Kvarken Space Economy Education Module #3

Module title: Kvarken Space Conversations #3 "Springtime Vegetation Blooms" Satellite Imagery

Background: Kvarken Space Economy presents space-based observations to society within the Finnish Bothnia-Atlantic area with monthly articles. For our monthly contribution (June 2020) in science and technology feature magazine, Mega, we introduced the concept of "Normalized Difference Vegetation Index – NDVI temporal calculation". Web access to this monthly sequence can be found at the following link location: http://www.kvarkenspacecenter.org/index.php/kvarken-space-discussions/ By looking at the section, "#3 Springtime Vegetation Blooms", you can find discussions about NDVI.

Module purpose: This education module shows you the steps needed to create the same image as in the article on your computer. The magazine image for June is seen here: http://www.kvarkenspacecenter.org/wp-content/uploads/2020/06/third-imagev3_smaller.png. Once these steps are completed, you will understand the mechanics of replicating the space observations from ESA's MSI and be ready to try other locations anywhere in the world. **It takes several steps to complete this module.**

STEP 1 OPEN THE APPLICATION For our work here, we use ESA's Copernicus data hub to download the data. It provides complete, free and open access to Sentinel satellite products. To visualize, process and analyze downloaded Sentinel data products, ESA provides an open source software called Sentinel Application Platform (SNAP). To begin, let us first download the data used in the magazine, open the following link in your browser.

https://scihub.copernicus.eu/dhus/#/home

You should be able to see as shown in the image below. We take the approach here to focus on our goal of duplicating the "#3 Springtime Vegetation Blooms" image found in the magazine. **As you follow the steps, think what each step accomplishes. This should give you ideas to try other possibilities after the education module is completed.**

To download the data, one must first sign up for an account in Copernicus Open Access Hub. To do that, follow the instructions as provided in the following link: https://scihub.copernicus.eu/userguide/SelfRegistration Also, to process the data, install SNAP Toolbox on your computer from the following link: https://step.esa.int/main/download/snap-download/

	Windows 64-Bit	Windows 32-Bit	Mac OS X	Unix 64-bit
Sentinel Toolboxes	These installers contain the **Sentinel-1**, **Sentinel-2**, **Sentinel-3** Toolboxes			
	Download	Download	Download	Download
SMOS Toolbox	These installer contains only the **SMOS Toolbox.** Download also the Format Conversion Tool (Earth Explorer to NetCDF) and the user manual.			
	Download	Download	Download	Download
All Toolboxes	These installers contain the **Sentinel-1**, **Sentinel-2**, **Sentinel-3** Toolboxes, **SMOS** and **PROBA-V** Toolbox			
	Download	Download	Download	Download

STEP 2 DOWNLOAD THE IMAGERY Our "#3 Springtime Vegetation Blooms" discusses about NDVI temporal calculation, which is difference in the vegetation (NDVI) of an area over two different time period. Therefore, we need to use two-satellite imagery at different time, for e.g., satellite imagery covering same area taken at two different months as considered in the article. For this analysis, let us use same imagery previously used in #2 Wavelengths Tell Many Stories article (**#KvarkenSpaceModule2**) as one satellite imagery. The second imagery need to be the same area centered over the Vaasa, Ostrobothnia region as shown in figure. The Copernicus Open Access Hub upon login with an account, it is not focusing on this area. As our "**A**rea **O**f **I**nterest (AOI)" is centered over the Vaasa, let us follow the steps below to select the right region and download the images.

1. Click the navigation mode icon on the right side of the screen and use the mouse scroll to zoom in to the Vaasa region.
2. Click Area mode icon on the right side of the screen, then left click and drag over the area to form a rectangle shape as shown in the figure.
3. To download the second imagery used for NDVI temporal calculation, click on the icon ≡ on the top left of the screen that enables 'Advanced Search' window.
4. 'Sensing Period' tab enables us to search satellite imagery taken by a satellite on a particular date. For temporal calculation, the first imagery was taken in April so let us download second imagery taken by satellite during May to compare the NDVI difference during May and April. The second imagery used in the article was taken by satellite on 2020/05/25. Therefore, use sensing period date as ¨2020/05/24 to 2020/05/25¨.
5. Click on the ¨Mission: Sentinel-2¨ with product type 'S2MSI2A' and cloud cover [0 TO 20] as shown in the

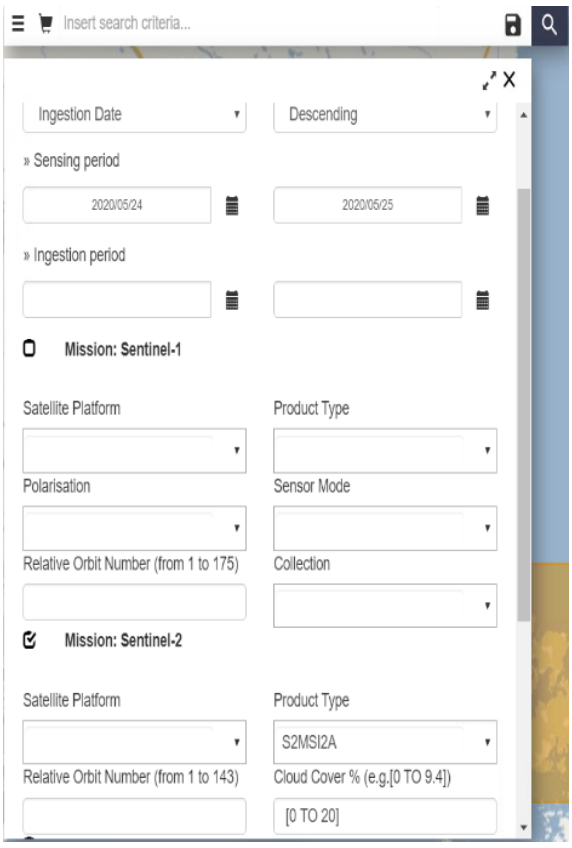
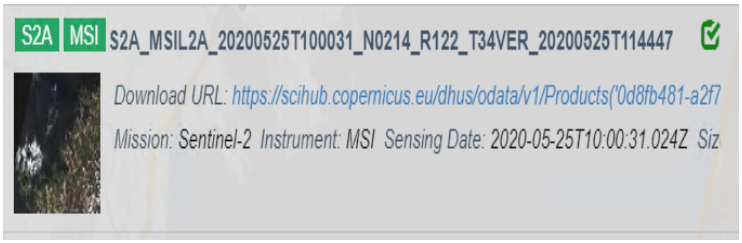


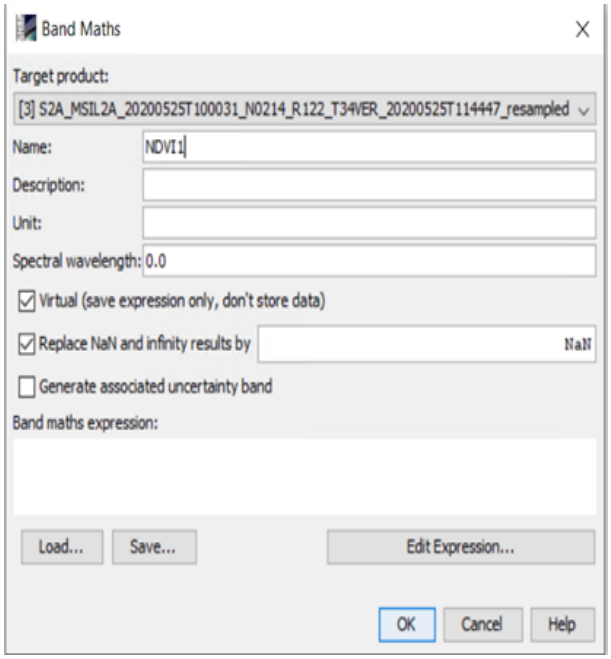
figure. Sentinel-2 satellite produce level 1 and level 2 products denoted as 'S2LIC' and 'S2MSI2A'.

6. Click 'Search' icon and it displays products that are available from Sentinel-2 mission on that particular sensing period.
7. Select the following data from the lists as shown in the figure, and click download icon on the bottom edge of that particular product in the list.
8. Downloaded data will be in Zip format.

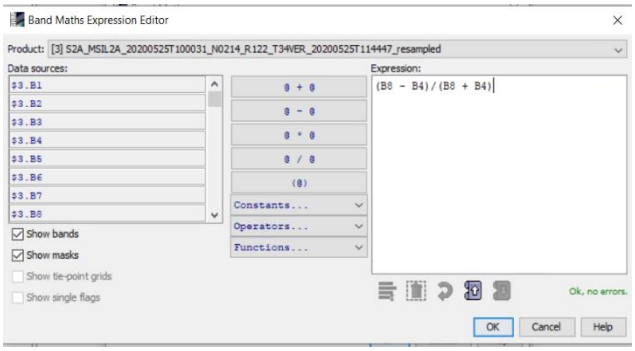


STEP 3 PROCESSING THE IMAGERY IN SNAP From the **KvarkenSpaceEduModule2**, the concept of different band combinations of Sentinel-2 MSI in SNAP and their results such as natural color image, false color image and vegetation analysis were known. By using SNAP, it is possible to visualize, process and obtained high quality data. We will calculate the normalized difference vegetation index for two Sentinel-2 images and find the difference of their NDVI, which is known as NDVI temporal calculation using band math expression. Before going through the following steps, it is important to go through **#KvarkenSpaceEduModule2** to start using SNAP.

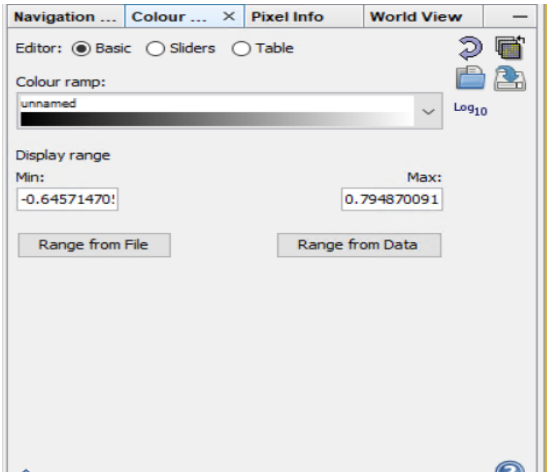
1. Load the SNAP application from your computer, open the two downloaded ZIP format product using File → Open product. The product will be displayed in the product explorer. Double click the product to get information on different bands under Bands section and other details of the data.
2. Sentinel-2 consists of 13 bands and each band has different resolution such as 10 meters, 20 meters and 60 meters. Our goal now is to calculate NDVI based on different band combinations. Therefore, it is important to have all the bands in same resolution for calculating NDVI based on band combinations. Resampling is the method used to obtain all bands in same resolution.
3. For resampling, select Raster → Geometric Operations → Resampling. In the resampling window, under I/O Parameters, select the product and enable the box near ¨Save as: BEAM-DIMAP¨. In addition, enable ¨open in SNAP¨ option with directory path same as path were two images are located.
4. In ¨Resampling Parameters¨ tab, select ¨By reference band from source product¨ and from the dropdown list box select ¨B2¨. Click 'Run'.
5. Thus, the resampled product will have all the 13 bands with a resolution same as source product band B2, which is 10 meters.
6. Right click May month image resampled product (S2A_MSIL2A_20200525T100031_N0214_R122_T34VER_20200525T114447_resampled) and select ¨Band Maths¨. A pop-up window appears as shown in figure. Type Name as NDVI1, leave remaining as default and click 'Edit Expression'.

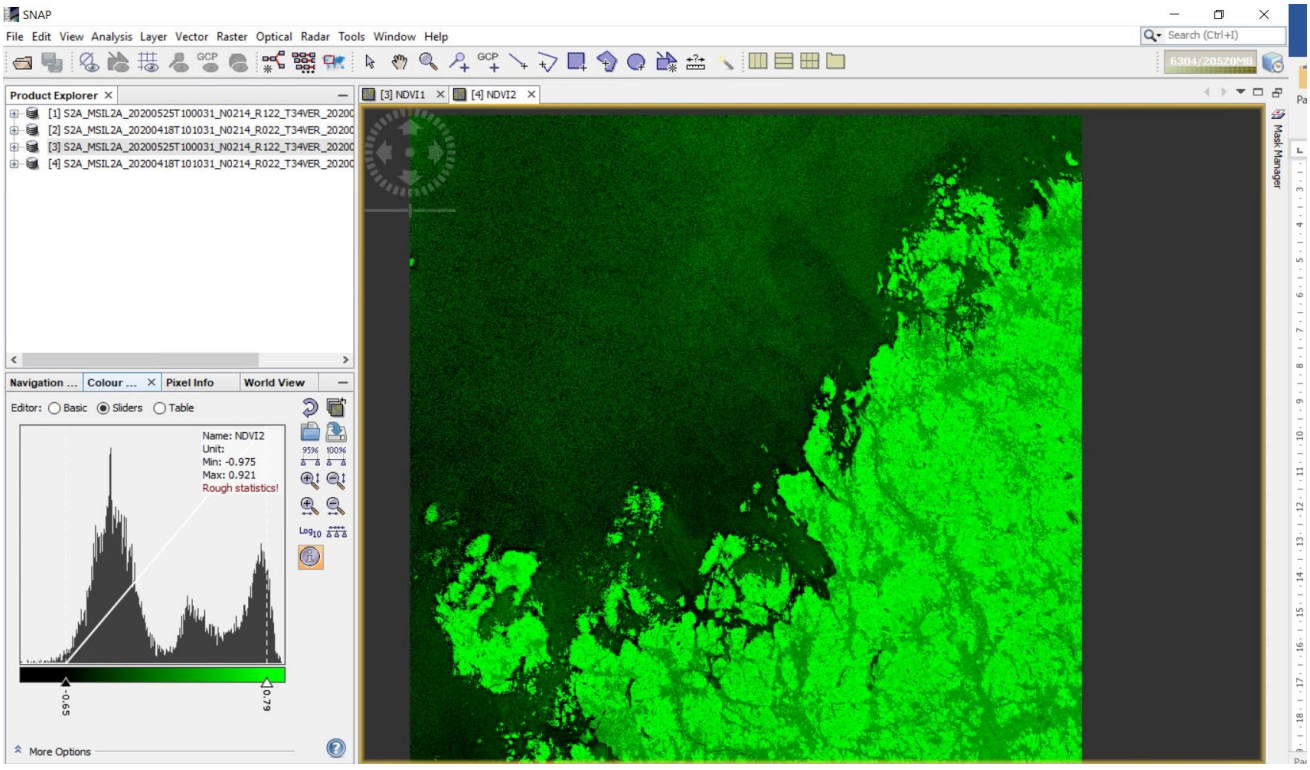


7. In the ‘Band Maths Expression Editor’ type the NDVI formula as shown in figure. The formula for calculating NDVI = (B8 – B4) / (B8 + B4), where B8 is near infrared band and B4 is red band. Click ‘OK’.



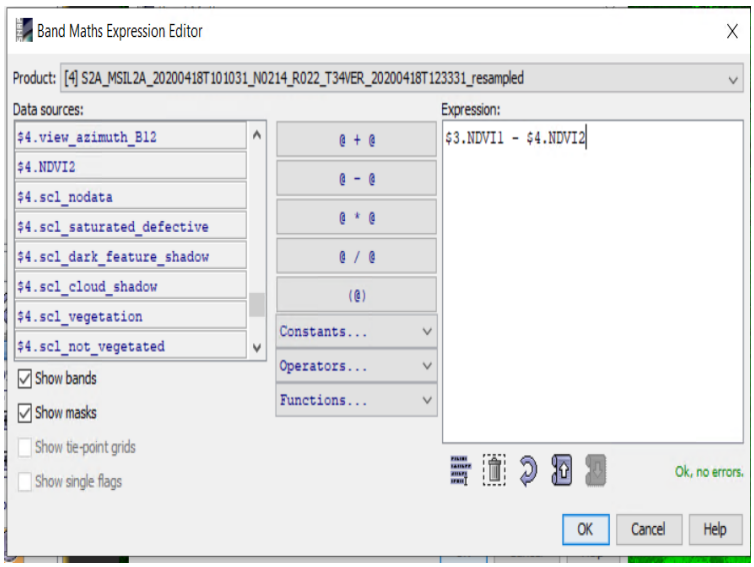
8. An NDVI virtual image is created, which is located in the resampled product under bands section as NDVI1. Double click the product to see the virtual band created. This is the NDVI calculated for May month. Right click the resampled product and select ‘Save Product’.
9. Similarly, create an NDVI2 virtual band for the April month resampled product (S2A_MSIL2A_20200418T101031_N0214_R022_T34VER_20200418T123331_resampled) and save it. (Repeat steps 6 to 9).
10. From the ‘Color Manipulation’ tab, in the ‘Editor:’ select ‘Basic’ option. Change the ‘Color ramp:’ from ‘unnamed’ to ‘gradient_green’ from the dropdown list.
11. Click ‘Sliders’ option again from the ‘Editor:’ and drag the slider with ‘green’ to the slider with ‘white’ to obtain the image as shown in figure below. Apply color for both the NDVI1 and NDVI2 images.



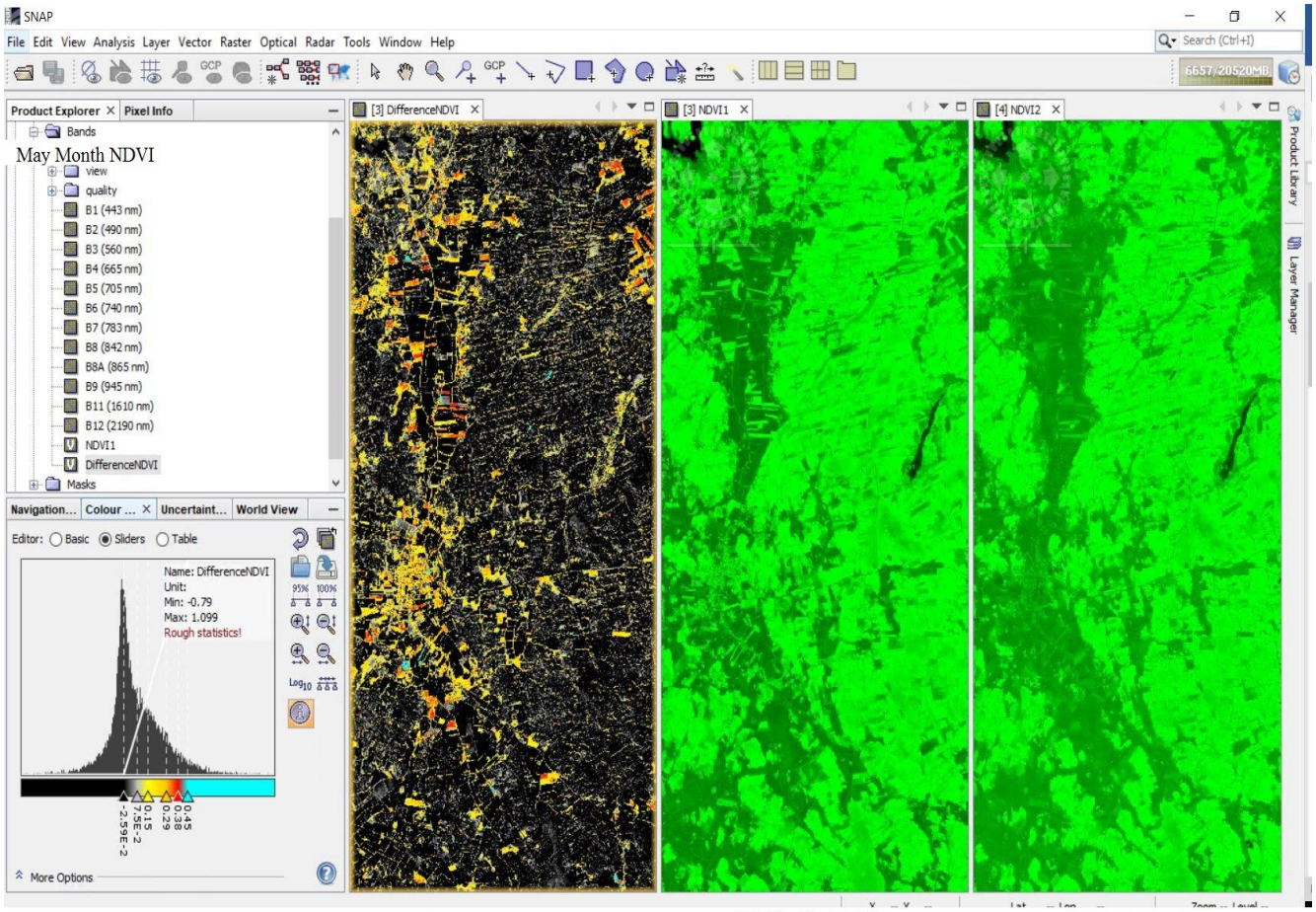


STEP 4 VISUALIZING THE IMAGERY Here, user will do the final process to obtain desired results similar to the magazine.

1. For NDVI temporal calculation, which is the difference in NDVI between May and April, we need to subtract the two virtually created and saved NDVI bands namely NDVI1 and NDVI2. NDVI1 was NDVI calculated for May month and NDVI2 was NDVI calculated for April month.
2. Right click the May month resampled product and select 'Band Maths' and retype Name as 'DifferenceNDVI'. Click 'Edit Expression'.
3. Make sure that 'Product' dropdown box indicates May month product and 'Show bands and Show masks' options are enabled. From 'Data sources:' Select NDVI1 band and click '–' symbol.
4. From the 'Product' dropdown box, now select April month resampled product. Select 'NDVI2' band from the 'Data sources:' and click 'OK' as shown in figure.
5. 'DifferenceNDVI' image, which is the NDVI temporal calculation made from the two satellite images stored under 'Bands' section in the May month as a virtual band.



6. Change the color of the 'DifferenceNDVI' image under 'Color Manipulation' tab similar to step 10 from previous section. In the 'Color Ramp:' under 'Basic' instead of 'unnamed' select 'meris_algal' from the list.
7. Now, change the slider color and adjust it accordingly for better visualization as shown in the figure below.
8. Select the 'Navigation' panel on the bottom left, use the zoom in and out icons to navigate to the desired region. Also, make sure that and icons are enabled to synchronize view and cursor positions over multiple image windows.
9. Select Window → Tile Horizontally option. This will display NDVI1, NDVI2 and DifferenceNDVI in individual window with same region. Thus, the NDVI difference between two images taken over same area at different time can be estimated as shown in the figure below used for magazine.
12. Now user can right click on the three images separately and select 'Export view as Image'. In the 'Export Image' pop-up window, select the desired file type such as JPEG, GeoTiff to save the image.



NDVI Difference NDVI - During May NDVI - During April

Step 5 SHARING YOUR RESULTS Select your own AOI, Sentinel-2 satellite instrument, two images covering same area, download, process and develop in SNAP the NDVI temporal calculation based on two satellite data images. Take a screenshot and send it to kvarkenspacecenter@univaasa.fi. We will collect and display on our web pages for the world to observe. Please include the satellite name, products created such as NDVI1, NDVI2, DifferenceNDVI, and what interested you from this NDVI temporal calculation. Inform us if you want your name included associated with the imagery on our webpage.