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Sentinal-1 SAR Data Preparation for Mapping of Water Bodies – A CASE STUDY

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ABSTRACT

An important area of satellite-based remote sensing is the mapping of water bodies. Sentinel-1 satellite data is the accurate source of data that can be downloaded freely and rapidly in the operational water body monitoring work using satellite data. The method of water body mapping by using Sentinel-1 Satellite data with high resolution is provided in order to make proper use of these data to extract water body information. Due to its ability to obtain data in day and night even in adverse weather conditions as it can penetrate through haze, rainfall, clouds and dust, Microwave Synthetic Aperture Radar (SAR) satellite data is often used for mapping water bodies and flood affected areas. Because SAR data is complex and coherent in nature, before processing the data, extensive data preparation is required. The basic steps for SAR data preparation are described in this paper are orbit file application, calibration, speckle filtering, terrain correction and linear conversion to decibels by using SNAP tool. The method is used in the lake plateau of Mecklenburg, Germany and demonstrates Potential results. Microwave SAR satellite data may be used widely and effectively to provide accurate water body information for water resource management, flood warning, real-time flood growth monitoring, fast and precise flood damage loss assessment.

Keywords:Sentinel-1, Water body, SNAP tool, SAR image, pre-processing

1. Introduction

A wide variety of landscapes are included in the description of water bodies, from oceans to small wetlands. Water sources are also called dynamic transition regions, such as wetlands. In comparison, flood incidents can be used as a special case of bodies of water involving quick mapping in the form of an emergency response. One of the most valuable water supplies is the surface water body of the World. Using the satellite, water body shift identification may provide valuable knowledge for flood hazard control and management of water supply. High spatial resolution synthetic aperture radar (SAR) is very useful for collecting accurate information about the water body.

Synthetic aperture radars have benefits over optical sensors in order to measure the degree of surface water spatial and temporal variation. Such benefits include 'all-weather' and 'day-and-night' capacity, as well as both open water and under-canopy inundation sensitivity. Surface water detection using SAR backscatter depends on the fact that areas in open, smooth (no or low waves relative to the wavelength of energy employed by the SAR) water bodies usually exhibit lower backscatter coefficients. In increasing flood events and a range of ecosystems, including reservoirs, waterways, and wetlands, SAR backscatter coefficients from both spaceborne and airborne platforms have been used to map surface water extent. Several SAR-based experiments used either histogram thresholding techniques, approaches to classification or multi-temporal thresholding to map the depth of the water surface. The effect of incidence angle wave conditions and vegetation cover on SAR backscatter has been investigated by a variety of studies. Numerous operational mapping algorithms rely on single-polarized (e.g. HH, HV, or VV), dual-polarized (HH/HV or VV/VH) or quad-polarized (HH/HV/VV/VH) data from SAR backscatter, where polarizations are transmitted and obtained by the first and second characters.

This research discusses the preparation of SAR data using the Sentinel 1Toolbox (S1TBX) Sentinel Application Platform (SNAP) of the European Space Agency (ESA) for water body mapping. SNAP is an open source platform with a series of executable tools and Application Programming Interfaces (APIs) designed to allow different remotely sensed data to be accessed and managed.

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2. Material and Methods

2.1 Study Area

The study area taken for this study is the Part of the Mecklenburg lake plateau located in the Germany. The study area occupies location from to 25° 9' 0"N to 25° 27' 0"N latitude and 86° 13' 58.8"E to 86° 39' 21.6"E longitude. Mecklenburg lake is the largest coherent lake and canal area in Germany and is also called "the land of a thousand lakes". In the area, there are many nature parks and well-known lakes with special flora and fauna, such as the Müritz, the largest German lake entirely within Germany, the Plauer See, the Fleesensee, the Tollensesee, the Kölpinsee and the SchmalerLuzin.

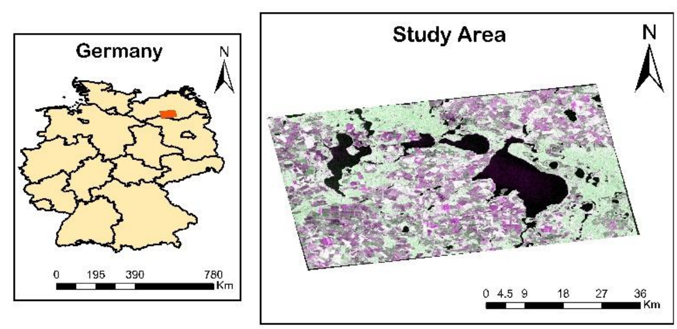

Figure 1: Study area location map

2.2 Data Used

The Remote Sensing (RS) datasets used for this study is Sentinel 1 SAR data. The field of research is a subset of 4665 x 3552 pixels from the entire product scene, the full specifications of which have been tabulated in Table 1. Sentinel-1 is a space mission sponsored by the European Union and carried out within the scope of the Copernicus Program by the ESA, consisting of two satellite constellations, Sentinel-1A and Sentinel-1B. Sentinel-1A, the first satellite, was launched on 3 April 2014 and Sentinel-1B on 25 April 2016. The Sentinel-1 payload is a C band Synthetic Aperture Radar that offers continuous imaging (day, night and all weather). Sentinel-1 is used in this paper, to obtain surface water information in time so it is not affected by cloudy, rainy, all-weather observation. It acquires C band data with a centre frequency of 5.407 GHz in the Polarization of VV as well as VH. The combined constellation's temporal resolution is 6 days. Sentinel-1 acquires data in four modes shown in table2.Through raw Level-0 data, Level-1 Single Look Complex (SLC) data, Level-1 Ground Range Detected (GRD) data and Level-2 ocean data, each mode will produce products. Originally, the GRD product was generated with a spatial resolution of 20x22 metres, then resampled to 10x10 metres.

Table 1: Characters of Sentinal-1A/B

Operation mode	Spatial resolution	Swath width	Polarisation
Stripmap(SM)	5×5 m2	80 km	HH or VV VV+VH or HH+HV
Interferometircwideswath(IW)	5×20 m2	250 km	HH or VV VV+VH or HH+HV
Extra-Wide swath (EW)	20×40 m2	400 km	HH or VV VV+VH or HH+HV
Wave mode (WV)	20×5 m2	20×20km2 every 100km	HH or VV

3. Methodology

The complete data preparation flow chart is shown in figure 2. Sentinel 1B SAR data in VH and VV polarisation is used for the analysis

3.1 Data Downloading

Sentinel-1 has been downloaded from ESA's Copernicus Open Access Hub website (https://scihub.copernicus.eu/ dhus/#/home). First, user have to create a account and then Click the SIGN UP button on the upper right side of the web map. Insert entries that are valid for your name, email, and location. Register by clicking. Get your email validated. You have obtained access to ESA's Sentinel data with a few mouse clicks. Use the SEARCH CRITERIA text box in the top-left portion to select your area of interest. And type your area of interest name. Then the rectangular box, as seen in the figure 4, must be dragged on the map. Enable the Advanced Search screen by clicking on the menu. It's in the search bar on the far left. Check the checkbox "Mission: Sentinel 1" and include other parameters such as time of sensing, period of ingestion, form of product, sensor mode, etc. as shown in the figure 5

The search result give product and the product that is needed our study area is S1B IW GRDH 1SDV 20161015T165945 20161015T170010 002520 00440D CF2D, Clicking the download symbol shown in the list, below the same product name as seen in the figure 6, was downloaded.

Table 2: Details of the data used

S.N.	Satellite	Product name	Date and time	Product Type	Acquisition mode	Polarization	Spatial Resolution
1	Sentinel-1B	S1B IW GRDH 1SDV 20161015T165945 20161015T170010 002520 00440D CF2D	2016-10-15T 23:48:33.897Z	Level-1GRD product	Interferometric Wide Swath (IW)	VV VH	10x10 meters

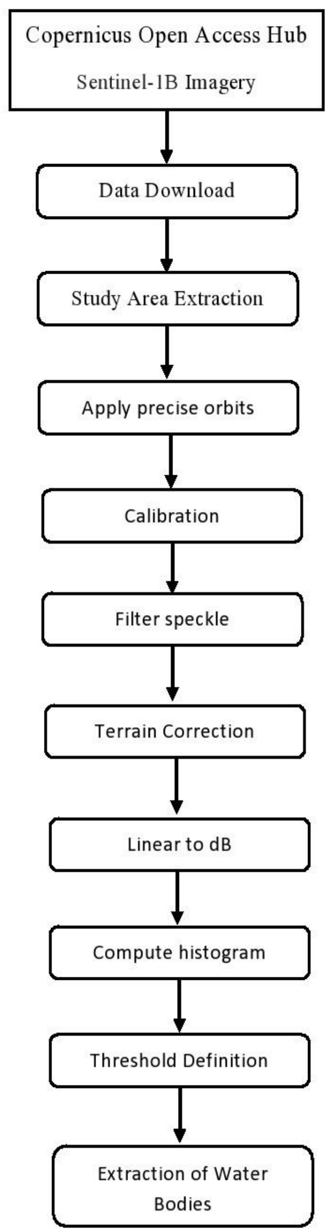

Figure 2: Flowchart of the Data Preparation

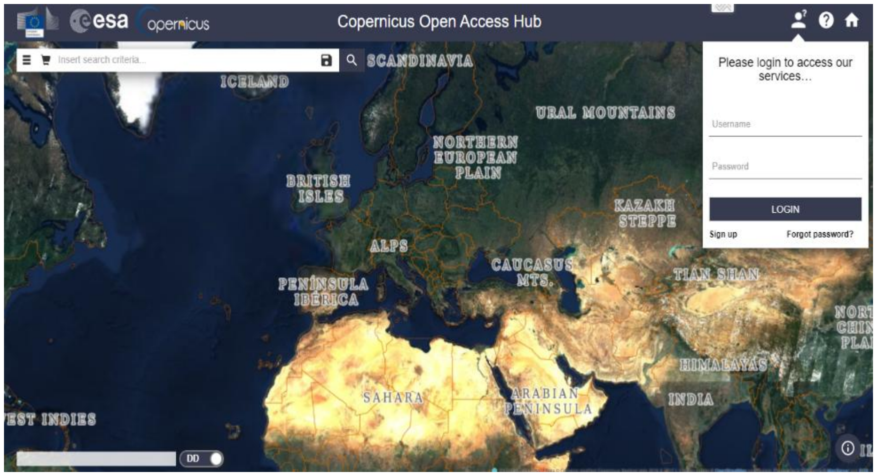

Figure 3: The Copernicus Open Access Hub's login page

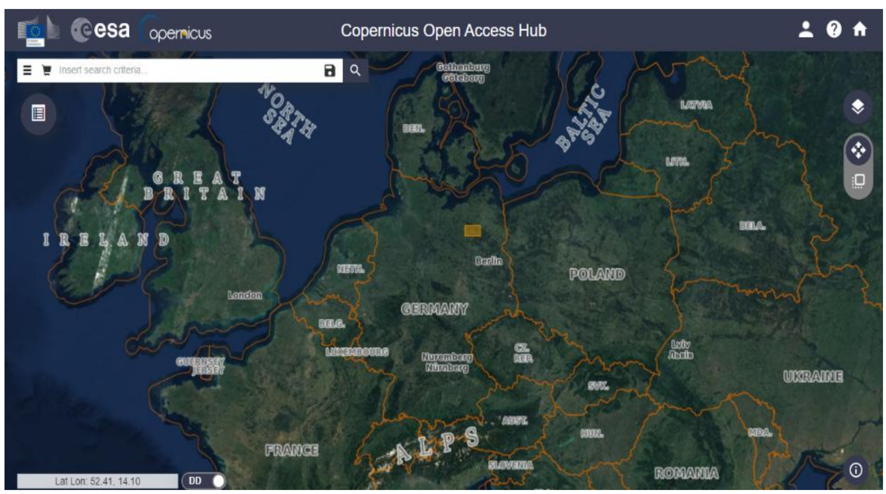

Figure 4: Selection of Study Area

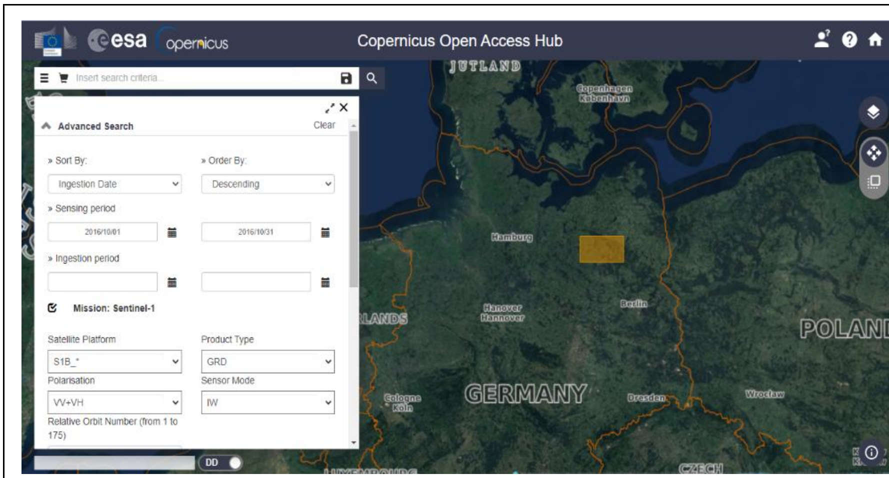

Figure 5: Advanced options for searching

3.2 Apply Orbit File:

The orbit file includes satellite location information and velocity information in the metadata. This process will affect the output of multiple pre-processing steps, particularly for geo-referencing, stacking of images and correction of terrain. Using the Apply Orbit File operator contained in Radar>Apply Orbit File in the toolbar, SNAP makes updating the orbit file as seen in Figure 6(a). Both operator processing parameters are shown in the figure 6(b).

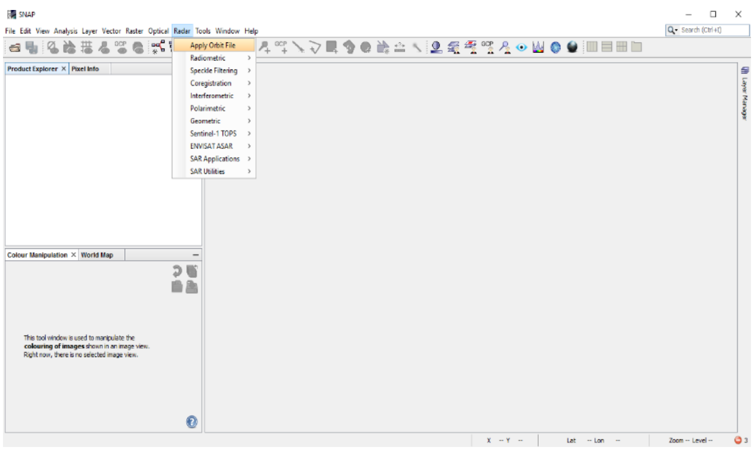

Figure 8(a): Location of the Apply Orbit File operator in the toolbar.

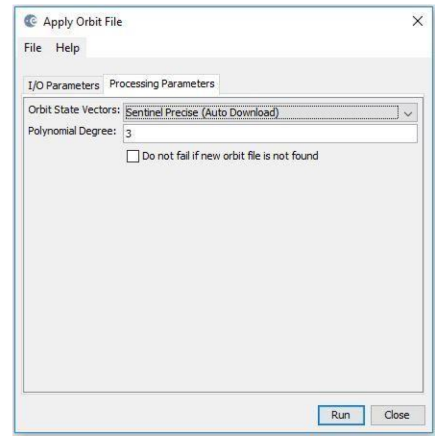

Figure 6(b): Processing Parameters of the Apply Orbit file tool operator.

3.3 Radiometric Calibration

For quantitative measurements, the SAR imagery needs to be calibrated into physical units. This move allows the SAR images' digital pixel values truly describe the reflected surface radar backscatter to equate SAR images obtained from the same sensor but at different times with different sensors in different modes or processed by various processors. In SNAP, the "Calibrate" operator is located at Radar menu, go to Radiometric and select Calibrate. View the tab for "Processing Parameters" (but leave all settings as default).

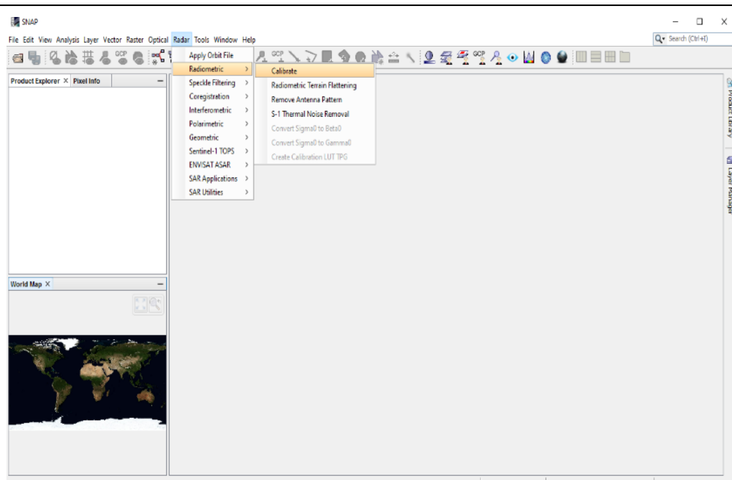

Figure 7(a): Location of the Calibration operator in the toolbar.

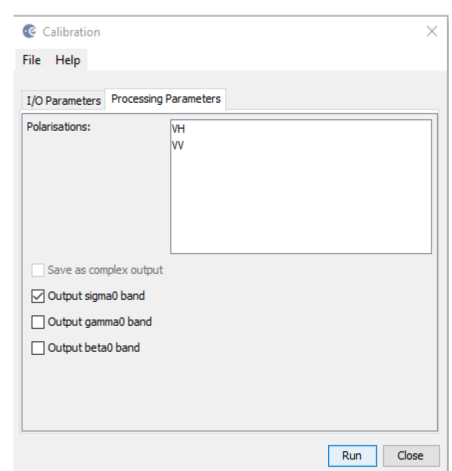

Figure 7(b): Processing Parameters of the Calibration operator.

3.4 Speckle Filtering

Speckle is induced in the image by spontaneous constructive and destructive interference that results in salt and pepper noise. To minimise the amount of speckle at the expense of blurred features or decreased resolution, speckle filters may be added to the results. Select the Radiometric Calibration product, and from the Radar menu, select Speckle Filtering/Single Product Speckle Filter. Choose the Refined Lee speckle filter from the Speckle Filtering dialogue. "When preserving edges, the Refined Lee filter averages the image. In “Filter Size X:” and “Filter Size Y:” select 5, and 5 respectively and then View the tab for "Processing Parameters" (but leave all settings as default). All the processing parameters in the operator are as shown in figure 8.

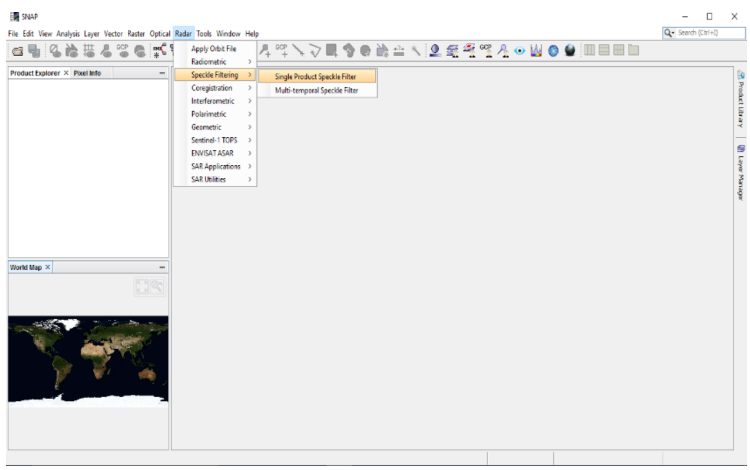

Figure 8(a): Location of the Single product speckle filter operator in the toolbar.

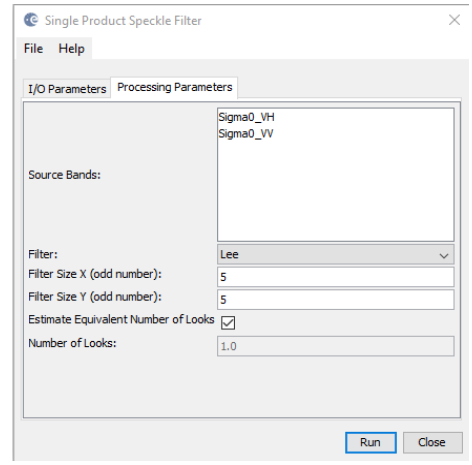

Figure 8(b): Processing Parameters of the Single product speckle filter operator.

3.5 Terrain Correction

By correcting SAR geometric distortions using a digital elevation model (DEM) and producing a projected map product, Terrain Correction will geocode the image. Geocoding transforms an image into a Map Coordinate System from Slant Range or Ground Range Geometry. Terrain Geocoding requires the use of a Digital Elevation. Model (DEM) to correct inherent effects of SAR geometry such as foreshortening, layover and shadow. This is possiblewith the support of SNAP operator called 'Range Doppler Terrain Correction'. Select the speckle filtered product, and from the SAR Processing/Geometric menu, select Range Doppler Terrain Correction. The terrain correction will use the SRTM 3 sec DEM by default. The programme will decide the appropriate DEM tiles automatically and automatically download them from internet servers. Geographic Latitude / Longitude is the default output map projection.

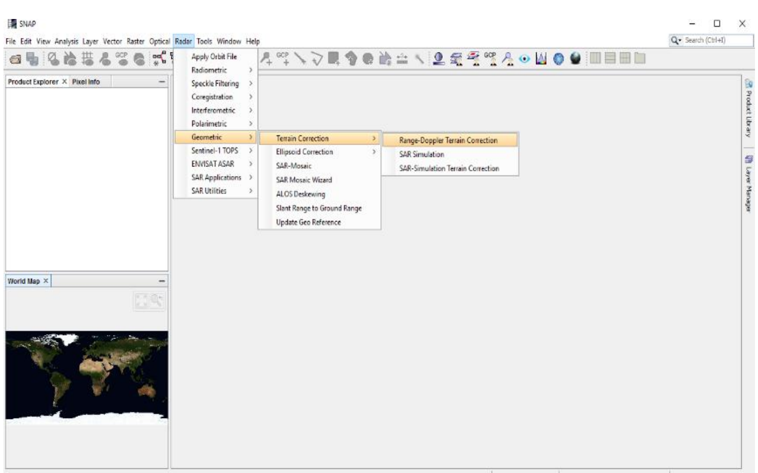

Figure 9 (a): Location of the Terrain Correction operator in the toolbar.

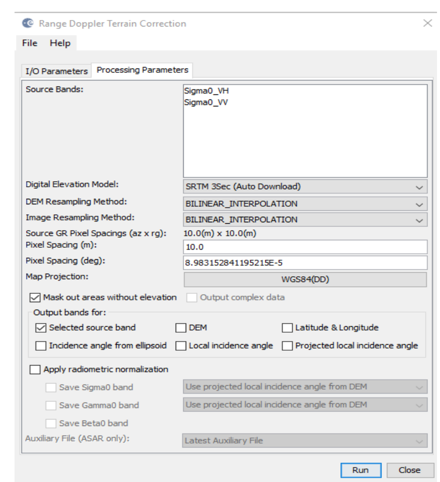

Figure 9(b): Processing Parameters of the Terrain Correction operator.

3.6 Linear to decibels conversion

The preparation of data requires the logarithmic transformation of data values for linear amplitude to decibels. The SNAP operator "Converts bands to/from dB" helps to do this conversion. As shown in the figure, it can be found under Raster>Data Conversion>Converts bands to/from dB. A new virtual band will be formed with the 10*log10 expression. All operator processing parameters are shown in the figure 10.

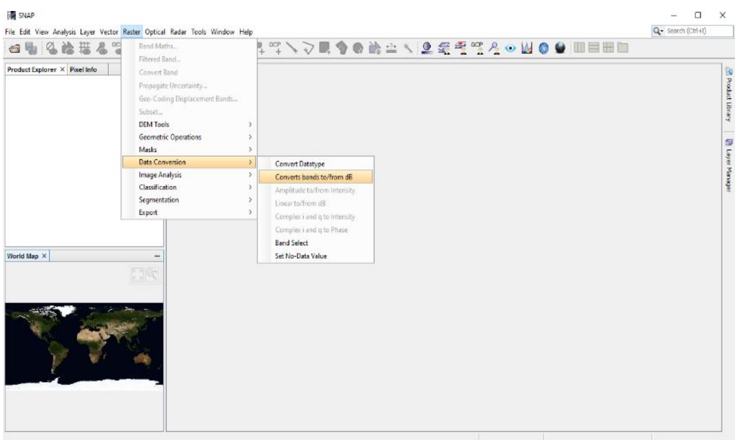

Figure 10(a): Location of the Convert bands to/from dB operator in the toolbar.

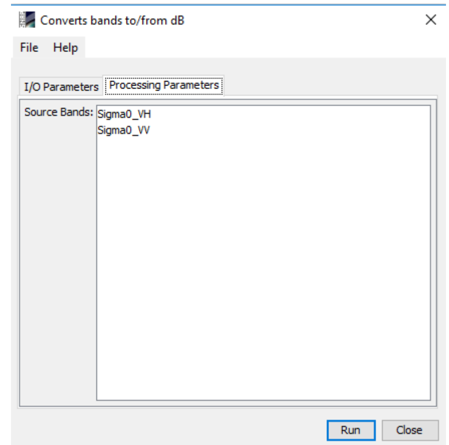

Figure 10(b): Processing Parameters of the Convert bands to/from dB operator.

4. Results and Discussion

Figure 11 displays the image of the study region updated with exact orbit file. Its accompanying histogram shows that the pixel values did not change, minimum and maximum being 6.0 & 1026.0 for VH and 11.0 & 3268.0 for VV. But in the metadata as discussed, the orbit information is modified.

The digital numbers were converted to backscatter values by calibrating the image to Sigma-naught and the image is shown in Figure 12 with its corresponding histogram with minimum and maximum values of 8.84E-5 & 2.583 for VH and 2.98E-4 & 25.949 for VV respectively.

After applying the window size 5x5 lee filter as seen in the diagram, the speckle in the picture is considerably reduced. The minimum and maximum values of the histogram are found to 5.15E-4 & 1.307 for VH and 0.002 & 18.784 for VV and the variance is found to be 0.9341 for VH and 2.3259 for VV. Before implementing the filter, the variance is 1.4364 for VH and 4.2819 for VV this means that the image has been improved. To view RGB image, it can be found under Window / Open RGB Image Window. As we select the following bands: Red = Sigma0 VV, Green = Sigma0 VH, Blue = Sigma0 VV show in fig1. When we compare both speckle filtered and non-speckle filtered images. The speckle filtered image was smoothened and enhanced.

Terrain correction modified the image's orientation to the true North, showing its true geolocation on the ground as seen in the figure, and as discussed, all the distortions were eliminated. Its respective minimum and maximum histogram values are 4.49E-4 & 4.204 for VH and 0.002 & 83.002 for VV.

As seen in the figure 15, the next stage in data processing, i.e. the conversion of linear to decibels, greatly improved the contrast between water and non-water. This helps to find the threshold for water identification in the visual understanding of water/land borders. The minimum and maximum values are observed to be -33.017 & 6.236 for VH and -28.199 & 19.191 for VV. To Compute histogram, it can be found under Analysis / Histogram and Select "Bands" folder in "Product Explorer" window and select Terrain correction product. For VV image the small second peak between around -19 and -25 db could be seen. For VH image third peak between around -26.5 and -32.5 db could be seen. There are back scatterers for bodies of water.We can add a basic threshold to both VH and VV backscatter to extract water bodies. Select Raster / Band Maths / Edit Expression to mask the areas. In the "Expression" window, Terrain correction product in db< -19 for VV and < -26.5 for VH. With this some single bright pixels in the lake are classified as non-water.

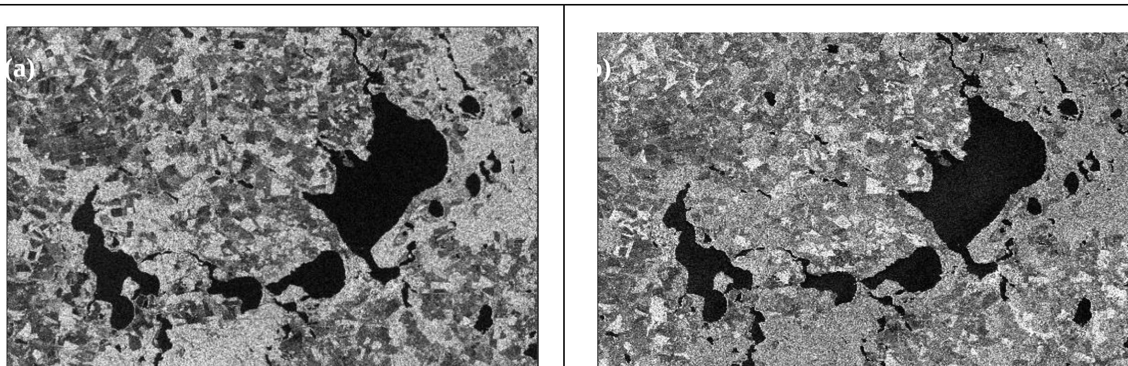

Figure 11: Orbit file updated image

(a) VH and (b)VV

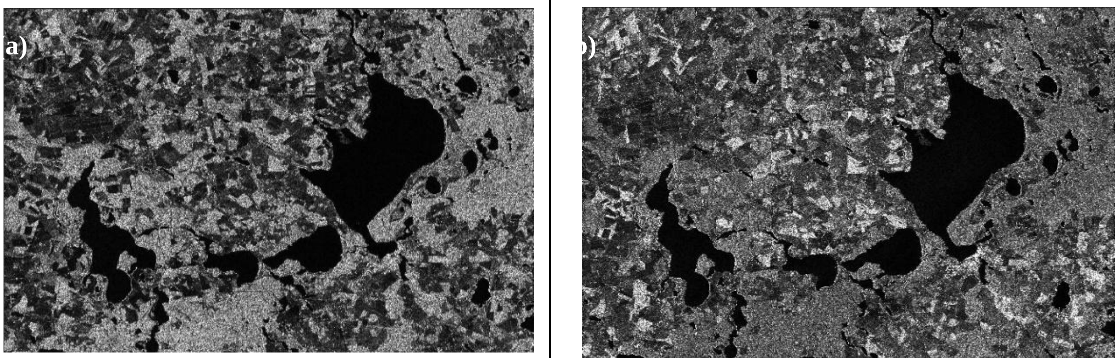

Figure 12: Calibrated Image **(a) VH and (b)VV**

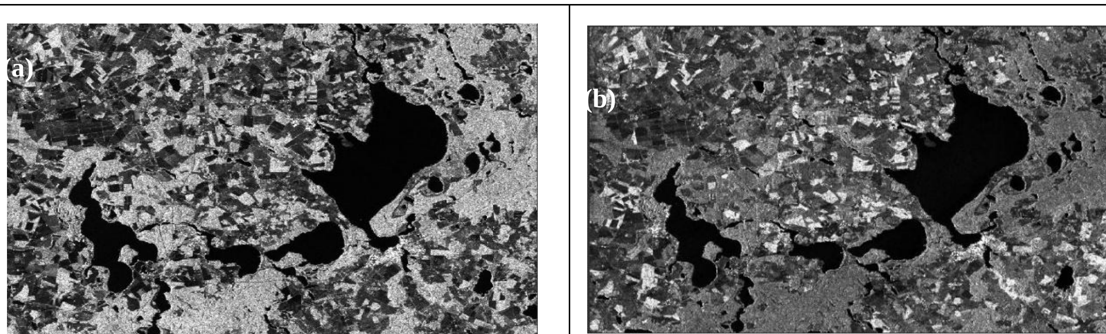

Figure 13: Speckle filtered image **(a) VH and (b)VV**

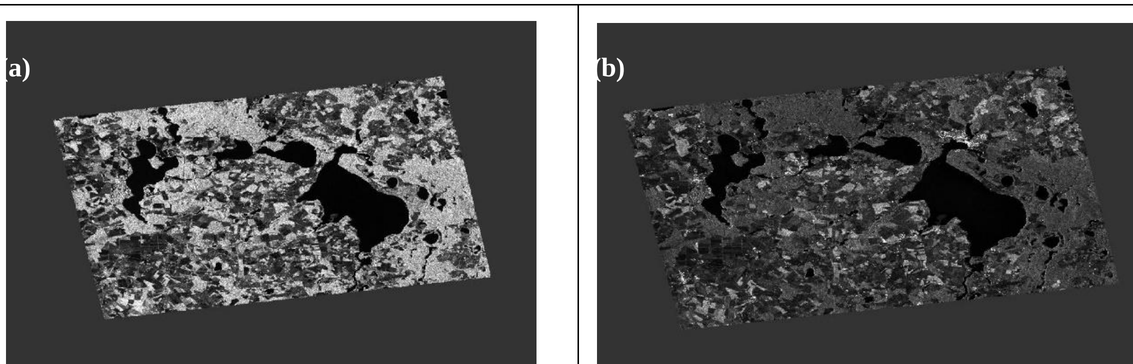

Figure 14: Terrain corrected image **(a) VH and (b)VV**

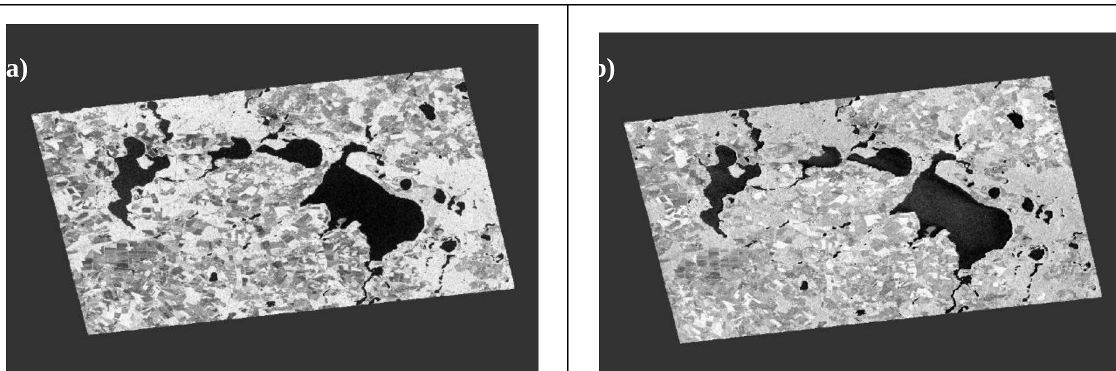

Figure 15: Decibels converted image **(a) VH and (b)VV**

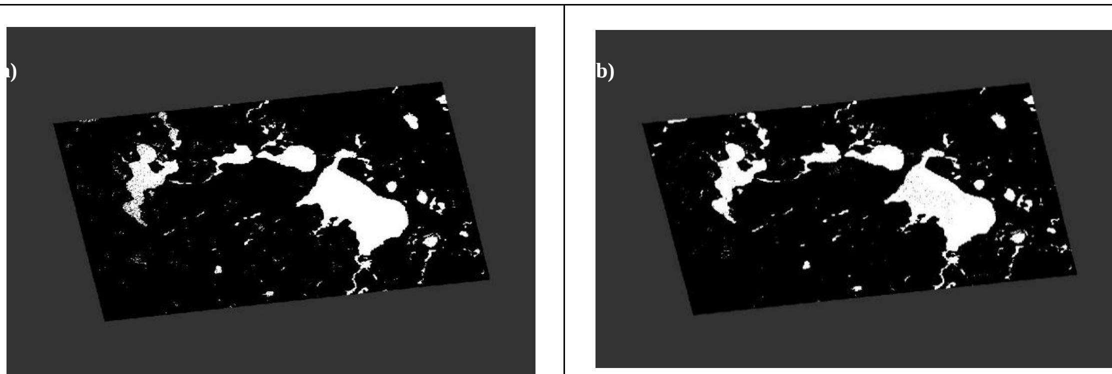

Figure 16: Extraction of water bodies (a) VH and (b)VV

5.Conclusion

The different data preparation steps needed for Sentinel-1 SAR data analysis are mentioned in this paper. The final product clearly shows the water bodies present in the study area. The use of ESA SNAP toolbox to illustrate the steps.

It is therefore allows researchers and disaster managers to plan SAR data before extracting features, particularly for the near-real-time extraction of flooded areas. More forms of satellite data can easily be accessible with the increasing development of earth observation technologies. The water body visualisation system SAR-based data can be constantly enhanced.

6.Acknowledgements

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REFERENCES

[1]. Wei Zheng and Jiali Shao (2018), Water Body Change Detection Based on Sentinel-1 and HJ-1A/B Satellites Data, In Proceedings of the International Workshop on Environment and Geoscience (IWEG 2018), pages 484-488.

[2]. Wenli Huang, Ben DeVries, Chengquan Huang, Megan W. Lang, John W. Jones, Irena F. Creed and Mark L. Carroll, Automated Extraction of Surface Water Extent from Sentinel-1 Data, Remote Sens. 2018, 10, 797; doi:10.3390/rs10050797.

[3]. Mission Summary, Sentinel-1 Overview, ESA Online.(https://sentinel.esa.int/web/sentinel/missions/sentinel1/overview/mission-summary)

[4].Peters M., Bulk Processing with SNAP, Processing, UserGuide,SNAP,https://senbox.atlassian.net/wiki/spaces/SNAP/pages/70503475/Bulk+Processing+with+GPT

[5]. Small D., Flattening Gamma(2011): Radiometric Terrain Correction for SAR imagery, *IEEE Transaction on Geoscience and Remote Sensing*, DOI: 10.1109/TGRS.2011.2120616,**49(8)**, 3081-3093

[6].Kuntla Sai Kiran, PanchagnulaManjusreeand M. Viswanadham (2019), Sentinel-1 SAR Data Preparation for Extraction of Flood Footprints- A Case Study, Disaster Advances, Vol. 12 (12).

[7].Twele A., Cao W., Plank S. and Martinis S(2016), Sentinel-1- based flood mapping: a fully automated processing chain, International Journal of Remote Sensing, https://doi.org/10.1080/01431161.2016.1192304.

[8]. SNAP Desktop Help file,http://step.esa.int/main/download/ snap-download/

[9]. Abileah R and Vignudelli S A (2011), Completely Remote Sensing Approach To Monitoring Reservoirs Water Volume International Water Technology Journal Alexandria 1(1) 63-77

[10]. Liao J J, Shao Y and Wang S X 2004 Monitoring for 2003 Huai River flood in China using multisource SAR dat International Geoscience and Remote Sensing Symposium 4 2260-2263

[11]. Tholey N, Clandillon S and Fraipont P D 1997 The contribution of spaceborne SAR and optical data in monitoring food events: examples in northern and southern France Hydrological Processes 11 1409-1413

[12]. Tholey N, Clandillon S and Fraipont P D 1997 The contribution of spaceborne SAR and optical data in monitoring food events: examples in northern and southern France Hydrological Processes 11 1409-1413