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A Microphysics Guide to Cirrus Clouds - Part I: Cirrus Types

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The microphysical and radiative properties of cirrus clouds continue to be beyond understanding and thus still represent one of the largest uncertainties in the prediction of the Earth's climate (IPCC, 2013). Our study provides a guide to cirrus microphysics, which is compiled from an extensive set of model simulations, covering the broad range of atmospheric conditions for cirrus formation and evolution (Krämer et al., 2015, ACPD). The model results are portrayed in the same parameter space as field measurements, i.e. in the Ice Water Content-Temperature (IWC-T) parameter space. We validate this cirrus analysis approach by evaluating cirrus data sets from seventeen aircraft campaigns, conducted in the last fifteen years, spending about 94 h in cirrus over Europe, Australia, Brazil as well as Southern and Northern America. Altogether, the approach of this study is to track cirrus IWC development with temperature by means of model simulations, compare with observations and then assign, to a certain degree, cirrus microphysics to the observations. Indeed, the field observations show characteristics expected from the simulated cirrus guide. For example, high/low IWCs are found together with high/low ice crystal concentrations.

An important finding from our study is the classification of two types of cirrus with differing formation mechanisms and microphysical properties: the first cirrus type is rather thin with lower IWCs and forms directly as ice (in-situ origin cirrus). The second type consists predominantly of thick cirrus originating from mixed phase clouds (i.e. via freezing of liquid droplets – liquid origin cirrus), which are completely glaciated while lifting to the cirrus formation temperature region (< 235 K). In the European field campaigns, in-situ origin cirrus occur frequently at slow updrafts in low and high pressure systems, but also in conjunction with faster updrafts. Also, liquid origin cirrus mostly related to warm conveyor belts are found. In the US and tropical campaigns, thick liquid origin cirrus which are formed in large convective systems are detected more frequently.