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Case Study for Change Detection Analysis and Land Surface Temperature Retrieval in Uttrakhand Region and their correlation

Rahul Kumar[1] & Shalini Singh[2]
[1]University of Petroleum and Energy Studies
[2]Lecturer, Centre For Development of Advanced Computing (C-DAC), Noida.

Abstract: *Uttrakhand Region is an area where forest and dense vegetation areas are rapidly turning into population zone or into areas of diminished vegetation. In this paper the area is mapped using unsupervised classification and matrix and change vector techniques are applied on it. Land Surface Temperature is also retrieved and general correlations are drawn between the findings from change detection and land surface temperature findings.*

1. Introduction

Uttrakhand is a land of very dense vegetation that has been lessened due to cattle grazing, deforestation, and land takeovers. Remote Sensing and GIS Techniques are very important for understanding the changes occurring in an area and for resource management. CVA technique is used for land change dynamics and data used is Landsat TM 1996 and Landsat ETM+ 2006.[2]

2. Material and Method:

This study was done by Landsat TM scene for 1996 and Landsat ETM+ scene for 2006. Image processing software used was Erdas Imagine 9.1. The area used for this study was Uttrakhand and Nearby Regions as projected by Landsat Satellite on April of 1996 and on April of 2006.

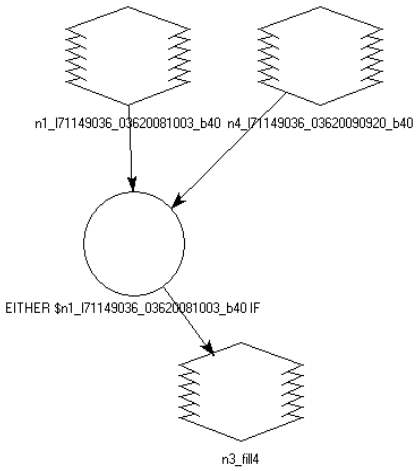
3. Preprocessing:

As the Landsat images are already geometrically coordinated, very few corrections are required for preprocessing step. Haze reduction and cloud reduction can be done if required but it can be avoided by selecting a good quality image.

The real problem with ETM+ images is that due to a problem with SLC scanner in 2003, the images captured after that point have certain dark lines(~ 22%) that are areas with no information .That has to be corrected.

Thus Erdas Modeler was used to remove those dark areas with the use of Transfer method, i.e. selecting SLC off images over a period of few days later to the required image and using them to fill the required gap.

The final image thus had very few "no information areas" (about <5%) and could be used for analysis and for performing other operations. Later Subset of the images was taken to extract areas of interest.



4. Land Surface Temperature Retrieval :

Land Surface Temperature (LST) is the temperature of the land derived from solar radiation. From a satellite's point of view, the "surface" looks different for different area at different times. Where there is snow and ice, the temperature would be low and if there is barren land volcano like structure, LST would be high. [9]

Erdas Modeler was used for applying LST calculation on the scene.[11][15]

The requirements of the model were

1. L min
2. L max
3. K1 (For that Particular Band)
4. K2(For that Particular Band)

(All information is provided with Landsat Image file)

The formulae used are

1. L = L min + (L max – L min) * Digital Number / 255

L = Spectral radiance for the band
L min = Spectral radiance of Digital Number value 1
L max = Spectral radiance of Digital Number value 255.

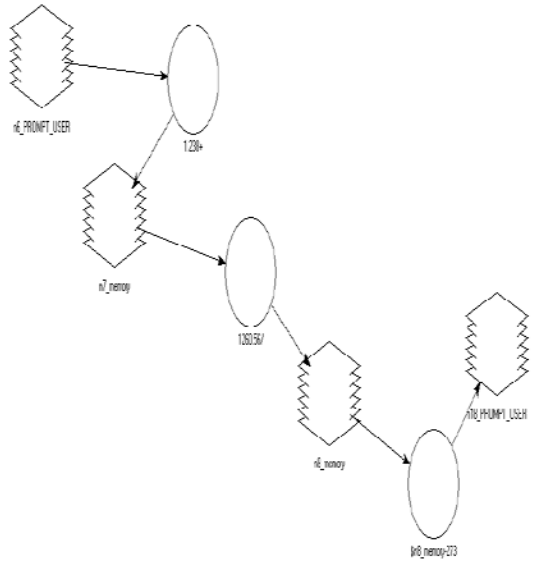
2.

$$Temp = k2/\ln(^{k1}/_{L} + 1)$$

K1 = Calibration constant
K2 = Calibration constant

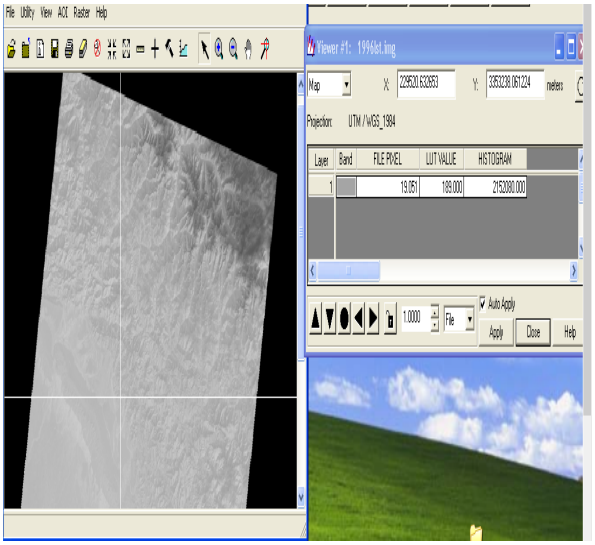
3. Temp from Kelvin to Celsius

$$°C = °K - 273$$



The final image files are:

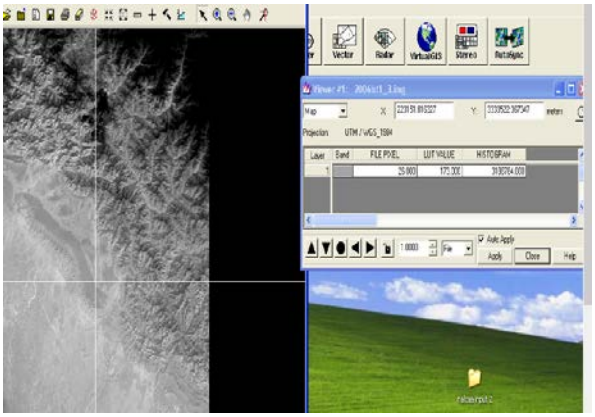
1. For 1996



Highest Noted Temp: 20.16°C , Lowest Noted Temp: -22°C

Average temp = -1°C

1. For 2006



Highest Temp: 28°C , Lowest Temp: -4°C

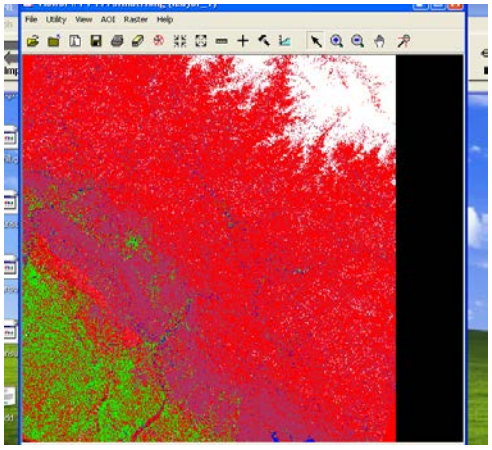
Average Temp: 12°C

5. Classification of images :

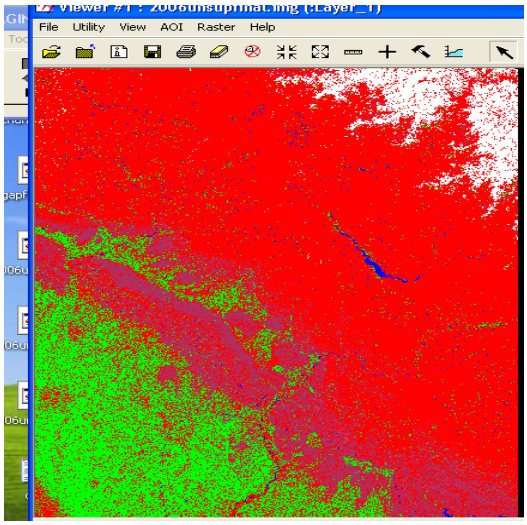
The images are classified according to visual interpretation.
The classes are

1. Land(with less or no vegetation)
2. Dense Vegetation
3. Water
4. Ice
5. Urban area

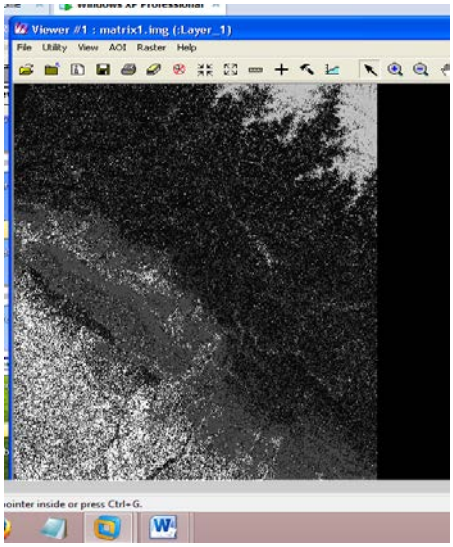
1996 classified and recoded image



2006 classified and recoded image .



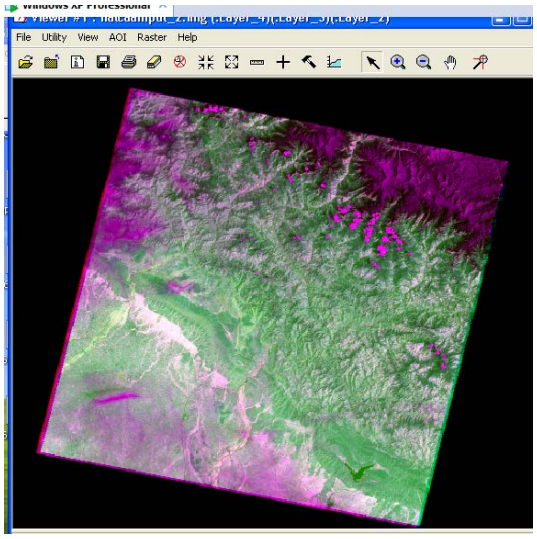
Later Matrix operation was performed that displayed the pixel by pixel change that had occurred between the two dates.



6. Change Vector Analysis:

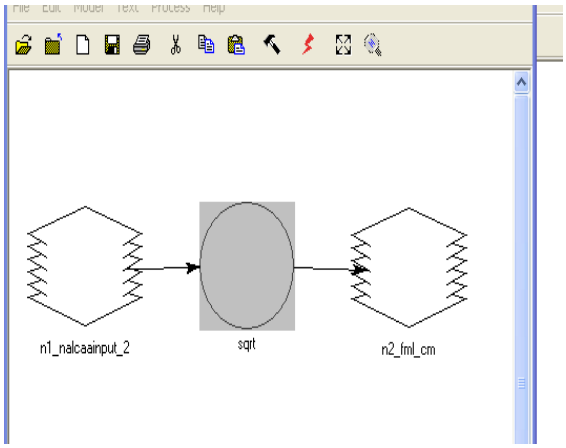
In change vector analysis, we first compute the change magnitude and change direction to identify changes in multispectral band data [3]. A threshold value is decided and changes are measured according to that threshold value. Change is measured accordingly.[1]

To measure the magnitude of variation among spectral change vector, Euclidian distance is calculated on a pixel by pixel transformation. For this four bands from the first image and four bands from the second image are combined to form a composite image. (bands from 1996 and 2006).

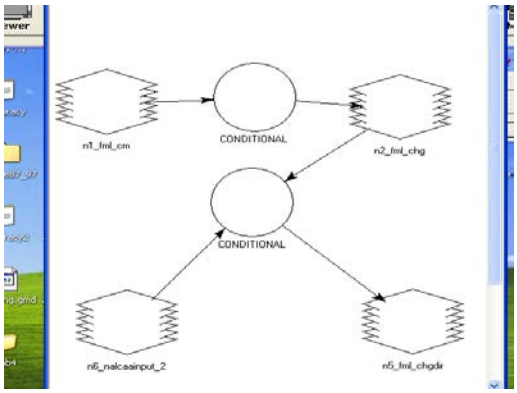


This image has the Red, Green ,Near Infrared1and Near Infrared 2 bands from both the images stacked on each other. The operation of Euclidian distance is applied on the images by the formula [4]

SQRT((Red2006-Red1996)*2+(Green2006-Green1996)*2+(Infrared(1)2006-Infrared(1)1996)*2+(Infrared(2)2006-Red(2)1996)*2)



For Change Direction analysis, Using Hit and Trial find the Threshold for the final magnitude. The result of using is an image of vector change that filters the changes below the threshold value and gives the specific class information.
The model used is



With the threshold statement being
If(change magnitude value ≥threshold) pixel value = 1 else 0;
Example if the threshold value for vegetation is 40 the 1st statement will be If(change magnitude value ≥40) pixel value = 1 else 0;
After the threshold image is produced, it is checked against the direction codes (in which band change has occurred) from band1 to band4.
If pixel value = 1and change in red<0 and change in infrared 2 <0 then 1; If pixel value = 1and change in red>0 and change in infrared 2 <0 then 2; etc.
Finally we can calculate the percent changes occurred in the various bands for a particular class.

6. Results and Conclusions:

The following significant observations are done from the change vector analysis. These are the percentage changes that occurred from 1996 to 2006.

1. Land to water : 0.33%
2. Land to urban land : 7%
3. Dense Vegetation to less vegetation land : 17%
4. Dense Vegetation to urban Land : 4%
5. Ice to Land : 2%

Correlation between land surface temperature and Land Use Pattern :

According to a research , change in forest area to farm land/ change in forest area to urban or water per cell are the major factors in determining the land surface temperature variation. This study further proves that theory as a probable cause of lst variation can be deforestation (~20%)

The population density is also an important factor for increase in lst. Population density increased from 1996 to 2006 by about 7%. The temperature of roof surfaces is significantly more the vegetation or water surfaces and constitutes to increase in lst.

This study, however, is not conclusive. Further research is required to accommodate factors like census data, no of roads, type of vegetation etc. There are many more factors that can cause changes in land surface temperature that they are a subset of urban class e.g. High rise building, low rise buildings, buildings with padded rooftops etc. Further and even contradicting results are welcome and appreciated if they acclimatize the above mentioned factors and then some. Thus the field for studying other factors and analysis is open for further studies.

7. Acknowledgements:

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