EGU22-5119
https://doi.org/10.5194/egusphere-egu22-5119
EGU General Assembly 2022

Occurrence patterns of cloud particles sizes in cirrus and mixed-phase clouds

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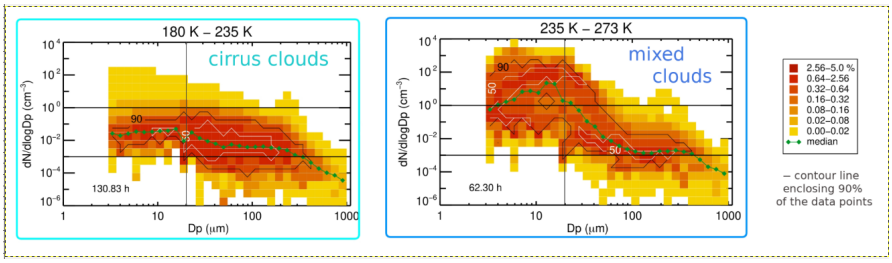
The sizes and number of cloud particles are crucial parameters that determine the physical and optical properties of clouds and with that their radiative feedback to climate. However, measurements of cloud particle size distributions (PSDs) are difficult to accomplish, because clouds are always located at a certain height in the atmosphere. In addition, the entire cloud particle size range cannot be covered with one instrument and also, an undisturbed sampling cloud particles across their entire size range has only been successful for about 15 years.
To build a larger data set of cloud PSDs, we have merged PSD measurements from 11 airborne field campaigns between 2008 and 2021 in tropical, mid-latitude and Arctic ice, mixed and liquid clouds, where we spend a total of 238 hours of measurement time in clouds during 163 flights, of which 131 hours in ice clouds, 62 hours in mixed clouds and 45 hours in liquid clouds. The cloud PSDs are from different instruments which do not
record particle sizes in equally sized intervals. Therefore, the cloud particle numbers are interpolated to a logarithmic equidistant size grid. From this synchronized data set it is now possible to derive not only averaged PSDs, but occurrence frequencies of particle sizes and numbers. We will present occurrence patterns of particle sizes and concentrations in mixed-phase and cirrus clouds in 10°C temperature intervals between -90 to 0°C.



Cloud PSD heatmaps of cirrus and mixed phase clouds.

In this study we will also present more detailed analyses of cirrus clouds by sorting the PSDs in three ranges of ice water content and temperatures, respectively. First results show that in thin cirrus - which are mostly of in-situ origin- the dominant ice particle size changes from small ice particles at low temperatures (~3-20µm diameter) to larger sizes in warmer cirrus (~20–200µm diameter). Thick cirrus, which are a mixture of in-situ and liquid origin, generally contain larger ice particles at all temperatures, the warmer the temperature, the larger ice particles appear in the PSDs.
These occurrence patterns of cloud particle sizes represent a valuable data set that can be used to validate and improve the representation of especially ice clouds in global climate models and in the retrieval of satelllite-based remote sensing observations.

Accompanying presentations @ EGU 2022, AS 1.15:
- Spang, R., Krämer, M. and Spelten, N.: A database of microphysical and optical properties of thin to thick cirrus clouds derived from bimodal particle size distributions.
- Bartolome Garcia, I., O. Sourdeval, M. Krämer, R. Spang: Parametrization of in-situ cloud particle size distributions including small particles.