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Measurement of aerosol cloud interactions in mixed phase convective and frontal clouds

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The microphysics of precipitating supercooled clouds were investigated in relation to the aerosol size and composition entering the cloud, as part of the NERC APPRAISE programme. In-situ measurement of cloud microphysics and aerosol properties using the FAAM (Facility for Airborne Atmospheric Measurement) BA146 aircraft were made in conjunction with remote sensing observations from the Chilbolton Radar facility. In this paper the role of aerosol and secondary ice particles in initiating and developing the ice phase and precipitation will be compared in convective and deep frontal clouds.

Isolated convective cumulus and shallow convective cumulus clouds spanning the temperature ranges +4.5 to –12C and -1 to -7C respectively, will be presented. In the isolated convective cumulus case, supercooled droplets were found throughout the clouds vertical extent with predominantly ice at cloud top. At the lower levels, low concentrations of rimed ice and graupel (up to 10 L-1) were present together with some supercooled drizzle. A constant altitude run at -11C showed an increased ice number concentration (to around 50 L-1). The majority of ice crystals at -11C were lightly rimed column crystals, suggesting Secondary Ice Production (SIP) had occurred at lower levels. The second case studied a narrow but extensive line of shallow convective clouds consisting of supercooled droplets throughout and rimed ice and columns at higher levels. Column crystals were found in regions of high ice concentrations (200 per litre) and at temperatures consistent with the Hallett-Mossop SIP process. Detailed microphysics modelling was undertaken to investigate the sensitivity of the convective cloud properties and precipitation to inflow IN and CCN numbers. Preliminary results suggest a greater sensitivity existed to CCN than IN number, and that secondary ice was critical to precipitation formation.

In deep frontal cases, nucleation at cloud top (CT) (with temperatures around -35C) was seen as the primary source of ice. For lower CT cases (temperatures around -25 degrees C), a layer of supercooled liquid water was often seen at CT. Ice nucleated at CT grew via deposition and aggregation into snow. Embedded convection originating from near the surface was observed frequently and generated regions of supercooled water and high number concentrations of ice crystals (up to 100 L-1) at temperatures around -6C. These ice crystals were usually small (<300 μm in length) un-rimed columns, and most likely the result of Hallett-Mossop SIP. The horizontal extent to which SIP appeared to influence ice number concentrations was over 10's of km where a significant amount of condensate was also observed (peaking at over 0.5 g m-3). Sensitivity studies of the precipitation field produced to the treatment of the microphysics and aerosol have been undertaken and will be presented.