FALL 2019 – COS 397 COMPUTER SCIENCE CAPSTONE PROJECT PROPOSALS

Project Title: Using Satellite Remote Sensing to Quantify Surface Elevation Change and Mass Balance Parameters across the Juneau Icefield, Alaska

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Brief Description (approximately 500 words)

Since the 1960's, Alaska glaciers have contributed more to sea level rise than any other glacier system in the world. Projections suggest that some major icefields in Alaska may lose over 60% of their total volume in the next 100 years. An immediate consequence of this ice loss may be coastal community flooding due to sea level rise. Among many other concerns, increased freshwater input may also have significant impacts on the important Gulf of Alaska marine ecosystem, associated fisheries, and economy. Some questions remain regarding the physics of glacier volume changes in Alaska which are important to consider for future prediction and planning. Glacier volume loss is generally estimated by glacier surface lowering. Glacier surface lowering occurs through some combination of dynamic thinning (i.e. increased ice flow velocities result in stretching and thinning of glaciers), densification of snow or firn, and melt. Current research predicts that surface lowering is dominated by melt in Alaska. However, the three contributors have not yet been fully quantified, and they are highly variable across the complex Alaska glacier systems. Variability arises from complexities in glacier elevations, aspects, geometries, slope, and proximity to the Gulf of Alaska as a dominant moisture source. We aim to determine what the spatial and temporal variability of surface lowering from melt, densification processes, and dynamic thinning is across Alaska.

Our long-term goals are to quantify and differentiate dynamic thinning, melt, and densification contributions to surface lowering. An initial step required to achieve these longer term goals is to develop a time series of surface elevation changes in high spatial and temporal resolution across Alaska. The recently launched NASA ICESat-2 satellite completes repeat elevation surveys every 0.8 m along tracks across Earth's surface every ± 90 days which are vertically accurate on the order of 1 cm. This data therefore provides an unprecedented opportunity to develop time-series of surface elevation over changing glaciers with astounding accuracy and at relatively short time-scales. This project will focus on building a user-friendly GUI to analyze, interpret (differentiate) multiple ICESat-2 tracks. The GUI will be used in actual research efforts as well as in multiple courses both at UMaine, the Juneau Icefield Research Program (JIRP; http://juneauicefield.org/), and over a dozen participating institutions of JIRP.

Goals for the Project (approximately 50 words)

- Produce a GUI which selects ICESat-2 data based on geographical and temporal bounding boxes, and which can perform some statistical and data analysis of repeat-track ICESat-2 data.
- Produce a time-series of surface elevation change across the Juneau Icefield from ICESat-2 data though the designed GUI Interface

Total Duration / Elapsed Time [in weeks]:

We feel the scope of the proposal is of the right size for approximately a two-semester project (1

semester for ICEsat-2 software development and 1 semester for testing and improving the software on available datasets).

External Schedules / Deadlines [if any]:
This project is designed to assist current research efforts on the Juneau Icefield by JIRP, UMaine, and over a dozen other participating institutions. Our goals on the icefield are to quantify and differentiate contributions to surface lowering caused by 1) dynamic thinning; 2) snow and firn densification; and 3) surface melt. Results from this project will also feed into multi-agency collaborations between UMaine, the U.S. Geological Survey, U.S. Forest Service, University of Alaska, and Massachusetts Institute of Technology, providing ample opportunity for students to collaborate and work with a range of scientists. We have multiple National Science Foundation and NASA proposals being submitted this year focused, in part, on this research, so the development of easy user interfaces to work with the data as non-experts would be ideal. One proposal is due February 8, 2020 which we consider an external deadline for preliminary elevation results which could be used in the proposal. An earlier proposal is due October 8, 2019, so if students select this project, they and this effort would be listed on the proposal.

Learning Objectives for student teams:
By undertaking this project, students will:

- Apply their computer science skills to a scientific problem of societal interest
- Develop an understanding of multiple satellite remote sensing platforms which are used for a range of basic and applied research applications
- Learn to work with a professional team of scientists and to contribute to a multi-organization collaboration including academic, private sector, and federal agencies
- Develop new skills in big data analysis, interpretation, and presentation
- Assist with the development of multiple high level NSF and NASA proposals and potentially peer-reviewed manuscripts which are focused on a topic of societal importance
- Become familiar with technical details of data acquired from the recently launched, $1B NASA ICEsat-2 satellite (https://icesat-2.gsfc.nasa.gov/) and potentially other NASA satellites and acquired data products.

Expected Project Experiences (select from the list):

Problem definition
Project scope definition
Data analysis
Workflow analysis
Use of Applied Statistics
Development of functional specifications
Examination of an unfamiliar technical area
Identification of others' technical expertise
Identification and evaluation of alternatives
Development and presentation of recommendations
Responsibility and accountability for a discrete product
Role definition in a task group and participation in group dynamics
Observation of management styles
Observation of organizational politics

Preparation of a manuscript for publication

Recommended experience (What operating system is required? What programming language? Other skills?):

The primary need is in Python with flexibility on operating system. Students will work with a range of Python scripts developed collaboratively before, during, and after the University of Washington sponsored ICESat-2 Hackweek (https://icesat-2hackweek.github.io/). Students will need to become familiar with navigating multiple data warehouses operated by NASA. An interest in Earth science applications to computer science is ideal, but not entirely necessary.

Expected Outputs/Products and likely requirements (specific programming language, operating system, integration with existing software, web-based requirements, *etc.*):

We desire a GUI to be available for multiple platforms (ideally Windows and Mac), preferably a stand-alone application so that users do not need to install Python and its dependencies on their host machines. Many data processing scripts are written in Python that are currently available. We envision a stand-alone application, but a web-served model is also an option. However, ideally the GUI operates without internet access (i.e. with data in hand, the GUI will function). Finally. documentation should be as a user-guide and tutorial from the Juneau Icefield as an example. The goal is to make this GUI useful for analysis of ICESat-2, but potentially other datasets if students are inclined to pursue other efforts useful to our science goals (e.g. building a GUI to estimate changing surface velocities using repeat stereo images).

Past experiences by the client (If software already exists, what is wrong? What has worked in previous versions, and what has not?):

ICESat-2 was launched in 2018 and the first round of proposals is due October 8, 2019. The data was recently made available in July of 2019 and the first round of python-based openly available scripts have been developed by a team of scientists interested in using the satellite for a range of Earth science applications. ICESat-2 data is therefore new and has not yet been widely used by the broader science community. Our hope is to make user-friendly applications which will be available to education programs as well as non-specialized scientists. No software currently exists for this application. We envision other NASA data products may be incorporated into the GUI developed by this project. However, our first goal is to support analysis and comparison of ICESat-2 data.

Proposed Testing Plan (How will the team test their product? Do you have recommended/required testing strategies? What resources are available (test platform, stand-alone network, *etc.*)? Is test data available?):

We envision the team testing their product by using available ICESat-2 data across the Juneau Icefield. ICEsat-2 data is now freely available online and multiple surveys across the Juneau Icefield have already been acquired. You can access the data at: https://nsidc.org/data/icesat/data.html

Benefits to U Maine:
ICESat-2 is the most recently launched NASA satellite gaining significant traction and publicity by the climate, cryosphere, and Earth science community. The acquired data products will likely revolutionize our understanding of glaciers, ice sheets, sea ice, permafrost, and many other changing Earth systems. The development of easily available and user friendly GUI's for education programs and research scientists that do not specialize in big data analysis, would be a leap for UMaine, NASA, and the broader cryosphere community. Note, UMaine is also the academic home for the Juneau Icefield Research Program (JIRP) which is the longest operating field program in North America. The development of this GUI as a teaching and research tool on JIRP, which has strong potential for bringing major research funding and international collaborations to UMaine, would be a significant positive step forward for UMaine, JIRP, and the STEM education-research community.

Project Sponsor(s):

NASA and National Science Foundation

Other Resource People:
Ann Hill, graduate student
Scott Braddock, graduate student

Software/server access required:
NASA and affiliated data servers such as the NSIDC: https://nsidc.org/data/icesat/data.html