**Holographic Cloud Particle Imager (HCPI) for Unmanned Aircraft Systems (UASs)**

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Many current climate models assume a homogeneous and uncorrelated spatial distribution of the particles within clouds. *In situ* measurements point toward small-scale (mm to cm) correlations between particles due to droplet inertia and turbulence, and adjusting climate models to account for the inhomogeneity of clouds would increase the accuracy of climate predictions. The spatial distribution of droplets in a cloud influences radiative transfer, collision and coalescence, and droplet growth by condensation. This work presents results from two test flights of a prototype holographic cloud particle imager (HCPI) and the design and fabrication of a lighter UAS-compatible version. The HCPI measures both the 3-D spatial distribution *and* size distribution of cloud particles in the 14 mm to several millimeter size range. The 3-D spatial distribution of particles can also help identify artifacts such as particle shattering by the probe. The instrument was developed as part of a Department of Energy Small Business Innovation Research program and is meant to fly on a Group 3 UAS like the TigerShark.

The instrument uses in-line holography, a common technique due to its simplicity and the resolution constraints of currently available imagers, to generate cloud particle holograms. Diffraction theory enables a numerical reconstruction of the particle positions and sizes within the sample volume (about 20 cm$^3$). With this information, the "patchiness" of the particles relative to a Poisson distribution can be quantified with the pair correlation function. This patchiness affects the optical transport and energy balance, and other important parameters in climate models that include clouds.

A synopsis of test flight results from Grand Junction, CO in August 2018 and Fargo, ND in February 2019 will be presented. The resulting cloud particle holograms and spatial distributions will be presented, along with a discussion of the meaning of the results with respect to the particular clouds that were sampled. The radiative impact of droplet clustering in observed clouds will be estimated with a Monte-Carlo radiative transfer code. There will also be a discussion of changes that have been made for the lighter UAS-compatible prototype.

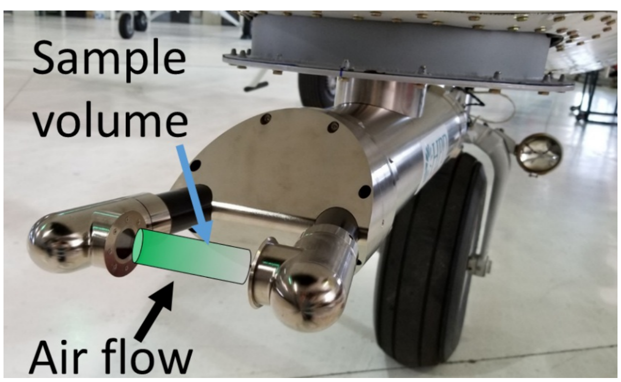


**Figure 1.** Manned aircraft version of HCPI mounted under the nose of a Twin Otter aircraft.

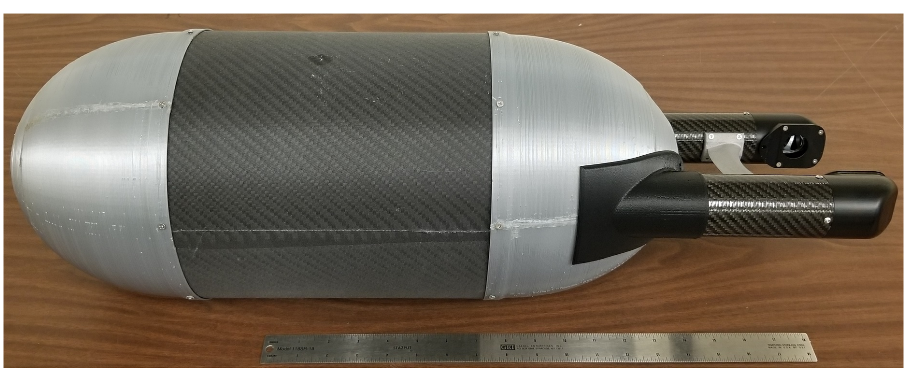

**Figure 2.** UAS-compatible HCPI prototype with 18-inch ruler for size reference.