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UAV Applications for Thermodynamic Profiling:Emphasis on Ice Fog Visibility

Ismail Gultepe (1), Andrew Heymsfield (2), Joseph Fernando (3), sebastian hoch (4), Eric pardyjack (4), faisal Boudala (1), Randolph Ware (2,5)

(1) Environment and climate change canada, Toronto, Canada (ismail.gultepe@canada.ca), (2) NCAR, Boulder, CO, US, (3) University of Notre Dame, IL, US, (4) University of Utah, Salt Lake City, UT, US., (5) Radiometrics Corp., Boulder, CO, US.

Abstract

Ice fog often occurs over the Arctic, in cold climates, and near mountainous regions about 30% of time when temperatures (T) drop to -10ºC or below. Ice fog affects aviation operations, transportation, and local climate. Ice Nucleation (IN) and radiative cooling play an important role by controlling the intensity of ice fog conditions. Ice fog can also occur at T above -10ºC, but close to 0ºC it mainly occurs due to freezing of supercooled droplets that contain an IN. To better document ice fog conditions, observations from ice fog events of the Indirect and Semi-Direct Aerosol effects on Climate (ISDAC) project (Barrow, Alaska), Fog Remote Sensing And Modeling (FRAM) project (Yellowknife, Northwest Territories), and the Mountain Terrain Atmospheric Modeling and Observations (MATERHORN) project (Heber City, Utah), were analyzed. Difficulties in measuring small ice fog particles at low temperatures and low-level research aircraft flying restrictions prevent observations from aircraft within the atmospheric boundary layer. However, Unmanned Aerial Vehicles (UAVs) can be operated safely to measure IN number concentration, Relative Humidity with respect to ice (RHi), T, horizontal wind speed (Uh) and direction, visibility, and possibly even measuring ice crystal spectra below about 500 micron, to provide a method for future research of ice fog. In this study, thermodynamic profiling was conducted using a Radiometrics Microwave Radiometer (PMWR) and Vaisala CL51 ceilometer to describe vertical spatial and temporal development of ice fog conditions. Overall, ice fog characteristics and its thermodynamic environment will be presented using both ground-based and airborne platforms such as a UAV with new sensors. Some examples of measurements from the UAV and a DMT GCIP (Droplet Measurement Technologies Ground Cloud Imaging Probe), and challenges related to both ice fog measurements and visibility parameterization will also be presented.