

Remote Sensing Project: Chennai Floods 2015

IT in Domains

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Outline

- Objective
- Research Questions
- Sentinel Data Overview
- Sentinel-1 Toolbox
- Methodology
- Results
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Objective

To use remote sensing data to monitor floods and to the assess damage caused by the floods in Chennai in the year 2015



Research questions

1. How can we identify flooded areas from SAR images?
 - a. Given the remotely sensed satellite images of the study area, how can we map a certain pixel as water pixel?
 - b. How can we analyse the changes based on temporal data?
2. Classification
 - a. How to classify the water bodies from land areas using radar data ?



Radar data

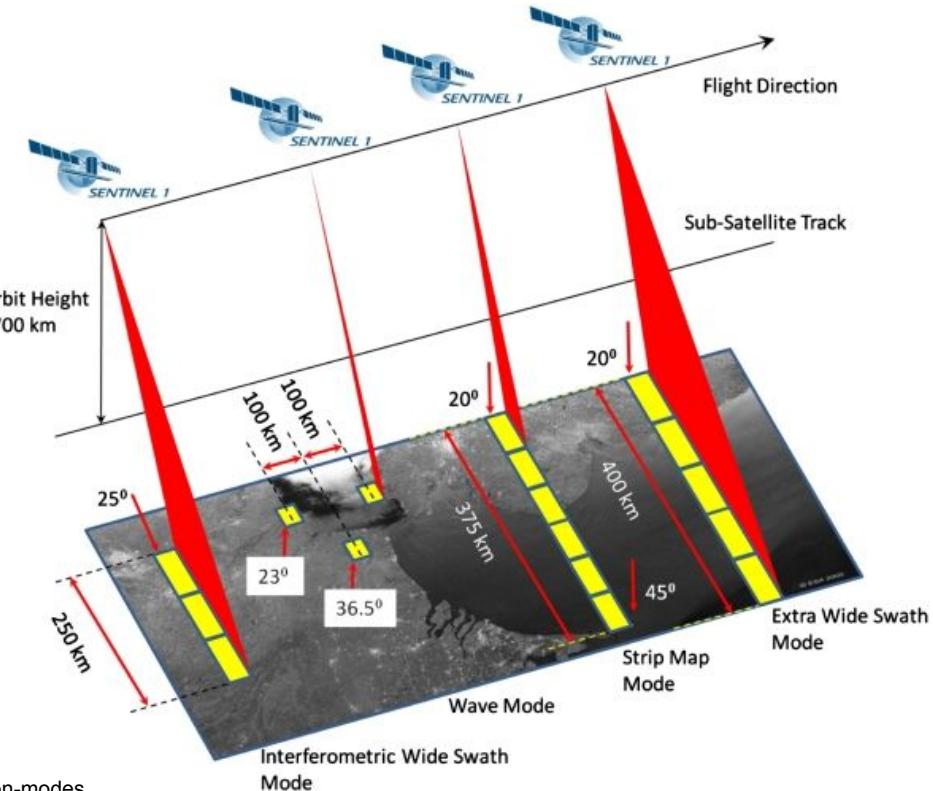
- Sentinel-1 radar data is fundamentally different from Landsat data, which is optical
- The grey levels of the scene are related to the relative strength of the microwave energy backscattered by the landscape elements
- Different surface features exhibit different scattering characteristics:
 - Urban areas: very strong backscatter
 - Forest: medium backscatter
 - Calm water: smooth surface, low backscatter
 - Rough sea: increased backscatter due to wind and current effects



Sentinel 1 data overview

The SENTINEL-1 Synthetic Aperture Radar (SAR) instrument may acquire data in four exclusive modes:

- Stripmap (SM)
- Interferometric Wide swath (IW)
- Extra Wide swath (EW)
- Wave (WV)





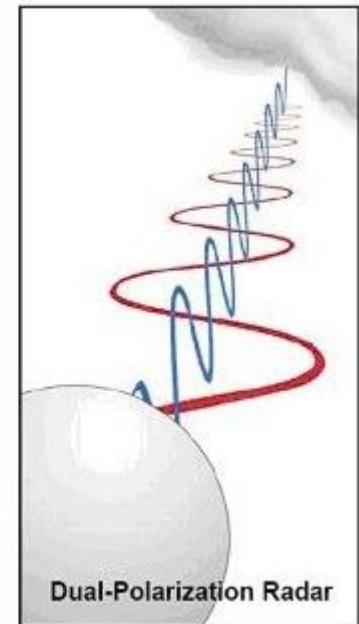
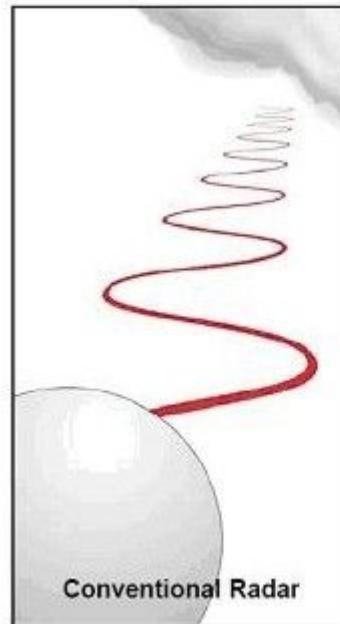
Sentinel 1 data overview

- Raw Level-0 data
- Processed Level-1 Single Look Complex (SLC) data comprising complex imagery with amplitude and phase
- Ground Range Detected (GRD) Level-1 data with multi-looked intensity only
- Level-2 Ocean (OCN) data for retrieved geophysical parameters of the ocean

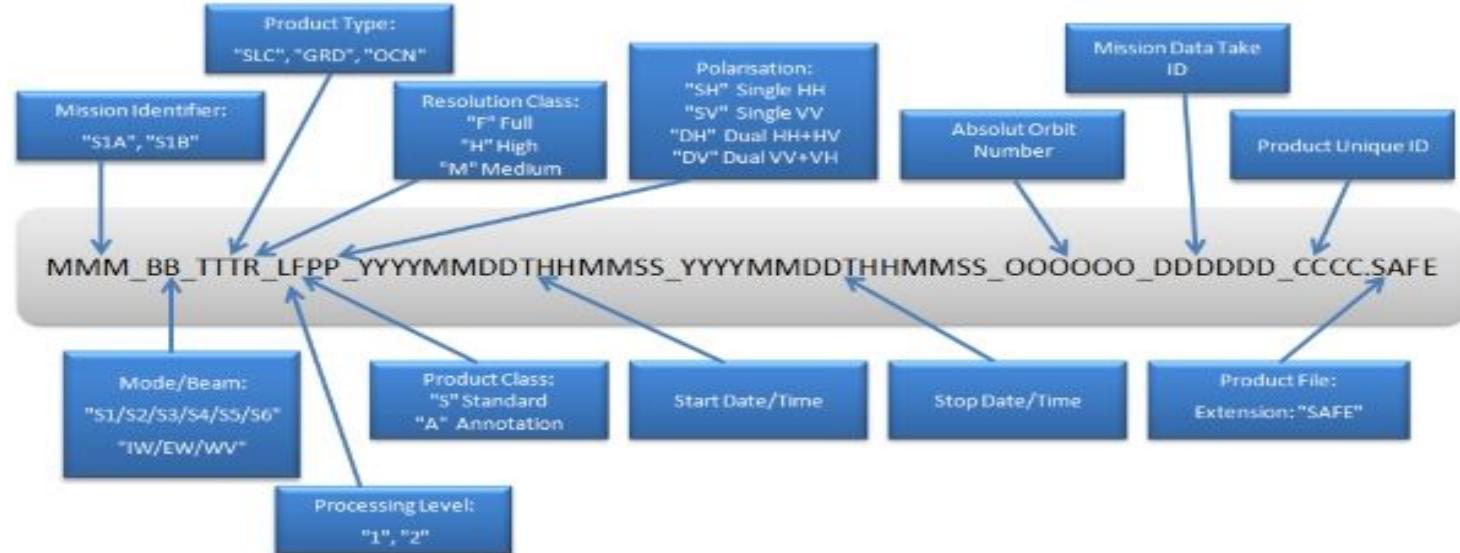
Sentinel 1 data overview

Polarizations:

- Horizontal Transmit Horizontal Receive (HH)
- Horizontal Transmit Vertical Receive (HV)
- Vertical Transmit Vertical Receive (VV)
- Vertical Transmit Horizontal Receive (VH)



Data Format



S1A_IW_GRDH_1SDV_20160522T003123_20160522T003152_011364_01142B_0465.SAFE



Sentinel-1 Toolbox S1TBX

The Sentinel-1 Toolbox (S1TBX) consists of a collection of processing tools, data product readers and writers and a display and analysis application to support the large archive of data from ESA SAR missions

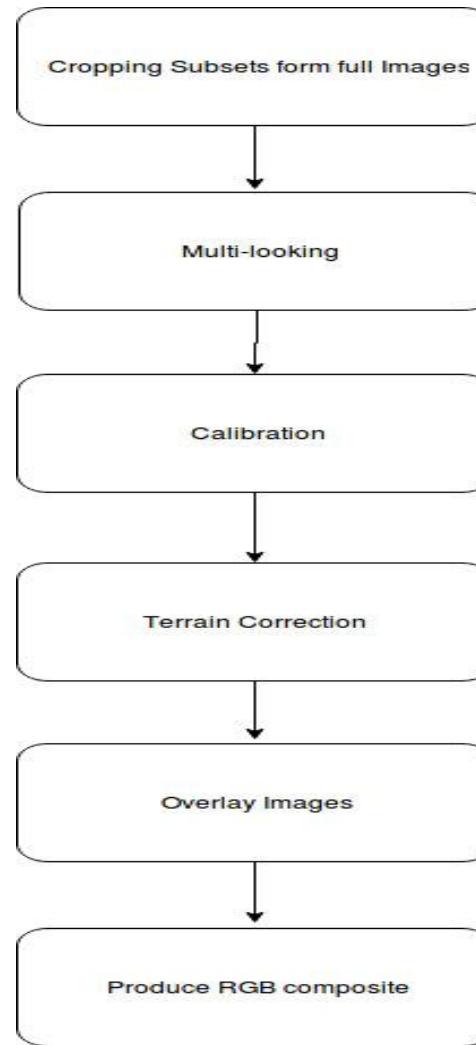


Data used



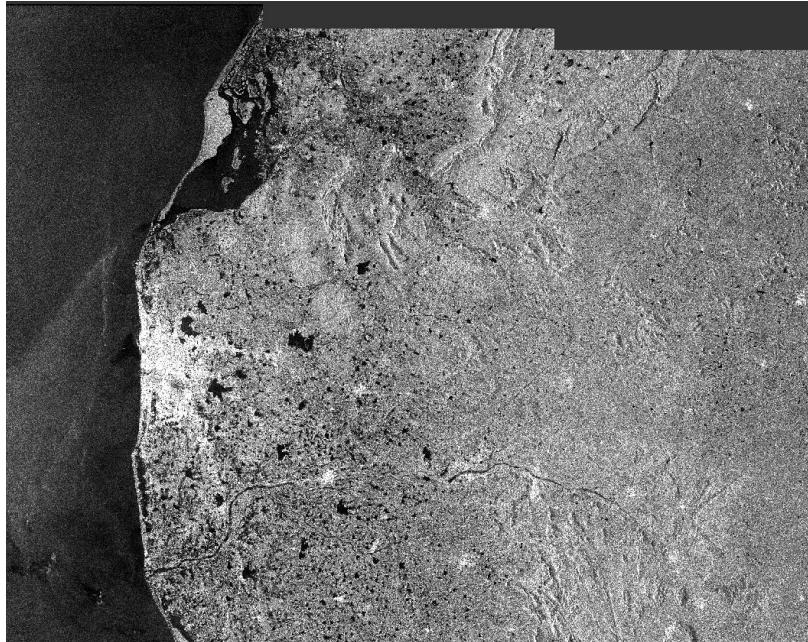


Methodology

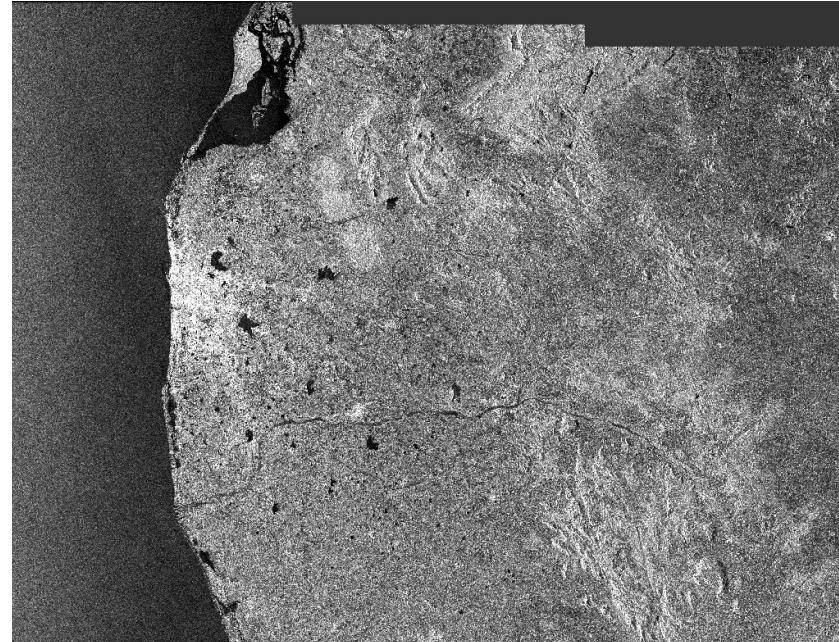




Original



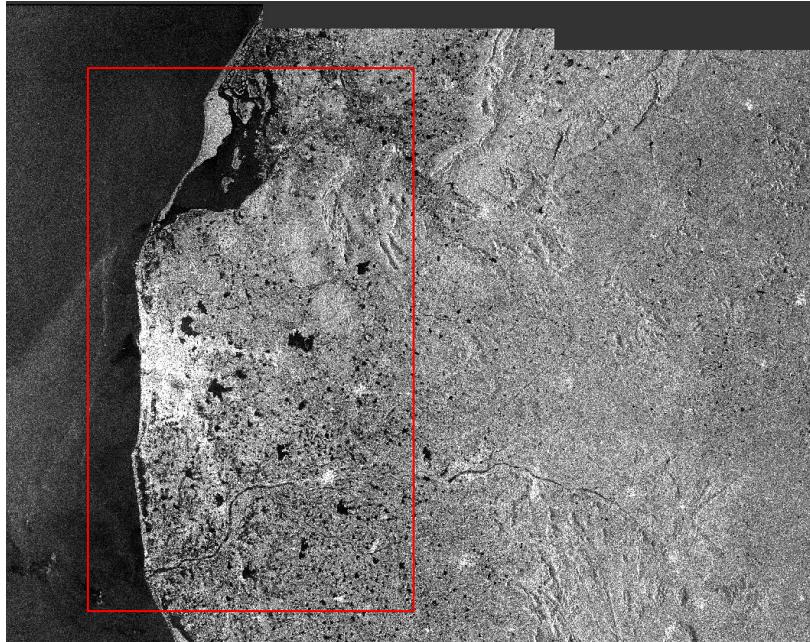
24-11-2015



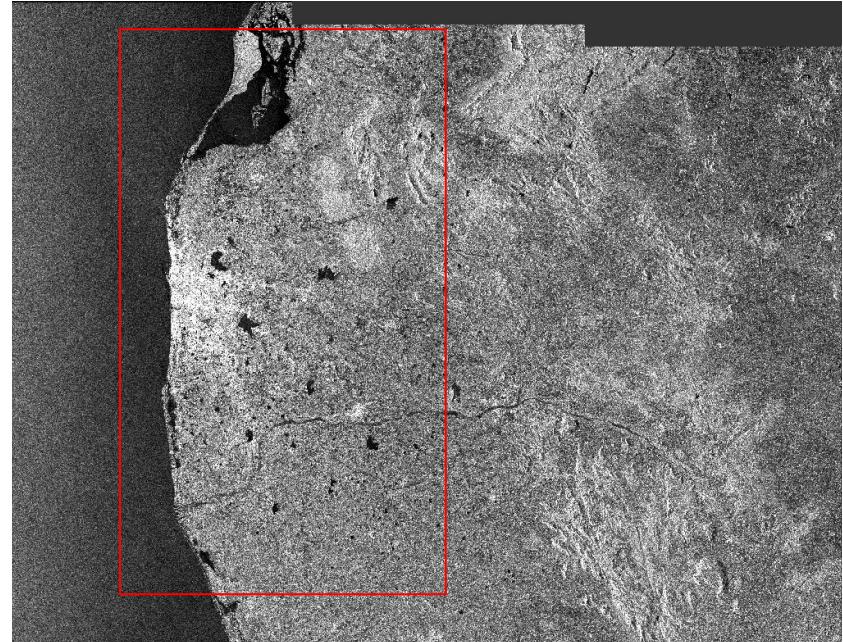
22-05-2016



Subsets



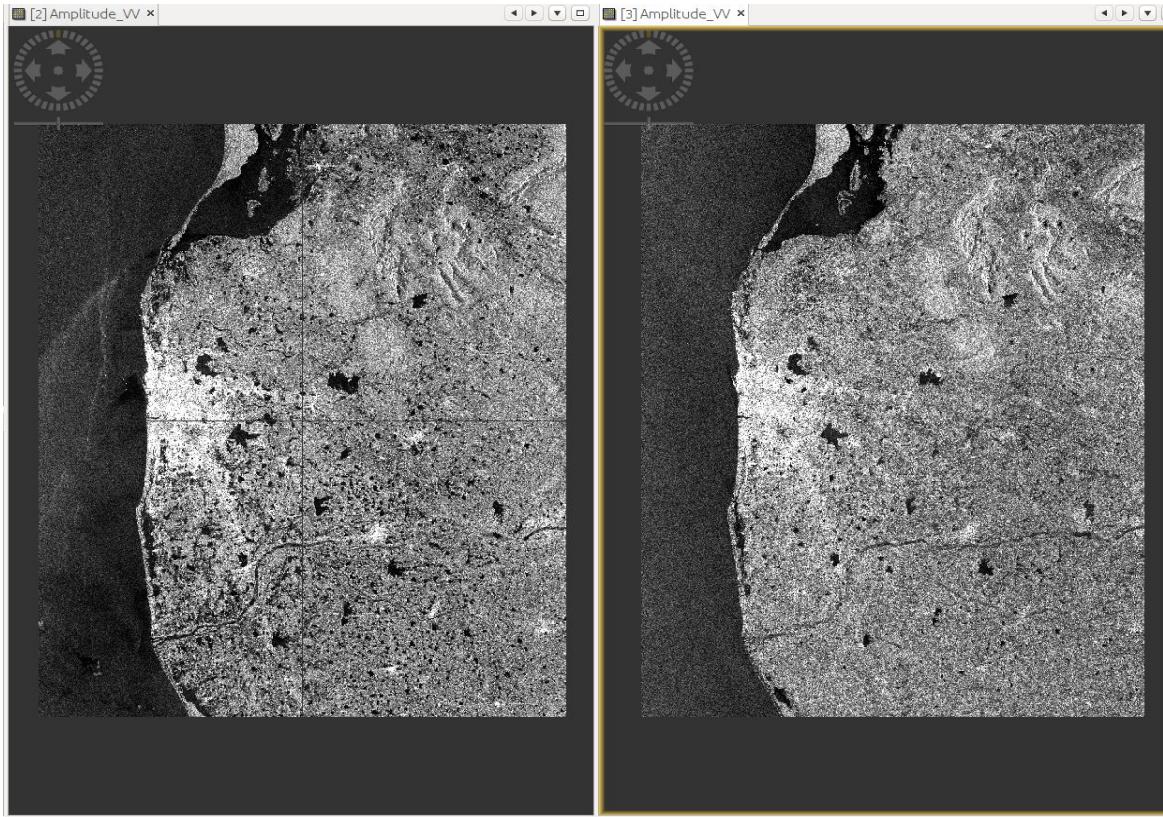
24-11-2015



22-05-2016

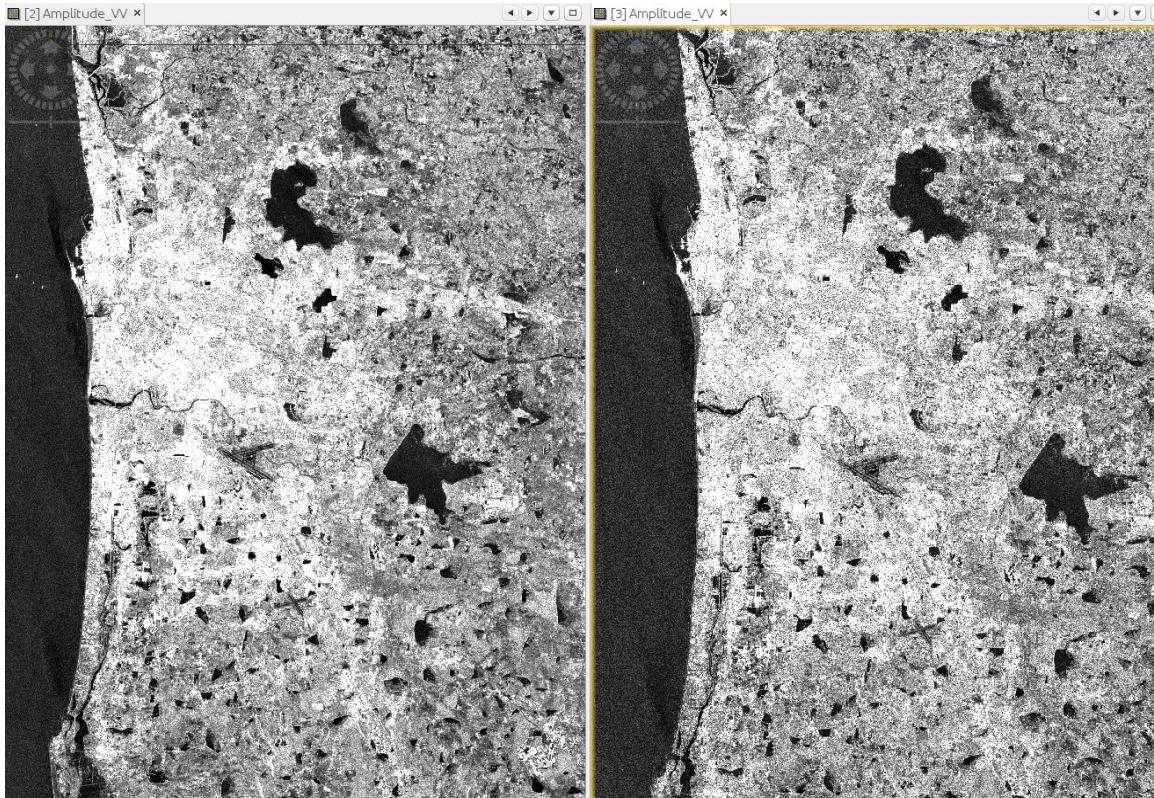


Cropped Subsets



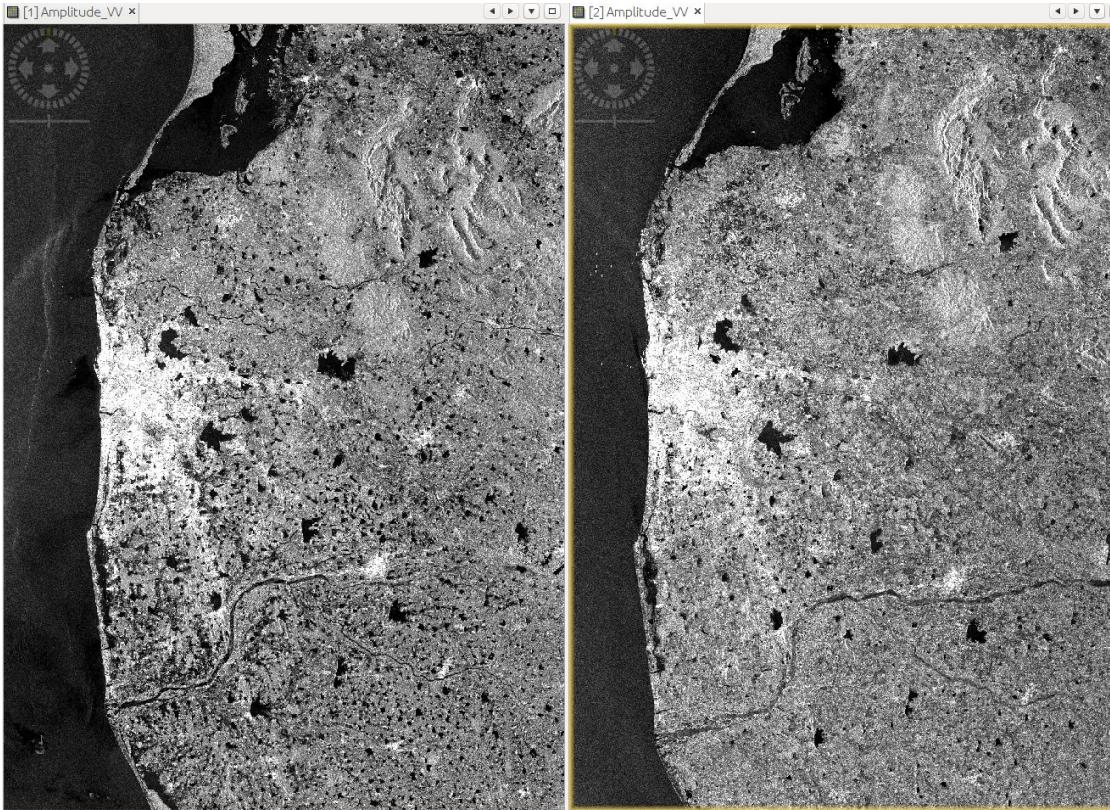


Multi-looking

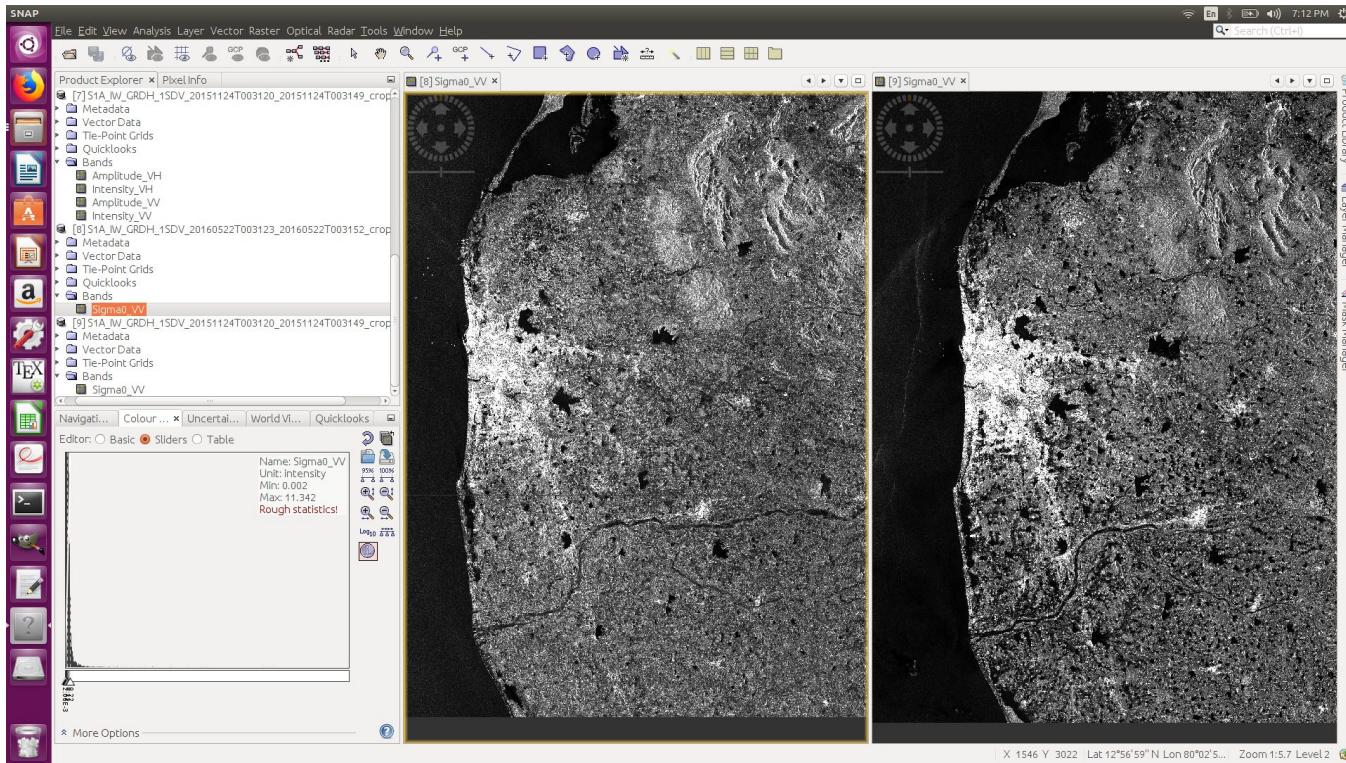




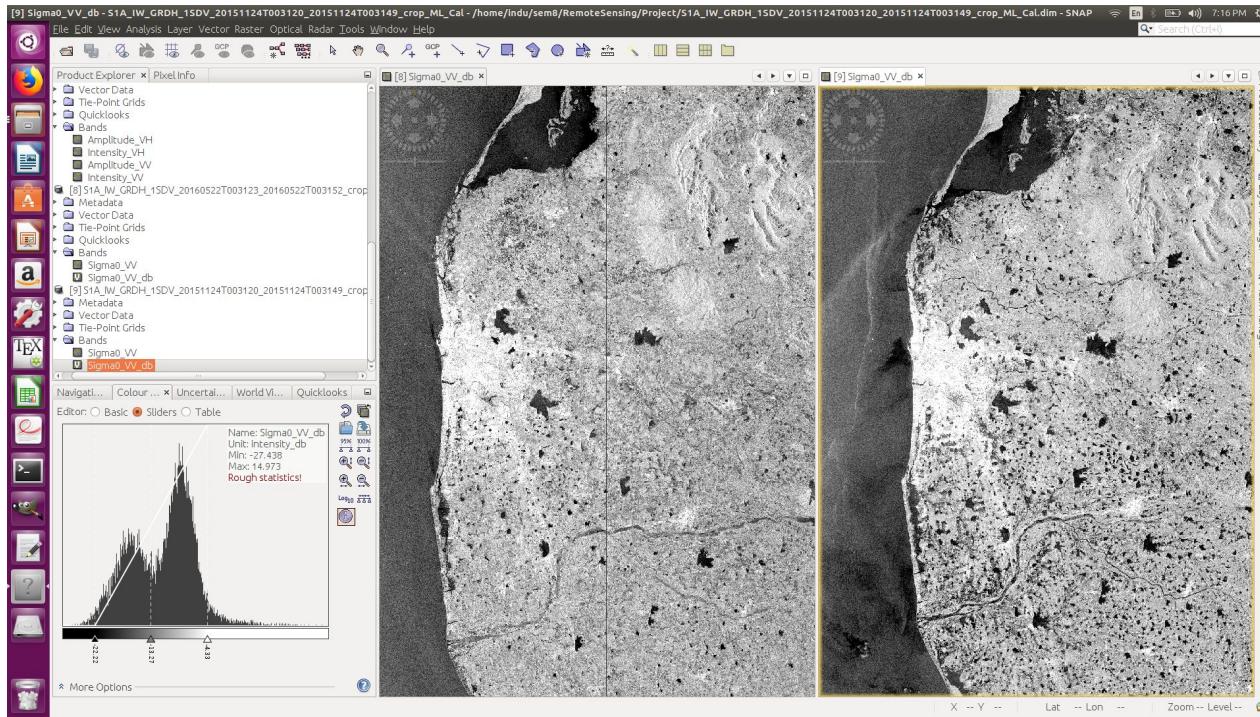
Multi-looked images



Calibration

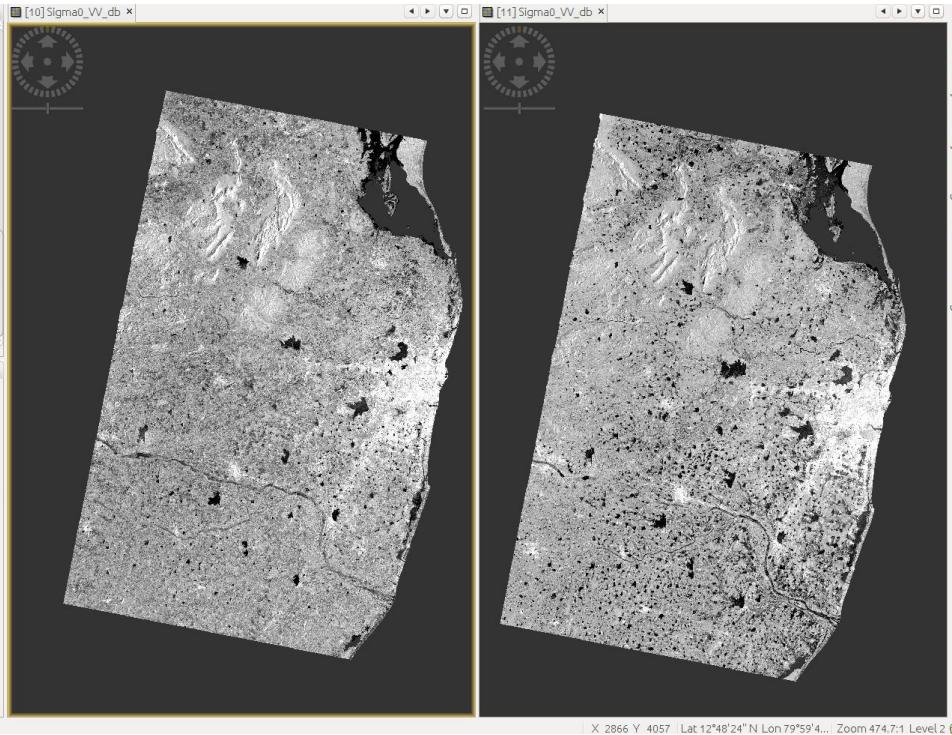


Conversion to dB

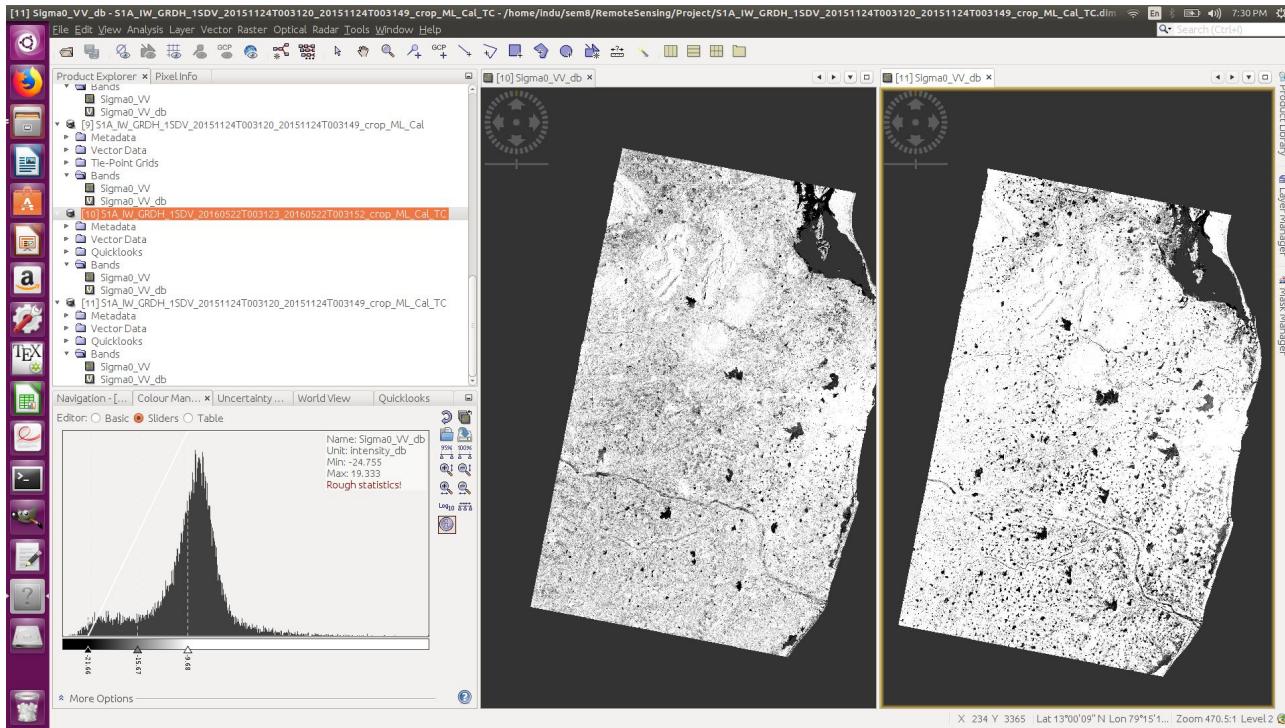




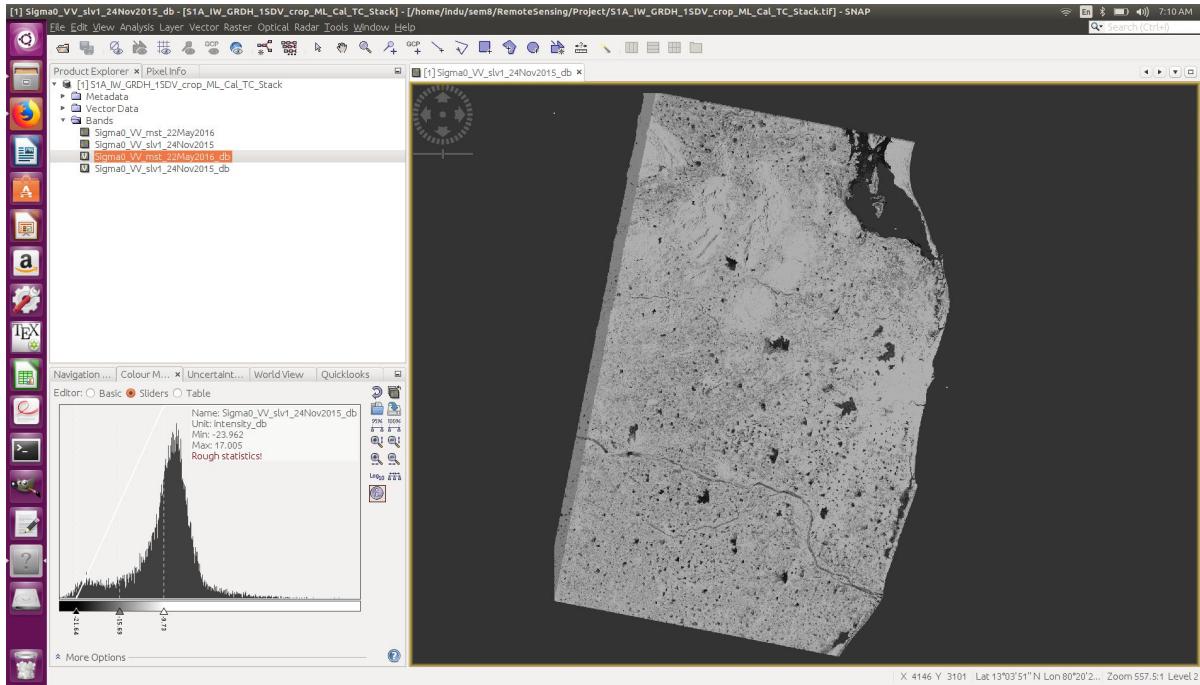
Terrain correction (after conversion to dB)



Changing Contrast

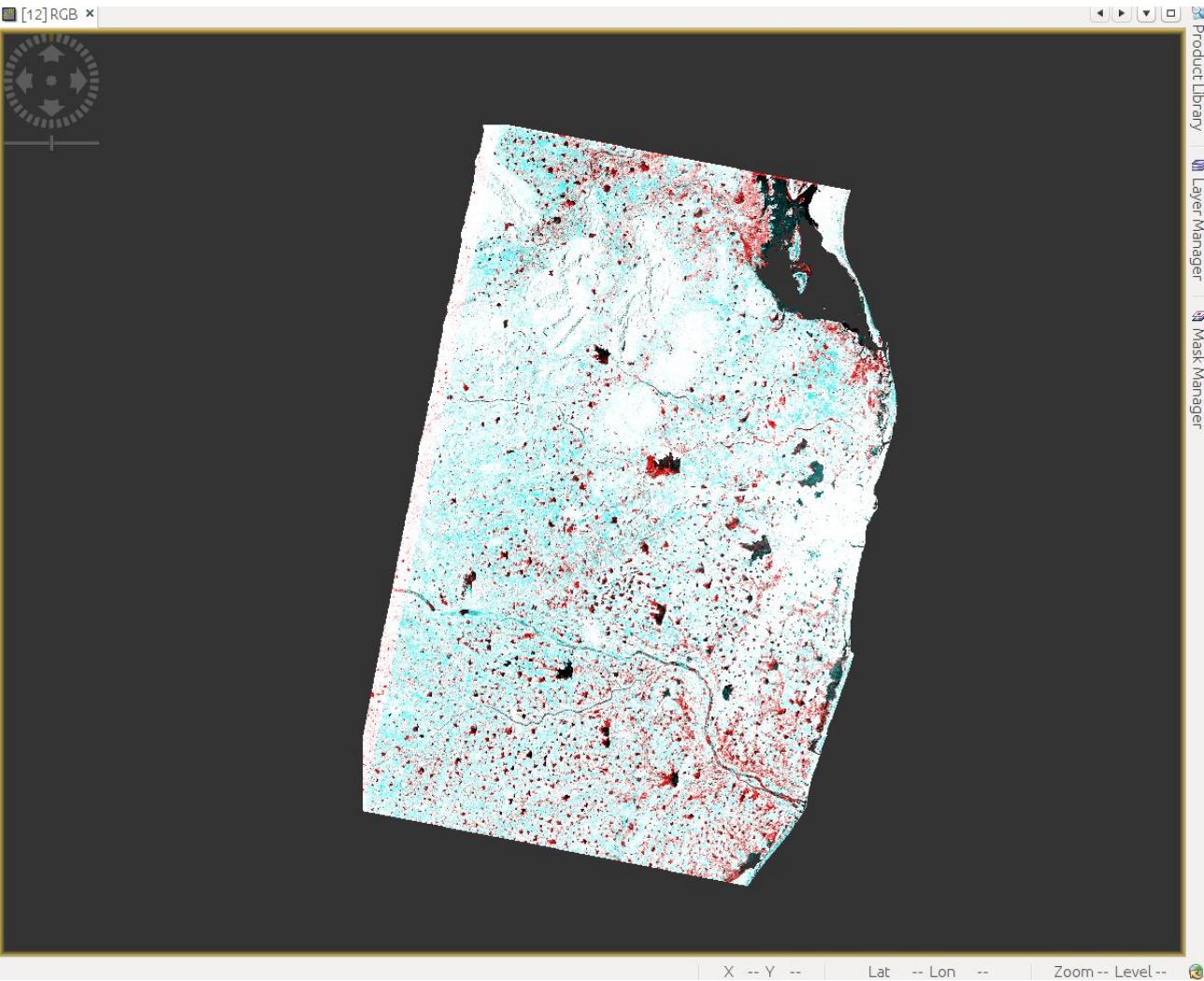


Stacked Images

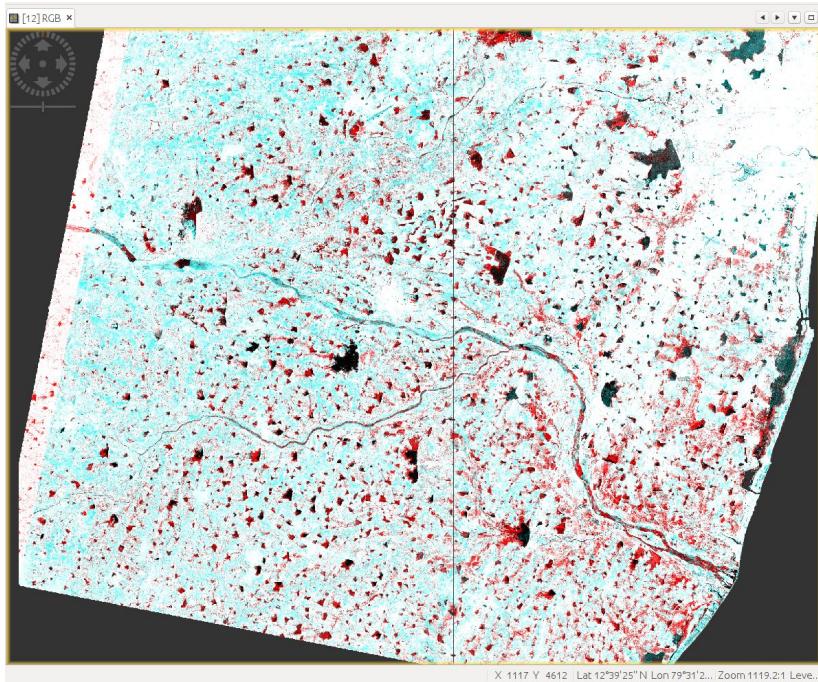




RGB

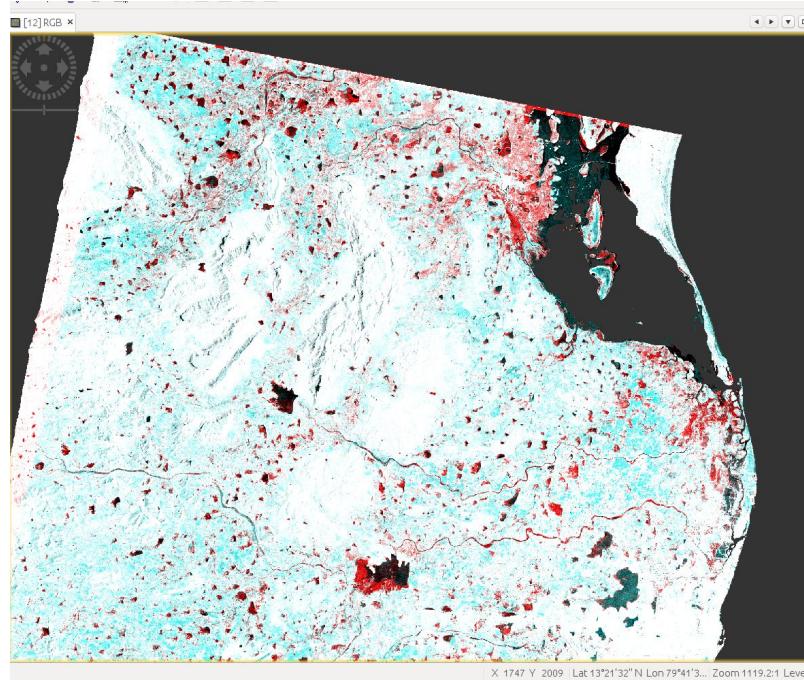


RGB (Zoomed Bottom)





RGB (Zoomed Top)





Conclusion

Radar data is different from optical data and requires different set of preprocessing steps

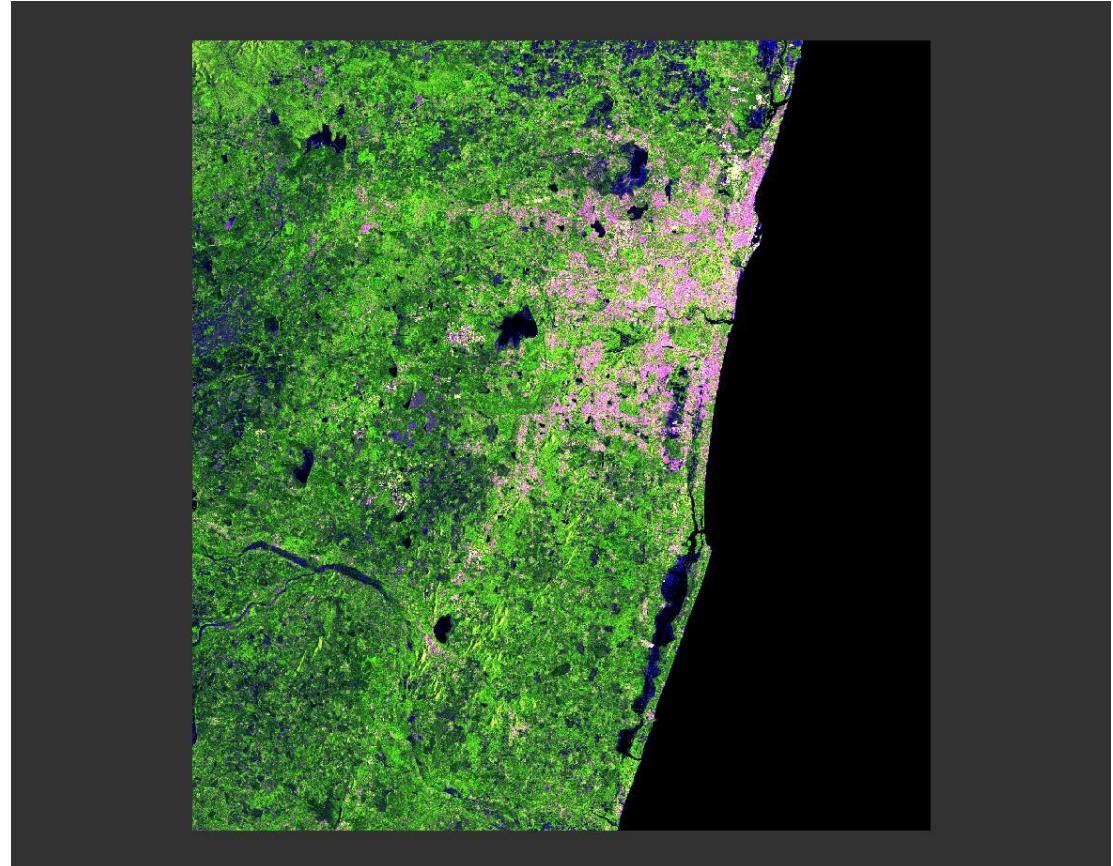
- Multi-looking/speckle filtering
- Calibration
- Terrain Correction

For flood mapping, we have followed these steps:

- Time series analysis using overlay
- Visualize difference in water maps using RGB composite

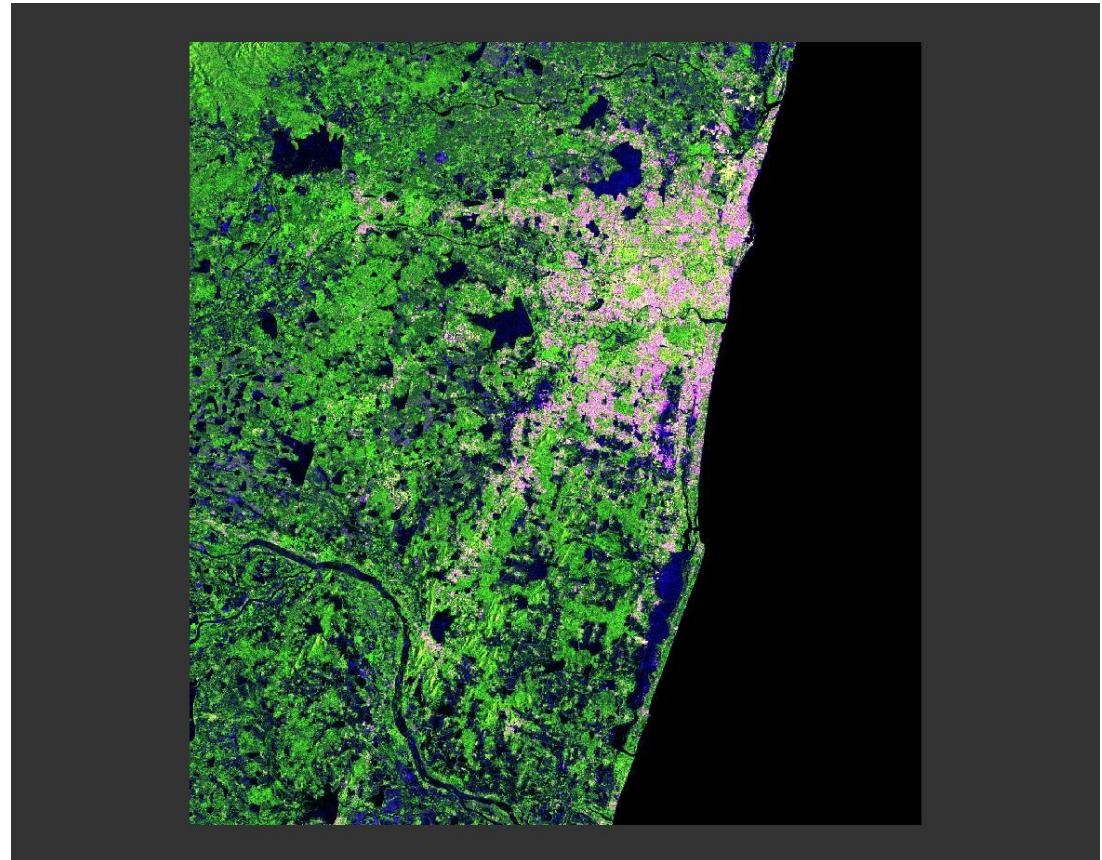


RGB 31/10



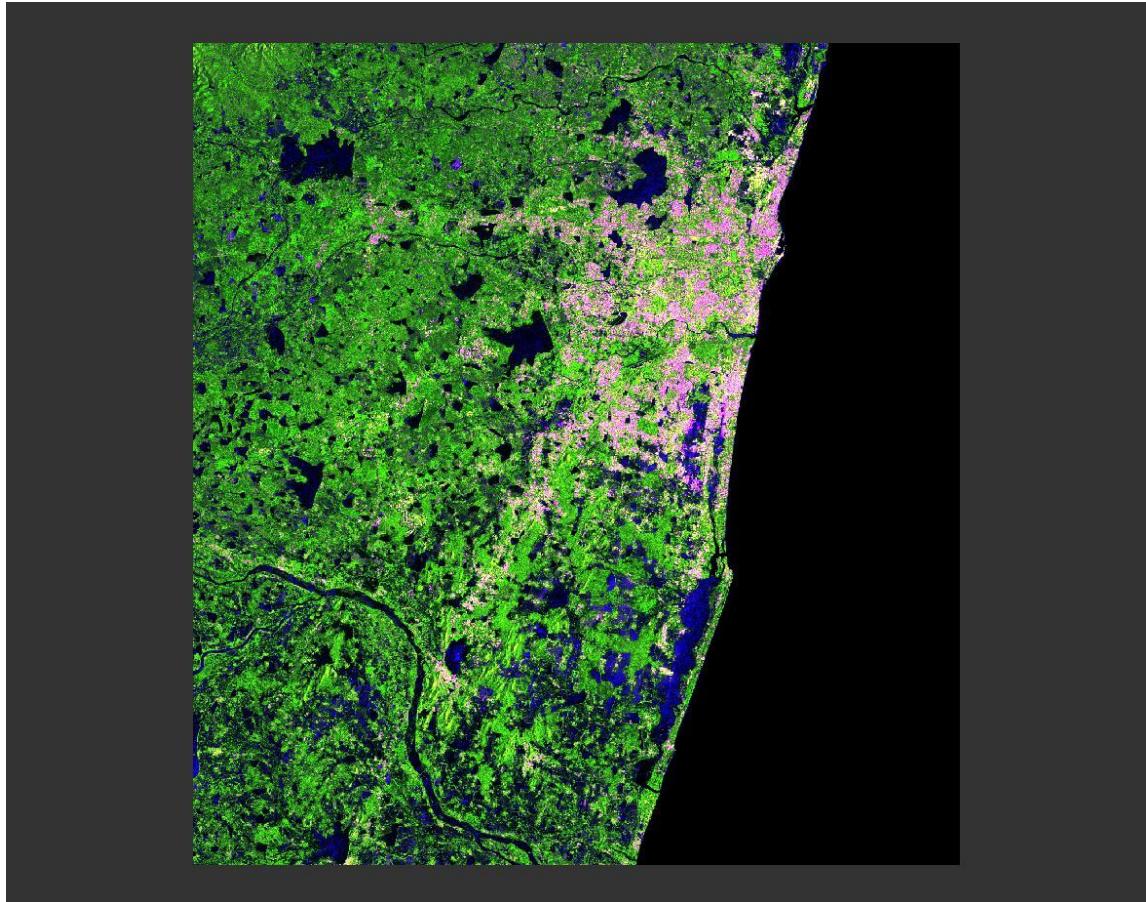


RGB 24/11





RGB 6/12





Training data and Test data

	31-10-2015	24-11-2015	06-12-2015
Training Set	131699	122810	131699
Test Set	137946	144611	137946



Accuracy assessment - overall accuracy

	31-10-2015	24-11-2015	06-12-2015
SVM	0.9344	0.9064	0.9349
MLP	0.9178	0.9029	0.9503
RandomForest	0.9122	0.8972	0.9327



Precision

	31-10-2015	24-11-2015	06-12-2015
SVM	0.9344	0.9064	0.9384
MLP	0.9178	0.9029	0.9503
RandomForest	0.9122	0.8972	0.9327



Recall

	31-10-2015	24-11-2015	06-12-2015
SVM	0.9344	0.9064	0.9384
MLP	0.9178	0.9029	0.9503
RandomForest	0.9122	0.8972	0.9327



Kappa score

	31-10-2015	24-11-2015	06-12-2015
SVM	0.8689	0.8380	0.8970
MLP	0.8373	0.8331	0.9173
RandomForest	0.8279	0.8232	0.8879

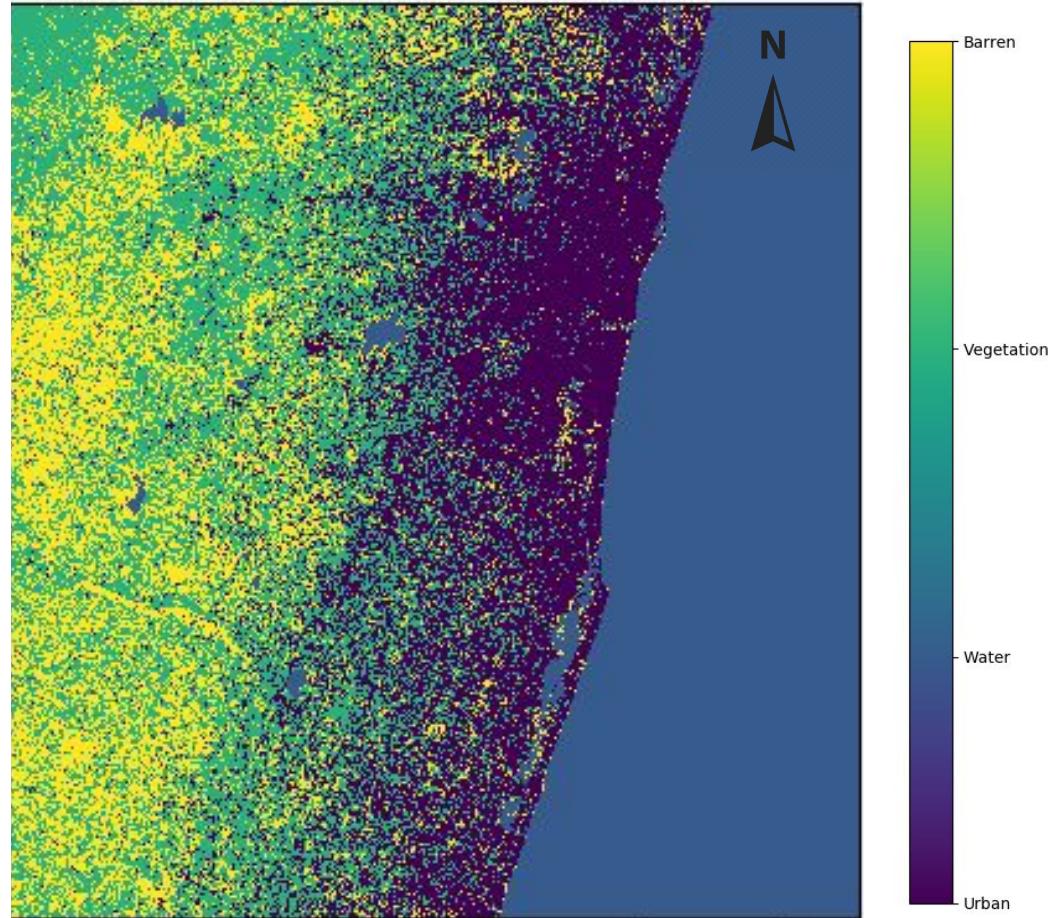


OOB and importance of Bands (RF)

	31-10-2015	24-11-2015	06-12-2015
OOB	92.2041%	94.1495%	95.6522%
Band Importance	Band 0 importance: 0.108451731987 Band 1 importance: 0.146252843402 Band 2 importance: 0.127333094343 Band 3 importance: 0.172086444633 Band 4 importance: 0.191412233899 Band 5 importance: 0.254463651735	Band 0 importance: 0.0511213887536 Band 1 importance: 0.0729701476495 Band 2 importance: 0.0793171008437 Band 3 importance: 0.270990538248 Band 4 importance: 0.25841721172 Band 5 importance: 0.267183612785	Band 0 importance: 0.0666043633464 Band 1 importance: 0.0564836015953 Band 2 importance: 0.107757597493 Band 3 importance: 0.259653704732 Band 4 importance: 0.215748590113 Band 5 importance: 0.293752142721

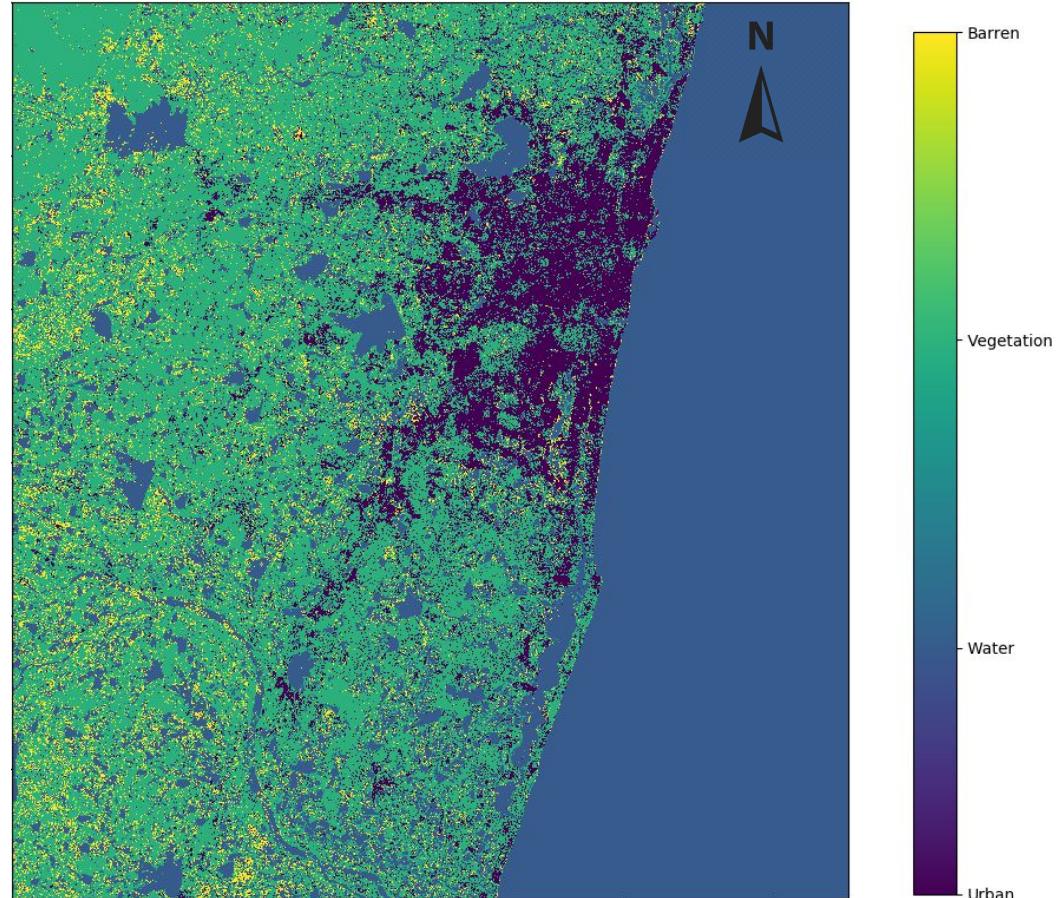


RF 31/10



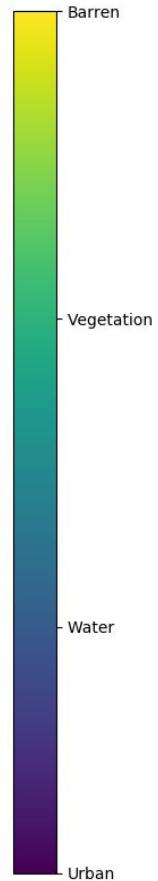
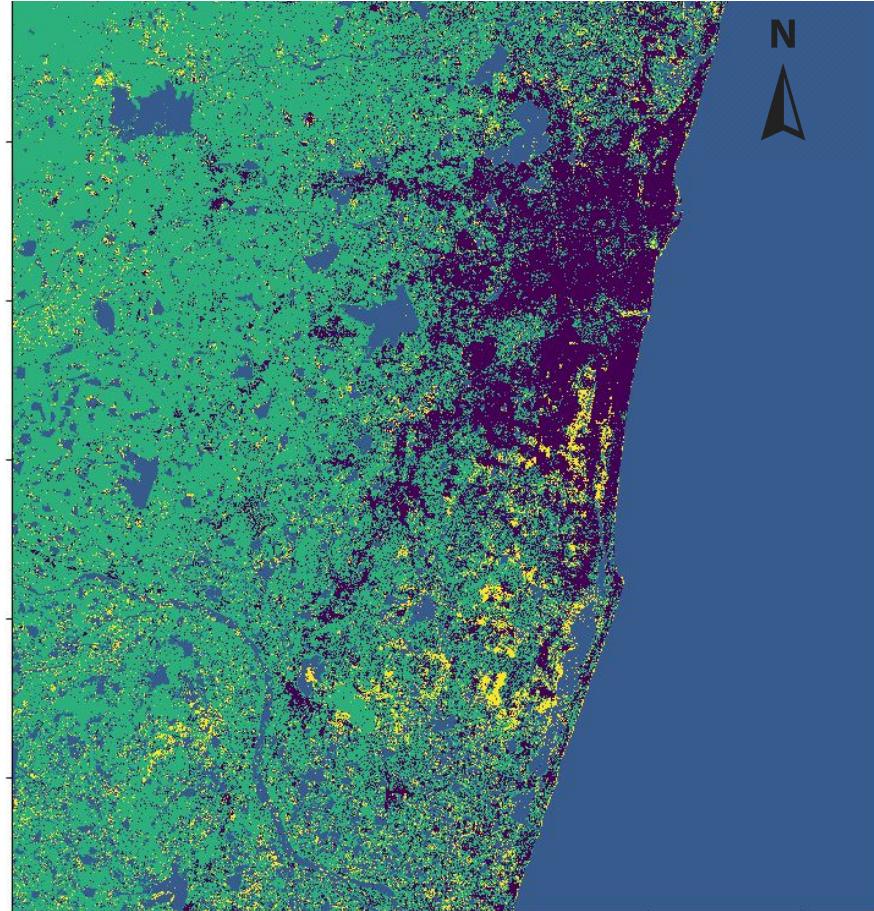


RF 24/11





RF 6/12





Distribution of pixels (RF)

Water	2496504
Urban	1809231
Vegetation	2273948
Barren	1411223

Water	3366244
Urban	892004
Vegetation	3290429
Barren	436767

Water	3190314
Urban	1204257
Vegetation	3288477
Barren	302396

Difference in water pixels(before rains and during rains):869740

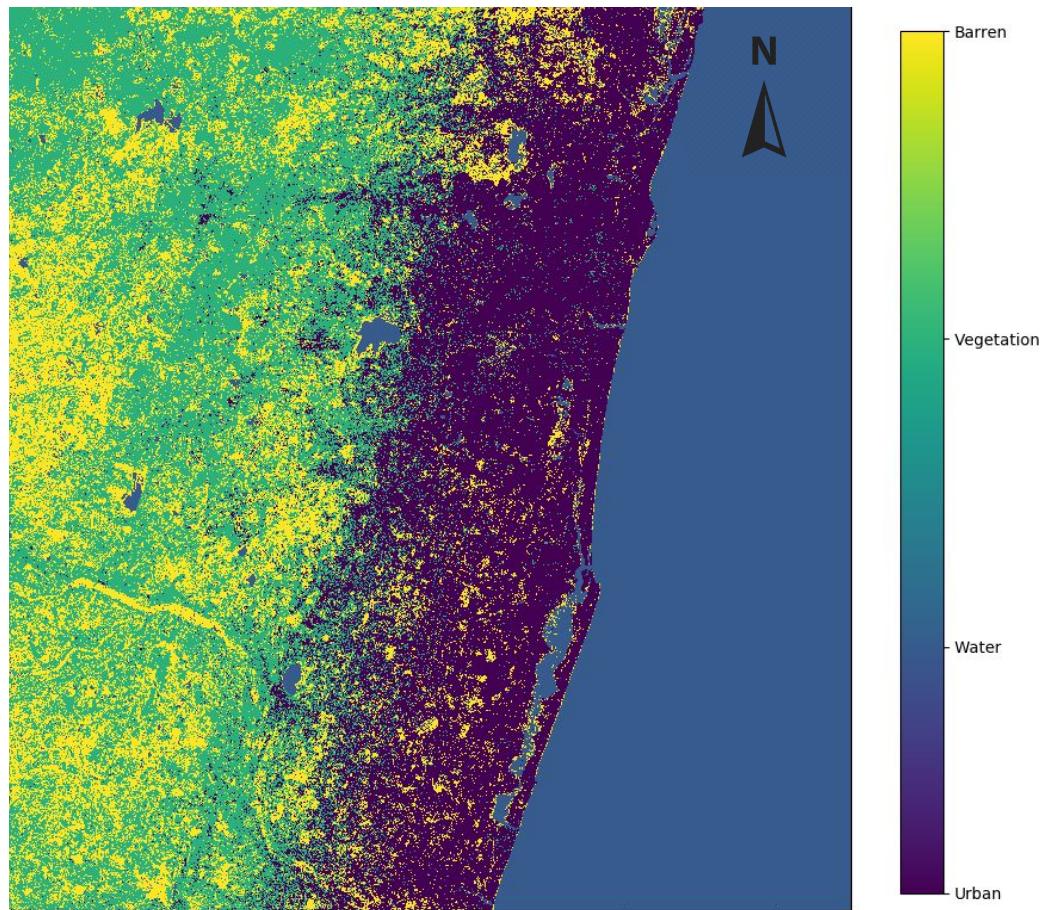
Difference in water pixels(during rains and after rains):175930

Difference in area (in sq. km) (before and during floods):86.9740

Difference in area (in sq. km) (during and after floods):17.5930

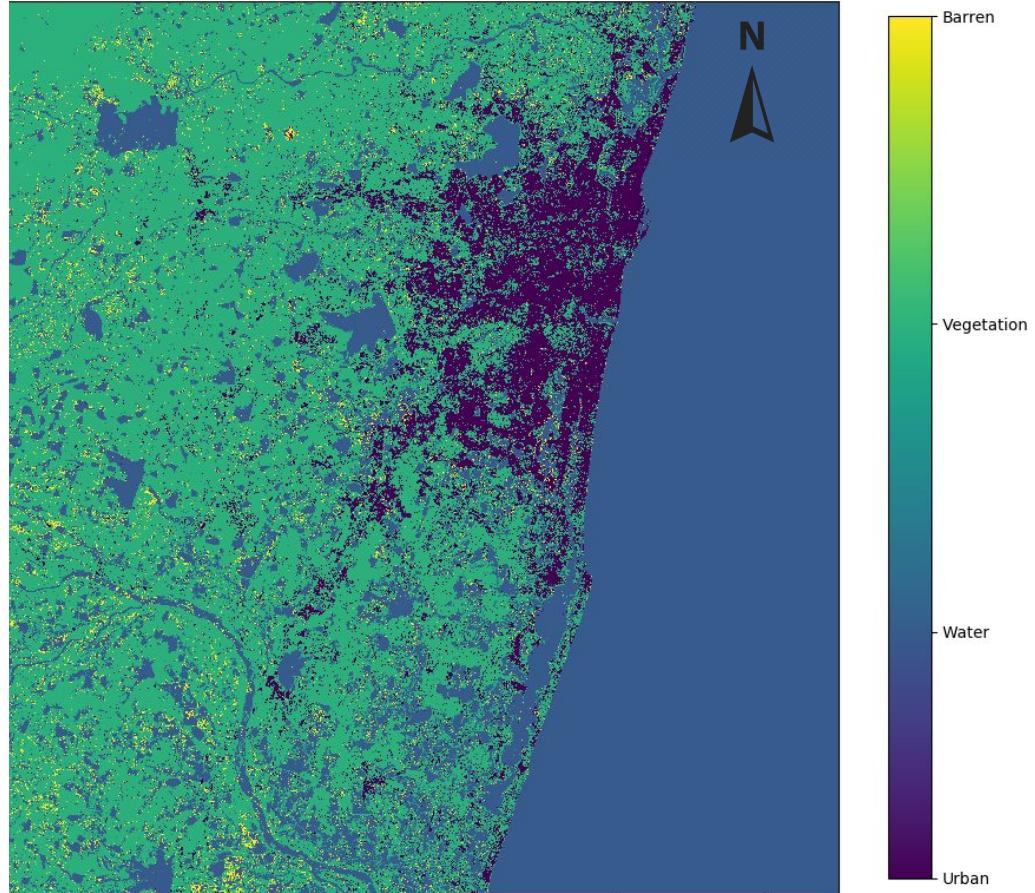


MLP 31/10



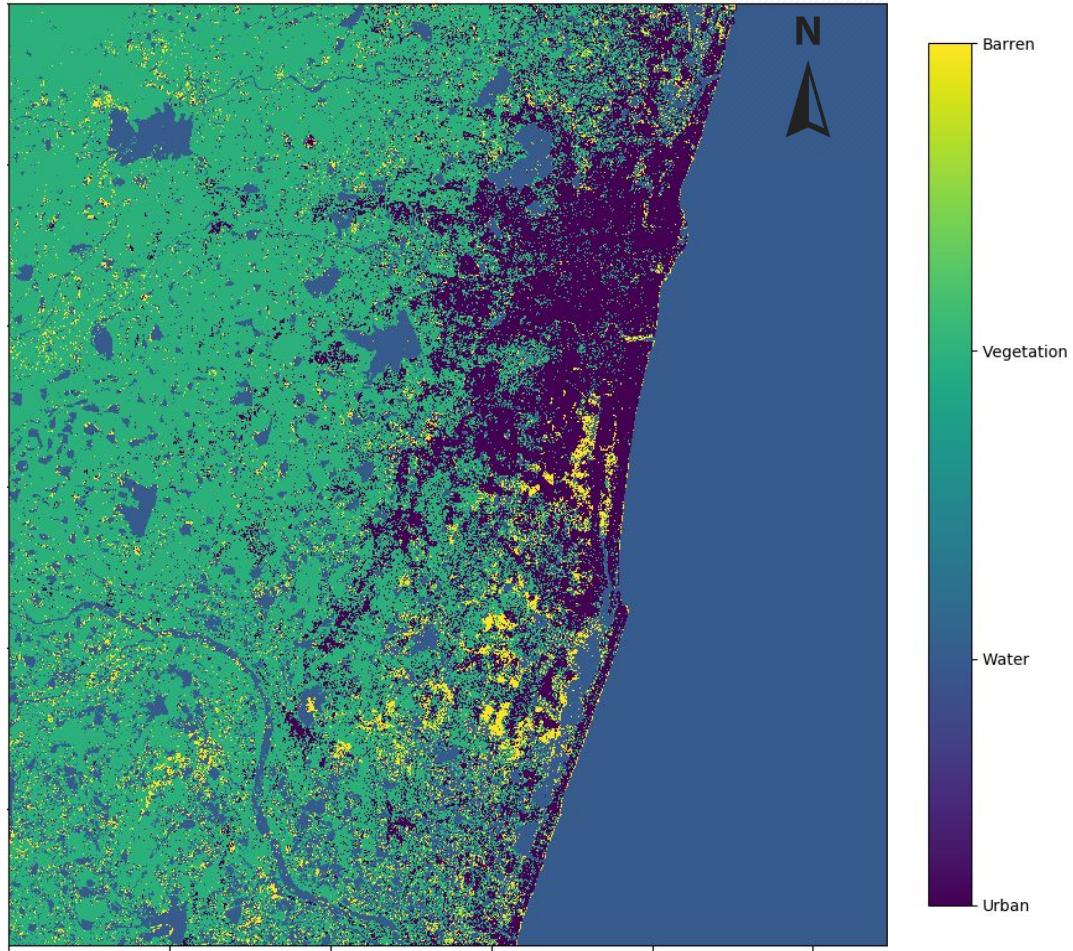


MLP 24/11





MLP 6/12





Distribution of pixels (MLP)

Water	2496053
Urban	1805209
Vegetation	2278672
Barren	1410972

Water	3484529
Urban	769140
Vegetation	3560815
Barren	170960

Water	3224278
Urban	1124064
Vegetation	3351629
Barren	285473

Difference in water pixels(before rains and during rains): 988476

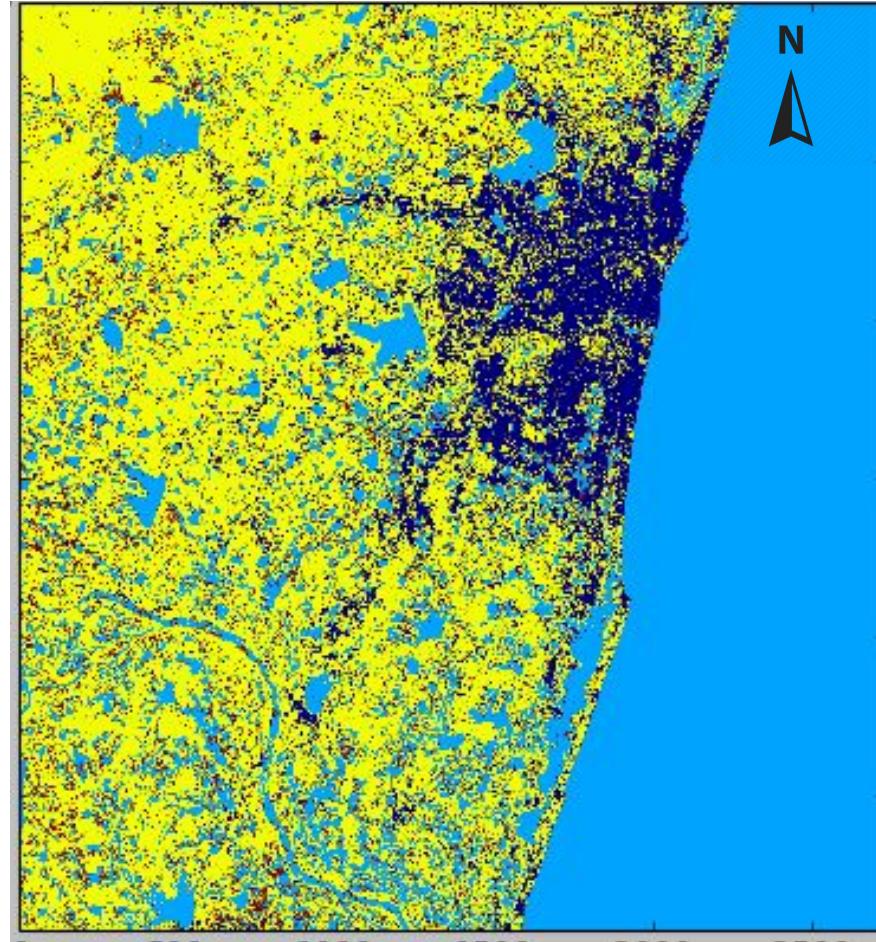
Difference in water pixels(during rains and after rains): 260251

Difference in area (in sq. km) (before and during floods): 98.8476

Difference in area (in sq. km) (during and after floods): 26.0251



SVM 24/11





Distribution of pixels (SVM)

Water	3317316
Urban	905471
Vegetation	341869
Barren	344008



User Accuracy (Water)

	31-10-2015	24-11-2015	06-12-2015
SVM	0.8931	0.9899	0.9280
MLP	0.9005	0.9922	0.9320
RandomForest	0.8927	0.9899	0.9270



User Accuracy (Urban)

	31-10-2015	24-11-2015	06-12-2015
SVM	0.9831	0.8850	0.9539
MLP	0.9651	0.8697	0.9558
RandomForest	0.9570	0.8734	0.9390



User Accuracy (Vegetation)

	31-10-2015	24-11-2015	06-12-2015
SVM	0.8324	0.9567	0.9292
MLP	0.8150	0.9774	0.9602
RandomForest	0.8176	0.9466	0.9370



User Accuracy (Open Land)

	31-10-2015	24-11-2015	06-12-2015
SVM	0.8402	0.3508	0.7263
MLP	0.8194	0.2842	0.7636
RandomForest	0.8056	0.3790	0.7258



Product Accuracy (Water)

	31-10-2015	24-11-2015	06-12-2015
SVM	0.9031	0.9024	0.9706
MLP	0.9005	0.8764	0.9670
RandomForest	0.8763	0.8876	0.9670



Product Accuracy (Urban)

	31-10-2015	24-11-2015	06-12-2015
SVM	0.9522	0.9768	0.9563
MLP	0.9485	0.9892	0.9760
RandomForest	0.9567	0.9787	0.9609



Product Accuracy (Vegetation)

	31-10-2015	24-11-2015	06-12-2015
SVM	0.9492	0.9139	0.9223
MLP	0.9038	0.7978	0.9295
RandomForest	0.8788	0.7998	0.9014



Product Accuracy (Open Land)

	31-10-2015	24-11-2015	06-12-2015
SVM	0.6825	0.6556	0.5800
MLP	0.6427	0.7576	0.5896
RandomForest	0.5877	0.5305	0.5648



Thank You



Appendix



Random Forest - 6/12

The training data includes 4 classes: [10. 50. 100. 150.]

Number of training and test points:

Training data size: (114174, 6)

Training labels vector length: (114174,)

Testing data size: (100852, 6)

Testing labels vector length: (100852,)

OOB prediction of accuracy is: 95.6522500744%

Accuracy : 0.93271328283%

Precision : 0.93271328283%

Recall : 0.93271328283%

Kappa Score : 0.887905397143%

Confusion matrix

```
[[50936      34 3132 138]
 [ 22 12468    36 923]
 [1899 34 29243      32]
 [ 148 358    30 1419]]
```

Band 0 importance: 0.0666043633464

Band 1 importance: 0.0564836015953

Band 2 importance: 0.107757597493

Band 3 importance: 0.259653704732



SVM 06/12

Accuracy : 0.938464284298%

Precision : 0.938464284298%

Recall : 0.938464284298%

Kappa Score : 0.897017806457%

Confusion matrix

```
[[51744    23 2372 101]
 [ 26 12482    36 905]
 [ 2165    21 29000  22]
 [ 168  33433 1420]]
```



MLP 6/12 with (100,50), init_lr = 1e-5

Accuracy : 0.950333161464%

Precision : 0.950333161464%

Recall : 0.950333161464%

Kappa Score : 0.917247497685%

Confusion matrix

```
[[51846    30  2215  149]
 [    7 12535   31  876]
 [ 1201    24 29969   14]
 [  65  373  24 1493]]
```

Water pixels: 3224278

Urban pixels: 1124064

Veg pixels: 3351629

Open pixels: 285473



RF - 31/10

The training data includes 4 classes: [10. 50. 100. 150.]

Number of training and test points:

Training data size: (131699, 6)

Training labels vector length: (131699,)

Testing data size: (137946, 6)

Testing labels vector length: (137946,)

OOB prediction of accuracy is: 92.2072301232%

Accuracy : 0.911878561176%

Precision : 0.911878561176%

Recall : 0.911878561176%

Kappa Score : 0.8272978159%

Confusion matrix

```
[[86207    19  3615  223]
```

```
[ 10 670622   756]
```

```
[ 3852     21 28045  2456]
```

```
[  26   999   227 10223]]
```



SVM - 31-10

Accuracy : 0.934445362678%

Precision : 0.934445362678%

Recall : 0.934445362678%

Kappa Score : 0.868940921693%

Confusion matrix

```
[[88542    5 1317  200]
 [ 13 669315  773]
 [ 4379    2 28615 1378]
 [ 51  711  199 5053]]
```



MLP - 24/11

Accuracy : 0.902905034887%

Precision : 0.902905034887%

Recall : 0.902905034887%

Kappa Score : 0.833112255212%

Confusion matrix

```
[[72374  249 10425  166]
 [    0 13786    81   27]
 [ 749  187 43582    72]
 [  39 1509  537  828]]
```

Water pixels: 3484529

Urban pixels: 769140

Veg pixels: 3560815

Open pixels: 170960



References

- [1].<https://sentinel.esa.int/web/sentinel/sentinel-data-access>
- [2].<https://sentinel.esa.int/web/sentinel/toolboxes/sentinel-1>
- [3]. <https://onlinelibrary.wiley.com/doi/pdf/10.1111/jfr3.12303>



RF - 24/11

The training data includes 4 classes: [10. 50. 100. 150.]

Number of training and test points:

Training data size: (122810, 6)

Training labels vector length: (122810,)

Testing data size: (144611, 6)

Testing labels vector length: (144611,)

OOB prediction of accuracy is: 94.1494992264%

Accuracy : 0.897179329373%

Precision : 0.897179329373%

Recall : 0.897179329373%

Kappa Score : 0.8231492162%

Confusion matrix

[72676 175 10099 264]

[1 13754 76 63]

[1463 269 42208 650]

[112 1288 222 112 41]