Guam Direct Broadcast Polar Orbiter Applications Workshop
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Lab 2 Part 1: The Utility of High Spatial/Spectral Resolution

1.1. Launch HYDRA, choose **File** from the **Main HYDRA window**, click on **Directory->VIIRS** and guide HYDRA to the directory containing S-NPP VIIRS data from 26 March 2018, 03:35 UTC. Select the directory and click on **Choose**. Select I-Band 1 (.64 μm) from the list of bands under **Datasets**. Select the region shown in Figure 1 by holding down the left mouse button as you outline the region with the mouse. Once you have done that click the **Display** button. This will load a full resolution (375 m) image of VIIRS I-Band 1 (.64 μm) reflectances into Window 1. Your display should look like the image shown in Figure 1.
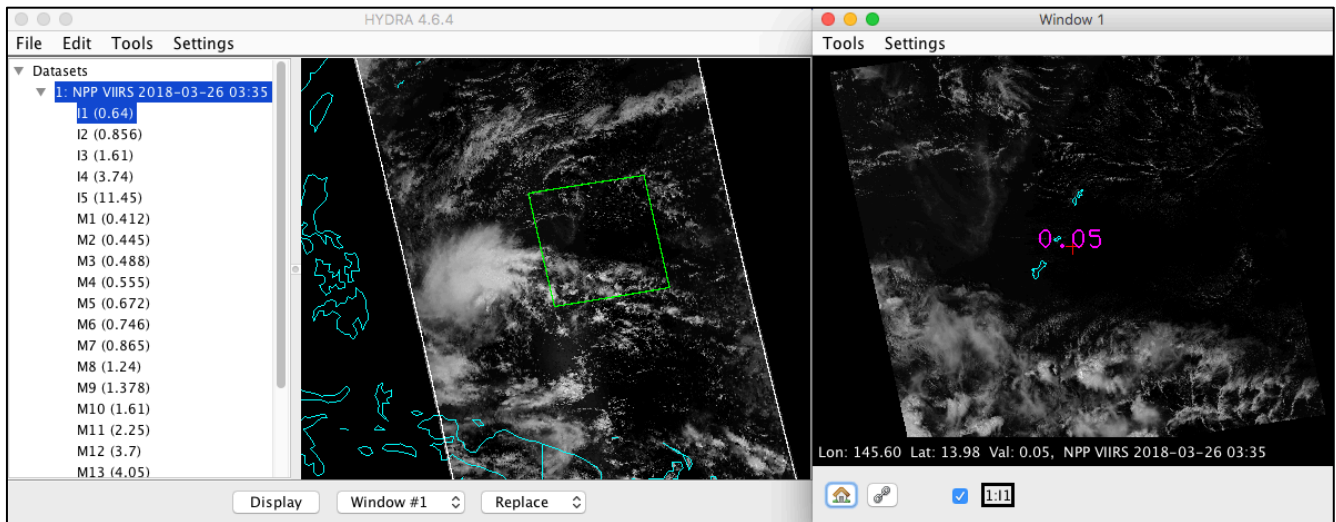

Figure 1: HYDRA display of the VIIRS overpass observed on 26 March 2018, 03:35 UTC with a full resolution (375 m) subset display of I-Band 1 (.64 μm) reflectances in the right panel.

1.2. Next, Choose **File** from the **Main HYDRA window**, click on **Directory->AHI** and guide HYDRA to the directory containing Advanced Himawari Imager (AHI) Geostationary data from 26 March 2018 03:40 UTC. Select the directory and click on **Choose**. Overlay the AHI Band 3 (.64 μm) reflectances into Window 1 (the Green box will automatically be collocated with the box chosen for VIIRS). Zoom in on the island of Guam. Change the image enhancement in both images by clicking on the black outline band boxes, **2:C03** and **1:I3,** and change the range values to go from .002 to .18. You can either type these values into the **range** boxes, or drag the green vertical lines (**right click+drag**) to set the values. Turn off the coastline overlay (**Settings->coastlines**). Compare the details that can be seen over the land and surrounding waters of Guam in both scenes by stepping through both images (**< >** controls). Which sensor provides better detailed resolution?

1.3. Now overlay the VIIRS I-Band 2 (.86 μm) and AHI Band 4 "Veggie Band" (.86 μm) into Window 1. Set the enhancement range for this set of bands to go from .012 to .675 reflectance. Compare the detail of the two images over Guam (See Figure 2) and surrounding waters. Which

instrument provides more detail? Are there clouds over the island? When and how would higher detail in spatial resolution for the "Veggie Band" be useful to a forecaster?

Figure 2: HYDRA display of VIIRS I-Band 2 (.86 μm) 375 m reflectances in the left panel, and AHI "Veggie" Band 4 (.86 μm) 1 km reflectances in the right panel from datasets observed over Guam at 03:35 UTC and 03:40 UTC respectively.

1.4. Load VIIRS I-Band 4 (3.74 μm) brightness temperatures into a new window (Window 2), and overlay AHI "Shortwave Window" Band 7 (3.9 μm) into the same Window (2). What are the max/min values over the whole scene, and how do they compare in value and location? You can turn on the Window 2 **Settings->min/max** option to help you.

1.5. Zoom in on Guam again and set the enhancement range for both the VIIRS and AHI images to be 230. To 340. degrees Kelvin. Use the probe to compare brightness temperatures over a few different points on the island (See Figure 3). What is the typical difference in brightness temperature values. What is the maximum difference that you found? Can you identify this feature? Why is improved spatial resolution important in the infrared? How can it be useful to forecasters?
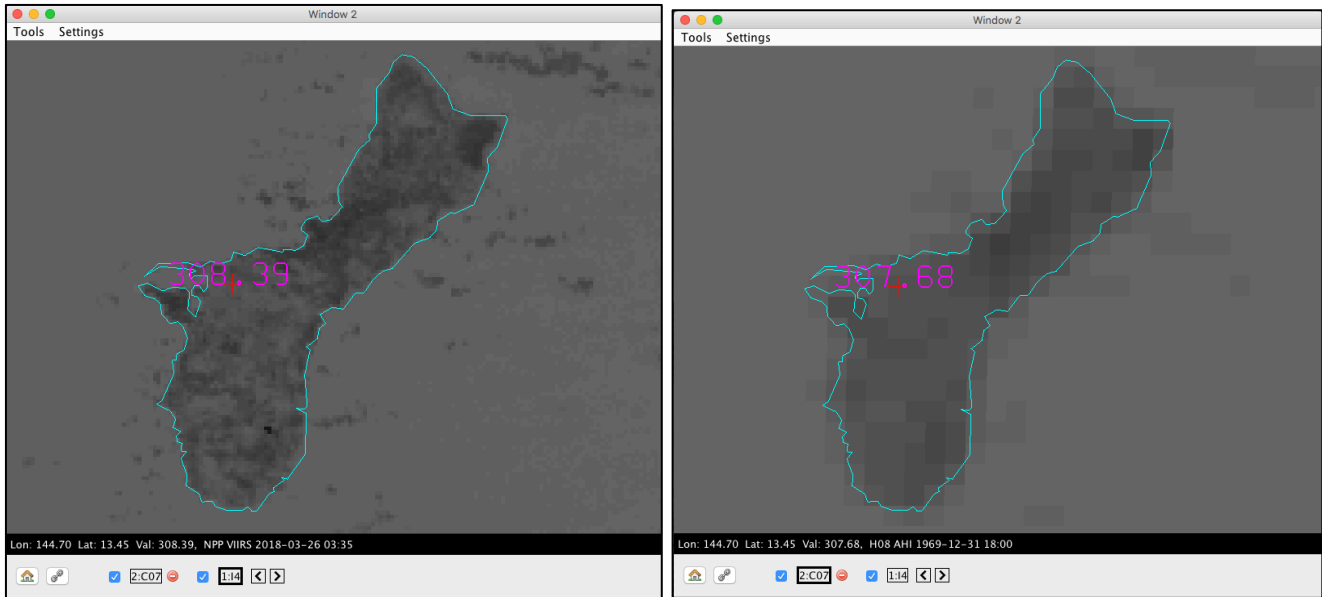
Figure 3: HYDRA display of VIIRS I-Band 4 (3.74 μm) 375 m brightness temperatures in the left panel, and AHI "Shortwave Window" Band 7 (3.9 μm) 2 km brightness temperatures in the right panel from datasets observed over Guam on 26 March 2018, at 03:35 UTC and 03:40 UTC respectively.

1.6. Now overlay the NOAA Advanced Clear-Sky Processor for Oceans (ACSPO) Sea Surface Temperature file that was created from the VIIRS dataset we have been viewing. Choose **File** from the **Main HYDRA window**, click on **File(s)** and guide HYDRA to the directory containing ACSPO file: **20180326033000-STAR-L2P_GHRSST-SSTskin-VIIRS_NPP-ACSPO_V2.40-v02.0-fv01.0.nc**. Once you have selected the file, click **Open**. Once again, the Green box will automatically outline the collocated region, and the dataset will appear at the top of the Datasets list. Select "SST" from the SST ACSPO dataset, and overlay it into Window 1. Your display should resemble Figure 4. Now examine the detail and quality of the product. Is there cloud contamination? How can this high spatial resolution product be useful to you in operations?
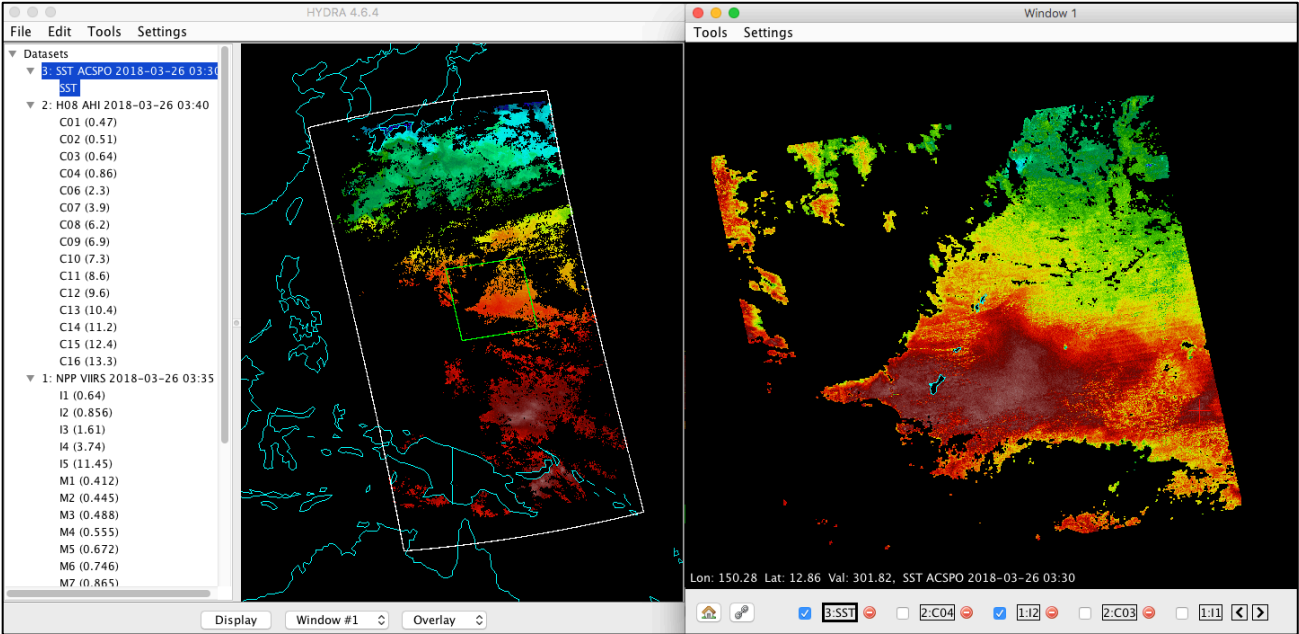

Figure 4: VIIRS ACSPO Sea Surface Temperatures as display in HYDRA from 26 March 2018 .

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Lab 2 Part 2: Using MODIS to Investigate the 2005 Eruption of Mt. Anatahan Volcano

2.1 Launch HYDRA, click on **File**-> **File(s)**, and load the Terra MODIS Level 1B 1000m data from 5 April 2005 (Day 95), 01:30 UTC (**t1.05095.0130.1000m.hdf**). Select the sub-region shown in Figure 5, and display Band 31 (11.0 μm) brightness temperatures at full spatial resolution (1km).

On this day, Anatahan erupted and sent a plume that "probably went up to at least 50,000 feet." See event recap at http://www.vulkaner.no/v/volcan/anatahan_e.html . Where is the plume in this scene? How do the brightness temperatures compare between the plume and the clouds? Is the plume easily to distinguish from the clouds?
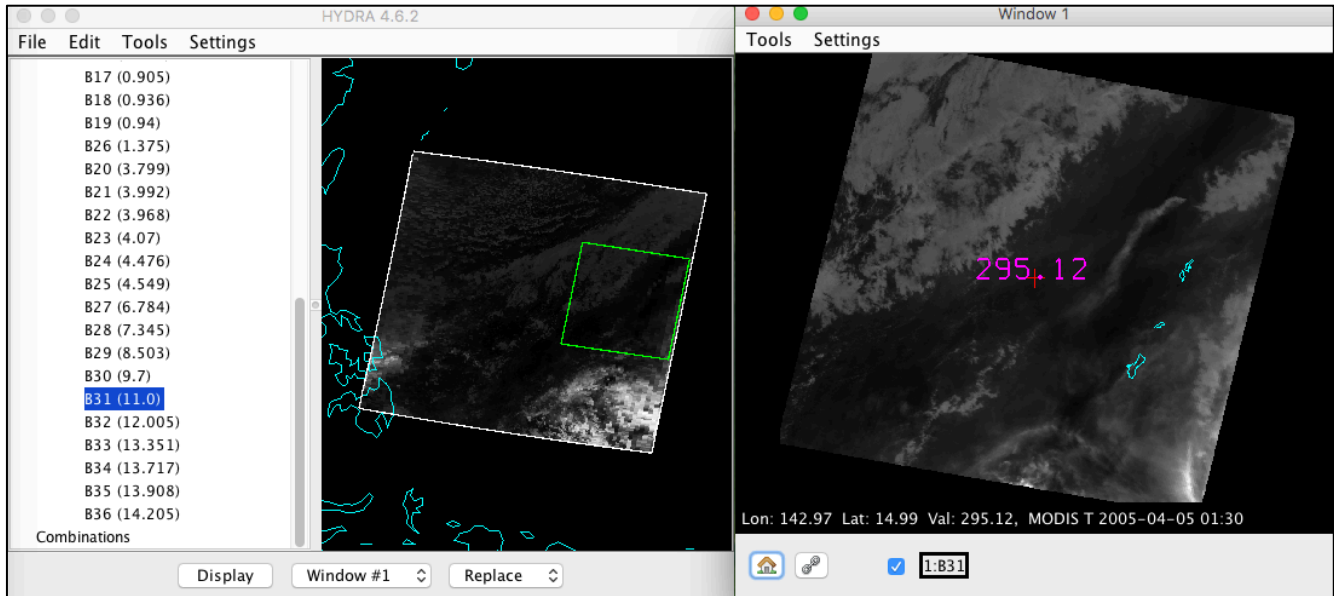

Figure 5: Terra MODIS observations from 5 April 2005, 01:30 UTC.

2.2. Now overlay the MODIS Band 1 (.65 μm) visible band reflectances into Window 1. Can you see the plume in this image? How do the reflectances in this band compare with the cloud reflectances (you can enhance the image if you need to). If you were just using these two bands, IR Window Band 31 (11 μm) and visible reflectance Band 1 (.65 μm), how easy/hard would it be to confidently outline the volcano plume? Could you deduce anything about the plume composition or height?

2.3. The MODIS instrument includes high spatial resolution bands that can be used to detect volcanic ash as well as Sulphur Dioxide (SO_2). Some eruptions are dominated by ash, whereas others produce large amounts of SO_2 and very little ash. When volcanic ash is present, brightness temperatures generally increase with increasing wavelength between 11 and 12 microns (absorption decreases), whereas brightness temperatures generally decrease when ice clouds are present (absorption increases) - see Figure 6.

Create a brightness temperature difference image in a New Window. First, select **Tools->Band Math** from the Main HYDRA window top navigation bar. When you select this option, a new Band Math window will open. Select Band 32 (12 μm) in the first box (click on B32 in the dataset list to populate the box), and Band 31 (11 μm) for the second box. Once you have B32 – B31 entered in the Band Math window, click the **Create**. The brightness temperature difference option that you selected will appear under the **Combinations** heading in the datasets list. Now display this brightness temperature

difference into a new window, by changing the Window option to **New** and then selecting **Display**. Change the image enhancement from **gray** to **Rainbow**. Your display should appear as shown in Figure 7 – left panel. Can you identify the plume in this image? Can you find a threshold to use to discern the ash plume in this scene. Does that agree with what you would expect (hint: see Figure 6).

2.4. Now repeat the steps to create an image in a New Window of the brightness temperature difference between Band 31 (11 µm) and Band 29 (8.5 µm) (Figure 7 – right panel). This band combination can be useful in detecting SO_2 in volcanic eruptions. How easy is it to identify the plume in this image? What are the brightness temperature difference values in the plume? Based upon you investigation, is there SO_2 present in this plume?
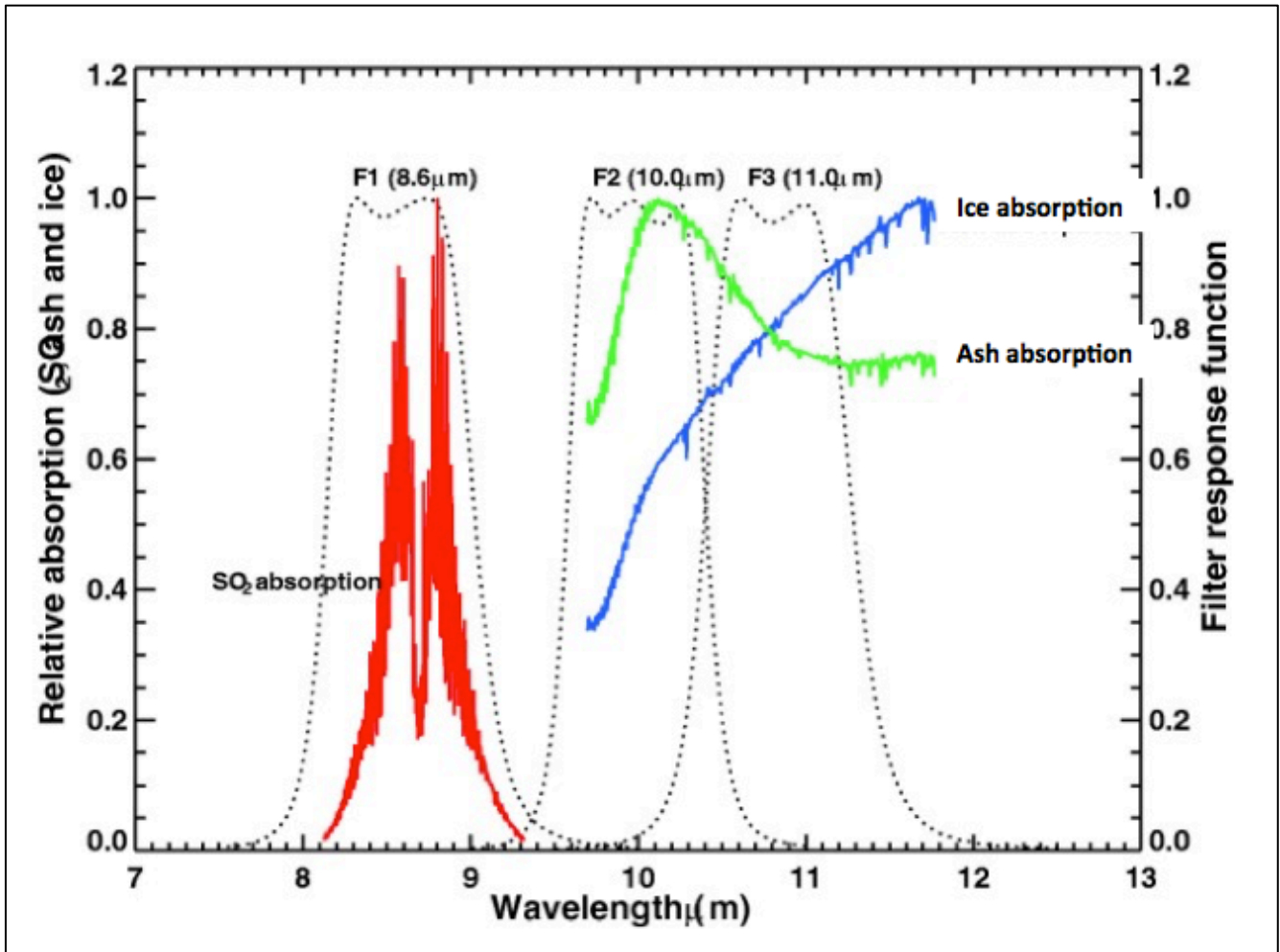

Figure 6: Relative absorption of Sulphur Dioxide (SO_2), Ice and Ash across the long wave infrared spectrum.
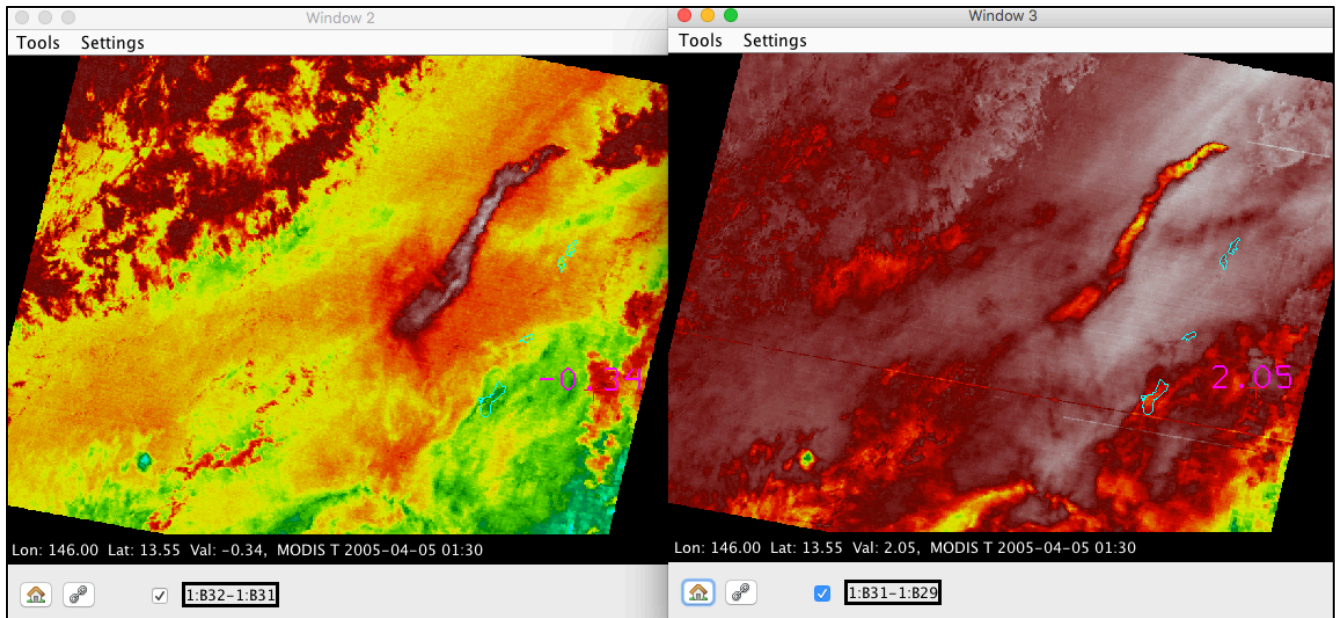
Figure 7: Terra MODIS Brightness Temperature difference enhanced images observed on 5 April 2005. Left panel – Band 32 (12 μm) minus Band 31 (11 μm). Right panel – Band 31 (11 μm) minus Band 29 (8.5 μm).

2.5. As a way of combining the detection capabilities of these band differences, an RGB visualization has been developed as a way to quickly alert users to the presence of an eruption and its qualitative composition.

Create an RGB that is used by the University of Wisconsin-Madison Volcano Team. Choose **Tools->RGB** Composite from the main HYDRA window. Highlight a color box from the **RGBComposite** window, and then choose a Dataset band or Combination from the **Datasets list** to insert. Choose **Red->B32-B31, Green->B31-B29** and **Blue->Band 31 (11 μm)**. Once the RGBComposite boxes are filled, select the **Create** button. Your RGBComposite bands will be added to the top of the dataset list, under the **Combinations** heading. Once it has been added, overlay the band combination image into Window 1. Enhance your RGB image by clicking on the **band combination box** in your image Window 1. Type in the following values in the boxes (hit enter after typing a value in each box):

B32-B31	Red range:	-2.0	4.0
B31-B29	Green range:	-6.0	6.0
B11	Blue range:	243.0	293.0

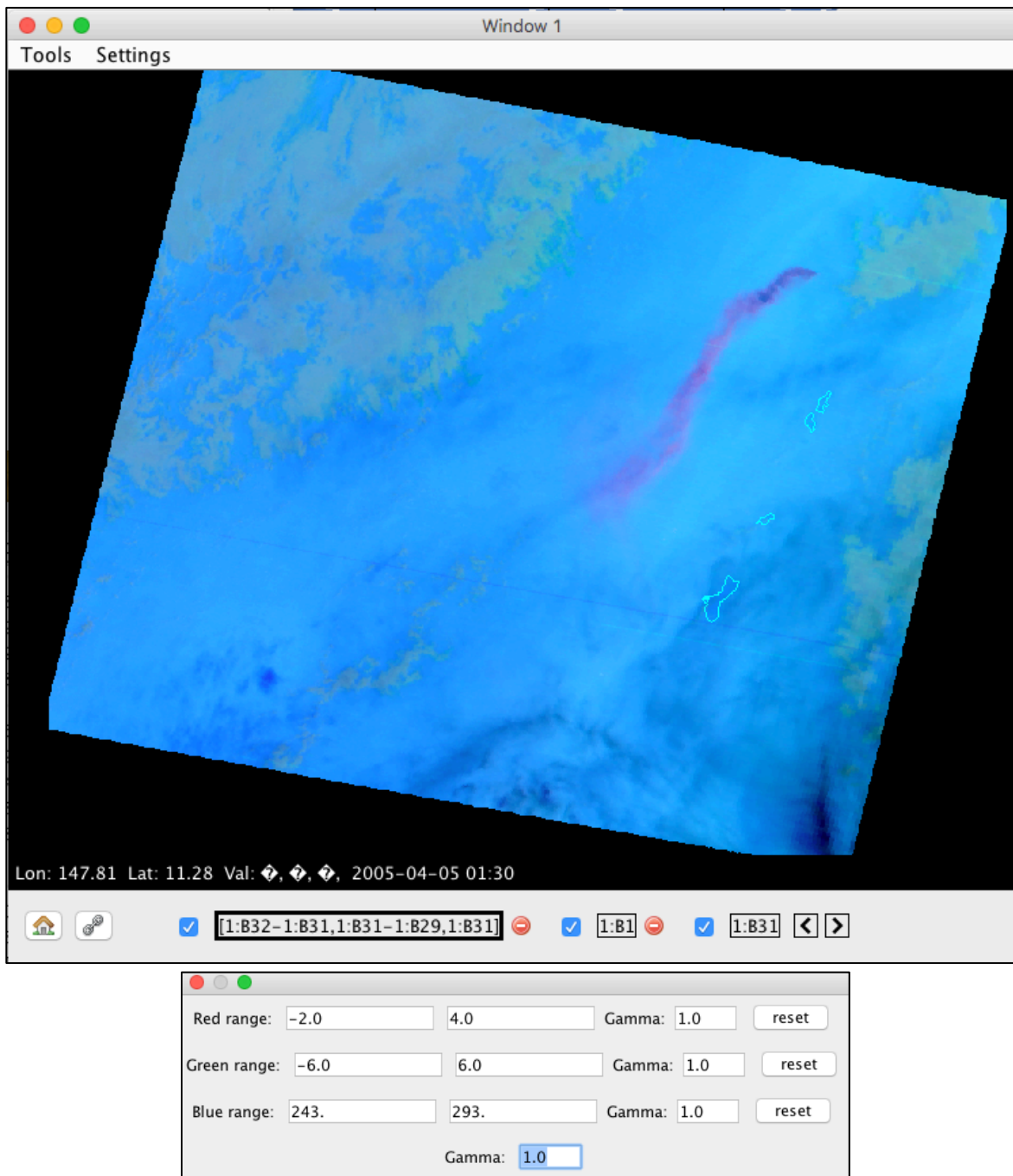Your display should look like Figure 8.

Figure 8: MODIS RGB brightness temperature combination image using observed on 5 April 2005, R: B32-B31, G: B31-B29, B: B31.

2.6. Examine the RGB. What is the color of the plume? Which band difference is contributing most to the image? What does this tell you about the composition of the plume?

Extra Credit

2.7. This eruption continued for quite some time. Based upon the Tropical Surface Analysis Charts from 00 UTC and 18 UTC 5 April 2005 (Figures 9 and 10), and Guam soundings (Figures 11 through 13) and your experience, what forecast would you make plume look like in 24 hours?
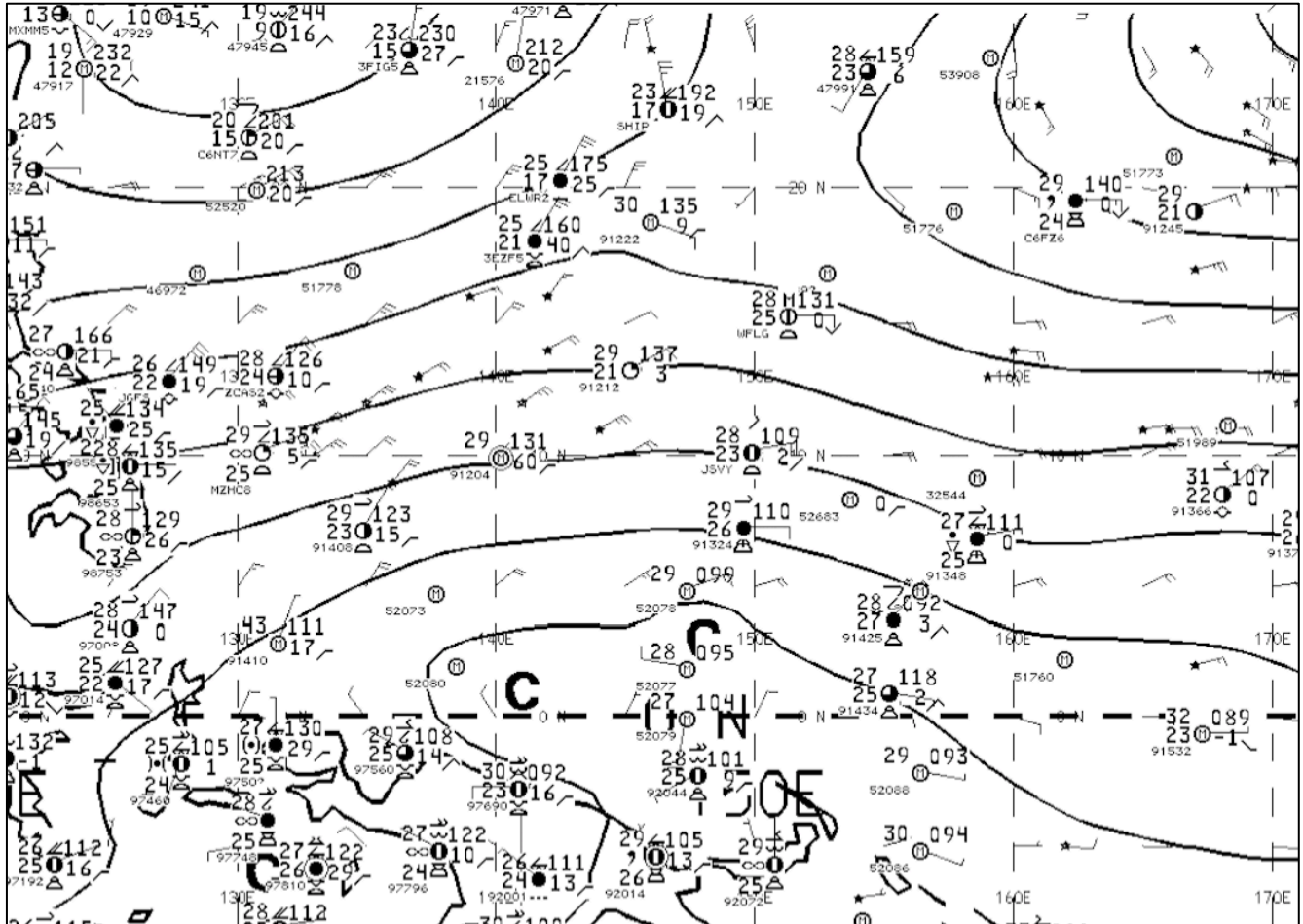
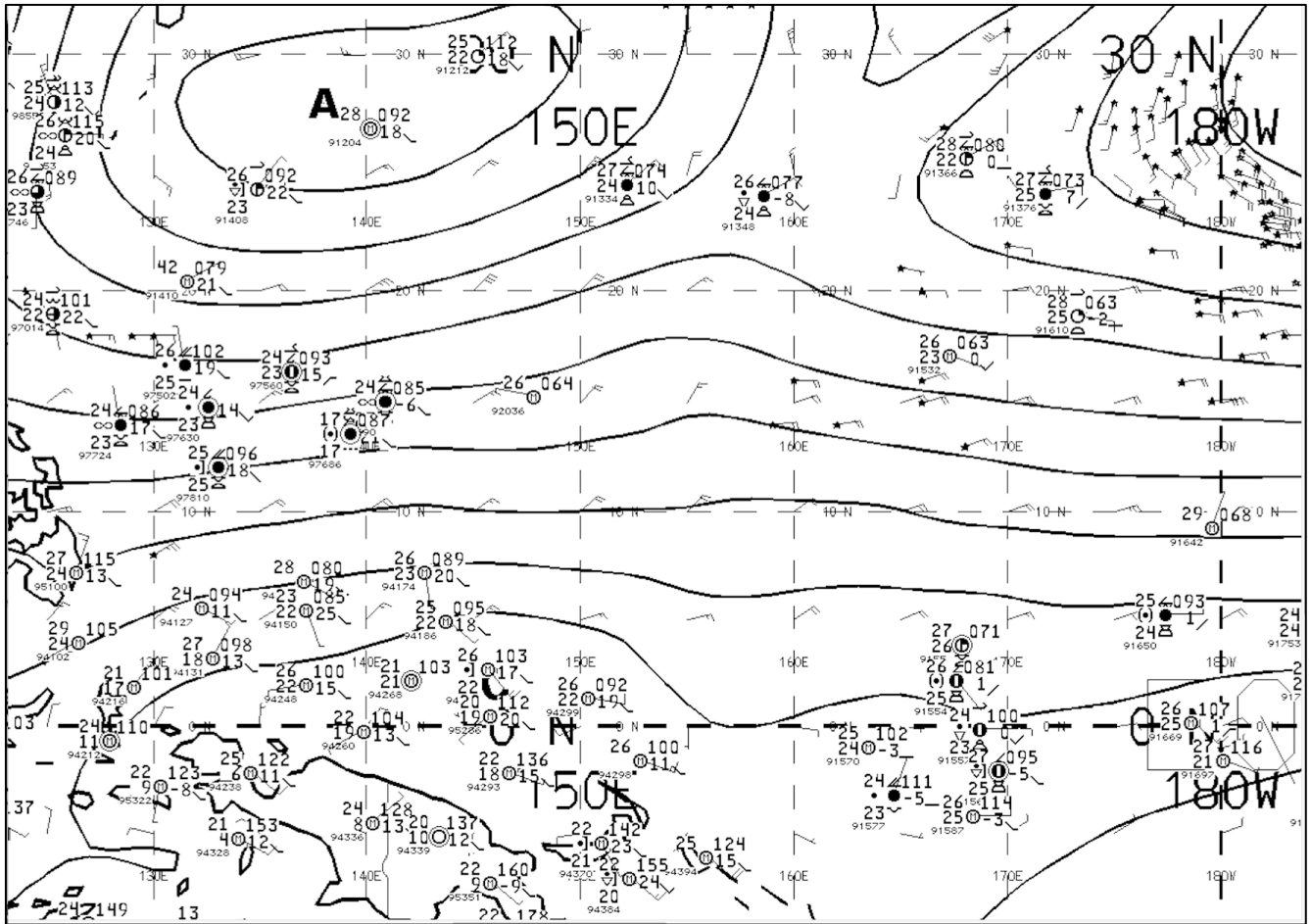**Figure 9:** Tropical Surface Analysis Chart from 00 UTC, 5 April 2005.

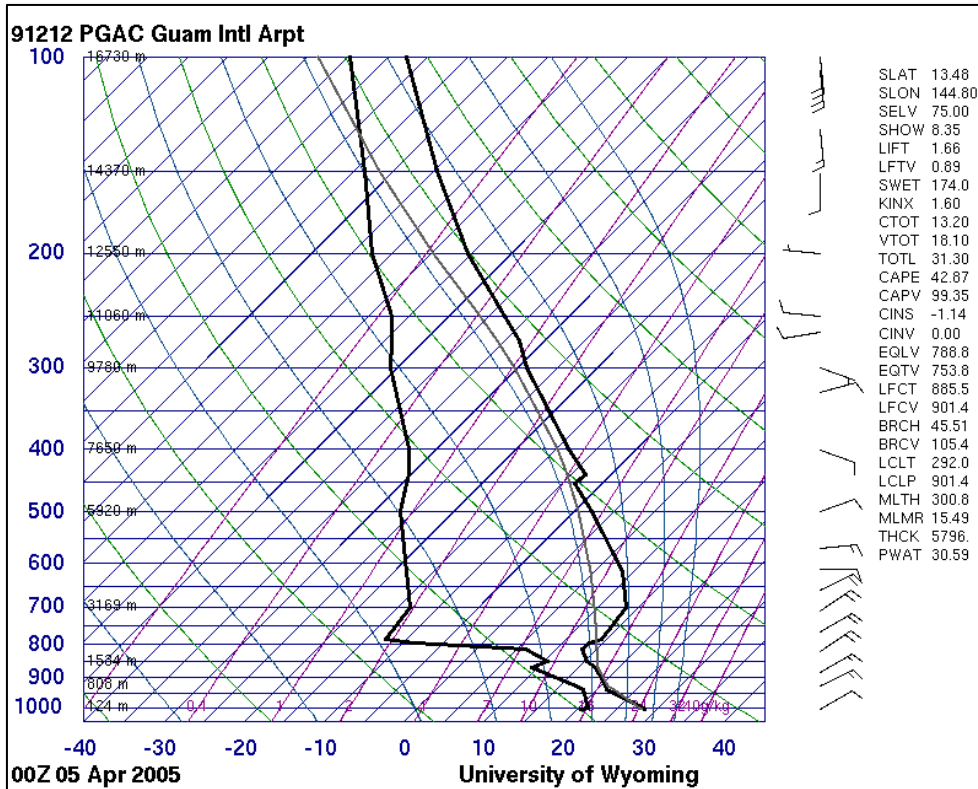**Figure 10:** Tropical Surface Analysis Chart from 18 UTC, 5 April 2005.

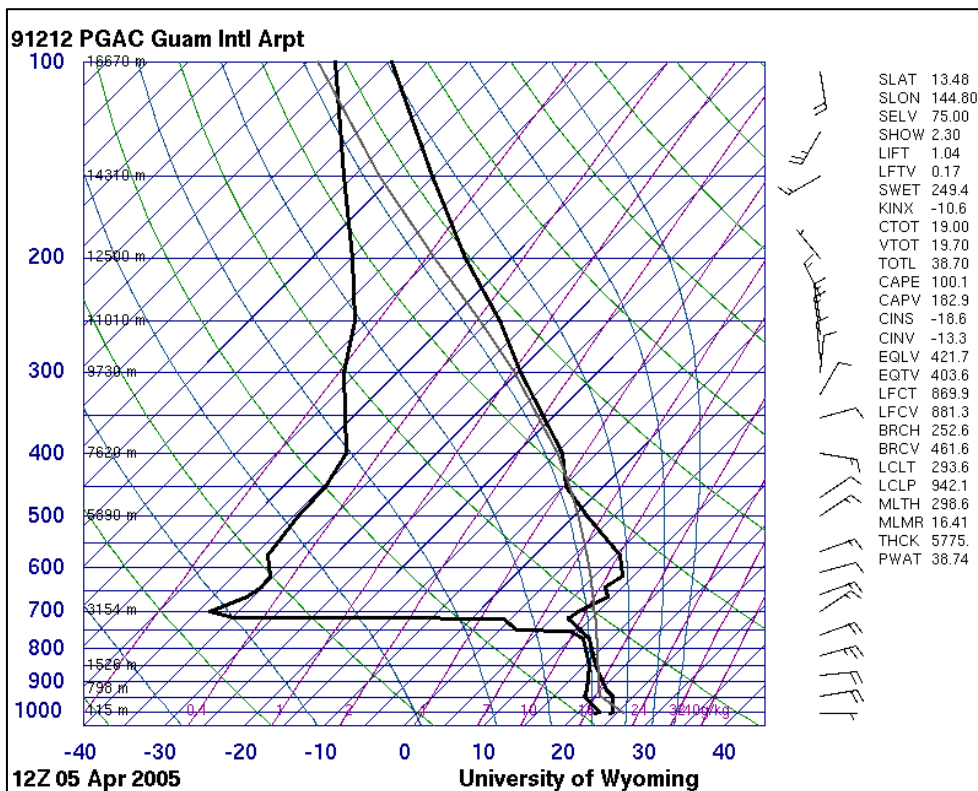**Figure 11:** Guam Skew-T Sounding Plot, 00 UTC, 5 April 2005.

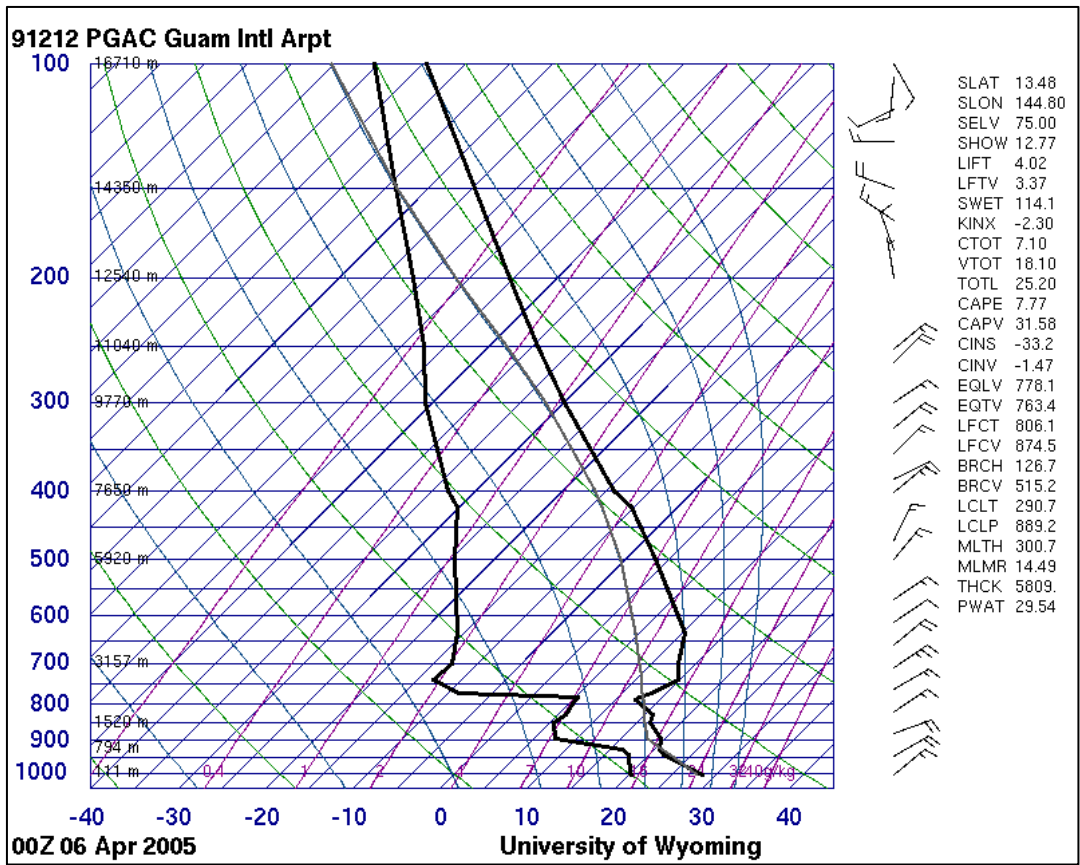**Figure 12:** Guam Skew-T Sounding Plot, 12 UTC, 5 April 2005.

Figure 13: Guam Skew-T Sounding Plot, 00 UTC, 6 April 2005

8. Create another Volcanic Cloud RGB as we did in exercise 2.5, using the Terra MODIS overpass on April 6, 2005, 00:35 UTC. Once you display the combination, the same enhancement will be automatically applied to the image (See Figure 11).

How does the extent of the ash plume match with your forecast? Is ash or SO2 dominating this plume? Give reasons for your answer.

Does the following recap of this event, recorded on 6 April 2005, help validate your findings?

"Volcanic ash blanketed the skies above the Northern Mariana Islands yesterday, forcing
motorists to drive with their headlights on in the middle of the day and bombarding the
Emergency Management Office with phone calls from panic-stricken residents.
Strong sulfur odor permeated the air and the morning sky was as dark as night.
It was like nighttime at nine in the morning. It was so dark that streetlights, which operate
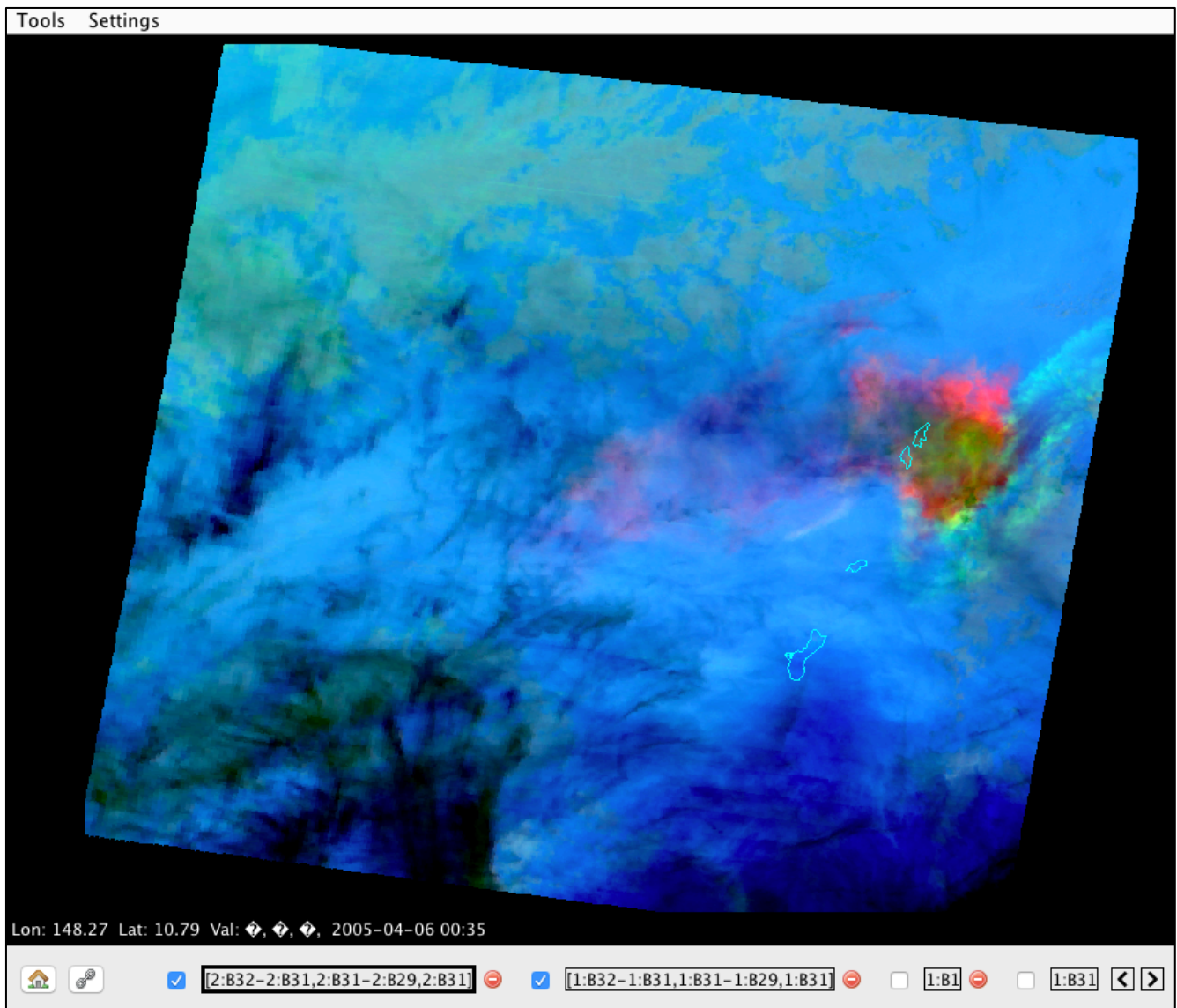with automatic sensors, turned themselves back on."

Figure 14: MODIS RGB brightness temperature combination image using observed on 6 April 2005, R: B32-B31, G: B31-B29, B: B31.