

A Study of Land Cover and Thermal Changes at Kilauea Volcano, Hawaii

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ABSTRACT

The Kilauea volcano is located on the southeast side of the big island of Hawaii. It has been erupting continuously since January of 1983. This study uses a series of Landsat Thematic Mapper satellite images to derive spatial comparisons over a three month time period. These satellite images contain thermal bands that allow surface temperature patterns to be assessed. The thermal patterns evident on the images are the result of both surface and subsurface volcanic activity. Classifications of the satellite images were used to study the changing spatial thermal patterns of the growing volcano. Statistical results indicate that surface temperature increased for approximately 24% of the study area and decreased for approximately 13% of the study area.

INTRODUCTION

Natural disasters, such as earthquakes, floods, and volcanic eruptions are events that can be very destructive to human settlements. These events often happen very quickly, without much warning. Scientists and researchers have been working for many years to try to understand these events better so that actions can be taken to protect the people who live in areas where these events are known to take place. For hot spot volcanic eruptions, Hawaiian volcanoes have become the central areas of focus in the world for those trying to understand volcanic eruptions. The events that have been witnessed and recorded in, on and around these volcanoes have greatly influenced current scientific theories about volcanoes (Strahler and Strahler, 2002).

There are many different characteristics that are watched, recorded and calculated when monitoring a volcano. Recording small earthquakes and measuring the tilting or swelling of the land are two of the main processes researchers monitor. For actively erupting volcanoes, the temperature, viscosity and chemical content of the lava and gases being emitted can also be measured (Strahler and Strahler, 2002). This study focuses on the thermal changes that occur. Changes in temperature indicate changes in the volcanic activity. This is important because volcanoes do not just continue to erupt over and over in the exact same spot; areas of activity change and move around (Graves, 1970). Kilauea is currently erupting out of a vent named Pu'u O'o. It is located in the East rift zone, which is one of the three areas of the volcano which is known to be active (Decker, 2001). Past studies have used infrared cameras to monitor changes in surface temperature and to find hidden hot spots (Herbert, 1968). As satellites have become more common, affordable and available for use in research, their thermal bands have been used more and more to do this kind of monitoring. The thermal information collected can show how a volcano is evolving and possibly predict where future areas of surface activity will occur.

METHODS

Two Landsat TM images were used in this study to compare thermal changes taking place on Kilauea. One was from February 14, 2000, and the other from May 23, 2000. The February image was acquired already georectified, and the May image was referenced to it. The area contained in the May image was only that of the current and recent volcanic activity on Kilauea. Therefore, the February image was subset so it was the same size, and this became the study area.

In order to create the thermal classifications, the thermal bands from each image were divided into 10 clusters each using the unsupervised ISODATA classification algorithm in ERDAS Imagine. The statistics of the clusters were used to create the different thermal rankings. Clusters that had statistics that were very similar to each other were grouped together to create one class. Clusters that were statistically separated from the others became an individual temperature class. Six classes were used based on natural class breaks in the clusters of both images because this provided enough classes to create a meaningful comparison that could be easily viewed and understood.

The land cover classification was created in a similar way to the thermal classifications. In this case, only the February image was used. Since the project focuses on the thermal changes, the land cover classification was used as a reference. This image was divided into 15 clusters using ISODATA, and then grouped into five classes: vegetation, old lava field, new lava field, water, and cloud cover. This was done mainly through visual interpretation. The original true color image was displayed under the clustered image, and then the swipe function was used to see where each cluster fell. There were many clusters that had mixtures of land cover. Most of these were a mixture of the dark lava fields, water, and cloud shadows. These mixed clusters were set aside, and then a mask was done to remove all of the clusters that could be classified. The mixed areas were subsequently broken into 5 clusters. Finally, these clusters were classified into the original 5 classes. This process greatly reduced the amount of mixture found in the land cover classification and helped to create a fairly accurate representation of the existing surface cover.

A matrix was created using the two thermal classifications in order to show more specifically how and where changes in temperature were taking place. A matrix is often used to determine exactly which classes changed. In this study it was used to create a classification showing where temperature stayed the same, where it got hotter, and where it got colder.

RESULTS AND DISCUSSION

The land cover classification (Figure 1) shows four surface types that could be identified from the imagery: vegetation, old lava field, new lava field and water. The thermal classifications (Figure 2) show very clearly what the temperature patterns are at Kilauea. These classifications are valuable to show where the most active areas of the volcano are located. The use of the matrix brought the two images together to show how they compared to one another (Figure 3). Some of the changes could be detected by simply looking at the original classifications, but the change classification created from the matrix clearly shows where changes are taking place over the three month period between the two images. This is where the use of remote sensing can be very valuable in the monitoring process. The change classification provides a way to determine which areas have been active recently.






Vegetation	
Old Lava	
New Lava	
Water	
Cloud Cover	



Figure 1. Land Cover Classification.

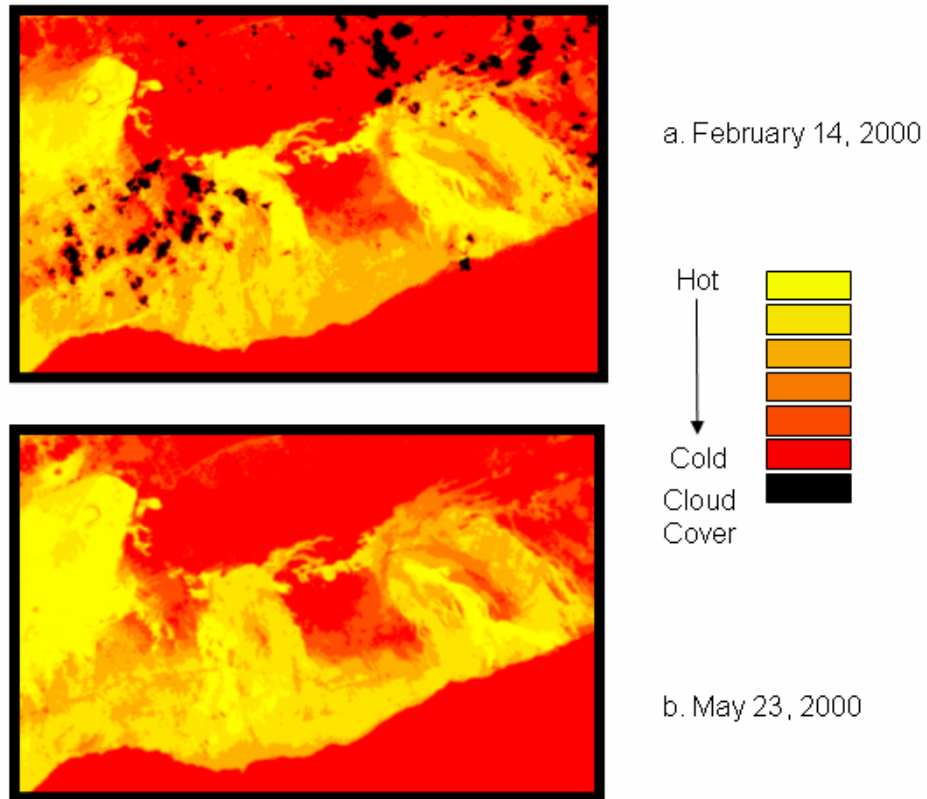


Figure 2. Thermal Classification.

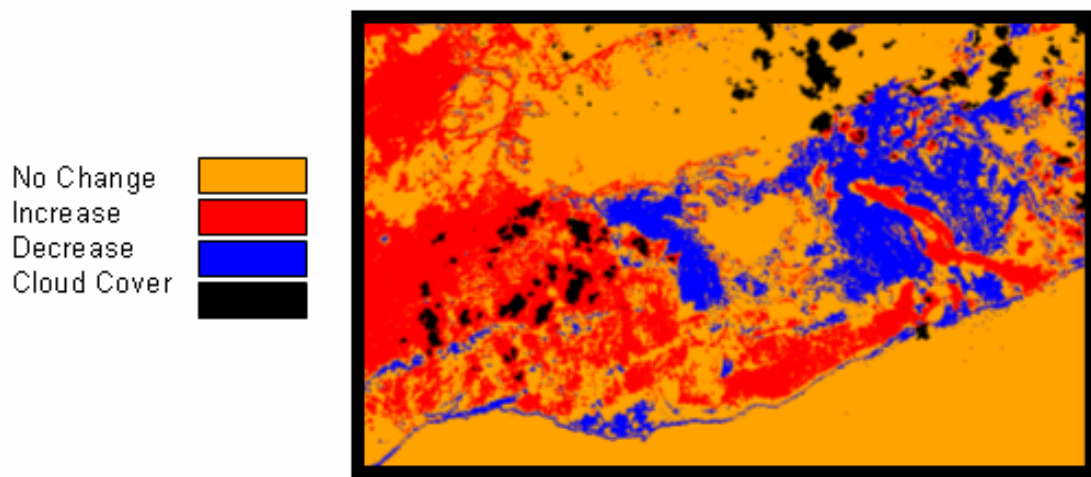


Figure 3. Changes in Surface Thermal Conditions Between February and May 2000.

The statistics indicate that approximately 62% of the land remained the same temperature, 13% got cooler, and 24% got warmer. The results also suggest the following:

(1) It would be unrealistic for an area to go from very hot to cold during three months. This is because the volcano is holding so much heat that it would take a long time for an area to cool off. Therefore, there should not be any large jumps in any of the temperature classes. This was indeed the case for the majority of this study's results. The few areas that showed a relatively large decrease in temperature can probably be explained through random misclassifications and were not representative of real thermal change that took place.

(2) A comparison of the thermal classifications to the land cover classification shows that the coldest areas and the areas with the least amount of change were either water or vegetated. Although these two classes were not the same temperature, they appeared to be in these classifications. This was due to the sharp jump in temperature between the water or vegetated areas and the lava fields. The difference in temperature between the water and vegetated land was so small compared to the lava fields that this difference did not show up in the classifications.

CONCLUSION

This study examined changes in relative surface temperature for the Kilauea Volcano in Hawaii using Landsat TM satellite images. Two images taken three months apart were assessed using the thermal band. Statistical results indicate that surface temperature remained the same for approximately 62% of the study area. This was accompanied by an increase in temperature for approximately 24% of the study area and a decrease for approximately 13% of the study area.

Satellite images provide a means for examining changes in surface conditions over a relatively large area. The primary limitation to this study was that actual temperatures could not be derived. However, the results should prove valuable to understanding where thermal patterns are changing over time.

REFERENCES

- Decker, R., and Decker, B. 2001. *Volcanoes in America's National Parks*. New York: Norton.
- Graves, W. 1970. *Hawaii*. Washington D.C.: National Geographic Society.
- Herbert, D., and Bardossi, F. 1968. *Kilauea: Case History of a Volcano*. New York: Harper & Row.
- Strahler, A.H. and Strahler, A. 2002. *Physical Geography: Science and Systems of the Human Environment*. New York: John Wiley and Sons, pp. 320-405.