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Investigating the simulation of liquid cloud microphysical processes in numerical models using a 1-D dynamical framework

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This work describes the method by which the performance of a suite of microphysics schemes of varying levels of complexity can be compared in isolation. Bulk schemes using both single-moment and dual-moment treatments of liquid water will be considered, and also an explicit bin-resolving scheme will be used which determines droplet activation from Kohler theory. The purpose is to establish the level of microphysical sophistication required for the successful simulation of liquid clouds in operational models, paying particular attention to the required level of coupling with aerosols. It is important to capture liquid phase processes accurately, not just because they determine the structure of warm clouds, but also because liquid droplets can exist at temperatures below 0degC in the form of supercooled water, which plays a role in ice formation through homogeneous and heterogeneous freezing mechanisms.

Each scheme will be implemented within the same 1-D dynamical framework for consistency, and a range of idealised single column cloud simulations will be conducted to explore the parameter space of key variables such as cloud base vertical velocity, aerosol concentration and type. Once the comparison of the microphysical schemes has been conducted in the 1-D framework, a series of warm and mixed-phase cloud case studies will be performed in a mesoscale model framework, to qualitatively demonstrate whether the use of a dual-moment bulk microphysical treatment can lead to improvements in the representation of cloud relative to a single-moment scheme. The simulations will be assessed through quantities such as cloud reflectivity structure, precipitation rate and phase. Ultimately the work will aim to advance our understanding of the key microphysical processes that need to be parameterised in NWP and climate models, and on this basis will seek to quantify the strengths and weaknesses of each scheme.