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A Study of Cirrus Ice Particle Size Distribution Using TC4 Observations

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Study of the ice particle size distribution (IPSD) is important for at least three reasons. First, it is of intrinsic value for validating and advancing our understanding of the microphysical processes underlying the production and evolution of the ice particles. Second, it is of importance in climate studies because the IPSD and the particle shapes affect the radiation balance of the earth-atmosphere system. Finally, knowledge of the IPSD helps in remote sensing of ice water content, mean size of ice particles, and other parameters of the IPSD, which affect the earth's climate. Indeed, climate studies have been the main impetus for the recent explosion in the study of ice in clouds.

There have been extensive analyses of in-situ measurements of IPSDs. One objective of these studies has been to find a few parameters that are sufficient to describe an entire IPSD. For this purpose, many authors have normalized the particle size and concentration using one or two moments of the IPSD. Plots of normalized concentration against normalized particle size, called normalized spectra, for a population of IPSDs, have been found to cluster around a 'universal' curve, or a 'universal' distribution, irrespective of the values of the moments of individual IPSDs. Knowledge of the 'universal' distribution and the moments, used for the normalization, are then sufficient to recover an entire distribution and calculate its properties. (e. g. , Field et al. 2007; Delanoe et al. 2005).

The current study presents an analysis of IPSDs observed in tropical cirrus during NASA's Tropical Composition, Cloud and Climate Coupling (TC4) mission [http://www.espo.nasa.gov/tc4/]. The PSD transformations presented here differ from the other normalizations in that they are designed to collapse specific multi-parameter particle size distributions to a single curve, whose form is predicted in advance, irrespective of the values of the parameters of the distribution. This scaling is essentially similar to that used by Sekhon and Srivastava (1971) and other two-moment normalizations (e.g., Willis, 1984). Our aim is to find the best functional representation of the observed IPSDs. An analysis of two days of in-situ observations of ice particle size spectra, in convectively generated cirrus is presented. The observed spectra are examined for their fit to the exponential, gamma and lognormal function distributions. Characteristic particle size and concentration density scales are determined using two (for the exponential) or three (for the gamma and lognormal functions) moments of the spectra. It is shown that transformed exponential, gamma and lognormal distributions should collapse onto standard curves. An examination of the transformed spectra, and of deviations of the transformed spectra from the standard curves, shows that the observed distributions are not well fitted by the exponential function, except in the mid-size range of particle sizes, and moreover, the observations depart systematically from the expected curve. The gamma function provides a better fit over the mid and small sizes but underestimates the concentrations at larger sizes. The lognormal function provides the best fit to the observed spectra.

The details can be found in Tian et al. (2009).
(http://ams.allenpress.com/perlserv/?request=get-abstract&doi=10.1175%2F2009JAS3114.1)

Reference

Delanoë, J., A. Protat, J. Testud, D. Bouniol, A. J. Heymsfield, A. Bansemer, P. R. A. Brown, and R. M. Forbes, 2005: Statistical properties of the normalized ice particle size distribution, *J. Geophys. Res*., **110**, D10201, doi:10.1029/2004JD005405.

Field, P. R., R. J. Hogan, P. R. A. Brown, A. J. Illingworth, T. W. Choularton, and R. J. Cotton, 2005: Parameterization of ice particle size

distributions for mid-latitude stratiform cloud. *Quart. J. Roy. Meteorol. Soc.*, **131**, 1997–2017.

Sekhon R. S., and R. C. Srivastava, 1971: Doppler radar observation of drop-size in a thunderstorm. *J. Atmos. Sci.,* **28,** 983-994.

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Willis, P.T., 1984: Functional fits to some observed drop size distributions and parameterization of rain. *J. Atmos. Sci.*, **41**, 1648–1661.