

ESA TRAINING COURSE ON RADAR AND OPTICAL REMOTE SENSING

SENTINEL-1 PROCESSING IN SNAP

Data: Sentinel-1B IW GRDH 1SDV:

- S1B_IW_GRDH_1SDV_20170601T045051_20170601T045116_005852_00A42A_4595.zip

1. Open file

- 1.1. File / Open Product
- 1.2. Browse to S1B_IW_GRDH_1SDV_20170601T045051_20170601T045116_005852_00A42A_4595.zip

2. View metadata

- 2.1. Select plus icons by filenames in “Product Explorer”, expand “Metadata”, double click on “Extracted Metadata”. Here you can see the basic product information such as acquisition date, product type, acquisition mode, and geometry (antenna pointing, incidence angle, pass).

3. View world map

- 3.1. View / Tool Windows / World Map
- 3.2. Select magnifying glass icon to zoom to image footprint
- 3.3. Use mouse wheel and left click to zoom and pan respectively

4. View image single bands

- 4.1. Select “Bands” folder in “Product Explorer” window and view each band by double clicking on band name.

5. View multiple viewers

- 5.1. Close metadata views, leaving only viewers with bands
- 5.2. Synchronise views by selecting the relevant icons in the “Navigation” tab
- 5.3. Select: Window / Tile Horizontally

6. Crop

- 6.1. Zoom into Kaliningrad (use World View tab in lower left window to help you find it).
- 6.2. Raster / Subset... and select OK

7. Save the newly created subset image

- 7.1. Select image in “Product Explorer”
- 7.2. Select: File / Save Product As...
- 7.3. Select “Yes” to convert to BEAM DIMAP format (SNAP native file format)
- 7.4. Select an output filename and location, and select “Save”
- 7.5. In order to view the saved file with the filename you specified, close the cropped image and reopen it

8. Calibrate

- 8.1. Radar / Radiometric / Calibrate
- 8.2. Convert S0 to decibel (logarithmic scale)
- 8.3. Expand the list of bands of the calibrated image, right mouse click on the band “Sigma0_VH”, select: “Linear to/from dB”. Repeat this also for the “Sigma0_VV” band.
- 8.4. Right click on the newly created “Sigma0_VH_db” and “Sigma0_VV_db” bands and select “Convert Band” to save the virtual bands to file.

9. Filter speckle

- 9.1. Radar / Speckle Filtering / Single Product Speckle Filter
- 9.2. In the "Processing Parameters" tab, select only the "Sigma0_VH" and "Sigma0_VV" bands in the "Source Bands" list (using the control key with the left mouse button to select both simultaneously).
- 9.3. In the "Filter" dropdown box, select "Lee"
- 9.4. In "Filter Size X:" and "Filter Size Y:" select 3, and 3 respectively.
- 9.5. Select "Run"
- 9.6. When the process is finished, convert the speckle filtered bands of the new image again to dB.

10. RGB image view

- 10.1. Window / Open RGB Image Window
- 10.2. Select the following bands: Red = Sigma0_VV_db, Green = Sigma0_VH_db, Blue = Sigma0_VV_db
- 10.3. Contrast stretch the images: Colour Manipulation tab, move triangular sliders to either side of the larger peak in the histogram for each R, G and B channel.
- 10.4. Repeat the process for the image prior to speckle filtering, and compare both speckle filtered and non-speckle filtered images: Window / Tile Horizontally, then link viewers in the "Navigation" tab

11. Terrain Correction

- 11.1. Radar / Geometric / Terrain Correction / Range-Doppler Terrain Correction
- 11.2. In the "Processing Parameters" tab, select only the Sigma0_VH and Sigma0_VV bands
- 11.3. For "Map Projection", scroll down the dropdown box and select "UTM WGS84 (Automatic)" instead of "WGS84(DD)"
- 11.4. Deselect "Mask out areas without elevation"
- 11.5. Select "DEM" in the "Output bands for" list.
- 11.6. Now select "Run"
- 11.7. When the process is finished, convert the terrain corrected bands of the new image again to dB.
- 11.8. This time, save the dB bands to the file (so they are no longer virtual):
 - 11.8.1. Right click on each, and select "Convert band"
 - 11.8.2. File / Save Product
- 11.9. View the same RGB combination of the terrain corrected bands in dB: Red = Sigma0_VV_db, Green = Sigma0_VH_db, Blue = Sigma0_VV_db.

12. Compare S1 and DEM

- 12.1. Open in separate viewers the terrain corrected Sigma0_VH_db and Sigma0_VV_db bands and the DEM ("elevation" band in the terrain corrected S1 image), and enhance the contrast of each by moving the triangular sliders to either side of the histogram in the "Colour Manipulation" tab.
- 12.2. If you wish you can change the LUT (Look Up Table) of the DEM (elevation) image: In the "Colour Manipulation" tab, select the icon labelled "Import colour palette from text file" and select another colour palette.
- 12.3. In one of the image viewers, add as separate layers all images that have been opened (terrain corrected Sigma0_VH_db, Sigma0_VV_db and elevation): Select "Layer Manager", select the "Add Layer" icon, select "Image of Band / Tie-Point Grid", select "Next", then browse to each band in turn.

SENTINEL-2 PROCESSING IN SNAP

Data: Sentinel-2A Level 1C:

- S2A_MSIL1C_20170528T095031_N0205_R079_T34UDF_20170528T095032.SAFE

13. Open the file

- 13.1. File / Import / Optical Sensors / Sentinel-2 / S2- MSI L1C
- 13.2. Browse to S2A_MSIL1C_20170528T095031_N0205_R079_T34UDF_20170528T095032.SAFE / MTD_MSIL1C.xml

14. View metadata

- 14.1. Select plus icons by filenames in “Product Explorer”, expand “Metadata / Level-1C_User_Product / General_Info” folder and double click on “Product_Info”. Here you can see the basic product information such as acquisition date, processing level and processing baseline (that indicates quality of pre-processing)
- 14.2. Double click on “Product_Image_Characteristics”. Here you can see the solar irradiance per band and correction factors necessary to convert from *Top of Atmosphere Reflectance* to *Top of Atmosphere Radiance*.

15. View World Map

- 15.1. View / Tool Windows / World Map
- 15.2. Select magnifying glass icon to zoom to image footprint
- 15.3. Use mouse wheel and left click to zoom and pan respectively

16. View image single bands

- 16.1. Select “Bands” folder in “Product Explorer” window and view each band by double clicking on band name.

17. View multiple viewers

- 17.1. Close metadata views, leaving only viewers with bands
- 17.2. Synchronise views by selecting the relevant icons in the “Navigation” tab
- 17.3. Select: Window / Tile Vertically

18. Display a RGB composite

- 18.1. Close all viewers
- 18.2. Select image name in “Product Explorer” window
- 18.3. Select: Window / Open RGB Image Window
- 18.4. Leave default natural colour (Red, Blue, Green) combination¹ and select OK
- 18.5. Display also a false colour (NIR, Red, Green) combination image
- 18.6. Compare the two images by using the multiple viewers tool explained above (Tile Vertically).
- 18.7. Discover the Pixel Info View (in View / Pixel Info View)

19. Resampling

- 19.1. Raster / Geometric Operations / Resampling
- 19.2. In the “Resampling Parameters” tab, select “By pixel resolution (in m):” and set the resolution to 20m.
- 19.3. Select “Run”

20. Crop

- 20.1. Display an RGB composite of the resampled image
- 20.2. Zoom into an area including urban and coastal land cover.
- 20.3. Raster / Subset... and select OK

21. Save the newly created subset image

- 21.1. Select image in “Product Explorer”
- 21.2. Select: File / Save Product As...
- 21.3. Select “Yes” to convert to BEAM DIMAP format (SNAP native file format)
- 21.4. Select an output filename and location, and select “Save”
- 21.5. In order to view the saved file with the filename you specified, close the cropped image and reopen it

22. Spectral analysis

- 22.1. Open a false colour RGB of the cropped image
- 22.2. View / Tool Windows / Pin Manager
- 22.3. Select the “Pin Placing Tool” (icon on top toolbar)
- 22.4. Click to place a pin on an area of water in the image

¹ See the Annex about the Sentinel-2 spectral bands displayed on the EM spectrum.



- 22.5. In the “Pin Manager” window, double click in the “Label” field to rename the pin “Water”
- 22.6. Click in the colour field to change the colour to blue
- 22.7. Repeat the steps above to create 2 other pins, one over an area of vegetation (shown as red on false colour image), and another over an urban area (shown as cyan), giving each a unique colour and label.
- 22.8. Select the Filter icon and select bands 1 to 12
- 22.9. Export the pins to both XML and TXT using the relevant icons in the “Pin Manager” window
- 22.10. Select: Optical / Spectrum View
- 22.11. View spectral signature of all pins
- 22.12. Deselect “Show spectra for all pins” and select “Show spectrum at cursor position”
- 22.13. Move the mouse over image to view spectra of different pixels.
- 22.14. Now close the Spectrum View and delete all pins in Pin Manager window: select pins, then select “remove selected pin” icon. Then close also the Pin Manager window.

23. NDVI (Normalised Difference Vegetation Index)

- 23.1. Raster / Band Maths
- 23.2. Change name to NDVI
- 23.3. Deselect “Virtual”
- 23.4. Select “Edit Expression...”
- 23.5. Type in the following expression in the “Expression” field: “(B8 - B4)/(B8 + B4)” then select OK and OK.
- 23.6. View the newly created NDVI band

24. Change Projection

- 24.1. Raster / Geometric Operations / Reprojection
- 24.2. In “Reprojection Parameters” leave default projection “Geographic Lat/Lon (WGS84)” and select “Run”

25. Export to Google Earth

- 25.1. Open the NDVI band of the reprojected S2 image subset.
- 25.2. File / Export / Other / View as Google Earth KMZ
- 25.3. Double click on the newly created KMZ file to open it in Google Earth

SENTINEL-1 AND 2 MERGE

26. Raster / Geometric Operations / Collocation

- 26.1. Select the S2 image subset resampled to 20m in the “Master” dropdown box, and the S1 subset terrain corrected to UTM in the “Slave” dropdown box.
- 26.2. Provide a name for the merged product in the “Name:” field
- 26.3. Select “Run”
- 26.4. Compare S1 and S2 bands in the same viewer using the Layer Manager.

SENTINEL-3 OLCI PROCESSING IN SNAP

Data: Sentinel-3A OLCI Level 1:

- S3A_OL_1_EFR____20170621T092115_20170621T092415_20170621T111949_0180_019_093_1979_SVL_O_NR_002.SEN3

27. Open the file

- 27.1. File / Import / Optical Sensors / Sentinel-3 / Sentinel-3
- 27.2. Browse to
S3A_OL_1_EFR____20170621T092115_20170621T092415_20170621T111949_0180_019_093_1979_SVL_O_NR_002.SEN3 / xfdumanifest.xml



28. View image bands

- 28.1. Expand the folder “Bands / Oa*_radiance”
- 28.2. Window / Open RGB Image Window

29. Subset

- 29.1. Zoom into the area around Kaliningrad, including part of the sea
- 29.2. Raster / Subset... then select “OK”
- 29.3. Save subset area: File / Save Product

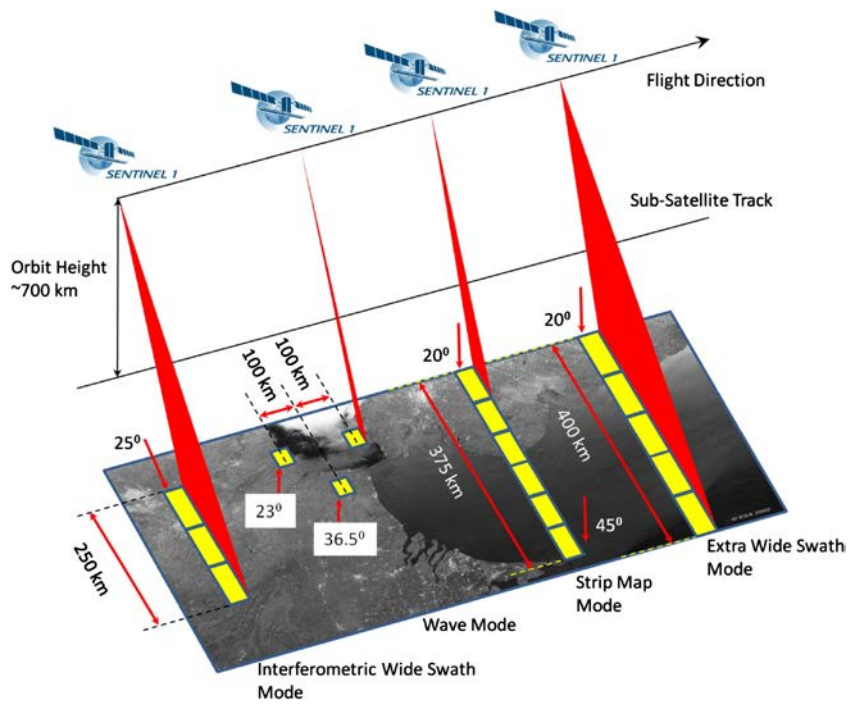
30. Spectrum View

- 30.1. View an RGB composite of the subset area
- 30.2. Optical / Spectrum View
- 30.3. Move the mouse icon over the viewer, holding the shift key at the same time. See the spectral signatures of various land cover types.

31. Unsupervised Classification

- 31.1. Raster / Classification / Unsupervised Classification / K-Means Cluster Analysis
- 31.2. In the “I/O Parameters” tab, select the subset as the “Source Product” and provide a name and path for the classified image
- 31.3. In the “Processing Parameters” tab, select only the Oa..._radiance bands
- 31.4. Select “Run”
- 31.5. View the results of the classification by double clicking on the “class indices” band of the output image.

ANNEX 1: Sentinel-1 Characteristics



Characteristic	Value
Swath width	250 km
Incidence angle range	29.1° - 46.0°
Sub-swaths	3
Azimuth steering angle	± 0.6°
Azimuth and range looks	Single
Polarisation options	Dual HH+HV, VV+VH Single HH, VV
Maximum Noise Equivalent Sigma Zero (NESZ)	-22 dB
Radiometric stability	0.5 dB (3σ)
Radiometric accuracy	1 dB (3σ)
Phase error	5°

Characteristics of Interferometric Wide swath mode

ANNEX 2: Sentinel-2 MSI spectral bands

THE SPATIAL RESOLUTION OF SENTINEL-2 IS DEPENDENT ON THE PARTICULAR SPECTRAL BAND

A. 10 meter spatial resolution:

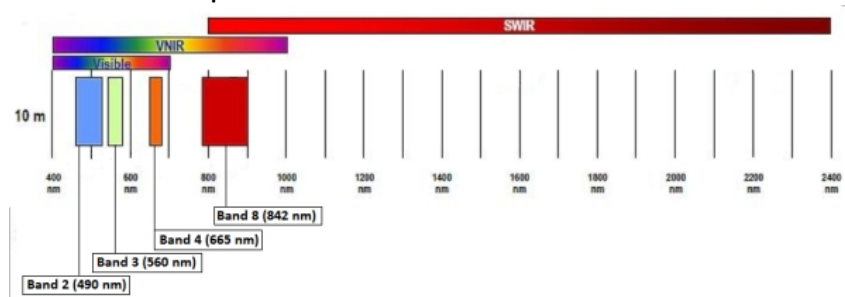


Figure 1: SENTINEL-2 10 m spatial resolution bands: B2 (490 nm), B3 (560 nm), B4 (665 nm) and B8 (842 nm)

B. 20 meter spatial resolution:

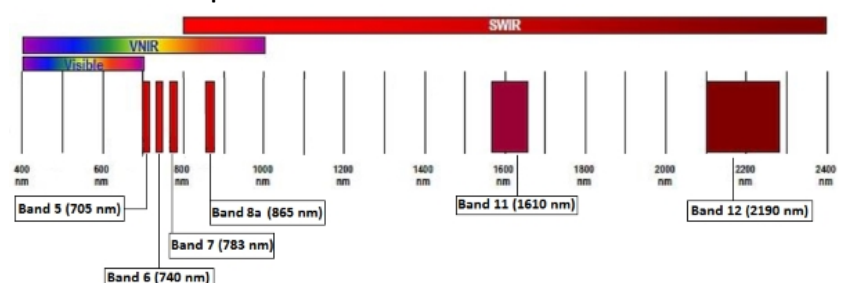


Figure 2: SENTINEL-2 20 m spatial resolution bands: B5 (705 nm), B6 (740 nm), B7 (783 nm), B8a (865 nm), B11 (1610 nm) and B12 (2190 nm)

C. 60 meter spatial resolution:

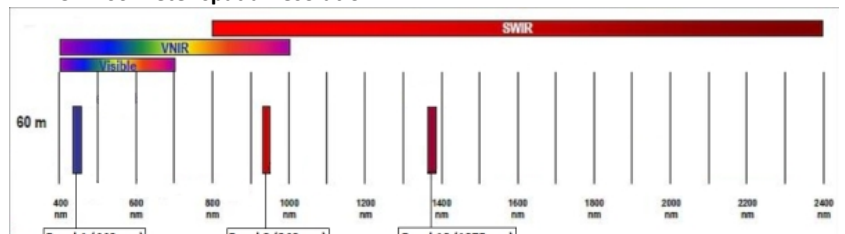
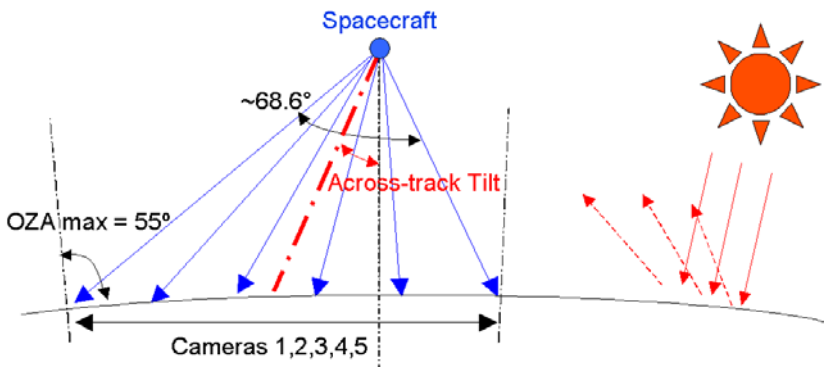


Figure 3: SENTINEL-2 60 m spatial resolution bands: B1 (443 nm), B9 (940 nm) and B10 (1375 nm)

ANNEX 3: Sentinel-3 OLCI instrument characteristics



Band	λ centre (nm)	Width (nm)	Function
Oa1	400	15	Aerosol correction, improved water constituent retrieval
Oa2	412.5	10	Yellow substance and detrital pigments (turbidity)
Oa3	442.5	10	Chl absorption max., biogeochemistry, vegetation
Oa4	490	10	High Chl, other pigments
Oa5	510	10	Chl, sediment, turbidity, red tide
Oa6	560	10	Chlorophyll reference (Chl minimum)
Oa7	620	10	Sediment loading
Oa8	665	10	Chl (2nd Chl abs. max.), sediment, yellow substance/vegetation
Oa9	673.75	7.5	For improved fluorescence retrieval and to better account for smile together with the bands 665 and 680 nm
Oa10	681.25	7.5	Chl fluorescence peak, red edge
Oa11	708.75	10	Chl fluorescence baseline, red edge transition
Oa12	753.75	7.5	O2 absorption/clouds, vegetation
Oa13	761.25	2.5	O2 absorption band/aerosol corr.
Oa14	764.375	3.75	Atmospheric correction
Oa15	767.5	2.5	O2A used for cloud top pressure, fluorescence over land
Oa16	778.75	15	Atmos. corr./aerosol corr.
Oa17	865	20	Atmos. corr./aerosol corr., clouds, pixel co-registration
Oa18	885	10	Water vapour absorption reference band. Common reference band with SLSTR instrument. Vegetation monitoring
Oa19	900	10	Water vapour absorption/vegetation monitoring (max. reflectance)
Oa20	940	20	Water vapour absorption, atmos./aerosol corr.
Oa21	1 020	40	Atmos./aerosol corr.

Band characteristics of the SENTINEL-3 Ocean and Land Colour Instrument (OLCI)

ANNEX 4: Sentinel-3 SLSTR instrument characteristics

- swath width: dual view scan, 1 420 km (nadir) / 750 km (backwards)
- spatial sampling: 500 m (VIS, SWIR), 1 km (MWIR, TIR)
- spectrum: nine bands [0.55-12] μm

The nine The radiometric bands in VNIR/SWIR/TIR of SLSTR are presented in the table below:

Band	λ centre (μm)	Width (μm)	Function	Comments		Res. (m)
S1	0.555	0.02	Cloud screening, vegetation monitoring, aerosol	Visible Near IR	Solar reflectance bands	500
S2	0.659	0.02	NDVI, vegetation monitoring, aerosol			
S3	0.865	0.02	NDVI, cloud flagging, Pixel co-registration			
S4	1.375	0.015	Cirrus detection over land	Short-Wave IR		
S5	1.61	0.06	Cloud clearing, ice, snow, vegetation monitoring			
S6	2.25	0.05	Vegetation state and cloud clearing			
S7	3.74	0.38	SST, LST, Active fire	Thermal infra-red Ambient bands (200 K - 320 K)		1000
S8	10.85	0.9	SST, LST, Active fire			
S9	12	1	SST, LST			
F1	3.74	0.38	Active fire	Thermal infra-red fire emission bands		
F2	10.85	0.9	Active fire			

The radiometric bands of SLSTR, F1 and F2 fire bands are based on the same detectors as S7 and S8 but with an increased dynamic range to prevent saturation over fires.