Closing the Water Vapor Exchange Budget Between the Ice Sheets and Free Atmosphere

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Project Objectives: This project has deployed the first UAV with a gas-sampling pod optimized for water vapor collection and analysis in the field following flight. In doing so, the project stands to provide the first detailed and high-resolution airborne measurements of water vapor isotopes in the critical atmospheric boundary layer just above the Greenland Ice Sheet. The exchange processes across the interface between atmosphere and the surface of the ice sheet control the climate signal archived in ice cores, and vapor flux constrains sublimation and by extension, a portion of ice sheet mass balance.

Keywords: Water vapor, Isotopes, Arctic, Greenland ice sheet, Hydrology, Snow surface, Mass balance

Progress To Date/Future Plans: We have successfully deployed a multi-rotor UAV and a 3 meter fixed wing UAV aircraft for proof of concept to obtain profiles above the Greenland Ice sheet of temperature, pressure, humidity and made measurements of discrete samples for water vapor content and isotopic signature. Future plans include new and improved sample collection payload, better and faster temperature and humidity sensors, automated boundary layer detection, and improved flight control. Team has expanded to include expertise with MAR models and will return to Greenland for final season in 2021 to obtain high-resolution data in space and time.

Highlights or Expected Outcomes: We have helped pioneer the pathway for overcoming challenges associated with flying UAV aircraft in the cold and challenging high Arctic environment. We have identified and solved a number of hurdles in collecting and making accurate measurements of water vapor isotopes from the surface to 1500 m aloft including low humidity samples. This has potential applications to help validate other ground based and satellite measurements of water vapor (eg. TCCON). With the addition of more data, we hope to inform regional atmospheric models (MAR) for higher quality outputs. The sample collection method may also be applied to sampling other gases of interest. The fixed wing UAV with a modular configuration will also leverage new applications that can employ on-board instruments for in situ measurements, such as methane.

NNA Community Collaboration and Research Coordination: I am interested in connecting with other NNA researchers exploring water vapor isotopes, near surface atmospheric measurements or other surface processes. Since we have a proposal pending to extend our work to measuring methane other parts of the Arctic, I would be interested in leveraging projects of mutual interest that could couple our measurements with others at different scales across thermokarst environments.

Advice for Overcoming NNA Project Challenges: We've learned a bit about operating UAV aircraft in the Arctic environments and happy to share what we've learned. In general: Design, plan, fabricate, build, test, evaluate, and repeat until satisfied. A balance tenacity and patience is helpful.