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Calculating the ice loss in the Patagonia Icefields

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GEOL 4048 - Geological Applications of Remote Sensing

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Introduction

The investigation focuses on the study of ice lost in the icefields of Patagonia located in the country of Chile in South America. Patagonia is an area rich in geologic features such as glaciers, deserts, rivers and icefields. The Northern (NPI) and Southern Patagonia Icefields (SPI) cover about 3,950 to 12,550 km^2 of territory. This makes it the largest icefield of the Southern Hemisphere (Sakakibara & Sugiyama, 2014). Using the satellite instruments we compare the ice coverage in that area throughout a decade. During recent investigations, it has been discovered that over the years these icefields have been losing volume. This loss has become a major contribution to the global sea level rise in a disproportionate manner. This issue is also responsible for water shortages in arid zones of Argentina where glacial meltwater is their main water source (https://e360.yale.edu/features/andes-meltdown-new-insights-into-rapidly-retreating-glaciers).

Objectives

One of the objectives for this research was to observe how drastically global warming is affecting the ice coverage in the Patagonia icefields. We also wanted to observe the ice coverage trends in the Patagonia icefields throughout a decade, during the winter months of July and August. This process is performed with the Enhanced Thematic Mapper Plus (ETM+) sensor. Analyzing the changes in the area of the icefields every winter using the ENVI software was one of the main priorities when executing this research. Finally, the comparison of the ice coverage areas every month and year is also an essential part of this project.

Methodology

For this research about icefields, we used the satellite Landsat 7 with the Enhanced Thematic Mapper Plus (EMT+) sensor. This satellite was in use and produced data from the year 1999 until 2021. This was the ideal sensor to be used in this research since it covers the entire decade we will be studying. In addition to that, its spatial resolution was similar to other sensors that were considered making it the most convenient sensor to use. The ETM+ can detect seven bands: blue, red, green, near infrared (NIR), two mid-infrared (MIR) bands, the far infrared (FIR) and the panchromatic band. The ETM+ images were obtained from the Earth Explorer database. There the search was conducted using the Landsat 7 ETM+ C2 L2 Collection. The range of the image search was from 2011 to 2020. The only months analyzed were July and August. In total 20 images were selected for this research, one image for each of the two months selected per year.

Using the images selected in the ENVI software, it was attempted to perform a Dark Subtraction on them. This however, was not possible due to negative values that were presented in the valleys between the mountains. Once Dark Subtraction was performed the Cursor value tool showed that the digital values of the new image were higher than those of the unprocessed image, something that was not supposed to be happening. That issue did not allow for a successful image classification so it was decided, after some trial and error, that the images would be classified without any atmospheric correction. Before starting on the classification of images a Region of Interest (ROI) file was created with the classifications: Earth, Snow, Water, and Clouds. Multiple areas of training were selected over a vast distance that covered all of the areas that there were images of.

The next step was to perform a supervised or unsupervised classification on the images. It was attempted to use the K-Means unsupervised classification tool and the Minimum Distance supervised classification tool. When comparing these the K-Means image did not have satisfactory results while the Minimum Distance image resembled more what was being observed in the unclassified image. To further improve the classification method, the Maximum Likelihood supervised classification tool was also used alongside Minimum Distance on various images to analyze which tool gave more accurate results (**Figure 1**).

After various trials it was decided that the Maximum Likelihood tool was going to be used for the research. All of the images were processed and to every figure a North Arrow and a Legend were added to it. With every image the Quick stats tool was used to obtain the amount of pixels each area contained. From there the amount of pixels classified as snow was converted into snow coverage area in km2. Using that data a graph was constructed to better observe the trends of the snow coverage throughout the decade (**Figure 17**).

Results

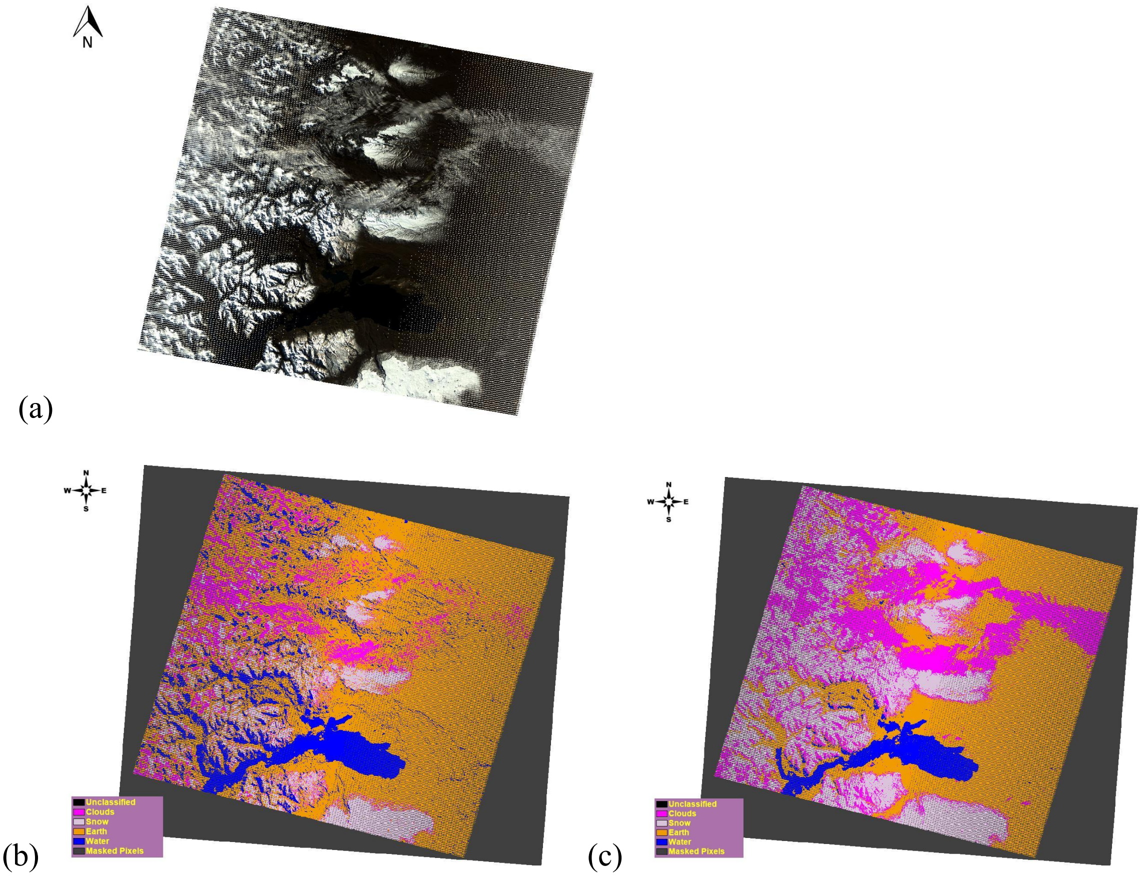
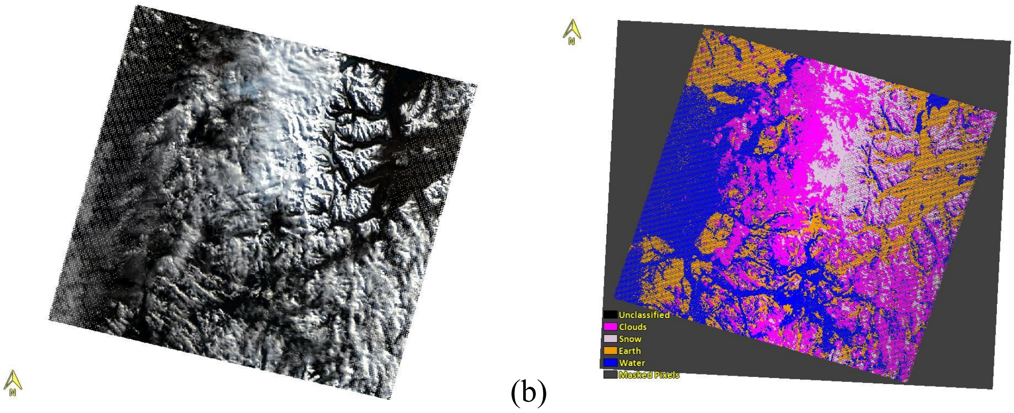
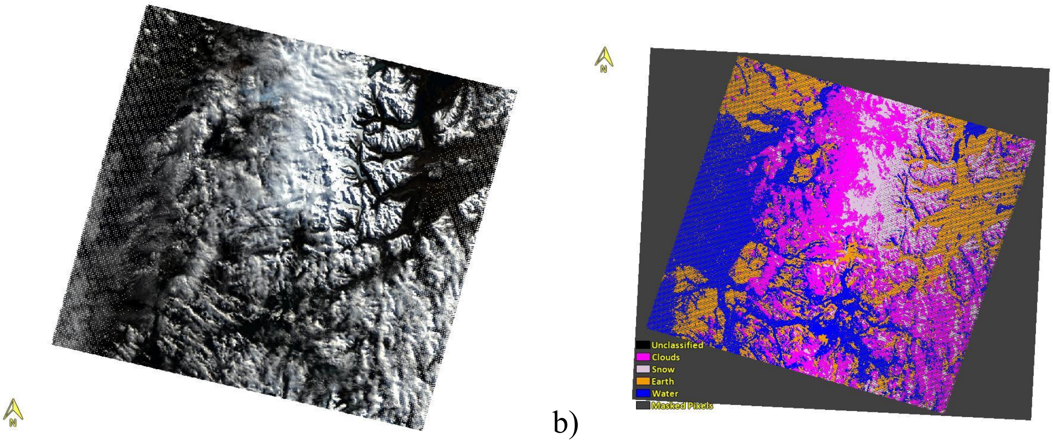


Figure 1. (a) Raw image. (b) Image classified with the Minimum distance tool. (c) Image classified using the Maximum Likelihood tool.



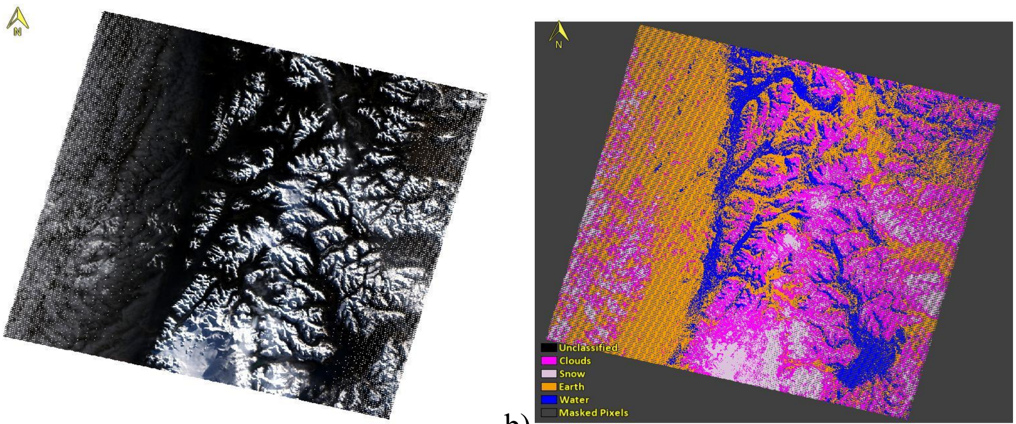
a) (b)

Figure 2. (a)Raw image of July 2011. (b)Classified image of July 2011.



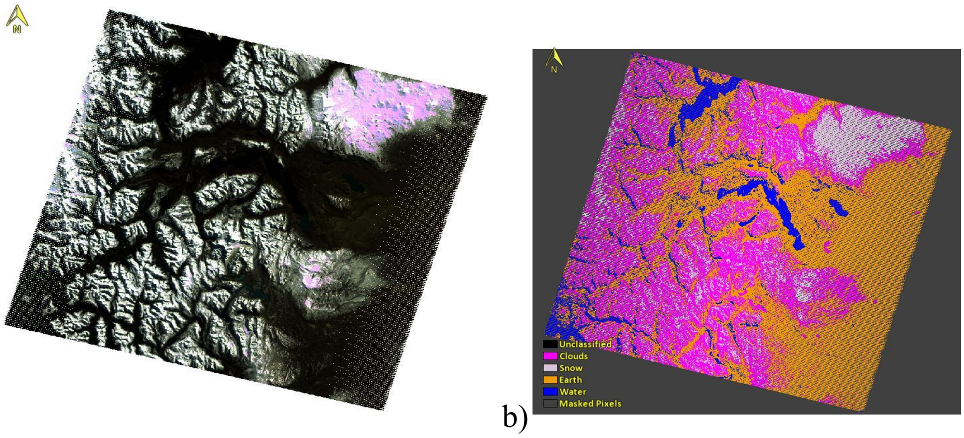
a) b)

Figure 3. (a) Raw image of August 2011. (b) Classified image of August 2011.



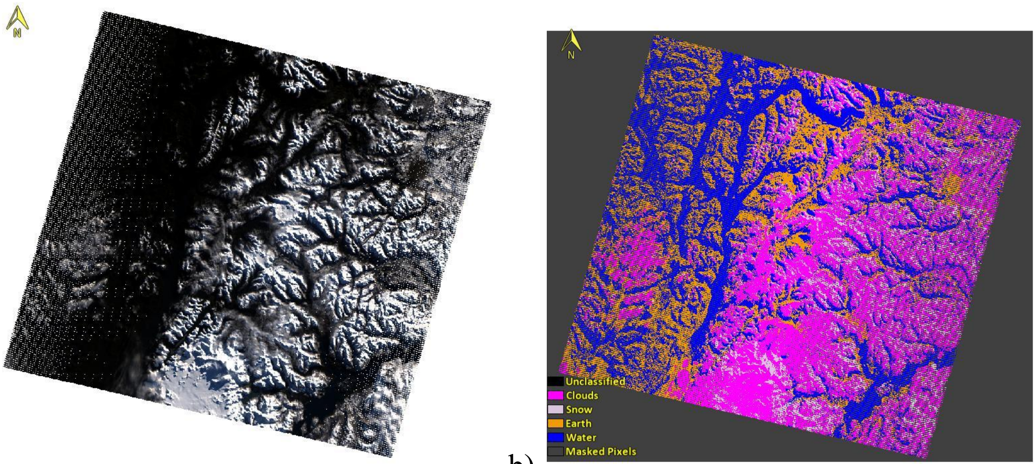
a) b)

Figure 4. (a)Raw image of July 2012. (b) Classified image of July 2012.



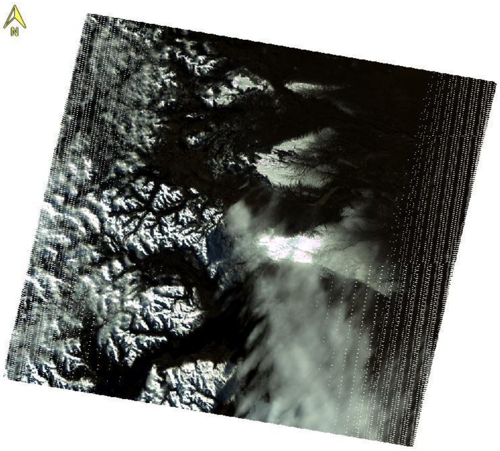
a) b)

Figure 5.(a) Raw image of August 2012. (b) Classified image of August 2012.



a) b)

Figure 6. (a)Raw image of July 2013. (b) Classified image of July 2013.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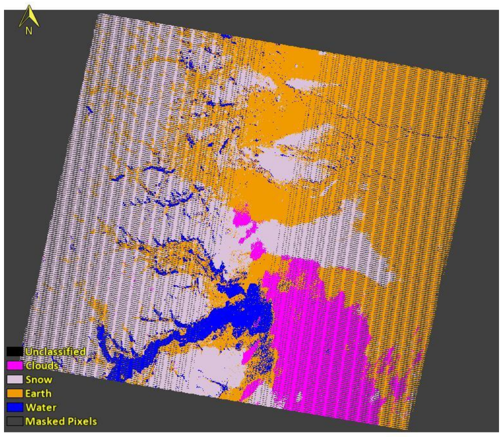
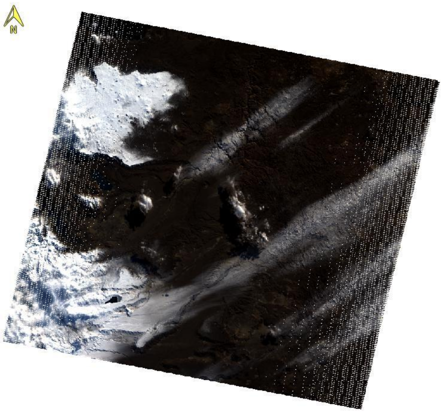


b)

Figure 7. (a) Raw image of August 2013 . (b) Classified image of August 2013.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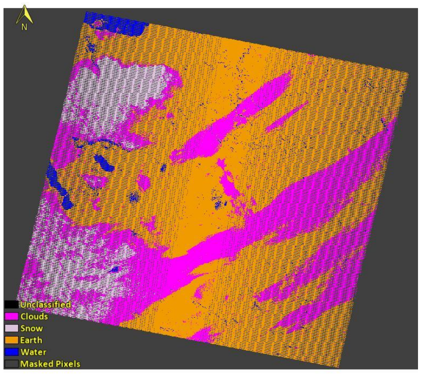
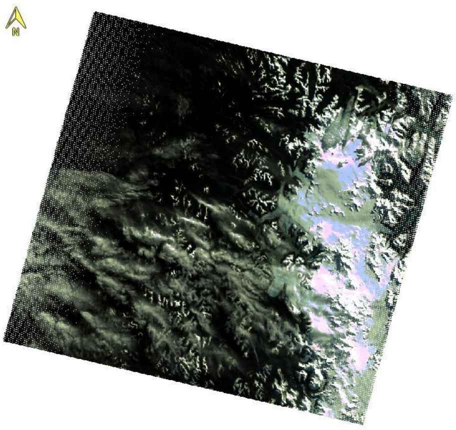
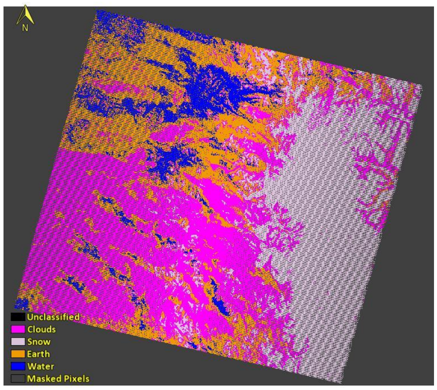


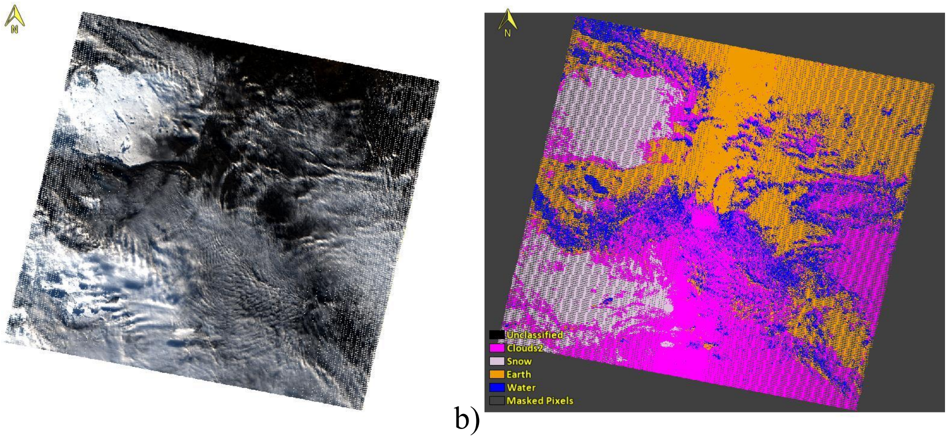
b)

Figure 8. (a) Raw image of July 2014. (b) Classified Image of July 2014.


a)


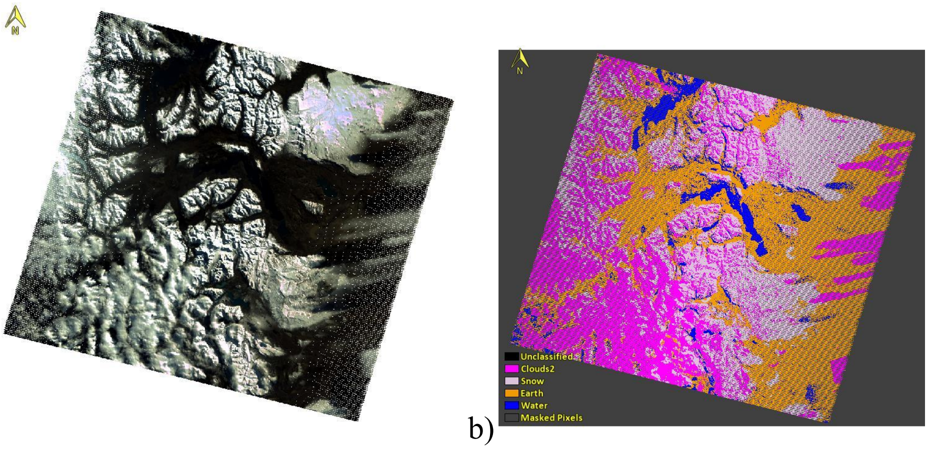
b)

Figure 9. (a) Raw image of August 2014. (b) Classified image of August 2014



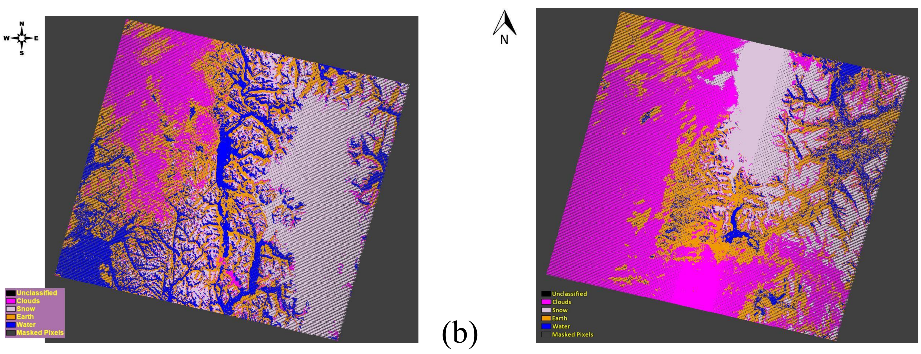
a) b)

Figure 10. (a) Raw image of July 2015. (b) Classified image of July 2015



a) b)

Figure 11. (a) Raw image of August 2015. (b) Classified image of August 2015.



(a) (b)

Figure 12. (a) Classified image of July 2016. (b) Classified image of August 2016.

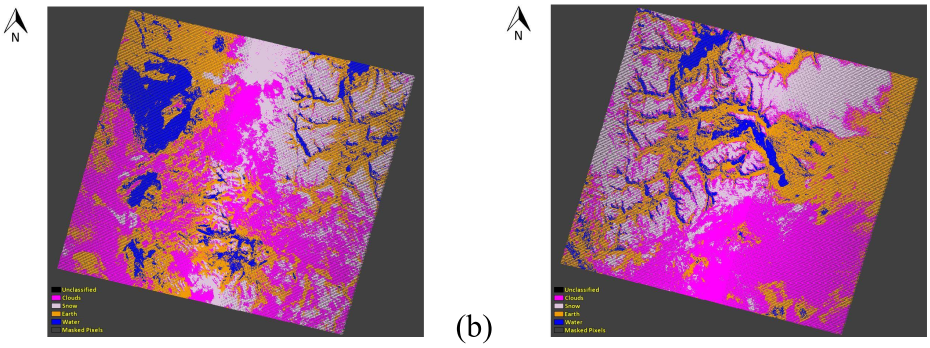


Figure 13. (a) Classified image of July 2017. (b) Classified image of August 2017.

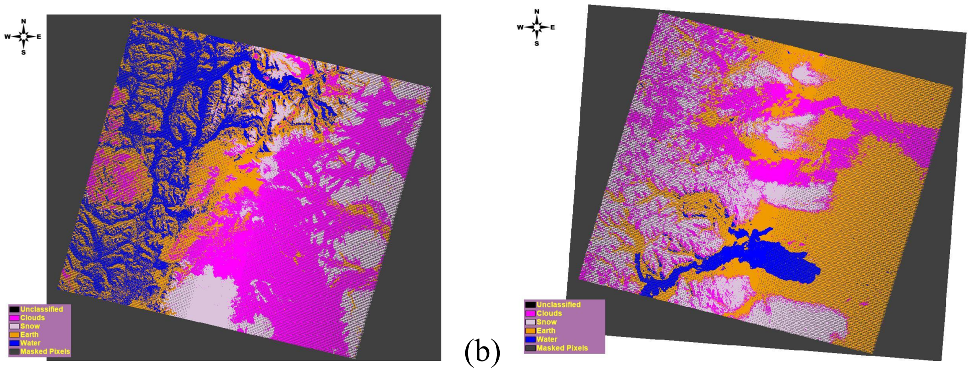


Figure 14. (a) Classified image of July 2018. (b) Classified image of August 2018.

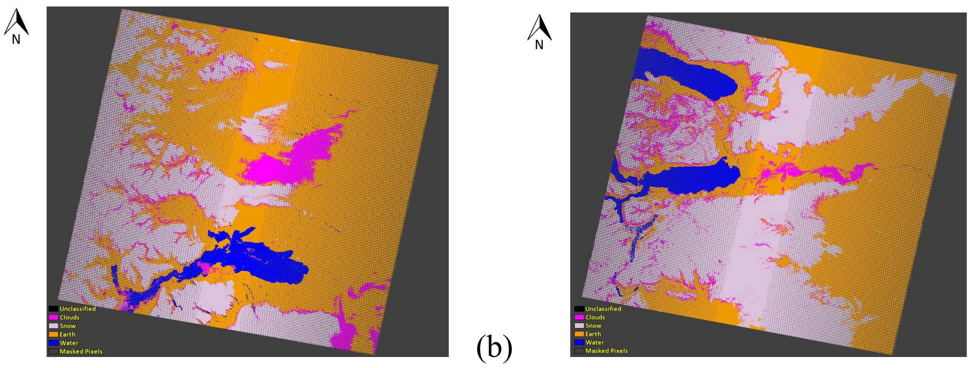


Figure 15. (a) Classified image of July 2019. (b) Classified image of August 2019.

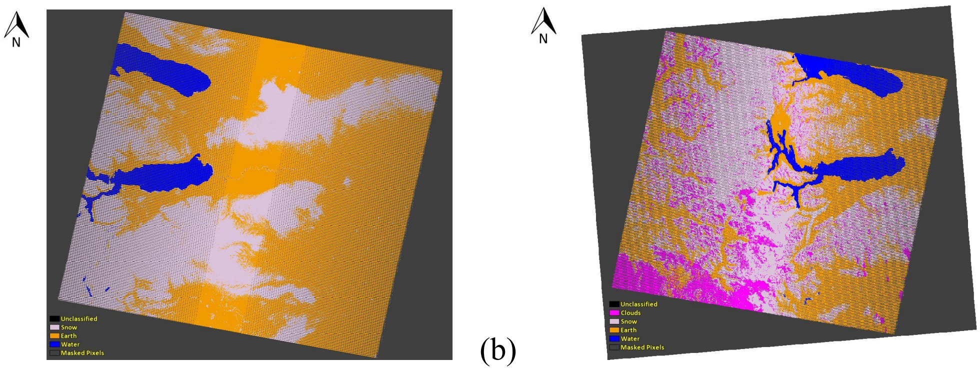


Figure 16. (a) Classified image of July 2020. (b) Classified image of August 2020.

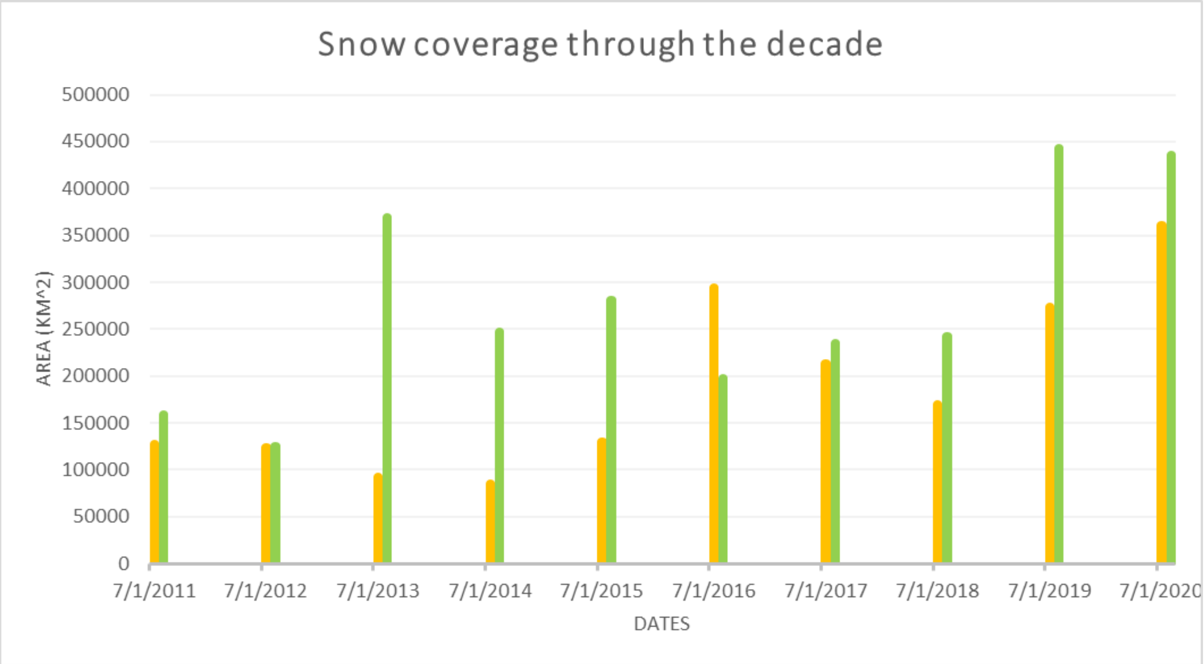


Figure 17. Data compilation of the winter month's snow coverage area from 2011 to 2020. The orange color represents the month of July and the green color represents the month of August.

Data Discussion

During the image processing, it was determined that the best image classification method was the Maximum Likelihood. This type of image classification showed the most accurate image classification compared to the raw image. After classifying the images of the decade from the months chosen, a graph was made with the data of the snow coverage of the area. After comparing all the years, the graph exposes a higher percentage of snow coverage in the last two years of 2019 and 2020. Also, it showed more snow during the month of August. The final results are inconclusive since the percentage of snow in the area can't be higher in the last two years due to climate change and evidence presented in previous studies where it was clear the volume decrease of snow through the years.

Conclusion

After extensive research and processing of images during the past month the results were not what we expected. Interpreting the excel table of the area coverage of the ice fields it seems to have more percentage of ice field coverage in the last 2 years. These results don't coincide with past research and news about the ice lost in the area due to factors like global warming. These incorrect results can be explained by the image classification that was carried out. Since, the images from each year were not exactly of the same area of research, it affected the outcome of the ice loss area that was calculated.

Recommendations

To do a better comparison of the ice lost on the fields it would be recommended to have the images of the exact same area during the entire decade.having this data, would provide more trustworthy and precise results. Also, using other sensors would have been very useful to make comparisons and observe how their results would differ depending on the sensor's spatial resolutions. In addition, obtaining data from other internet databases to find images of better quality and of the same areas would be a decision that could improve the overall results of this type of research. Finally, time management is a really important factor that should be given more weight since it controls the entire development of the investigation. Due to issues with time management further investigation processes that were initially planned to be conducted had to be omitted from the research.

References

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