Glacier Bay National Park Snow and Ice Analysis

REMS 6023-Assignment 3
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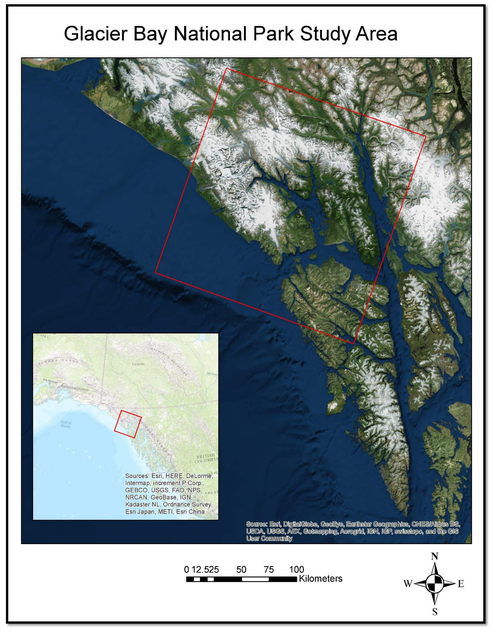
AREA OF INTEREST

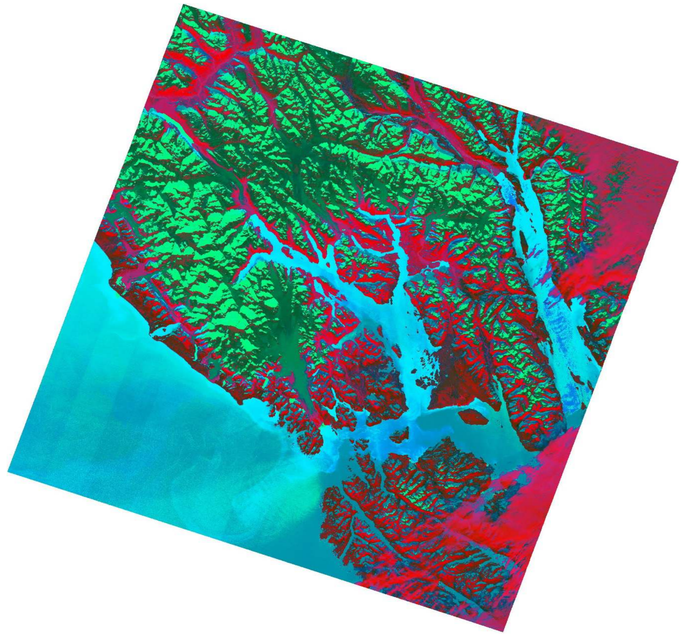
Glacier Bay National Park and Preserve, located on the South Eastern Alaska coastline, is home to spectacular glaciers and ice fields. The park is designated as a UNESCO World Heritage Site due to its glaciers and bio-diversity. Glacier Bay contains 11 glaciers, all of which converge in to the bay, where glacial melt water mixes with the salt water of the Gulf of Alaska. Snowfall rate, topography, and climate trends all factor in to whether a glacier is advancing or retreating. Glacial retreat is occurring throughout the bay's east and southwest sides. Glacier advance is occurring on the west side due to consistent snowfall high in the Fairweather Mountain Range. The purpose of this poster is to display the topography, snow, and water within the bay using Landsat 8 satellite imagery.



METHODS

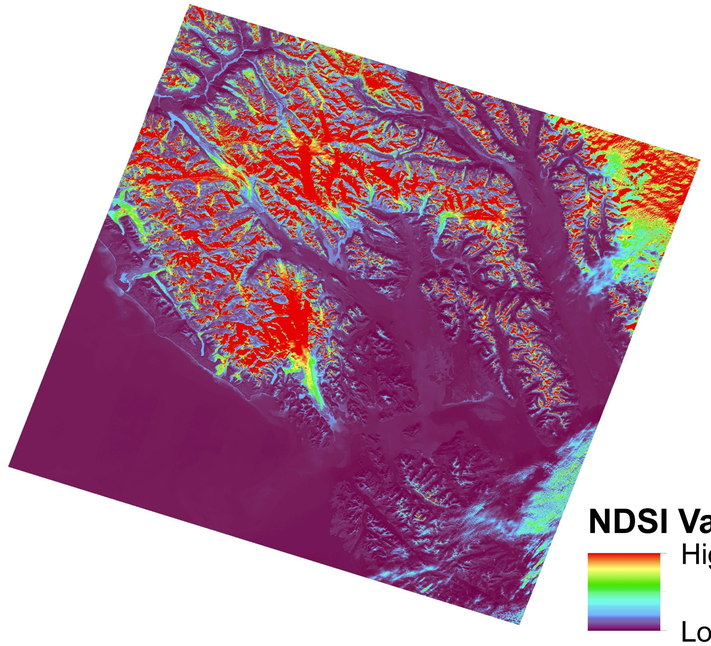
A Landsat 8 scene (Level 1 GeotTiff Data Product) of Glacier Bay was initially downloaded from the USGS Earth Explorer website. Using PCI Geomatica's Focus software, the image was added as a multispectral image and atmospheric effects were subsequently removed. The Image Channel Algorithm (ARI) was used for computing new band ratios to be applied to the RGB image. Three new band ratios were created using the ARI algorithm; Band 7 (SWIR2) / Band 4 (Red), Band 2 (Blue) / Band 5 (NIR), Band 4 (Red) / Band 6 (SWIR 1). A value of 1 was also applied to all denominators in the ratios to eliminate any possibilities of dividing by zero. In order to create the RGB composite a new raster layer was created and the ratios were assigned as follows Red: Band 7 (SWIR2) / Band 4 (Red), Green: Band 4 (Red) / Band 6 (SWIR 1), Blue: Band 2 (Blue) / Band 5 (NIR). In order to improve the visualization of the composite an Equalization enhancement was applied to the image. In order to highlight snow/ice within the scene a Normalized Difference Snow Index (NDSI), where NSDI = (Green-SWIR 1) / (Green+SWIR1), was applied and added as a pseudo-color layer.

RGB IMAGE



Band ratios are used to show variations within spectral reflectance curves between the two bands involved. One advantage of using ratios is that they enhance spectral characteristics of features regardless of illumination conditions. Ratios also compensate for shadows caused by variations in topography. Using bands from different sections of the electro magnetic spectrum also tends to produce better results by avoiding noise associated with bands in the same portion of the spectrum. In order to highlight snow and ice features throughout the area, Band 4 (red) was divided by Band 6 (SWIR 1), both bands belong to separate sections of the EM spectrum. Band 4 has a very high spectral response to snow and ice while Band 6 has a very low. Due to the large differences between pixel values of the two bands the ratio has a greater value, and therefore produces a brighter reflectance among snow/ice features. In order to separate the snow and ice from surrounding rock and vegetation, Band 7 (SWIR 2) was divided by Band 4 (Red), both band belong to separate sections of EM spectrum. Band 7 generally has a very low response with the rocks in the area (both glacial till and bedrock) while band 4 generally has a higher response. Although a ratio of bands 5 and 3 would be better suited for vegetation, the above ratio still produces a higher reflectance for vegetation along with the rocks. In order to display the water throughout the scene the ratio of Band 2 (Blue) / Band 5 (NIR) was chosen due to water having a high response to visible blue and virtually no response in the Near Infrared (denominator set to 1). The SWIR 2 / Visible red ratio is applied to the red channel in order to show a clear differentiation from the surrounding ice and water. The very dark reddish brown (e.g. western coast) represents vegetation while bright red areas represent either bedrock or glacial till, mixed reddish purple areas represent glacial outwash where water and sediment is mixed. Cloud cover causes the southern and eastern red sections. The Band 4 (Red) / Band 6 (SWIR 1) was applied to the green channel in order to display the snow and ice and distinguish where glacial melt water enters in the blue ocean water. Darker green areas represent glacial ice sheets, which have a lower response to the above ratio, while brighter green represents snowcapped mountaintops and glacier walls. The Band 2 (Blue) / Band 5 (NIR) ratio was applied to the blue channel in order to retain some of the natural color of water. As mentioned above the purple-red colors are a result of sediment and water mixing near the toe of the glacial ice flows.

NDSI



A spectral index is a combination of surface reflectance at two or more wavelengths and are more complex than just simple ratios. Due to normalization all values should fall between -1 and 1.For the purpose of this study the Normalized Snow Difference Index (NDSI)was used, where NDSI = (Green-SWIR 1) / (Green+SWIR1). The NDSI highlights snow/ice cover using visible green (strongly reflected) and SWIR 1 (strongly absorbed). The image above indicates areas of snow/ice cover as high positive values (yellow to red). Red areas represent areas of clean snow and ice while yellow areas represent snow and ice with till and sediment mixed throughout. Green and blue areas represent transition zones where there is still glacial melt (minor ice and snow) mixing with open water. Purple areas represent water, vegetation, and glacial till/exposed bedrock, where there is very little response to the NDSI.

CONCLUSIONS

In conclusion, it can be surmised that using band ratios and an NDSI can both aid in the analysis of Snow and Ice within Glacier Bay. The RGB image is better suited for defining clear boundaries between snow/ice and the surrounding vegetation, rocks, and open water. The index image is better suited for analyzing transition zones between glacier ice flows, glacial melt, and the open water. Both of these images could be compared temporally to other images in order to recognize the patterns of glacier retreat or advancement within Glacier Bay National Park.

Reference Material:
Source: Image courtesy of the U.S. Geological Survey
Acquisition Date: 2016-10-26
Platform/Senor: Landsat 8 OLI_TIRS
Row: 19 Path: 59
Projection: UTM Zone 8 Northern Hemisphere