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Ice and liquid partitioning in mid-latitude and artic mixed-phase clouds: how common is the real mixed-phase state

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The influence of mixed-phase clouds on the radiation budget of the earth is largely unknown. One of the key parameters to determine mixed-phase cloud radiative properties however is the fraction of ice particles and liquid droplets in these clouds. The separate detection of liquid droplets and ice crystals especially in the small cloud particle size range below 50 μm remains challenging though.

Here, we present airborne NIXE-CAPS mixed-phase cloud particle measurements observed in mid-latitude and Arctic low-level mixed-phase clouds during the COALESC field campaign in 2011 and the Arctic field campaign VERDI in 2012. NIXE-CAPS (Novel Ice EXpEriment - Cloud and Aerosol Particle Spectrometer, manufactured by DMT) is a cloud particle spectrometer which measures the cloud particle number, size as well as their phase for each cloud particle in the diameter range 0.6 to 945 μm.

The common understanding in mixed-phase cloud research is that liquid droplets and ice crystals in the same cloud volume are rather sparse, but instead either liquid droplets or ice crystals are present. However, recently published model studies (e.g. Korolev, A. & Field, P., The effect of dynamics on mixed-phase clouds: Theoretical considerations. J. Atmos. Sci. 65, 66–86, 2008) indicate that a cloud state containing both liquid droplets and ice crystals can be kept up by turbulence. Indeed, our particle by particle analyses of the observed mixed-phase clouds during COALESC and VERDI indicate that the real mixed-phase state is rather common in the atmosphere. The spatial distribution of the mixed-phase ice fraction and the size of the droplets and ice crystals however vary substantially from case to case. The latter parameters seem to be influenced not only by concentration of ice nuclei but also - to a large degree - by cloud dynamics.