The complex response of Arctic cloud condensation nuclei to sea-ice retreat

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The complex coupling of sea-ice, cloud and Arctic aerosol

Response of cloud condensation nuclei to sea-ice retreat

A Global Model of Aerosol Processes (GLOMAP-mode)

- GLOMAP is a global microphysics model capable of simulating aerosol mass and number in multiple segmented modes (Mann et al., 2011).

- After recent improvements to the treatment of scavenging GLOMAP has been shown to reproduce observed aerosol size spectra from the 2008 Arctic summer cloud ocean study (ASCOS) (Martin et al., 2011) show good agreement with measurements (A,B)

- Modelled Arctic CCN are shown in GLOMAP to originate primarily from boundary layer nucleation of H2SO4 (B)

- However, observations suggest that primary organic material from the ocean surface is a significant source of boundary layer Arctic CCN (Grennfelt et al., 2011).

- For a combination of DMS, OC and Sea-Salt to grow all particles to sizes where they can be scavenged more easily

- More sea-salt aerosol alone reduces CCN suppression -50% and is strongly scavenged

- More DMS alone can cause a reduction in CCN because the increase in H2SO4 grows all particles to sizes where they can be scavenged more easily

- A combination of DMS, OC and Sea-Salt accelerates the growth of primary particles (increasing the scavenging rate) while simultaneously suppressing nucleation.

How can higher emissions decrease BL CCN?

Conclusions

Sea-ice retreat significantly increases local fluxes of primary aerosol and pre-cursor gas DMS

The response of boundary layer CCN to sea-ice retreat is spatially non-uniform ranging from 30% to 60%.

The modelled CCN change is the result of enhanced aerosol growth and nucleation processes competing in a strongly scavenging environment.

Our study highlights the significant uncertainties that remain in trying to quantify aerosol-cloud processes in the poorly understood Arctic system.

Response of local emissions to sea-ice retreat

Arctic Sea-salt Emissions x10
Dimethyl Sulphide emissions x15
Marine organic emissions x4

Experimental set-up:
1) Present day: run with 2000 sea ice
2) no-ice: same as present day but with sea-ice fraction set to zero from Jul-Sep
3) no-ice-SS: where the removal of sea-ice affects only sea salt emissions
4) no-ice-DMS: where the removal of sea-ice affects only DMS emissions

All runs had identical meteorology emission inventories (BC,SO2)

DMS sea-water concentrations precipitation rates