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Modelling secondary ice enhancement in coastal Antarctic clouds

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Numerical models are notoriously poor at reproducing the fraction and distribution of boundary layer clouds in polar regions. This inadequacy is largely due to our poor understanding of the microphysical interactions within these clouds.

In the summertime, polar boundary layer clouds are often mixed-phase, containing both liquid cloud droplets and ice crystals. However, during the Microphysics of Antarctic Clouds (MAC) campaign of 2015, O'Shea et al., 2017 found that the boundary layer stratocumulus clouds observed over the Weddell Sea, Antarctica were predominantly liquid. Ice crystals were found in high number concentrations in sporadic, isolated patches; patches which are unlikely to be captured by the primary ice parameterisations commonly used in models. In these moderately supercooled clouds, the role of secondary ice formation, likely through the Hallett-Mossop rime-splintering mechanism, is thought to be of great importance.

Here, we use observations from two MAC case studies as a guide to establish a realistic treatment of cloud ice production in the polar-optimised Weather Research and Forecasting (PolarWRF) model. A key hurdle in this effort is these isolated ice patches: primary ice production is commonly parameterised based solely on temperature, thus the sporadic bursts of ice are not readily produced. However, by adapting the representation of the Hallett-Mossop secondary ice production mechanism in the Morrison double-moment microphysics scheme, we can greatly improve agreement with our aircraft observations, suggesting that efficient secondary ice production processes play a key role in these clouds.

References:
O'Shea, S. J., et al.: In situ measurements of cloud microphysics and aerosol over coastal Antarctica during the MAC campaign, Atmospheric Chemistry and Physics, 17, 13 049–13 070, doi:10.5194/acp-17-13049-2017, 2017.