Remote Sensing: a Closer Look at Bangalore, India

A Training Module for IDRISI Explorer

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For:

Introduction to Remote Sensing course

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Introduction

The goal of this project was to create a guide to help new IDRISI Explorer users learn the basics of remote sensing. Please note that this training module should not be used as a substitute for a traditional remote sensing text. While this module does discuss some of the science and theory behind remote sensing, it does not provide the detailed explanations and graphics needed to understand this amazing technology.

This module does not require any additional materials beyond a registered version of IDRISI Explorer, a stable Internet connection, and a working computer with a recent version of Windows operating service. Chapter 1 of this module will overview how to download free satellite images from the U.S. Geological Survey. You will **not need to purchase any images** to work the exercises in this training module.

Completing the chapters in this module will teach and expose you to the following remote sensing skills:

Chapter 1 – The Basics of IDRISI

- File management, downloading and importing images, creating raster groups

Chapter 2 – Image Manipulation in IDRISI

- False color composites, windowing, image stretching, histograms

Chapter 3 – Enhancing Images Spatially

- Multiplicative image resolution, macro modeler

Chapter 4 – An Introduction to Spectral Enhancement

- NDVI, Vegindex, PCA (Principle Component Analysis), Decorrelation Analysis

Chapter 5 – Radiometric Calibration

- Image normalization, vector/raster masks, regression accuracy analysis

This training module was developed by Macalester College geography students Paul Bendernagel, Matt Cresey, Jordan Lim, Evan Moorman, and Caitlin Toner for an Introduction to Remote Sensing course in Fall 2013. Special thanks to Visiting Professor Harini Nagendra for teaching the course and guiding us through this project. If you have any questions or have suggestions on how to improve this IDRISI tutorial, feel free to send them to Macalester College's geography department coordinator, Laura Kigin (kigin@macalester.edu), who will pass the information on the appropriate members of the department.

Chapter 1: The Basics of IDRISI Explorer

Goals:

- Learn to navigate within the IDRISI workspace
- Create folders and establish and organized workflow
- Import files into IDRISI
- Displaying and grouping images together

Required Materials and Data:

- Access to IDRISI
- Access to the Bangalore_Chapters1-5 folder
- An up to date web browser with flash and java

We will be working with the Bangalore images for chapters 1-5 of this remote sensing tutorial. This will make it easier for you to start labs and return to them if you don't finish in one go. After this chapter of the lab manual, you won't have to move any files and create any folders outside of IDRISI until chapter 5.

Make sure not to delete the ***Bangalore_Chapters1-5 folder and always keep it backed up to the server*** since this is the sole folder you will be working with over the next couple of labs. You will learn more about creating, accessing, and filling this folder later on in chapter 1.

1.1 Opening IDRISI and Navigating the Workspace

- Open IDRISI by double clicking on the desktop shortcut or by searching for the application in the start menu/search bar.
- After the program loads, you'll be at the main IDRISI workspace (Figure 1.1)

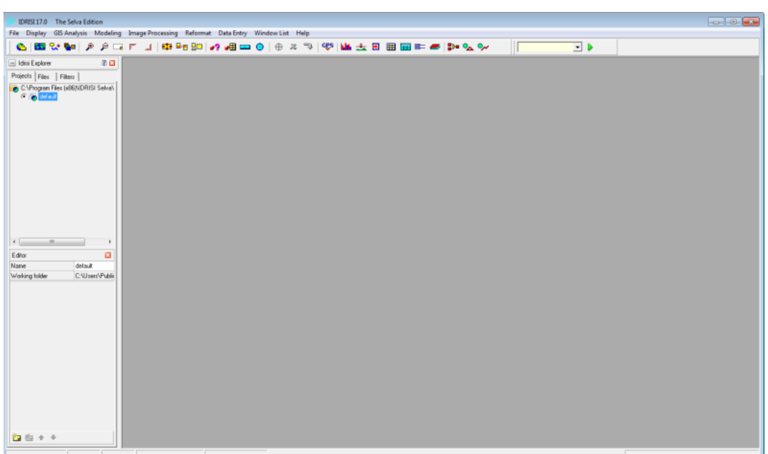


Figure 1.1.1, the IDRISI workspace.

- Now let's go over some vocabulary that will be important for operating in the IDRISI workspace. Make note of the following components of IDRISI:
    - See below in figure 1.1.2
        - Menu system
        - Tool bar
        - Shortcut utility
        - Status Bar
    - See below in figure 1.1.3
        - Progress Bar
        - IDRISI Explorer
        - Composer Dialog Box
        - Display System

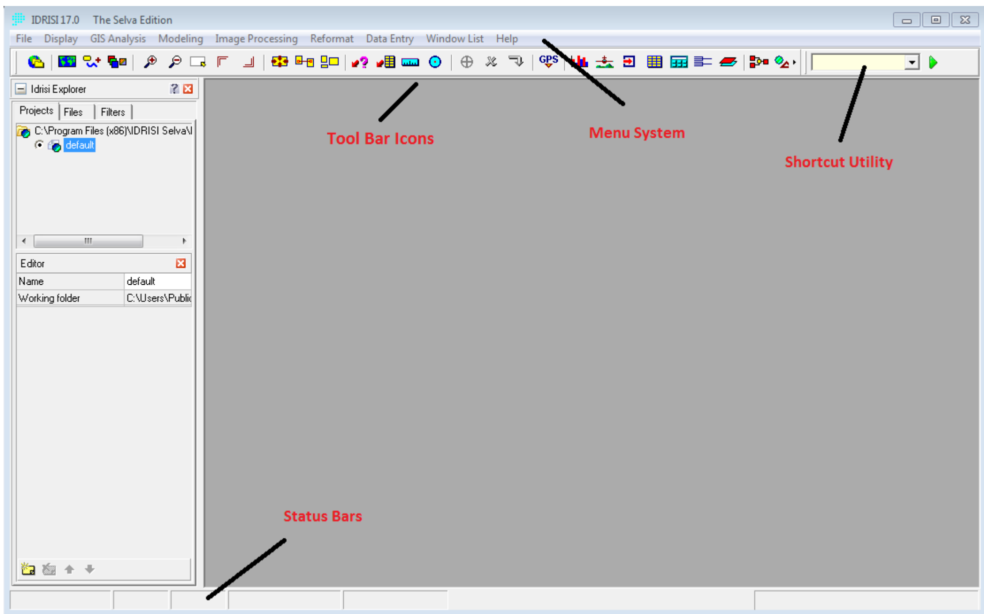


Figure 1.1.2, important features in the IDRISI workspace

The IDRISI ***menu bar*** is similar to many other menu systems for other applications and operating systems. A single click will bring up a list of subsets. Moving your cursor over these subsets might pull up another set of tools/options. Regardless of how deep into the menu subsystem the option you are looking for is, the activation is the same—a single click.

The ***tool bar*** is home to a variety of crucial functions. We will practice using the tool bar in this lab and all subsequent ones.

The ***shortcut utility*** is every IDRISI users' best friend. Once you become more familiar with common operations and tools, you can type them into the shortcut utility and it will pull up the operating window. This is a lot faster than searching for the tools in the menu bar's sub layers.

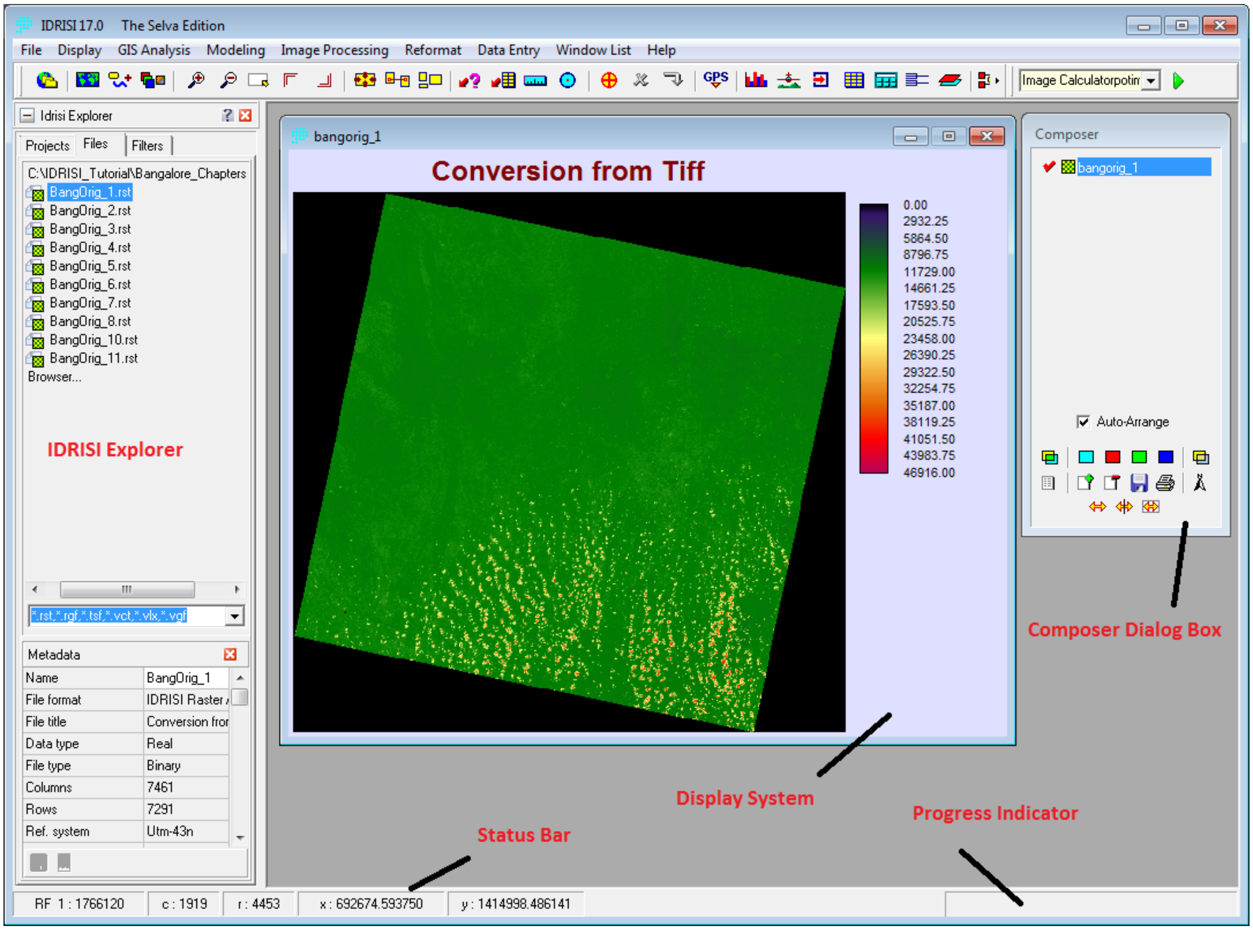


Figure 1.1.3, More important features in the IDRISI workspace

The ***display system*** presents images in IDRISI. It is also referred to as the display or the display window. These display windows are resizable and you can shrink and expand like you would any other window or webpage in a Windows operating system by dragging in edge or corner. Displays also include a default legend in IDRISI.

The ***composer dialog box*** indicates which images are currently open or are being displayed in the IDRISI workspace. This window also has many other helpful image manipulations, which we will cover in future chapters. Not the buttons at the bottom window, these will all be covered in chapters 1-5 of this IDRISI tutorial.

IDRISI Explorer is the data hub of the IDRISI workspace. It plays a similar role to the table of contents and ArcCatalogue for those of you who are familiar with ArcMap. You will use this folder to manage and organize remote sensing data. We will learn more about the IDRISI Explorer window in the following section of chapter 1.

1.2 IDRISI Online Help

The program comes with a great online help resource that can be accessed in program very easily. This help section is extensive and includes a variety of detailed explanations and illustrations to help users navigate the various aspects of the program and understand remote sensing processes in general (Figure 1.2.1)

To access the help section, click to the following route: **Help—Contents**

The on-line help resource can also be reached by clicking on the "Help" button at the bottom of many of the programs function windows (Figure 1.2.2)

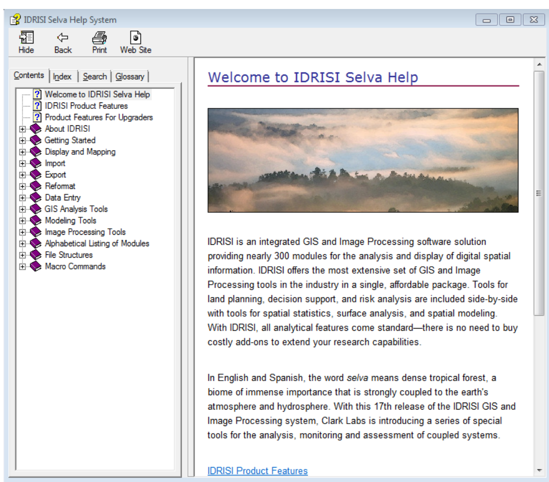


Figure 1.2.1, the IDRISI help page

Figure 1.2.2, the IDRISI help page is available from many different windows

1.3 Managing Files and Folders in IDRISI Explorer

In order to work in IDRISI, it is crucial that we become familiar with IDRISI Explorer. Located on the left side of the workspace, click on the plus tab to expand the Explorer. The Explorer is made up of two panes: a project pane and an editor pane. If you think of the workflow as a pyramid, a project is the tip top of the pyramid and there are often numerous files and file groups within a project. It's time to start using the program! ***Create a project of your own*** and call it ***"Bangalore_Chapters1-5"***

Create a new project file and specify the working and resource folders with the IDRISI EXPLORER
Menu Location: **File - IDRISI EXPLORER**
1. Start the IDRISI EXPLORER from the main menu or toolbar. 2. In the IDRISI EXPLORER window, select the *Projects* tab. 3. Right click within the *Projects pane,* and select the *New Project Ins* option. 4. A Browse For Folder will open. Use this window to navigate to *C:IDRISI_Tutorial\Bangalore_Chapters1-5* and click *OK* in the *Browse for Folder* window. 5. A new project file *BangaloreChapters1-5* will now be listed in the *Project pane of* IDRISI EXPLORER.

Once you are done with the steps in the box above, you should have a project named *Bangalore_Chapters1-5* and working folder with the same file path as step 4. **Projects should have accompanying working and resource folders.** This will help the program load the files associated with the project you are working on.

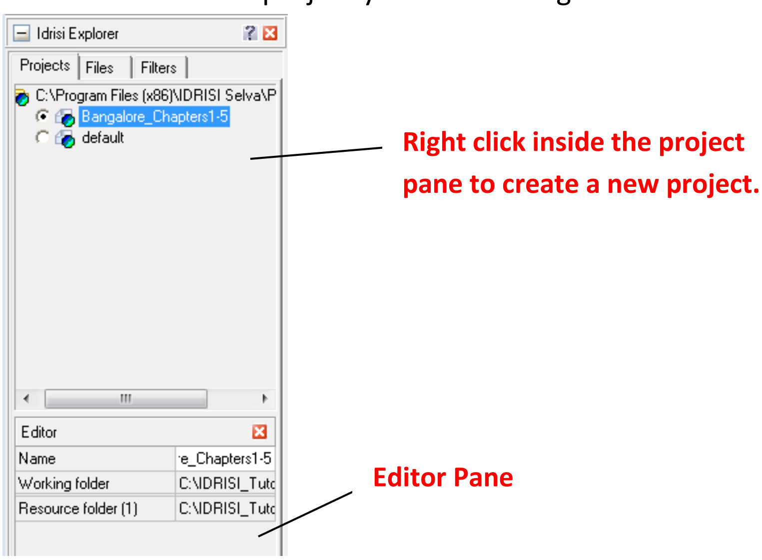


Figure 1.3.1, IDRISI explorer with Bangalore_Chapters1-5 project and corresponding working and resource folders.

Create a new project file and specify the working and resource folders with the IDRISI EXPLORER
6. Right click in the editor pane and select "add folder". 7. A new line will appear in the editor pane called "resource folder (1)". 8. Click on the "…" in the right hand side of the new resource folder. 9. Navigate to the *C:IDRISI_Tutorial\Bangalore_Chapters1-5* and click *OK.*

Now we have all the necessary components to start importing and manipulating images in IDRISI. In the next section we will learn how to import images into the program. The target location should be the *Bangalore_Chapters1-5* folder that we've now linked IDRISI working and resource folders to.

1.4 Downloading images from Landsat

Now that we are familiar with the IDRISI workspace and have created the workflow and folders for chapters 1-5, it's time to acquire some images! Follow these steps to download the images we will be using.

Determining the coordinates of the Bangalore study area
1. Go to http://glovis.usgs.gov/, this is where we will download the images from. 2. The default location will be close to your true location, where you are when working on this lab. 3. Go to Google earth and **estimate the latitude and longitude of of Bangalore**. You can do this by clicking on "Tools" in Google Earth menu bar and then clicking on "options. 4. In the options window find the "show lat/long" section and click on the radio button for Decimal Degrees. From here you can place your cursor on top of any point on the globe and get a lat/long readout on the bottom of the program. Search for Bangalore in Google Earth and then record what you think the lat/long of the city is. 5. When you've found the lat/long of Bangalore, search for "WRS-2 path/row to latitude/longitude converter" in a search engine of choice. Click on the first link (it should be a USGS website). 6. On the WRS-2 path/row to latitude/longitude Converter page, click on the radio button to convert lat/long to path row. Now type in the latitude and longitude estimation you got form Google Earth. 7. A map will pop up when you enter your estimation. Does Bangalore look like it's in the cross hairs on the map? If not, go back to Google Earth and recheck your latitude and longitude. Also check and make sure that you've set the options to decimal degrees (as described in step 4). After double checking, re-enter your second estimation into the WRS-2 path/row to latitude/longitude Converter.

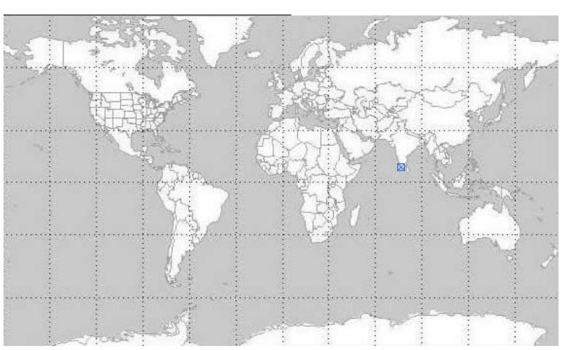


Figure 1.4.1, typing in an accurate lat/long should produce a locator map similar to this.

Downloading the Bangalore Images

1. 144/51 is the correct path and row you should have obtained through Google Earth and the Lat/Long to Path/Row Converter. If you didn’t obtain this value, revisit the “Determining the Coordinates of the Bangalore Study Area” section above and make sure that you are zoomed into Bangalore before placing your cursor and recording a latitude and longitude.
2. In your browser of choice, open up http://glovis.usgs.gov/. This is a mapping and image downloading service hosted by the USGS.
3. Type in 144/51 into the path and row boxes accordingly. Click the go button.
4. The red dot on the locator map should be focused on the Southern part of India, where Bangalore is. If the locator map isn’t focused on Bangalore, check to make sure you entered in the correct latitude and longitude.
5. For the highest quality and most recent images we will be using Landsat 8. Navigate to **Collection-Landsat Archive-Landsat 8 OLI** and click to set Glovis to Landsat 8 images.
6. Take some time to explore the Glovis online imaging service. Adjust the date (show in the image below with a red circle) and see what kinds of changes occur in the region.
7. To the right of the date in the information box, circled in the image below in red, is the percentage cloud cover. This is denoted as “CC: %”. Click through the months in 2013 and see how the cloud-cover changes. Which months have the highest cloud-cover, which ones have the lowest?
8. April 13th and November 7th, have cloud-cover percentages of 3. These are the most cloud free and we will use Landsat 8 Bangalore April 13th, 2013 images for this module.
9. After selecting the April 13th image, click the “Add” button underneath “Landsat 8 OLI scene List”. The image ID (LC81440512013103LGN01) should appear in the scene list with a shopping bag icon. Once you see this click on “send to cart”.
10. You’ll get a pop up window asking you for a user ID. In order to download the images, create an account by clicking the “register” button. Once this is done a “pending scenes” page should open up.
11. Click on the hard drive icon near the X on the far right of the “Item Basket – Pending Scenes” page. This will take you to an option window (figure 1.4.5) and select “Level 1 GEOTIFF Data Product”. This should start the download, but check your browsers “downloads” section.

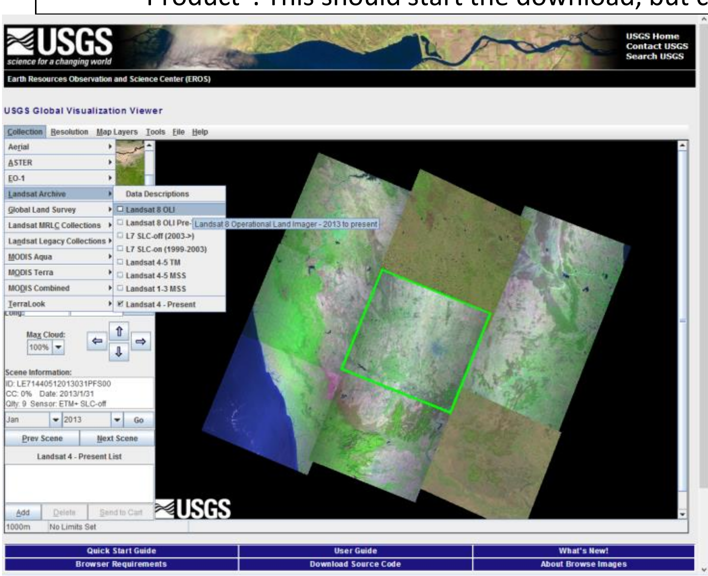


Figure 1.4.2, Make sure that you download the April, 2013 images for Landsat 8.

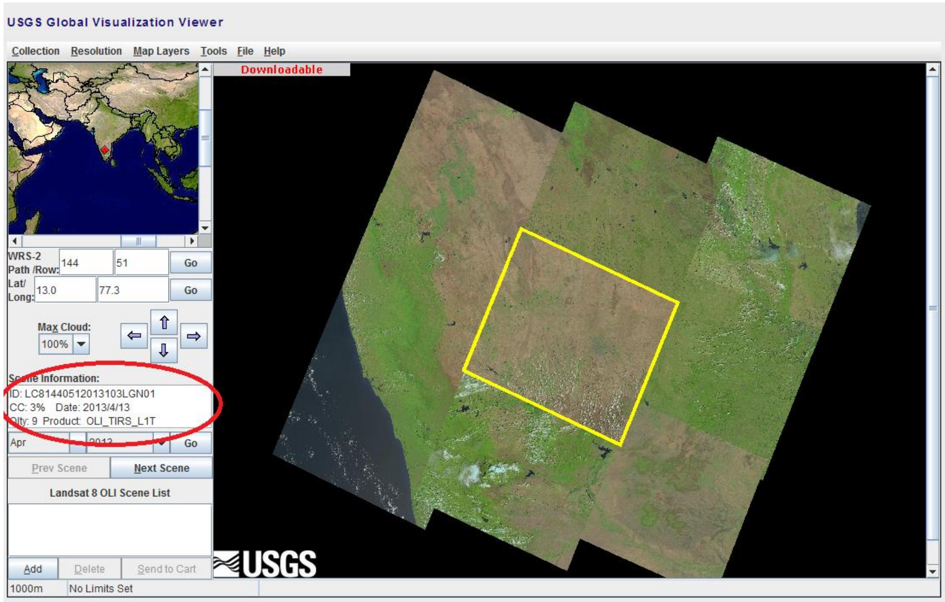


Figure 1.4.3, April 13th, 2013 has a very low cloud cover, 3%.

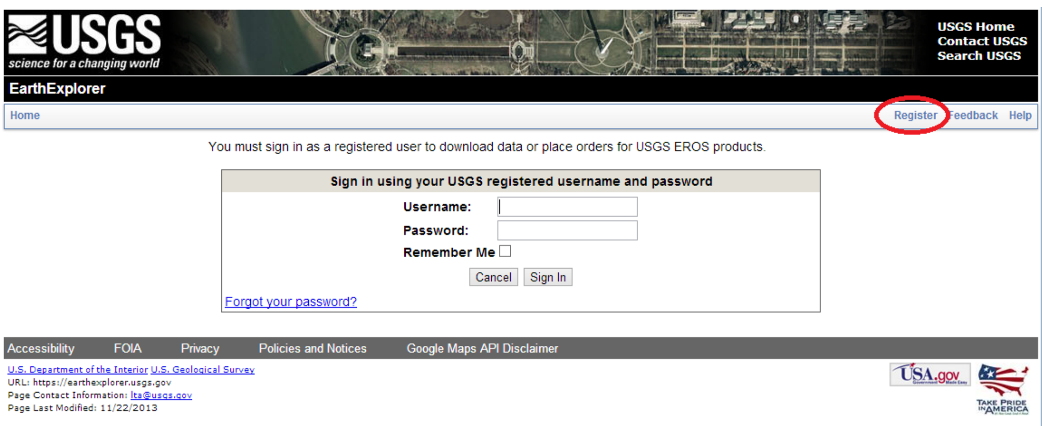


Figure 1.4.4, click on the register button in the upper right to create and account.

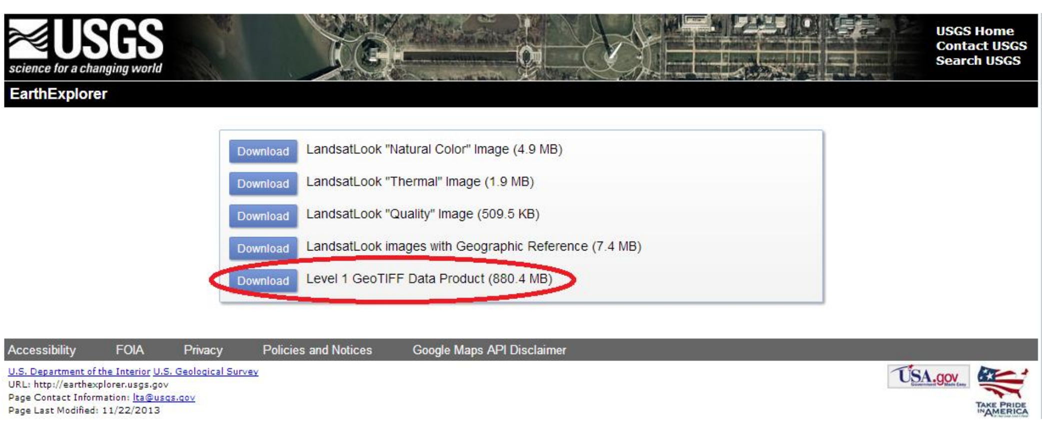


Figure 1.4.5, GEOTIFF is an image file type and we want the full “Data Product” for this module.

Decompressing the Downloaded Bangalore Images

1. While waiting for the download to finish, create a new folder on the C-drive called “IDRISI_Tutorial” and a folder inside of that labeled ***Bangalore_Chapter1-5***.
2. Once the download finishes (it should appear as “LC81440512013103LGN01.tar.gz” unless you gave it another name) copy the compressed file over to “Bangalore_Chapter1-5”.
3. After completing the copy, right click on “LC81440512013103LGN01.tar.gz” and navigate to either Winzip, 7-zip, or some other zip file utility of your choosing.
4. Regardless of what utility you choose, the goal is to “unzip” or decompress the file inside the ***Bangalore_Chapters1-5*** folder, the main place of storage for this training module.
5. “LC81440512013103LGN01.tar.gz” will have to be unzipped twice—first to unpack the .gz and then the .tar. Follow the same steps on the second unzip, make sure that files are being extracted from the zip and going into the ***Bangalore_Chapters1-5*** folder.
6. After completing two decompression passes, there should be 10 TIFF images in the ***Bangalore_Chapters1-5*** folder. Check to make sure that images have unpacked correctly before moving on.

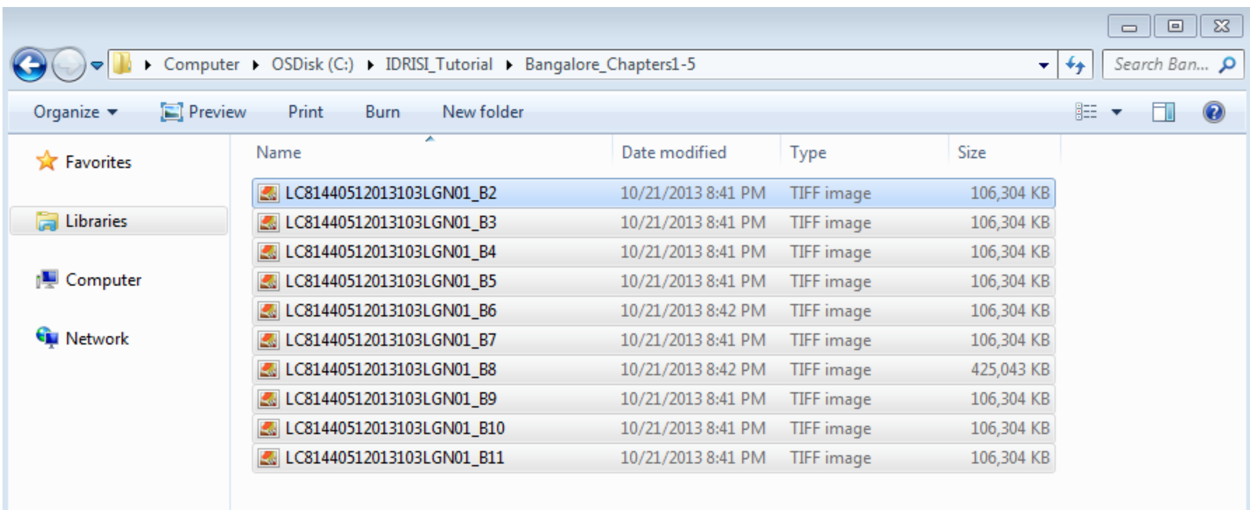


Figure 1.4.6, you should have 10 TIFFs in the Bangalore_Chapters1-5 folder.

1.5 Importing images into IDRISI

Now that we have a folder full of TIFFS, we can work on getting them into IDRISI. The program will not able to view them until we do this.

Import the Bangalore images into IDRISI

12. Navigate to the following**, File – import – desktop publishing formats – geotiff/tiff**
13. Click and open up the GEOTIFF/TIFF window
14. Select “GEOTIFF/TIFF to IDRISI” option.
15. Click on the “…” on the “GEOTIFF file name” line and navigate to the first band (see figure 1.5.2 for more details)
16. Change the name of the image by typing “BangaloreOrig_1” into the “IDRISI image to create” line, and then click OK

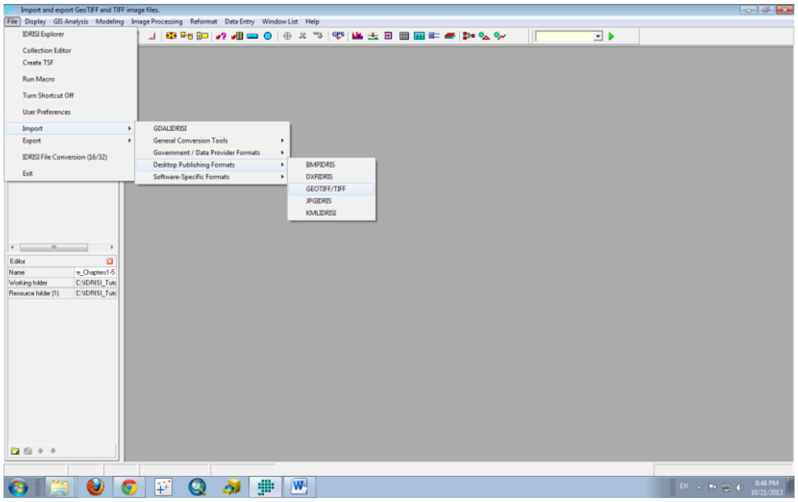


Figure 1.5.1, open up the GEOTIFF/TIFF window to convert and import

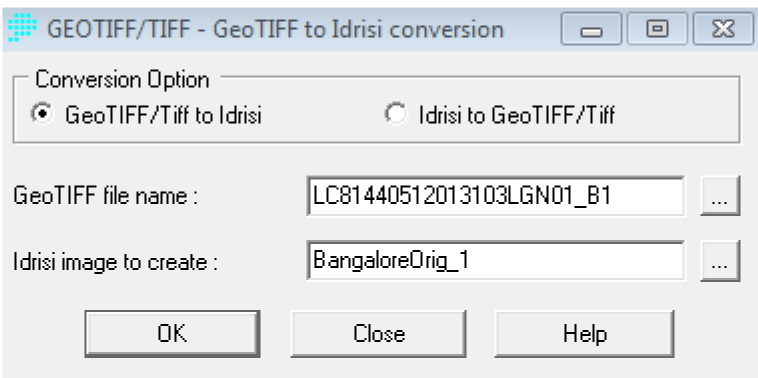


Figure 1.5.2, once you click OK with these settings, IDRISI will import this image and create two files in your Bangalore_Chapters1-5 folder: a .rst and a .rdc

Import the Bangalore images into IDRISI continued…
17. Import the rest of the bands into IDRISI. 18. Navigate to the *_B2* for the “GEOTIFF File name” input. 19. Change the “IDRISI image to create” line to *BangaloreOrig_2.* 20. Follow the same steps for bands 3-11. Keep the same output naming system. 21. Once you are done, you should have an .rst and a .rdc for bands 1-11—go to the *Bangalore_Chapters1-5* folder and see if this is the case. 22. Now go to IDRISI Explorer pane and click on the “*files*” tab. You should see all the .rst files underneath *C:\IDRISI_Tutorial\Bangalore_Chapters1-5* (See figure 1.5.3). Hit refresh (by right-clicking on the yellow folder) if you can’t see them.

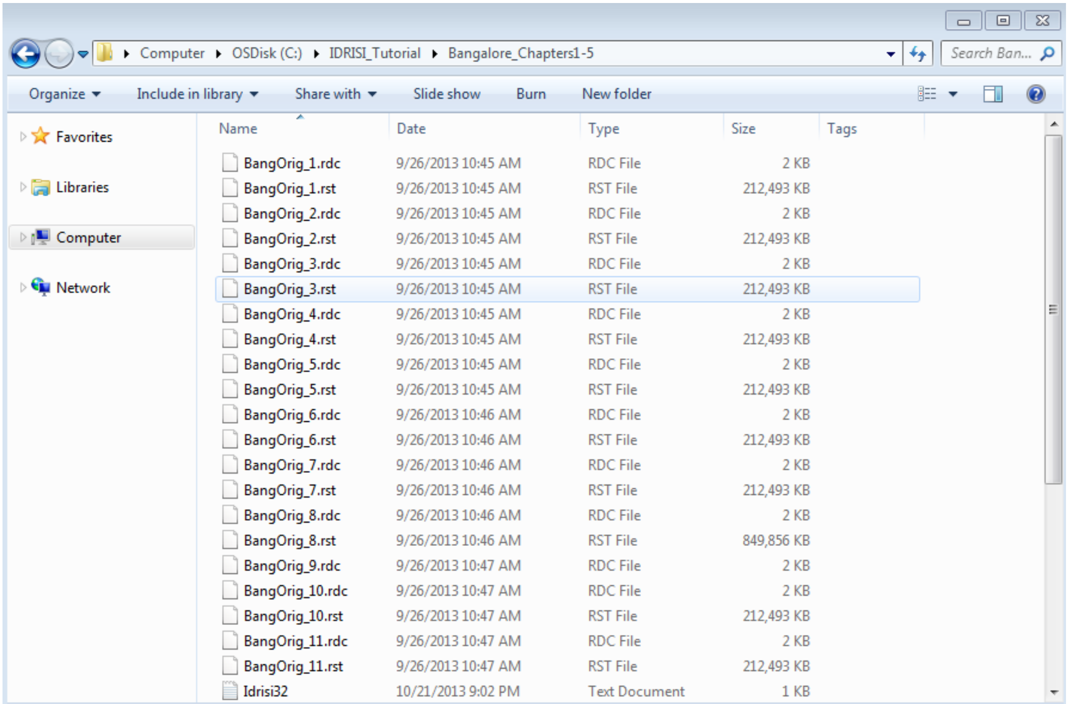


Figure 1.5.3, you should have .rst and .rdc files in your Bangalore_Chapters1-5 folder after importing.

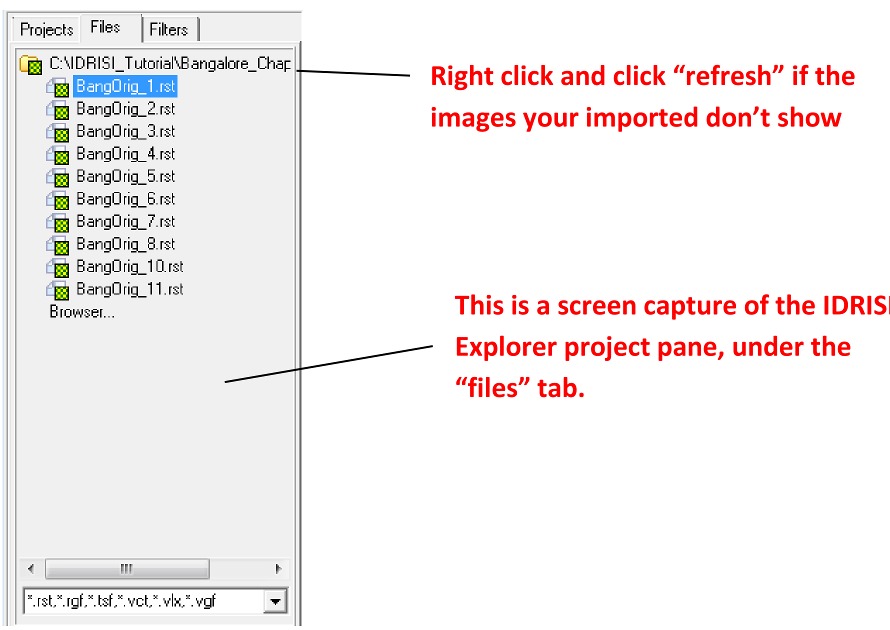


Figure 1.5.4, you should be able to access the bands you imported by going to the files tab in the IDRISI Explorer.

1.6 Displaying Images

You can open up images in IDRISI in a number of ways. The first method is the easiest and most intuitive—just click on an image in the Explorer and it will open up! This window can be resized by dragging on an edge or corner. You can open up multiple images at once, minimize them, and basically treat them like any other window you can open in a Microsoft operating system.

Images can also be displayed by using the ***Display*** tool. You can access this tool by clicking on the icon in the toolbar (see figure 1.6.1) or by following the directions in the box on the following page.

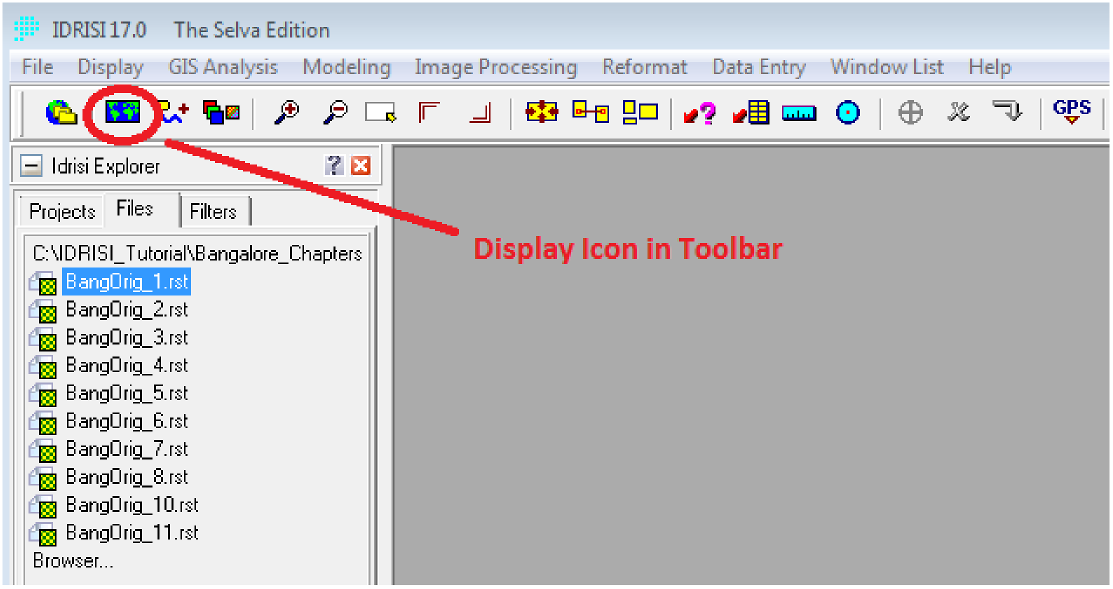


Figure 1.6.1, the display launcher is available from the toolbar via this handy icon.

Open an image using the Display Launcher and converting to Greyscale
Menu Location: **Display – Display Launcher**
1. Start the IDRISI EXPLORER from the main menu: click on *Display* and then select the *Display launcher* option from the pull out menu 2. Enter the Bangalore band you want to display by clicking "…" and selecting the desired band from the pick list. 3. Choose the *Grayscale* radial button, leave all other defaults, and click OK. 4. A grayscale version of the band you selected should open in the middle of your workspace. Each pixel in a grayscale image carries intensity information and are displayed as a shade of the white to black spectrum depending on the intensity of the original pixel.

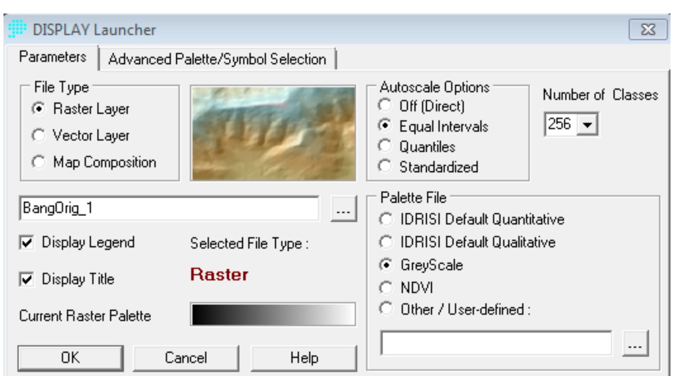


Figure 1.6.2, follow these settings to produce a grayscale version of band 1

Following these directions should produce an image like the one below (see figure 1.6.3). You can produce grayscales of any images by following the same process and choosing the desired image in the "…" pick window.

There are many ways to make this change permanent, however, **what we've just done will only make the image grayscale temporarily**—we wouldn't want to make the change permanent to our originals anyways! You can check this by closing the window and double clicking on *BangOrig_1* in the Explorer pane. You will learn how to make permanent changes to images in future chapters of this tutorial.

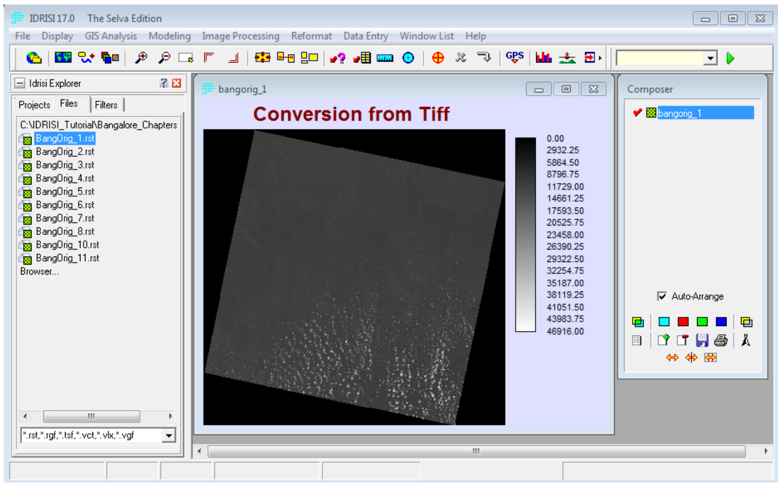


Figure 1.6.3, follow these settings to produce a grayscale version of band 1

1.7 Creating Raster Groups

The last step of chapter 1 is to create an image group, or a raster group in this case. Now that we have original images uploaded, grouping them will allow us to run processes to all of them at once. This will become very helpful in later chapters of this tutorial. Follow the directions in the box below to create a rater group of our Bangalore images.

Create a rater group of the all the Bangalore images/bands
Menu Location**: Explorer-Select All-Right Click-Create-Raster Group**
1. Click on the first band, *BangOrig_1,* in the Explorer pane. Make sure that it is highlighted. 2. While holding down shift, move your mouse all the way to the last Bangalore band, *BangOrig_11*, and click. All of the bands should be highlighted like in figure 1.7.1 below. 3. Right click on any of the highlighted images and navigate the *Create* sub header. 4. From *Create*, find *Raster Group*, and click. 5. You will get an alert saying that the rows and columns of some of the images don't line up. Ignore this warning because we will learn how to adjust rows and columns (the dimensions or zoom of an image) in chapter 2 of this tutorial. 6. Doing this will create a raster group and you should see it in the explorer (see image 1.7.2). 7. Double click the raster group to see the contained bands.

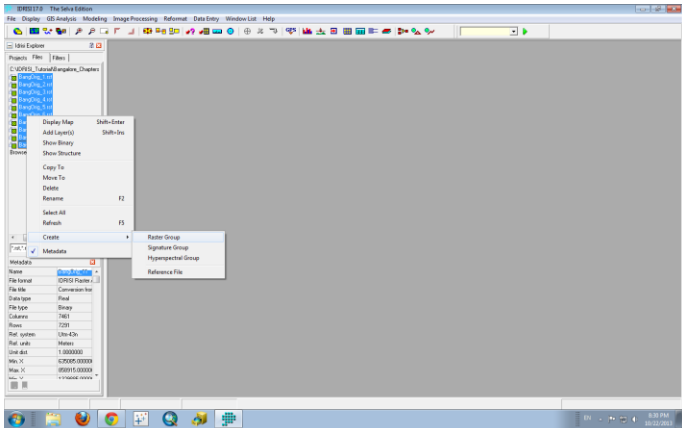


Figure 1.7.1, follow this path to create a raster group

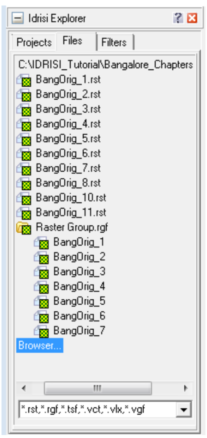


Figure 1.7.2, double click on the raster group folder in Explorer to view nested images

1.8 Checking for Understanding

We covered a lot in the first chapter, so let's take some time to reflect and make sure that the basics are covered. ***In this chapter you learned the following:***

- How to open up IDRISI
- The basics of the IDRISI workspace—including some of the basic functions in the menu bar, tool bar, and the explorer/editor pane.
- Key elements of the IDRISI workflow including project creation, working folders, resource folders, and the tabs in in the IDRISI Explorer pane
- How to import TIFF or GEOTIFF files into IDRISI using the *Import* tool
- Displaying images and grayscaling with the display launcher
- Creating a raster group in IDIRISI Explorer pane out of multiple bands

This chapter lays down the foundational skills that you will need to work on future projects in this tutorial. It also creates the folder, *C:IDRISI_Tutorial\Bangalore_Chapters1-5,* that we will be working out of for the rest of the tutorial. ***Make sure that this folder has the following images:***

- BangOrig_1 through BangOrig_11, excluding band 9
- A raster group containing BangOrig_1 through BangOrig_7

If you have these skills and these images in your Bangalore_Chapters1-5 folder, you are ready to move on to the next section of the tutorial! But before doing so, please complete the following discussion questions.

Discussion Questions:

City planners in Bangalore have asked you to look at the carbon sequestration potential of the green cover in the city. In order to do this you'll need to have an understanding of the current green cover distribution in the city, a geographic area totaling about 800 square kilometers (about 300 square miles), in order to estimate the current carbon storage potential of the city.

Draw upon your BangOrig_band# images in IDRISI, Google Earth, the course text, and lecture notes to help you respond to the following questions:

1. What type of spatial resolution you would prefer to conduct the study—1km resolution (AVHRR), 250 m (MODIS), 30 m (Landsat), 10 m (SPOT) or 1 m (IKONOS)? Keep in mind that your study area is approximately 800 square km. Support your choice in sensor system range by providing some pros and cons of the listed options above.

2. What other geographic imaging tools or resources could help you determine the carbon sequestration capacity of Bangalore (e.g. soil maps, vegetation plots, or digital terrain models)? Please justify your choices in supplemental resources.

3. How would you share your findings? What kind of outputs would there be?

Chapter 2: Image Manipulation in IDRISI

Goals:

In this chapter we will learn about histograms, WINDOW, contrast, saturation, contrast stretching, and how to make a false color composite. Understanding all of these is critical to a basic working knowledge of IDRISI.

We'll start with histograms, which are graphs that display the frequency of certain brightness values throughout an image. Don't worry about the vocabulary—it will be explained throughout the chapter! Then, in order to work with our images we'll learn more about the WINDOW tool so that we are working with an appropriate image for our contrast stretching. Some terms throughout the contrast section may be new. Don't worry! They will be explained as we go along. We will create three different types of contrast stretches: linear, histogram equalization, and linear with saturation. Lastly, with all of our new knowledge, we'll construct a false color composite of Bangalore. Let's have some fun!

Required Materials and Data:

- C:IDRISI_Tutorial\Bangalore_Chapters1-5
- You should have these files for this section of the manual:
- BangOrig_3, Bang_Orig_4, and BangOrig_5

2.1 Opening and Examining the Histogram

A histogram is a graph which shows the prevalence of certain brightness values in the image. By examining the histogram, we can usually get an idea of what values are outliers and how contrast stretches affect an image.

Opening and examining histograms in IDRISI
Menu Location**: Display - HISTO**
1. Click the '…' button next to the blank field to the right of "Input File Name" 2. In the *Pick List* window, select **BangOrig_5** 3. Change the class width to 200 4. Accept all other defaults and click OK

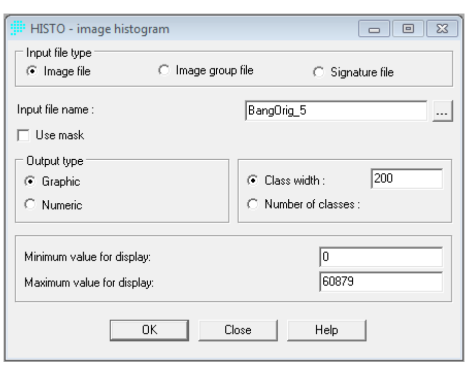


Figure 2.1.1, Histogram display window

There seems to be a relatively uniform curve except for a spike close to zero. Speculate as to what that could be.

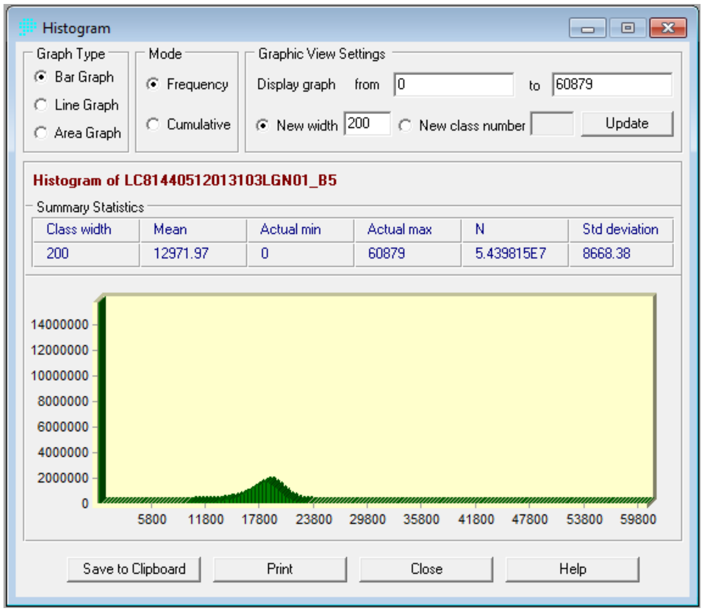


Figure 2.1.2, Unclipped Histogram

2.2 Clipping your window and re-examining the histogram

Making sure your windows are the correct size is integral to most features in IDRISI. In order to execute most functions, images must be the same size—this includes creating false color composites, which we'll do later. The numbers we'll be entering in the 'WINDOW' window correspond to a specific row and column. We will specify a row to be the top of the image, a column to be the left bound, and then choose another row and column to specify the right bound and the bottom of the image. These numbers provided will give us a good view of Bangalore to work with.

Clipping your image using WINDOW
Menu Location: Reformat - WINDOW
1. Click in the blank field under the heading *Filename* 2. Click the ' …' button 3. Select **BangOrig_5** from the *Pick List* window 4. Click *OK* 5. Enter **4850** into the first blank field, to the right of Upper-left column 6. Enter **3450** into the second field, to the right of Upper-left row 7. Enter **5600** into the third field, to the right of Lower-right column 8. Enter **4000** into the fourth field, to the right of Lower-right row 9. Click the field to the right of *Output image:* 10. You will now enter a name for your image 11. Enter ***CLIP_BangOrig_5*** 12. Make sure your window matches below 13. Click *OK*

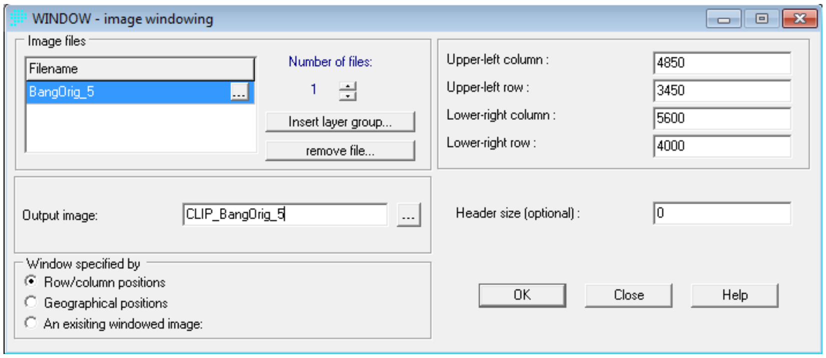


Figure 2.2.1, WINDOW display parameters

Now to prepare for making a false color composite and to better understand the window function, we'll clip **BangOrig_3** and **BangOrig_4** to the window size of **CLIP_BangOrig_5**.

A false color composite is an image created where bands from the outside the visible light spectrum are assigned a color – either red, green, or blue – in order to perform analysis.

Clipping your images using WINDOW

Menu Location: Reformat - WINDOW

1. Under *Number of files:* click the up arrow until the number reads 2
2. Click in the blank field under the heading *Filename*
3. Click the ' …' button
4. Select **BangOrig_4** from the *Pick List* window
5. Click *OK*
6. Click in the blank field under **BangOrig_4**
7. Select **BangOrig_3** from the *Pick List* window
8. Click *OK*
9. Enter **4850** into the first blank field, to the right of Upper-left column
10. Enter **3450** into the second field, to the right of Upper-left row
11. Enter **5600** into the third field, to the right of Lower-right column
12. Enter **4000** into the fourth field, to the right of Lower-right row
13. Click the field to the right of *Output prefix:*
14. You will now enter a prefix for your image
15. Enter *CLIP*
16. Click *OK*

Now we will display the histogram of the clipped band 5 image.

Display the histogram of your clipped band 5

Menu location: **Display - HISTO**

1. Click the '…' button next to the blank field to the right of *Input file name:*
2. In the *Pick List* window, select **Clip_BangOrig_5**
3. To the right of *Maximum value of display:* enter **30000**

4. Accept all other defaults
5. Click *OK*

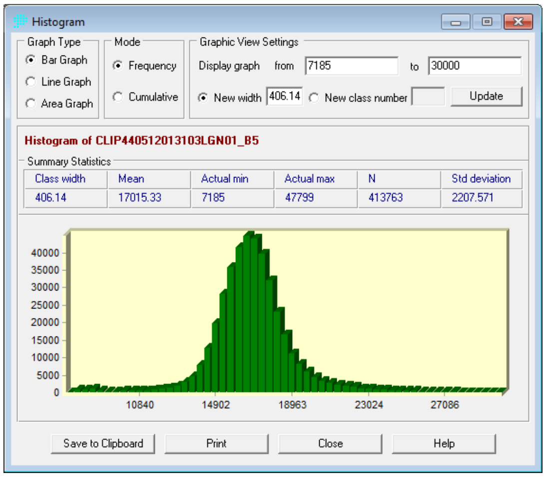


Figure 2.2.2, Clipped histogram with display max of 30,000

Checking for understanding:

- How does this histogram differ from the previous? Explain.

2.3 Applying Contrast Stretches to Your Images

We are now going to apply contrast stretches to your image in order to produce a sharper image for analysis.

Contrast is defined as the differences between dark and light. High contrast means that there is a greater range between the light and dark parts of an image. Low contrast are often referred to as “flat” in photography, because the ranges between light and dark in the image are low. In this case, we are going to change the display parameters of an image such that all the values are squished closer and displayed using only 256 values instead of the potentially thousands present in the original image. This will make the blacks darker and the whites brighter when used in conjunction with greyscale images. With colors in the visible light spectrum (e.g. red, green, blue), it increases difference in brightness and darkness.

At the end of this section, you will display a histogram of one of the stretches you’ve made, in order to better understand this concept. A linear contrast stretch redefines the minimum and maximum of the values to ones between 0 and a maximum display value, which can vary between satellites. Landsat has a maximum display value of 255 while earlier satellites, such as Landsat 7, have considerably lower ones.

Creating a linear contrast stretch

Menu location: **Display – Stretch**

1. Click the ‘…’ button next to the blank field to the right of *Input image:*
2. In the *Pick List* window select **CLIP_BangOrig_5**

3. Enter the name **LinStretch_5** into the *Output image:* field
4. Accept all other defaults
5. Click *OK*

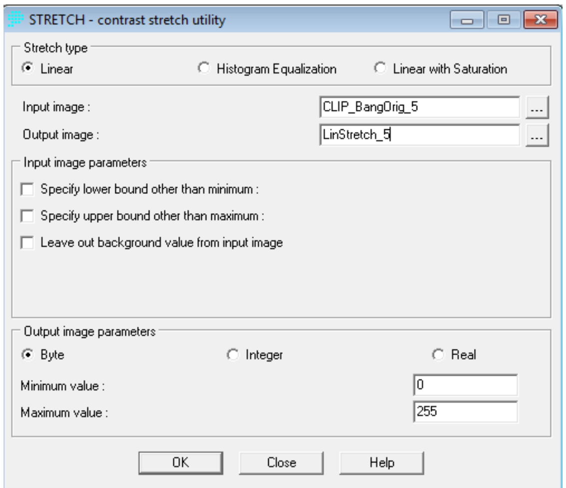


Figure 2.3.1, Linear stretch parameters

Compare LinStretch_5 and CLIP_BangOrig_5. Do they look very different? Now return to the Stretch window to make a histogram equalization stretch!

A histogram equalization stretch evenly distributes all values across the values from 0 to 255. Due to the simplistic nature of this stretch it not only increases contrast in important areas of the image, but also things such as noise, distortion, and other anomalies that you might not otherwise want in your image.

Creating a histogram equalization stretch

Menu location: **Display – Stretch**

1. Click the *Histogram Equalization* radio button
2. Click the '…' button next to the blank field to the right of *Input image:*
3. In the *Pick List* window select **CLIP_BangOrig_5**
4. Enter the name **HistStretch_5** into the *Output image:* field
5. Accept all other defaults
6. Click *OK*

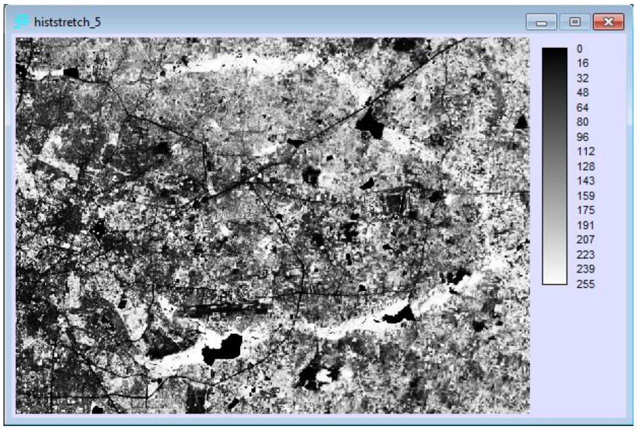


Figure 2.3.2, Histogram stretch

How does this image differ from the others? We will now display the histogram of the histogram equalization stretch so you will get an idea of how images are stretched.

Display the histogram of your histogram equalization
Menu location: **Display - HISTO**
1. Click the '…' button next to the blank field to the right of *Input file name:* 2. In the *Pick List* window, select **HistStretch_5** **3.** Accept all defaults **4.** Click *OK*

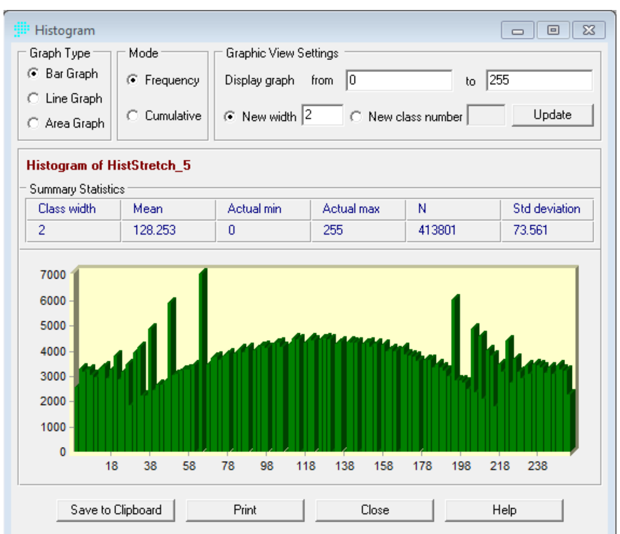


Figure 2.3.3, Histogram of your histogram stretched band 5

Examine where the values fall. You may want to open the histogram of your linear contrast stretch to compare and better understand the differences between these types of stretches.

We will now create a linear contrast with saturation stretch. Saturation determines how much at each end of the scale will be left out or saturated.

Creating a linear contrast with saturation stretch
Menu location: **Display – Stretch**
1. Return to the *Stretch* window, assuming you have not closed it (reopen if you have) **2.** Click the *Linear with Saturation* radio button **3.** Click the '…' button next to the blank field to the right of *Input image:* **4.** In the *Pick List* window select **CLIP_BangOrig_5** **5.** Enter the name **LinSatStretch_5** into the *Output image:* field **6.** Choose a value between 1 and 5 **7.** Enter that value in the field to the right of *Percent to be saturated at each end of scale:* **8.** Accept all other defaults **9.** Click *OK*

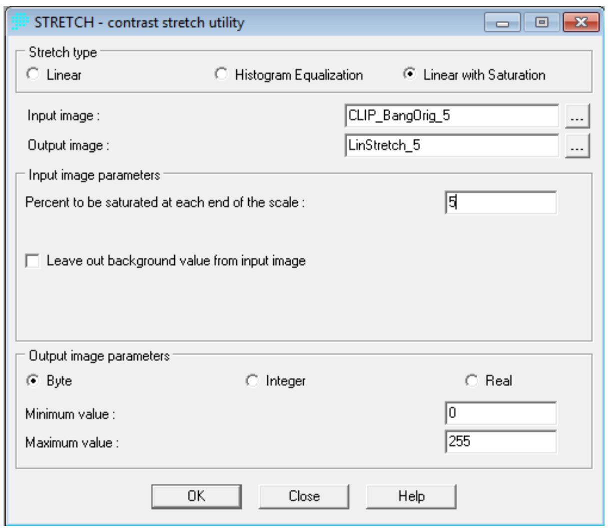


Figure 2.3.4, Linear stretch with saturation parameters

Now examine your linear contrast with saturation stretch. It should look something like below. How does it differ from the other stretches you've made? More importantly, however, what is saturation?

Saturation refers to the dominance of the hue in the color. At one end of the spectrum we have the pure color, and as we move along the spectrum it moves to black—it loses its dominant hue.

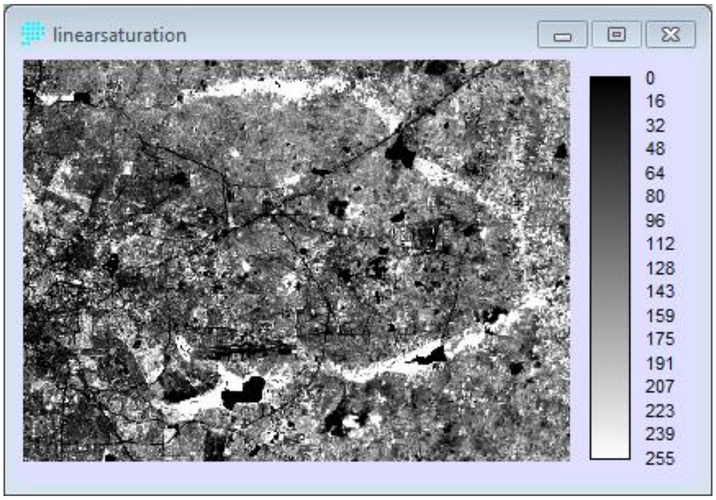


Figure 2.3.5 Linear stretch with saturation. Does yours appear similar?

2.4 Creating False Color Composites

False color composites are very important to image analysis and remote sensing for a variety of reasons. To begin, they allow us to both assign colors to the infrared scale and combine bands together. This means that we can assign infrared an actual color (oftentimes red) and then pick out areas which emit more infrared than other, e.g. areas with faster growing and/or more vegetation.

We will now create a "543" false color composite. "543" correlates with RGB, meaning that we will display band 5 or infrared as Red, band 4 or red as Green, and band 3 or blue as Blue—hence RGB. Remember when we clipped bands 3 and 4 way back in section 2.2? We are finally going to put them to use!

Creating a false color composite
Menu location: **Display – COMPOSITE**
1. Click the '…' button next to the blank field to the right of *Blue image band:* **2.** In the *Pick List* window, select **CLIP_BangOrig_3** **3.** Click *OK* **4.** Repeat steps 1 – 3, while adhering to the steps below **5.** Enter **CLIP_BangOrig_4** in the *Green image band:* **6.** Enter **CLIP_BangOrig_5** in the *Red image band:* **7.** In the *Output image field*, type **FCC_543_Bang** **8.** Enter a percentage between 1 and 5 in the field to the right of *Percent to be saturated at each end of scale:* **9.** Accept all other defaults **10.** Refer to the image below, and make sure your parameters match the screenshot below **11.** Click *OK*

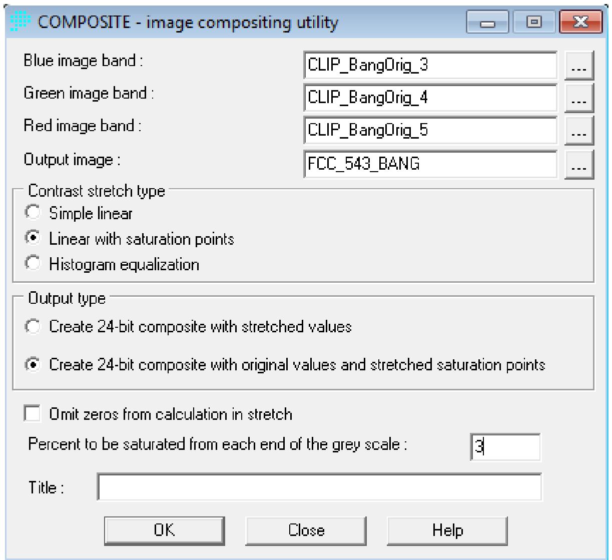


Figure 2.4.1, False Color Composite parameters window

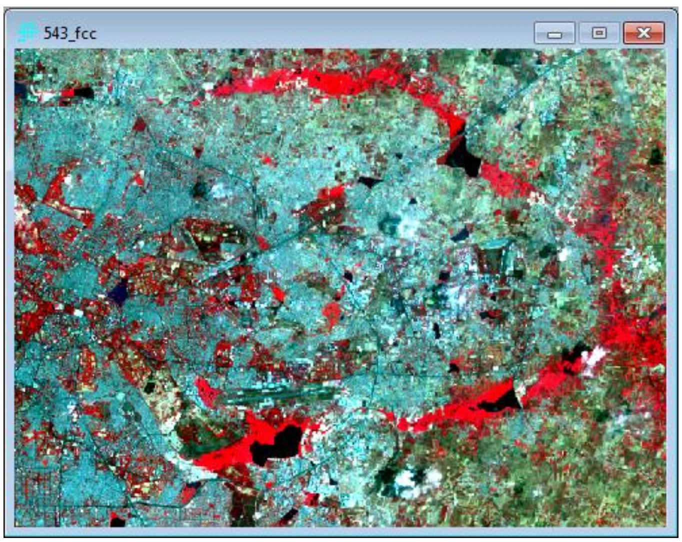


Figure 2.4.2 Bangalore - 543 False Color Composite

2.5 Checking for Understanding

You have now successfully created a false color composite image of Bangalore! Does it look like the image below? If not, try again. If yes, congratulations! You made it to the end of chapter 2! You might try creating a 742 composite. A 742 is a versatile composite that displays vegetation as green, water as blue, and other dry vegetation and dirt as earth colors. You may also want to look up band combinations on the NASA or ESRI website to get a better idea of what they're used for. It's used for geologic analysis, forestry, and agriculture. Remember that the bands correspond to RGB and that the window in IDRISI asks for the bands (in order from top to bottom) blue, green, and then red.

After completing chapter 2 of this IDRISI tutorial you should be able to the following:

- Display histograms
- Clip images
- Create a variety of contrast stretches
- Explain how their histograms differ
- Be able to define contrast and saturation
- Create false color composites

Discussion Questions:

Now create a 742 false color composite using the Bangalore images. How does it compare to the 543? What are some similarities? What are some differences?

Chapter 3: Enhancing Images Spatially

Goals:

- Develop fundamental understanding of Spatial Enhancement
- Practice image import and windowing techniques
- Complete a successful Multiplicative Resolution Merge to see the effects of incorporating a panchromatic band to create an image that is high in both spectral and spatial resolution

Image enhancement is an essential process in Remote Sensing that allows for the user to better recognize patterns contained within the data. There are numerous tools and techniques in Idrisi that can be employed to help improve both **Spatial** and **Spectral Enhancement**. This chapter will deal with **Spatial Enhancement** and the processes by which the user can improve the visual quality of the image by making alterations to and manipulating the spatial properties of an image.

Spatial Enhancement techniques typically involve processes that focus on groups or "neighborhoods" of pixels. Spatial Enhancement often relies upon spatial filters to perform functions such as reduce noise in an image or increase image contrast. We will incorporate spatial filtering techniques during this lab when we incorporate a filter into the model that you will develop.

Another important enhancement technique that you will be called upon to use in this lab is the merging of data of differing spatial resolutions. This capability of spatial enhancement is important to remote sensing because many bands of differing spectral values recorded by satellite arrays come in different spatial resolutions, and being able to effectively merge these images is necessary in order to be able to use them in conjunction with one another. The most common example of this is the presence of a single high-spatial resolution band in a sensor array that works with a number of lower-spatial resolution bands that are all calibrated to detect specific spectral wavelengths. The aforementioned high resolution band is referred to as the **panchromatic** band. This name traces its etymology to black and white aerial film, which was the precursor to modern remote sensing. Multi-spatial resolution allows for the spatial information obtained by the panchromatic to be integrated with the spectral information from the lower spatial resolution bands, thereby creating a high-resolution multispectral image.

In this chapter we will work towards spatially enhancing the Bangalore Landsat images. Using multispectral bands 4,3,and 2 from Landsat 8 and band 8 from Landsat 8 as our panchromatic, we will perform a multiplicative resolution merge in order to create a spatially enhanced 4-3-2 false color composite.

3.1 Convolution

Before we begin with the multiplicative merge, it is important to understand the concept of **Convolution**. From taking this class and reading this text, you now have an understanding of the concept of an image being comprised of units with discrete values know as **Pixels**. In this chapter, we will explore the idea of **Windows**. Windows are local groups of pixels that can occur in any size, but by definition are a subset of the overall image. The window is comprised of a central pixel and its immediate neighbors. Hypothetically, if we were examining a 3x3 window (Figure 3.1.1), the window would be comprised of one center pixel and eight surrounding neighbor pixels. A window moves sequentially around an image, allowing each of the image's pixels to serve as a center pixel to the window at one point.

Convolution combines the DN values of each pixel in the window to create a weighted average of the brightness values within the designated area of the window. For our purposes, we will be applying spatial convolution filter know as a **High-pass filter**. *Spatial frequency* measures the change in brightness values per unit distance in any part of the image. A high-pass filter is applied to an image to enhance detail by enhancing the *high-frequency* local variations, while simultaneously removing the *low-frequency* local variations.

Neighbor	*Neighbor*	*Neighbor*
Neighbor	*Center*	*Neighbor*
Neighbor	*Neighbor*	*Neighbor*

Figure 3.1.1, 3x3 pixel window

3.2 Importing Landsat 8 Band 8 Image of Bangalore to IDRISI

Importing the Landsat Band 8 Image of Bangalore
Menu Location**: File-Import-Government/Data Provider Formats-GEOTIFF/TIFF**
5. Import the complete Landsat 8 Band 8 image from the class data folder **C:IDRISI_Tutorial\Bangalore_Chapters1-5** following the steps delineated in section 1.5 of the textbook. 6. Make sure that the radio button next to **GeoTIFF/Tiff to IDRISI** is selected as the conversion option. (Figure 3.2.1) 7. Enter BangOrig_8 into the text box next to **Idrisi image to create**. 8. Press *OK.*

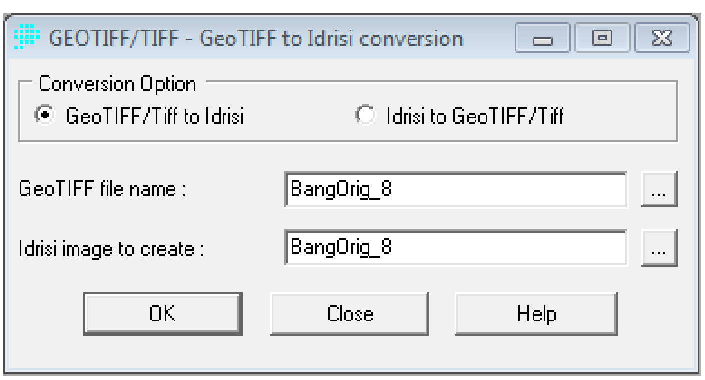


Figure 3.2.1, Import window

3.3 Windowing Imported Band 8 image to previously windowed image of Bangalore

Windowing the Imported Band 8 Image
Menu Location: **Reformat-Window**
1. Follow the steps for windowing an image as delineated in section 2.2 of this textbook to open the window function. 2. Click on the "…" to open the pick menu and select the **BangOrig_8** image. 3. To window the Band 8 image to the same dimensions as the clipped images you made in the last chapter, select the radio button to the right of ***An existing windowed image:*** in the *Window specified by* section of the page. 4. Then click the "…" and select one of the **Clipped_ (1,2,3,4,5,7)** images that you windowed for chapter 2. 5. Enter the name **Clipped_8** in the *Output image* text box. 6. Check that your window page resembles the one depicted in figure 3.3.1 7. Press *OK*

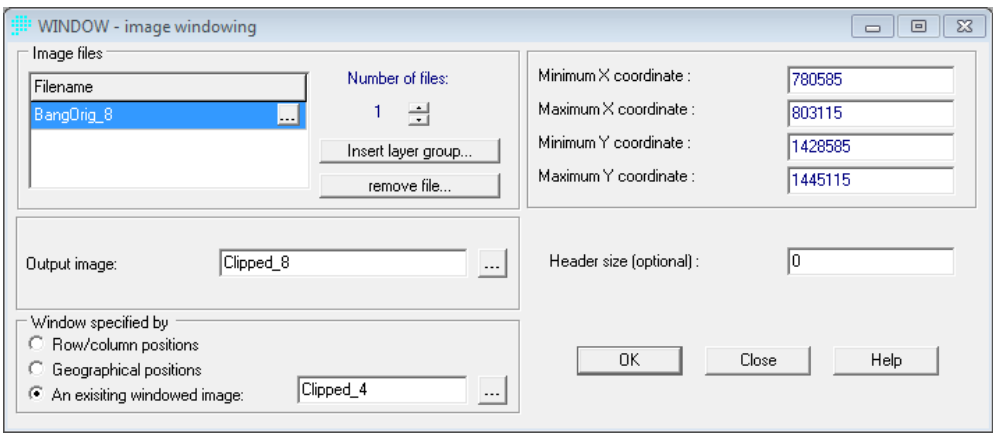
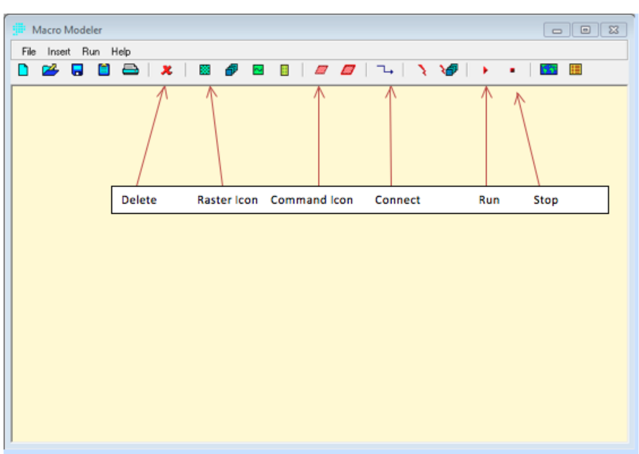


Figure 3.3.1, Window settings for imported Band 8 image

3.4 Multiplicative Resolution Merge



MACRO MODELER toolbar key

Multipicative resolution merge with MACRO MODELER
Menu Location**: Modeling- Model Deployment Tools- MACRO MODELER**
1. Start the Macro Modeler using the icon bar or via the main menu. 2. Click on *File* and select *delete all temporary files* in the window for the MACRO MODELER. 3. Click on *file* and select Set/Reset *temporary file counter* in the drop down menu. 4. Click the *Reset* button in the *Set/Reset TMP File Counter* window. Change the value in the *Set next counter window* to **0** if it is not already **0**. Click *ok.* 5. Use the raster *Raster Layer* icon to insert data layer ***Clipped_2, Clipped_3*** and ***Clipped_4*** into the model 6. Insert the *expand* command module into the model by clicking the *Module* icon. Add two more *expand* modules by following the same steps. 7. Arrange the three *expand* modules so that they form a parallel column to the ***Clipped_2***, ***Clipped_3***, and ***Clipped_4*** icons. (Figure 3.4.1) 8. Connect each of the blue rectangles representing ***Clipped_2***, ***Clipped_3***, and ***Clipped_4*** to the adjacent expand module by using the connect icon. 9. Right-click each *expand* command module. Set the *Expansion* factor in the *Parameter* window to **2** in all three. We do this because the pan band in Landsat 8 has a 15 m resolution, while the other bands all have resolutions of 30 m. In order to make them compatible, it is necessary to use the *expand* command to standardize the resolution. (Figure 3.4.2)

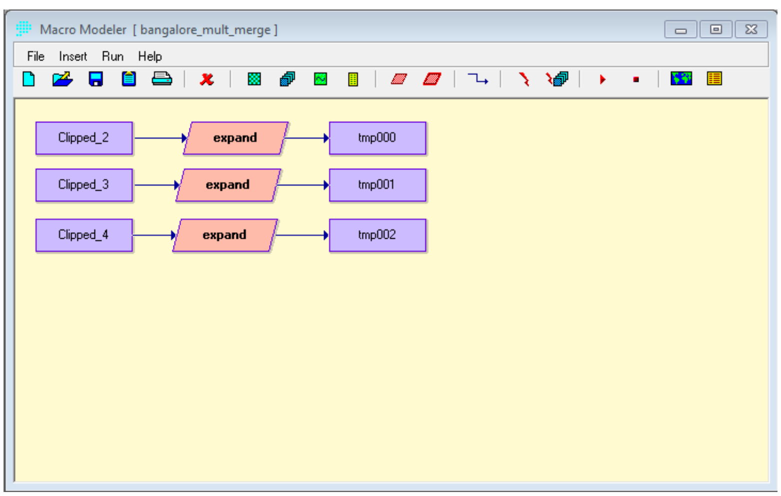


Figure 3.4.1, Initial Model with three expand modules

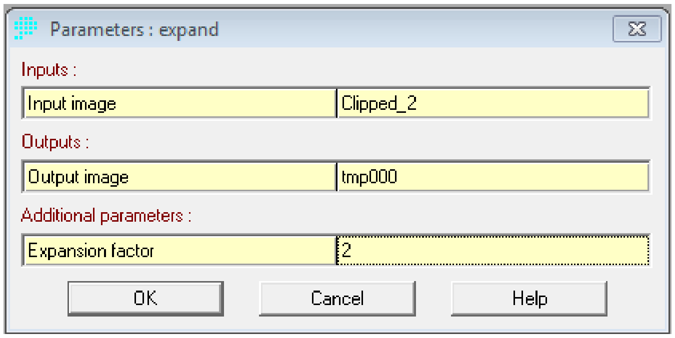


Figure 3.4.2, Setting the Expansion factor to 2

Multipicative resolution merge with MACRO MODELER (con't)

Menu Location: **Modeling- Model Deployment Tools- MACRO MODELER**

10. Insert data layer ***Clipped_8*** into the model using the *Raster Layer* icon.
11. Arrange the ***Clipped_8*** rectangle so that it is directly beneath the other data layers.
12. Insert the *Filter* command module into the model using the *Module* icon.
13. Connect the ***Clipped_8*** layer to the *filter* module using the *connect* tool.
14. Bring up the *Parameters* window by right clicking on the *Filter* module.
15. Change the *Filter-type* to *High-pass* by right-clicking in the field to the right of *Filter-type.*
16. Click on *OK* to close the *Parameters* window. (Figure 3.4.3)

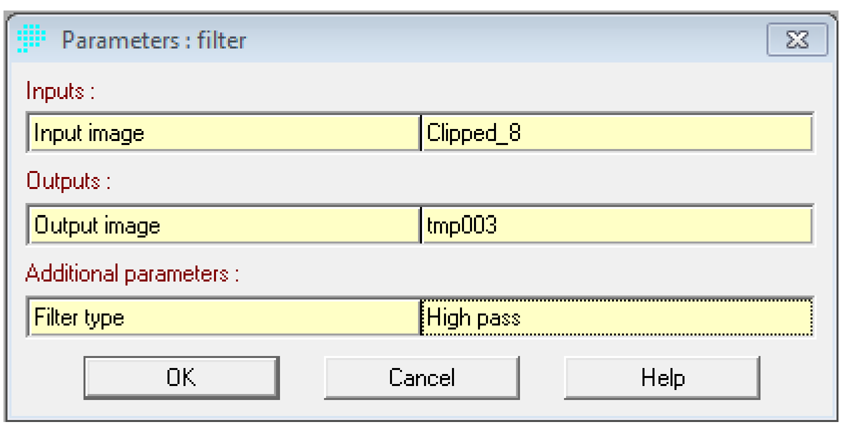


Figure 3.4.3, Setting the Filter type to High Pass

Multiplicative resolution merge with MACRO MODELER (con't)

Menu Location: **Modeling- Model Deployment Tools- MACRO MODELER**

1. Insert a *Stretch* command module in the model via the *Module* icon.
2. Arrange the *Stretch* module so that its output is below the *Filter* module
3. Connect the output of the filtered ***Clipped_8*** image to the *Stretch* module using the *Connect* tool. (Figure 3.4.4)

4. Bring up the *Parameters* window by right-clicking the *Stretch* icon.
5. Set the *Output Data* to *Real* by right clicking in the field to the right and selecting it form the pop-up menu.
6. Select *No* for *Exclude Background?* by right-clicking in the field to the right
7. Enter **0** for the *Lowest non-background output value* by clicking in the field to the right**.**
8. Enter **2** for the *Highest non-background output value* by clicking in the field to the right.
9. Leave the all other fields unchanged, and then click *OK* to close the window. (Figure 3.4.5)

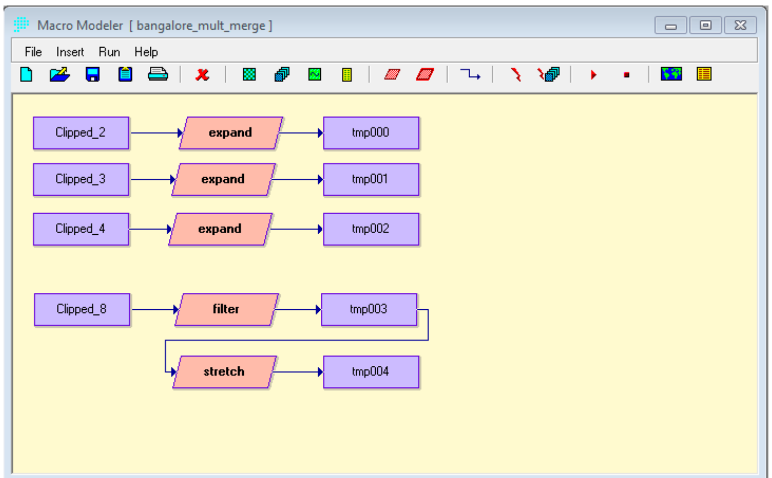


Figure 3.4.4, The model with the Stretch and Filter modules added

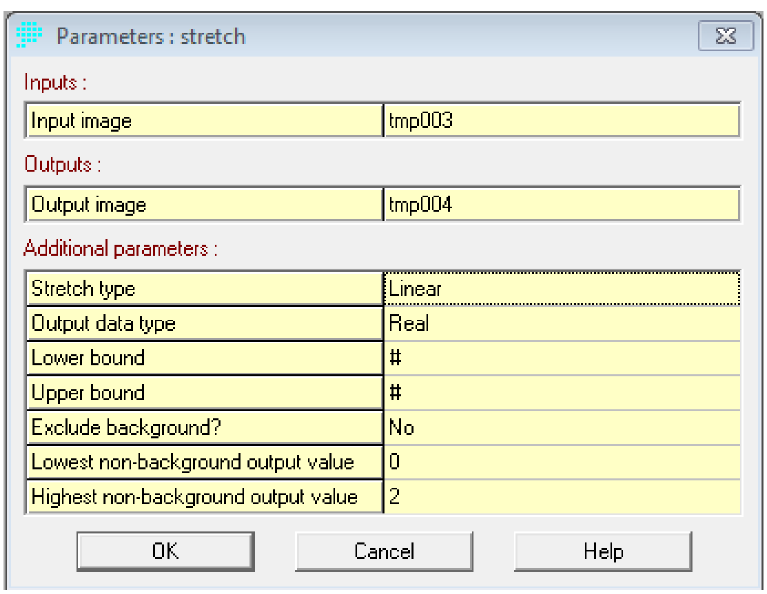


Figure 3.4.5, The Stretch module Parameter window

Multipicative resolution merge with MACRO MODELER (con't)
6. Add an *Overlay* command module by clicking on the *Command module*. 7. Arrange the three *overlay* modules in another column that runs parallel to the columns of the *Expand* modules and *expand* module output temporary files (as seen in figure 3.4.6). 8. Connect the icons for temporary files **tmp000, tmp001,** and **tmp002** to their adjacent *Overlay* modules using the *connect* tool. **9.** Connect the stretch output file **tmp003** to each of the three *overlay* modules using the *connect* tool. **10.** Open the *Overlay Parameters* window by right-clicking on the *Overlay* module. **11.** Select *Multiply* from the pop-up menu in the filed to the right of *Operations* by clicking in th field. (Figure 3.4.7) **12.** Repeat steps 30 and 31 for the two remaining *Overlay* modules.

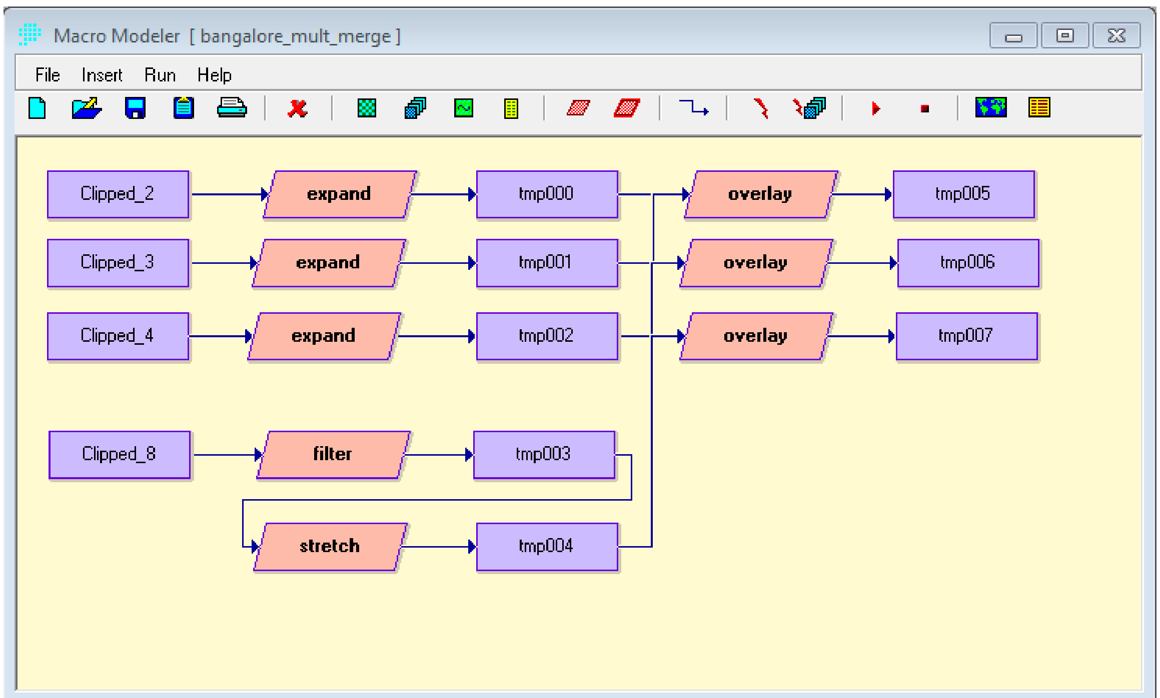


Figure 3.4.6, The model with the three Overlay modules connected

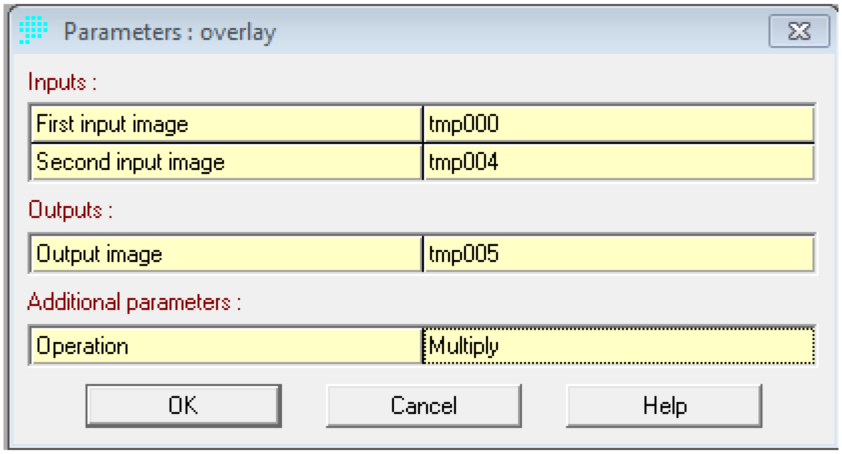


Figure 3.4.7, The Overlay module Parameter window

Multipicative resolution merge with MACRO MODELER (con't)
33. Insert the *Composite* command module into the model via the *Module* icon. 34. Connect all three of the temporary raster files created by the three *Overlay* modules to the *Composite* module using the *Connect* tool. Connect temporary raster files in descending order, staring with **tmp005**, then **tmp006**, and finally **tmp007**. Your model should resemble the model depicted in figure 3.4.8. 35. Change the name of the output file from the *Composite* module from **tmp008** to **432_pan_mult_merge** by right-clicking on the purple temporary file and entering the new name in the *Change Layer Name* dialog box. 36. Click on *OK*. 37. Click on the *Save* icon. 38. Specify **mult-merge** as the model name. 39. Click on *OK*. 40. Review the model to see that the components are linked, arranged and titled in the same manor as they are in figure 3.4.8. 41. Click on the *Run* icon. 42. Click on *Yes to all* in the window that warns that the files created by the model will overwrite any existing files of those names.

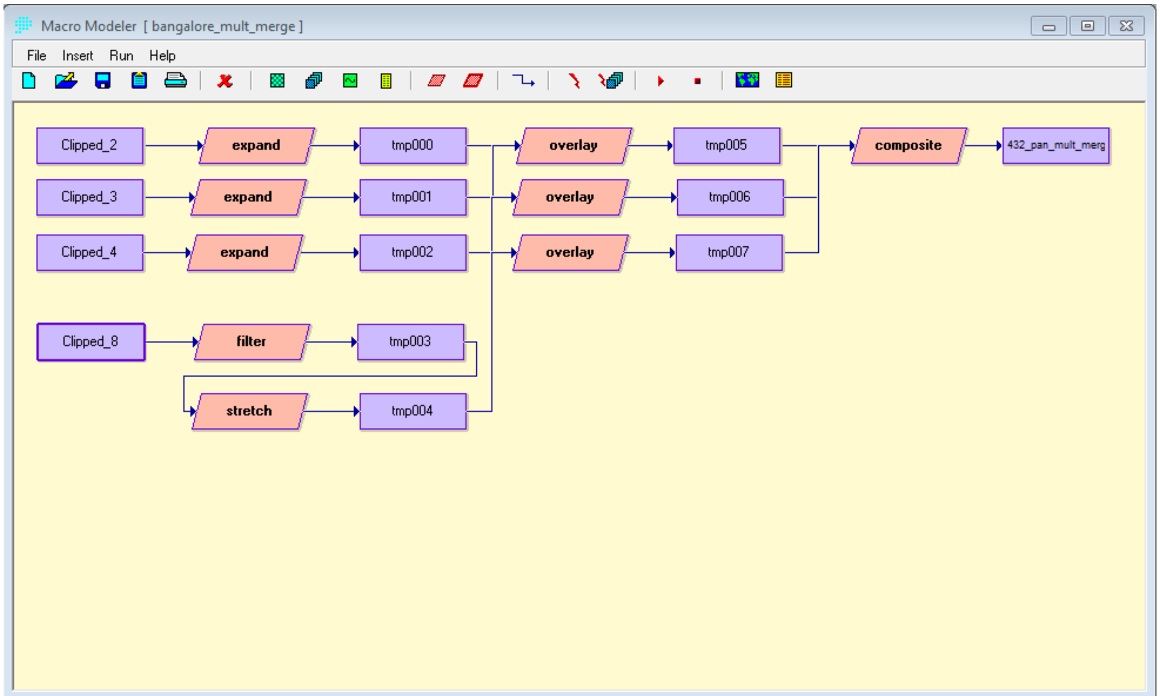


Figure 3.4.8, The Multiplicative resolution merge model

Make a standard 4-3-2 false color composite for comparison
Menu Location: **Display-Composite**
1. Follow the steps outlined in section 2.4 of the textbook to create a 4-3-2 false color composite. 2. Title the new composite image **432_fcc.** (figure 3.4.11) 3. Your output image should resemble figure 3.3.9.

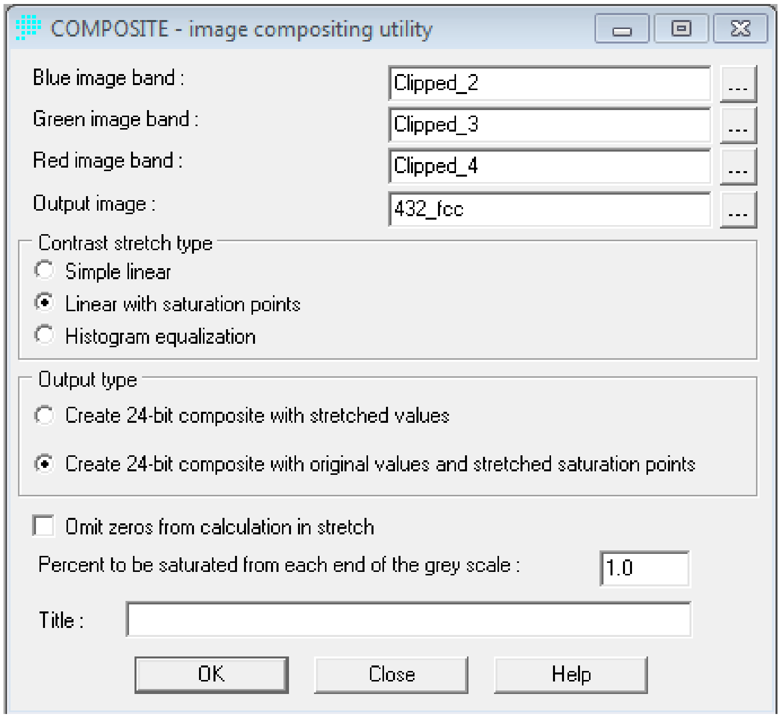


Figure 3.4.9, 4-3-2 false color composite settings

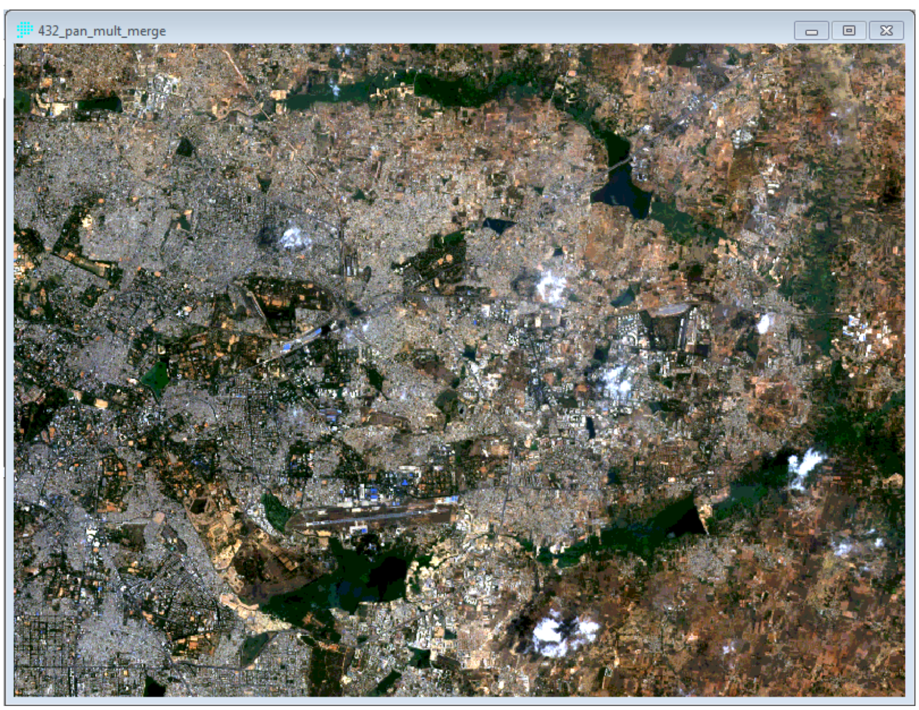


Figure 3.4.10, 4-3-2 Pan_mult_merge

Figure 4.11, Standard 4-3-2 False color composite

3.5 Checking for Understanding

- Develop fundamental understanding of Spatial Enhancement
- Practice image import and windowing techniques
- Complete a successful Multiplicative Resolution Merge to see the effects of incorporating a panchromatic band to create an image that is high in both spectral and spatial resolution

This chapter details the basics of spatial enhancement and provides an overview of Multiplicative Resolution Merging in IDRIS. Over the course of this lab you should have created the image **Clipped_8**, a Multiplicative Merge image titled **4-3-2 Pan_mult_merge**, and a standard 4-3-2 false color composite titled **432_fcc**.

Discussion Questions:

Examine the 4-3-2 multiplicative merge false color composite and a standard 4-3-2 false color composite that has not been merged with the Band 8 Panchromatic image. Take a close look at both images and look for differences between the two. What features stand out as being sharper or clearer? Are these changes more pronounced in the natural or built environment? Are there any land surface types or features that seem unchanged? Take note of these specific features. Remember that the high-pass filter makes areas in which brightness values change relatively more quickly, more pronounced, so drastic shifts and stark contrast will be accentuated.

Chapter 4: An Introduction to Spectral Enhancement

Introduction

In this section, I will be explaining how an IDRISI user can enhance satellite imagery for purposes of providing better images for visualization and analysis. Spectral enhancements are achieved through mathematical processes that IDRISI will do; unlike spatial enhancements, spectral enhancement is focused upon individual pixels with minimum attention paid to the surrounding pixels.

4.1 Displaying and Composing Images

We will first begin this lab with a review of displaying and composing images.

9. Open up the **Clipped_BangOrig_5** image of Bangalore using the same technique. This is the near infrared image.
10. Open up the **Clipped_BangOrig_4** image of Bangalore using the "Display" and the "Display Launcher" tool.
11. Open up the **Clipped_BangOrig_3** image of Bangalore under the "display launcher" window.

Once all the images are up, start the composite program (this is initiated by clicking "display" and then scrolling down to "composite"). Make a 5,4,3 composite, click "linear with saturation points," and for "output type, click "create 24 bit composite with stretched values." Experiment with the "percent to be saturated." Essentially, when you change this number, you are determining the amount of pixels – relative to the total amount of pixels—that you will not include in the image. What differences do you see between, say, 1 and 3 percent? Then, try a 7,5,4 composite. What images are accentuated in this area?

4.2 VegIndex with NDVI

Now that we have reviewed compositing images, we will move on to more specific types of spectral enhancements. One of the most widely used methods is referred to as a normalized difference vegetation index (NDVI). The creation of an NDVI allows the analyst to look at the amount of vegetation in a specific area. If the analyst uses multiple images in the creation of an NDVI, he/she can explore how the vegetation cover changes over time. AN NDVI ratio is found through the equation of:

NDVI= (Near Infrared - Red) - (Near Infrared + Red).

This equation will produce outputs between -1 and 1 (when the output is near 1, vegetation is predominating and if the output is near 0 or is negative, non-vegetation is dominating).

Before we do this, however, we will need to create a raster group.

1. Click on the **Clipped_BangOrig_3** layer, the **Clipped_BangOrig_4** layer, and the **Clipped_BangOrig_5** layers. One can highlight all of these by holding the "control" button and then respectively clicking on each of them.

2. Right click on these highlighted layers and click “create” and then “raster group.”
3. Name this raster_group_1 or any other name that is easy to remember and identify.

Now that our raster group is created, navigate to the top of the screen and press “image processing” and scroll down to “transformation.” Scroll down again to “VegIndex.” Under “vegetation index type,” click “NDVI.” Our red band is band 4 and our infrared layer is 5, according to the Landsat website: (http://landsat.usgs.gov/band_designations_landsat_satellites.php).

Thus, we input the **Clipped_BangOrig_4** layer for the red band and the **Clipped_BangOrig_5** layer for the infrared band. The screen should look something like this. Name the output image “veg_ndvi_4_5”. Click “OK.” The screen should look identical to the image below.

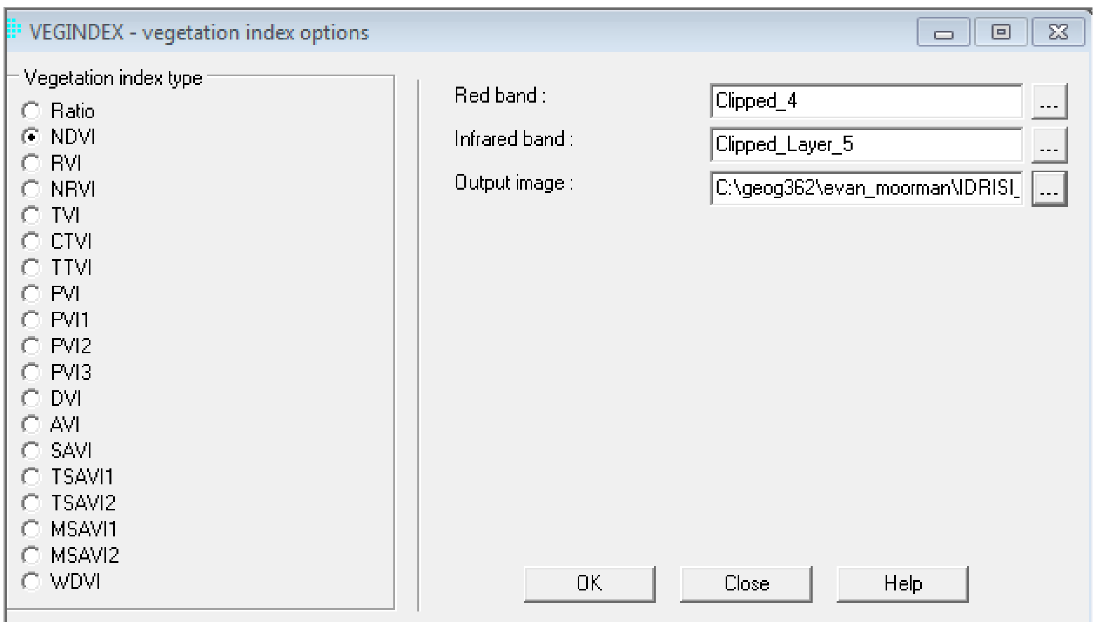


Figure 4.2.1

The file “veg_ndvi_4_5” should appear identical to the one below.

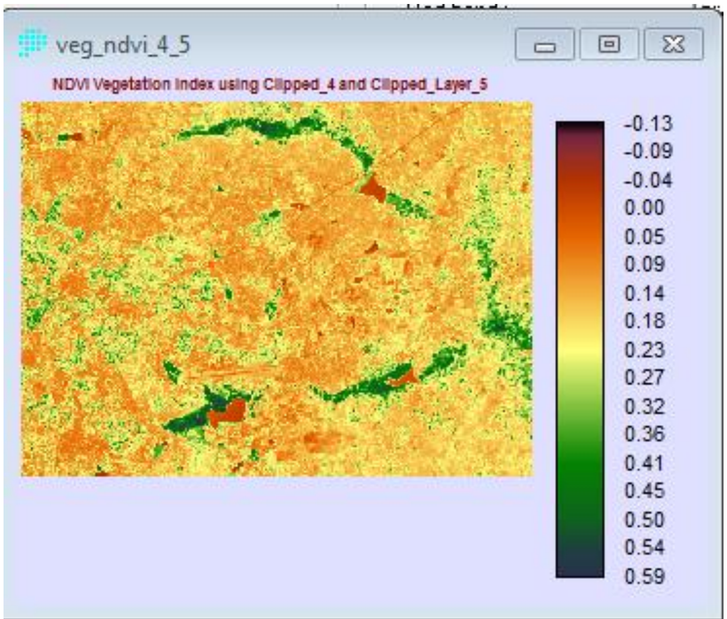


Figure 4.2.2

However, using VegIndex with NDVIs should have a range between -1 and 1. Therefore, we will navigate to “layer properties” and change the “display min” and the “display max” to -1 and 1 respectively. Click “apply,” then “save,” then “OK.” The image should look identical to the image below.

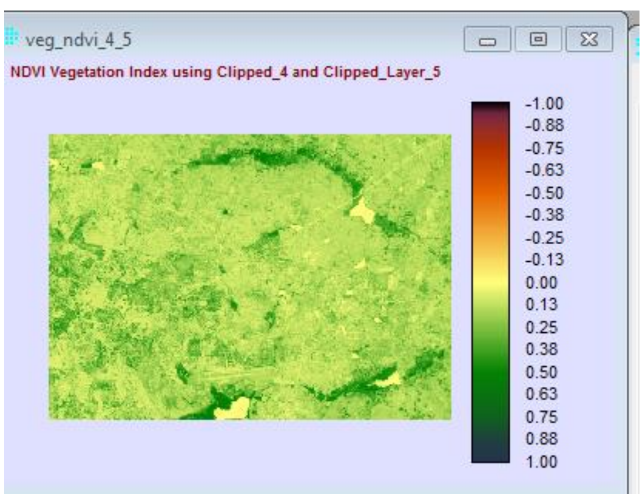


Figure 4.2.3

4.3 PCA Analysis

PCA (or principle components analysis) is a method in which one can derive uncorrelated variables or band values from an original data set. A PCA essentially rotates the original bands so that they become linearly uncorrelated with each other (in mathematical terms, they become *orthogonal*). By doing this, we ensure that all maximum variance is apparent to the viewer.

1. Navigate to "image processing," then click "transformation" and then "PCA."
2. In the dialogue box, click "insert a layer group" and insert the layer group you just made (raster_group_1).
3. Change the "number of components to be extracted" to 6.
4. Make sure that you write in" PCA" into the "prefix for output value" box.
5. Make sure you click "complete output."
6. Leave all other settings as default and click "OK."

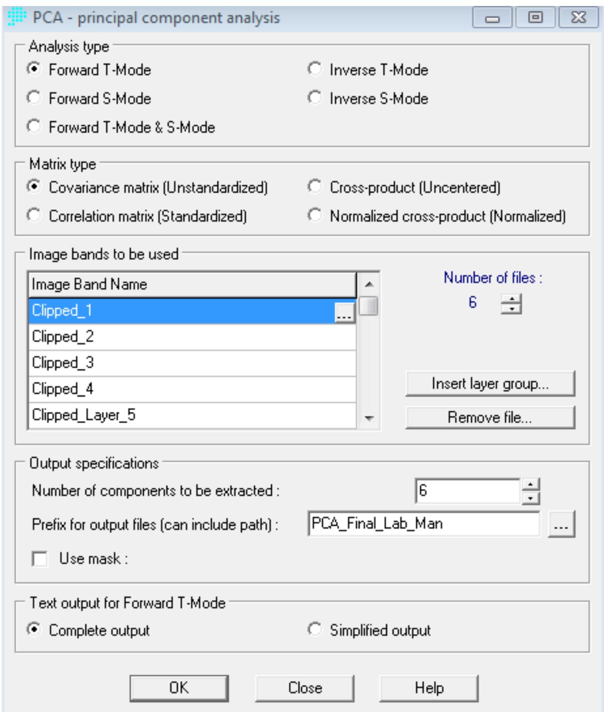
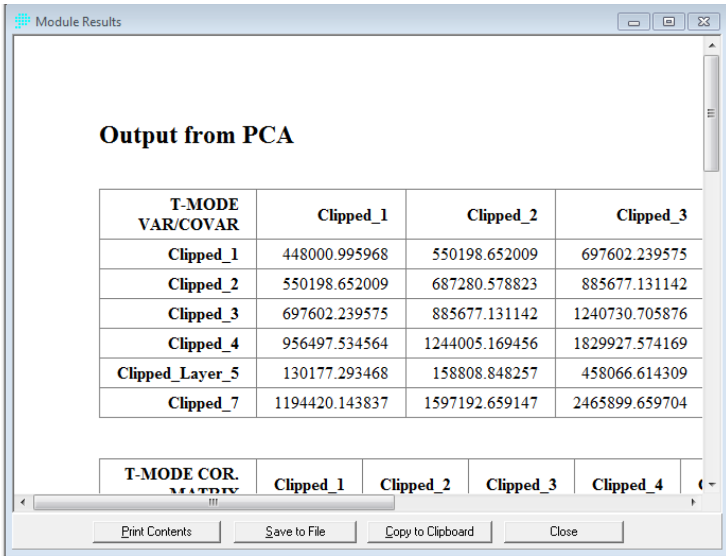


Figure 4.3.1

After you click "OK," IDRISI will return a screen similar to the one below. Click "save to file" in the window. Although at first this output seems difficult to make sense of, essentially the computer is constructing a variance/covariance matrix in which orthogenality is maximized with the addition of each new band.. When this orthogenality is maximized, it becomes easier to see how new inputs into the system (bands) actually change the image.



T-MODE VAR/COVAR	Clipped_1	Clipped_2	Clipped_3
Clipped_1	448000.995968	550198.652009	697602.239575
Clipped_2	550198.652009	687280.578823	885677.131142
Clipped_3	697602.239575	885677.131142	1240730.705876
Clipped_4	956497.534564	1244005.169456	1829927.574169
Clipped_Layer_5	130177.293468	158808.848257	458066.614309
Clipped_7	1194420.143837	1597192.659147	2465899.659704

Figure 4.3.2

Now open the “display launcher” and experiment with opening the new files (called PCAcmp.1, PCAcmp.2, etc.). Display these in greyscale; displaying in greyscale is to be preferred here considering that when comparing two or more bands with each other, greyscale is better because it is more consistent across the bands (black always represents areas of lowest intensity, white almost always represents areas of highest intensity). Moroever, when comparing between different images, colors sometimes can signify different values. Experiment with the ranges in the layer properties so that contrast is maximized.

Now, we will display a composite PCA.

1. Click “display” and then “composite.”
2. Input **PCAcmp3** for the blue band.
3. Input **PCAcmp4** for the green band.
4. Input **PCAcmp5** for the red band.
5. Name the file **PCAfcc543.**
6. Click “OK.”

The map should look similar to the one below. Although it looks quite strange right now, we are not done yet (we will now do a correlation analysis).

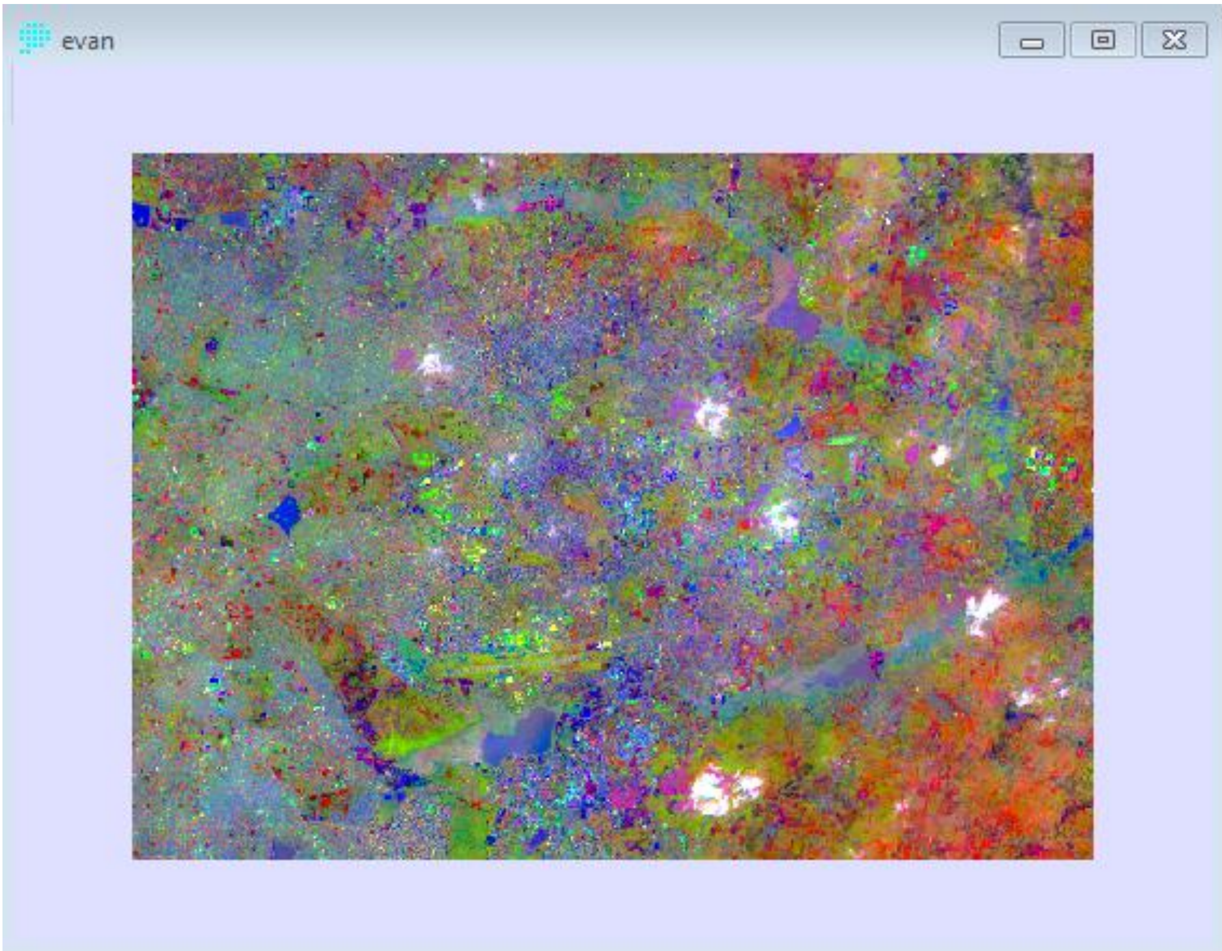


Figure 4.3.3

4.4 Decorrelation Analysis

To translate the image above into something more useful, we will conduct a PCA decorrelation stretch. Essentially what this tool does is it first conducts a traditional PCA and then the data is stretched to maximize contrast and a reverse PCA is done before the data is reformatted back to the original space.

1. Start the “scalar” program.
2. The input image is **PCAcmp3** and the output image you should name **PCAcmp3_b.**
3. Type a scalar value of two and ensure that this being multiplied.
4. Do the same exact process for **PCAcmp4** and **PCAcmp5.**

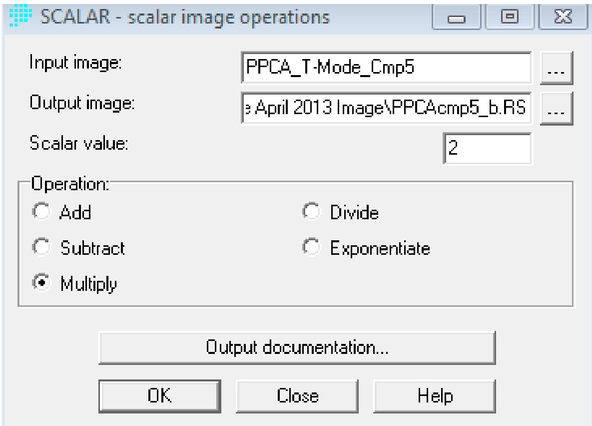


Figure 4.4.1

Now, we must create a raster group for five different files (“PCAcmp3_b,” “PCAcmp4_b,” PCAcmp5_b,” “PCAcmp3,” and “PCAcmp6”) using the same method outlined earlier. Call this raster group “raster group 2.” Rename this file under IDRISI explorer as PCA2.

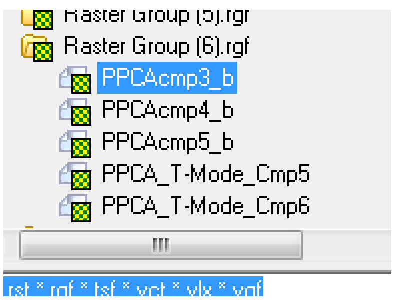


Figure 4.4.2

Now, we need to find the eigenvector file that we made earlier. However, this is currently not being displayed because it is not a raster file.

1. Go to IDRISI explorer and click on files.
2. Go to the bottom of the top pane and click on the drop down menu.
3. Click “All Files.”
4. Find the file that we made earlier (**PCA.eig**) and right click on it to select.
5. Rename the file **PCA2.eig**

Again, go to the PCA window. In the window, click “Inverse T mode.” Input the raster group made earlier ((RasterGroup (2)) and the eigenvector file that we just pulled up and renamed (“PCA2”). The “list of components to be used is 1-4 and the output bands are 1-6. Use a prefix of “décor.” Click “OK.” Nothing will be immediately displayed.

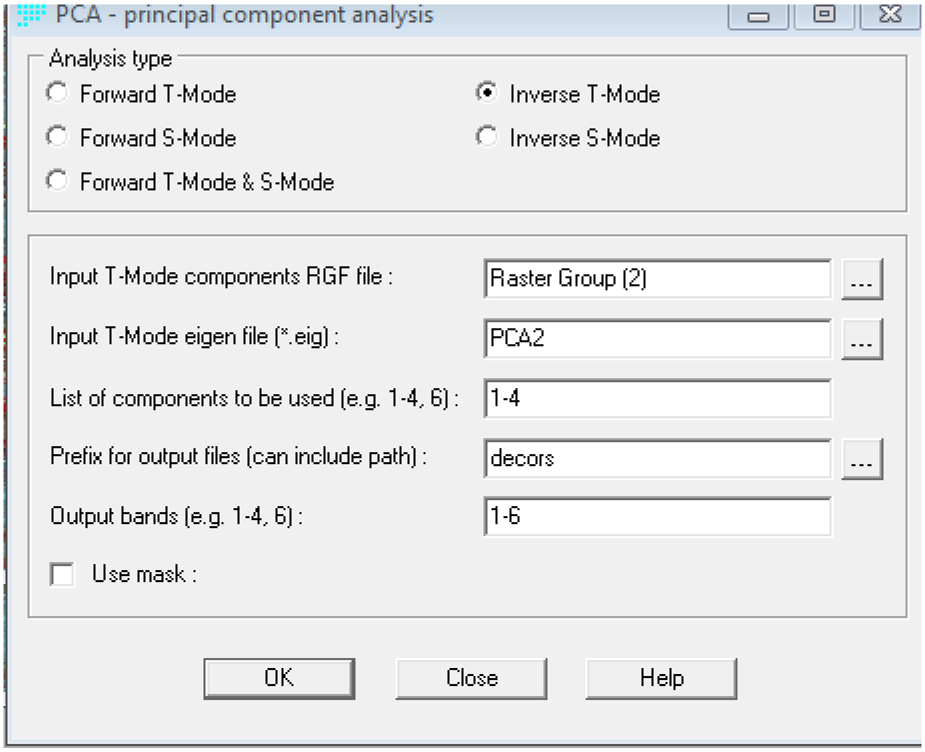


Figure 4.4.3

To display what we have just made, make a composite image, with **décor_3** being the blue band, décor_4 being the green band, and **décor_5** being the red band. Name the output image **543_decor_final.** Click "OK."

This is what the image should look like the first image on the following page. Compare this image with an original 5,4,3 composite made earlier in the lab manual to see how the image has been cleaned. Pay particular focus to the bottom-right side of the image, where the haze now appears weaker in the cleaned up image. To this end, you might want to link the images and zoom in and out (although the improvements are relatively minor because the original image was very good quality).

Discussion Questions:

Why is it so important to linearly uncorrelate the variables through the PCA analysis? What would happen to the image if the variables were not made orthogenal to each other? Can you explain the concept of eigenvectors?

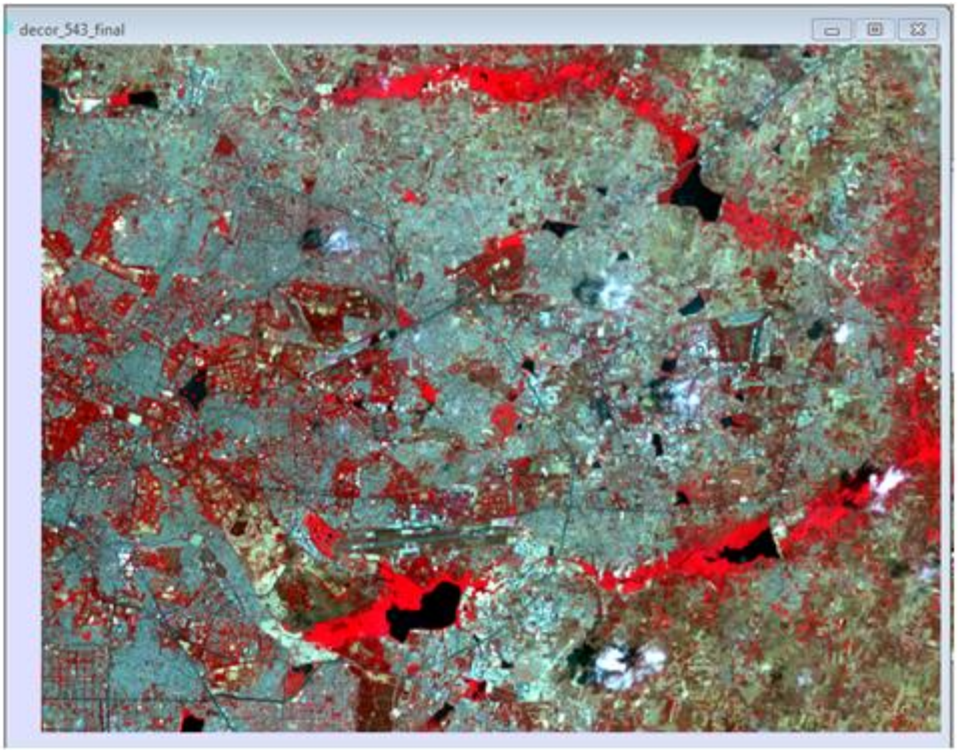


Figure 4.4.5

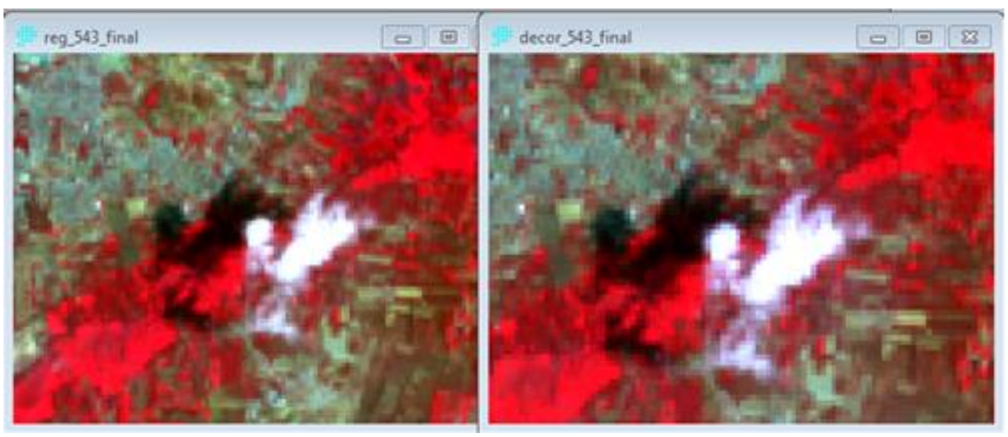


Figure 4.4.6

Chapter 5: Radiometric Calibration

Goals:

- Compare the image of Bangalore 2003 with the image of Bangalore 2013
- Create a multi-temporal false color composite
- Digitizing change areas on the multi temporal composite
- Conduct a regression analysis
- Create an Image Differencing analysis

Materials:

- Access to IDRISI
- Access to Bangalore2013 and Bangalore 2003 images

Radiometric Calibration is the process of altering images to improve the spectral accuracy. This can help improve the reflectance, emittance, or back-scattered measurements.

In this lab, we will look at Bangalore images of 2003 and 2013 and compare them. The tasks we will do are:

Radiometric normalization

Image DN values are adjusted to reduce variation due to atmospheric transmission, and other scattering properties. This helps compare two images of the same location but different time periods due to clouds or other atmospheric variables that could affect reflectance.

Radiometric Normalization Methods:

1) **Radiance difference:** The RADIANCE tool in IDRISI consists of two things. First it takes all the atmospheric factors based on its date, time, and location and calibrate images with less noise. Second, the tool puts the image back into radiance units. **This will not be performed in this lab.**

2) **Regression Relationship:** The regression analysis compares the DN value of each pixel between the two images. The value of image A would be on the x axis and the value of image B would be on the y axis. A regression line that shows no change between the two images would all the values on a y-x line, because a DN value of 2 for image A would also be a DN image value of 2 for image B. We will create a regression graph to help find the regression equation. The equation will then be used to normalize the image. We will then extract our regression formula from this graph and use it create an image that follows this formula.

Rasterized Mask: We want a regression line with the least amount of change between the two images. Less change between the two images will help create a better regression formula to create the normalized image. That means we will clip out the parts of the image where the most change occurs between the 2003 and 2013 images. That way the regression analyisis only looks at pixels the have similar DN values in both the 2003 and 2012 image. We create a mask to cut out the area that has a lot of change, and then create the regression with the remaining pixels.

5.1 Preparatory

Create a new project file and specify the working folders with the IDRISI EXPLORER

Menu Location**: File - IDRISI EXPLORER**

12. Under the Projects tab, right click and select new Project
13. The 2013 Bangalore images can already be found in **C:IDRISI_Tutorial\Bangalore_Chapters1-5** named as **BangOrig_1** to **BangOrgi_11**. To avoid confusion with 2003 images, you may want to right click and rename these **BangOrig13_1**.
14. Import Bangalore 2003 (ex. LE71440512003068SGS00_B1-7)**.** If you forget how to import, refer to Chapter 1.5.
15. Name the images for 2003 **BangOrig03_B1-7** and name the 2013 images **BangOrig13_B1-7**
16. If you cannot see the imported images in the files tab, close IDRISI Explorer and open it again.
17. Create two raster groups: one for the 2003 images named Bangalore2003 and one for the 2013 images named Bangalore2003. Follow section 1.7 to create raster groups

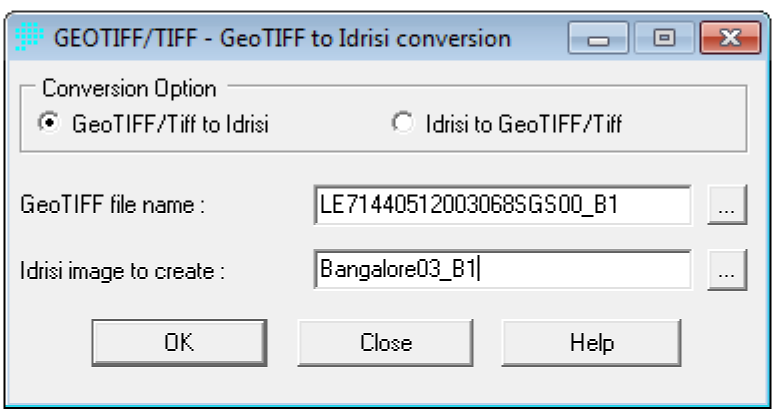


Figure 5.1.1, GEOTIFF Window

5.2 Clip

Clip Bands 5 and 4

Menu Location: **Reformat – Window**

10. Follow 2.2 how to clip the images
11. Name the output image as **clipped13_b5**
12. Enter the upper left column, row coordinates of 1500 and 1000; and the lower right column and row coordinates of 6000 and 6000
13. Click *OK*
14. Do the same steps 1-3 to clip 2003 image band 4. Name it **clipped03_b4**

15. Because we want the 2003 band 4 (infra-red) image do be the same size clip as the 2013 band 5 image(also infra-red), choose the radio that says *An existing windowed image* under *Window specified by*
16. Click on the pick list and choose **clipped13_b5**
17. Click *OK.*

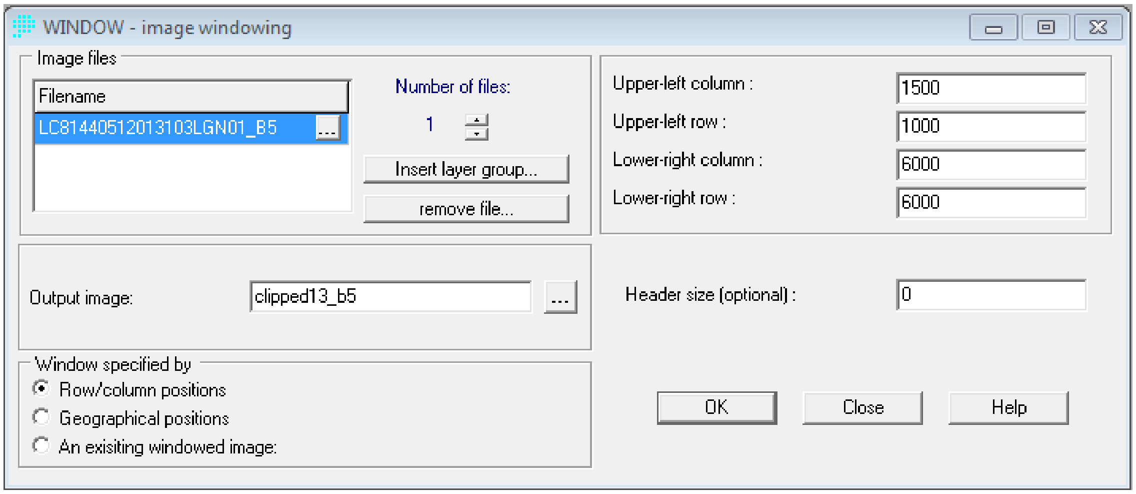


Figure 5.2.1, WINDOW Window

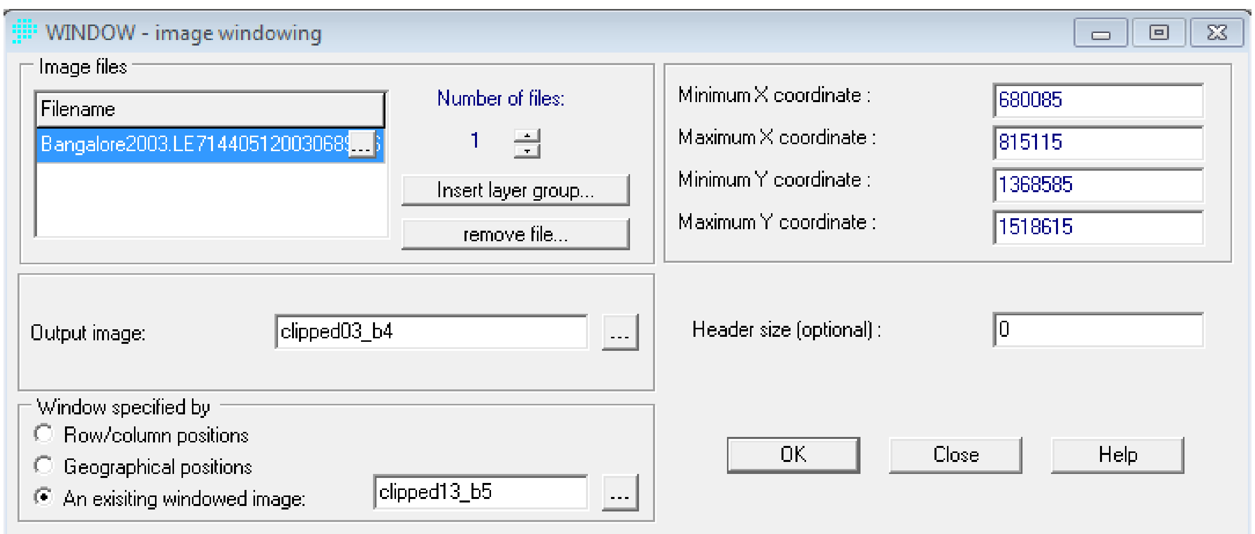


Figure 5.2.2, WINDOW window

5.3 Image Normalization through Regression

Create temporal Display

Preparing a multi-temporal false color composite
Menu location: **Display – DISPLAY LAUNCHER**
13. In the DISPLAY LAUNCHER window, click On the click on the pick list and choose

clipped03_b4

14. Choose Grey Scale under Palette File
15. Click *OK*
16. In the *Composer* dialog box, click on the *red* button at the bottom of the window
17. The image should now be displayed red

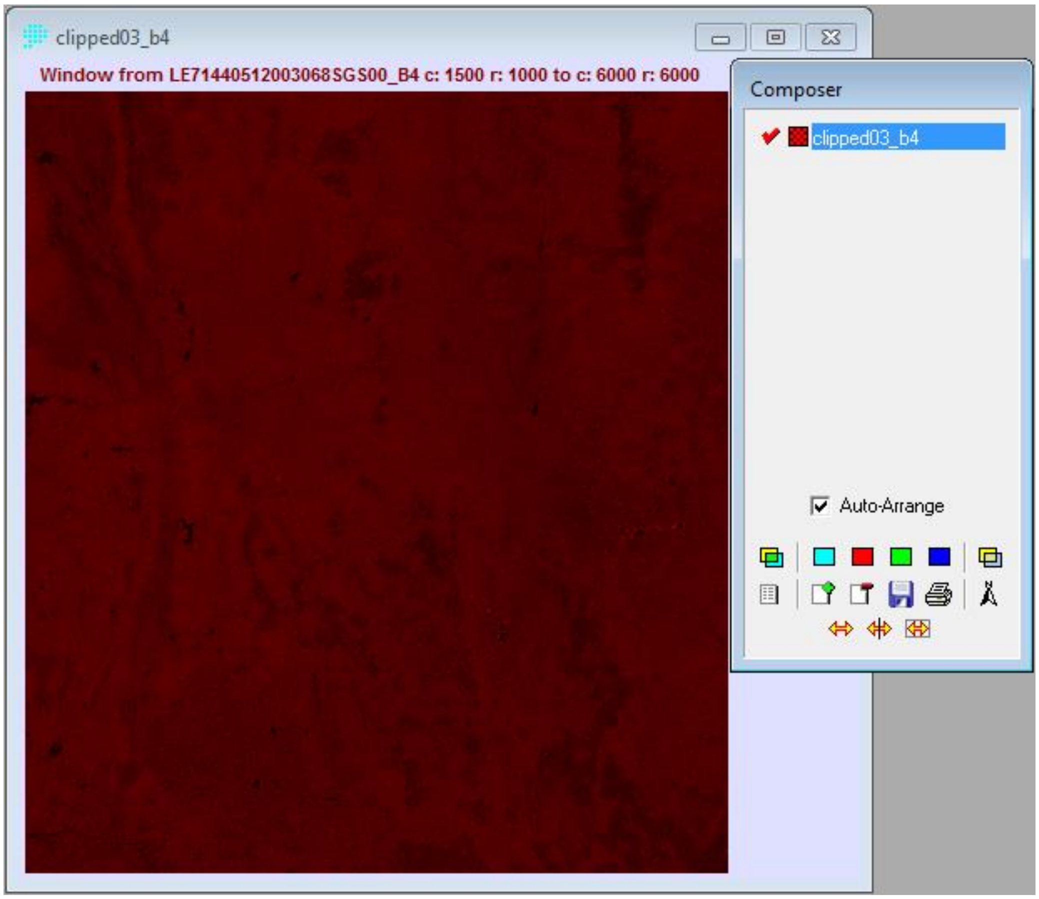


Figure 5.3.1, 2003 Bangalore image after clicking on red button

Preparing a multi-temporal false color composite (cont.)

18. In the composer dialog box, click *Add Layer*
19. The *Add Layer* dialog box will open
20. In the *Add Layer window,* click on the *Raster Layer* radio button under *File Type*
21. In the pick list, choose on **clipped13_b5**
22. Click *OK*
23. The **clipped13_b5** image will now be placed on top of the **clipped03_b4,** but transparently so that both images can be seen at once. Both images are listed in the composer dialog box
24. With **clipped13_b5** highlighted in the composer box, click on the button for the green layer at the bottom of the window.
25. Repeat steps 6-10 with band **clipped03_b4** and select the blue layer.

The maroon and blue shows what is displayed in the 2003 band for image, and the green shows what is displayed for Bangalore 2013 band 5 image. Areas that are strongly colored are areas with significant change. The gray areas are places with little change.

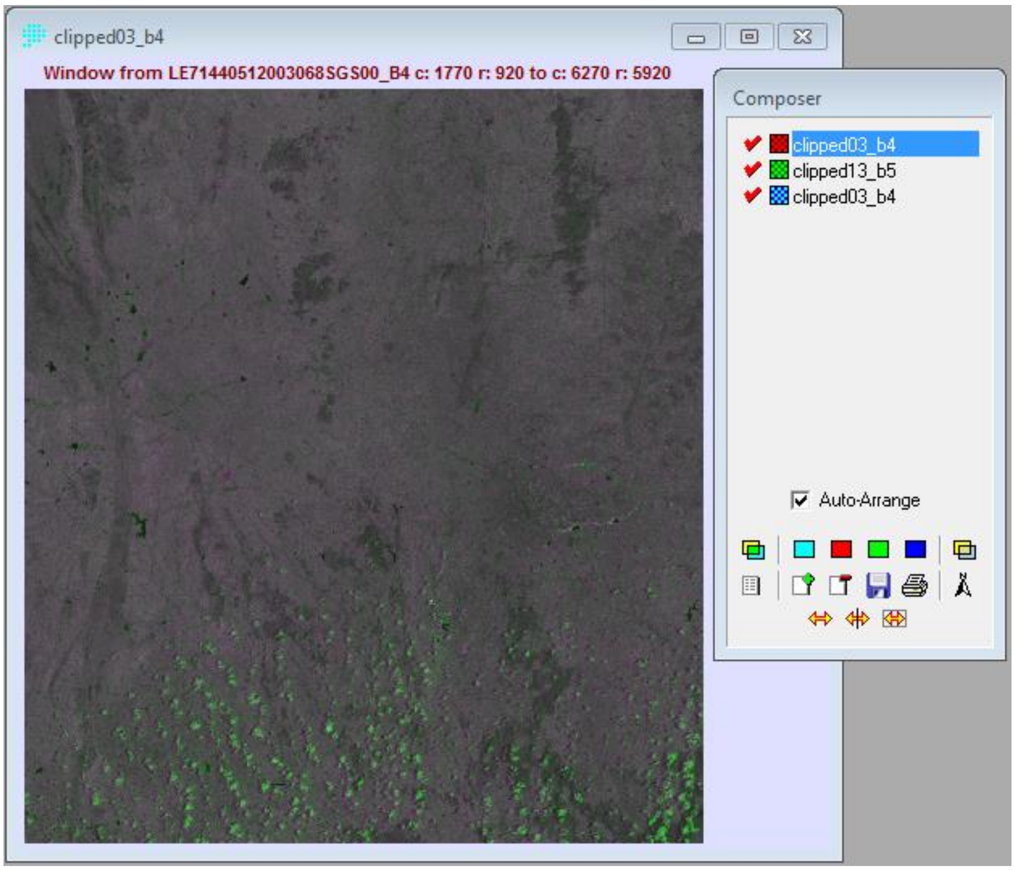


Figure 5.3.1, Bangalore Multitemporal false color composite: 2003 as Magenta, 2013 as 2013

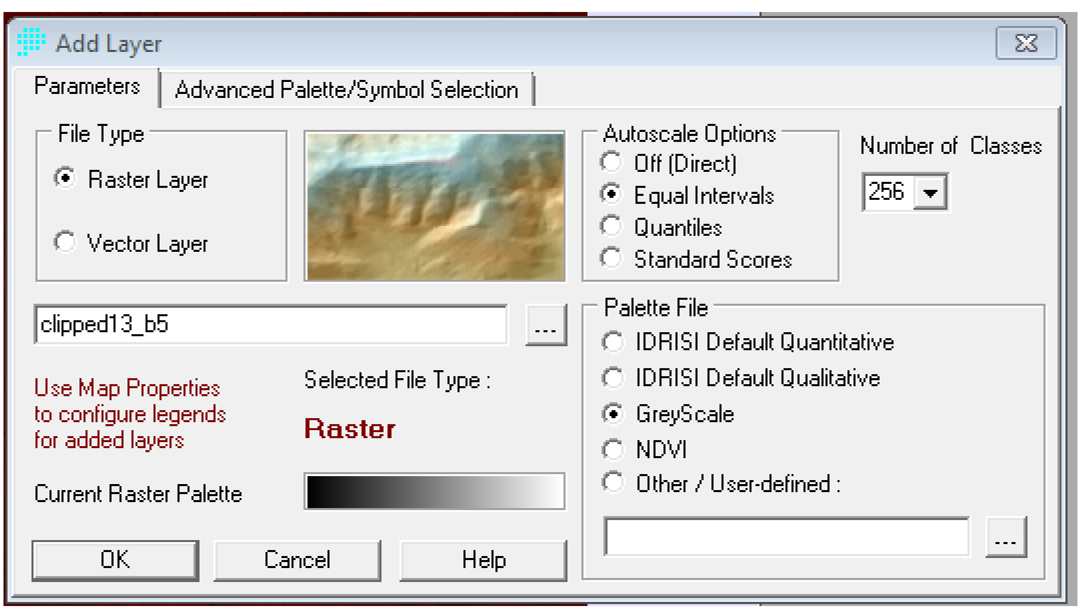


Figure 5.3.2, Add Layer window

5.4 Digitize change Mask

To take out the change areas, we are going to mask them with a DN value of 0. The remaining pixels will be used for the regression analysis

Digitizing change areas on the multitemporal composite
1. Make sure the multi-temporal composite is still displayed. 2. From the main icon toolbar, click on *Full extent normal*  3. Click on *Full extent maximized*  4. Select the *Digitize* icon  5. In the *Digitize* dialog box, select **Mask** under *Name of layer to be created* 6. In the text box for *ID or Value,* enter 0 7. Click on *OK* 8. To digitize the image, click on the image to create line segments, and create a polygon around most of Bangalore. Close the polygon by clicking on the first line segment. Digitize most of the image, except for the top left corner as shown in the image below. 9. Right click to close the polygon 10. Click on the icon *Save digitized data*  11. Close the *DISPLAY* window.

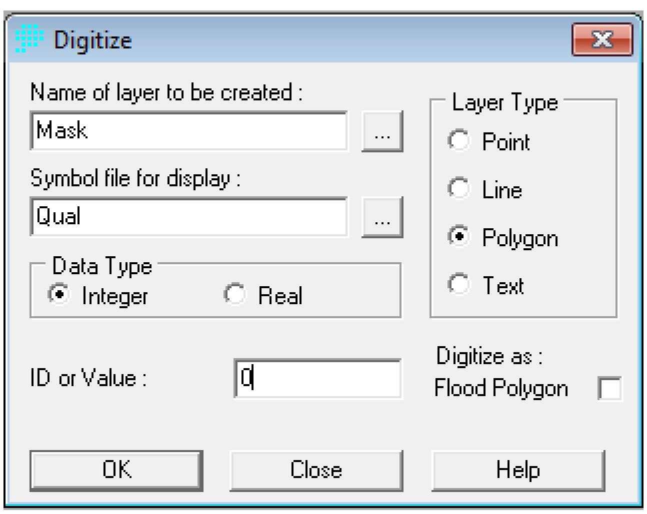


Figure 5.4.1, DIGITIZE Window

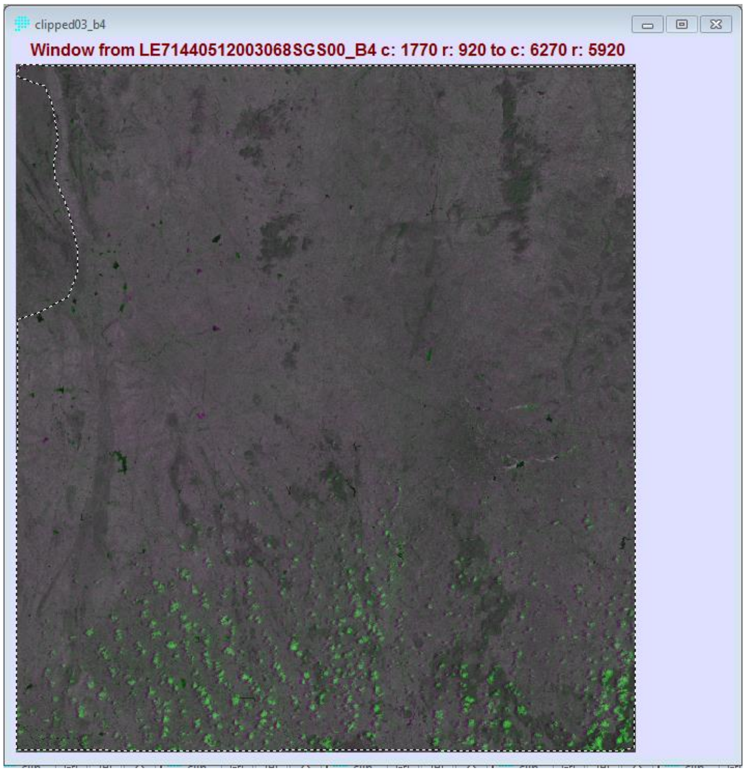


Figure 5.4.2, Digitizing the changed areas before right clicking

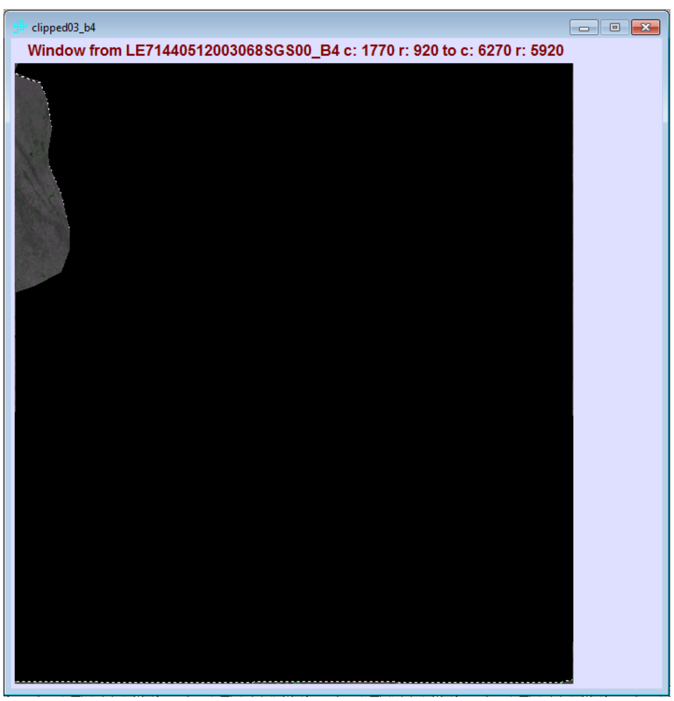


Figure 5.4.3, Rasterized mask of changed area

5.5 Rasterize the vector mask

The mask is a vector file that has to be rasterized. To rasterize we must first make a blank value where every pixel has a value of 1. Then we use the vector file to create the mask shape on top with pixel values of 0.

Create a new file prior to rasterization
Menu location: **Data entry - INITIAL**
1. Under the initial window, choose the radio *Copy spatial parameters from another image* 2. For the Output image, choose Mask under the pick list window 3. For *Image to copy parameters from,* choose **clipped03_b4** in the pick list window 4. Output data type should be *byte* 5. *Initial value* must be 1 instead of 0 6. Click *OK*

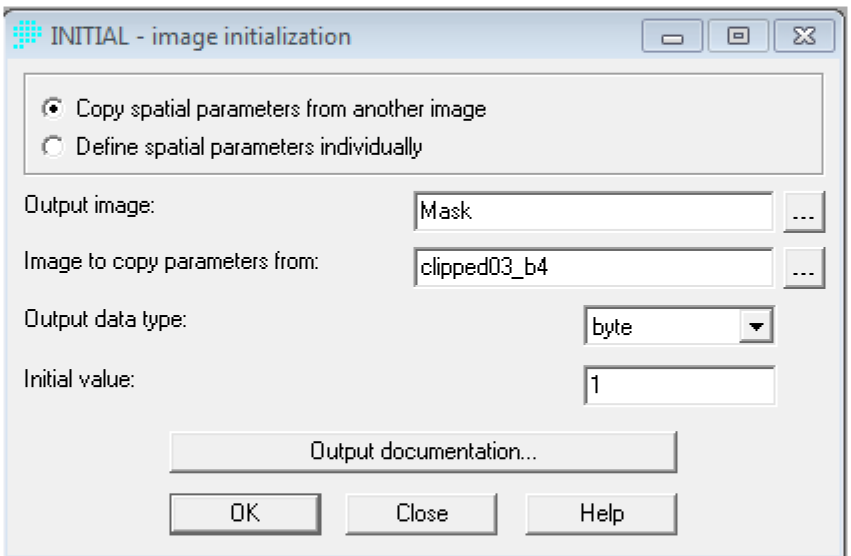


Figure 5.5.1, INITIAL Window

Now that we have the vector file, we need to clarify that all the pixels in the masked area have a value of 0.

Rasterize the vector file with the polygon of change areas
Menu location: **Reformat - RASTERVECTOR**
1. In the RASTERVECTOR window, under conversion option, choose *Polygon to Raster* 2. In the *Vector polygon file* text box, choose ***Mask*** under the pick list 3. Under *Image file to be updated* text box, choose ***Mask*** under the pick list **4.** Click on *OK*

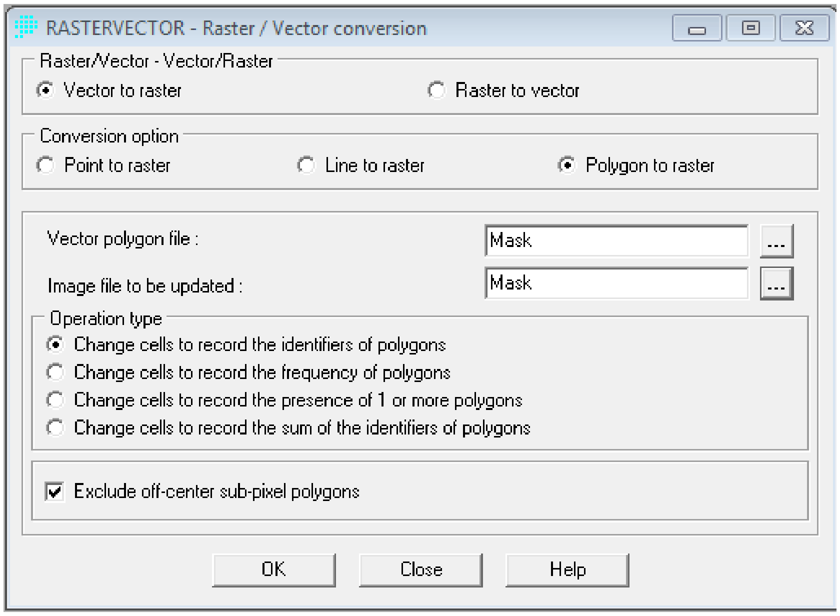


Figure 5.5.2, RASTERVECTOR Window

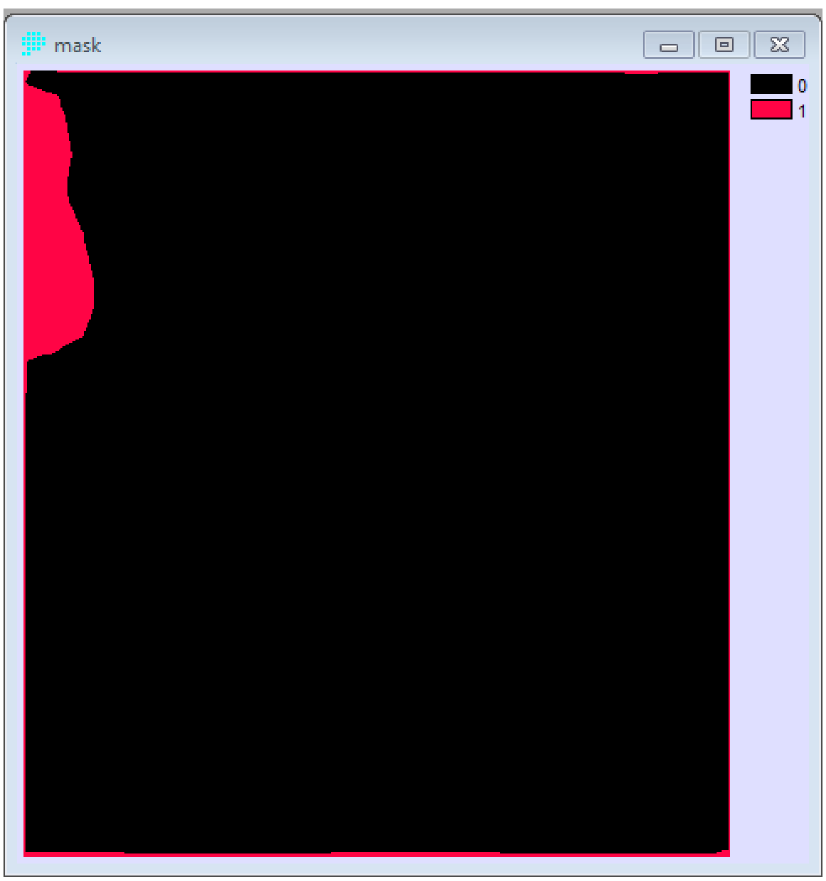


Figure 5.5.2, MASK Window

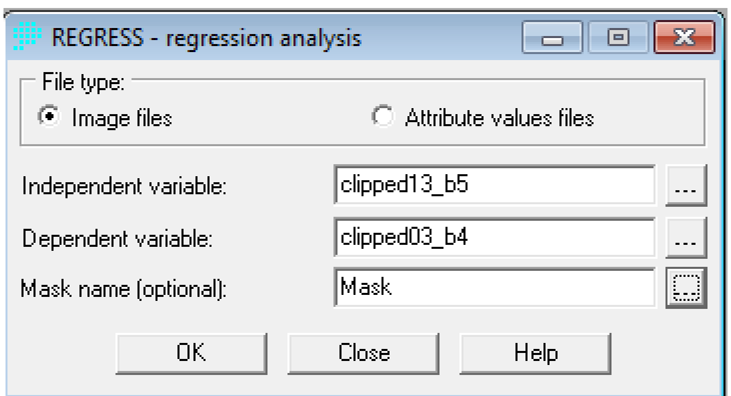
5.6 Regression of the masked imagery

We will make a regression analysis equation that shows us 2003 DN values that have no or little change compared to 2013 DN values. The formula we are looking for is:

2013 DN = a +b *2003DN

Where a and b are the regression parameters. Therefore, we will specify the 2013 as the independent and 2003 as the dependent variable in the regression.

Regression Estimation
Menu location: **GIS Anlaysis – Statistics - REGRESS**
1. Under *Independent variable* click on the pick list and choose **clipped13_b5** 2. Under the *Dependent variable* click on the pick list and choose **clipped03_b4** 3. Under *Mask Name,* click on the pick list and choose Mask. 4. Click *OK* 5. The regression equation is on top of the graph. Write this down for the normalization calculator.



5.6.1, REGRESSION Window

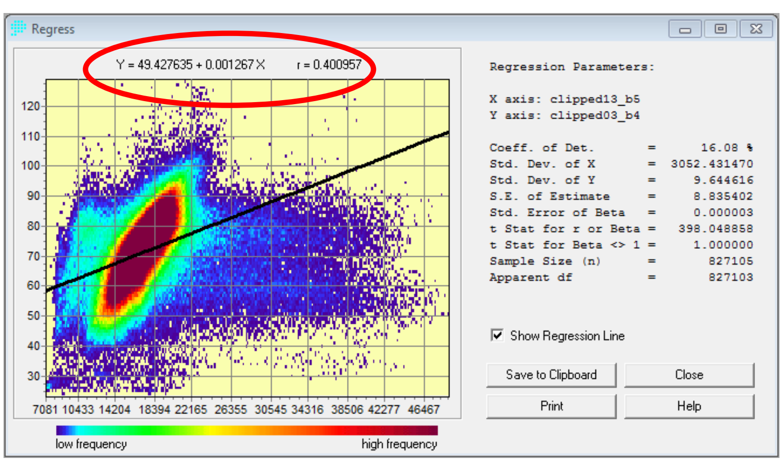


Figure 5.6 Regression of 2013 band 5 and 2003 band 4. Each point shows the DN value was in 2003 (x axis) and the DN value in 2013 (y axis). The color spectrum shows how frequently these pixels occur, for example it it is very frequent to have a pixel that had a value of 14204 in the 2003 image and a value of 70 in the 2013 image.

5.7 Normalize 2003 data using the regression equation

With this graph, we now have the regression equation that we can use to create a band image with regression. This image will have less noise than the original image.

Apply normalization equation
Menu location: Modeling – Model Deployment Tools – IMAGE CALCULATOR
1. In the *IMAGE CALCULATOR* window, enter in the *Output file name* text box = **clipped03_b4_regress** 2. In the *Expression to process* text box enter regression equation found in the regression analysis 3. Use* to represent multiply 4. Instead of entering X, click on the button for *Insert Image.* 5. In the resulting pick list, double click on **= clipped03_b4.** The equation becomes: *49.427635+.001267*[clipped03_b4]* 6. Click on *Process Expression* 7. The output image will be displayed automatically

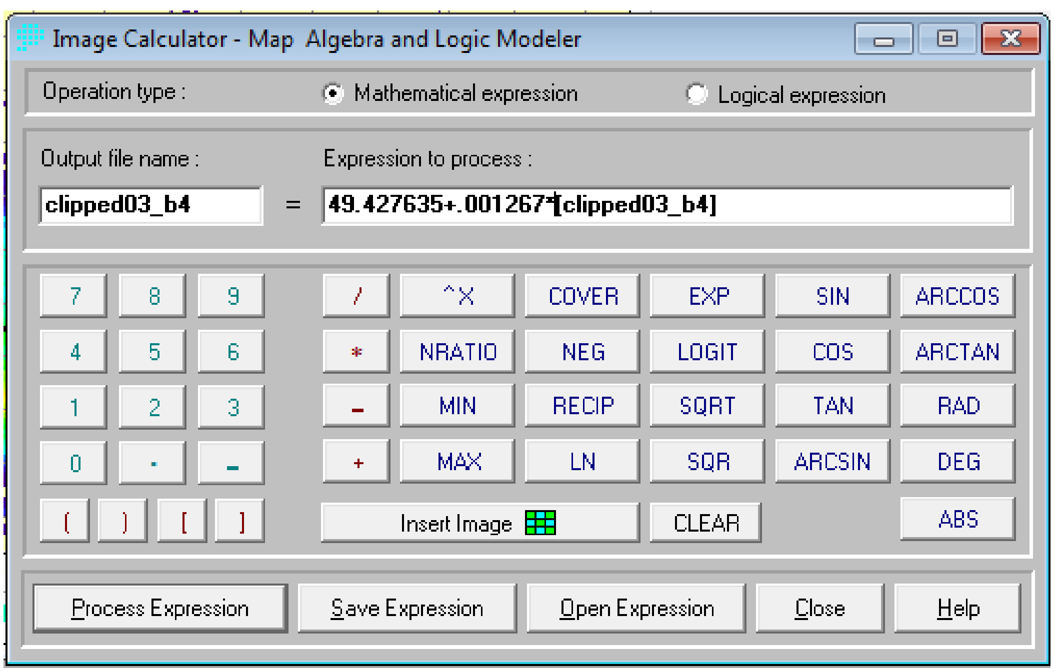


Figure 5.7.1, IMAGE CALCULATOR Window

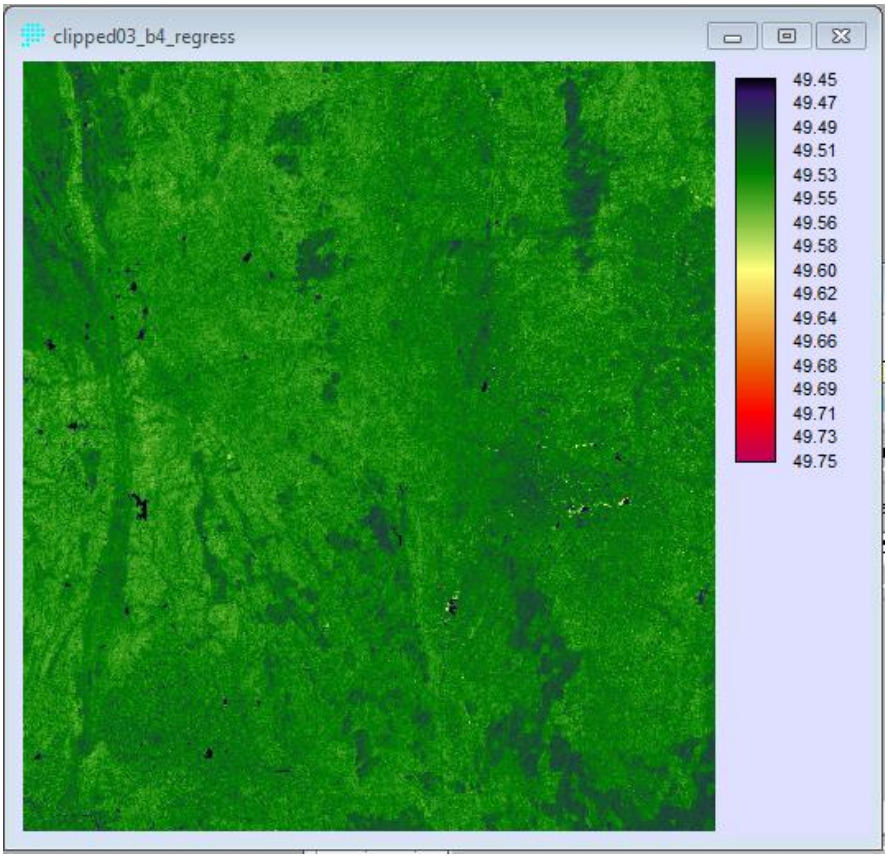


Figure 5.7.2, Regression image of 2003 Bangalore

5.8 Spectral Change Detection

Now that the images have been normalized, we can now perform an image subtraction where we can see the change in DN values from the 2003 images to the 2013 images.

Image differencing
Menu location: GIS Analysis – Change/Time Series - IMAGEDIFF
1. For *Earlier image,* go to the pick list and double click on **CLIPPED03_b4_REGRESS** 2. For *Later image*, go to the pick list and choose **clipped13_b5** 3. For *Output filename,*name it **03-13-imagediff** 4. For the *Output option,* select the radio button for the *standardized class image.* 5. Click *OK* 6. IDRISI will display the resulting image.

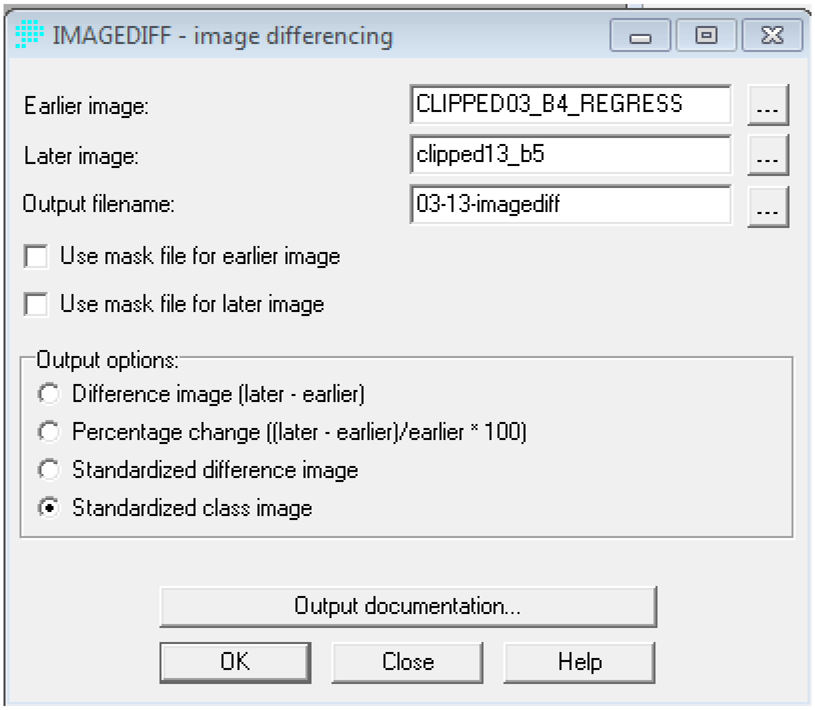


Figure 5.8.1 IMAGEDIFF Window

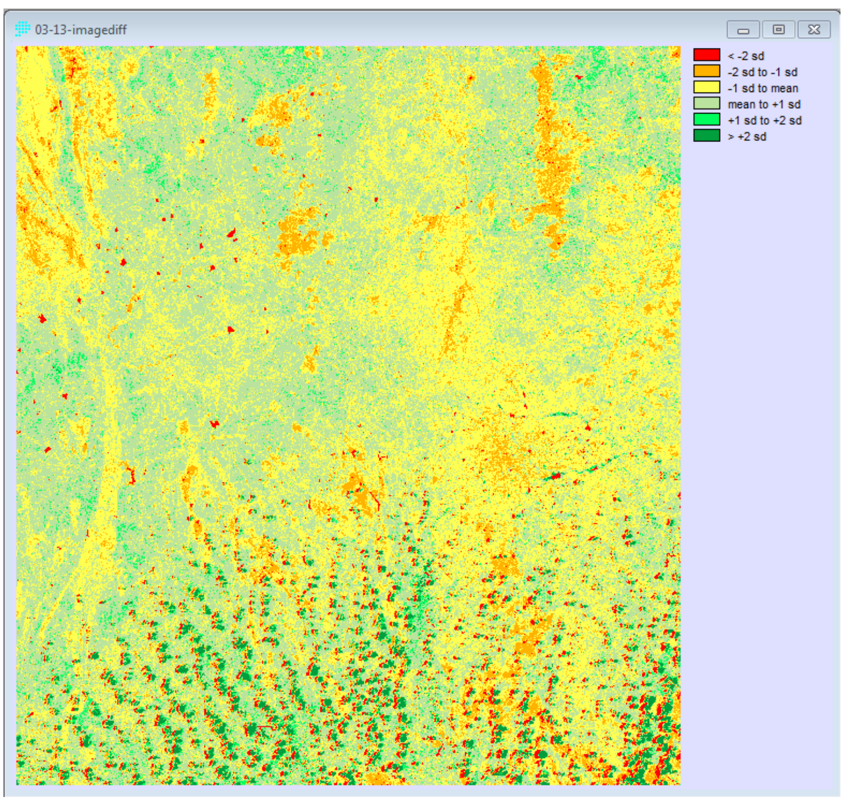


Figure 5.8.2 Results of image differencing using band 4 for 2003 and band 5 2013 (both the infrared band.)

To focus in on downtown Bangalore, zoom in or adjust the window.

Zoom in to Bangalore
1. Click on the Zoom In/Center Button. A magnify glass should appear as the cursor. 2. Inside the **03-13-imagediff** click to zoom in. 3. To move around within the window, click on the Zoom In/Center Button again. A hand should appear as the cursor 4. Hold down to move about the window

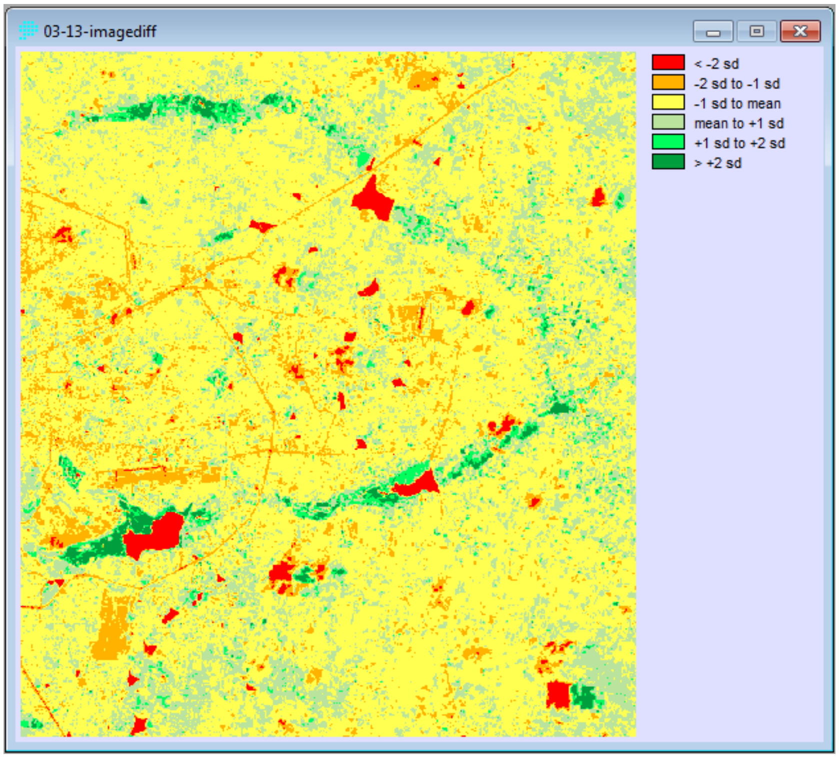


Figure 5.8.3 Zoomed in image of Bangalore

5.9 Compare with original

To compare the image difference with regression, repeat 5.8. Instead of choosing **CLIPPED03_b4_REGRESS** as the *earlier image* in the IMAGEDIFF, choose clipped03_b4

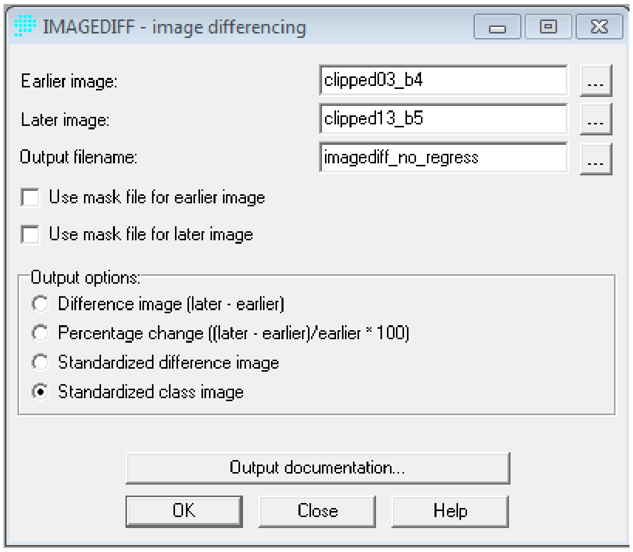


Figure 5.9.1 IMAGEDIFF window with original clipped03_b4

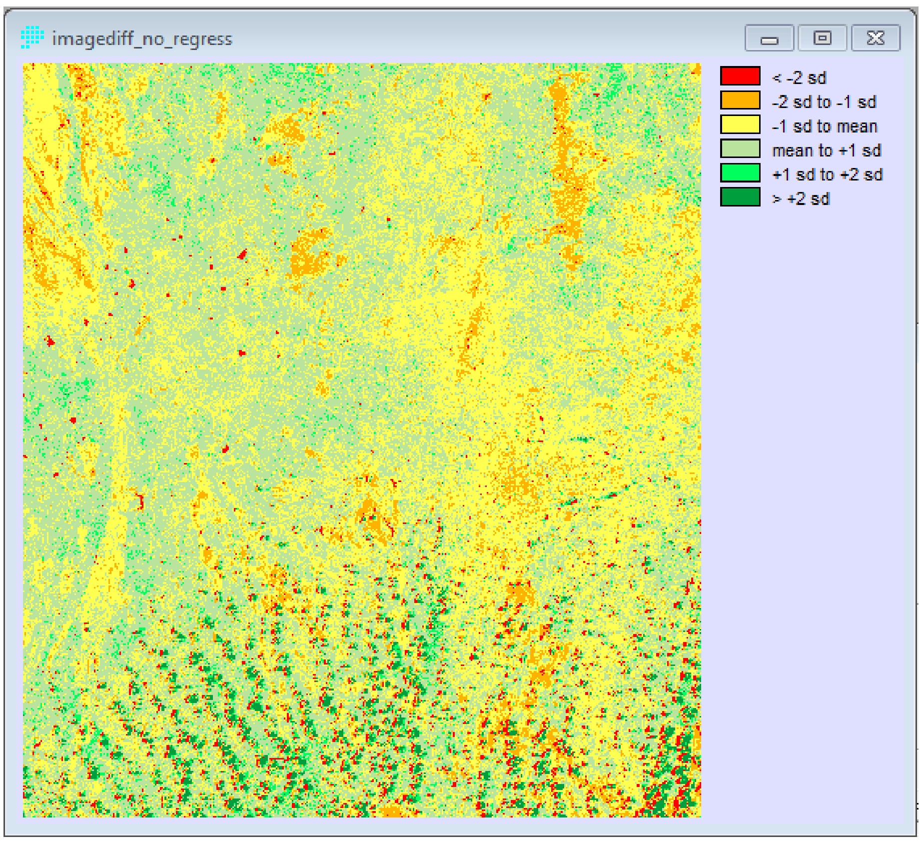


Figure 5.9.2 output image after performing Imagediff

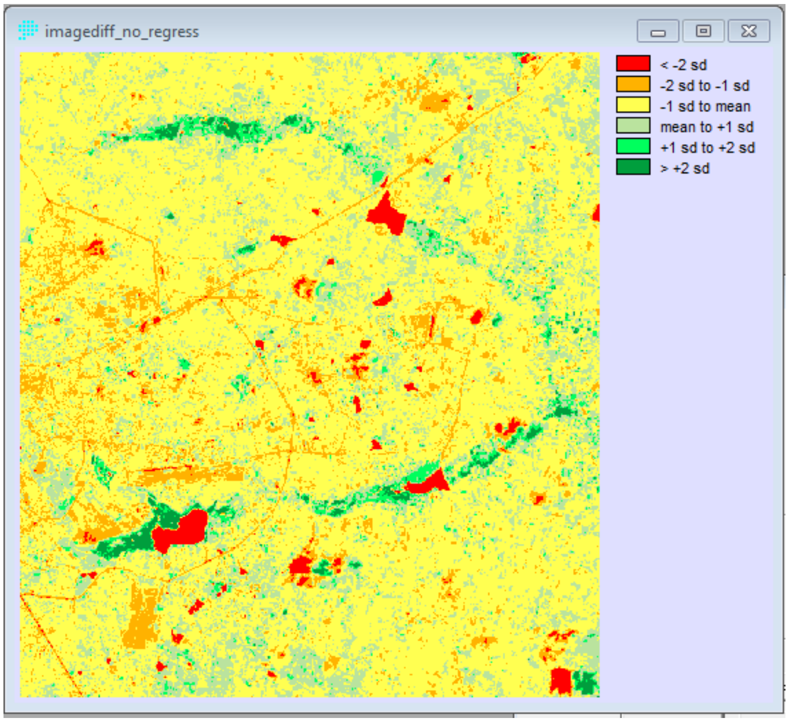


Figure 5.9.3 Zoomed in image of Bangalore

5.10 Check for understanding

Tasks you should be able to do after this lab:

- Create multi temporal composite
- Digitize a mask creating a vector file
- Perform a regression analysis and use it to find the equation regression
- Create a normalized regression image using the IMAGE CALCULATOR
- Perform Spectral Change Detection using Image Differencing

Here are the bands that should have been created during this lab:

- Bangalore03_B1-7
- Bangalore13_B1-7
- clipped03_b4
- clipped13_b5
- Mask
- CLIPPED03_b4_REGRESS
- 03-13-imagediff

Discussion questions:

Compare the image difference images, the one with normalization regression of 2003 band 4 image, and the one with the original 2003 band 4 image. What differences do you see? What are some of the similarities? What do the image difference images tell us about 2003 band 4 versus 2013 band 5?
What do the colors in both images correspond to?