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COPERNICUS DATA SPACE ECOSYSTEM Data and Services

Service Description and Evolution Roadmap

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1 SERVICE OVERVIEW

Copernicus Data Space represents an overall and comprehensive data ecosystem accessible via [web portal](#), applications and APIs. It contains services and applications allowing the discovery and processing of the Copernicus missions and related Earth Observation (EO) data and will be growing over the coming years. The Copernicus Data Space Ecosystem provides the essential data and service offering for everyone to use, for commercial and non-commercial purposes. Third-party providers can build their services around of the Copernicus Data Space Ecosystem, the first one of these being CREODIAS. In the future additional players (typically third-party providers but not only) are expected to join the Copernicus Data Space Ecosystem, enriching the ecosystem to offer a variety of additional services (free and commercial) as members of the Copernicus Data Space.

The services envisioned address a comprehensive set of use-cases - from curious beginners in the EO space, researchers processing data on their laptops or running cloud-native workflows, companies building added value services or data scientists building machine learning models on the global scale, as well as governmental bodies, who want to access or share EO data and related socio-economic information. The Copernicus Data Space Ecosystem will include all the supportive elements required to use the services and to become part of the ecosystem - from helpdesk, tutorials, specific functionalities like cataloguing, billing, user management, etc., to proactive campaigns to promote the ecosystem and increase the user uptake. All user feedback is welcome to help improving the service and making the Copernicus Data Space Ecosystem the most valuable asset for all participants.

The principle is shown in following diagram.

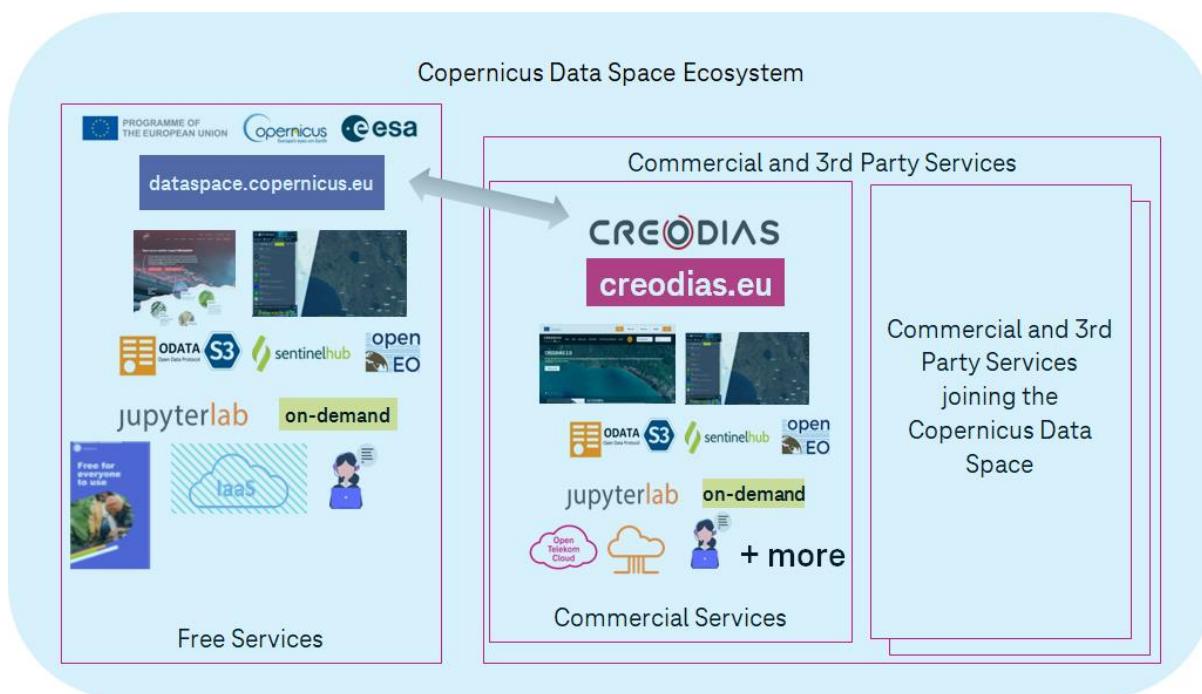


Figure 1: Overview Copernicus Data Space Ecosystem

The landing page dataspace.copernicus.eu gives users direct access to the Copernicus Data Space Free Services funded by the European Union and operated under ESA responsibility (hereafter referred as “Copernicus Free Services”). Other services, including commercial Services will be available via respective third-party providers like CREODIAS which includes among other services IaaS from Open Telekom Cloud and CloudFerro.

To provide a comprehensive view of all services available in the frame of the Copernicus Data Space

Ecosystem, this document describes both the “Copernicus Free Services” as well as the services operated by third parties. Each of the main sections (Data, Applications and Services, Auxiliary Services) first describes the free offering, followed by a description of the services provided by each of the third-party providers, in the alphanumerical order. The usage quotas for the “Copernicus Free Services” is provided in the B Annex - Service Quotas. Links to third-party services' conditions and prices are available in the C Annex .

Do note that Copernicus Data Space Ecosystem, as well as accompanying third-party services, will be evolving in the future, with the document being updated accordingly.

The foreseen services evolution of the during the firsts months is described in the “Service Road map” Annex of this document, providing a detailed plan of when specific data collections and services will become available.

2 DATA

2.1 Copernicus Data Space Free Data Offering

The data listed in this section are available through the Copernicus Data Space Ecosystem portal. In general, all data are free and open, however for some specific data collections of the Copernicus Contributing Mission, expert-only accessible Sentinel data and non-Copernicus data, specific license and access conditions may apply.

Vast majority of the data are available as "immediately available data" (IAD) - available for interactive data exploitation (i.e. processing within the Copernicus Data Space Ecosystem or integrated in third-party applications) and download.

Some less commonly used data collections, however, are available as "deferred available data" (DAD) - these can include a potential waiting time from the data request to become available for download or exploitation.

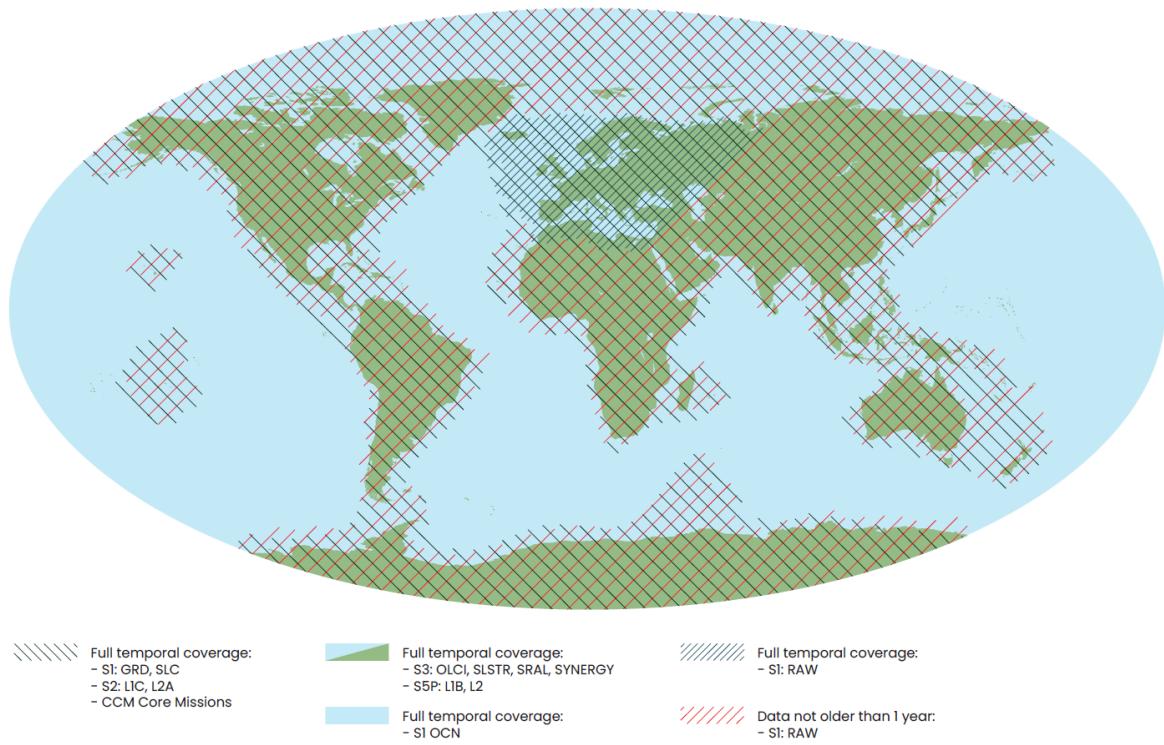
The following table provides an overview on the available data. More information is provided in the following sections.

Data category	Description	Refer to section
Sentinel	All Sentinel 1, Sentinel 2, Sentinel3, Sentinel 5p user level data	2.1.1.1
Cloudless mosaics	Cloudless mosaics based on and Sentinel-2 L2A data and median mosaics based on Sentinel-1 GRD data	2.1.1.2
Copernicus Contributing Missions Datasets	CCM CORE Datasets	2.1.1.3
Digital Elevation Models	Datasets which include Digital Elevation Models, e.g. Copernicus DEM	2.1.2
Copernicus Services Information	Data from Copernicus Services	2.1.3
Additional Collection	Additional data sets like e.g. Landsat, ENVISAT	2.1.4
Data via openEO	Belgian Collaborative Ground Segment hosted data	2.1.5

2.1.1 Copernicus data

The following figure provides a high-level graphical overview of data in the IAD. Details are provided in subsequent sections.

Immediately Available Data



2.1.1.1 Sentinel

Data collections comprising all Copernicus Sentinel data for Sentinel-1, Sentinel-2, Sentinel-3, Sentinel-5P missions, and enriched with future Sentinel missions as they become operational.

The data are available in compliance with the EU regulations concerning the use of Copernicus [Sentinel Data and Service Information](#).

The table below shows the complete data offer for the Copernicus Sentinel missions as planned to be available by October 2023. The roadmap for the gradual availability of the data is provided in Annex A.4.

The following is highlighted:

- Vast majority of the data is available in an unpacked form to allow efficient exploitation. This allows users to fetch individual files or just parts of the file without the need for data download. Some less commonly used data collections, however, are only available in zipped form for the sake of efficient storage management - these are marked as "packed". All data is available for download as zipped form.
- Vast majority of data is available in IAD. Some are available in DAD – these are mostly less frequently used data from outside of Europe marked as “Rest of the World” (RoW).
- Some data is available in IAD for a given time window and in DAD for the remaining time span, for example the S1 L0 RAW. This is indicated in the table as follows:
 - o IAD: last 12 months
 - o DAD: 10/2014 – (present-last 12 months)

Table 1: Copernicus Sentinel Data Offer.

Mission	Product types / groups	Coverage
Sentinel-1	IAD: - GRD (SAFE-COG ¹) - GRD (packed, original SAFE) - OCN - SLC - L0 (RAW) - AUX data (packed) - Engineering data ² (packed) DAD: - L0 (RAW) (packed) - GRD (packed, original SAFE)	World: 10/2014 – present World: last 12 months World: 12/2014 – present World: 10/2014 - present Europe: 10/2014 - present, RoW: last 12 months World: 10/2014 - present World: 2 weeks retention time World: 10/2014 - present-12 months World: 10/2014 - present-12 months
Sentinel-1 based products	On-demand processing (by CREODIAS) - CARD-BS - CARD-COH6 - CARD-COH12	World, orderable in best effort mode World, orderable in best effort mode World, orderable in best effort mode
See full list of available Sentinel-1 products		
Sentinel-2	IAD: - L1B (EUP) - L1C - L2A - AUX data (packed) - Engineering data* (packed) DAD: - L1B (EUP)* (packed)	World: 2 weeks retention time World: 07/2015–present World: 07/2015–present World: 07/2015–present World: 2 weeks retention time World: 07/2015–present
See full list of available Sentinel-2 products		
Sentinel-3	IAD:	World: 03/2016-present World: 1 month retention time World: 1 month retention time World: 03/2016-present World: 2 weeks retention time
See full list of available Sentinel-3 products		
Sentinel-5P	IAD:	World: 04/2018-present World: 1 month retention time World: 04/2018-present World: 2 weeks retention time
See full list of available Sentinel-5p products		

2.1.1.2 Cloudless mosaics

Mission	Product types / groups	Coverage
Sentinel-1	Median annual mosaic based on Sentinel-1 GRD data, fine-tuned for visualisation and smoothed accordingly.	World: 2015 - latest year
Sentinel-2	Cloudless annual mosaic based on Sentinel-2 L2A data, fine-tuned for visualisation and smoothed accordingly.	World: 2016 - latest year

¹ SAFE-COG stands for SAFE data with GeoTiffs reformatted to COG.

² “Engineering data” stands for Sentinel data other than “user level data”, i.e. data generated as part of the Copernicus Sentinel operations which is intended for operational purposes (e.g. specific instrument calibration data, Level-0 data for mission data preservation, etc.). Access restrictions may apply.

Cloudless mosaics are available in several ways:

- via standard download interfaces (licensed as CC-BY)
- via Sentinel Hub APIs (licensed as CC-BY)
- Cloud Optimized GeoTiffs directly accessible via HTTP (S3) (licensed as CC-NC)

2.1.1.3 Copernicus Contributing Missions Datasets

Copernicus Contributing Missions (CCM) CORE datasets (“Systematic Datasets”) are made available in accordance with the applicable dataset license. Access restrictions may apply. The list of available datasets is presented Annex - A Service Roadmap.

2.1.2 Digital Elevation Models

The following Digital Elevation Models datasets are available:

- Copernicus DEM (part of CCM): GLO-90 (global), GLO-30 (global)
- Mapzen DEM
- SRTM GL1

2.1.3 Copernicus Services Information

The following selected Copernicus Services datasets are available:

- CAMS (Atmosphere)
- CEMS (Emergency)
- CLMS (Land)
- CMEMS (Marine)

Currently we provide and update selected list of collections in two formats - native and zarr/COG³ as cloud-optimized data format storage for multi-dimensional arrays of data and preferred format.

2.1.4 Additional Collections

Access to additional datasets, including in particular Landsat data, ENVISAT, are planned to be available in the future. The detailed planning will be communicated as part of the service roadmap updates through the service portal.

2.1.5 Data via openEO

Using the OpenEO aggregator APIs, users can access the data stored on other OpenEO back-ends. The Belgian Collaborative Ground Segment hosted data (www.terrascope.be) can be accessed using the openEO API within the specified free quotas. Following data sets are offered:

- SPOT-VGT Collection 3, full archive
- PROBA-V Collection 2, full archive
- ESA WorldCover, full archive

³ Converter available where applicable.

- Various Sentinel-based L3 products

A complete list can be found at: <https://docs.terrascope.be/#/DataProducts/DataProducts>

2.2 Copernicus Data Space Ecosystem – Third Party data offer

2.2.1 CREODIAS Data Offering

2.2.1.1 Access to Copernicus Data Space Ecosystem data

All data available within Copernicus Data Space Ecosystem is available to CREODIAS users as well.

Additional data is also available on CREODIAS. The list of the available data is constantly evolving.

2.2.1.2 Federated Data via Sentinel Hub

Using Sentinel Hub APIs, users will be able to access the data stored on other clouds:

- Landsat Collection 2 - full archives from USGS, from Landsat-1 to Landsat-9, both Level 1 and 2
- MODIS (MCD43A4.006)
- Various open data collections, all presented in the [collections web-page](#)

2.2.1.3 Commercial data

Commercial data give users access to a wide range of very high-resolution satellite data. Diversified sources of archival or new products ordered according to customer's tasks, provide the possibility to choose an appropriate product for every project where VHR imaging is crucial. Depending on the source, VHR imagery varies by product type - it can be optical or radar data. Above all, the diversity lies in the resolution and also over the number and type of bands provided by supported sensors mounted on satellites. For the satellites listed below, the user has the possibility to order archive and new task products.

Data available at licenses and costs provided by data owners.

- Airbus SPOT, Pléiades and Pléiades Neo
- Maxar/European Space Imaging WorldView and GeoEye
- Planet PlanetScope and SkySat
- CG Satellite, Jillin – 1
- KGS – KazEOSat-1-2
- SIIS- KOMPSAT (2, 3, 3a, 5)

We are continuously discussing with satellite imagery providers to make more of their data available within the commercial services.

3 APPLICATIONS AND SERVICES

3.1 Copernicus Data Space Ecosystem Offering

3.1.1 Plethora of services for data exploitation

Service	Description	Refer to section
Copernicus Browser	Web user interface for data exploitation and download	3.1.2
Data Workspace	Interface for advanced users, who would like to trigger on-demand processing, fetch data that are available in deferred access mode, etc.	3.1.3
JupyterHub	Online processing utility with integrated programming libraries and shared underlying compute resources	3.1.4
Catalog APIs	APIs for querying the available data	3.1.5
Download products APIs	APIs for downloading data products	3.1.6
Sentinel Hub APIs	APIs for streamlined data access, processing and visualization	3.1.7
openEO API	APIs for data processing	3.1.8
On-Demand production	APIs for on-demand data production	3.1.9

3.1.2 Copernicus Browser

Copernicus Browser is the main user interface for interactive browsing, exploitation and processing of data available within Copernicus Data Space Ecosystem. It also provides an ability to download individual products.

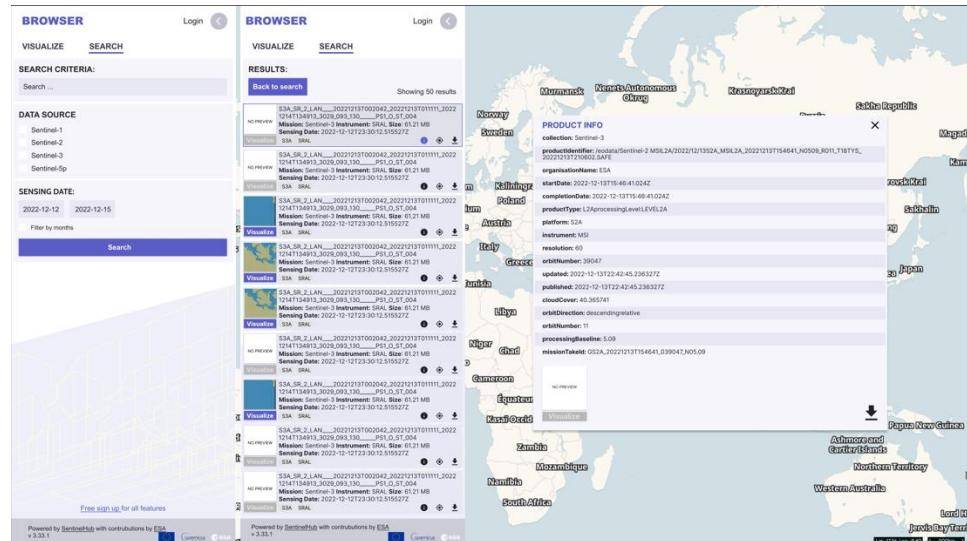
Check [User manual](#) for detailed list of features.

3.1.2.1 Functionalities

3.1.2.1.1 Search

User can use the following criteria to find scenes of interest:

- Collection (i.e. Sentinel-1, Sentinel-2, Sentinel-3, Sentinel-5P later extended to federated data sources such as Landsat and MODIS)
- Area of interest (AOI) – CDS Browser will by default use the current map extent, as well as allow to "polygon selection", to ensure simplicity of user experience
- Time range – setting start and end date, by default set to "day's accuracy", but also allowing more fine-tuned time selection (e.g. hours, minutes, seconds) as well as more advanced options (i.e. June-July across the years).
- Collection specific fine-tuning filters - sensor (i.e. SLSTR, OLCI, etc.), processing level (i.e. raw, L1C, L2A, GRD, SLC, etc.), satellite platform (i.e. S2A, S2B), cloud coverage (only for selected data sources) – based on scenes' meta-data, ascending/descending orbit, polarization, relative orbit number, other parameters specific to the product type and collection



3.1.2.1.2 Visualize

Users can also choose "Visualize" at one of the scenes, in order to be presented with full-resolution browsing experience.

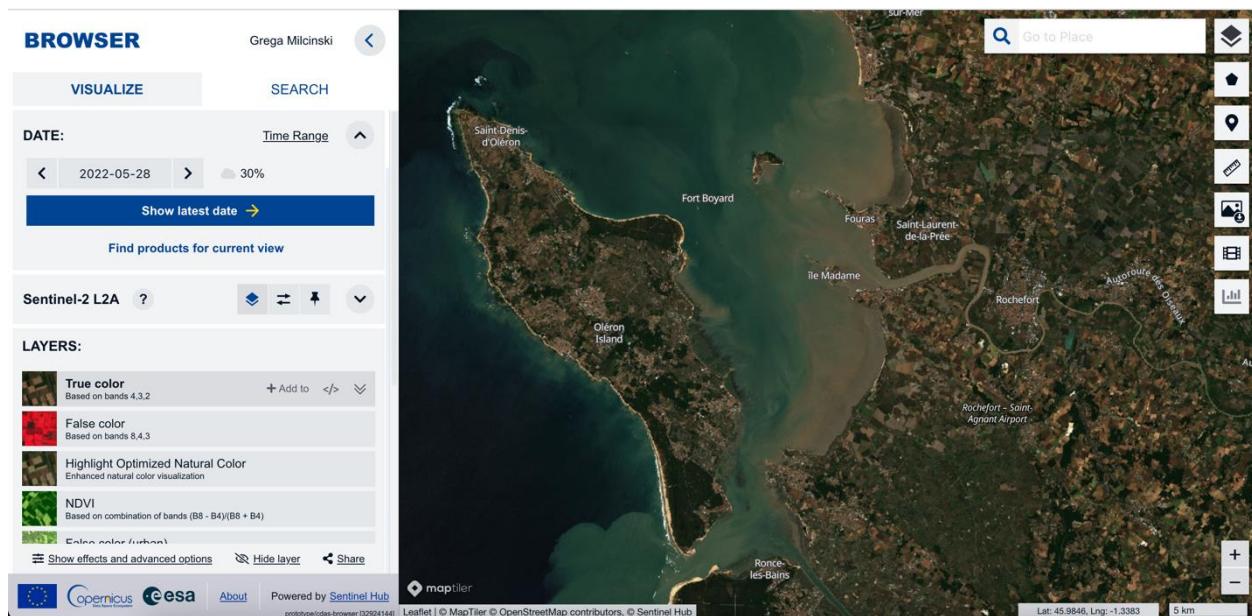


Figure 3: Visualisation

When visualizing a selection, users can choose among several pre-defined visualization options or create a new one using “custom band selection” (create RGB composite or visualization based on an index) or “custom script” (a custom script is a piece of Javascript code that allows the user to define how the data is processed).

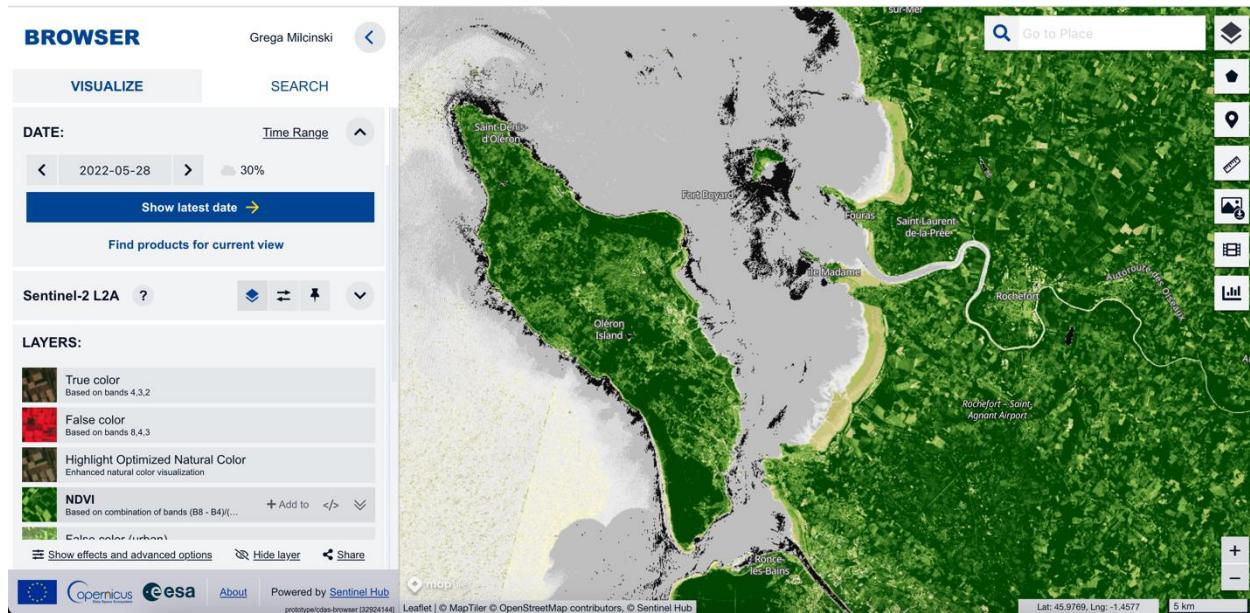


Figure 4: Possibilities of visualisation

3.1.2.1.3 Compare and save visualizations

Visualizations can be added to a compare mode that allows for easy comparison between different acquisitions to highlight changes through time.

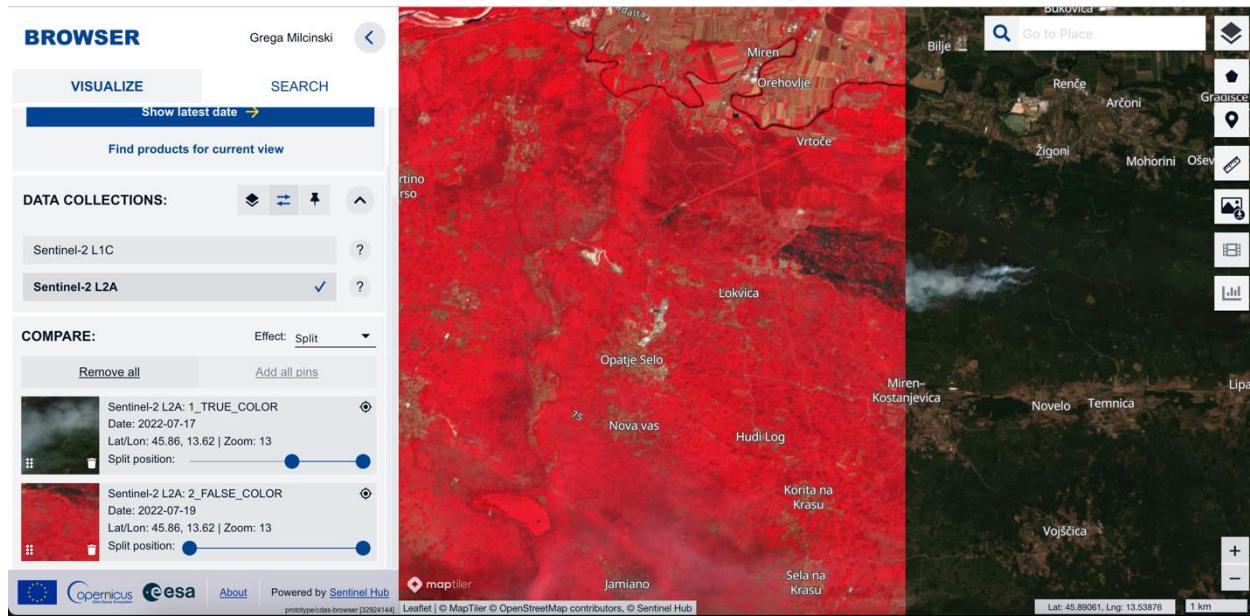


Figure 5: Comparison

User can save preferred visualizations and settings within a pin and through that reload the visualization at a later point in time or easily share it with others. Shared pins can be imported as .json. User can provide additional context to the visualization by adding a description to the pins.

3.1.2.1.4 Download an image for area subset

User can download an image (JPG/PNG) for any visualization and chosen AOI (limited to one scene or going beyond). It is also possible to add a title, labels, logos (i.e. Copernicus) and a legend to

the downloaded image.

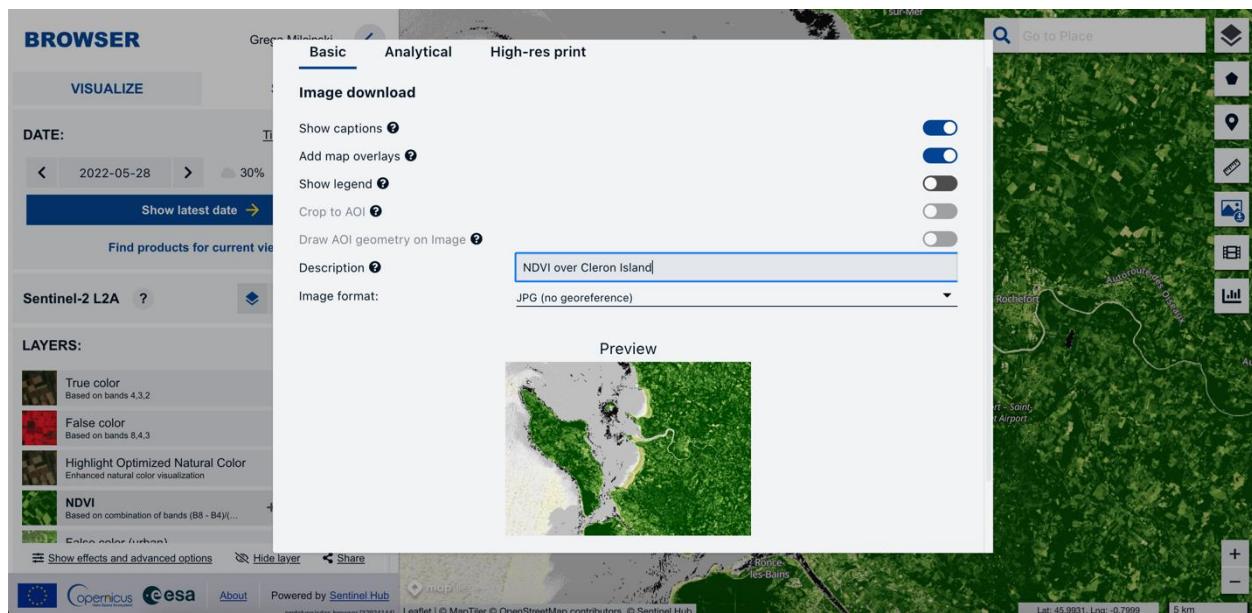


Figure 6: Download

3.1.2.1.5 Export data for analysis

The user can export an analytical version of the chosen satellite image/AOI/date. They have the option to select between GeoTiff or KMZ, different image resolution and two coordinate systems (one geographic and one projected).

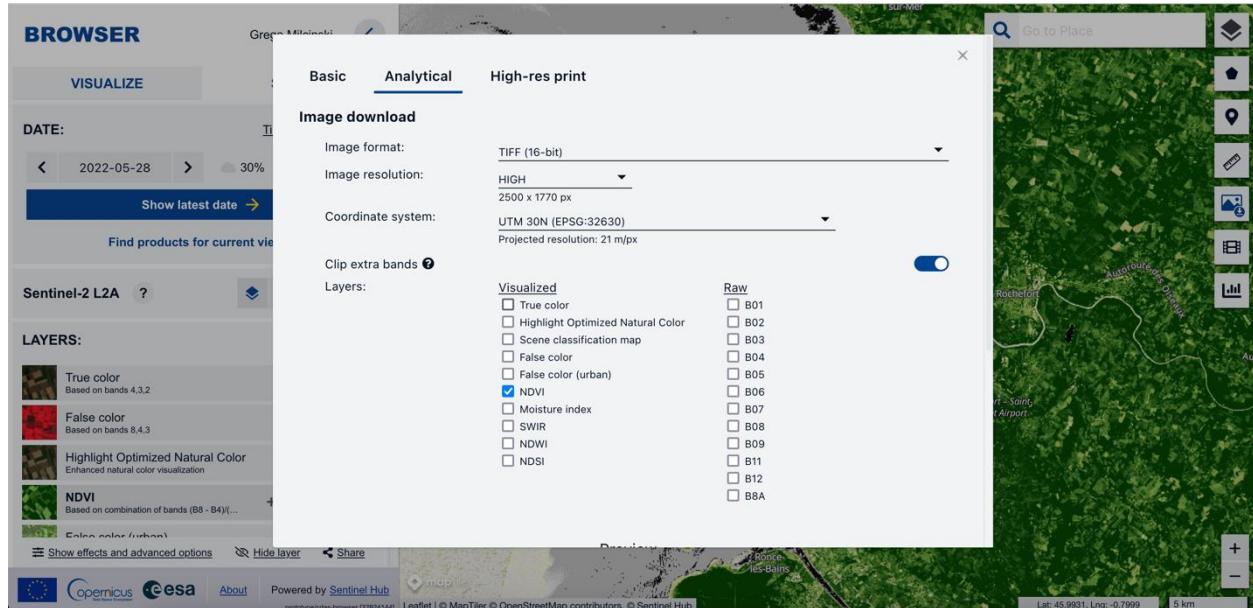


Figure 7: Export data for analysis

3.1.2.1.6 Export a high-resolution image print use

User can download a high-resolution image (JPG, PNG) with caption, legend and description for use e.g., in print media.

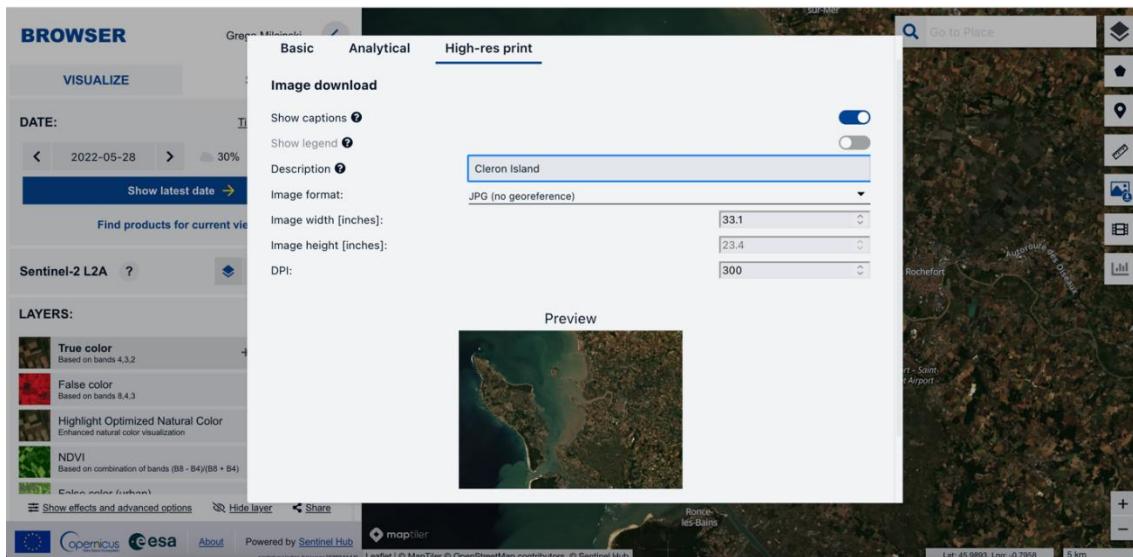


Figure 8: Download high-resolution images

3.1.2.1.7 Time-lapse

User can set START and STOP date and data filtering criteria (filter by month, one image per period, cloud coverage for selected data sources, tile coverage). A time-lapse⁴ will be generated of the user's current AOI (set by the polygon or full window extent) with all available scenes in the chosen AOI. For a smoother transition between frames, it is possible to add fade between images.

It is even possible to create time-lapse using various visualisation options or mixing data from several missions.

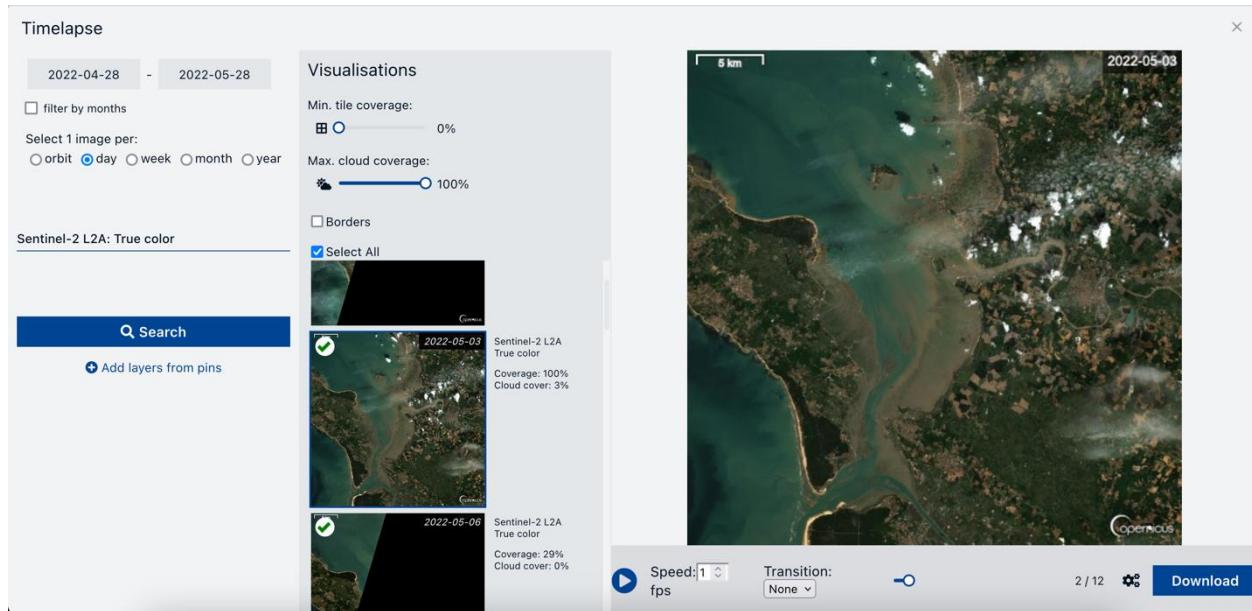


Figure 9: Time-lapse

The final timelapse can be exported as GIF/MPEG4 or shared directly from within the CDS browser on social media or with other users via link. Following the share-link will open the created timelapse in a preview mode, auto playing the animation.

3.1.2.1.8 Point/area analysis

User can perform an analysis of the point or selected area (determined by a polygon) and a chosen algorithm. In case a polygon option is chosen, mean value of specific index will be calculated. The result over time is then visualized as a chart and the statistics can be downloaded as .csv file.

3.1.2.1.9 Histogram

User can calculate a histogram for layers representing single values (indices) for the entire viewport or a custom AOI.

⁴ <https://medium.com/sentinel-hub/timelapse-in-eo-browser-962a78e3ee53>

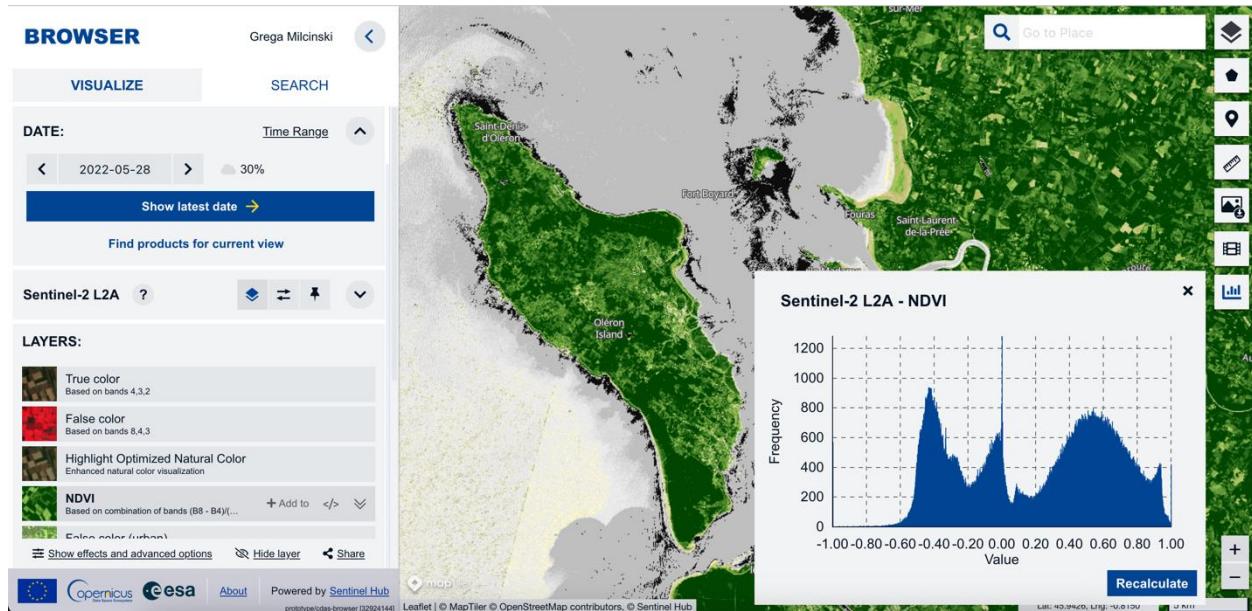


Figure 10: Histogram

3.1.2.1.10 3D visualization

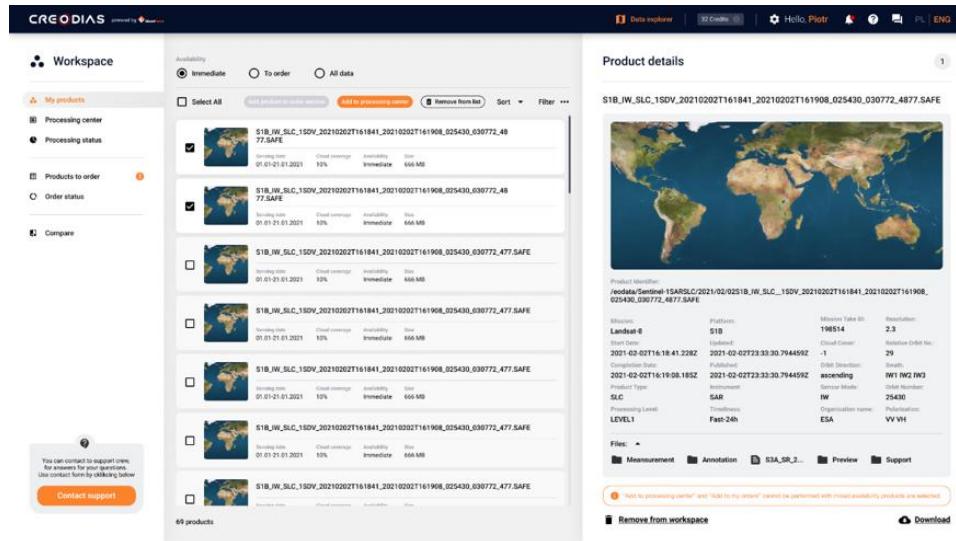
User interface provides a full-fledged 3D visualization engine⁵, allowing for better interpretation of specific natural phenomena. The 3D engine is fluently integrated in the overall user interface and most 2D functionality can be used just the same in 3D.

3.1.3 Data Workspace

Data Workspace is a dedicated interface for advanced actions related to the data products. These actions would typically be of asynchronous nature, which is why we are separating these from the Browser, which should be kept as simple as possible.

Products saved in the Data Workspace can be reviewed and aggregated into orders for the On-Demand Production or data ordering services.

⁵ <https://medium.com/sentinel-hub/terrain-viewer-in-eo-browser-a-play-of-light-and-shadow-64ccf22959f>



The screenshot shows the CREODIAS Data Workspace interface. On the left, there's a sidebar with navigation options: 'My products', 'Processing center', 'Processing status', 'Products to order' (which is selected), and 'Order status'. Below these are 'Compare' and 'Contact support' buttons. The main area displays a list of products under 'Products to order'. Each item has a thumbnail, a unique identifier, and details like 'Georeferencing', 'Cloud coverage', 'Availability', and 'Size'. A 'Select All' checkbox is at the top of the list. On the right, a 'Product details' panel is open for a specific product: 'S1B_IW_SLC_150V_20210202T161841_20210202T161908_025430_030772_4877.SAFE'. It shows a world map thumbnail, product identifier, mission details (Landsat-8, Platform S1B, Mission Type: SLC, Resolution: 2.3 m), and a table of properties. At the bottom of the panel are 'Download' and 'Remove from workspace' buttons.

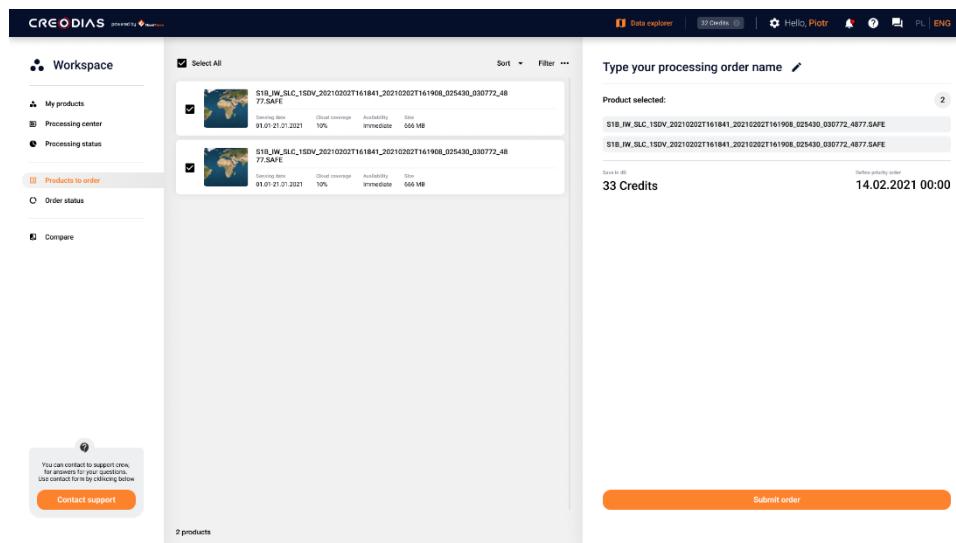
Figure 11: Products in Data Workspace

For each product (or set of products) the user can trigger further actions:

Offline products (in the long-term preservation archive or in the remote repository) can be ordered and the retrieval monitored in the “Order status”;

- Online products can be selected for processing with higher level processors or downloaded.

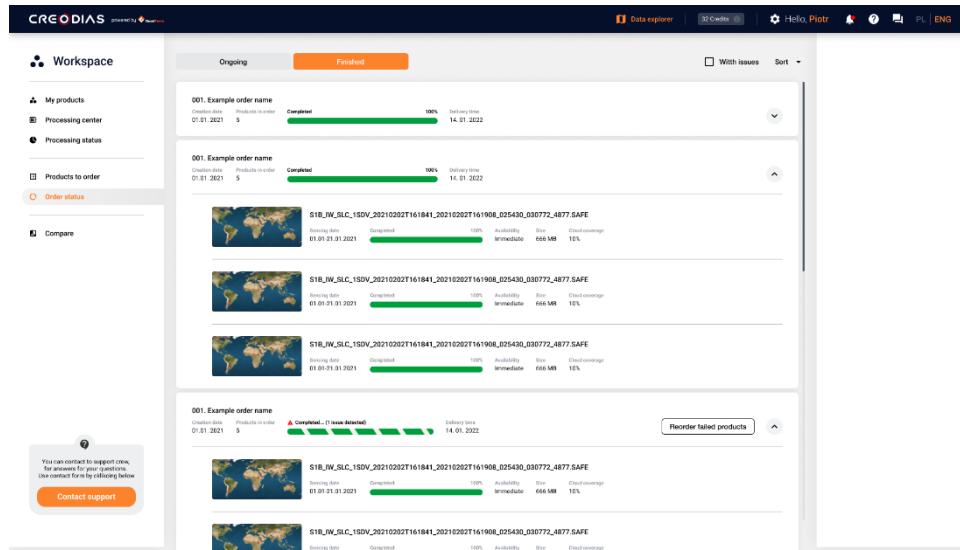
Products available for ordering (from the remote data hub, Long Term Archive, through deferred access or on-demand processing) are added to the order. The same approach is also valid for the additional or commercial dataset which have been added to the catalog.



This screenshot shows the 'Products to order' section of the CREODIAS Data Workspace. It lists two products with their details. To the right, a large orange 'Submit order' button is prominent. Above it, a dialog box asks for a 'Processing order name' and shows the selected products: 'S1B_IW_SLC_150V_20210202T161841_20210202T161908_025430_030772_4877.SAFE' and 'S1B_IW_SLC_150V_20210202T161841_20210202T161908_025430_030772_4877.SAFE'. It also displays '33 Credits' and the date '14.02.2021 00:00'.

Figure 12: Ordering offline products

The status of the orders can be monitored in the status page. The orders can be updated while executed giving the flexibility to cancel the unnecessary tasks.

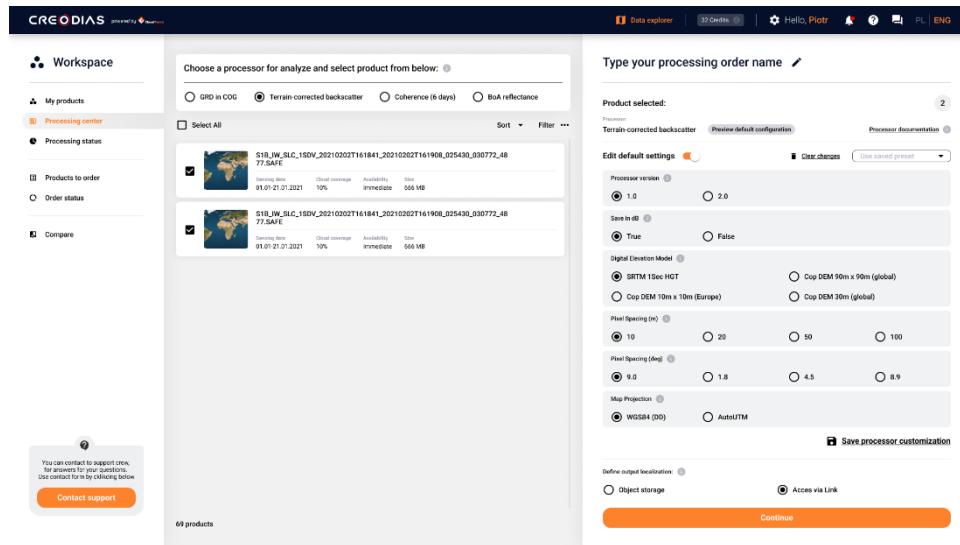


The screenshot shows the CREODIAS Order status interface. On the left, there's a sidebar with navigation links: 'My products', 'Processing center' (which is selected), 'Processing status', 'Products to order', 'Order status' (selected), and 'Compare'. Below the sidebar is a message: 'You can contact to support crew, for answers for your questions. Use contact form by clicking below.' with a 'Contact support' button. The main area has tabs for 'Ongoing' and 'Finished'. Under 'Ongoing', there are two entries for '001. Example order name'. Each entry includes a creation date (01.01.2021), a progress bar (100%), and a delivery date (14.01.2022). Below each entry is a thumbnail of a world map and detailed product information: S1B_IW_SLC_1SDV_20210202T161841_20210202T161908_025430_030772_4877.SAFE. The 'Finished' tab shows three completed orders with similar details. A 'Reorder failed products' button is located at the top right of the finished section.

Figure 13: Order status

If the products are selected for processing, the user is provided with the list of processors which are capable of processing relevant data types. The processors can be further parametrized to fine tune the results.

For the standard Copernicus L1/L2 processing the parameters are limited to selection of baseline, but can be extended in the future, based on the capabilities of the processors.



The screenshot shows the CREODIAS Parametrization of processor interface. On the left, there's a sidebar with the same navigation links as Figure 13. The main area has a search bar 'Choose a processor for analyze and select product from below:' with radio buttons for 'GRD in COG' (selected), 'Terrain-corrected backscatter', 'Coherence (6 days)', and 'BoA reflectance'. Below the search bar is a 'Select All' checkbox. There are two product entries: 'S1B_IW_SLC_1SDV_20210202T161841_20210202T161908_025430_030772_4877.SAFE' and 'S1B_IW_SLC_1SDV_20210202T161841_20210202T161908_025430_030772_4877.SAFE'. To the right, there's a large panel for 'Type your processing order name' with fields for 'Processor selected:', 'Processor version' (set to 1.0), 'Save in dB' (set to True), 'Digital Elevation Model' (set to SRTM 1Sec HGT), 'Pixel Spacing (m)' (set to 10), 'Pixel Spacing (deg.)' (set to 0.0), 'Map Projection' (set to WGS84 (DD)), and 'Define output location' (set to Object storage). At the bottom right is a 'Save processor customization' button and a 'Continue' button.

Figure 14: Parametrization of processor

Once the order for processing is submitted, the progress can be monitored similarly to orders for product retrieval.

The status dashboards include also all orders submitted through the ordering API.

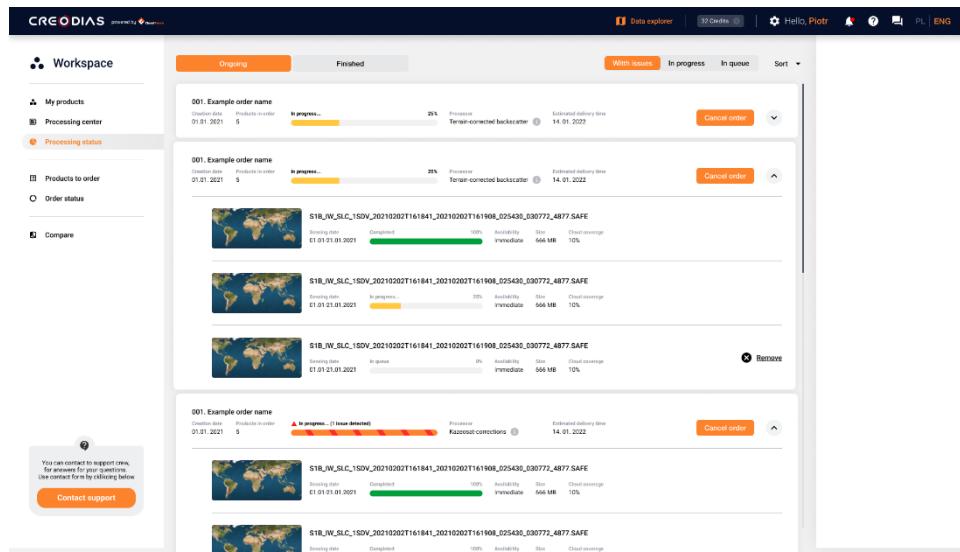


Figure 15: Processing status

The users can save their sets of parameters and use them for future processing.

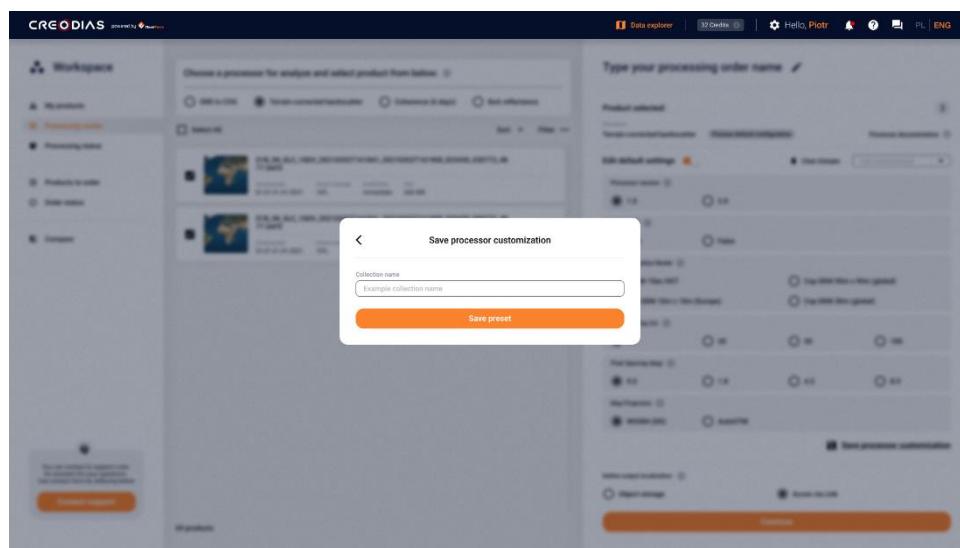


Figure 16: Save parameters

Capabilities of the Data Workspace complement other interfaces dedicated for processing like the openEO Editor and Jupyter Hub, but are targeted towards less experienced users who do not need to learn the complexity of the programmatic approach to data processing.

3.1.4 JupyterHub

Jupyter Notebooks are an intuitive entrance for all who want to start programming their own processors for EO data processing without in-depth programming knowledge, or for developers who want to quickly test different prototypes on the data.

Jupyter Hub is an open-source, online, interactive web application. It gives access to computational environments and resources without burdening the users with installation and maintenance tasks. Users, including students, researchers and data scientists, can get their work done in their own workspaces on shared resources which can be managed efficiently by system administrators. It is

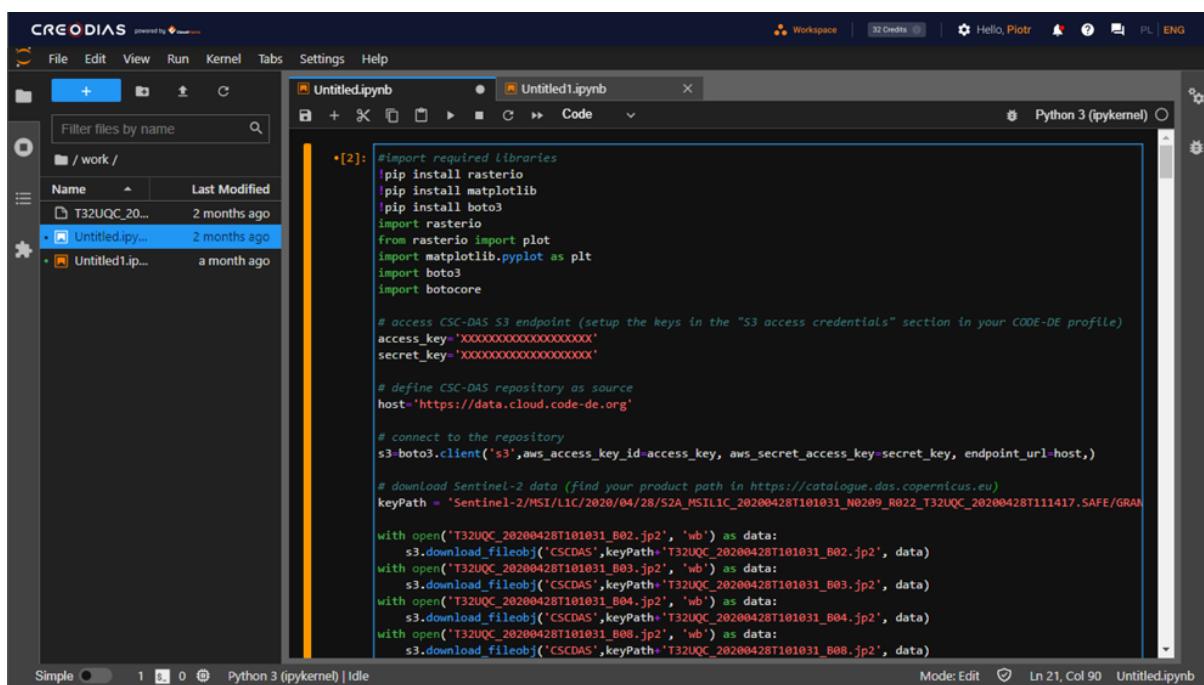
a very suitable tool for prototyping, developing and testing your ideas for Earth Observation data processing.

JupyterHub is the latest web-based interactive development environment for Jupyter Notebooks. Its flexible interface allows users to configure and arrange workflows in data science, scientific computing, computational journalism, and machine learning. A modular design invites extensions to expand and enrich functionality.⁶

Registered Copernicus Data Space Users have access to JupyterLab and Jupyter Notebooks free of charge at a limited capacity of resources beneath.

Notebooks are not only convenient for data access, but also integrate well with services which have a Python SDK, like Sentinel Hub⁷ and OpenEO⁸. Next to a Python SDK, Sentinel Hub also provides an ML library with lots of readily available examples⁹ and an xcube plugin¹⁰ that allows generating data cubes from the Sentinel Hub API.

Each Notebook has a direct access to the EO Data repository. To make the interaction with the data and services easier, several example notebooks are available for the users. As different tools also come with different dependencies and library versions, several notebooks kernels are provided and kept up to date with the provided notebook samples. This ensures that the users don't need to take care of installing the required dependencies, which allows them to immediately start prototyping without having to solve technical dependency obstacles first.



```

  File Edit View Run Kernel Tabs Settings Help
  + Untitled.ipynb Untitled1.ipynb
  Filter files by name
  / work /
  Name Last Modified
  T32UQC_20... 2 months ago
  Untitled.ip... 2 months ago
  Untitled1.ip... a month ago
  [2]: #import required libraries
  !pip install rasterio
  !pip install matplotlib
  !pip install boto3
  import rasterio
  from rasterio import plot
  import matplotlib.pyplot as plt
  import boto3
  import botocore

  # access CSC-DAS S3 endpoint (setup the keys in the "S3 access credentials" section in your CODE-DE profile)
  access_key='XXXXXXXXXXXXXXXXXXXX'
  secret_key='XXXXXXXXXXXXXXXXXXXX'

  # define CSC-DAS repository as source
  host='https://data.cloud.code-de.org'

  # connect to the repository
  s3=boto3.client('s3',aws_access_key_id=access_key, aws_secret_access_key=secret_key, endpoint_url=host)

  # download Sentinel-2 data (find your product path in https://catalogue.das.copernicus.eu)
  keyPath = 'Sentinel-2/MSI/L1C/2020/04/28/S2A_MSIL1C_20200428T01031_N0209_R022_T32UQC_20200428T111417.SAFE/GRANULES'

  with open('T32UQC_20200428T01031_B02.jp2', 'wb') as data:
    s3.download_fileobj('CSCDAS',keyPath+'T32UQC_20200428T01031_B02.jp2', data)
  with open('T32UQC_20200428T01031_B03.jp2', 'wb') as data:
    s3.download_fileobj('CSCDAS',keyPath+'T32UQC_20200428T01031_B03.jp2', data)
  with open('T32UQC_20200428T01031_B04.jp2', 'wb') as data:
    s3.download_fileobj('CSCDAS',keyPath+'T32UQC_20200428T01031_B04.jp2', data)
  with open('T32UQC_20200428T01031_B08.jp2', 'wb') as data:
    s3.download_fileobj('CSCDAS',keyPath+'T32UQC_20200428T01031_B08.jp2', data)
  with open('T32UQC_20200428T01031_B09.jp2', 'wb') as data:
    s3.download_fileobj('CSCDAS',keyPath+'T32UQC_20200428T01031_B09.jp2', data)

```

Figure 17: Jupyter Lab on CREODIAS:

More about Jupyter can be found at:

⁶ <https://jupyter.org/>

⁷ <https://github.com/sentinel-hub/sentinelhub-py>

⁸ <https://github.com/Open-EO/openeo-python-client>

⁹ <https://github.com/sentinel-hub/eo-learn/tree/master/examples>

¹⁰ <https://github.com/dcs4cop/xcube-sh/>

<https://creodias.eu/creodias-jupyter-hub>,
<https://www.youtube.com/watch?v=qEYIJ2NWcBI&feature=youtu.be>

3.1.5 Catalog APIs

There are various interfaces providing capability to search the catalog, to serve various users' needs and to ensure continuity over the existing Copernicus Hubs. All interfaces are connected to the same database to guarantee consistency.

3.1.5.1 OData

OData is an SO/IEC approved, OASIS standard, which is based on http RESTful Application Programming Interfaces.

Product Query

The functionality allows the users and other systems to query the products based on the search criteria, which may include publication date, product name, metadata, geographic criteria and other complex queries combining multiple searching conditions. This shall be used to identify the products which may be subsequently retrieved from the catalogue as well as to export the products' metadata.

Odata query consists of elements which in this documentation are called "options". Interface supports the following search options:

- filter
- orderby
- top
- skip
- count
- expand

More detailed description is provided at:

<https://documentation.dataspace.copernicus.eu/#/APIs/OData>

3.1.5.2 STAC data

STAC data have become a de-facto standard in the EO community, also being onboarded to OGC at the moment. STAC items are provided for all online products, as well as for products generated by users within the Copernicus Data Space Ecosystem. STAC is a powerful metadata standard thanks to a framework to allow the user community to define extensions. This allows metadata to be specified and standardized beyond the level of any other standard.

Given this rich and comprehensive specification, other applications and services can easily integrate additional datasets that are available in the catalog. This allows Users and service providers to operate more efficiently on the platform.

STAC Catalog API

Even though users have direct access to STAC items, it is typically quite cumbersome and often also technically complicated to efficiently parse millions of items and filter them by relevant

parameters. This is why we expose a STAC compliant Catalog API¹¹ interface, allowing users to connect to it with their applications.

3.1.5.3 Open Search

To ensure compatibility with previous versions (such as EO Finder on CREODIAS), both catalog and ordering API in Open Search version are available. Search can be performed based on multiple attributes such as collection, spatial extent, time range, metadata. Orders can be based on the data collection, area, time range or any other selection criteria available in the search APIs. Ordering API is extended to support requests for deferred data access and processing / On-demand Production. Ordered data is automatically downloaded and made available in the EO Repository Cache area from where it can be accessed using the same API-s as for local data. Users can query the API to obtain an order's fulfillment progress status.

The documentation of the current version of the API:

<https://documentation.dataspace.copernicus.eu/#/APIs/OpenSearch>

3.1.6 Download products APIs

EO data can be accessed using S3 and HTTP based interfaces. It can be accessed directly through the S3 interface. Data stored in the repository can be also dynamically published in the form of user-configurable OGC WMS/WMTS/WCS web services powered by Sentinel Hub API. Data products can also be accessed via HTTP Download while information services can be made accessible via an http Proxy service. Available interfaces are described below.

3.1.6.1 OData

OData is an SO/IEC approved, OASIS standard , which is based on http RESTful Application Programming Interfaces. It enables resources, which are identified by URLs and defined in a data model, to be created and edited using simple HTTP messages.

Product Retrieval

The catalogue exposes interfaces for product retrieval, enabling to download the data from various locations. This includes directly accessible catalogue storage, or processed data available via the on-demand processing component, depending on the type the requested type of data. The Product Retrieval functionality allows for the full product package download as well as the individual components from the product package.

More detailed description OF OData is provided at:

<https://documentation.dataspace.copernicus.eu/#/APIs/OData>

3.1.6.2 Object Data Access API (S3)

The object access API is the main access method for EO data. It is suitable for Third Party applications that require high performance parallel access and scalability. This way Users can access individual products, their parts, such as granules or metadata. They can even access parts

¹¹ <https://docs.sentinel-hub.com/api/latest/api/catalog/>

of a single data file, which may be useful for applications such as individual tiles extraction from large jpeg2000 image files, Cloud Optimized GeoTiffs and ZARRs. Any user who wants to connect from an external infrastructure to the Copernicus Data Space Ecosystem collection can do so through the S3 protocol. The user can simply use Copernicus Data Space Ecosystem credentials to login and generate S3 keys. After generating the S3 key (Access and Secret Key) and using the software supporting S3 protocol, the user has the possibility to connect remotely to EO data with via S3-compatible endpoint. It may also be used by Users to download data directly to their workstation.

3.1.6.3 Zipper

The Zipper application allows to download entire EO Data products. It transparently delivers data products as a single compressed file regardless of the actual storage form of the relevant dataset. Products stored in unpacked form are compressed on the fly.

Zipper is integrated with product retrieval functionality of the catalog APIs interfaces, enabling to download the data from various locations. This includes directly accessible catalogue storage, or processed data available via on-demand, depending on the type the requested type of data. The Product Retrieval functionality allows for the full product package download as well as the individual components from the product package.

3.1.7 Sentinel Hub APIs

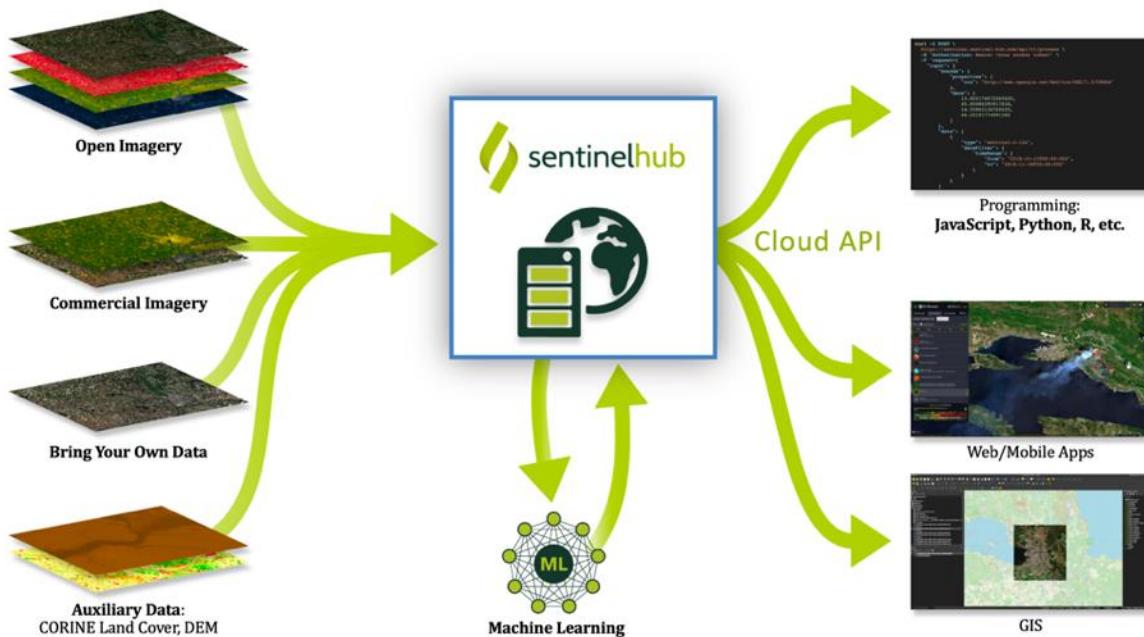


Figure 18: Sentinel Hub concept

3.1.7.1 Process API

Process API performs processing of a user-defined function ("Evalscript¹²" or "Custom script") over a chosen data collection(s), Area of Interest (AOI) and temporal period. It can be used for retrieving original sensor values, visualised products (i.e. "true color", "false color", NDVI and others), as well as more complex operations (i.e. ML model inference such as Leaf Area Index¹³, "built-up area model¹⁴", etc.). Results can be combination of raster data and JSON-based meta-data.

In order to grow the uptake of the EO data processing, we are managing an open-source repository of custom scripts¹⁵, which contains several hundreds examples, many of them based on scientific exercises.

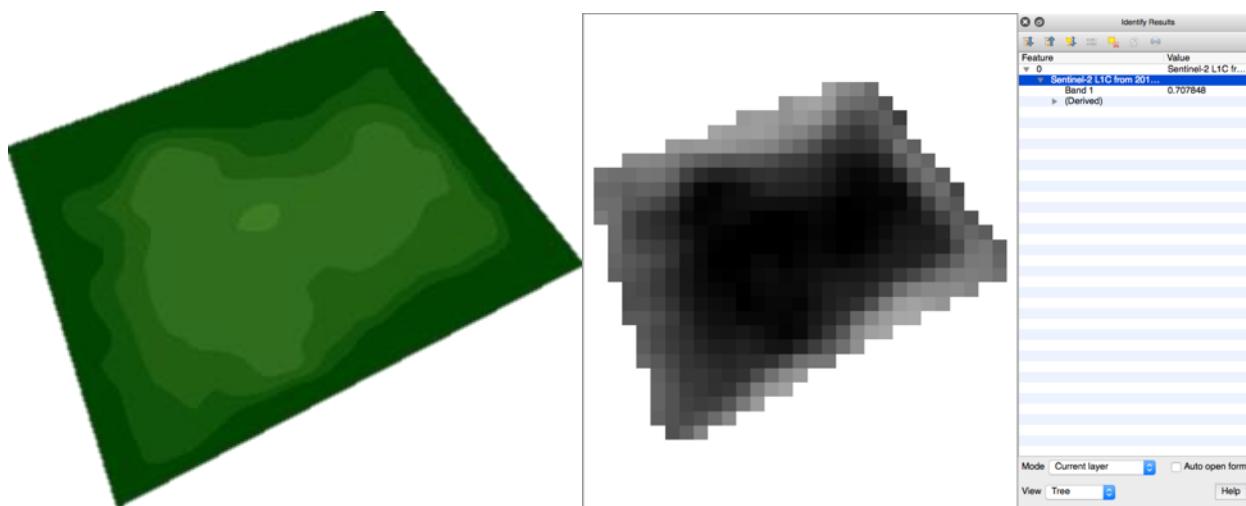


Figure 19: Two forms of data output - visualized or actual values

Under the hood, process API is able to perform various advance operations, which are essential to hide the complexity of Earth Observation data from the end-user - download of relevant data subset, decoding, stitching scenes, reprojection (from data's original CRS, which can be many, or even from satellite projection, into the one defined by the user), up- and down-scaling (with user-defined interpolation settings such as bicubic, bilinear, nearest neighbor, box), mosaicking, meta-data parsing, backscatter calibration, orthorectification reprojection and more.

Process APIs come in three flavors:

- synchronous process API¹⁶, which is meant for instant response, typically within half-a-second; it has limitations set to allow for immediate processing (order of magnitude of 100 million pixels processed) - results of the processing are returned directly in a response;
- asynchronous process API (note that this does not exist yet, it will be developed within 6 months after contract start), providing same set of features as synchronous process API but designed for order of magnitude larger requests (i.e. annual mosaic of 100x100km region) - the processing might take several minutes and is therefore not appropriate for instant retrieval; service response

¹² <https://docs.sentinel-hub.com/api/latest/evalscript/>

¹³ <https://github.com/sentinel-hub/custom-scripts/blob/master/sentinel-2/lai/script.js>

¹⁴ <https://medium.com/sentinel-hub/area-monitoring-how-to-train-a-binary-classifier-for-built-up-areas-7f2d7114ed1c>

¹⁵ <https://sentinel-hub.github.io/custom-scripts/>

¹⁶ <https://docs.sentinel-hub.com/api/latest/api/process/>

is a pointer to the status of the request and, when available, reference of the result, which will typically be output to the user's object storage;

- Batch process API¹⁷, which provides same functionality but is optimized for large scale processing. It was optimized for large scale machine learning processes. It allows one to prepare features to be used in ML in fast and cost optimized fashion. Results are output to the user's object storage.

More info here:

- <https://medium.com/sentinel-hub/scale-up-your-eo-learn-workflow-using-batch-processing-api-d183b70ea237>
- <https://medium.com/sentinel-hub/large-scale-data-preparation-introducing-batch-processing-b3a58755b8a1>

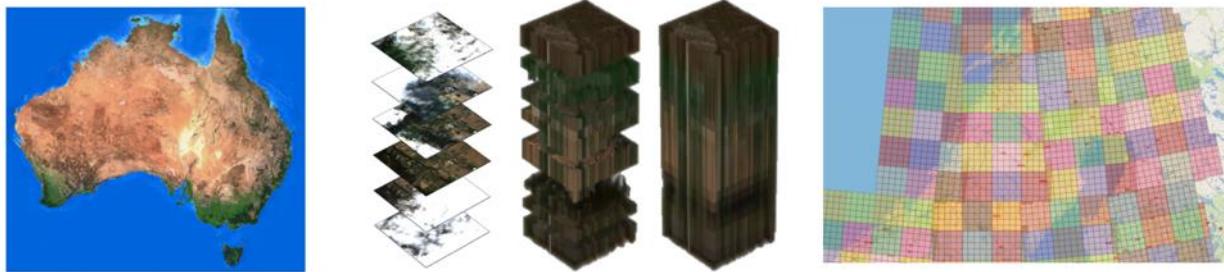


Figure 20: Demonstration of the data processing and gridding method of the Batch API

Sentinel Hub process API supports data fusion¹⁸, providing access to various datasets within the same processing algorithm. More info here:

- <https://medium.com/sentinel-hub/data-fusion-combine-satellite-datasets-to-unlock-new-possibilities-26356c481169>

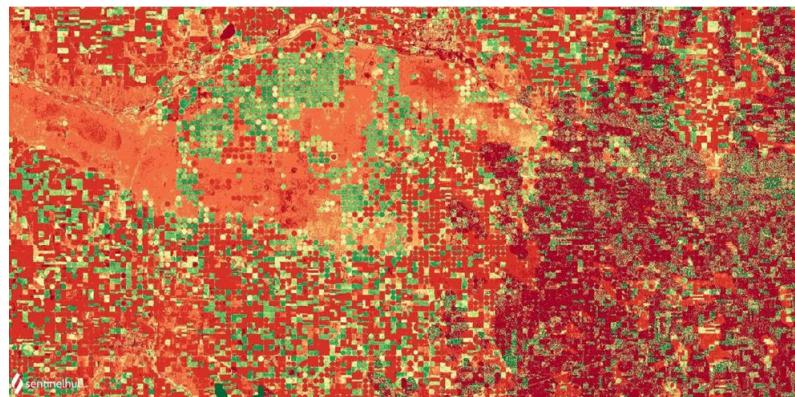


Figure 21: An example of the Sentinel-1 and Sentinel-2 data fusion, using S1-derived NDVI-like index in areas, which are cloudy, and Sentinel-2 based NDVI elsewhere

3.1.7.2 Statistical API

Statistical API was developed based on the user-provided insight that they often need time-series of averaged data, rather than individual pixels. It started with the requirement to visualise NDVI of

¹⁷ <https://docs.sentinel-hub.com/api/latest/api/batch/>

¹⁸ <https://custom-scripts.sentinel-hub.com/custom-scripts/#data-fusion>

the farm parcel over a long period of time. The need intensified when data scientists started to execute large-scale machine learning workflows on object-level. They have realised that this is much easier to do on statistical representation of data, rather than the data themselves. The fact that they can condense the data by several orders of magnitude make their procedures much faster, cost-efficient and, most importantly, interactive - rather than waiting for hours to process tens of thousands of multi-temporal and multi-spectral data cubes for each of the objects, they could do the same in a couple of minutes, making it possible to fine-tune the algorithm much faster.

Sentinel Hub statistical API is an abstraction layer on top of process API, described in the previous section, providing various aggregation options over the data (i.e. average, median, low and top edge, binning, etc.). Users can combine temporal mosaicking and aggregation function to get exactly the statistic they need. As it integrates the Sentinel Hub's processing engine ("Custom script"), it is possible to include various algorithms and machine learning models. One can therefore run a full-fledged machine learning model over each object (i.e. searching for mowing events, built-up area, bare soil, etc.) and use the service as the core processing engine.



Figure 22: demonstration of the Statistical API concept

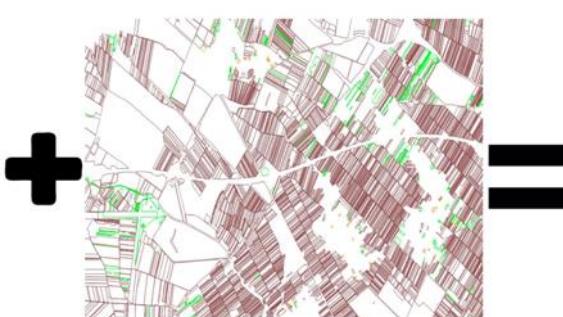
The statistical API comes in two flavors:

- synchronous Statistical API¹⁹, which returns results for a specified geometry in JSON in a matter of seconds;
- Batch Statistical API²⁰, which takes geopackage with geometries (up to a million of them), the processing instructions and then processes each of the geometries, outputting the results to the user's object storage.

```
evalscript = """
//VERSION=3
function setup() {
  return {
    input: [{bands: ["B04", "B08", "SCL", "dataMask"]}],
    output: [
      {id: "data", bands: 1},
      {id: "dataMask", bands: 1}
    ]
  }
}

function evaluatePixel(samples) {
  let ndv = (samples.B08 - samples.B04)/(samples.B08 + samples.B04)
  var validNDVIMask
  if (samples.B08 + samples.B04 == 0 ){
    validNDVIMask = 0
  }
  var noWaterMask = 1
  if (samples.SCL == 0 ){
    noWaterMask = 0
  }
  return {
    data: [ndv],
    dataMask: [samples.dataMask * validNDVIMask * noWaterMask]
  }
}
"""

```



```
{
  "data": [
    {
      "interval": {"from": "2020-01-01", "to": "2020-01-31"},
      "outputs": [{"data": "Channel", "CMB": "Catalyst"}, {"data": "Channel", "CMB": "Catalyst"}, {"data": "Channel", "CMB": "Catalyst"}, {"data": "Channel", "CMB": "Catalyst"}],
      "max": 8.238030072368972,
      "mean": 8.238030072368972,
      "min": 8.238030072368972,
      "stdev": 0.4232342818242093,
      "total": 8.238030072368972,
      "sampleCount": 3600,
      "radiation": 11100000000000000
    },
    {
      "interval": {"from": "2020-02-01", "to": "2020-02-28"},
      "outputs": [{"data": "Channel", "CMB": "Catalyst"}, {"data": "Channel", "CMB": "Catalyst"}, {"data": "Channel", "CMB": "Catalyst"}, {"data": "Channel", "CMB": "Catalyst"}],
      "max": 8.423238018543823,
      "mean": 8.423238018543823,
      "min": 8.423238018543823,
      "stdev": 0.223238018543823,
      "total": 8.423238018543823,
      "sampleCount": 3600,
      "radiation": 11100000000000000
    }
  ],
  "interval": {"from": "2020-03-01", "to": "2020-03-31"},
  "outputs": [{"data": "Channel", "CMB": "Catalyst"}, {"data": "Channel", "CMB": "Catalyst"}, {"data": "Channel", "CMB": "Catalyst"}, {"data": "Channel", "CMB": "Catalyst"}],
  "max": 8.892159307976159,
  "mean": 8.892159307976159,
  "min": 8.892159307976159,
  "stdev": 0.8566829795450314,
  "total": 8.892159307976159,
  "sampleCount": 3600,
  "radiation": 11100000000000000
},
  {
    "interval": {"from": "2020-04-01", "to": "2020-04-30"},
    "outputs": [{"data": "Channel", "CMB": "Catalyst"}, {"data": "Channel", "CMB": "Catalyst"}, {"data": "Channel", "CMB": "Catalyst"}, {"data": "Channel", "CMB": "Catalyst"}],
    "max": 8.664733830423704,
    "mean": 8.664733830423704,
    "min": 8.664733830423704,
    "stdev": 0.853934715247238,
    "total": 8.664733830423704,
    "sampleCount": 3600,
    "radiation": 11100000000000000
  }
],
  "status": "OK"
}
```

Figure 23: Batch Statistical API

3.1.7.3 OGC APIs

Visualization API is operated on top of Sentinel Hub Process API (see 3.1.7.1 Process API) and exposes most of the functionality over OGC²¹ (and INSPIRE) compliant interfaces, specifically:

- WMS (Web Map Service), version 1.0, 1.1 and 1.3.
- WCS (Web Coverage Service), version 1.0.
- WMTS (Web Mapping Tiling Service), version 1.0.0.
- WFS (Web Feature Service), version 2.0.0.

Note that users can use Process API for visualization as well, depending on the client they are using.

Registered users have an ability to configure their own specifics for layers exposed via OGC APIs.

¹⁹ <https://docs.sentinel-hub.com/api/latest/api/statistical/>

²⁰ <https://docs.sentinel-hub.com/api/latest/api/batch-statistical/>

²¹ https://www.sentinel-hub.com/develop/documentation/api/ogc_api

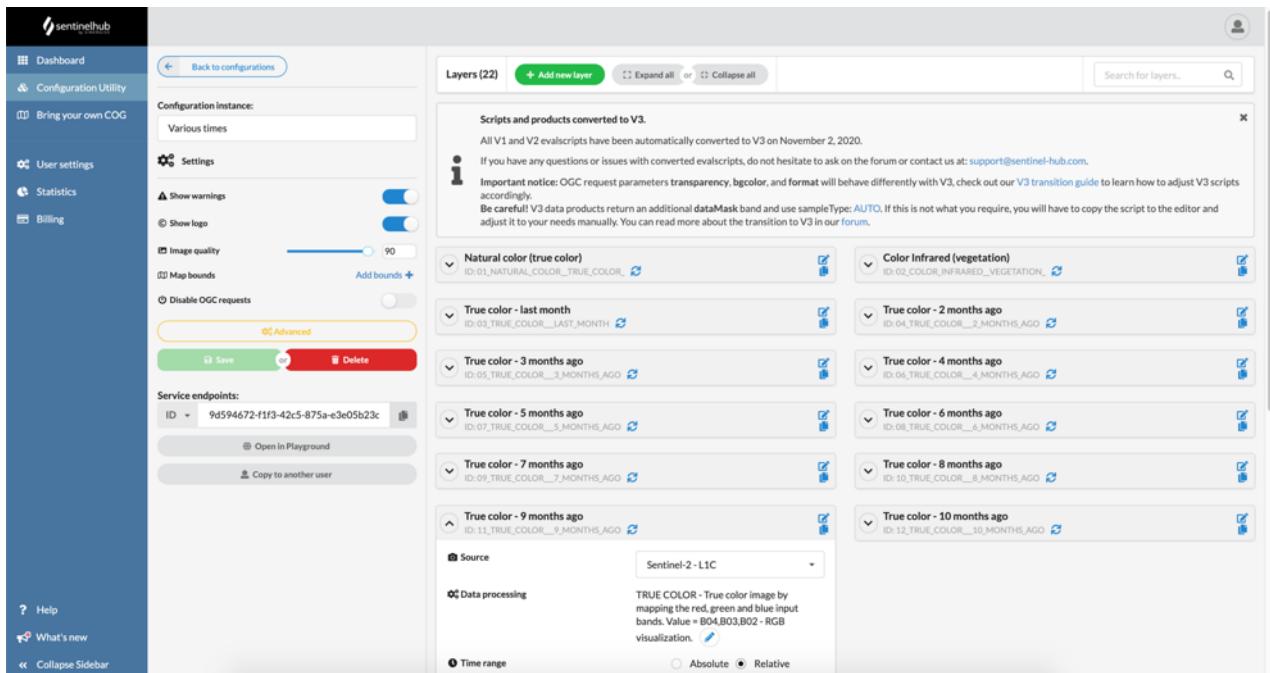


Figure 24: Configuration utility, allowing users to set preferred parameters for layers exposed via Visualization API

3.1.7.4 Bring your own data API

Users can bring their own data and use it either themselves or share it with others.

We support the self-serving on-boarding of most common data formats - Cloud Optimized GeoTiff (COG) and zarr. For these, users simply need to upload the data to the Object storage and use the Sentinel Hub facility to register the data in the platform. Once done, all APIs can be used on top of these data. The access to these data is controlled by the data owner and they are not available publicly unless configured in this manner.

Technically, the integration is simple:

- the data should be stored in object storage;
- the data are in one of the supported data formats (e.g. Cloud Optimized GeoTiff and zarr); there are toolkits^{22, 23} available to convert data in one of the supported formats;
- the data are ingested in Sentinel Hub using a dedicated API

3.1.7.5 Integration capabilities

To make it easier for users to integrate APIs in their workflows and third-party components, we have developed dedicated plug-ins or SDKs for most used environments:

- [QGIS plug-in](#)
- [sentinelhub-py](#) - for Python workflows
- [sentinelhub-js](#) - for integration in JavaScript-based WebGIS applications such as Leaflet, React JS

²² <https://github.com/bcdev/nc2zarr/>

²³ [https://docs.sentinel-hub.com/api/latest/api/byoc/#converting-to-co](https://docs.sentinel-hub.com/api/latest/api/byoc/#converting-to-cog)

- [xcube-sh](#) - for xarray-based workflows used in tools like xcube, Open Data Cube, Pangeo
- [eo-learn](#) and [eo-flow](#) - libraries for easier development of machine learning workflows, acting as a bridge between EO data and well-known tools like TensorFlow, PyTorch and others.

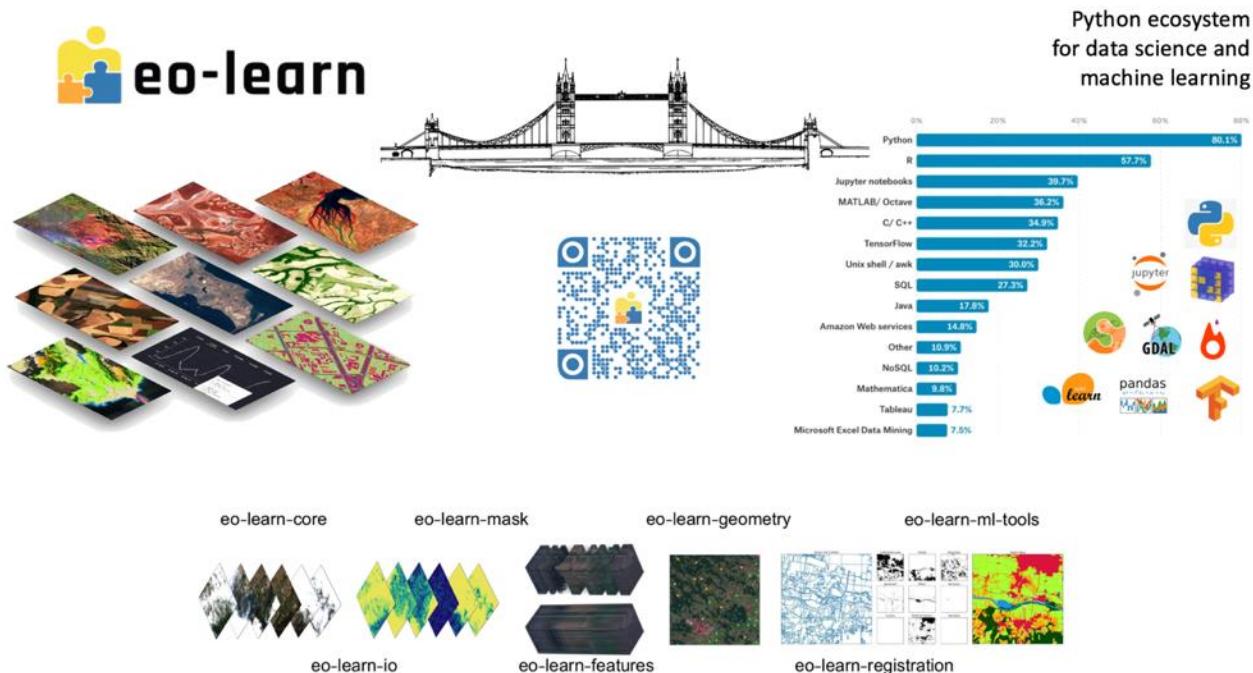


Figure 25: eo-learn environment

3.1.8 openEO API

To take an EO application from an idea to an operational workflow, users need to carry out various tasks, that are not always about actual EO algorithm design. For instance, much time is spent on various common tasks like IT tools to deploy a workflow on top of IAAS, data visualization, data access, preprocessing and so on. EO data scientists also often need significant software engineering skills to successfully complete a large EO data project.

With openEO, this efficiency problem is addressed by providing a platform with a comprehensive vision on EO data processing, that targets data scientists who are able to write basic scripts in Python, R or JavaScript. Providing a scalable system that can handle continental and global processing, of complex workflows, while still being easy to use is the main goal.

3.1.8.1 Data cube processing

Like other systems, openEO adopts a ‘datacube’ view at its core which allows to design workflows without thinking in terms of files or products. It combines this data model with a growing set of 100+ processes that allow the construction of complex workflows.

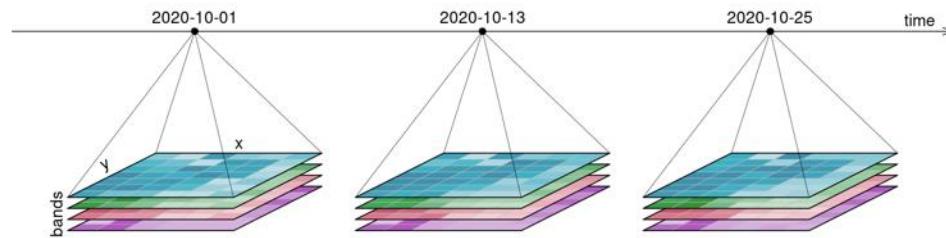


Figure 26: An example datacube with 4 dimensions

This approach serves two important purposes: users do not deal with files, formats, data loading or memory management, and the processing system can perform smart optimizations to execute the described workflow in a manner that is optimal for the underlying infrastructure, and scalable.

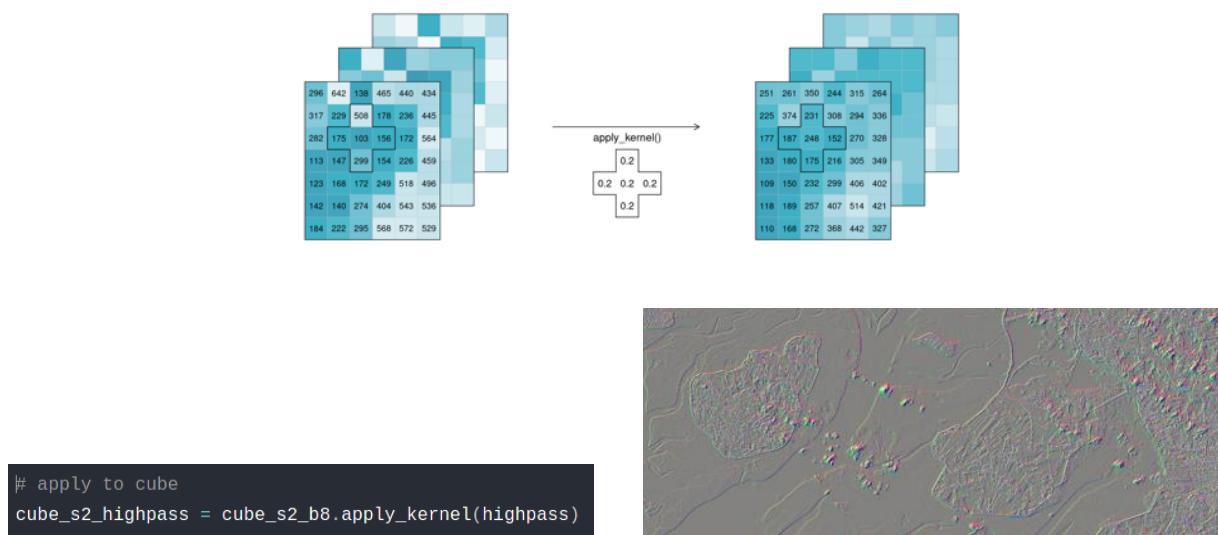


Figure 27: Example of applying a 2D convolution for edge detection

The complete list of available processes can be found at <https://processes.openeo.org/>, this list is continuously being extended based on new use cases.

3.1.8.2 User interfaces

While openEO is a REST based web service, interfaces are provided that target various potential user groups. For data scientists, the main interfaces are the Python and R programming libraries that provide a familiar environment for researchers. They also come with additional convenience functionality that simplifies working with openEO. These libraries are complemented with a web editor interface that simplifies certain tasks such as exploring available datasets, managing batch jobs and visualizing results. This interface is shown in Figure 28

For users that are not programmers, the web editor also provides a visual interface to create and modify workflows. This interface can even export the visual workflows into Python or R scripts again, in case users want to continue working in those environments.

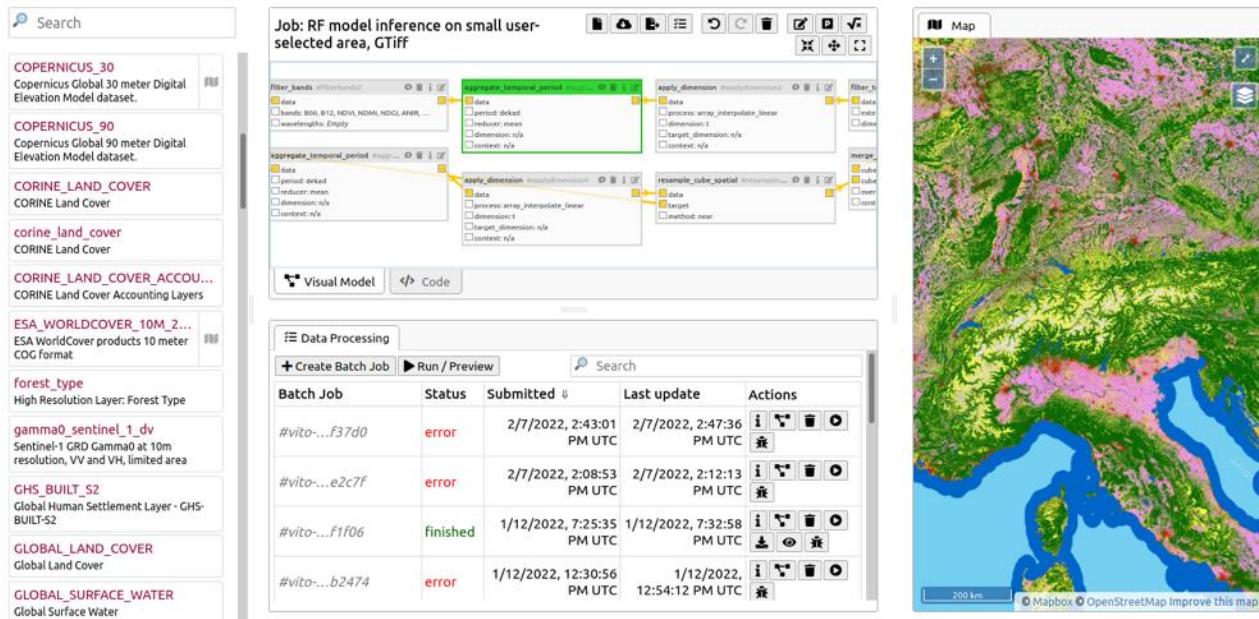


Figure 28: openEO web editor

When the openEO Python library is used in a Jupyter notebook, the user benefits from enhanced visualization for batch jobs, collections, processes and so on. Figure 29 shows how to for instance show a visual list of batch jobs from inside a Jupyter notebook.

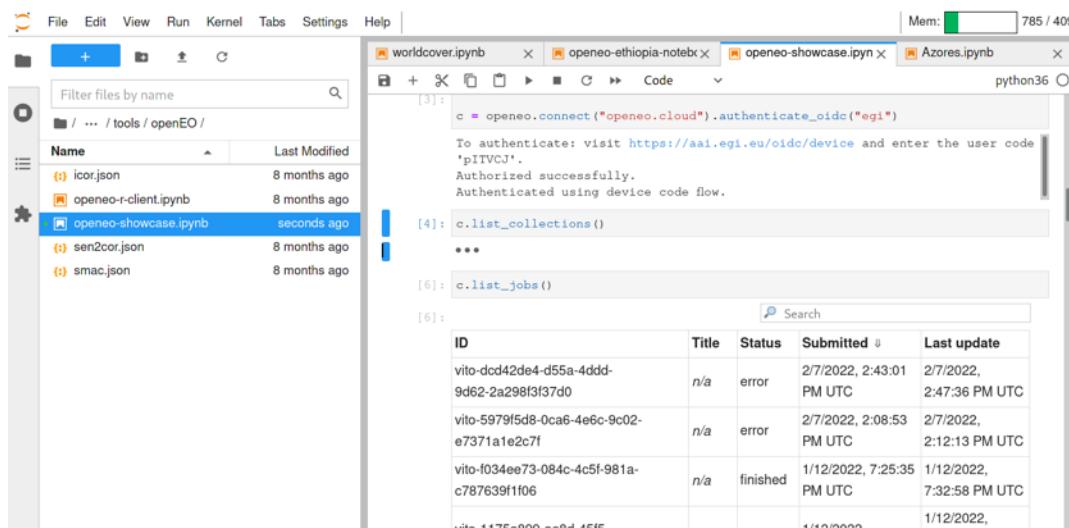
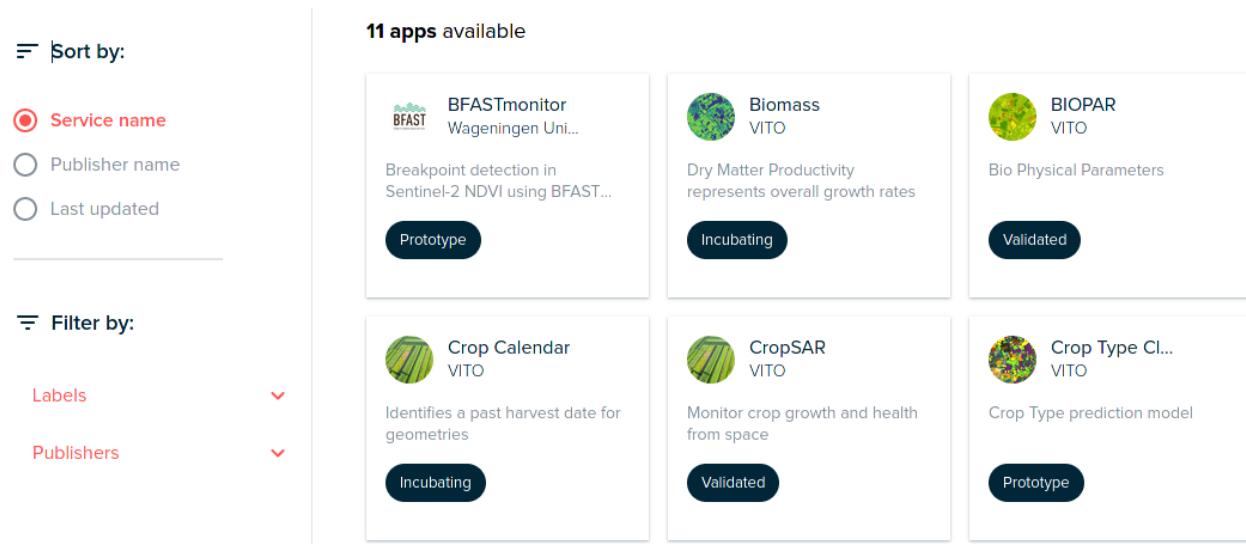


Figure 29: Listing openEO batch jobs in Jupyter

Another interface which supports openEO is the marketplace (see section 4.1.2), where users can share their user defined processes. This interface also targets users that are looking for an end-to-end workflow, without necessarily having to know the details of creating workflows in openEO.



The screenshot shows the Copernicus Data Space Ecosystem Marketplace interface. On the left, there are filtering and sorting options. Under 'Sort by:', 'Service name' is selected. Under 'Filter by:', 'Labels' and 'Publishers' dropdown menus are shown. The main area displays 11 apps in a grid:

- BFASTmonitor** (Wageningen Uni...): Prototype
- Biomass** (VITO): Dry Matter Productivity represents overall growth rates; Incubating
- BIOPAR** (VITO): Bio Physical Parameters; Validated
- Crop Calendar** (VITO): Identifies a past harvest date for geometries; Incubating
- CropSAR** (VITO): Monitor crop growth and health from space; Validated
- Crop Type Cl...** (VITO): Crop Type prediction model; Prototype

Figure 30: Copernicus Data Space Ecosystem Marketplace interface – apps are built on top of OpenEO

3.1.9 On-Demand production

On-demand production is a serverless processing service, which allows easy mass processing of Sentinels products without using virtual machines. The On-demand production solution allows the user to save time related to preparing the environment for the implementation of the required processors. In this scenario, a user does not need to configure the operating system and the entire cloud environment required to scale the processing to get results faster.

On-demand production is integrated with the CDS Browser and user Workspace and can be triggered via API or GUI. The on-demand production of following products is available for registered users:

- Sentinel-1
- Sentinel-2
- Sentinel-3

An easy-to-use ordering mechanism is available to trigger processing tasks, and data will be delivered to a cache repository from where users can download the data to the preferred location or they can use the link provided in the order completion message.

3.1.9.1 Product Generation Service

In addition to on-demand processing of Sentinel products, we offer a Product Generation Service.

PGS allows users to easily select the type of processor they want to use. After choosing processor, user defines the group of products to be processed by selecting an area of interest, a date range and optionally other parameters. The user may also define additional processor output parameters if needed.

Within Copernicus Data Space Ecosystem, Products Generation is available in a best effort mode. The **best effort** scenario assumes queuing orders on a specific pool of cloud resources, with no guarantee that the processing will be done in a specific time. In this case the customer's order is

processed on limited, shared resources. In this mode, the service is free of charge. This solution is best for projects that require small scale (several tens) of processed products. In case of a large queue and another few hundred products, the waiting time for the completion of processing may take even several weeks. In such a case, user can look for CREODIAS offering (see 3.2.3).

3.1.9.2 Available processors:

- CARD BS – generating Sentinel 1 Level 2 products with correction for terrain induced radiometric effects applied to radar backscatter using DEM data, i.e. projecting each DEM facet into the plane that is perpendicular to the instrument's range direction. This processor is based on GPT graph that can be ran with ESA SNAP GPT. The SNAP recipe was provided by the European Commission's Joint Research Centre .
- CARD COH6/12 – generating Sentinel 1 Level 2 products that are results of coherence estimation of two image pair combinations (consisting of primary image and overlapping two secondary images acquired up to six or twelve days prior) and creating a mosaic afterwards. This processor also uses DEM in order to correct data for the terrain correction and is based on ESA GPT graph. The SNAP recipe was provided by the European Commission's Joint Research Centre.
- COG – producing Sentinel-1 Level-1C GRD data in Cloud-Optimised Geotiff (COG) format.

3.2 CREODIAS Offering

3.2.1 Applications and services

Service	Description	Refer to section
CDS Browser	Web user interface for data exploitation and download	3.1.2
Data Workspace	Interface for advanced users, who would like to trigger on-demand processing, fetch data that are available in deferred access mode, etc.	3.1.3
JupyterHub	Online processing utility with integrated programming libraries and shared underlying compute resources	3.1.4
Catalog APIs	APIs for querying the available data	3.1.5
Download products APIs	APIs for downloading data products	3.1.6
Sentinel Hub APIs	APIs for streamlined data access, processing and visualization	3.1.7
openEO API	APIs for data processing	3.1.8
On-Demand production	APIs for on-demand data production	3.1.9
Commercial data order API	APIs for search and ordering of the commercial data provided by third parties.	3.2.2
Product Generation Service	APIs for on-demand product generation	3.2.3
Cloud environment	Infrastructure as a service on CloudFerro and Open Telekom Cloud	3.2.4

3.2.2 Commercial data order API

In order to extend the data coverage beyond the open data, we have integrations in place with several commercial data providers:

- Airbus (Pleiades Neo, Pleiades, SPOT),
- European Space Imaging/Maxar (WorldView, GeoEye),
- Planet (PlanetScope, SkySat),
- CG Satellite, Jillin – 1
- KGS – KazEOSat-1-2
- SIIS- KOMPSAT (2, 3, 3a, 5)
- more providers will be added in the near future.

For commercial data we have not just harmonized the access, but also the commercial conditions, making it as easy as possible (constrained by specifics various providers) for users to start using the data at small scale and grow it from there.

3.2.3 Product Generation Service

Product Generation Service is a serverless processing service, which allows easy mass processing of EO products without using virtual machines (see 3.1.9.1). Within CREODIAS commercial offering, the premium version of PGS with additional processors is available.

The premium service uses the full potential of CloudFerro's cloud environment, which allows users to generate thousands of products in a limited, well defined timeframe. To activate this mode, the user can order the products through the workspace and agree on individual processing conditions. An appropriate pool of cloud resources is allocated, to guarantee the generation of the products in a limited timeframe. Premium services are billed according to a price list. Processing costs depend on the number of processed products and the type of processor selected.

Processors are implemented in the form of docker files and with the use of configurations provided by the author of the processor (i.e. either organization like ESA or CNES or an external user, e.g. scientist) specific for the processing and adjusted to the user's needs. Users can request to run the above processors or their own with any possible parameter configurations set up. It is possible to contact the sales team in order to discuss the possibility of adding externally developed processors on the platform and requirements in regards to timeframe in which processing shall be completed.

In addition to the processors described in section 3.1.9.1, there are additional processors available, such as:

- Sentinel-2 Level 2A Sen2Cor - The Sen2Cor processor generates Sentinel-2 Level 2A product (Bottom-Of-Atmosphere reflectances) by performing the atmospheric, terrain and cirrus correction of Top-Of-Atmosphere Level 1C input data. In addition, Aerosol Optical Thickness, Water Vapor, Scene Classification Maps and Quality Indicators for cloud and snow probabilities can be generated. The Sen2Cor products are in the equivalent format to the Level 1C User Product: JPEG 2000 images, preserving the original band spatial resolutions, i.e. 10, 20 and 60 meters.
- Sentinel-2: Resolution Enhancer - a commercial processor that allows for object enhancement in images for 8 spectral channels with simultaneous preservation of radiometric quality. The result of the processing is a Sentinel-2 L2A product with a resolution of 2.5m GSD, saved as a multilayer geoTIFF file. The solution gives the possibility to access current and historical data of the Sentinel-2 in a so far unavailable resolution.
- Sentinel-2 NARA Space Resolution Enhancer: NARA Space Technology Resolution Enhancer improves the spatial resolution of Sentinel-2 L2A TCI (True Color Images) image from 10 m to

3.2 m (by factor of 3). The algorithm uses convolutional neural networks (CNN) to produce higher image resolution. Currently, this algorithm focuses on RGB band, so its output is 3.2 m-GSD Sentinel-2 image with RGB band.

3.2.4 Cloud environment

Cloud services are a substantial component of the Platform. They allow Third Parties to create their own private data processing environments with direct access to the EO Data Repository which is particularly important for a large scale processing projects.

The cloud computing solution is based on the existing CREODIAS cloud by CloudFerro and Open Telekom Cloud by T-Systems. Both cloud platforms are public clouds based on open-source [OpenStack technology](#). Users can choose the preferred site for the storage and processing purpose as well as design their application and processing chains in a way to have an improved redundancy. All sites have direct access to the online EO Data repository.

Extensive documentation for both clouds can be found in:

- for CloudFerro: <https://creodias.eu/computing-cloud>
- for Open Telekom Cloud: <https://open-telekom-cloud.com/resource/blob/data/305476/3433c472384be87e7406b8b80048f683/open-telekom-cloud-white-paper.pdf>

Please also refer to following URLs which give you access to comprehensive information about the available cloud offering:

- <https://open-telekom-cloud.com/en>
- <https://cloudferro.com/en/>

3.2.4.1 EO Specific Configurations and Software

Within CREODIAS we provide several VMs with pre-configured GIS specific software and/or tooling that allows to process EO data.

3.2.4.1.1 OSGeoLive

[OSGeoLive](#) is a self-contained bootable Virtual Machine based on [Ubuntu](#), that allows you to try a wide variety of open source geospatial software without installing anything. It is composed entirely of free software, allowing it to be freely distributed, duplicated and passed around. It provides pre-configured applications for a range of geospatial use cases, including storage, publishing, viewing, analysis and manipulation of data. It also contains sample datasets and documentation.

OSGeoLive is an [OSGeo Foundation](#) project. The OSGeo Foundation is a not-for-profit supporting Geospatial Open Source Software development, promotion and [education](#). More description available at:

<https://live.osgeo.org/en/>

<https://creodias.eu/-/how-to-get-access-to-qui-on-vm-with-osgeolive-image->

<https://creodias.eu/-/available-tools-on-osgeolive-image>

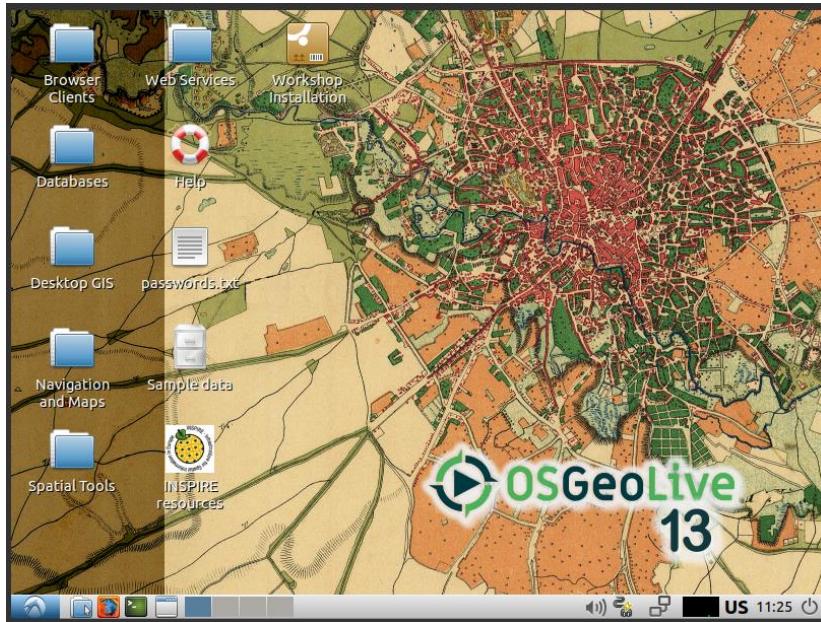


Figure 31: Example OSGeoLive image

In addition to standard image, our OSGeoLive image contains other preinstalled software, helpful with processing of EO-Data:

- ESA SNAP Desktop version 8.0.0 with all toolboxes:
<https://step.esa.int/main/toolboxes/snap/>
- configured ESA snappy module for Python 3.6 for interacting with ESA SNAP API that could be used in eg. Jupyter Notebook. You can just run python3 and then import snappy, more info here:
<https://senbox.atlassian.net/wiki/spaces/SNAP/pages/19300362/How+to+use+the+SNAP+API+from+Python>
- snaphu package - a tool for phase unwrapping:
<https://step.esa.int/main/third-party-plugins-2/snaphu/>

3.2.4.1.2 QGIS

QGIS is free of charge and open source software, available to any users who work with GIS and Earth Observation data in their projects. In our image of virtual machine QGIS is already configured with local access to our EO DATA archive.

In CREODIAS, user can launch a VM with preinstalled Linux Ubuntu and QGIS software from the catalogue of ready images of virtual machines on CREODIAS. This solution can be used with every type of virtual machine available on CREODIAS and is available during the creation process of virtual machine.

More can be found at: <https://www.qgis.org/en/site>;
<https://creodias.eu/use-of-snap-and-qgis-on-a-creodias-virtual-machine>

3.2.4.1.3 ArcGIS

ArcGIS Pro is a commercial tool that supports data visualization; advanced analysis; and authoritative data maintenance in 2D, 3D, and 4D. CREODIAS users can utilise the full power of ArcGIS Pro combined with direct satellite data access through CREODIAS. In the ArcGIS Catalog,

a direct connection to the CREODIAS data repository can be established that allows users to directly access any satellite or other geospatial data set and display and analyse it in ArcGIS.

In case a user would like to analyse any newly acquired satellite image in ArcGIS, one can just enter the CREODIAS file path in the ArcGIS Catalog and import it into ArcGIS. In the example below, two Sentinel-2 images have been imported that display the damage related to wildfire on the island of Gran Canaria. This allows the user to use satellite data for emergency mapping using the full power of the ArcGIS Pro software. Additional to the ArcGIS GUI, users can use command line programming to batch process large volumes of data using ArcGIS functionalities.

More can be found at:

<https://creodias.eu/esri-arcgis-on-creodias>

<https://creodias.eu/-/how-to-register-in-myesri-get-a-trial-license-for-arcgis-pro-and-connect-it-with-eodata>

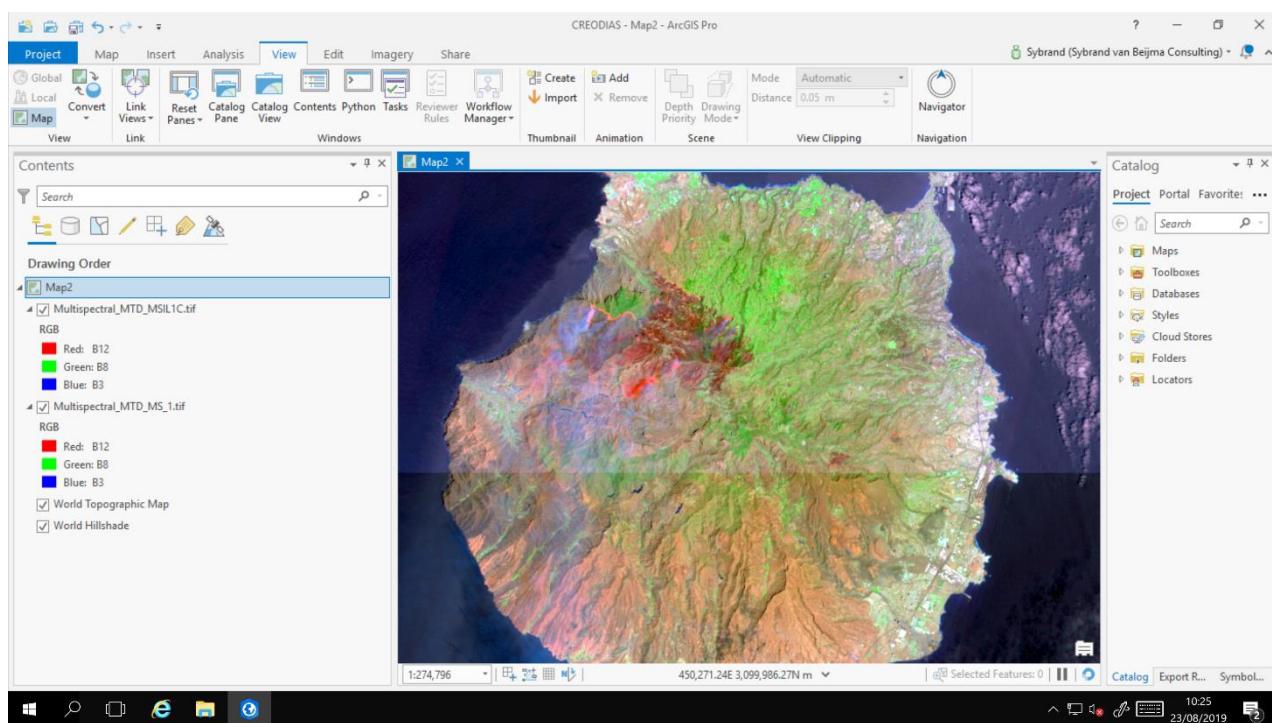


Figure 32: Use of ArcGIS on CREODIAS

3.2.4.1.4 Sen4CAP

Sen4CAP is fully open-source remote sensing software solution which uses Earth Observation (EO) Sentinel data for monitoring tasks. It provides biophysical indicators, crop type map, grassland mowing, and agricultural practices monitoring in one place.

It is designed to fulfill the needs of agricultural paying agencies and all national and European stakeholders of the CAP Policy. Sen4CAP can be beneficiary for everyone interested in monitoring environmental changes and agricultural activities.

Users can select on the CREODIAS an already prepared Virtual Machine (VM) image on which the latest stable Sen4CAP software is installed and checked. Users can directly access a complete repository of satellite data while harnessing the processing capabilities of the computing cloud. This significantly accelerates the processing and allows the usage of multiple datasets also back in time.

The VM is configured and ready-to-use. It not only includes Sen4CAP, but it is also equipped with all additional

software components required for Sen4CAP (e.g. PostgreSQL Database and the MAJA processor) execution. Furthermore, it is connected with all EO data collections, which are needed by the Sen4CAP:

- Sentinel-1
- Sentinel-2
- Landsat-8
- Different DEMs and SWBD (Water Body) data were also integrated

Once logged into the VM, the user can immediately run the Sen4CAP software and benefits from both the direct access to the comprehensive Copernicus Sentinel satellite data repository and the dynamically scalable processing opportunities of the CREODIAS cloud computing environment. The VM with Sen4CAP can be accessed e.g. through web browser or Remote Desktop using X2Go Client.

More details are described at:

<http://www.esa-sen4cap.org/>

<https://creodias.eu/-/how-to-access-sen4cap>

For users who are not interested in handling the infrastructure, an Sen4CAP is available in as a Service Mode. The fully-managed cloud services support fully operational workflows including backup strategies and parallel instances for testing of new software versions and variations of parameter settings. Details are available at:

<https://creodias.eu/eo-data-software-based-services>

https://creodias.eu/documents/20195/0/CloudFerro_Sen4CAP_epub.pdf/455b4145-9ae1-4b24-8d72-c522ac0505dd

4 AUXILIARY SERVICES

4.1 Copernicus Data Space Ecosystem Offering

4.1.1 Helpdesk

The user support is based on a cloud-based support platform (Zendesk). It is setup to support following tasks:

- collect users' questions arriving via e-mail and web form,
- ensure timely responses
- follow-up and resolve tickets.
- escalate support tickets within the consortium (e.g. IaaS support).
- Integrate a publicly available user forum to allow for support within the user community
- Integration of knowledge base for automated answer suggestions

The main support philosophy is to avoid as many tickets as possible by providing a solid knowledge base and guides to users, reference to a proper documentation system and provide video-assisted tutorials on the use of the data space.

The service desk is operated during normal working days (NWD) and normal working hours (NWH) using the English language. In the event that tickets are not resolved in due time, users will get informed on a timeline for resolution.

Specific user questions requiring engineering support or specific onboarding needs (e.g., to deploy a new service on the Marketplace, incubation of new datasets or federated cloud systems) are handled outside of the standard support portfolio.

Please take note that the help desk and user support services is gradually extended during the initial phase of the project. Together with the first services being made available end of January 2023 registered users are given the opportunity to raise requests. However, the full support organization as described in this section above is only available from April 2023. Respective changes in the support interfaces are announced to users via the webpage.

4.1.2 Marketplace

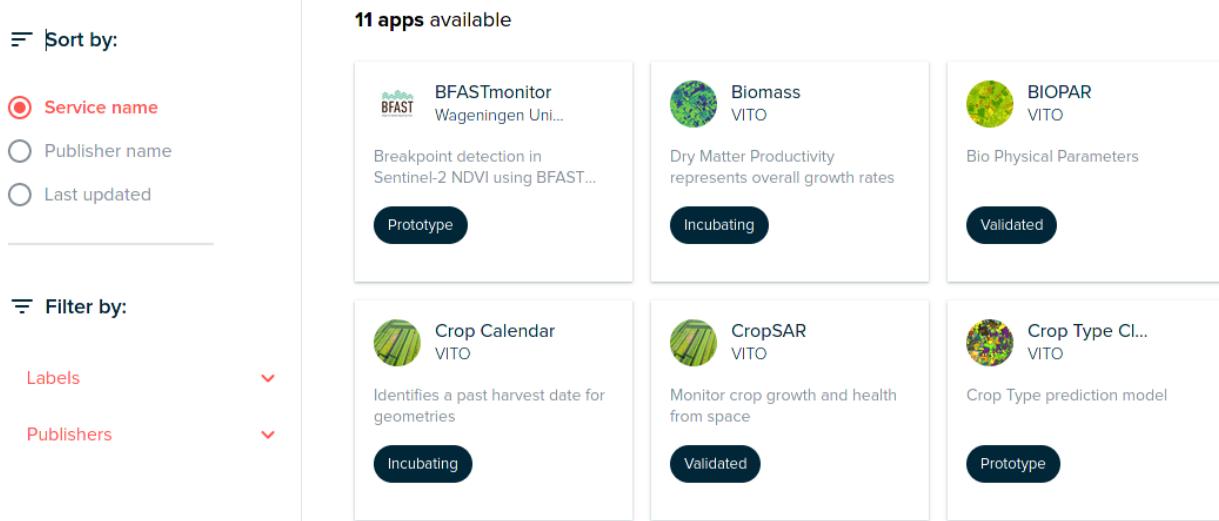
Processing EO data and generating value on it is challenging and presents a high entry barrier for the value creators. This is mainly because it requires high IT investments - both in the form of hardware and software engineering skills - EO domain knowledge and understanding of the EO business ecosystem.

With the Marketplace, users are offered a new platform and a community where they not only can access various datasets and EO services, but also create, and share their own services. Increasing a service's visibility by e.g., publishing it on a marketplace enables users to easily share their work among peers and other communities and deliver added value to the right target audience. Each service is labelled with a service maturity level, giving a clear indication to the user what to expect in terms of quality and performance. This encourages providers to onboard their services from a prototype level to gather feedback from the community to a fully operational level..

By using openEO, service providers can easily create services on top of the available datasets. OpenEO is aimed at creating re-usable code that can run on different platforms, not binding the

user to a single platform. Moreover, different types of interfaces (Graphical User Interfaces, Application Programming Interfaces, Jupyter Notebooks) are offered to serve users with varying technical skills to ease the service creation process for service providers or for end users to consume these services.

Additional to a public service offering, the marketplace also includes built-in functionalities for billing and reporting. With this capability, service providers do not have to deal with financial and legal aspects of a service offering and can instead focus on their service and enjoy the platform's benefits. End users have a set of free credits available to test the different algorithms available and can purchase their subscription with a few clicks to continue using the platform once they deplete their free credits. The organization of credits can both be done on a user individual level and company/institutional level.



The screenshot shows the Copernicus Data Space Marketplace interface. On the left, there are filtering options: 'Sort by' (Service name selected), 'Publisher name', and 'Last updated'. Below that is a 'Filter by' section with 'Labels' and 'Publishers' dropdown menus. The main area displays 11 app cards in a grid:

- BFASTmonitor** (VITO): Breakpoint detection in Sentinel-2 NDVI using BFAST... (Prototype)
- Biomass** (VITO): Dry Matter Productivity represents overall growth rates (Incubating)
- BIOPAR** (VITO): Bio Physical Parameters (Validated)
- Crop Calendar** (VITO): Identifies a past harvest date for geometries (Incubating)
- CropSAR** (VITO): Monitor crop growth and health from space (Validated)
- Crop Type Cl...** (VITO): Crop Type prediction model (Prototype)

Figure 33: CDS Marketplace

Onboarding an EO algorithm as a service onto the marketplace consists of three steps:

- Developing the algorithm using openEO
- Sharing the algorithm as a service using openEO “Used Defined Processes”
- Publishing the service on the marketplace catalogue

The first step requires the third-party service provider to develop (or migrate) their algorithm using openEO. Orchestrators other than openEO may also be supported in the future. Once the algorithm is developed, the provider must make this algorithm available to the other users. Lastly, to increase the visibility and publish it on the marketplace catalogue, the provider must create a metadata with service description via the marketplace interface. The service provider can include extensive information in this metadata including service description, useful links, input requirements, output examples, cost estimation etc.

4.1.3 Traceability services

Traceability service allows user to verify and register traces for user level data available in the Copernicus Data Space. The general design of the Traceability Service centers around a REST API service, which brokers access to a registry of digitally signed product traces. These traces are generated for every product within the archive, be it those generated by the Copernicus Core Ground Segment, by contributing missions, or by the users. Each trace holds the necessary information to validate by means of a fingerprint both the product as a whole, or subcomponents of a product, e.g., individual bands.

Each user of the Copernicus Data Space Ecosystem has a possibility to verify the trace of the product at no additional cost by checking the trace at open traceability endpoint. This functionality is available using GUI, CLI and API. Users receive the "tracetool" tool on an OpenSource basis as a CLI tool with interfaces to the most popular programming languages (Java, Python, C), which guarantees full scalability, easy adaptability, implementation independence in data production environments and at the same time compliance with the requirements.

Ground Segment Data producers (service providers) have an access to Traceability service for registering and verification of traces. This group of users has access to the endpoint with detailed instruction how to register the traces or verify the trace at no additional cost.

In addition to that, Third parties and other users are also able to register new traces for their own data on a commercial basis.

If needed, optional (commercial) support / professional services and further integration with Ground Segment service providers can be provided on demand.

The high-level architecture of the traceability is presented below:

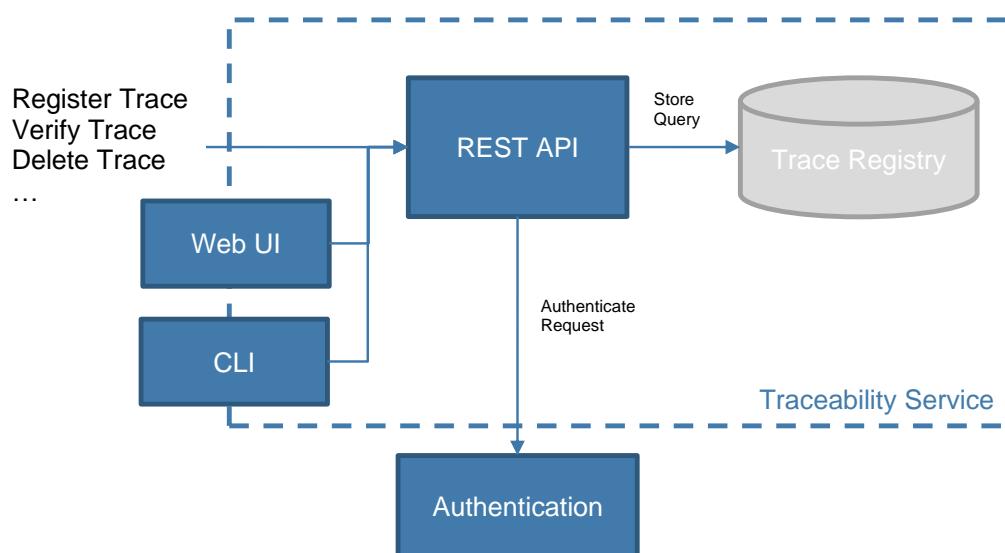


Figure 34: High-Level Architecture of Traceability Service

4.2 CREODIAS Offering

All auxiliary services available within Copernicus Data Space Ecosystem are available to CREODIAS users as well.

A ANNEX - SERVICE ROAD MAP

This annex provides information about the schedule and evolution of the service portfolio.

A.1 Short summary

- January 2023
 - New Data Access portal
 - Start of user registration
 - Initial Sentinel data offering
 - Browser
 - Catalogue APIs: OData and OpenSearch
- April 2023
 - Catalogue API: STAC, S3
 - Processing API: Sentinel Hub and OGC for supported collections
 - On-demand production API
- July 2023
 - Full archive of Sentinel missions
 - Complementary open datasets
 - Access to commercial data
 - Processing API: extended Sentinel Hub APIs, OpenEO
 - Jupyter Lab
 - Marketplace
 - Traceability GUI, API and Trace tool. Most recent traces available, gradually adding historical traces.
- November 2023
 - Sentinel engineering and auxiliary data
 - Copernicus Contributing Missions

A.2 Legend

Color Codings

- capabilities
- remarks related to constraints

Abbreviations

- EUR - Europe
- RoW - world with exception of Europe
- DAD – deferred available data
- IAD – immediately available data

A.3 Copernicus Data Space Ecosystem and CREODIAS

A.3.1 What to expect

Type	Offering
Copernicus Data Space Ecosystem	Largest EO data offering in the world, with discovery, download and processing capabilities.
CREODIAS	Free of charge for users, within limited quotas.

A.3.2 Roadmap schedule

Type	01/23	07/23	11/23
Copernicus Data Space Ecosystem	Available, with limited functionality	All core functionalities supported (see details in the coming sections)	All functionalities supported (see details in the coming sections)
CREODIAS	Current version One region available (Warsaw, powered by CloudFerro)	Extended portal with new functionalities. Additional region added (Amsterdam, powered by Open Telekom Cloud)	Additional updates (more info will be provided on the CREODIAS webpage)

A.4 Data catalog

A.4.1 Sentinel-1

A.4.1.1 What to expect

Type	Offering	Access
RAW	World - full archive	[IAD for last year and entire Europe, DAD otherwise]
GRD	World - full archive, in COG and SAFE	[IAD for COG, DAD for SAFE older than 1 year]
SLC	World - full archive	[IAD] Query and download of SLC burst for full archive
OCN	World - full archive	[IAD]
Mosaic		Median CARD4L annual mosaics in COG (available also via non-authenticated HTTP API)

On-demand services:

- Sentinel-1 on-demand services, see section A.5.3 for more information

A.4.1.2 Roadmap schedule

Type	01/23	03/23	07/23	11/23	02/24
RAW	World – 01/2021 - now [IAD] World - full archive [DAD] Available through deferred access delivery		EUR – full archive [IAD] RoW - full archive [DAD] [IAD for last year] RoW older than one year through deferred access delivery		
	World - 1full archive in SAFE [IAD]	World - last year, in COG [IAD]	World - full archive, in COG and SAFE [IAD]	On-demand services	
GRD			SAFE available for last year in IAD, complete archive in DAD, conversion tool available for full archive.		
SLC	EUR – full archive RoW - 02/2021 - now [IAD]		World - full archive [IAD]	On-demand services.	Query and download of SLC burst for full archive
OCN	World - full archive [IAD]		World - full archive [IAD]		
Mosaic			Median CARD4L annual mosaics in COG		

A.4.2 Sentinel-2

A.4.2.1 What to expect

Type	Offering
L1C	World - full archive, Collection 1
L2A	World - full archive, Collection 1
Mosaic	Median annual L2A mosaics in COG (available also via non-authenticated HTTP API)

On-demand services:

- Sentinel-2 on-demand services see section A.5.3 for more information

A.4.2.2 Roadmap schedule

Type	01/23	07/23	11/23
L1C	World - full archive [IAD]	World - full archive [IAD]	On-demand services
	World - 12/2021 - now [IAD]	World - full archive [IAD]	On-demand services
L2A	IAD includes Sentinel-2 Level-2A products older than last year generated by the CREODIAS using the Sentinel-2 Toolbox – identified by baseline 99.99		
Mosaic		Median annual L2A mosaics in COG	

Notes:

For Sentinel-2 L2A, the initial service offer, as from 01/2023, includes:

- IAD access to the original Sentinel-2 Level-2A products generated by the ESA Copernicus Ground Segment **for all data acquired since 1st December 2021**.
- IAD access to a combination of Sentinel-2 Level-2A products generated by the ESA Copernicus Ground Segment and by CREODIAS using the sen2cor processor for Sentinel-2 data acquired **between 1st January 2020 and 31st November 2021**.
 - The products generated by Creodias slightly differ from the products generated by the ESA Copernicus Ground Segment and are not visualized in the Browser, they are available for query and download. Products generated by the ESA Copernicus Ground Segment can be visualized in the Browser and are also available for query and download.
 - The products generated by the ESA Copernicus Ground Segment and by CREODIAS can be differentiated through the processing baseline indicated in the product filename, being always “**N9999**” for **CROEDIAS generated products**.
Example:
Original ESA product:
S2B_MSIL2A_20220518T073609_**N0400**_R092_T38SMA_20220518T093719.SA
FE
Product generated by CREODIAS:
S2A_MSIL2A_20210905T143731_**N9999**_R096_T20QCD_20221112T112946.SA
FE
 - More information on the sen2cor and difference in the processing chain can be found here: <https://step.esa.int/main/snap-supported-plugins/sen2cor/sen2cor-v2-11/>

In addition, IAD access to the new **Collection-1 for the Sentinel-2 Level-2A products** generated by the ESA Copernicus Ground Segment in the frame of the Sentinel-2 reprocessing campaign (please also refer to <https://sentinel.esa.int/web/sentinel/technical-guides/sentinel-2-msi/copernicus-sentinel-2-collection-1-availability-status>) will be gradually available as from April 2023.

A.4.3 Sentinel-3

A.4.3.1 What to expect

Type	Offering
OLCI Level 1	World – NTC full archive, NRT and STC 1 month retention time
OLCI Level 2	World – NTC full archive, NRT and STC 1 month retention time
SLSTR Level 1	World – NTC full archive, NRT and STC 1 month retention time
SLSTR Level 2	World – NTC full archive, NRT and STC 1 month retention time
SRAL Level 1	World – NTC full archive, NRT and STC 1 month retention time
SRAL Level 2	World – NTC full archive, NRT and STC 1 month retention time
SYNERGY Level 1	World – NTC full archive, NRT and STC 1 month retention time
SYNERGY Level 2	World – NTC full archive, NRT and STC 1 month retention time

On-demand services:

- Sentinel-3 on-demand services, see section A.5.3 for more information

A.4.3.2 Roadmap schedule

Type	01/23	07/23
OLCI Level 1	World - last year	World - full archive
OLCI Level 2	World - full archive	
SLSTR Level 1	World - last year	World - full archive
SLSTR Level 2	World - full archive	
SRAL Level 1	World - last year	World - full archive
SRAL Level 2	World - last year	World - full archive
SYNERGY Level 1	World - last year	World - full archive
SYNERGY Level 2	World - last year	World - full archive

A.4.4 Sentinel-5p TROPOMI

A.4.4.1 What to expect

Type	Offering
L1B	World - full archive
L2 AER_AI	World - full archive, NRT – 1 month retention time
L2 AER_LH	World - full archive, NRT – 1 month retention time
L2 CH4	World - full archive
L2 CLOUD	World - full archive, NRT – 1 month retention time
L2 CO	World - full archive, NRT – 1 month retention time
L2 HCHO	World - full archive, NRT – 1 month retention time

Type	Offering
L2 NO2	World - full archive, NRT – 1 month retention time
L2 NP_D	World - full archive
L2 O3	World - full archive, NRT – 1 month retention time
L2 O3_PR	World - full archive, NRT – 1 month retention time
L2 O3_TCL	World - full archive
L2 SO2	World - full archive, NRT – 1 month retention time

A.4.4.2 Roadmap schedule

Type	01/23
L1B	World - full archive
L2 AER_AI	World - full archive
L2 AER_LH	World - full archive
L2 CH4	World - full archive
L2 CLOUD	World - full archive
L2 CO	World - full archive
L2 HCHO	World - full archive
L2 NO2	World - full archive
L2 NP_D	World - full archive
L2 O3	World - full archive
L2 O3_PR	World - full archive
L2 O3_TCL	World - full archive
L2 SO2	World - full archive

A.4.5 Sentinel Engineering data

Access restrictions apply

A.4.5.1 What to expect

Mission	Type	Offering
Sentinel-1	RAW	World, last two weeks - WV modes, RF Characterisation, Notch modes, GPS
	Orbit and Burst Synchronisation	World, last two weeks
Sentinel-2	L0	World, last two weeks - Datastrip, granule
	L1A	World, last two weeks - Datastrip, granule
	L1B	World, last two weeks - Datastrip, granule
	AUX	World, last two weeks - Satellite ancillary data
Sentinel-3	DORIS	World, last two weeks - L0 DOP, NAV
	GNSS	World, last two weeks - L0 GNS
	MWR	World, last two weeks - L0, L1 data
	OLCI	World, last two weeks - L0, L1 data (*)
	SLSTR	World, last two weeks - L0 data
	SRAL	World, last two weeks - L0, L1 data (*)
	Synergy	World, last two weeks - L1, L2 data (*)

Mission	Type	Offering
Sentinel-5p	L0	World, last two weeks
	L1	World, last two weeks
	Calibration	World, last two weeks
	VDAF	World, last two weeks
	PyCAMA	World, last two weeks

(*) Only for specific data types.

A.4.5.2 Roadmap schedule

Mission	Type	10/23	11/23
Sentinel-1	RAW		World, last two weeks
	SLC		World, last two weeks
	GRD		World, last two weeks
	OCN		World, last two weeks
	PSCalibration		World, last two weeks
	Orbit and Burst Synchronisation		World, last two weeks
Sentinel-2	L0		World, last two weeks
	L1A		World, last two weeks
	L1B	World, last two weeks	
	AUX		World, last two weeks
Sentinel-3	DORIS		World, last two weeks
	GNSS		World, last two weeks
	MWR		World, last two weeks
	OLCI		World, last two weeks
	SLSTR		World, last two weeks
	SRAL		World, last two weeks
	Synergy		World, last two weeks
Sentinel-5p	L0		World, last two weeks
	L1		World, last two weeks
	Calibration		World, last two weeks
	VDAF		World, last two weeks
	PyCAMA		World, last two weeks

A.4.6 Sentinel Auxiliary data

Access restrictions may apply

A.4.6.1 What to expect

Mission	Type	Offering
Sentinel-1	AUX	World, full archive
	POD	World, full archive
	ORBRE	World, full archive

Mission	Type	Offering
	TLEPRE	World, full archive
Sentinel-2	AUX	World, full archive
	POD	World, full archive
	GIP	World, full archive
	GRI	World, full archive
Sentinel-3	AUX	World, full archive
	POD	World, full archive
	AX	World, full archive
	SR	World, full archive
	MV	World, full archive
	OL	World, full archive
	SL	World, full archive
	GN	World, full archive
	SY	World, full archive
Sentinel-5p	MPL	World, full archive
	VIIRS	World, full archive
GNSS	L1b	World, full archive

A.4.6.2 Roadmap schedule

Mission	Type	10/23	11/23
Sentinel-1	AUX		World, full archive
	POD	World, full archive	
	ORBRE		World, full archive
	TLEPRE		World, full archive
Sentinel-2	AUX		World, full archive
	POD	World, full archive	
	GIP		World, full archive
	GRI		World, full archive
Sentinel-3	AUX		World, full archive
	POD	World, full archive	
	AX		World, full archive
	SR		World, full archive
	MV		World, full archive
	OL		World, full archive
	SL		World, full archive
	GN		World, full archive
	SY		World, full archive
Sentinel-5p	MPL	World, full archive	
	VIIRS	World, full archive	
GNSS	L1b		World, full archive

A.4.7 Copernicus Contributing Missions

A.4.7.1 What to expect

Type	Offering
DEM	10m (EU), 30m (global), 90m (global) 10m available under restricted license conditions
VHR	Europe Restricted license conditions
VHR Urban Atlas	Europe Restricted license conditions
Optical HR	Europe Restricted license conditions
Optical HR2	Multitemporal Restricted license conditions
Optical MR	Europe, multitemporal Restricted license conditions
SAR	Systematic Daily SAR of ice-covered areas Restricted license conditions
Optical HR2	Sub-Saharan coverage Restricted license conditions

A.4.7.2 Roadmap schedule

Type	07/23	11/23
DEM	Start of gradual publication	Full CCM coverage
VHR	Start of gradual publication	Full CCM coverage
VHR Urban Atlas	Start of gradual publication	Full CCM coverage
Optical HR	Start of gradual publication	Full CCM coverage
Optical HR2	Start of gradual publication	Full CCM coverage
Optical MR	Start of gradual publication	Full CCM coverage
SAR	Start of gradual publication	Full CCM coverage
Optical HR2	Start of gradual publication	Full CCM coverage

A.4.8 Complementary open data

A.4.8.1 What to expect

Type	Offering
SMOS	MIRAS
Landsat Collection 2	5, 7, 8, 9
Envisat	MERIS, ASAR
DEM	Mapzen DEM, SRTM GL1
CAMS	Copernicus Atmosphere Monitoring Service
CEMS	Copernicus Emergency Management Service
CLMS	Copernicus Land Monitoring Service

Type	Offering
CMEMS	Copernicus Marine Service
S2GLC	High resolution Land Cover Map of Europe
ESA WorldCover	High resolution Land Cover Map of the world for 2020 and 2021, in COG

A.4.8.2 Roadmap schedule

Type	07/23
SMOS	MIRAS
Landsat Collection 2	5, 7, 8, 9
Envisat	MERIS, ASAR
DEM	Mapzen DEM, SRTM GL1
CAMS	Copernicus Atmosphere Monitoring Service
CEMS	Copernicus Emergency Management Service
CLMS	Copernicus Land Monitoring Service
CMEMS	Copernicus Marine Service
S2GLC	High resolution Land Cover Map of Europe
ESA WorldCover	High resolution Land Cover Map of the world for 2020 and 2021, in COG

A.4.9 Data via OpenEO

A.4.9.1 What to expect

Type	Offering
SPOT-VGT	Collection 3, full archive
PROBA-V	Collection 2, full archive
ESA WorldCover	Full archive

Sentinel-based L3 products	Various L3 products based on Sentinel data (see : https://docs.terrascope.be/#/DataProducts/DataProducts)
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A.4.9.2 Roadmap schedule

Type	11/23
SPOT-VGT	Collection 3, full archive
PROBA-V	Collection 2, full archive
ESA WorldCover	Full archive

Sentinel-based L3 products	Various products
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A.5 APIs

A.5.1 Product search and download

A.5.1.1 What to expect

Type	Offering
OData	Query all data products in IAD and DAD using various filtering options. Download zipped products, individual product parts and selection of product parts. <i>Data collections, which are only integrated via Sentinel Hub, are not available via OData.</i>
OpenSearch (Resto)	Query all data products in IAD and DAD using various filtering options. <i>Data collections, which are only integrated via Sentinel Hub, are not available via OpenSearch.</i>
STAC items	Spatio-temporal Asset Catalog meta-data available for all data products in IAD. <i>Data collections, which are only integrated via Sentinel Hub, do not have STAC items available.</i>
STAC API	STAC-compliant API providing querying capabilities for all data products in IAD using various filtering options. <i>Data collections, which are only integrated via Sentinel Hub, are not available via STAC API.</i>
Sentinel Hub Catalog API	STAC-compliant API providing querying capabilities for supported data products using various filtering options. <i>Only available for data collections, which are integrated via Sentinel Hub.</i>
S3	Download all hosted data products or their parts. <i>Data collections, which are only integrated via Sentinel Hub, are not available via S3.</i>

Notes:

- Majority of product search and download services work with all hosted data products (see section 2 Data), with exceptions explicitly marked.
- All APIs require authentication
 - There might be exceptions for specific data collections and/or parts of the functionality.

A.5.1.2 Roadmap schedule

Type	01/23	04/23	07/23
OData	Available for search and full product download		Available for search and product download (full and partial)
OpenSearch (Resto)	Available for search and full product download		Available for search and product download (full and partial)
STAC items		Fully available	
STAC API		Fully available	
Sentinel Hub Catalog API		Available for supported data collections	
S3		Fully available	

A.5.2 Data processing

A.5.2.1 What to expect

Type	Offering
Sentinel Hub OGC API	OGC-compliant WMS/WMTS/WCS services providing access to all data collections supported by Sentinel Hub.
Sentinel Hub Process API	Advanced synchronous RESTful API for processing of all data collections supported by Sentinel Hub.
Sentinel Hub Asynchronous Process API	Advanced asynchronous RESTful API for processing of all data collections supported by Sentinel Hub.
Sentinel Hub Batch Processing API	Advanced asynchronous RESTful API for large-scale processing of all data collections supported by Sentinel Hub.
Sentinel Hub Statistical API	Advanced synchronous RESTful API for retrieval of statistics over defined AOI, for all data collections supported by Sentinel Hub.
Sentinel Hub Batch Statistical API	Advanced asynchronous RESTful API for large-scale retrieval of statistics over defined AOI, for all data collections supported by Sentinel Hub.
Sentinel Hub Bring your own COG API	Asynchronous API providing users an option to ingest their own S3-hosted data collections in COG to Sentinel Hub.
Sentinel Hub Bring your own Zarr API	Asynchronous API providing users an option to ingest their own S3-hosted data collections in Zarr to Sentinel Hub.
OpenEO API	Advanced synchronous and asynchronous APIs providing users ways for complex EO algorithm calculations without the burden of preprocessing. This for all data collections supported by the OpenEO aggregator and mature federated datasets.

Notes:

- Sentinel Hub APIs are available for supported data collections (Sentinel-1 GRD, Sentinel-2 L1C/L2A, Sentinel-3 OLCI/SLSTR Level 1 and Level 2, Sentinel-5p Level 2, cloudless Sentinel-1 and Sentinel-2 collections, Landsat Collection 2, MODIS MCD43A4.006, Copernicus DEM, Bring your own COG, Bring your own Zarr, Third-party data collations)

A.5.2.2 Roadmap schedule

Type	04/23	07/23	11/23	07/24
Sentinel Hub data collection support	Sentinel-1 GRD, Sentinel-2 L1C/L2A, Sentinel-3 OLCI and SLSTR Level 1, Sentinel-5p	Sentinel-1 and Sentinel-2 cloudless mosaics, Bring your own COG/Zarr.	Landsat Collection 2, MODIS, Third party data	Sentinel-3 OLCI and SLSTR Level 2
Sentinel Hub OGC API	Available for supported data collections			
Sentinel Hub Process API	Available for supported data collections			
Sentinel Hub Asynchronous Process API		Available for supported data collections		

Type	04/23	07/23	11/23	07/24
Sentinel Hub Batch Processing API		Available for supported data collections		
Sentinel Hub Statistical API	Available for supported data collections			
Sentinel Hub Batch Statistical API		Available for supported data collections		
Sentinel Hub Bring your own COG API		Available for supported data collections		
Sentinel Hub Bring your own Zarr API		Available for supported data collections		
OpenEO API		Available for Sentinel-1 GRD, Sentinel-2 L1C/L2A, Sentinel-3 OLCI Level 1, Sentinel-5p NTC Level 2	Available for all data collections supported by Sentinel Hub, SPOT-VGT, PROBA-V and ESA WorldCover.	

A.5.3 On-demand production and product generation services

A.5.3.1 What to expect

Type	Offering
All processors	Processing workflow for on-demand processing available through the Workspace, fully integrated with the catalog and data interfaces via API and GUI.
Sentinel 1 production	Generation of L1 and / or L2 data ESA Sentinel-1 Data Processor.
Sentinel 2 production	Generation of L1 or L2 data (L1A, L1B, L1C, L2A) using ESA Sentinel-2 data Processor.
Sentinel 3 production	Generation of higher-level products (L1, L2) from archived lower-level products (L0, L1) triggered by a user request.

A.5.3.2 Roadmap schedule

Type	10/23
Sentinel 1, 2, 3 production	The on-demand processing software will be available for the users, integrated with the data interfaces, data catalog and ordering mechanism.

A.5.4 Traceability

A.5.4.1 What to expect

Type	Offering
Traceability	Verification of the traces of available Copernicus User Level data. Registration of traces for Copernicus data providers

A.5.4.2 Roadmap schedule

Type	04/23	07/23	12/23	05/24
Traceability	Initial version of Traceability service, start of registering of traces of published fresh data available for new ingested data.	Traceability Service operational for the Data Access. Registered traces for all published User Level Data (excluding historical data). Service is operational for verification for any user.	Traceability service is operational also for registering traces for all ESA GS services allowing to register and verify traces.	Registered traces for all historical User Level data

A.6 Identity service

A.6.1 What to expect

Type	Offering
Common Identity management	Registration on Copernicus Data Space Ecosystem portal, with Single-sign-on to integrated applications. Management of organizations and user roles. Access management to applications and data for different type of users.

A.6.2 Roadmap schedule

Type	01/23	07/23
User registration and identity management	Start of registration of users allowing to access first free services on Copernicus Data Space Ecosystem. Management of user and organization.	Full functionality, access to all integrated applications with SSO.

A.7 Applications

A.7.1 What to expect

Type	Offering
CDS Browser	Web application to search, download, visualize and process various data collections. Visualisation and processing are only available for data collections supported by Sentinel Hub. Download is only available for data collections supported by OData.
Data Workspace	Dedicated interface for advanced (mostly asynchronous) actions related to the data products. Workspace allows to save collections, order processing or deferred access data, monitor processing status. On-demand production and other data processing can be limited.
OpenEO Web Editor	Web application for processing of data using OpenEO capabilities. Only available for data collections supported by OpenEO.
JupyterLab	Hosted JupyterLab with integrated various Python libraries, supporting various data analysis and processing tasks.

A.7.2 Roadmap schedule

Type	01/23	03/23	04/23	07/23	11/23
CDS Browser	Available for registered users, visualisation limited to Sentinel-2 L1C/L2A, simple querying capabilities.	Visualisation support for Sentinel-1 GRD added.	Available also for non-registered users, with limited functionality. Advanced querying capabilities.	Visualisation support for all core data collections supported by Sentinel Hub.	Visualisation support extended to Landsat Collection 2 and MODIS.
Data Workspace			Available for registered users.	Available, supporting on-demand services	
OpenEO Web Editor				Available, supporting Sentinel-1 GRD, Sentinel-2 L1C/L2A, Sentinel-3 OLCI Level 1 and Sentinel-5p NTC Level 2	Additional data collections available.
JupyterLab				Available	

A.8 Web Portal

A.8.1 What to expect

Type	Offering
Web portal	A web portal (dataspace.copernicus.eu) is the entry point for users to enter the free and open Copernicus Data Space Ecosystem. It hosts and integrates all elements of the services: access to EO data, login/registration, dashboards, traceability, documentation resources, and free ecosystem services like Jupyter lab, catalogues and EO browser. It also hosts the entry point for users that want to consume third-party services from the growing ecosystem and marketplace.
Public dashboard	Dashboard containing information about the status of each of the service modules, as well as statistics of their use.

A.8.2 Roadmap schedule

Type	01/23	04/23	07/23	11/23
Web portal	Landing page available with road map, registration, browser, documentation, news section	Content on additional data, services and documentation (STAC, S3, OGC and Sentinel Hub APIs, traceability service and on demand)	New data, services and documentation (marketplace, user forum, Jupyter lab, processing APIs)	Additional information and reference to new data and services.
Public dashboard			Available with all relevant metrics	

A.9 Help desk

A.9.1 What to expect

Type	Offering
Service desk	Web form for provision of user support. Automatic suggestions are made to users based on keywords in the documentation Mail based support is also available
User forum	Community user forum for public user interaction

A.9.2 Roadmap schedule

Type	01/23	04/23	07/23
Service desk	Mail support	Web form in web portal	
User forum			Available

A.10 Marketplace

Type	Offering
EO marketplace	EO marketplace that integrates OpenEO user-defined algorithms as a service. This allows users and third parties to publish and consume various on-demand algorithms expanding the Copernicus Data Space Ecosystem. Services are subjected to maturity levels depending on the Technology ReadinessLevel. Users get free credits to test the different services and are able to buy more credits if they need more processing resources.

A.10.1 Roadmap schedule

Type	07/23
Marketplace	Integration into web portal Provision of engineering support on Marketplace services

B ANNEX - SERVICE QUOTAS

B.1 Copernicus users' typologies

Following type of users have been defined for the use of the Copernicus Data Space Ecosystem. For each user group specific quotas have been defined where applicable. Quotas are allocated within the limits of resources allocated available for funding the free-to-the-user services. These quotas may be adjusted in agreement with EC and ESA according to the observed usages of the services, changes will be documented within future versions of this document.

B.1.1 Copernicus General Users

General Users are all users registered on Copernicus Data Space Ecosystem on the basis of self-registration and not falling into the user typologies defined in the subsequent sections. There are no restrictions on who can register to access the data.

B.1.2 Copernicus Services

Copernicus Services and authorised users (e.g. European Union institutions and bodies, National or regional public authorities in the EU or Copernicus Participating States).

B.1.3 Copernicus Collaborative Ground Segment Partners

This user typology includes all Copernicus Participating States, following signature of a Collaborative Ground Segment agreement with ESA and an internal agreement with the European Commission.

B.1.4 Copernicus International Partners

This user typology is open to international partners, following signature of a cooperation agreement with the European Commission and technical operating agreements with ESA.

B.2 Credits for research and pre-commercial exploitation

To be written

B.3 Copernicus Browser

	Copernicus General users	Copernicus Services users	Copernicus Collaborative Partners	Copernicus International Partners
Search		unlimited		
Interactive browsing		within limits of the B.8 Sentinel Hub APIs		
Download full products		within limits of the B.7 Download products APIs		
Download image for area subset, time-lapse		within limits of the B.8 Sentinel Hub APIs		

	Copernicus General users	Copernicus Services users	Copernicus Collaborative Partners	Copernicus International Partners
Export data for analysis	within limits of the B.8 Sentinel Hub APIs			

B.4 Data Workspace

The use of the Data Workspace is free of charge for all users. The actions executed in the Data Workspace are in line with quotas/pricing described in the section B.10 On-Demand production.

B.5 JupyterHub

JupyterHub is available free of charge for all registered users. Registered users can access example Notebooks. Each user receives a separate container with an upper limit (8GB RAM, 2 vCores per container).

B.6 Catalog APIs

Searching and accessing catalog is available free of charge for all users. Depending on the actual utilization there may be some limitation on number of requests to API per user per minute, preventing abuse of the system to assure high quality of service to all users.

B.7 Download products APIs

We highlight here main aspects of data retrieval service for the users.

The data retrieval services are not limited when they originate from the integrated cloud infrastructure. However, per-user limits can be imposed for remote access to the data, according to user typology defined by ESA. The goal of such limitations is to provide optimum services for different user groups and allow for fair sharing of free tier resources within these groups.

In order to manage bandwidth usage in the free tier, depending on the user type, the system limits the number of parallel connections and the transfer rate available per connection. Optionally, a limit can be defined on the quantity of data that can be retrieved each month. After reaching this limit, the maximum bandwidth drops to 1 MB/s and the number of connections drops to 1. The monthly transfer limit allows to provide high speed downloads for multiple users who need a limited (though quite large) quantity of data.

The following table presents a sample quota configuration per user-type. The table contents are just for illustration purposes - actual configuration will be adjusted depending on the number of active users and their bandwidth needs to optimize user experience.

Table 2: Data Retrieval - quota configuration per user-type

	Copernicus General Users	Copernicus Service Users	Copernicus Collaborative Partners	Copernicus International Partners
Immediate Access Data				
Bandwidth limit per connection (MB/s)	20	Not-restricted	100	100
Number of concurrent connections	4	20	20	15

	Copernicus General Users	Copernicus Service Users	Copernicus Collaborative Partners	Copernicus International Partners
Monthly transfer limit* (TB)	6	Limited (equivalent to monthly production volume)	Limited (equivalent to monthly production volume)	Limited (equivalent to monthly production volume)
Deferred Access Data				
Number of concurrent orders	1	5	2	2
Monthly transfer limit for DAD (TB)	0,1	5	2	2

*After reaching this monthly transfer limit, the maximum bandwidth drops to 1MB/s and the number of connections drops to 1.

For direct HTTP access to COGs free access is limited to 50.000 requests per user per month. Extensions are available via CREODIAS offering (see 3.2.3).

B.8 Sentinel Hub APIs

Sentinel Hub APIs are based on on-demand processing engine, where consumption is based on the [processing units](#).

For easier understanding we include some typical conversions between processing unit and km²:

Table 3: Conversion examples between processing unit and km²

Mission	Product	Resolution [m]	km ² for one PU	EUR ²⁴ per 1 km ²
Sentinel-2	True color	10	26.2	0.00006
	NDVI	10	39.3	0.00004
	All 13 bands	10	6.0	0.00025
Sentinel-1	VV gamma0 ortho	20	157.3	0.00001
Sentinel-3 OCI	True color	300	23 593.0	0.00000007
	OTCI	300	35 389.4	0.00000004
Landsat-8	True color - pansharpened	15	44.2	0.00003
	NDVI	30	59.0	0.00003

Table 4: Quotas for Sentinel Hub APIs

	Anonymous User	Copernicus General users	Copernicus Services users	Copernicus Collaborative Partners	Copernicus International Partners
Requests per month	N/A	10 000	unlimited	1 000 000	10 000
Requests per minute	N/A	300	1200	600	300
Processing units per month	N/A	10 000	400 000	100 000	10 000

²⁴ An average cost of 1 EUR per 1000 PU is considered.

	Anonymous User	Copernicus General users	Copernicus Services users	Copernicus Collaborative Partners	Copernicus International Partners
Processing units per minute	N/A	300	1200	600	300
Accessible services	CDS Browser	visualisation API process API (sync and async) Statistical API (sync) openEO	visualisation API process API (sync, async, batch) Statistical API (sync, batch) openEO	visualisation API process API (sync, async, batch) Statistical API (sync, batch) openEO	visualisation API process API (sync and async) Statistical API (sync) openEO

B.9 openEO API

When registering on the Copernicus Data Space Ecosystem, each user is provided with 1000 free credits enabling them to explore the marketplace offer based on OpenEO orchestration. This allows users to process multiple km²s to new added value products.

B.10 On-Demand production

For each product, on-demand production can be ordered at no additional cost for the user. To ensure the fair share of service and its performance among users, quotas are imposed per user typology.

Requests are limited by a quota mechanism:

- maximum number of orders per user per month and the maximum number of simultaneous production orders running in parallel, i.e. the orders in “In progress” status.

The following table presents an example quota configuration per user-type. The table contents and its split should guarantee a fair share of resources for the users within the baseline offer, taking into account that most data are available for IAD. Actual configuration and quotas should be adjusted depending on the number of active users and demand for on-demand production service within the project duration.

Table 5: Maximum numbers of orders for On-Demand Production

	Copernicus General users	Copernicus Services users	Copernicus Collaborative Partners	Copernicus International Partners
Processsed products per month	25	1 000	1 000	1 000
Concurrent processing tasks	2	20	10	10

Other Products Generation

Copernicus Data Space Ecosystem has a dedicated limited pool of resources, shared across all users, which can be used for processing the data free of charge. This is suitable for users who need to process smaller batches of products. There is no guarantee that processing will be completed in certain time.

C ANNEX THIRD PARTY SERVICES PRICING

C.1.1 CREODIAS

<https://creodias.eu/billing-models>

D COPERNICUS DATA SPACE ECOSYSTEM Q&A

Please refer to:

<https://documentation.dataspace.copernicus.eu/#/FAQ>