

FLOOD MAPPING

Data: Sentinel-1 IW GRDH 1SDV:

- S1A_IW_GRDH_1SDV_20160905T091347_20160905T091412_012915_0146AC_88E4 (not crisis image)
- S1B_IW_GRDH_1SDV_20170614T091259_20170614T091324_006044_00A9CE_80EB (crisis image)

1. Open the 2 S1 images in SNAP
 - 1.1. File / Open Product... (use control key to select multiple files)
2. Inspect the images
 - 2.1. Select plus icons [MAC = triangle icon] by filenames in "Product Explorer", expand "Bands" folder and double click on "Amplitude".
 - 2.2. Synchronise the displays (in the Navigation tab at the bottom left, one of the icons on the right side)
 - 2.3. On which images can you see floods?
 - 2.4. When were the images acquired (see metadata)?
 - 2.5. Where are the floods (View / Tool Windows / World Map)?
3. ~~Crop the images to include only general area of floods~~
 - 3.1. ~~Raster / Subset...~~
 - 3.2. ~~Crop first the image with floods~~
 - 3.3. ~~Open the cropped flood image, then open the archive (non-flood) image and crop the archive to the same extent as the viewer (the synchronised displays will show the same extent)~~
~~Note: the "Step3_subsets" you are provided with were created using the Geo coordinates below:~~
 - ~~- North Latitude bound: -30.1~~
 - ~~- West Longitude bound: -57.23~~
 - ~~- South Latitude bound: -30.68~~
 - ~~- East Longitude bound: -58.16~~
 - 3.4. ~~In the Band Subset tab, for simplicity select only the data for one polarization (VV or VH). In this example, we choose to continue with VV. Uncheck VH.~~
4. Multi Look the images by a factor of 3x3
 - 4.1. Radar / Multilooking. In "Processing Parameters" change "Number of Range Looks" and "Number of Azimuth Looks" both to 3. Select both Amplitude and Intensity. Adapt output folder and name. Select "Run"
5. Calibrate images
 - 5.1. Radar / Radiometric / Calibrate
If needed, specify again the polarisation choice you made in Step 3.
6. Speckle filtering
 - 6.1. If not done in Step 3, specify the polarisation choice.
 - 6.2. Gamma map 5x5 (test other filters if you want)
 - 6.3. Adapt output name and folder
 - 6.4. Compare the output with the previous result
7. Terrain correct the images
 - 7.1. Radar / Geometric / Terrain Correction / Range-Doppler Terrain Correction
 - 7.2. You can select SRTM 1sec HGT (Auto Download)
 - 7.3. If you want to see the DEM, in the "Processing Parameters" tab, select "DEM" in the "Output bands for" check boxes.



8. Convert bands to decibel
 - 8.1. In the "Product Explorer" window, right click on the band name, and select "Linear to/from dB"
 - 8.2. Now right click on the new dB band and select "Convert Band"
 - 8.3. Save the image

9. Stack terrain corrected images
 - 9.1. Radar / Coregistration / Stack Tools / Create Stack
 - 9.2. In the first tab (1-ProductSet-Reader) use the plus icons to insert the terrain corrected images to the list.
 - 9.3. In the second tab (2-CreateStack) select "Product Geolocation" as the "Initial Offset Method".
 - 9.4. In the third tab (3-Write) select the output name and directory. Then select "Run".

10. Check the coregistration
 - 10.1. Double click to open one of the bands of the stack
 - 10.2. Select the Layer Manager: View / Tool Windows / Layer Manager
 - 10.3. Select the plus icon (Add Layer)
 - 10.4. Select "Image of Band / Tie-Point Grid"
 - 10.5. Select "Next" and select one of the other bands from the stack **Select one of the Sigma0_VV_db bands**
 - 10.6. Repeat the steps above for the ~~third~~ band **Select the other Sigma0_VV_db band**
 - 10.7. Back in the "Layer Manager" window, select and deselect the check boxes of the ~~three~~ bands (or use the transparency slider) to compare the flood image with the archive and the DEM **two**

11. View RGB composite
 - 11.1. With the Stacked image selected in the "Product Explorer" window, select: Window / Open RGB Image Window
 - 11.2. To display the flooded areas in red:
 - Red: Non crisis image in dB
 - Green: Crisis in dB
 - Blue: Crisis in dB
 - 11.3. To display the flooded areas in blue:
 - Red: Crisis image in dB
 - Green: Non crisis in dB
 - Blue: Non crisis in dB
 - 11.4. Stretch the histogram of the various channels in the "Colour Manipulation" tab by sliding the triangular sliders to either side of the histograms
 - 11.5. Can you interpret those results?

12. Save the image in Google Earth kmz format and view in Google Earth
 - 12.1. File / Export / Other / View as Google Earth KMZ
 - 12.2. Double click on the saved KMZ file to open it in Google Earth
 - 12.3. Use the transparency slider in Google Earth to compare the flood map with the optical imagery

Next we quantify the area flooded. This is an interactive process where we estimate the threshold that separates water from land.

13. Define a threshold that will be applied to the pixel values in the crisis image
 - 13.1. Select and display one of the images that are not in dB
 - 13.2. Go to Colour Manipulation tab (bottom left). Select log10 and use the grey triangle to estimate a threshold.
 - 13.3. Go to Raster > Band Maths. As name, add the prefix "water_" and the date of the crisis image. Uncheck the Virtual box. Select "Edit expression" and write the following, adapting the band you have used and the threshold you want to test.


```
if Sigma0_VV_slv1_08Nov2014 < thresholdvalue then 1 else NaN
```

 Have a look at the output and see if it is as you expected it.
 Below are some thresholds we tested, as examples. Which one do you think works best? We chose B.



Threshold	Value
A	7.93E-2
B	5.3E-2
C	3.06E-2

- 13.4. Adapt the colour in the Colour Manipulation tab > Table (to blue, for example)
- 13.5. Export it as KMZ (Note this will export the layer you are displaying!): File > Export > Other > View as Google Earth

14. Not all the pixels in the mask of step 13 are likely to belong to the flooded area. We use a mask to export only the area that interests us:

- 14.1. View > Tool Windows > Mask Manager > New Geometry icon. This creates a New Vector Data Container, that we can name " My Area of interest".
- 14.2. Check that it now appears un the Product Explorer window, in the Vector Data folder of your product.
- 14.3. If needed, activate the Tools toolbar via View > Toolbars > Tools.
- 14.4. Use the Select Polygon Tool to draw a polygon around the area that interests us. Once done, click on the arrow symbol to stop the Polygon Drawing Tool.
- 14.5. The Water_8Nov_thresB band needs now to be converted into a mask, so that the Mask Manager can use it as input: Go to Mask Manager > f(x) button, and simply enter the expression below. It will create a mask containing every pixel in the Water_8Nov_thresB band whose value is 1 (condition satisfied by all pixels in the band!):

Water_8Nov_thresB == 1

- 14.6. In the mask manager, feel free to rename it, as "Water_8Nov_thresB_mask" for example, and to change the colour.
- 14.7. Highlight both masks (click on one, then SHIFT and click on the other) and select the symbol to create a new mask containing the intersection of the selected masks. Rename the output mask as Intersect
- 14.8. Take some time to view the different results. Try to display the intersection mask on top of a S1 image
- 14.9. Export your display (with the S1 image) as KMZ for Google Earth
- 14.10. You can export the intersect mask itself as KMZ for Google Earth, but first it will need to be converted from mask into a band: Raster > Band Math. Name the new band, uncheck Virtual, and in Edit Expression, check Show Masks:

if Intersect then 1 else NaN

Then, in the Colour Manipulation tab, change the colour to, for example, dark blue.

Then display this Intersect_band and Export it as KMZ for Google Earth.

Note: with an image editor (e.g. Irfan View), KMZ colours can be adapted as well)

15. Calculate the extent of the flood:

- 15.1. Does the Intersect band correspond to the flooded area? Why/Why not?
- 15.2. Display the Intersect_band. In Analysis > Statistics, click on Refresh and the statistics will compute for this band. How many pixels does your Intersect_band have? In this example, 89 160 pixels.

Note: another way of doing this is to display one of the S1 bands (e.g. one of the Sigma0_VV bands), click Use ROI Mask(s) and check the Intersect mask. Then click Refresh, and the statistics will compute. How many pixels from the Sigma0_VV bands intersect with the Intersect mask? It should be the same number as in Step 15. 2. above.

15.3. What is the size of each pixel? Find the range spacing and azimuth spacing in Metadata > Abstracted Metadata. It should be 30 m.

15.4. Calculate the area covered by the Intersect_band pixels: 89 160 pixels x 30m x 30m = 80 244 000 m²

16. If this event was mapped by another institution, you can compare your output (e.g. Copernicus Emergency or International Disasters Charter add PNG !!)

