

Acquiring and Exploring Earth Observation (EO) Data (Images)

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Outline

- **Setting Up PC (Working Environment)**
 - ❖ Installing ESA SNAP Toolbox
 - ❖ Installing Anaconda (Python)
 - ❖ Create Python environment and install required packages
- **Downloading Satellite Earth Observation Data (Sentinel 1, 2 & 3)**
 - ❖ Register a Copernicus account
 - ❖ Download Images Directly from Copernicus Web portal
 - ❖ Download Images via Python API

- Here I give some tips on how to download Sentinel images from the Hub (and the API for those who are interested in this) including the image we are going to use in this practical
- I also give some instructions on how to do the atmospheric correction in SNAP
- If you do not manage to download and apply the atmospheric correction on the image **don't worry – I also provide a copy of the images**
- **What I want you to do (in order to have a better experience in the practical session) is to download Anaconda and install the libraries for this practical: please look at Slides 7-13**

Setting Up PC (Working Environment)

- Installing ESA SNAP Toolbox

- Developed by the European Space Agency (ESA)
- For downloading, preprocessing, analysing, visualising, Sentinel EO products.
- Support other EO products E.g. MERIS



<https://step.esa.int/main/download/snap-download/>
<https://tinyurl.com/esasnap>



DOWNLOAD

SNAP Download

Here you can download the latest installers for SNAP and the Sentinel Toolboxes.

Data provision is available to all users via the [Sentinel Data Hub](#).

Current Version

The current version is 9.0.0 (29.06.2022 15:00 UTC).

For detailed information about changes made for this release please have a look at the release notes of the different projects: [SNAP](#), [S1TBX](#), [S2TBX](#), [S3TBX](#), [SMOS Box](#), [PROBA-V Toolbox](#)

We offer three different installers for your convenience. Choose the one from the following table which suits your needs. During the installation process, each toolbox can be excluded from the installation. <https://github.com/senbox-org/probav/blob/2.3.0/ReleaseNotes.md> Toolboxes which are not initially installed via the installer can be later downloaded and installed using the plugin manager. Please note that SNAP and the individual Sentinel Toolboxes also support numerous sensors other than Sentinel.

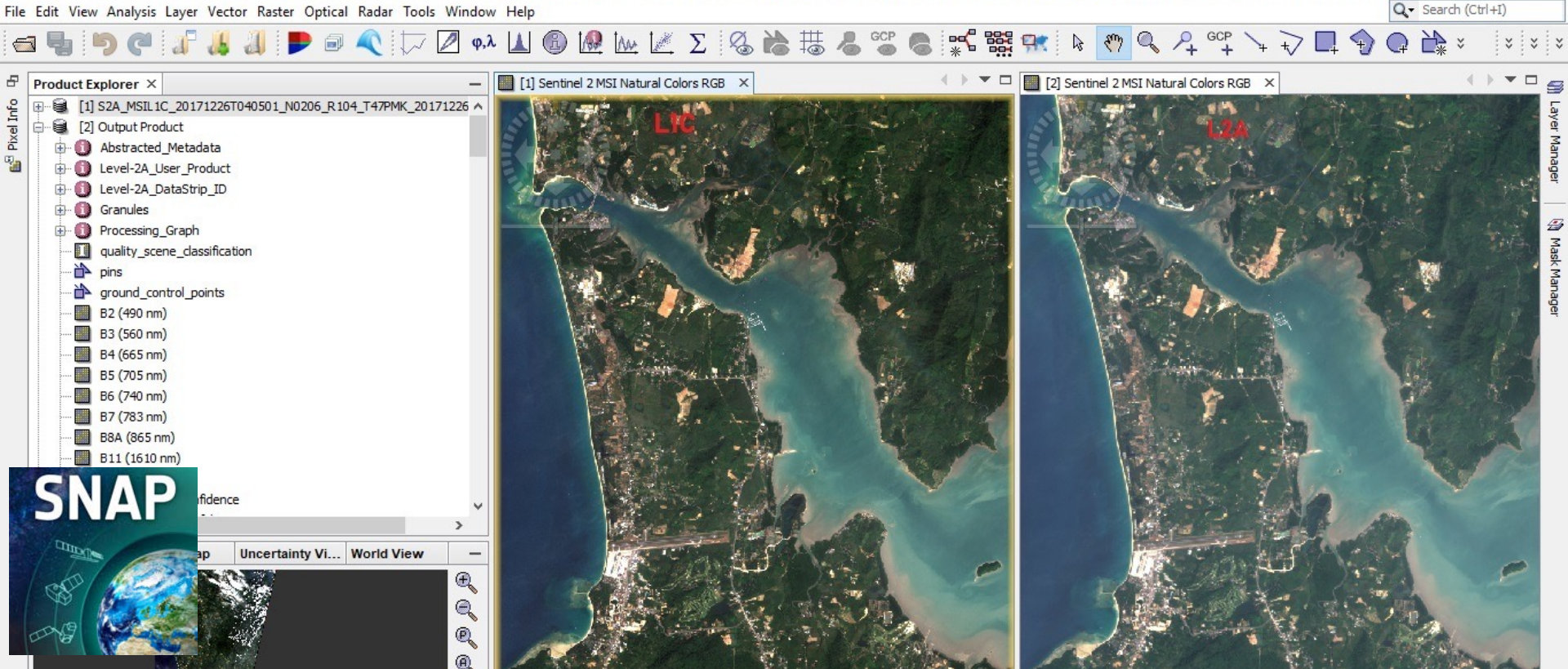
If you previously used SNAP before, we recommend uninstalling the older SNAP version before installing the latest version.

	Windows 64-Bit	Mac OS X	Unix 64-bit
Sentinel Toolboxes	These installers contain the Sentinel-1, Sentinel-2, Sentinel-3 Toolboxes, download size is close to 900MB.		
	Main Download	Main Download	Main Download
	Mirror Download	Mirror Download	Mirror Download
SMOS Toolbox	These installers contain only the SMOS Toolbox, download size is close to 500MB. Download also the Format Conversion Tool (Earth Explorer to NetCDF) and the user manual .		
	Main Download	Main Download	Main Download
	Mirror Download	Mirror Download	Mirror Download
All Toolboxes	These installers contain the Sentinel-1, Sentinel-2, Sentinel-3 Toolboxes, SMOS and PROBA-V Toolbox, download size is close to 1GB.		
	Main Download	Main Download	Main Download
	Mirror Download	Mirror Download	Mirror Download

<https://step.esa.int/main/download/snap-download/>

<https://tinyurl.com/esasnap>





ONLINE TUTORIALS

<https://step.esa.int/main/doc/tutorials/>

Setting Up PC (Working Environment)

- Installing Anaconda (Python Programming)

- For deploying python and managing python packages
- Simplify creation of environment for data analysis with python
- *Setting up Integrated Development Environment (IDE)*



<https://www.anaconda.com/download>

Applications on base (root)

Channels



Datalore

Online Data Analysis Tool with smart coding assistance by JetBrains. Edit and run your Python notebooks in the cloud and share them with your team.

Launch



IBM Watson Studio Cloud

IBM Watson Studio Cloud provides you the tools to analyze and visualize data, to cleanse and shape data, to create and train machine learning models. Prepare data and build models, using open source data science tools or visual modeling.

Launch



JupyterLab

3.2.1

An extensible environment for interactive and reproducible computing, based on the Jupyter Notebook and Architecture.

Launch



Jupyter Notebook

6.4.5

Web-based, interactive computing notebook environment. Edit and run human-readable docs while describing the data analysis.

Launch



Qt Console

5.1.1

PyQt GUI that supports inline figures, proper multiline editing with syntax highlighting, graphical calltips, and more.

Launch



Spyder

5.1.5

Scientific Python Development Environment. Powerful Python IDE with advanced editing, interactive testing, debugging and introspection features

Launch



VS Code

1.80.2

Streamlined code editor with support for development operations like debugging, task running and version control.

Launch



Glueviz

1.0.0

Multidimensional data visualization across files. Explore relationships within and among related datasets.

Install



Orange 3

3.32.0

Component based data mining framework. Data visualization and data analysis for novice and expert. Interactive workflows with a large toolbox.

Install



PyCharm Professional

A full-fledged IDE by JetBrains for both Scientific and Web Python development. Supports HTML, JS, and SQL.

Install

Anaconda Notebooks

Cloud notebooks with hundreds of packages ready to code.

Learn More

A full Python IDE directly from the browser

Documentation

Anaconda Blog

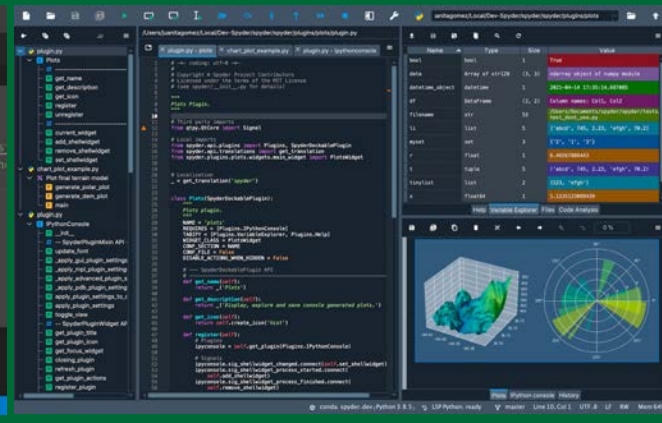
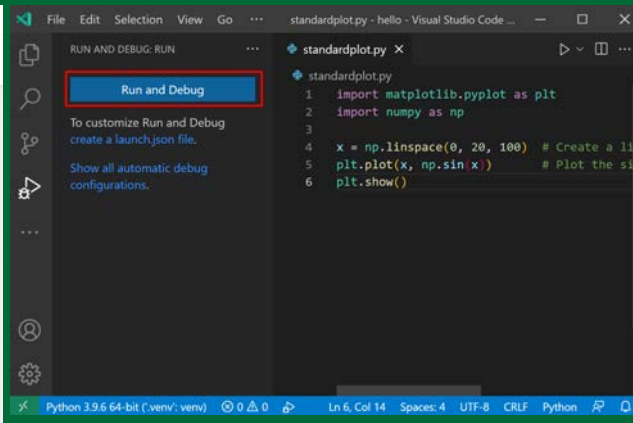
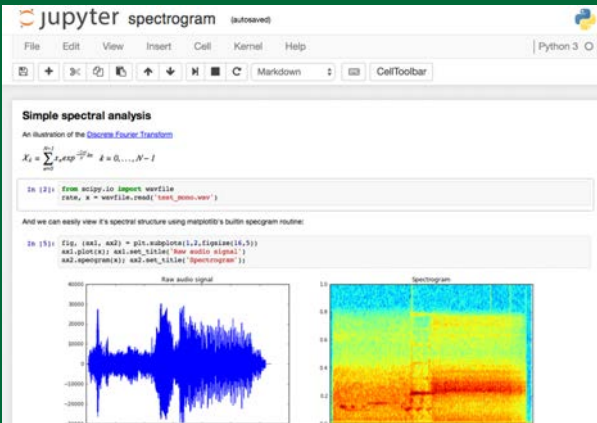


RStudio

<https://www.anaconda.com/download>

Setting Up PC (Working Environment)

- Setting up Integrated Development Environment (IDE)



Setting Up PC (Working Environment)

- Create Python environment and install required packages (GUI)

The screenshot displays the Anaconda Navigator application interface. The left sidebar contains navigation links: Home, Environments, Learning, and Community. The 'Environments' tab is selected, showing a list of environments: base (root), biopy, data_procs, and ds_env. A red box highlights the 'Environments' tab and the list of environments. A green box labeled 'Step 1' points to the 'base (root)' environment. A green box labeled 'Step 2' points to the 'Create' button at the bottom of the sidebar. A green box labeled 'Step 3' points to the 'ds_env' environment. A green box labeled 'Step 4' points to the 'Channels' tab in the main panel, which shows a list of installed packages. The main panel also has a 'Channels' tab and an 'Update Index...' button. The 'Channels' tab shows a list of installed packages with columns for Name, Description, and Version. A red box highlights the 'Channels' tab and the list of installed packages.

Step 1

Step 2

Step 3

Step 4

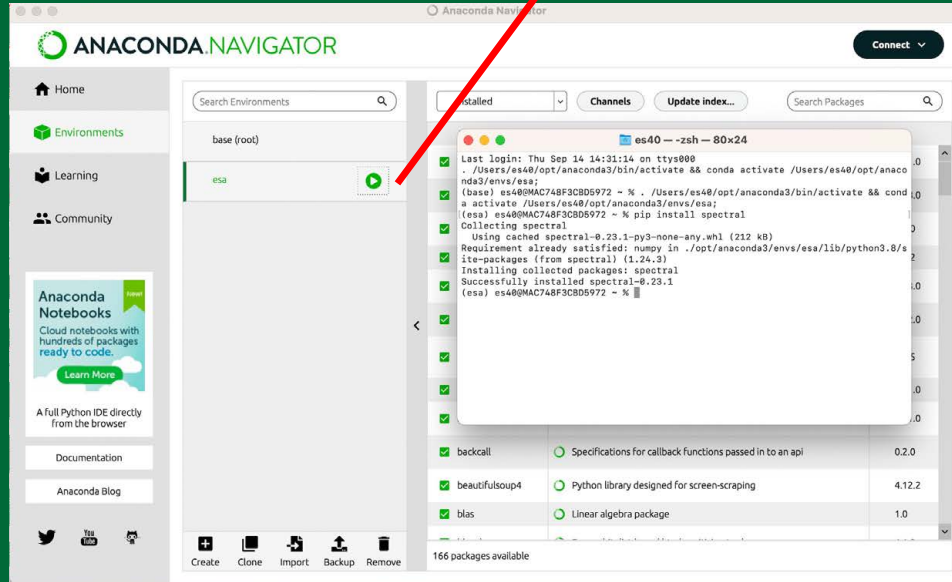
Name	Description	Version
._ipyw_lab_nb_ex...	A configuration metapackage for enabling anaconda-bundled jupyter extensions	0.1.0
alabaster	Configurable, python 2+3 compatible sphinx theme.	0.7.12
anaconda	Simplifies package management and deployment of anaconda	2021.11
anaconda-client	Anaconda cloud command line client library	1.9.0
anaconda-project	Tool for encapsulating, running, and reproducing data science projects	0.10.1
anyio	High level compatibility layer for multiple asynchronous event loop implementations on python	2.2.0
apodirs	A small python module for determining appropriate platform-specific dirs.	1.4.4
applaunchservices	Simple package for registering an app with apple launch services to handle uti and url.	0.2.1
appnope	Disable app nap on os x 10.9	0.1.2
appscript	Control applescriptable applications from python.	1.1.2
argh	The natural cli.	0.26.2
argon2-cffi	The secure argon2 password hashing algorithm.	20.1.0
arrow	Better dates & times for python	0.13.1
asn1crypto	Python asn.1 library with a focus on performance and a pythonic api	1.4.0
astroid	A abstract syntax tree for python with inference support.	2.6.6
astropy	Community-developed python library for astronomy	4.3.1
async-generator		1.10
async_generator	Async generators and context managers for python 3.5+	1.10
atomicwrites	Atomic file writes	1.4.0

392 packages available

Setting Up PC (Working Environment)

- For this practical we will need to download these libraries: `os`; `numpy`; `matplotlib.pyplot`

For the spectral library right click on the play button will give you the option to the terminal – you can use this to install spectral as following: `pip install spectral`





Home



Environments



Learning



Community



A full Python IDE directly
from the browser

[Documentation](#)[Anaconda Blog](#)

Applications on ds_env

Channels



Datalore

Online Data Analysis Tool with smart coding assistance by JetBrains. Edit and run your Python notebooks in the cloud and share them with your team.

Launch



IBM Watson Studio Cloud

IBM Watson Studio Cloud provides you the tools to analyze and visualize data, to cleanse and shape data, to create and train machine learning models. Prepare data and build models, using open source data science tools or visual modeling.

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Install



Qt Console

5.3.1

PyQt GUI that supports inline figures, proper multiline editing with syntax highlighting, graphical calltips, and more.

Install



RStudio

1.1.456

A set of integrated tools designed to help you be more productive with R. Includes R essentials and notebooks.

Install



Spyder

5.2.2

Scientific Python Development
Environment. Powerful Python IDE with

Click to start IDE

import the libraries



UPDATE Read the [migration plan](#) to Notebook 7 to learn about the new features and the actions to take if you are using extensions - Please note that updating to Notebook 7 might break some of your extensions.

File Edit View Insert Cell Kernel Help Not Trusted Python 3 (ipykernel)

```
In [1]: import os
import numpy as np
import matplotlib.pyplot as plt
import spectral.io.envi as envi

In [2]: # set your path here for the files
os.chdir(os.path.expanduser('~es40/Documents/teaching/ESA Croatia/Practical2'))
```

set the path for the files. please note that this is for mac os environment. For windows path could be set as `os.chdir('S:\.....\practical_files')`

<https://scihub.copernicus.eu/>

Downloading Satellite Earth Observation Data (Sentinel 1, 2 & 3)

- Register a Copernicus account

Step 1

Step 2

Step 3

Step 4

<https://scihub.copernicus.eu/>

Downloading Satellite Earth Observation Data (Sentinel 1, 2 & 3)

- Download Directly from Copernicus Web portal

Step 1

Step 2

Step 3

Downloading Satellite Earth Observation Data (Sentinel 1, 2 & 3)

- Download Directly from Copernicus Web portal

The screenshot displays the Copernicus Open Access Hub web portal. On the left, the 'Advanced Search' panel is visible, featuring filters for 'Sort By' (Ingestion Date), 'Order By' (Descending), 'Sensing period', 'Ingestion period', and 'Mission' (Sentinel-1, Sentinel-2, Sentinel-3). The 'Mission' dropdown is currently set to 'Sentinel-1'. The main area shows a map of Ukraine with a highlighted region in the center. A red box highlights the 'Download' button in the top right corner of the map area. A red arrow points from the 'Download' button to the 'Mission: Sentinel-1' dropdown. Another red arrow points from the 'Download' button to the 'Download' button in the top right corner of the map area.

Step 7

Step 6

Step 5

Only a maximum of 2 concurrent downloads per user is allowed with Web Portal

Downloading Satellite Earth Observation Data (Sentinel 1, 2 & 3)

- Download Directly from Copernicus Web portal

For this practical we will need to download the following S3A image from the 17th of June 2023

when all options are selected press search

The screenshot shows the 'Copernicus Open Access Hub' Advanced Search page. The interface includes a sidebar with search filters and a main map area. Red arrows point from text annotations to specific elements in the interface:

- An arrow points to the 'Search' button at the top right of the sidebar.
- An arrow points to the 'Sensing date' input field, which contains '2023/06/17'.
- An arrow points to the 'Mission' dropdown menu, which is set to 'Sentinel-3'.
- An arrow points to the 'Sensor' dropdown menu, which is set to 'OLCI'.
- An arrow points to the 'Product Level' dropdown menu, which is set to 'L1'.
- An arrow points to a polygon drawn on the map over the North Adriatic region.

select sensing date 17/06/2023

select Sentinel-3

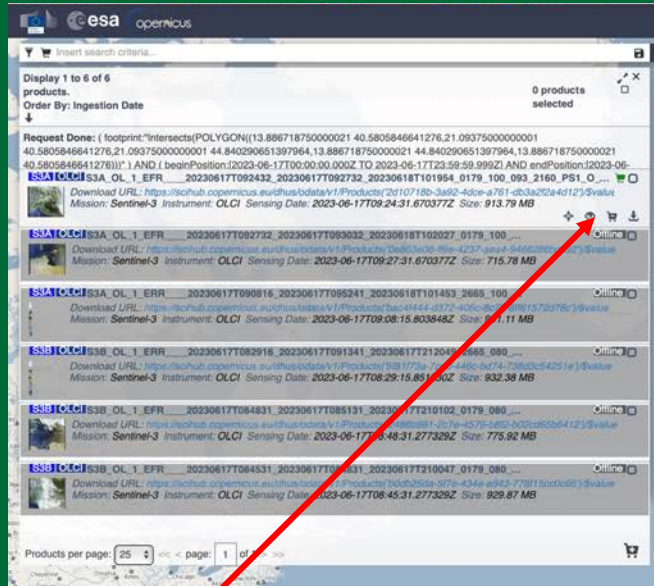
draw a polygon around N. Adriatic

select OLCI as a sensor

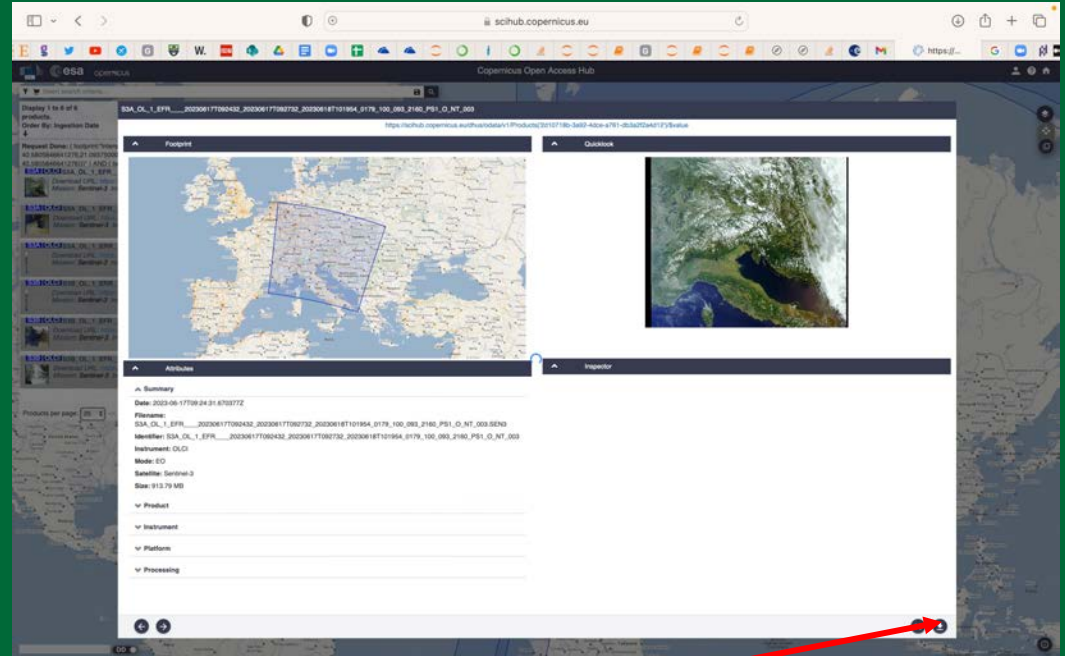
select L1

Downloading Satellite Earth Observation Data (Sentinel 1, 2 & 3)

- Download Directly from Copernicus Web portal

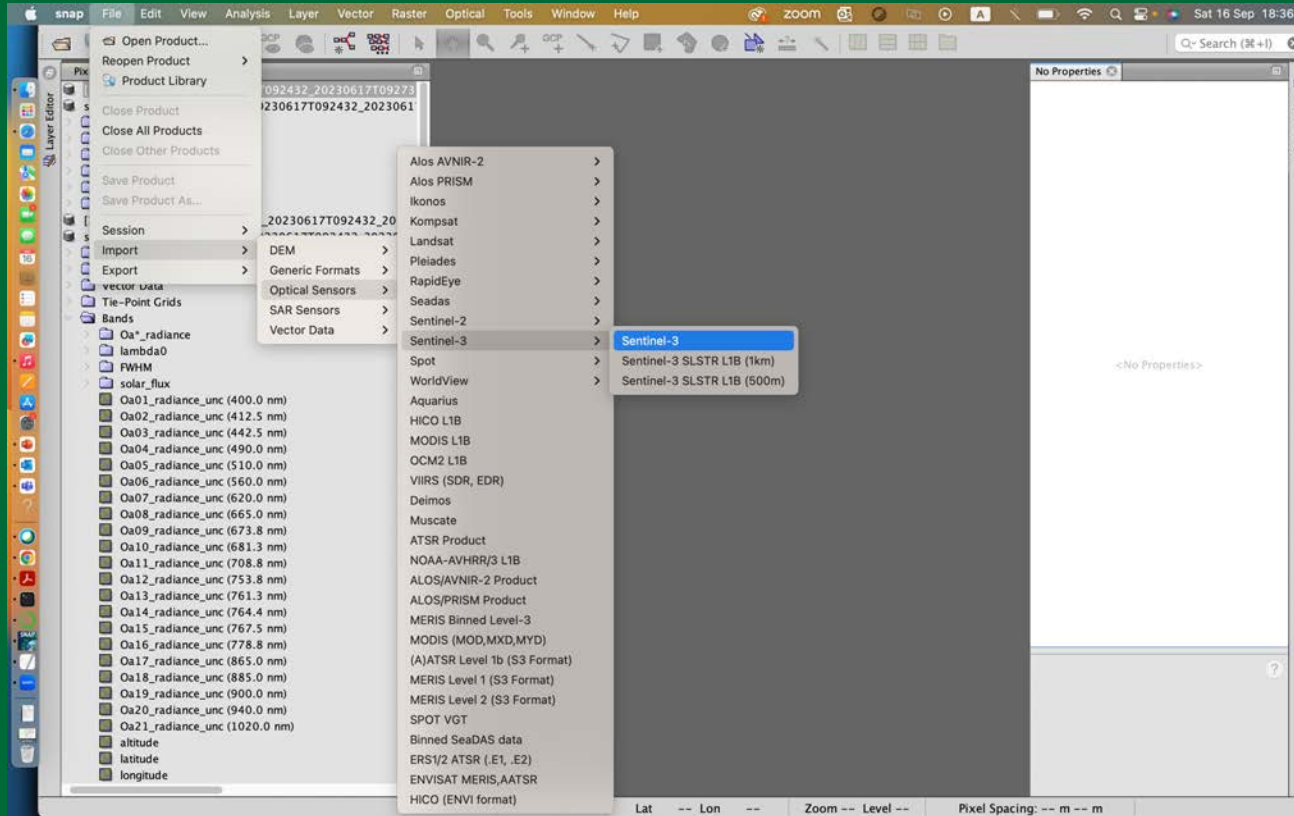


press the eye icon to preview the image



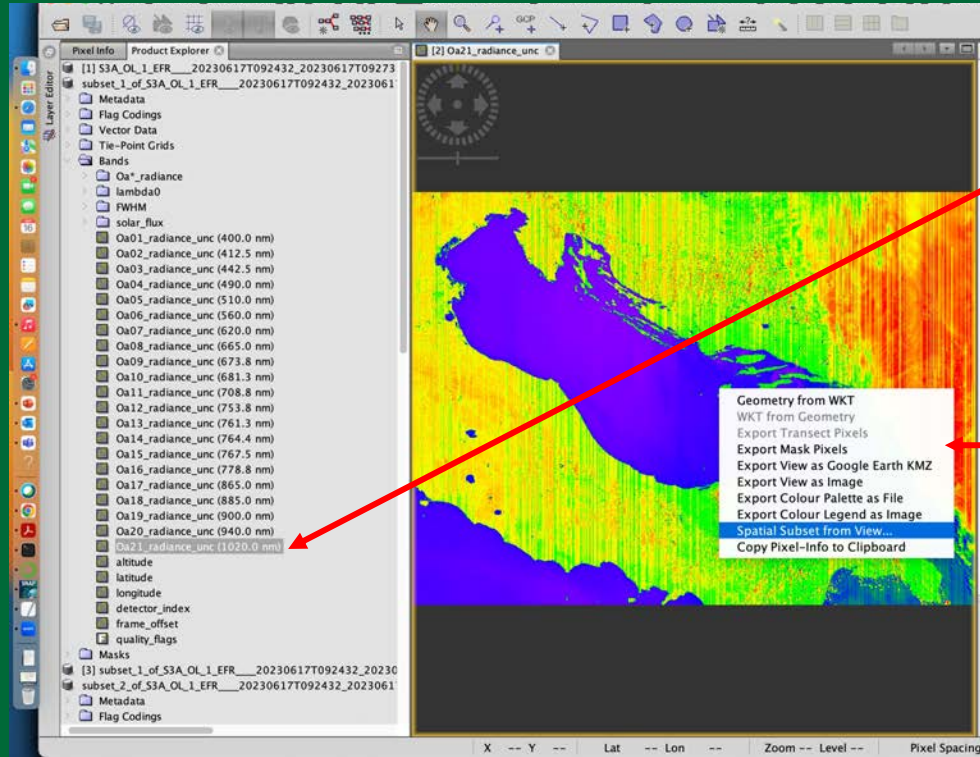
press download to download

Preprocessing a S-3 OLCI image in SNAP



In SNAP:
File>
Import>
Optical Sensors>
Sentinel >
choose the
image you
downloaded

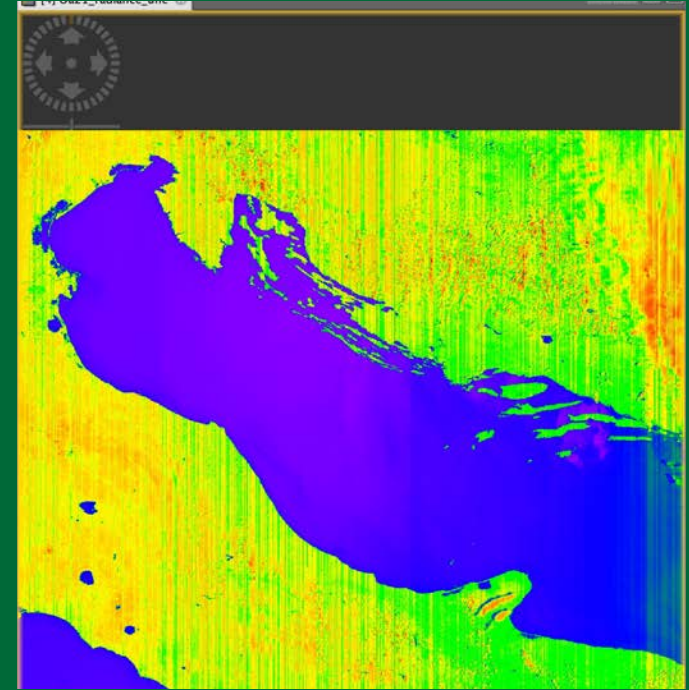
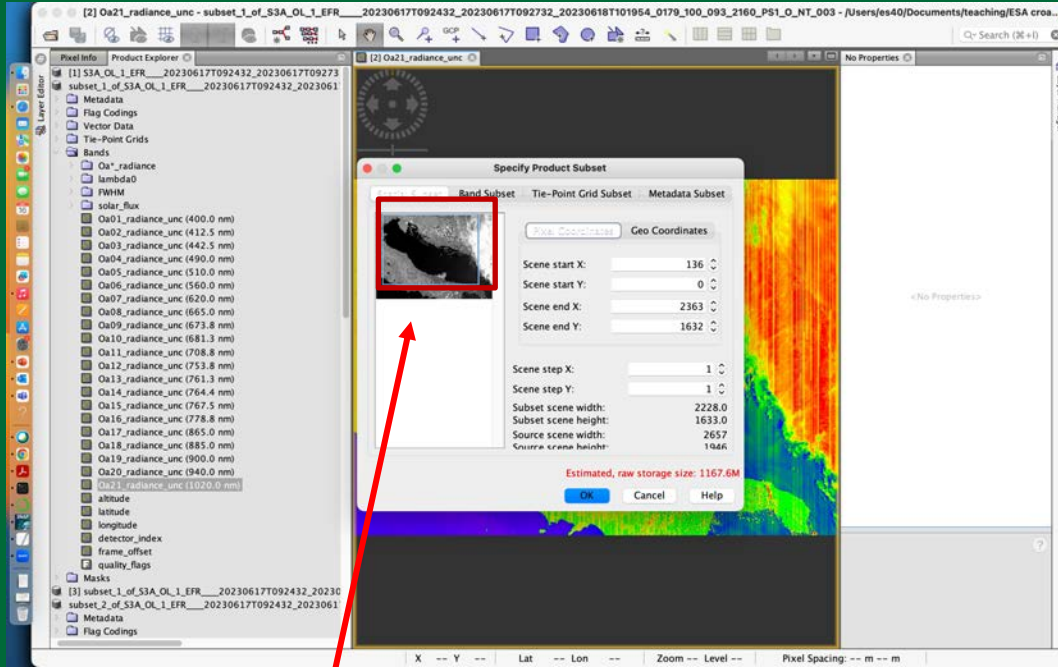
Preprocessing a S-3 OLCI image in SNAP



double click one of the bands
e.g. Oa21 to view the image

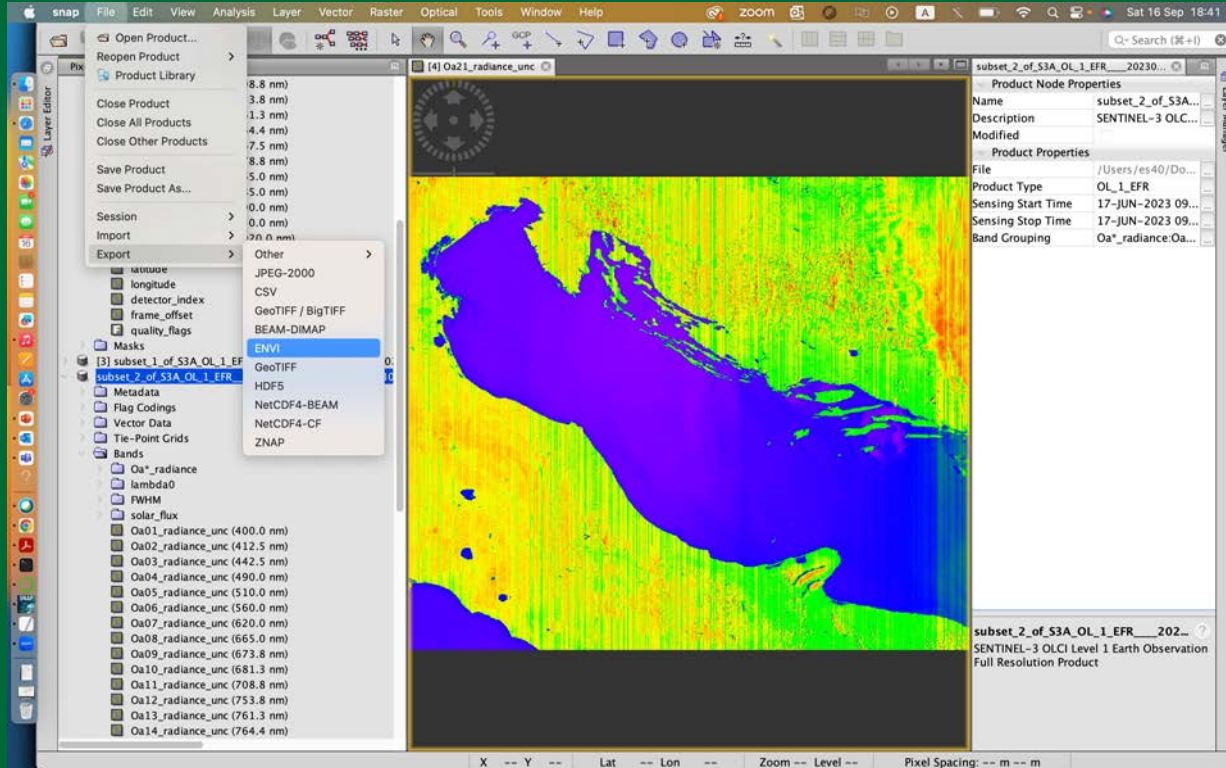
right click on the image and
select spatial subset from view

Preprocessing a S-3 OLCI image in SNAP



select part of the Adriatic as in the image on the right by adjusting the box and click ok

Preprocessing a S-3 OLCI image in SNAP



select the subset image
by just clicking on the
file as shown here and
then

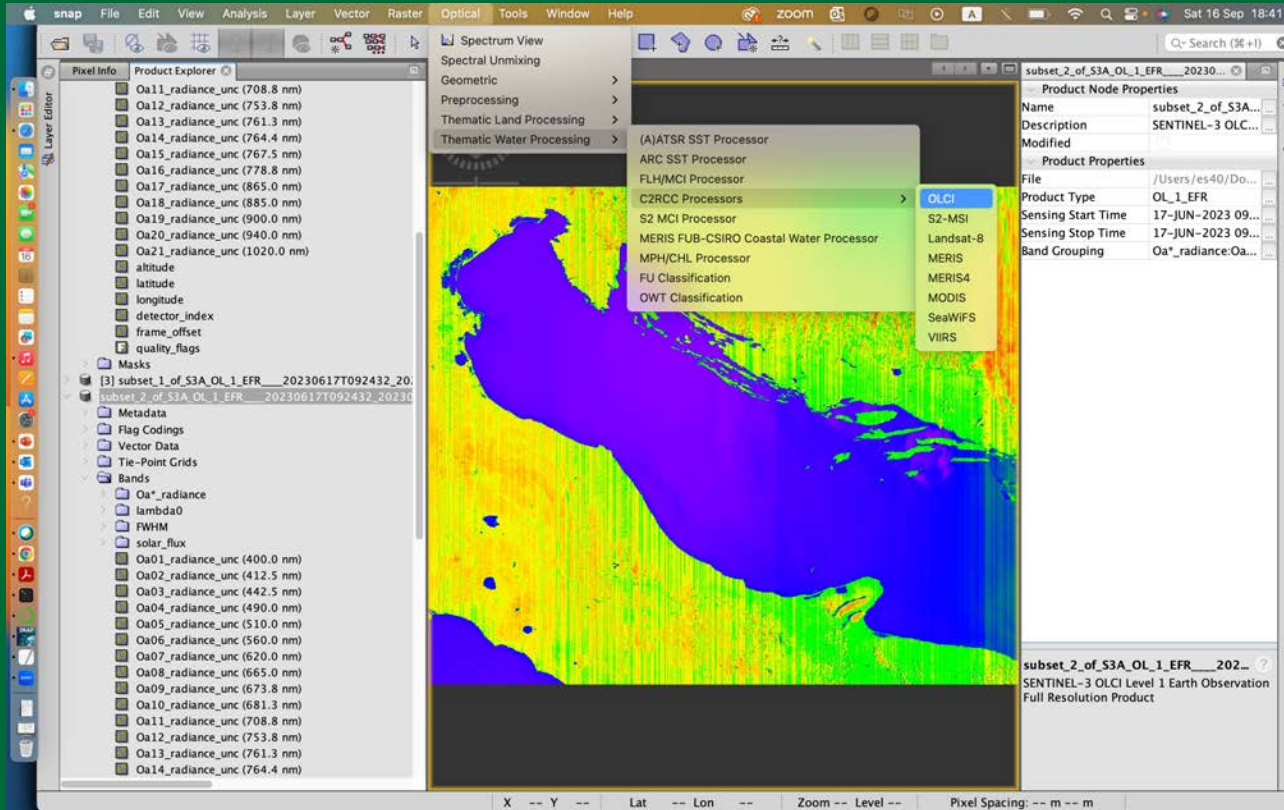
File>

Export>

ENVI

save it in a folder (you
will use the same
folder as your directory
in Jupyter notebook)

Atmospheric correction of S-3 OLCI



select the subset image
by just clicking on the
file as shown here and
then

Optical>
Thematic Water
Processing>
C2RCC >
OLCI

Atmospheric correction of S-3 OLCI

The screenshot shows the 'C2RCC OLCI Processor' window with the 'Processing Parameters' tab selected. The window contains various input fields and checkboxes for configuring the atmospheric correction process. A red arrow points from the text 'make sure you have selected the options shown here' to the 'Output AC reflectances as rrs instead of rho_w' checkbox. Another red arrow points from the text 'once you have selected these options click run (this may take a while). Save the file and then export it as shown before File>Export>ENVI...' to the 'Run' button.

Parameter	Value	Unit
Valid-pixel expression:	_inland_water)	...
Salinity:	35.0	PS
Temperature:	15.0	C
Ozone:	330.0	DL
Air Pressure at Sea Level:	1000.0	hP
TSM factor:	1.06	
TSM exponent:	0.942	
CHL exponent:	1.04	
CHL factor:	21.0	
Threshold rtosa OOS:	0.01	
Threshold AC reflectances OOS:	0.15	
Threshold for Cloud_risk flag on down transmittance @865:	0.955	
Atmospheric aux data path:		
Alternative NN Path:		

- ☒ Output AC reflectances as rrs instead of rho_w
- ☐ Derive water reflectance from path radiance and transmittance
- ☒ Use ECMWF aux data of source product
- ☒ Output TOA reflectances
- ☐ Output gas corrected TOSA reflectances
- ☐ Output gas corrected TOSA reflectances of auto nn
- ☐ Output path radiance reflectances
- ☐ Output downward transmittance
- ☐ Output upward transmittance
- ☒ Output atmospherically corrected angular dependent reflectances
- ☒ Output normalized water leaving reflectances
- ☒ Output out of scope values

Buttons: Run, Close

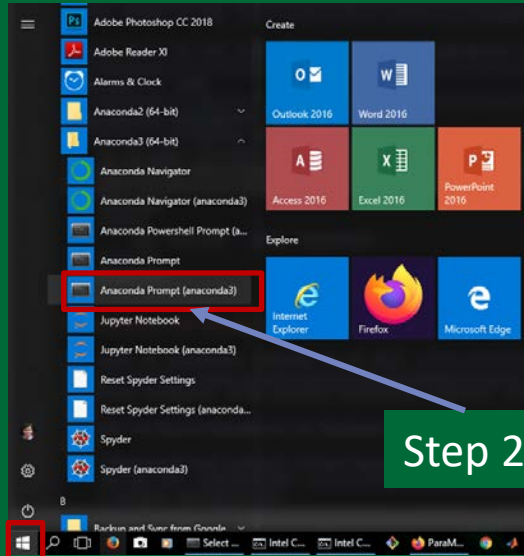
make sure you have selected the options shown here

once you have selected these options click run (this may take a while). Save the file and then export it as shown before File>Export>ENVI...

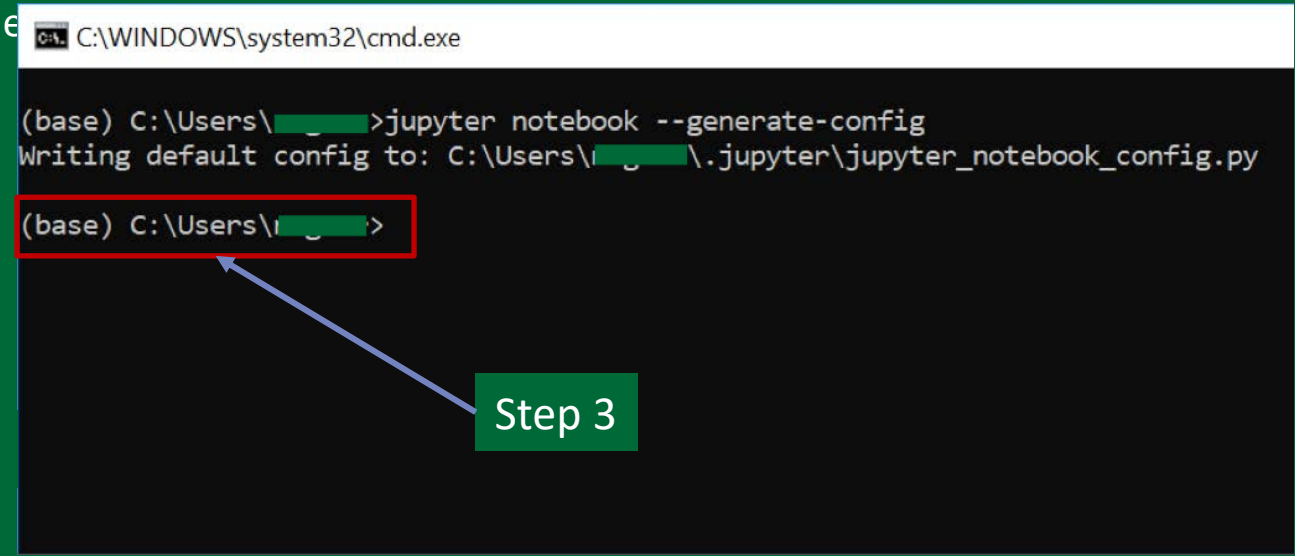
BE THE DIFFERENCE

Further reading –
for those who are
confident with
Python

Setting Up PC (Working Environment) – this is an alternative way to the one shown in the previous slide



Step 2



Step 3

Step 1

At step 3 the “Conda” the command line tool for anaconda can be used to create and manage python environment.
Link to “Conda” documentation: <https://docs.conda.io/en/latest/>
Link to “Conda” user guide: <https://tinyurl.com/conda-user>

Setting Up PC (Working Environment)

- Create Python environment and install required packages (Terminal , Conda)

QUICK START	
Tip: It is recommended to create a new environment for any new project or workflow.	
verify conda install and check version	<code>conda info</code>
update conda in base environment	<code>conda update -n base conda</code>
install latest anaconda distribution (see release notes)	<code>conda install anaconda=2022.05</code>
create a new environment (tip: name environment descriptively)	<code>conda create --name ENVNAME</code> ← Step 1
activate environment (do this before installing packages)	<code>conda activate ENVNAME</code> ← Step 2

<https://tinyurl.com/conda-cheat>

Setting Up PC (Working Environment)

- Create Python environment and install required packages (Terminal , Conda)

CHANNELS AND PACKAGES	
Tip: Package dependencies and platform specifics are automatically resolved when using conda.	
list installed packages	<code>conda list</code>
list installed packages with source info	<code>conda list --show-channel-urls</code>
update all packages	<code>conda update --all</code>
install a package from specific channel	<code>conda install -c CHANNELNAME PKG1 PKG2</code> ← Step 3
install specific version of package	<code>conda install PKGNAME=3.1.4</code>
install a package from specific channel	<code>conda install CHANNELNAME::PKGNAME</code>
install package with AND logic	<code>conda install "PKGNAME>2.5,<3.2"</code>
install package with OR logic	<code>conda install "PKGNAME [version='2.5 3.2']"</code>
uninstall package	<code>conda uninstall PKGNAME</code>

<https://tinyurl.com/conda-cheat>

Downloading Satellite Earth Observation Data (Sentinel 1, 2 & 3)

- Download Images via Python API

sentinelSAT/
sentinelSAT



Search and download Copernicus Sentinel satellite images

30

Contributors



443

Used by



909

Stars



236

Forks



Installation

```
conda install -c conda-forge sentinelSAT
```

Installers

🍏 🍷 🐍 noarch v12.1

conda install ?

To install this package run one of the following:

```
conda install -c conda-forge sentinelSAT
```


Downloading Satellite Earth Observation Data (Sentinel 1, 2 & 3)

- Download Images via Python API

```
# connect to the API
from sentinelsat import SentinelAPI, read_geojson, geojson_to_wkt
from datetime import date

api = SentinelAPI('user', 'password', 'https://apihub.copernicus.eu/apihub')

# download single scene by known product id
api.download(<product_id>)

# search by polygon, time, and SciHub query keywords
footprint = geojson_to_wkt(read_geojson('/path/to/map.geojson'))
products = api.query(footprint,
                    date=('20151219', date(2015, 12, 29)),
                    platformname='Sentinel-2',
                    cloudcoverpercentage=(0, 30))

# download all results from the search
api.download_all(products)

# convert to Pandas DataFrame
products_df = api.to_dataframe(products)

# GeoJSON FeatureCollection containing footprints and metadata of the scenes
api.to_geojson(products)

# GeoPandas GeoDataFrame with the metadata of the scenes and the footprints as geometries
api.to_geodataframe(products)

# Get basic information about the product: its title, file size, MD5 sum, date, footprint and
# its download url
api.get_product_odata(<product_id>)

# Get the product's full metadata available on the server
api.get_product_odata(<product_id>, full=True)
```

Steps

- Import required python packages and functions
- Call the API, enter *username*, and *password*
- Create a footprint for the Region of Interest (ROI)
- Write the search and run query
- Download products
- Store query results as table (dataframe) (Optional)

Downloading Satellite Earth Observation Data (Sentinel 1, 2 & 3)

- Download Images via Python API

Search Sentinel-2 L1C by tile

To search for recent Sentinel-2 L1C imagery by MGRS tile, you can use the *tileid* parameter:

```
from collections import OrderedDict
from sentinelsat import SentinelAPI

api = SentinelAPI('user', 'password')

tiles = ['33VUC', '33UUB']

query_kwargs = {
    'platformname': 'Sentinel-2',
    'producttype': 'S2MSI1C',
    'date': ('NOW-14DAYS', 'NOW')}

products = OrderedDict()
for tile in tiles:
    kw = query_kwargs.copy()
    kw['tileid'] = tile
    pp = api.query(**kw)
    products.update(pp)

api.download_all(products)
```

Steps

- Import required python packages and functions
- Call the API, enter *username*, and *password*
- Create a list of images tiles
- Write the search and run query
- Download products
- Store query results as table (dataframe) (Optional)



Home



Environments



Learning



Community

Anaconda Notebooks

Cloud notebooks with hundreds of packages ready to code.

Learn More

A full Python IDE directly from the browser

Documentation

Anaconda Blog



Search Environments



base (root)

esa



Installed ▾

Channels

Update index...

Search Packages



es40 --zsh -- 80x24

```
Last login: Thu Sep 14 14:31:14 on ttys000
. /Users/es40/opt/anaconda/bin/activate && conda activate /Users/es40/opt/anaconda3/envs/esa;
(base) es40@MAC748F3CBD5972 ~ % . /Users/es40/opt/anaconda3/bin/activate && conda activate /Users/es40/opt/anaconda3/envs/esa;
(es40) es40@MAC748F3CBD5972 ~ % pip install spectral
Collecting spectral
  Using cached spectral-0.23.1-py3-none-any.whl (212 kB)
Requirement already satisfied: numpy in ./opt/anaconda3/envs/esa/lib/python3.8/site-packages (from spectral) (1.24.3)
Installing collected packages: spectral
Successfully installed spectral-0.23.1
(es40) es40@MAC748F3CBD5972 ~ %
```

backcall	Specifications for callback functions passed in to an api	0.2.0
beautifulsoup4	Python library designed for screen-scraping	4.12.2
blas	Linear algebra package	1.0

166 packages available



Create



Clone



Import



Backup



Remove