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Plausibility of in situ Measurements of Numerous Small Crystals in Cirrus Clouds

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In situ aircraft measurements in cirrus clouds made over the past few decades using a variety of techniques (FSSP, CVI, replicators) have generally indicated the ubiquitous presence of small (diameters less than 40 microns) ice crystals. These measurements have been used to infer ice crystal nucleation processes, cirrus radiative properties, cirrus climatic effects, and aerosol indirect effects on cirrus. The in situ measurements are also now being used for development of next-generation cloud parameterizations in general cicurlation models for climate-change prediction.

Here, we present examples of in situ measurements of subtropical anvil cirrus from the CRYSTAL-FACE mission. As in other cirrus datasets, the small crystals are indicated by the measurements throughout the vertical extents and ages of the anvils sampled. We compare these measurements with cloud-resolving model simulations of deep convection/anvil cirrus systems as well as remote sensing retrievals of cloud-top effective radii. The in situ measurements, remote-sensing measurements, and simulations all indicate numerous small crystals near the tops of the anvils. However, the bases of the simulated anvils consist of only much larger crystals that precipitated from above. We explore various processes not included in the cloud model that might produce the ubiquitous small crystals indicated by the measurements. We suggest that the most plausible explanation for the model/measurement discrepancy is shattering of larger crystals at the inlets of the aircraft instruments.