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The influence of marine monoterpene emissions on cloud condensation nuclei concentrations over the Southern Hemisphere oceans

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Changes in the concentration of cloud condensation nuclei (CCN) can affect Earth's climate by altering cloud properties such as lifetime, spatial extent, and brightness. Cloud properties are most sensitive to changes in CCN at the low concentrations typical of the remote marine environment.

Underestimation of remote marine water-soluble organic carbon aerosol suggests that a source of secondary organic aerosol is missing from current model mechanisms. Oxidation products of oceanic reactive carbon are a candidate for this missing source, and have the potential to contribute to new particle formation and particle growth.

Marine phytoplankton are known to produce monoterpenes ($C_{10}H_{16}$) and elevated monoterpene concentrations have been observed in regions of enhanced biological activity. A top-down estimate places the global oceanic monoterpene source in the region of 30 TgC a^{-1} but it remains very uncertain.

In this study we use a global model of aerosol processes (GLOMAP) to investigate the potential impacts of oceanic monoterpenes on CCN concentrations over remote ocean regions. Satellite observations of chlorophyll-a inform the spatial distribution of oceanic monoterpene emission in the model. Using comparisons with new observations of atmospheric monoterpene concentrations from cruises in the North and South Atlantic oceans, we determine the optimum emission for marine monoterpenes.

GLOMAP is implemented within the global chemistry-transport model TOMCAT and includes a detailed aerosol microphysics scheme, simulating size- and composition-resolved aerosol. Oxidation products of monoterpenes contribute to new particle formation. Oxidation products of both monoterpenes and isoprene contribute to particle growth.

We find that oceanic monoterpene emission rates of 1–35 Tg a^{-1} (approximately 0.7–24 % of the estimated terrestrial source) lead to average annual global increases in CCN (particles having a dry diameter greater than 50 nm) of 1.6–31 % at the surface. The model simulates a strong response to monoterpene emissions over remote oceans south of 45° S, in particular during Southern Hemisphere summer (up to 388 % for 35 Tg a^{-1}). We investigate the impact of co-located emissions of monoterpene and dimethyl sulphide in a small region of the Southern Ocean on CCN concentration. We use an offline radiative transfer model to calculate the radiative effects of the modelled CCN concentrations.