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Why can't current large-scale models predict mixed-phase clouds correctly?

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Stratiform mid-level mixed-phase clouds have a significant radiative impact but are often missing from numerical model simulations for a number of reasons. This is particularly true more recently as models move towards treating cloud ice as a prognostic variable. This presentation will demonstrate three important findings that will help lead to better simulations of mixed-phase clouds by models in the future. Each is briefly covered in the paragraphs below.

1) The occurrence of mid-level mixed-phase clouds in models is compared with ground based remote sensors, finding an under-prediction of the supercooled liquid water content in the models of a factor of 2 or more. This is accompanied by a low bias in the liquid cloud fraction whilst the ice properties are better simulated. Models with more sophisticated microphysics schemes that include prognostic cloud ice are the worst performing models.

2) A new single column model is used to investigate which processes are important for the maintenance of supercooled liquid layers. By running the model over multiple days and exploring the parameter-space of numerous physical parameterizations it was determined that the most sensitive areas of the model are ice microphysical processes and vertical resolution.

3) Vertical resolutions finer than 200 metres are required to capture the thin liquid layers in these clouds and therefore their important radiative effect. Leading models are still far coarser than this in the mid-troposphere, limiting hope of simulating these clouds properly. A new parameterization of the vertical structure of these clouds is developed and allows their properties to be correctly simulated in a resolution independent way by numerical models with coarse vertical resolution. This parameterization is explained and demonstrated here and could enable significant improvement in model simulations of stratiform mixed-phase clouds.