GNR 639 (Disaster Management) ASSIGNMENT 3

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## Differential SAR Interferometry

Differential SAR Interferometry (DInSAR) is the process of differencing two interferograms (one is Defo-pair and another is Topo-pair) for measuring surface movement with an accuracy of millimetre range.

DInSAR is used to monitor Glacier movement, **Earthquake deformations**, Volcanic activities and Subsidence or uplift caused due to the extraction of ground water or coal.

The following will be done as methodology for DInSAR:

- Coarse/Fine co-registration
- Interferogram generation
- Phase filtering
- Phase unwrapping
- Displacement map
- Convert to velocity map

Two data sets are downloaded, called **Master** and **Slave** image and the process is followed for both of them. The data is from the **PRE** and **POST** earthquake event in Japan and help us to analyse ground deformations relative to the two data sets.

- Open Graph builder and perform the following:
  `RADAR > InSAR GRAPHS > TOPSAR COREG INTERFEROGRAM`
  Under `READ`, Select 2 opened images (master and slave) and under `TOPSAR-Split`, Select one of the swath (IW1) and polarization (HH). Under `INTERFEROGRAM`, select the DEM by enabling the tick mark, and RUN.
- MULTI-LOOKING
-
  Perform `RADAR > SAR UTILITIES > MULTILOOKING` and set **Range looks to 8** and **Azimuth looks to 2**, and click RUN.

- PHASE FILTERING
  Perform `RADAR > INTERFEROMETRIC > FILTERING > GOLDSTEIN PHASE FILTERING` and set **FFT size to 64** and **Window size to 3**, then click RUN.

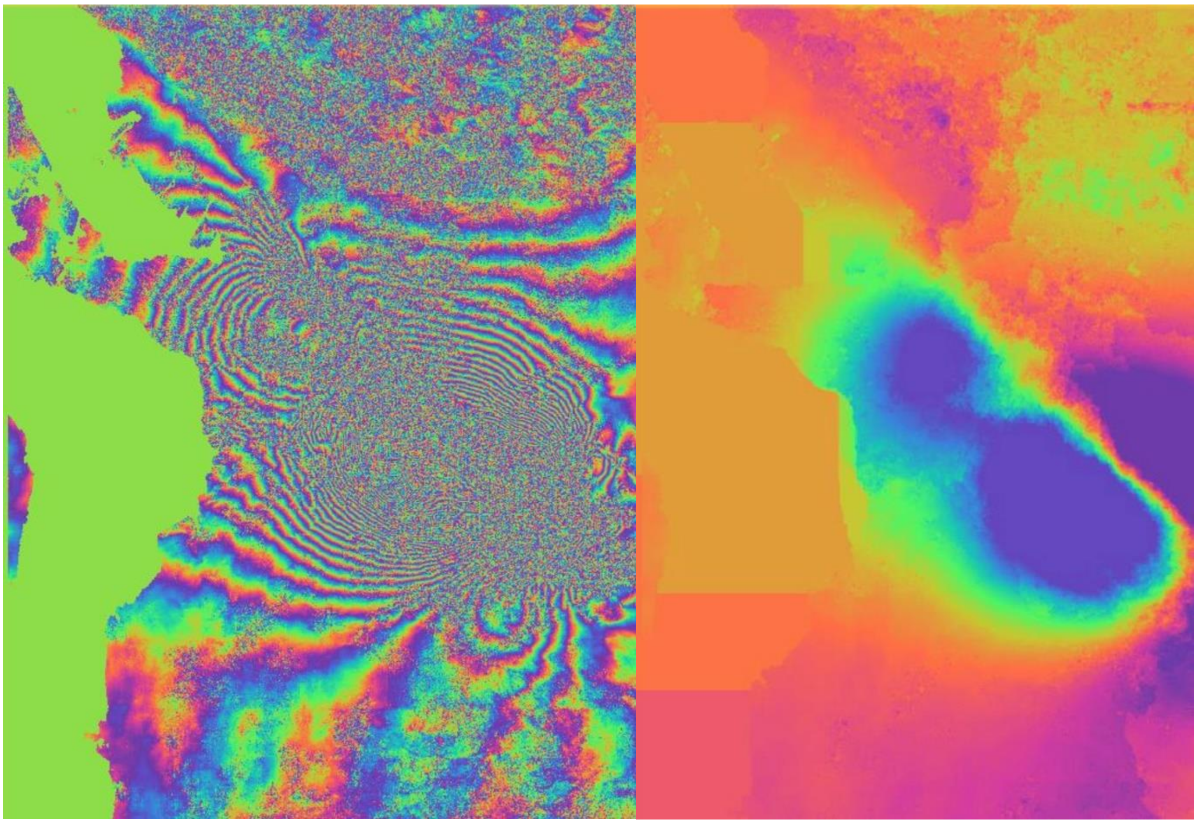
- PHASE UNWRAPPING
  Perform `RADAR > INTERFEROMETRIC > UNWRAPPING > SNAPHU EXPORT`
  This is by far the lengthiest process and may take up to 6 hours.

  **Instructions :**
- Download the archive and unpack it (SNAPHU)
- Add the bin subfolder of the extracted folder to the system path
- Verify your installation by running SNAPHU in console. It will print out the execution parameters

- Export the filtered flattened interferogram from SNAP to SNAPHU
( Perform `RADAR > INTERFEROMETRIC > UNWRAPPING > SNAPHU EXPORT`)
- Navigate to the output folder where we find the generated " snaphu.conf " file
- Run SNAPHU from the console using the command can be found in snaphu.conf

Go back to SNAP, and then select the wrapped phase file which was filtered. Click 2-Read-Unwrapped-Phase. Name the file as "UWP" and RUN.

We will the following result:



Before Unwrapping

After Unwrapping (Phase)

The unwrapped phase tells us the difference in terms of phase (angle) in the electromagnetic wave.

However, let us convert this into displacement to understand the result better. The image represents the phase difference and it is converted into displacement by the following formula:

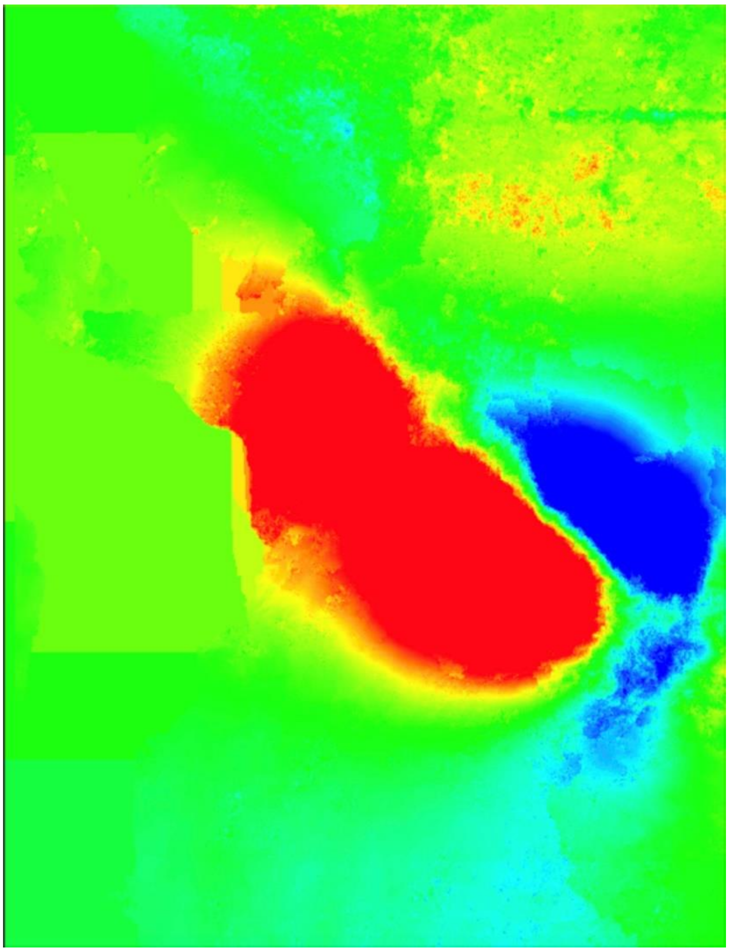
$$\frac{\Delta d}{\lambda} = \frac{\Delta\theta}{2\pi}$$

Where $\lambda$ , and $\Delta\theta$ are known. Hence, we are going from $\theta$ space to $d$ space.

To do this, perform:

`INTERFEROMETRIC > PRODUCTS > PHASE TO DISPLACEMENT` and name the file "UWP_dsp" and click RUN.

We get the following result (in the next page)



The displacement is adjusted according to phase as:

$$\Delta d = \frac{\Delta\theta}{2\pi} * \lambda$$

Where

$\Delta d \sim d$ space (displacement)

$\Delta\theta \sim \theta$ space (phase)

$\lambda$ is known (wavelength)

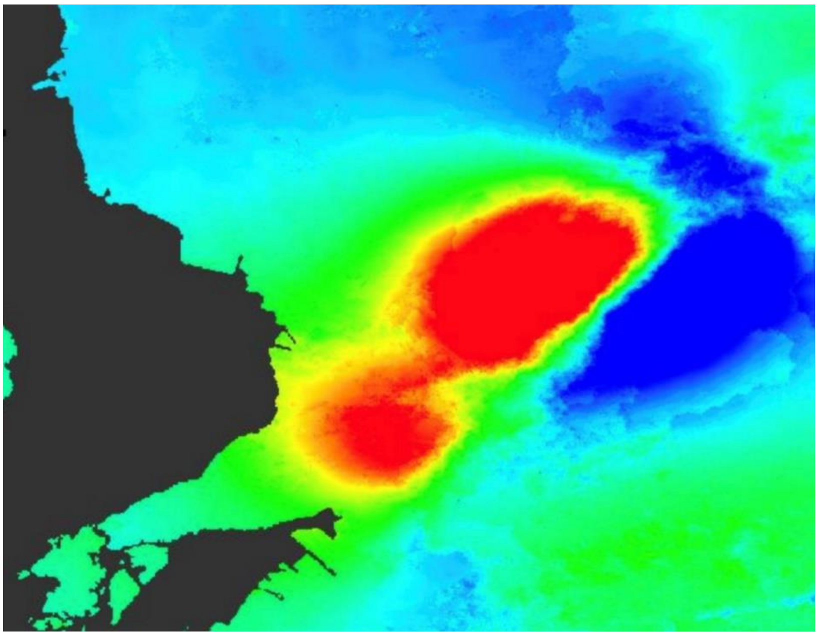
$2\pi$ is a value which can be calculated.

There is not much difference between the Phase plot and the Displacement plot. After all, $\Delta d$ is directly proportional to $\Delta\theta$ from the equation, with a proportionality constant $\frac{\lambda}{2\pi}$

Next step is very important. It is TERRAIN CORRECTION.

Perform `GEOMETRIC > TERRAIN CORRECTION > RANGE DOPPLER TERRAIN CORRECTION`

The importance of terrain correction has been explained in the previous assignment. Terrain corrected data takes into account the geography and the latitude of the area and fits our data on to a map so we can superimpose the map and the data.

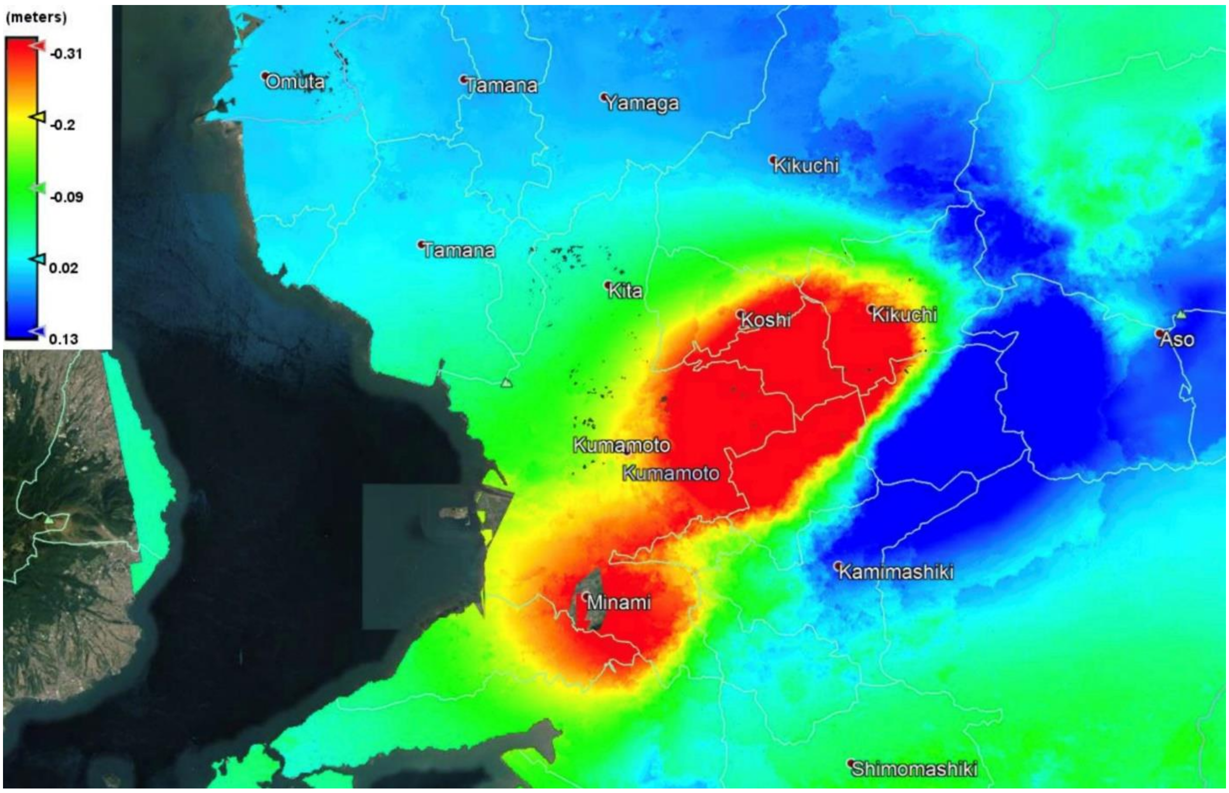


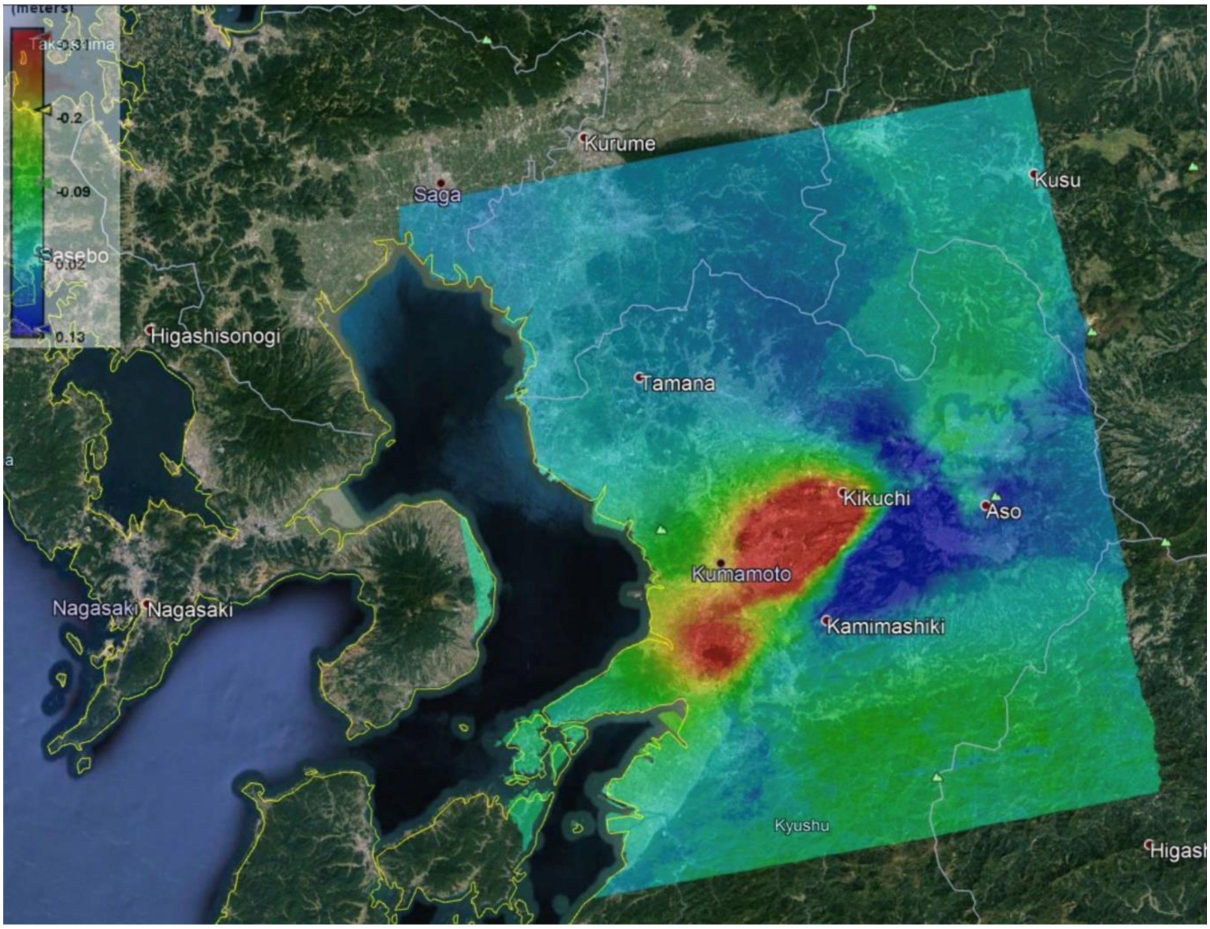
**TERRAIN CORRECTED DISPLACEMENT DATA**

Now, to compare it with the map, perform the following:

```
EXPORT > OTHER > VIEW AS GOOGLE EARTH KMZ
```


SUPER-IMPOSING DATA AND THE MAP






FINAL SUPERIMPOSED IMAGE (After reducing the hue intensity of the data)

INFERENCES:

The regions in the map highlighted in red suffered the most deviation, and sank by more than 25 $cm$ or 0.25 $m$. The comparison is between the **Master** and **Slave** images.

This is probably because of a catastrophic event such as an earthquake which results in land deformations and unstable regions in and around the tectonic plates. As a result, we can see the land sink in the RED regions while in the areas around, we can see that the level has risen.

This phenomenon is known as **Land Deformation** and is very common during earthquakes.

The recipe that is used to detect Land Deformation is :

- Measure the Phase difference by using DInSAR
- Convert the Phase difference into Displacement by using the formula

$$\Delta d = \frac{\Delta\theta}{2\pi} * \lambda$$

  Where $\Delta d$ is the Displacement and $\Delta\theta$ is the Phase difference.
- Superimpose the data with the Google Maps.

Hence, DInSAR is a very good technique to measure land deformations in earthquake prone regions and for effective disaster management.