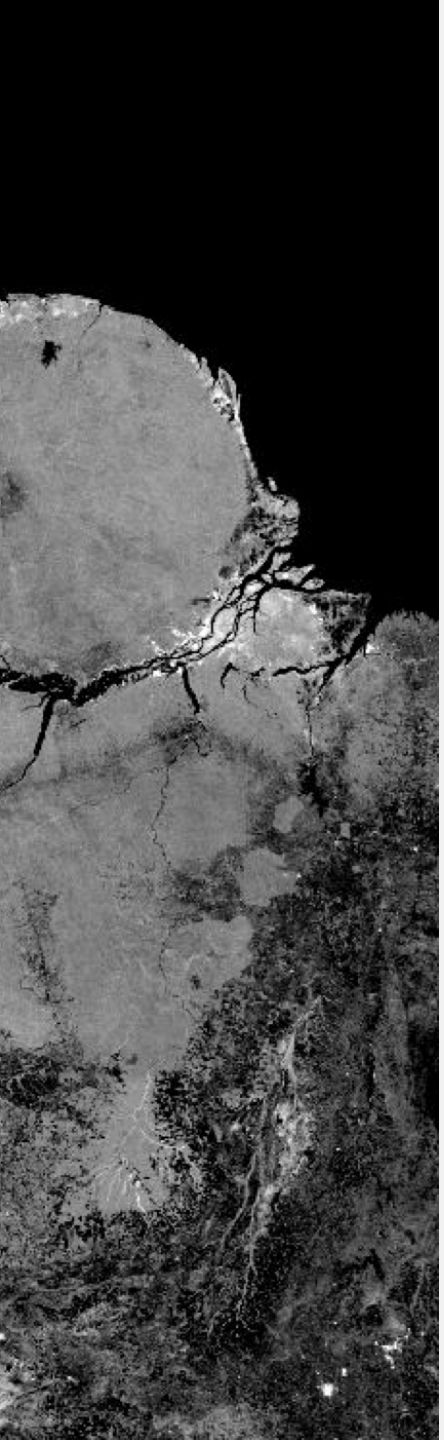


National Aeronautics and
Space Administration

ARSET

Applied Remote Sensing Training

http://arset.gsfc.nasa.gov

@NASAARSET

SAR Processing and Data Analysis

Erika Podest

Learning Objective

1. Understand Sentinel Data
2. Perform image preprocessing
3. Analyze SAR imagery to classify land and water

Outline

1. Sentinel-1 Background
2. Accessing, Opening, and Displaying the Data
3. Preprocessing
4. Analysis

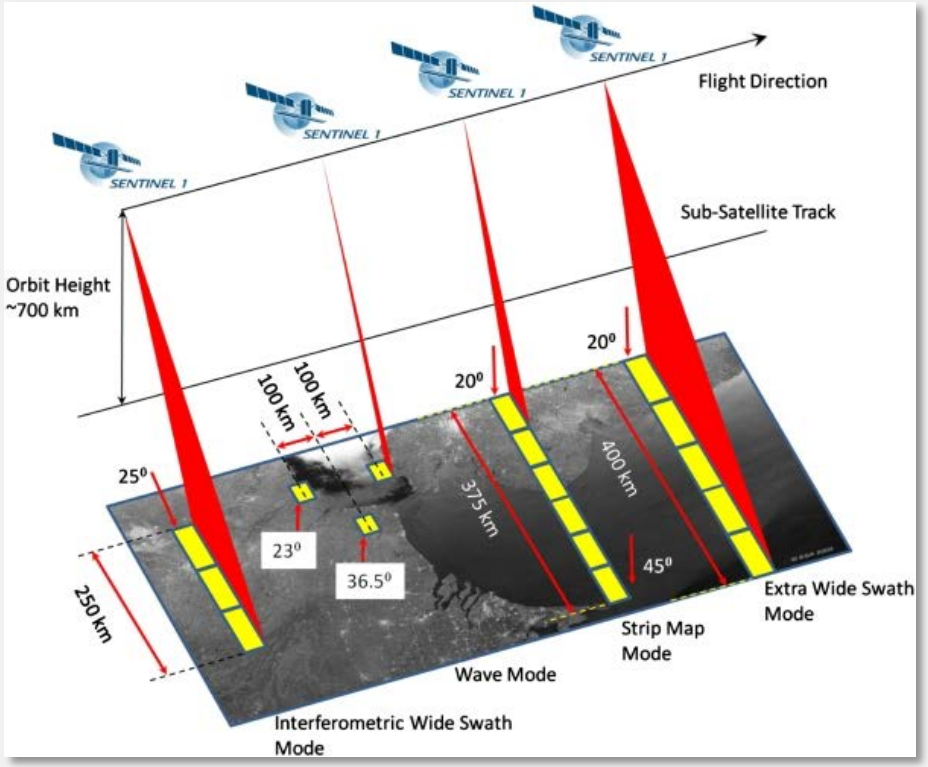
Sentinel-1 Background

Characteristics of SAR Images from Different Satellites

Sensor Name	RADARSAT-2	Sentinel-1A	RISAT-1
Agency	Canadian Space Program (CSP)	European Space Agency (ESA)	Indian Space Research Organization (ISRO)
Instrument	C-band SAR (5.4 GHz)	C-band SAR (5.4 GHz)	C-band SAR (5.35 GHz)
Incidence Angle	Side-looking, 15-45° off-nadir	Side-looking, 15-45° off-nadir	36.85 deg.
Polarization	HH, HV, VV and VH	(VV and VH) or (HH and HV)	HH an HV
Sensor Height at Equator	798 km	693 km	542 km
Orbit	Sun Synchronous (dusk/dawn)	Sun Synchronous (dusk/dawn)	Sun Synchronous (dusk/dawn)
Revisit time (Orbit Repeat cycle)	24 days	12days	25 days
Resolution	100 m	5 m X 20 m	~25 meters
Swath Width	500 km (ScanSAR mode)	250 km (IWS mode)	115 km (MRS)
Mean local time	6:00 AM Descending	6:00 AM Descending	6:00 AM
Launch	Dec 14th, 2007	April 3rd, 2014	April 26th, 2012
Planned Lifetime	7 years minimum	7 years	5 years

Sentinel-1: Modes of Acquisition

1. Extra Wide Swath
   - for monitoring oceans & coasts
   - 400 km swath, 25 x 40 m spatial resolution
2. Strip Mode
   - special order only
   - 80 km swath, 5 x 5 m spatial resolution
3. Wave Mode
   - routine collection for the ocean
   - 20 km swath, 5 x 5 m spatial resolution
4. Interferometric Wide Swath
   - routine collection for land
   - 250 km swath, 5 x 20 m spatial resolution



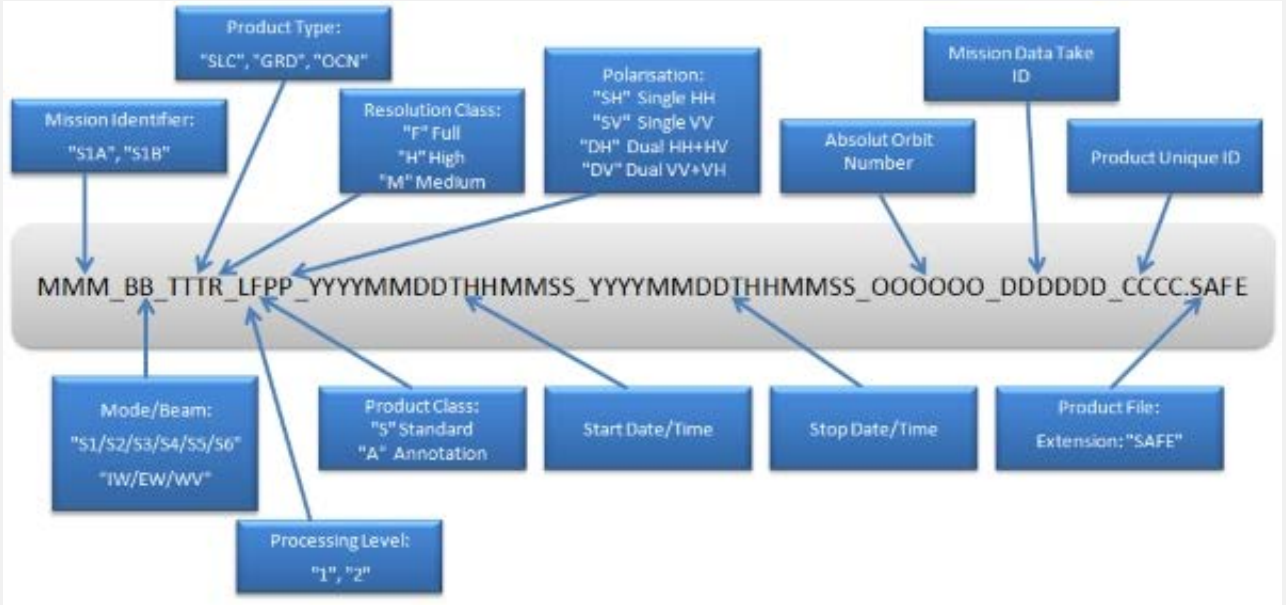
How to Access Sentinel-1 Images

- Alaska SAR Facility
  - http://www.asf.alaska.edu/sentinel/

- European Space Agency Portal
  - http://sentinel.esa.int/web/sentinel-data-access/access-to-sentinel-data/

File Naming Format

- There are three types of product types: SLC, GND, and OCN
  - SLC: Single Look Complex
  - GND: Ground Range Detected (You should select this one)
    - Full Resolution (FR), High Resolution (HR), Medium Resolution (MR)
    - Resolution is dependent on the amount of multi-looking performed
  - OCN: Level-2 Ocean



Sentinel-1 Toolbox

- Free and open source software developed by ESA for processing and analyzing radar images from Sentinel-1 and other satellites
- Can be accessed through: http://step.esa.int/main/download
- Includes the following tools:
  - Calibration
  - Speckle Noise
  - Terrain Correction
  - Mosaic Production
  - Polarimetry
  - Interferometry
  - Classification

Accessing, Opening, and Displaying SAR Data

Accessing Sentinel-1 Data

1. Go to the Alaska Satellite Facility Sentinel Data Portal: http://vertex.daac.asf.alaska.edu/
2. Identify your area (-60.31,-4.52,-57.81,-4.52,-57.81,-2.92,-60.31,-2.92,-60.31,-4.52) and dates (Apr 25-29, 2015) of interest
3. Identify images of interest (Sentinel-1 A/B)
4. Click **Search**
5. Select Granule: S1A_IW_GRDH_1SDV_20150428T093856_20150428T093921_005682_0074A 1_D968
6. Download the L1 Detected High-Res Dual-Pol (GRD-HD) Product

Accessing Sentinel-1 Data

Granule Information

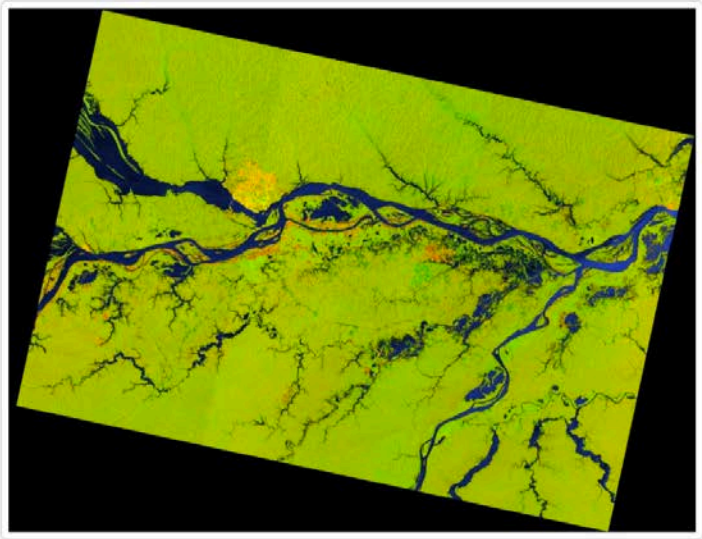
Data courtesy of ESA

Dataset: Sentinel-1A
Granule: S1A_IW_GRDH_1SDV_20150428T093856_20150428T093921_005682_0074A1_D968

Granule Details

- Acquisition Date: 2015-04-28
- Beam mode: IW
- Path: 10
- Frame: 603
- Ascending/Descending: Descending
- Polarization: VV+VH
- Absolute Orbit: 5682
- Frequency: C-Band

Products	Download
L1 Detected High-Res Dual-Pol (GRD-HD) (1.01 GB)	+ Queue, Download
L1 Single Look Complex (SLC) (4.51 GB)	+ Queue, Download
L0 Raw Data (RAW) (1.54 GB)	+ Queue, Download
XML Metadata (RAW) (40.62 KB)	+ Queue, Download



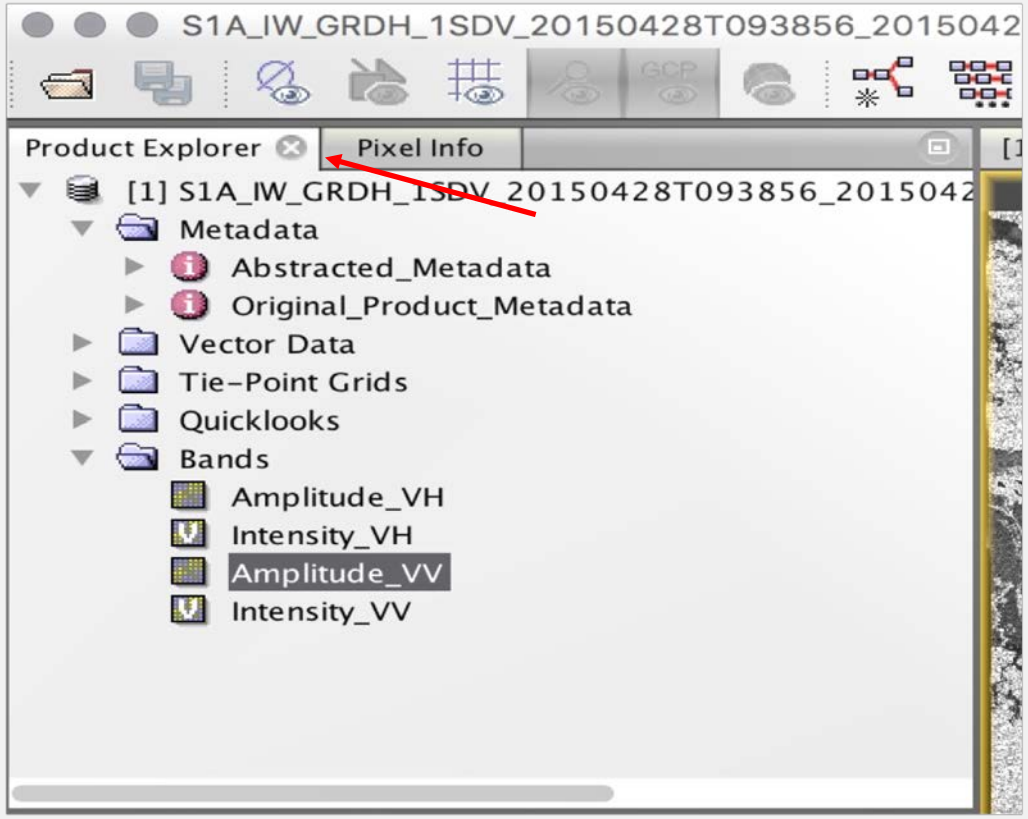
Full Resolution Browse Image

Opening the Data with the Sentinel Toolbox

1. Initiate the Sentinel Toolbox by clicking on its desktop icon
2. In the Sentinel Toolbox interface, go to the **File** menu and select **Open Product**
3. Select the folder containing your Sentinel-1 file, and double click on the **.zip** file (do not unzip the file; the program will do it for you)

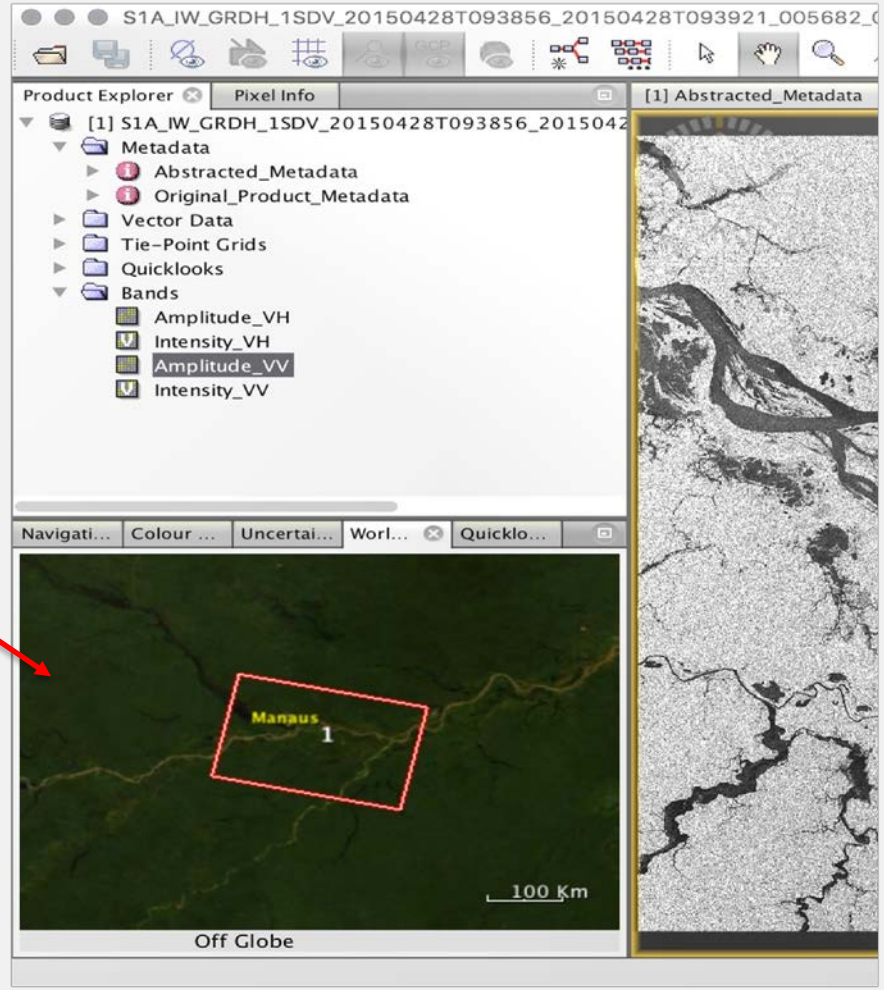
Opening the Data with the Sentinel Toolbox

1. The Product Explorer window of the Sentinel Toolbox contains your file. Double click on the file to view the directories within the file, which contain information relevant to the image, including:
   - Metadata: parameters related to orbit and data
   - Tie Point Grids: interpolation of latitude/longitude, incidence angle, etc.
   - Bands: Intensity and amplitude (intensity is the amplitude squared)



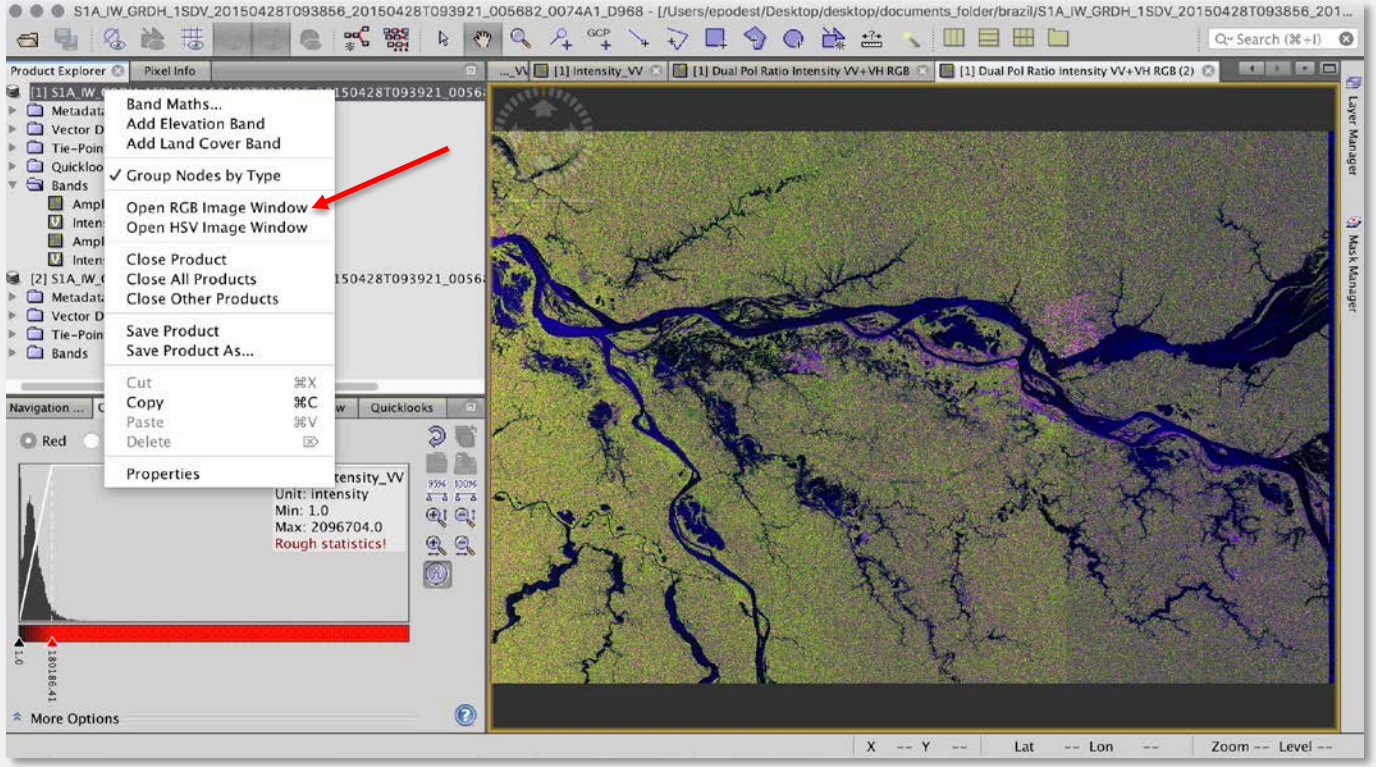
Opening the Data with the Sentinel Toolbox

4. Worldview image (lower left) shows the footprint of the image selected.
   - **Note**: it is inverted because it is oriented the same way it was acquired



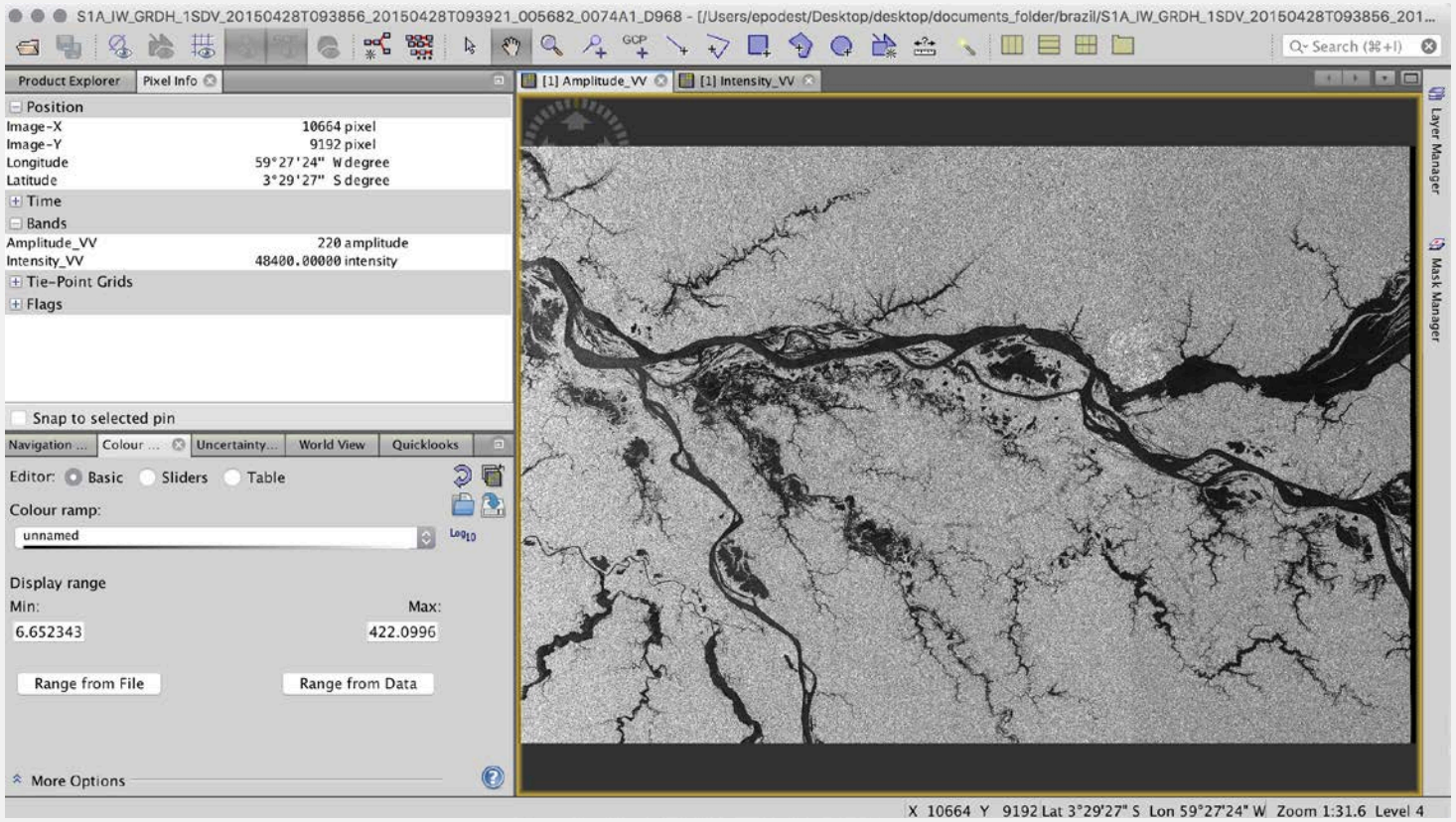
Opening the Data with the Sentinel Toolbox: RGB Image

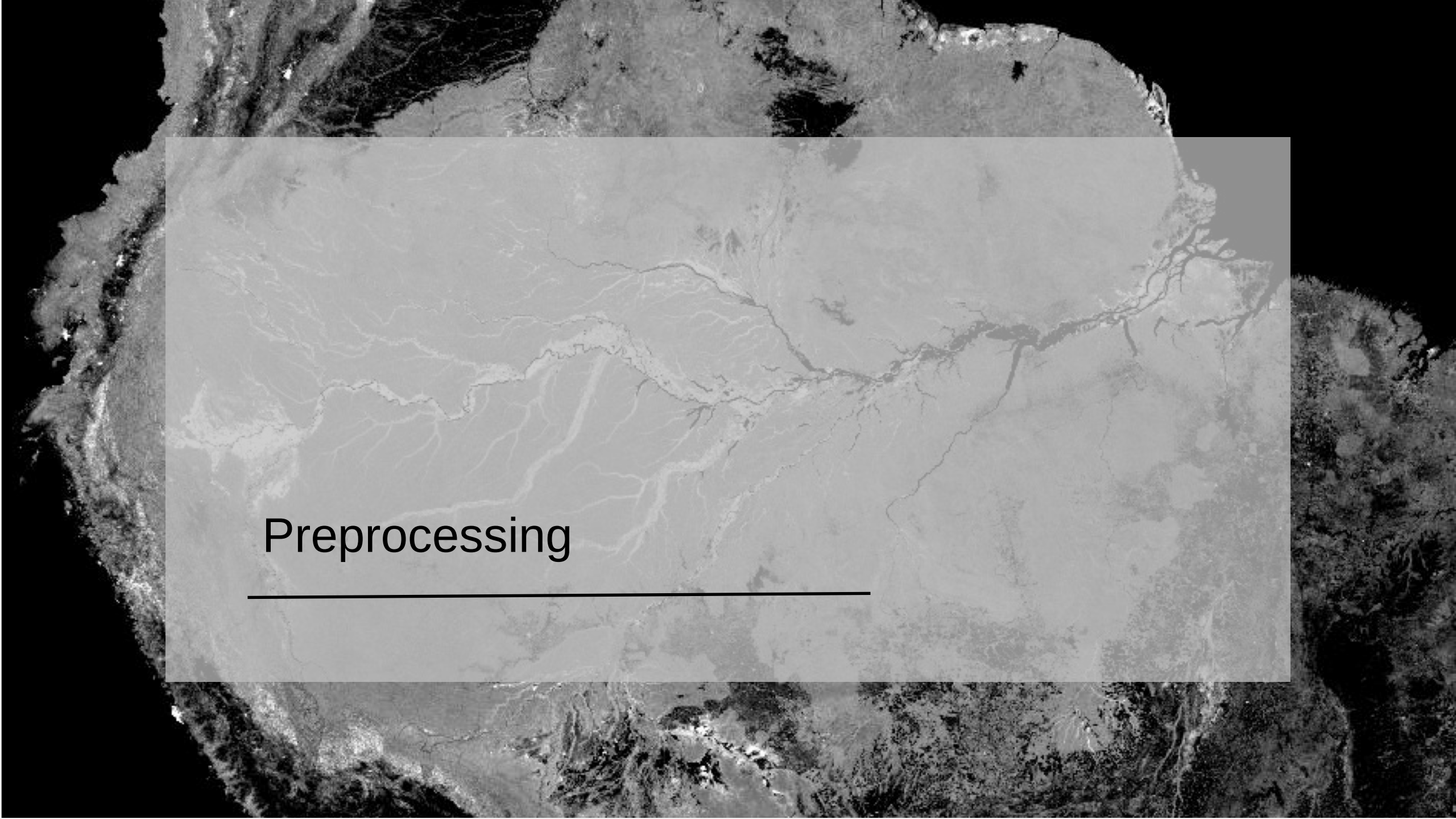
6. Go back to the **Product Explorer** tab
7. Select the filename of the Sentinel-1 dataset
8. Select **Open RGB Image Window** to display a color image of VV, VH, and VV/VH ratio



Opening the Data with the Sentinel Toolbox: RGB Image

9. In the upper, left window, select **Pixel Info** to see the value and the latitude and longitude of each pixel in the opened image

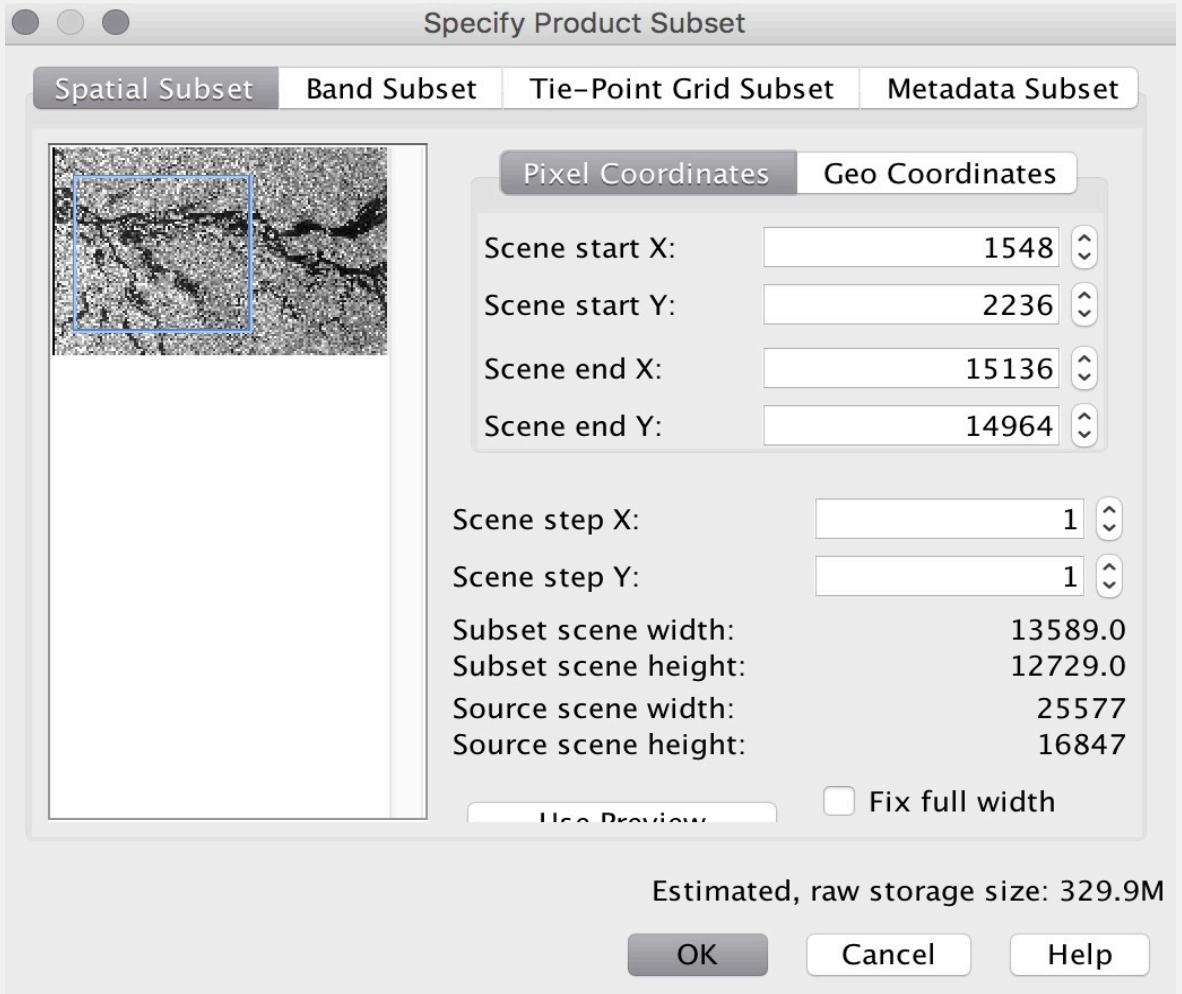




Preprocessing

Data Preparation: Defining a Subset

1. From the top, main menu bar, select **Raster** and then **Subset** according to the parameters on the right
   - From this point on, work only with the subset image
   - The created subset is added as a new product on your file window

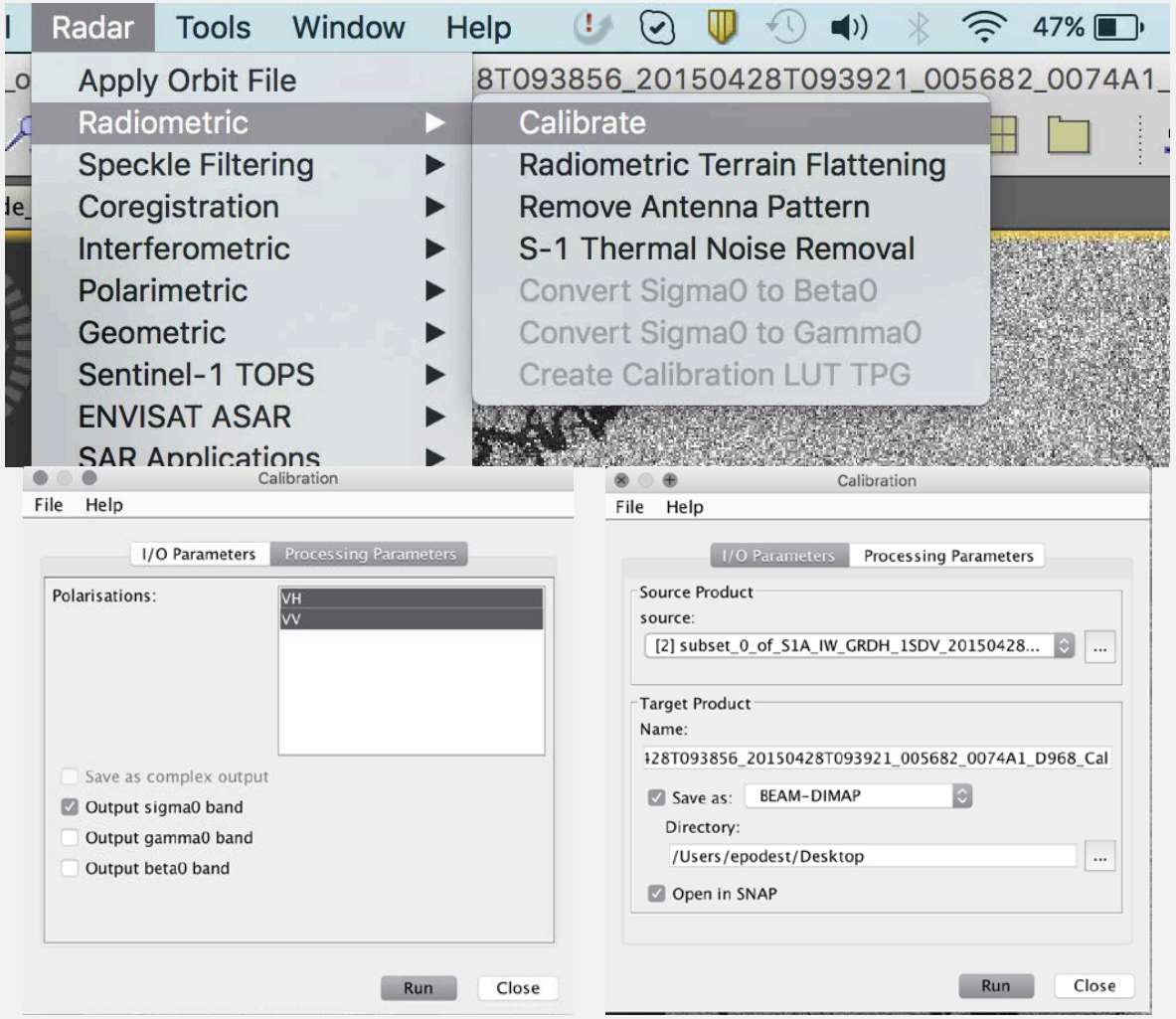


Preprocessing: Geometric and Radiometric Calibration

- The objective in performing calibration is to create an image where the value of each pixel is directly related to the backscatter of the surface
- This process is essential for analyzing the images in a quantitative way
- It is also important for comparing images from different sensors, modalities, processors, or images acquired at different times

Preprocessing: Radiometric Calibration

1. The subset output from the previous step appears in the Product Explorer window. Highlight that output by clicking on the file name
2. From the top menu, select **Radar** > **Radiometric** > **Calibrate** and use the default parameters
   - this will create a new product with calibrated values of the backscatter coefficient



Preprocessing: Radiometric Calibration

- The main radiometric distortions are due to:
  - Signal loss as it propagates
  - Non-uniform antenna pattern
  - Difference in gain
  - Saturation
  - Speckle

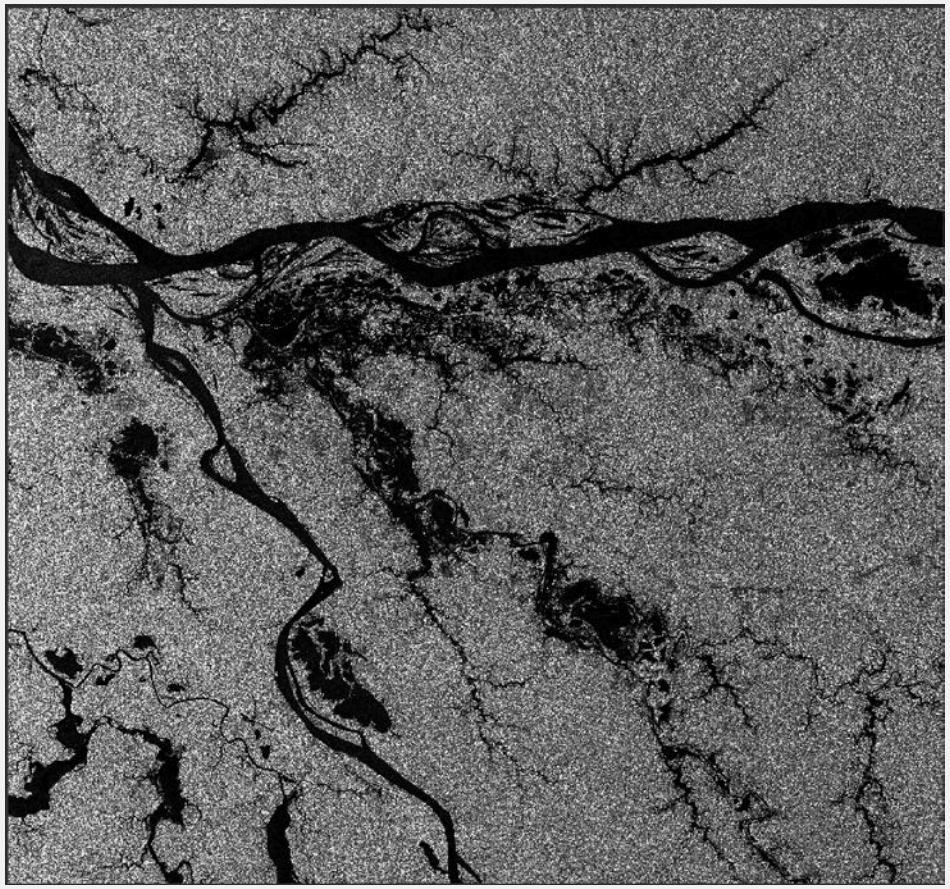
Preprocessing: Speckle Reduction

- Speckle is part of radar images and makes interpretation difficult because the “salt and pepper” effect corrupts information about the surface
  - There are many techniques to extract radar information from images that have a lot of speckle
  - You can use speckle filters, or multilook the image. We will use multilook

3. The output from the previous step appears in the Product explorer window (filename ending in _**Cal**). Highlight that output by clicking on the file name
4. Select **Radar** > **Multilook**, then choose the **Processing Parameters** window. Specify **6** for both number of range and azimuth looks

Preprocessing: Speckle Reduction

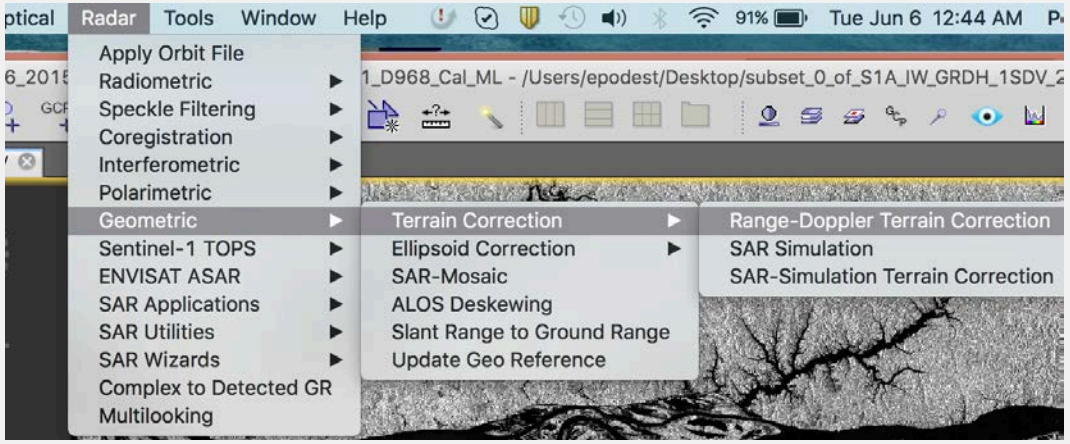
Calibrated VV



Calibrated-Multilooked VV

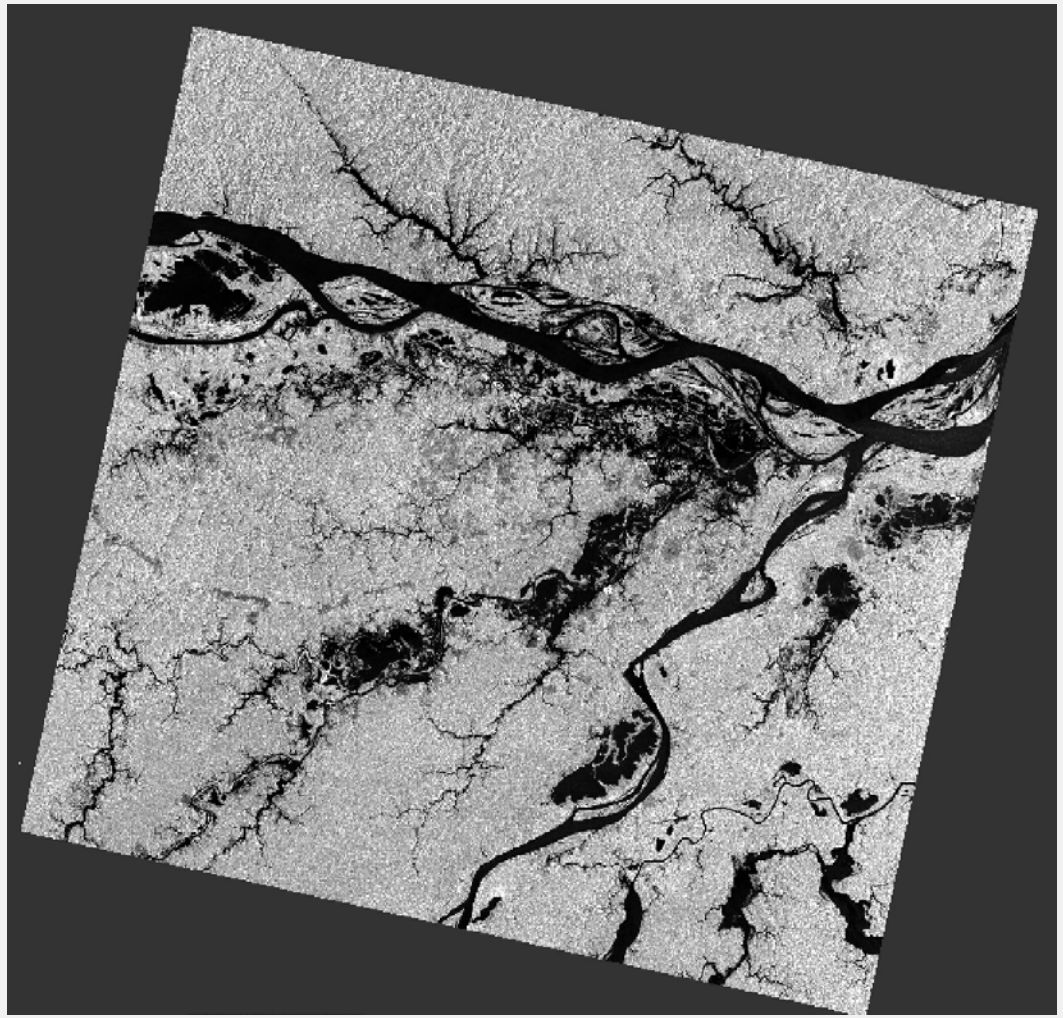
Preprocessing: Geometric Calibration

1. The output from the previous step appears in the Product explorer window (filename ending in **_Cal_ML**). Highlight that output by clicking on the file name
2. Select **Radar** > **Geometric** > **Terrain Correction** > **Range-Doppler Terrain Correction**
3. In the Processing Parameters tab, use the default options for the output files, and select **UTM/WGS 84** for the map projection
   - This will take ~30 min



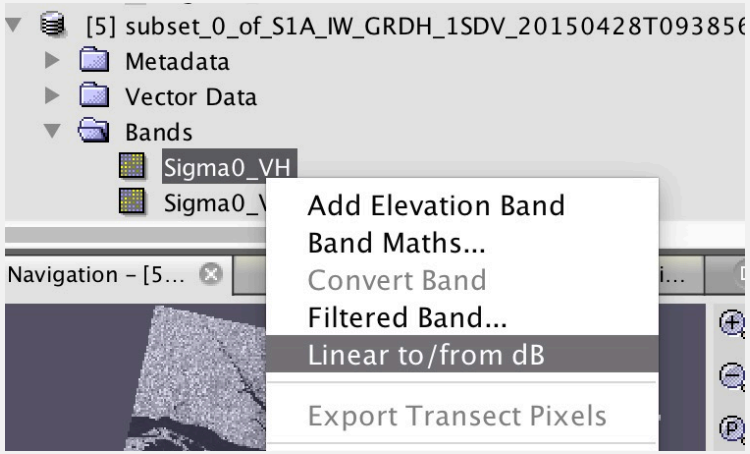
Preprocessing: Geometric Calibration Result

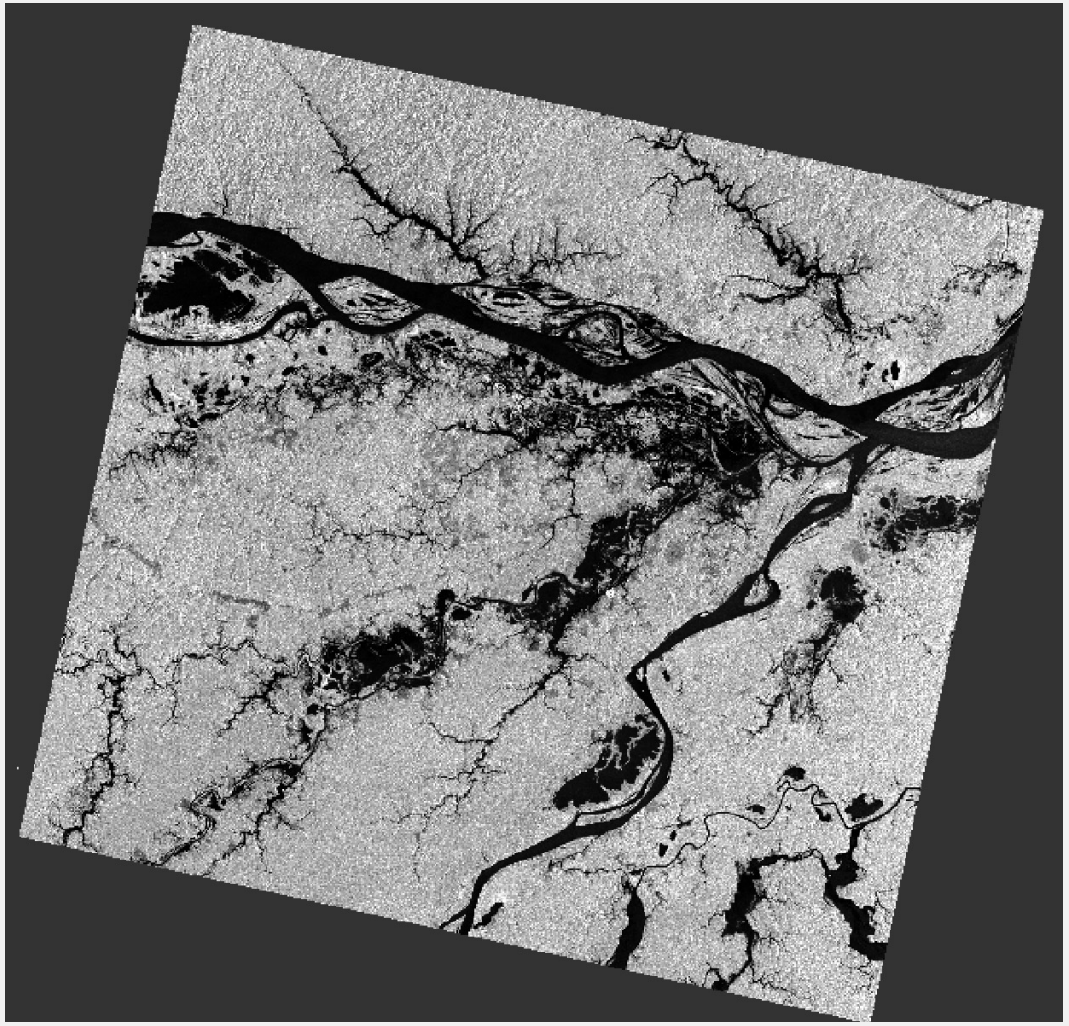
- The main geometric distortions are due to:
  - Slant Range
  - Layover
  - Shadow
  - Foreshortening
- The algorithm uses a DEM to make the corrections
- The corrected image is in its correct orientation

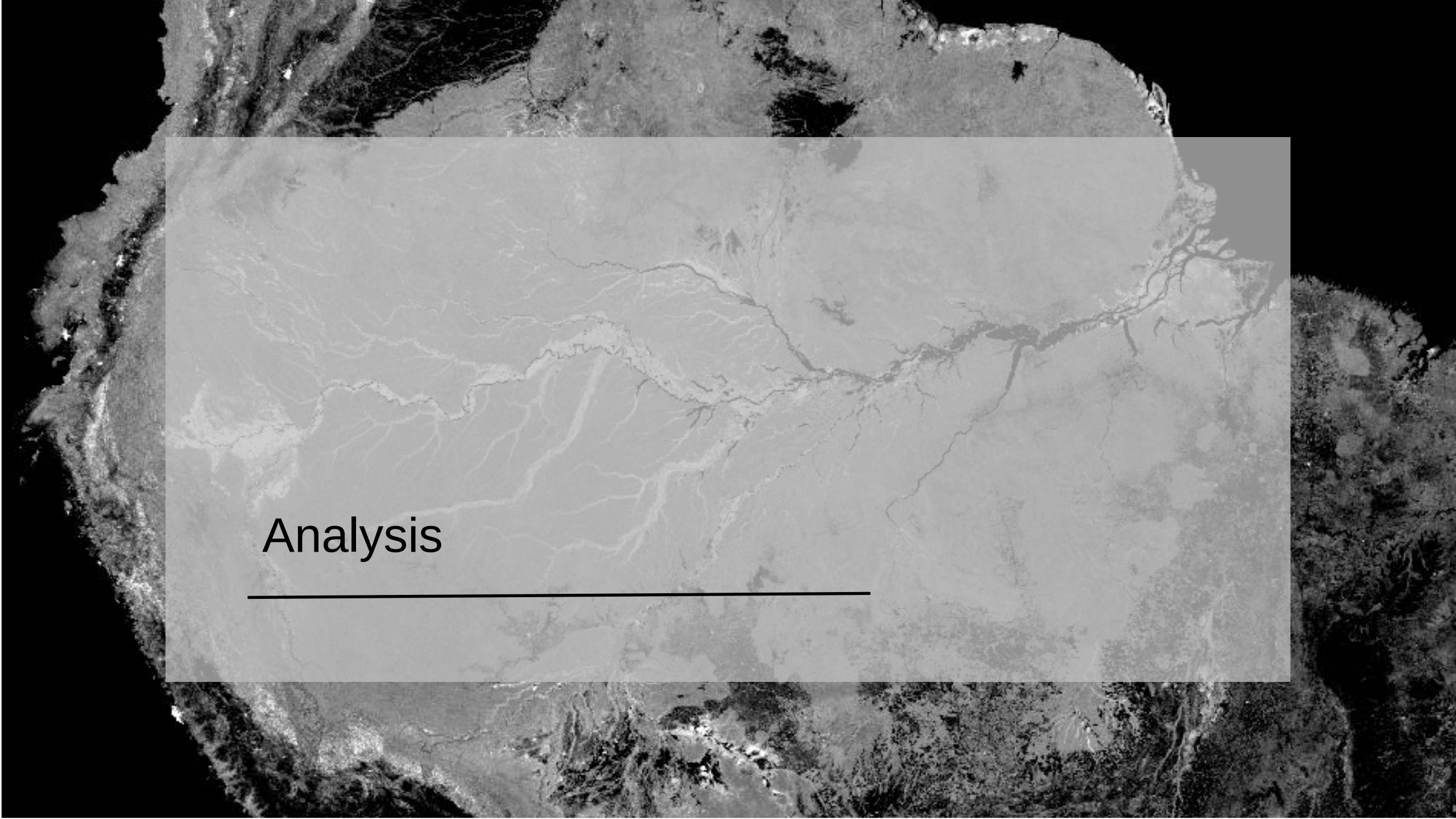


Preprocessing: Geometric Calibration Result

4. Convert Sigma^0 into dB by highlighting **Sigma0_VH** and left clicking
5. A menu will pop up. Select **Linear to/from dB**. Do the same for VV
6. Display the dB images



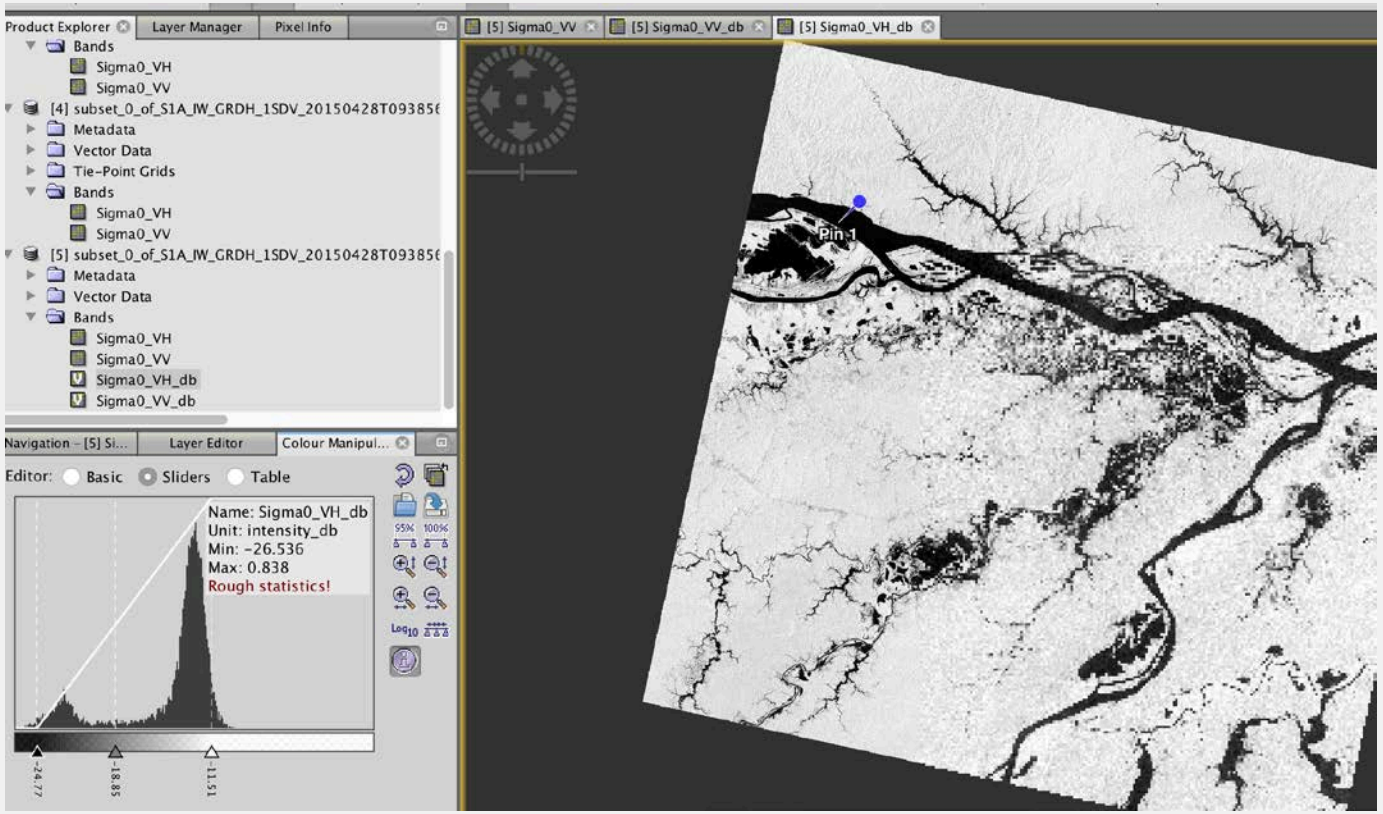




Analysis

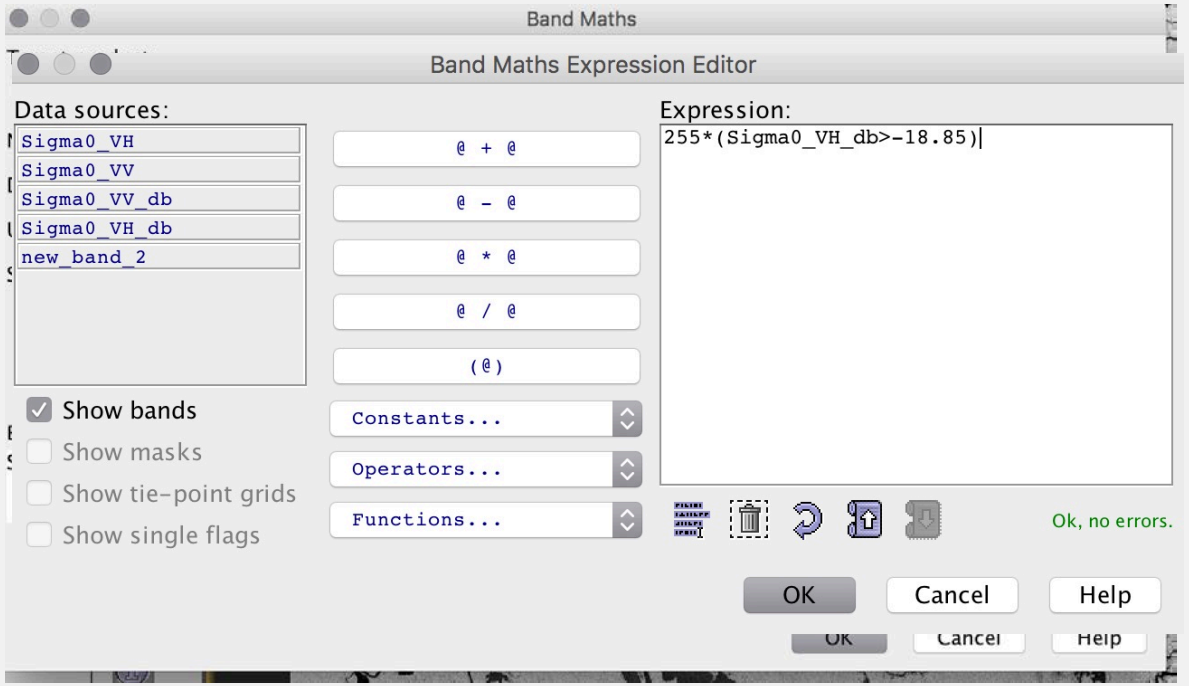
Histogram Analysis

1. Analyze the image histogram in the lower, left window
2. Identify the two peaks: the lower one represents water and the higher one represents everything else
3. Select the value that separates water from everything else.
   - In this case it is -18.85 dB

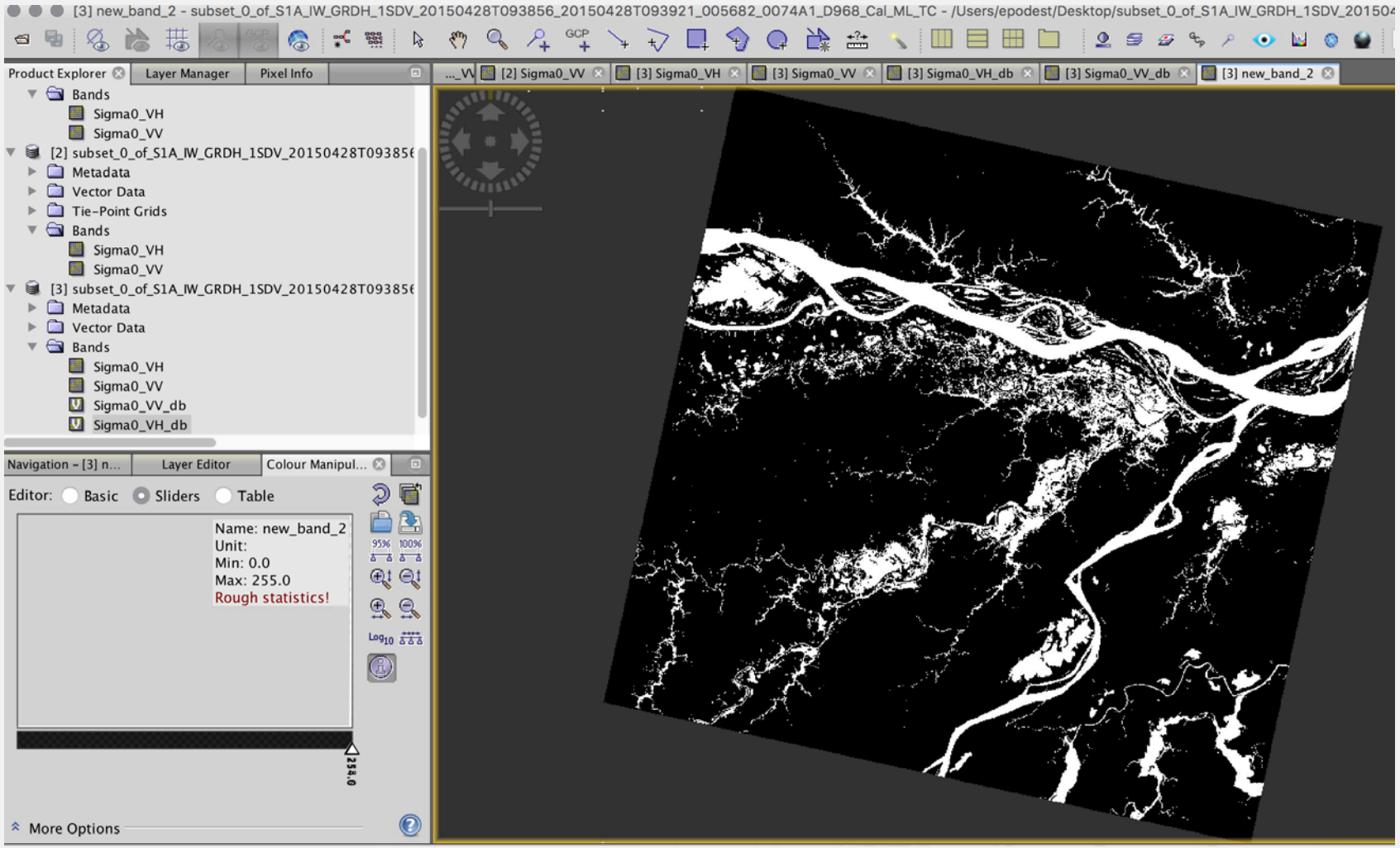


Creating a Threshold to Separate Water and Land

4. Select **Raster** > **Band** > **Math**
5. Edit the expression so that it reads:
   – 255*(Sigma0_VHdB<-18.85)
6. The result will be an image where water will have a value of 255. Call this new image **water**.

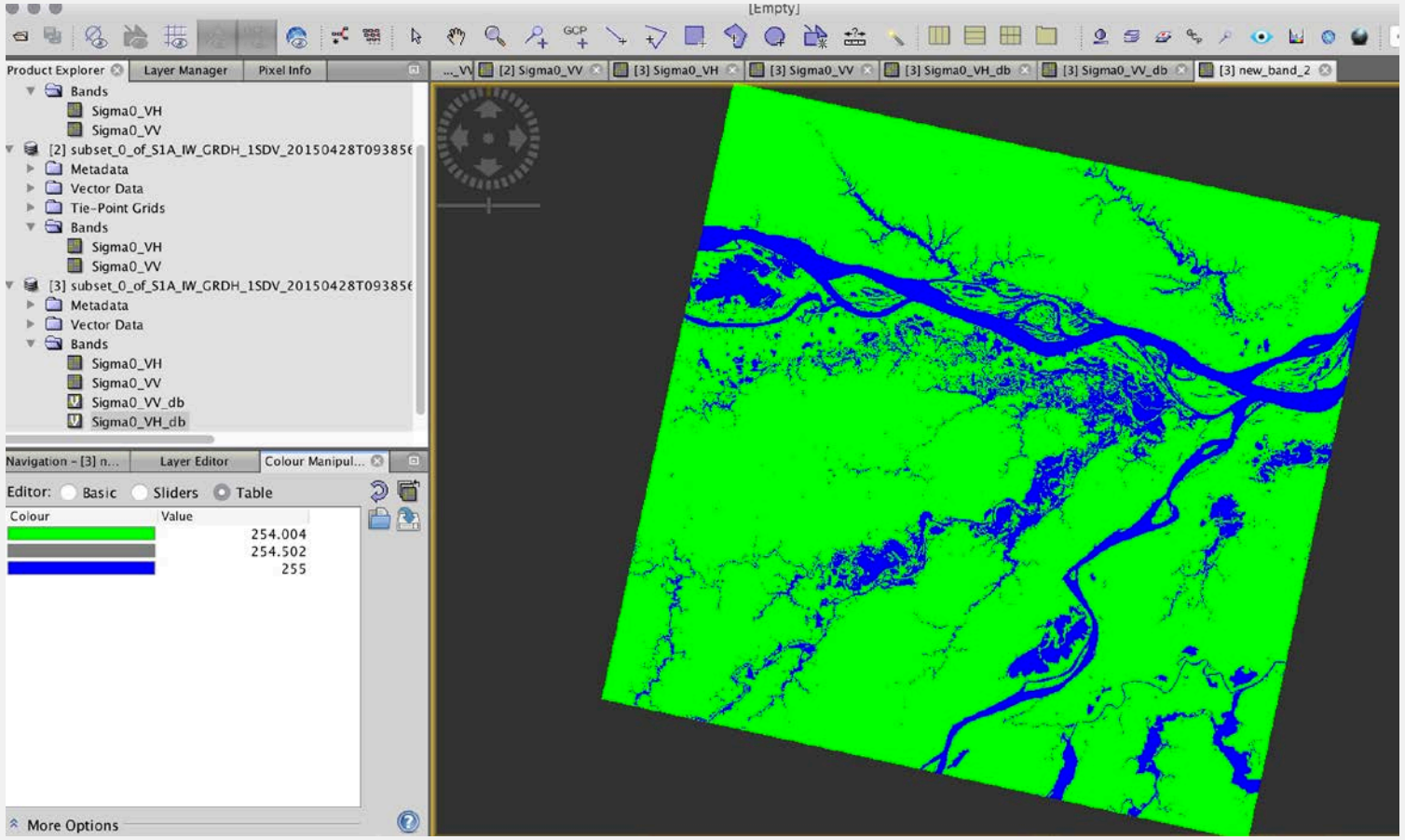


Creating a Threshold to Separate Water and Land



Example: Processing – Classifying Water and Land

1. To change the colors, go to the color manipulation window on the bottom left and select **Table**
2. Assign a color to each of the three classes



Summary

It takes different stages in a particular order to generate a product:

- Data Preparation
  - Acquire the images
  - Identify a subsection of the image or create a mosaic, if needed
- Preprocessing the Image
  - Radiometric calibration
  - Filter application to reduce speckle
  - Geometric Calibration
- Processing the Image
  - Generate a map through threshold, supervised, or non-supervised approaches