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The effect of shattered artifacts on derivation of bulk cloud parameters from optical array probe data collected during ISDAC and IDEAS-4

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Many existing parameterizations of ice clouds in climate and weather models are based on observations of number concentrations of ice crystals with maximum dimension D < 500 micrometers from forward scattering and optical array probes that have been artificially amplified by the detection of small crystals generated by the shattering of large crystals on probe tips and inlets. This produces uncertainties in the model representation of ice sedimentation and single-scattering radiative properties and of liquid to ice conversion rates in mixed phase clouds. In addition to uncertainties in how past data are affected by shattered artifacts, recent studies have reached varying conclusions regarding the efficacy of shatter reducing tips and correction algorithms to remove shattered artifacts. Here, the effect of shattering on bulk microphysical properties derived from the two-dimensional cloud probe (2DC), such as total ice crystal concentration, ice crystal number distribution function N(D), extinction, ice water content, effective radius and median mass diameter, is quantified. Such properties, computed from data acquired by 2DCs with standard and shatter reducing tips on the National Research Council of Canada Convair-580 during the Indirect and Semi-Direct Aerosol Campaign (ISDAC) and on the National Center for Atmospheric Research C-130 during the Instrumentation Development and Education in Airborne Science phase 4 (IDEAS-4), are compared as a function of true air speed, pitch, roll, and attack angles, ice crystal habit, degree of riming, median diameter, and temperature. In general, use of algorithms to remove shattered artifacts reduces N(D< 500 micrometers) by a factor of 2 or greater. But, the 2DC shatter reducing tips eliminate more shattered artifacts than does application of shatter correction algorithms. Thus, both techniques must be used in concert to maximize the removal of artifacts. Therefore, considerable improvements in model parameterizations are possible with improved measurements of ice.