Detecting Terminus Advance and Velocity of Hubbard Glacier Using Image Correlation

Joseph M. Krenzelok
krenz036@umn.edu
University of Minnesota Twin Cities Department of Geography

Introduction

Hubbard Glacier is the only advancing glacier in Alaska. Due to its geographic location, the advancement of this glacier has created a glacial dammed lake out of Russell Fjord twice in its history[1] (Fig. 1). Both instances resulted in failure of the dam leading to two of the largest glacial outburst floods recorded worldwide[2]. In the case of a future damming event, it is possible that the dam could hold, and the newly formed Russell Lake will continuously grow until it overflows into the Situk River and floods the nearby village of Yakutat[3].

The objectives of this study were to determine the likelihood of a future closure of Russell Fjord and to develop a system for predicting closures based on terminus advancement and velocity using image correlation techniques.

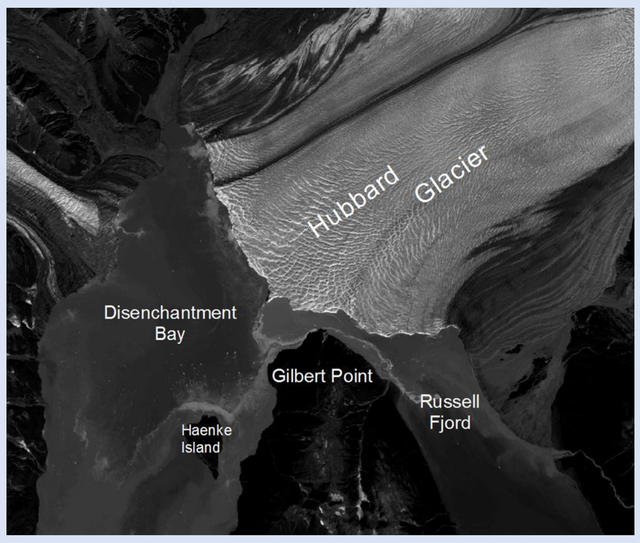

Figure 1: *Yakutat Bay, Alaska. Hubbard Glacier has been pushed into Gilbert Point, sealing off Russell Fjord and causing it to fill with freshwater in both 1986 and 2002.*

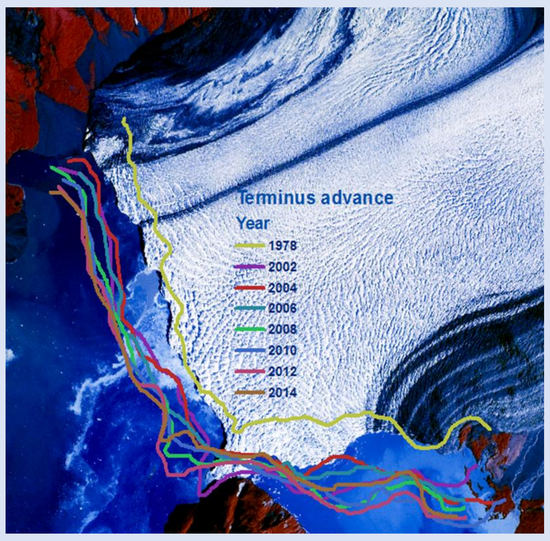

Figure 2: *Summer Terminus positions of Hubbard Glacier. Background image is from the Alaskan High Altitude Photography Program showing the 1986 closure.*

Materials and Methods

Velocity Data

- Landsat 7 and 8 images were collected every other year from 2002-2014.
- Image pairs were collected within a timespan of thirty days.
- Velocity was analyzed from the image pairs using the feature tracking software CIAS[4].

Advancement Data

- Same image pairs used for velocity data were used.
- Terminus positions were digitized for each of the images.
- The difference between the digitized terminus positions of each image pair was calculated and standardized giving an advancement rate.

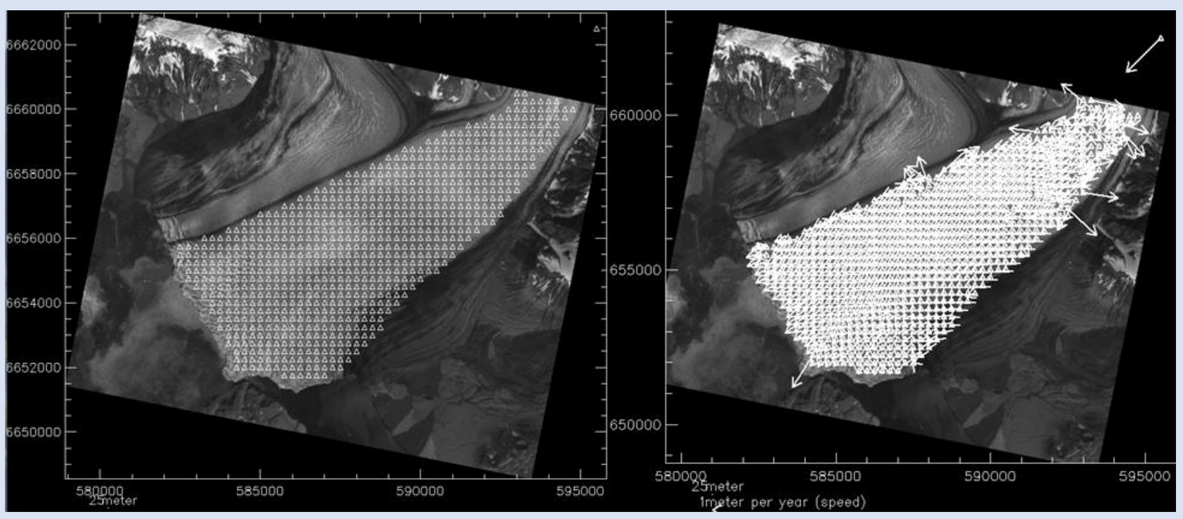

Figure 3: *CIAS feature tracker visual output. Data points collected (left), the azimuthal directions shown as vectors for each data point (right).*

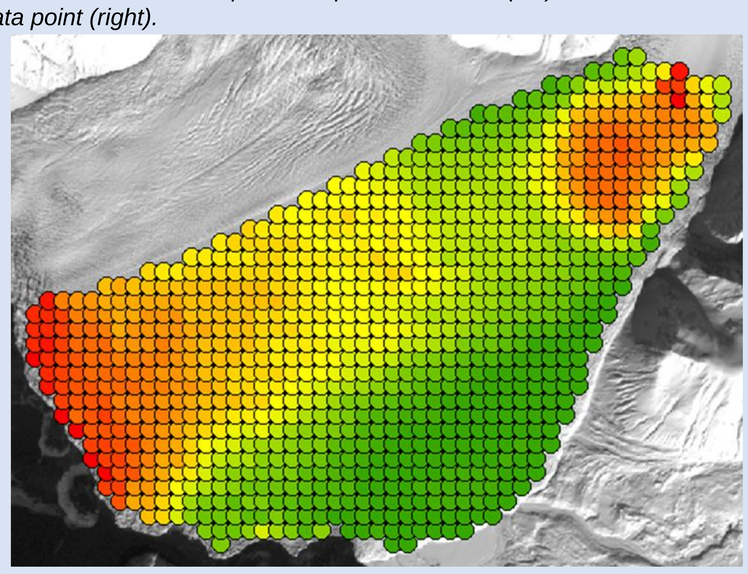

Figure 4: *Velocity data of Hubbard Glacier by geographic location. Green is the slowest moving while red is the fastest.*

Results

- Digitized terminus positions show Hubbard Glacier has advanced throughout time (Fig 2).
- CIAS feature tracker gives both velocity and azimuthal direction, but also provides correlation coefficients to find spurious data (Fig. 3).
- The fastest moving parts of the glacier are in the valley as well as the portion discharging into Disenchantment Bay (Fig. 4).
- The slowest moving portion is discharging into Russell Fjord as well as onto areas of land (Fig. 4).
- Seasonal trends show average velocity is highest in late spring.
- Velocities for Disenchantment Bay and Gilbert Point were at there highest in 2010 (Fig. 5).
- The Disenchantment Bay portion of the terminus has seen a steady increase in advancement (Fig. 6)

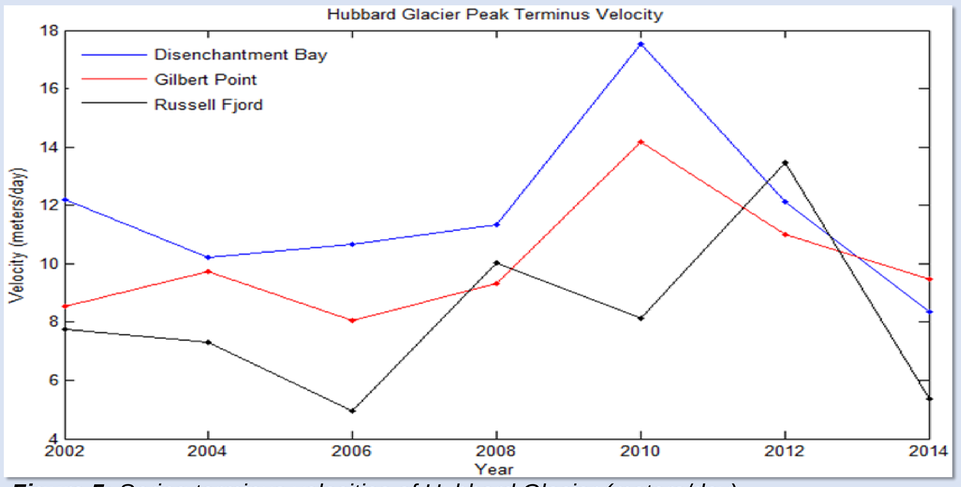

Figure 5: *Spring terminus velocities of Hubbard Glacier (meters/day)*

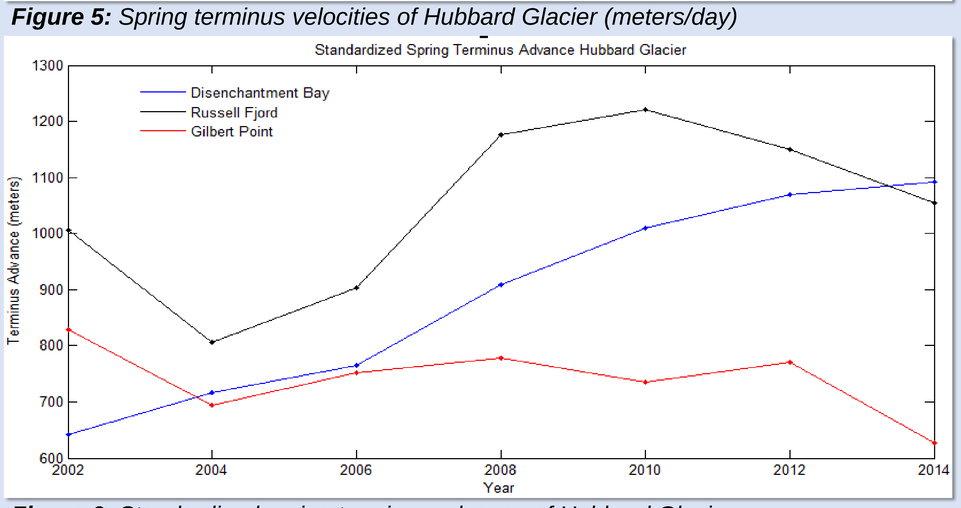

Figure 6: *Standardized spring terminus advance of Hubbard Glacier.*

Discussion

The terminus discharging into Disenchantment Bay has seen a steady increase over time. This is because the water is much deeper in this location, reducing the constraints on where the glacier is allowed to go.

The terminus discharging into Russell Fjord and Gilbert point are confined to shallower waters and the glacier is forced to disperse the advance.

Gilbert Point showed peaks in advance in 2008 and 2012. Comparing these two events with the terminus extents shows that Hubbard Glacier was getting close to a closure (Fig. 4).

There are many different variables that affect the advance of tidewater glaciers. Velocity alone cannot be the only predictor. It is important to take into account location of the advancement. Whether it is on land or water, and what material the glacier is sliding across are important aspects.

Feature tracking is an effective way to collect data to better understand the movement of glaciers using satellite image pairs.

Acknowledgements

This research was done with help and resources provided by the Polar Geospatial Center (PGC). A special thank you to Claire Porter from the PGC for providing scientific guidance throughout the project, as well as to Steven Manson from the University of Minnesota for providing advising along the way.

References

1. Trabant et al. (2003) Annals of Glaciology 36, no. 1: 45-50.
2. Gubernick and Paustian (2007) *PNW Research Station, USDA Forest Service* Vol. II 401-418.
3. Motyka and Truffer (2007) Journal of Geophysical Research: Earth Surface 112, no. F2.
4. Kääb (2013) “Image correlation software CIAS.” *University of Oslo Department of Geosciences*.