**Lab Session 2: Cloud Masking and Fire Detection**

1.   Start ENVI. Load the Terra MODIS scene of the Eastern Australian coast collected on 31 Dec 2001 at 0000 UTC by selecting 'File, Open Image File' in the main ENVI menu. The image is stored on disk in

D:\WASTAC\Fires_NSW\MOD021KM.A2001365.0000.img

Move the image selector so that the Image Window includes the clouds near the center of the scene, as shown in the figure below. Start the Cursor Location / Value tool to track the image values.
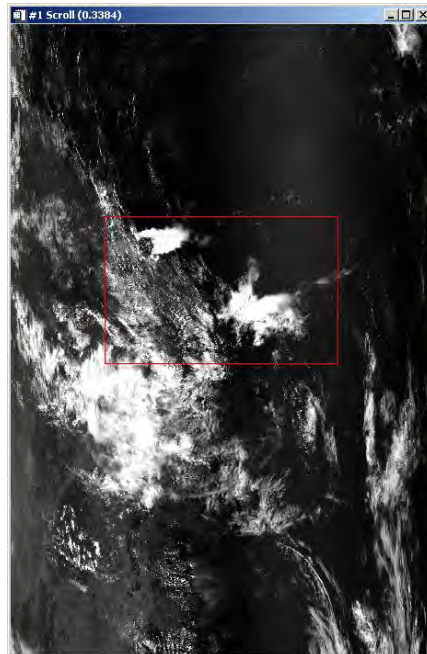
(a) Investigate the reflectance and brightness temperature characteristics of the image in bands 1 (0.65 μm), 2 (0.86 μm), 6 (1.64 μm), 20 (3.7 μm), 31 (11.0 μm), and 35 (13.9 μm), and comment on the appearance of water, land, and cloud features in each band (e.g., dark, bright).
(b) Which three bands would you select to determine a cloud / no cloud mask. Explain why you selected each band.
(c) What reflectance or brightness temperature thresholds would you use for each band?
(d) Consider the band 31 image. What is the range of brightness temperatures over the land surface? What are the brightness temperatures of the different cloud types in the scene?
(e) Could you assume something about cloud phase solely from the band 31 image?

2.   Now several band combinations will be used to assist in detecting clouds. In the main ENVI menu, select 'Basic Tools, Band Math'. In the dialog box titled 'Enter an expression:', enter the following expression (the ratio of band 2 to band 1):

B2 / B1

and hit 'OK'. In the 'Variables to Bands Pairings' dialog, click on 'B1' in the top box, and then click on '1' in the bottom box. Then click on 'B2' in the top box, followed by '2' in the bottom box. Select 'Output Result to Memory', and hit 'OK'. When ENVI finishes computing the expression, the new pseudo-band will appear at the top of the Available Bands List. Select the 'B2 / B1' pseudo-band, and hit 'Load Band' to display an image.

(a) Investigate the following pseudo-band combinations, and indicate the advantages and disadvantages of each pseudo-band for cloud detection (over land vs. water for example):

   (band 2) / (band 1)
   (band 1 – band 6) / (band 1 + band 6)
   (band 2 – band 1) / (band 2 + band 1)

3.   Now the 2D Scatter Plot tool will be used to determine thresholds for each pseudo-band. First, load band 1 in the image window. Then select 'Tools, 2-D Scatter Plots' in the Image Window. In the dialog box that appears, select band 1 on the left for the X axis, and a pseudo-band (e.g. B2 / B1) on the right for the Y axis, then hit 'OK'. A scatter plot of all points within the Image window will appear. Note that you can load any band in the Image window; it is independent of the bands displayed in the scatter plot. In the Scatter Plot window, select 'Options, Density: On' to enable pixel density display (more pixels = red, less pixels = purple).

Enlarge the Scatter Plot window to a comfortable size. Within the Scatter Plot window, middle-click anywhere on the plot to draw a small colored box (Use Ctrl Left-Click instead if your mouse only has two buttons). Pixels that fall within the colored box on the scatter plot will be highlighted in the Image Window. You can also left click and drag in the Image Window to highlight the corresponding pixels in the Scatter Plot. Finally, you can left click and drag within the Scatter Plot window to define a group of pixels (right to click to complete the selection), and the group of pixels enclosed by your selection will be highlighted in the Image Window. Within the Scatter Plot window, select 'Options, Clear Class' to clear the previously defined group of pixels.

(a) Estimate what threshold values you would use for each pseudo-band listed in 2(a) to indicate the presence of clouds.
(b) Can the same thresholds be used over both land and water?

4.   Now investigate the following pseudo-bands in the Image Window:

   band 29 – band 31
   band 31 – band 32

(a) Describe the regions where the largest values occur in each pseudo-band image.

(b) Are there clouds visible in these pseudo-band images that cannot be seen in the visible images (e.g. band 1)? Try loading a band 1 image in a linked display (as described in question 9 from Lab Session 1) to flick between a band 1 image and the pseudo-band image. Describe the circumstances where clouds are visible in the pseudo-band but not band 1.

5.   Now select the region shown in the figure below for display in the Image Window:
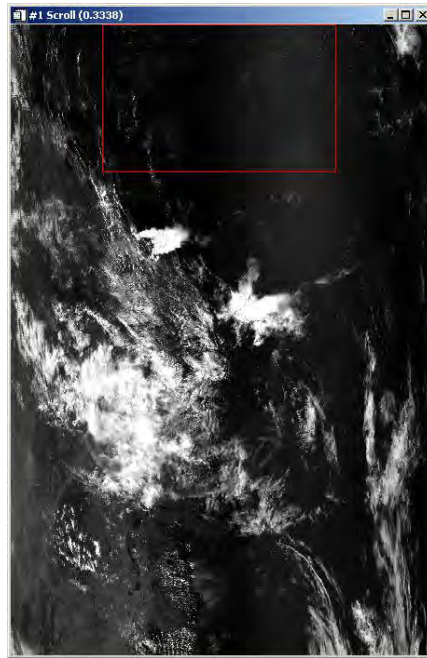

Load band 1 in the Image Window, and enhance the image.

(a) Describe the cloud features seen in this region.
(b) Can you observe any other bright features on the ocean surface in this region? Can you speculate on the cause of the bright features, other than clouds?

6.   Now load band 31 in a new image window as explained in question 9 from Lab Session 1. Reverse the color scale in the band 31 Image Window by selecting 'Tools, Color Mapping, Control RGB Image Planes'. In the 'RGB Channels' dialog, select 'Options, Invert All Channels', then 'Options, Apply', and then close the dialog. The clouds should now be white and the ocean surface dark. Flick between band 1 and band 31 by left clicking in the Image Window.

(a) Can you see cloud features in band 31 that are not obvious in band 1?
(b) Instead of band 1, try loading band 26 (1.38 μm) instead. Band 26 is a water vapor absorption band that highlights thin high clouds, and obscures features close to the surface. Does band 26 support your observations about the presence of cloud in this region?
(c) What threshold would you use for band 26 to detect thin high clouds?

7.   Now select the region shown in the figure below for display in the Image Window:
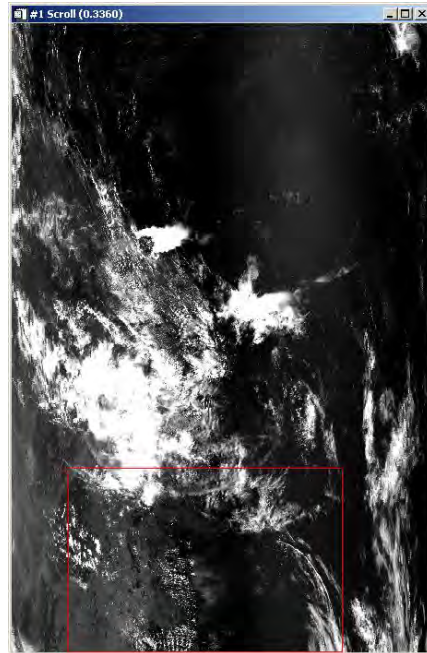
In this part of the scene, fires are burning in eastern NSW. See if you can locate the fires by looking for saturated pixels in band 22 (3.9 μm). Band 22 is used in conjunction with bands 21 and 31 for fire detection. Note that band 21 has the same spectral response as band 22 but with a lower gain setting, and therefore a higher saturation temperature.

(a) Select a Region of Interest (ROI) over the largest fire and compute statistics within the ROI as described in question 5 of Lab Session 1. What are the maximum brightness temperatures found in bands 21, 22, and 31?
(b) Assuming that the image has already been masked for clouds using the following algorithm
        if (B1 + B2 > 0.9) or (B31 < 265) or (B1 + B2 > 0.7 and B32 < 285) then cloudy
what thresholds would you choose to detect fires in
- band 31
- band 22 or 21
- band 21 – band 31

Keep in mind that terrestrial targets such as hot deserts or bright clouds should not be mis-identified as cloud.
(c) Can you see any pixels that appear to be flaming but do not pass all the threshold tests you defined? Speculate on why a given pixel might contain a fire, and yet not pass a simple fire detection test.

8.   Close all open files in ENVI by selecting 'File, Close All Files' from the ENVI main menu. Load the Terra MODIS scene of the Victoria and Tasmania collected on 4 May 2002 at 0025 UTC by selecting 'File, Open Image File' in the main ENVI menu. The image is stored on disk in

D:\WASTAC\FiresSmoke_VIC\MOD021KM.A2002124.0025.img

Move the image selector so that the bottom portion of the scene is displayed in the Image Window. You should be able to see a fire and associated smoke plume in northwest Tasmania. To see the smoke plume, click on 'RGB Color' in the Available Bands List window, then click on bands 1, 4, 3 in the band list to define red, green, and blue channels, and finally click on 'Load RGB'. Move the zoom selector over the fire and smoke plume and enhance the image by selecting 'Enhance, [Zoom] Linear'. Now load band 22 in a separate linked display, and observe the range of brightness temperatures in the fire.

(a) Find the maximum brightness temperatures in bands 21, 22, and 31 around the fire as you did in question 7 (a).
(b) Does this fire meet the brightness temperature thresholds you determined in question 7 (b)? If not, how might you detect this fire, assuming that clouds and water pixels had already been masked out (hint: think about how a fire pixel stands out from it's neighbors).