RESEARCH STATEMENT

My research centers on the characterization of Earth's glaciers and ice sheets. This is a critical area of research as glaciers and ice sheets are currently losing mass at accelerating rates, directly contributing to global sea-level rise threatening both current and future societies. Additionally, subglacial aqueous systems represent compelling environments that inform the search for life beyond Earth - a quest that is fundamental to all of humanity and currently focused on extraterrestrial sub-ice water environments. In service to these two areas of cryosphere research, I am particularly interested in leveraging the unique insights gained through the acquisition, analysis and synthesis of radar sounding observations. Specifically, my past, on-going, and future research contributes towards an improved understanding of the near-surface and subglacial conditions critical to understanding the cryospheric implications of ongoing climate change and reduce uncertainty in global sea-level rise predictions. Additionally, my future research will build the necessary groundwork for in-situ sampling of a unique hypersaline subglacial water system in the Canadian Arctic and reveal new, previously unknown water systems highly relevant for planetary analog studies. In all aspects of my research, I strive to improve and adapt radar sounding analysis techniques to further the science that can be extracted from a given dataset through i) joint analyses with other remote sensing, geophysical and geological datasets and ii) novel approaches to radar sounding data processing and interpretation. I believe that there is a wealth of polar radar sounding data that have yet to be explored to their full potential.

For me, the use of radar sounding observations to improve our understanding of glaciological processes is the most powerful approach to investigate past, current and future changes in the cryosphere, while simultaneously revealing previously hidden environments that potentially host unique ecosystems that inform the search for life beyond Earth. My research will facilitate collaborations within the Prestigious University, as well as with other national and international institutions and will be attractive to external funding agencies. The multifaceted nature of my research to a wide range of glaciological problems also represents a powerful vehicle to attract a talented and diverse group of students. Within the broad range of radar sounding applications over glaciers and ice sheets, there are two main research themes that I am currently working on and plan to pursue in the future:

1. Geophysical characterization of subglacial hydrological conditions

Subglacial water systems have been shown to host active microbial life despite the extremely dark and cold conditions, making them compelling analogs for icy planetary bodies where life may exist under similar conditions. However, accessing these systems for in-situ sampling to assess the microbiological environment is challenging and first requires detailed geophysical characterization. In parallel, subglacial hydrological conditions exert a strong control on ice flow dynamics and play a fundamental role in a glaciers' future response to atmospheric and oceanic temperature forcing. Knowing the distribution and characteristics of subglacial water systems provides crucial boundary conditions for predictions of future sea-level contributions.

My research in this area has focused on Devon Ice Cap, Canadian Arctic, where my work led to the discovery of the world's first hypersaline subglacial lake complex. This work combined radar sounding measurements with ice temperature- and subglacial hydrology models, and knowledge of the surrounding geology, in order discern the unique basal conditions. The Devon lakes and their surrounding geological conditions represent a tantalizing analog for brines inferred to exist on other planetary bodies such as Europa, Mars and Enceladus. Since 2018, I have co-led a multi-national project (SEARCH^{Arctic}) working towards the holistic geophysical characterization of the Devon subglacial environment, and ultimately towards in-situ sampling of the lake water. I am also a critical member of the NASA-funded ESCHER project that will identify, characterize and assess the habitability of Devon subglacial hypersaline fluids by using airborne radar sounding to identify where the system discharges into the ocean and submersible in-situ water sampling. My role in these ongoing projects focuses on the planning, collection and synthesis of novel aerogeophysical data (multi-polarized and multi-frequency radar sounding, magnetics, gravimetry) to further define and delineate this complex subglacial water system.

Based on my work on Devon Ice Cap as well as on-going preliminary data analysis, I am also interested in evaluating the existence of similar hypersaline subglacial water systems that may exist beneath outlet glaciers of other Canadian Arctic ice caps. I plan to investigate these subglacial hydrological conditions through the integration of radar sounding measurements, geological datasets, and other remote sensing observations (i.e. ice flow velocity). The joint interpretation of these datasets will provide insight into the influence of the subglacial hydrological role on ice dynamics, while also illuminating the potential to leverage these subglacial environments as part of future planetary analog studies. To do so, I will seek out external funding opportunities relevant to both the sea-level rise and planetary perspectives and will take advantage of existing radar sounding datasets and collaborations as well as conduct new aerogeophysical surveys. Finally, I plan to extend the scope of my research to include Antarctica, where I am currently involved in a project with Dr. J. Greenbaum (Scripps), investigating a potential subglacial volcano in the Princess Elizabeth Land. I am also looking to apply my radar sounding techniques in other Antarctic locations, such as Thwaites Glacier, where I recently participated in an aerogeophysical survey specifically designed to identify the configuration of its subglacial hydrological system.

2. Airborne radar sounding to derive near-surface firn properties

At the other end of the ice column, my research also involves the use of airborne radar sounding to characterize near-surface firn (compressed snow that has accumulated over several years). In response to atmospheric warming, Arctic ice masses have experienced a significant increase in surface melting over the past two decades, which is now the main contributor to mass loss of the Greenland Ice sheet (GrIS). In areas covered by firn, surface meltwater runoff into the ocean is buffered by percolation and refreezing of meltwater within the firn itself, thereby leading to significant firn densification and the formation of thick widespread ice layers. However, as the percolated and refrozen meltwater increases, firn pore space is progressively reduced and the firn loses its meltwater buffering capacity. Thus, knowledge of firn properties and understanding its evolution in response to surface melting are crucial for future projections of meltwater runoff from Arctic ice masses and their contribution to sea-level rise.

My past research in this area led to the development of a new technique that allows the identification of refrozen ice layers within firn using low-frequency radar sounding measurements that do not image the firn structure directly. While, in its current form, this technique allows for the qualitative characterization of ice layers within the firn, in the future I will look to extend the technique in order to develop a reliable approach to *quantify* firn properties (i.e. ice content) through airborne radar sounding. This research will leverage existing datasets and combine airborne radar measurements made over various frequency ranges with laser altimetry, in-situ firn core observations, and associated models. Based on promising preliminary results, I am currently preparing a proposal to NASA in order to secure funding for this project. In addition to the GrIS, I will also apply firn characterization methods to Antarctic ice shelfs, where firn densification can increase an ice shelf's susceptibility to collapse, which could trigger significant mass loss.