Application of Remote Sensing in Radiometric Correction for Empirical Line Calibration and Spectral Analysis

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Abstract

A radiometric correction has being used to improve the quality of atmospheric scattering often called haze. The atmosphere maintains balance through solar radiation of Albido, reflection, absorption and scattering. The technology to correct anomalies to have a clean-up viewing of the atmosphere is defined in remote sensing where the GIS data can be modeled. The data can be classified in the cluster classification of Landsat TM image from non-radiometric image correction such as digital elevation model DEM, or digital terrain model DTM. The idea is that using both GIS and remote sensing technology will enhance the illumination on the earth terrain as well as the earth-atmosphere. Urban areas classified with vegetation, or without vegetation, savanna, shrublands, grassland and arid region. Radiometric correction helps in estimating surfaces and spectral analysis of optical depth, sensor calibration. The results obtained depict vegetation dynamics.

Keys words: radiometric correction; remote sensing; GIS; DET; DTM

INTRODUCTION

Empirical Line Calibration

The empirical line method is an atmospheric correction technique that provides an alternative to radioactive transfer modeling approaches. It offers a relatively simple means of surface reflectance calibration, providing that a series of invariant-in-time calibration target measurements are available. This technique has been applied with variable success to both airborne data and coarser spatial resolution satellite sensor data Hall (1991). However, with the advent of higher spatial resolution space-borne sensors there is a need to re-evaluate its potential. The empirical line method was tested for correcting multispectral IKONOS imagery acquired over the tropical island of San Andres, Colombia. The high spatial resolution (4 m) of the data made it possible to identify a number of homogeneous targets with a range of reflectance that was used for the calibration. Coefficients of determination of the prediction equations observed were large, ranging from 0.96–0.99 for each of the four wavebands. An accuracy assessment was performed using a set of independent targets. It demonstrated that the empirical line method can be applied to correct such imagery with accurate results. Goldberg (2007)

| Ground Feature	Bands Used	Contrast Manipulation	Limits
Water	1,2,3; 1,2,4; 1,4,5	No	No
Urban	1,2,3; 1,4,5	Yes band 4 (1,4,5)	Yes band 4 (1,4,5)
Farmland	1,2,3; 1,4,5	Yes band 4 (1,4,5)	Yes band 4 (1,4,5)
Forest	1,2,3; 1,4,5	Yes band 4 (1,4,5)	Yes band 4 (1,4,5)
Salt Scald	1,2,3; 1,4,5	Yes band 4 (1,4,5)	Yes band 4 (1,4,5)
Scrub	1,4,5	Yes band 4 (1,4,5)	Yes band 4 (1,4,5)
Parks/Golf	1,2,3	No	No

Land Cover Type	Spectral Band Combination
Water	Band 1, 4 & 7 / Band 1, 2 & 3
Urban	Band 1,4 & 7
Farmland	Band 1, 2 & 3
Forest	Band 1, 4 & 7
Salt Scald	Band 1, 2 & 3
Remnant Vegetation	Band 1, 4 & 7
Irrigated Vegetation	Band 1, 4 & 7

| Terrain Feature	Reflectance Response
Water Bodies	Generally reflect high in the visible spectrum, however, clearer water has less reflectance than turbid water. In the Near IR and Mid-IR regions water increasingly absorbs the light making it darker. This is dependent upon water depth and wavelength. Increasing amounts of dissolved inorganic materials in water bodies tend to shift the peak of visible reflectance toward the red region from the green region (clearer

Perform Empirical Line Calibration Using the IMAGINE Spectral Analysis Workstation

Prepare spectral profiles for the ELC preprocessed image and the original image for the following land cover types:
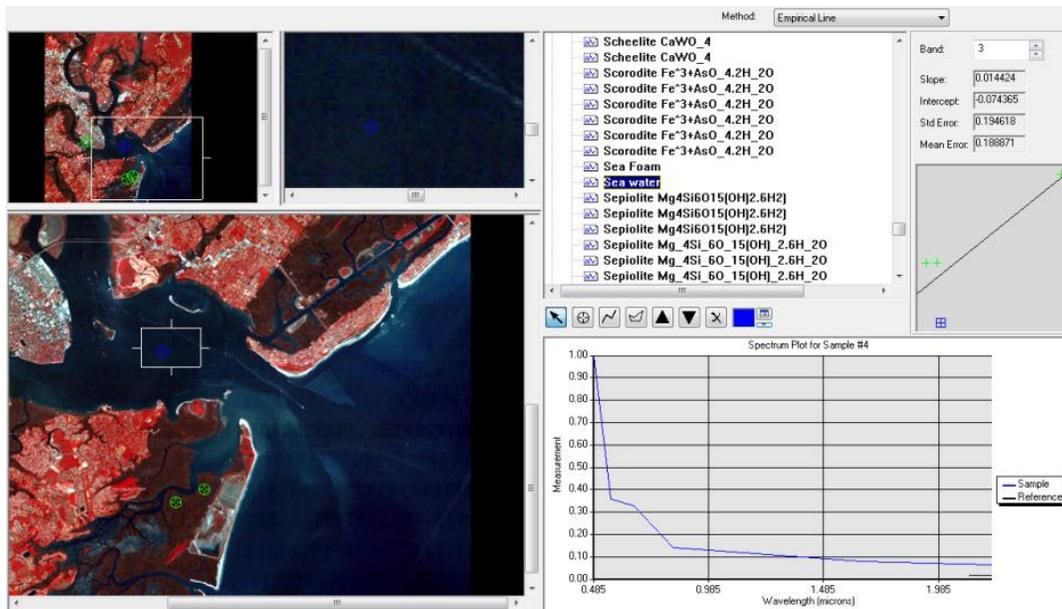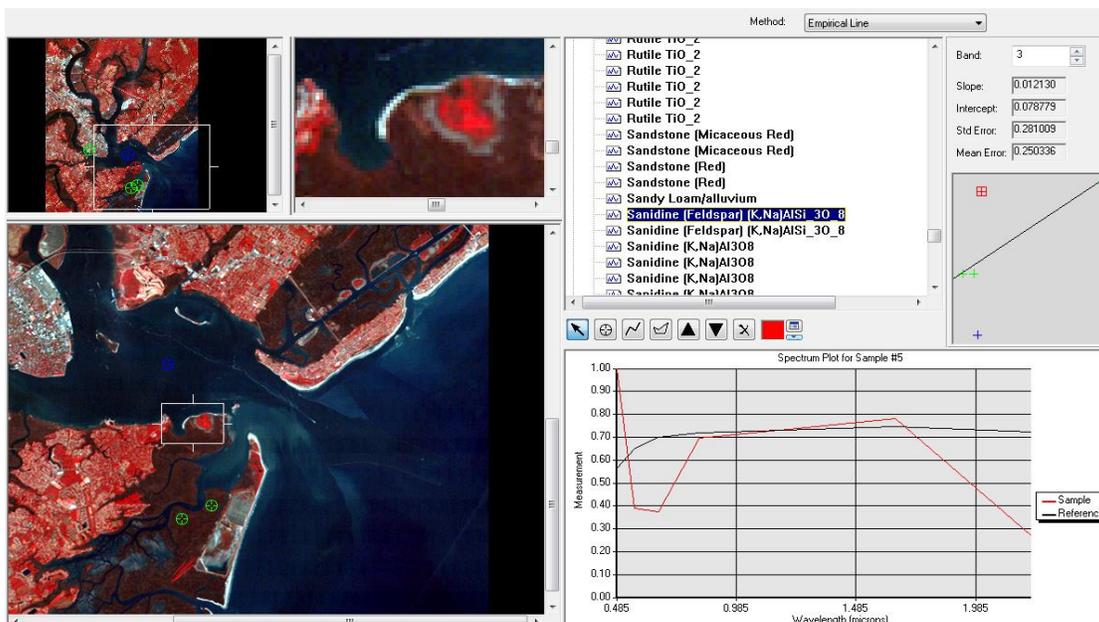
- Healthy Vegetation
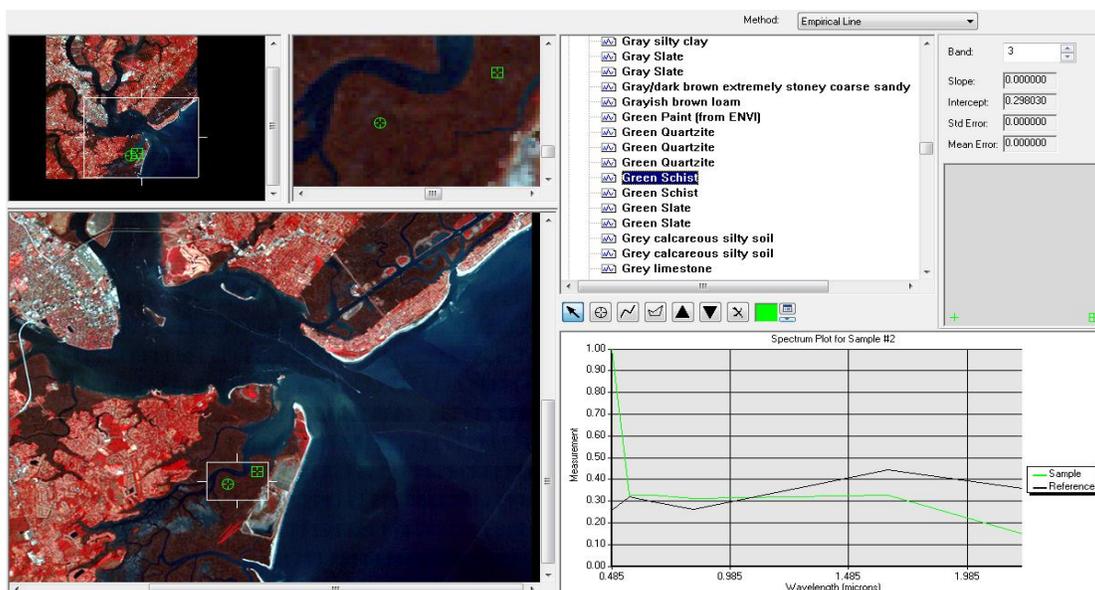
- Urban
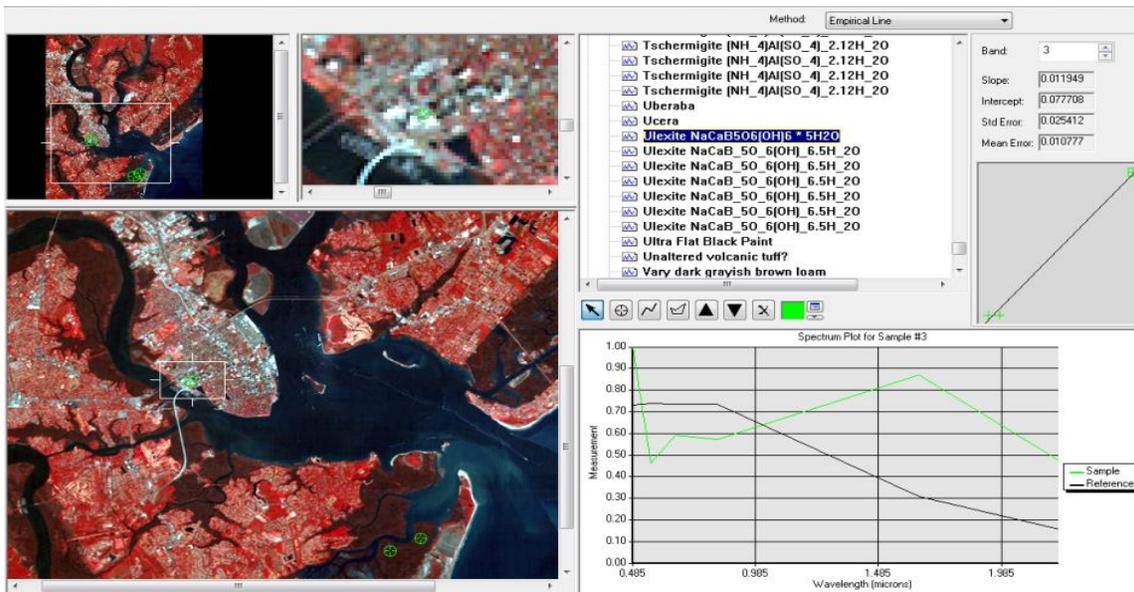
Sea Water

Beach

The empirical line method is an atmospheric correction technique that provides an alternative to radioactive transfer modeling approaches. It offers a relatively simple means of surface reflectance calibration, providing that a series of invariant-in-time calibration target measurements are available.When such empirical methods are applied it is essential to ensure that certain conditions are met, especially if there are no validation data to assess how well the empirical model has performed. The calibration targets used must be selected carefully to cover the whole range of reflectance, to be of an appropriate size in respect to the pixel size of the imagery and have as much as possible near-Lambert Ian properties. To ensure that wide ranges of reflectance are measured and to reduce extrapolation beyond the calibration data, preliminary spectral measurements should be made before final selection of the targets. If ground measurements cannot be made concurrent with the image acquisition then the targets should be spectrally stable in time. The empirical line method assumes that the effects of the atmosphere are uniform across the image, which often not the case is and that there are no differences in illumination across the image, i.e. due to shadows from topography or clouds (Smith and Milton 1999). For this study area the calibration targets were all within the scene to be corrected and the small coverage of the imagery suggests that spatial variation of the atmosphere would be small. Whilst some cloud shadowing was present, topographic shadowing was less of an issue in this low-lying terrain. Schott (1988) described several possible causes for this; we could not determine which was the most important. We conclude from these studies that for scenes containing reflectance stable elements, radiometric rectification should be a useful alternative to atmospheric radiative transfer codes and sensor calibration approaches when reliable atmospheric optical depth data or calibration coefficients are not available. When atmospheric optical data and sensor calibration information are available for one of a sequence of radiometrically rectified images, an atmospheric radiative transfer code may be used to correct each image in the sequence to absolute surface reflectance, Pohl (1998). the visible

bands are used in this combination, ground features appear in colors similar to their appearance to the human visual system, healthy vegetation is green, recently cleared fields are very light, unhealthy vegetation is brown and yellow, roads are gray, and shorelines are white.Band 1 combination provides the most water penetration and superior sediment and bathymetric information.It is also used for urban studies.Cleared and sparsely vegetated areas are not as easily detected here.

> ➢ *Band 1 (0.45 - 0.52u m): provides increased penetration of water bodies and also capable of differentiating soil and rock surfaces from vegetation and for detecting cultural features.*

- The result which will have negative reflectance values because when doing the analysis, the area we choose to analyze was not the higher or lower wavelength of the image. So, when the software detected the wavelength which was higher or lower that it, the negative value will get.
- Use the different band to combine and get the most accurate and nearest result

Geometric Correction

Images are rarely provided in the correct projection, coordinate system and free of geometric distortions. Geometric distortions occur due to Earth rotation during acquisition and due to Earth curvature Pohl, (1998).

In order to combine images with other digital map data-sets they must be transformed from the acquisition coordinate system (rows/cols) to that of the digital map data sets. For well defined orbital geometry parameters this can be achieved using predefined transformations (see Mather p76-78) which model the aspect, skew and rotational distortions of a sensor. These terms are defined as follows:

1. Aspect ratio - unequal across-track and along-track pixel scale.
2. Skew - image skew with respect to Earth's north/south axis.
3. Rotation - column coincident pixels do not have same longitude.

However, not all possible causes of geometric distortion can be modeled using these predefined transformations - therefore a more general approach is required e.g., using ground control data, Richards (1999).

Correction using Ground Control

Correcting for geometric distortions using ground control is a multi-step process that involves the following procedures:

1. Recognising in the image and map enough locations which are the same in order to accurately express the distortion present.
2. Using these locations to calculate the transformation between the image and the map.
3. Actually performing the transformation to the new coordinate system for each pixel to generate a new image.
4. Calculating the actual DN that should be assigned to each pixel in the new image.
5. Estimating how well the procedure has actually performed.

The current equations and rescaling factors for converting calibrated Digital Numbers (DNs) to absolute units of at-sensor spectral radiance, Top-Of-Atmosphere (TOA) reflectance, and at-sensor brightness temperature. It tabulates the necessary constants for the Multispectral Scanner (MSS), Thematic Mapper (TM), Enhanced Thematic Mapper Plus (ETM+), and Advanced Land Imager (ALI) sensors. These conversions provide a basis for standardized comparison of data in a single scene or between images acquired on different dates or by different sensors. Chander (2009).

A scene-to-scene radiometric normalization technique has been developed which corrects for atmospheric degradations, illumination effects, and sensor response differences in multi-temporal multispectral imagery. The technique is based on the statistical invariance of the reflectance of man-made in-scene elements such as concrete, asphalt, and rooftops. Chavez (1996) states the differences in the grey-level distributions of these invariant objects is assumed to be a linear function and is corrected statistically to perform the normalization.

Correction using Ground Control

Ground control points correction are georeferenced points known in a map on the image to model distortion and define an empirical transformation between the image and the map as represented below. The left-hand image represents digital map data where ground points are recognised and used to model distortion from reciprocal points on the image data on the right.

An illustration of the use of ground control points from verification data (left) to geo-correct image data (right

Correction using Ground Control

There are a certain number of points to remember when recognising and choosing ground control points (GCPs):

- They should be distinct features in both the map and image.
- They should have clear boundaries and regular geometry.
- Good GCPs would be house corners, road intersections, field corners etc.

- Bad GCPs would be water bodies, natural vegetation, oval or circular features.

How many GCPs should you use?

- The minimum is the number required to estimate the transformation coefficients - see later.
- General rule of thumb - the more the better.
- Try to avoid excessive clustering and leaving unsampled areas.
- Always ensure that you have GCPs close to the image boundary.
- Sample more intensively in areas where you think there may be considerable distortion of high spatial frequency.

Least Squares Approximation

Given a set of ground control of known map (Easting, Northings) and related image (column, row) we need to estimate the transformation between the two co-ordinate sets. We can express this as a least squares estimation problem as summarised in Figure 11 below:

$$\text{Eastings we have}$$

$$e = \begin{bmatrix} e_1 \\ . \\ e_n \end{bmatrix} \qquad p = \begin{bmatrix} 1 & c_1 & r_1 \\ 1 & . & . \\ 1 & c_n & r_n \end{bmatrix} \qquad a = \begin{bmatrix} a_0 \\ a_1 \\ a_2 \end{bmatrix}$$

$$\text{A single estimation of an Easting from c \& r is}$$

$$e_i = a_0 + a_1 c_i + a_2 r_i$$

$$\text{In matrix form this can be represented as}$$

$$e = Pa$$

$$\text{But we want } a \text{ so that we can use the above for unknown } e \text{ so}$$

$$a = (P'P)^{-1} P'e$$

11: Least squares estimation summarised in matrix notation.

Assessing Geometric Accuracy

The co-ordinates resulting from a transformation are an estimate and need to be checked for their degree of accuracy. Accuracy is normally expressed for each control point and overall root mean square. For example, in Table 1 below control points 1 and 2 have been evaluated for the degree of error they exhibit in both the X and Y direction, producing an individual point error which then contributes to the overall RMS error of the transformation. High RMS values (> 1 pixel) can indicate to the user how inaccurate the transformation is and whether the chosen GCPs were adequate, the process can then be repeated with additional/different GCPs in order to decrease the point and total error.

Note: a high RMS error for a particular point can indicate to the user a GCP that could be removed or replaced.

Root Mean Square (RMS) point and total error for a 2 point example

Point	Error X	Error y	Point Error
1	-1.542023	1.346588	2.047226
2	-0.960491	1.837280	2.073196
RMS = 1.909580 (pixel)			

Note: This example in the Table above is only for known points; it tells us nothing about unknown locations.

Resampling

Once the least squares coefficients have been derived and the (x,y) calculated for a pixel, a DN must be assigned to it. This is done by a reverse least squares estimation. However, the resulting col/row of an X/Y is likely not to be an integer as the corrected pixel lies across two or more pixels in the raw image (as illustrated in Figure 12 below). So we need to estimate the new DN value by interpolation this is called resampling.
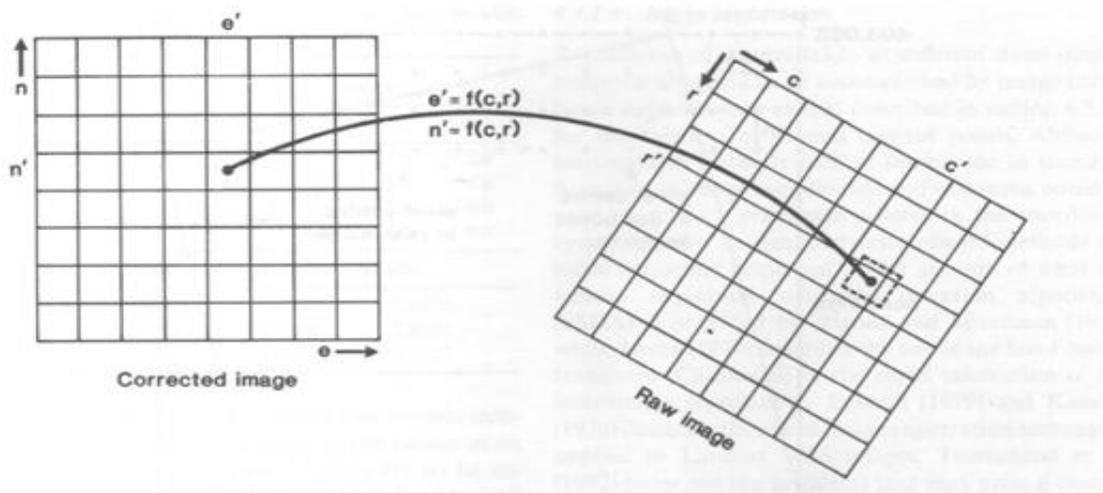
Pixel interpolation after geometric correction

Resampling

Three interpolation routines can be used for resampling the image.

(i) Nearest neighbour:

- In this procedure a pixel is selected that is nearest to the estimated col/row of the reverse least squares:
- The advantage of this approach is that it retains the original image histogram (distribution).
- The disadvantage of this approach is that visually the resulting images can be "blocky".

(ii) Bilinear:

- This approach uses the four surrounding neighbours with equal weighting.
- Assumes that the pixel value lies on a planar surface.
- The disadvantages of this approach are that it modifies the original histogram and can give a blurred image.

(iii) Bicubic:

- This approach uses the 16 nearest pixels to estimated col/row (unequal weighting).
- This approach is computationally the most intensive.
- Although there is considerable modification of the original histogram, this approach produces the best visual results.

The Result - but not quite the end!

The corrected image is likely to need clipping to remove null buffering and derive a sub-image of known geographic origin, such a procedure would be necessary on Figure below.
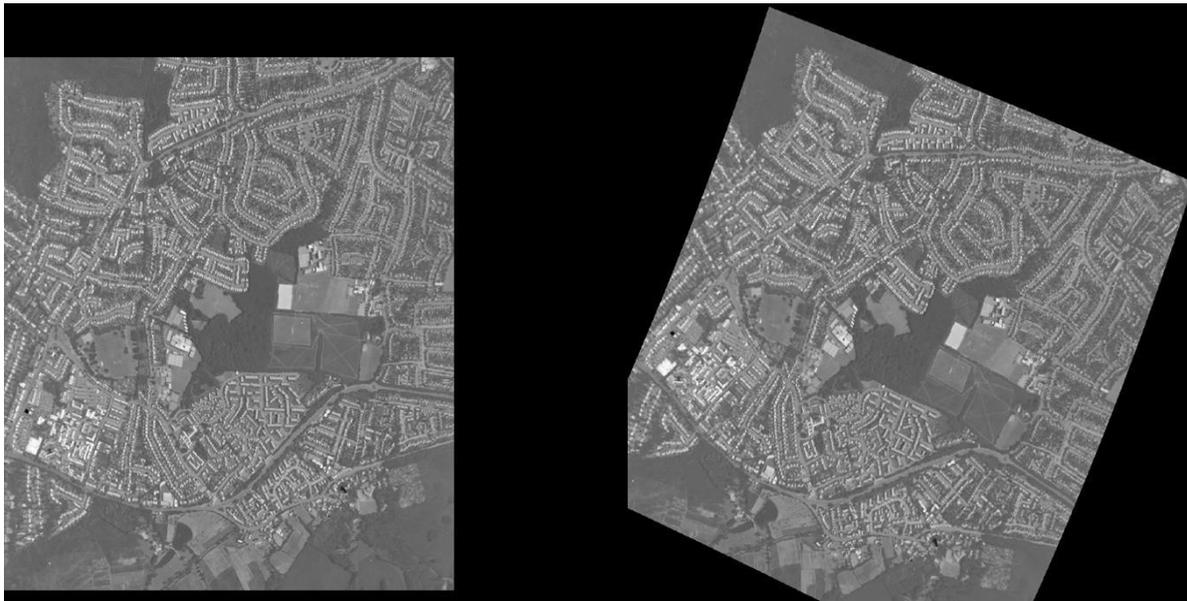
After pre-processing the image may need clipping to a cover a specific study area.

The Result and the End

Chavez, Pat S. (1988) stated the following image above represents ATM data that has been geometrically corrected using a second-order least squares polynomial, using 32 ground control points resulting in a RMS of 1.9 pixels, nearest neighbour resampling and clipped to match OS Landline (the left-hand figure). The final image after this pre-processing is illustrated on the right.
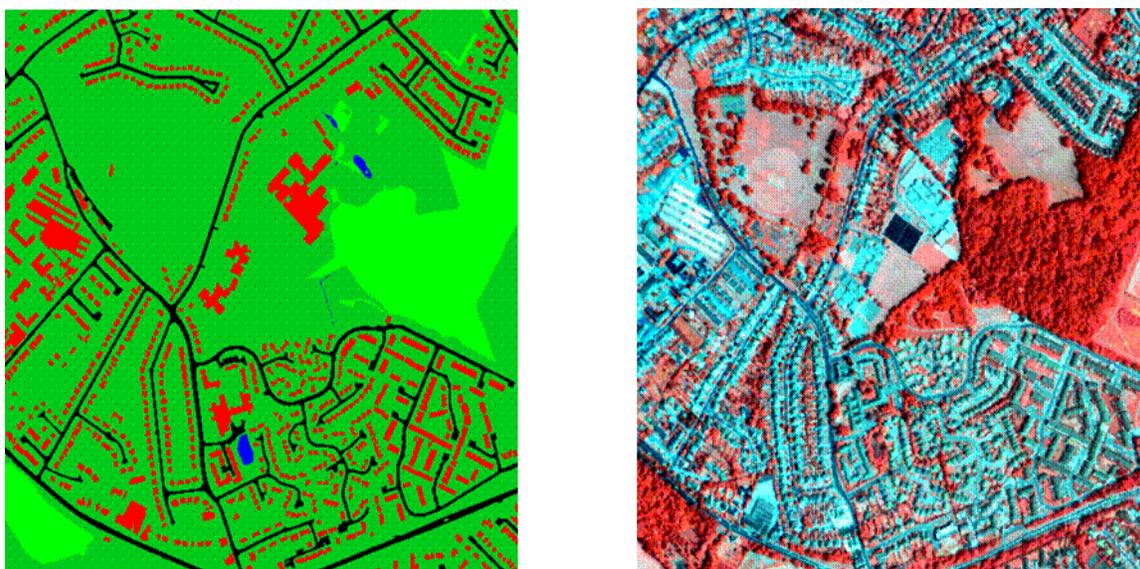
An ATM pre-processed image (right), with digital land cover data (left).

Method I – Image-to-Map Rectification

According to Jensen (1987) digital image is one of the source of GIS data convertible into use by means of image processing in remote sensing such as the processed data below

1. Open the image *myrtle-beach_cams_1997-08-02.img* from the file data provided.
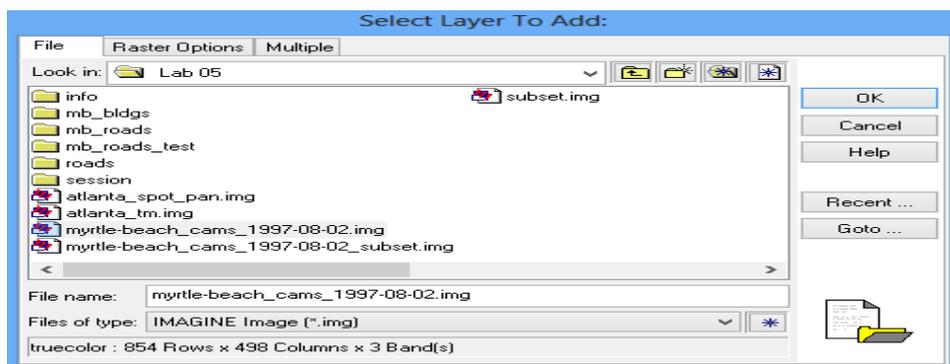
2. Change the raster options into true color RGB as 3, 2, 1.
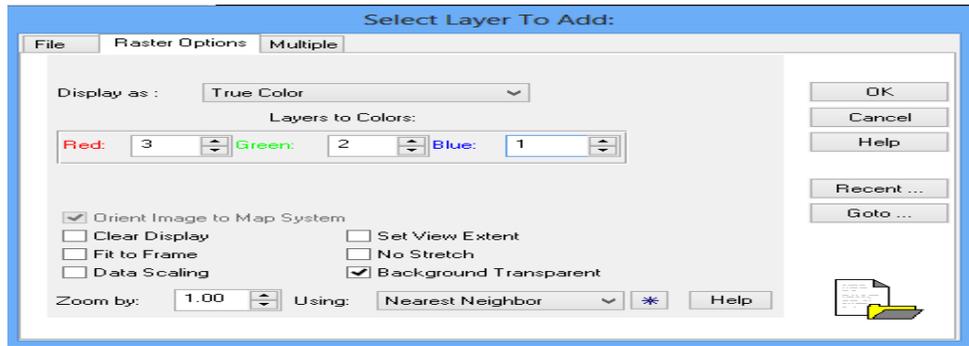
2. The image will appear as display below.
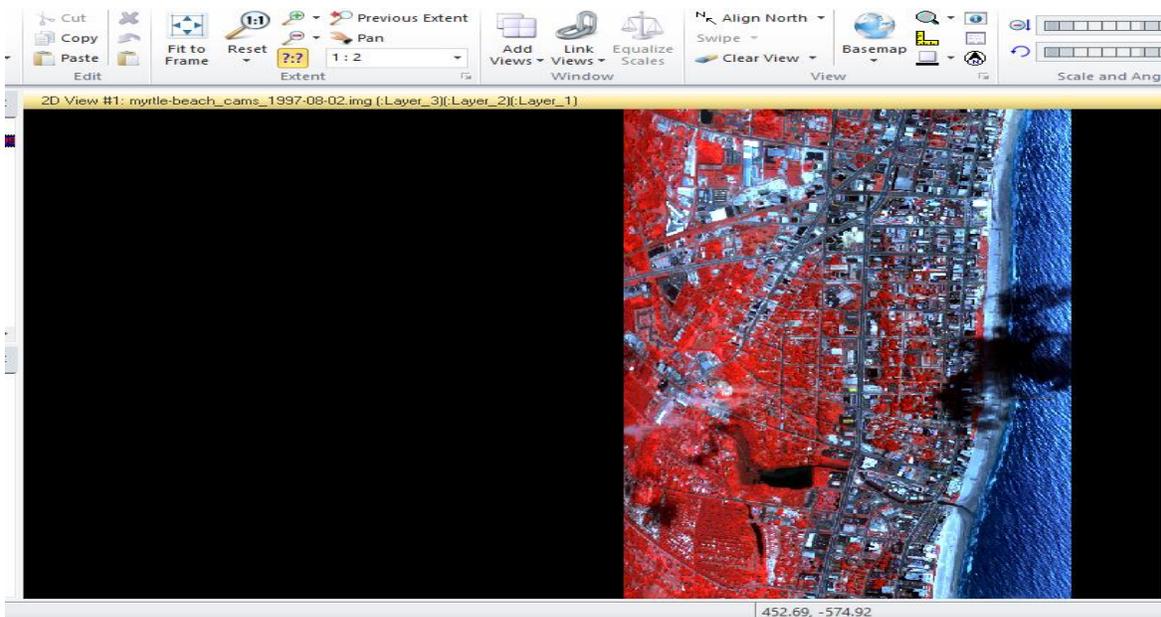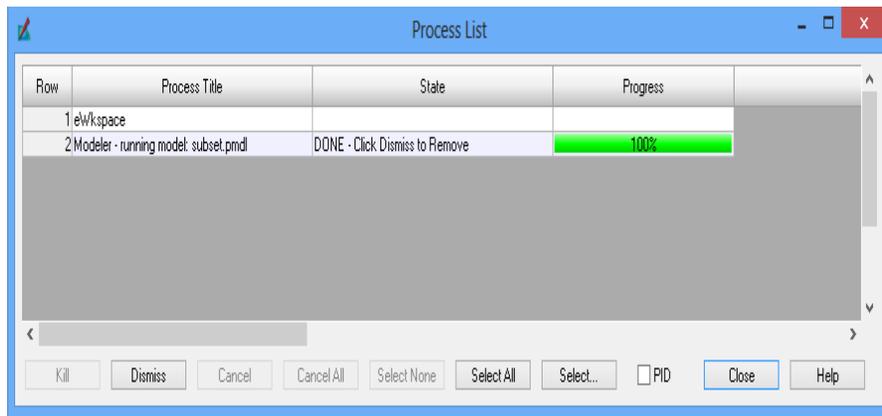

3. Select the Multispectral, Subset & Chip.
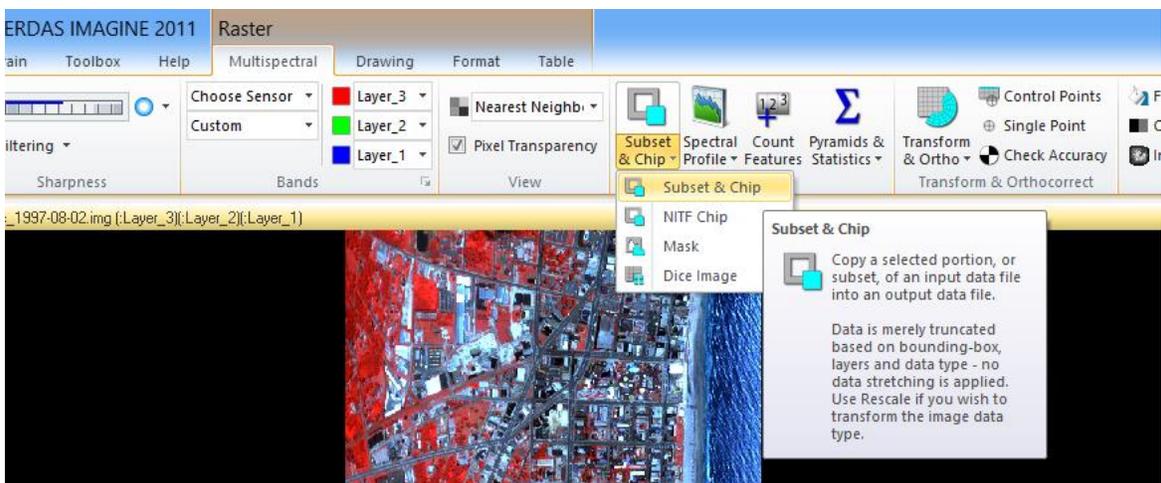
4. Select the input file *myrtle-beach_cams_1997-08-02.img*. Name the input file as *myrtle-beach_cams_1997-08-02_subset.img*. Change the type into File and set the coordinate as
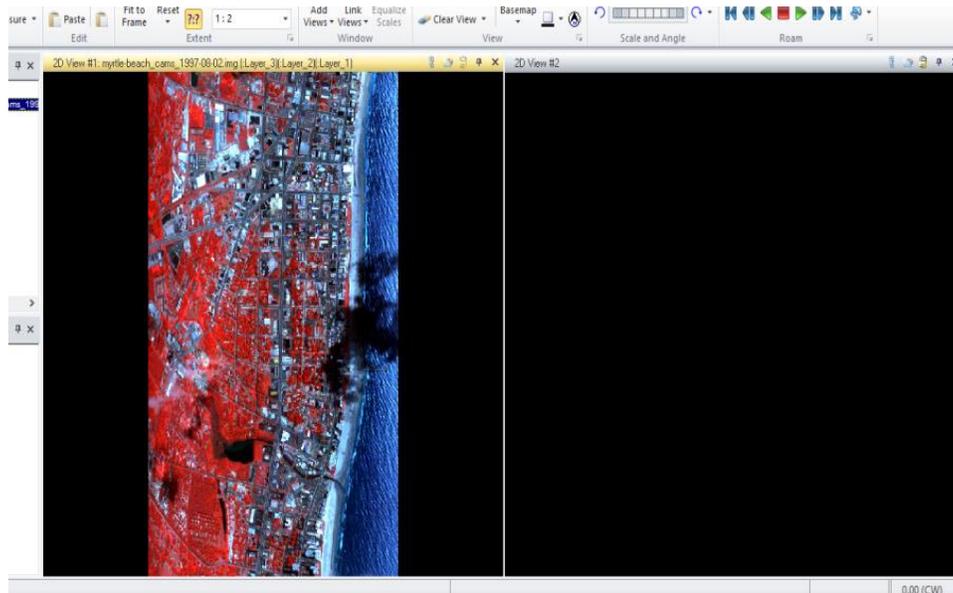   **ULX** 38 **ULY** 5 **LRX** 450 **LRY** 400
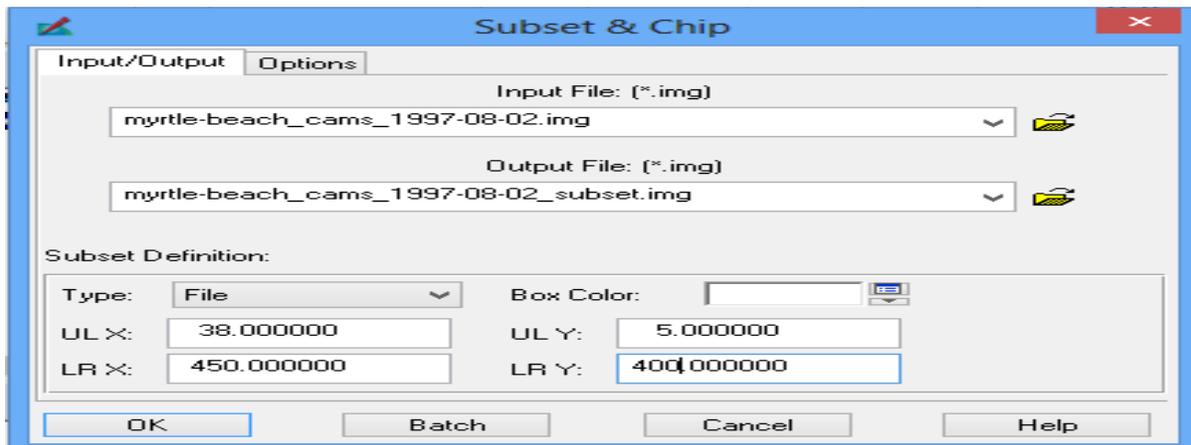
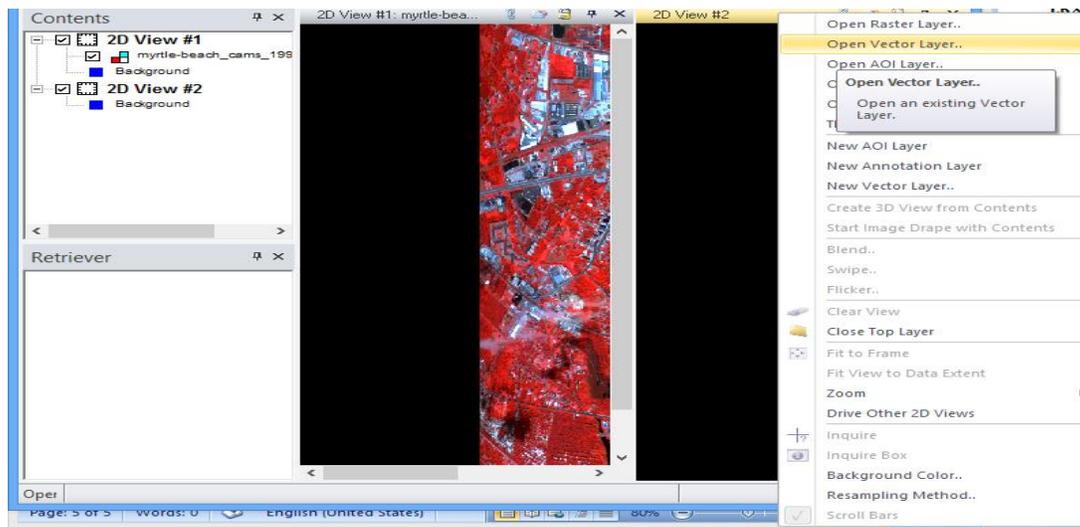5. Change the options into Output: Unsigned 8 bits, Select Layers: 1:3.
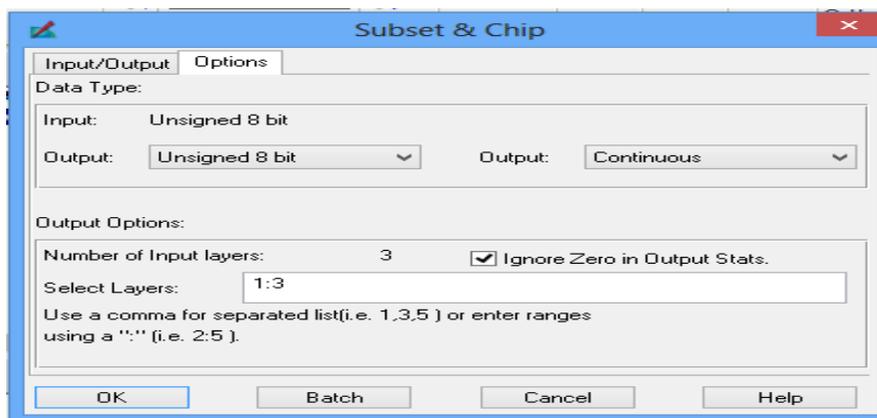
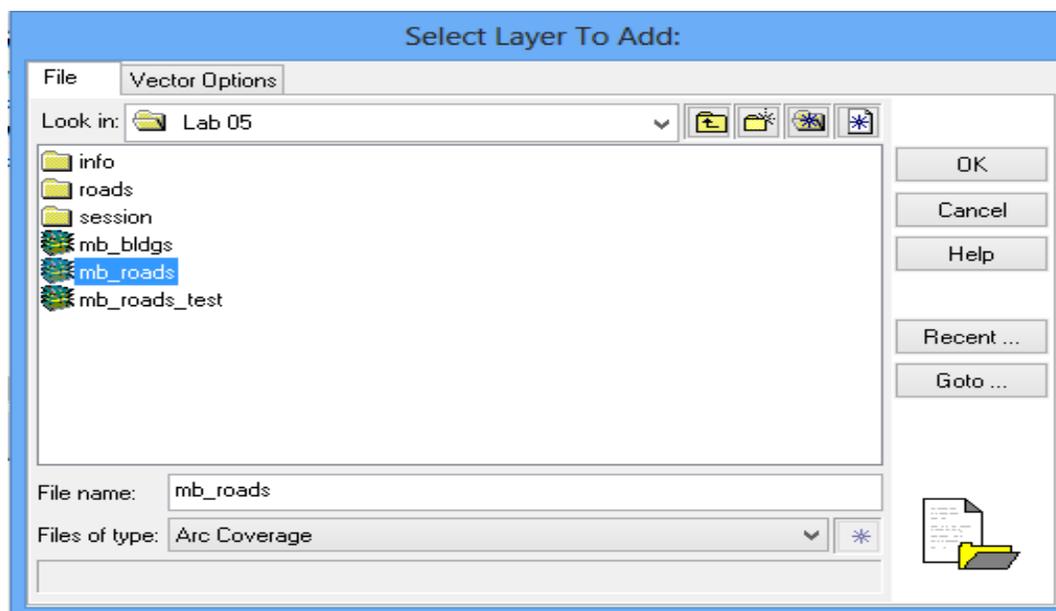6. Click OK to run the Subset file in Process List.

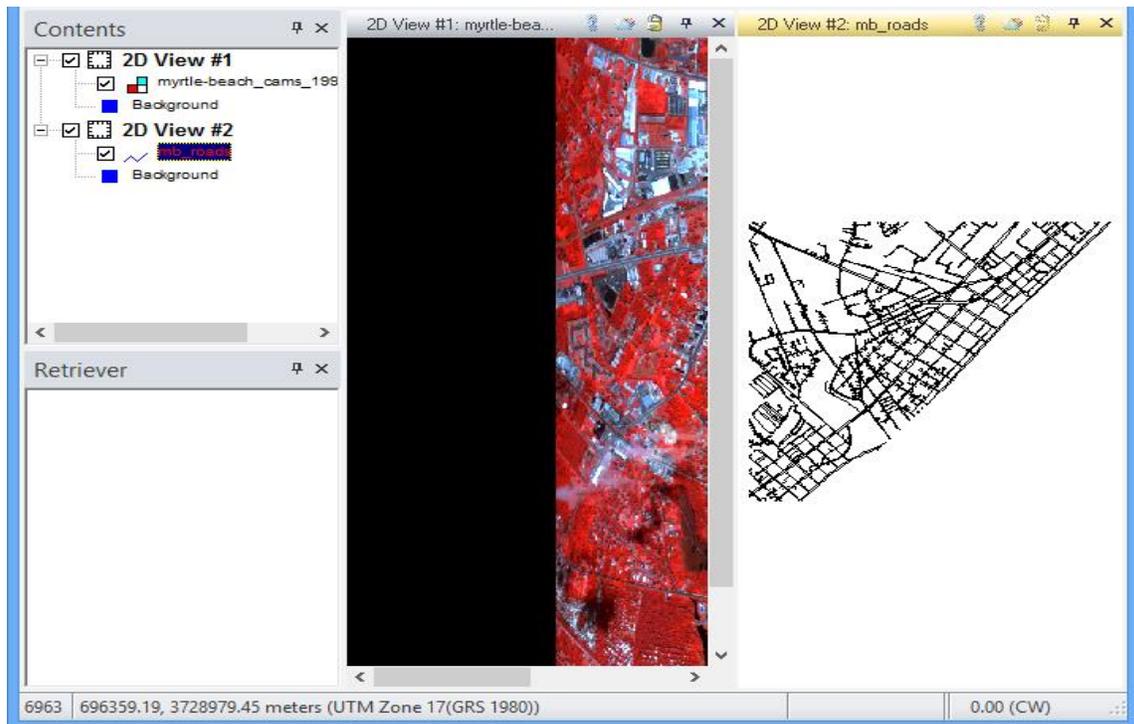7. Open two viewer on the screen ERDAS IMAGINE 2011.

8. Open vector layer by click the second viewer, right click the mouse on second

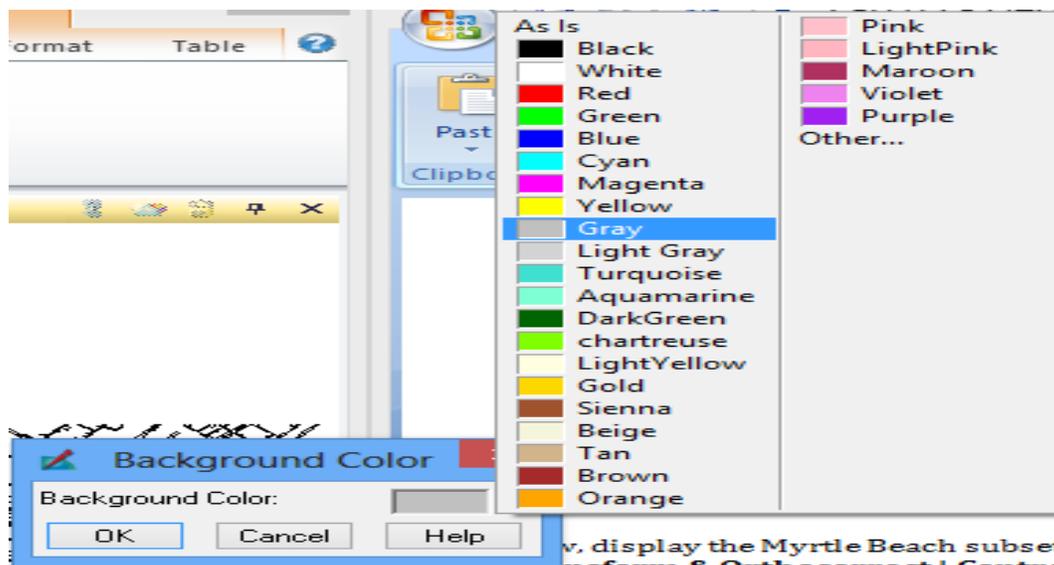viewer, select the Open Vector Layer.

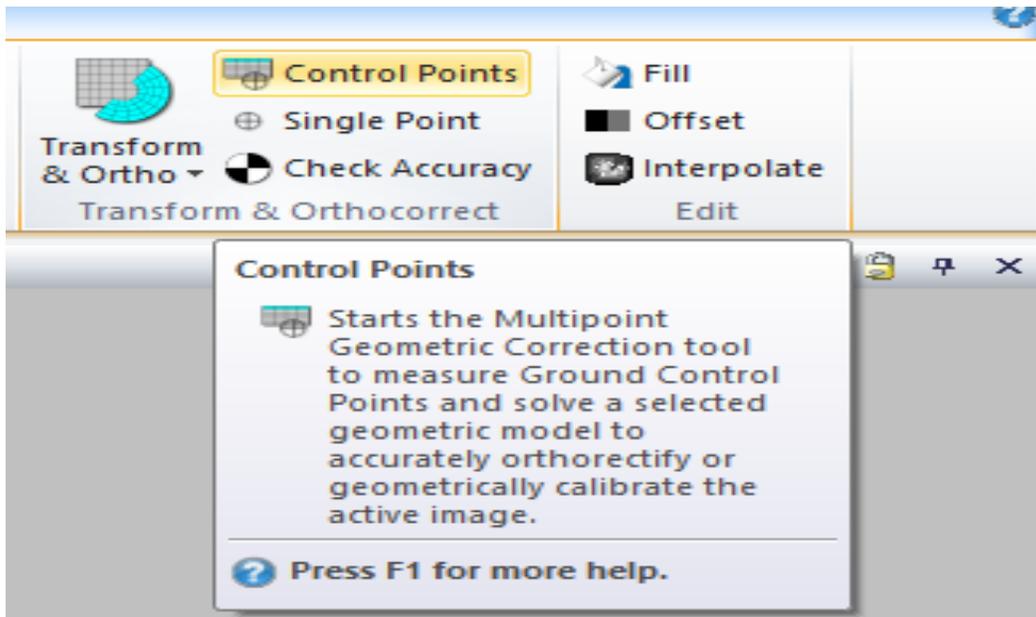9. Change the File of type into Arc Coverage. Choose the file mb_roads.

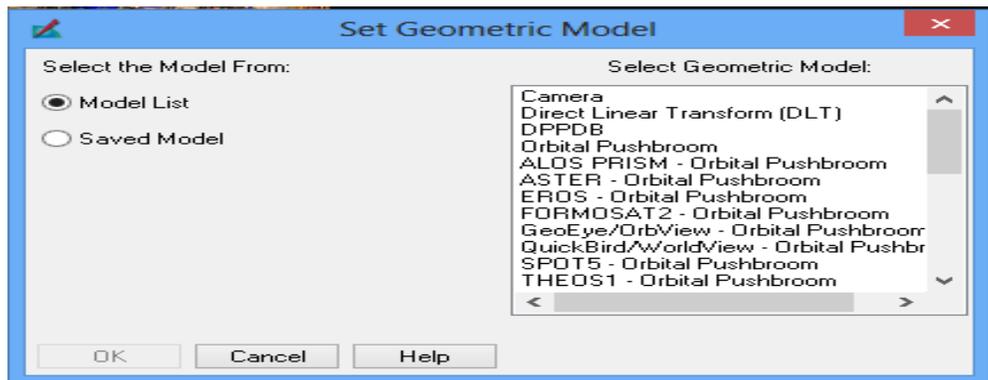10. After open the mb_roads, the screen will appear as below.

11. Change the background color by right click the mouse, select background color as gray color for good view in the map.
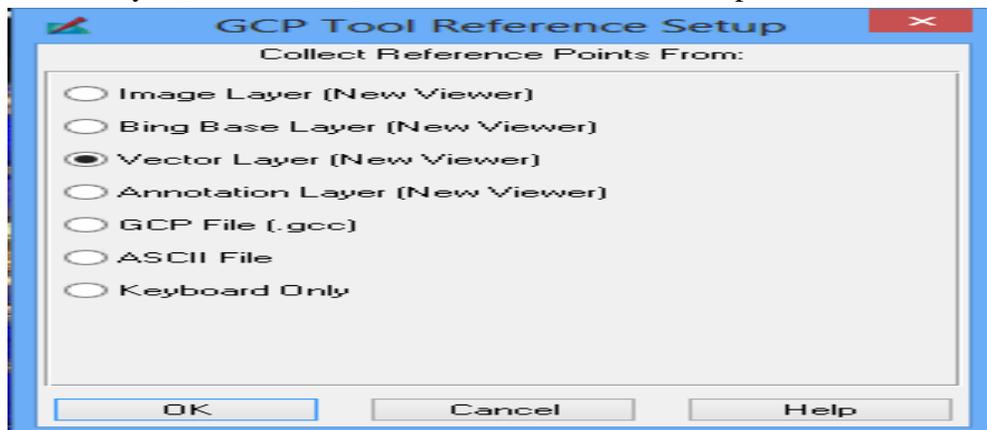

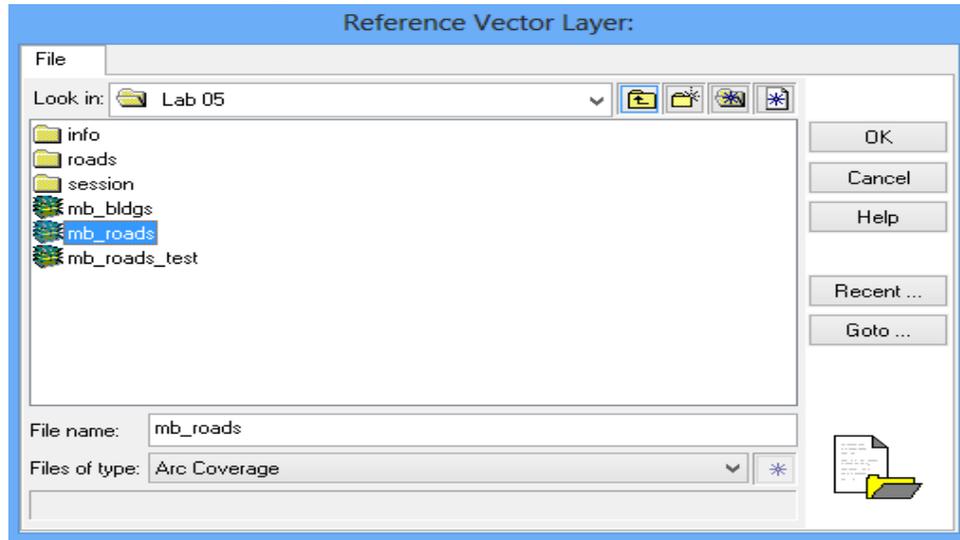• Select the Control Points on tab Transform & Orthocorrect. To make good image.

- The screen will display Set Geometric Model. Select Model List and Geometric Model as Polynomial.
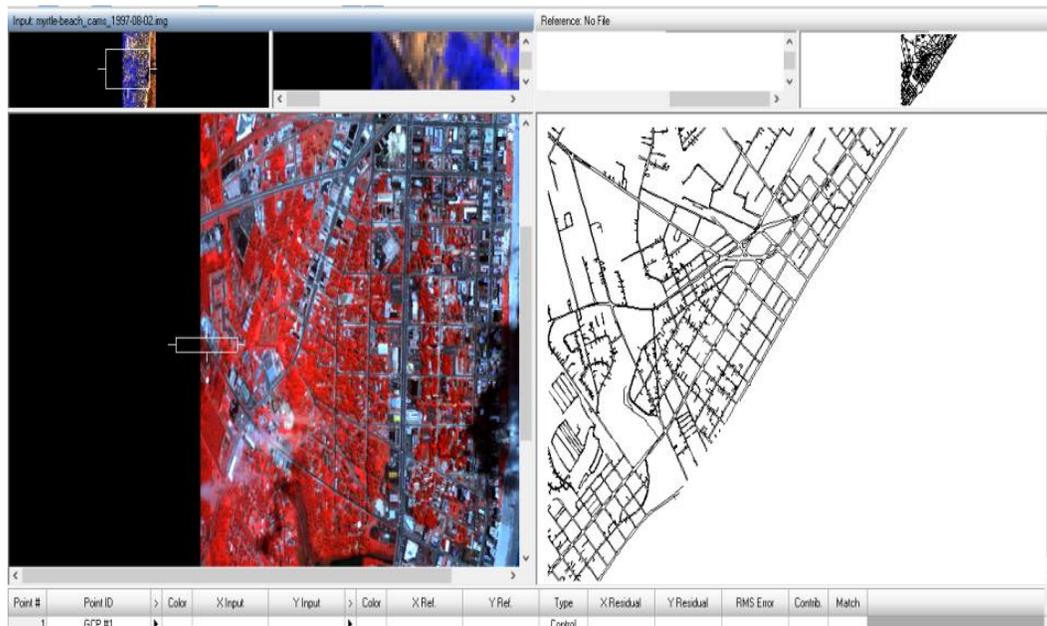

- Select Vector Layer [New Viewer] in GCP Tool Reference Setup.
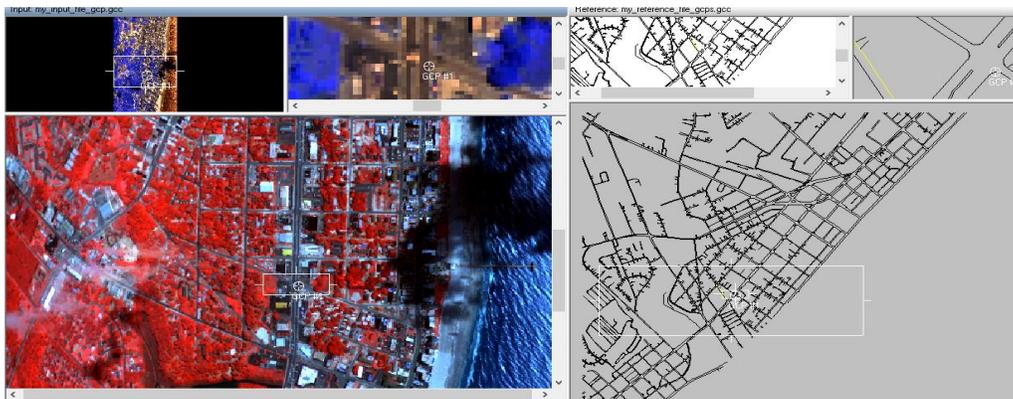
- Select the file mb roads to display this map.

- Change the band combination RGB into 3, 2, 1 to get a good viewing.

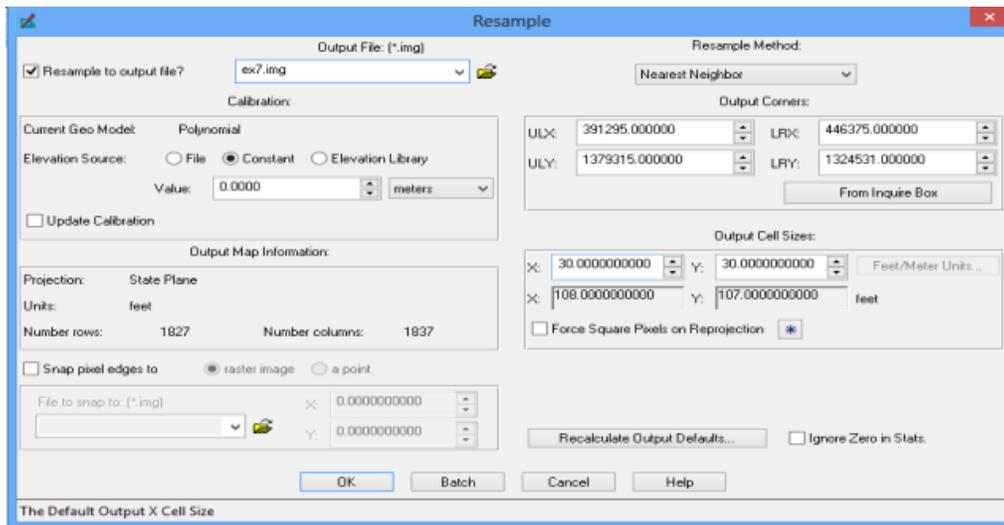- Save the reference GCPs file as My_reference_file_GCPs.gcc.

- Select the GCPs in the unrectified image and map. Make sure select the location such as road intersections, the intersection of fence lines and other.
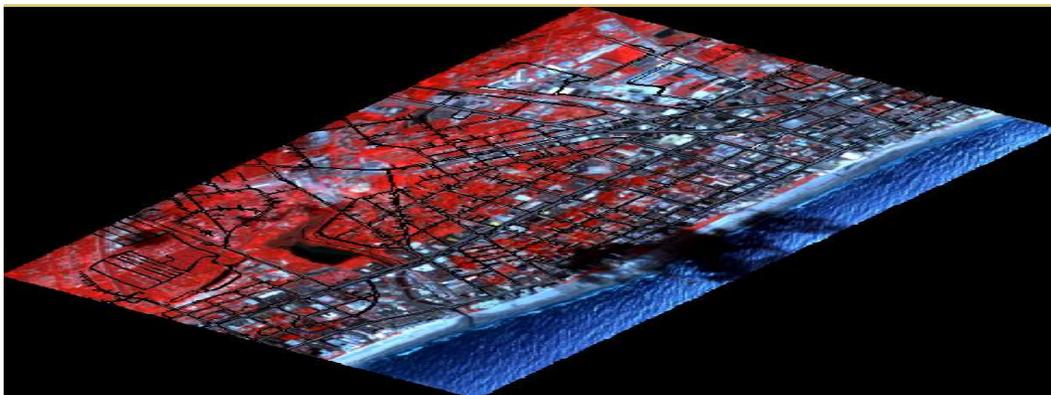

- Check the RMS errors between the file points and map points. Make sure RMS was less than 1. If the RMS more than 1, delete the column point data until the RMS less than 1.

Point #	Point ID	>	Color	X Input	Y Input	>	Color	X Ref.	Y Ref.	Type	X Residual	Y Residual	RMS Error	Contrib.	Match
1	GCP #1			260.471	-521.611			695549.068	3729352.002	Control	-0.194	-0.446	0.487	1.033	
2	GCP #4			218.188	-493.197			695497.263	3729502.245	Control	0.690	-0.129	0.702	1.490	
3	GCP #6			217.933	-398.480			695664.669	3729737.963	Control	-0.293	0.069	0.301	0.640	
4	GCP #7			222.434	-350.467			695762.384	3729847.363	Control	-0.241	0.120	0.269	0.571	
5	GCP #8			272.199	-253.835			696059.059	3729987.348	Control	-0.204	-0.615	0.648	1.377	
6	GCP #9			275.346	-182.313			696197.139	3730159.316	Control	-0.169	0.303	0.347	0.737	
7	GCP #11			314.638	-302.270			696081.161	3729787.837	Control	0.369	0.309	0.482	1.023	
8	GCP #13			216.576	-444.982			695579.554	3729625.159	Control	0.374	0.147	0.402	0.854	
9	GCP #18			237.095	-701.977			695167.558	3728955.501	Control	-0.332	0.241	0.411	0.872	
10	GCP #22	▶				▶				Control					

- Select the Display Model Properties and save the data. Then select the Display Resample Image Dialog save the output image as *ex7.img*.

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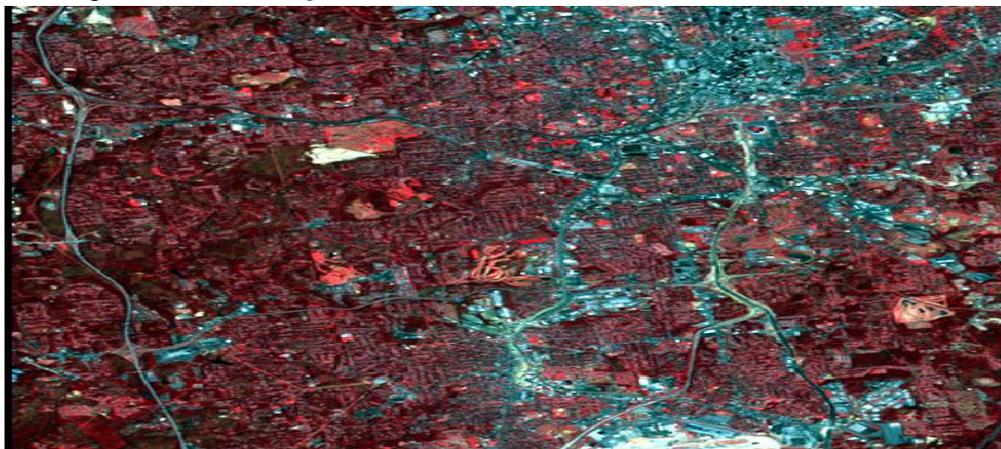e-ISSN: 2348-795X
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- Open the image ex7.img in new view. The image will be display as below.
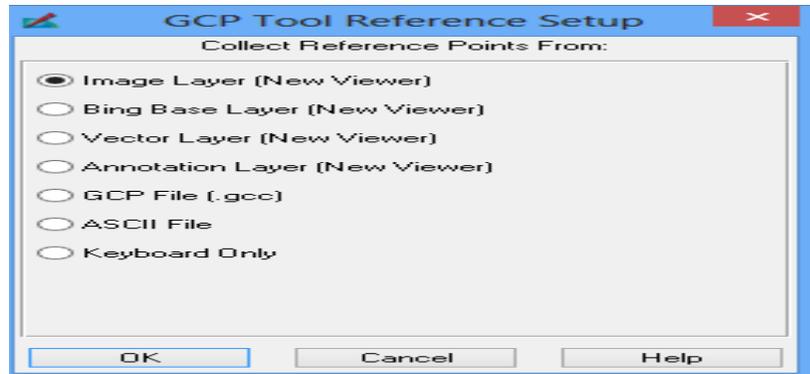

## Method II – Image-to-Image Registration

1. Open the image *atlanta_tm.img* from the file Lab 05.

2. Follow the step from the method 1, but only different with select Image layers (New Viewer) on GCP Tool Reference Step.


3. Select the GCPs in the unrectified image and the reference image. Make sure select the location such as road intersections, the intersection of fence lines and other.
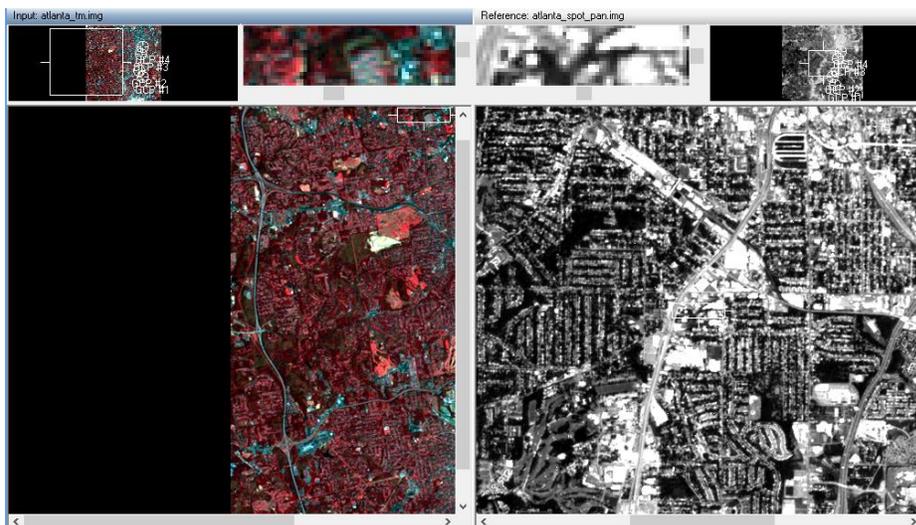

4. Check the RMS errors between the unrectified image points and map rectified image. Make sure RMS was less than 1. If the RMS more than 1, delete the column point data until the RMS less than 1.

Point #	Point ID	>	Color	X Input	Y Input	>	Color	X Ref.	Y Ref.	Type	X Residual	Y Residual	RMS Error	Contrib.	Match
1	GCP #1			384.858	-350.650			429155.145	1341197.209	Control	0.000	0.019	0.019	0.020	
2	GCP #2			359.588	-304.562			427578.820	1345845.821	Control	0.001	0.440	0.440	0.474	
3	GCP #3			375.422	-191.545			430806.925	1355742.584	Control	-0.005	-1.484	1.484	1.598	
4	GCP #4			382.027	-143.578			432220.505	1360248.575	Control	0.003	1.026	1.026	1.105	
5	GCP #5	▶				▶				Control					

5. Select the Display Model Properties and save the data. Then select the Display Resample Image Dialog save the output image as *ex5.img*.
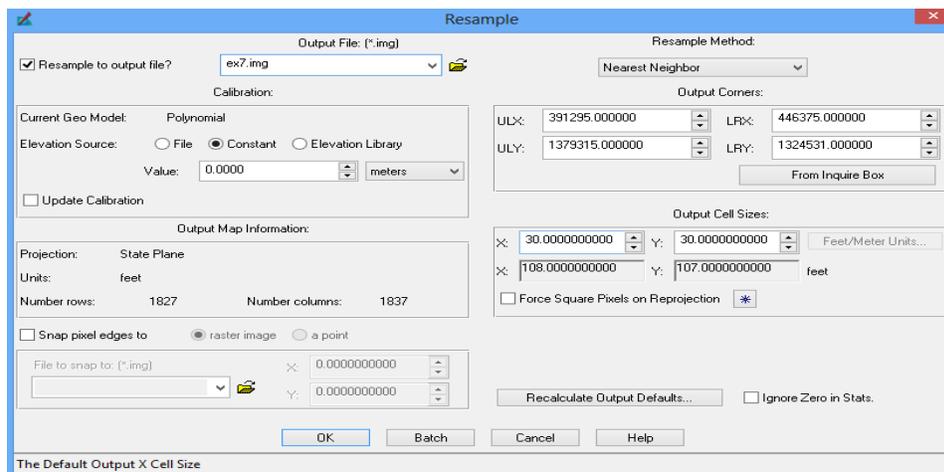
6. Open the image ex5.img in new view. The image will be display as below.
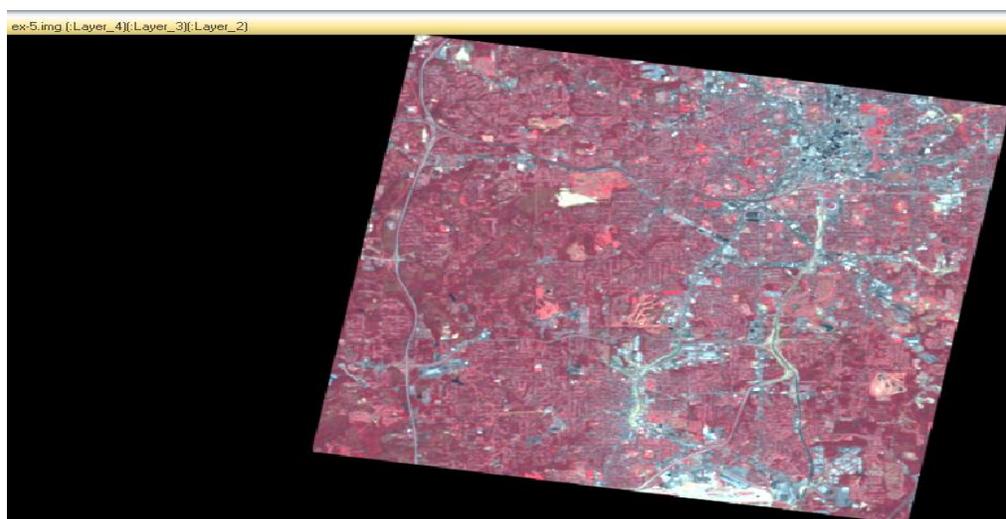
Conclusion

Visually check the image for visual atmospheric effects example the visible haze can occur in the blue spectral-band. It is important to consider radiometric correction in aviation, navigation as well as in all other means of transportations. In geographic information system, the captured images sometime known as orthophoto is corrected through coordinate shift and georeferencing the scan image data. Recently, different remote sensing software is used to investigate the atmosphere for accurate decision, planning and corrections. . Differences in the grey-level distributions of these invariant objects are assumed to be a linear function and are corrected statistically to perform the normalization.

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