Remote Sensing in Geosciences
GEOG 361
Department of Geography
Texas A&M University

LABORATORY 5
Thermal Infrared Image Interpretation

Points Possible: 10
Course Instructor: Dr. Anthony M. Filippi

Objective

- Analyze various thermal infrared images and understand basic thermal properties and characteristics.

Materials Required

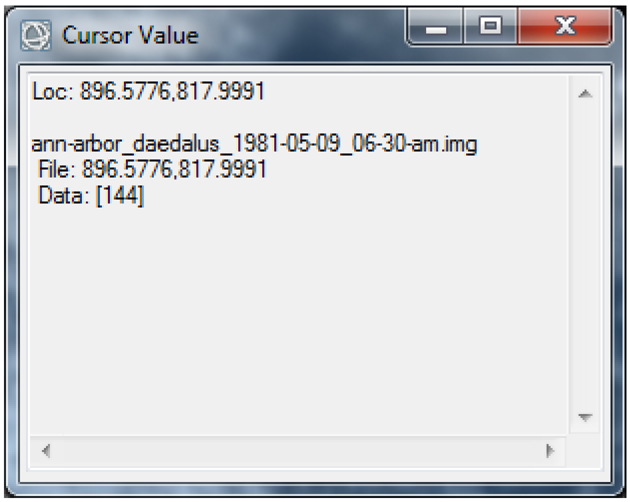
- A computer workstation with ENVI 5.x installed;
- Image data sets supplied;
- Thermal IR RS lecture notes and/or your textbook, as a reference: Jensen, J. R., 2007, *Remote Sensing of the Environment: An Earth Resource Perspective*, 2nd Ed., Upper Saddle River, NJ: Prentice Hall, 592 pp., ISBN 0-13-188950-8.

1. Introduction

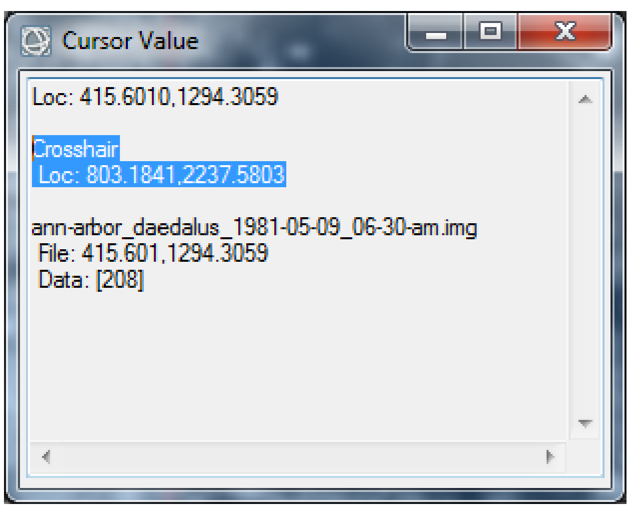
This exercise will involve the display and analysis of three different single-band thermal images. We will be using ENVI for image display. You will be opening and viewing the files specified below via an image view: **File | Open…**, and then navigate to the proper file directory. All data files for this laboratory exercise are located in the **Lab_05** directory on the **\\vh2stor.geos.tamu.edu\geogclass\geog361filippi** under Labclass network volume/server, or on **ecampus -> GEOG 361 Course Materials -> Lab_05**. Once you have copied the Lab 5 data files to your Geosciences computer account, select the desired filename with the left mouse button (lmb), and then click **Open**. You will want to open each of these thermal images as gray scale, which is the default for a single band in the modern (Silver Sphere) version of ENVI. To do so in Classic ENVI, make sure that the radio button for “Grey Scale” is selected and then click “Load Band”. These images will not be in color because they consist of a single band. After you have analyzed each dataset, answer the questions that follow for each image.

To enhance your interpretation of the images, there are various (**optional, and done in modern ENVI**) steps that you can take:

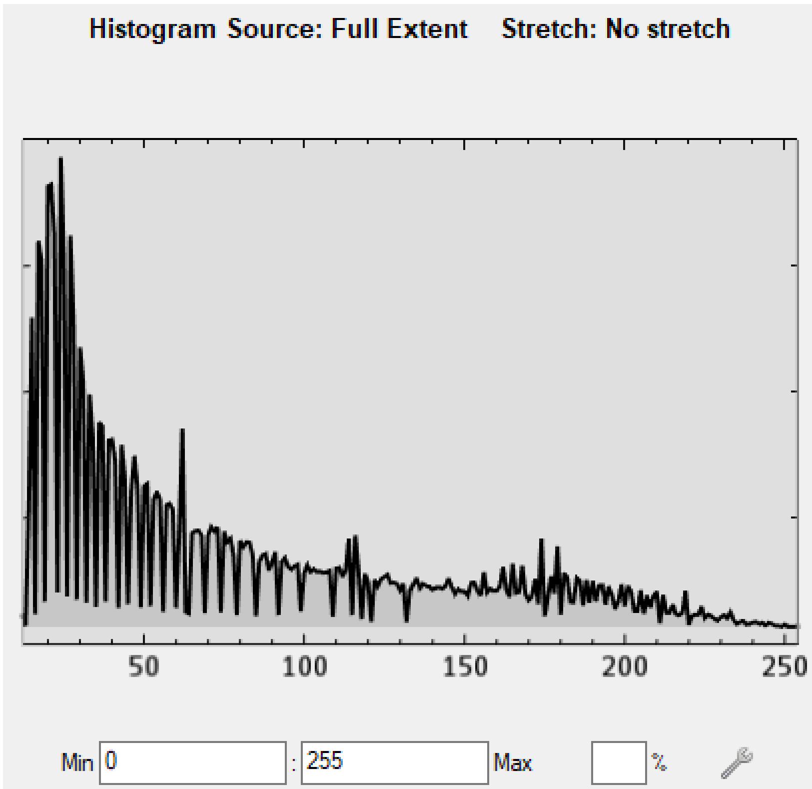
1) You may want to quantitatively compare image data values to more precisely compare one image location to another. To do so, you will want to use tools on the main Tool Bar. The **Cursor Value** tool (fourth button from the left, which looks like a red balloon with a black dot in it) and the **Crosshairs** will be very useful. The Cursor Value will change as you move the cursor around over the display.



The values for the Crosshairs are locked and will not change unless you move the focus point of the Crosshairs.

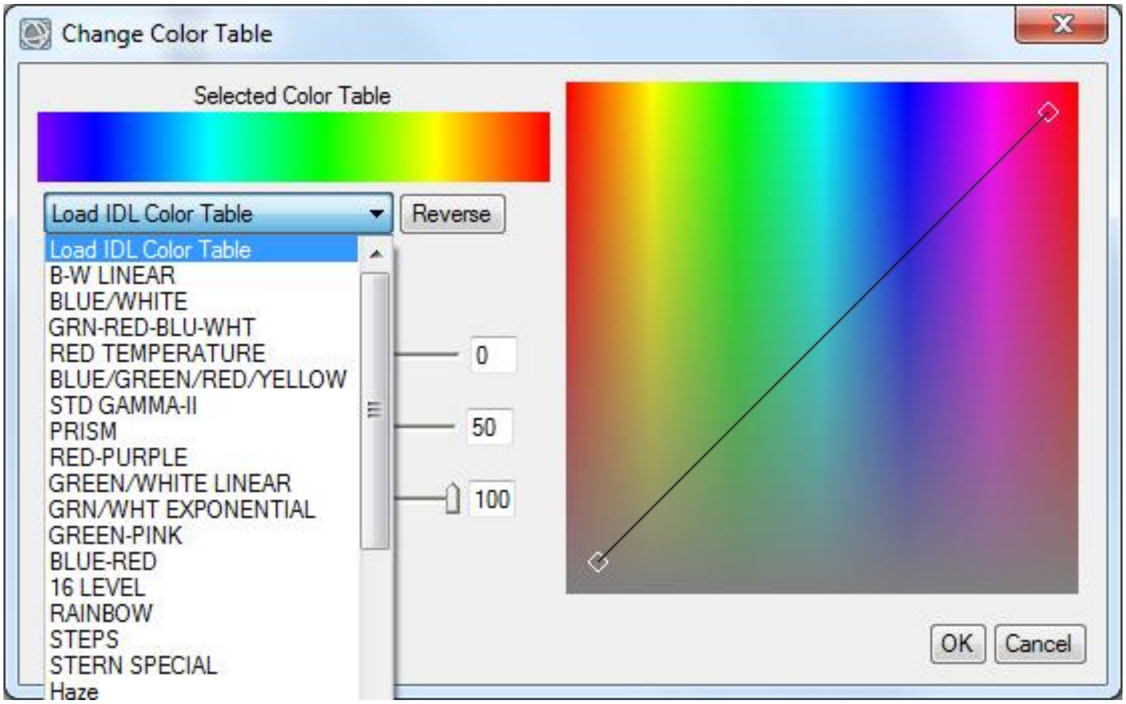


2) You may want to perform ***interactive (custom) stretching*** of your image to alter how the data values are displayed on the screen. To bring up the **Custom Stretch** dialog, look to the tool ribbon across the top and look in the middle. There is a drop-down with preset stretches (such as linear, equalization, and clipping by percentage (increases image contrast)), to the immediate right, a reset button (two arrows forming a circle) and the "Histogram Stretch" button. When clicked, the following dialog box appears:



You can manually enter a min and/or a max cut-off based on the sensor's radiometric resolution or enter a percentage. The stretching of the image being displayed will interactively change as you manipulate the stretch settings. You can always reset the stretch to how it was when you opened the dialog by clicking the **Reset** button to the left if the "Histogram Button". You may want to alter the min or max locations so as to make the image darker so you can see heat differences more clearly. You can also experiment with applying different standard default stretch algorithms (e.g., Gaussian) under the dropdown menu on the tool ribbon. The ENVI default is to apply *no stretch*, but for the purposes of this lab exercise, the *Linear* of *Optimized Linear* will suffice. To eliminate any image stretch changes you may have made, select *No stretch* in the stretch dropdown.

3) You may want to map the image data values to various color mapping ramps, which may potentially enhance your interpretation of the images. (Note: the questions below, however, refer to the original/default gray scale image visualizations.) When color mapping, you are not altering/modifying the image data values, but rather, you are simply changing how the data are displayed. To assign the pixel values to various other color ramps, right-click on the image file in the **Layer Manager** and navigate to the (**Change Color Table | More)** (about half way down the menu), as shown below (the “Custom” tab” has been selected in the following image):



You may experiment with the various standard IDL color tables (e.g., Red Temperature, Std Gamma-II, Rainbow + white, etc.) to see which ones, if any, enhance your interpretation of the image via visualization of the differences in the brightness values (BVs). Again, to answer the questions below, you may want to revert back to the default gray scale image visualizations. To do so, you can either select “B-W LINEAR” in the list of color tables, or you can simply close the display windows and re-open the image.

2. Image Analysis

Ann Arbor, MI Thermal Imagery

Image : *ann-arbor_daedalus_1981-05-09_06-30-am.img*
Sensor : Daedalus DS-1230 Quantitative Thermal Infrared Scanning System
IFOV : 1.0 milliradian
Detector : Mercury Cadium Telluride (Hg-Cd-Te) operating in the 8 - 14 micrometer region
Acquired : May 9, 1981
Altitude : 3600 meters above ground level (AGL)
Time over Target : 6:30 am
Air Temp at Ground Level : 19 °C

Questions

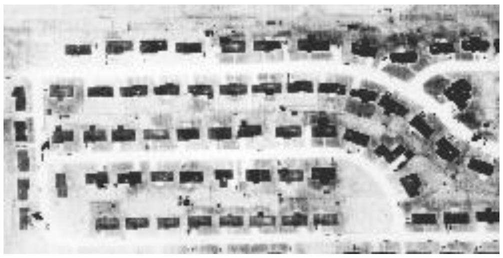
1. What is the diameter of the circular ground area (spatial resolution), *D*, viewed at nadir in this image? Please show your calculations.

2. What would be the smallest dimension (in meters) of features you will be able to resolve on the ground?

3. Notice that the roads and river image in lighter tone than the vegetated areas. Explain why this phenomenon occurs.

4. What are the extremely dark, "block" areas in downtown Ann Arbor?

5. Do you see evidence of a thermal gradient as you progress from the Central Business District (CBD) out into the countryside? Explain why this phenomenon exists and is amenable to being sensed in the 8 - 14 micrometer region.



Residential Area Fort Worth, TX Thermal Imagery

Image : *fort-worth_daedalus_1980-01-10_06-45-am.img*
Sensor : Daedalus DS-1230 Quantitative Thermal Infrared Scanning System
IFOV : 1.0 milliradian
Detector : Mercury Cadium Telluride (Hg-Cd-Te) operating in the region 8 - 14 micrometers
Acquired : January 10, 1980
Altitude : 250 meters above ground level (AGL)
Time over Target : 6:45 am
Air Temp at Ground Level : 12 °C

Questions

6. What is the diameter of the circular ground area, *D*, viewed at nadir in this image? Please show your calculations.

7. Provide a brief description of why the following features appear as they do in this thermal infrared image:

Roads
Natural and man-made vegetation
Sidewalks and patios
Storage sheds in back yards
Automobiles
Bright spots on many of the roof tops

8. Explain why the front parts of the cars have a hot spot on them at arrows number 1 and 2 (pan around in the Scroll window to located the numbered arrows).

9. Explain the reason some yards are darker that others, and why many backyards are brighter than front yards.

10. Note the heat loss in the roof at the house located at arrow number 3. Describe the variables you would demand to know if you owned the house and a salesperson was trying to convince you that you needed insulation based on an analysis of this image.

USC Thermal Imagery

Image : *columbia_1983-03-10.img*
IFOV : 2.5 milliradians
Acquired : March 10,1983
Altitude : 500 meters above ground level (AGL)

Thermal imagery has many uses, one of which involves energy loss detection. A major means of heat energy transfer is through steam-pipes, such as the heat pipeline network that the University of South Carolina (USC) has in place. Thermal imagery will allow us to inventory the pipeline network, as well as to monitor it for excessive heat loss and/or leaks.

Open the image and orient yourselves to campus landmarks, such as the Horseshoe in the upper left portion of the image (an old, historic, tree-covered portion of campus), or the Thomas Cooper library in the lower left portion. Refer to your Jensen (2007) textbook, p. 267, for further help locating various features of the USC campus. Although the steam pipes may be buried under concrete, soil, vegetation, and asphalt, they are visible as thin, white lines on the thermal image. If your image appears "burned out" or too bright (i.e., saturated), you may want to perform interactive stretching as described above.

Questions

11. What is the diameter of the circular ground area, *D*, viewed at nadir in this image? Please show your calculations.

12. What are the bright features found along the steam-pipes as well as at their intersection?

13. Thermal imagery will often show relief distortion perpendicular to the flight path. Was this thermal image flown east/west or north/south? What type of distortions are evident in the image? List examples that are apparent in the image.

14. After a close examination of the imagery, do you think the data was acquired in the day or night? Explain your reasoning.

15. The large building in the upper right corner of the image shows high heat loss along its sides. What might be the cause of this?

16. Most of the building roofs have brighter sections or points on them. The building immediately left of the physical plant has a large bright area on its roof. What could this be from?

17. Notice the numerous small white dots located throughout the image that are not part of the steam-line network. What might these be?

18. Explain the differences between the thermal signatures of trees and grass in the scene. If water typically is brighter than the surrounding terrain in a pre-dawn thermal image, why is the pool in front of the Cooper Library dark?

DELIVERABLES:

Provide answers for the questions posed for each thermal IR image. Your write-up should be typed and coherent.

Acknowledgment: This lab was modified from a laboratory exercise written by J. R. Jensen.