I recall the first time I stepped onto glacial ice, specifically the McLaren glacier, which flows south off the spine of the Alaska range. I was a student in the National Outdoor Leadership School, which seeks to develop leadership skills through the development of outdoor competence, and we were traversing the range from the McLaren, in the southeast portion of the range, to the Yanert glacier near Denali National Park. It was raining heavily. The moraine was composed of loose cobbles and everyone kept losing their footing. Slowly we made our way to the toe of the clean, opaque ice. I though that it was going to be slick, but as I stepped onto the glacier, and with the (now familiar) sound of boots crunching on blocky crystals in my ears, I realized that the glacier was not slick, rather more like sandpaper. But why? What caused the McLaren to defy every other experience that I had had with frozen water?

We spent six more weeks on or near glaciers. Near the margins, I would pick up the rocks that had become perched on pedestals due to differential melt, and found that the ice under these was slick. Hanging inside a crevasse (for practice), I noticed that the walls were smooth. When crossing east-west trending glaciers, the south sides were always more slippery than the north sides. This body of empirical evidence suggested that the sun was responsible for making the glacier surface sticky. I surmised that sunlight was melting water and dissolving the ice fabric and causing individual crystals to protrude. Though retrospectively this was a somewhat simplistic explanation of the physical processes that govern surface roughness on a glacier, it is a good approximation. With the physical intuition that develops after spending enough time in any dynamic environment, the basic processes that caused glaciers to form, that defined their characteristic topography, and that governed the dynamics of water and ice became clear. I saw hypotheses everywhere as I realized that the physics of glaciers are the same as those elsewhere, and that characteristics that defied initial expectations made sense. The bear, of course, remains in the quantitative details.

I grew up in an era where climate change finally made it into the United States' social consciousness, and the media was (and is still) saturated with sweeping statements about the state of the cryosphere, rife with numbers that are impossible for the layman to contextualize (how big is a gigaton?). I wanted to understand the provenance of these numbers, and figured that the best way to do this was to get a degree in Geosciences. During this time, and in service to environmental policy and stewardship (the other pillar of my intellectual life), I volunteered as an undergraduate researcher studying the effects of the removal of Milltown Dam, which had altered the historic sedimentation patterns of western Montana's Clark Fork, and also held behind it a large reservoir of copper-laden mine tailings. In this capacity, I performed repeated surveys of the river's geometry and physical characteristics to quantify change, corroborated these surveys with analyses of aerial imagery and remotely sensed topography, used geochemical signals to trace contaminants as they moved through the system, and throughout helped to communicate these findings to river managers, policy makers, and to the general public.

This work was scientifically satisfying and socially important. Yet, I also felt somewhat limited in my ability to explain the phenomena that we were observing from a physical perspective. Coincidentally, I was working a job as a library janitor, and stumbled upon a book about physical and statistical modelling that had been left on a table (the cover was a picture of solutions to the Lorenz equations). Browsing through the book, though the mathematics were unknown at the time, the text made referenced principles that I had already been using to make qualitative arguments, like mass and energy conservation. I resolved to learn how to make these arguments quantitative.

I managed to do well enough in a numerical differential equations course to be offered a graduate research assistantship in Computer Science. During winters, I developed ice sheet models. During summer, I collected data on the Greenland ice sheet. This was an excellent opportunity to advance my understanding of the physics governing the natural world, and also to become reimmersed in the environment that had piqued my interest in science in the first place. One of the key processes that we were investigating was the behavior of liquid water under the ice sheet. My modelling efforts were designed to support our field efforts; in order to establish the location of the between frozen and temperate basal conditions, we developed a numerical model of thermomechanically coupled ice flow, which we applied to Isunnguata Sermia, our study area in western Greenland. We used the model to explore the sensitivity of the temperature at the ice sheet bed to a variety of unobserved thermal parameters. These results ended up being rather general, and I was able to publish a paper on this project as first author.

During summer field seasons in Greenland, we drilled in regions that the model predicted would be at the melting point. I was a member of a small team of faculty and graduate students charged with using a diesel-powered hot water spray nozzle at the end of a kevlar-reinforced hose to drill saucer-sized holes through hundreds of meters of ice. After connecting with the bed, we lowered instruments to measure water pressure, temperature, and deformation rates. We also performed active tests of the subglacial hydrologic system, such as rapidly pumping several thousand liters of water into a borehole. This produced strange and interesting behavior, such as phased oscillations with other nearby boreholes, as these holes, connected by a network of subglacial channels and conduits responded like a manometer. Other holes, equally near did not respond at all, or had already drained completely. Boreholes demonstrated spatially heterogeneous connections to an efficient drainage network. This work lead to an invited talk at the annual American Geophysical Meeting, of which I was a co-author, as well as a paper in Nature authored by my supervisor. Further publications are in preparation.

Following completion of my MS in Computer Science, I took a job as a professional developer of ice sheet models. During this time, I produced an open source and freely available ice sheet model called VarGlaS, which is currently being used for active research by groups in Montana, Texas, and Alaska. I was author or co-author to several other publications on numerical ice sheet modelling. During this period, I also took part in scientific service, from several years judging student projects at the Montana State Science Fair, to participating in a NASA organized initiative aimed at developing guidelines for benchmarking climate-cryosphere model coupling experiments. I also had the time to volunteer for the Selway Bitterroot Frank Church Foundation in my native Idaho, rehabilitating trails, naturalizing campsites, and helping with public outreach and fundraising at community events. I once worked with a group of volunteers to replace an aging and dangerous boat ramp at a remote air strip along the Middle Fork of the Salmon River.

Working as a staff researcher at Univerity of Montana was both professionally and personally lucrative, but I also knew that my strict focus on ice sheet model development was pulling me away from the observational, tactile component of science that I found appealing. Also, my long term career goal was (and remains) to achieve a faculty position at a research institution. Furthermore, though I had become proficient in the applied mathematical subset in which I was working (finite elements, dynamical systems), I needed to develop additional mathematical prowess in other disciplines to adequately pursue the research that I was interested in. These arguments suggested that a PhD was the next logical step. Ideally, I could combine my modelling experience with the opportunity to both inform and verify new glacier modelling approaches with data collected from a targeted field campaign.

It is with these goals in mind that I have begun my doctoral studies at the University of Alaska. I have developed a research plan that addresses the confusing implications of the dramatic but natural advance of Taku glacier in southeast Alaska superimposed upon the much more subtle signals of climate change. A more detailed proposal is included in the accompanying document, but the essence of the project will be to calibrate an advanced numerical model with constitutive properties inferred from instrumented boreholes as well as remotely sensed topography and imagery, in order to explain the physical controls on the time scale of tidewater glacier cycles. This work is both socially and scientifically relevant because it will provide a framework to begin deconvolving the natural and anthropogenic forcings that affect glacial ice in the marine environement. This is also an opportunity for scientific communication to a more general audience; when the public is consistently exposed to the idea that there is a one-to-one correspondence between climate change and shrinking glaciers, phenomena such as contemporary glacial advance is rightfully confusing. I'd like to use this work as an opportunity to start a concurrent digital media project (in the vein of recent multimedia features in the New York Times, for example) that will address these seemingly counterintuitive phenomena in generally accessible terms, using examples from Taku Glacier and elsewhere. I think that combining the social importance of climate change, the aesthetic imagery and gritty experience of glaciological field work, and interactive glacier models in a polished and accessible style has the distinct capacity to engage and inform the public, and so promote scientific literacy. This is a broader impact.

Ultimately, I would characterize my motivation to pursue a PhD in glaciology as follows: there is something to be said for floating a ski pulk across a supra-glacial stream, repairing a diesel boiler, and solving a partial differential equation in a tent while waiting out a blizzard on the same day. These sorts of tribulations promote development of a useful set of skills, namely a capacity for drawing techniques from disparate fields of study and applying them to precise (and often unlikely) problems. This emphasis on lateral thinking is motivated by some of the physical realities of glaciological research: glaciers guard their secrets jealously. They exist exclusively in inhospitable places. Despite rich behaviour throughout, only the ice surface is easily observed. The spatial and temporal scales on which many glaciological processes operate are too short to allow averaging and too long to observe wholly. As such, many fundamental unanswered questions exist (How fast do glaciers slide in the future? At what rate does calving occur?), both for curiosity's sake and for the socially mandated task of projecting the dynamics of glaciers into the future. Specifically, glacier contribution to sea level rise provides a guide for scientific inquiry. The lack of both complete data and complete mathematical descriptions of glacier processes require complementary experimental and mathematical treatments. These factors, namely that glaciers are difficult to study, possess fundamental uncertainties (thus interesting questions), and also possess social importance provide my motivation to choose glaciological research as a career path.