Aircraft Observations of Cloud Particle Clustering using In-situ Probes

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Overview

Research aircraft conduct in-situ observations of cloud particles with scattering probes and imaging probes that are able to measure individual particles. Typically, measurements of individual particles are combined over a short (i.e. 1 or 10 s) time period to obtain a particles size distribution. During many field projects, in-situ measurements are obtained to provide details required to understand remote sensing observations made over a much larger area. Even active remote sensing observations (i.e. lidars and radars) make assumptions about particles which affect measurement accuracy. For example, the accuracy of remote sensing measurements in mixed-phase and ice clouds is reduced if spherical particles are assumed instead of using the actual shape of the cloud particles. A common assumption is that particles are randomly distributed in space and do not cluster into patches. In-situ aircraft observations using the particle-by-particle (pbp) data from the Cloud Droplet Probe (CDP) and the asynchronous data from the Two-dimensional Sterographic Probe (2D-S) and High Volume Precipitation Probe (HVPS) show particle clustering in many cloud environments. Analysis of concurrent remote sensing and in-situ measures is conducted to the uncertainty introduced in remote sensing observations by the observed particle clustering.

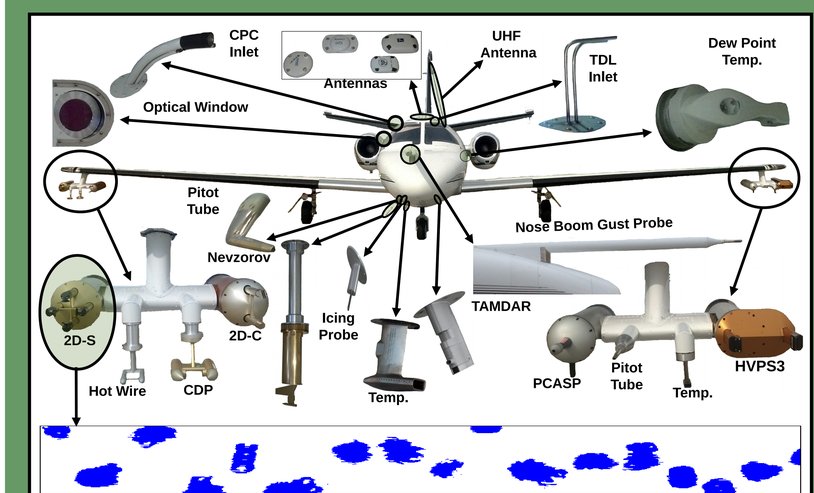


Image showing the instrumentation on the North Dakota Citation Research Aircraft for the CAPE2015 field project conducted to sample Florida thunderstorm anvils. An example image buffer is shown for the 2D-S, where the top to bottom length is 1,280 µm, corresponding to 128 diode of 10 µm each.

Spatial Distribution of Cloud Particles

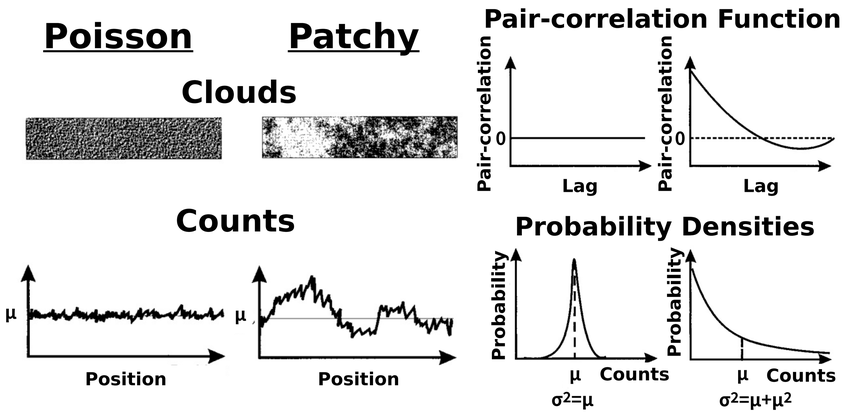
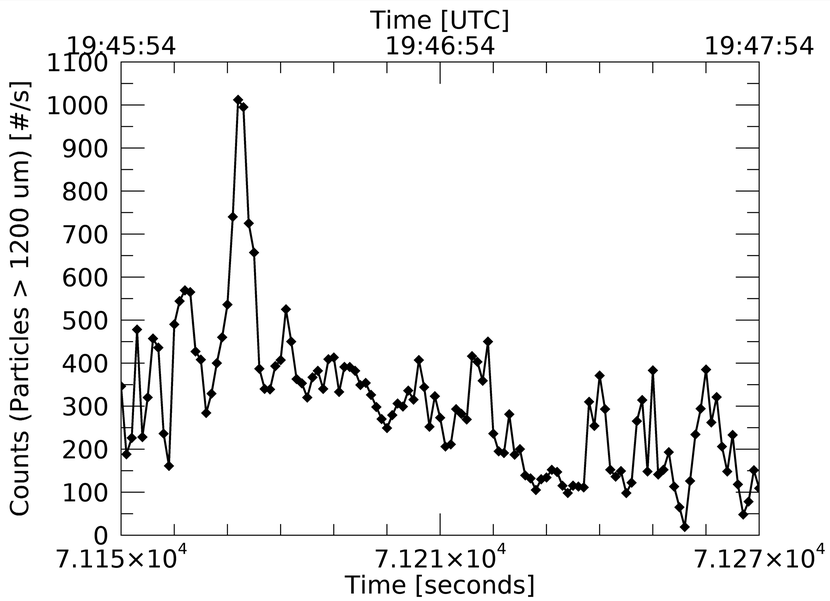
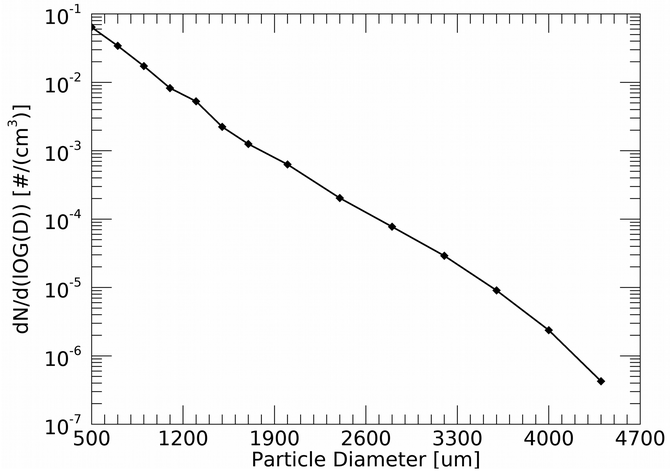


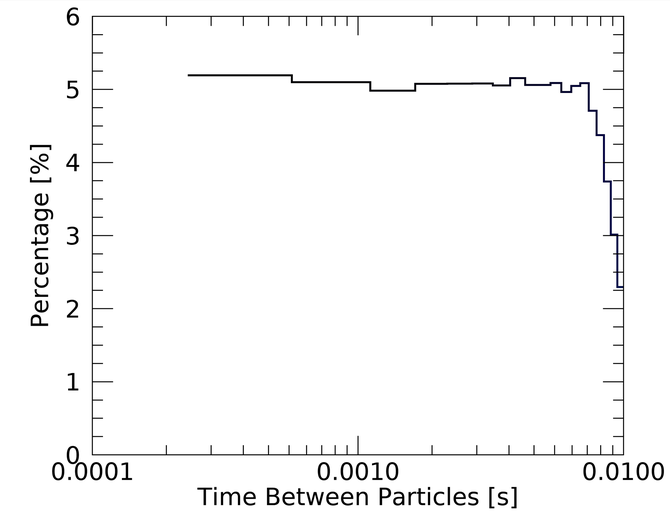
Image adapted from Figure 1 of Kostinski and Jameson, 2000



Plot of the particle counts larger than 1200 µm determined from HVPS3 measurements made on 1 August 2015 while sampling cirrus cloud anvil (11.3 km, -43.4 °C) concurrent with radar measurements (Schmidt et al., 2019) of between 0 and 10 dBZ. The two minute sample covered a distance of 18.6 km. HVPS image buffers are shown at the maximum of the particle count peak (19:46:07.31).



Plot showing the particle spectrum on 1 August 2015 between 71150 and 71270 seconds from midnight (sfm).



Plot showing the time between HVPS detected particles on 1 August 2015 between 71150 and 71270 (sfm).

References and Acknowledgments

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Kostinski, A. B., and A. R. Jameson, 2000: On the Spatial Distribution of Cloud Particles. J. Atmos. Sci., 57, 901–915, doi:10.1175/1520-0469(2000)057<0901:OTSDOC>2.0.CO;2.

Schmidt, J. M., and Coauthors, 2019: Radar Detection of Individual Raindrops. Bulletin of the American Meteorological Society.

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