GNR 639 (Disaster Management) ASSIGNMENT 1

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(Since this is my first time using this software, I have decided to make a detailed explanation on how to analyze data along with the conclusions, using the lecture and the PPT slides)

## $\sigma_0$ Based Analysis

Steps carried out:

- Downloaded Before/After data from drive, and imported them to SNAP
- Calibrate the image (dB for back-scattering), Performed dB calibration and obtain `Data(2)`: Bands which contains: `Sigma0_HH_dB, Sigma0_HV_dB, Sigma0_VH_dB, Sigma0_VV_Db`
- Data obtained is comparatively bright, because it is in dB scale i.e. $10 * \log\left(\frac{x}{x_0}\right)$
- For Multi-looking, Perform: `RADAR > SAR Utilities > Multi-looking` and select Data(2), change settings to `3:20` (Mean GR square pixel will be 42.515865 ).
- Obtain the multi-look data, which has reduced noise and increased clarity.
- Perform Terrain Correction by `RADAR > GEOMETRIC > TERRAIN CORRECTION > RANGE-DOPPLER TERRAIN CORRECTION`. Terrain Correction is very important to fit the data on to the ground.
- Change the following settings: Digital Elevation Model: `SRTM 1Sec HGT (Auto Download)` and Map Projection: `UTM Zone 84( Automatic)`
- HH, VV Bands are called Co-Polarization bands while HV,VH Bands are called Cross-Polarization bands
- Color Coding the data: `WINDOW > OPEN RGB IMAGE WINDOW` and select combination of HH,HV,VV. I have selected Red: HH, Green: HV and Blue: VV.
- HV Band tells us about the presence of vegetation, VV band tells us about the presence of Urban areas
  REPEAT THIS PROCESS FOR AFTER DATA

Keeping track of variables

- (1) Raw Data
- (2) Calibrated Raw Data
- (3) Multi-looking of Raw Data
- (4) Multi-looking + Calibrated Data
- (5) Multi-looking + Calibrated + Terrain Corrected Data

Obtain RGB ( Color coded image from (5) )

**This has been explained in more detail with stepwise pictures in Assignment 2 ( Volcano)**

Compare (5) RGB and (10) RGB to make the following inferences:

Pre-Disaster (5) RGB

Post-Disaster (10 RGB)

On close observation, we can find that there are more pink/violet/magenta areas in the Post-Disaster picture imported from SNAP.

However, Back scattering is not that efficient at differentiating between Pre and Post disaster events.

## Polarization Decomposition Analysis

Steps carried out:

- Close all the products and re import the initial data, and calibrate it, and while doing so, click on "Save as Complex Output"
- Perform the following: `RADAR > POLARIMETRIC > POLARIMETRIC MATRIX GENERATION` and click T3 Matrix (Selecting T4 or C2 may affect the decomposition)

BASICS OF RADAR SCATTERING

There are 4 scattering powers in Radar scattering: **Surface** ($P_S$), **Double Bounce** ($P_D$) , **Volume** ($P_V$) and **Helix** ($P_C$) scattering.

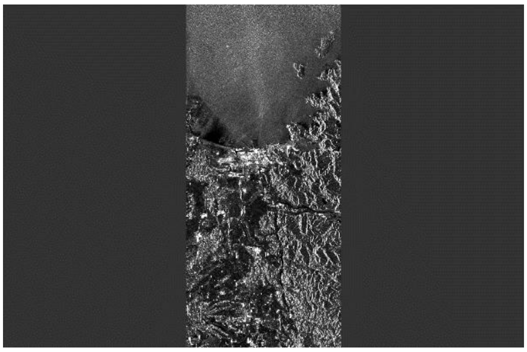
The 4 scattering components are then normalised by dividing by the total power, $TP$

- $p_S = \frac{1}{TP} * P_S$
- $p_D = \frac{1}{TP} * P_D$
- $p_V = \frac{1}{TP} * P_V$
- $p_C = \frac{1}{TP} * P_C$

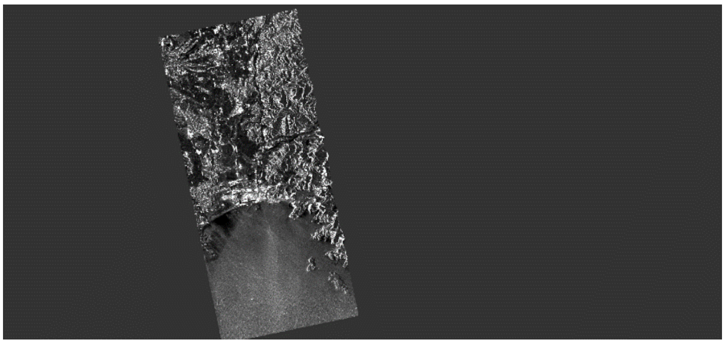
Where $P_S + P_D + P_V + P_C = TP$

- After decomposing, we can find the 9 elements ($T_{11}$, $T_{22}$, $T_{33}$, $T_{12}$, $T_{12}$*, $T_{13}$, $T_{13}$*, $T_{23}$, $T_{23}$*). The components with complex numbers will be given after simplification as follows:
  $T_{12}{}^{real} = \frac{1}{2}(T_{12} + T_{12}{}^*)$
  $T_{12}{}^{imaginary} = \frac{1}{2}(T_{12} - T_{12}{}^*)$
  $(and\ the\ same\ applies\ to\ the\ rest\ of\ the\ T_{ij})$
- The next step is multi-looking. We restrict the range looks to 3 and azimuth to 20 as usual.
- Apply terrain correction to the multi-looked data.

**Significance of Terrain correction**: It helps in fitting the data on to the ground, and to orient directions in the true north/south. For example, this is the difference between the Raw Multi-looked calibrated data and Terrain corrected $T_{11}$ band:



$T_{11}$ band without Terrain correction



$T_{11}$ band with Terrain correction

- Carry out Polarimetric decomposition as follows:
  `RADAR > POLARIMETRIC > POLARIMETRIC DECOMPOSITION`
  Set processing parameters as Yamaguchi decomposition with Window size 1.
- Now, finally colour code the image as RGB, which is saved by default.

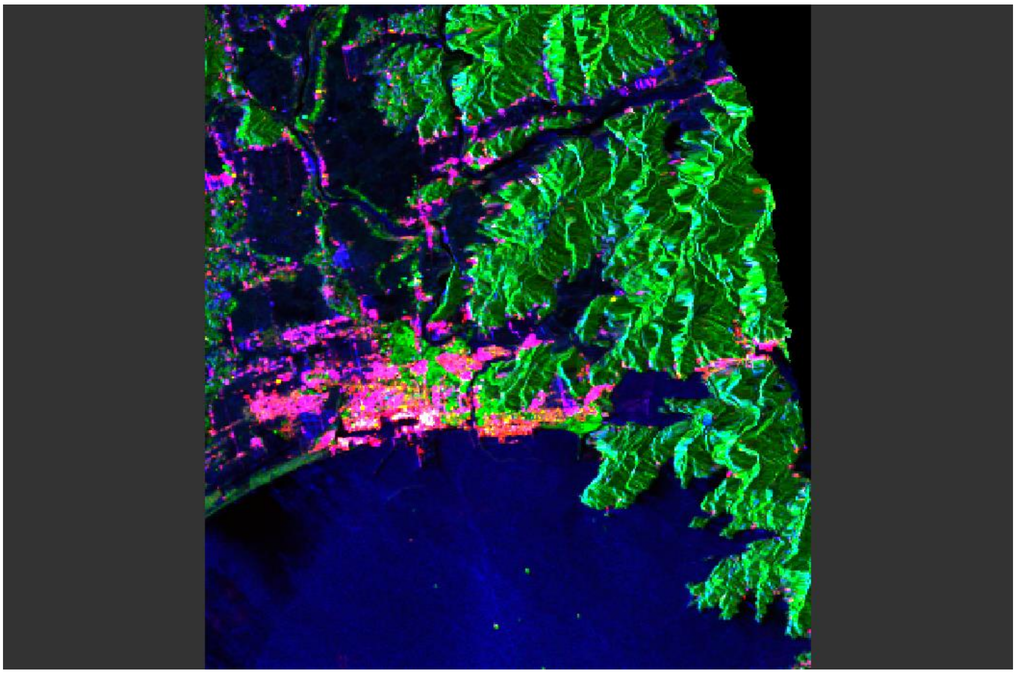
Repeating this for both PRE and POST data, and Co-registering,

We obtain a product with the 4 component bands from both PRE and POST data. However, there seems to be a contrast issue, and hence comes the need for normalising.

- Convert each component into dB scale to bring out finer variations and see more variations easily. Convert virtual into bands for all the components.
- Now, since there is a cropping problem, I will take a subset of the image. To take a subset, perform the following:
  `RASTER > SUBSET` and choose a suitable dimension.
- Next, colour-code the image but rather than using the linear scale, use the dB scale for better interpretation. Make two colour-coded images for PRE and POST data.
- We will now get processed images (14)RGB 1 and (14)RGB 2 which can be clearly distinguished with the naked eye, in terms of double bounce scattering. Remember the following codes:

  RED: Double bounce scattering
  GREEN: Volume scattering
  BLUE: Surface scattering

**This has been explained in more detail with stepwise pictures in Assignment 2 ( Volcano)**

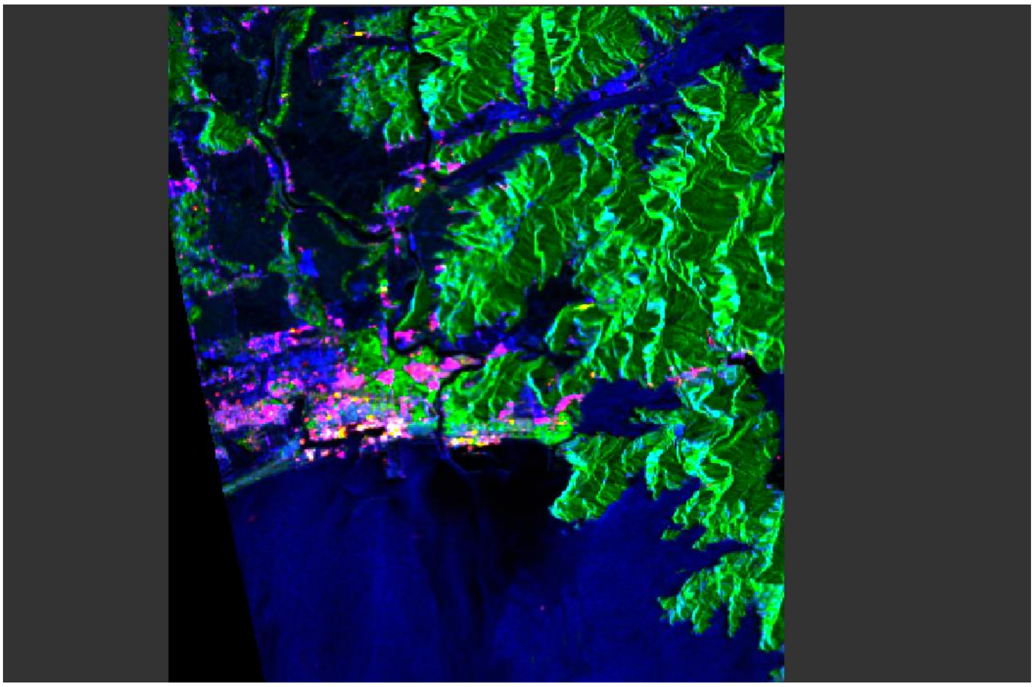


PRE-Disaster scattering

**2 April 2009**

POST-Disaster scattering

**8 April 2011**



# OBSERVATIONS:

RED spots on the map refer to double bounce spots (buildings, platforms etc) which are in **plenty** in the PRE image but **diminish** in the second. This is because of possible extensive damage from the Tsunami.

BLUE regions on the map refer to surface scattering, and in this case most surface scattering happens on water (Ocean)

GREEN regions on the map refer to volume scattering, and this is done by terrain (mountains, plateaus, landforms etc)

Thus, we have looked at two methods of data extraction, one based on back scattering and the other based on polarization-decomposition based analysis. In the first method, it was not that easy to distinguish between PRE and POST images (as seen from above)

Back Scattering RGB (PRE)

Back Scattering RGB (POST)

But significant inferences can be made about the impact of the Tsunami/Earthquake on the environment through Polarization-Decomposition based analysis.

To see the exact difference, do as follows:

- `BAND MATHS > EDIT EXPRESSION`
  We must normalize the data if we are to subtract. For this, simply divide by the total powers as explained above

**Significance of Normalisation:** If the resolutions/total powers of the two observations are radically different, then it does not make sense to take the direct difference. We must divide each component (in this case, the most significant component is Double Bounce) by the total powers and then subtract, to account for any erratic behaving pixel/data points.

I will write the following expression:

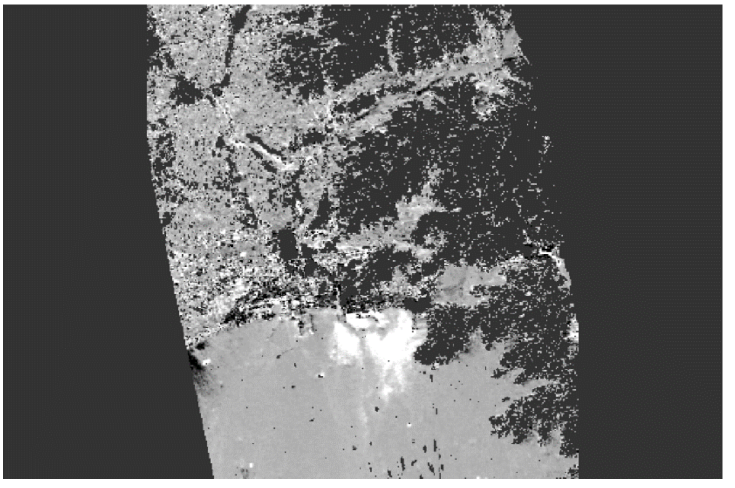
Yamaguchi2/(Yamaguchi2+ Yamaguchi_vol_g_slv2_08Apr20112+ Yamaguchi_surf_b_slv3_08Apr20112+ Yamaguchi_hlx_slv4_08Apr20112)

– Yamaguchi/(Yamaguchi+ Yamaguchi_vol_g_mst_02Apr20092+ Yamaguchi_surf_b_mst_02Apr20092+ Yamaguchi_hlx_mst_02Apr20092)

Where

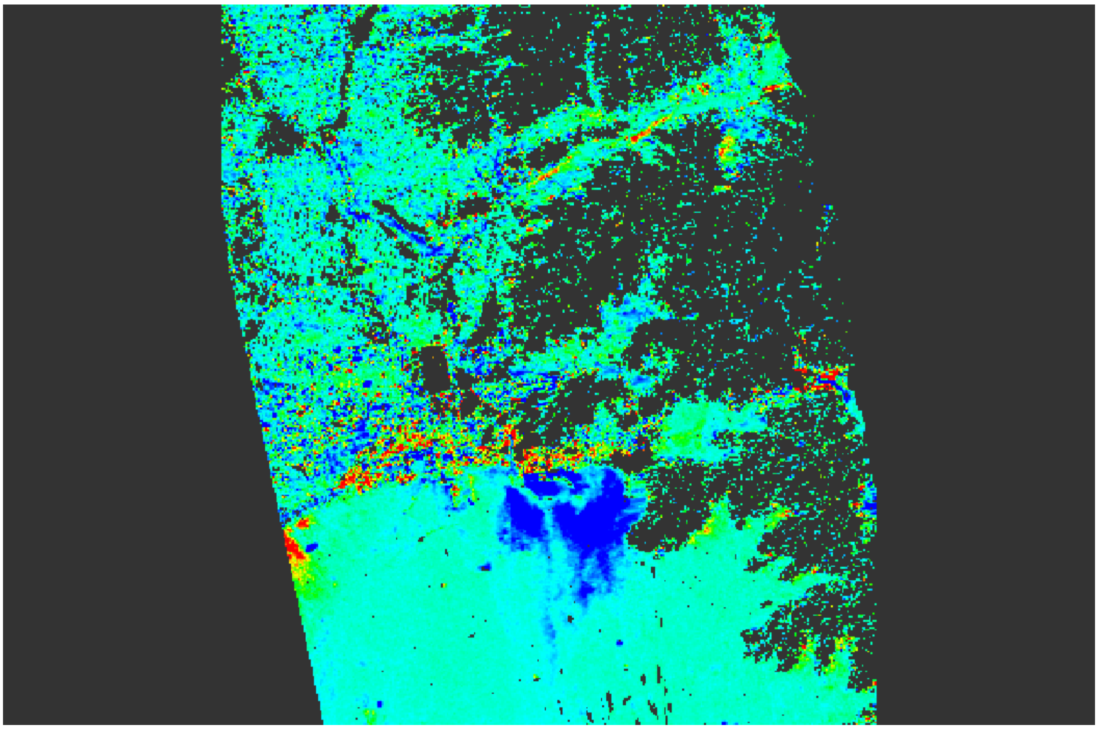
Yamaguchi2 ~ Double bounce scattering in POST
Yamaguchi_vol_g_slv2_08Apr20112 ~ Volume in POST
Yamaguchi_surf_b_slv3_08Apr20112 ~ Surface scattering in POST
Yamaguchi_hlx_slv4_08Apr20112 ~Helix scattering in POST
Yamaguchi ~ Double bounce scattering in PRE
Yamaguchi_vol_g_mst_02Apr20092 ~ Volume in PRE
Yamaguchi_surf_b_mst_02Apr20092 ~ Surface scattering in PRE
Yamaguchi_hlx_mst_02Apr20092 ~Helix scattering in PRE

## Difference Analysis



In this image, black means negative change and white means positive change (in double bounce scattering). As it can be seen, there are a large number of **black** regions along the coast and in the middle regions also. This means that double bounce has effectively **decreased** from the PRE to POST period, as it was expected, because of lesser vertical structures like buildings and houses.

On making a basic colour code, ie Red-Blue spectrum where Red~White and Blue~Black,



The red regions represent areas of destruction, of reasonable high threshold. This means that there was wiping out of buildings and houses in this region.