Research Experience and Future Directions

The speed up, thinning, and retreat of marine-terminating glaciers have been attributed to, in part, the negative mass balance of the Greenland Ice Sheet (GrIS) over the past two decades (Csatho et al., 2014, van den Broeke et al., 2016; Kjeldsen et al., 2015). Despite exhibiting loss over long time scales, there is significant heterogeneity in the amount and duration of terminus retreat for individual glaciers (Murray et al., 2015) making it difficult to predict the future behavior of any one glacier. In part, this is because glacier termini sit at the intersection of the ice sheet, ocean, atmosphere, and sedimentary environments and thus their positions represent a complex response to a myriad of processes acting upon them. In order to develop ice sheet models to create an accurate enough picture of how glaciers lose mass, it is vital to have long-term and robust observational records. Therefore, I focus on remote sensing of the cryosphere, particularly in Greenland at the ice-ocean boundary or the terminus of glaciers over the last 100 years. My research aims to create, analyse and share these records in order to understand how and why glaciers change in a warming climate.

Current research

IcePicks: a collaborative database of Greenland outlet glacier termini

Marine-terminating outlet glacier terminus change mapped from satellite and aerial imagery in Greenland is used extensively in understanding how outlet glaciers adjust to climatic changes over a range of time scales. Numerous studies have digitized termini manually, but this process is labor-intensive and may lead to duplication of efforts. Additionally, these studies use different methods to pick the front, which makes them difficult to compare. This project aims to create a database of manually digitized terminus picks and an intercomparison of picking techniques to determine errors and best practices for future efforts in digitization. These data are being cleaned, associated with appropriate metadata, and compiled so they can be easily accessed by scientists. This is a multi-institution collaboration between Taryn Black (University of Washington) , Daniel Cheng (University of California Irvine), and James Lea (University of Liverpool).

Characterizing buoyant conditions in West Greenland glaciers

Two major styles of calving have been identified for West Greenland glaciers through remote sensing of terminus change; full-thickness buoyant fracture and serac failure (Fried et al., 2018). The former is expected to happen at glaciers that are close to or at floatation. For these glaciers, basal crevasses form at the grounding line and propagate upward where they connect with surface crevasses as they are advected to the front of the glacier, promoting calving of large tabular icebergs. Using a time series of the spatial pattern of buoyancy conditions for several glaciers in central west Greenland using Polar Geospatial Center's ArcticDEM strips from 2012-2017, I have highlighted the differences in buoyant conditions between these two different calving types. Preliminary results confirm floating conditions for those glaciers that experience full-thickness calving events. I use the height above buoyancy to determine the penetration height of basal crevasses in order to understand how these vary across different glaciers.

Current Undergraduate Projects

Sediment Plume Identification

Sediment plumes breaching the surface of fjord waters are commonly found at the front of marine-terminating glaciers. Suspended sediment concentration (SSC) in glacial plumes has been measured and correlated to Landsat infrared imagery in Svalbard (Schild et al., 2017), however this has not been done in Greenland as the front of glaciers is often too dangerous to approach. An undergraduate student is working to automatically delineate the sediment plume in the fjord waters in Landsat 8 imagery and will then apply the SSC calculation form Svalbard. It is assumed that this is a minimum estimate as Svalbard glaciers are much slower and therefore would produce much less sediment and vigorous plumes. This project will aid in our understanding of erosion at the base of Greenland glaciers, which is a fairly unknown quantity at this time.

Topography Extraction at the Terminus of Greenland

The two most extensive surveys of the role of bed topography in glacial retreat are Catania and others (2018), which surveyed a suit of 15 glaciers in west Greenland from 1960 to 2016 and Bunce and others (2018), which surveyed glaciers in northwest and southeast Greenland over 2000-2010. Both studies confirmed the role of the size of overdeepenings, width of fjords, and slope of sills on controlling the retreat of glaciers in Greenland by comparing the retreat to individual glacier bed geometry. Recent 2-D modeling of an ideal glacier has shown that the slope of the retrograde bed slope controls the timing of retreat (Robel et al., 2020). An undergraduate is working to extract bed topography data from BedMachine radar-derived topographic map for Greenland (Morlighem et al., 2017) using terminus picks from IcePicks to test the hypothesis that the specific slope of the retrograde bed determines the timing of retreat for real glaciers in Greenland.

Future research

Characterization of terminus retreat patterns in Greenland

After the completion of the IcePicks database, we will have the most complete record of terminus positions for Greenland as well as bed topography extracted from these picks. This data will be used to identify the shape (sinuosity, skewness, and curvature) of the glacier terminus through time to determine the retreat style and what forcing may be acting on the glacier. This is particularly important to study over a long period of time to identify times where retreat style changes. This may show a change in calving style and the stability of the glacier as it is retreating. We hypothesize that changes in retreat style are determined by bed topography shape and ice thickness changes that determine if the glacier is at or near floatation.

Citizen Science for Greenland: Crowdsourcing digitization of ice-ocean regions

Crowdsourcing has been a lucrative method for science in data-rich regions. With IcePicks, a Google Earth Engine Digitisation Tool (GEEDiT; Lea, 2018) is being developed for Greenland-specific digitization. I will collaborate with Dr. James Lea to crowd-source terminus picks, sediment plumes, and ice melange to engage with the public. The goal is to educate on glaciology and remote sensing as well as include the public on the data collection process.