Earth Observation
Centre for Doctoral Training

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Liquid Over Ice: Using Fogbows to Help Understand the Properties of Clouds Over the Greenland Ice Sheet

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Figure 1. A fogbow observed over Summit, Greenland.

Over the Greenland Ice Sheet, low-level liquid clouds (fog; See Figure 1) forms year-round and plays a significant role in the energy balance of the ice sheet. The formation and persistence of this fog is odd as the liquid exists at temperatures well below freezing (i.e., they are super-cooled). Understanding the physical properties of this fog and how these properties moderates the energy budget of the ice sheet is key to understanding how the ice sheet will change into the future. This information, in turn, is vital for understanding sea-level changes caused by climate change.

Unfortunately, fog over the ice sheet is hard to observe by traditional space and ground-based remote sensing instrument. Thus, understanding it has remained largely elusive. Therefore, we would like to trial a new method for this project that will derive properties of the fog from images of fogbows. In this project, you will use images collected at the U.S. NSF's Summit, Greenland Observatory and Mie scattering software, IRIS, to derive the drop size distribution of the fog (see Figure 2).

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Figure 2. An example of the analysis to be done in this project. The inset image is a picture of a fogbow while the larger imagine is the output of a simulation. The Mie scattering simulation used a mean droplet diameter of 60 micron with a lognormal distribution of diameters having a standard deviation 12% to match the width of the primary fogbow and the position of the two supernumerary arcs inside the main bow.

Knowing the drop size distribution of the fog is essential for modelling fog formation and understanding of fog interacts with solar and thermal radiation. This retrieval of properties will then be compared to in situ observations of fog particles collected by optical particles sensors that have been operation since 2018. Further, if time permits, combining this information with radar and lidar observations that tell us about the persistence and thickness of the fog should allow for a full assessment of the fog's cloud radiative properties.

This work is part of a larger project with scientists from the U.K. and U.S. entitled ICECAPS. As such, you will become a member of a team that has been making ground-based remote sensing observations at the highest point on the Greenland Ice sheet for the past ten years. The output of this project will likely underpin a peer-reviewed publication because it will be the first assessment of fog drop sizes at Summit using this methodology.

A previous study from other members of our ICECAPS team took a first rigorous look at Summit. We hope that this project will build on this, so please look at this before applying (We are happy to answer questions about it and do not expect you to the details):

Cox, C. J., Noone, D. C., Berkelhammer, M., Shupe, M. D., Neff, W. D., Miller, N. B., Walden, V. P., and Steffen, K.: Supercooled liquid fogs over the central Greenland Ice Sheet, Atmos. Chem. Phys., 19, 7467–7485, https://doi.org/10.5194/acp-19-7467-2019, 2019.

Once you join our team, other references will be provided.