

CHANGE DETECTION USING OPTICAL DATA IN SNAP

EXERCISE 1 (Water change detection)

Data: Sentinel-2A Level 2A:

- **S2A_MSIL2A_20170101T082332_N0204_R121_T34HCH_20170101T084543.SAFE**
- **S2A_MSIL2A_20180116T082251_N0206_R121_T34HCH_20180116T120458.SAFE**

1. Open file

1.1. 'File' / 'Open Product'

1.2. Browse to:

/day_2/practice/Change_Detection/data/WaterChange/S2A_MSIL2A_20170101T082332_N0204_R121_T34HCH_20170101T084543.SAFE

/day_2/practice/Change_Detection/data/WaterChange/S2A_MSIL2A_20180116T082251_N0206_R121_T34HCH_20180116T120458.SAFE

1.3. Select the 'MTD_MSIL2A.xml' file for each product and click 'Open'

2. View RGB image view

2.1. Select the first product in "Product Explorer" window

2.2. Select: 'Window' / 'Open RGB Image Window'

2.3. Leave default natural colour combination and click OK

2.4. Repeat the step for the second product [2]

3. View multiple viewers

3.1. Synchronise views by selecting the relevant icons in the "Navigation" tab

3.2. Select: 'Window' / 'Tile Horizontally'

The Sentinel-2 data contains 13 spectral bands at different spatial resolution (10, 20 and 60 meters), therefore before to apply the processing involving bands at different resolution we need to resample them.

Due to the short time slot dedicated to the practical we will focus the attention to the Waterskloof Dam (South Africa) running a pre-processing graph that will subset spatially and spectrally the original product. The steps to set-up the pre-processing graph in SNAP are shown below.

4. Pre-processing Graph Builder

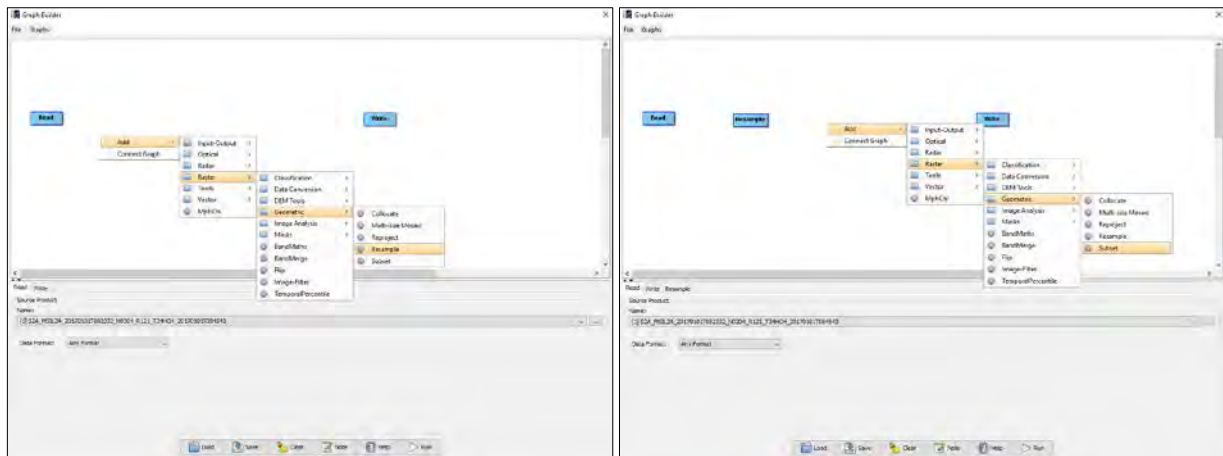
4.1. Select the product in "Product Explorer" window

4.2. Select: 'Tools' / 'GraphBuilder' or the icon 

4.3. In the GraphBuilder window we can start to build our graph clicking the right button of the mouse and add all the SNAP modules that we need.

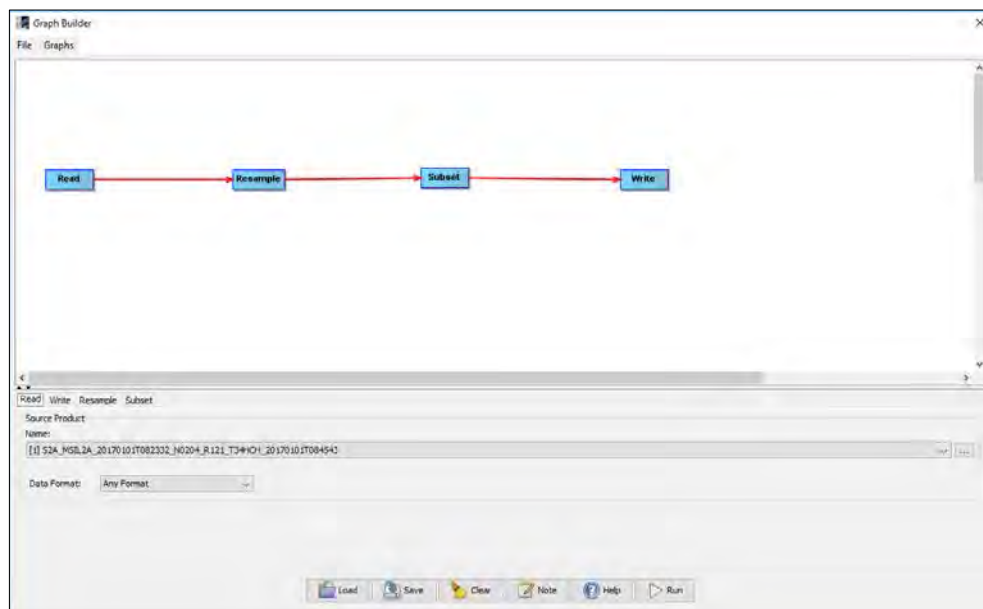
4.4. Resample Module: 'Add' / 'Raster' / 'Geometrics' / 'Resample'

4.5. Subset Module: 'Add' / 'Raster' / 'Geometrics' / 'Subset'

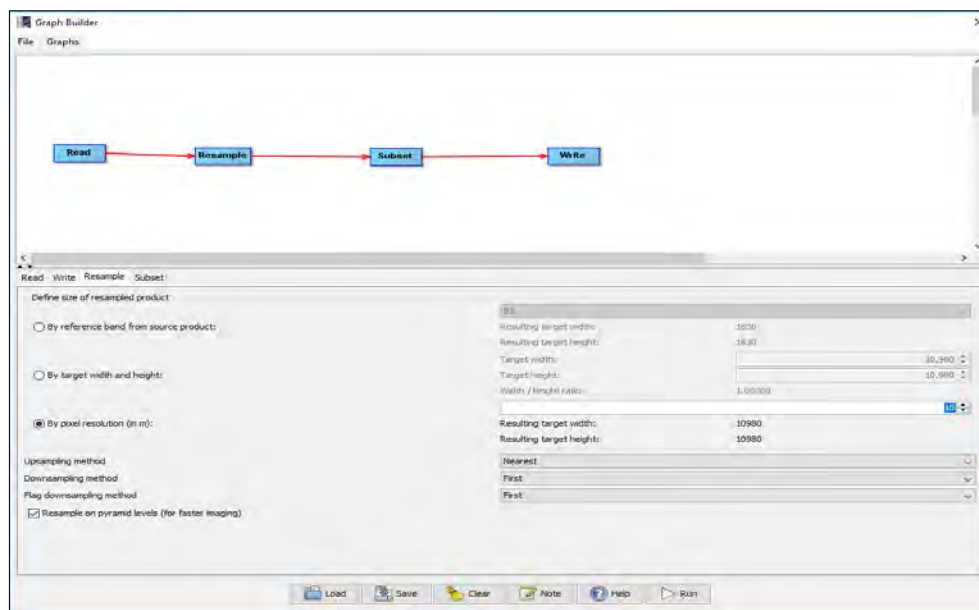


4.6. Right click on the GraphBuilder window and select 'Connect Graph'

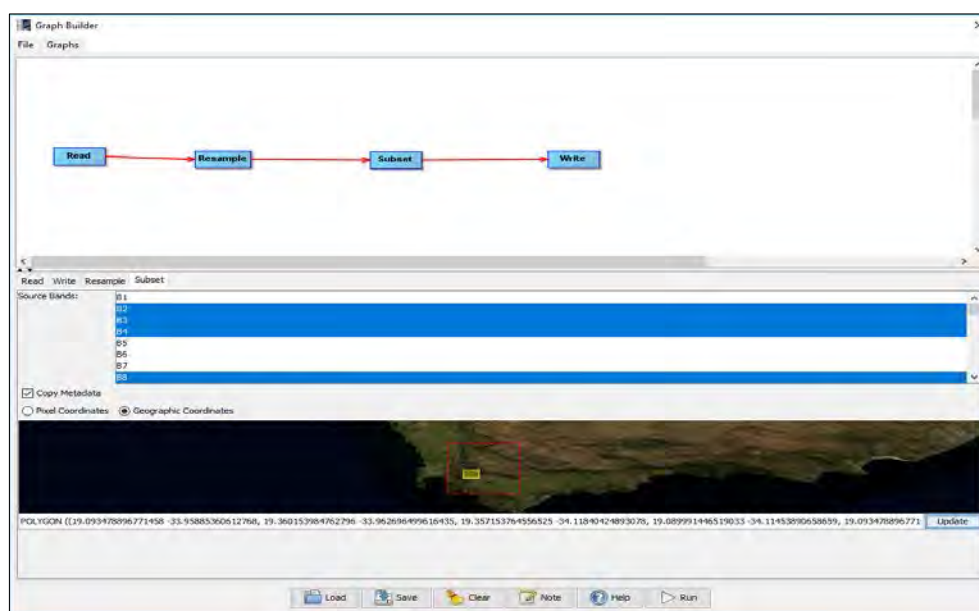
4.7. Once that all the modules of the graph are connected we can set up the parameters as shown below



Reader: Select the product acquired on 2017.



Resample: Select the third option 'By pixel resolution (in m)' and specify 10.



Subset: From the Source Bands select B2, B3, B4, B8, B11 and B12. To crop spatially select 'Geographic Coordinates' option and copy and paste the polygon on the 'Waterskloof Dam Polygon.txt' file and click on 'update'.

5. Open the newly created product

- 5.1. Close all viewers
- 5.2. Select image name in "Product Explorer" window
- 5.3. Select: 'Window' / 'Open RGB Image Window'
 - 5.3.1. Leave default natural colour combination and click 'OK'
- 5.4. Synchronise views by selecting the relevant icons in the "Navigation" tab
- 5.5. Select: 'Window' / 'Tile Horizontally' and compare the images

6. NDWI-2 (Second Normalized Difference Water Index)

The second Normalized Difference Water Index algorithm was developed by McFeeters (1996) to detect surface waters in wetland environments and to allow for the measurement of surface water extent. The equation is similar to NDVI, except that it uses Green (B3) and the Near InfraRed (NIR) wavelengths.

$$NDWI2 = \frac{(Green - NIR)}{(Green + NIR)} = \frac{(B3 - B8)}{(B3 + B8)}$$

The NDWI-2 makes use of reflected near-infrared radiation and visible green light to enhance the presence of such features while eliminating the presence of soil and terrestrial vegetation features. A high NDWI-2 value generally indicates presence of water. The water curve is characterised by a high absorption at near infrared wavelengths range and beyond. Because of this absorption property, water bodies as well as features containing water can easily be detected, located and delineated with remote sensing data.

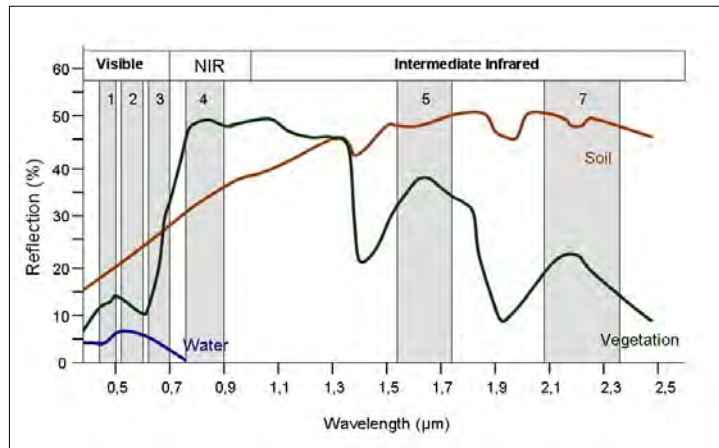


Image Source: Siegmund, Menz 2005 with modifications

6.1. Create New NDWI2 Band (based on band maths expression)

6.1.1. Select: 'Raster' / 'Band Maths...'

6.1.2. Set up the I/O and the processing parameters as shown in the Figure below

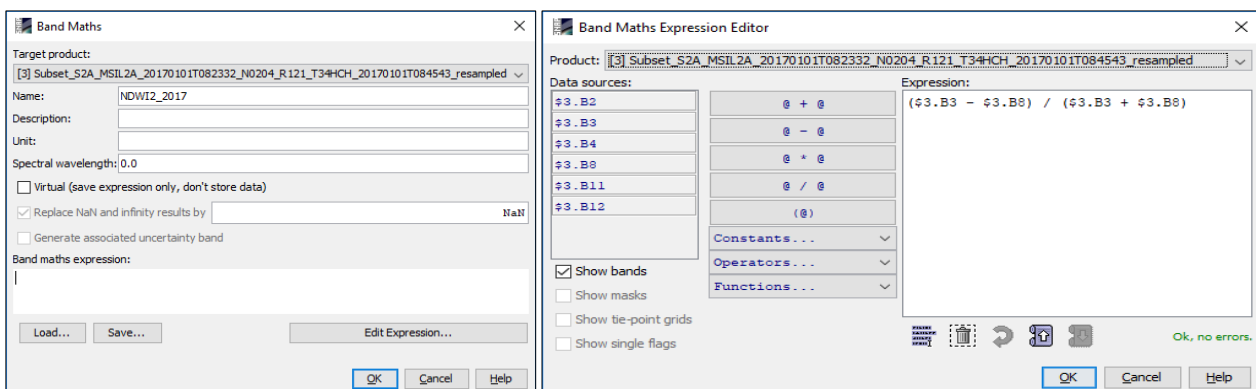
6.1.3. Change the output name in 'NDWI2_2017'

6.1.4. Deselect "Virtual"

6.1.5. Select "Edit Expression..."

6.1.6. Type the following expression in the 'Expression' field: "(\$3.B3 - \$3.B8) / (\$3.B3 + \$3.B8)

6.1.6.1. The symbol '\$' is the link to the product as displayed in the Product Explorer Window.

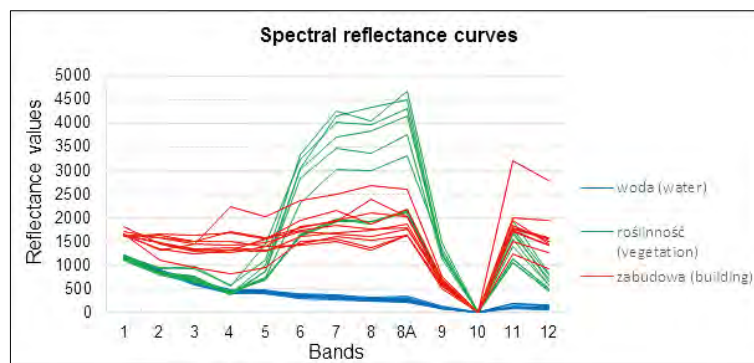


6.1.7. Click 'OK'

6.1.8. Repeat the process for the second product [4] changing the output name 'NDWI2_2018'

7. SWM (Sentinel Water Mask)

The Sentinel Water Mask algorithm was presented by Marta Milczarek during ESA Land Training Corse 2017 winning the best poster award in the category "Optical Remote Sensing". SWM provides quick and effective detection of water.



After analysis of spectral reflectance curves for water and other types of land cover (Figure above), two bands with the highest reflectance for water (Blue and Green) and two with the lowest one (NIR and SWIR) were selected and new index formula was developed:

$$SWM = \frac{(Blue + Green)}{(NIR + SWIR)} = \frac{(B2 + B3)}{(B8 + B11)}$$

7.1. Create New SWM Band (based on band maths expression)

7.1.1. Select: 'Raster' / 'Band Maths...'

7.1.2. Set up the I/O and the processing parameters as shown in the Figure below

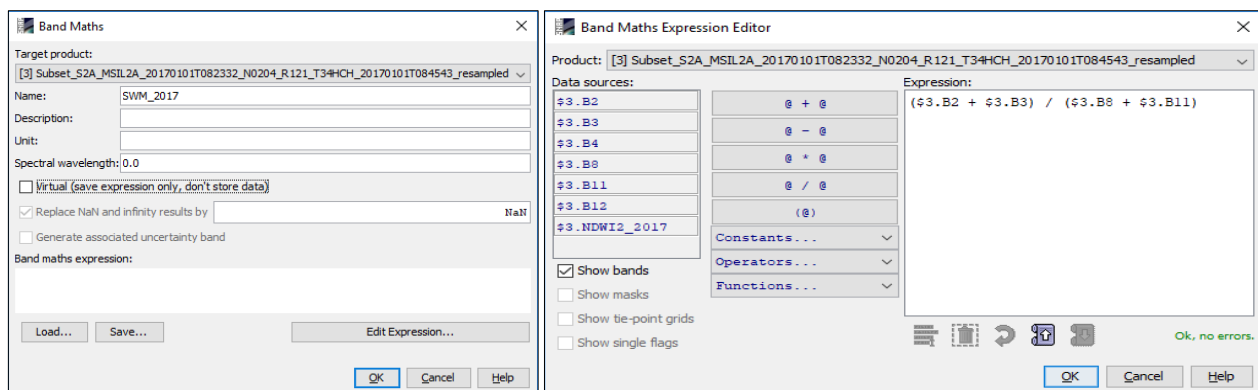
7.1.3. Change the output name in 'SWM_2017'

7.1.4. Deselect "Virtual"

7.1.5. Select "Edit Expression..."

7.1.6. Type the following expression in the 'Expression' field: "(\$3.B2 + \$3.B3) / (\$3.B8 + \$3.B11)

7.1.6.1. The symbol '\$' is the link to the product as displayed in the Product Explorer Window.



7.1.7. Click 'OK'

7.1.8. Repeat the process for the second product [4] changing the output name 'SWM_2018'

7.1.8.1. The symbol '\$' is the link to the product as displayed in the Product Explorer Window.

8. Create Water band based on NDWI2 and SWM

8.1. Close all viewers

8.2. Select product in "Product Explorer" window

8.3. Select: 'Raster' / 'Band Maths...'

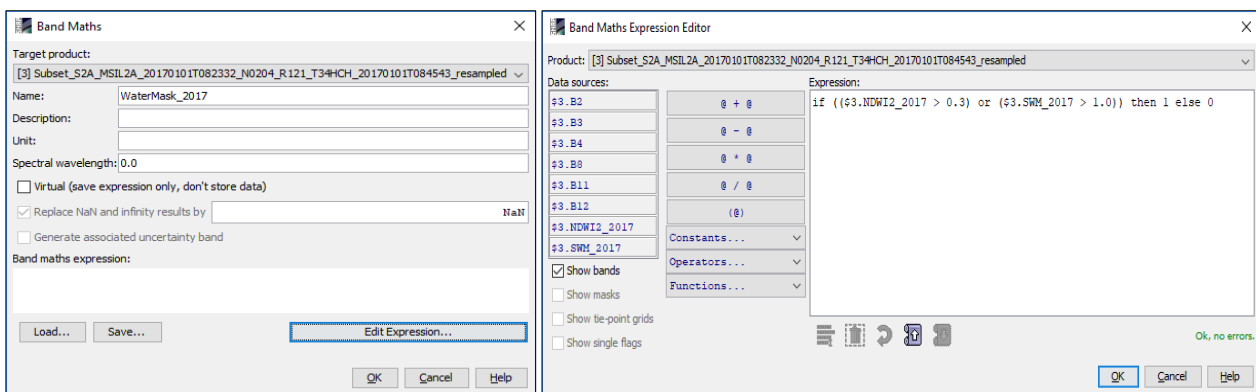
8.4. Set up the I/O and the processing parameters as shown in the Figure below

8.5. Change the output name in 'WaterMask_2017'

8.6. Deselect "Virtual"

8.7. Select "Edit Expression..."

8.8. Type the following expression: "if ((\$3.NDWI2_2017 > 0.3) or (\$3.SWM_2017 > 1.0)) then 1 else 0"



8.9. Click 'OK'

8.10. Repeat the process for the second product [4] changing the output name 'WaterMask_2018'

8.10.1. The symbol '\$' is the link to the product as displayed in the Product Explorer Window.

9. Water Change detection

9.1. Close all viewers

9.2. Select product in "Product Explorer" window

9.3. Select: 'Raster' / 'Band Maths...'

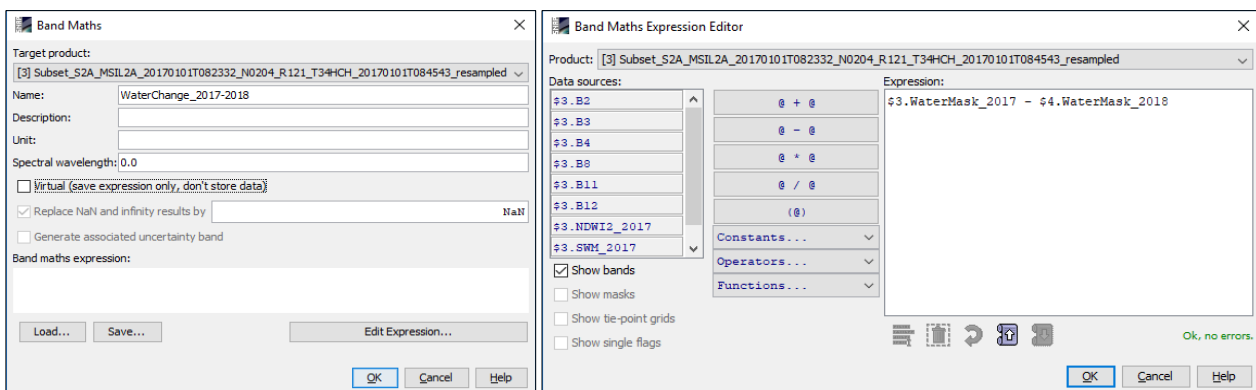
9.4. Set up the I/O and the processing parameters as shown in the Figure below

9.5. Change the output name in 'WaterChange'

9.6. Deselect "Virtual"

9.7. Select "Edit Expression..."

9.8. Type the following expression: "\$3.WaterMask_2017 - \$4.WaterMask_2018"



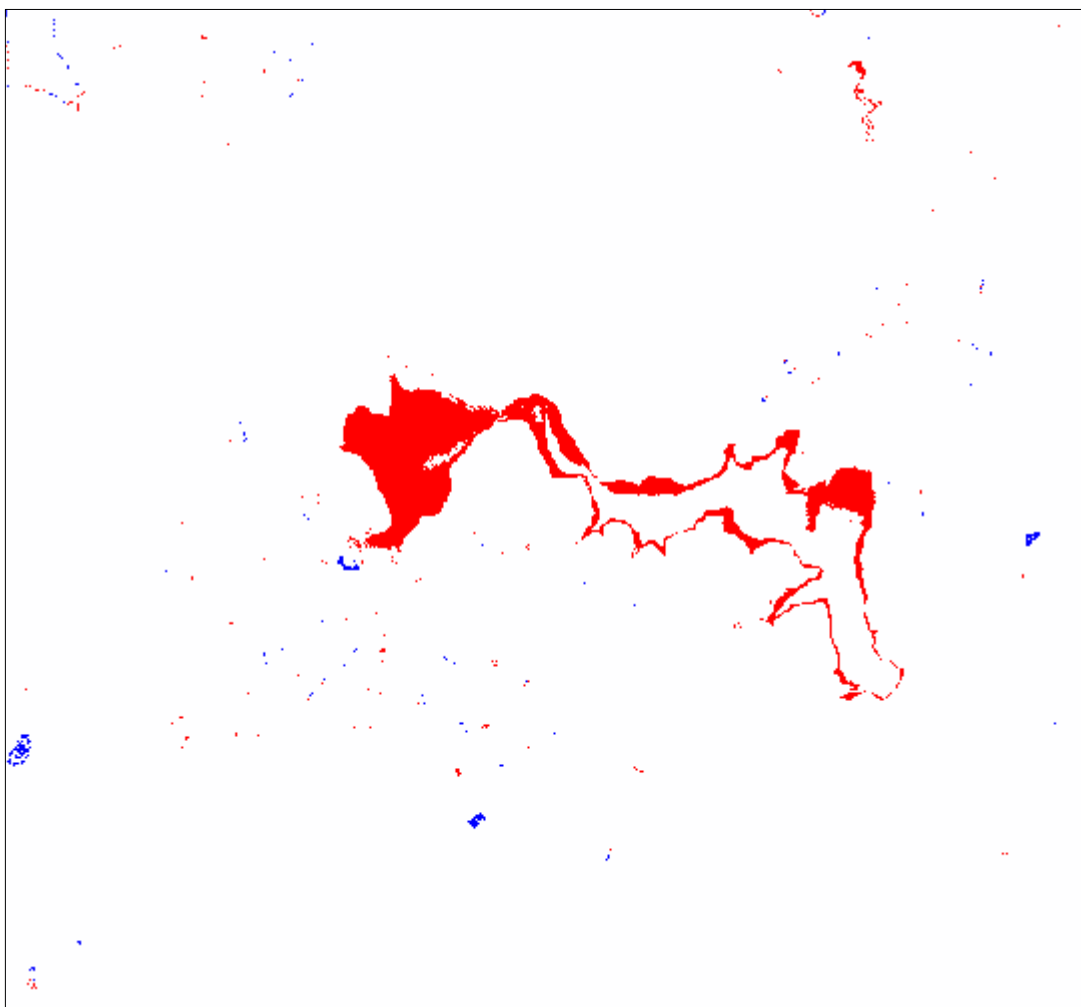
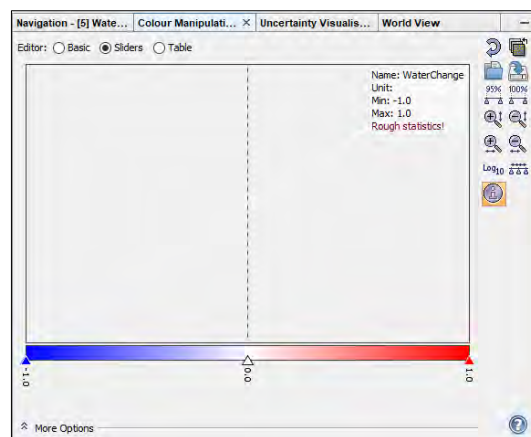
9.9. Click 'OK'

9.10. Open the newly generated product

9.11. Select: "Colour Manipulation" tab

9.12. [-1.0: Blue]; [0.0: White]; [1.0: Red]

The red pixels indicate water decreasing, the white ones represent no change in water level and the blue pixels are associated to an increasing of the water.



EXERCISE 2 (Forest change detection)

Data: Sentinel-2A Level-2A pre-processed:

Subset_S2A_MSIL2A_20170614T112111_N0205_R037_T29TNE_20170614T112422_10m.data

Subset_S2A_MSIL2A_20170704T112111_N0205_R037_T29TNE_20170704T112431_10m.data

The data have been atmospherically corrected, resampled at 10m, cropped spatially and spectrally (B2, B3, B4, B8, B11, B12) and exported in BEAM-DIMAP (SNAP native file format).

1. Open files

1.1. 'File' / 'Open Product'

1.2. Browse to:

/day_2/practice/Change_Detection/data/ForestChange/Subset_S2A_MSIL2A_20170614T112111_N0205_R037_T29TNE_20170614T112422_10m.dim

/day_2/practice/Change_Detection/data/ForestChange/Subset_S2A_MSIL2A_20170704T112111_N0205_R037_T29TNE_20170704T112431_10m.dim

1.3. Click 'Open'

2. View RGB image view

2.1. Select image name in "Product Explorer" window

2.2. Select: 'Window' / 'Open RGB Image Window'

2.3. Leave default natural colour combination and click OK

2.4. Repeat for both of the products

3. View multiple viewers

3.1. Synchronise views by selecting the relevant icons in the "Navigation" tab

3.2. Select: 'Window' / 'Tile Horizontally'

4. NBR (Normalized Burn Ratio)

The Normalized Burn Ratio (NBR) was designed to highlight burned areas and estimate fire severity and is calculated applying the equation reported below:

$$NBR = \frac{(NIR - SWIR)}{(NIR + SWIR)} = \frac{(B8 - B12)}{(B8 + B12)}$$

Pre-fire, healthy vegetation has very high near-infrared reflectance and low reflectance in the shortwave infrared portion of the spectrum. Recently burned areas on the other hand have relatively low reflectance in the near-infrared and high reflectance in the shortwave infrared band. A high NBR value generally indicates healthy vegetation while a low value indicates bare ground and recently burned areas.

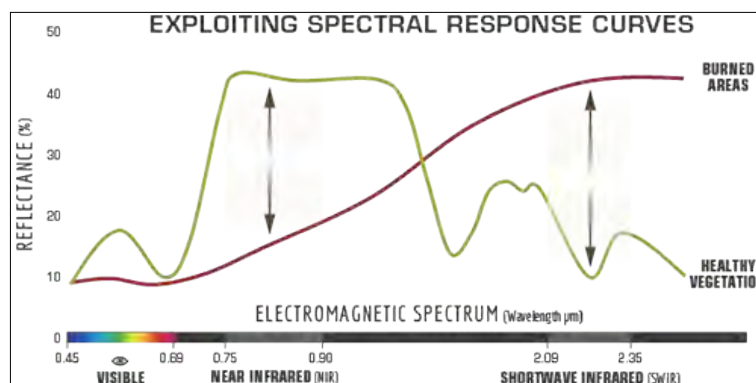


Image Credit: US Forest Service

4.1. By Band Maths

4.1.1. Select: 'Raster' / 'Band Maths...'

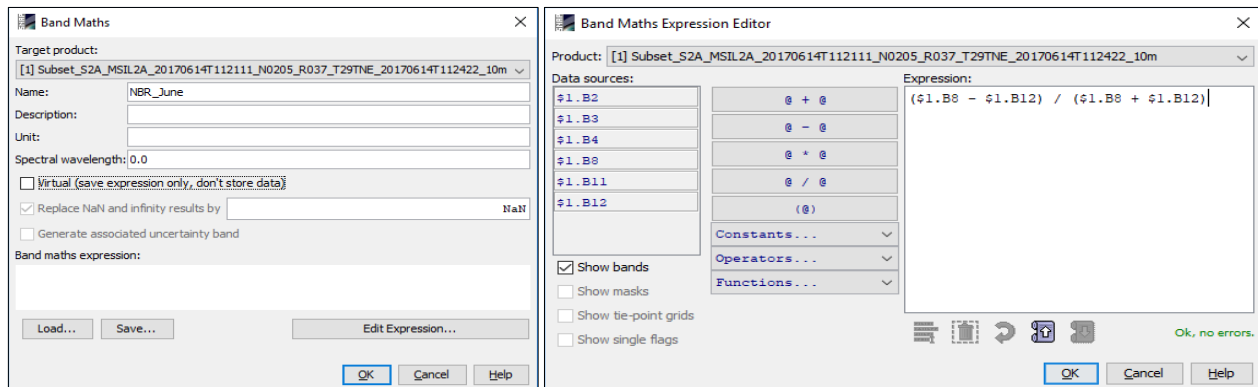
4.1.2. Set up the I/O and the processing parameters as shown in the Figure below

4.1.3. Change the output name in 'NBR_June'

4.1.4. Deselect “Virtual”

4.1.5. Select “Edit Expression...”

4.1.6. Type in the following expression in the ‘Expression’ field: “ $(\$1.B8 - \$1.B12) / (\$1.B8 + \$1.B12)$ ”



4.1.7. Click ‘OK’

4.1.8. The newly created NBR band is added as band of the input product

4.1.9. Replicate the action for the second product [2] changing the output name ‘NBR_July’

5. View NBR bands

5.1. Select ‘NBR_June’ band name in “Product Explorer” window and double click

5.2. Repeat for the ‘NBR_July’ band associated to the second image

5.3. Synchronise views by selecting the relevant icons in the “Navigation” tab

5.4. Select: ‘Window’ / ‘Tile Horizontally’

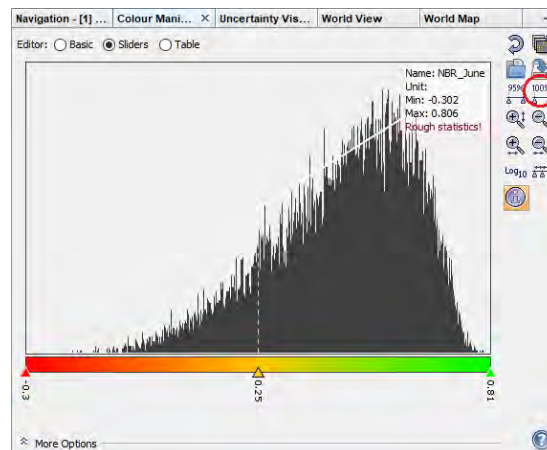
6. Colour Manipulation

6.1. Select NBR_June image displayed

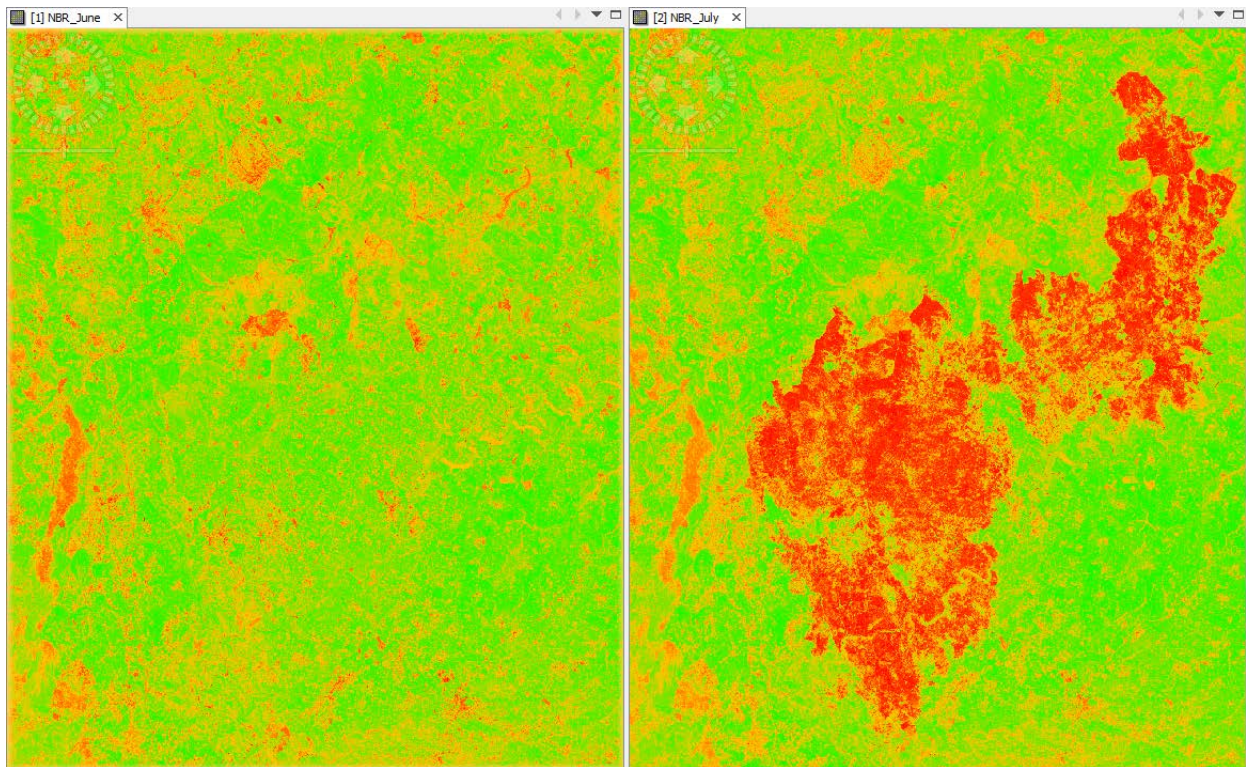
6.2. Select: “Colour Manipulation” tab

6.3. Click on “Auto-adjust to 100% of all pixels” as shown in figure below

6.4. [Min: Red]; [Mean: Orange]; [Max: Green]



6.5. Repeat for the NBR_July obtaining the following result



7. Burn Severity

Normalized Burn Ratio is frequently used to estimate burn severity. Imagery collected before a fire will have very high near infrared band values and very low mid infrared band values and a Imagery collected over a forest after a fire will have very low near infrared band values and very high mid infrared band values. Higher dNBR indicate more severe damage. Areas with negative dNBR values may indicate increased vegetation productivity following a fire.

$$dNBR \text{ or } \Delta NBR = PrefireNBR - PostfireNBR = NBR_{June} - NBR_{July}$$

The meaning of the ΔNBR values can vary by scene, and for best results interpretation in specific instances should always be based on some field assessment. However, the table below from the USGS FireMon program can be useful as a first approximation for interpreting the NBR difference.

dNBR	Burn Severity
< -0.25	High post-fire regrowth
-0.25 to -0.1	Low post-fire regrowth
-0.1 to +0.1	Unburned
0.1 to 0.27	Low-severity burn
0.27 to 0.44	Moderate-low severity burn
0.44 to 0.66	Moderate-high severity burn
> 0.66	High-severity burn

7.1. Select: 'Raster' / 'Band Maths...'

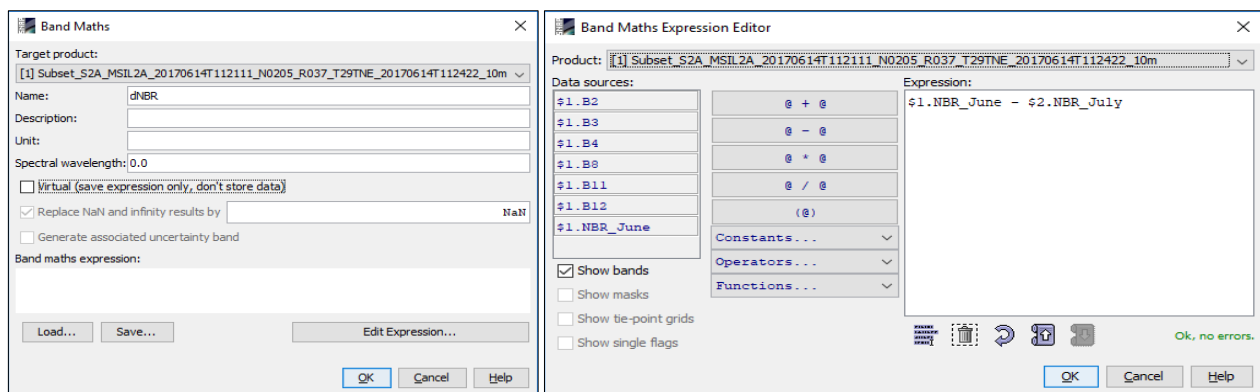
7.2. Set up the I/O and the processing parameters as shown in the Figure below

7.3. Change the output name in 'dNBR'

7.4. Deselect "Virtual"

7.5. Select "Edit Expression..."

7.6. Type in the following expression in the 'Expression' field: "\$1.NBR_June - \$2.NBR_July"



7.7. The symbols “\$1.” and “\$2.” are the links to the different products

7.8. Obtaining the following result




7.9. The brightest pixels represent high dNBR meaning high-severity burn.

8. Colour Manipulation

8.1. Select dNBR band displayed on the screen

8.2. Go to “Colour Manipulation” tab (bottom left) and select ‘Basic’ as editor

8.3. Import colour palette from text file clicking on the icon  and selecting the file named ‘dNBR_ColourPalette.cpd’

8.4. In order to take the range from the file click ‘No’ on the pop-up message

dNBR	Burn Severity	Colour Palette
< -0.25	High post-fire regrowth	Blue
-0.25 to -0.1	Low post-fire regrowth	Cyan
-0.1 to +0.1	Unburned	Green
0.1 to 0.27	Low-severity burn	Yellow
0.27 to 0.44	Moderate-low severity burn	Orange
0.44 to 0.66	Moderate-high severity burn	Red
> 0.66	High-severity burn	Purple

