Abstract

- 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 m) 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.
- Many current particle-counting measurements are plagued by artifacts due to scattering.
- This work presents the development of a UAV-mountable holographic cloud particle imager (HCPI) that measures both the 3D spatial distribution and size distribution of cloud particles in the 10 μm to several millimeter size range in a sample volume of about 20 cm³, which enables the calculation of the pair correlation function and the recognition of scattering.

Design for Manned Test Flight

- System is mounted in a standard PMS canister.
- Power: 3.25 A at 110 VAC.
- Weight: Check with HPD.
- Two twisted pairs for Ethernet.

Light-weighting

To get from an instrument weighing about 13 kg to the target of 6 kg, several changes must be made to reduce weight and volume.

- Reduce structural stiffness assuming lower airspeeds on drone.
- Transfer all electronics to a single PCB, including camera CCD.
- Reduce size/thickness of canister.
- High Precision Devices (HPD) estimates that these changes can get the instrument mass down to 6 kg.

In-Flight Data Transfer

- An antenna will be included to send the user data during the flight.
- The in-flight data transfer system will include a software-defined radio and antenna on the instrument and a ground station node to receive signals.
- Distance will determine the data rate.
- Single hologram size: ~ 20 MB.

Particle Size and Concentration

- A literature review shows the range of potential particle sizes to be close to the current 14 μm resolution (7 μm per pixel) performance of the HCPI.
- Marine clouds have a majority of mass in particles larger than current resolution.
- Continental clouds have greater mass fraction in smaller particles.
- Requires about 1000 particles per hologram for statistically significant pair correlation function.
- Current minimum concentration: ~ 50 cm⁻³.
- 2x magnification would require >400 cm³ which is found in polluted areas.

Magnification module

- A telecentric lens can be used to magnify the sample volume.
- Magnification, M, reduces sample volume by M².
- The multiple element telecentric lens reduces aberrations.

Monte Carlo Simulation

- A particle in the climate calculation toward droplet shattering in clouds with various spatial distributions.
- Top of atmosphere shortwave flux for clouds with various spatial distributions.

Future Work

- Testing on piloted aircraft.
- Designing housing for mounting on TigerShark UAV.
- Goal: 6 kg total.

Benefits from UAV mounting

- UAV-mounted cloud instruments enable greater sampling statistics (every cloud is different).
- The long-term promise of UAVs is reduced cost of operations.
- The HCPI not only provides data for radiative transfer models, but also models of radiative production by collision/coalescence and turbulent mixing at cloud edges.

References