

A Comparison of Airborne Data Processing Methods on Single Scattering Properties of Cloud Ice Habits

Ice induction in jet engines flying at high altitudes has been known to extinguish exhaust and pose a major hazard, particularly in thin, visibly unnoticeable clouds. In an effort to mitigate this hazard the Federal Aviation Administration (FAA) has determined that jets must be equipped with the ability to alert pilots when flying in areas containing ingestible ice crystals. Corporations which produce aviation instruments are working toward producing a plane-integrated LIDAR system used to determine high ice crystal environments and quickly notify the pilots. To assist in assessing the performance of these LIDAR sensors this study will compare aircraft probe derived backscatter to the backscatter from a LIDAR system. Deriving backscatter from aircraft probes requires accurate size distributions and habit identification. Several case studies of different cloud types will be used to determine the importance of different processing methods for calculating particle size and the importance of the crystal habit used for calculating the LIDAR backscatter.

The University of North Dakota's Citation Research Aircraft was used to take in-situ measurements of cloud particles in North Dakota (2010-2015), North Carolina (2014) and Florida (2015). Particle imaging probes onboard for these campaigns included a two-dimensional stereographic (2D-S) probe and a High Volume Precipitation Spectrometer Version 3 (HVPS3) probe. The clouds observed range from high altitude anvil cirrus clouds to deep convective cumulus allowing for samples in both homogenous and heterogeneous habit structure environments. Three different size distribution calculation algorithms are to be performed on the 2D-S data: "reconstruction", "center-of-mass", and "all-in". The "reconstruction" method involves reconstructing edge images by mirroring the observed part of the particle. The "center-of-mass" method involves only using edge images where the center of mass of the particle is known to be within the image. The "all-in" method does not use particles that are not entirely in the image. These three methods are to be evaluated by comparison with manual review of images for consistency. Each size-distribution will be used to calculate the backscatter of the cloud habits with the uncertainty of the distributions calculated using the poisson counting statistics (the square root of the number of particles divided by the total number of particles observed). Thus, a higher number of particles observed will result in a lower uncertainty. Since the ice habit must be known to calculate the particle backscatter, uncertainty associated with the use of proper habit structure will be assessed by applying the assumption that all crystals are columns for the backscatter calculation and then recalculating the backscatter applying the assumption that all crystals are plates instead with the difference between the results of the two habits recorded.

It is anticipated that there will be fewer small particles using "all-in" and "center-of-mass" processing techniques versus "reconstruction" as a result of the "reconstruction" method processing partially captured large particles as if they were fully captured small-particles. Methods which produce more small particles will likely result in higher values of backscatter generated as well. Another valuable result of this particular study will be determining if the uncertainty in the calculated size-distribution of the cloud particles or the uncertainty in the known cloud crystal habits is more vital. It is expected that the particle size-distribution is more influential in cirrus clouds; therefore, the crystal habit is of secondary important and may be disregarded.