Processing of SAR data for Sea Ice Concentration

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ABSTRACT

Antarctic has the coldest and hostile environments still the research stations operate in such conditions. Sea water freezes into ice and hence makes the navigation and other marine operations difficult. So a unit-less term Sea Ice concentration is used to describe the relative amount of area covered by ice compared to some reference area. Prior to Sea Ice concentration retrieval SAR data has to be prepared (data-pre-processing). In this study, pre-processing of the data has been done by using SNAP software developed by European Space Agency, steps of pre-processing includes orbit correction, calibration, speckle filtering, Range Doppler terrain correction and converting linear to dB. Information about study area has also been provided in this document, the python modules are written to show the image information, edge detection and histogram generation.

INTRODUCTION

In Antarctic region ship navigation in the Antarctic Ocean is not easy, in winters the temperature can go as low as -60 degree in this extreme environment the sea water freezes and sea ice gets formulated.

Ship navigation and other marine operations can be halted due to thick sea ice formation. To resolve such issues Sea Ice Concentration is used to find the area covered by the sea ice with respect to some reference area.
Sea ice concentration (SIC) is a unit less term, It is typically given either in fraction (0 - 1), percentage (0% - 100%) or sometimes in tenths (0/10 - 10/10). It is dependent on the scale, in fine enough scale the SIC is either zero (open water) or one (ice).[1]

SIC retrieval is essential for ship navigation in the Antarctic region, this is done by using Remote Sensing principles and SAR backscatters. The processing of the SAR images are done using a software developed by European Space Agency (ESA) called SNAP. SIC maps can also be generated manually but it is time consuming as manual charting requires long and thorough analysis. Hence, we use SAR images for the SIC classification and charting.

Optical satellites are not favourable in this geographic as the cloud coverage is always high hence only microwave bands can be used as waves in microwave band can easily penetrate through any obstacle.

Before doing the actual processing of Sentinel 1-A SAR dataset, preparation of the dataset is essential. The methodology for the pre-processing is given below:

1. Download DATA from Copernicus open Hub access.
2. Apply orbit file
3. Create a subset
4. Calibration(Sigma0)
5. Speckle Filtering(Refined Lee)
6. Range Doppler terrain correction
7. Linear to dB conversion

SPECIFICATIONS OF SENTINEL 1-A

Spacecraft type	**Satellite**
Constellation	**Active: 2(4 Planned)**
Launch Mass	**2,300 kg**
Dry Mass	**2,170 kg**
Dimensions	**3.9 m x 2.6 m x 2.5 m**
Power	**5900 watts**
Launch	**3 April 2014**
Data Products	**RAW,GRD,SLC,OCN**

Objectives:

Development of python modules for the processing of SAR data for Sea Ice concentration retrieval **.**

DATA PRE-PROCESSING

Downloading the data: 1. Sentinal-1A data is available at Copernicus Link i.e. https://scihub.copernicus.eu/dhus/#/home.

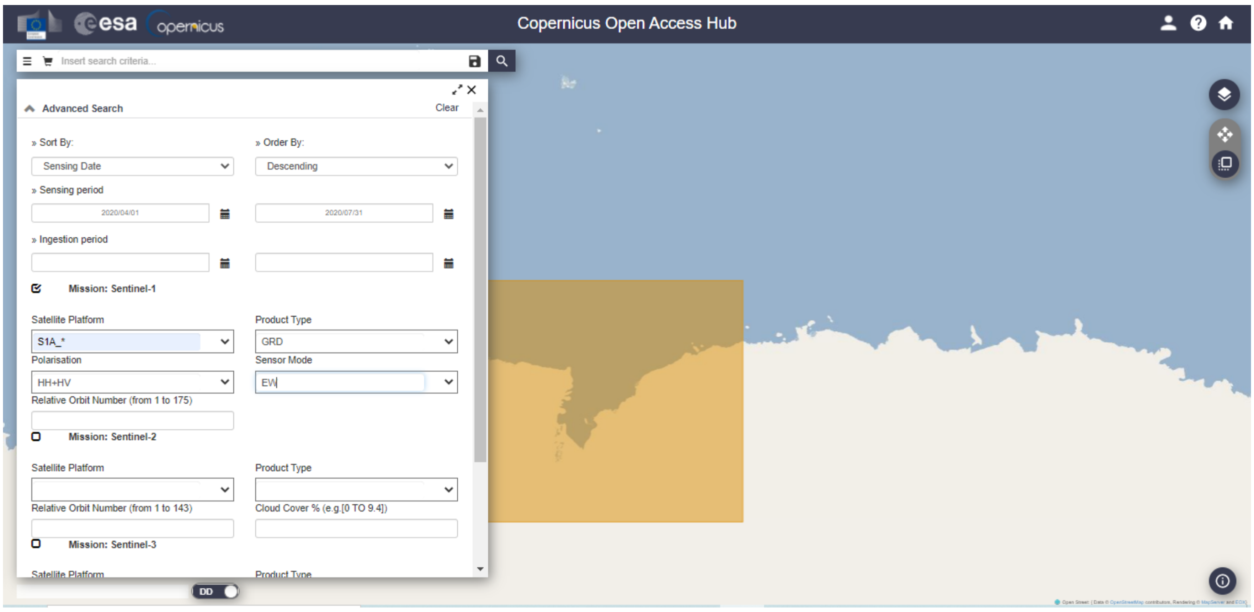
2. Sign up if new user, otherwise sign in if already existing user.

3. Select the ROI over Antarctica. Our study field is Indian Antarctic Research Station Bharati. Draw the polygon (using left and right mouse key)

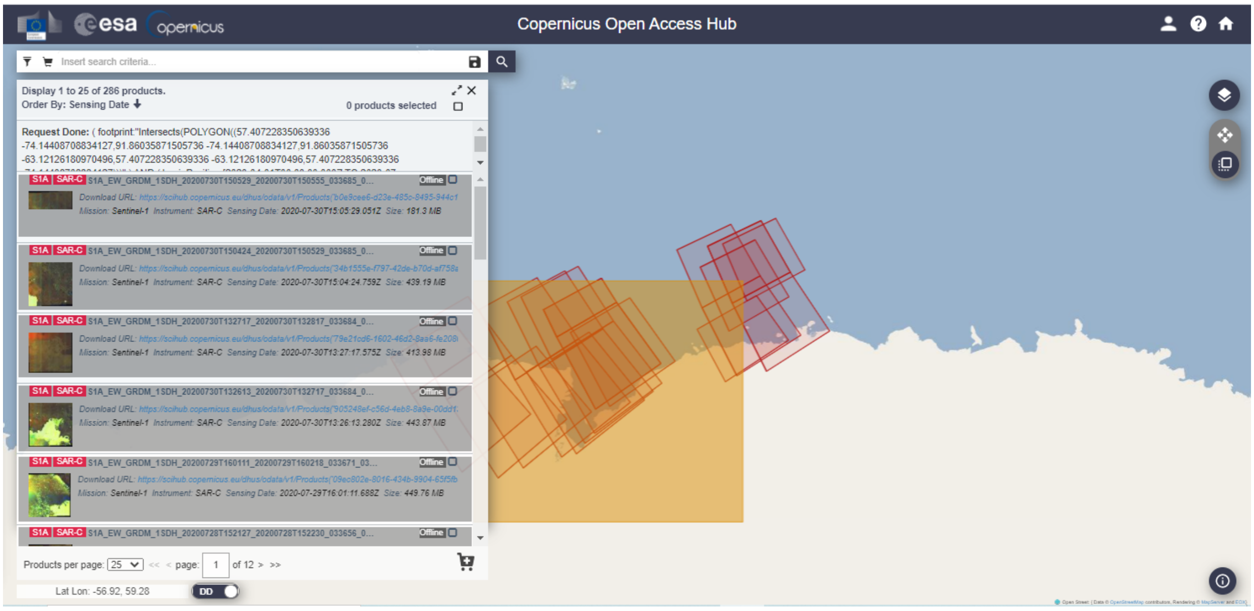
4. Go to Advance search

Parameter value:

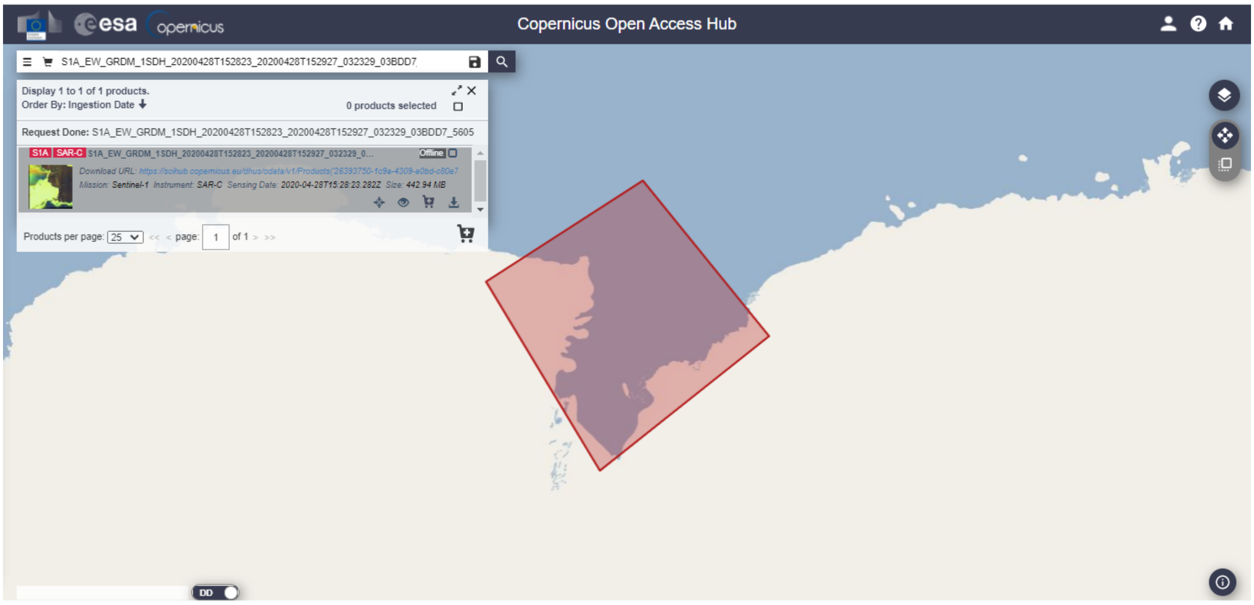
Satellite Platform: S1A Product Type: GRD Polarization: HH+HV Sensor mode: EW



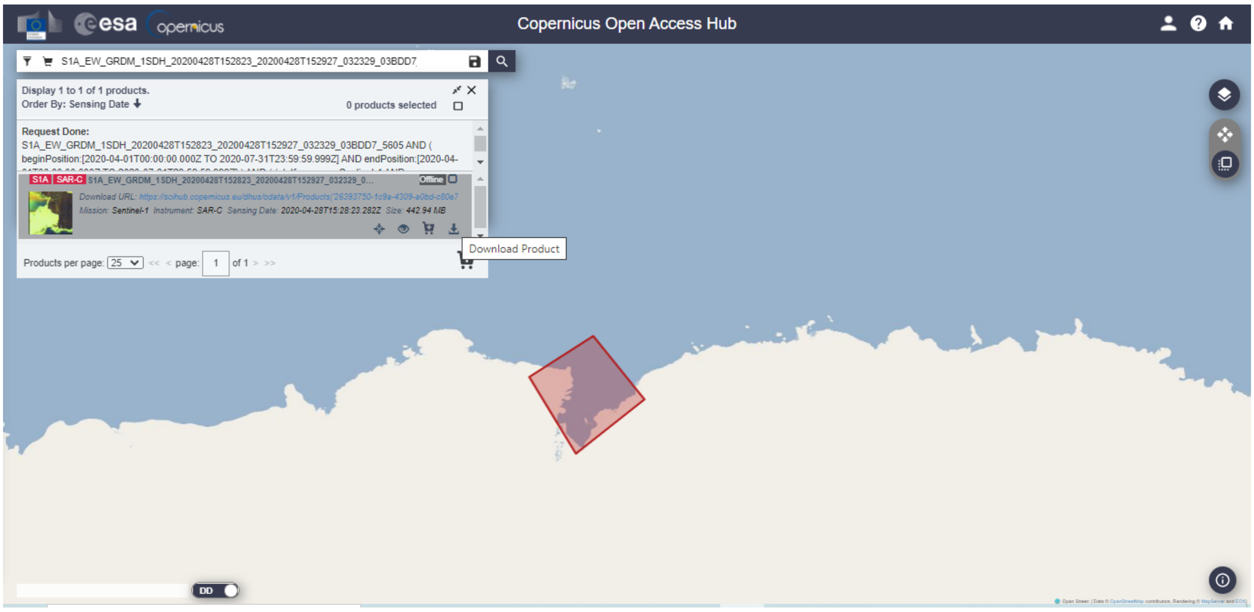
5 Go to Search



6 Select the data which cover entire Polygon. By selecting the data, it will show the dark colour over the data patch.



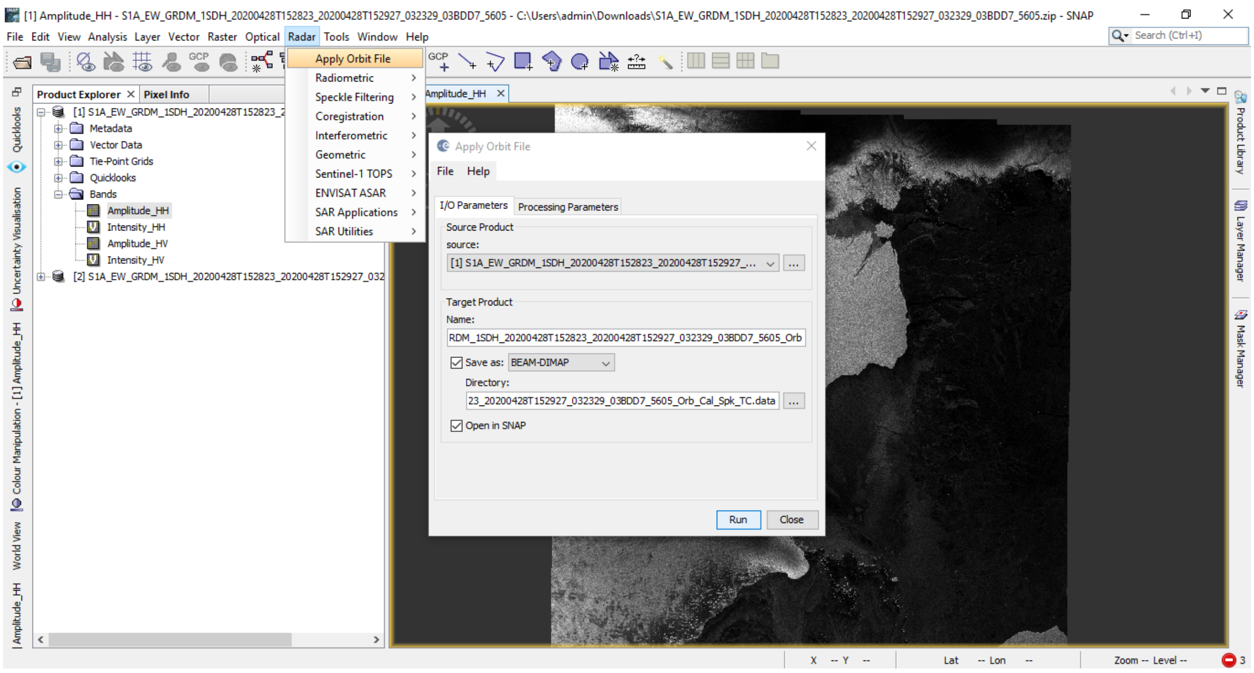
7 Download the Data.



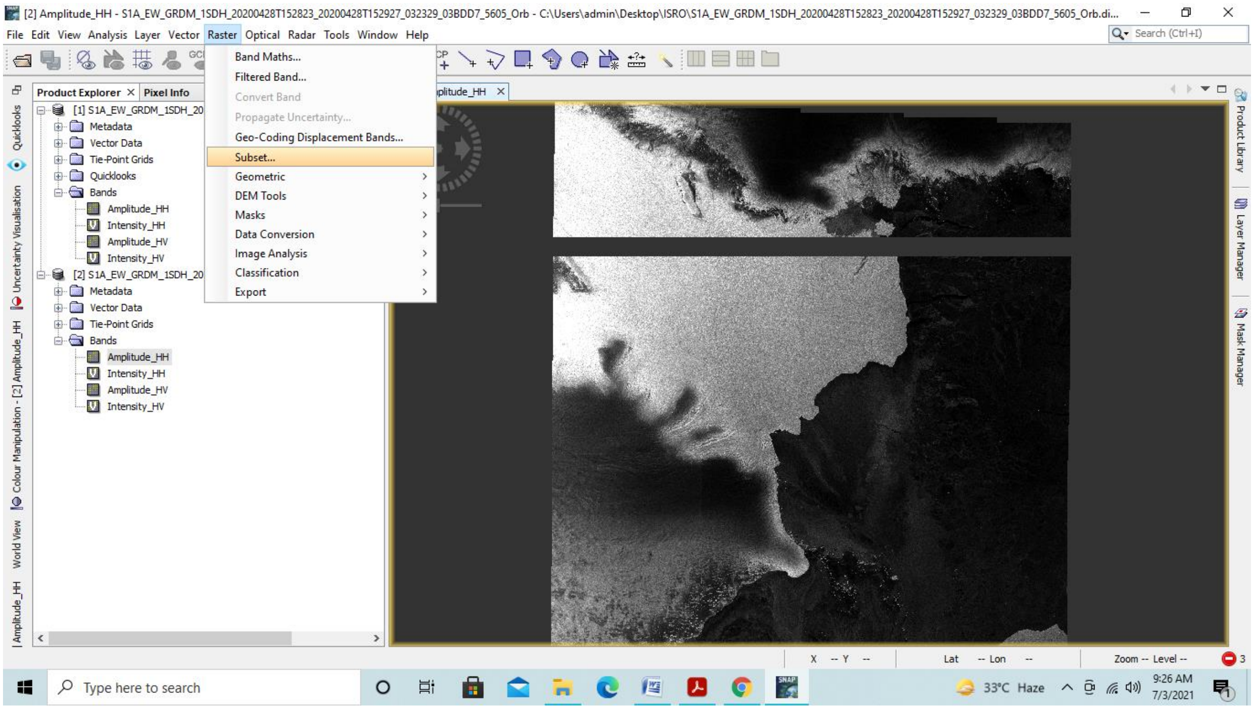
8 After download Unzip the folder and Load the manifest. Safe file in SNAP.

The steps followed for the pre-processing is given below:

Apply Orbit File: Orbit state vectors, contained within the metadata information of SAR products, are generally not accurate. The precise orbits of satellites are determined after several days and are available days-to-weeks after the generation of the product. SNAP software comes with built-in feature to apply orbit file, it is done using 8^{th} order langrage interpolation.[2]



Create a subset: By creating subset we reduce the image size so that it can become manageable. Subset can be created on the basis of pixel coordinates or Geo coordinates.



Calibration(Sigma0): The objective of this is to provide imagery in which the pixel values can be directly related to the radar backscatter of the scene. [2]

The radiometric calibration is applied by the following equation:

$$value(i) = \frac{|DN_i|^2}{A_i^2}$$

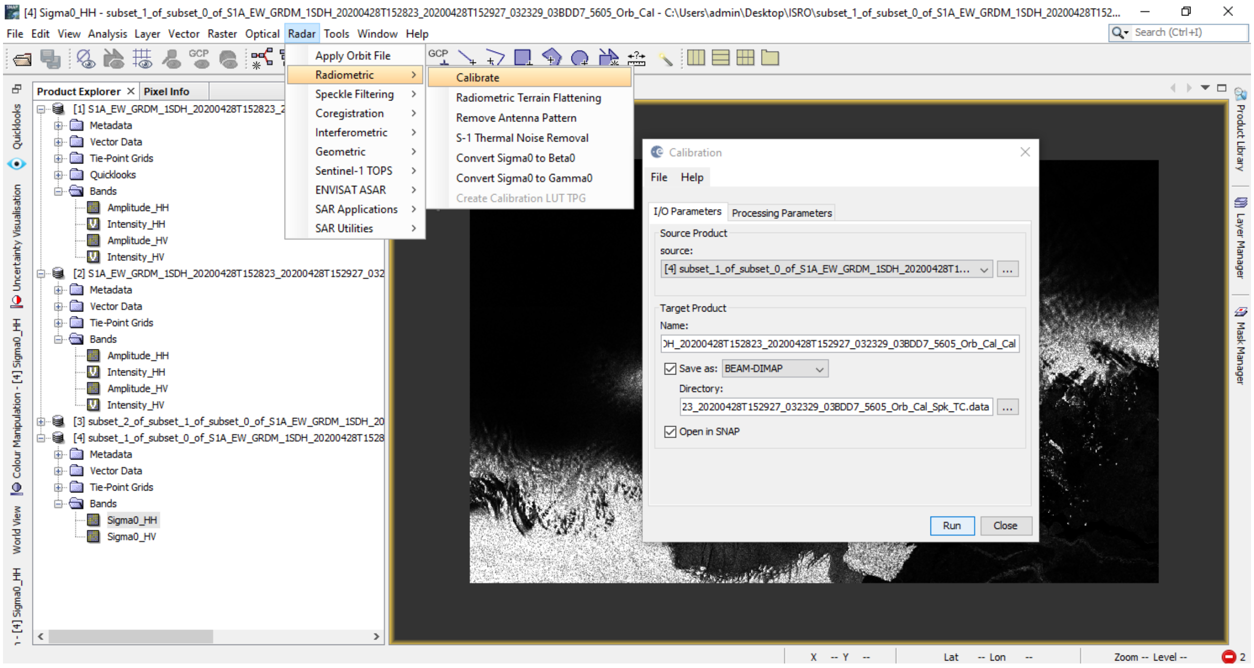
where, depending on the selected LUT,

$$value(i) = \text{one of } \beta^0{}_i,\ \sigma^0{}_i \text{ or } \gamma_i \text{ or } originalDN_i.$$

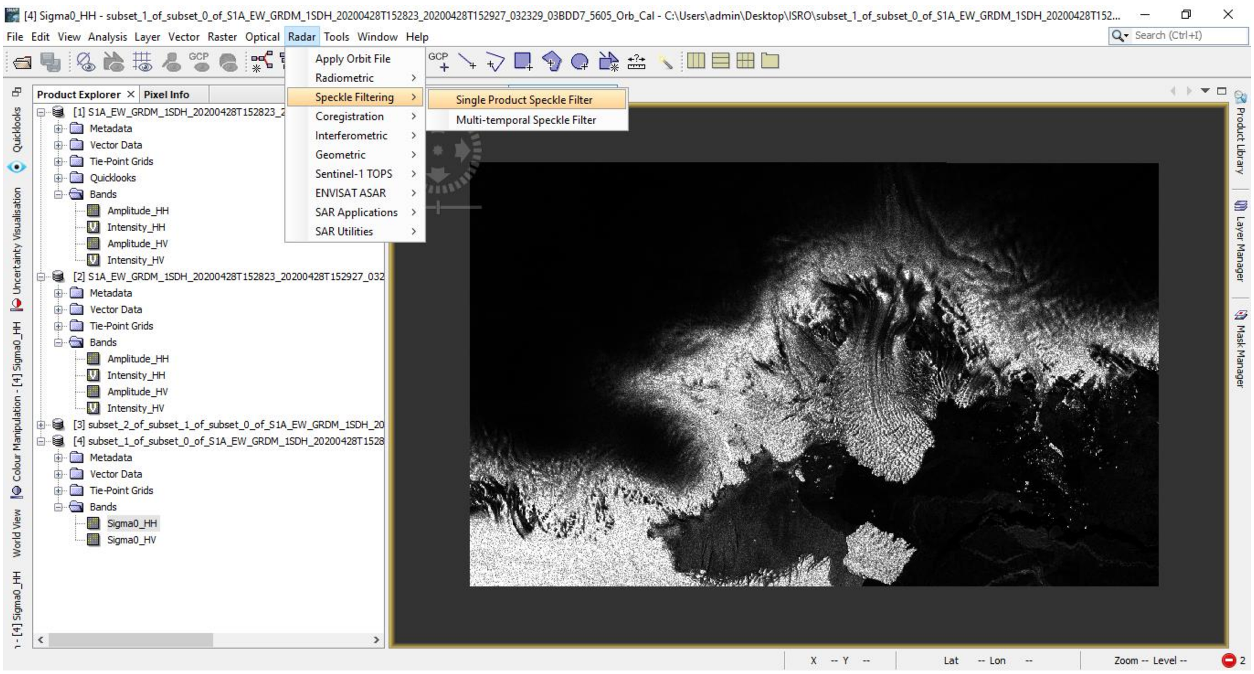
$$A_i = \text{one of } betaNought(i),\ sigmaNought(i),\ gamma(i) \text{ or } dn(i)$$

Bi-linear interpolation is used for any pixels that fall between points in the LUT.

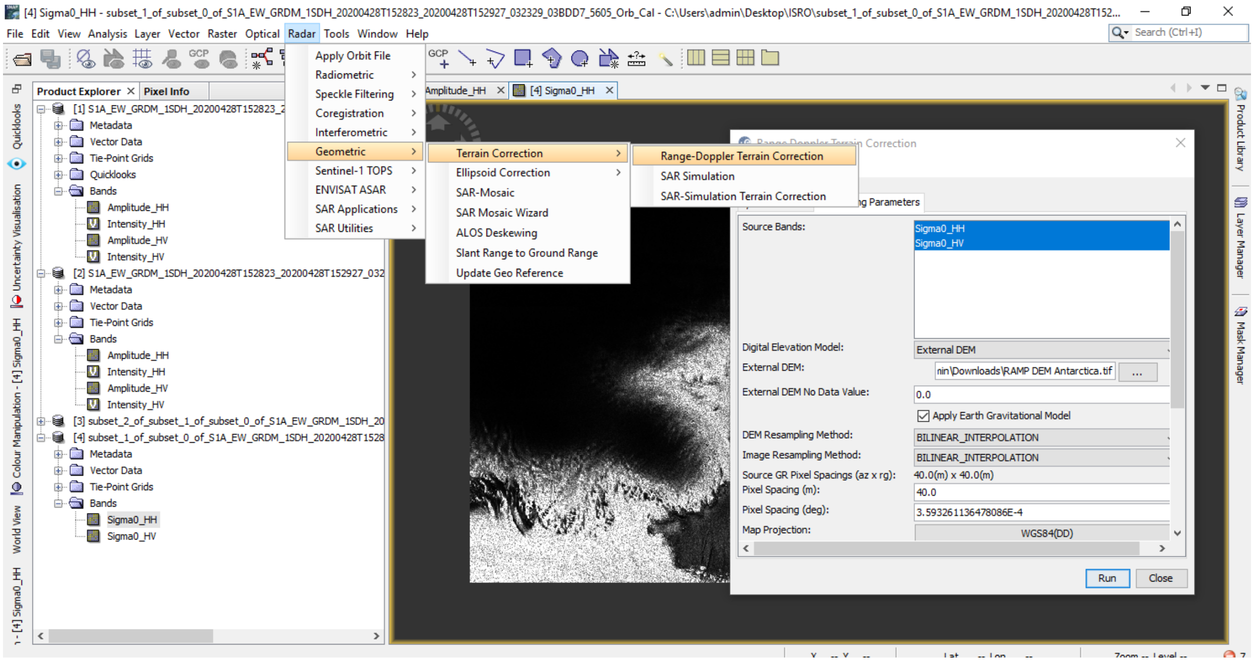
Here, DN= Digital number



Speckle Filtering: The SAR imagery has inherent salt and pepper like texture which degrade the quality of SAR image, speckles are caused by destructive and constructive interference of the de-phased but coherent return waves scattered by the elementary scatters within each resolution cell. There are different types of speckle filters available these types are based on the types of different distributions (Gaussian, multiplicative or Gamma).[2] For this project, Refined Lee filter is used for speckle filtering purpose, The **refined Lee Filter** is an adaptive filter and such a type of filter is required in order to maintain the edges in the scene. It is based on local variance if local variance is greater than threshold value then that area is considered an edge area.[1]

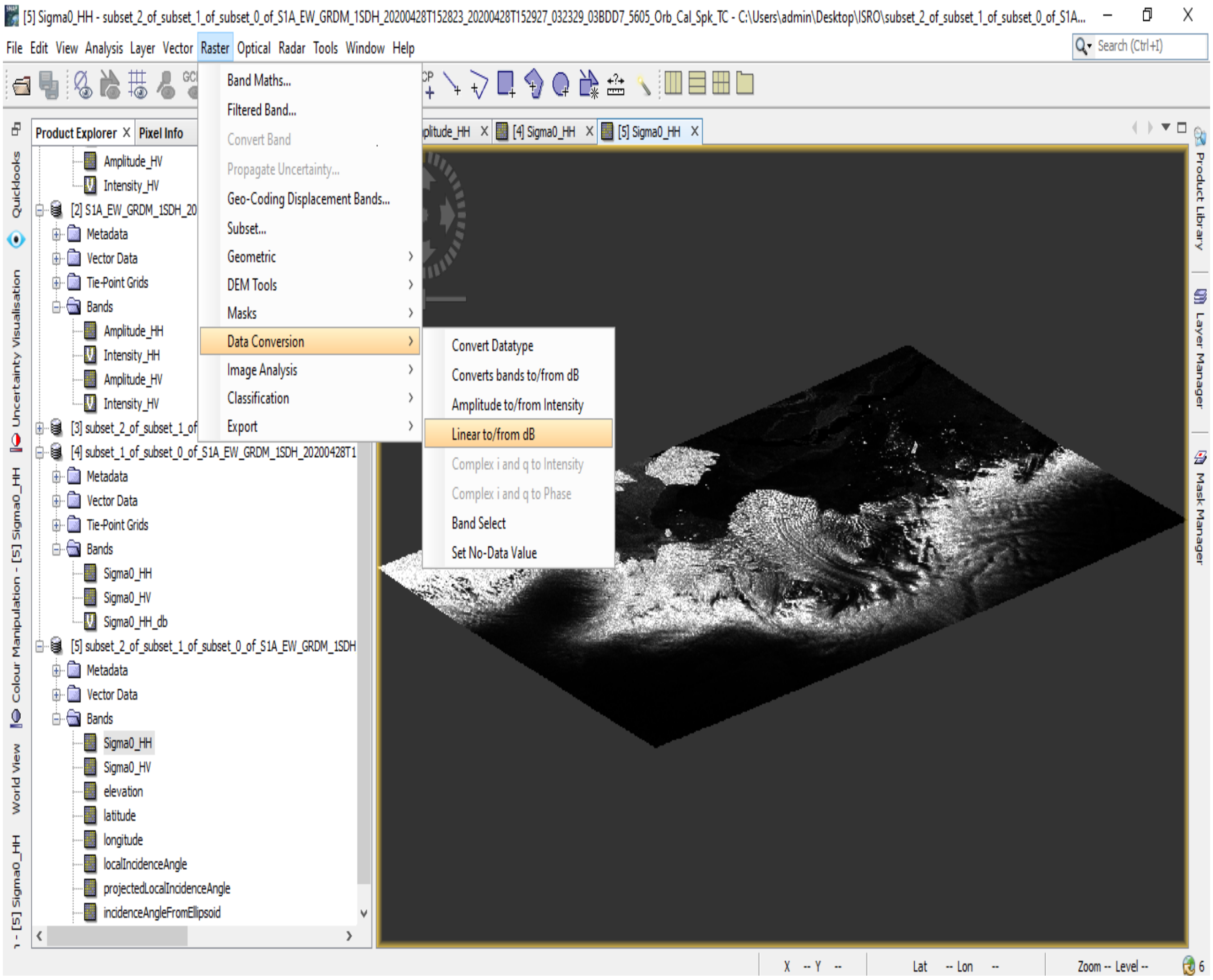


Range Doppler terrain correction: Due to topographical variations of a scene and the tilt of the satellite sensor, distances can be distorted in the SAR images. Image data not directly at the sensor's Nadir location will have some distortion like overshadow, layover, foreshortening. By terrain correction these distortion will be corrected so that the geometric representation of the image will be as close as possible to the real world. There are various ways to do this process but for now RAMP V2 DEM model will be used, DEM stands for Digital Elevation Model it is superimposed to the SAR image to correct all the topographical distortion.[2]



Linear to dB conversion: As a last step of the pre-processing, the unit less backscatter coefficient is converted to dB using a logarithmic transformation.

$A(dB) = 10*\log_{10}(ratio)$[2]



[5] Sigma0_HH - subset_2_of_subset_1_of_subset_0_of_S1A_EW_GRDM_1SDH_20200428T152823_20200428T152927_032329_03BDD7_5605_Orb_Cal_Spk_TC - C:\Users\admin\Desktop\ISRO\subset_2_of_subset_1_of_subset_0_of_S1A...
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Search (Ctrl+I)
Product Explorer
Pixel Info
Band Maths...
Filtered Band...
Convert Band
Propagate Uncertainty...
Geo-Coding Displacement Bands...
Subset...
Geometric
DEM Tools
Masks
Data Conversion
Image Analysis
Classification
Export
Convert Datatype
Converts bands to/from dB
Amplitude to/from Intensity
Linear to/from dB
Complex i and q to Intensity
Complex i and q to Phase
Band Select
Set No-Data Value
Amplitude_HV
Intensity_HV
[2] S1A_EW_GRDM_1SDH_20
Metadata
Vector Data
Tie-Point Grids
Bands
Amplitude_HH
Intensity_HH
[3] subset_2_of_subset_1_of
[4] subset_1_of_subset_0_of_S1A_EW_GRDM_1SDH_20200428T1
Sigma0_HH
Sigma0_HV
Sigma0_HH_db
[5] subset_2_of_subset_1_of_subset_0_of_S1A_EW_GRDM_1SDH
elevation
latitude
longitude
localIncidenceAngle
projectedLocalIncidenceAngle
incidenceAngleFromEllipsoid
[4] Sigma0_HH
[5] Sigma0_HH
Product Library
Layer Manager
Mask Manager
Quicklooks
Uncertainty Visualisation
Colour Manipulation
World View
X -- Y --
Lat -- Lon --
Zoom -- Level --

Study Area and Datasets

The study area for this analysis is Indian Antarctic Research Station Bharati and its surrounding area attached to the Amery Ice Shelf. There are three Indian Antarctic Research Station namely Dakshin Gangotri, Maitri, and Bharati. The latitudes and longitudes are latitude 69° 24.41' S and longitude 76° 11.72' E for Bharati[1]. The reason to choose Bharati as a study area is because it is on the coast, and the station is operational year-round the expedition ships reaches generally in the summer by the time the ocean water gets frozen and thus sea ice is formed. Thick ice sheet can do collateral damage to the ships and other marine equipments.

DATASETS USED IN THE STUDY

REMOTE SENSING DATA	**Sentinel-1A C-band Level-1 (GRDM) EW mode**
SENSING DATE	**2020-04-28**
FREQUENCY	**5.405 GHz**
POLARIZATION	**HH+HV**
ANCILLARY DATA	**Elevation Data from RAMP 2.0 DEM 200m**

PYTHON MODULES FOR SAR DATA PROCESSING

Reading Raster values of an image in GDAL

With GDAL, we can read and write several different raster formats in Python. Python automatically registers all known GDAL drivers for reading supported formats when the importing the GDAL module. Most common file formats include for example TIFF and GeoTIFF.

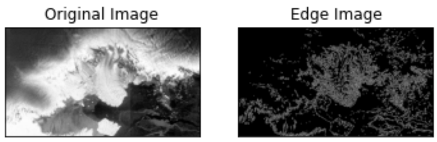
```
In [3]: from osgeo import gdal
        from gdalconst import *
        dataset = gdal.Open("c:\\users\\sigma_db.tif")
        band = dataset.GetRasterBand(1)
        band.ReadAsArray(0,2,5,5,10,10)

Out[3]: array([[48, 48, 50, 50, 49, 49, 52, 52, 54, 54],
               [48, 48, 50, 50, 49, 49, 52, 52, 54, 54],
               [49, 49, 48, 48, 46, 46, 47, 47, 59, 59],
               [49, 49, 48, 48, 46, 46, 47, 47, 59, 59],
               [49, 49, 51, 51, 49, 49, 54, 54, 64, 64],
               [49, 49, 51, 51, 49, 49, 54, 54, 64, 64],
               [48, 48, 50, 50, 46, 46, 57, 57, 66, 66],
               [48, 48, 50, 50, 46, 46, 57, 57, 66, 66],
               [49, 49, 52, 52, 50, 50, 55, 55, 63, 63],
               [49, 49, 52, 52, 50, 50, 55, 55, 63, 63]], dtype=uint8)
```

Pixel values using openCV library in python

```
In [8]: import numpy as np
        import cv2
        mypath ="C:\\users\\sigma_db.tif"
        img = cv2.imread(mypath,1)
        print(img)
        p=cv2.imread(mypath, cv2.IMREAD_COLOR).dtype
        print(p)
        print(type(img))

        [[[ 44  44  44]
          [ 46  46  46]
          [ 50  50  50]
          ...
          [ 18  18  18]
          [ 17  17  17]
          [ 17  17  17]]

         [[ 44  44  44]
          [ 51  51  51]
          [ 55  55  55]
          ...
          [ 18  18  18]
          [ 15  15  15]
          [ 20  20  20]]

         [[ 48  48  48]
          [ 50  50  50]
          [ 49  49  49]
          ...
          [ 20  20  20]
          [ 14  14  14]
```

Edge Detection Using Canny Operator in OpenCv

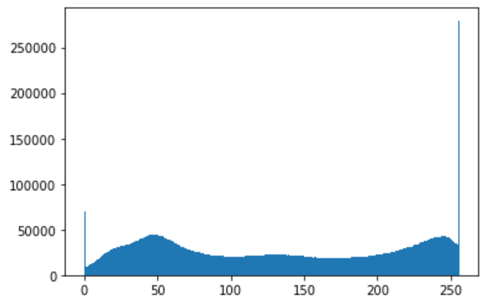
```
In [12]: import numpy as np
         import cv2
         from matplotlib import pyplot as plt
         mypath = "C:\\Users\\sigma_db.tif"
         cv2.namedWindow("output", cv2.WINDOW_NORMAL)        # Create window with freedom of dimensions
         im = cv2.imread(mypath,1)                           # Read image
         imS = cv2.resize(im, (960, 540))                    # Resize image
         cv2.imshow("output", imS)                            # Show image
         cv2.waitKey(0)
         edges = cv2.Canny(imS,100,200)                       #canny operator
         plt.subplot(121),plt.imshow(imS,cmap = 'gray')
         plt.title('Original Image'), plt.xticks([]), plt.yticks([])
         plt.subplot(122),plt.imshow(edges,cmap = 'gray')
         plt.title('Edge Image'), plt.xticks([]), plt.yticks([])
         plt.show()
         lines=cv2.HoughLines(edges,1,np.pi/180,50)
         lines
```




```
Out[12]: array([[[ 440.       ,   1.3439035]],

                [[ 459.       ,   1.3089969]],

                [[ 435.       ,   1.2915436]],
```

Histogram Generation using OpenCV library

```
In [20]: import numpy as np
         import cv2
         from matplotlib import pyplot as plt
         mypath = "C:\\Users\\sigma_db.tif"
         lena=cv2.imread(mypath,0)
         hist=cv2.calcHist([lena],[0],None,[256],[0,256])             #histogram of image
         xaxis=np.arange(256).reshape(256,1)
         histogram=np.hstack((xaxis,hist)).astype(int)
         plt.hist(lena.flatten(),256,[0,256])
         plt.show
Out[20]: <function matplotlib.pyplot.show(close=None, block=None)>
```



Conclusion: In this study Sentinel 1A SAR C band image processing has been done using SNAP and python. Using Canny edge detection we can see the edges present in the image. It is concluded that SAR image is benevolent to those geographical locations where weather conditions are harsh and sunlight is not proper, in such locations optical satellites cannot be preferred.

References

1. Kavita Mitkari, Jayaprasad P., Deepak Putrevu And Arundhati Misrhra High Resolution Sea Ice Concentration Retrieval using Dual Polarized C-band SAR Data.
2. SNAP help section.
3. https://automating-gis-processes.github.io/2016/Lesson7-read-raster.html