Geophysical Research Abstracts
Vol. 18, EGU2016-4049-1, 2016
EGU General Assembly 2016
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Measuring the efficiency of ice formation in mixed-phase clouds over Europe with Cloudnet

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Mixed-phase clouds play an important role in current weather and climate research. The complex interaction between aerosols, clouds and dynamics taking place within these clouds is still not understood. The unknown impact of ice formation on cloud lifetime and precipitation evolution introduces large uncertainties into numeric weather prediction and climate projections.

In the framework of the BACCHUS project, we have evaluated combined remote sensing data gathered at different European Cloudnet sites (Leipzig, Lindenberg, Potenza and Mace-Head) to study the relation between ice and liquid water in mixed-phase cloud layers. In this way, we can quantify the efficiency of ice production within these clouds. The study also allows contrasting marine (Potenza and Mace-Head) and continental sites (Leipzig and Lindenberg). We derive liquid and ice water content together with vertical motions of ice particles falling through cloud base. The ice mass flux is quantified by combining measurements of ice water content and particle fall velocity. The efficiency of heterogeneous ice formation and its impact on cloud lifetime is estimated for different cloud-top temperatures by relating the ice mass flux and the liquid water content at cloud top.

Cloud radar measurements of polarization and fall velocity yield, that ice crystals formed in cloud layers with a geometrical thickness of less than 350 m are mostly pristine when they fall out of the cloud. A difference of four orders of magnitude in ice formation efficiency in mixed-phase cloud layers is found over the cloud-top-temperature range from -40 to 0 °C.