Vegetative Succession of Mount St. Helens

By Seth Rose and Jeremy Miller

Department of Geography and Geology
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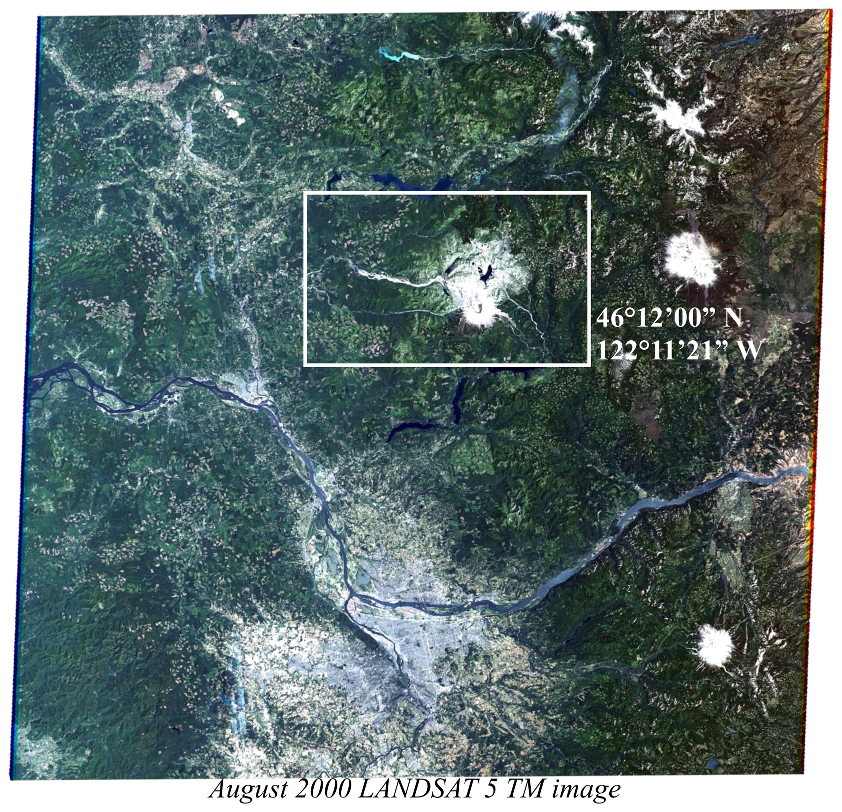
Dr. Eman Ghoneim

Background

Mount St. Helens is an active stratovolcano located in Cowlitz County, Washington. In the year 1980, it erupted due to an influence of a 5.1 earthquake. This eruption caused its northern face to collapse and cause the largest debris avalanche in recorded history. This collapse and eruption also decreased the total elevation of the volcano by 1,300 feet. The volcanic episode caused massive destruction of vegetation in the surrounding areas. The vegetation has been making a slow regrowth into areas where there has been none.



August 2000 LANDSAT 5 TM image

Research Question

A variety of issues surround the 1980 eruption of Mount St. Helens and of the different topics, two were most prevalent: glacial reduction and vegetation succession. In that, the objective was to determine the rate and extent of the glacial reduction and the regrowth of vegetation populations.

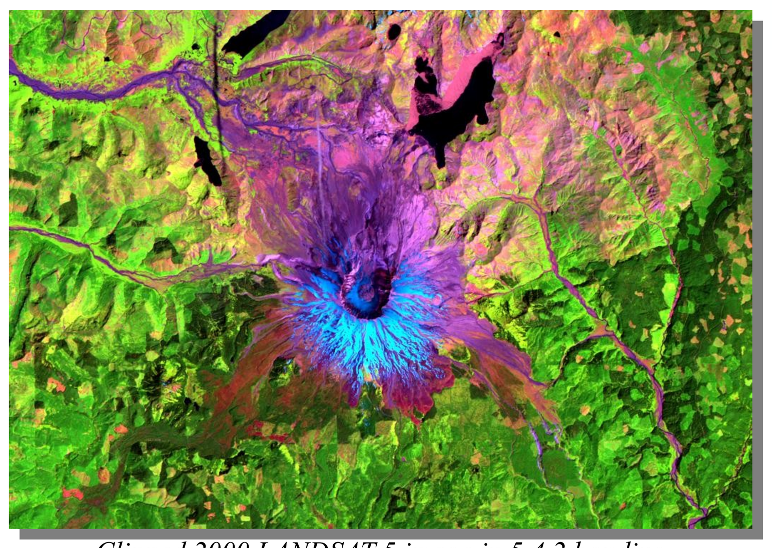
Methods and Materials

The project required four images in a span of 30 years. Unfortunately, due to the lack of suitable images and bands, the start date for image processing was 1986 using LANDSAT 5 TM. Upon attaining the image files, they were pre-processed into reflectance and clipped to an appropriate size for the research focus. The images were initially classified using the unsupervised K-means method, but there was no distinguishable class features. Then the images underwent a classification through band ratioing using the NDSI, however the water in the region also classified as snow. Finally, we classified the images through the supervised Maximum Likelihood method with 5 classes (snow, ice, bare earth, vegetation, water). In order to differentiate the classes and then classify them properly, a banding of 5 - 4 - 2 was used. This produced a detailed classified image with each class feature easily distinguishable.

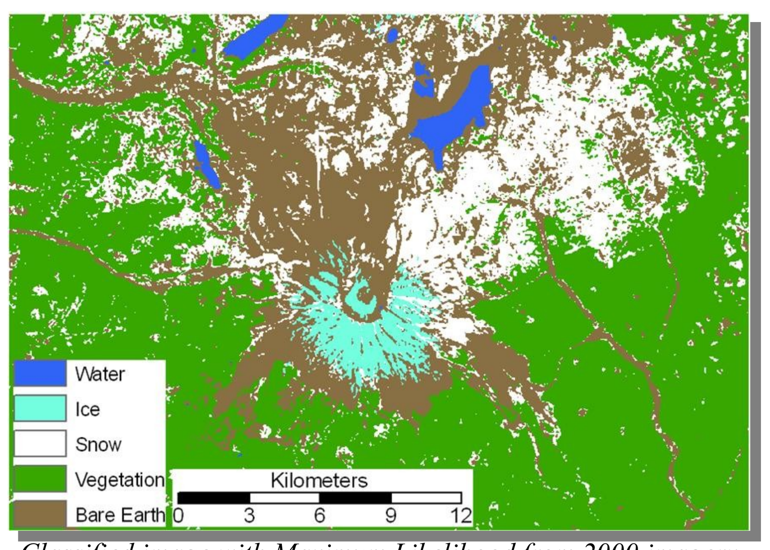
Clipped 2000 LANDSAT 5 image in 3 2 1 banding

This is a true color image of Mount St. Helens. A majority of the snow and ice is located on the south-facing slope. Spirit Lake is the large water body to the north and the large debris field flowing from the north-facing slope is the current extent of the 1980 collapse. This image was clipped from the original to limit any extraneous snow and ice that could skew research results from other mountains in the area.

This is Mount St. Helens in a 5 4 2 banding. Since there were issues classifying the image using other techniques, a supervised classification was instead used. The colors of this band combination distinguishes the various characteristics that were required for differentiation of ice and snow. The near black/dark blue represents the bodies of water. All the shades of green represent vegetation. The pink represents bare earth. The dark purple represents snow. And the cyan/blue represents ice. The reason this combination worked so well was the matter of absorption and reflectance in green, near-infrared, and close near-infrared with ice, snow, and earth.



Clipped 2000 LANDSAT 5 image in 5 4 2 banding

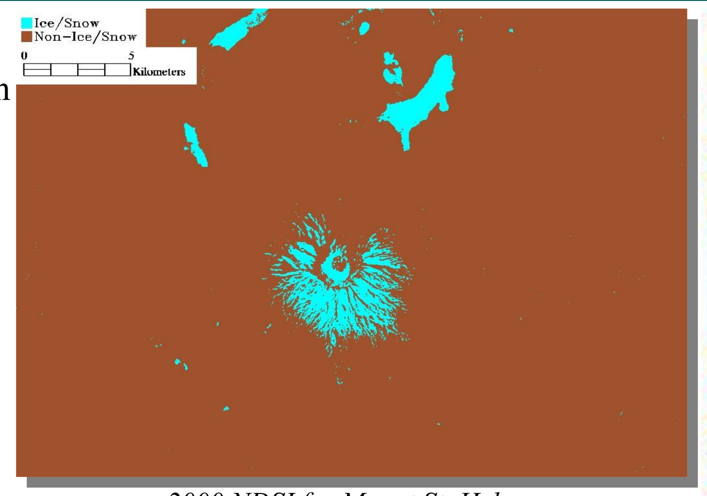


Classified image with Maximum Likelihood from 2000 imagery

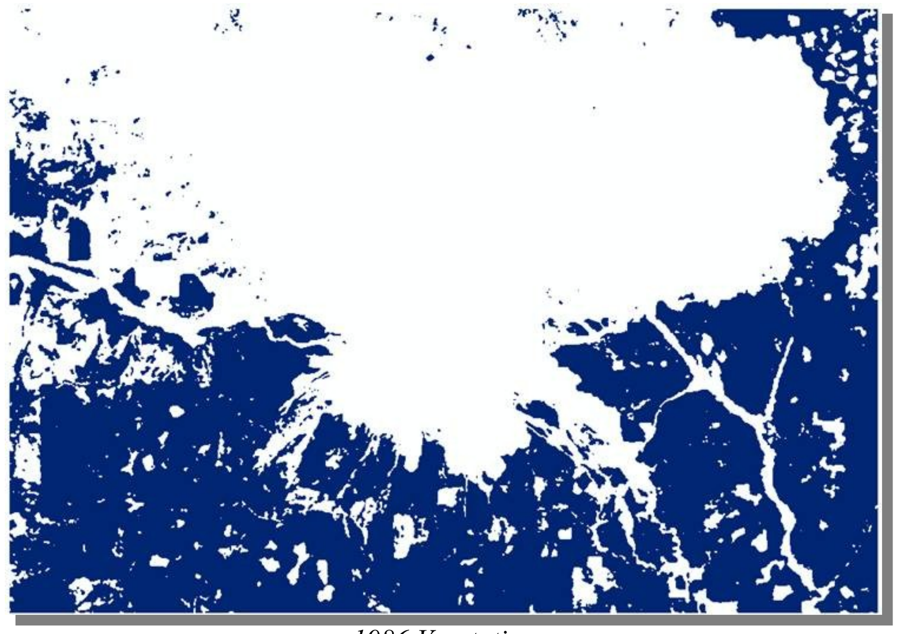
Through a supervised classification using Maximum Likelihood and a Minority/Majority analysis for post-classification, this image clearly shows the different classes that were being researched.

Issues with Band Ratioing

Since one of the objectives was to look at glacial reduction since 1986, using the Normalized Difference Snow Index (NDSI) was a technique attempted to reduce shadows and hone in on snow and ice. By using band math with (Band 2 + Band 5)/(Band 2 - 5), the result is the image to the right. As can be seen, the large bodies not near the center of the mountain are actually bodies of water that the band ratioing equated as snow and ice. This technique proved to be unsuccessful and required the classification to be performed using a different method.



2000 NDSI for Mount St. Helens



1986 Vegetation

Mount St. Helens in 1986:

281.84 sq. km of vegetation

Accuracy Assessment:

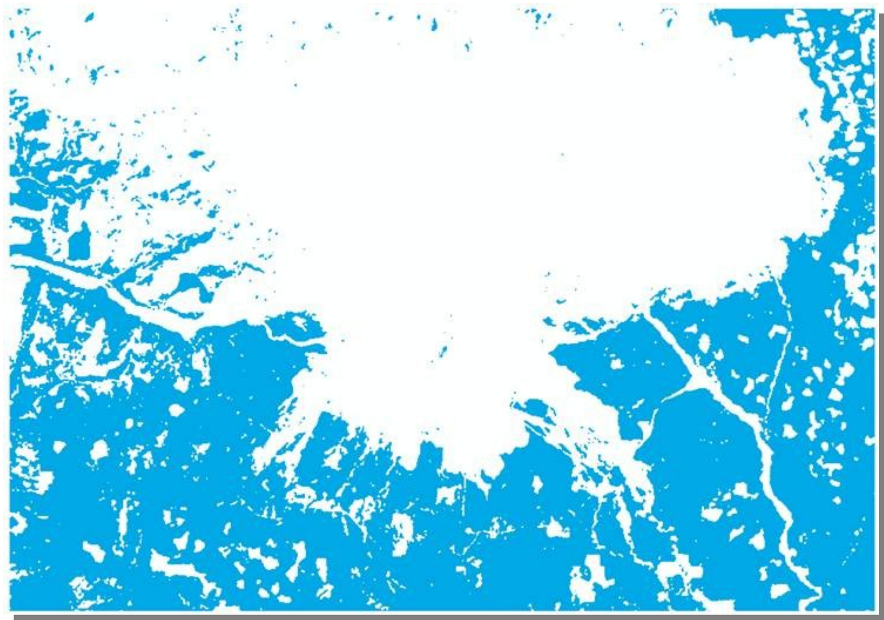
99.52% accurate
Kappa of .9932

Mount St. Helens in 1990

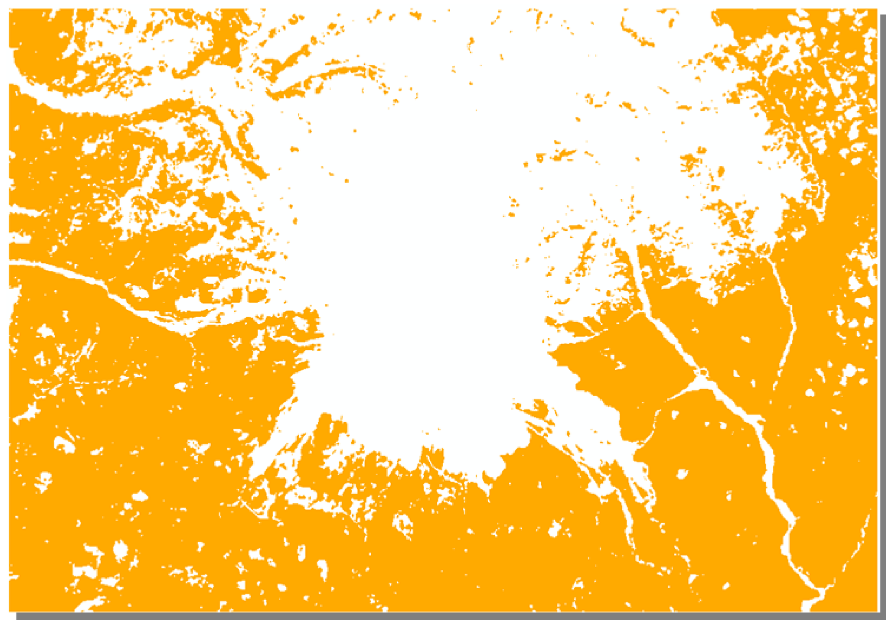
283.02 sq. km of vegetation

Accuracy Assessment:

99.06% accurate
Kappa of 0.9868



1990 Vegetation



2000 Vegetation

Mount St. Helens in 2000

372 sq. km of vegetation

Accuracy Assessment:

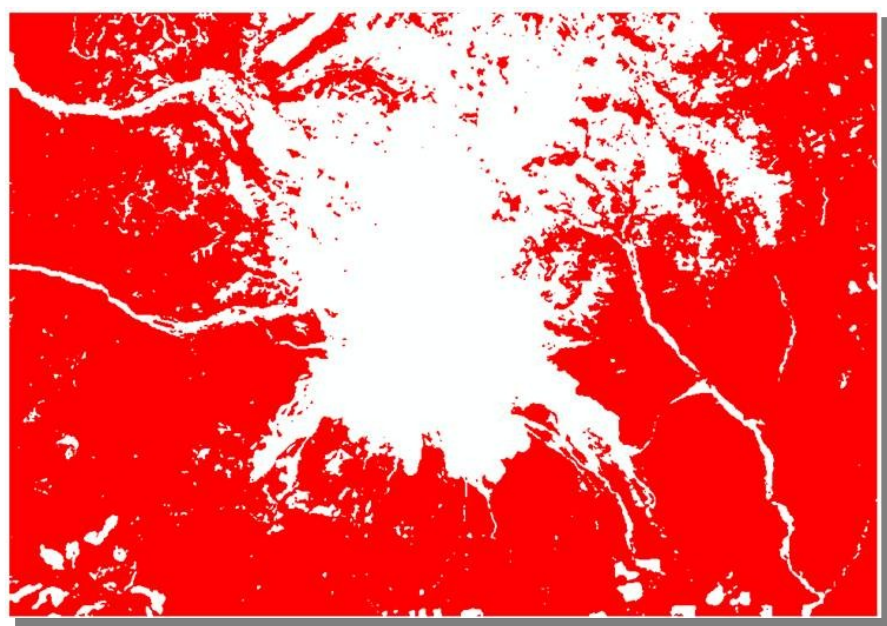
93.37% accurate
Kappa of 0.9918

Mount St. Helens in 2009

448.71 sq. km of vegetation

Accuracy Assessment:

97.59% accurate
Kappa of 0.9692

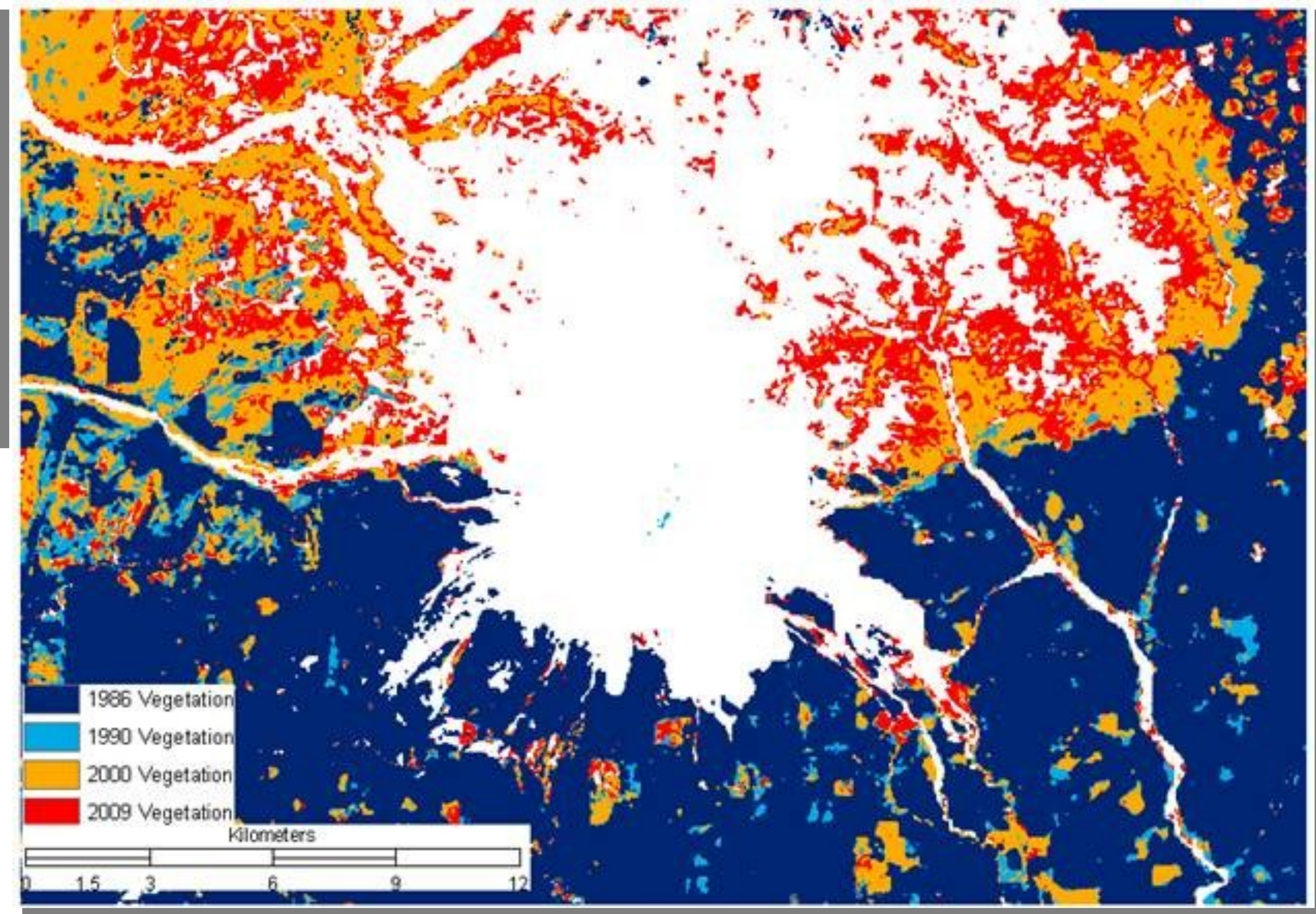


2009 Vegetation

Sources of error

The first source of error was imagery availability. LANDSAT 5 TM first became available in 1982. However, the imagery for the months that were being researched (July/August) were either unavailable, non-existent, cloudy, or were corrupted. In that, the time span is not equal between images. The next issue in error and accuracy deals with the shadows in the crater. Initially, the use of band ratioing was implemented to reduce the effect of shadows. However, the band ratioing itself became a source of error as there were issues with the band math and water in the vicinity.

Using an accuracy assessment on the supervised images, there was an overall 97% accuracy among all four images. The biggest sources of errors were dependent on year. In 1986 the biggest error was in the ice, which had little area, compounding the error. In 2009, it was bare earth which was probably caused by rapid erosion on the northern-face.



Percentage of Vegetation Gained

1986—1990: 0.42% 1990—2000: 31.43% 2000—2009: 20.62%

Total Gains

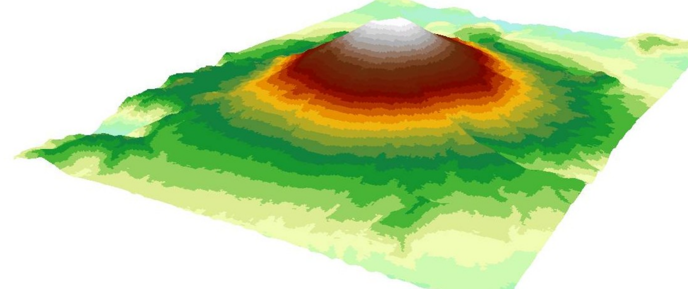
1986—2009: 37.12%

Conclusions

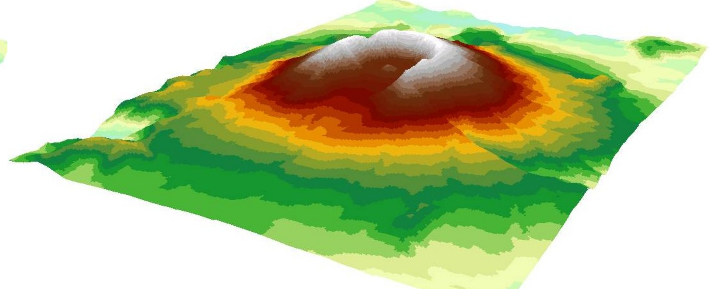
From 1986 to 2009, there was a 37.12% gain of vegetation from previously non-vegetated areas, mostly from bare earth. Turner, Dale, and Everham came up with the same conclusion: a 35% gain of vegetation from 1987 to 1994. This time frame also correlates with the percentages that the greatest increase in vegetation was seen in the project (1990-2000). Most of the vegetative regrowth occurred on the northern slopes adjacent to the collapse of the mountain face. This area was completely void of life following the eruption.

There is a lot of potential for future research of the vegetative succession on Mount St. Helens. A comparison of species and succession rates with other ecosystems that have suffered from rapid disturbances on a large scale could provide methods for mitigating any issues or loss of species specific to those ecosystems. Additionally, there is further research potential in the area of glacial recession and snow deposition.

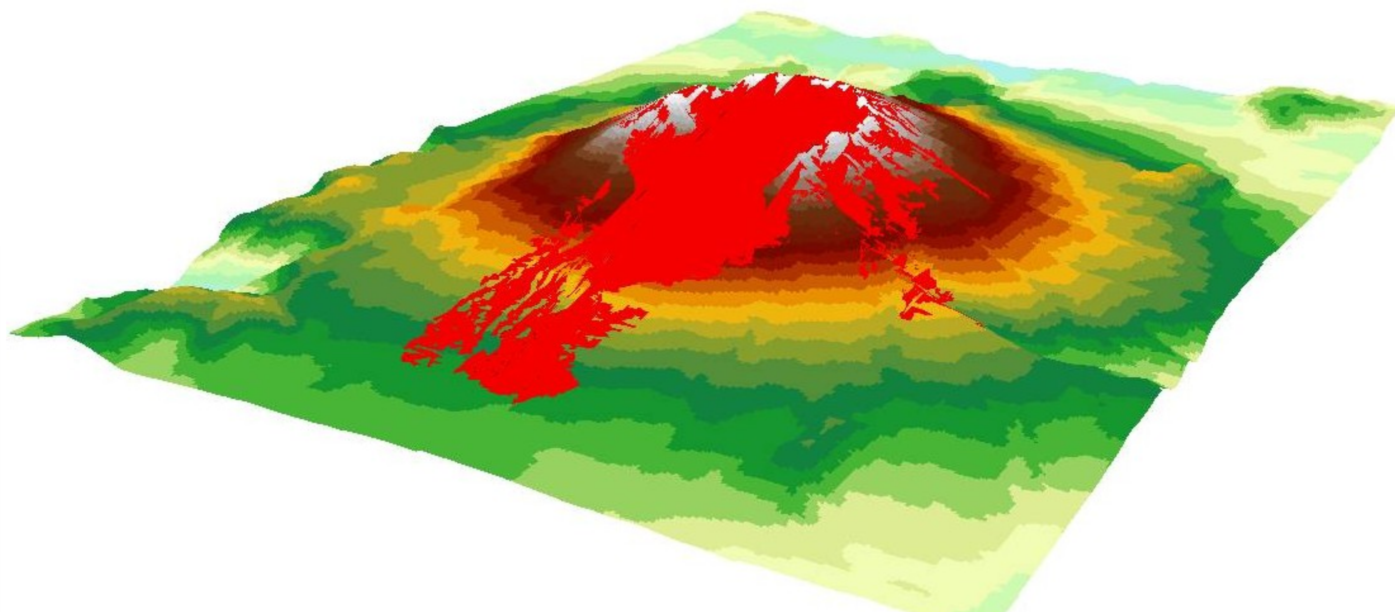
Though the research failed to conclusively determine any viable information, it did show that better techniques and methods would garner useable results. Mount St. Helens lost a considerable amount of volume in the form of glacial ice and through remote sensing it could be determined how much has re-formed after the eruption.



Pre-eruption Digital Elevation Model of Mount St. Helens



Post-eruption Digital Elevation Model of Mount St. Helens



Digital Elevation Models

Mount St. Helens is a classic case for DEM analysis. When the volcano erupted, the northern face collapse causing one of the largest loss in volume and elevation in a volcanic event. In the above, the red area is the area of major loss caused by the eruption. As seen, it was primarily the northern slope that was affected. In the recent years since the eruption, there has been a resurgent dome that has slowly been developing.

Acknowledgements

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