





TRAINING KIT – OCEA04

OCEAN COLOUR WITH SENTINEL-3 OLCI JULY 2017, NORTH SEA









Research and User Support for Sentinel Core Products

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Authors would be glad to receive your feedback or suggestions and to know how this material was used. Please, contact us on training@rus-coperenicus.eu

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1 Introduction to RUS

The Research and User Support for Sentinel core products (RUS) service, provides a free and open scalable platform in a powerful computing environment, hosting a suite of open source toolboxes preinstalled on virtual machines, to handle and process data derived from the Copernicus Sentinel satellites constellation.

2 Ocean colour monitoring – background



Source: NASA - Algal bloom



(http://www.teachoceanscience.net)

Ocean colour refers to the hue of the water caused by the presence of tiny plants that containing the pigment chlorophyll, sediments and coloured dissolved organic material.

From satellite observations in the optical part of the spectrum we can estimate the concentrations of different constituents (pure water, chlorophyll, sediments, coloured dissolved organic matter) provided we know their effect on the spectral response of the water (inherent optical properties - IOPs).

Chlorophyll concentrations are perhaps of most interest to us as they are indicators of algal blooms. Phytoplankton blooms occur naturally in areas with high nutrient concentrations (coastal areas – nutrient runoff from land). When phytoplankton cells die, they sink to the seabed where they are decomposed by bacteria requiring oxygen.

In extreme cases (eutrophication), this process can result in oxygen depletion (hypoxia) and the creation of "dead zones" where all marine life either died or left the area. While the occurrence of such zones on periodic basis is natural, they have been observed more often and affecting larger areas in the past few decades. This is mainly

attributed to nitrogen and phosphorous from agricultural runoff, but sewage, vehicular and industrial emissions play a role.

The study area for this exercise will be the southern part of the North Sea. Eutrophication and hypoxia have been increasingly observed in the coastal areas and the countries surrounding the North Sea have been working together for the past few decades to reduce pollution runoff. Monitoring of the chlorophyll concentrations is an important input to assessing these efforts.

3 Training

Approximate duration of this training session is 1 hour.

3.1 Data used

 One Sentinel-3A level 1 image that had been acquired on 9 July 2017 [downloadable @ https://codarep.eumetsat.int]

```
S3A_OL_1_EFR____20170709T095656_20170709T095856_20171021T033004_0119_019_350_____MR1_R_NT_002
```

 One Sentinel-3A level 2 image that had been acquired on 9 July 2017 [downloadable @ https://codarep.eumetsat.int]

S3A_OL_2_WFR___20170709T095656_20170709T095856_20171110T054242_0119_019_350_____MR1_R_NT_002

3.2 Software in RUS environment Internet browser, SNAP + Sentinel-3 Toolbox

4 Sentinel-3 OLCI

Sentinel-3 is a multi-sensor mission comprising of two satellites (Sentinel-3A and Sentinel-3B) in identical orbit with a phase shift of approximately 140°. Sentinel-3A has been in orbit since February 2016 and Sentinel-3B since 25 April 2018. The mission's main objective is to measure with accuracy sea-surface topography, sea- and land-surface temperature and ocean- and land-surface colour, in support of ocean forecasting systems, and for environmental and climate monitoring. It provides Near-real time data for ocean forecasting, sea-ice charting, and maritime safety services on the state of the ocean surface, including surface temperature, marine ecosystems, water quality and pollution monitoring.



Sentinel-3 sensors (Credits: Sentinel-3 SLSTR User Guide, ESA)

The **O**cean and Land Colour Instrument (OLCI) is a medium-resolution imaging spectrometer that uses five cameras to provide a wide field of view (swath width: 1270 km). It provides 21 bands, ranging from the visible to the near infrared (400 - 1020 nm), acquired simultaneously with approximately 300 m spatial resolution.

5 Register to RUS Copernicus

To repeat the exercise using a RUS Copernicus Virtual Machine (VM), you will first have to register as a RUS user. For that, go to the RUS Copernicus website (<u>www.rus-copernicus.eu</u>) and click on *Login/Register* in the upper right corner.

CORRUS Research and User Support	🖓 🚜 👘 📭 esa
The RUS Service * The RUS Offer * The RUS Library * The RUS Community *	
	Seath
	News from RUS
	One year on!
	Copernicus Info Session – Reykjavik – 19 September 2018
	SPIE Remote Sensing 2018 – Berlin (Germany) – 11-12 September 2018
	SIWI World Water Week 2018 - Stockholm - 26-31 August 2018
	MedRIN Kick-off Meeting - Chania - 13 & 14 July 2018
	RUS Webinar – Special edition "AskRUS – Sentinel-1" – 12 July 2018
Welcome to Research and User Support	RUS Training Session - Valencia - 22 July 2018
	IGARSS 2018 - Valencia - 22-27 July 2018
Welcome to the Copernicus Research and User Support (RUS) Service portal!	 The RUS agenda
The RUS Service is the "New Expert Service for Sentinel Users" funded by the European Commission,	Conferences & Workshops

Select the option *Create my Copernicus SSO account* and then fill in ALL the fields on the **Copernicus Users' Single Sign On Registration**. Click *Register*.



Within a few minutes you will receive an e-mail with activation link. Follow the instructions in the email to activate your account.

You can now return to <u>https://rus-copernicus.eu/</u>, click on *Login/Register*, choose *Login* and enter your chosen credentials.

Login / Register	Credentials			-
The registration system to access the RUS service platform has moved toward the COPERNICUS Single Sign On authentication server. • New Users who have not yet registered to the RUS portal shall first create a COPERNICUS SSO account. Note that your Copernicus SSO account will be activated only after the reception of the third email sent by the Copernicus service. We advise you to consult <u>this document</u> and <u>this page</u> to facilitate your registration procedure.	CDS-SSO ID Password Max Idle Time	half a day	Ţ	0 0
REGISTER COPERNICUS SSO account Users who already have a COPERNICUS SSO account can login here:	Max Session Time	Until browser close	• et	0
Login		Forgot your password?		

Upon your first login you will need to enter some details. You must fill all the fields.

The RUS Service = The RUS O	Do you want t	o subscribe for a new RUS account?	Î	
	Your ESA-SSO subscription	data:		
+ Your RUS service	Login		- 1	٩
This section gathers pages retired to re	FirstName			
· Your profile: displays your person	Last Name	(matter)	US	
	Email	Second Seco	EntPa	
· Your dashisterti alloys you to at-	Organization	(Real Processing of the International Processing of the Intern	111	
· Your training silons you to main	Country	-	in the	
	Additio	nal subscription information		
	Please complete the followi	ng information:	-	
	Where did you hear about the	outreach event	(4)	
	RUS service?	colleagues	(Dec)	
	Seres one or more nems	conference	and a second	
		social media		
	Institution type	Select one item	v jida	
	Phone number Italy (IT):	+39	a Acar	1976.
	Title	Select one item	~	

6 Request a RUS Copernicus Virtual Machine

Once you are registered as a RUS user, you can request a RUS Virtual Machine to repeat this exercise or work on your own projects using Copernicus data. For that, log in and click on **Your RUS Service** \rightarrow **Your Dashboard**.



Click on *Request a new User Service* to request your RUS Virtual Machine. Complete the form so that the appropriate cloud environment can be assigned according to your needs.

								Hello, Migue
The RUS Ser	vice The R	US Offer 🔻 T	he RUS Lit	orary • The RUS Co	mmunity • 👷 You	r RUS service 🔻		
							You are here: Home > Yo	our RUS service > Your dash
Your dashboard	d							
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-0	ew oser servic	le						anat with Support Desi
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US_training1	231	2017-08-31	Open	Follow my project	Get support Get a webinar kit	Close my service Rate my service	Access my Virtual Machine(s) Freeze my Virtual Machine(s)	Access my CPU monitoring dashboard Report a technical incident
RUS_training1	231	2017-08-31	Open	Follow my project	Get support Get a webinar kit Getaupport	Close my service Rate my service ****	Access my Virtual Machinela) Freeze my Virtual Machinela) Argent my Virtual Machinela	Access my CPU monitoring dashboard Report a technical incident darcest m [*] C ^H [*] monitoring dashboard
NUS_training1	231	2017-08-31 2018-05-07	Open	Follow my project Cancel my request View history	Get support Get a webinar kit Getaunoort	Close my service Rate my service * * * * * Closemy service	Access my Virtual Machine(s) Freeze my Virtual Machine(s) Argent my Vintual Missionesti Vistual Argenting()	Access my CPU monitoring dashboard Report a technical incident Armen range CPU monitoring dashboard

If you want to repeat this tutorial (or any previous one) select the one(s) of your interest in the appropriate field.

Sken 4/2 Vaur augustance	
step 1/3 Your experience	
Please help us learn more about your background by answering .	a few questions. Th
information will be stored in your User Profile.	
How many years of experience in Remote Sensing do you have?	
Choose one Item	
Have you already downloaded Copernicus data via the Copernicus Open acce	ss hubs?
® Yes	
© No	
Have you already handled/processed Copernicus data?	
W Yes	
© No	
Do you wish to practice a tutorial exercise shown in a RUS webinar? If yes, ple (hold down CTRL key for multiple selections).	ase select your choice
HAZA01 - Flood Mapping in Malawi	
HAZA02 - Burned Area Mapping in Portugal HYDR01 - Water Bodies Mapping over Northern Poland	
LAND01 - Crop Mapping in Seville	
LAND04 - Land Monitoring in Cyprus	-
OCENOT - Ship Detection in Guillor meste	
If you wish to request another tutorial exercise that doesn't appear in the about its name or code. Note that you can request multiple tutorial exercises.	ve list, please type here

Complete the remaining steps, check the terms and conditions of the RUS Service and submit your request once you are finished.

Summary mormation on your request.		
This is a collection of information selected	d across the USR forms.	
You can go back and edit this information	if necessary.	
General information on your request:		
Years of experience in Remote Sensing	5-10 years	
Downloaded Copernicus data?	1	
Handled/processed Copernicus data?	1	
Webinar codes	HAZA02, LAND04	
About your RUS project:		
Thematic area	Cryosphere (ice and snow)	
Operations to perform on RUS	Algorithm development	
Preference for downloading process	Self-downloading	
Foreseen activities and support needs	Develop a land cover classification	
Project name	RUS_Project1	
Earth Observation Data information:		
Type of Earth Observation Data:		
Sentinel-1	1	
	S1-Product 1	
S1 - Product type	GRD	
S1 - Sensor mode	-	
S1 - Polarisation	e	
S1 - Orbit direction		
Sentinel-2	X	
Sentinel-3	X	
Other	X	
I don't know	x	
Min Latitude	39 3303	
Max Latitude	40.5877	
Min Longitude	-4.6736	
Max Longitude	-2.7205	
Reference polygons		
Data acquisition date(s):		
None		
Additional data specifications		
I have read and agree to the Terms and	conditions of RUS Service.	

Further to the acceptance of your request by the RUS Helpdesk, you will receive a notification email with all the details about your Virtual Machine. To access it, go to **Your RUS Service** → **Your Dashboard** and click on **Access my Virtual Machine**.

							You are here: Home >	Your RUS service > Your dash
Your dashboard								
Request a new Lines	Conde						6	Chat with Support Dark
	Servic	-						Chat with Support Desk
Project Name	ID	Date of submission	Status		Actions		Virtual	Environment
			2.1	Follow my project	Get support	Close my service	Access my Virtual Machine(s)	Access my CPU monitoring dashboard
{US_training1	231	2017-08-31	Open	Cancel averaging	Get a webinar kit	Rate my service ★★★★★	Freeze my Virtual Machine(s)	Report a technical incident

Fill in the login credentials that have been provided to you by the RUS Helpdesk via email to access your RUS Copernicus Virtual Machine.



This is the remote desktop of your Virtual Machine.

Applications			-			10.00
AL System	(Redes		BIRAT Schuseblar	() 385	R	SNAP
ARANA	December of			CONTRACT.	Juppilea- Naturació	Adoretice and
dister	Tiesdo					
		opernicus				

7 Step by step

7.1 Data download - CODARep

In this step, we will download the Sentinel-3A Level-1 EFR product (TOA radiances at Full Resolution) and a corresponding Level-2 WFR product (Full Resolution: Ocean Colour, Water and atmosphere parameters), from the EUMETSAT Copernicus Online Data Access (REProcessed) using the online interface.

TIP: All Sentinel-3 products are available in the EUMETSAT Copernicus Online Data Access (<u>https://coda.eumetsat.int/</u>) only for 1 year from the acquired date. After 1 year, they are only available in the CODA REProcessed portal (<u>https://codarep.eumetsat.int</u>).

Go to <u>https://codarep.eumetsat.int</u> and click OK at the dialog that appears.



You will be redirected to a login page. If you do not have an account, please register through the **"NEW USER – CREATE NEW ACCOUNT"** as shown below and then log-in.

€ EUN	NETSAT MONITORING WEATHER AND CLIMATE FROM SPACE
EARTH OBS	SERVATION PORTAL - MY ACCOUNT
HOME LOGIN HELP	Authentication
	Welcome to the Earth Observation portal. Please login to access your account.
	PLEASE LOGIN
	Please enter your user ID and password to login User Name: *
	Please note the fields marked with * are mandatory.
	FORGOTTEN YOUR PASSWORD? FILOGIN FILOGIN FILOGIN

EUMETSAT MONITORING WEATHER AND CLIMATE FROM SI	ACE		
CARTH OBSERVATION PORTAL - MY ACCOUNT	ACE EUMETSAT EO Portal Account Creat USER DETAILS USER Name: * Password: * Pas	Ion User Name' is mandatory	
	Private Individual National Institution Presearcher Education International Organisation Commercial SME* Commercial SME* Commercial SME* Ihave read and accept the Terms Please note the fields marked with * are 'The category of micro, small and media annual fumover net exceeding EUR 80 m	and Conditions. mandatory. m-sized enterprises (SMEs) is made up of enterprises which empl million, and/or an annual balance sheat total not exceeding EUR 43	cy lever than 250 persons and which have an million.

Once you are logged-in, switch the *"rectangle-drawing mode"* to *"pan mode"* by clicking on the icon in the upper right corner of the map and navigate to the northern part of the English Channel.

Then switch to *"drawing mode"* and draw a rectangle approximately as indicated below. Open search menu by clicking at the left of the search bar. Specify the following parameters and then search:

Sensing period: From 2017/07/09 to 2017/07/09 Check Mission: Sentinel-3 Instrument: OLCI



The search returns 4 results for the period we defined over our area of interest.

We need to download the 2 scenes that are of Full Resolution (always download the products of larger size – full resolution / EFR and WFR) by clicking the download icon 🛃 on each product:

S3A_OL_1_EFR____20170709T095656_20170709T095856_20171021T023004_0119_019_350____MR_1_NT_002 S3A_OL_2_WFR____20170709T095656_20170709T095856_20171021T023004_0119_019_350____MR_1_NT_002



Once the scenes are downloaded, move them from */home/rus* folder to */shared/Training/OCEA04_OceanColour_S3_TutorialKit/Original* folder.

Then right-click on each of the zipped products in turn and go to "Extract Here".

NOTE 1: There might be a case that you may are not allowed to draw a rectangle at CODA using the browser at your Virtual Machine. Open the website at another browser out of your VM, find the products you need, add them to cart by clicking at this 🕅 icon and then connect to your CODA account through the browser in the VM and download them from your cart.

	Copernicus Online Data Access (REProcessed)	
G.C. OLGI S3A_OL_2_WFR20170709T0956566 Download URL: https://codarep.eumetsa Mission: Sentinel-3: Instrument: OLCI, Se	Your cart contains 2 products. Display 1 to 2 of 2 products. 201707097095856_201711107054242_0119_019_350MR1_R_NT_002 aLint/bdata/v1/Products(*Dc2bd907-bBca-da&6-dB6-dB67019ad32d*)/&value ensing Date: 2017-07-09709:56:56.2177832; Stze: 170.27 MB	Allowed functions Q ±
Download URL: https://codarup.eumetaa Download URL: https://codarup.eumetaa Mission: Sentinel-3: Instrument: OLCI, Se	201707097093855,20171021T033004,0119_019_350MR1_R_NT_002 at.int/bdata/v1/Products(*D7111:Bif-462c-4415-in505-20072285aa177)/Svalue ensing Date: 2017-07-09709:56-56.2177832; Size: 451.25 M8	Locour
Products per page: 25 v << < Page#: 1 of 1 =	5p	DOWNLOAD CART CLEAR CART

In this case, make sure that once the scenes are downloaded, you will move them from */home/rus* folder to */shared/Training/OCEA04_OceanColour_S3_TutorialKit/Original* folder.

Then right-click on each of the zipped products in turn and go to "Extract Here".

7.2 SNAP – open and explore data

Open **SNAP Desktop** from your desktop or search it in *Applications* → *Processing*.

Click on the *"Open product"* icon *[™]* or go to *"File* → *Open Product"* and find the: /shared/Training/OCEA04_OceanColour_S3_TutorialKit/Original folder.

Navigate to both folders of the extracted products and open in each one the "*xfdumanifest.xml*" file to load the products to SNAP.

The opened products will appear at the **Product Explorer** tab in the upper left part of the window. Right click on the Level-1 product (S3A_OL_1_EFR____20170709T095656_20170709T095856_201710 21T023004_0119_019_350____MR_1_NT_002) and select **Open RGB Image Window** to create and visualize an RGB composition image.

Set: Red: 0a08_radiance, Green: 0a06_radiance, Blue: 0a04_radiance.

[1] S3A_OL_1_EFR20170	709T095656_20170709T095	856_20		Select RGB-Image Channels	÷.	E ×
Elle Edit View Analysis Layer	Vector Raster Optical Radar		Profile: OLCI LI	Tristimulus (modified) 🖉 🥌		(面)
Product Explorer × Pixel Info → ④ [1] S3A_OL_1_EFR20170 → ⑤ [2] S3A_OL_2_WFR2 B	roduct Explorer X Pixel Info Image: Image in the image	201710 201711	Red: Green:	\$1.0a08_radiance \$1.0a06_radiance		
A IZ G	dd Land Cover Band iroup Nodes by Type		Blue:	\$1.0a04_radiance Expression		valid
Open RGB In Open HSV In Close Produ Close All Pro	Ipen RGB Image Window Ipen HSV Image Window Iose Product Iose All Products		Stor	e RGB channels as virtual bands in current product	1	Help

Click **OK** and the RGB image will appear in the "View Window".

The view of the image is very dark and for that reason we will enhance it a bit. Go to the **Colour Manipulation** tab in the lower left corner of the SNAP window. Here we have to change the histogram stretch for each of the RGB component bands.

Check that the **Red** histogram is shown, click on the right-hand slider below the histogram and move it leftwards to approximately **70**.

Change the histogram to **Green** at the top of the tab and set the right-hand slider to approximately **90**. Last, change the histogram to **Blue** and set the right-hand slider to approximately **100**.



As we can see, the majority of our image is covered by land or clouds and does not contain any valuable information for our purposes, so let's subset it to a smaller area of interest.



7.3 Subset

Make sure the Level-1 EFR product is selected (highlighted) in the **Product Explorer** tab, if needed click once on it even if it is highlighted.

Go to **Raster** → Subset.

At the **Spatial Subset** tab go to **Pixel Coordinates** tab and set the following coordinates:

Scene start X: 600 Scene start Y: 50 Scene end X: 2800 Scene end Y: 2250



The subset area is indicated by the blue rectangle on the left of the dialog window.

Click OK.

A subset product will be created and will appear at the Product Explorer tab with index number [3].

Let's open the RGB view in the same way we have done for the full product and enhance the histogram.

Right click on the [3] subset_0_of_S3A_OL_1_EFR____20170709T095656_20170709T095856_2017 1021T023004_0119_019_350____MR_1_NT_002 product and select Open RGB Image Window to create and visualize an RGB composition image.

Set: Red: 0a08_radiance, Green: 0a06_radiance, Blue: 0a04_radiance.

Set again the **Red** histogram to approximately **70**, the **Green** to **90** and the **Blue** to **100**.



7.4 C2RCC Processor

The **C**ase **2 R**egional **C**oast **C**olour processor had originally been developed by Doerffer and Schiller for the MERIS sensor, and then it was improved through the ESA DUE CoastColour project (Brockmann et al., 2016). It is applicable to all past and current ocean colour sensors (such as Sentinel-3) as well as Sentinel-2. It has been validated in various studies and is available through ESA's Sentinel toolbox SNAP. It is also used in the Sentinel-3 OLCI ground segment processor of ESA for the generation of the Case 2 water products. We will use it here to reproduce the Level-2 Water product that we have also downloaded.

To run the processor, go to **Optical** \rightarrow **Thematic Water Processing** \rightarrow **C2RCC Processors** \rightarrow **OCLI**. You can see that the C2RCC processor is available for a variety of different sensors.



In the **I/O Parameters** tab, make sure that the subset product with index number [3] is selected as source **OLCI L1b product**.

The original name of the S3 product is quite long so let's replace it with something more manageable.

C2RCC OLCI Processor	In the Target Product section under "Name",
File Help	the "C2RCC" ending will be added
I/O Parameters Processing Parameters	outomotically.
Source Products	automatically.
OLCI L1b product:	
[3] subset_0_of_S3A_OL_1_EFR20170709T095656_20170709T095856_20 🔻 📖	Donomo the product and keep it as
Ozone interpolation start product (TOMSOMI): (optional)	Rename the product and keep it as:
×	"Subset S3A OL 1 EFR 20170709T095656
Ozone interpolation and product (TOMSOMI): (optional)	
	C2RCC".
Air pressure interpolation start product (NCEP): (optional)	
Air pressure interpolation end product (NCEP): (optional)	Below the Directory , set as output: /shared /
	Training/OCEA04 OceanColour S3 Tutorial/
Target Product	
Name:	Processing.
Subset_S3A_OL_1_EFR_20170709T095656_C2RCC	
Save as: BEAM-DIMAP	
Directory:	In the Processing Parameters tab, we will define
/shared/Training/OCEA04_OceanColour_S3_Tutorial/Processing	the values about "colinity" and "temperature"
Øpen in SNAP	the values about samily and temperature
	that correspond to our area of interest for that
	certain date, 8 th of July 2017.
	These variables among others are used to
	determine the absorption and scattering of pure
	water.
	You can find and download the dataset for the
<u>R</u> un <u>C</u> lose	specific date we need at the following link:
	- specific date we need at the following link.

https://opendap.jpl.nasa.gov/opendap/SalinityDensity/smap/L3/JPL/V3/8day_running/2017/185/co ntents.html

Instructions how to use it can be found here: <u>https://www.youtube.com/watch?v=npOKkLtXE0w</u> Alternatively, you can find the values for salinity and sea surface temperature, as shown below (note that this dataset might not be available anymore):



Sea Surface Salinity SST (Dataset: JPL SMAP Level 3 CAO Sea Surface Salinity Standard Mapped Image 8-Day Running mean V3.0 Validated dataset) for 8 July 2017. Left: spatial variability; Right: study area SST average value; Source: JPL Climate Oceans and Solid Earth group. 2017)

C2RCC OLCI Processor	(* E
le Help	
I/O Parameters Processing Parameters	
Valid-pixel expression:	esh_inland_water)
Salinity:	34.6 PSU
Temperature:	15,0 C
Ozone:	330.0 DU
Air Pressure:	1000.0 hPa
TSM factor bpart:	1.72
TSM factor bwit:	3.1
CHL exponent	1.04
CHL factor.	21.0
Threshold AC reflectances OOS	0.05
Threshold for cloud flag on transmittance down @865	0.955
Atmospheric aux data path	
Alternative NN Path:	
Output AC reflectances as rrs instead of rhow	
Derive water reflectance from path radiance and tr	ansmittance
Use ECMWF aux data of source product	
Output TOA reflectances	
Output gas corrected TOSA reflectances	
Output gas corrected TOSA reflectances of auto no	n
Output path radiance reflectances	
Output downward transmittance	
Output upward transmittance	
V Output atmospherically corrected angular depende	nt reflectances
V Output normalized water leaving reflectances	
Output of out of scope values	
Output of irradiance attenuation coefficients	

For **"Salinity"**, set value of 34.6 PSU and for **"Temperature"** of 15°C.

We will keep the default values for Ozone and Air Pressure, while the total ozone and sea level pressure grids that are available in the OLCI L1b products (ECMWF auxiliary met data) will be used.

This option below must be ticked (✓ Use ECMWF aux data of source product).

The other parameters define the arithmetic relationship between inherent optical properties (IOPs) of the water constituents (absorption by pure water, phytoplankton pigments, yellow matter, etc.) and the actual concentrations of chlorophyll and total suspended matter. We will leave all default values as these have been widely tested and validated and are also used to derive the S-3 Level 2 product.

The only parameter we will change in the **Processing Parameters** tab will be the **Valid-pixel expression**. To edit the default expression, click on the three dots at the upper right corner.

Based on the default expression, pixels are valid if: the invalid flag is false, and the land flag is false as well, with the exception of inland water bodies. (! equals to **not**) (**&&** equals to **and**).

*		Expression Edit	or	+ E ×		
Data sources:				Expression:		
quality_flags.land		@ and @		!quality_flags.invalid &&		
quality_flags.coastline	=	@ or @		(!quality_flags.land quality_flags.fresh_inland_water)		
quality_flags.fresh_inland_water						
quality_flags.tidal_region		not @				
quality_flags.bright		(@)				
<pre>quality_flags.straylight_risk</pre>		Constants				
quality_flags.invalid		constants				
quality_flags.cosmetic	*	Operators	-			
Show bands		Functions	-			
Show masks						
Show tie-point grids						
Show single flags				Ok, no errors.		
				<u>Q</u> K <u>Cancel</u> <u>H</u> elp		

We will change the expression: we will remove from the expression the inland waterbodies and we will add the sun glint risk flag because we want to also exclude these pixels from our calculations. To achieve this, the final expression will be set as:

!quality_flags.invalid && !quality_flags.land && !quality_flags.sun_glint_risk

*		Expression Edit	or		+ = ×
Data sources:				Expression:	
quality_flags.land	@ and @			!quality_flags.invalid &&	
quality_flags.coastline	=	8 05 8	_	[quality_flags.land &&	
quality_flags.fresh_inland_water		10 UT (0		rquatity_rtags.sun_gtint_risk	
quality_flags.tidal_region		not @	_		
quality_flags.bright		(@)			
quality_flags.straylight_risk		Constants	1-		
quality_flags.invalid		constants	-		
quality_flags.cosmetic	+	Operators	-		
Show bands		Functions	-		
Show masks			-	1	
Show tie-point grids					50
Show single flags					Ok. no errors.
				<u>OK</u> <u>C</u> ancel	Help

Click **OK** and then click **Run** to execute the C2RCC processor. This might take up to 10 minutes depending on your VM/PC.

Once the processing has finished and notification window will appear, click **OK**.

Close the C2RCC OLCI Processor dialog window.

In your **Product Explorer** tab, you will find a new product with index number [4].

7.5 Visualization

Now let's see our outputs. Expand the new product in the **Product Explorer** tab and then expand the **Bands** folder. In the Bands folder, you will find 7 folders and 2 additional bands.

The 1st folder *"iop"* contains the absorption coefficient bands for different water constituents at 443 nm.

The 2nd folder *"conc"* contains the absolute concentration bands for total suspended matter dry weight (*conc_tsm* [g*m⁻³]) and chlorophyll concentration (*conc_chl* [mg*m⁻³]).

The next folder we are interested in is the 5th one, **"rhown"** containing the Normalized water-leaving reflectances for each original radiance band (See 1 NOTE 2).

Lastly, we need to pay attention to the 7th, "*unc*" folder that contains uncertainty estimates for the IOPs and the concentration bands.

NOTE 2: **Radiance** is the variable directly measured by remote sensing instruments. It is the amount of light seen by instrument from a surface of an object. In the SLSTR products is given as radiance of a surface per wavelength unit [mW*m⁻²*sr⁻¹*nm⁻¹ = watt per square meter per nanometer]. **Reflectance** is the ratio (percentage) of the amount of light leaving a target to the amount of light arriving to the target. It has no units. It is the property of the observed object/material.

Let's expand the "*conc*" folder and double click on "*conc_chl*" band to open it in view window.



We can see that all the land areas have been removed but clouds appeared are misclassified as high concentration. We can use the masks included in the product to eliminate them.

Firstly, go to **"Colour Manipulation"** tab and import/open the colour palette named **"cc_chl.cpd"**. At the dialog that will appear at the bottom left, click **NO** to keep the predefined colour classes.



Then go to **View** \rightarrow **Tool Windows** \rightarrow **Mask Manager**. The **Mask Manager** window should appear docked at the right side of the SNAP window (if not already there).

There you can enable flags indicating land (*quality_flags_land* - green) and clouds (*Cloud_risk* - gray). You may need to zoom-in and out to load the masks properly.

IMPORTANT! The masks do not remove the values corresponding to clouds from the histogram; they only hide them from view.



You can also inspect the uncertainty of these concentration estimates.

Go to the "*unc*" folder and open the "*unc_chl*" band. Then, go to "**Colour Manipulation**" tab and open the colour palette named "*spectrum*". You can again use the masks (*quality_flags_land* - green) and (*Cloud_risk* - gray) to mask out the land and cloud values.



You can also explore the total suspended matter estimates.

Open the "conc_tsm" band, the go to "Colour Manipulation" tab and import/open the colour palette

named "*cc_tsm.cpd*" and click again **NO** at the dialog that will appear at the bottom left, to keep the predefined colour classes. Finally, investigate the "*unc_tsm*" band as well and at the "Colour Manipulation" tab, open the colour palette named "*spectrum*".





Close all views except the "conc_chl" view.

7.6 Comparison to the Level-2 WFR product

In the beginning of the exercise, we have downloaded two products, Level-1 EFR product (that we have processed) and Level-2 WFR product. Now let's compare our output to the operationally generated. In the **Product Explorer** tab, highlight the Level-2 product (index number 2).

Go to **Raster** \rightarrow **Subset** and subset the product using the same pixel coordinates as for the Level-1. At the **Spatial Subset** tab go to **Pixel Coordinates** tab and set the following coordinates:

Scene start X: 600 Scene start Y: 50 Scene end X: 2800 Scene end Y: 2250

Expand the subset with index number [5] in the **Product Explorer** tab and expand the **Bands** folder. Expand the **"CHL"** folder and double click on **"CHL_NN"** band. Again, go to the **"Colour Manipulation"** tab and load the **"cc_chl.cpd"** colour palette. At the dialog that will appear at the bottom left, click **NO** to keep the predefined colour classes.



Open the Mask Manager and turn on the "WQSF_Isb_LAND" mask as well as all the cloud related masks ("WQSF_Isb_CLOUD", "WQSF_Isb_CLOUD_AMBIGUOUS", "WQSF_Isb_CLOUD_MARGIN").



In the **Transparency** column, change the transparency to 0 for those 4 masks.



Go to Window \rightarrow Tile Horizontally; in Navigation tab select Zoom all.

You can also open the uncertainty bands and compare them. You will see some minor differences mostly due to the additional pre-processing applied during the generation of the Level-2 WFR product by the ground segment. These pre-processing steps are not applied to the Level-1 product we have processed and are not part of the C2RCC algorithm.

Export as GeoTIFFs 7.7

Close all view windows. In Product Explorer, expand the Subset of the Level-1 processed product with index number [4]. Expand "Bands" folder. Then expand "conc" folder. Right-click on the "conc_chl" band and select **Convert Band** (this converts the band from virtual to physical, so we can export it).

Do the same for the *"unc_chl"* band. Right-click the product name and select **Save Product**.



Go to File \rightarrow Export \rightarrow GeoTiff (NOT! Geotiff/Big Tiff). In the dialog, that opens click Subset.

At the **Band Subset** (second tab) use the **Select none** button to deselect them all first and then select only bands "*conc_chl*" and "*unc_chl*".

Then go to the **Metadata Subset** tab and click **Select none**.

	Specify Product Subset	• • ×	Specify Product Subset	• • ×
Spatial Subset	Band Subset Tie-Point Grid Subset Metadata	Subset	Spatial Subset Band Subset Tie-Point Grid Subset Metadata	Subset
Conc_tam Conc_tam Conc_chi Unc_apig Unc_adet Unc_adet Unc_adet Unc_adg Unc_atot Unc_atot Unc_tam Vunc_atot Unc_tam Vunc_tam Vunc_dd89	Total suspended matter dry weight concentration Chlorophyll concentration (expression was 'powliop_apig uncertainty of pigment absorption coefficient uncertainty of detritus absorption coefficient uncertainty of detritus absorption coefficient uncertainty of particle scattering coefficient uncertainty of total gelbstoff absorption coefficient uncertainty of total water constituent absorption coefficient uncertainty of total water constituent absorption coefficient uncertainty of total suspended matter (TSM) dry weight c uncertainty of interfame attenuation coefficient uncertainty of total suspended matter (TSM) dry weight c uncertainty of irradiance attenuation coefficient uncertainty of irradiance attenuation coefficient	ent ent oncentration pow/unc_apig	Abstracted Metadata Manifest 0 001_radance 0 002_radance 0 003_radance 0 004_radance 0 005_radance 0 005_radance 0 000_radance 0 009_radance 0 009_radance 0 009_radance 0 001_radance 0 011_radance 0 011_radance 0 011_radance 0 011_radance 0 011_radance 0 011_radance 0 011_radance 0 011_radance 0 011_radance	
	Estimated, raws	storage size: 20.7M	Estimated, raw s	torage size: 20.7M

Then click **OK**. In the dialogs (one or two), that appear, click **NO**.

Save the file to the "*Processing*" folder as: *Chlorophyll_conc_20170709.tif* and press "Export Product". Repeat the same for the TSM bands (save as *TSM_20170709.tif*).

Now, we can import the image to another GIS/ Remote sensing software for further processing or map creation. In the extra steps of this tutorial, we will use QGIS. To download the results to your local computer, see section **6.1 Downloading the outputs from VM**.

8 Extra steps

8.1 Downloading the outputs from VM

Press **Ctrl+Alt+Shift.** A pop-up window will appear on the left side of the screen. Click on bar below **Devices**, the folder structure of your VM will appear. Navigate to your Processing folder and **double click any file you want to download**.



9 Further reading and resources

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JPL Climate Oceans and Solid Earth group. 2017. JPL SMAP Level 3 CAP Sea Surface Salinity Standard Mapped Image 8-Day Running Mean V3.0 Validated Dataset. Ver. 3.0. PO.DAAC, CA, USA. Dataset accessed 2018-02-21] at <u>http://dx.doi.org/10.5067/SMP30-3TPCS</u>.

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