Effect of Tributary Glacier Surge on Tidewater Terminus Stability: College Fjord, Prince William Sound, Alaska

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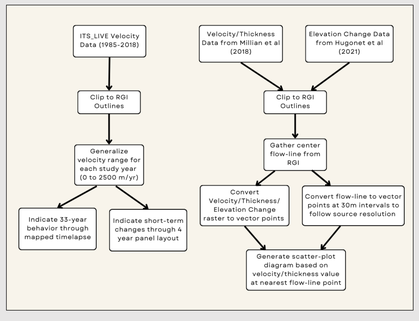
Abstract

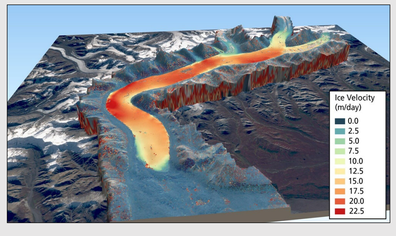
The Harvard and Yale Glaciers represent an inverse relationship to each other which grants a key outlook on tidewater glacier dynamics. Over a period of 64 years (1945-2012), Harvard Glacier advanced 28 observable times while Yale Glacier retreated 20 times. With two glaciers in similar climatic, geometric, and hydrothermal forcings, other factors must be considered to better determine the cause(s) of their behavioral differences. To examine the drivers of this relationship, a geospatial analysis was performed using current velocity, thickness, and elevation change data, determining the relationships between each and granting an outlook on overall tidewater glacier behavior from 1985-2018. The results indicated evidence of Alaskan-type surge occurring in Harvard Glacier, as well as in Harvard's leading tributary, Radcliffe Glacier. Furthermore, there was a positive correlation in the frequency of surges within Harvard and Radcliffe, indicating that Harvard may be highly influenced by increased mass deposition coming from Radcliffe within 1-2 years of increased velocity.

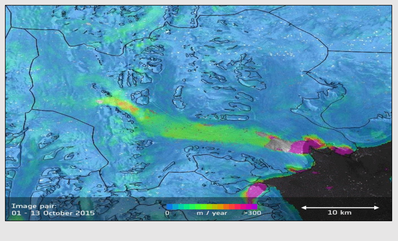
Methods

All data used in this study was reviewed and then implemented using ESRI's ArcGIS Pro 3.0 software. Within, shapefiles from the *Global Land Ice Measurements from Space* (GILMS) and *Randolph Glacier Inventory* (RGI) databases were used to clip the velocity, thickness, and elevation change data gathered from external resources.



Types of Glacier Surge





Alaskan

- Found in temperate mountain glaciers typically in Alaska, USA.
- Characterized by higher peak velocity values on 1–2-year cycles.

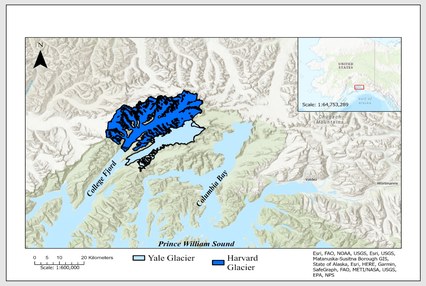
Svalbard

- Found in polar glaciers typically in Svalbard, Norway or Antarctica.
- Characterized by lower peak velocities on multidecadal or centennial cycles.

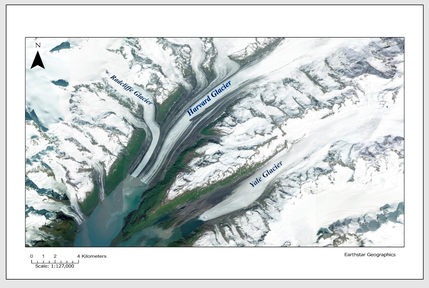
ESA, NPS

Study Area

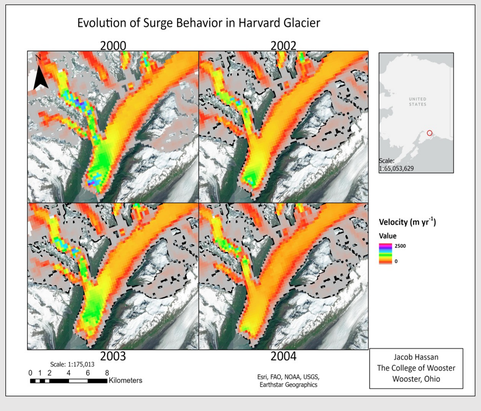
College Fjord is a large system stretching to the northeast of Port Wells and is approximately 38km long with a varying width of 3-5km (Santos et al, 2010).. The glaciers here drain from the larger Chugach Icefield which supports some of the largest glaciers in Alaska. Despite having a relatively mild climate, College Fjord receives a mean annual precipitation of up to 350cm and an annual snowpack of 200cm. Santos and others (2010) comment that the topography around College Fjord greatly affects maritime air masses coming in from the Pacific, which results in heavier amounts of snowfall and higher developments of active glaciers on the seaward slopes.



The Harvard and Yale Glaciers are some of the largest tidewater glaciers within Alaska, taking up 527km^2 and 165km2, respectively. Radcliffe Glacier is the leading tributary glacier and directly impacts the unstable terminus of Harvard Glacier. Tributary-Terminus behavior is loosely studied. As such, the environment of College Fjord lends itself perfectly to research of this nature.

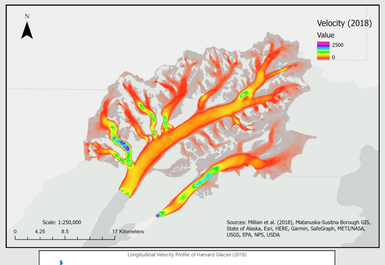


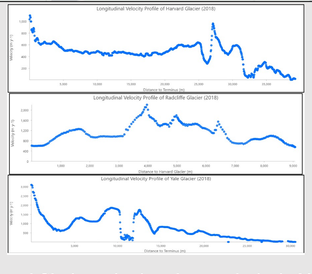
Findings



There were 4 unique surge events that occurred in Harvard Glacier from 1985-2018:

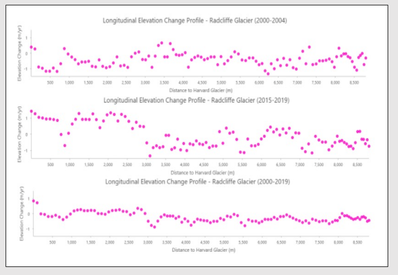
- 1985-1986
- 2000-2004
- 2008-2009
- 2010-2014

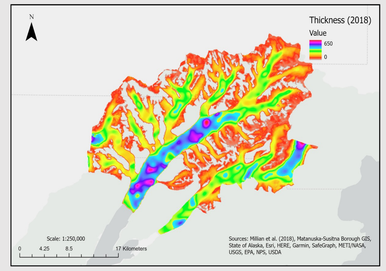


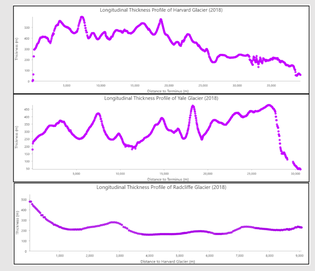


- Harvard Glacier maintains a lower velocity in 2018.
- Radcliffe Glacier demonstrates a higher average velocity than Harvard.
- Yale Glacier shows glacial retreat, with a high velocity terminus that doesn't continue past 3000m.

- Elevation change data from both Harvard and Yale over 2000-2019 further demonstrates their inverse behavior.



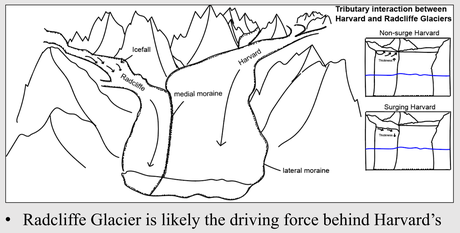




- Thickness from 2018 shows that Harvard Glacier is much more stable than the retreating Yale Glacier, and the hyper-active Radcliffe Glacier.
- Higher peak points of thickness also correlate to tributary glacier input points.

Elevation change for Radcliffe Glacier indicates two main behavior types:

- Loss of mass when Harvard is surging.
- Buildup of mass when Harvard is stable or retreating.



- Radcliffe Glacier is likely the driving force behind Harvard's surges.
- Yale Glacier's continual retreat with a lack of tributaries indicates the importance of tributary glaciers in ice dynamics.

Thank you!

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Thank you for taking the time to view my poster! See some of my other work at jakehassan.github.io

Key References

Millan, R., Mouginot, J., Rabatel, A., and Morlighem, M., 2022, Ice velocity and thickness of the world's glaciers: Nature geoscience, v. 15, p. 124–129, doi:10.1038/s41561-021-00885-z.

McNabb, R.W., and Hock, R., 2014, Alaska tidewater glacier terminus positions, 1948-2012: Journal of geophysical research. Earth surface, v. 119, p. 153–167, doi:10.1002/2013jf002915.

Hewitt, K., 2007, Tributary glacier surges: an exceptional concentration at Panmah Glacier, Karakoram Himalaya: Journal of glaciology, v. 53, p. 181–188, doi:10.3189/172756507782202829.

Clarke, G.K.C., Schmok, J.P., Ommanney, C.S.L., and Collins, S.G., 1986, Characteristics of surge-type glaciers: Journal of geophysical research, v. 91, p. 7165–7180, doi:10.1029/jb091ib07p07165.