TIR and RADAR Image Processing

Computer Lab #3: November 8, 2023
Due: November 29, 2023

Instructions: You will be examining Thermal Infrared (TIR) ASTER *(collected on October 30, 2006)* and airborne radar (SAR) data *(collected way back on August 4, 1990)* of Kilauea Volcano, Hawaii. The written report should be similar to what you did for labs #1 & #2. Remember, It should be written in full/complete sentences and focus mainly on the synthesis of the analysis in sections III - V. Before writing this laboratory report, make sure you incorporate ***any/all*** feedback from the TA on your first two labs. You must turn in your completed write up and completed copy of this lab report no later than **November 29th**. *Remember: this lab report is worth the most of all three reports and being late will result in a deduction of points.*

I. TIR Data Processing

- start ENVI and use the directory field in ENVI to navigate to the ASTER-TIR file
  - load band 12 and briefly describe the features you see.

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- perform a *Transform → Decorrelation Stretch* on bands 14, 12, 10
- save this process to memory, open the file with bands 14, 12, 10 in R, G, B, and then describe the colors of the lava flows. *Hint: basaltic flows should be blue to purple in this color combination.* Why might they be so variable if we assume that all the lava flows in Hawaii are basaltic in composition?

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- what different compositions might you expect for the Hawaiian flows based on the colors you see and the class discussion on TIR spectra? *Hint: look at the figures on page 6 of the TIR notes. Hawaiian flows would have more Labradorite and Olivine than Quartz.*

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- save a *subset* of this image in JPG format centered over Kilauea crater
- *include this image as figure 1 in your lab report*

II. SAR Header Exploration

- the SAR data are from the NASA airborne AIRSAR instrument
- open/examine the **CLP_rotate.lbl** file by right-clicking on the file in Windows and clicking *Open With* … and select **Wordpad or Notepad**.

- using information in this file and the notes from class, calculate the pulse duration (τ_o) of the AIRSAR instrument. *Hint: what is the relationship between look angle, depression angle, and range resolution from the notes?*

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II. Data Processing & Analyses

- now open the AIRSAR data file **(CLP_rotate)** in ENVI
- scan through all nine images of the file and note the variations in radar return for each band
  - briefly describe these variations *(especially noting the differences between the HH and HV images as well as the between the different bands)*

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  - Identify the main geologic feature(s) and describe them in the HH image.

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  - Can you correlate these features with those in the TIR image from the first section?

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- north is up in this image, so what is the radar illumination direction? __________
  - looking at the large shadow located around **(300, 360)**, use *Basic Tools → Measurement Tool* to calculate the shadow length in pixels *(hint: measure this perpendicular to the illumination direction)* ____________________________
  - using that distance, the depression angle, and assuming the pixel resolution as an average of the range and azimuth values, calculate the height of the object creating the shadow. *Hint: geometry is your friend!* ____________________

- now use the Rayleigh Criteria equations for radar roughness given in the class notes to calculate the required surface roughness *(for the HH polarization only in each wavelength band)* to produce a **strong** radar backscatter *(rough surface)* and **no** radar backscatter *(smooth surface)*
  - C_{hh}: ____
  - L_{hh}: ____
  - P_{hh}: ____

- assuming there is a linear relationship between a 0 DN value *(for the smooth criteria derived above)* and a value of 255 DN *(for the rough criteria)*, estimate the surface roughness in centimeters for the following pixels in each wavelength band for the HH polarization
  - (**442, 445**): ____
  - (**430, 666**): ____

- clearly, the surface roughness does not change, but it appears to do just that with each wavelength, so why do these values vary?

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IV. Comparison to Other Data

- open a web browser and go to the following web site:
  https://www.usgs.gov/volcanoes/kilauea/geology-and-history

- take a few minutes to read the associated pages on the geologic history
  - near the bottom of the page on the right hand side is a link to the *Kilauea Caldera simplified geologic map*. You can also find it here:

    https://www.usgs.gov/media/images/k-lauea-caldera-simplified-geologic-map-monthyear-labels-lava

  - click on the image or the link above and closely examine the map
  - launch Google Earth, search for Kilauea, and use the clock icon to view the crater in April 2002
    - you should be able to use this image to find and zoom in on lava flows that are identified on the geologic map as well as differences in roughness seen in the SAR images
    - you could also Google search for "Kilauea lava flow surface images" to find images from the ground that may be part of the region\
    - *hint: don't focus on images showing active flows, even though they are cool to look at! Rather, try to find images of older surfaces*

  - Using all these tools, you should now be able to more accurately interpret the AIRSAR scenes when you write the report. *In other words, what type and what age of flows cause more radar backscatter?*

- place the ***like polarizations*** for each band into a color composite image and compare these images to the geologic map and Google Earth view
  - what are the ages of the lava flows that appear the smoothest?

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- how does this change with increasing wavelengths?

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- find the **1919** lava flows on the map. This eruption produced lavas that completely covered the crater floor. Next, locate this area in the radar images.
  - qualitatively, is this surface smooth or rough? ____________________
  - which band best shows the various scales of roughness for the 1919 flows?

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  - does that make sense compared to the pictures and Google Earth?

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- now locate the 9/82 flow area on the map and in the radar image(s)
  - what level of flow roughness do you expect for this flow area?

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  - in general, does the flow map correlate well with the radar images? Why or why not?

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V. Color Composites

- place the **hh** bands in R, G, B from shortest to longest wavelengths
  - what might be causing the overall bright radar return in the areas to the <u>north</u> and <u>east</u> of Kilauea crater?

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  - south of the crater, this radar brightness abruptly ends along a N-S line. Can you think of any climatologic or geologic reason why there would be such a sharp dividing line in this region? *Hint: Google Earth may help!*

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- now place $\mathbf{C_{hv}}$ in red, $\mathbf{L_{hv}}$ in green, and $\mathbf{P_{hv}}$ in blue
  - the area to the north and east of the crater displays variable radar returns
  - does this make sense with what you determined in the previous step?

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VI. Topographic Data *(Optional Extra Credit for up to 10 additional points)*

- for the extra credit you will look at two digital elevation models (DEM) produced using ASTER data, of the Kilauea Caldera pre (2015) and post (2021) the 2018 eruption. The goal of the extra credit is to determine the extent of topographic change that occurred from the eruption
- open the two dataset files **(Hawaii_caldera_2015** and **Hawaii_caldera_2021)** in ENVI in two separate displays
- link the two displays together and investigate the differences in the data
- can you identify the caldera in the data? (*Hint: darker areas are lower in elevation)*
  - describe the differences between the two scenes

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  - what do you think the white shapes adjacent to the caldera in the 2021 scene are?

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- once you have identified the caldera use the T*ools → Profiles →Arbitrary Profile* and draw a transect across both datasets going from NW to SE (north is up in the image)
  - describe the difference between the two transects and speculate at what geologic process may have occurred

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- assuming that the caldera is a cylinder, use the equation for the volume of a cylinder (below), the measure tool, the transect you took above, and calculate the volume of the two calderas. What is the difference between the two? Be sure to include these three values in the report.

$$V = \pi h r^2$$

V, is the volume of the caldera/cylinder (m^3)
r, is the radius of the caldera (m)
h, is the depth of the caldera (m)