eurac research

OGC Data Cube Standardisation

Alexander Jacob

OGC API

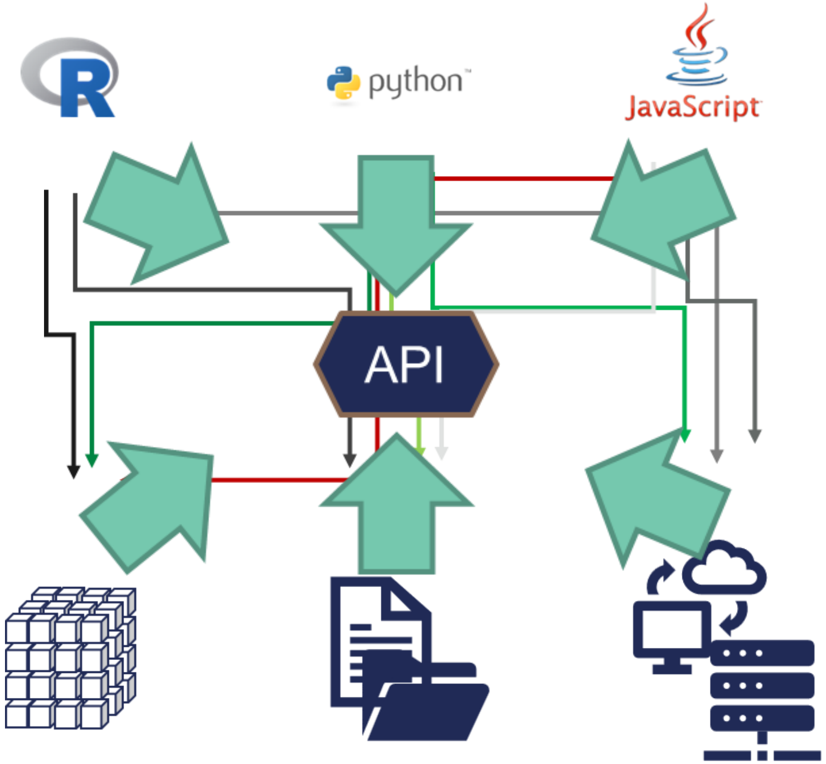
https://ogcapi.ogc.org/

- Fully integrated suite of standards
- Modular by design
- Meant to replace existing suite of standards like
  - WMS, WFS, WCS, WPS, CWS, ….
- All based on openAPI definitions as restful services

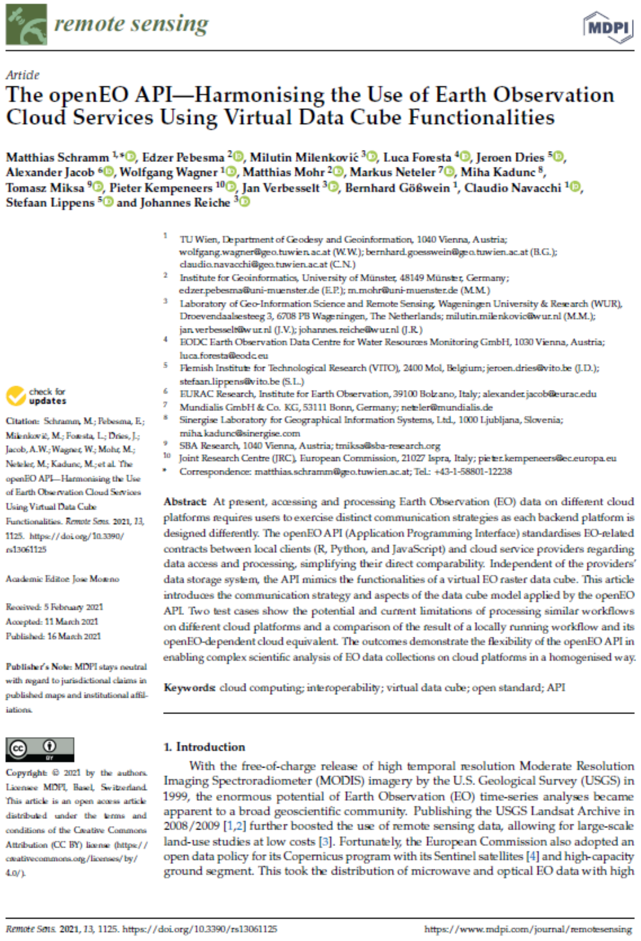
- Service offering:
  - OGC API – Commons
- Data interfaces
  - OGC API – Coverages
  - OGC API – Features
- Data Processing
  - OGC API – Processes
- Data Visualization
  - OGC API – Maps
  - OGC API - Tiles

openEO API

- Defined in OpenAPI
- api.openeo.org
- HTTPS & JSON
- Functionality
- Capabilities
- Data Discovery
- Authentication
- File management
- Data Processing / Workflow management
- Data Export / Web Services
- Extensions



https://doi.org/10.3390/rs13061125


remote sensing
MDPI

Article

The openEO API—Harmonising the Use of Earth Observation Cloud Services Using Virtual Data Cube Functionalities

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check for updates

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Abstract: At present, accessing and processing Earth Observation (EO) data on different cloud platforms requires users to exercise distinct communication strategies as each backend platform is designed differently. The openEO API (Application Programming Interface) standardises EO-related contracts between local clients (R, Python, and JavaScript) and cloud service providers regarding data access and processing, simplifying their direct comparability. Independent of the providers' data storage system, the API mimics the functionalities of a virtual EO raster data cube. This article introduces the communication strategy and aspects of the data cube model applied by the openEO API. Two test cases show the potential and current limitations of processing similar workflows on different cloud platforms and a comparison of the result of a locally running workflow and its openEO-dependent cloud equivalent. The outcomes demonstrate the flexibility of the openEO API in enabling complex scientific analysis of EO data collections on cloud platforms in a homogenised way.

Keywords: cloud computing; interoperability; virtual data cube; open standard; API

1. Introduction

With the free-of-charge release of high temporal resolution Moderate Resolution Imaging Spectroradiometer (MODIS) imagery by the U.S. Geological Survey (USGS) in 1999, the enormous potential of Earth Observation (EO) time-series analyses became apparent to a broad geoscientific community. Publishing the USGS Landsat Archive in 2008/2009 [1,2] further boosted the use of remote sensing data, allowing for large-scale land-use studies at low costs [3]. Fortunately, the European Commission also adopted an open data policy for its Copernicus program with its Sentinel satellites [4] and high-capacity ground segment. This took the distribution of microwave and optical EO data with high

Remote Sens. **2021**, *13*, 1125. https://doi.org/10.3390/rs13061125 https://www.mdpi.com/journal/remotesensing

Implementations

- ❖ GeoPyspark / Geotrellis (VITO, CDSE)
- ❖ Xarray / Dask (EODC, EURAC, local processing, …)
- ❖ Google Earth Engine
- ❖ WCPS / rasdaman (EURAC)
- ❖ GRASSGIS / actinia (mundialis)
- ❖ Sentinel Hub (Sinergise)
- ❖ … (RISE, IBM, WASDI)

- Python
  - opinionated, pythonic implementation
  - Jupyter integration
- R
  - Rstudio integration
  - Rmarkdown
  - Jupyter integration
- JavaScript (TypeScript)
  - Web Apps
  - Mobile Apps
- Julia
- Web Editor: editor.openeo.org
  - Simple UI for the browser
  - Model Builder

openEO community standard

- Submitted to OGC
  - Scope: API and Processes
  - Type: Community Standard
  - Submitter: openEO PSC

Public Comment requested on adoption of

openEO

as a Community Standard

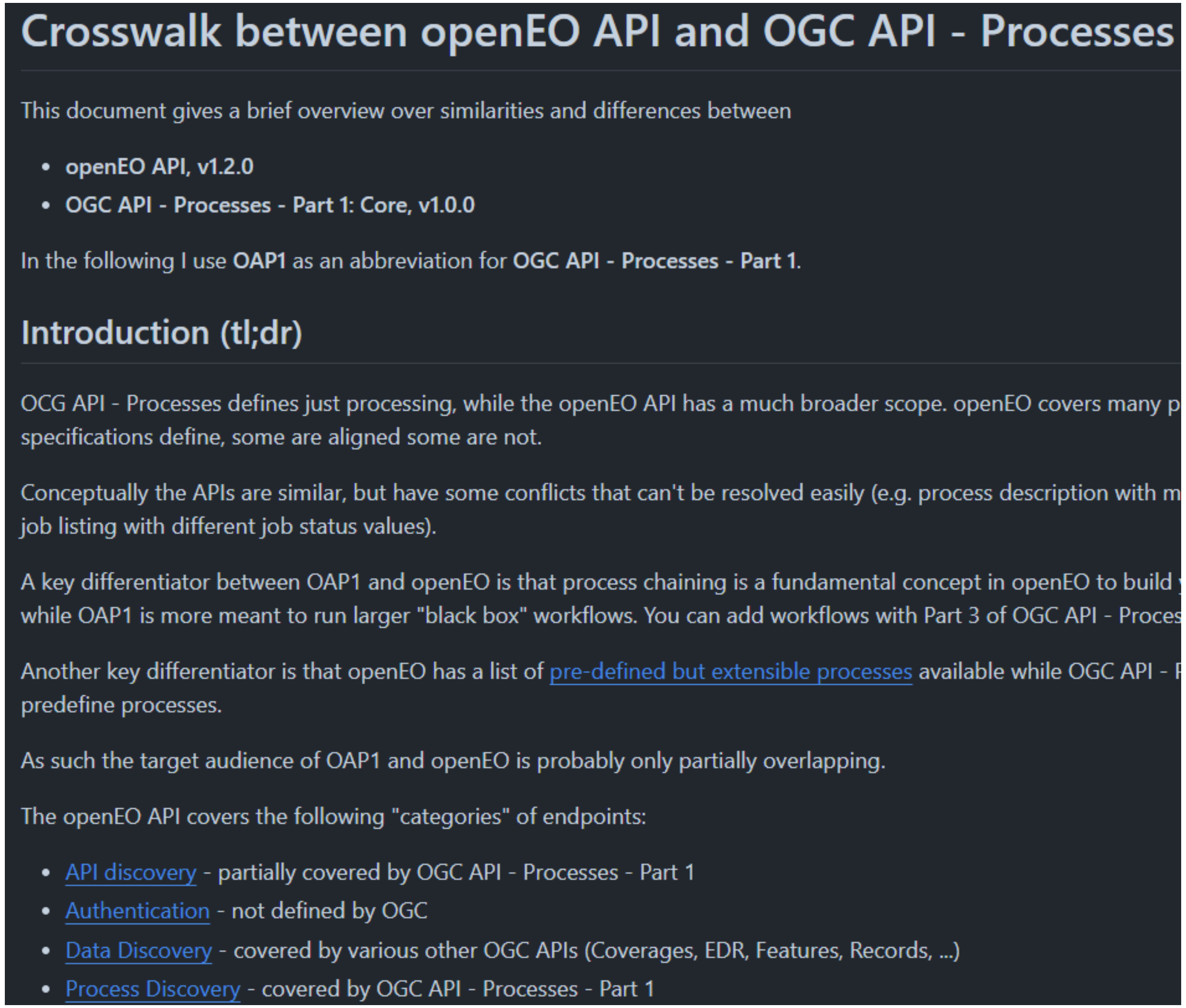
Comments due by February 27

Open Geospatial Consortium

- RFC started Feb 6th ; ended Feb 27th 2024
- Justification document
- Presentation at OGC MM in Delft 26th & 28th of March 2024
- Vote has past with quorum on May 16th 2024
- Awaiting final approval from OGC Technical Committee
  - Next member meeting in Monreal next week (17th – 20th of June 2024)

openEO + OGC API - Processes

- Crosswalk
- Similar APIs, but **different scope**
- openEO has **process specifications**
- Minor conflicts which require new versions
- OGC API - Processes - Part 3 may run openEO UDP
- openEO may run Application Packages (OGC API - Processes - Part 1)



Crosswalk between openEO API and OGC API - Processes

This document gives a brief overview over similarities and differences between

- **openEO API, v1.2.0**
- **OGC API - Processes - Part 1: Core, v1.0.0**

In the following I use **OAP1** as an abbreviation for **OGC API - Processes - Part 1**.

Introduction (tl;dr)

OCG API - Processes defines just processing, while the openEO API has a much broader scope. openEO covers many p specifications define, some are aligned some are not.

Conceptually the APIs are similar, but have some conflicts that can't be resolved easily (e.g. process description with m job listing with different job status values).

A key differentiator between OAP1 and openEO is that process chaining is a fundamental concept in openEO to build while OAP1 is more meant to run larger "black box" workflows. You can add workflows with Part 3 of OGC API - Proces

Another key differentiator is that openEO has a list of pre-defined but extensible processes available while OGC API - F predefine processes.

As such the target audience of OAP1 and openEO is probably only partially overlapping.

The openEO API covers the following "categories" of endpoints:

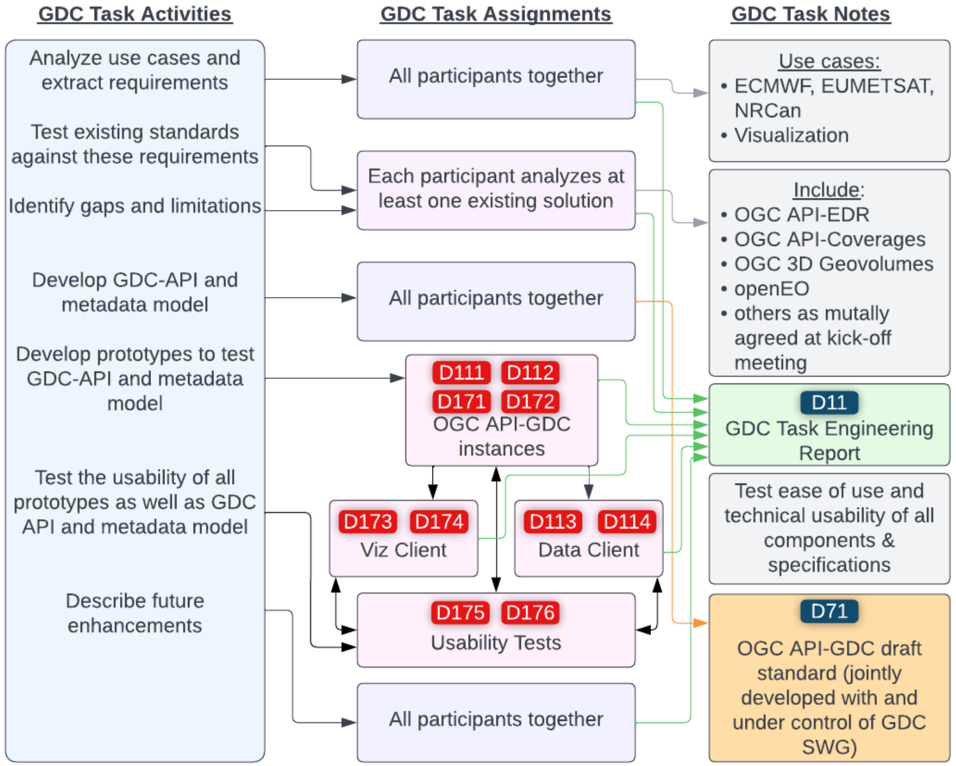
- API discovery - partially covered by OGC API - Processes - Part 1
- Authentication - not defined by OGC
- Data Discovery - covered by various other OGC APIs (Coverages, EDR, Features, Records, ...)
- Process Discovery - covered by OGC API - Processes - Part 1

OGC GeoDataCube API

INITIAL IDEAS

- General “mostly” consensus GDC API is an implementation profile for existing OGC APIs
- Could also be expressed as best practice or implementation guideline
- openEO is already in many cases an implementation of OGC API

Testbed 19
Interoperability and Collaboration
From Oceans to Space
Open Geospatial Consortium



GDC Task Activities

Analyze use cases and extract requirements

Test existing standards against these requirements

Identify gaps and limitations

Develop GDC-API and metadata model

Develop prototypes to test GDC-API and metadata model

Test the usability of all prototypes as well as GDC API and metadata model

Describe future enhancements

GDC Task Assignments

All participants together

Each participant analyzes at least one existing solution

All participants together

D111 D112 D171 D172 OGC API-GDC instances

D173 D174 Viz Client

D113 D114 Data Client

D175 D176 Usability Tests

All participants together

GDC Task Notes

Use cases:
- ECMWF, EUMETSAT, NRCan
- Visualization

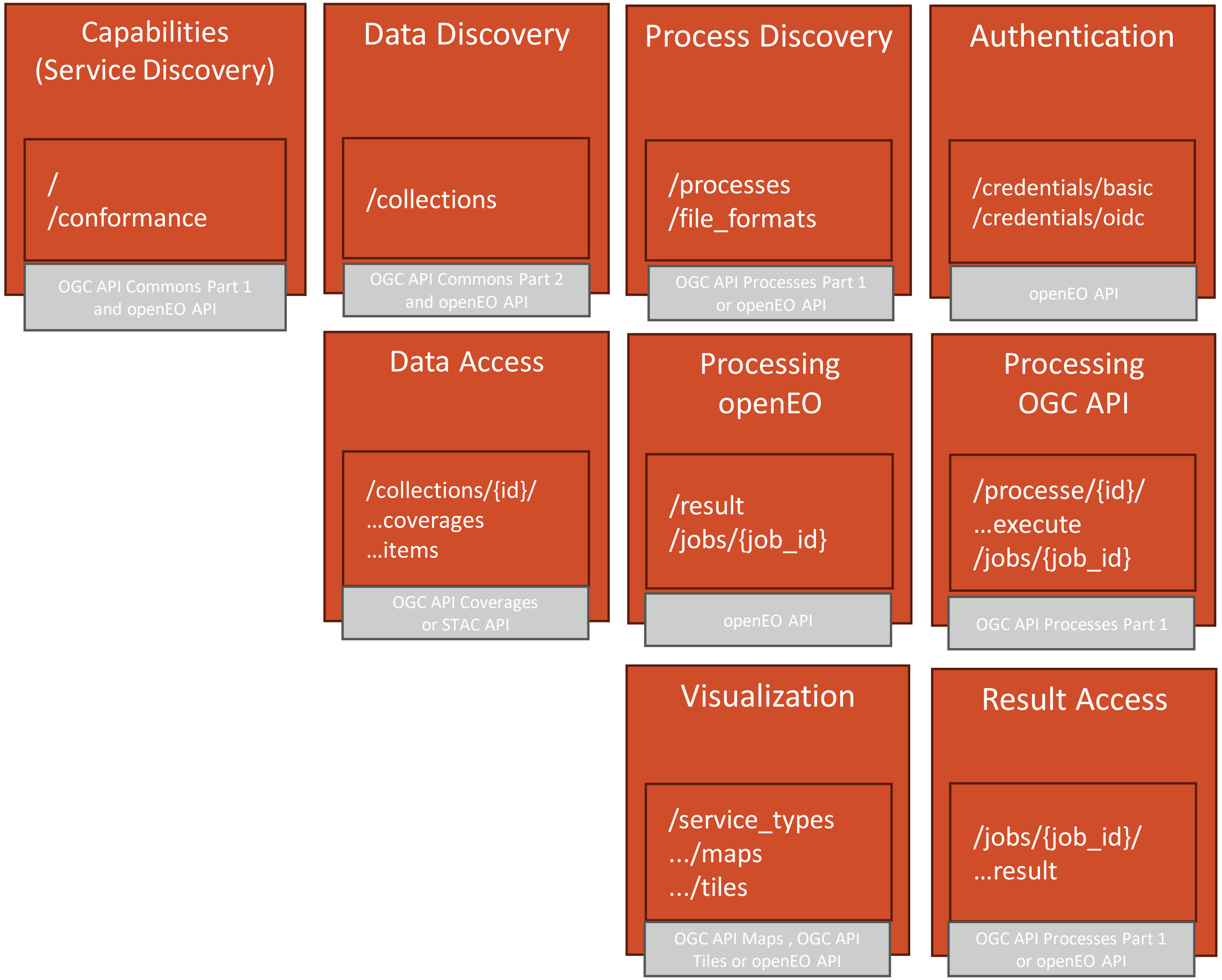
Include:
- OGC API-EDR
- OGC API-Coverages
- OGC 3D Geovolumes
- openEO
- others as mutally agreed at kick-off meeting

D11 GDC Task Engineering Report

Test ease of use and technical usability of all components & specifications

D71 OGC API-GDC draft standard (jointly developed with and under control of GDC SWG)

OGC GeoDataCube API



Capabilities (Service Discovery)

/
/conformance

OGC API Commons Part 1 and openEO API

Data Discovery

/collections

OGC API Commons Part 2 and openEO API

Process Discovery

/processes
/file_formats

OGC API Processes Part 1 or openEO API

Authentication

/credentials/basic
/credentials/oidc

openEO API

Data Access

/collections/{id}/
…coverages
…items

OGC API Coverages or STAC API

Processing openEO

/result
/jobs/{job_id}

openEO API

Processing OGC API

/processe/{id}/
…execute
/jobs/{job_id}

OGC API Processes Part 1

Visualization

/service_types
.../maps
.../tiles

OGC API Maps , OGC API Tiles or openEO API

Result Access

/jobs/{job_id}/
…result

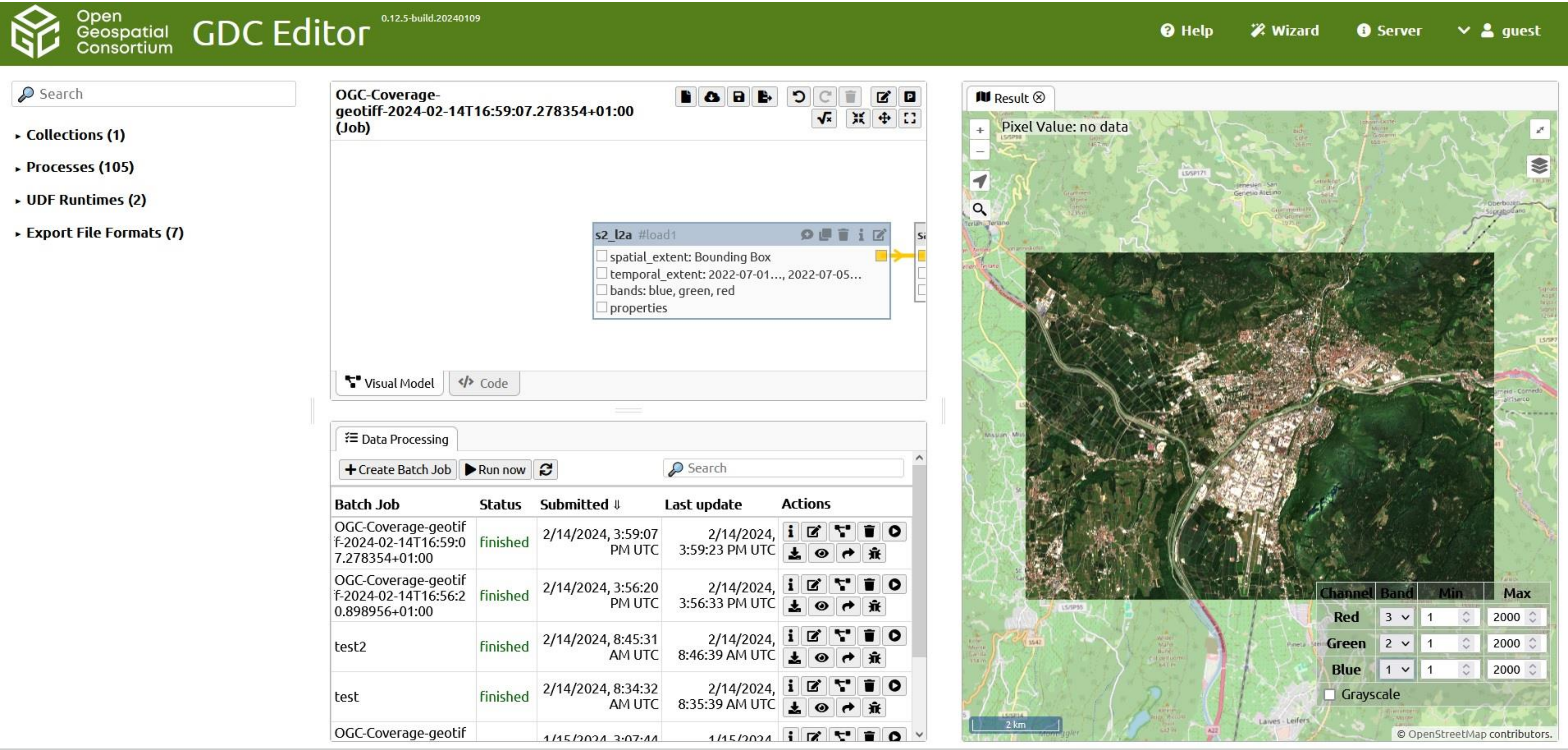
OGC API Processes Part 1 or openEO API

Discovery Layer. Gives information about everything you can do with the service.

Data processing Layer. Allows simple data modification during data access or complex processing scenarios using openEO or OGC API including workflows.

Result Access Layer. Download results or access them through a web service.

GDC Editor



OGC-Coverage-geotiff-2024-02-14T16:59:07.278354+01:00 (Job)

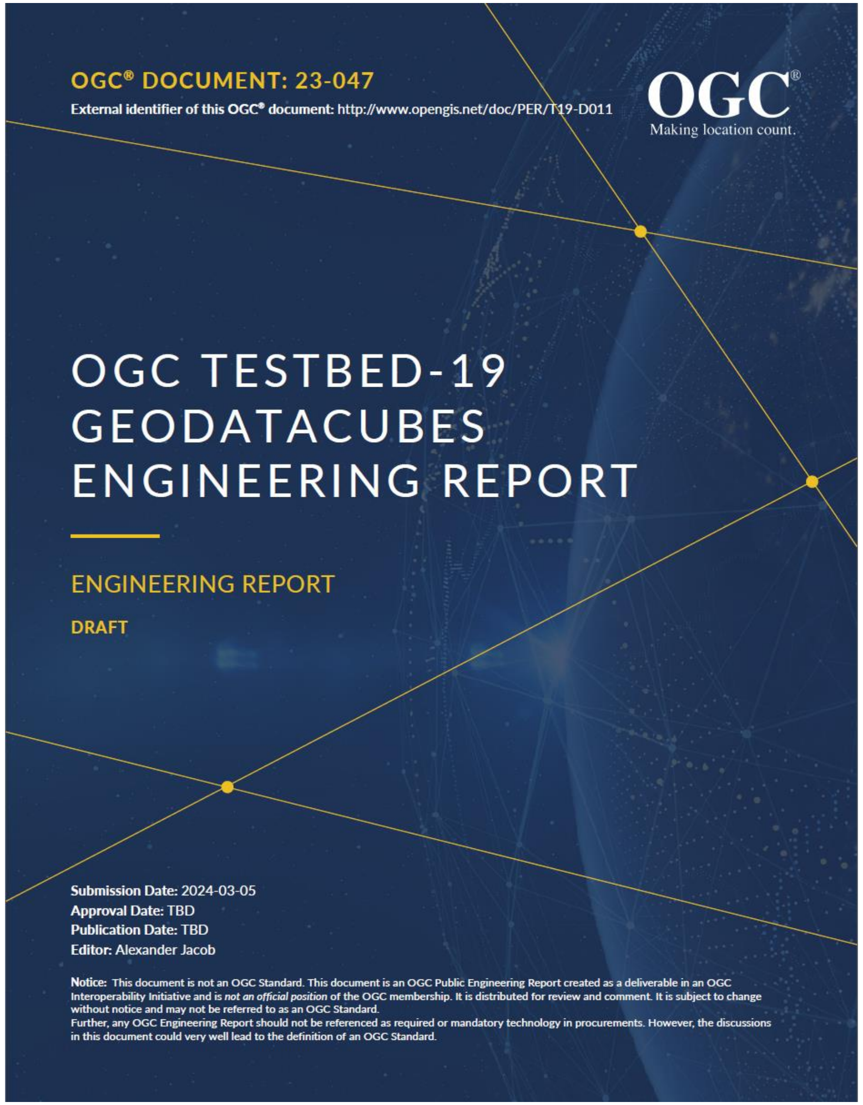
s2_l2a #load1
- □ spatial_extent: Bounding Box
- □ temporal_extent: 2022-07-01..., 2022-07-05...
- □ bands: blue, green, red
- □ properties

Batch Job	Status	Submitted ⇓	Last update	Actions
OGC-Coverage-geotiff-2024-02-14T16:59:07.278354+01:00	finished	2/14/2024, 3:59:07 PM UTC	2/14/2024, 3:59:23 PM UTC	
OGC-Coverage-geotiff-2024-02-14T16:56:20.898956+01:00	finished	2/14/2024, 3:56:20 PM UTC	2/14/2024, 3:56:33 PM UTC	
test2	finished	2/14/2024, 8:45:31 AM UTC	2/14/2024, 8:46:39 AM UTC	
test	finished	2/14/2024, 8:34:32 AM UTC	2/14/2024, 8:35:39 AM UTC	
OGC-Coverage-geotif		1/15/2024, 3:07:44	1/15/2024,	

Channel	Band	Min	Max
Red	3	1	2000
Green	2	1	2000
Blue	1	1	2000

□ Grayscale

OGC GeoDataCube API



OGC® DOCUMENT: 23-047

External identifier of this OGC® document: http://www.opengis.net/doc/PER/T19-D011

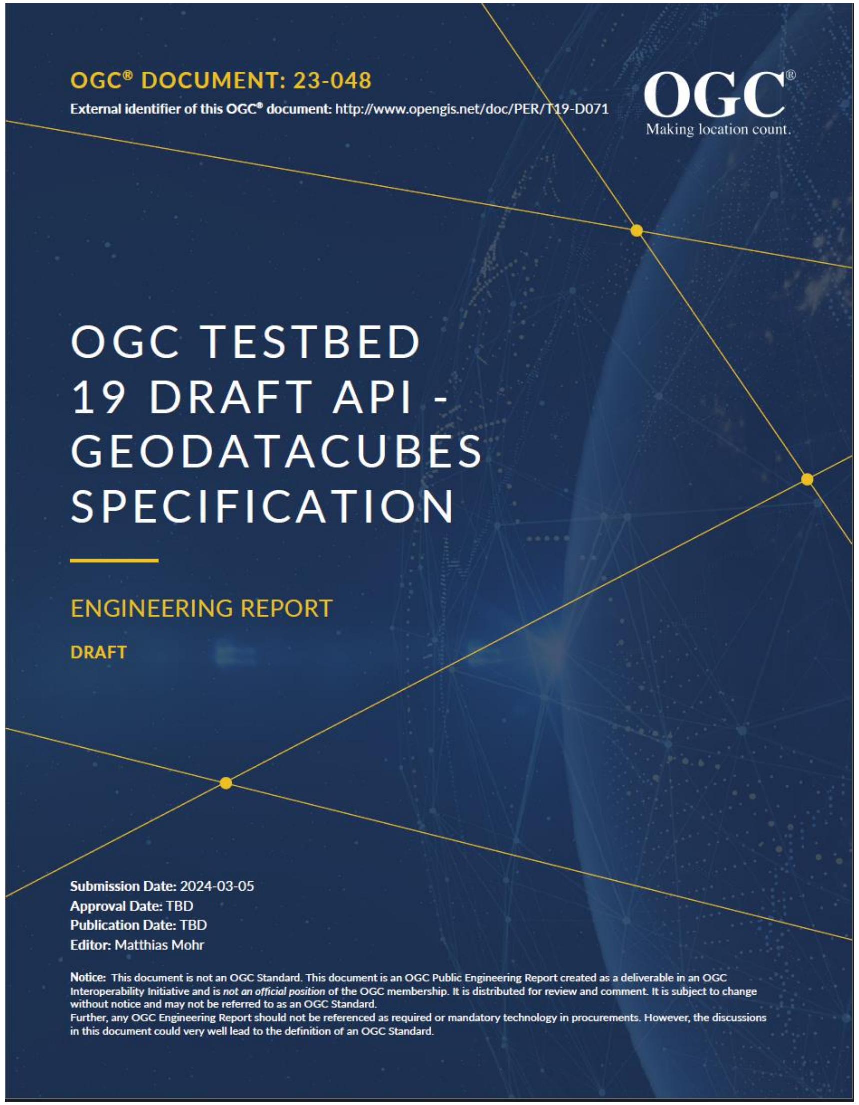
OGC TESTBED-19 GEODATACUBES ENGINEERING REPORT

ENGINEERING REPORT

DRAFT

Submission Date: 2024-03-05
Approval Date: TBD
Publication Date: TBD
Editor: Alexander Jacob

Notice: This document is not an OGC Standard. This document is an OGC Public Engineering Report created as a deliverable in an OGC Interoperability Initiative and is *not an official position* of the OGC membership. It is distributed for review and comment. It is subject to change without notice and may not be referred to as an OGC Standard.
Further, any OGC Engineering Report should not be referenced as required or mandatory technology in procurements. However, the discussions in this document could very well lead to the definition of an OGC Standard.



OGC® DOCUMENT: 23-048

External identifier of this OGC® document: http://www.opengis.net/doc/PER/T19-D071

OGC TESTBED 19 DRAFT API - GEODATACUBES SPECIFICATION

ENGINEERING REPORT

DRAFT

Submission Date: 2024-03-05
Approval Date: TBD
Publication Date: TBD
Editor: Matthias Mohr

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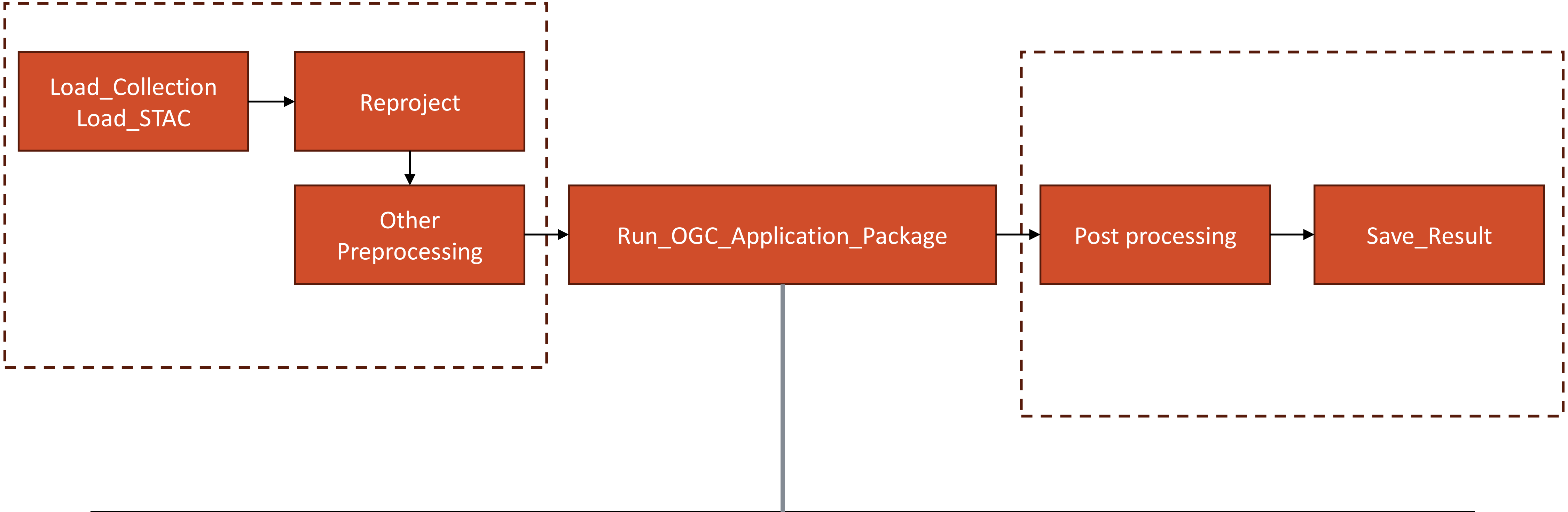
Engineering Report

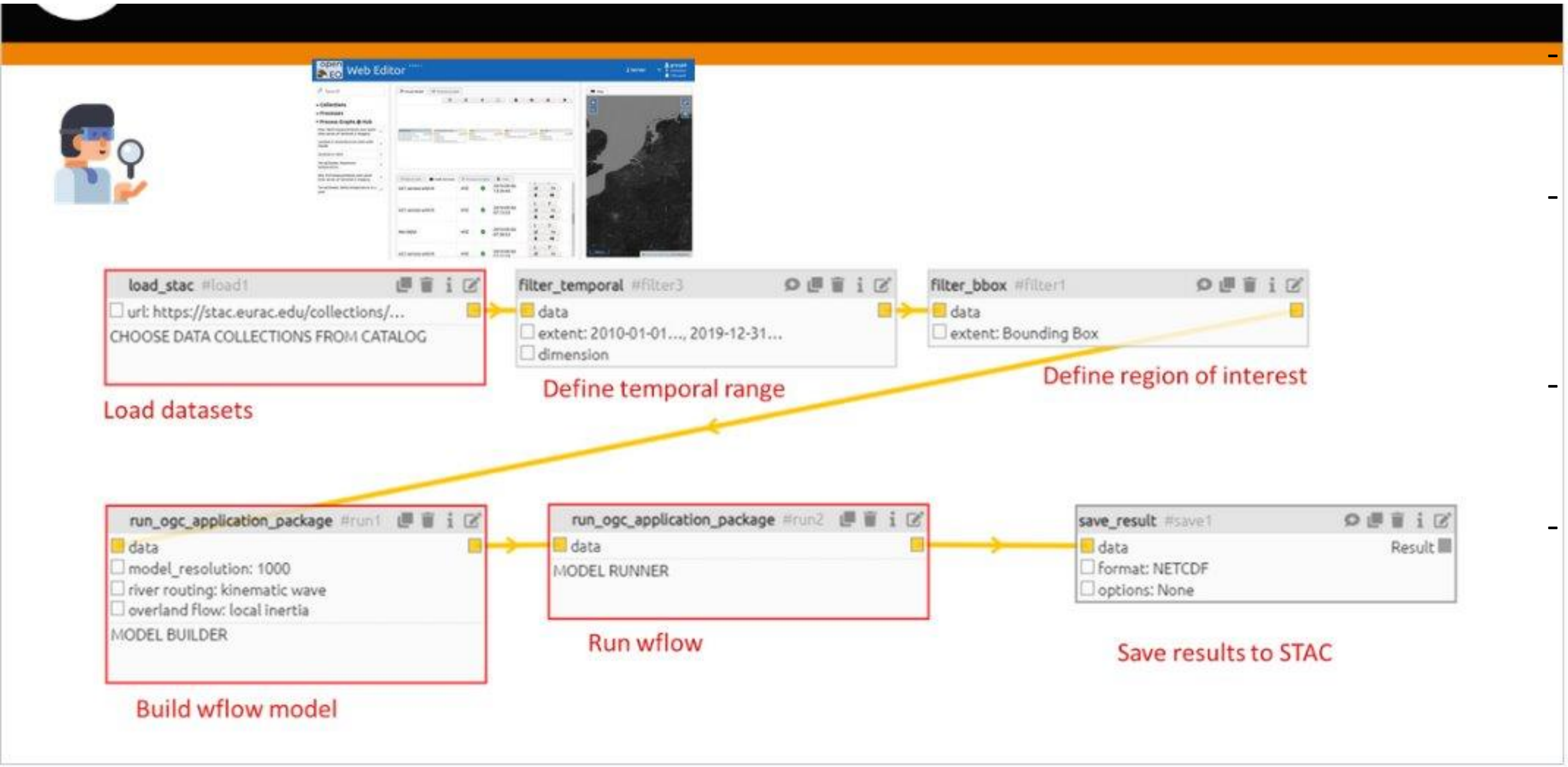
Draft Specification

To be continued (interTwin)



The JSON Process graph is **split**, and the processing is redirected to the CWL executor to run the Application Package, returns a result back to OpenEO for postprocessing

To be continued (interTwin)



load_stac #load1
□ url: https://stac.eurac.edu/collections/...
CHOOSE DATA COLLECTIONS FROM CATALOG

Load datasets

filter_temporal #filter3
data
□ extent: 2010-01-01..., 2019-12-31...
□ dimension

Define temporal range

filter_bbox #filter1
data
□ extent: Bounding Box

Define region of interest

run_ogc_application_package #run1
data
□ model_resolution: 1000
□ river routing: kinematic wave
□ overland flow: local inertia
MODEL BUILDER

Build wflow model

run_ogc_application_package #run2
data
MODEL RUNNER

Run wflow

save_result #save1
data
□ format: NETCDF
□ options: None
Result

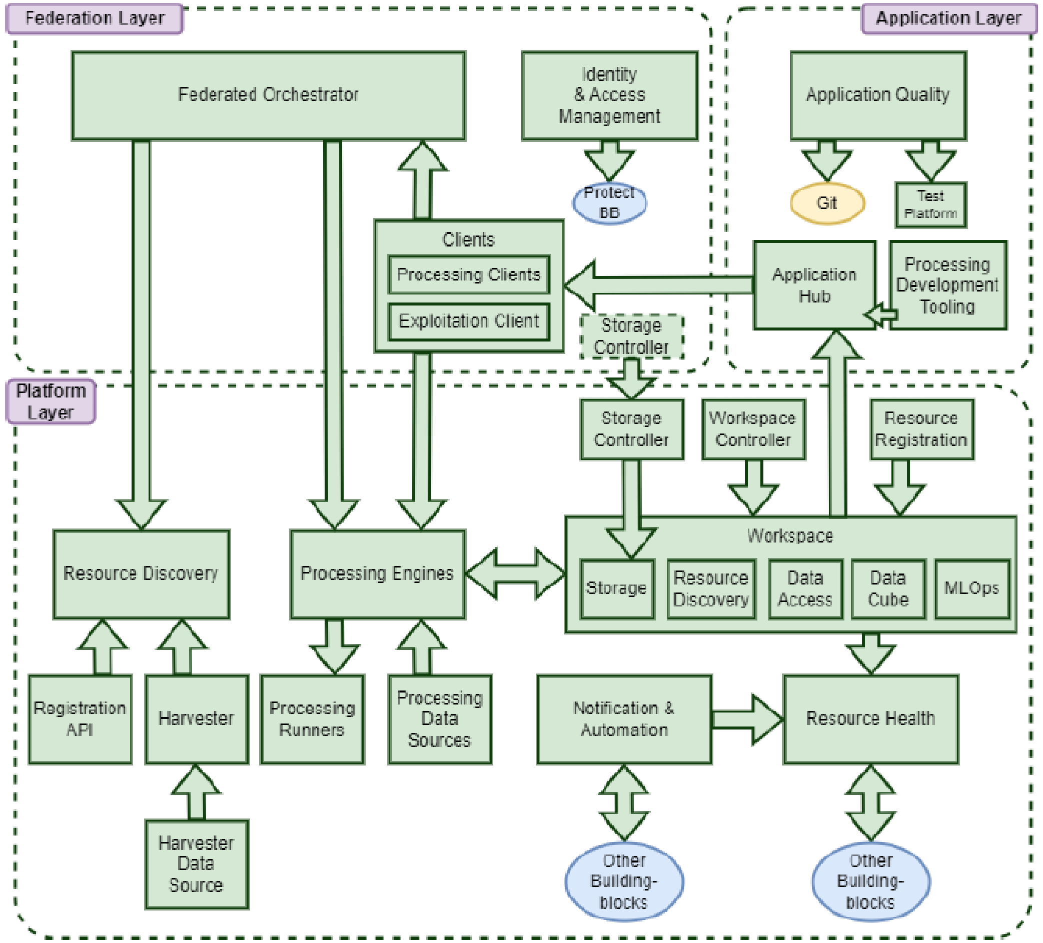
Save results to STAC

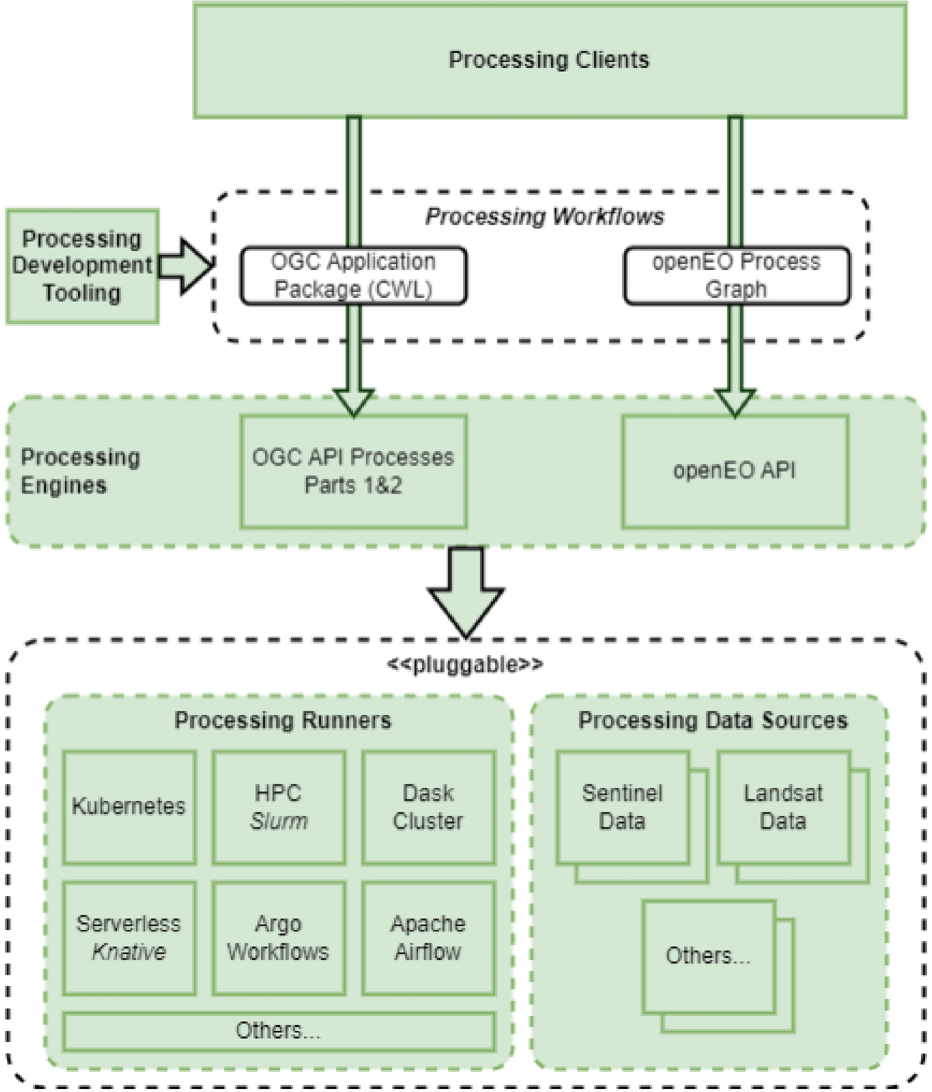
- New process available via the OpenEO clients
- Provide information about the available processes (e.g. HydroMT)
- Allow the user to specify input and output parameters
- Ongoing discussion about the process definition available on GitHub

To be continued (EOEPCA+)

esa

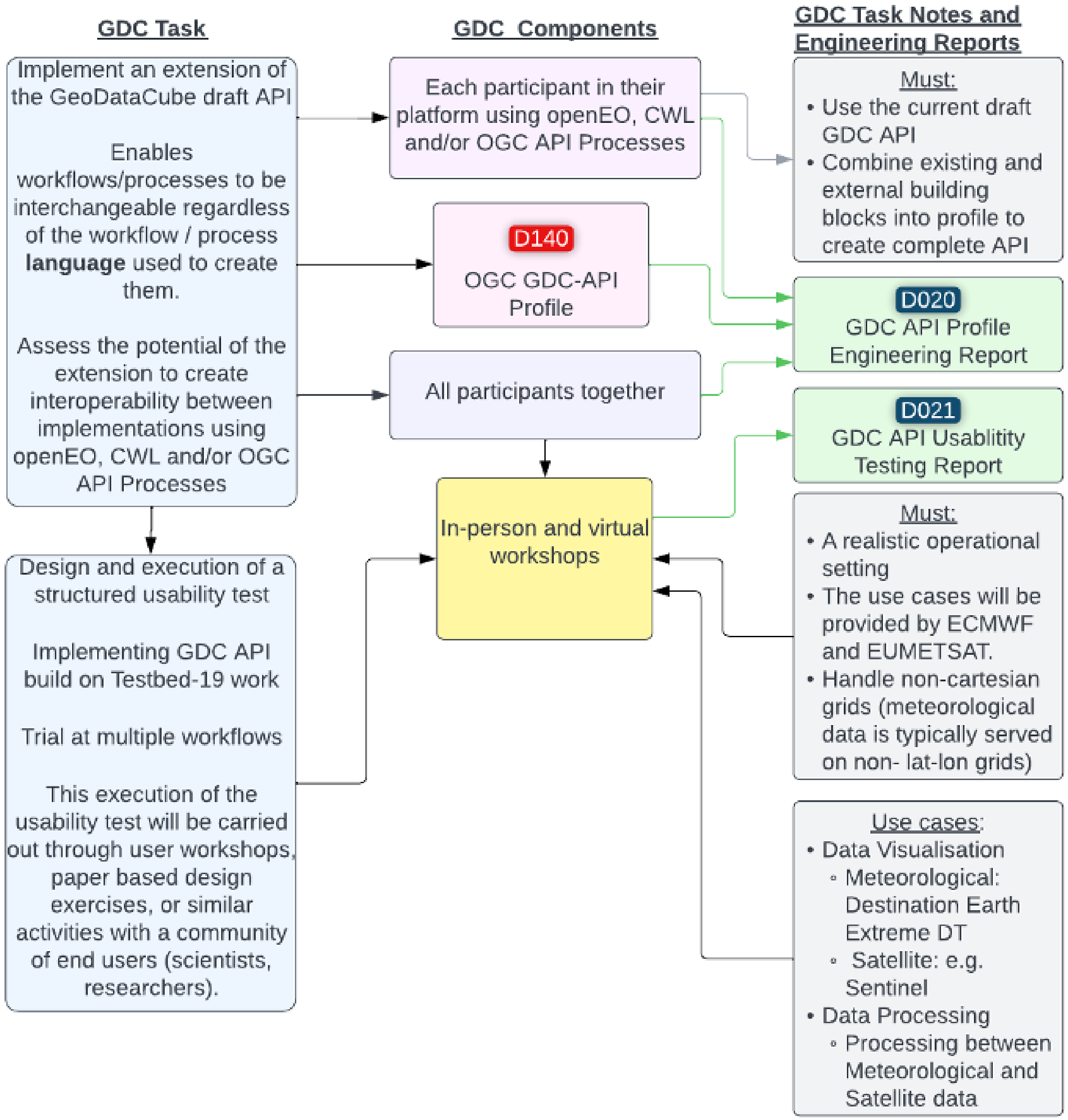
TELESPAZIO
a LEONARDO and THALES company





To be continued ...

Calling for Participation in
Testbed-20
Applications close June 10
Open Geospatial Consortium



GDC Task

Implement an extension of the GeoDataCube draft API

Enables workflows/processes to be interchangeable regardless of the workflow / process **language** used to create them.

Assess the potential of the extension to create interoperability between implementations using openEO, CWL and/or OGC API Processes

Design and execution of a structured usability test

Implementing GDC API build on Testbed-19 work

Trial at multiple workflows

This execution of the usability test will be carried out through user workshops, paper based design exercises, or similar activities with a community of end users (scientists, researchers).

GDC Components

Each participant in their platform using openEO, CWL and/or OGC API Processes

D140 OGC GDC-API Profile

All participants together

In-person and virtual workshops

GDC Task Notes and Engineering Reports

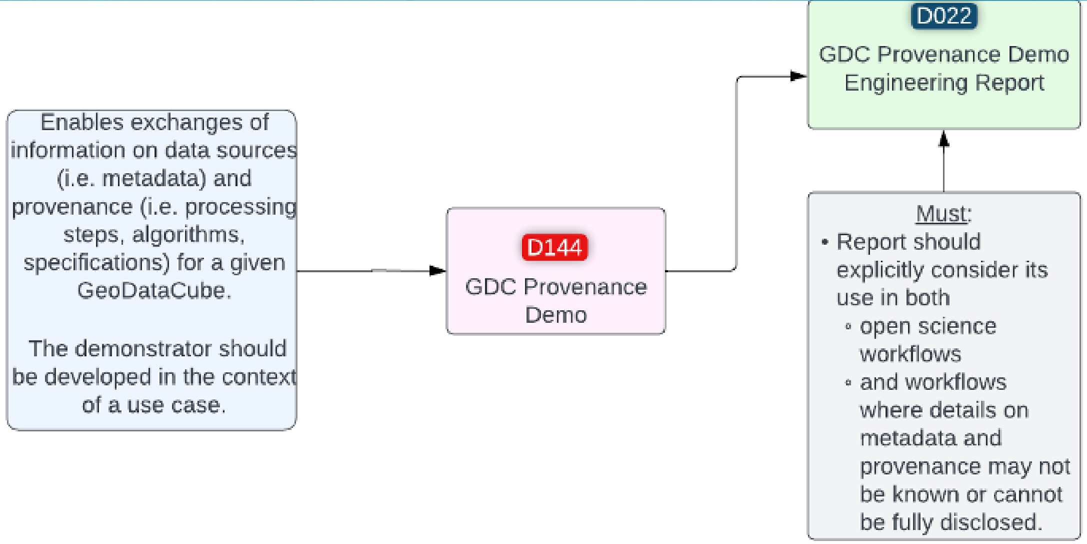
Must:
- Use the current draft GDC API
- Combine existing and external building blocks into profile to create complete API

D020 GDC API Profile Engineering Report

D021 GDC API Usablity Testing Report

Must:
- A realistic operational setting
- The use cases will be provided by ECMWF and EUMETSAT.
- Handle non-cartesian grids (meteorological data is typically served on non- lat-lon grids)

Use cases:
- Data Visualisation
  - Meteorological: Destination Earth Extreme DT
  - Satellite: e.g. Sentinel
- Data Processing
  - Processing between Meteorological and Satellite data



Enables exchanges of information on data sources (i.e. metadata) and provenance (i.e. processing steps, algorithms, specifications) for a given GeoDataCube.

The demonstrator should be developed in the context of a use case.

D144 GDC Provenance Demo

D022 GDC Provenance Demo Engineering Report

Must:
- Report should explicitly consider its use in both
  - open science workflows
  - and workflows where details on metadata and provenance may not be known or cannot be fully disclosed.

eurac
research

Thanks for your attention

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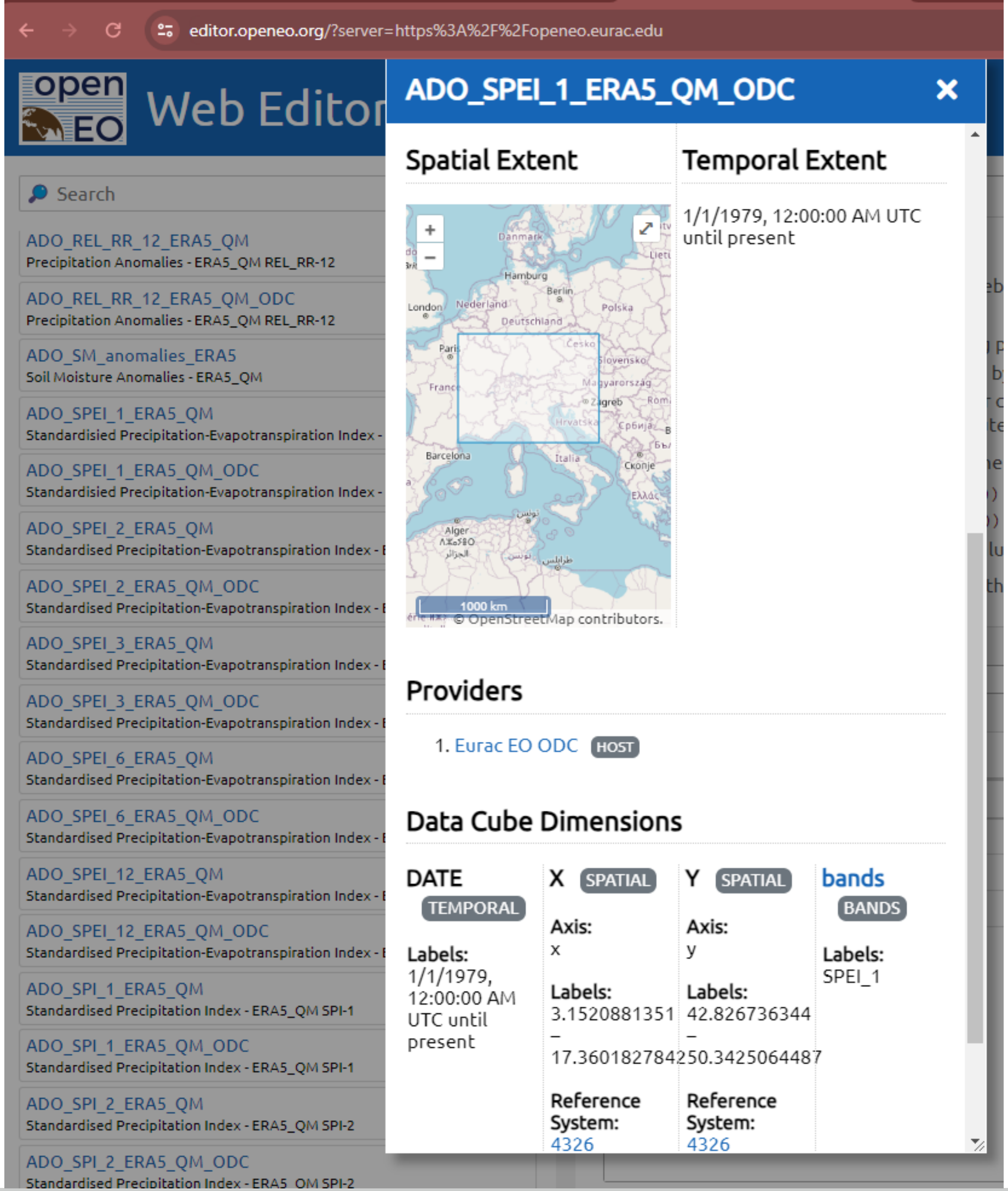
alexander.jacob@eurac.edu

Discovery

- Data Discovery via STAC
  - only Collections by default
  - can be extended to include Items
  - Commercial Data support (extension)
- File Formats (In & Out)
- Auth
  - Clients can „self-configure“
  - OpenID Connect (various flows/grants)
  - HTTP Basic
- Federation (extension)



editor.openeo.org/?server=https%3A%2F%2Fopeneo.eurac.edu

ADO_REL_RR_12_ERA5_QM
Precipitation Anomalies - ERA5_QM REL_RR-12

ADO_REL_RR_12_ERA5_QM_ODC
Precipitation Anomalies - ERA5_QM REL_RR-12

ADO_SM_anomalies_ERA5
Soil Moisture Anomalies - ERA5_QM

ADO_SPEI_1_ERA5_QM
Standardisied Precipitation-Evapotranspiration Index -

ADO_SPEI_1_ERA5_QM_ODC
Standardisied Precipitation-Evapotranspiration Index -

ADO_SPEI_2_ERA5_QM
Standardised Precipitation-Evapotranspiration Index - E

ADO_SPEI_2_ERA5_QM_ODC
Standardised Precipitation-Evapotranspiration Index - E

ADO_SPEI_3_ERA5_QM
Standardised Precipitation-Evapotranspiration Index - E

ADO_SPEI_3_ERA5_QM_ODC
Standardised Precipitation-Evapotranspiration Index - E

ADO_SPEI_6_ERA5_QM
Standardised Precipitation-Evapotranspiration Index - E

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Standardised Precipitation-Evapotranspiration Index - E

ADO_SPEI_12_ERA5_QM
Standardised Precipitation-Evapotranspiration Index - E

ADO_SPEI_12_ERA5_QM_ODC
Standardised Precipitation-Evapotranspiration Index - E

ADO_SPI_1_ERA5_QM
Standardised Precipitation Index - ERA5_QM SPI-1

ADO_SPI_1_ERA5_QM_ODC
Standardised Precipitation Index - ERA5_QM SPI-1

ADO_SPI_2_ERA5_QM
Standardised Precipitation Index - ERA5_QM SPI-2

ADO_SPI_2_ERA5_QM_ODC
Standardised Precipitation Index - ERA5_QM SPI-2

ADO_SPEI_1_ERA5_QM_ODC ✕

Spatial Extent

Temporal Extent

1/1/1979, 12:00:00 AM UTC until present

Providers

1. Eurac EO ODC HOST

Data Cube Dimensions

DATE TEMPORAL

Labels: 1/1/1979, 12:00:00 AM UTC until present

X SPATIAL

Axis: x

Labels: 3.1520881351 – 17.360182784

Reference System: 4326

Y SPATIAL

Axis: y

Labels: 42.826736344 – 50.3425064487

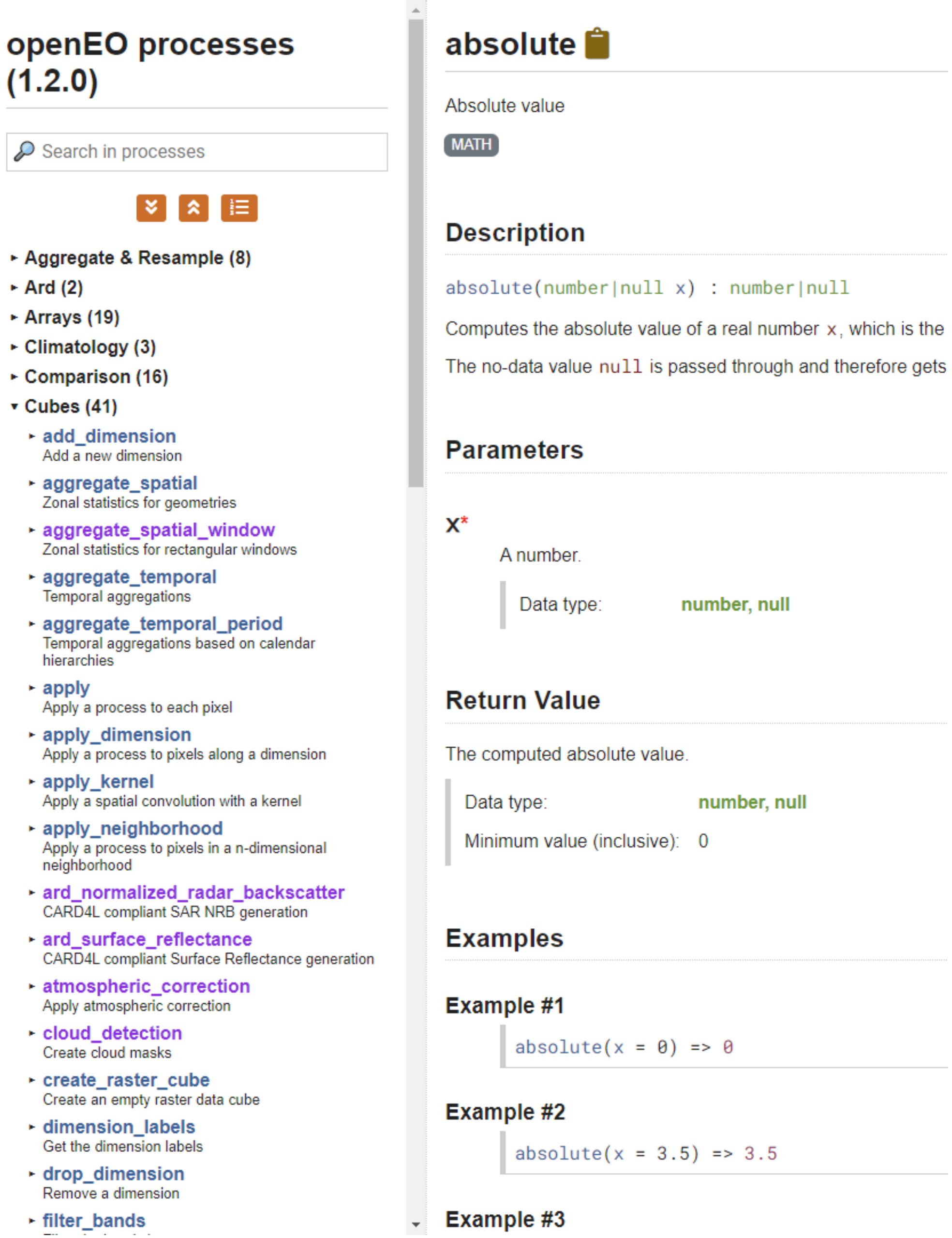
Reference System: 4326

bands BANDS

Labels: SPEI_1

Processes

- Pre-defined processes
  - processes.openeo.org (150+)
  - Can be customized (e.g. remove a parameter)
  - JSON Schema
- User-defined processes
  - Combine processes to a new process (like functions in programming)
  - Parameters
  - Metadata
- User-defined Functions
  - Run custom code (e.g. in Python, R)
  - Runtimes (e.g. Python 3.10 with xarray and geopandas)
  - Docker Images



openEO processes (1.2.0)

- Aggregate & Resample (8)
- Ard (2)
- Arrays (19)
- Climatology (3)
- Comparison (16)
- Cubes (41)
  - **add_dimension** Add a new dimension
  - **aggregate_spatial** Zonal statistics for geometries
  - **aggregate_spatial_window** Zonal statistics for rectangular windows
  - **aggregate_temporal** Temporal aggregations
  - **aggregate_temporal_period** Temporal aggregations based on calendar hierarchies
  - **apply** Apply a process to each pixel
  - **apply_dimension** Apply a process to pixels along a dimension
  - **apply_kernel** Apply a spatial convolution with a kernel
  - **apply_neighborhood** Apply a process to pixels in a n-dimensional neighborhood
  - **ard_normalized_radar_backscatter** CARD4L compliant SAR NRB generation
  - **ard_surface_reflectance** CARD4L compliant Surface Reflectance generation
  - **atmospheric_correction** Apply atmospheric correction
  - **cloud_detection** Create cloud masks
  - **create_raster_cube** Create an empty raster data cube
  - **dimension_labels** Get the dimension labels
  - **drop_dimension** Remove a dimension
  - **filter_bands**

absolute

Absolute value

MATH

Description

`absolute(number|null x) : number|null`

Computes the absolute value of a real number `x`, which is the

The no-data value `null` is passed through and therefore gets

Parameters

x*

A number.

Data type: number, null

Return Value

The computed absolute value.

Data type: number, null

Minimum value (inclusive): 0

Examples

Example #1

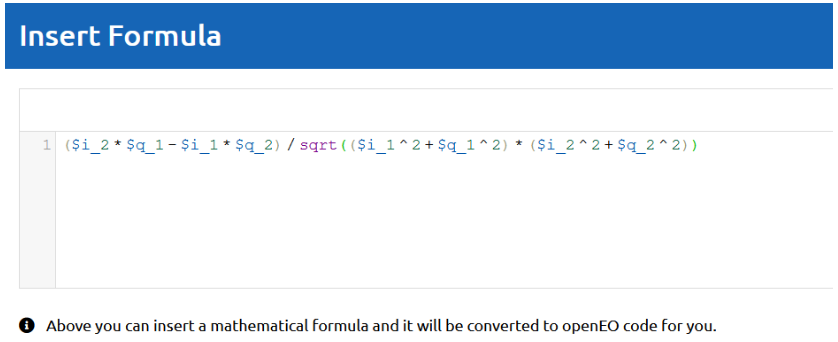
```
absolute(x = 0) => 0
```

Example #2

```
absolute(x = 3.5) => 3.5
```

Example #3

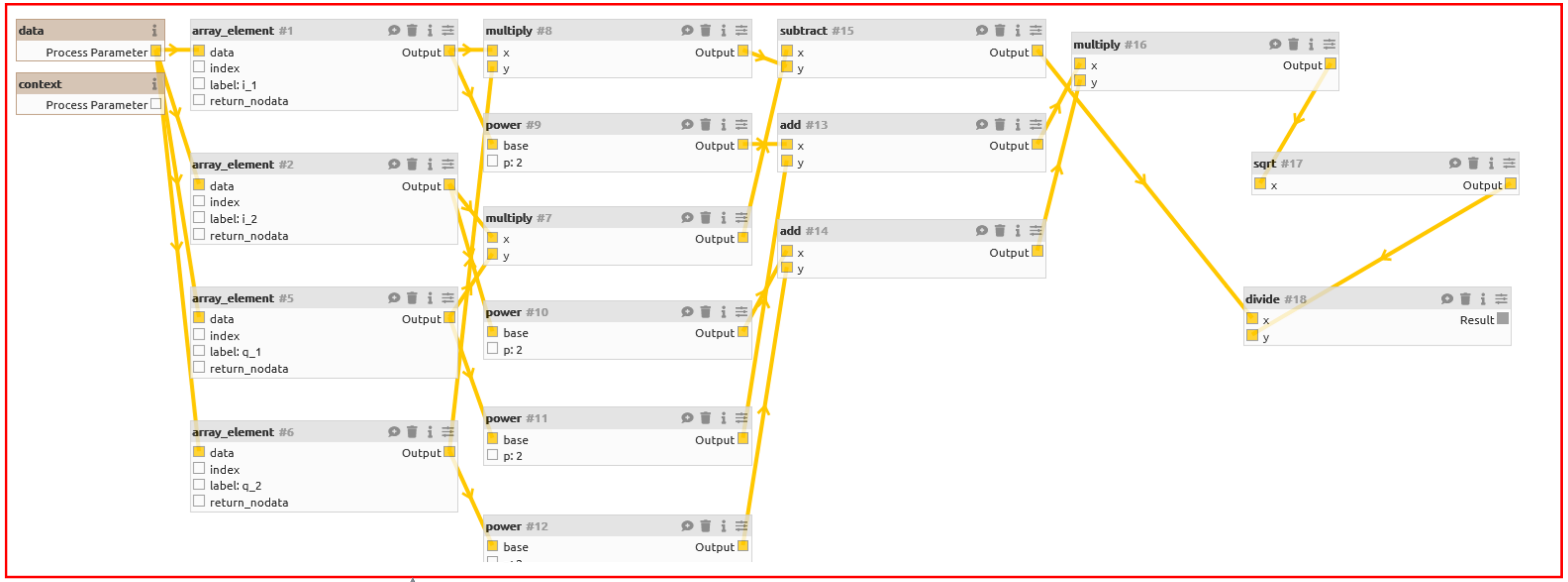
Process: Process Graphs

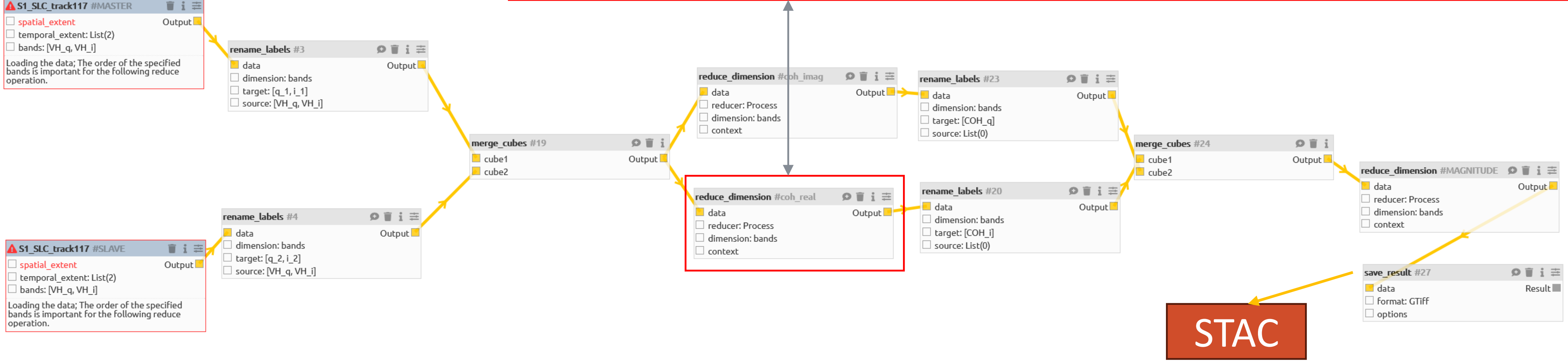


Insert Formula

```
($i_2 * $q_1 - $i_1 * $q_2) / sqrt(($i_1 ^ 2 + $q_1 ^ 2) * ($i_2 ^ 2 + $q_2 ^ 2))
```

Above you can insert a mathematical formula and it will be converted to openEO code for you.





Python Client

```python
import openeo

con = openeo.connect("openeo.cloud")
s2_radio = con.datacube(
  "SENTINEL2_L2A",
  spatial_extent = {
    "west": 16.1, "east": 16.6, "north": 48.6, "south": 47.2
  },
  temporal_extent = ["2018-01-01", "2018-02-01"]
)

blue = s2_radio.band("B02")
red = s2_radio.band("B04")
nir = s2_radio.band("B08")
evi_cube = (2.5 * (nir - red)) / ((nir + 6.0 * red - 7.5 * blue) + 1.0)

evi_cube.reduce("t", "min")
        .save_result("GTiff")
```

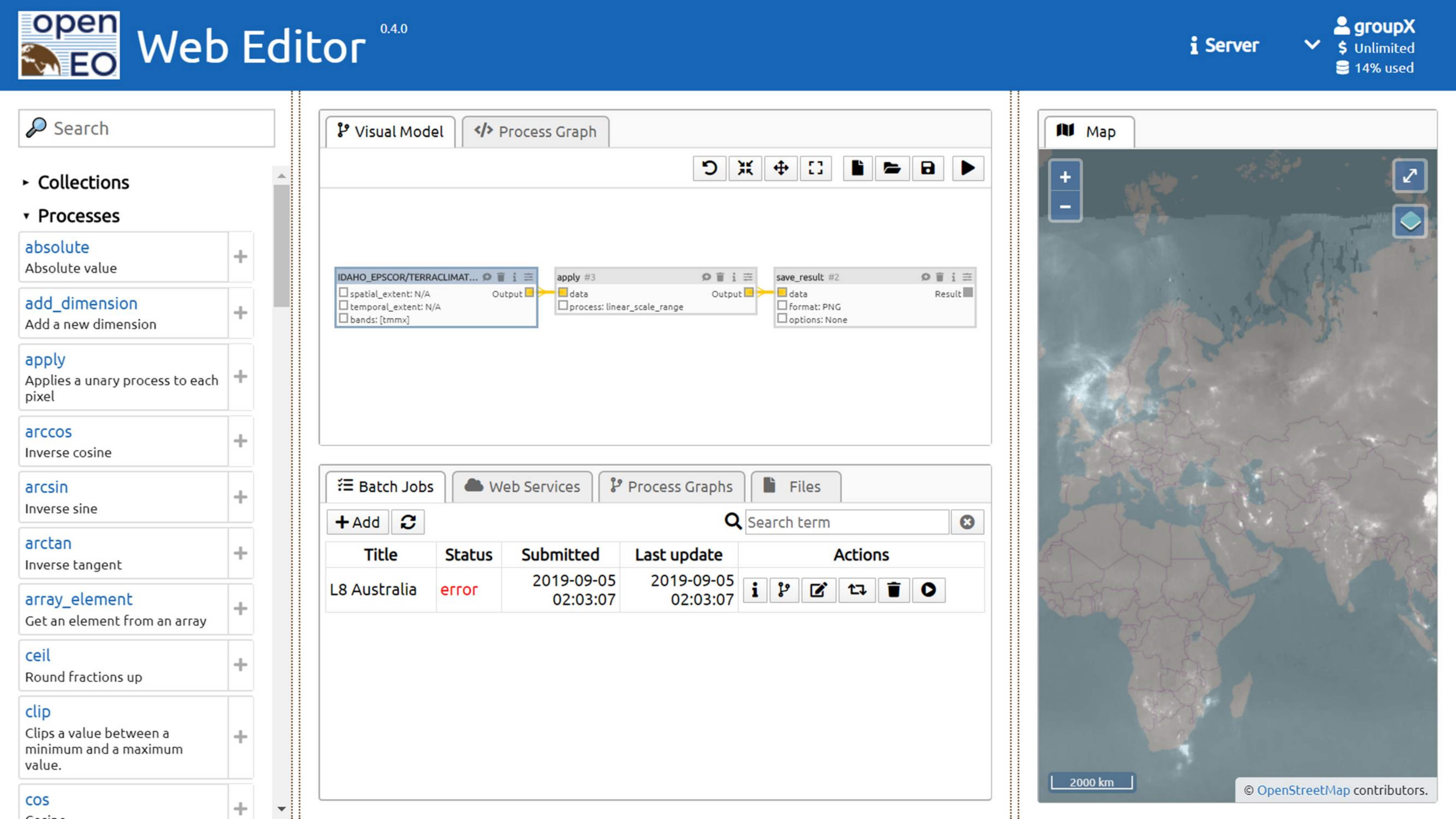
R Client

```
library(openeo)

con = connect(host = "openeo.cloud")
cube = con$processes()
data = cube$load_collection(
    „SENTINEL2_L2A",
    spatial_extent = list(west=16.1, east=16.6, north=48.6, south= 47.2),
    temporal_extent = list("2018-04-01", "2018-05-01")
)

data = cube$reduce(data = data, dimension = "bands",reducer = function(x) {
  B08 = x["B8"]
  B04 = x["B4"]
  B02 = x["B2"]
  (2.5 * (B08 - B04)) / sum(B08, 6 * B04, -7.5 * B02, 1)
})

data = cube$reduce(data = data, dimension = "t", reducer = min)
cube$save_result(data = data, format = "GTiff")
```



- absolute: Absolute value
- add_dimension: Add a new dimension
- apply: Applies a unary process to each pixel
- arccos: Inverse cosine
- arcsin: Inverse sine
- arctan: Inverse tangent
- array_element: Get an element from an array
- ceil: Round fractions up
- clip: Clips a value between a minimum and a maximum value.
- cos

IDAHO_EPSCOR/TERRACLIMAT...
□ spatial_extent: N/A
□ temporal_extent: N/A
□ bands: [tmmx]
Output

apply #3
□ data
□ process: linear_scale_range
Output

save_result #2
□ data
□ format: PNG
□ options: None
Result

Title	Status	Submitted	Last update	Actions
L8 Australia	error	2019-09-05 02:03:07	2019-09-05 02:03:07	