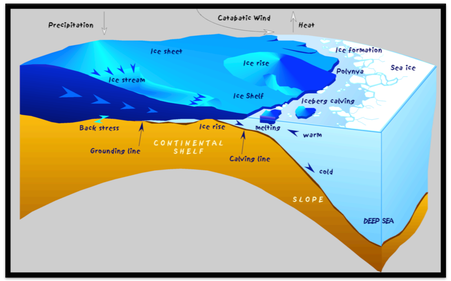
Validation of the basal stress boundary utilizing Satellite Imagery along the George VI Ice Shelf, Antarctica

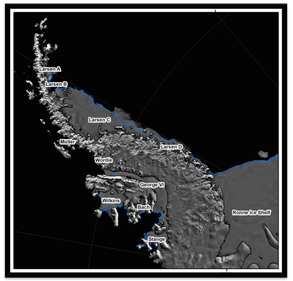
Omar Owens (WSSU), Anthony Scott (WSSU) Mentor: Mr. Michael Jefferson (ECSU) Principal Investigator: Dr. Linda B. Hayden (ECSU), 1704 Weeksville Rd, Box 672, Elizabeth City, North Carolina 27909

Abstract

Majority of ice shelves are fed by inland glaciers. Together, an ice shelf and the glaciers feeding it can form a stable system, with the forces of outflow and backpressure balanced. Warmer temperatures can destabilize this system by increasing glacier flow speed and more dramatically by disintegrating the ice shelf. Without a shelf to slow its speed, the glacier accelerates. After the 2002 Larsen B Ice Shelf disintegration, nearby glaciers in the Antarctic Peninsula accelerated up to eight times their original speed over the next 18 months. Similar losses of ice tongues in Greenland have caused speed-ups of two to three times the flow rate in just one year.

Rapid changes occurring in regions surrounding Antarctica are causing concern in the polar science community to research changes occurring in coastal zones over time. During the research, the team completed a study on George VI Ice Shelf located on the western coast of the Antarctic Peninsula. The study included a validation of the Antarctic Snow and Ice Accumulation Discharge Basal Stress Boundary (ABSB) vs. the natural basal stress boundary (NBSB) along the George VI Ice Shelf. The ASAID BSB was created by a team of researchers headed by National Aeronautics and Space Administration Goddard Space Flight Center (NASA GSFC), with an aim of studying coastal deviations as it pertains to the mass balance of the entire continent. The point data file was aimed at creating a replica of the natural BSB. Select cloud free Landsat satellite imagery from satellites 1 through 7 was used to detect changes occurring over the span of 19 years. The last major interest in the study included documenting the deviations or incorrect placements of the ABSB vs NBSB. Changes that occurred were documented in the form of a table with the change that occurred along with the geographic coordinates.





Methodology

-Path/Row of George VI Ice Shelf

The initial step in of the analysis involved finding the path and row of the George VI Ice Shelf. The reason for establishing the path and row was so that the best possible cloud free Landsat images were chosen to cover the entire designated region.

-Retrieving Landsat Images

The United States Geological Survey (USGS) online archives of Landsat imagery through the Global Visualization Viewer (GloVis) (http://glovis.usgs.gov/) and Earth Explorer (http://earthexplorer.usgs.gov/) browsers were used to locate pre-2003 cloud free Landsat images. The websites included images recorded by the Landsat 1 and 3 Multi-spectral Scanner (MSS); the Landsat 4 and 5 Thematic Mapper (TM); and the Landsat 7 Enhanced Thematic Mapper (ETM+).

-BSB Text file

The team then analyzed a large text file that included latitude, longitude and ENVI point data for the Antarctica Peninsula. Dr. Robert Bindschalder along with a team of researchers from around the world created the point data file to show the basal stress boundary (BSB) of the entire continent [4]. Loading the data in ENVI 5.0, a software application distributed by Exelis Visual Information Solutions, presented a challenge due to the size of the document. The project required an edit to truncate the 236-megabyte file to 38.4-megabytes so that the text file would load faster and only include the area of interest for the research. Viewing images of the peninsula the latitude and longitude points of the area of interest were found. Using the latitude and longitude points found, the 3,575,503 lines of records were accessed and then point data was edited to only include the points within (-1807366.800 W, 306894.810 S, 73 14’ 35.35” S, 80 21’ 46.70” W) and (-1971911.500 W, 1030714.100 S, 69 45’ 37.64” S, 62 24’ 14.49” W). The edited text points extend from Larsen D Ice Shelf to Larsen A Ice Shelf and extended around the peninsula through the extent of George VI Ice Shelf.

-Creating Vector file

The next step in the process was to create a vector file (.evf) from the text file. This process was completed using ENVI Classic (4.7) point collection feature. The points were imported into an ENVI point collection data table. Within the table properties, settings were changed to assign the point data values to the correct column. After completing the point collection process the file was saved as vector file to be overlaid over the downloaded satellite images.

-Creating mosaics

ENVI 5.0 was then utilized to create mosaics of the reference images (images from 2001-2003) and the older images (images from 1974-1988). Mosaics were created to overlay the images on one another to view them together displaying the George VI Ice Shelf. Creating the mosaics helped visualize the area of George VI Ice Shelf that was covered with the retrieved images. It was also used as a reference tool for the older images. Upon completion of the creation of the mosaics after the first downloaded image sets, it was determined that another image was essential to covering the entirety of the George VI Ice Shelf. The additional image was downloaded and the mosaic was recreated with the additional image included.

The reference images were then linked to the older images using ENVI Classic (4.7), permitting the screening of superimposed geographically mutual areas. Linking the images allowed a pixel-by-pixel flickering or temporary superimposition of a small region of one image over another to make any variations between two images more recognizable.

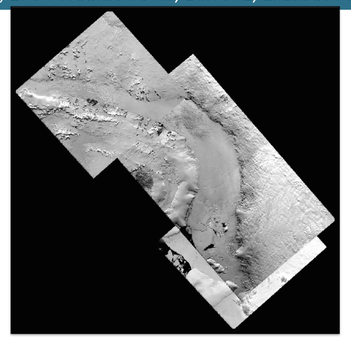
-Warping Images

Further, the warping of each pre-2003 Band 4 (0.75-.90 um) older image to one of four reference images to provide necessary common, geographically consistent, pixel registration was finalized. Band 4 TM images (spectrally similar to MSS Band 2 images) provided the most efficient scene contrast for ice shelf, the natural basal stress boundary and sea ice discrimination. ENVI 5.0 was utilized for the warping procedure. This process required a minimum of five tie-points fixed to geographic features. Five or more broadly dispensed tie points were sought in each image duo (consisting of a reference and older image) to develop a greater efficiency of the warp. A least square bi-linear warping was performed to optimize the image-to-image correspondence relative to the selected geographic points that were established in each image duo.

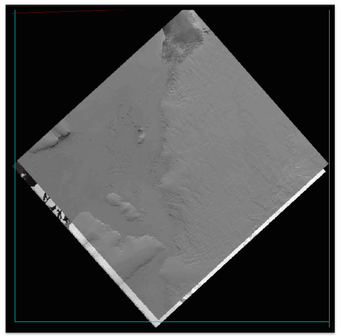
-Validation Process

Trailed by the warping procedure, the ASAID BSB line was superimposed onto each warped image using ENVI Classic. The validation of the BSB along the George VI Ice Shelf was then conducted. The validation process involved using a standard zoom of ~x4 or greater of the ENVI Classic zoom window in order to view deviations. The deviations either positive or negative of the ASAID BSB compared to the NBSB if any were observed in the satellite imagery.

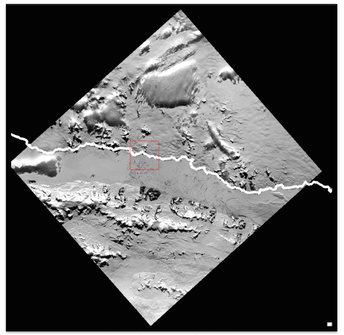
Basal Stress Boundary



Mosiac



Warp Image



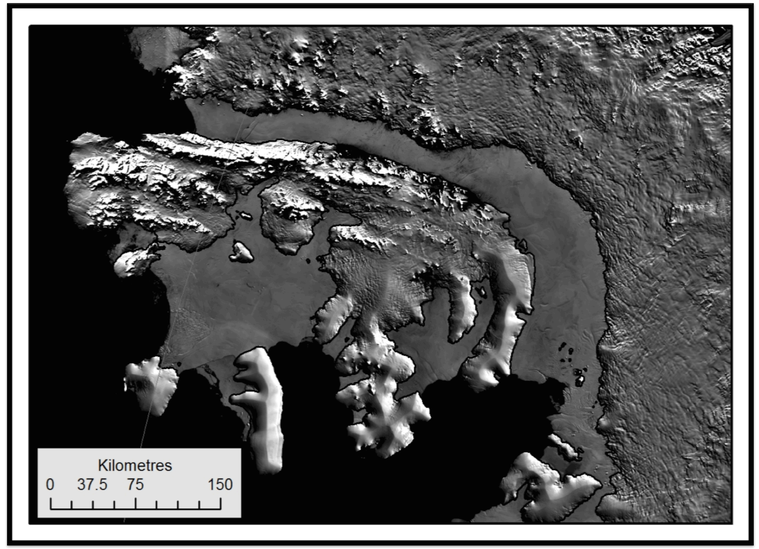
Validation of BSB

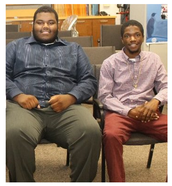
Conclusion/Results

After examining Landsat images throughout the years of 1984-2003 using a standard zoom of ~x4 or greater of the ENVI Classic zoom window, the team conducted the validation of the ASIAD BSB (ABSB) vs. the natural BSB (NBSB) along the George VI Ice Shelf. The team also concluded that the location of the BSB has been stable over the approximately 20-year study period. Dynamics that may change the position of the BSB are all slow processes such as sea level rise. These slow procedures are unlikely to change the placement of the BSB at the Landsat-pixel scale over the twenty years of observations suggesting that this is a reasonable assumption. Supporting the assumption of the BSB stability is the teams’ observation that all images display essentially the same geographic features along the coastline of George VI Ice Shelf.

Future Work

Furthering this research, areas south of the George VI Ice Shelf and the Antarctic Peninsula should be examined to validate the grounding line. Looking at maps related to Antarctic Peninsula, the Abbot Ice Shelf would be the next area of interest. While looking at the BSB along Abbot Ice Shelf, there should be a survey of the coastline for ice shelf loss. When continuing this research methods to keep ENVI from freezing while uploading large files should be looked at. Splitting up the BSB text file into different sections to make it easier to determine what points are needed for research project.





Acknowledgement

The team would like to acknowledge Dr. Linda B. Hayden, Dr. Robert Bindshadler, and Mr. Michael Jefferson for the guidance during the period of this research.

References

For a full reference listing, please see http://nia.ecsu.edu/reuomps2014/teams/antarctica/FinalResearchPaper.pdf