

**General Meteorology****Laboratory #4**

Name \_\_\_\_\_

Date \_\_\_\_\_

Partners \_\_\_\_\_

Section \_\_\_\_\_

**MODIS and ASTER****Purpose:**

Understand the capabilities of satellite collection of data  
Estimate the changes in a glacier over several months.

**Equipment:**

MultiSpecW32

Multispectral Data

**Data & Software Web Sites:**<http://terra.nasa.gov><http://cobweb.ecn.purdue.edu/~biehl/MultiSpec/><http://aqua.nasa.gov>**Background:**

The satellite Terra was launched on Dec. 18, 1999 and began collecting data on Feb. 24, 2000. Five instruments flew on this satellite platform (ASTER, CERES, MISR, MODIS, & MOPITT) with the goal of monitoring climate and environmental changes. It will complete its mission in 2015. A complementary satellite Aqua was launched on May 4, 2002 with six instruments (AIRS, AMSU-A, HSB, AMSR-E, MODIS, & CERES). Both of these satellites are in a sun synchronous, near-polar orbit. Terra crosses the equator at 10:30 am local time with a descending node (traveling from north to south). Aqua crosses the equator at 1:30 pm with an ascending node. A constellation of satellites with the same orbital parameters as Aqua will form what is called the A-Train and will consist of OCO, Aqua, CloudSat, CALIPSO, PARASOL, and finally Aura. Each of these satellites have complementary sensing equipment used to record and study the earth system (land, ice, sea, and atmosphere). Each satellite orbits at an altitude of 705 km and uses instruments to remotely sense reflected and emitted radiation at a number of different wavelengths within the electromagnetic spectrum.

MODIS (MODerate-resolution Imaging Spectroradiometer) scans the earth system using a rotating mirror which sweeps in a direction perpendicular to the satellite's motion. Subsequent sweeps view a different portion of the earth due to the satellite's motion. As a result, data from MODIS consists of a 2,330 km wide swath with a resolution of  $\frac{1}{4}$  to 1 km depending on the spectral band being measured. A total of 26 spectral bands are measured ranging from the visible to the thermal infrared. With a swath width of this size it is possible to nearly monitor the whole earth's surface once everyday. Gaps of coverage occur at the equator and these gaps are covered on the following day.

For higher resolution ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) measures a swath width of 60 km and has a resolution ranging between 15 m and 90 m over 14 spectral bands.

**Procedure:****I. Generating a true color satellite image**

Copy all of the files on the provided CD to the temp directory on the C: drive of the computer. When you are done, you should delete the files you added to this directory.

1. Begin the program MultispecW32 by double-clicking on its icon in the directory temp\MultiSpecWin32.
2. Open the MODIS file by clicking on File and the sub-menu Open. Select the file MOD02HKM.A2005222.2020.005.2005224064339.hdf. This data has a resolution of ½ km and contains data for spectral bands of red, green, and blue. This makes it possible to generate a real color image of the earth's surface. The other MODIS file has ¼ km resolution, but only contains two bands (red and near IR).
3. When you open the file, you will get a dialog box indicating which data you want to use within the file. Click on the combo box labeled HDF Data Set and find EV\_250\_Aggr500\_RefSB. After clicking on OK, continue to click OK on the subsequent dialog boxes until MultiSpec generates an image.
4. The displayed image uses the 2 spectral bands in this data set. Channel 1 has a wavelength range of 620-670 nm and corresponds to red. Channel 2 has a wavelength range of 841-876 nm and corresponds to the near infrared.
5. To get a true color image another data set must be linked into the image. To do this open a new file. At the dialog box click on the check box labeled Link to Active Image Window. Once you have done that, select the file MOD02HKM.A2005222.2020.005.2005224064339.hdf and click on OK. In the next dialog box find the HDF Data Set EV\_500\_RefSB and click on OK. You will be given another dialog box for opening a file. At this point, click on Cancel.
6. Your displayed image is unchanged; however, an additional 5 channels have been added to this image. The first two additional channels correspond to 459-479 nm (blue) and 545-565 nm (green). To display the appropriate channels, chose the menu item Processor and the submenu Display. Within the dialog box you will have the option to set which channels corresponds to red, green, and blue. Set red to channel 1, blue to channel 3, and green to channel 4. Click on OK and you will see a change in your image.
7. The image still does not appear to be realistic. Once again go to the Display image option and look at the area labeled Enhancements. Under stretch select the option Equal Area and press OK. A more realistic image should appear on your screen.
8. To zoom in on your image, click on the toolbar item that looks like a mountain shape. To zoom out click on toolbar item that has a smaller set of mountain shapes on it. You can also select a region by dragging over the area with your mouse and then click on the zoom button.
9. As you scroll around on the image, you will notice to the right and left sides of the image a misregistration of the subsequent sensor scans. This is due to a loss of resolution as you move away from nadir (looking straight down).
10. Using trigonometry determine the resolution loss at the left and right edges of the image. Record your calculations at the end of the lab in the space provided.

**II. Saving an image as a TIF file.**

You may want to save your image in a format that can be used by a graphics program. MultiSpec can export images in the TIF format, which can then be converted to GIF's or JPG's using PhotoShop or PaintShop Pro. In this case we want to look at Glacier Bay National Park. This park is in Alaska and is close to Juneau.

1. Zoom out until you can see the whole image. At the bottom left of the image you will see a deck of marine stratocumulus clouds. The cloud deck ends near the coast of Alaska. Zoom in to this coast line and find Glacier Bay National Park. Compare the coast line to the map provided in your handout.
2. Set the zoom level so you can see the whole park including some of the stratocumulus clouds to the southwest. Draw your mouse over this region to select it.
3. Once you have selected this portion of the map, select the menu item File and the submenu item Save Image Selection to TIF as. You may use the default name given to this file by MultiSpec or you may choose your own file name. You may email this file to yourself if you so choose.
4. Make a printout of this same selection by choosing the menu item File and submenu item Print Image Selection. Include this printout with your lab.
5. On both the map and your MultiSpec image find Brady Glacier. Indicate on your map, where you estimate the terminus of the glacier exists. Also explain why you chose the terminus as you did in the space provided at the end of the lab.

### III. Using ASTER data.

ASTER provides a higher resolution data set than MODIS. We will use two files to study changes in the Brady Glacier over a period of 5 months. The first image is from Aug. 10, 2005 and corresponds to the MODIS image just viewed.

1. Open the file AST\_L1B\_00308102005202331\_20060607103956\_13855.hdf. Select the HDF Data Set ImageData1\_G1 and click on OK. Three channels are present in this data set and they are Band 1: 520-600 nm (green), Band 2: 630-690 nm (red), and Band 3: 760-860 nm (near IR). The displayed image is not true color, but it is easy to identify Brady Glacier in the image.
2. Select the terminus of Brady Glacier and click on the X1 button on the toolbar. Notice the structure on the glacier surface and the ripple pattern in the debris carried by the glacier.
3. On your map draw the terminus with more detail as obtained from this ASTER image.
4. Open the file AST\_L1B\_00303032005202324\_20060629153510\_21298.hdf. Again select HDF Data Set ImageData1\_G1. This image was obtained on Mar. 3, 2005. On your map draw the extent of snow cover, for the end of Brady Glacier and label it so it doesn't get confused with the other items drawn on the map.
5. On this Mar. 3 image, there is a bright region to the upper left. It looks like part of the Brady Glacier. The image is a bit too bright so adjust the colors by selecting Display Image. Set min-max to Entire Range and Stretch to Linear. Now zoom in on the upper left part of the image. The puffy shape is indicative of stratocumulus clouds.
6. It is difficult to identify where the clouds end and the snow starts. It is easier to make this distinction in a thermal IR channel. Open the file AST\_L1B\_00303032005202324\_20060629153510\_21298.hdf again, but now choose HDF Data Set ImageData10\_G3. The edge of the cloud deck is now clearly visible as a transition between darker shaded clouds and the lighter shaded glacier. On your map identify the location of the cloud edge and label it. On ASTER there are 5 thermal IR bands ranging from 8,125-11,650nm. Each channel clearly shows the cloud edge.
7. In light of the information gathered during this lab, how would you describe the changes in the extent of Brady Glacier since 1961. Record your answer at the end of the lab.

**IV. Calculations and Questions**

Several questions were asked throughout the lab. Place the calculations and answers in this portion of the lab.

1. Loss of resolution for MODIS.

The diagram below illustrates how MODIS records its data as it sweeps across the earth. Using trigonometry, find the angular resolution of the MODIS sensor.

- a. Use the altitude and the nadir resolution to determine the resolution angle,  $\delta$ .

$$\tan \delta = \frac{opp}{adj} \qquad \delta = \underline{\hspace{2cm}}$$

- b. Use the half swath width to determine the maximum viewing angle,  $\theta$ . Ignore the curvature of the earth in this calculation and again use the tangent formula.

$$\theta = \underline{\hspace{2cm}}$$

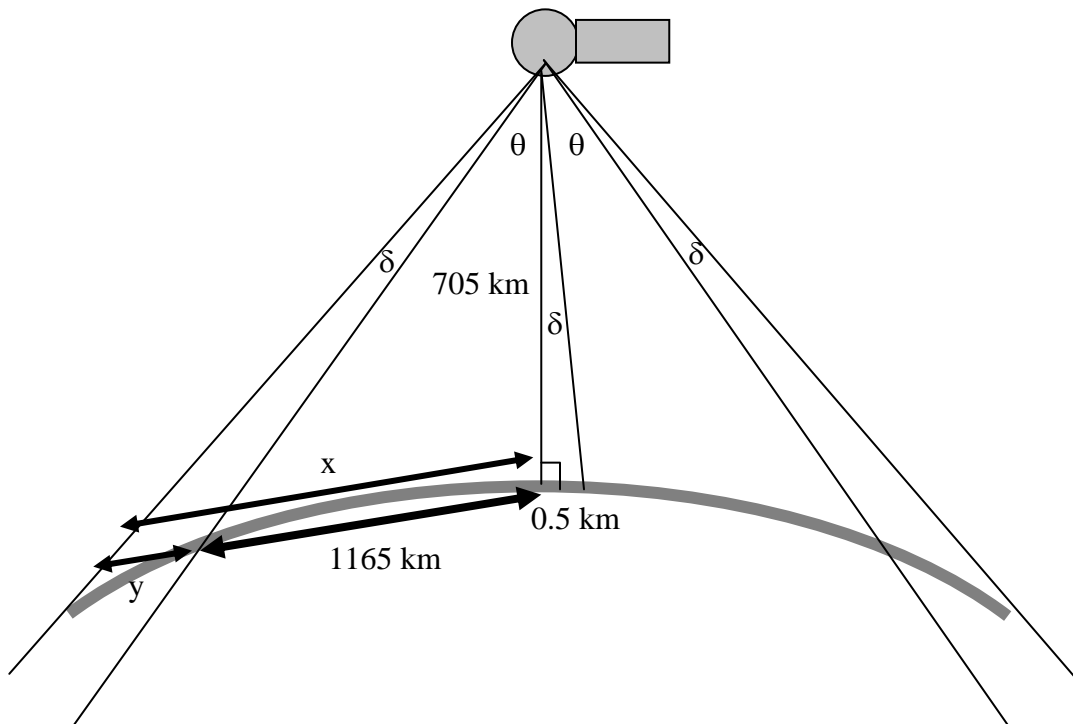
- c. Calculate the distance between nadir and the last pixel of the swath,  $x$ . Combine the angles  $\delta$  and  $\theta$  to get this new distance. Again use the tangent formula and ignore the curvature of the earth.

$$x = \underline{\hspace{2cm}}$$

- d. Calculate the resolution at the end of the swath,  $y$ .

$$y = \underline{\hspace{2cm}}$$

- e. If the curvature of the earth were included, would this pixel size be larger or smaller? Why?



2. Include the printout of Glacier Bay National Park. Below explain why you chose the terminus of Brady Glacier as you did.
3. Comparing the locations of the terminus of Brady Glacier on your map, describe how Brady Glacier has changed since 1961? How certain are you of your conclusions?

Map of Brady Glacier taken from the park map for Glacier Bay National Park, AL.

