**Collaborative Research:**
**Integrated Characterization of Energy, Clouds, Atmospheric state, and Precipitation at Summit (ICECAPS)**

## INTELLECTUAL MERIT

Clouds play key roles in both the surface energy and ice mass balances in Polar regions. These roles are largely defined by cloud macro- and microphysical properties which are intimately tied to atmospheric thermodynamics and dynamics on many scales. In spite of the obvious importance of these cloud-related processes, models continue to struggle to accurately represent occurrence, vertical distribution, microphysical composition, and radiative properties of the clouds over the Arctic and over the Greenland Ice Sheet (GIS). As a result, model simulations of surface energy budgets and precipitation are highly uncertain. Over the past decade, the effects of climate change have become quite apparent over the GIS where melt rates are large and increasing. However, due to a lack of observations and subsequent model deficiencies, the source of these changes is unclear as is their projection into the future. Significant GIS melt can have a dramatic potential impact on global sea-level and thus human populations and ecology. Thus, it is warranted to make focused measurements of the cloud, atmosphere, precipitation, and radiation properties over the GIS to address these issues over Greenland and to expand such observations across the Arctic.

A field campaign is proposed here that will expand the Arctic Observing Network by adding cloud, atmosphere, and precipitation measurements, and associated higher-order data products, to Summit, Greenland at the top of the GIS. The proposed instrument suite consists of a cloud radar, two microwave radiometers, an Atmospheric Emitted Radiance Interferometer, an X-band precipitation sensor, a ceilometer, a micropulse lidar, and a twice-daily radiosonde program. Measurements from this advanced suite of instruments, combined with some ongoing measurements at Summit, will be input for a number of algorithms to produce climatically useful geophysical data products to support GIS-specific and Arctic-wide research. Data products will include:

(i) ***Atmospheric State*** - temperature and moisture profiles through the troposphere and lower stratosphere;
(ii) ***Cloud Macrophysics*** - cloud occurrence, vertical boundaries, and temperatures;
(iii) ***Cloud Microphysics*** - cloud phase, water content, optical depth, and particle size;
(iv) ***Precipitation*** - precipitation type and rate; and
(v) ***Cloud Radiative Forcing*** - impact of clouds on the surface radiation balance.

Together these products will augment similar data sets that are produced at other locations across the Arctic. It is anticipated and intended that these data sets will be widely used by the broader scientific community to understand the climates of the GIS and broader Arctic Basin and to validate satellite retrievals and model simulations over Greenland.

## BROADER IMPACTS

The proposed additions to the Arctic Observing Network are very specifically outlined and requested in the SEARCH implementation plan, and are therefore expected to have a significant impact on both "observing change" and eventually "understanding change" in the Arctic. The proposed observations will be the first of their kind on the Greenland Ice Sheet and will expand the existing, although modest, network of such measurements across the Arctic. Uncertainty in polar cloud properties is a major deficiency in current models of polar climate; the proposed observations of cloud macro- and microphysics will provide some of the necessary constraints for improving model cloud algorithms.

This project will provide important field work and data processing experience for graduate students at the University of Wisconsin, University of Colorado, and University of Idaho. In addition, data and experiences from the field program will be integrated into undergraduate coursework at the University of Idaho and summer workshops at the University of Wisconsin.