Change Detection Analysis of the Hubbard Glacier

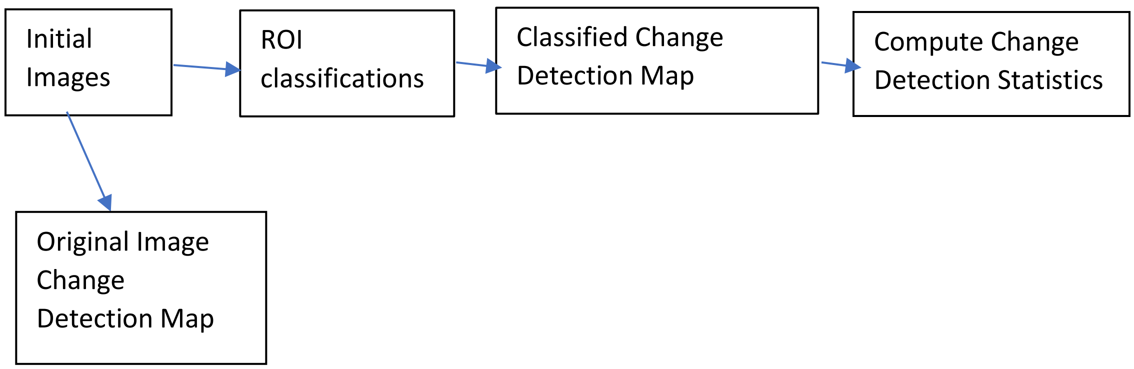
Introduction.

The image-processing objective of this project consisted of the attempted change detection analysis of the Hubbard Glacier through ENVI classic 5.3. The Hubbard Glacier is a glaciated area covering parts of eastern Alaska, spilling over into Yukon, Canada, two hundred miles northwest of Juneau. The glacier face can reach heights of four hundred feet and is more than six miles wide where it meets the ocean, the specific area of interest for this analysis. I found the Hubbard Glacier to be an intriguing area of interest due to its atypical, active growth patterns. There have been two major growth surges of the glacier in the last thirty years, in May of 1986 the glacier grew and ended up blocking the Russel fjord creating a lake. This actually presented some problems for the surrounding area. Threatening to flood the nearby town of Yakutat, Alaska. Sea level rose within the blocked off fjord, raising it by over eighty feet. This glacier runoff began to dilute the salinity of the water and threatened native sea life. On October eighth, this natural dam gave way and ensued a massive glacial lake outburst flood. With its peak discharge of water equating to 3,970,00 liters a second of water. The glacier again surged in June of 2002, once again blocking the entrance of the fjord. The new dam ended up breaking in August of the same year. This time caused by rain causing the water level to overflow the glacial dam and cause major erosion to the moraine. And causing yet another massive glacial lake outburst flood, causing a peak discharge of 1,850,000 liters of water a second. Both of these dam failures are the largest glacial lake outburst floods recorded.

Figure 1: Hubbard Glacier, Alaska

I was interested in the biophysical materials of the glacial ice, water, vegetation, and bare ground of the surrounding area. All are important physical features in differentiating the differences in the change and growth of the glacier. The remote sensing data appropriate to collect were Landsat satellite imagery of the glacier in different years to compare glacial changes. I specifically wanted to look at the initial glacial change between May third of 1985 and September eleventh of 1986. 1985 being a year the glacier was not blocking the fjord and 1986 being a year it did. Landsat 4-5TM was the satellite collecting data during this time-period. The imagery of this satellite is taken 60m spatial resolution. The glacier surged and retreated at different times of the year, so images from different years and different months had to be used, seasonal variance had to be taken into account.

Methods.



The image processing objective was directly derived from the change detection tool available in Envi. This was in inspiration for the objective, put within an environmental context. The process of the experiment began with the collection of Landsat satellite imagery. The two images of glacier taken from earth explorer from 1985 and 1986 were uploaded into Envi classic 64 bit. These were displayed with the bands 4,3,2. First I wanted to explore the change between the two original images. I processed a change detection map of the two images unchanged from their original band uploads. Next I wanted to look at more specific change between all of the aspects of the images. To do this I classified water, ice, vegetation, and the bare ground of the images with the region of interest tool. I then went to attempt to create a more specific change detection image. I had to choose a single band from each image, one from 1985, displaying the “initial” state, and one from the 1986 image representing the “final” state. The change type was set to simple difference. This simply subtracted the initial state image from the final state image. And normalization was the option chose from the data pre-processing options. This took the image minimum and divided it from the overall image range. This was then saved to a file and resulted in a difference map. The map is color coded with darker shades of red representing more intense positive change and darker blue representing more extreme negative change. Gray indicated little to no change. Next I wanted a more statistical analysis of the change detection image I had just computed. This was achieved through the change detection statistics tool. I again chose a single band from the initial, 1985, image and final, 1986 image. Equivalent classes then had to be paired, and each of the same ROI classifications were matched from each of the images. The option of what statistics would be displayed were shown, I chose percent. This tool also allowed classification masks to be created and these were saved to files and created. Envi then created a change statistics report.

Results.

The computed change detection map (figure 3/4) highlighted a change in ice blocking the fjord between the two years. However, the map produced was a bit confusing and displayed changes in pixels such as water that hadn’t changed, especially in the specific area I was observing. A large change in vegetation was highlighted as well. The original image change detection map (figure 2) computed, highlighted a clear, less noisy difference in glacial growth in the fjord between the two years. The change detection statistics suggested a different picture. Depicting ice change into bare ground and vegetation, rather than melting into water. I did not take the unclassified percentage data into account when comparing the statistics. The largest in change in classes from the initial ice other than to final ice, were bare ground and vegetation. It appeared the ROI classifications were not incredibly clear and ended up including a sizeable amounts of pixels in wrong classes.

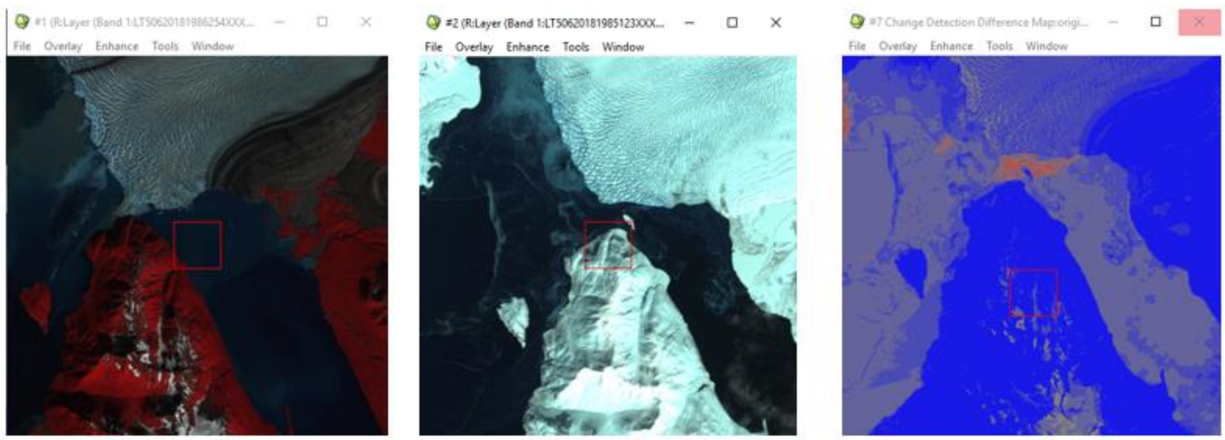


Figure 2: Original Image Change Detection Map

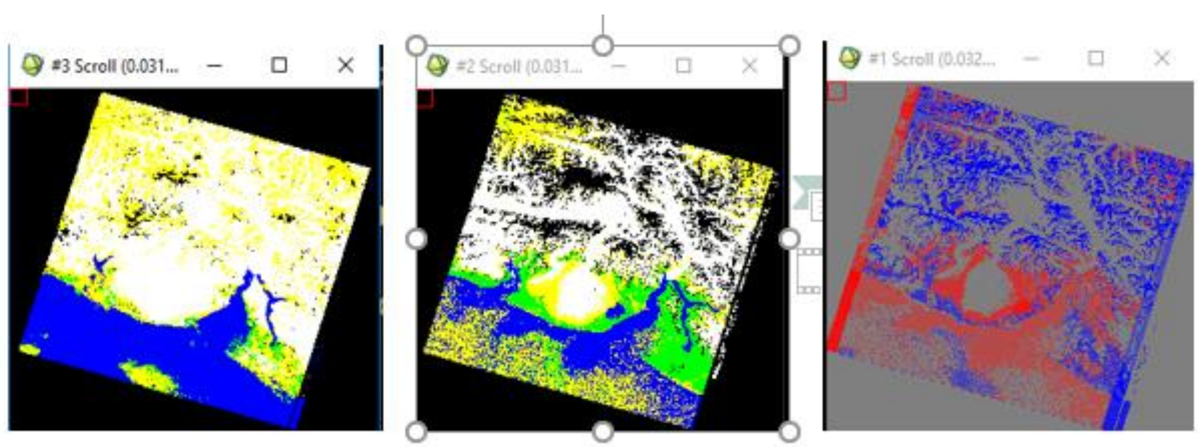


Figure 3: Classified Change Detection Map (Full Image)

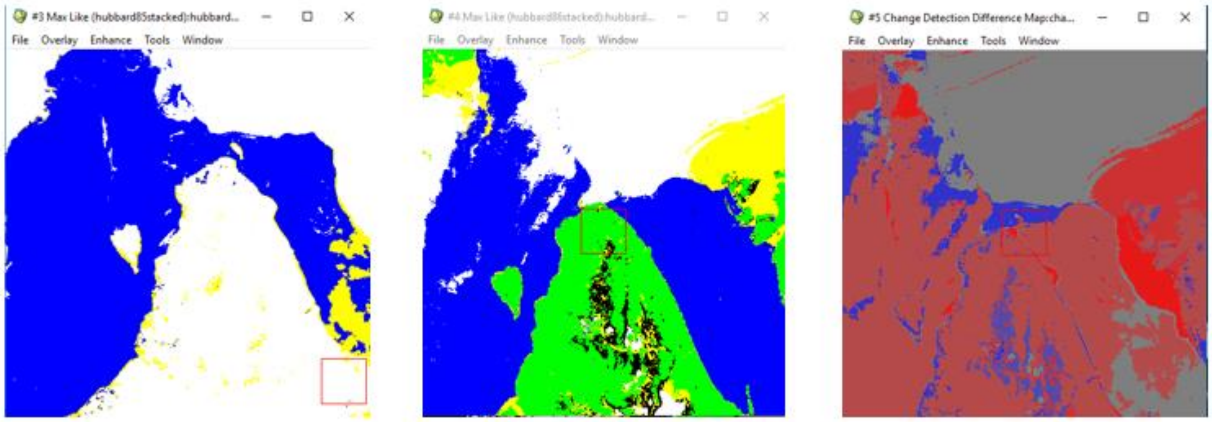


Figure 4: Classified Change Detection Map

Change Detection Statistics (Initial State: hubbard85classification, Final State: hubbard86classification)

File Options Help

Pixel Count | Percentage | Area (Square Meters) | Reference

		Initial State						
		Unclassified	Ice85 [White] 1143 points	egetation85 [Green] 1037 point	Water85 [Blue] 1031 points	are Ground85 [Yellow] 306 point	Row Total	Class Total
Final State	Unclassified	92.275	19.120	8.612	3.605	36.925	100.000	100.00
	Ice [White] 1803 points	3.778	60.031	0.029	0.463	19.908	100.000	100.00
	Vegetation [Green] 1075 points	0.542	6.874	64.255	5.508	17.226	100.000	100.00
	Bare Ground [Yellow] 1062 points	2.568	13.260	15.723	33.219	21.198	100.000	100.00
	Water [Blue] 1045 points	0.837	0.714	11.381	57.205	4.742	100.000	100.00
	Class Total	100.000	100.000	100.000	100.000	100.000		
	Class Changes	7.725	39.969	35.745	42.795	78.802		
	Image Difference	22.689	-27.084	391.711	-34.110	1.000		

Figure 5: Change Detection Percentage Statistics

Discussion.

Overall the classification of the images could have been much more accurate, this was due to user error when trying to define the ROIs. The initial difference map before user classification presented a much clear image of the glacial growth at the mouth of the Russell fjord. The second, classified change detection map showed change in pixels that had actually changed, for example water to bare ground. The change detection statistics actually made the result more confusing. I expected ice to mostly change to water, specifically thinking of the glacier interacting with the fjord. However, ice mostly changed to vegetation and bare ground, with thirteen percent changing to bare ground and six percent changing to vegetation. I believe what this was demonstrating was a reduction in snow cover, rather than glacial ice. These two glacial features were not taken into consideration at the beginning of the project. There was not really a way to differentiate these pixels when classifying the ROIs by hand so reduction of growth in glacial ice and simple snow cover, something that is much more variable with seasonality, was not taken into account. Due to the difference in seasons of each images this played a major role in computing the percentage of change for each class. This can clearly be seen in the classified change detection image map. Overall what this classification seem to do was actually measure the change in overall snow cover between the two years and did not highlight the change in glacial growth statistically. No accuracy assessment was done with the classifications, was there was no way of knowing exactly how accurate the ROIs ended up being. Visually for the whole images they definitely could have been significantly more accurate.

In retrospect, the processing objective was difficult to complete accurately with the tools used. Comparing images from different years, and especially from different seasons created results that were not necessarily reflective of what the initial objective, specifically looking at glacial growth affecting the Russel fjord, was intended to do. Attempting an objective of possibly observing overall snow cover of an area from different years, but from the same seasonal timeframe. Change detection in this context may very well show a more complete and accurate picture.

References

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