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Ice nuclei in marine air : bioparticles or dust?

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Ice nuclei (IN) concentrations impact clouds, but their sources and distribution in the atmosphere are still not well known. Particularly little attention has been paid to ice nuclei IN sources in marine environments, although anecdotal evidence suggests that IN populations in remote marine regions may be dominated by a biological particles associated with sea spray. It is also known that certain plankton species can act as IN at comparatively high temperatures, while others do not.

In this exploratory model study, we aim to bring attention to this long-neglected topic and identify promising target regions for future field campaigns. We assess the possible global distribution of marine biological ice nuclei using a combination of historical observations, satellite data and model output. By comparing simulated marine biological IN distributions and dust IN distributions, we predict strong regional differences in the importance of marine biological IN relative to dust IN. In particular, our analysis suggests that marine biological IN may play a dominant role in determining IN concentrations over the Southern Ocean and possibly over regions of the Arctic, while dust IN likely dominate in continental outflow regions.

Marine biological IN may be an important aspect to consider in proposals for marine cloud brightening by artificial sea spray production. Devices for artificial sea-spray production could potentially be designed to include high concentrations of biological particulate matter in the generated spray, which could dramatically increase the concentrations of IN. To our knowledge, this potential has previously not been considered in such proposals. A small number of previous studies indicate that Arctic clouds in particular may be highly sensitive to IN concentrations, with impacts on radiative properties, precipitation and cloud lifetime, but further study will be needed to evaluate the sensitivity of marine clouds to a possible biological IN source.

We believe these results will help motivate further study of marine biological IN. Important routes for further study include laboratory measurements of the ice nucleating activity of plankton species and other marine particulate matter, and field studies using modern instrumentation (such as a CFDC combined with mass spectrometry) to more accurately count and analyze IN in the remote marine boundary layer.