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Verification on the parameterization of the cloud droplet size distribution with in-situ observational data for GCM simulations

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A parameterization of the cloud droplet size distribution (CDSD) plays a significant role in global climate models (GCMs), especially for estimating the aerosol indirect effects on warm cloud properties and on the initiation of rain formation. Considering the difference in the spatial scale between the real cloud and the GCM grid box, it is difficult to solve the cloud processes in global models. Therefore a parameterization is expected to represent the CDSD in terms of the cloud microphysical and dynamic variables those can be prognosticated in GCMs.

Liu et al. (1995), Liu and Hallett (1997) theoretically deduced that the Weibull distribution (which is a kind of Gamma distribution) might appropriately represent the CDSD of large-scale clouds, i.e., stratus/stratiform clouds that are typically less turbulent than convective clouds. The derived CDSD is a function of the cloud water content, cloud droplet number concentration (CDNC) and the size spectral parameter (ε) of droplets at cloud base, where both CDNC and ε depend on the updraft velocity thus relate to the dynamic turbulence in clouds.

In this study, the CDSD following the Weibull distribution is derived from the measurement of clouds during two in-situ experiments over the North Atlantic Ocean, by averaging on a cloud scale and a GCM grid size scale (horizontal extension is 2-10 km and 100-300 km) respectively. Both derived CDSD agree adequately to the observed CDSD on the corresponding scale, which verifies the parameterization of CDSD following the Weibull distribution for large-scale clouds. A difference in the shape of the derived CDSD between the cloud scale and the GCM scale is attributed to the dynamic effect of turbulence on the respective scales.