



SENTINEL-1

Flood mapping tutorial

Issued February 2019

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Introduction

Using SNAP 6.0, this tutorial will walk through the calibration steps needed to prepare Sentinel-1 data for flood mapping analysis, and then apply reclassification techniques to assess the changes in flooding in our selected study area. This tutorial is not tested with earlier versions of SNAP, so be sure to update your SNAP version to 6.0 or higher if you are running an older version.

In the spring of 2018, the Saint John's River in Fredericton, New Brunswick saw record levels of flooding, with water reaching 8.31 meters higher than normal levels, with the flooding beginning at the end of April, and flood waters receding by the second week of May.

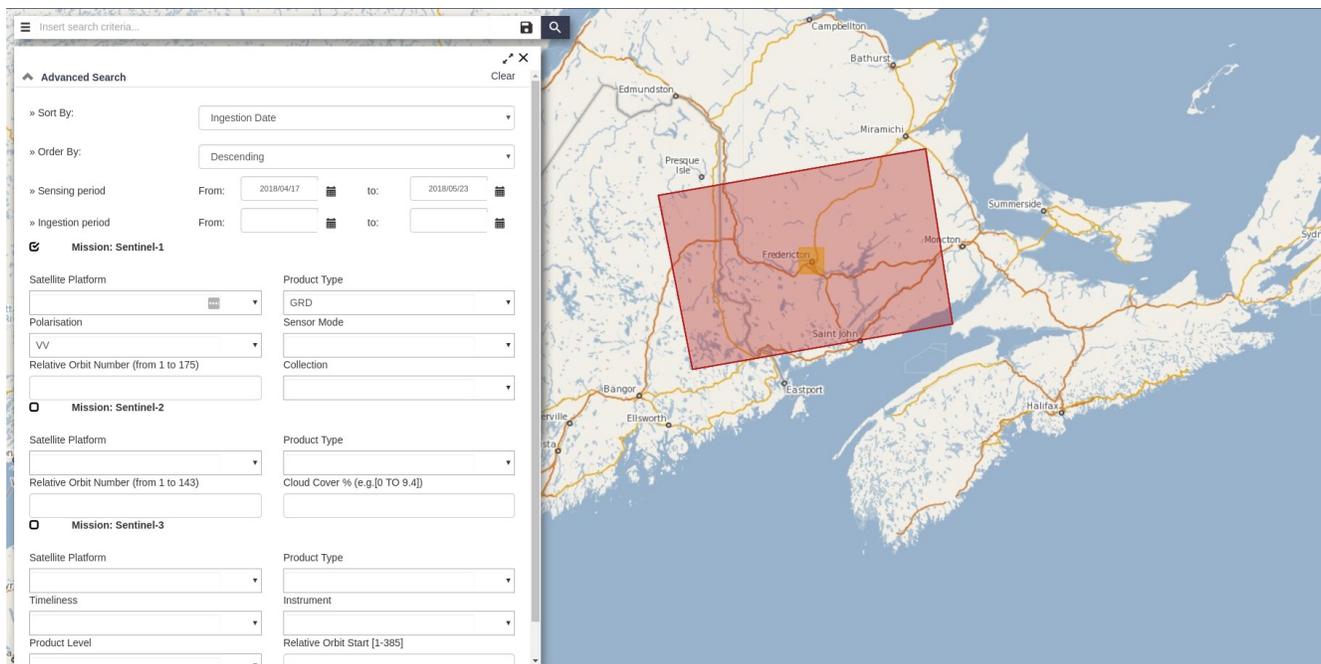
Using Sentinel-1 SAR data, we can analyze and map the affected flooded areas and compare them to official flood maps. With SAR data, we can map the flooding even during inclement weather.

Data download

For this tutorial, we will be downloading three GRD-type Sentinel-1 products from <https://scihub.copernicus.eu/> that intersect with Fredericton, NB, with VV polarization data available. The capture dates that we are interested in are:

Product name	Date	Flooding timeline
S1A_IW_GRDH_1SDV_20180429T221923_20180429T221948_021688_025687_F8C7	2018-04-29	Flooding is at its peak
S1A_IW_GRDH_1SDV_20180511T221923_20180511T221948_021863_025C1E_4D4C	2018-05-11	Flooding is beginning to recede
S1A_IW_GRDH_1SDV_20180523T221924_20180523T221949_022038_0261AC_ADCD	2018-05-23	Flood water has receded

With these three data products, we will be able to map change in flooded areas of Fredericton.



Preprocessing

Once we have our data downloaded, its time to import the products into SNAP and do the necessary pre-processing to the data to do flood mapping analysis. Since we are going to have to run these preprocessing steps on three products, we will generate a graph to allow us to run the same workflow four times.

Orbit file application

The first step to any SAR preprocessing is to apply a precise orbit file to improve the geocoding of the product. This tool (**Apply-Orbit-File**) is available under **Radar**.

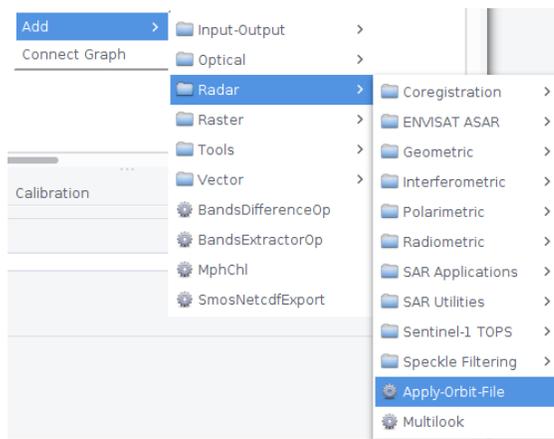


Image subset

Now that our image is accurately geocoded with the new orbit file, we should subset our product to only the boundary of Fredericton, which can be downloaded here:

https://s3-us-west-2.amazonaws.com/skywatch-public/snap/shared/sentinel_flood_mapping_tutorial/Fredericton_Boundary.zip . This data is provided courtesy of Statistics Canada.

Open one of the products in SNAP and import the Fredericton vector file so we can get an extent, and then view one of the bands. Zoom into the boundary and right click in the band view window to open the Spatial Subset from View tool.

A screenshot of the 'Spatial Subset' dialog box in SNAP. The 'Geo Coordinates' tab is selected. The dialog contains the following fields and values:

- North latitude bound: 46.078
- West longitude bound: -66.792
- South latitude bound: 45.829
- East longitude bound: -66.541
- Scene step X: 1
- Scene step Y: 1
- Subset scene width: 2803.0
- Subset scene height: 2778.0
- Source scene width: 2803
- Source scene height: 2778

At the bottom, there is a 'Use Preview' button and two checkboxes: 'Fix full width' (unchecked) and 'Fix full height' (unchecked).

Copy these latitude/longitude bound values, and then add to the graph **Subset (Raster > Geometric > Subset)**. Input these into the tool in the graph.

Next, add the **Import-vector** tool under **Vector** and set the path to be the path to the file ending in **.shp** provided in this tutorial. Next, use the **Land-Sea-Mask** tool under **Raster > Masks** and specify the Fredericton vector data added by the Import Vector tool. This will subset the data further to only the boundary of Fredericton.

Radiometric image calibration

With our image now subsetting, we must apply image calibration. This step is necessary to normalize the values in the image into backscatter values so we can compare multiple images in a time series. This is available through **Radar > Radiometric** as the tool **Calibration**. Select the **VV** band as input.

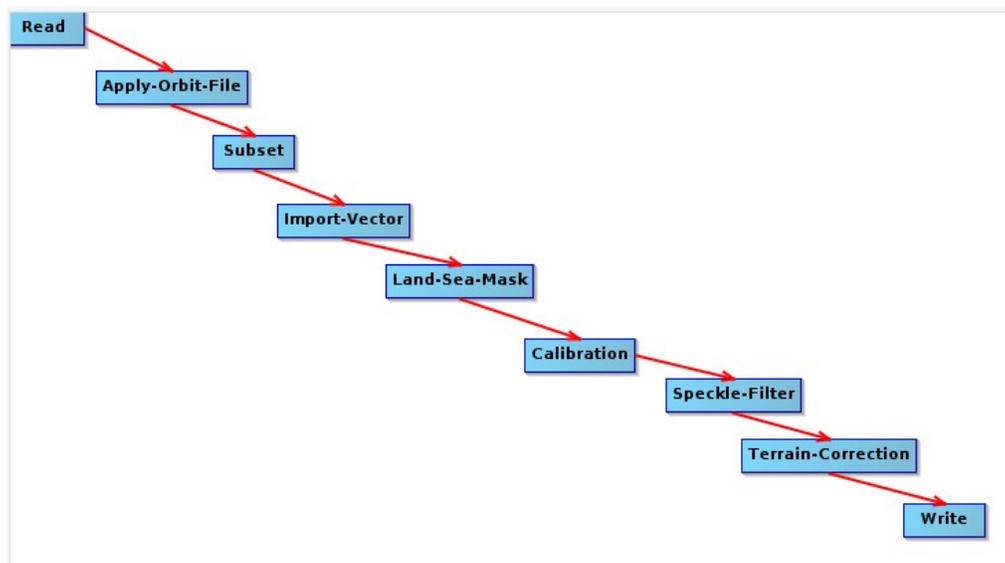
Despeckle

Despeckling removes thermal noise introduced by the sensor from the image to remove potential sources of error in analysis. This tool is available through **Radar > Speckle Filtering** as **Speckle-Filter**. Use the **Lee** filter and keep the filter size the same as the default of 3x3.

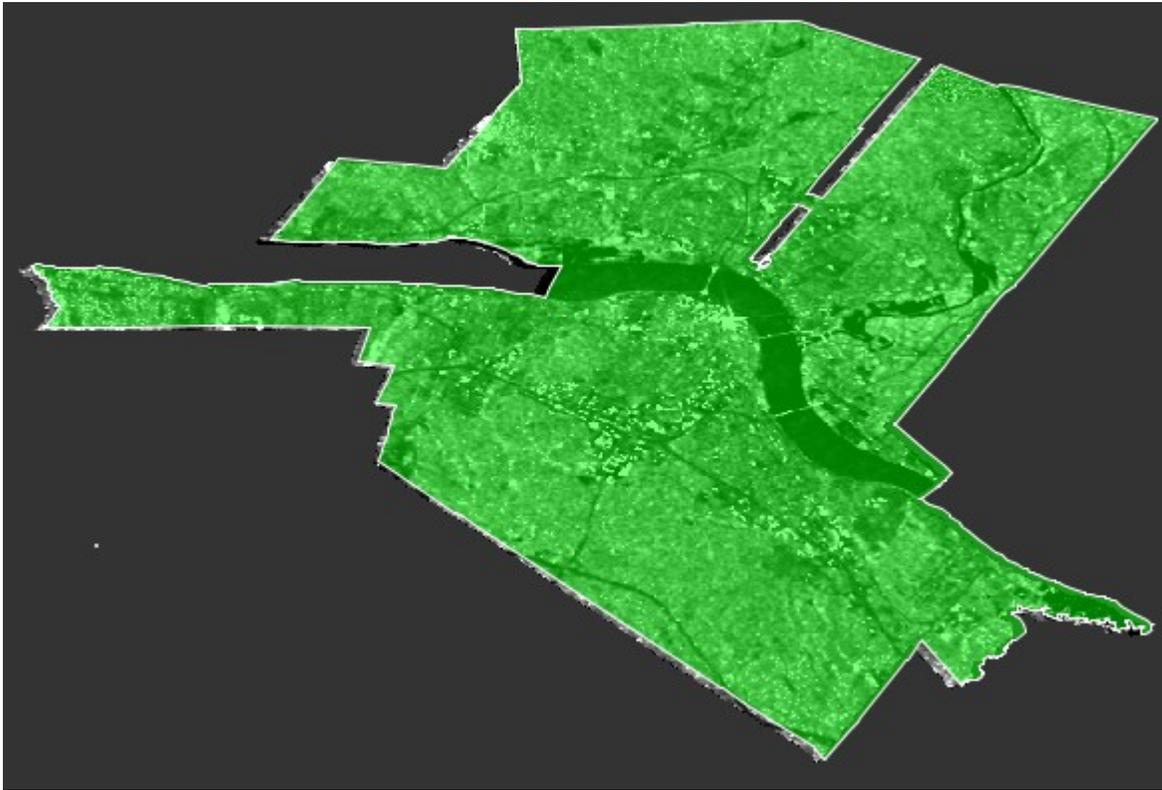
Terrain correction

The last step in our graph for image pre-processing is to apply terrain correction to the product, ensuring that all the pixels are moved to the right locations (eg if the nadir angle of the image is off, it will align the pixels correctly so it is closer to a top-down view of the imagery). This is available through **Radar > Geometric > Terrain Correction**.

Your graph should look similar to this.



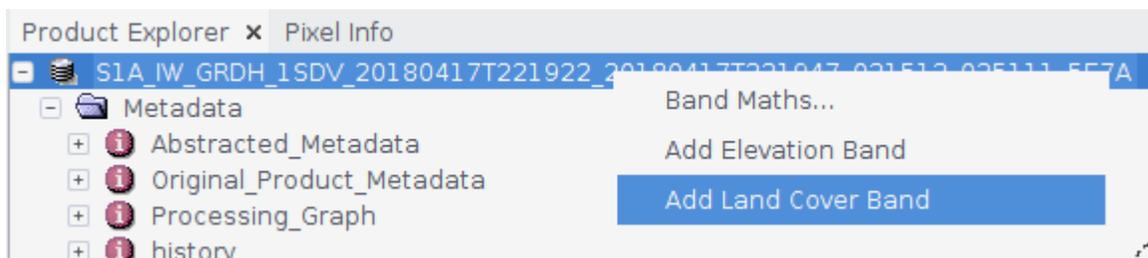
Once run, your output product should have one band, named **Sigma0_VV** which will look like the screenshot below when opened in SNAP. Depending on your hardware, this graph may take a while to run. You can save the graph and then use the Batch processing tool under Tools to run the graph on the remaining raw products.



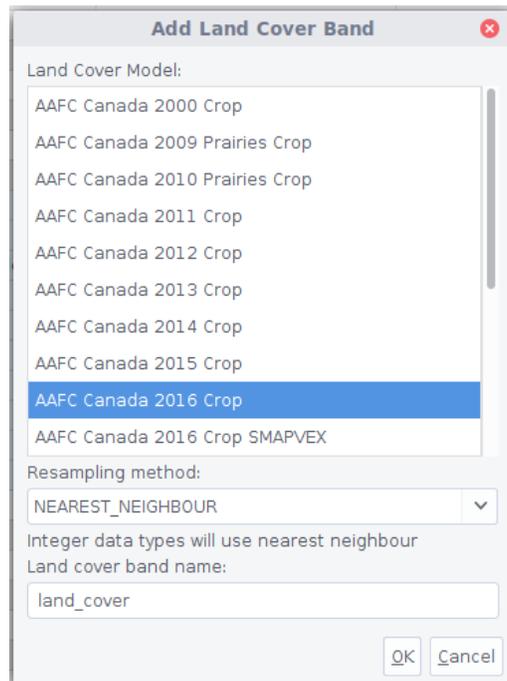
Flood assessment

With our data subset to only contain Fredericton NB, and our products containing calibrated backscatter values, it is time to do some flood calculations on the data to automatically determine how much of Fredericton is affected by the flooding over the time series of images.

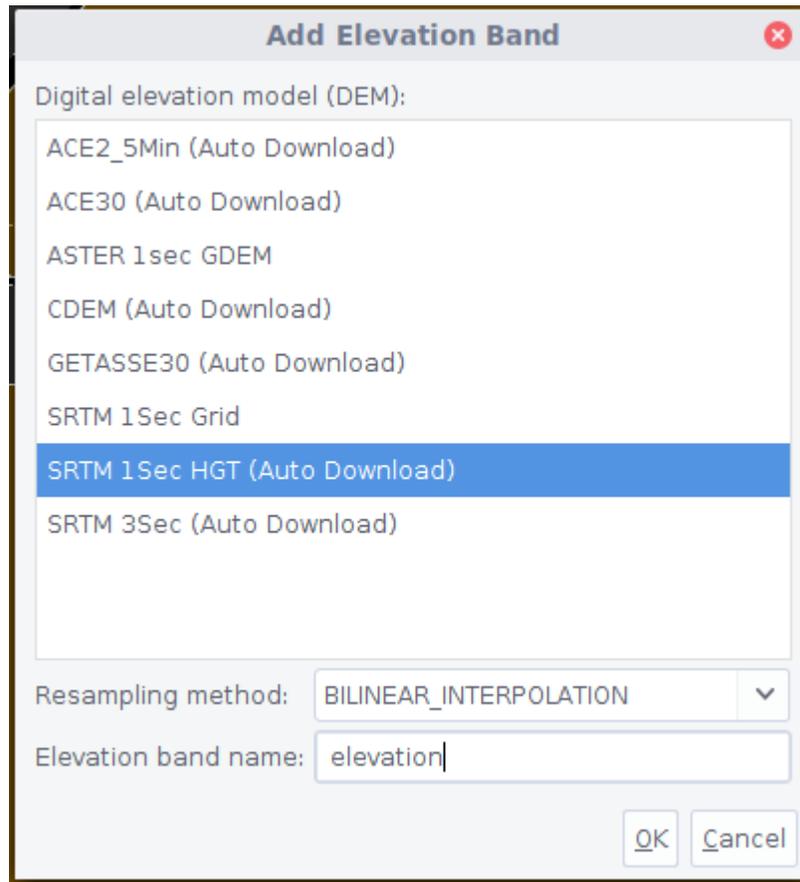
Areas with low backscatter indicate wet areas. Since our calibrated images contain calibrated backscatter coefficients, we can create a binary image from the products, highlighting areas below a cutoff threshold. Since the Saint John river runs through Fredericton, it is important that we do not count known water sources in our flood mapping. To do so, we can add the AAFC land cover band to our product in SNAP by right clicking on the product in Product Explorer and selecting “Add Elevation Band”.



Select “AAFC Canada 2016 Crop” from the list and name the band “land_cover”.



We also want to add an elevation band, to avoid misclassifying areas of high elevation as flooded. Add an elevation band by right clicking on the product and selecting “Add Elevation Band” and select “SRTM 1Sec HGT (Auto Download)”.

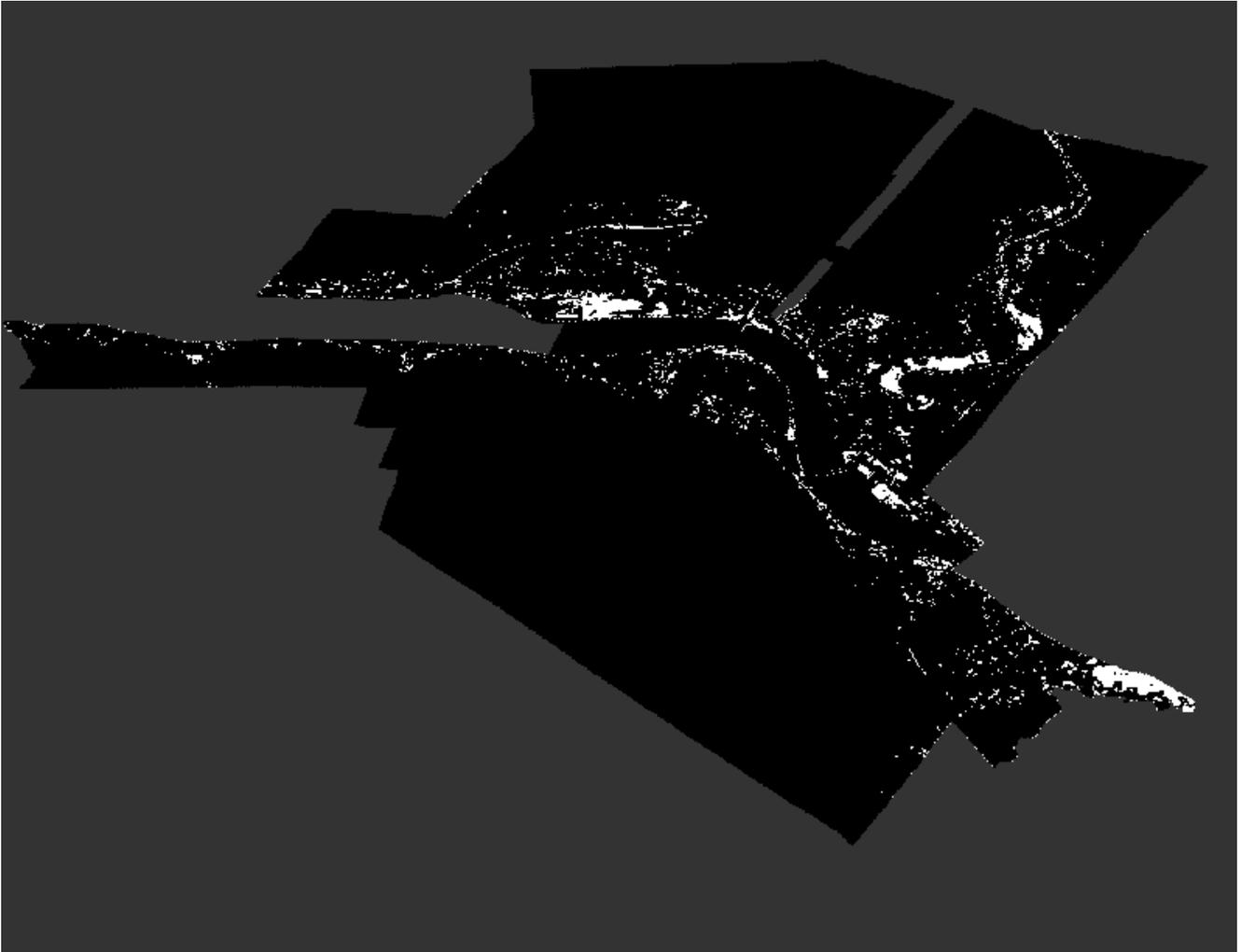


With all of our necessary bands added, it is now time to create our new flooding band. Right click on the product and select “Band Maths”. Enter into the expression text box

$\text{Sigma0_VV} < 0.05 \ \&\& \ \text{land_cover} \neq 20 \ \&\& \ \text{elevation} < 10$

This will create a binary mask where the backscatter is below our cutoff threshold of 0.05 and does not fall under land cover classified as water (Class 20), and elevation is below 10m above sea level.

Your output flooding band should look like this (For April 29th, peak of flooding):



Repeat the process on the remaining two Sentinel products. To export this product out to view in other GIS software and map the flooding change over time, you must convert the flood band to a non-virtual band first before exporting to GeoTIFF. Do so by right clicking on the band and selecting **Convert Band**. Optionally, you can remove the other bands before export to save on file size and export time.



As we can see, the flood waters recede over time, with areas close to the river banks saturated and still having low backscatter, thus resulting in it still showing as flooded. This map was made using QGIS, with Google Maps satellite view as a basemap. For more information on generating maps in QGIS like this, please refer to the following tutorials to start:

<https://opengislab.com/blog/2018/4/15/add-basemaps-in-qgis-30>

https://www.qgistutorials.com/en/docs/raster_styling_and_analysis.html

<https://www.polarmicrobes.org/tutorial-on-qgis-how-to-make-a-map/>