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In-situ statistical validation of airborne reflectivity measurements during AMMA2006 and Megha-Tropiques 2010 experiments: importance of hydrometeor growth processes and particle size distribution variability.

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During the AMMA 2006 experiment, collocated remote sensing and in-situ estimation of radar reflectivities of MCS systems have been performed by the French Falcon research aircraft using airborne radar (RASTA) and in-situ measurements of particle size distributions (PSD) obtained with hydrometeors imaging instrumentation (2DC, 2DP and 1DP Knollenberg probes). In addition, the Megha-Tropiques experiment in August 2010, located in the same region, allowed us to extend the observed MCS cases using modern imaging probes (2DS, CIP and PIP) as compared to AMMA.

In-situ estimation of reflectivity is very sensible to the assumed diameter to mass function which resumes the main mode of hydrometeor growth (vapour diffusion at low supersaturation, dendritic growth, agglomeration or riming). This function could be estimated using the observed hydrometeor shapes (condensation pristine crystals, dendrites, snowflakes or graupels). A rather good statistical estimation of this function can be obtained for the more intense part of the cloud system (the core convective regions) using a power law function of the diameter with a pre-factor and a characteristic exponent. In case we use the same diameter to mass relationship also for the regions outside of the convective core, we may observe both under and over estimation of reflectivity due to the variability of the local main growth processes (transition between riming to agglomeration) and the variability of the shape of the PSD (e.g. bimodal spectra on the edges of convective cores).

We have developed tools to separate the main hydrometeor growth processes along the flight. On the one hand, we estimate a mean mass density of the hydrometeors using an iterative comparison of the radar reflectivity observed near the aircraft with the radar reflectivity computed with the PSD. On the other hand, we derive a “rugosity exponent” from the bi-dimensional histograms of surface and perimeter of a local population of hydrometeor images. The large values of rugosity exponent correspond to low densities dendrites and snowflakes while dense objects such as graupels or hails have low rugosity exponent. Therefore, this exponent can represent the differences in growth processes.

Using the mean mass density, the rugosity exponent and a classical shape recognition technique, we observe that the variability of the growth processes is smaller in MCS than in mid-latitude convective systems.

Moreover, these two experiments allow statistical comparison of reflectivities measured with an airborne radar and derived from in-situ measurements on a large data set (few thousands km with a 250 meters resolution) with various microphysical properties. We also compare these results with simulated reflectivities obtained with the DESCAM detailed microphysical cloud model utilised for large convective systems.