17. Given Google Maps satellite views of a city, identify the amount of green cover

Github link: https://github.com/anirudh456/DIP_project_Greenery_Cover

Team members

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***Abstract*—**This project presents a technique to estimate the amount of green cover and urban cover when a satellite image is given. The proposed method is based on preprocessing the satellite image for image enhancement and use NDVI values along with the conventional RGB channels to get a segmentation technique which is able to classify green cover, urban cover and water cover. Using the two classified outputs collected in the classification step, a much better and accurate classification is obtained. The implementation is fully unsupervised and is used to generate the classification of the LANDSAT-8 satellite image.

I. INTRODUCTION :

Green areas are important parts of urban sprawl with environmental and social effects. Trees play important role in cleaning pollution, equilibration of water cycle and climate stability of the environment. Mapping of green cover is a basic condition for effective management and protection. Several types of satellite image datasets are available with different channels. This project uses the LandSat-8 satellite images which has 11 channels. The implemented method, based on the RGB and NIR channels of the image, have been proposed to calculate the amount of green cover by unsupervised learning using mean shift algorithm.

The implementation is divided into two sections, the input image is processed by the following steps:
-> Collection of LandSat datasets and separation of the bands.
Section 1: uses RGB channels of the image.

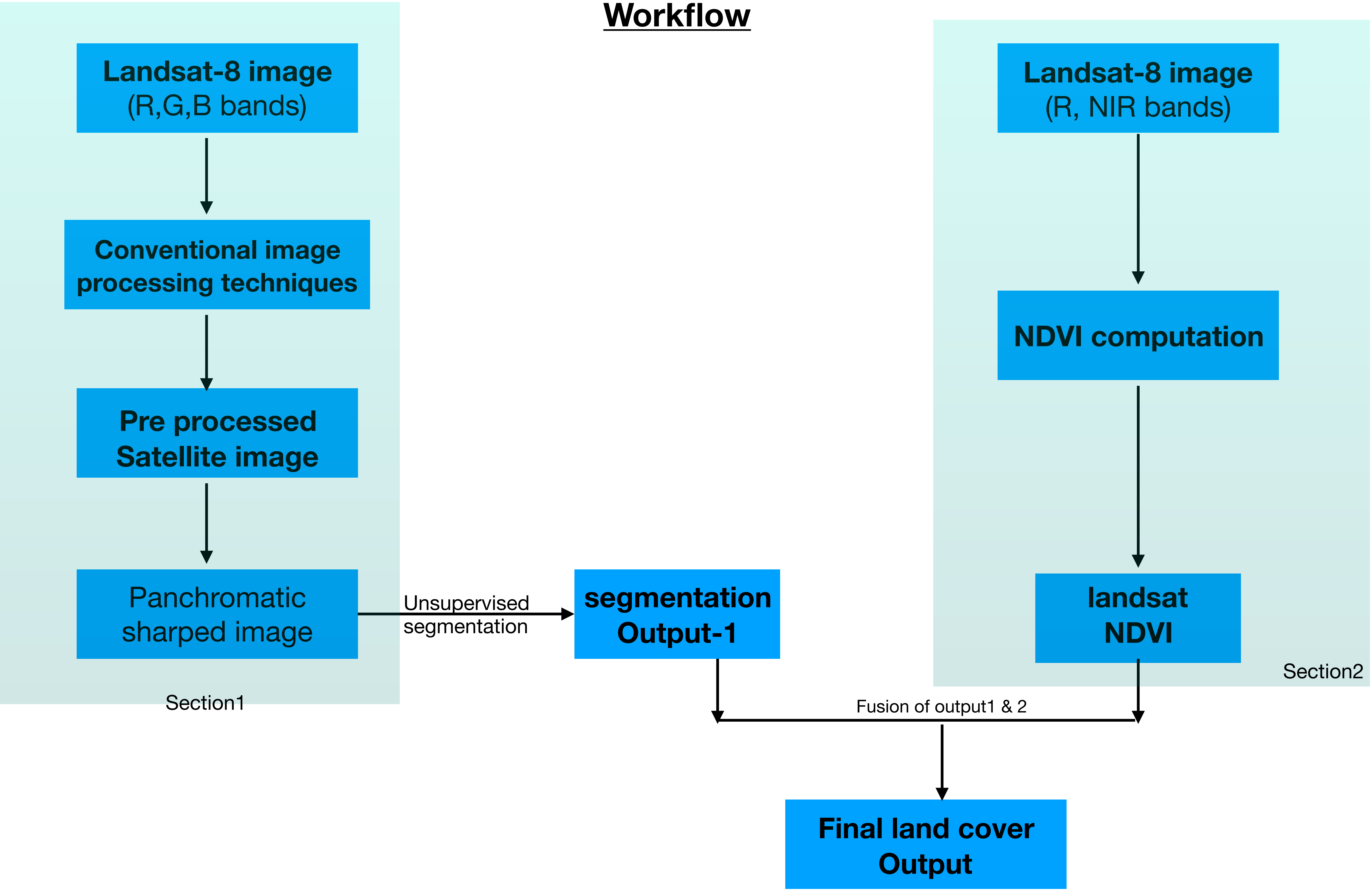
1) Preprocess the image with conventional image processing techniques like Histogram equalisation, Contrast and Color balance adjustment.
2) Panchromatic sharpening of the above image.
3) Segmentation of the image by unsupervised learning.

Section 2: uses the R and NIR channels.

1) **NDVI** (Normalised Difference Vegetation Index) computation.
2) Obtain the NDVI of Landsat image.

-> Compute the final classified output by combining the output from step1 and the output from step 2.

Workflow

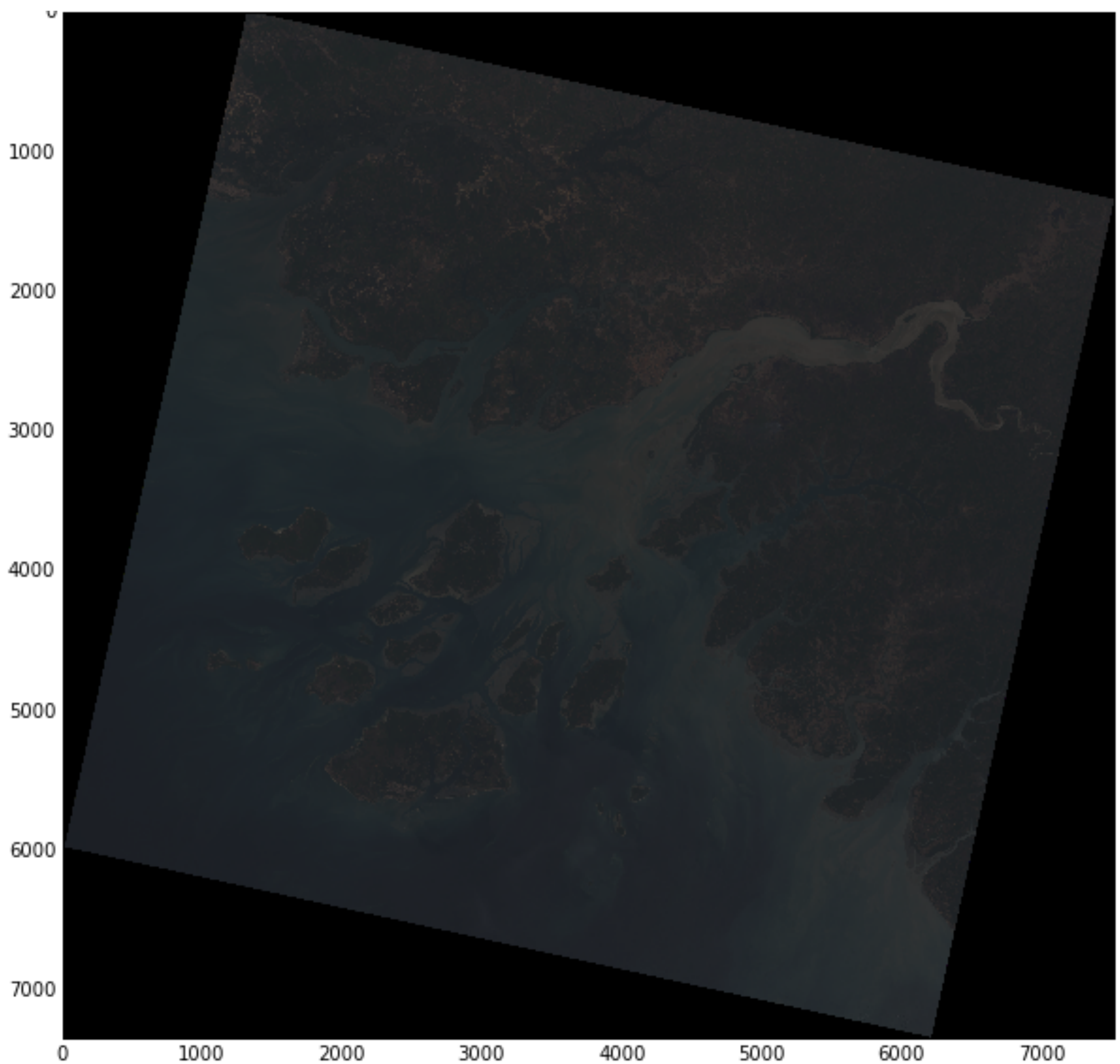


Landsat-8 image (R,G,B bands)
Conventional image processing techniques
Pre processed Satellite image
Panchromatic sharped image
Unsupervised segmentation
segmentation Output-1
Section1
Landsat-8 image (R, NIR bands)
NDVI computation
landsat NDVI
Section2
Fusion of output1 & 2
Final land cover Output

II. LandSat-8 dataset

The Landsat-8 Satellite image dataset, used for the estimation of green cover, has 11 different bands. A table is made showing the various bands with their wavelengths and the mapping of each band to extract a particular information.

Band	Wavelength	Useful for mapping
Band 1 – Coastal Aerosol	0.435 - 0.451	Coastal and aerosol studies
Band 2 – Blue	0.452 - 0.512	Bathymetric mapping, distinguishing soil from vegetation, and deciduous from coniferous vegetation
Band 3 - Green	0.533 - 0.590	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 4 - Red	0.636 - 0.673	Discriminates vegetation slopes
Band 5 - Near Infrared (NIR)	0.851 - 0.879	Emphasizes biomass content and shorelines
Band 6 - Short-wave Infrared (SWIR) 1	1.566 - 1.651	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 7 - Short-wave Infrared (SWIR) 2	2.107 - 2.294	Improved moisture content of soil and vegetation and thin cloud penetration
Band 8 - Panchromatic	0.503 - 0.676	15 meter resolution, sharper image definition
Band 9 – Cirrus	1.363 - 1.384	Improved detection of cirrus cloud contamination
Band 10 – TIRS 1	10.60 – 11.19	100 meter resolution, thermal mapping and estimated soil moisture
Band 11 – TIRS 2	11.50 - 12.51	100 meter resolution, Improved thermal mapping and estimated soil moisture


0
1000
2000
3000
4000
5000
6000
7000
0
1000
2000
3000
4000
5000
6000
7000

Input 1

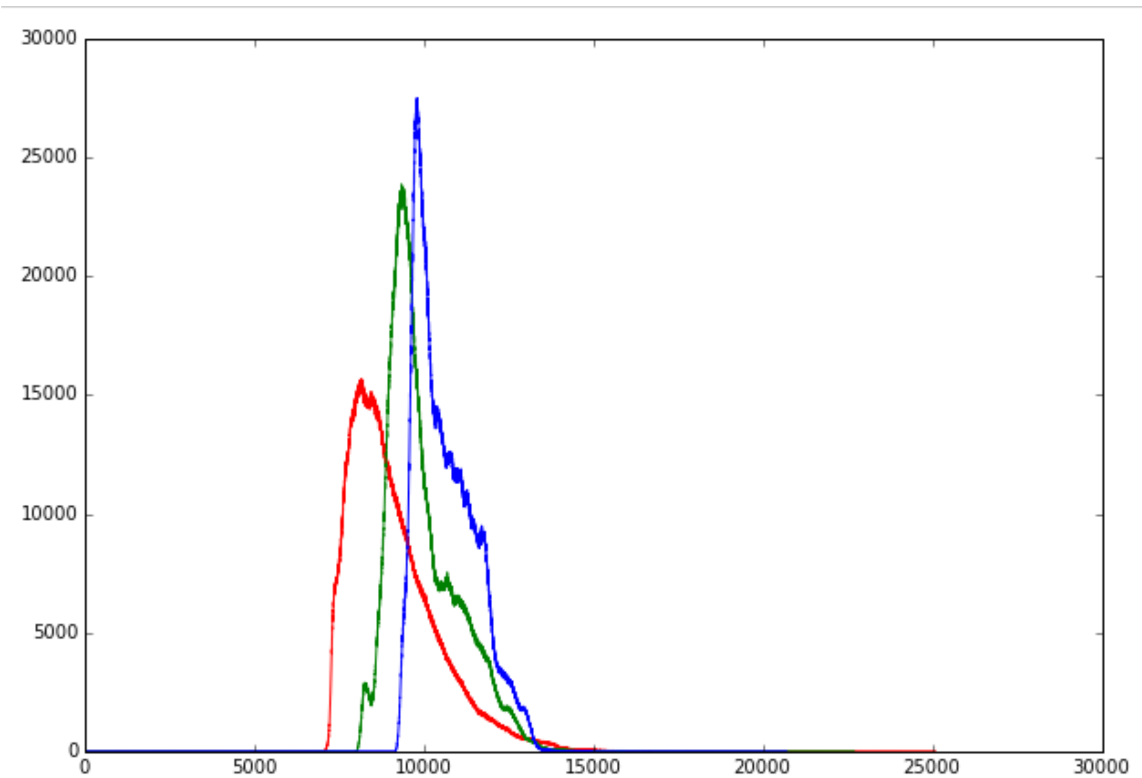
III. Pre-Processing the image

In this step, the RGB channels of the image are merged to get a coloured image and some image processing techniques are used to enhance the input image to obtain a much better image to work with And reduce noise.

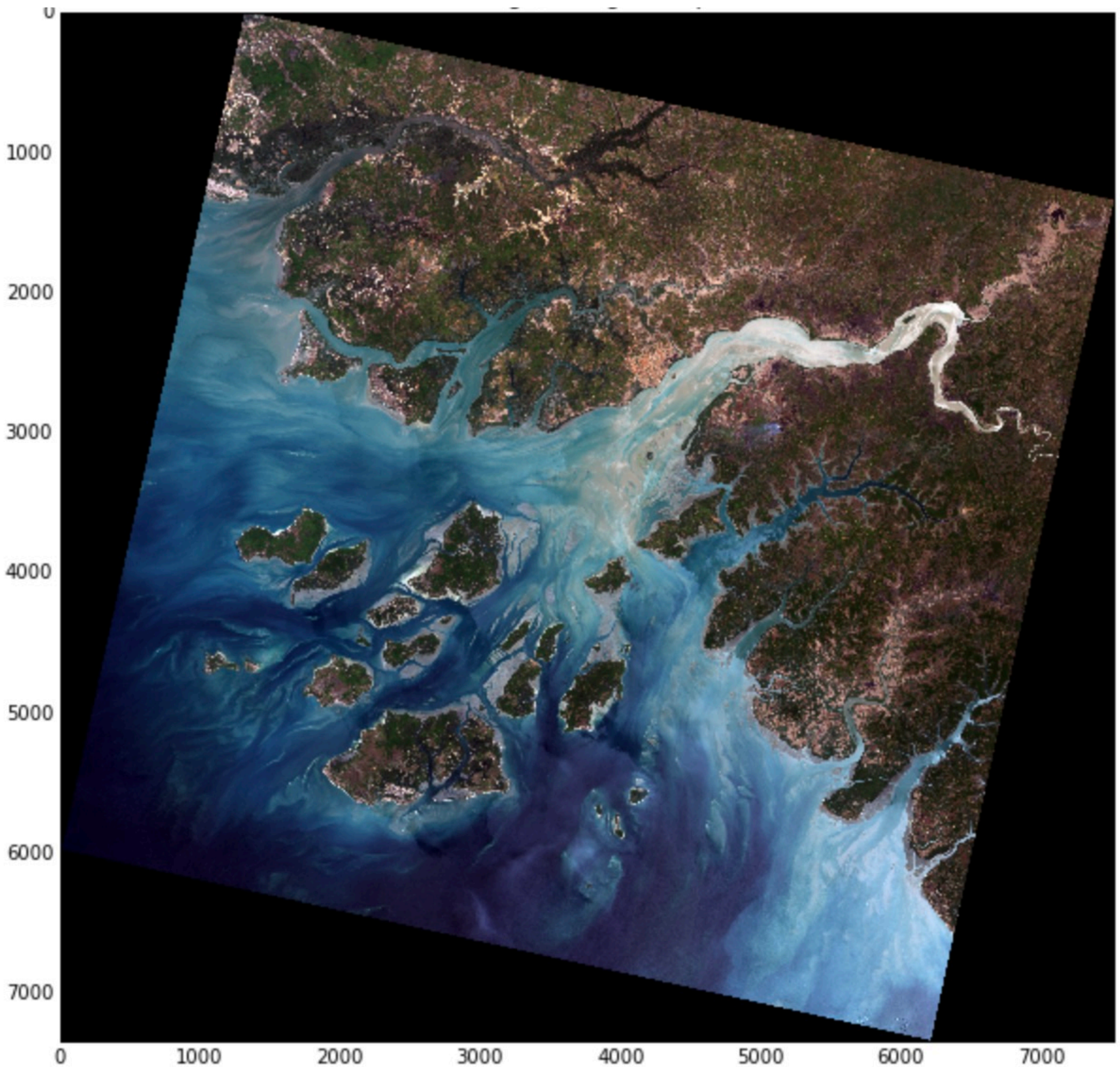
The following techniques were used to enhance the image:

Histogram equalisation

Histograms of RGB colours corresponding to raw data show that the data is not utilising full 16-bit range afforded by the detector. Limits for all three colours are picked and data is rescaled i.e; the RGB channels are histogram equalised and. This results in apparent brightening of the image .



Histogram of input 1



Input 1 histogram equalised

Contrast and Colour Balance Adjustment

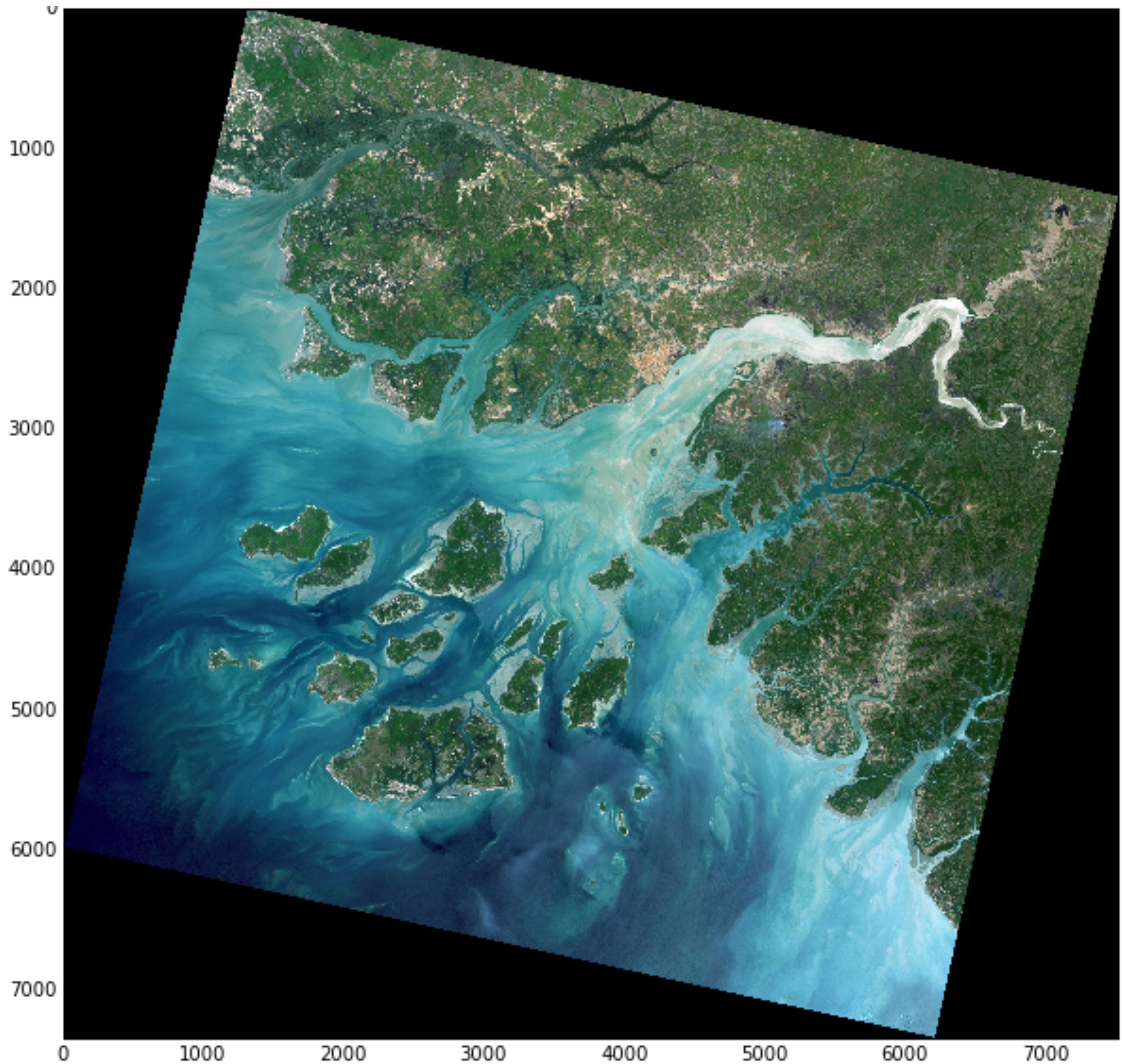
Adjusting contrast and colour balance of an image to their "right" levels is an iterative process. It involves the knowledge of how images at the same latitude and longitude look at a particular time of year. We will adjust balance of green and blue colours by shifting them to partially "brighter" values using gamma adjustment.

Gamma correction is a nonlinear operation used to encode and decode luminance or tristimulus values in video or still imagesystems. Gamma correction is, in the simplest cases, defined by the following power-law expression:

$$\boxed{s = c r^{\gamma}}$$

Images that are not corrected properly can look bleached out.

Trying to reproduce colours accurately also requires some knowledge of gamma correction because varying the value of gamma changes not only the intensity, but also the ratios of red to green to blue in a colour image.



Input 1 histogram equalised and colour gamma adjusted

IV. Panchromatic Sharpening

Panchromatic sharpening uses a higher-resolution panchromatic image (or raster band, refer to the table 1 , where band-8 is the panchromatic band) to fuse with a lower-resolution red-green-blue bands. The result produces a multiband raster dataset with the resolution of the panchromatic raster where the two rasters fully overlap.

Panchromatic sharpening is a radiometric transformation. Landsat dataset provides low resolution, multiband images and higher-resolution, panchromatic images of the same scenes. Panchromatic sharpening is used to increase the spatial resolution and provide a better visualization of a multiband image using the high-resolution, single-band image.

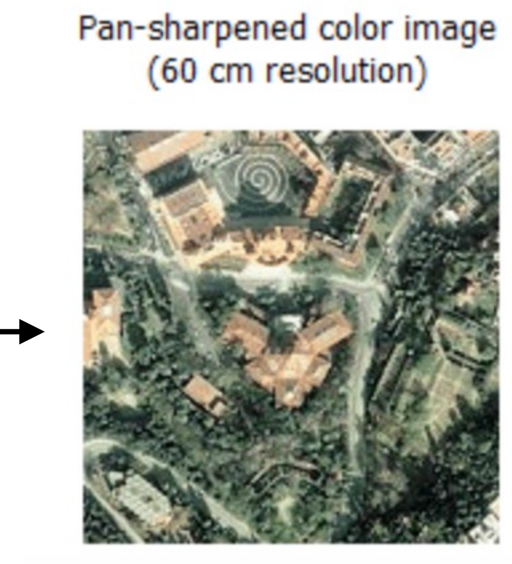
Spatial information in grayscale Band 8 and color information in the RGB color Bands 4, 3, and 2 is merged to create a high resolution color image.

Pansharpened image

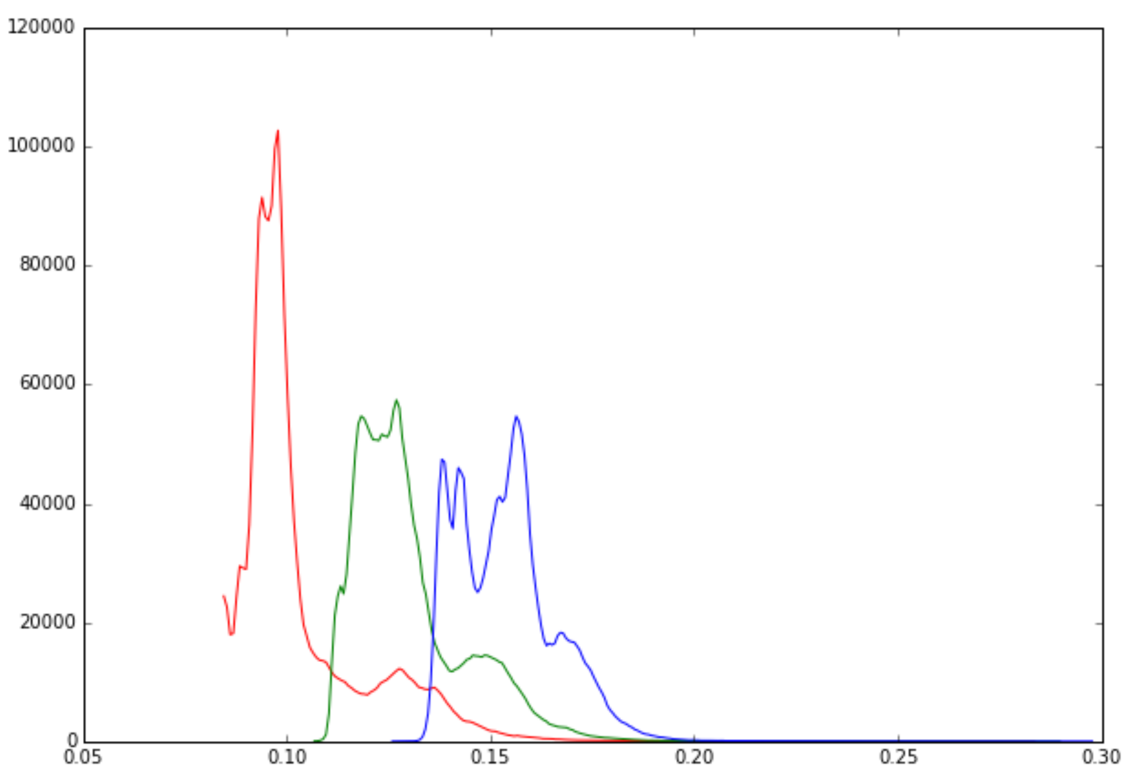
Raw image

Scale all the bands to to 0-1 range to ease the RAM requirements and transformations more apparent.Rescale RGB color image to match the resolution of the pan band (8).
Divide each of the upsampled RGB bands by their sumand multiply by pan band (8) to produce three high resolution RGB channels.

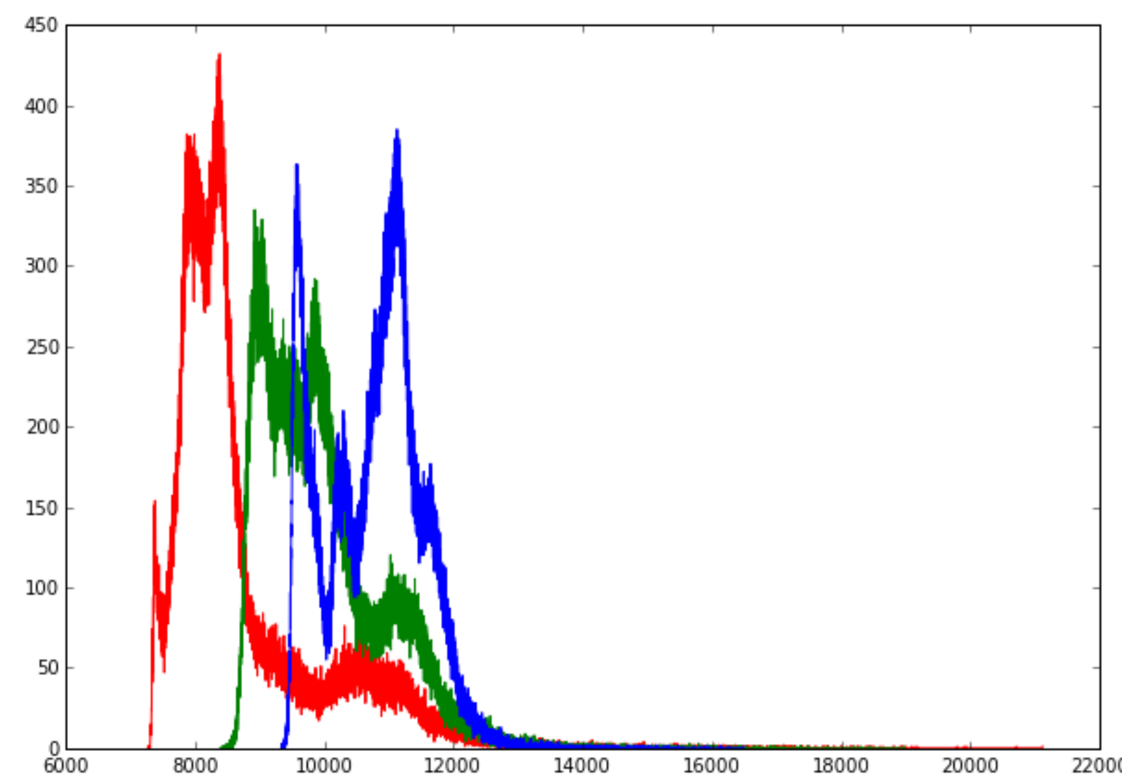
+



Panchromatic sharped image histogram



Raw image histogram



V. Segmentation of the image

The Final result obtained after histogram equalisation and gamma correction is segmented by unsupervised learning.We have implemented Mean shift algorithm and there are threshold values in the code which can be modified to get different segmentes images

Mean shift is a procedure for locating the maxima (modes) of a density function given discrete data sampled from that function. This is an iterative method, and we start with an initial estimate . Let a kernel function **$K(x_i - x)$** be given. This function determines the weight of nearby points for re-estimation of the mean. Typically a Gaussian kernel on the distance to the current estimate is used, **$K(xi - x) = e^{-c\|xi - x\|^2}$** The weighted mean of the density in the window determined by **K** is

$$m(x) = \frac{\sum_{x_i \in N(x)} K(x_i - x) x_i}{\sum_{x_i \in N(x)} K(x_i - x)}$$

where ***N(x)*** is the neighborhood of ***x***, a set of points for which **k(xi) $\neq$ 0** .

The difference ***m(x) - x*** is called *mean shift .* The mean shift now sets **x <— *m(x)*** and repeats the estimation until ***m(x)*** converges.

The results were obtained by varying various threshold values and the best classification Was taken as the output and sent to the next module in the workflow.

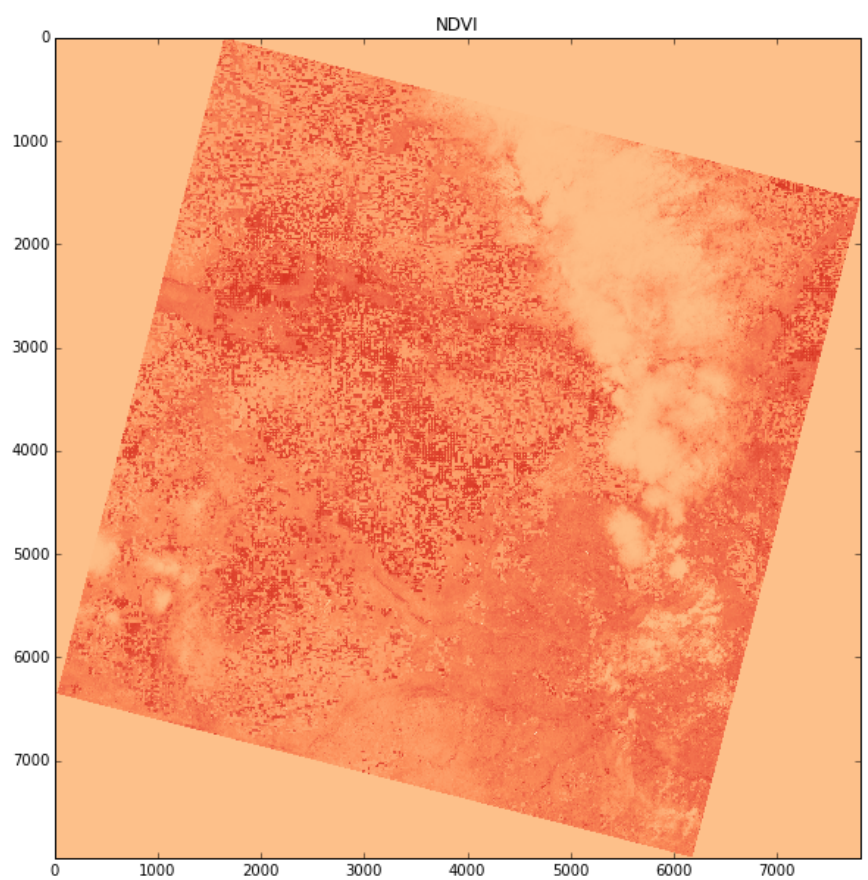
V. NDVI computation

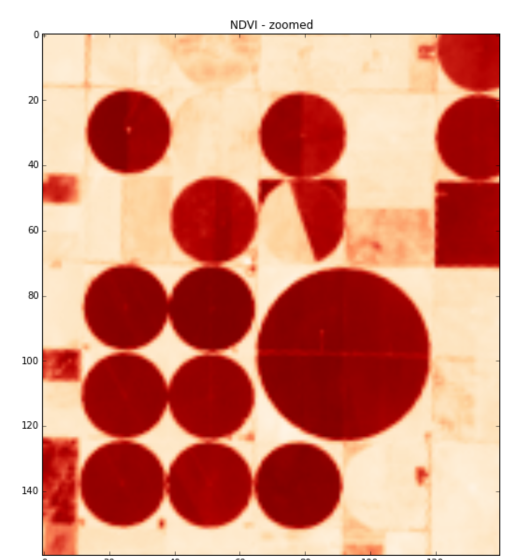
The normalized difference vegetation index (NDVI) is used to assess the state of vegetation. In living plants chlorophyll-A, from the photosynthetic machinery, strongly absorbs red color; on the other hand, near-infrared light is strongly reflected. Live, healthy vegetation reflects around 8% of red light and 50% of near-infrared light. Dead, unhealthy, or sparse vegetation reflects approximately 30% of red light and 40% of near-infrared light.

NDVI = (NIR - Red) / (NIR + Red)

Where NIR is near-infrared band-5
Red is colour red band-4

By its formulation, NDVI ranges from -1 to +1. In practice, an area of an image containing living vegetation will have NDVI in the range 0.3 to 0.8. High water content clouds and snow will have negative values of the index. Bodies of water, having low reflectance in both Band 4 and 5, exhibit very low positive or negative index. Soil, having slightly higher reflectance in near-infrared than in red, will produce low positive values of the index.





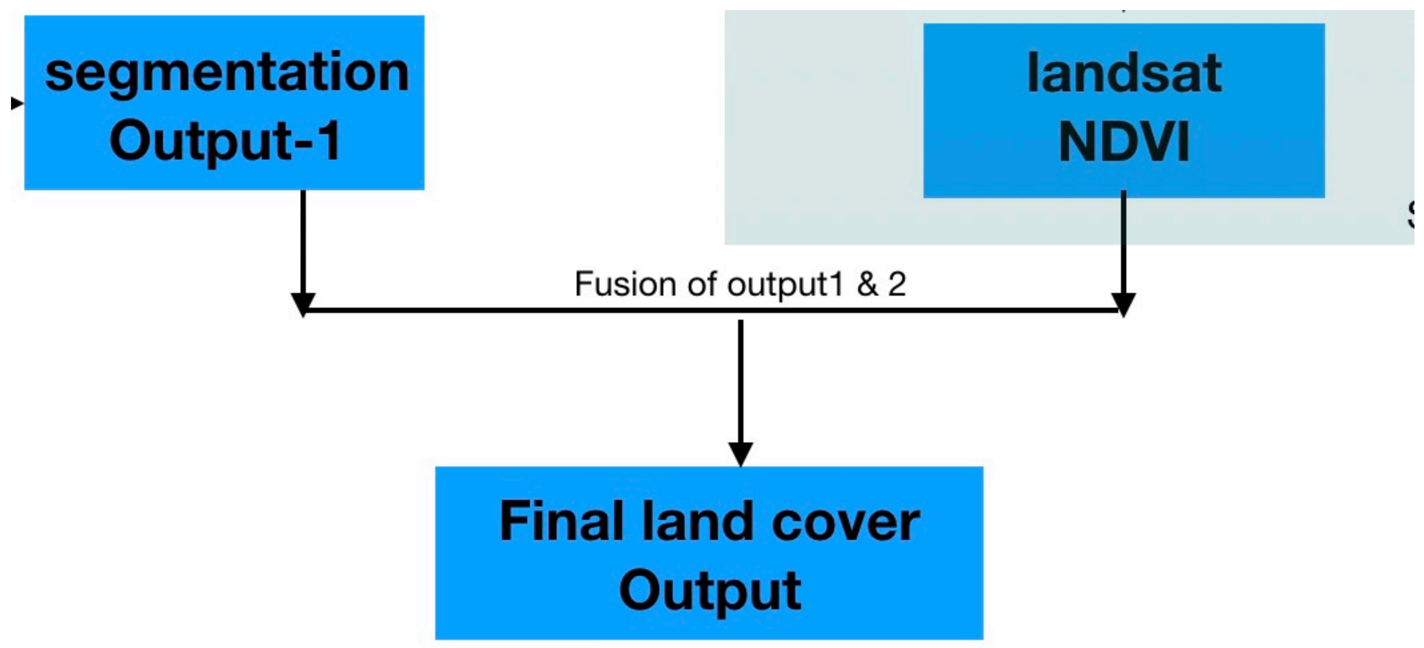
Zoomed ndvi

VI. Final classification

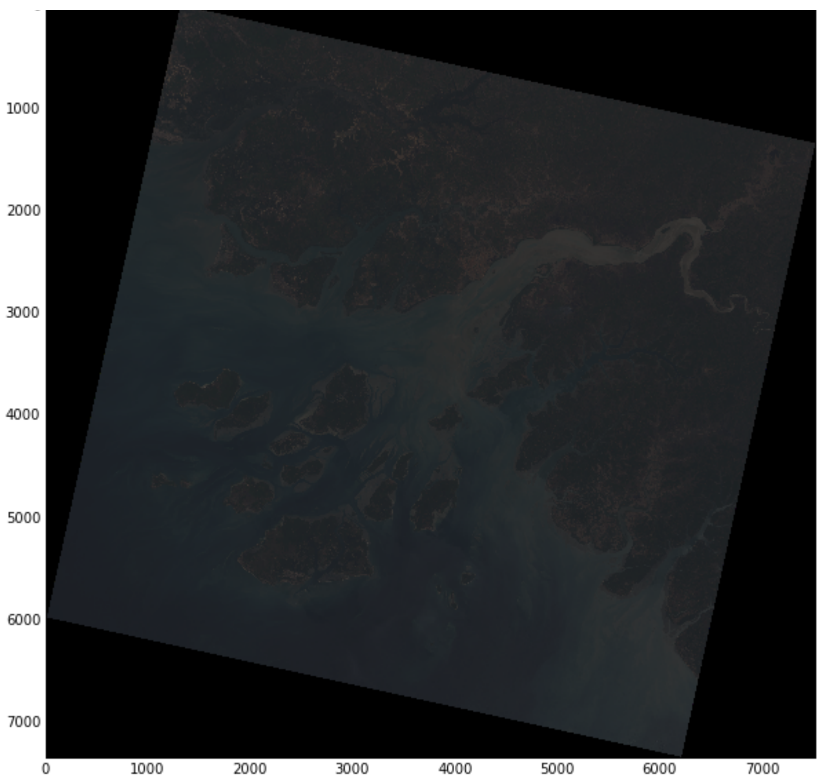
The output obtained from section 1 i.e; the classification with only RGB and the result obtained from section 2 which is the the NDVI computed Landsat image are both used to obtain a final and better classification of Input satellite image.

NDVI ranges from -1 to +1. In practice, an area of an image containing living vegetation will have NDVI in the range 0.3 to 0.8. We use this metric to keep a threshold and assign the value in the output 1 by checking the respective pixel value of the NDVI landsat image. If it falls in the range of the vegetation cover, then it is classified as green cover , and similarly for urban and water cover.

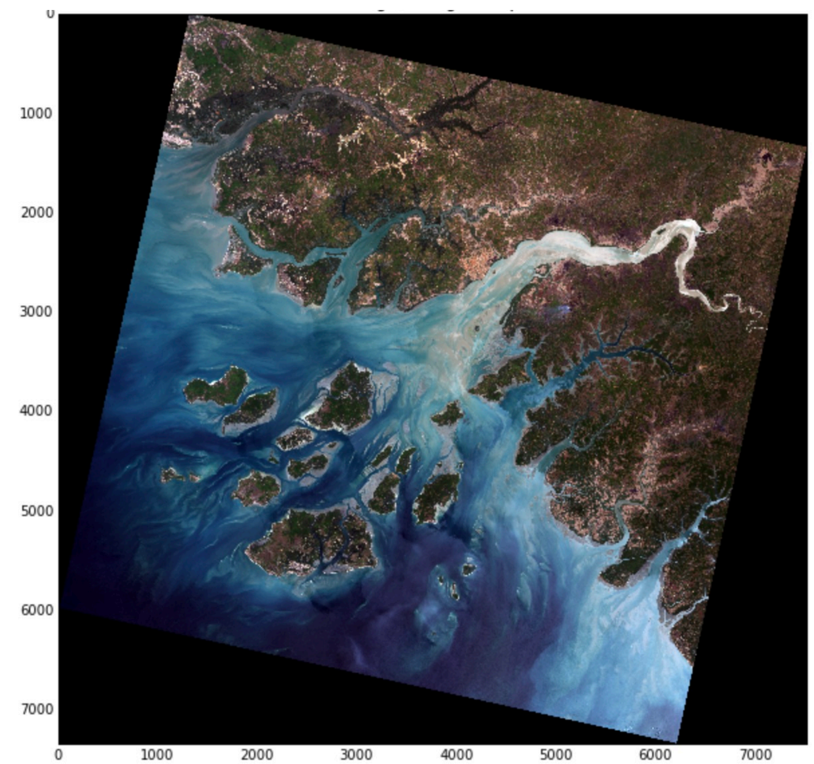
By final testing and segmentation by including the NDVI Landsat metric improves the detection and a huge extend and it can be seen in the results provided.



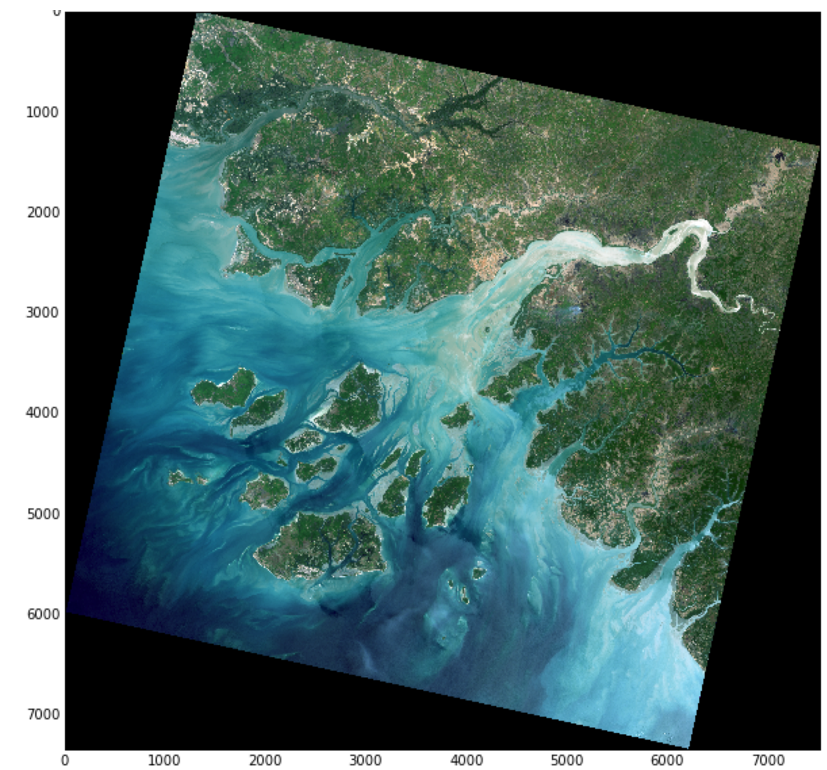
Results



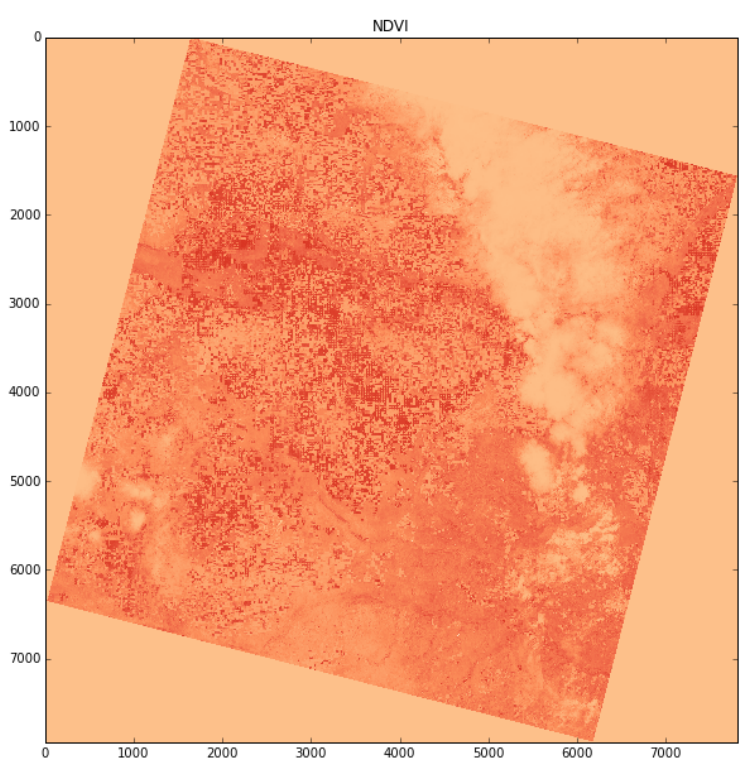
Input



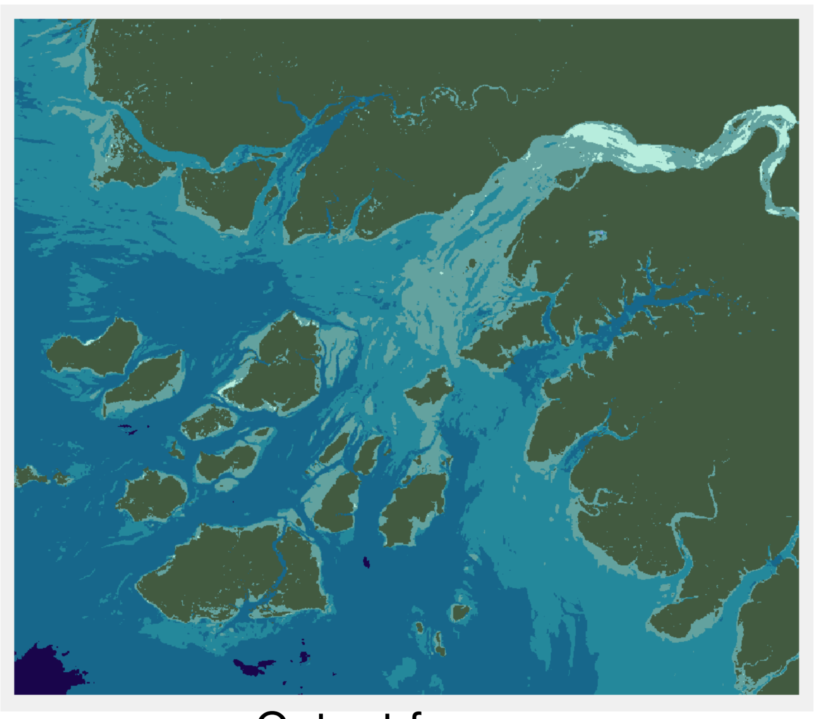
histogram equalised



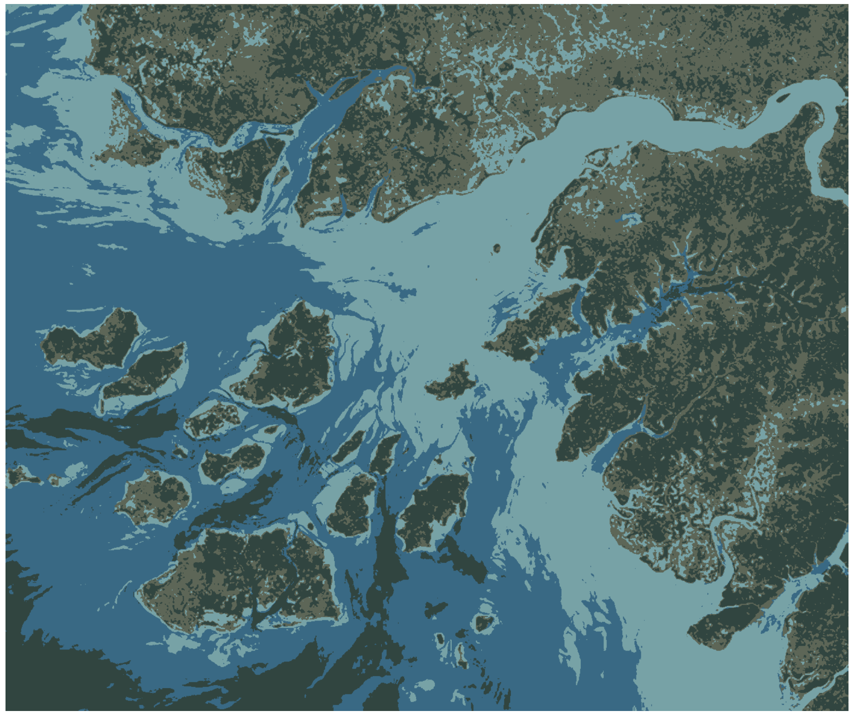
histogram equalised and
colour gamma adjusted



NDVI



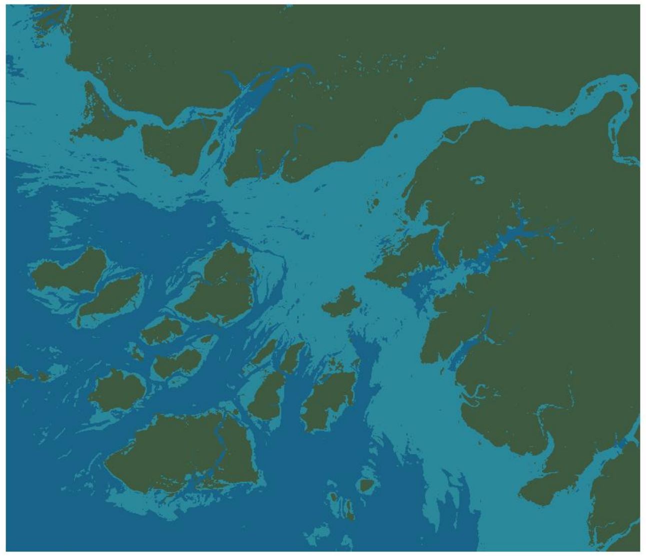
Output from
section 1



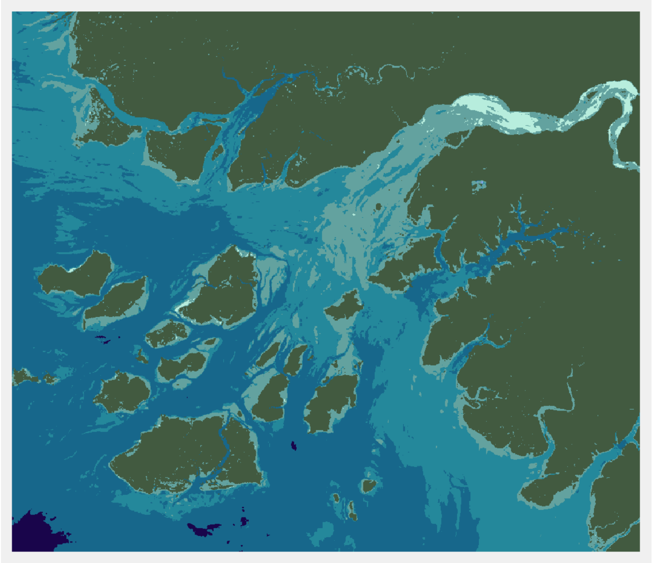
Final output

Subjective results : visual differences

A



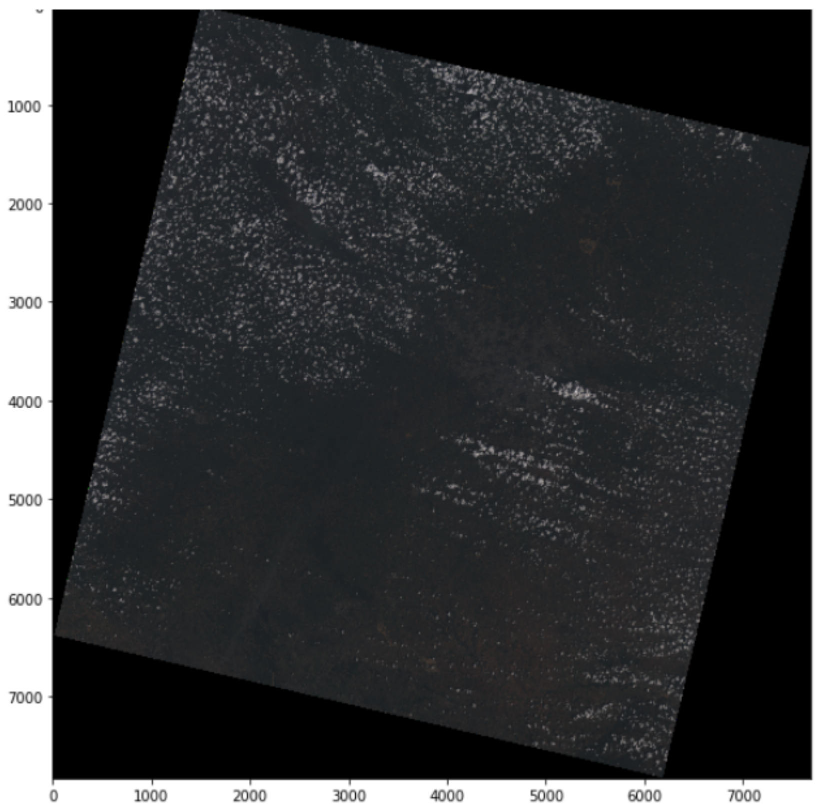
B



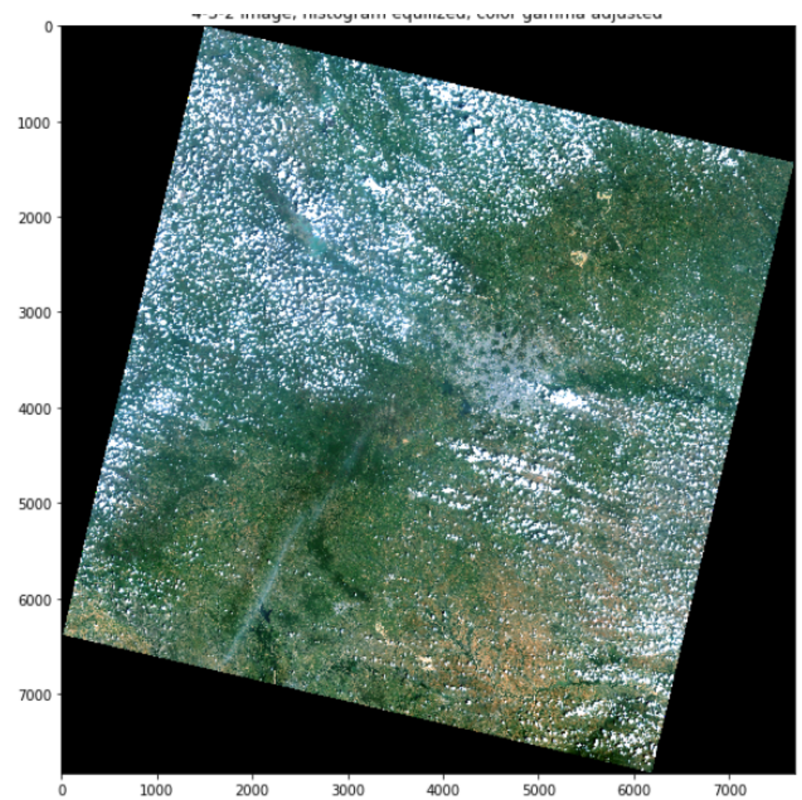
C

Objective results: difference through MSE

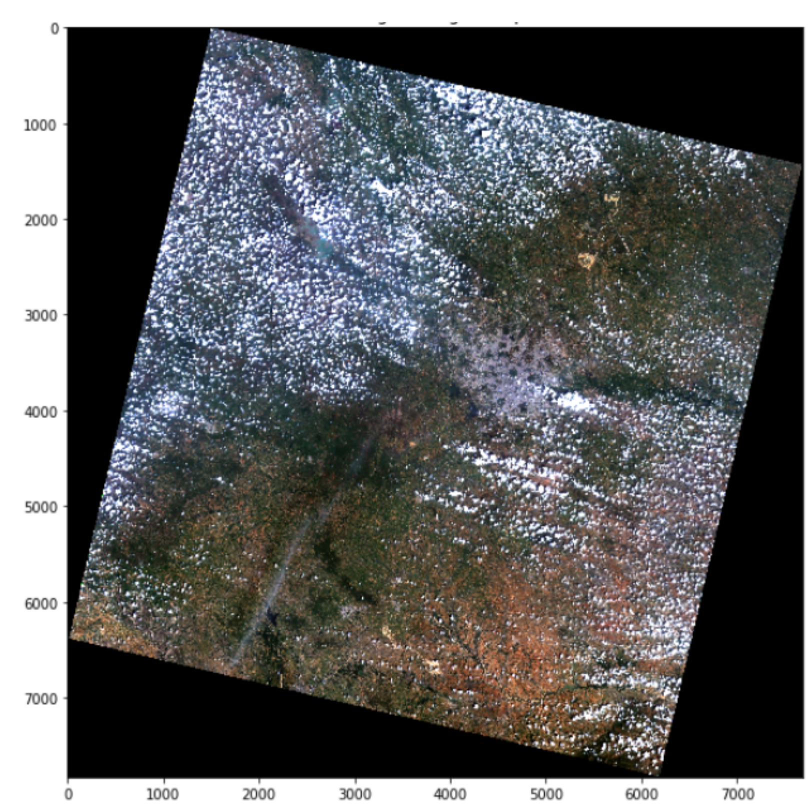
Threshold value	Threshold value	MSE
0.2	0.1	40
0.1	0.07	21



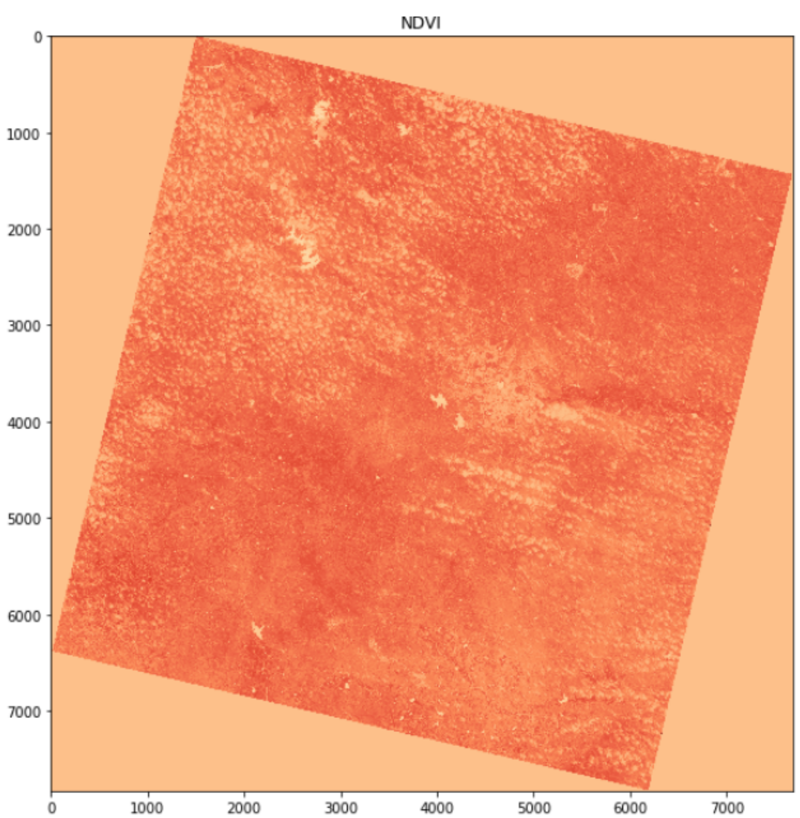
Input



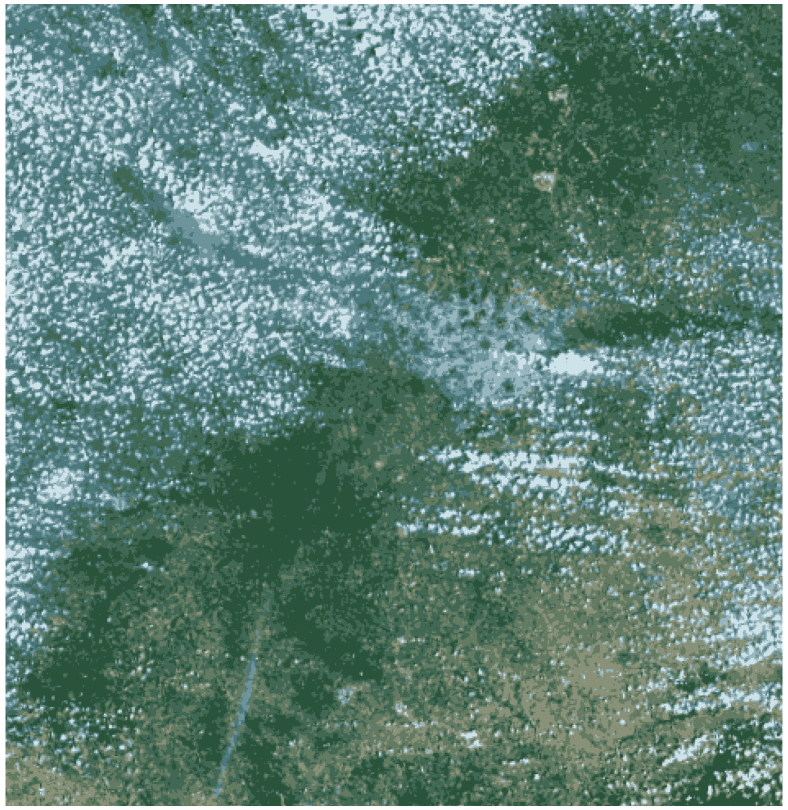
histogram equalised



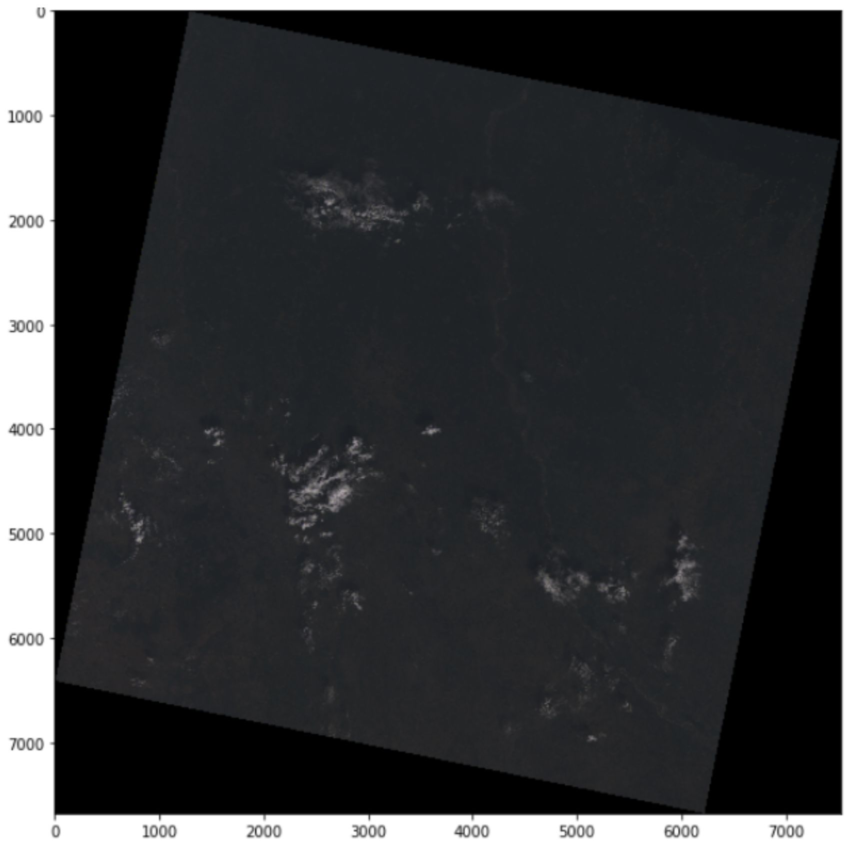
histogram equalised and
colour gamma adjusted



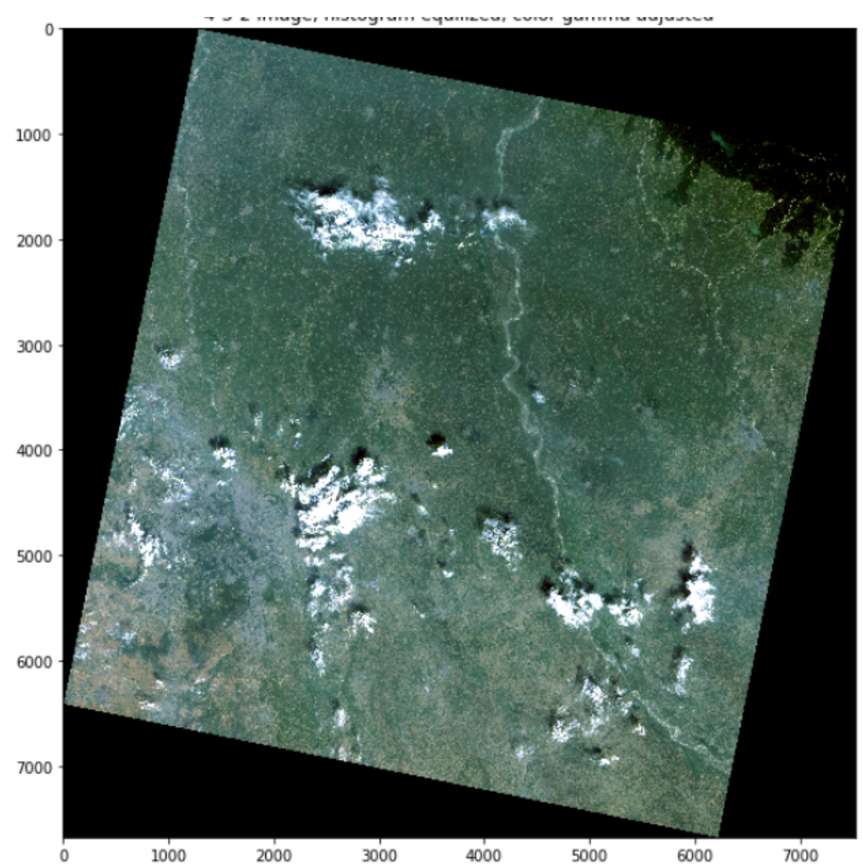
NDVI



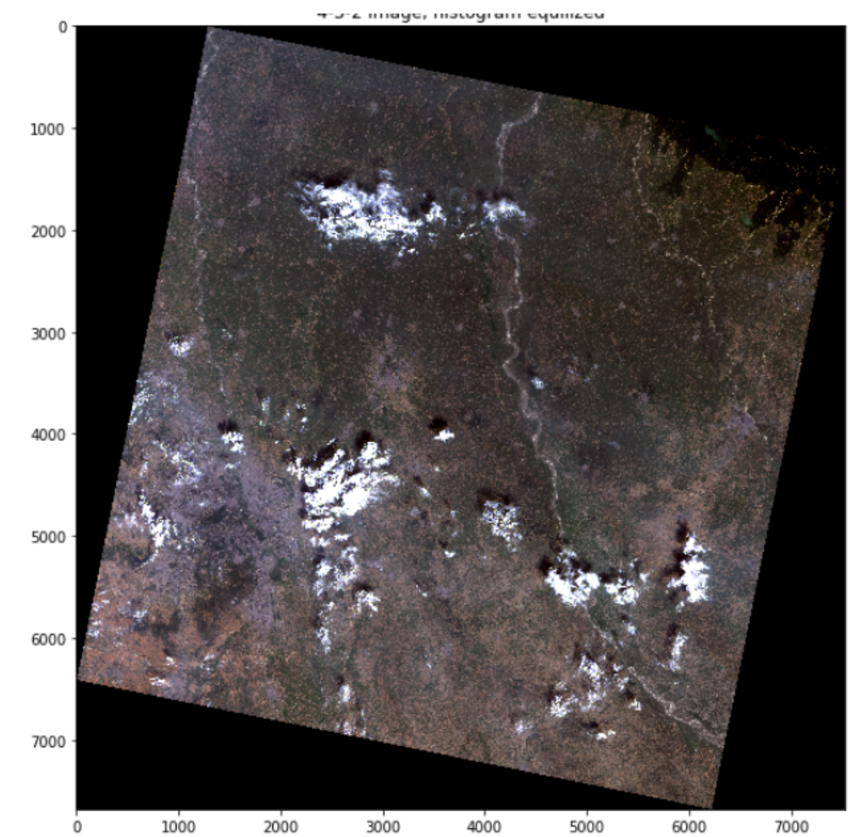
Final output



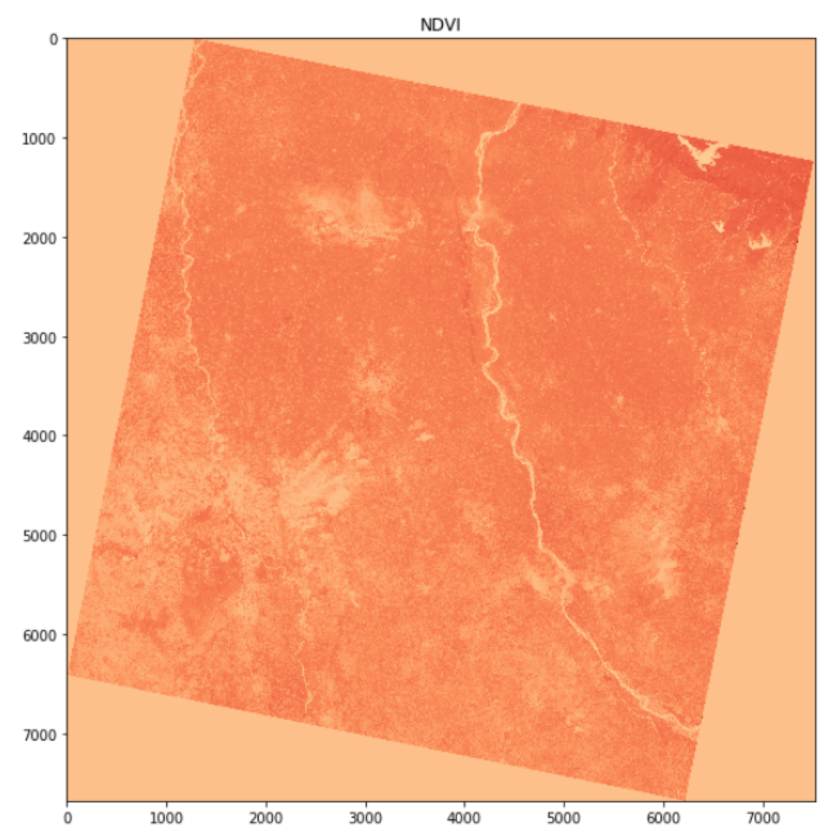
Input



histogram equalised

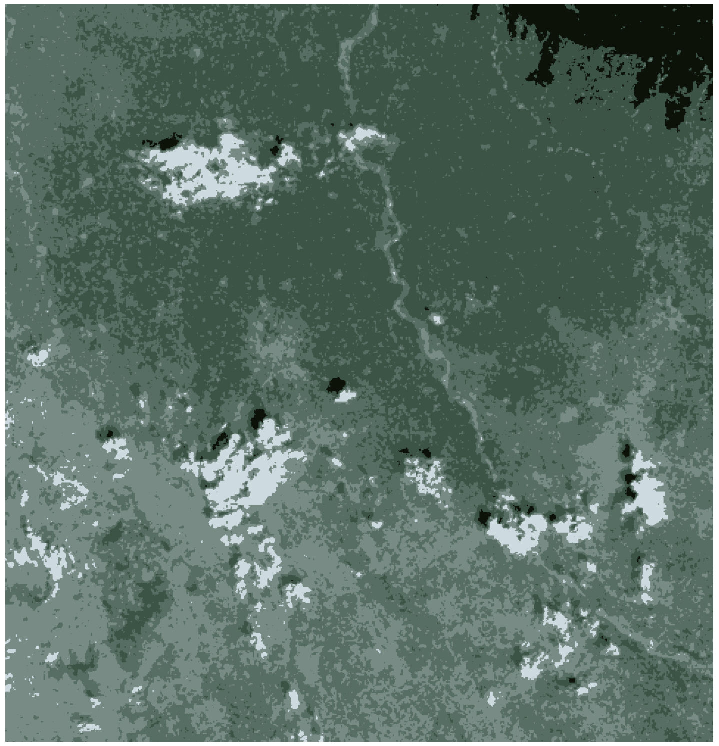


histogram equalised and colour gamma adjusted



NDVI

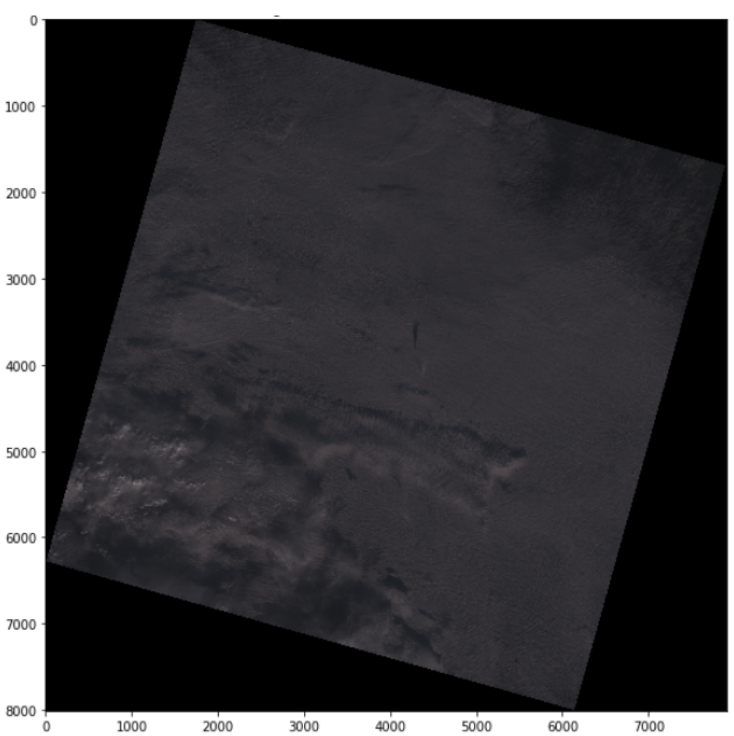
Output from section 1



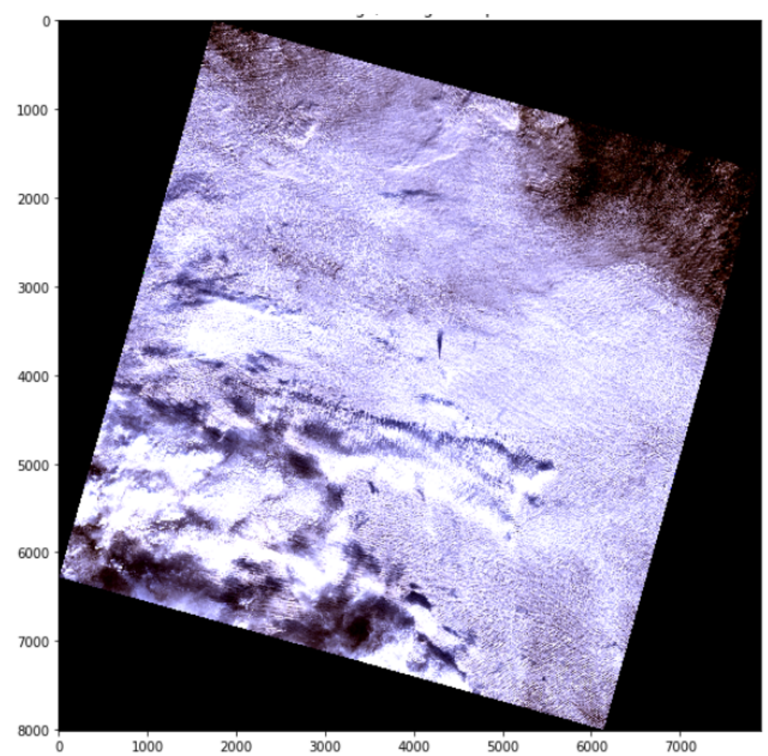
Final output

Failure case :

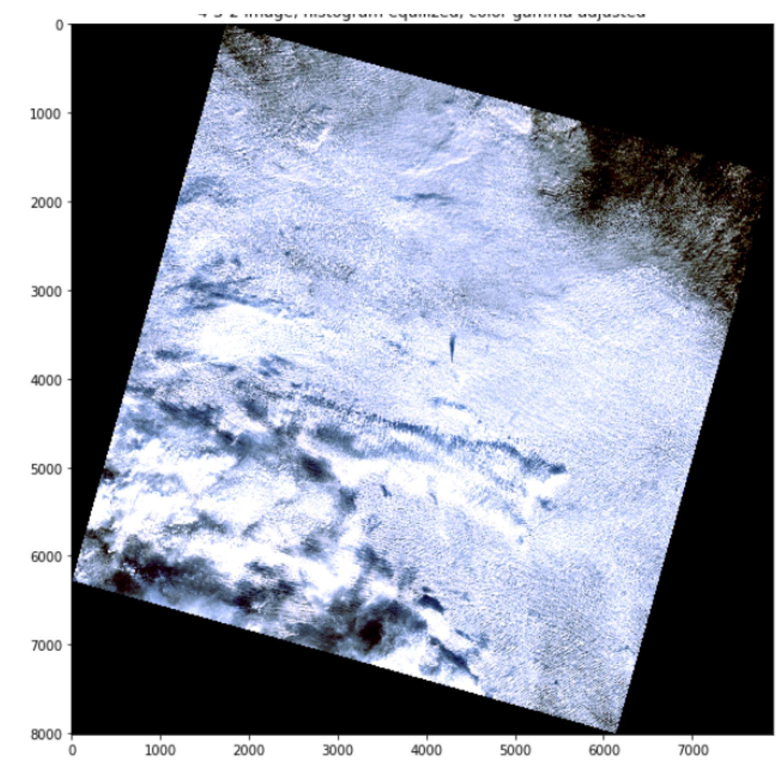
When there is cloud cover



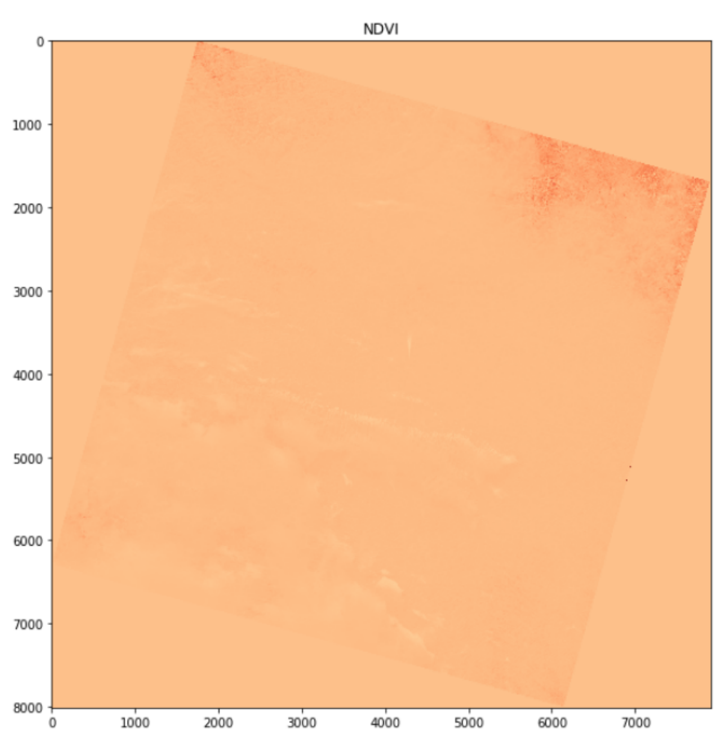
Input



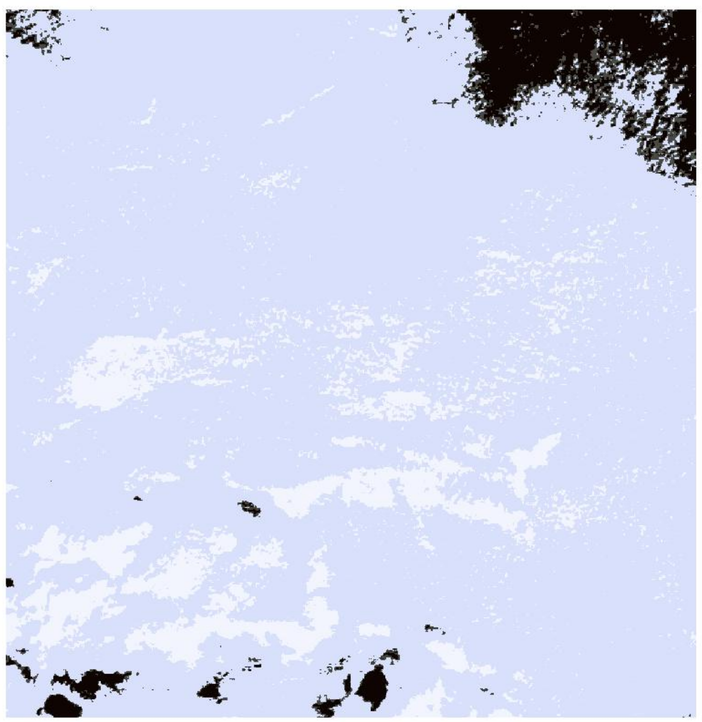
histogram equalised



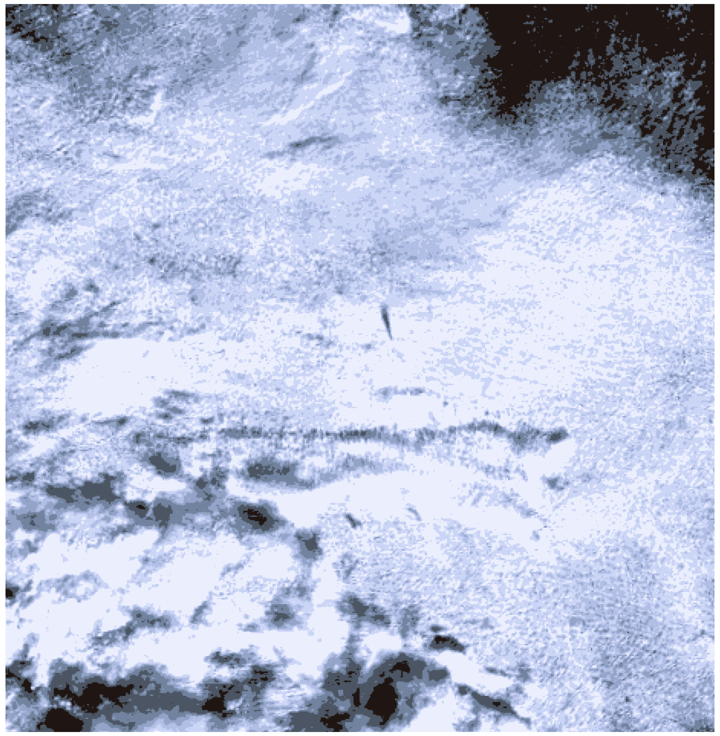
histogram equalised and colour gamma adjusted



NDVI



Output from section 1



Final output

Limitations

1) Obtaining the satellite image datasets to work it:

- There are many types of satellite images with different bands in each type but only a few datasets are made publicly available for free download.
- Each Satellite image has a very large resolution and have many bands. These images are very large (approx. 800-900 MB for each image). So, working on them is computationally very hard and run image processing algorithms on them.
- The datasets are very hard and very rare to acquire as most of them are at a price. Many options and choices are not available for ones that are freely available for downloading.

2) Calculation of the NDVI is sensitive to to a few factors:

- Atmospheric composition and appropriate modeling influence the calculation, especially if the correct water and aerosol content are initially incorrectly estimated.
- Thin, hard to spot clouds like cirrus can significantly affect the calculation.
- Sensor effects such as Sun angle not being calculated on per-pixel basis can influence the index estimation.