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Classification of Arctic, Mid-Latitude and Tropical Clouds in the Mixed-Phase Temperature Regime

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The degree of glaciation and the sizes and habits of ice particles formed in mixed-phase clouds remain not fully understood. However, these properties define the mixed clouds' radiative impact on the Earth's climate and thus a correct representation of this cloud type in global climate models is of importance for an improved certainty of climate predictions.
This study focuses on the occurrence and characteristics of two types of clouds in the mixed-phase temperature regime (238-275K): coexistence clouds (Coex), in which both liquid drops and ice crystals exist, and fully glaciated clouds that develop in the Wegener-Bergeron-Findeisen regime (WBF clouds).
We present an extensive dataset obtained by the Cloud and Aerosol Particle Spectrometer NIXE-CAPS, covering Arctic, mid-latitude and tropical regions. In total, we spent 45.2 hours within clouds in the mixed-phase temperature regime during five field campaigns (Arctic: VERDI, 2012 and RACEPAC, 2014 – Northern Canada; mid-latitude: COALESC, 2011 – UK and ML-Cirrus, 2014 – central Europe; tropics: ACRIDICON, 2014 – Brazil). We show that WBF and Coex clouds can be identified via cloud particle size distributions. The classified datasets are used to analyse temperature dependences of both cloud types as well as range and frequencies of cloud particle concentrations and sizes. One result is that Coex clouds containing supercooled liquid drops are found down to temperatures of -40 deg C only in tropical mixed clouds, while in the Arctic and mid-latitudes no liquid drops are observed below about -20 deg C. In addition, we show that the cloud particles' aspherical fractions - derived from polarization signatures of particles with diameters between 20 and 50 micrometers - differ significantly between WBF and Coex clouds. In Coex clouds, the aspherical fraction of cloud particles is generally very low, but increases with decreasing temperature. In WBF clouds, where all cloud particles are ice, about 20-40% of the cloud particles are nevertheless classified as spherical for all temperatures, possibly indicating columnar ice crystals (see Järvinen et al, submitted to JAS 2016).