melting sea-ice allows *Phaeocystis* to grow and produce DMS.
2. The pollution reduction in 2100 means CCN is more sensitive to the sulfate from DMS.
3. The partial melting of the sea-ice allows for effective ice-albedo feedback.

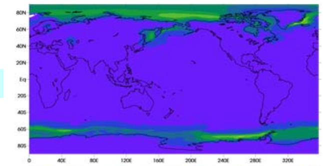
This may be a local version of the GAIA-CLAW hypothesis.

The increase in sea-ice partially compensates for global warming

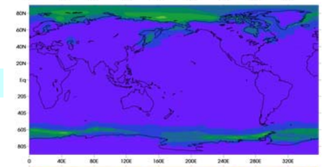
The increase in sea-ice is derived from the difference between simulations with and without DMS.

Note that these are difference plots. Sea-ice in the 2100 simulation with DMS is still significantly less than in the 1850 & 2000 simulations.

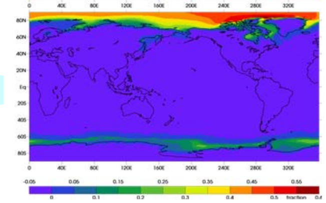
1850



2000



2100



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