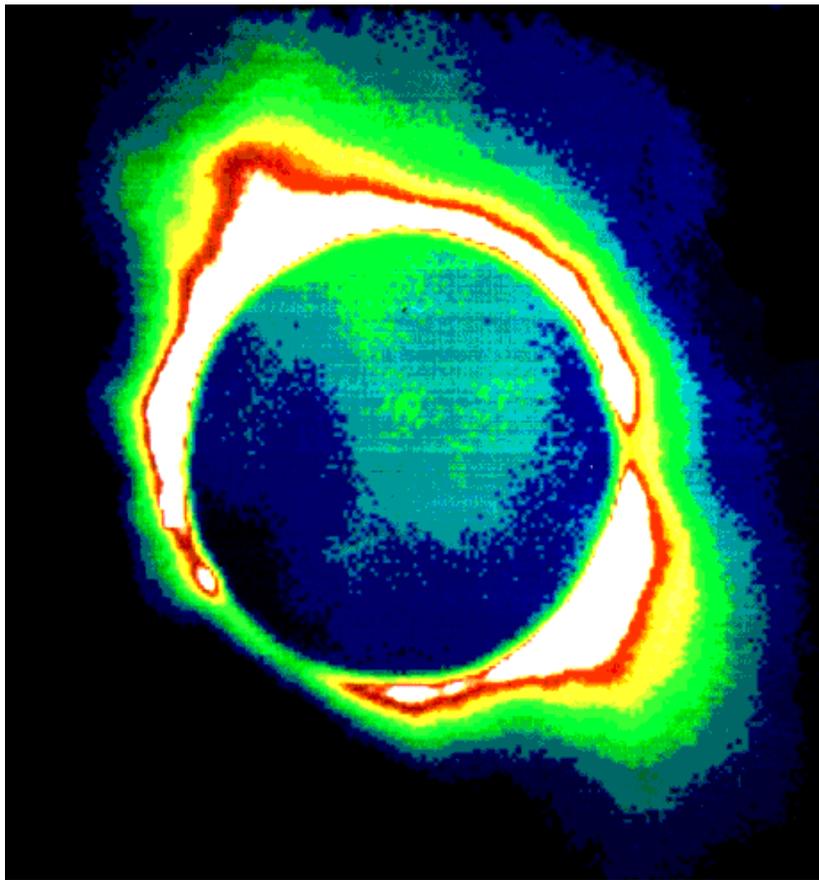


HANDS-ON UNIVERSE

HIGH SCHOOL SCIENCE AND MATH
IN THE CONTEXT OF ASTRONOMY
INVESTIGATIONS

Introduction to Image Processing



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by Lawrence Hall of Science
University of California, Berkeley
Lawrence Berkeley National Laboratory
and TERC of Cambridge, Massachusetts



HOU provides a visual and analytic way of exploring the universe.

Use HOU images from professional telescopes, along with HOU image processing software, to pursue investigations of astronomical objects, phenomena, and concepts. Opportunities available to HOU students can lead to accessing professional-grade telescopes via the World-Wide Web for observations as part of research projects such as searching for supernovae and asteroids.

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Introduction to Image Processing

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Constants Sheet

Planetary Data:

<u>Planet</u>	<u>Mass (kg)</u>	<u>Ave Radius (m)</u>	<u>Ave Orbital Radius(m)</u>
Mercury	3.32×10^{23}	2.44×10^6	5.79×10^{10}
Venus	4.87×10^{24}	6.08×10^6	1.08×10^{11}
Earth	5.97×10^{24}	6.36×10^6	1.49×10^{11}
Moon	7.35×10^{22}	1.74×10^6	
Mars	6.42×10^{23}	3.40×10^6	2.28×10^{11}
Jupiter	1.90×10^{27}	6.80×10^7	7.78×10^{11}
Saturn	5.69×10^{26}	5.70×10^7	1.43×10^{12}
Uranus	8.69×10^{25}	2.51×10^7	2.87×10^{12}
Neptune	1.03×10^{26}	2.44×10^6	4.50×10^{12}
Pluto	1.30×10^{22}	1.50×10^6	5.90×10^{12}

Physical and Astronomical Constants:

Gravitational Constant = $G = 6.673 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$

Speed of Light in a vacuum = $c = 2.9979 \times 10^8 \text{ m/s}$

Earth-Sun Distance = Astronomical Unit = $\text{AU} = 1.496 \times 10^{11} \text{ m}$

Earth-Moon Distance = $3.844 \times 10^8 \text{ m}$

Parsec = $\text{pc} = 206265 \text{ AU} = 3.26 \text{ ly} = 3.09 \times 10^{16} \text{ m}$

Light year = $\text{ly} = 9.5 \times 10^{15} \text{ m}$

Mass of the Sun = $1.989 \times 10^{30} \text{ kg}$

Luminosity of the Sun = $3.83 \times 10^{26} \text{ W}$

Radius of the Sun = $6.96 \times 10^8 \text{ m}$

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INTRODUCTION TO IMAGE PROCESSING

Activity I: Displaying An Image

- Double click on the **HOU** icon in the HOU window.

Your initial image processor screen should show the following:

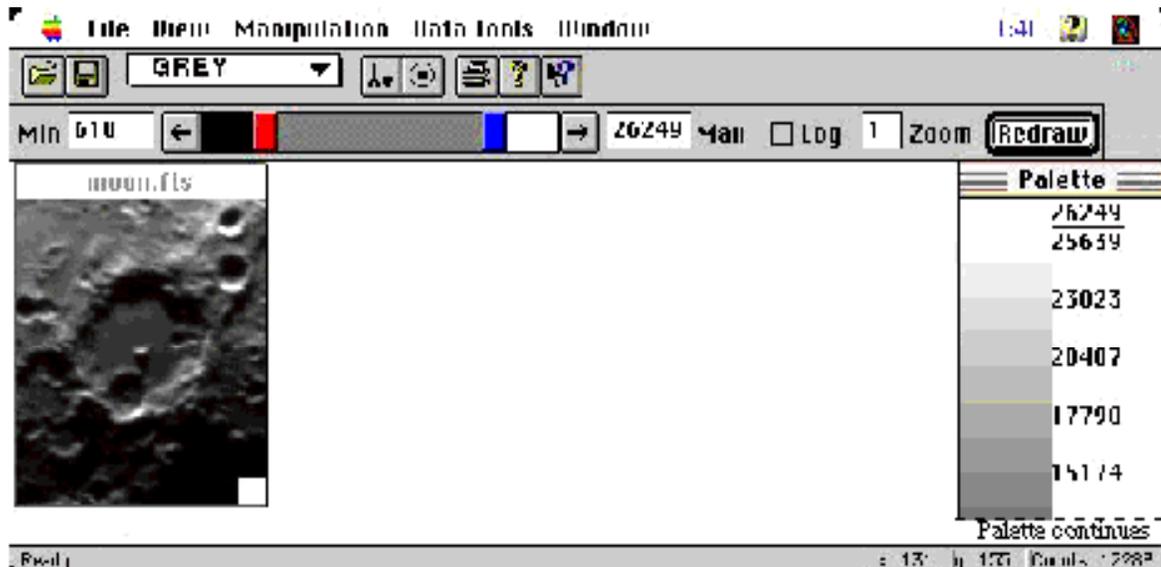


Note the row of icons on this Tool Bar. If you place the cursor on one of the icons, its name pops up.

1. Go to the answer sheet and write in the name for each of these icons.

To Open an Image

- Click on the open file folder icon or use the **Open** command in the **File** menu.
- Open the image called *Moon*. For older versions of the software, you will need to select 'All Files' from the list of file types to see the listing of all available fts and .fth files. From now on this instruction about opening images will be given in 'Screen Setup', as shown on the next page.



- In the **View** menu the options include four bars: **Tool Bar**, **Status Bar**, **Color Palette Bar**, and **Display Controls Bar**. Toggle these on and off to see what each name refers to.

2. On the answer sheet, label each of these bars.

To Use Zoom On An Image

- The default value for Zoom on the **Display Control Bar** is “1”. Change this to “2” and click on **Redraw** or press the Enter or Return key on your keyboard.
- Try other values for Zoom. When the image gets too large for the window, scroll bars appear on the window. Scroll to see all the parts of the image.

To Adjust the Image Contrast

Min/Max. This controls the shading (or the coloring). Assuming the palette is Grey, pixels dimmer than Min will be black and pixels brighter than Max white. Everything in between will be a shade of grey.

The software assigns shades of grey or colors across the range of brightness between the Min and Max. Changing the values to make the range narrower brings out more detail in the parts of the image whose brightness is within that narrower range.

Screen Setup: Two images of *Moon* side by side, labeled *Moon.fts;1* and *Moon.fts;2*, both with Zoom 2 or 3. From **View** choose **Color Palette Bar**.

With the same image in two windows, you can change settings in one and see by comparison what difference it makes. The **Display Controls Bar** and **Color Palette Bar** only refer to the active window, the one with its title bar highlighted. The **Status Bar**, however, gives the (x,y) coordinates of the cursor position and the Counts value of brightness at that position for whichever image the cursor is on.

Min/Max values in the **Display Controls Bar** can be changed in four different ways: Drag, Click, Press, or Enter.

Drag the tabs in the slide bar.

Click inside the slide bar to either side of the tabs.

Press on the arrows at the ends of the slide bar.

Enter new values in the boxes at either side.

- Change Max in one image to approximately one half as great.

3. Describe what happens to detail in the bottom left part of the image.

4. Describe what happens to detail in the top part of the image.

- Select **Reset Default Min/Max** in the **View** menu to reset to the original Min/Max values.

- Double, triple, or even quadruple the Min value.

5. Describe what happens to the detail in the bottom left part of the image.

6. Describe what happens to the detail in the top part of the image.

- Select **Reset Default Min/Max** and click on **Log**.

7. How does Log scaling alter the image? What is better? What is not?

Log Scaling brings out detail in dimmer parts of an image. You may need to adjust **Min/Max** to enhance the features you are interested in. Did you note the better detail in the lower part of the image?

Activity II: About the Display

Screen Setup: Two images of *Moon* side by side, labeled *Moon;1* and *Moon;2*, both with Zoom 2. Select **Log** for the *Moon;2* image. Display the **Color Palette Bar**.

Cursor Information: The (x,y) coordinates and the brightness in Counts for the cursor's position are displayed in the **Status Bar** at the bottom right of the screen. Each (x,y) pair of coordinates identifies a specific location, called a picture element or pixel for short.

Display Region: The dimensions in pixels of the image displayed without scrolling.

8. What are the (x,y) coordinates of the bottom left corner of the window in *Moon;1*?
9. What are the (x,y) coordinates of the top right corner of the window in *Moon;1*?
10. What are the window's dimensions?
- 11, 12 & 13. Increase the Zoom to 4 or 5 in *Moon;1* and answer #8, 9 & 10 again.
14. Compare *Moon;1* with *Moon;2* and describe the effect of Zoom on the displayed window dimensions and upon the (x,y) coordinates of features in the image.
15. Scroll *Moon;1* and compare the dimensions of the image window, only part of which is displayed at any one time, with the image window dimensions at Zoom 2.

Brightness: With Log Scaling in one image and normal linear scaling in the other, the two images look very different. It is the display of the image that is changed, not the image file data. To see this, choose a bright spot and a dark spot, such as the peak in the big crater and the dark center of a small crater. Go to the same place on each image.

16. Record your pixel coordinates and brightness values for the bright and dark spots in *Moon;1* and *Moon;2*.

Color Palette Bar. This bar shows the range of shades or colors associated with the palette in the active window. The numbers beside the bar are brightness in Counts.

- For both images, select *rain.pal* by pressing on the current palette name in the selection box on the **Tool Bar** or selecting **Load Color Palette** in the **File** menu.

17. By looking at the **Color Palette Bar**, estimate the range of values for the lightest shade of pink in *Moon;1*.
18. By comparing *Moon;1* and *Moon;2* describe how log scaling changes the range of Count values assigned to each color.

Activity III: Tools For Analyzing Images

Screen Setup: One Zoom 2 or Zoom 3 image of *moon* with default Min/Max (use **Reset Default Min/Max**).

A short description of any icon or highlighted option in the main menu is given at the bottom of the screen. Fuller descriptions are included in **Help**. Click on the Help icon, move the ? to the item and click again.

- Select **Zoom Box** in **Data Tools**. The cursor becomes a square icon. By dragging with the mouse, draw a box around part of the image.
- **Zoom Box** three more times. Use **Cascade** and **Tile** in **Window** to see what these options do to the display. If you do not see a window, select it in **Window** to bring it to the front as the active window.
- Click on the icon or select **Cleanup marks** from **View** if boxes are cluttering the image. This erases marks, but not the image, in the active window.

Screen Setup: One Zoom 2 or 3 image of *moon*.

- Use **Slice** in the **Data Tools** menu to get a brightness graph. A slice is drawn by dragging the cursor across a part of the image. Start above the central peak inside the crater, cross the central peak, and end beyond the crater ridge.

The *Slice* graph is a plot of brightness in Counts versus distance along the slice in pixels. Make the *Slice* window larger by dragging the borders (PC) or the bottom right corner button (Mac). Arrange the Image and Slice windows so both are visible.

- Drag with the mouse on the *Slice* graph to see Distance and Count values displayed at the cursor position. The position along the slice is also shown in the image window. Compare the values shown in the **Status Bar** with the values in the Slice window.
- Select **Axes Setup** from the **Options** menu, add Grid on both axes and change the Tick spacing as appropriate.

19. On the answer sheet draw your slice line on the image and sketch the graph. Label bright and dim points on the graph and their corresponding spots on the image.

20. Why are the cusps (high points) in the graph all different heights?

21. What is the distance, in pixels, from the central peak to the large crater rim?

Activity IV: Explore A Solar Eclipse



Screen Setup: *Eclipse1*. This image was taken in Hawaii in 1991 by an HOU team. If you have trouble downloading the compressed file, *.fth*, download the uncompressed version, *.fts*.

- Scroll down to the bottom rim of the sun.
- Try some color palettes such as *Rain.pal* and *WRMB.pal*. Adjust the contrast using Min/Max so you can see the sun's rim. See if Log scaling helps.

22. Record your settings.

Analyzing the Prominence at the Bottom of the Sun's Image

A solar prominence is a cloud- and flame-like structure in the corona and chromosphere, the sun's layers of atmosphere. They are only visible during a solar eclipse when the light from the sun does not block them out, just as the stars are blocked out in the daytime sky. A prominence in profile outside the solar disk is a bright feature that can extend thousands of kilometers from the solar disk and last for many months. The bright eruption at the bottom of the *Eclipse1* image is an example of a prominence. There are more bright spots visible in the image that are probably other prominences beyond the sun's edge.

- Select **Zoom box** from **Data Tools** and make a box around the prominence.
- In the **Display Controls Bar**, change Zoom to get as large a display of the prominence as possible that still fits on the screen (no scroll bars added to the window).

23. Using the cursor and the **Status Bar**, measure the height in pixels of the solar prominence above the sun's rim and the diameter of the sun. Note that height here is no different than thinking about height in opposite hemispheres on Earth – both are up.

24. Convert this to an estimate of the height of the prominence in kilometers.

(Sun's diameter = 1,390,000 km)

25. How many Earths could fit under the prominence?

(Earth's diameter = 12,756 km)

- Select **Slice** and draw two slice lines, one across the prominence to show its width and one out from the Sun to show its height. Be sure your slice lines include parts of the image beyond the prominence.

26. Make a sketch of your two graphs on the answer sheet.

Seeing is believing, so they say. But sometimes what you see is not enough. You have two ways to see the prominence, in the image itself and on the Slice graph.

- Drag in one of the graph windows so the distance and brightness coordinates are shown and a small box appears on the slice line in the image. Drag the cursor to the place on the graph corresponding to the left or outside edge of the prominence. In the image window does the box showing where you are along the slice also appear to be at the edge of the prominence? Often it does not.

27. Increase the value for Max until the prominence almost whites out. Make another Slice on top of one of slices you made for #26.

- A. Compare these two Slice graphs. What is different? What is the same?
- B. What is the distance in pixels between the apparent edge of the prominence in the image and the edge shown on the graph?

Date: _____

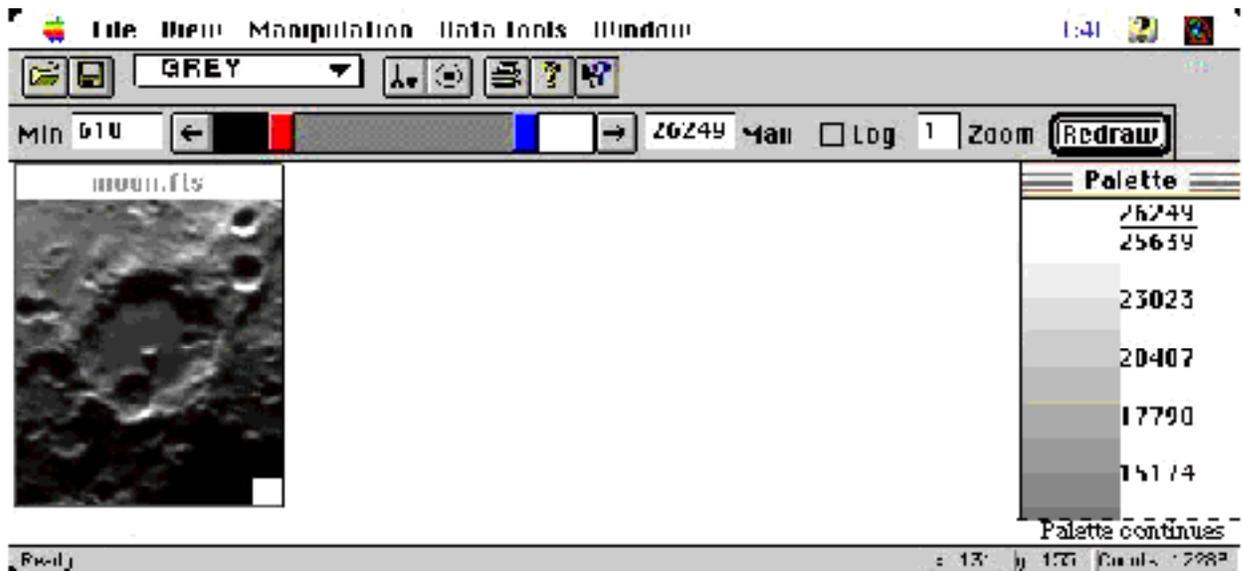
Name: _____

Answer Sheet: Activity I: Displaying An Image Introduction to Image Processing

1. Labels of the icons.



2. Labels of the 4 bars.



3. What happens to detail in the bottom left part of the image:

4. What happens to detail in the top part of the image:

5. What happens to detail in the bottom left part of the image:

6. What happens to the detail in the top part of the image:

7. How Log scaling alters the image - what is better, what not:

Date: _____

Name: _____

Answer Sheet: Activity II: About the Display
Introduction to Image Processing

8. The (x,y) coordinates of the bottom left corner of the window in *Moon*:
9. The (x,y) coordinates of the top right corner of the window in *Moon*:
10. The window dimensions:
11. The (x,y) coordinates, bottom left corner of the window:
12. The Window dimensions:
14. What Zoom does to the display window dimensions and to the (x,y) coordinates of any specific feature in the image:
15. The dimensions of the image window, only part of which is displayed at any one time, compared to the image window dimensions at Zoom 2.
16. Pixel and brightness values.

Original Image		Log Scaled Image	
(x,y)	Brightness	(x,y)	Brightness
Bright spot: _____,	_____	_____,	_____
Dark spot: _____,	_____	_____,	_____

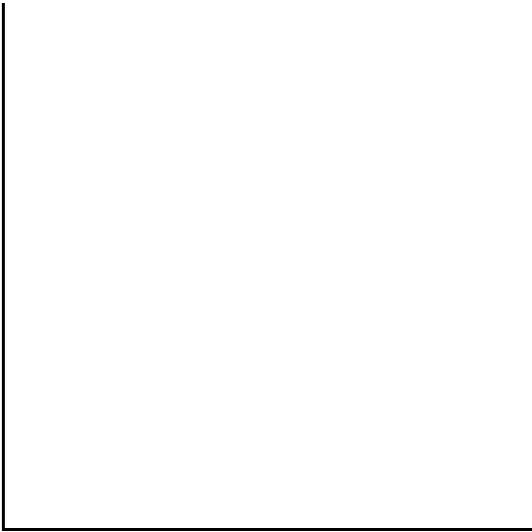
17. An estimate of the range of values for the lightest shade of pink in *Moon;I*:
_____ to _____ Counts
18. What happens to the range of each color when I use log scaling:

Date: _____

Name: _____

Answer Sheet: Activity III: Tools for Analyzing Images
Introduction to Image Processing

19. My slice on the image and the graph with labels of the bright and dim points on both.



20. Why the cusps (high points) in the graph are all different heights:

21. Distance, in pixels, from the central peak to the large crater rim:

Date: _____

Name: _____

**Answer Sheet: Activity IV: Explore a Solar Eclipse
Introduction to Image Processing**

22. Settings:

Color palette: _____

Min/Max: _____

Log (y/n) _____

23. Height of the solar prominence and the diameter of the sun in pixels

Prominence: _____

Sun: _____

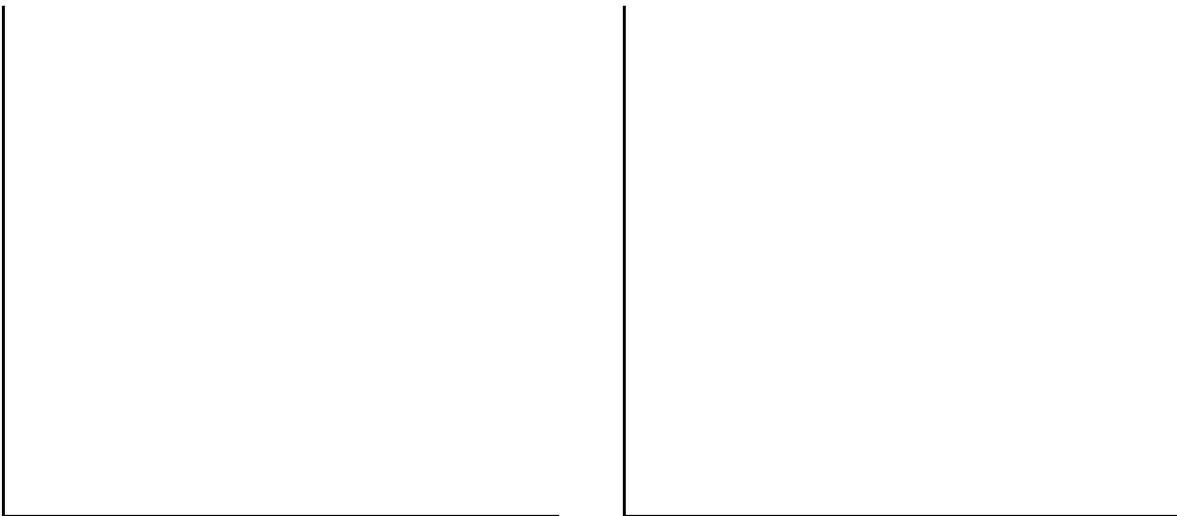
24. Height of the solar prominence in sun diameters:

(Sun's diameter = 1,390,000 km) _____

25. How many Earths could fit under the prominence:

(Earth's dia = 12,756 km) _____

26. Sketch of my two Slice graphs.



27 A. Different in my two slice graphs:

The same in my two slice graphs:

27 B. Difference between the edge of the prominence in the image and in the slice graph:

HANDS-ON UNIVERSE™
SUPPLEMENTARY ACTIVITY 1
CCD IMAGES - A Color Coding Activity

The images from the HOU telescopes are generated using a CCD camera. This kind of camera uses an electronic chip rather than the photosensitive chemical films used by regular cameras. The electronic chip is divided into many small areas that collect and record light. Each pixel on the screen is then given a number based on the amount of light from that particular area of the CCD chip. The more light at a pixel, the larger the number. The computer assigns a shade of gray or a color (when using a false color palette) at each pixel to produce the image you view on the screen.

Attached is a grid that simulates a CCD image with each pixel assigned a number between 0 and 9 to represent the amount of light at that pixel. Using only four different colored markers, develop a color coding scale for the ten different brightness values, 0 to 9. Indicate your color code in the Key at the bottom of the screen. Using your color scale, color each pixel with its proper color.

Tape your sheet on the wall with everyone else's and compare the result of using different color scales to represent the same data.

1. What is different and what is the same as you look at the collection of grids?
2. How does this activity relate to Min/Max settings in the image processing program?
3. Did anyone simulate a log scale in his or her color coding scale? If so, what difference did it make? If not, what difference do you believe it would have made?
4. Each coding scale can be thought of as a different color palette. Compare the grid images in terms of the pros and cons of using different palettes.

Activity V: Download an Image

The images used in the HOU curriculum units plus many more are stored in the Lawrence Berkeley Lab computer. They are available by going to the HOU Home Page on World Wide Web (WWW). You can get there by using a web browser for accessing the HOU website -- <http://hou.lbl.gov>. Click on the “Images” link and follow instructions there. As you might expect, websites are subject to revisions and improvements at any time, so we cannot give you step by step download instructions here. Find them on the HOU Images web page.

Give some thought to your own computer’s file folder hierarchy.

It is usually best to download the new image(s) into an HOU Images folder. This folder should be inside your HOU folder. If helpful, you can set up individual folders within your image folder.