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Land Cover Analysis of Greenland's Ice Sheet Using Remote Sensing Technology

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Abstract

Due to the continuous release of greenhouse gases into the atmosphere, the global surface temperature will continue to rise. Increasing surface temperatures lead to the melting of Earth's ice sheets. The melting of the ice sheets causes sea-levels to rise as well as impact global weather patterns. Scientists have estimated that if the Greenland Ice Sheet melted, it would cause the sea-level to rise about six meters (National Snow and Ice Data Center,2022). Through the use of remote sensing technology, critical ice sheets can be monitored. Landsat 8 OLI satellite images are collected from a particular region of interest between an eight-year period. The selected images are displayed using two different band combinations to analyze the land cover. A natural color image of the area was created by displaying bands 3,2, and 1. However, to differentiate from snow cover and cloud cover a SWIR color image was created using bands 7,5, and 2. Each SWIR color image provided the following four regions of interest, water, snow, ice, and barren land. It was hypothesized that the percentage of barren land increased within the eight-year period. Results showed that there was a decrease in snow cover and an increase in barren land.

Introduction

As humans continue to release more greenhouse gases into the atmosphere, the global surface temperature will continue to rise. Increasing surface temperatures lead to the melting of Earth's ice sheets. The melting of the ice sheets has an influence on weather patterns and causes the sea-level to rise. Scientists have estimated that if the Greenland Ice Sheet melted, it would cause the sea-level to rise about six meters (*National Snow and Ice Data Center*). Fortunately, as humans also continue to combat and adjust to climate change, remote sensing technology can be used to monitor the melting of ice sheets. The following research used remote sensing technology and techniques to analyze the difference in snow and ice cover of a portion of Greenland's ice sheet between September 2013 and August 2021.

Methods

Satellite images provided by Landsat 8 OLI were collected from the Earth Explorer USGS website. The area of interest is a small peninsula of Greenland just below the Smith Sound. Bands 1-7 were

downloaded of the area for September 6th, 2013 (Figure 1) and August 29, 2021 (Figure 2). For each image, bands 3,2, and 1 were displayed to create a natural color image.

Figure 1: Greenland 2013

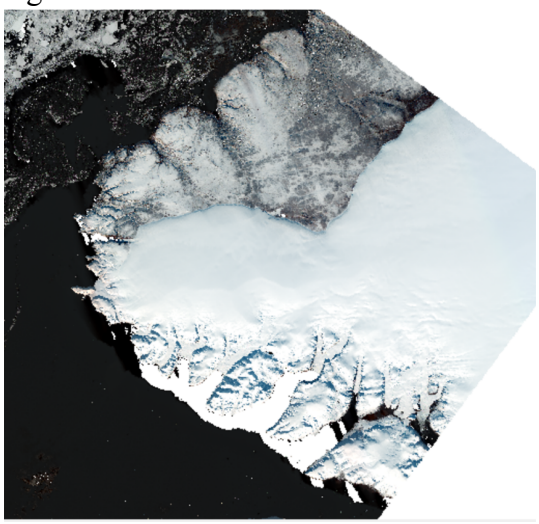
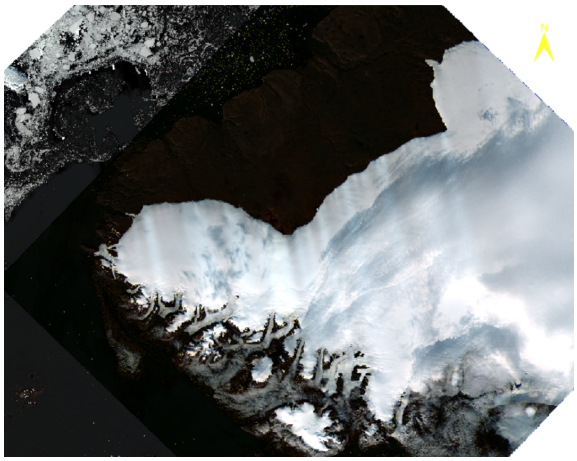


Figure 2: Greenland 2021



However, to better understand the snow cover and differentiate snow cover from cloud cover, bands 7,5, and 2 were displayed to create a SWIR color image (Figure 3 and Figure 4). Using shortwave infrared bands are most widely used for cloud and snow discrimination. The primary reason for their use is because snow is usually lower than clouds in reflectance. Therefore, snow appears darker than clouds in the SWIR wavelengths.

Figure 3: Greenland 2013

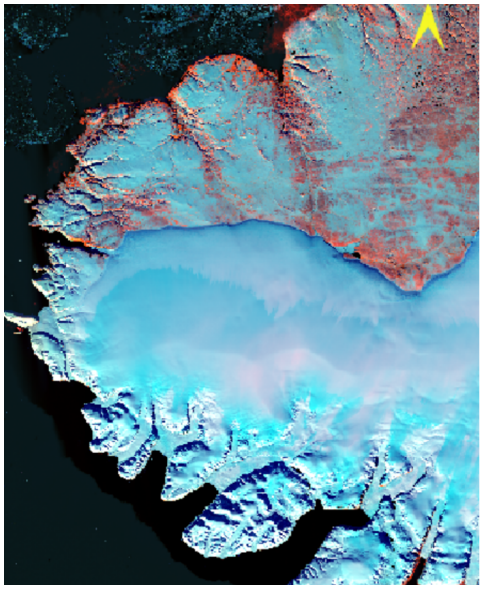
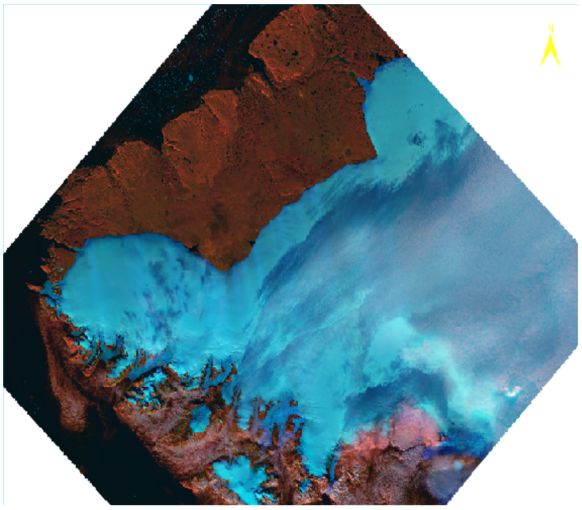


Figure 4: Greenland 2021



The SWIR color images were used to create regions of interest (ROIs) for each SWIR color image (Figures 5 and 6). The regions of interest for both images include water, ice, snow, and barren ground. Upon completion of the ROIs an unsupervised classification was performed to determine the percentage of land cover on each image.

Figure 5: Greenland 2013

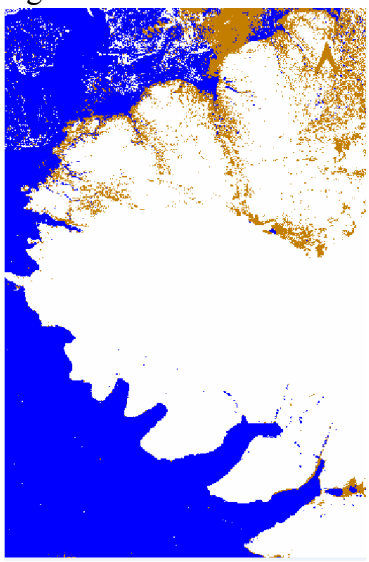
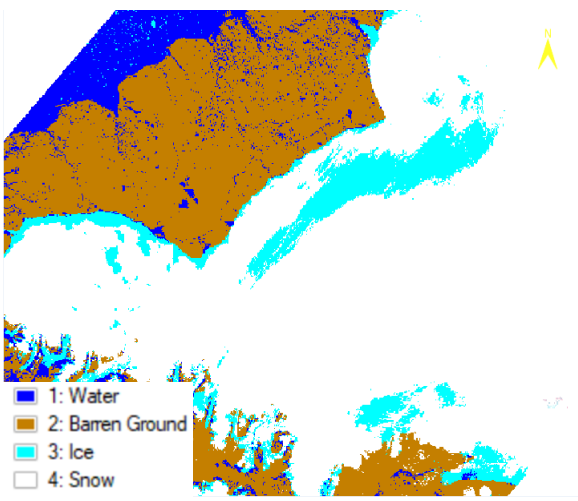


Figure 6: Greenland 2021



Results and Discussion

The land classification of each image provides evidence that Greenland has experienced a decline of snow and ice between September 2013 and August 2021. The percentage of snow cover in 2013 was 50.74% (Figure 7). However, in 2021 the percentage fell to 35.34%(Figure 8). The percentage of ice cover in 2013 was 8.62% (Figure 7) and in 2021 the percentage of ice cover fell to 5.32%(Figure 8). As a result of the decline in snow and ice cover from 2013 to 2021, the barren ground increased from 6.95% (Figure 7) to 22.10% (Figure 8) between 2013 to 2021. Lastly, the decrease in the percentage of water cannot be factored into the analysis because the 2013 image captured more water than the 2021 image.

Figure 7: Greenland 2013

Land Cover Type	Pixel Count	Percent
Water	65606	33.69%
Ice	16790	8.62%
Snow	98825	50.74%
Barren Ground	13531	6.95%

Figure 8: Greenland 2021

Land Cover Type	Pixel Count	Percent
Water	49272	12.61%
Ice	20791	5.32%
Snow	138042	35.34%
Barren Ground	86309	22.10%

The results of the research indicate a rise in global temperature within an eight-year period will cause a decrease in snow cover and an increase in barren land. However, there are two limitations to the study that must be noted. The first limitation is that there was no actual in-field assessment. An actual in-field assessment of the land cover would provide an accurate assessment of the land cover in the region. The second limitation is the images collected only represent two years within the eight-year period. Since melting and freeze of an ice sheet can change from year to year, more images with the eight-year time frame would provide stronger evidence of the change in land cover.

Despite the few limitations to the research, monitoring how an ice sheet is melting over time using remote sensing may provide scientists with a better understanding of the rate of melting. The results of the land cover analysis indicate a decrease in ice and snow and an increase in barren land. Therefore, the results of the land cover analysis provide evidence that remote sensing technology and techniques can be used to monitor the melting of ice sheets.

References

National Snow and Ice Data Center. Quick Facts on Ice Sheets | National Snow and Ice Data Center. (n.d.). Retrieved March 12, 2022, from https://nsidc.org/cryosphere/quickfacts/icesheets.html