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A new parameterization of particle size distribution for Arctic ice clouds

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The exact knowledge of particle size distributions (PSDs) is important to better understand the microphysical processes and radiation properties of ice clouds. Furthermore, it is needed to determine ice cloud properties, such as ice water content, from remote sensing measurements.
Many measurement campaigns have been conducted worldwide to determine and parameterize PSDs, but fewer measurements have been performed at high latitudes. For these measurements mainly airplanes were used. This means that due to shattering and poor resolution or low sample volume, the PSDs for smaller particles (<100μm) must be considered with great caution.
To obtain knowledge about Arctic ice clouds and small particles, we perform balloon-borne in-situ measurements with our high-resolution Balloon-borne Ice Cloud particle Imager (B-ICI) in northern Sweden. The measured PSDs are parameterized using a gamma and log-normal distribution function. Furthermore, the origin of the clouds is taken into account, i.e. if the particles were formed via the water phase at higher temperature (liquid origin, T>235K) or directly from the gas phase at lower temperature (in situ origin, T<235K). The calculated coefficients of the gamma and log-normal distribution functions show differences with respect to the cloud origin. The gamma fit coefficients, slope and dispersion, are larger in the case of in situ origin than those of liquid origin. In contrast, the coefficients mode and width of the log-normal function are usually greater and scatter more for liquid origin than for in situ origin. Besides, most literature values of these coefficients are found to be in the range of our values for liquid origin clouds. Only literature data for clouds at temperatures below -70°C have larger values, similar to our values for in situ origin clouds.
In most cases, the log-normal function describes the measured PSDs better than the gamma function, since the very large and very small particles are better represented. Furthermore, the coefficients of the log-normal distribution are fairly independent of each other and correspond to physical quantities, whereas this does not apply to the coefficients of the gamma function.
We propose a new set of parameterizations for Arctic ice cloud PSDs using the log-normal distribution and taking into account the cloud origin. We believe that our new parameterization imply that remote-sensing retrievals and weather and climate models could be improved when accounting for these differences rather than using parameterizations that solely depend on local conditions.