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Determining ice water content from 2D crystal images in convective cloud systems

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Cloud microphysical in-situ instrumentation measures bulk parameters like total water content (TWC) and/or derives particle size distributions (PSD) (utilizing optical spectrometers and optical array probes (OAP)). The goal of this work is to introduce a comprehensive methodology to compute TWC from OAP measurements, based on the dataset collected during recent HAIC (High Altitude Ice Crystals)/HIWC (High Ice Water Content) field campaigns.

Indeed, the HAIC/HIWC field campaigns in Darwin (2014) and Cayenne (2015) provide a unique opportunity to explore the complex relationship between cloud particle mass and size in ice crystal environments. Numerous mesoscale convective systems (MCSs) were sampled with the French Falcon 20 research aircraft at different temperature levels from -10°C up to 50°C. The aircraft instrumentation included an IKP-2 (isokinetic probe) to get reliable measurements of TWC and the optical array probes 2D-S and PIP recording images over the entire ice crystal size range.

Based on the known principle relating crystal mass and size with a power law ($m=\alpha \bullet D\beta$), Fontaine et al. (2014) performed extended 3D crystal simulations and thereby demonstrated that it is possible to estimate the value of the exponent β from OAP data, by analyzing the surface-size relationship for the 2D images as a function of time. Leroy et al. (2015) proposed an extended version of this method that produces estimates of β from the analysis of both the surface-size and perimeter-size relationships. Knowing the value of β, α then is deduced from the simultaneous IKP-2 TWC measurements for the entire HAIC/HIWC dataset.

The statistical analysis of α and β values for the HAIC/HIWC dataset firstly shows that α is closely linked to β and that this link changes with temperature. From these trends, a generalized parameterization for α is proposed. Finally, the comparison with the initial IKP-2 measurements demonstrates that the method is able to predict TWC values larger than 0.3g/m3 with an error close to 20%.

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