European Commission

Copernicus for **High resolution mapping of water quality**

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Space

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Marine Monitoring

Monitoring of sea waters in coastal areas

European Directives

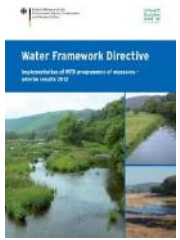
- ✓ Water Framework Directive (WFD)
- ✓ Marine Strategy Framework Directive (MSFD)
- ✓ Recommendation on Integrated Coastal Zone Management
- ✓ Bathing Water, Habitats (Natura2000), …

National regulations on productive activities in coastal areas

- ✓ Water waters treatment plants, Desalination plants
- ✓ Building and dredging activities (e.g. oil&gas)
- ✓ Aquaculture, …

Protect/improve productive activities in coastal areas

- ✓ Aquaculture
- ✓ Desalination plants, …



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Monitoring of coastal areas

Need for monitoring the "water quality" through a set of parameters, which are directly or indirectly referred within regulations.

Current practices mostly based on survey campaigns at sea. Commonly recognized gaps:

- ✓ **Very large marine areas to monitor**
- ✓ **Constant and frequent monitoring required**
- ✓ **Measurement/sampling costly and time/space limited**

Example of relevant parameters for water quality monitoring in coastal areas:

- ✓ Eutrophication (chlorophyll-a, water transparency,…)
- ✓ Aquaculture (chlorophyll-a, turbidity, algae bloom,…)
- ✓ Waste waters treatment plants (chlorophyll-a, suspended matter,…)
- ✓ Dredging activities (turbidity, suspended sediments,…)

Required measurements in proximity of the coast

Remote sensing of Water Quality

20 years of water quality measurements from Earth Observation (EO)

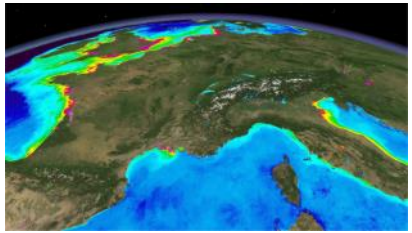
Large area coverage

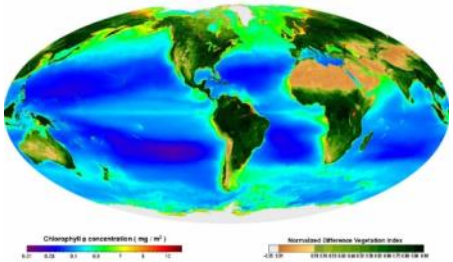
High temporal frequency

Scientific community recognizes its value

Main limitation for coastal areas

Spatial resolution too low (300m-1km) for monitoring in proximity to the coast





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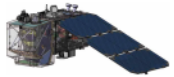
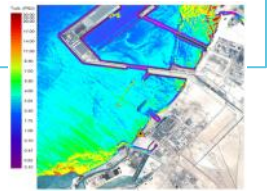
High resolution monitoring of Water Quality

Copernicus Sentinel-2



- Covers all the European coastal areas and the whole Mediterranean sea
- Spatial resolution of 10 to 20m
- Repetition frequency of <5 days (full constellation)

Empirical algorithms for high resolution water quality mapping developed for Landsat and/or very high resolution satellites (e.g. Pléiades, Worldview-2/3/4, etc.).



High resolution and high frequency

mapping of water quality parameters like:

- Chlorophyll-a concentration
- Water turbidity

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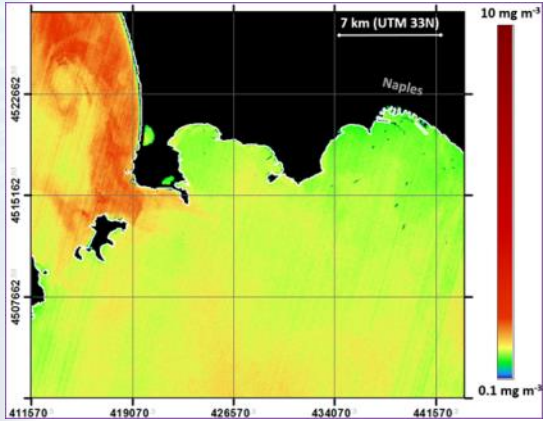
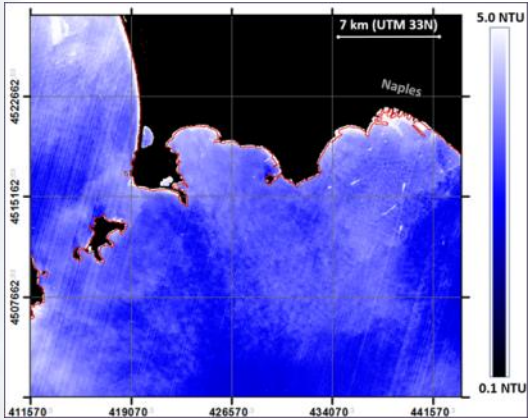
Useful data



Chlorophyll-a concentration at 10m



Turbidity at 10m

D E M O

DEMO

D E M O

Software used:

ESA -SNAP

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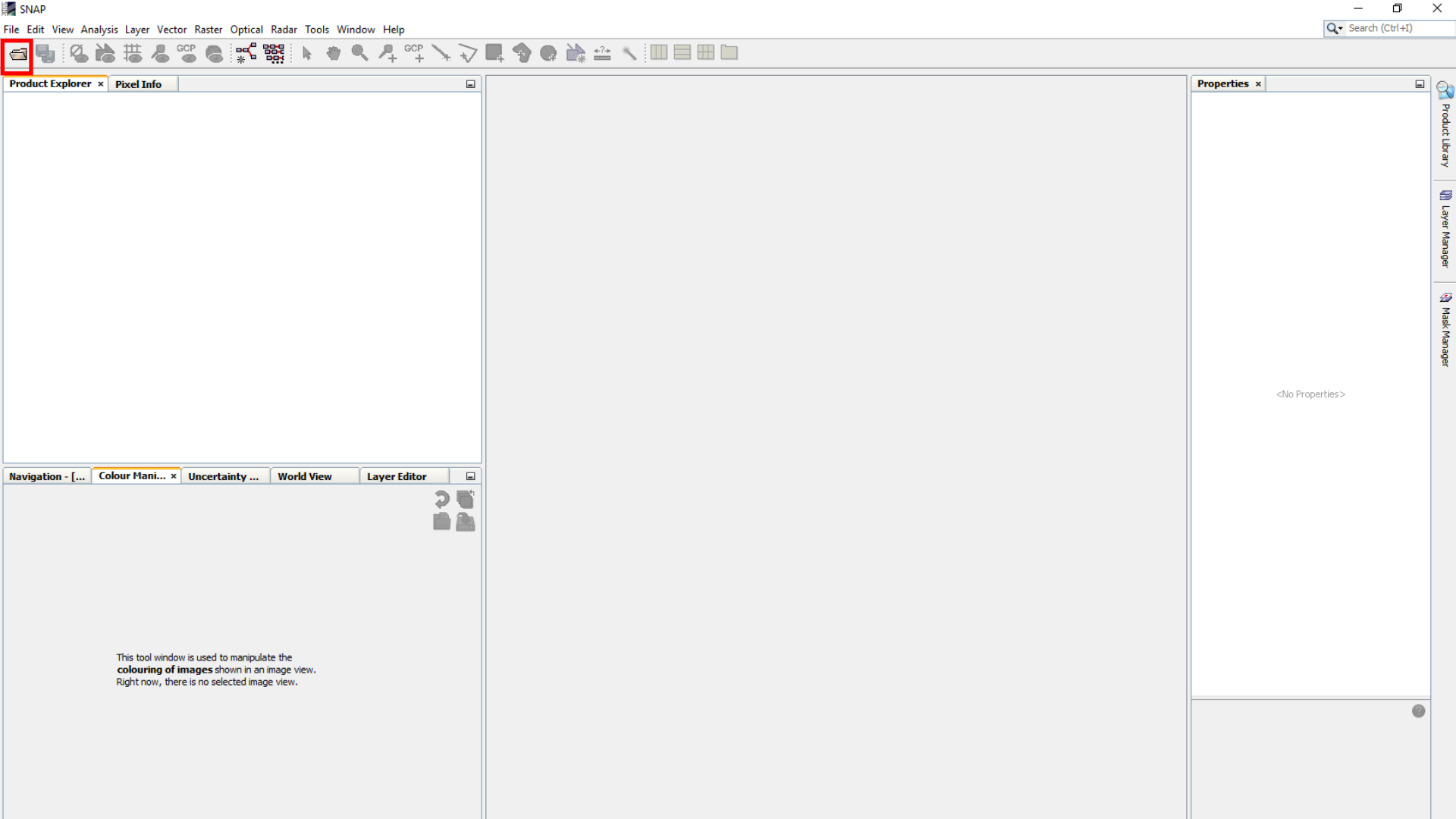
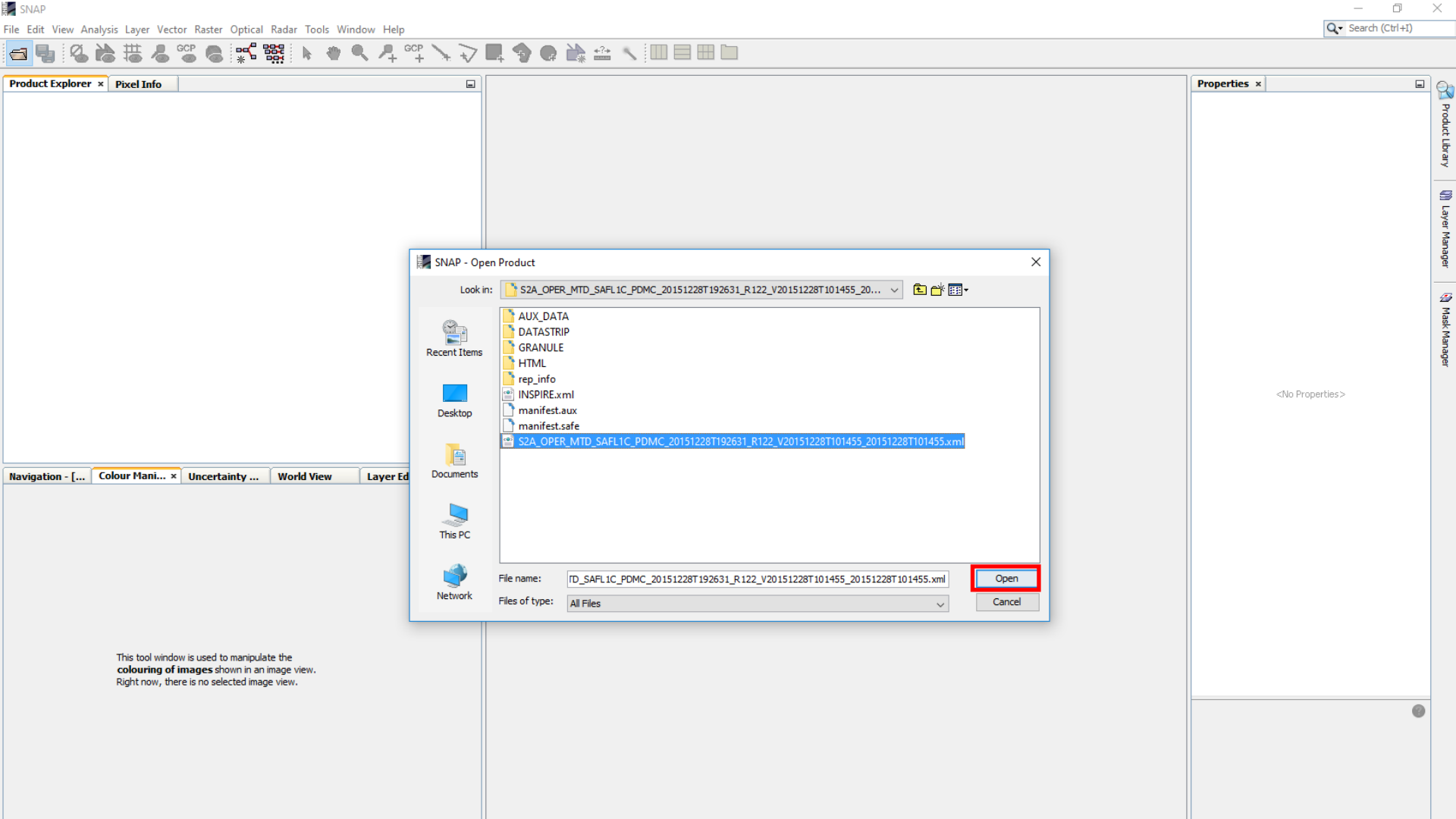
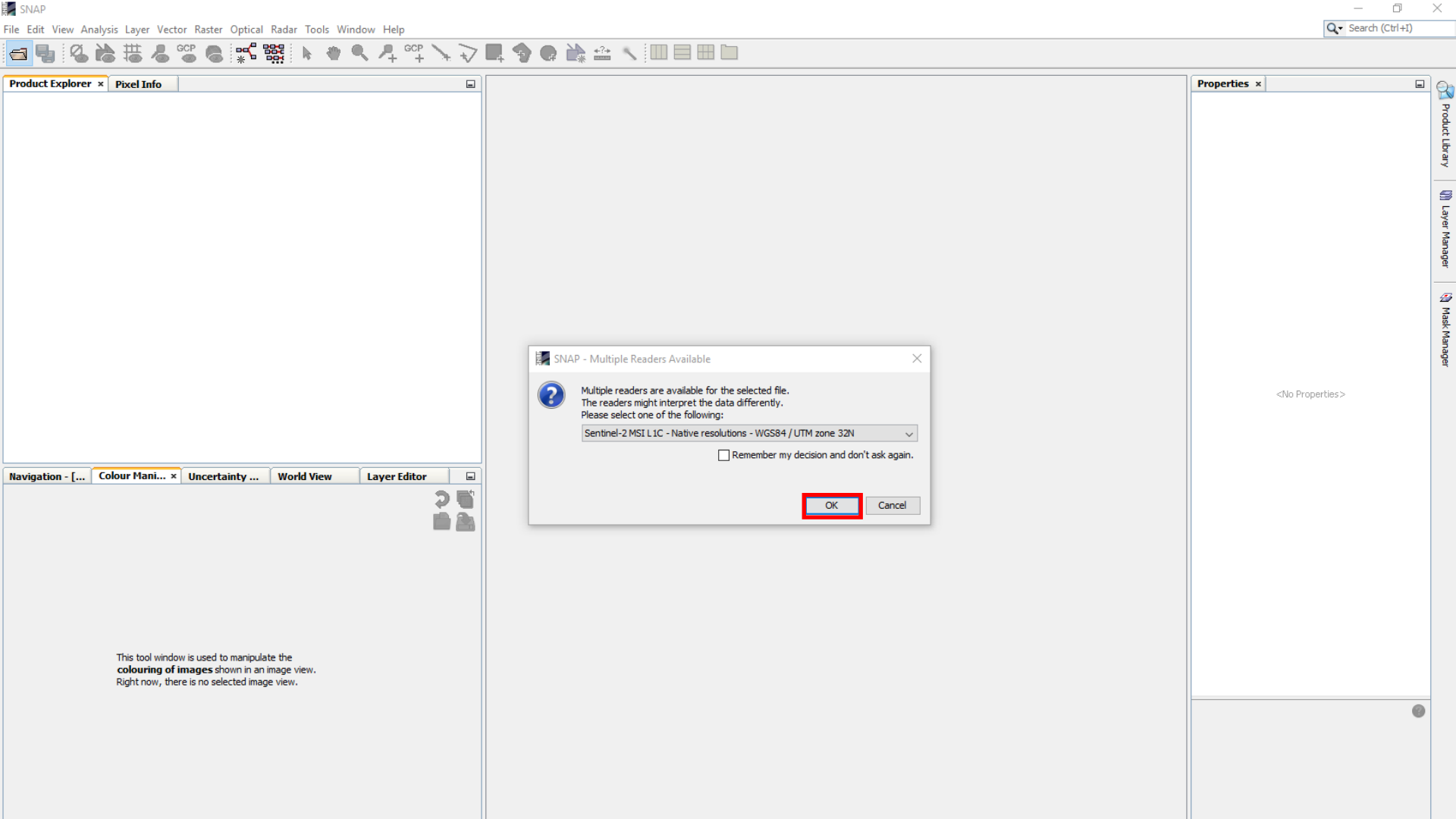
D E M O

Data used:

- Sentinel-2 image, acquired the 28th December 2015 on the Italian coast (Tyrrhenian sea)


SNAP
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Search (Ctrl+I)
Product Explorer
Pixel Info
Navigation - [...
Colour Mani...
Uncertainty ...
World View
Layer Editor
This tool window is used to manipulate the
colouring of images shown in an image view.
Right now, there is no selected image view.
Properties
<No Properties>
Product Library
Layer Manager
Mask Manager


SNAP
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Search (Ctrl+I)
Product Explorer
Pixel Info
Navigation - [...
Colour Mani...
Uncertainty ...
World View
Layer Ed
This tool window is used to manipulate the
colouring of images shown in an image view.
Right now, there is no selected image view.
Properties
<No Properties>
Product Library
Layer Manager
Mask Manager
SNAP - Open Product
Look in:
S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20...
Recent Items
Desktop
Documents
This PC
Network
AUX_DATA
DATASTRIP
GRANULE
HTML
rep_info
INSPIRE.xml
manifest.aux
manifest.safe
S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455.xml
File name:
TD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455.xml
Files of type:
All Files
Open
Cancel


SNAP
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Search (Ctrl+I)
Product Explorer
Pixel Info
Navigation - [...
Colour Mani...
Uncertainty ...
World View
Layer Editor
This tool window is used to manipulate the
colouring of images shown in an image view.
Right now, there is no selected image view.
SNAP - Multiple Readers Available
Multiple readers are available for the selected file.
The readers might interpret the data differently.
Please select one of the following:
Sentinel-2 MSI L1C - Native resolutions - WGS84 / UTM zone 32N
Remember my decision and don't ask again.
OK
Cancel
Properties
<No Properties>
Product Library
Layer Manager
Mask Manager

S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455 - [T:\vito\EUROGI\S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455.SAFE\S2A_OPER_MTD_SAFL1C_PDMC_20151228

File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help

Open Image Window
Open RGB Image Window
Open HSV Image Window
Open Metadata Window
Open Placemark Window
Tile Horizontally
Tile Vertically
Tile Evenly
Tile Single
New Workspace... Ctrl+W
Configure Window
Reset Windows
Go to Previous Window
Close Document
Close All Documents
Close Other Documents

Product Explorer | Pixel Info

[1] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V2015
- Metadata
- Vector Data
- Bands
  - sun
  - view
  - B1 (443 nm)
  - B2 (490 nm)
  - B3 (560 nm)
  - B4 (665 nm)
  - B5 (705 nm)
  - B6 (740 nm)
  - B7 (783 nm)
  - B8 (842 nm)
  - B8A (865 nm)
  - B9 (945 nm)
  - B10 (1375 nm)
  - B11 (1610 nm)
  - B12 (2190 nm)
- Masks

Navigation | Colour Mani... | Uncertainty ... | World View | Layer Editor

This tool window is used to manipulate the **colouring of images** shown in an image view.
Right now, there is no selected image view.

X -- Y --

S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455 - [T:\vito\EUROGI\S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455.SAFE\S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101...

File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help

Search (Ctrl+I)

Product Explorer | **Pixel Info**

- [1] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455
  - Metadata
  - Vector Data
  - Bands
    - sun
    - view
    - B1 (443 nm)
    - B2 (490 nm)
    - B3 (560 nm)
    - B4 (665 nm)
    - B5 (705 nm)
    - B6 (740 nm)
    - B7 (783 nm)
    - B8 (842 nm)
    - B8A (865 nm)
    - B9 (945 nm)
    - B10 (1375 nm)
    - B11 (1610 nm)
    - B12 (2190 nm)
  - Masks

Navigation | **Colour Mani...** | **Uncertainty ...** | **World View** | **Layer Editor**

This tool window is used to manipulate the **colouring of images** shown in an image view.
Right now, there is no selected image view.

Select RGB-Image Channels

Profile: Sentinel 2 MSI Natural Colors

Red: B4

Green: B3

Blue: B2

☐ Store RGB channels as virtual bands in current product

OK | Cancel | Help

B4 (665 nm) - Properties

Product Node Properties	
Name	B4
Description	Reflectance in band B4
Modified	☐
Raster Band Properties	
Unit	dl
Data Type	uint16
Raster size	20976 x 30978
Valid-Pixel Expression	B4.raw > 0
No-Data Value Used	☐
No-Data Value	0.0
Spectral Wavelength	665.0
Spectral Bandwidth	90.0
Ancillary Variables	
Ancillary Relations	

B4 (665 nm)

Reflectance in band B4, 665.0 nm, +/-45.0 nm, 20976 x 30978 pixels, (dl)

Product Library | Layer Manager | Mask Manager

S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455 - [T:\vito\EUROGI\S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455.SAFE\S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101...

File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help

Search (Ctrl+I)

Product Explorer × Pixel Info

- [1] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455
  - Metadata
  - Vector Data
  - Bands
    - sun
    - view
    - B1 (443 nm)
    - B2 (490 nm)
    - B3 (560 nm)
    - B4 (665 nm)
    - B5 (705 nm)
    - B6 (740 nm)
    - B7 (783 nm)
    - B8 (842 nm)
    - B8A (865 nm)
    - B9 (945 nm)
    - B10 (1375 nm)
    - B11 (1610 nm)
    - B12 (2190 nm)
  - Masks

Navigation - [... | Colour Mani... × | Uncertainty ... | World View | Layer Editor

Red Green Blue

Name: B4
Unit: dl
Min: 2.0
Max: 25386.0
Rough statistics!

95% 100%

497.78 7934.5

More Options

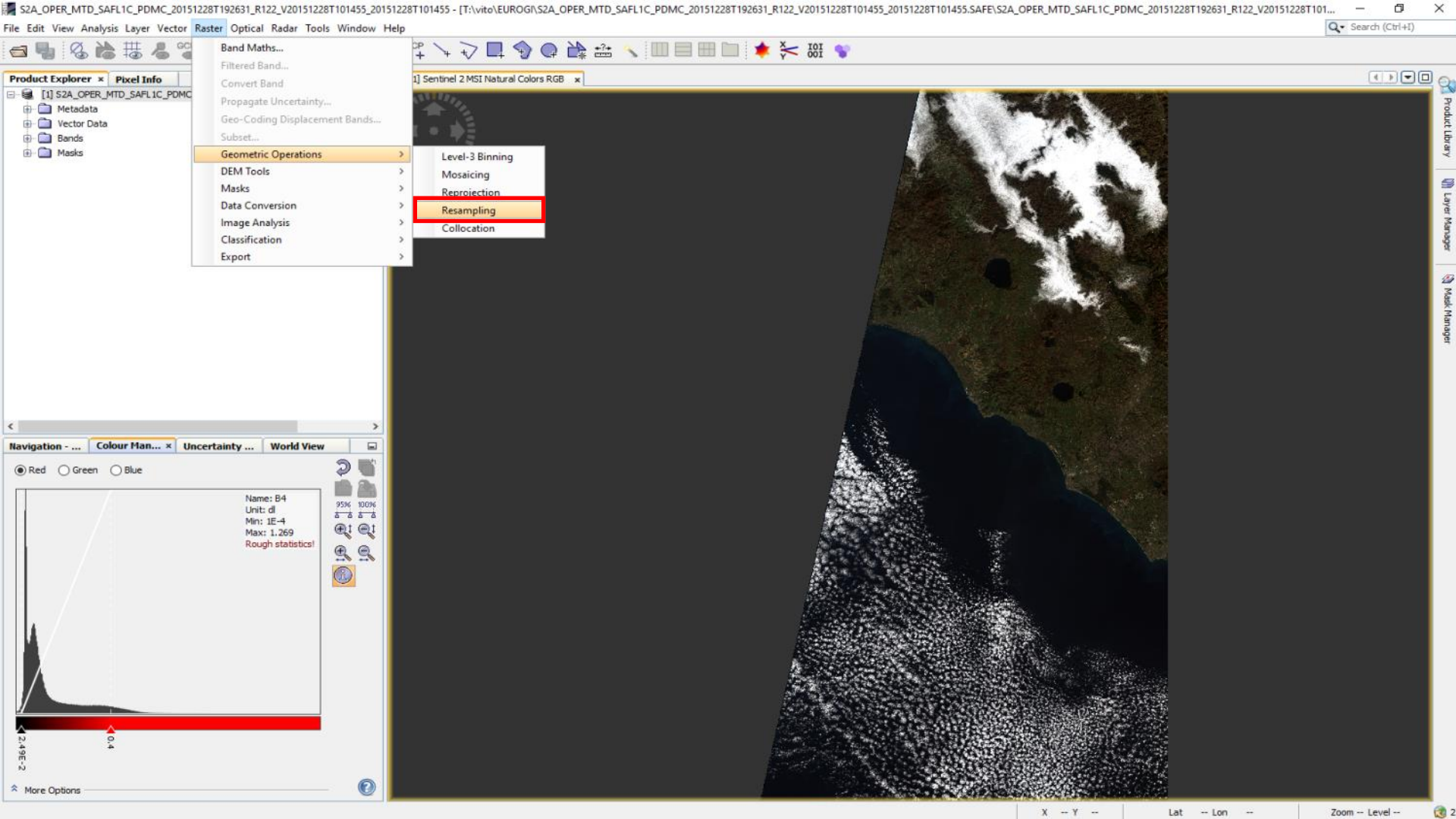
[1] Sentinel 2 MSI Natural Colors RGB ×

No Properties ×

<No Properties>

Product Library | Layer Manager | Mask Manager

X 1672 Y 7480 | Lat 42°40'14" N Lon 10°25'28" E | Zoom 1:353.6 Level 4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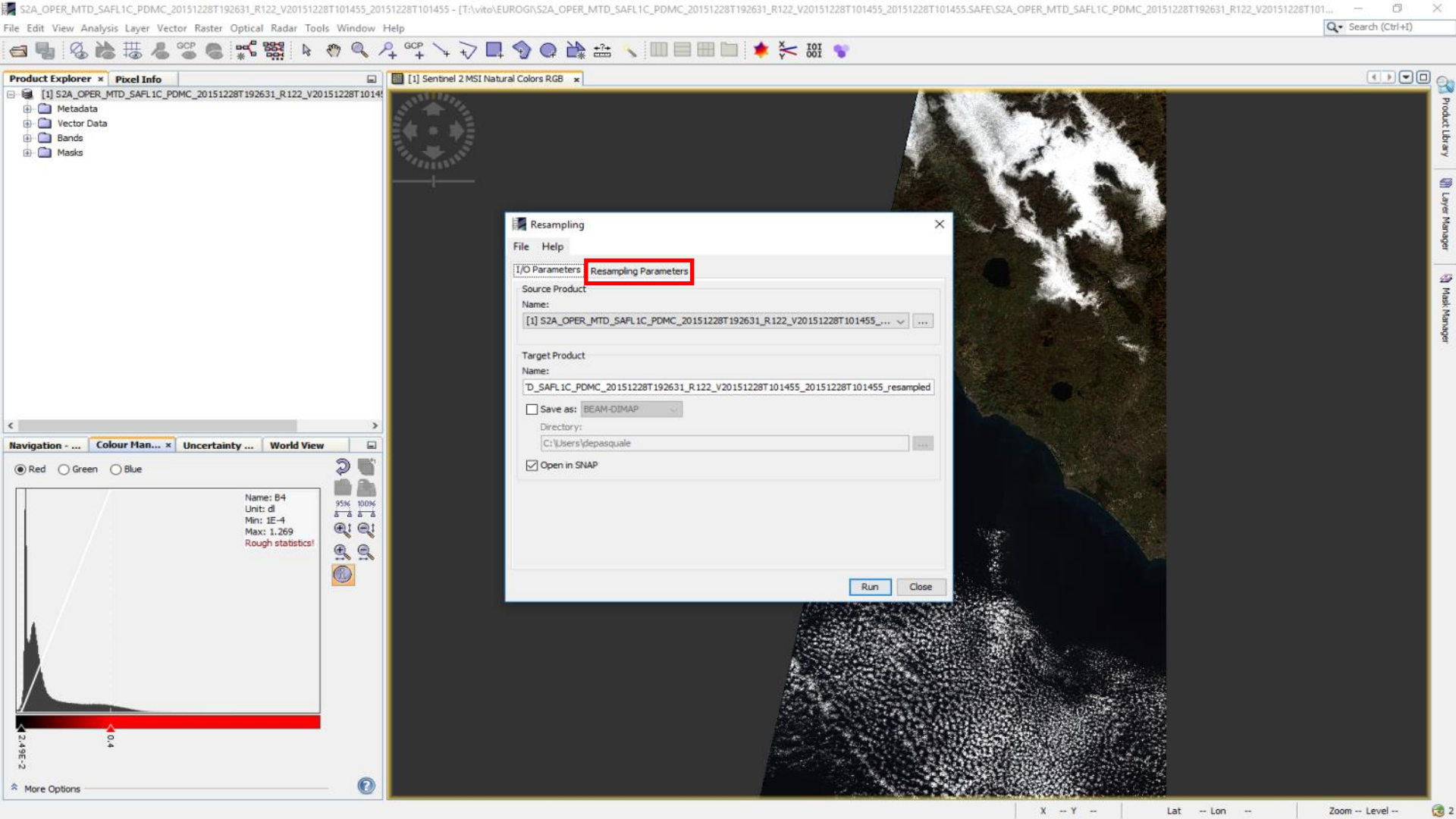
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Search (Ctrl+I)
Band Maths...
Filtered Band...
Convert Band
Propagate Uncertainty...
Geo-Coding Displacement Bands...
Subset...
Geometric Operations
DEM Tools
Masks
Data Conversion
Image Analysis
Classification
Export
Level-3 Binning
Mosaicing
Reprojection
Resampling
Collocation
Product Explorer
Pixel Info
[1] S2A_OPER_MTD_SAFL1C_PDMC
Metadata
Vector Data
Bands
Masks
[1] Sentinel 2 MSI Natural Colors RGB
Navigation - ...
Colour Man...
Uncertainty ...
World View
Red
Green
Blue
Name: B4
Unit: dl
Min: 1E-4
Max: 1.269
Rough statistics!
2.49E-2
0.4
More Options
Product Library
Layer Manager
Mask Manager
X -- Y --
Lat -- Lon --
Zoom -- Level --


File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Product Explorer
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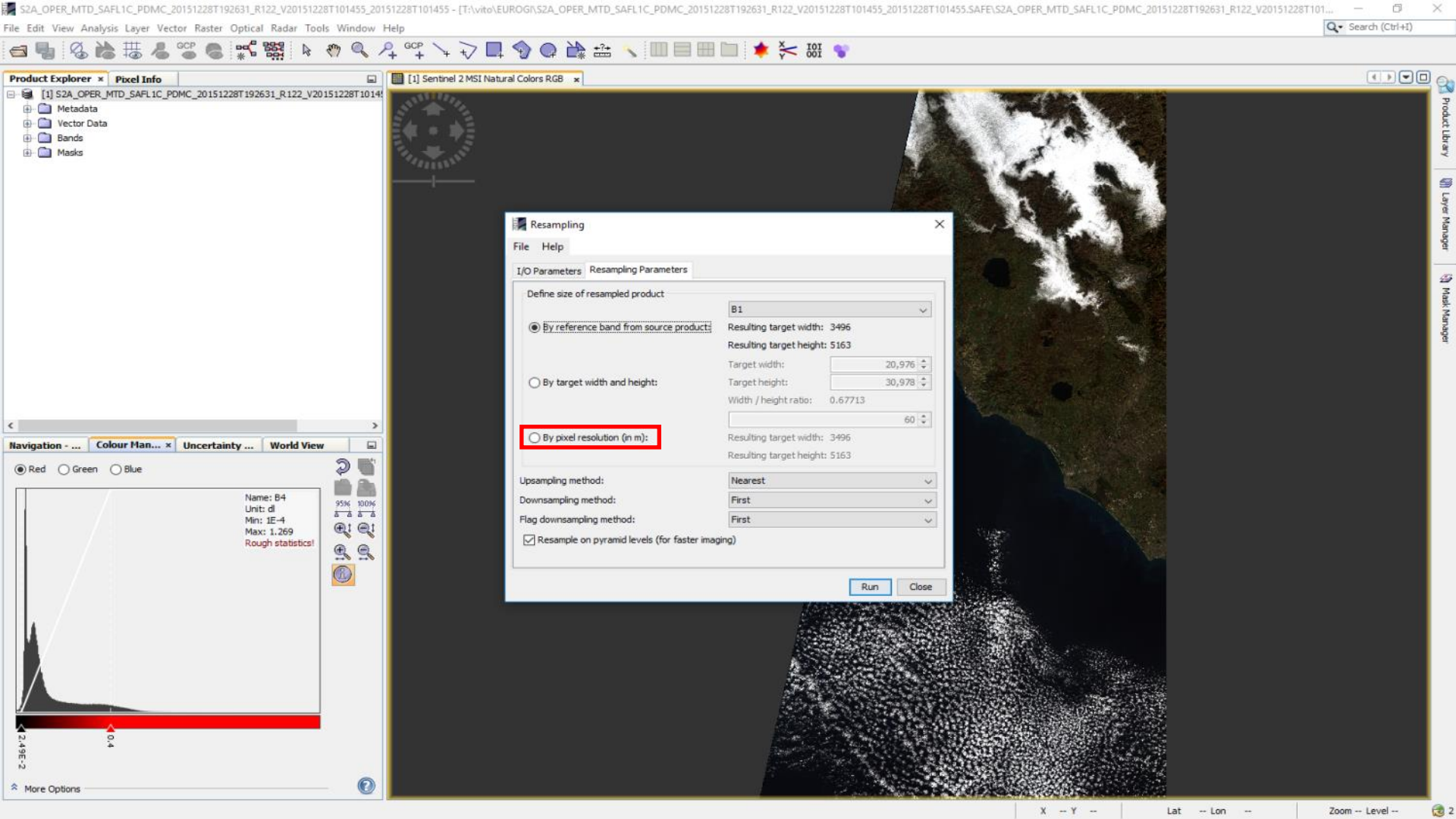
Metadata
Vector Data
Bands
Masks
[1] Sentinel 2 MSI Natural Colors RGB
Navigation - ...
Colour Man...
Uncertainty ...
World View
Red
Green
Blue
Name: B4
Unit: dl
Min: 1E-4
Max: 1.269
Rough statistics!
2.49E-2
0.4
More Options
Resampling
File
Help
I/O Parameters
Resampling Parameters
Source Product
Name:
[1] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_...
Target Product
Name:
D_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
Save as:
BEAM-DIMAP
Directory:
C:\Users\depasquale
Open in SNAP
Run
Close
Product Library
Layer Manager
Mask Manager


S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455 - [T:\vito\EUROGI\S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455.SAFE\S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101...
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Search (Ctrl+I)
Product Explorer
Pixel Info
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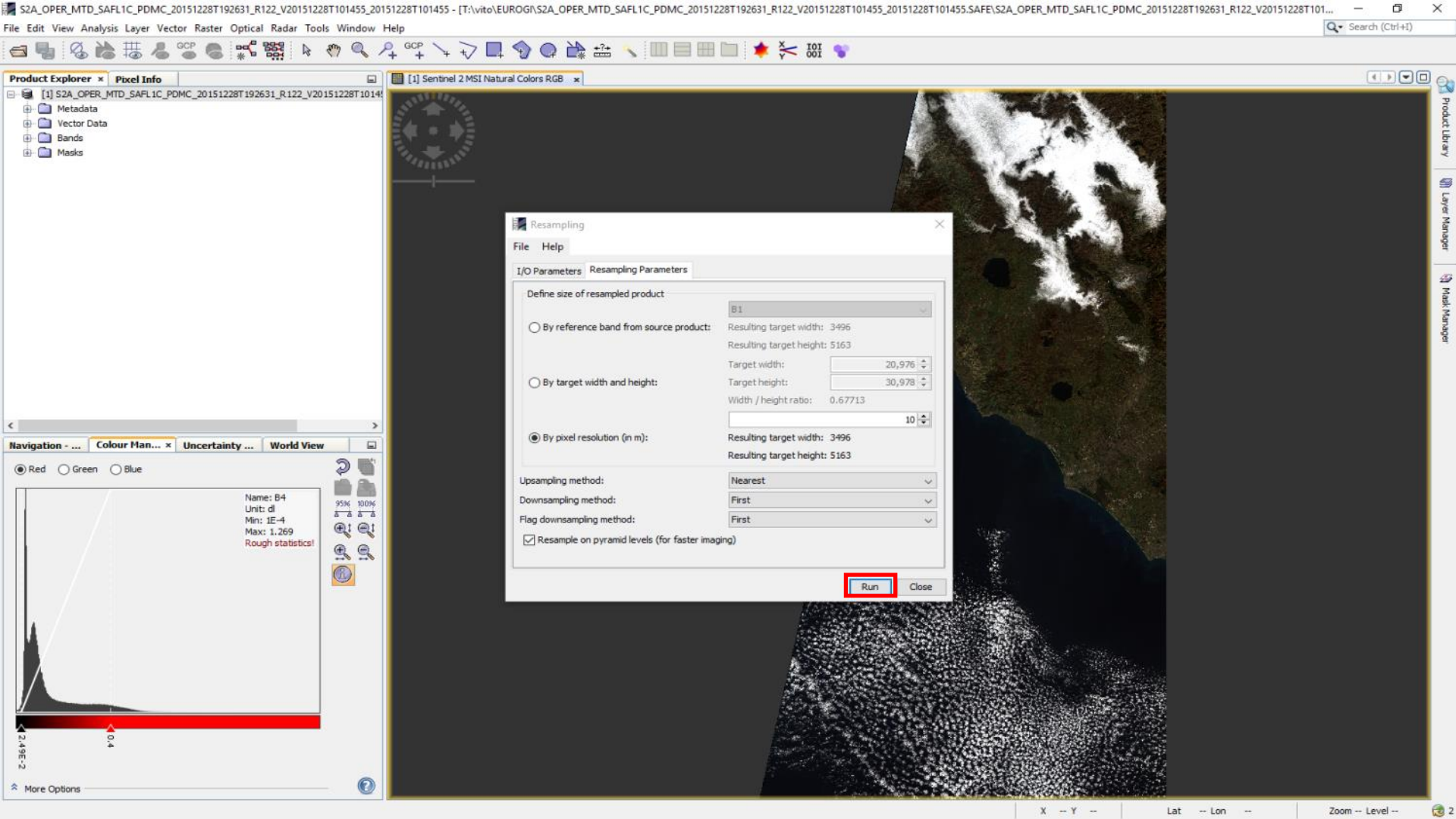
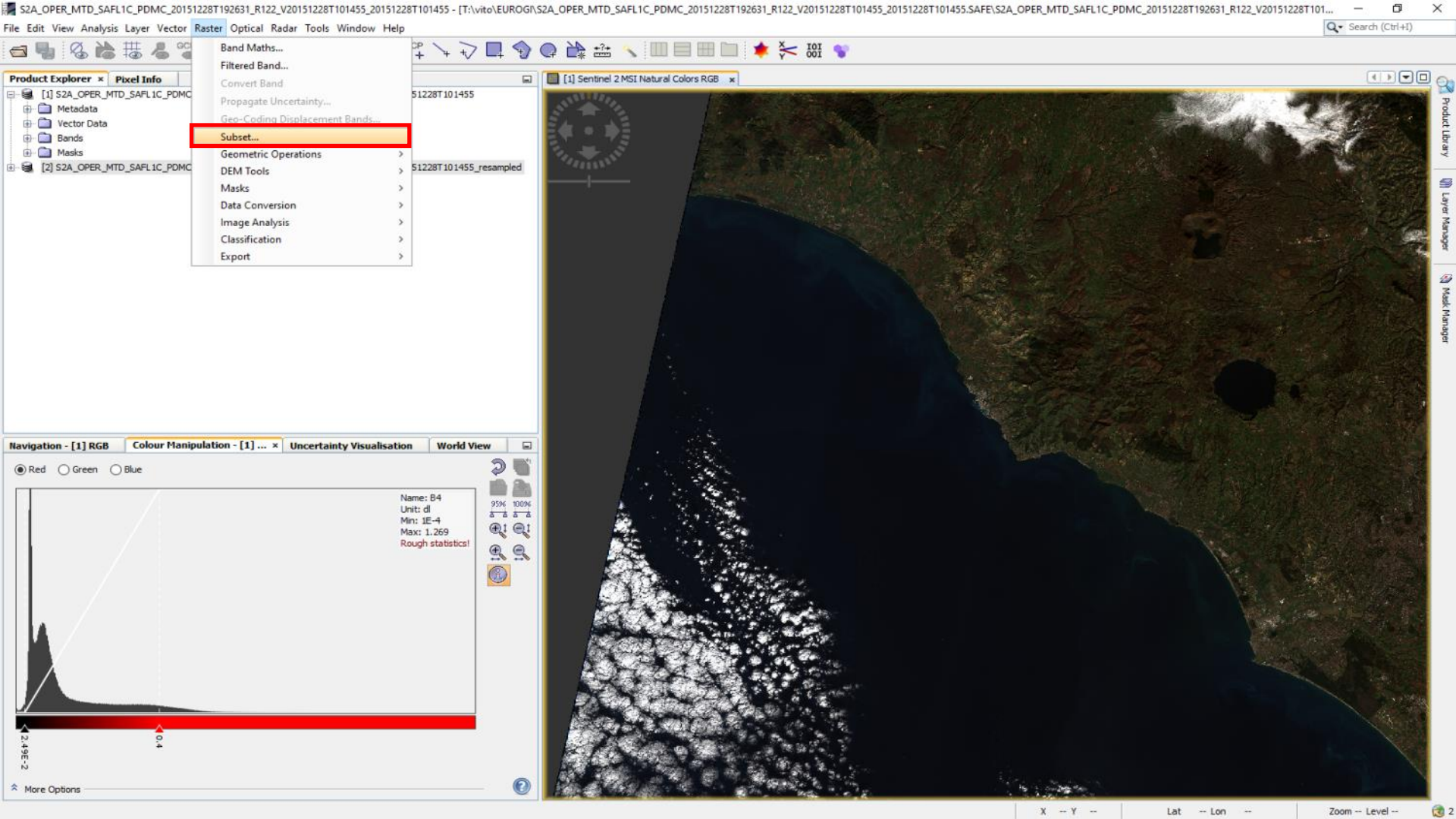
Metadata
Vector Data
Bands
Masks
[1] Sentinel 2 MSI Natural Colors RGB
Navigation - ...
Colour Man...
Uncertainty ...
World View
Red
Green
Blue
Name: B4
Unit: dl
Min: 1E-4
Max: 1.269
Rough statistics!
95%
100%
2.49E-2
0.4
More Options
Resampling
File
Help
I/O Parameters
Resampling Parameters
Define size of resampled product
B1
By reference band from source product:
Resulting target width: 3496
Resulting target height: 5163
By target width and height:
Target width: 20,976
Target height: 30,978
Width / height ratio: 0.67713
By pixel resolution (in m):
60
Resulting target width: 3496
Resulting target height: 5163
Upsampling method: Nearest
Downsampling method: First
Flag downsampling method: First
Resample on pyramid levels (for faster imaging)
Run
Close
Product Library
Layer Manager
Mask Manager
X -- Y --
Lat -- Lon --
Zoom -- Level --


S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455 - [T:\vito\EUROGI\S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455.SAFE\S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101...
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Product Explorer
Pixel Info
[1] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T1014
Metadata
Vector Data
Bands
Masks
[1] Sentinel 2 MSI Natural Colors RGB
Navigation - ...
Colour Man...
Uncertainty ...
World View
Red
Green
Blue
Name: B4
Unit: dl
Min: 1E-4
Max: 1.269
Rough statistics!
2.49E-2
0.4
More Options
Resampling
File
Help
I/O Parameters
Resampling Parameters
Define size of resampled product
B1
By reference band from source product:
Resulting target width: 3496
Resulting target height: 5163
By target width and height:
Target width: 20,976
Target height: 30,978
Width / height ratio: 0.67713
By pixel resolution (in m):
10
Resulting target width: 3496
Resulting target height: 5163
Upsampling method: Nearest
Downsampling method: First
Flag downsampling method: First
Resample on pyramid levels (for faster imaging)
Run
Close
Product Library
Layer Manager
Mask Manager
X -- Y --
Lat -- Lon --
Zoom -- Level --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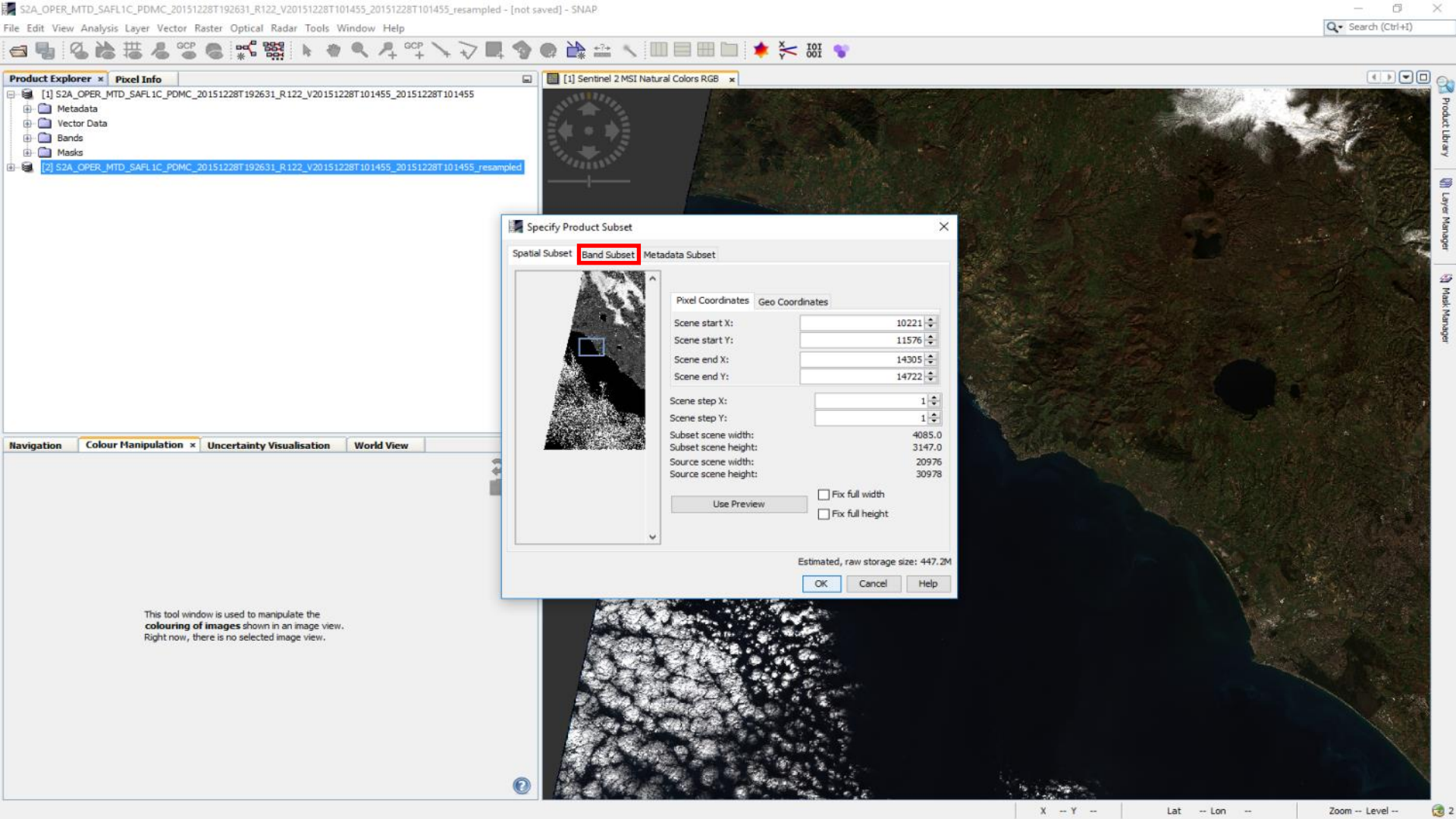
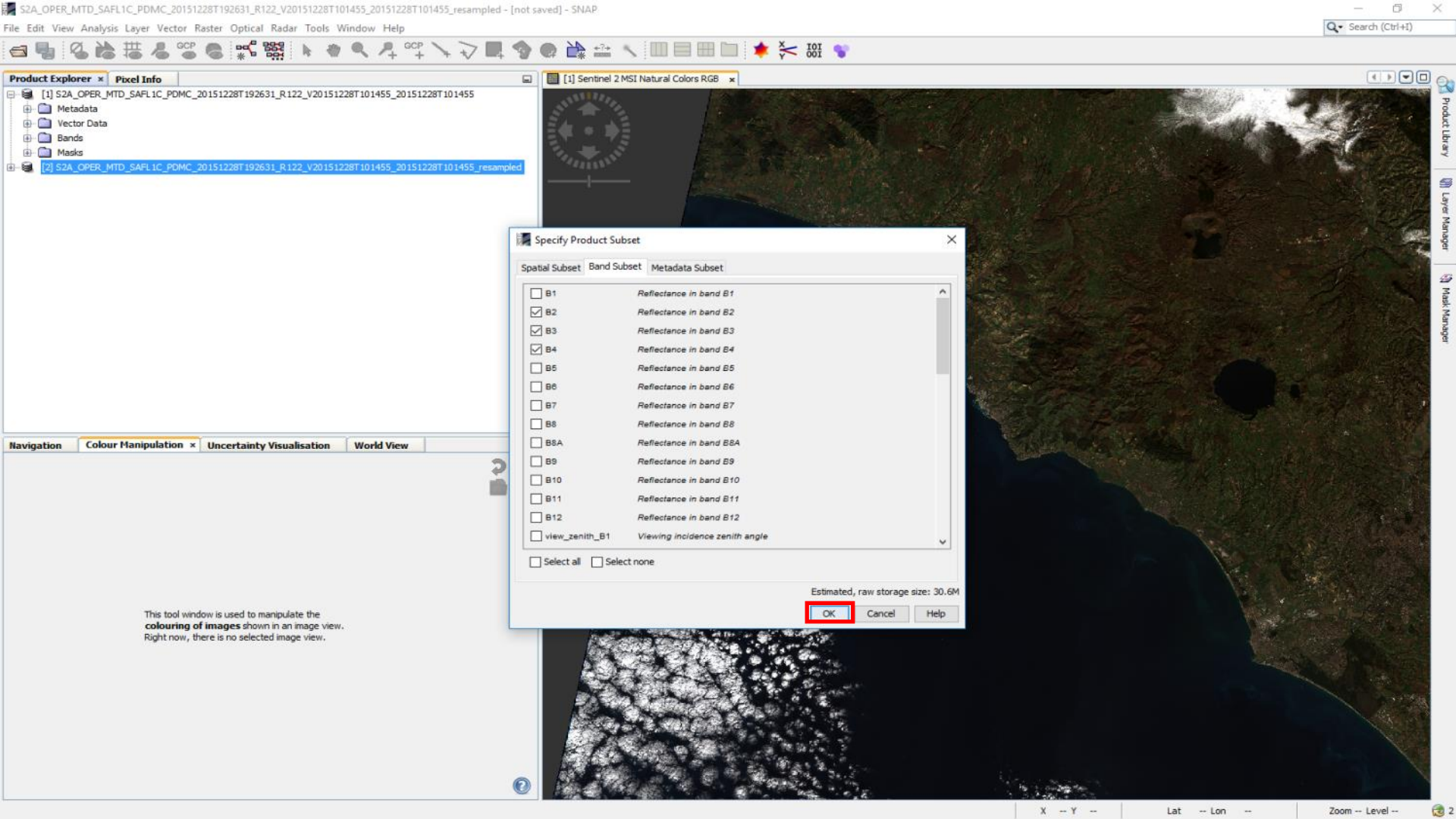
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Search (Ctrl+I)
Band Maths...
Filtered Band...
Convert Band
Propagate Uncertainty...
Geo-Coding Displacement Bands...
Subset...
Geometric Operations
DEM Tools
Masks
Data Conversion
Image Analysis
Classification
Export
Product Explorer
Pixel Info
[1] S2A_OPER_MTD_SAFL1C_PDMC
Metadata
Vector Data
Bands
Masks
[2] S2A_OPER_MTD_SAFL1C_PDMC
51228T101455
51228T101455_resampled
[1] Sentinel 2 MSI Natural Colors RGB
Product Library
Layer Manager
Mask Manager
Navigation - [1] RGB
Colour Manipulation - [1] ...
Uncertainty Visualisation
World View
Red
Green
Blue
Name: B4
Unit: dl
Min: 1E-4
Max: 1.269
Rough statistics!
95%
100%
2.49E-2
0.4
More Options
X -- Y --
Lat -- Lon --
Zoom -- Level --


S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled - [not saved] - SNAP
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Product Explorer
Pixel Info
[1] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455
Metadata
Vector Data
Bands
Masks
[2] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
[1] Sentinel 2 MSI Natural Colors RGB
Navigation
Colour Manipulation
Uncertainty Visualisation
World View
This tool window is used to manipulate the colouring of images shown in an image view.
Right now, there is no selected image view.
Specify Product Subset
Spatial Subset
Band Subset
Metadata Subset
Pixel Coordinates
Geo Coordinates
Scene start X: 10221
Scene start Y: 11576
Scene end X: 14305
Scene end Y: 14722
Scene step X: 1
Scene step Y: 1
Subset scene width: 4085.0
Subset scene height: 3147.0
Source scene width: 20976
Source scene height: 30978
Use Preview
Fix full width
Fix full height
Estimated, raw storage size: 447.2M
OK
Cancel
Help
Product Library
Layer Manager
Mask Manager
X -- Y --
Lat -- Lon --
Zoom -- Level --


S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled - [not saved] - SNAP
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Product Explorer
Pixel Info
[1] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455
Metadata
Vector Data
Bands
Masks
[2] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
[1] Sentinel 2 MSI Natural Colors RGB
Navigation
Colour Manipulation
Uncertainty Visualisation
World View
This tool window is used to manipulate the colouring of images shown in an image view.
Right now, there is no selected image view.
Specify Product Subset
Spatial Subset
Band Subset
Metadata Subset
B1 Reflectance in band B1
B2 Reflectance in band B2
B3 Reflectance in band B3
B4 Reflectance in band B4
B5 Reflectance in band B5
B6 Reflectance in band B6
B7 Reflectance in band B7
B8 Reflectance in band B8
B8A Reflectance in band B8A
B9 Reflectance in band B9
B10 Reflectance in band B10
B11 Reflectance in band B11
B12 Reflectance in band B12
view_zenith_B1 Viewing incidence zenith angle
Select all
Select none
Estimated, raw storage size: 30.6M
OK
Cancel
Help
Product Library
Layer Manager
Mask Manager
X -- Y --
Lat -- Lon --
Zoom -- Level --

subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled - [not saved] - [B4] - SNAP

File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help

Product Explorer | Pixel Info

- [1] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455
  - Metadata
  - Vector Data
  - Bands
  - Masks
- [2] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
- [3] subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_
  - Metadata
  - Vector Data
  - Bands
    - sun
    - B2 (490 nm)
    - B3 (560 nm)
    - B4 (665 nm)

Navigation - [3] RGB | Colour Manipulation - [3] ... | Uncertainty Visualisation | World View

Red Green Blue

Name: B4
Unit: dl
Min: 0.032
Max: 0.455
Rough statistics!

95% 100%

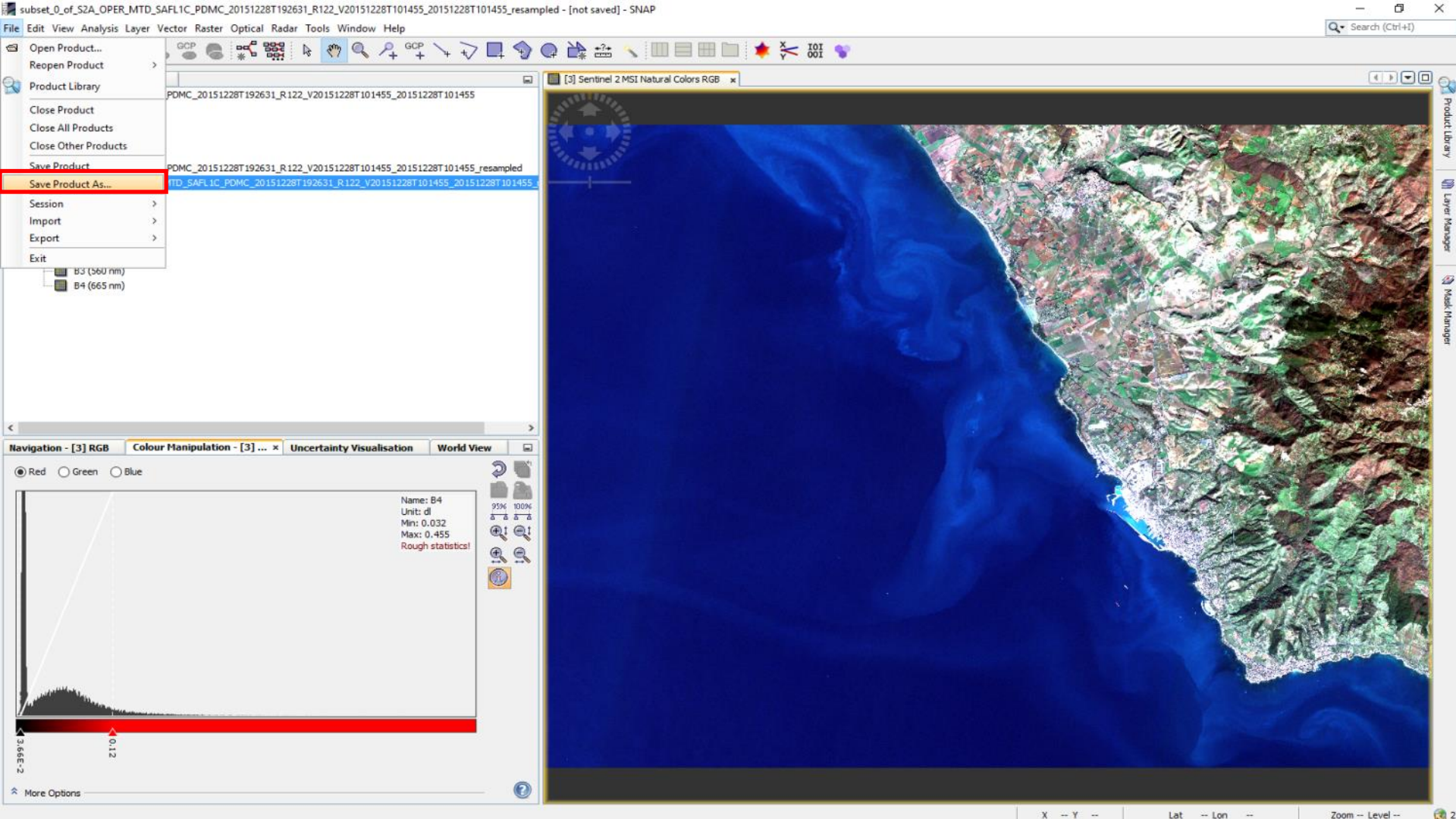
3.66E-2 0.12

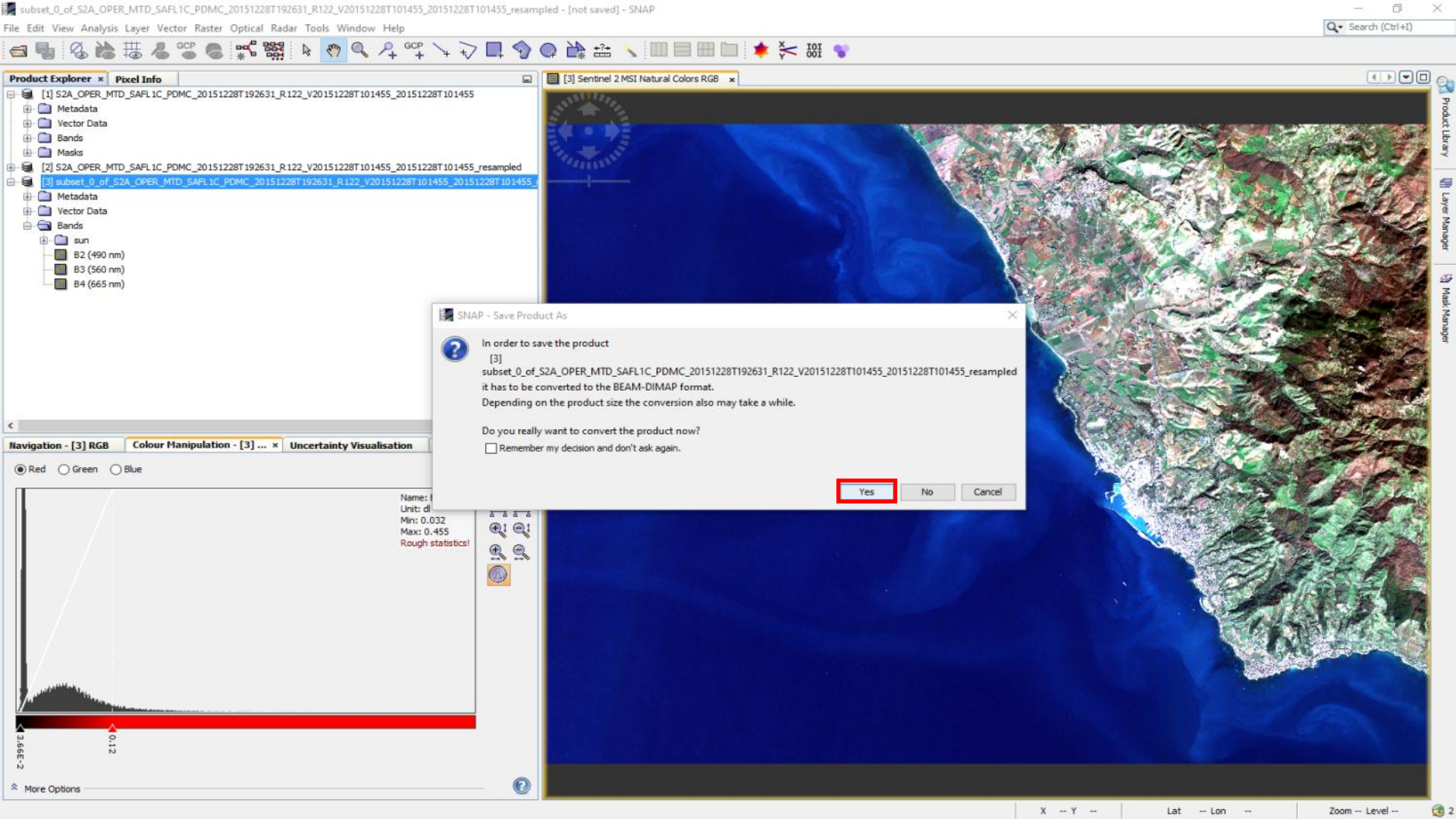
More Options

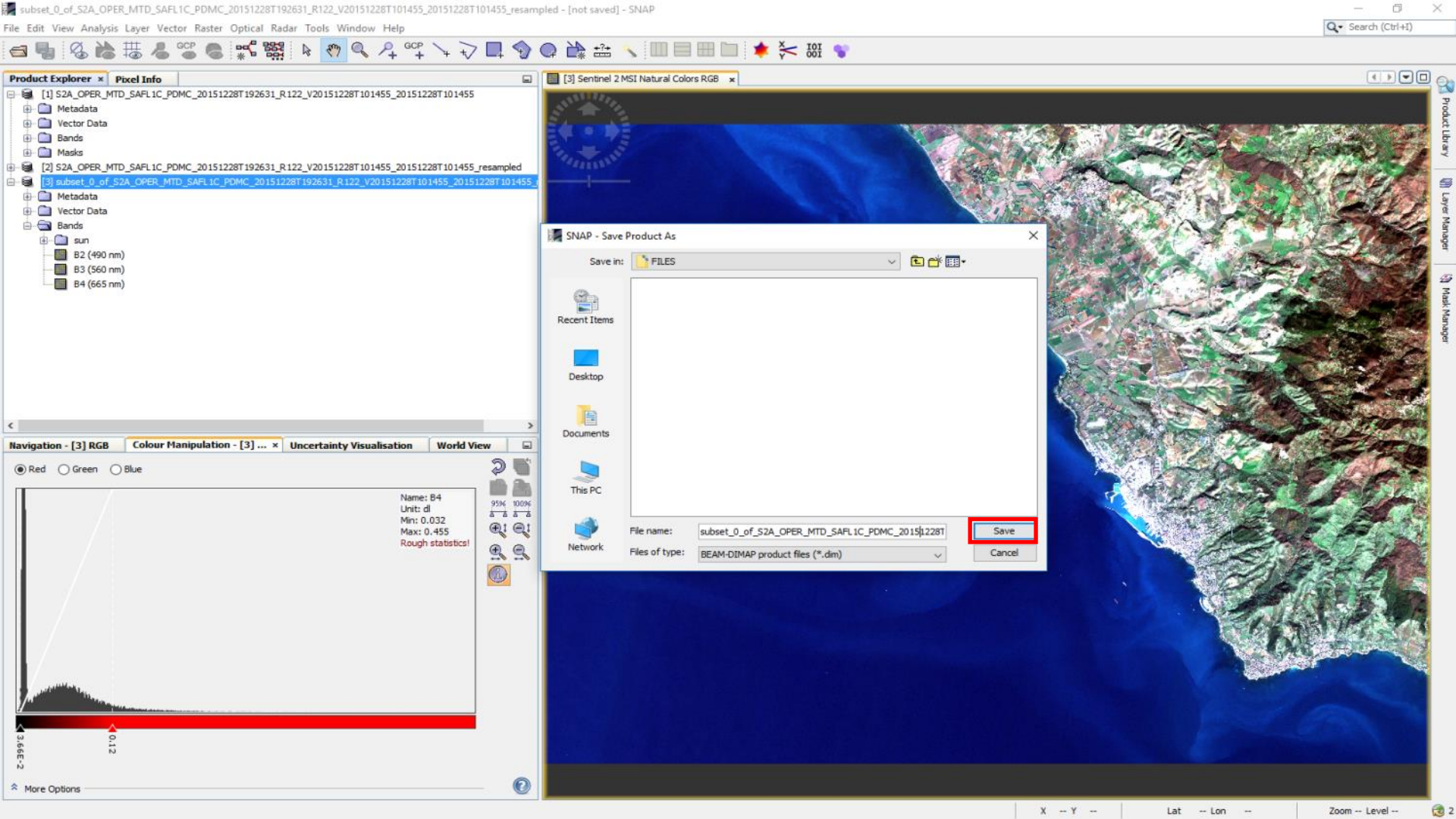
[3] Sentinel 2 MSI Natural Colors RGB

Product Library | Layer Manager | Mask Manager

X -- Y -- Lat -- Lon -- Zoom -- Level --


subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled - [not saved] - SNAP
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Open Product...
Reopen Product
Product Library
Close Product
Close All Products
Close Other Products
Save Product
Save Product As...
Session
Import
Export
Exit
PDMC_20151228T192631_R122_V20151228T101455_20151228T101455
PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
B3 (560 nm)
B4 (665 nm)
[3] Sentinel 2 MSI Natural Colors RGB
Navigation - [3] RGB
Colour Manipulation - [3] ...
Uncertainty Visualisation
World View
Red
Green
Blue
Name: B4
Unit: dl
Min: 0.032
Max: 0.455
Rough statistics!
3.695E-2
0.12
More Options
Product Library
Layer Manager
Mask Manager


subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled - [not saved] - SNAP
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Product Explorer
Pixel Info
[1] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455
Metadata
Vector Data
Bands
Masks
[2] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
[3] subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_
Metadata
Vector Data
Bands
sun
B2 (490 nm)
B3 (560 nm)
B4 (665 nm)
[3] Sentinel 2 MSI Natural Colors RGB
SNAP - Save Product As
In order to save the product
[3]
subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
it has to be converted to the BEAM-DIMAP format.
Depending on the product size the conversion also may take a while.
Do you really want to convert the product now?
Remember my decision and don't ask again.
Yes
No
Cancel
Navigation - [3] RGB
Colour Manipulation - [3] ...
Uncertainty Visualisation
Red
Green
Blue
Min: 0.032
Max: 0.455
Rough statistics!
3.66E-2
0.12
More Options
Product Library
Layer Manager
Mask Manager
Lat -- Lon --
Zoom -- Level --


subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled - [not saved] - SNAP
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Product Explorer
Pixel Info
[1] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455
Metadata
Vector Data
Bands
Masks
[2] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
[3] subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_
Metadata
Vector Data
Bands
sun
B2 (490 nm)
B3 (560 nm)
B4 (665 nm)
Navigation - [3] RGB
Colour Manipulation - [3] ...
Uncertainty Visualisation
World View
Red
Green
Blue
Name: B4
Unit: dl
Min: 0.032
Max: 0.455
Rough statistics!
3.66E-2
0.12
More Options
[3] Sentinel 2 MSI Natural Colors RGB
SNAP - Save Product As
Save in:
FILES
Recent Items
Desktop
Documents
This PC
Network
File name:
subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T
Files of type:
BEAM-DIMAP product files (*.dim)
Save
Cancel
Product Library
Layer Manager
Mask Manager
X -- Y --
Lat -- Lon --
Zoom -- Level --

Dark Object Subtraction method

1 – Select a dark pixel

2 – Subtract the dark pixel reflectance from image pixels' reflectances (dark is ~ 1% reflectance)

3 – Transform in remote sensing reflectance

$$R_{rs}^{k} = \frac{\rho_k - (\rho_k^{do} - 0.01)}{\pi}$$

Copernicus Europe's eyes on Earth
European Commission

subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled - [T:\vito\FILES\subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled.dim] - SNAP

File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help

Product Explorer | Pixel Info

Position

Time

Date	No date information	YYYY-MM-DD
Time (UTC)	No time information	HH:MM:SS:mm [AM/PM]

Bands

B2	0.11600	dl
B3	0.06690	dl
B4	0.03860	dl

Tie-Point Grids

Flags

Snap to selected pin

Navigation - [3] RGB | Colour Manipulation - [3] ... | Uncertainty Visualisation | World View

Red Green Blue

Name: B4
Unit: dl
Min: 0.032
Max: 0.455
Rough statistics!

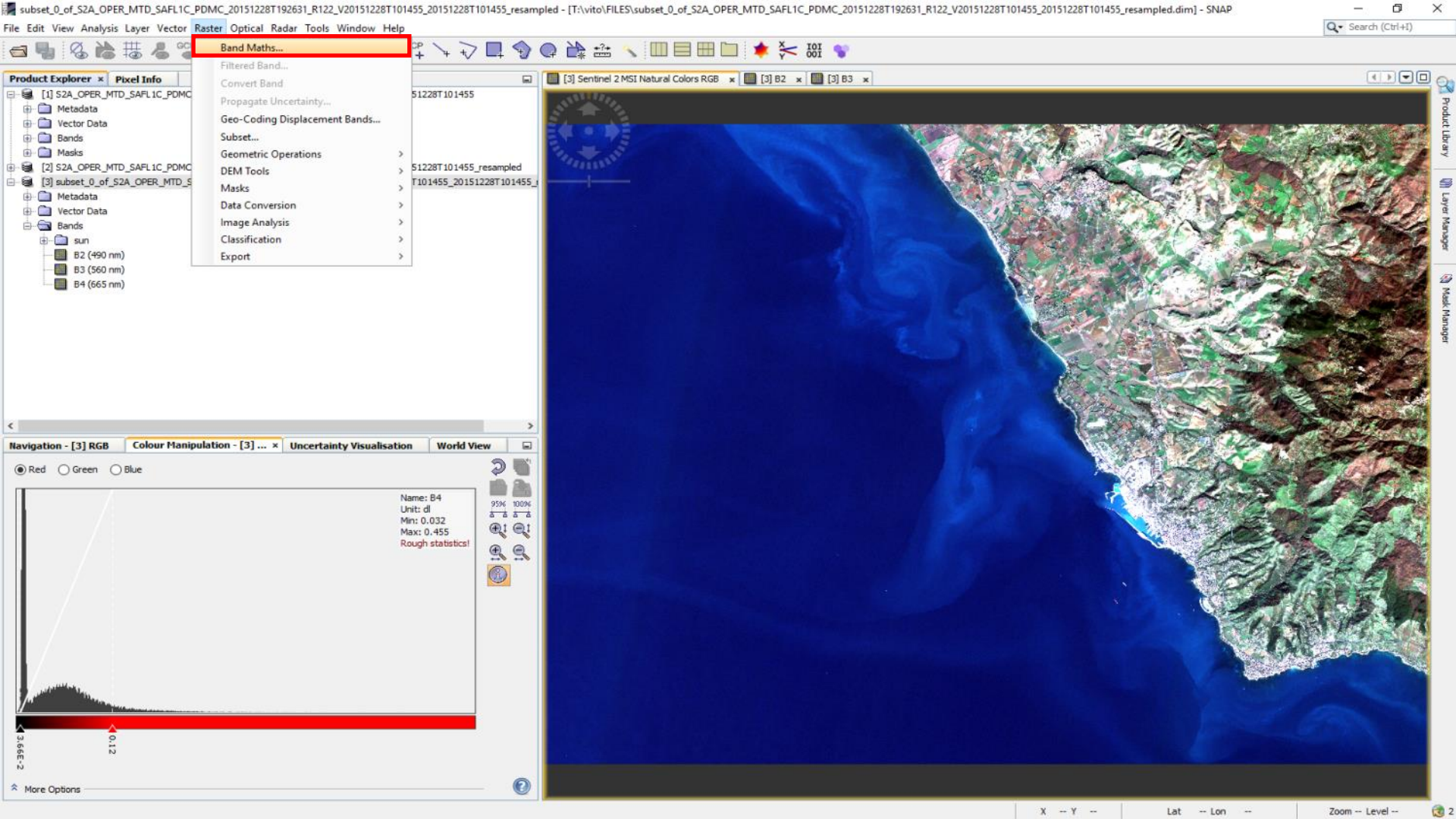
3.695E-2 0.12

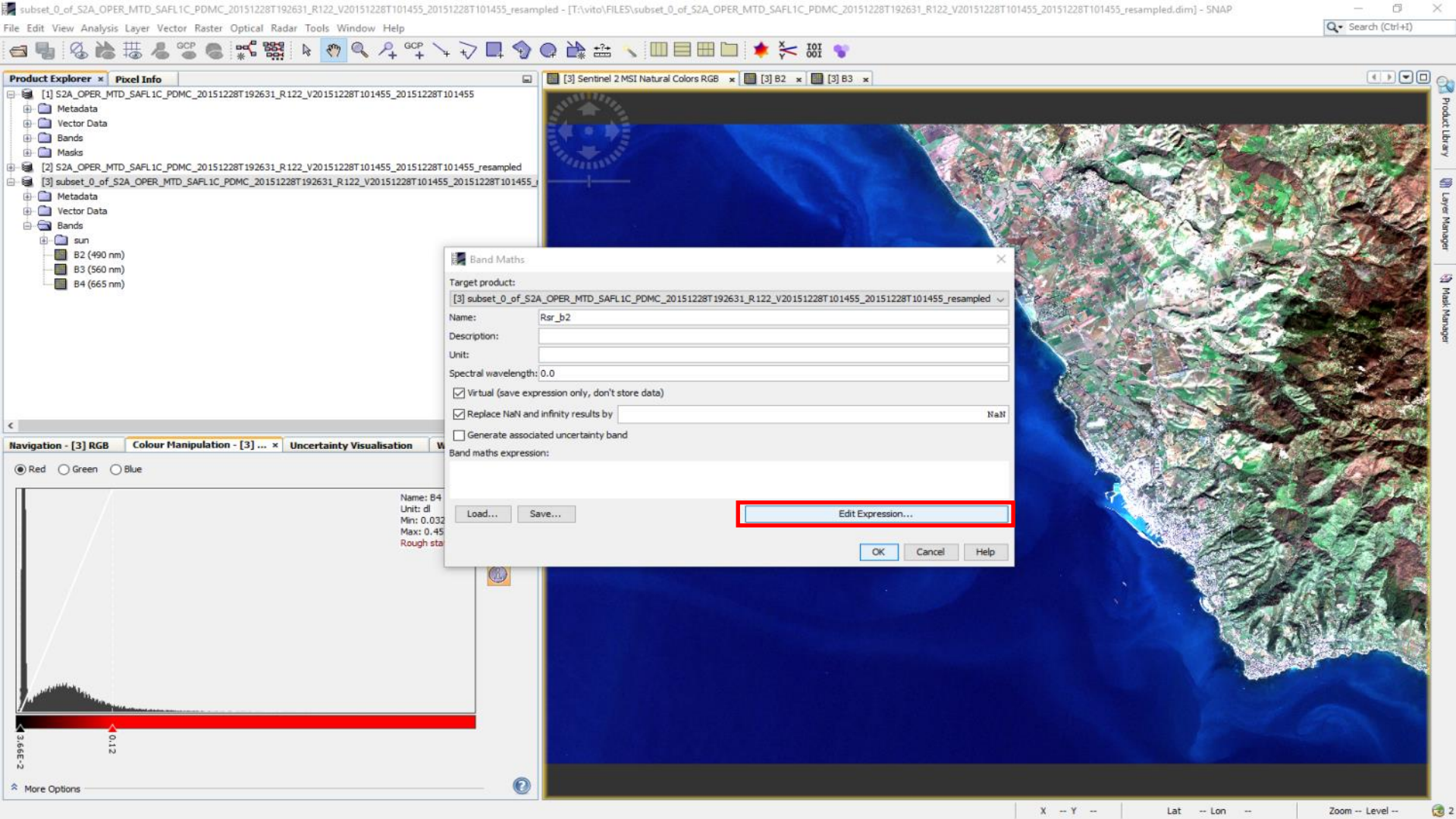
More Options

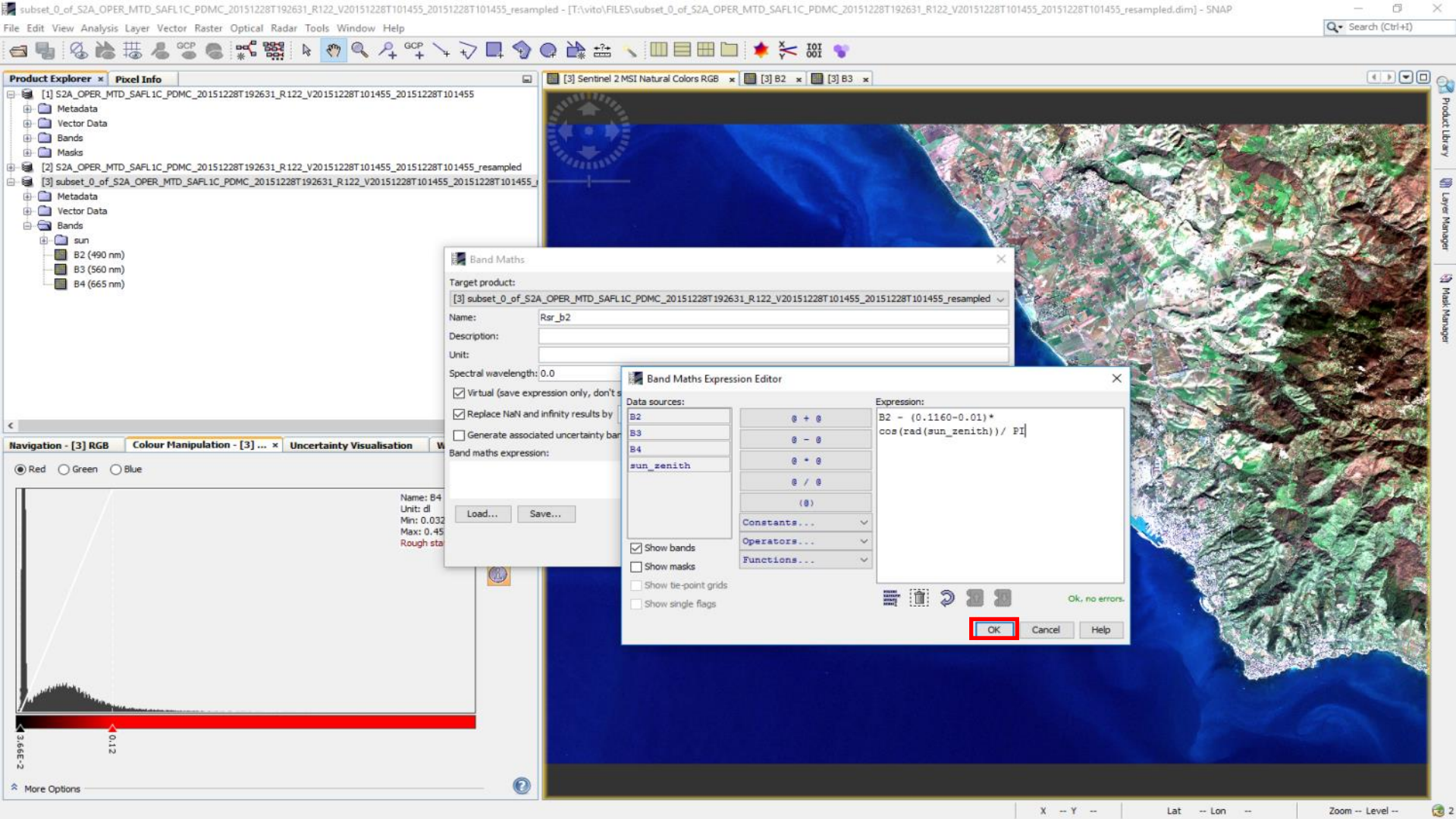
[3] Sentinel 2 MSI Natural Colors RGB | [3] B2 | [3] B3

Product Library | Layer Manager | Mask Manager

X 1157 Y 3019 | Lat 42°00'34" N Lon 11°34'54" E | Zoom 1:40.0 Level 1


subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled - [T:\vito\FILES\subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled.dim] - SNAP
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Search (Ctrl+I)
Band Maths...
Filtered Band...
Convert Band
Propagate Uncertainty...
Geo-Coding Displacement Bands...
Subset...
Geometric Operations
DEM Tools
Masks
Data Conversion
Image Analysis
Classification
Export
Product Explorer
Pixel Info
[1] S2A_OPER_MTD_SAFL1C_PDMC
Metadata
Vector Data
Bands
Masks
[2] S2A_OPER_MTD_SAFL1C_PDMC
[3] subset_0_of_S2A_OPER_MTD_S
Metadata
Vector Data
Bands
sun
B2 (490 nm)
B3 (560 nm)
B4 (665 nm)
[3] Sentinel 2 MSI Natural Colors RGB
[3] B2
[3] B3
Navigation - [3] RGB
Colour Manipulation - [3] ...
Uncertainty Visualisation
World View
Red
Green
Blue
Name: B4
Unit: dl
Min: 0.032
Max: 0.455
Rough statistics!
3.66E-2
0.12
More Options
Product Library
Layer Manager
Mask Manager
X -- Y --
Lat -- Lon --
Zoom -- Level --


subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled - [T:\vito\FILES\subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled.dim] - SNAP
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Product Explorer
Pixel Info
[1] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455
Metadata
Vector Data
Bands
Masks
[2] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
[3] subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_
Metadata
Vector Data
Bands
sun
B2 (490 nm)
B3 (560 nm)
B4 (665 nm)
[3] Sentinel 2 MSI Natural Colors RGB
[3] B2
[3] B3
Band Maths
Target product:
[3] subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
Name: Rsr_b2
Description:
Unit:
Spectral wavelength: 0.0
Virtual (save expression only, don't store data)
Replace NaN and infinity results by NaN
Generate associated uncertainty band
Band maths expression:
Load...
Save...
Edit Expression...
OK
Cancel
Help
Navigation - [3] RGB
Colour Manipulation - [3] ...
Uncertainty Visualisation
Red
Green
Blue
Name: B4
Unit: dl
Min: 0.032
Max: 0.45
Rough sta
3.66E-2
0.12
More Options
Product Library
Layer Manager
Mask Manager
X -- Y --
Lat -- Lon --
Zoom -- Level --


subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled - [T:\vito\FILES\subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled.dim] - SNAP
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Product Explorer
Pixel Info
[1] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455
Metadata
Vector Data
Bands
Masks
[2] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
[3] subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_
Metadata
Vector Data
Bands
sun
B2 (490 nm)
B3 (560 nm)
B4 (665 nm)
[3] Sentinel 2 MSI Natural Colors RGB
[3] B2
[3] B3
Band Maths
Target product:
[3] subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
Name: Rsr_b2
Description:
Unit:
Spectral wavelength: 0.0
Virtual (save expression only, don't s
Replace NaN and infinity results by
Generate associated uncertainty ban
Band maths expression:
Load...
Save...
Band Maths Expression Editor
Data sources:
B2
B3
B4
sun_zenith
Show bands
Show masks
Show tie-point grids
Show single flags
@ + @
@ - @
@ * @
@ / @
(@)
Constants...
Operators...
Functions...
Expression:
B2 - (0.1160-0.01)*
cos(rad(sun_zenith))/ PI
Ok, no errors.
OK
Cancel
Help
Navigation - [3] RGB
Colour Manipulation - [3] ...
Uncertainty Visualisation
Red
Green
Blue
Name: B4
Unit: dl
Min: 0.032
Max: 0.45
Rough sta
3.66E-2
0.12
More Options
Product Library
Layer Manager
Mask Manager
X -- Y --
Lat -- Lon --
Zoom -- Level --

subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled - [not saved] - SNAP

File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help

Product Explorer | Pixel Info

- [1] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455
  - Metadata
  - Vector Data
  - Bands
  - Masks
- [2] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
- subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_
  - Metadata
  - Vector Data
  - Bands
    - sun
    - B2 (490 nm)
    - B3 (560 nm)
    - B4 (665 nm)
    - Rrs_B2
    - Rrs_B4

Navigation - [4] Rrs_... | Colour Manipulatio... | Uncertainty Visualis... | World View

Editor: Basic Sliders Table

Colour ramp:

unnamed

Display range

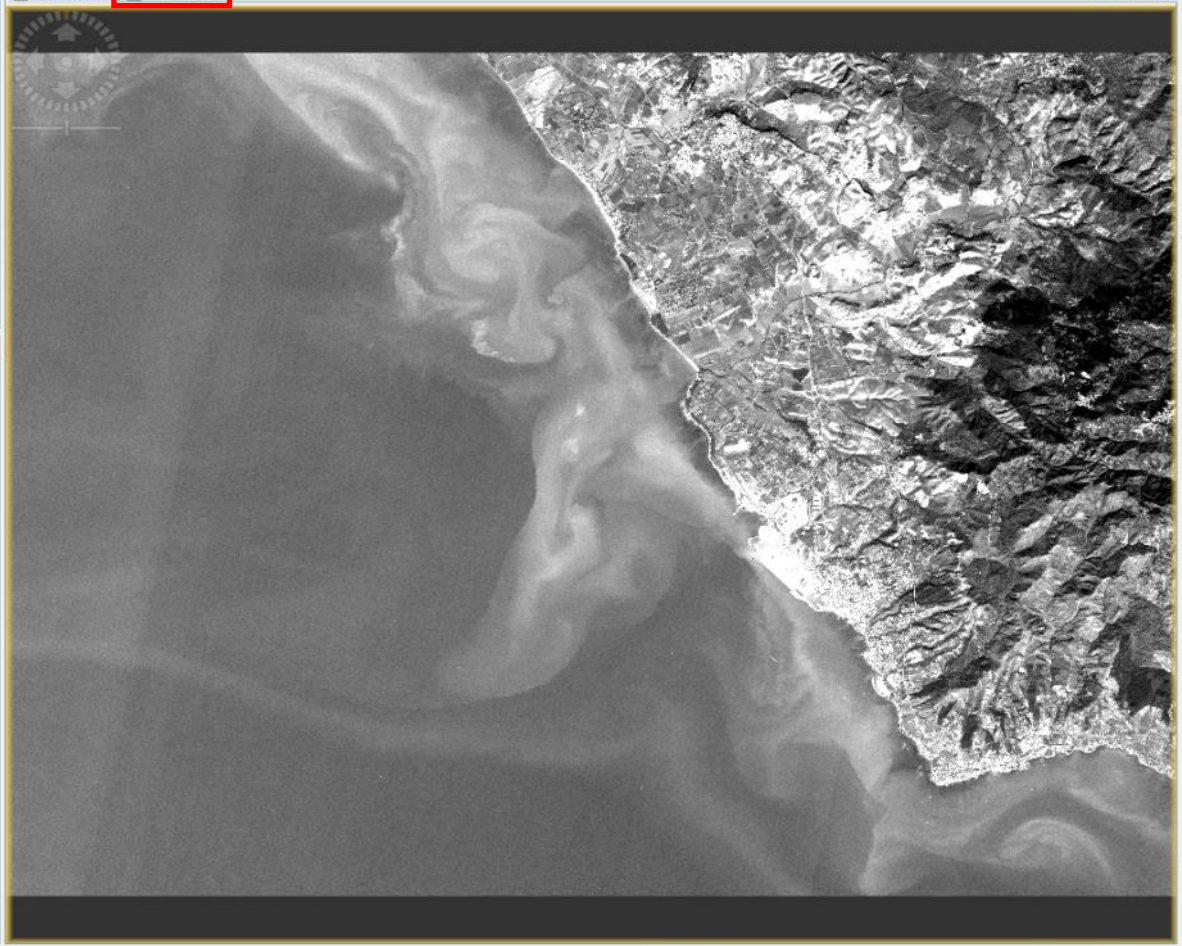
Min: -0.00055066

Max: 0.004311956

Range from File | Range from Data

More Options

[4] Rrs_B2 | [4] Rrs_B4



Product Library | Layer Manager | Mask Manager

X -- Y -- | Lat -- Lon -- | Zoom -- Level --

subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled - [not saved] - SNAP

File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help

Search (Ctrl+I)

Product Explorer | Pixel Info

- [1] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455
  - Metadata
  - Vector Data
  - Bands
  - Masks
- [2] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
- subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_
  - Metadata
  - Vector Data
  - Bands
    - sun
    - B2 (490 nm)
    - B3 (560 nm)
    - B4 (665 nm)
    - Rrs_B2
    - Rrs_B4

Navigation - [4] Rrs_... | Colour Manipulatio... | Uncertainty Visualis... | World View

Editor: Basic Sliders Table

Colour ramp:

unnamed

Log_{10}

Display range

Min: 0.000431749

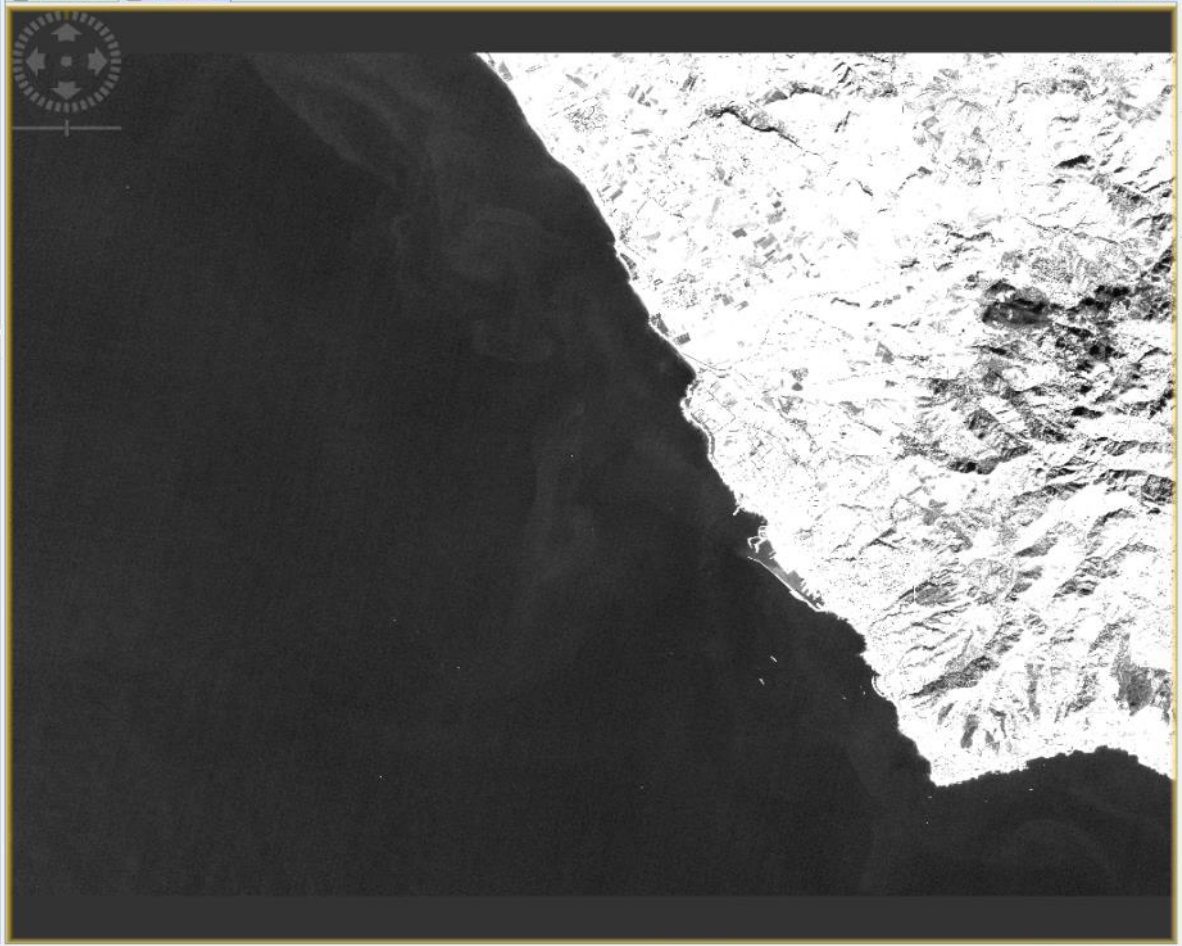
Max: 0.005

Range from File

Range from Data

More Options

[4] Rrs_B2 | [4] Rrs_B4



Product Library

Layer Manager

Mask Manager

X -- Y -- Lat -- Lon -- Zoom -- Level --

Turbidity

Simple algorithm based on red band (B4)

$$T = \frac{1030\, {R_{rs}^{4}}^{1.08}}{7} + 0.5$$

subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled - [not saved] - SNAP

File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help

Product Explorer | Pixel Info

- Metadata
- Vector Data
- Bands
- Masks
- [2] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
- subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_
  - Metadata
  - Vector Data
  - Bands
    - sun
    - B2 (490 nm)
    - B3 (560 nm)
    - B4 (665 nm)
    - Rrs_B2
    - Rrs_B4
    - Turbidity

Navigation - [4] Rrs_... | Colour Manipulatio... | Uncertainty Visualis... | World View

Editor: Basic Sliders Table

Colour ramp: unnamed

Display range

Min: 0.000431749

Range from File

More Options

[4] Rrs_B2 | [4] Rrs_B4

Band Maths

Target product: [4] subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled

Name:

Description:

Unit:

Spectral wavelengt

Virtual (save e

Replace NaN a

Generate asso

Band maths expres

Load...

Band Maths Expression Editor

Data sources:

B2
B3
B4
sun_zenith
Rrs_B2
Rrs_B4
Turbidity
Uncal_Chlorophyll

Show bands
Show masks
Show tie-point grids
Show single flags

0 + 0
0 - 0
0 * 0
0 / 0
(0)
Constants...
Operators...
Functions...

Expression:

```
1030*pow((Rrs_B4),1.08)/7+0.5
```

Ok, no errors.

OK | Cancel | Help

Product Library | Layer Manager | Mask Manager

X -- Y -- Lat -- Lon -- Zoom -- Level --

subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled - [not saved] - SNAP

File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help

Product Explorer | Pixel Info

- Metadata
- Vector Data
- Bands
- Masks
- [2] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
- subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_
  - Metadata
  - Vector Data
  - Bands
    - sun
    - B2 (490 nm)
    - B3 (560 nm)
    - B4 (665 nm)
    - Rrs_B2
    - Rrs_B4
    - Turbidity

Navigation - [4] Turb... | Colour Manipulatio... | Uncertainty Visualis... | World View

Editor: Basic Sliders Table

Colour ramp:

derived from 7_colors

Log_{10}

Display range

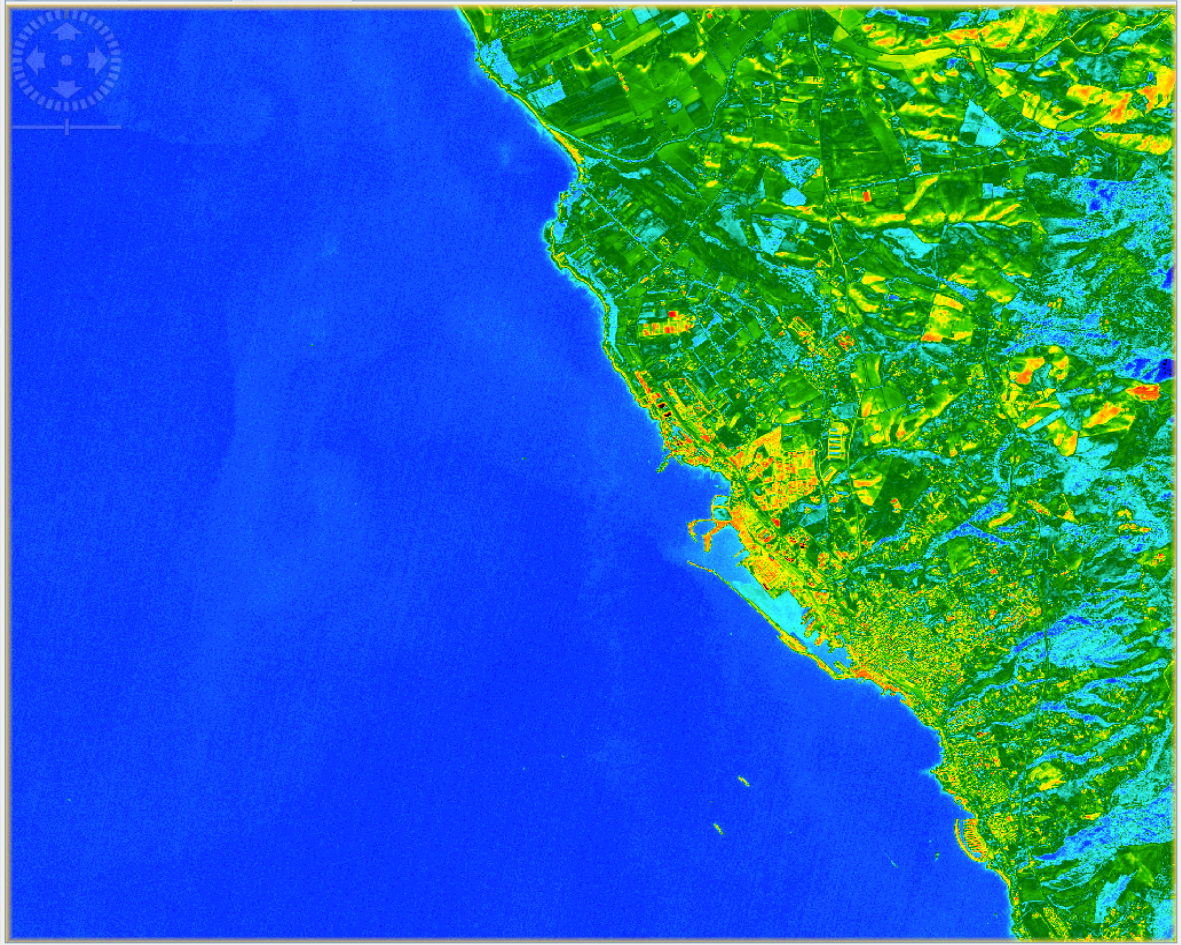
Min: 0.534181356

Max: 6.647912979

Range from File | Range from Data

More Options

[4] Rrs_B2 | [4] Rrs_B4 | [4] Turbidity

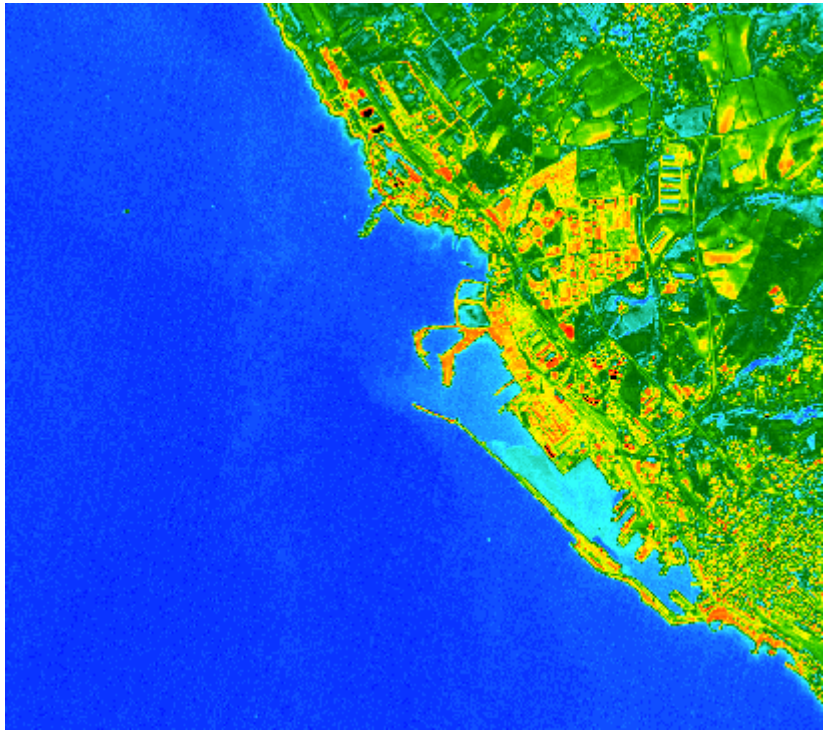


Product Library | Layer Manager | Mask Manager

X -- Y -- | Lat -- Lon -- | Zoom -- Level --

Marine Monitoring

Turbidity map from Sentinel-2



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European Commission

Chlorophyll concentration

From: Wong, M. S., Nichol, J. E., Lee, K. H., & Emerson, N. (2008). Modeling water quality using Terra/MODIS 500 m satellite images. In Proceedings of XXIst ISPRS Congress (Vol. 37, pp. 679-684)

$$Chl = e^{-0.335+0.01663\left(log\frac{R_{rs}^{b2}}{R_{rs}^{b4}}\right)}$$

Using MODIS data for a local calibration

$$Chl_{cal} = 2 * 10^{-13} e^{40.963 Chl} - 0.4$$

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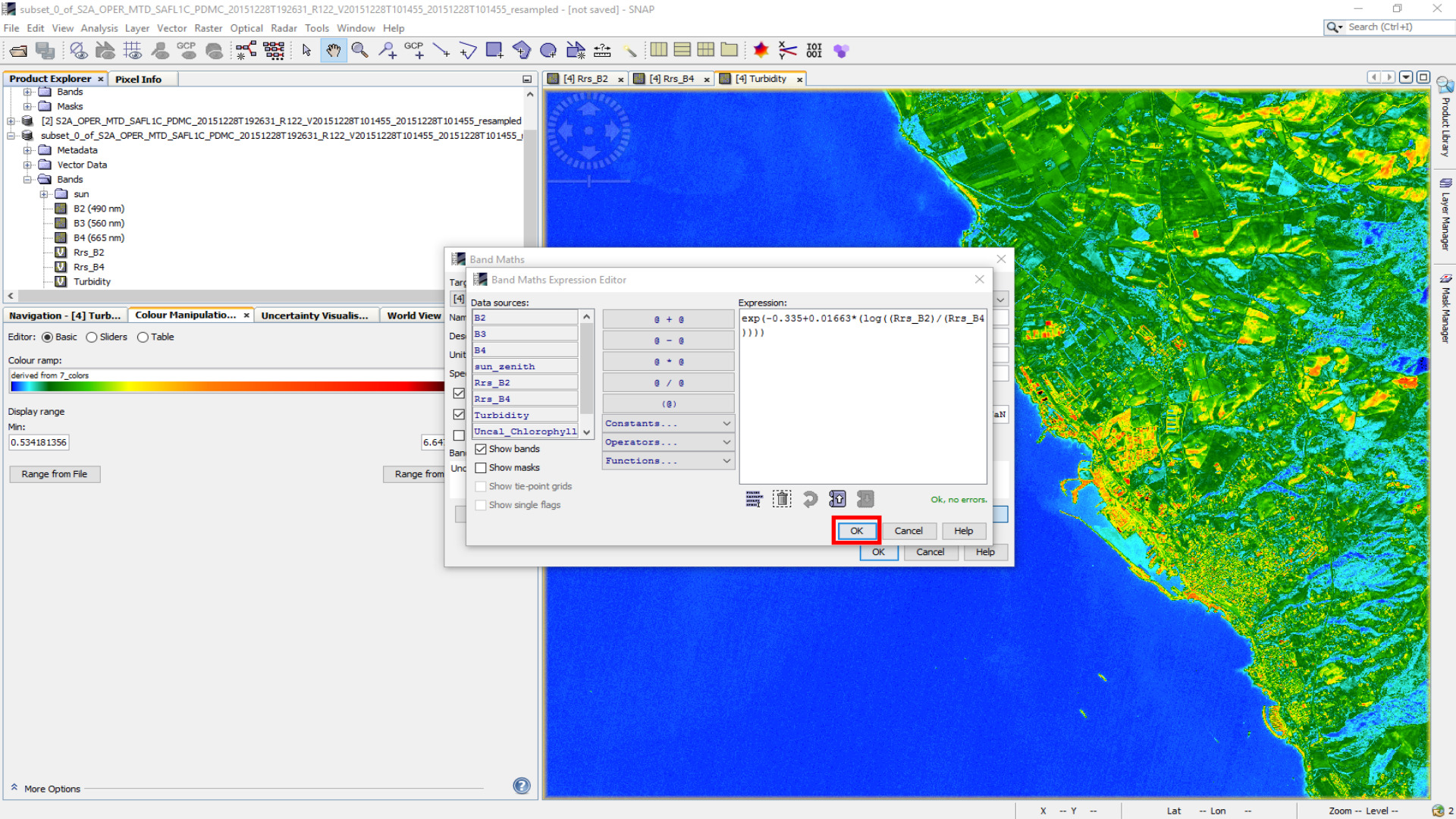

subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled - [not saved] - SNAP
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Product Explorer
Pixel Info
Bands
Masks
[2] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_
Metadata
Vector Data
Bands
sun
B2 (490 nm)
B3 (560 nm)
B4 (665 nm)
Rrs_B2
Rrs_B4
Turbidity
Navigation - [4] Turb...
Colour Manipulatio...
Uncertainty Visualis...
World View
Editor: Basic Sliders Table
Colour ramp:
derived from 7_colors
Display range
Min:
0.534181356
Range from File
More Options
[4] Rrs_B2
[4] Rrs_B4
[4] Turbidity
Band Maths
Band Maths Expression Editor
Data sources:
B2
B3
B4
sun_zenith
Rrs_B2
Rrs_B4
Turbidity
Uncal_Chlorophyll
Show bands
Show masks
Show tie-point grids
Show single flags
@ + @
@ - @
@ * @
@ / @
(@)
Constants...
Operators...
Functions...
Expression:
exp(-0.335+0.01663*(log((Rrs_B2)/(Rrs_B4))))
Ok, no errors.
OK
Cancel
Help
Product Library
Layer Manager
Mask Manager
X -- Y --
Lat -- Lon --
Zoom -- Level --

subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled - [not saved] - SNAP

File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help

Product Explorer | Pixel Info

- [2] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
- subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_
  - Metadata
  - Vector Data
  - Bands
    - sun
    - B2 (490 nm)
    - B3 (560 nm)
    - B4 (665 nm)
    - Rrs_B2
    - Rrs_B4
    - Turbidity
    - Uncal_Chlorophyll

Navigation - [4] Unc... | Colour Manipulatio... | Uncertainty Visualis... | World View

Editor: Basic Sliders Table

Colour ramp:

unnamed

Log_{10}

Display range

Min: 0.678359660

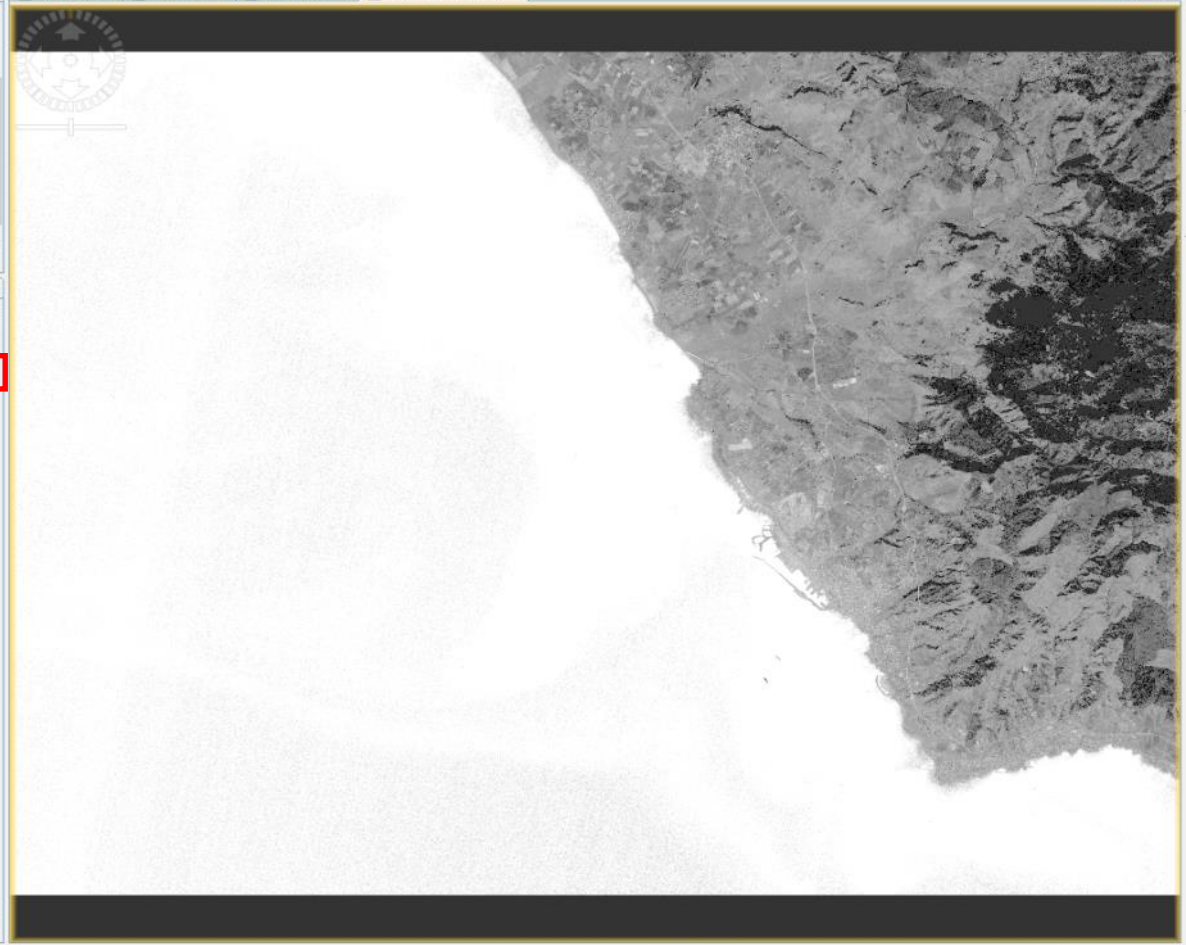
Max: 0.718196410

Range from File

Range from Data

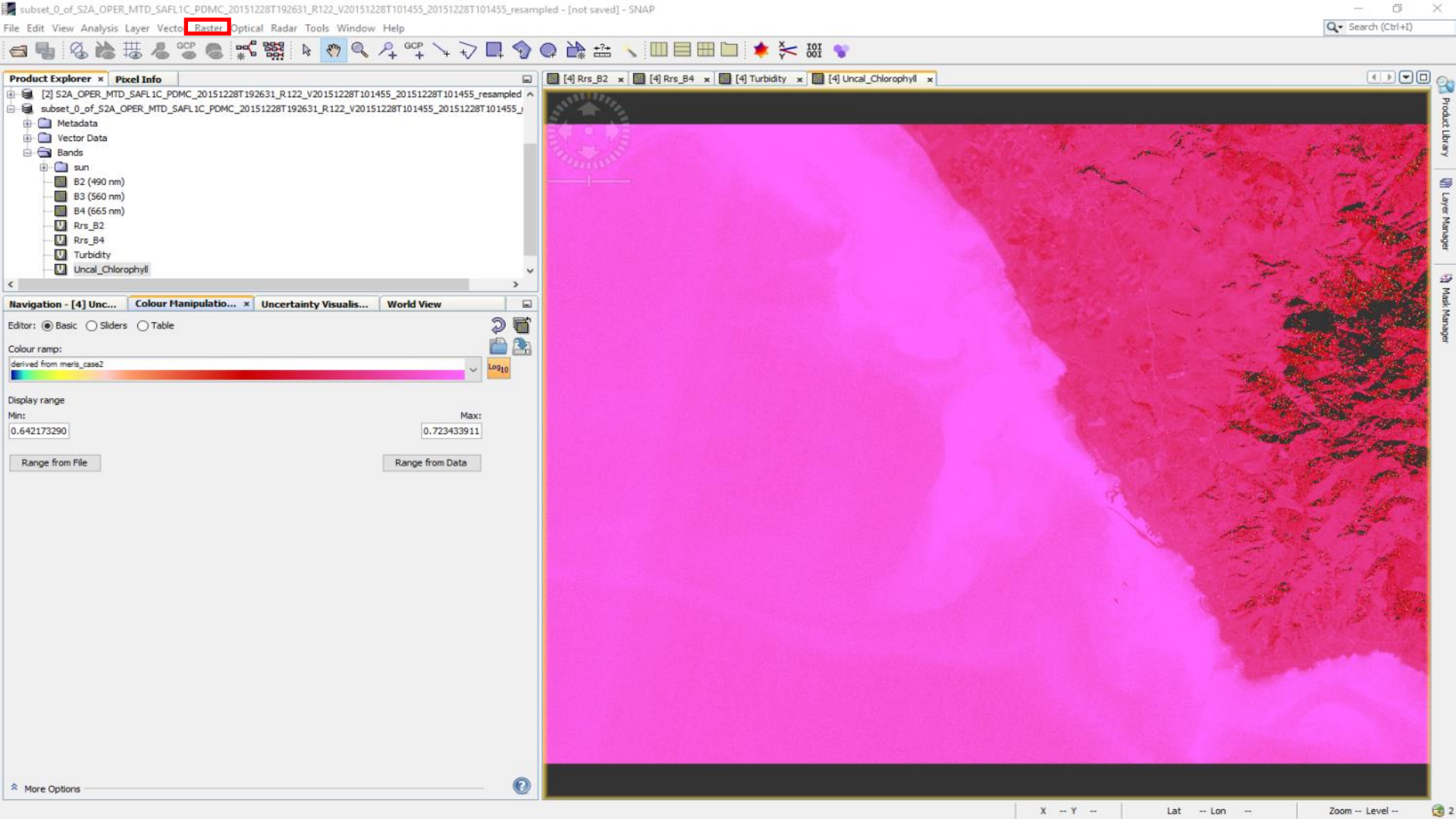
More Options

[4] Rrs_B2 | [4] Rrs_B4 | [4] Turbidity | [4] Uncal_Chlorophyll



Product Library | Layer Manager | Mask Manager

X -- Y -- Lat -- Lon -- Zoom -- Level --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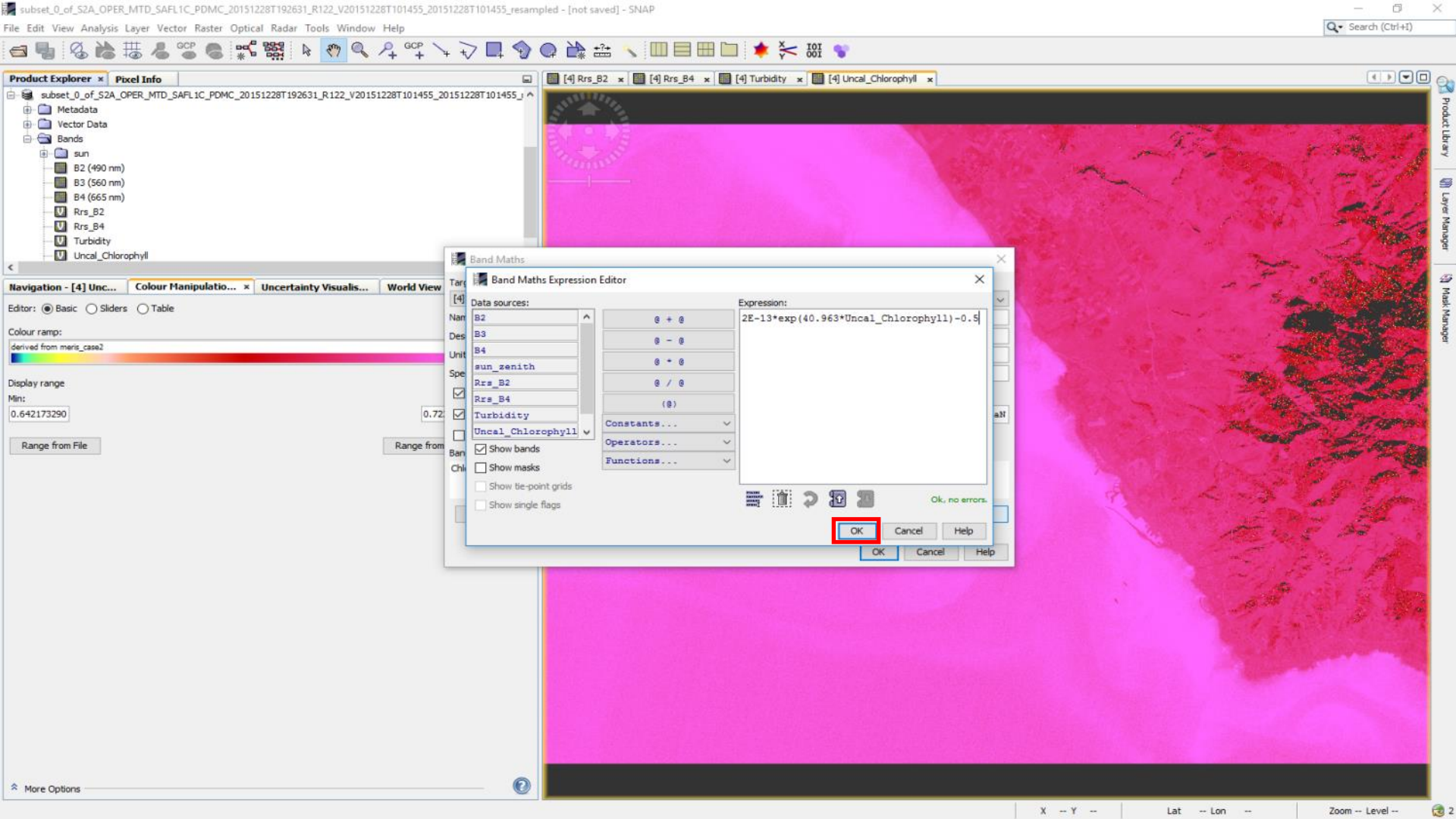
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Product Explorer
Pixel Info
[2] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_
Metadata
Vector Data
Bands
sun
B2 (490 nm)
B3 (560 nm)
B4 (665 nm)
Rrs_B2
Rrs_B4
Turbidity
Uncal_Chlorophyll
Navigation - [4] Unc...
Colour Manipulatio...
Uncertainty Visualis...
World View
Editor: Basic Sliders Table
Colour ramp:
derived from meris_case2
Log10
Display range
Min:
0.642173290
Max:
0.723433911
Range from File
Range from Data
More Options
[4] Rrs_B2
[4] Rrs_B4
[4] Turbidity
[4] Uncal_Chlorophyll
Product Library
Layer Manager
Mask Manager
X -- Y --
Lat -- Lon --
Zoom -- Level --


subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled - [not saved] - SNAP
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Product Explorer
Pixel Info
Metadata
Vector Data
Bands
sun
B2 (490 nm)
B3 (560 nm)
B4 (665 nm)
Rrs_B2
Rrs_B4
Turbidity
Uncal_Chlorophyll
[4] Rrs_B2
[4] Rrs_B4
[4] Turbidity
[4] Uncal_Chlorophyll
Navigation - [4] Unc...
Colour Manipulatio...
Uncertainty Visualis...
World View
Editor: Basic Sliders Table
Colour ramp:
derived from meris_case2
Display range
Min:
0.642173290
Range from File
More Options
Band Maths
Band Maths Expression Editor
Data sources:
B2
B3
B4
sun_zenith
Rrs_B2
Rrs_B4
Turbidity
Uncal_Chlorophyll
Show bands
Show masks
Show tie-point grids
Show single flags
Constants...
Operators...
Functions...
Expression:
2E-13*exp(40.963*Uncal_Chlorophyll)-0.5
Ok, no errors.
OK
Cancel
Help
Product Library
Layer Manager
Mask Manager
Lat -- Lon --
Zoom -- Level --

subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled - [not saved] - SNAP

File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help

Product Explorer | Pixel Info

- Bands
- Masks
- [2] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
- subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_
  - Metadata
  - Vector Data
  - Bands
    - sun
    - B2 (490 nm)
    - B3 (560 nm)
    - B4 (665 nm)
    - Rrs_B2
    - Rrs_B4
    - Turbidity
    - Uncal_Chlorophyll
    - Chlorophyll

Navigation - [4] Chlo... | Colour Manipulatio... | Uncertainty Visualis... | World View

Editor: Basic Sliders Table

Colour ramp:

unnamed

Display range

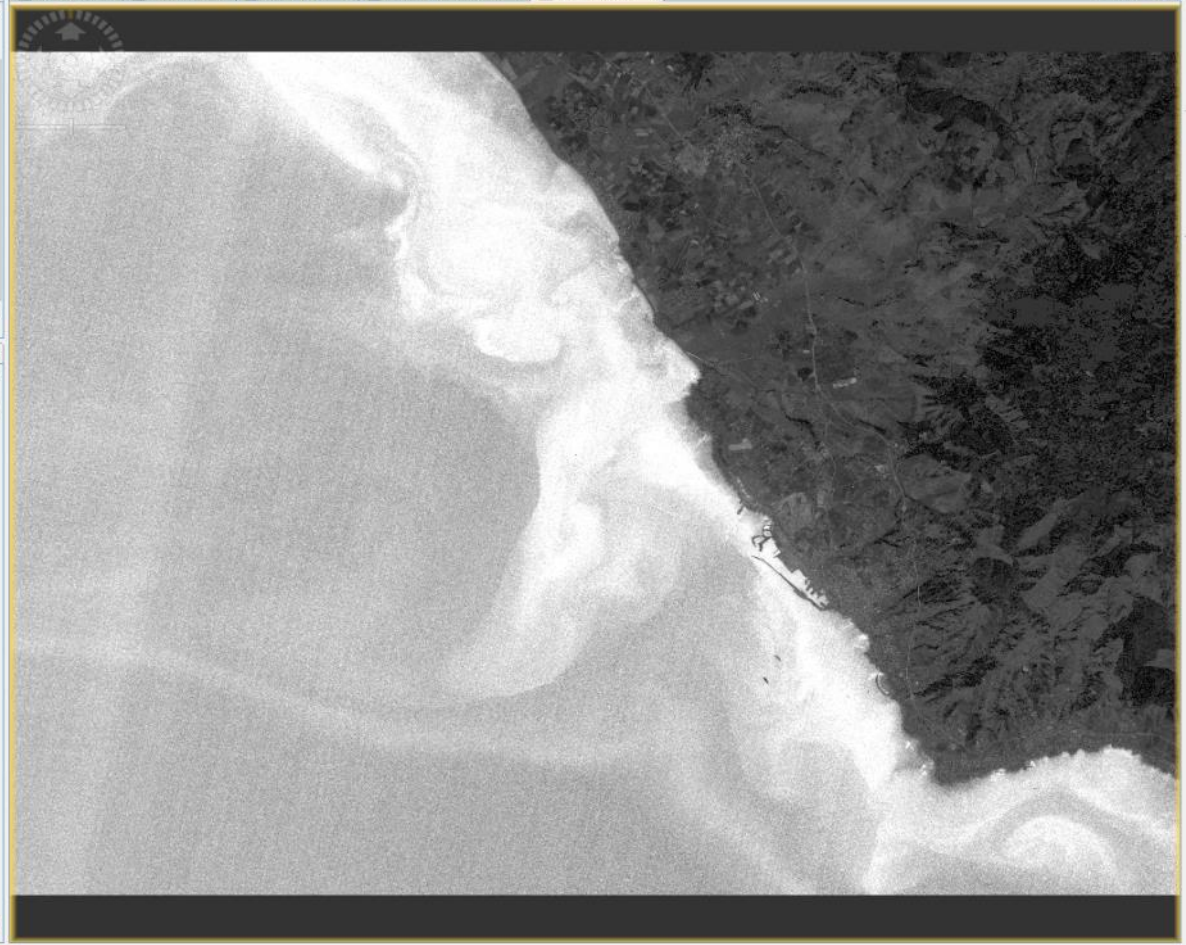
Min: -0.20850068

Max: 1.029140184

Range from File | Range from Data

More Options

[4] Rrs_B2 | [4] Rrs_B4 | [4] Turbidity | [4] Uncal_Chlorophyll | [4] Chlorophyll



Product Library | Layer Manager | Mask Manager

X -- Y -- Lat -- Lon -- Zoom -- Level --

subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled - [not saved] - SNAP

File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help

Product Explorer | Pixel Info

- Bands
- Masks
- [2] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
- subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_
  - Metadata
  - Vector Data
  - Bands
    - sun
    - B2 (490 nm)
    - B3 (560 nm)
    - B4 (665 nm)
    - Rrs_B2
    - Rrs_B4
    - Turbidity
    - Uncal_Chlorophyll
    - Chlorophyll

Navigation - [4] Chlo... | Colour Manipulatio... | Uncertainty Visualis... | World View

Editor: Basic Sliders Table

Colour ramp:

derived from meris_algal

Log10

Display range

Min: 0.5

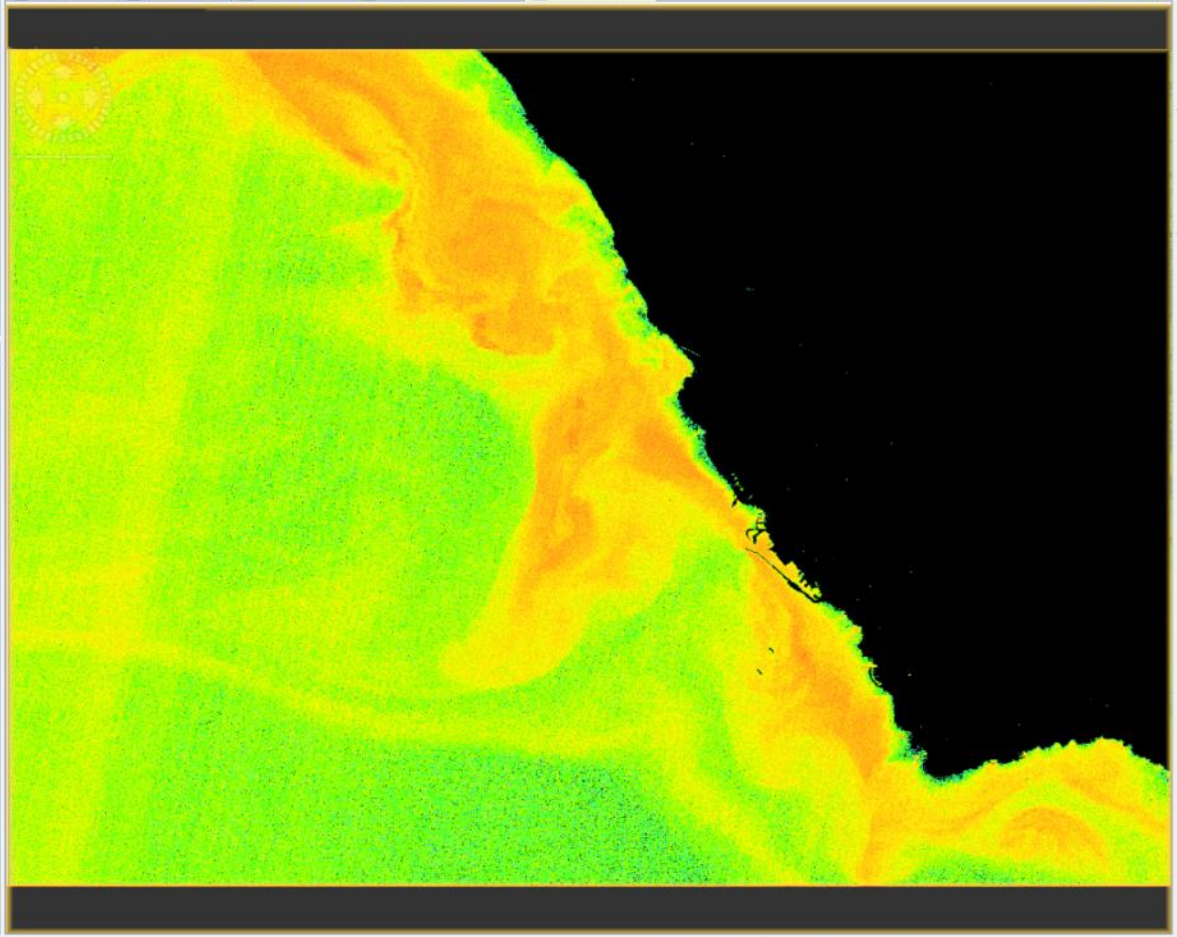
Max: 1.5

Range from File

Range from Data

More Options

[4] Rrs_B2 | [4] Rrs_B4 | [4] Turbidity | [4] Uncal_Chlorophyll | [4] Chlorophyll



Product Library | Layer Manager | Mask Manager

X -- Y -- | Lat -- Lon -- | Zoom -- Level --

subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled - [not saved] - SNAP

File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help

Product Explorer | Pixel Info

- Bands
- Masks
- [2] S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_resampled
- subset_0_of_S2A_OPER_MTD_SAFL1C_PDMC_20151228T192631_R122_V20151228T101455_20151228T101455_
  - Metadata
  - Vector Data
  - Bands
    - sun
    - B2 (490 nm)
    - B3 (560 nm)
    - B4 (665 nm)
    - Rrs_B2
    - Rrs_B4
    - Turbidity
    - Uncal_Chlorophyll
    - Chlorophyll

Navigation - [4] Chlo... | Colour Manipulatio... | Uncertainty Visualis... | World View

Editor: Basic Sliders Table

Colour ramp:

derived from meris_algal

Log10

Display range

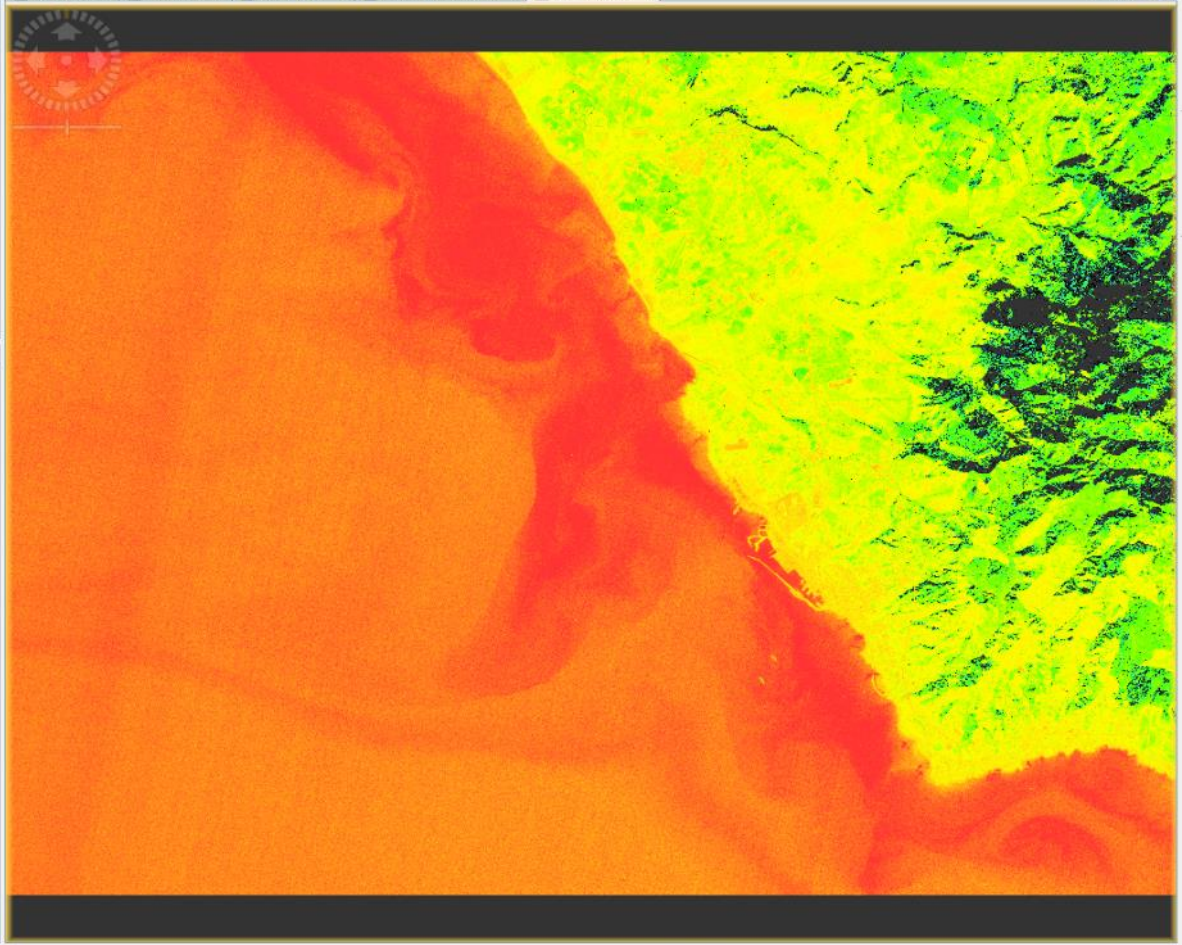
Min: -0.20850068

Max: 1.029140184

Range from File | Range from Data

More Options

[4] Rrs_B2 | [4] Rrs_B4 | [4] Turbidity | [4] Uncal_Chlorophyll | [4] Chlorophyll

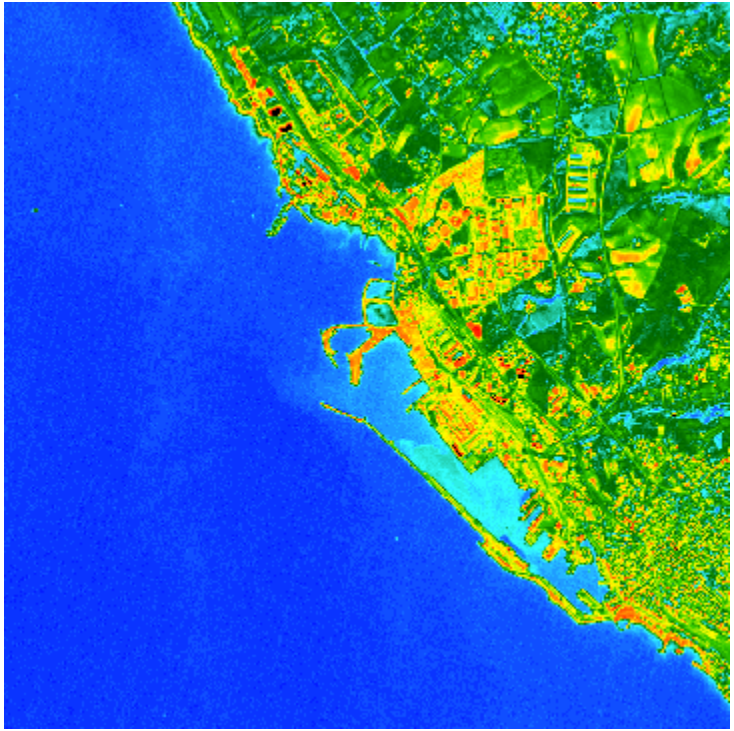


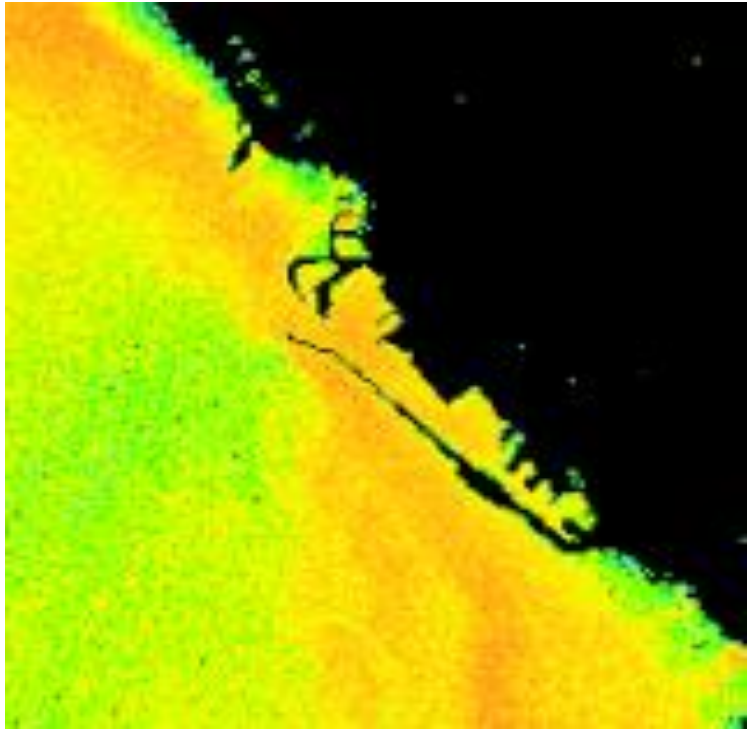
Product Library | Layer Manager | Mask Manager

X -- Y -- | Lat -- Lon -- | Zoom -- Level --

Marine Monitoring

Turbidity and Chlorophyll maps at 10m





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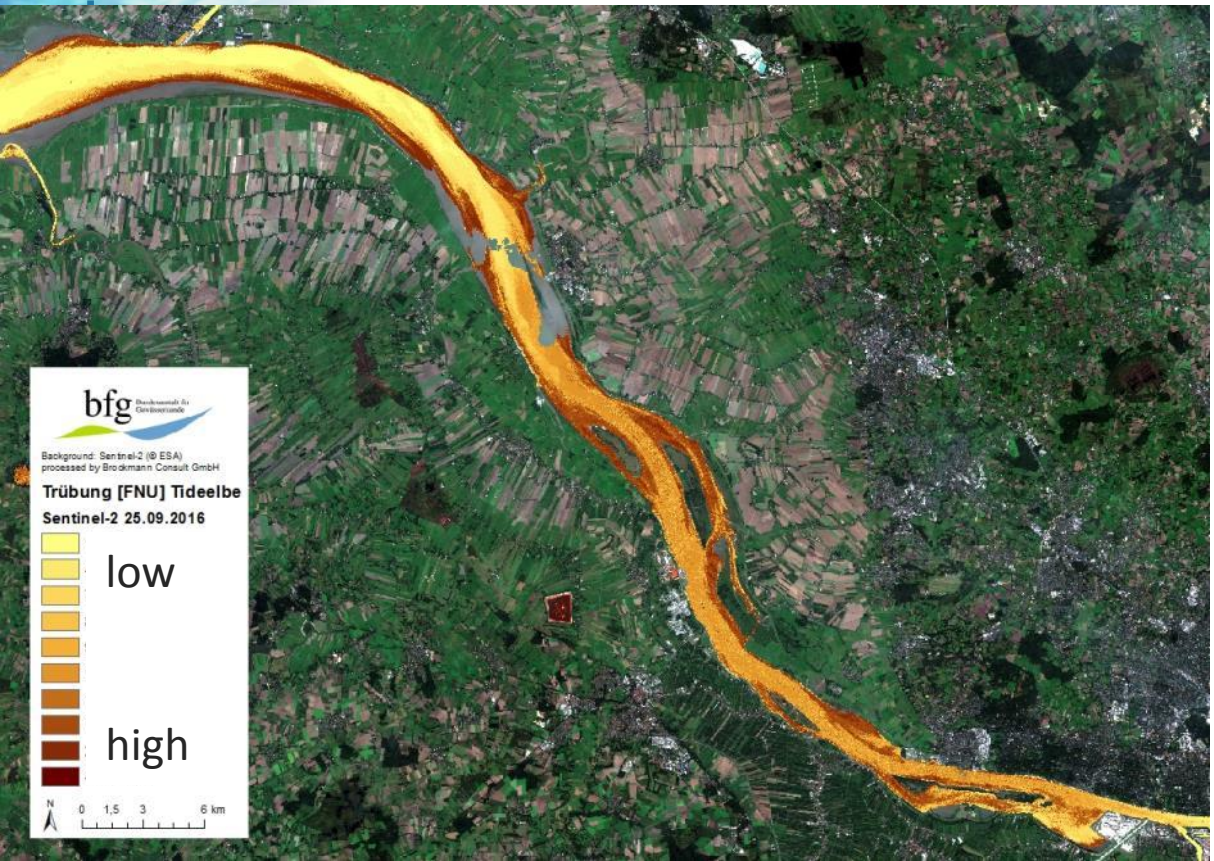
Monitoring of Turbidity in River Estuaries



Estuary of river Elbe:

- qood representation of patterns e.g. high turbidity zone
- quantitative validation ongoing
- artefacts in shallow water

- Contact: baschek@bafg.de
- Data: Senintel-2 © ESA
- Processed by Brockmann Consult and BfG; © BfG
- WasMon-CT-Project (funding BMVI/DLR)

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Marine Monitoring

Thank you

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European Commission