



TRAINING KIT – LAND04

LAND MONITORING WITH SENTINEL-3 Case Study: Cyprus, 2017









Research and User Support for Sentinel Core Products

The RUS Service is funded by the European Commission, managed by the European Space Agency and operated by CSSI and its partners.

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

Cover images produced by RUS Copernicus

The following training material has been prepared by Serco Italia S.p.A. within the RUS Copernicus project.

Date of publication: March 2018

Version: 1.2

Suggested citation:

Serco Italia SPA (2018). *Land monitoring with Sentinel-3 (version 1.2) Case study: Cyprus.* Retrieved from RUS Lectures at <u>https://rus-copernicus.eu/portal/the-rus-library/learn-by-yourself/</u>



This work is licensed under a <u>Creative Commons Attribution-NonCommercial-ShareAlike 4.0</u> International License.

DISCLAIMER

While every effort has been made to ensure the accuracy of the information contained in this publication, RUS Copernicus does not warrant its accuracy or will, regardless of its or their negligence, assume liability for any foreseeable or unforeseeable use made of this publication. Consequently, such use is at the recipient's own risk on the basis that any use by the recipient constitutes agreement to the terms of this disclaimer. The information contained in this publication does not purport to constitute professional advice.

Table of Contents

1	Int	ntroduction to RUS					
2	La	and monitoring – background					
3	Tra	Training4					
	3.1	Da	ata used4				
	3.2	So	oftware in RUS environment				
4	Re	egiste	er to RUS Copernicus				
5	Re	eques	st a RUS Copernicus Virtual Machine6				
6	Ste	ep by	/ step				
	6.1	Da	ata download – ESA SciHUB10				
6.2 SNAP – Open and explore data							
	6.3 G		raph Builder				
	6.3	3.1	IdePix Processor				
	6.3	3.2	Band Math				
	6.3	3.3	Subset				
	6.3	3.4	Reproject				
	6.3	3.5	Write				
	6.4	Ba	atch processing15				
	6.5	Co	ollocate (two images)				
	6.6	Ba	and Subset				
	6.7	Μ	ean NDVI				
	6.8	Tir	me series				
7	Ex	tra st	teps				
8	Fu	irther	r reading and resources				

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 pre-installed on virtual machines, to handle and process data derived from the Copernicus Sentinel satellites constellation.

In this tutorial, we will employ RUS to analyze the temporal evolution of the **N**ormalized **D**ifference **V**egetation Index (NDVI) over Cyprus using Sentinel-3 OLCI data.

2 Land monitoring – background



Land surface dynamics represent one of the key drivers to assess environmental change at different scales. Monitoring activities play a relevant role to detect and understand those patterns and to measure the resilience of ecosystems.

Satellite based Earth observation methods are one of the best approaches to perform those tasks at local, regional and global scale. The

Sentinel-3 **O**cean and **L**and **C**olor Instrument (OLCI) provides continuous and high frequency data that can be used to gather information about vegetation state.

In this webinar, you will learn the basics of image processing for land dynamics monitoring. We will show you how to access the RUS Service and how to download, process, analyze and visualize the free data acquired by the Copernicus satellites. We will employ the ESA SNAP Sentinel-3 Toolbox to demonstrate the methodology for monitoring land surface dynamics.

3 Training

Approximate duration of this training session is one hour.

The Training Code for this tutorial is LAND04. If you wish to practice the exercise described below within the RUS Virtual Environment, register on the <u>RUS portal</u> and open a User Service request from Your RUS service \rightarrow Your dashboard.

3.1 Data used

- 7 Sentinel-3A images acquired during May 2017 downloadable at https://scihub.copernicus.eu/
- Pre-processed data stored locally @ /shared/Training/LAND04_LandMonitoring_Cyprus/AuxData/

3.2 Software in RUS environment

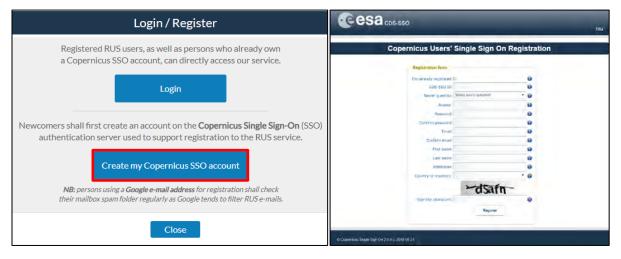
Internet browser, SNAP + Sentinel-3 Toolbox

4 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	
The RUS Service * The RUS Offer * The RUS Library * The RUS Community *	
	Senth
	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.

Credentials			
CDS-SSO ID Password Max Idle Time Max Session Time	half a day Until browser close Login Reset	Y Y	0000
	CDS-SSO ID Password Max Idle Time	CDS-SSO ID Password Max Idle Time half a day Max Session Time Until browser close	CDS-SSO ID Password Max Idle Time half a day Max Session Time Until browser close

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

		and Jort	18 18 Mar 2	÷	esa 	
	The RUS Service * The RUS C	Do you want t	to subscribe for a new RUS account?	1		
		Your ESA-SSO subscription	data:			
	+ Your RUS service	Login		- 1	9	
	Iniguection pathers pages related in m	FirstName		- 1		
	· Your profile: displays your distance	Last Name			us	
6	- Tom Induite antiversity for the so-	Email		- 1		
	· Your dashboard: allows you to ac-	Organization				
A	· Your training silows you to man	Country		- 1		
1.1			onal subscription information			
	/	Please complete the followi	ing information:			
		Where did you hear about the RUS service? Select one or more items	colleagues newsletter	*		
			conference social media other		than - Foujour - 255 27 Oct 2018	
		Institution type	Select one item	*	nda da	
		Phone number Italy (IT):	+39			
		Title	Select one item	~		
			Subscribe Cancel		y in f	
	Inspectified 9-2 - 12 Kommerlin Installater Kategorit	A REAL PROPERTY AND A REAL	and the second	Christin 1		

5 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**.

CORRUS Research and User Support	n Ki	
	Your RUS service Your profile Your dashboard	You are here: Home > Your RUS service
 This section gathers pages related to your RUS services: Your profile: displays your personal information linked to your ESA SSO and RUS accourting the section of the s		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 RUS Training Session - Valencia - 22 July 2018 IGARSS 2018 - Valencia - 22-27 July 2018

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.

CORRUS Research and User Support	a and the th	Hello, Miguel
The RUS Service The RUS Offer The RUS Library The RUS Con	nmunity • 🕀 Your RUS service •	
		You are here: Home > Your RUS service > Your dashboard
 Your dashboard 		
Request a new User Service		Chat with Support Desk.
Copyright © 2017 Research and User Support		Contact Us Terms and conditions Glossary Acronyms FAQ

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

Please help us learn more about your background by answering a few question 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 access hubs? Yes No Have you already handled/processed Copernicus data?	ns. ()
Choose one Item Have you already downloaded Copernicus data via the Copernicus Open access hubs?	
Have you already downloaded Copernicus data via the Copernicus Open access hubs?	•
® Yes © No	
© No	
the second se	
Have you alward (handled (anarose of Consenious date?	
Have you already handled/processed Copernicus data:	
I Yes	
© No-	
Do you wish to practice a tutorial exercise shown in a RUS webinar? If yes, please select your cl (hold down CTRL key for multiple selections).	hoice
HAZA01 - Flood Mapping in Malawi	
HAZA02 - Burned Area Mapping in Portugal HYDR01 - Water Bodies Mapping over Northern Poland	
LAND01 - Crop Mapping in Seville	- 11
LAND04 - Land Monitoring in Cyprus	-
OCEA01 - Ship Detection in Gulf of Trieste	
If you wish to request another tutorial exercise that doesn't appear in the above list, please typ	
	be here
its name or code. Note that you can request multiple tutorial exercises.	be here

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

Summary information on your request:			
This is a collection of information selecte	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?	V.		
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	-		
S1 - Orbit direction Sentinel-2			
Sentinel-2 Sentinel-3	X		
Other	×		
I don't know	X		
	x		
Region of Interest: 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			
There wand and arrests to the Towner	conditions of DLIC Condex		
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 das
Your dashboard								
Request a new U	Iser Servi	P					5	Chat with Support Desi
=0 Request a new c	Set Set 4							chat muroupport Dea
Project Name	ID	Date of submission	Status		Actions		Virtual	Environment
	1			Follow my project	Get support	Close my service	Access my Virtual Machine(s)	Access my CPU monitoring dashboard
	231	2017-08-31	Open		Get a webinar kit	Rate my service	Freeze my Virtual Machine(s)	Report a technical incident
S_training1	231	2017-08-31	Open	10 11 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		Rate my service	Machine(s) Freeze my Virtual	monitoring dashboar Report a technical

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

C A Not secure https://usr-231.rus-cop	pernicus.eu/#/	
	APACHE GUACAMOLE	
	APACHE GUACAMOLE	
	Username	
	Password	
	Login	

This is the remote desktop of your Virtual Machine.



6 Step by step

6.1 Data download – ESA SciHUB

Before starting the exercise, we need to make sure that we are registered in the Copernicus Open Access Hub so that we can access the free data provided by the Sentinel satellites.

Go to https://scihub.copernicus.eu/



Go to *"Open Hub"*. If you do not have an account please sign up in the upper right corner, fill in the details and click register.

Copernicus Op	en Access Hub	SIGN UP LOGIN 🕜 🛧
Register n	ew account	
Sentinel data access is free and open to all.		
On completion of the registration form below you will receive an e-mail with a link to valid Username field accepts only alphanumeric characters plus "", "", ", ", " and ","	ate your e-mail address. Following this you can start to download the data.	
Firstname	Lastname	•
Usemamo		
Plassword	Continu Password	
E-mái	Contirm E-mail	
Select Domain •		
Select Usagé		
Select Country •		
By registering in this website you are deemed	to have accepted the T&C for Sentinel data use.	GISTER

You will receive a confirmation email on the e-mail address you have specified: open the email and click on the link to finalize the registration.

Once your account is activated – or if you already have an account – log in.

Switch the rectangle drawing mode to pan mode by clicking on the icon in the upper right corner of the map (Green arrow), navigate to Cyprus *mode* and draw a rectangle approximately as indicated below.

Open search menu by clicking at the left of the search bar (\equiv), specify the following parameters press the search button (\square):

Sensing period: From 2017/05/01 to 2017/05/31 Check Mission: Sentinel-3 Product type: OL_1_EFR__ Instrument: OLCI Product Level: L1

		Copernicus Open Access Hub	±0 A
Insert search criteria Skope	Porter and Annual Annua	Since	Derbent ⁹ Telavi Zogatala
» Order By: Descending	+	Bathing Grundel Georgia Zerguldas Katanonu Samsung Artung	Telavi Zagatala Shaki Shabran
	17/05/01 🚆 to: 2017/05/31 🚆	Visiona Boru Cankin Comm Tokat Cumuphane Kan [®] Torean Burus Anaata Yonata Sakat Baybut Torean	Ganja Shamakhi Teter [®] Azerbaljan
Ingestion period From. Mission: Sentinel-1	to:	Kutahya Kutaka Kutaka Kutahya Kutahya Kutahya	Parsabad Saath
Satellite Platform	Product Type	Ugat Atjonkarahisar Aksarar Progenir Malata	Nakhchivan Lankaran Meshkirishahr Ardabil
Polarisation	Sensor Mode	Denizil Iparta Konya Nides Kahramanmaras Adiyaman Diyarbakir Siirt Sunak Hakkan	Sarab Sahand Banc
Relative Orbit Number (from 1 to 175)	Collection	Antalys Karaman Adama Gazianteo Rina Oamishi Dawys wilsto Mersin Kils Althouse Dahuts Siran	Bonab Maragheh Naragheh Naghadeh Zanjan Bukan
Mission: Sentinel-2 Satellite Platform	Product Type	Antaiya Aleppo Ar Ragah	Saqqez Abh
Relative Orbit Number (from 1 to 143)	Cloud Cover % (e.g.[0 TO 9.4])	Tartus Hama Sataniyah	Sulaymaniyah Oorveh Hamedan
Mission: Sentinel-3		Tripus Syria Turi Artisi Libbook	Gilangharb Nalayer
Satellite Platform	Product Type OL_1_EFR	livre Sdon Damaxus Failujan Iraa	Hame Khorramabad Air
Timeliness.		Tel Avio-Teb	Kuto Dezfulo
Product Level	Relative Orbit Start [1-385]	Alexandrio staladia Per Sald Al Andri Ober Sheva Jordan	Ash Shatrah Ahvaz
1 J.	al Qattaran	Tana Lana Lana Lana Lana Lana Lana Lana	Natariyah Abada 🗿

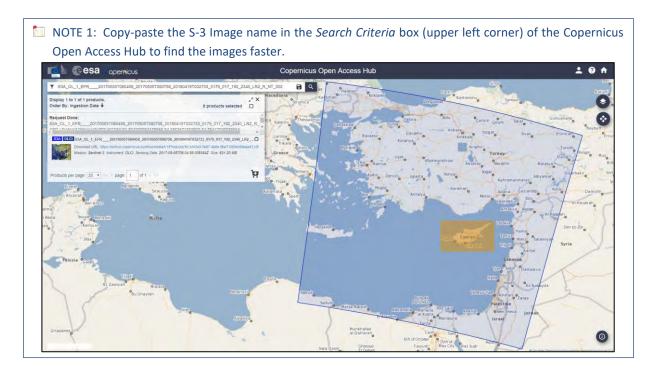
In our case, the search returns 22 results depending on the defined search area. Download the following scenes (See \sum NOTE 1):

Date	S-3 Image name
2017-05-05	S3A_OL_1_EFR20170505T080458_20170505T080758_20180419T032733_0179_017_192_2340_LR2_R_NT_002
2017-05-10	S3A_OL_1_EFR20170510T073503_20170510T073803_20180419T173805_0179_017_263_2340_LR2_R_NT_002
2017-05-13	S3A_OL_1_EFR20170513T075729_20170513T080029_20180420T025347_0179_017_306_2340_LR2_R_NT_002
2017-05-21	S3A_OL_1_EFR20170521T075000_20170521T075300_20180421T065708_0179_018_035_2340_LR2_R_NT_002
2017-05-24	S3A_OL_1_EFR20170524T081227_20170524T081527_20180421T154649_0179_018_078_2340_LR2_R_NT_002
2017-05-28	S3A_OL_1_EFR20170528T080842_20170528T081142_20180422T032713_0179_018_135_2340_LR2_R_NT_002
2017-05-29	S3A_OL_1_EFR20170529T074232_20170529T074532_20180422T061843_0180_018_149_2340_LR2_R_NT_002

Download the scenes by clicking the download icon on each product -

Once downloaded (@/home/rus/Downloads), copy them to the following path and unzip them (right click -> Extract Here)

Path: /shared/Training/LAND04_LandMonitoring_Cyprus/Original/May/



6.2 SNAP – Open and explore data

Open SNAP Desktop from your desktop (or Applications -> Processing -> SNAP), click on the Open product icon (\frown), navigate to the following path and open the Sentinel-3 product from 2017-05-10. Open the folder and select the file *xfdumanifest.xml*. Then, click OK.

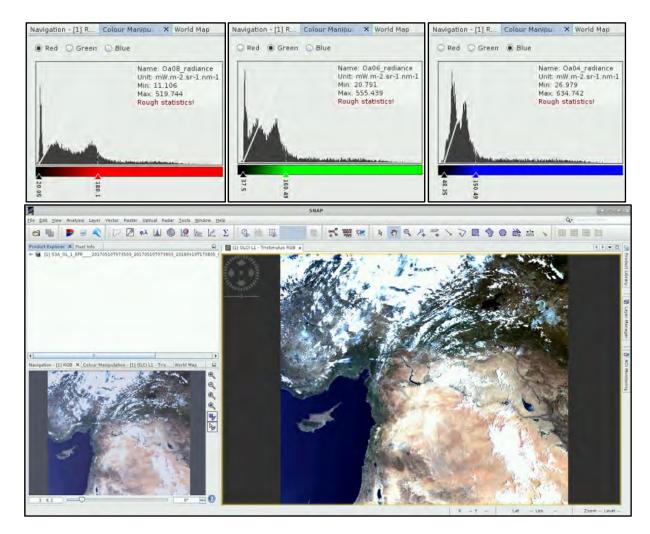
Path: /shared/Training/LAND04_LandMonitoring_Cyprus/Original/May/

In *Product Explorer* tab, right click on the product and select *Open RGB Image Window* to create and visualize an RGB composition image. Select the following band combination to create a true color RGB composition and click OK.

Red: Oa08_radiance | Green: Oa06_radiance | Blue: Oa04_radiance

Profile:		 	-
OLCILI	- Tristimulus (modified)		
Red:	Oa08_radiance	-	
Green:	OaO6_radiance	-	44
Blue:	OaO4_radiance	-	
Stor	e RGB channels as virtual band:	essions are roduct	vali

As the colors are distributed according to the image histogram, the view is very dark. To enhance it, we can change the color distribution for each RGB band in the *Color Manipulation* tab in the lower left corner of SNAP. Select the **red** channel, click on the right-hand slider below the histogram and move it to approx. 180. Change to the **green** channel at the top of the tab and set the slider to approx. 160. Last, change to **blue** and set the slider to approx. 150.



6.3 Graph Builder

For this exercise, we will process several Sentinel-3 images. Repeating the analysis for every image one by one would be very time consuming. For this reason, we can create a graph containing all the steps of our methodology and use the batch processing option of SNAP to run bulk processing. First, we need to open an empty graph. Go to *Tools -> GraphBuilder*. At the moment, the graph only has two operators: *Read* (to read the input) and *Write* (to write the output). To avoid any confusion, right click on the *Write* operator and delete it.

6.3.1 IdePix Processor

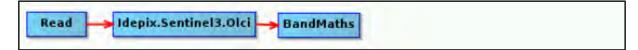
The first step of our methodology will aim to remove cloudy pixels from the image. For that, we will use the IdePix processor (See NOTE 2) available on SNAP, which provides a pixel classification into properties such as clear/cloudy, land/water, snow, ice etc. To add the operator, right-click on the white area and go to Add -> Optical -> Pre-processing -> IdePix.Sentinel3.Olci. Connect the new Idepix.Sentinel3.Olci operator with the Read operator by clicking to the right side of the Read operator and dragging the red arrow towards the Idepix.Sentinel3.Olci operator.

Read 🔶 Idepix, Sentinel 3. Olci

NOTE 2: The IdePix processor provided with the current SNAP version supports the following satellites/sensors: Sentinel-2 (MSI), Sentinel-3 (OLCI), Envisat (MERIS), Landsat-8 (OLI), Proba-V (Vegetation), SPOT (Vegetation), Terra/Aqua (MODIS), OrbView-2 (SeaWiFS), Suomi NPP (VIIRS). It calculates a certain set of physical features and a probabilistic combination of these features in order to calculate a set of pixel classification attributes. Only the implementation of how the features are calculated is instrument specific. For cloud detection, the following features are used: brightness, whiteness, height, temperature, spatial pattern, temporal consistency, Neural Network probability.

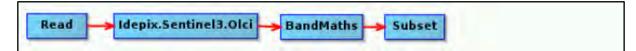
6.3.2 Band Math

The next processing step will be to derive the Normalized Difference Vegetation Index (NDVI) for the pixels that are not flagged as cloudy by the IdePix processor and that are not water pixels. For this task, we will use *Band Math*. Add the *Band Math* operator. Right-click and go to *Add* -> *Raster* -> *BandMaths*. Connect the operators as shown below.



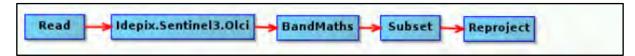
6.3.3 Subset

Next, we need to reduce the spatial extent to focus on our study area. For that, add the *Subset* operator. Right-click and go to *Add -> Raster -> Geometric -> Subset*. Connect the operators as shown below.



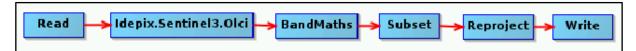
6.3.4 Reproject

The last step of the graph will consist of a reprojection. Sentinel-3 OLCI products are delivered georeferenced onto the Earth's surface. By reprojecting, we can assign a specific map projection and make sure all the inputs have the same spatial characteristics. Add the reproject operator by right-clicking *Add -> Raster -> Geometric -> Reproject*. Finally, *Right click -> Connect Graph* to connect all the operators. Connect the operators as shown below.



6.3.5 Write

Finally, we just need to properly save the output. For that, we first need to add the Write operator to our graph. Right click and navigate to Add -> Input-Output -> Write.



Finally, click on Save in the lower part of the pannel and save the graph in the following path as 'S3_Graph.xml' without setting any parameter.

Path: /shared/Training/LAND04_LandMonitoring_Cyprus/AuxData/

6.4 Batch processing

Before using batch processing, we need to load all the images we want to analyse in SNAP. An option would be to open one by one, but for convenience, we will use a saved SNAP session that already contains all the products loaded. Click on *File -> Session -> Open Session* navigate to the following path and select the session file *S3_May.snap*

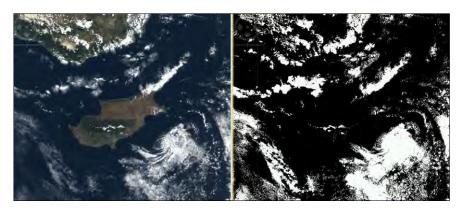
Path: /shared/Training/LAND04_LandMonitoring_Cyprus/AuxData/May/

Click on *Tools -> Bath Processing*. Press the *Add Opened* icon on the upper right side (second from top) and click refresh. Then, unselect the *Keep source product name*. Click *Load Graph* at the bottom of the window, navigate to the saved graph and open it. We see that new tabs have appeared at the top of window corresponding to the operators previously defined on the graph.

1.02 10 0.00 0.00 0.00 0.00	s Idepio	. Sentinel3. Old	ci BandMaths	Subset R	eproject Writ	te
File Nan	ne	Туре	Acquisition	Track	Orbit	4
S3A OL 1 EFR	2017	OL_1_EFR	05May2017	99999	99999	
S3A_OL_1_EFR_	2017	OL_1_EFR	10May2017	99999	99999	
S3A_OL_1_EFR_	2017	OL_1_EFR	13May2017	99999	99999	-
S3A_OL_1_EFR_		OL_1_EFR	21May2017	99999	99999	-
S3A_OL_1_EFR_		OL_1_EFR	24May2017	99999	99999	
S3A_OL_1_EFR_			28May2017	99999	99999	
S3A_OL_1_EFR_	2017	OL_1_EFR	29May2017	999999	99999	-
Target Folder						7 Prod
	200.0					7 Prod

In the *Idepix.Sentinel3.Olci* tab, make sure you select all the bands in the *'Select TOA reflectances to write to the target product'*. In that way, the IdePix processor output will contain already pixel values in reflectance and not radiance (See NOTE 3). For demonstration, the image below shows this

intermediate output: a RGB true color composition and the binary cloud mask ('*IDEPIX_CLOUD*') created using IdePix.



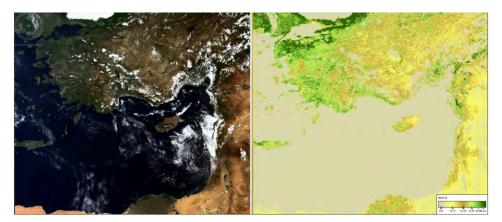
NOTE 3: **Radiance** is the variable directly measured by remote sensing instruments. It is the amount of light seen by instrument from a surface of an object. In the OLCI products, it is given as 10-3 W.m-2.sr-1.µm-1

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.

ile Graphs	
1/0 Parameters Idepix Sentinel3 Olci BandMat	hs Subset Reproject Write
Select TOA radiances to write to the target product:	Oa01_radiance • Oa02_radiance • Oa03_radiance • Oa05_radiance • Oa05_radiance • Oa05_radiance • Oa07_radiance • Oa07_radiance •
Select TOA reflectances to write to the target produc	0a01_reflectance 0a02_reflectance 0a03_reflectance 0a04_reflectance 0a05_reflectance 0a05_reflectance 0a07_reflectance 0a08_reflectance
Write NN value to the target product	
Compute a cloud buffer	
Width of cloud buffer (# of pixels):	

Click now on the *BandMaths* tab, set the target band name to *NDVI*, set the No-Data value to *NaN*, click on *Edit Expression* and copy-paste the following expression. Click Ok afterwards. For demonstration, the image below shows this intermediate output: a RGB true color composition and the NDVI calculated for land cloud-free pixels.

if IDEPIX_CLOUD == TRUE or IDEPIX_LAND == FALSE then 0 else (Oa17_reflectan
ce-Oa08_reflectance)/(Oa17_reflectance+Oa08_reflectance)



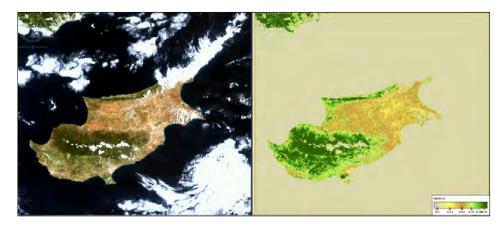
	Batch Processing : S3_Graph.xml
File Graphs	
1/O Parameters	Idepix.Sentinel3.Olci BandMaths Subset Reproject Write
Target Band:	NDVI
Target Band Type:	float32
Band Unit:	
No-Data Value	NaN
	4
	Edit Expression
	Load Graph Run <u>C</u> lose <u>H</u> elp

In the *Subset* tab, remember to select *Geographic Coordinates*, copy-paste the following Well-Known Text (WKT) and click *Update* to define the area and click to Zoom-in.

POLYGON ((32.401301 36.031754,34.667141 35.741352,34.374742 34.318205999999 996,32.149456 34.612776,32.401301 36.031754))

1/O Parameters	depix. Sentinel3. Olci BandMa	aths Subset	Reproject Write		
Source Bands:	NDVI				
Copy Metadata	Geographic Coordinates				Zoom-
and a loss of the second se			- China	100	

For demonstration, the image below shows the output of the processing chain: the cropped area shown as RGB (for reference purposes) and the corresponding NDVI calculated for land free-cloud pixels.



In the reproject tab, select *Custom CRS* to define the Coordinate Reference System. Select *UTM / WGS 84 (Automatic)* on the drop-down menu.

Caraba	Dutten	rocessing	. ab_orup	mann		0
e Graphs						
I/O Parameters	Idepix.Sentine	el3.Olci B	landMaths	Subset	Reproje	ect Write
Coordinate Referen	nce System (0	CRS)				
Custom CRS						
Geodetic datur	m:					1.
Projection: UTM / WGS 84 (Automatic)						
				F	rojection P	araméters
O Predefined CRS	5					Selerz.
Output Settings						
	ution	Denro	ject tie-poir	nt grids		
Preserve resol	ausii	In webic				
Output Para		No-data v		NaN		
	meters.	No-data v		-		
Output Para	meters n bands	No-data v	value:	-		
Output Para	meters n bands	No-data v	value: ng method:	-	33*24'1	9" E
Output Paran	meters . n bands pixel	No-data v	value: ng method:	Nearest	33*24'1 35*07'4	

Finally, in the *Write* tab, make sure you select the following path as output directory. Click *Run* after that. Path: */shared/Training/LAND04_LandMonitoring_Cyprus/Processing/May/*

	Batch Process	sing : S3_Gra	ph.xml		+ = ×
file Graphs					
I/O Parameters	Idepix Sentinel3. Olci	BandMaths	Subset	Reproject	Write
Target Product Name: [projected Subset	534 OL 1 FED 201	705057080458	20120505	T080758 20	1705057100601 (
Save as: BEAM-D Directory:		703031000430	20170303	1000750_20	170505(100001_0
/shared/Train	ing/LAND04_LandMonito	ring_Cyprus/Pr	ocessing/M	lay	1
		Load	Graph	Run	<u>Close</u> Help

6.5 Collocate (two images)

The following step will aim at stacking all the NDVI outputs of the batch processing in a single product to allow further processing. For this task, we will use the *Collocation* tool, which allows collocating two spatially overlapping products. Collocating two products implies that the pixel values of one product (the *slave*) are resampled into the geographical raster of the other (the *master*). Click on *Raster -> Geometric Operations -> Collocation*.

Unfortunately, the collocation tool only allows processing one master and slave product at once. Due to this, to collocate all the NDVI images in a single product, we need to do it step-by-step. For this exercise, you will find the output of this process in the following path. Close all the previous products opened in SNAP, navigate to the path and open the file *Collocate_May.dim*.

Path: /shared/Training/LAND04_LandMonitoring_Cyprus/AuxData/May/

6.6 Band Subset

Expand the collocated product and open the *Bands* folder. Before deriving the mean NDVI value per pixel, we will remove some of the bands of the collocated product that are not needed anymore. Click on the *Collocate_May.dim* and go to *Raster -> Subset*. Select the *Band Subset* tab on the top part of the window. Check the *Select None* option on the lower part of the window to unselect all the bands by default. Now, select the bands we want to keep by checking them:

NDVI_1 | NDVI_2 | NDVI_3 | NDVI_4 | NDVI_5 | NDVI_6 | NDVI_7

Once selected, click OK. Two pop-up messages will appear asking to include the *collocation_flags* bands created during the collocation process and to add a flag dataset. Click YES in both cases.

Specify Product Subset		Incomplete Subset Definition
Spatial Subset Band Subset Metadata Subset		The following dataset(s) are referenced but not included in your current subset definition:
<pre> NDV(1 latitude_1t8_t5_t10_t11_t12 longitude_1_t8_t5_t10_t11_t12 quality_flags_1_t8_t5_t10_t11_t12 TP_longitude_1_t8_t5_t10_t11_t12 TP_longitude_1_t8_t5_t10_t11_t12 OAA_1t8_t5_t10_t11_t12 OAA_1t8_t5_t10_t11_t12 SAA_1t8_t5_t10_t11_t12 SAA_1t8_t5_t00_t11_t12 SAA_1t8_t5_t00_t11_t12 sAA_1t8_t5_t00_t11_t12 sAA_1t8_t5_t10_t11_t12 sAA_1t8_t5_t5_t10_t11_t12 sAA_1t8_t5_t10_t11_t12 sAA_1t8_t5_t10_t10_t11_t12 sAA_1t8_t5_t5_t10_t11_t12 sAA_1t8_t5_t5_t5_t5_t5_t5_t5_t5_t5_t5_t5_t5_t5_</pre>	DEM corrected la DEM corrected la Classification and Latitude Longitude Observation (Vie Sun Azimuth Angi Sun Zenith Angie Air temperature p	<pre>in your current subset aerination. 'collocation_flags_110_111_112' 'collocation_flags_110_111_112' 'collocation_flags_112' 'collocation_flags_112' 'collocation_flags_112' 'collocation_flags_112'10_111_112' 'collocation_flags_112'10_111_112' 'f you do not include these dataset(s) into your selection. you might get unexpected results while working with the resulting product. Do you wish to include the referenced dataset(s) into your subset definition? Yes No Cancel</pre>
atmospheric_temperature_profile_pressure_level_2_1_t8_t9_t10_t11_t12	Air temperature p	No Flag Dataset Selected
atmospheric_temperature_profile_pressure_level_3_1_t8_t9_t10_t11_t12 atmospheric_temperature_profile_pressure_level_4_1_t8_t9_t10_t11_t12	Air temperature p Air temperature p	? No flag dataset selected
Select all Select none	1+1_1	If you do not include a flag dataset in the subset, you will not be able to create bitmask overlays.
Estimated, ra	w storage size: 4,5M <u>C</u> ancel <u>H</u> elp	Do you wish to include the available flag dataset(s) in the current subset? Ites No Cancel

Make sure to save to product. Right click on the subset product, select *Save Product*, navigate to the following path and set the name to *Collocate_May_subset.dim*. A window will appear asking you to convert the product to BEAM-DIMAP format. Click *Yes*.

Path: /shared/Training/LAND04_LandMonitoring_Cyprus/AuxData/May/

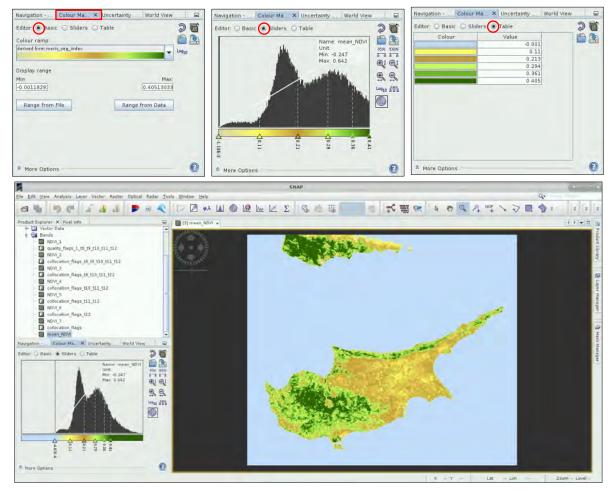
6.7 Mean NDVI

Now, we will derive the mean NDVI value for each pixel in the image. Right click on the *Collocate_May_subset* product and select *Band Math*. Set the name to *mean_NDVI*, unclick the option *Virtual (save expression only, don't store data)* and click on *Edit Expression*.

Copy-Paste the following expression and click Ok. Do not forget to save the product afterwards.

		Expression:	
•	9 + 0		2+ NDVI_3+ NDVI_4+
	1 - 0	NDVI_5+ NDVI_6+	+ NDVI_7)/7
12345_123456 =		_	
15 100 15 5			
45_123456	9/6		
23456	(@)		
		-	
Operators		-	
		A second s	
	12345 123456	12345_123456 345_123456 1234	12345 123456 9 · 0 945_123456 0 · 0 0 ·

Expand the *Bands* folder of the product and double click on the file *mean_NDVI*. You can change the colour on the *Colour* Manipulation tab in the lower left corner. First, select *Basic* as Editor. Change the colour ramp to *meris_veg_index*. Now, click the *Slider* Editor, and stretch the histogram to the 95% of the pixels by clicking on the icon. Finally, click *Table* and change the color of the first value (-0.001) to light blue.

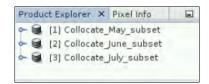


6.8 Time series

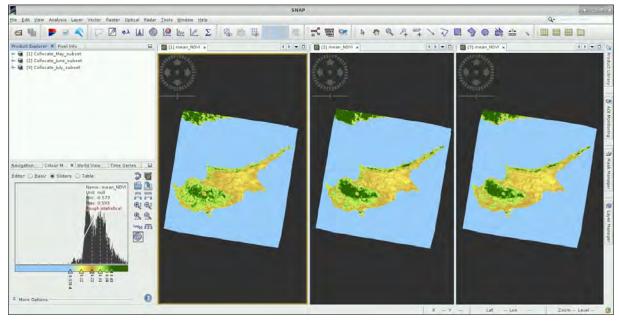
SNAP offers a time series analysis tools suitable to represent temporal evolution and improve monitoring activities. In our exercise, the same processing chain can be run to obtain the mean NDVI for consecutive months in our study area by changing the input images at the beginning of the methodology. For convenience, this analysis has been done in advance for the months of June 2017 and July 2017. Close all the files except *Collocate_May_subset* and open the mean NDVI files for each month located in the following path.

File 1: Collocate_June_subset.dim | File 2: Collocate_July_subset.dim

Path 1: /shared/Training/LAND04_LandMonitoring_Cyprus/AuxData/June/ Path 2: /shared/Training/LAND04_LandMonitoring_Cyprus/AuxData/July/



Expand each product and open the *Bands* folder. Double click on the *mean_NDVI* to visualize the mean NDVI image of each month. To make sure we are using the same colour distribution, select the first *mean_NDVI* visualization (index [1]) and press the *Apply to other bands* icon located in the upper right corner of the colour manipulation tab. A pop-up window will appear. Click *Select all* and press OK. Another pop-up window will appear, asking to whether to stretch the color palette between min/max values. Select No. Then, go to *Windows -> Tile Horizontally* to synchronize the three views.

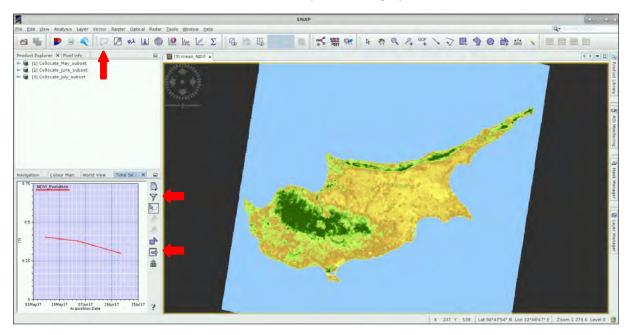


You might have noticed that the three images have identical names. This is a requirement of the Time Series Analysis Tool in SNAP.

Click on the Time Series Analysis button \checkmark on the main toolbar to open the toolview. In the Time Series Analysis window, press the P button to configure your graph and press the P icon to add all the open products in SNAP to the time series analysis. Press the refresh icon (P), rename the graph to *NDVI_evolution* and change the colour to red. Then, click *Apply* and Close.

		-						
-		Graph 1						
Type	Acquisition	Track	Orbit	7				
COLLOCATED	10May2017	99999	999999					
COLLOCATED		99999	99999					
COLLOCATED	02Jul2017	99999	99999					
				3 Products				
	COLLOCATED	COLLOCATED 02Jun2017	COLLOCATED 02Jun2017 99999	COLLOCATED 02Jun2017 999999 99999				

Now close two of the *mean_NDVI* views, click on the *Filter Bands* (\checkmark) icon of the Time Series Analysis tool (\checkmark), select *mean_NDVI* and click OK. You can now move the cursor over the image and see the evolution of the mean NDVI value of each pixel in the graph.



If you want to export the graph, you can do it as a text file (.csv) or as an image. Use the dedicated buttons in the lower right corner of the Time Series Analysis Tool (B and a).

In case you want to continue the temporal profile, download the corresponding Sentinel-3 OLCI images for each month and repeat the steps defined in this guide.

7 Extra steps

To download outputs from the Virtual Machine to your local computer 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 the path where the file you are interested in is located and **double click on it to download it.** In case you want to download a folder, you will have to zip it beforehand.



THANK YOU FOR FOLLOWING THE EXERCISE!

8 Further reading and resources

Sentinel-3 information

https://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Sentinel-3

Sentinel-3 mission

https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-3

Sentinel-3 OLCI User Guide

https://sentinels.copernicus.eu/web/sentinel/user-guides/sentinel-3-olci

Sentinel-3 OLCI Technical Guide

https://sentinels.copernicus.eu/web/sentinel/technical-guides/sentinel-3-olci

FOLLOW US!!!



@RUS-Copernicus



RUS-Copernicus



RUS-Copernicus



- **RUS Copernicus Training**
- RUS-Copernicus website
- RUS-Copernicus Training website