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The effect of aerosol and ice nuclei availability on shallow marine clouds

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Shallow marine clouds dominate subtropical and arctic oceans, where they are maintained by turbulent updrafts and radiative cooling from cloud tops. Cloud formation and dynamics is also affected by the availability of aerosol that can act as cloud condensation nuclei (CCN). Moreover, a fraction of the aerosol can act as ice nuclei and therefore have an effect on cloud development. These aerosol and ice particle effects can be quantified by using recently developed UCLALES-SALSA model (Tonttila et al., Geosci. Model Dev., 10, 169-188, 2017). It is a combination of a Large Eddy Simulation (LES) model, which accounts for the turbulent transport of scalar variables, and a sectional aerosol, cloud and precipitation microphysics module (SALSA). SALSA module was recently upgraded to include ice and snow categories and their basic microphysics such as condensation, coagulation, deposition and various ice nucleation modes.

The effect of aerosol and ice on cloud properties were examined by using boundary conditions from arctic observations (Tjernström et al., Atmos. Chem. Phys., 14, 2823-2869, 2014). The observations showed, for example, the presence of optically thin clouds during CCN-limited time periods. Simulation results are in agreement with the observations as they also show that the initially thick cloud layer starts to dissipate when the total aerosol concentration is decreased to about 30 cm^{-3}. On the other hand, a higher aerosol concentration means that the cloud layer is maintained throughout the 36 h simulation. Cloud dynamics is not significantly affected by ice formation until the total ice number concentration is increased up to 0.2 L^{-1}, but such concentrations are not common in remote arctic marine regions.