



Brockmann Consult

Environmental Informatics • Geoinformation Services

EuroSDR

Scaling up the Sentinels in Europe

26.-27.10.2020

Analysis Ready Data, data cubes and user tools for water colour products

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Managing Director Brockmann Consult GmbH, Germany

Data Usage, Levels and Tools



Raw data
Level 0

Instrument engineers
Technology experts



Processed data
Analysis ready data
Level 1, Level 2

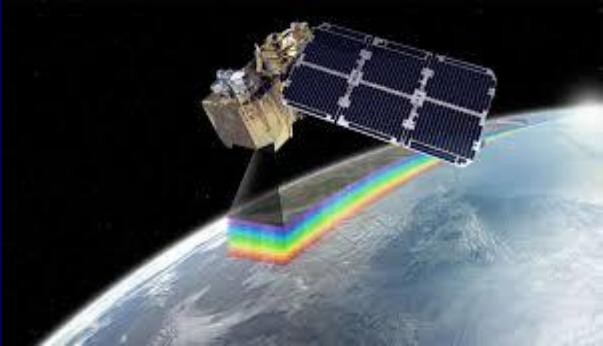
EO Experts
Value adding users



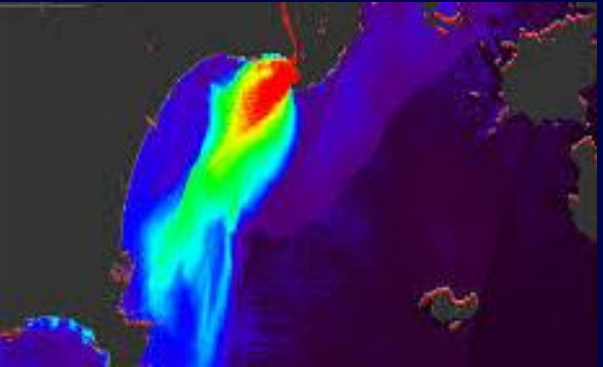
Thematic information
Interpretation ready data
Level 3, Level 4

Application domain users

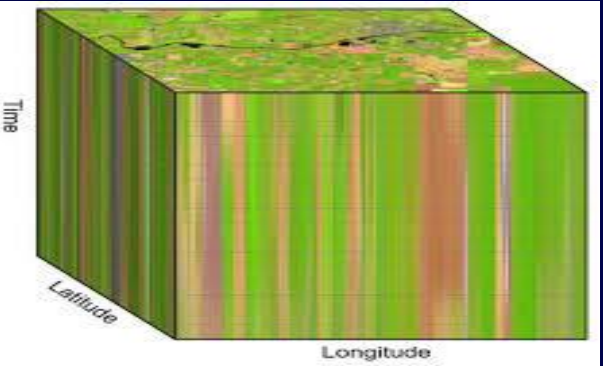
Data Usage, Levels and Tools



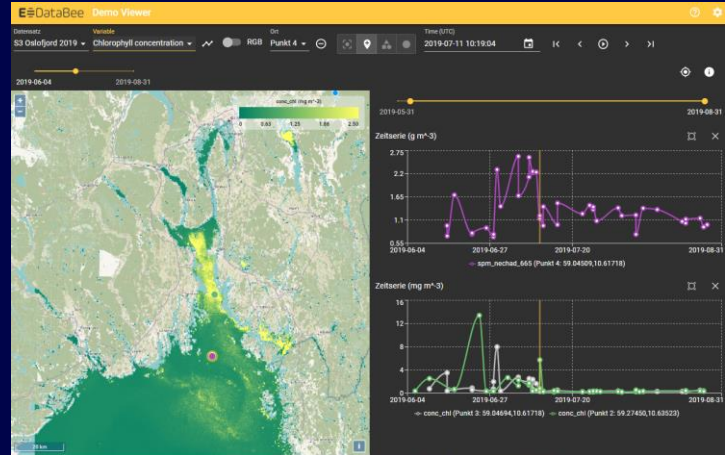
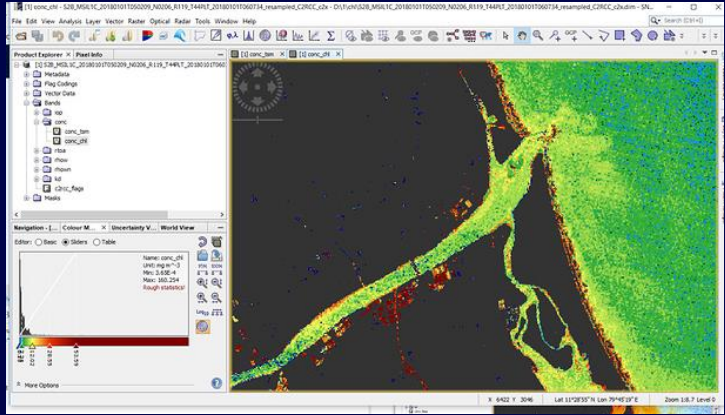
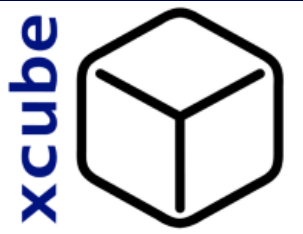
Raw data
Level 0



Processed data
Analysis ready data
Level 1, Level 2

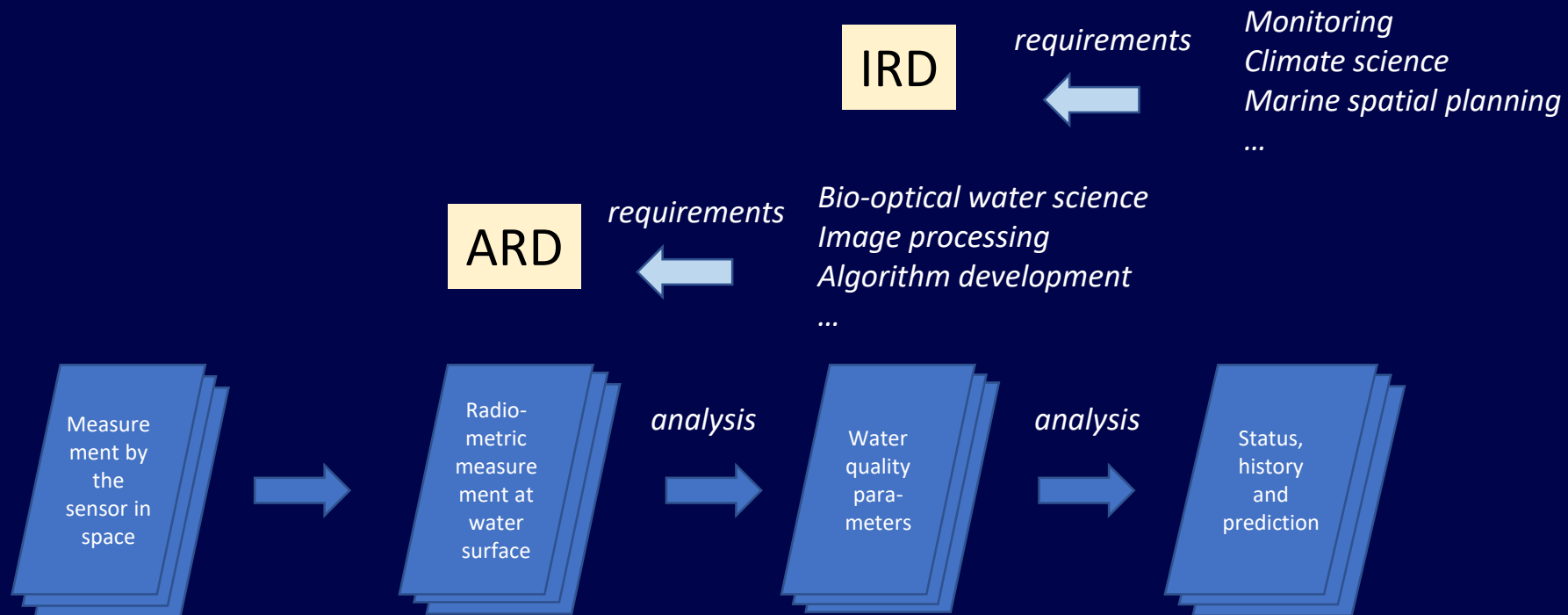


Thematic information
Interpretation ready data
Level 3, Level 4

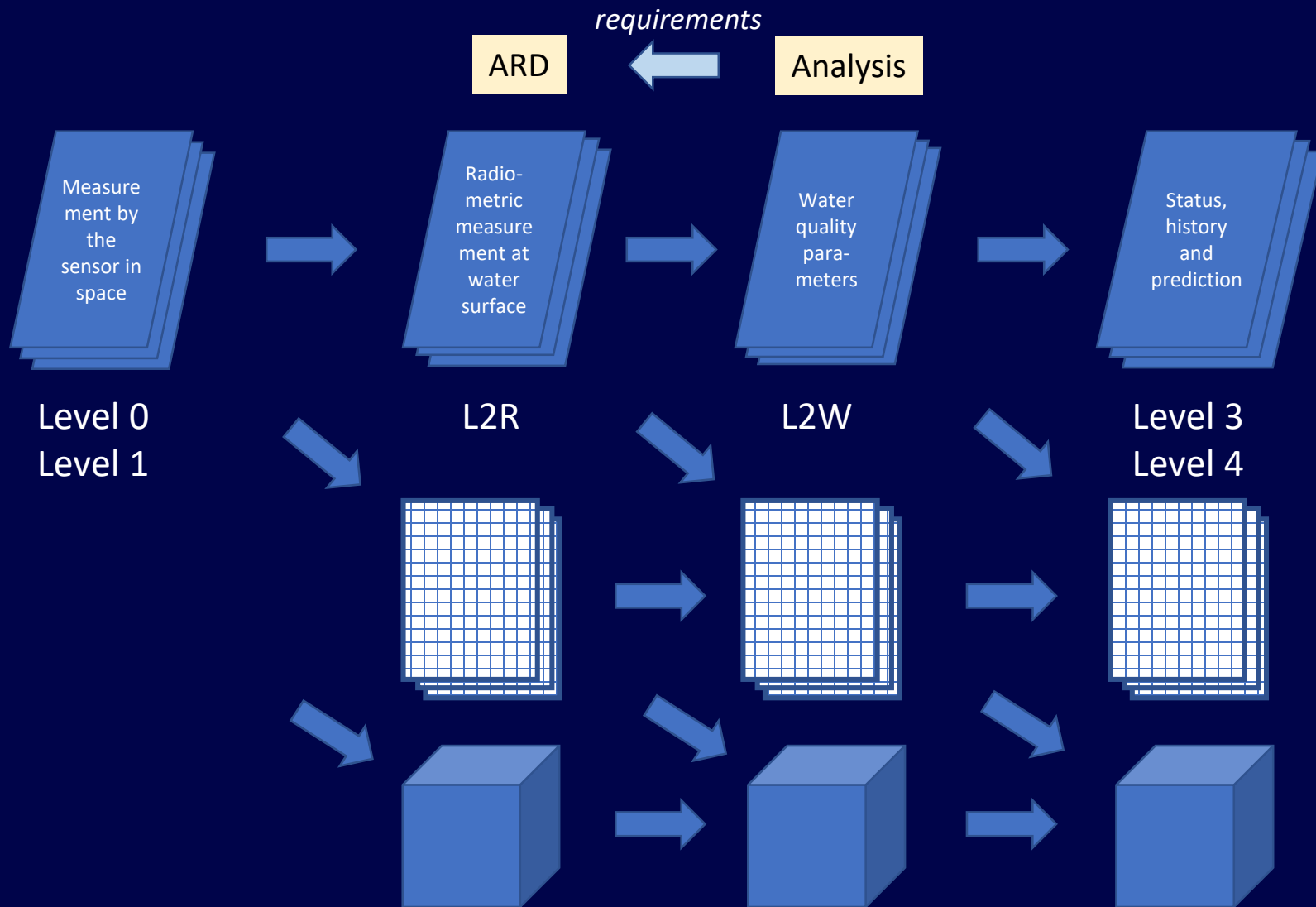


ARD-Water

- Analyses Ready – for which **analysis**?
 - depends who you are, and what is your profession
 - The **ANALYSIS** gives us the requirements for **READINESS**



ARD-Water



Variables space

- Common meta data @pixel, @product
- Same definition (method)
- Same validity (masking)
- Quality information @pixel, @product

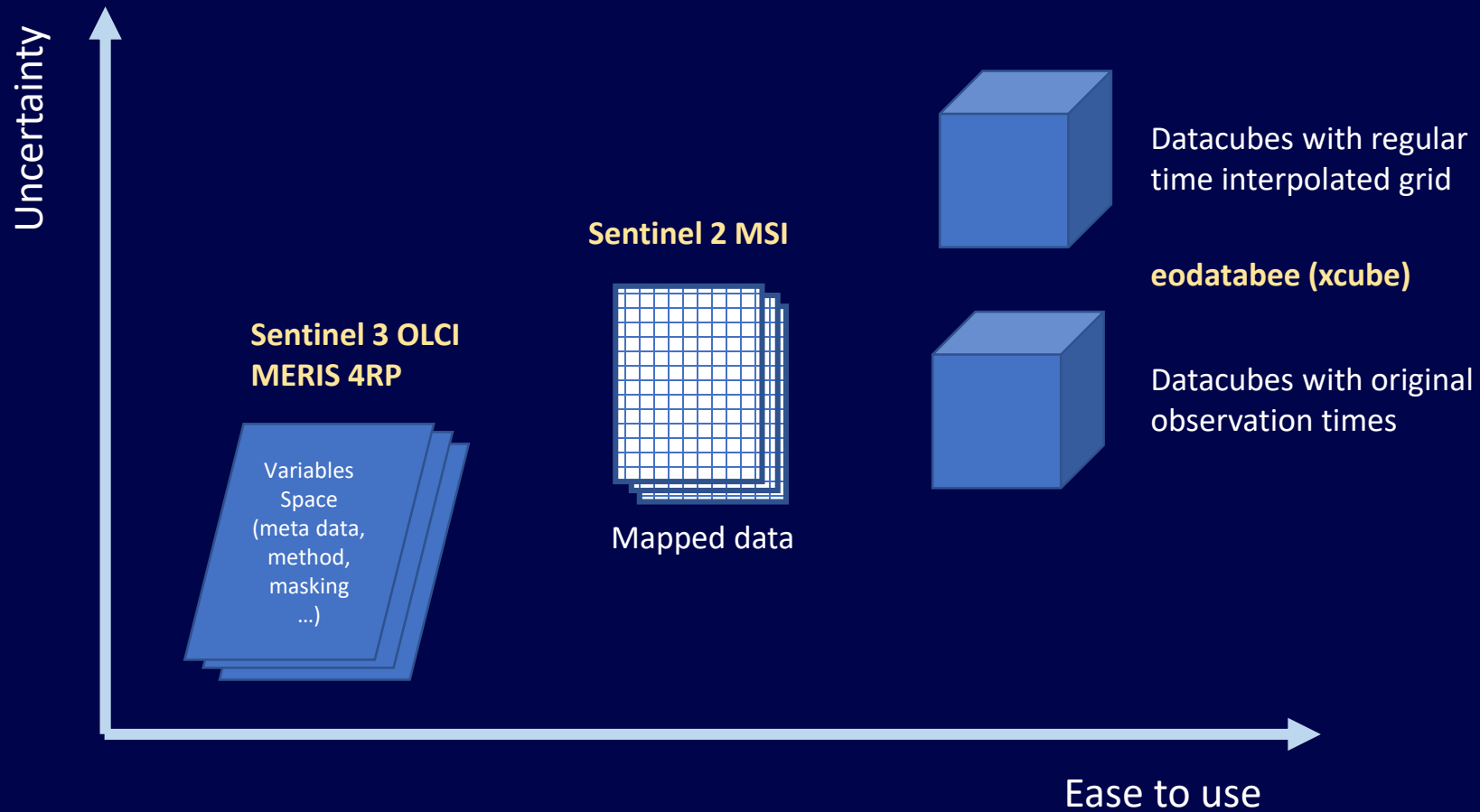
Mapped data

- Same spatial resolution
- Map projection
- Spatial grid

Datacubes

- Multiple variables
- Spatial grid
- Temporal grid
- Unique access (API)

ARD Benefit - Cost



CEOS - Analysis Ready Data

- CEOS: Satellite data that have been processed
 - to a minimum set of requirements
 - and organized into a form
 - that allows immediate analysis with a minimum of additional user effort
 - and interoperability both through time and with other datasets.
- Aquatic Reflectances, Product Family Specification (ongoing work)
 - Ongoing work by CEOS working group
 - Supported by GEO Aquawatch
- Requirements on
 - Product Meta data
 - Per-pixel meta data
 - Radiometric and Atmospheric corrections
 - Geometric correction
- Self-assessment table



Copernicus Space Segment

Copernicus Services

Downstream Services



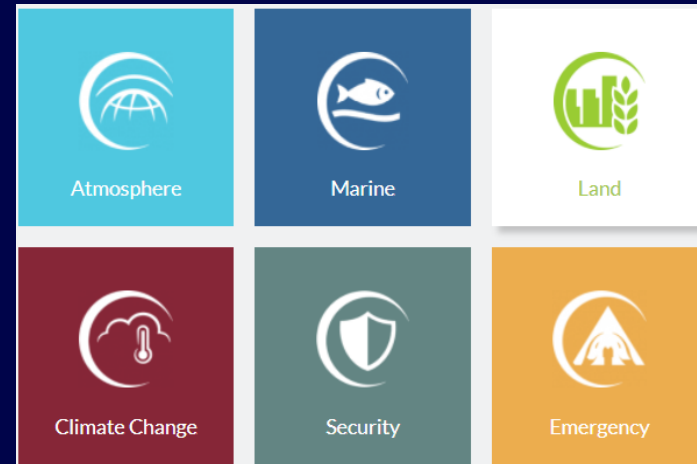
satellite raw data,
unprocessed

physical measurements
at satellite, e.g. top-of-
atmosphere radiance

thematic variables
at earth surface, in
L1 time-space
coordinates

temporal and
spatial aggregated,
map projection

Gap filled temporal and
spatial aggregation,
integration with models



Ground Segment Data relevant for Water Quality (not ARD)

Sentinel 2

- Level 1
 - TOA reflectances in 12 spectral bands
 - 15 – 180nm spectral bandwidth
 - 10 / 20 / 60 m spatial resolution
 - All inland waters and coastal areas (20km)
- Level 2
 - Scene classification (land-water-cloud etc)
 - Surface reflectances, good for land applications
 - No product for water applications
- **Water Quality products from CMEMS, CLMS & downstream service providers**

Sentinel 3


- Level 1
 - TOA radiances in 21 spectral bands
 - 10 – 20nm spectral bandwidth
 - 300m spatial resolution
 - Global coverage
- Level 2
 - Scene classification (land – water – cloud, including water specific classes)
 - Water leaving reflectance (ocean and coastal waters, not suitable for inland waters)
 - Chlorophyll and suspended matter concentrations
 - Yellow substance absorption
 - Attenuation coefficient
 - (more in preparation by EUMETSAT)

land.copernicus.eu


<https://land.copernicus.eu/global/products/lwq>

Copernicus Global Land Service

Providing bio-geophysical products of global land surface



- Home
- Products
- Use cases
- Product Access
- Viewing
- Library
- Get Support



- Lake Surf. Water Temp.
- Lake Water Quality
- Water Bodies
- Water Level

Water

Water is the key element of life on our planet.

To contribute to a better understanding of Earth's water cycle, the Copernicus Global Land Service helps to monitor:

- the water surface temperature and water quality (turbidity, trophic state) of medium and large-sized

Water product updates

300m Lake Water Quality products now available for more than 4000 inland waterbodies
Thu, 03 Sep 2020

1km Lake Surface Water

Copernicus Global Inland Water Service

- Spatial resolution

- 300m
- 100m

- Temporal

- 10days
- Best

- Time span

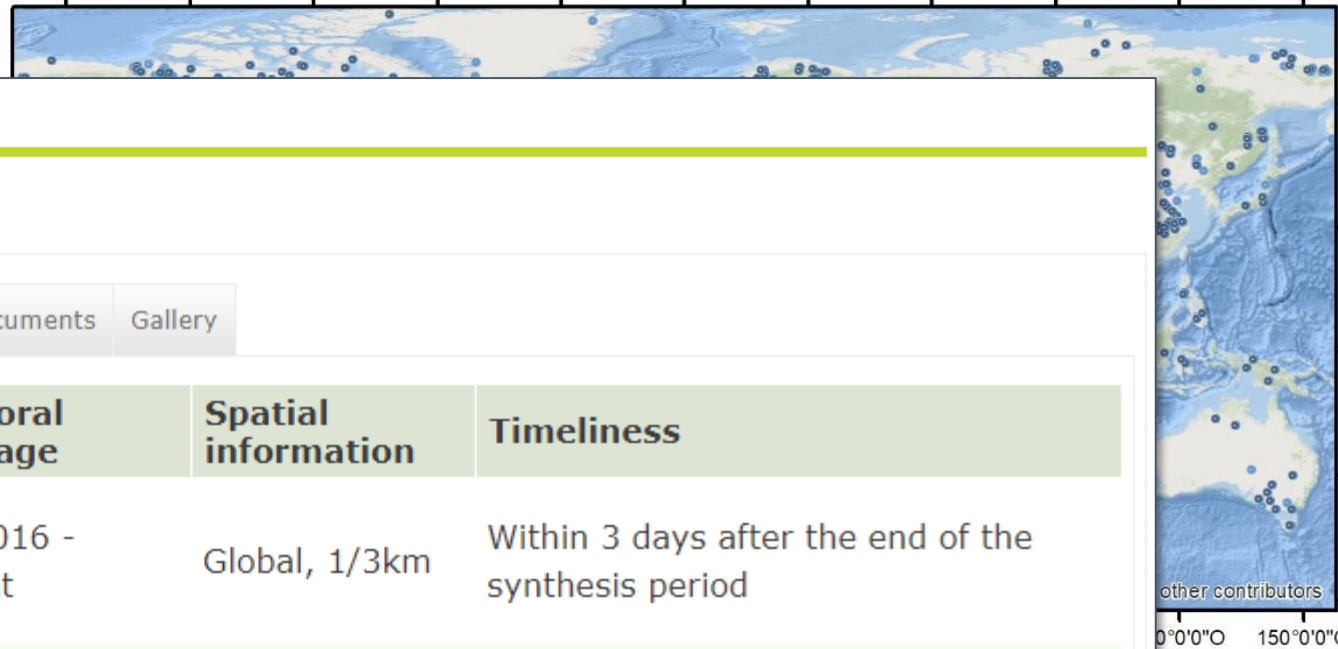
- 2002
- 2016

- Service

- Prod
- deca

- Status

- 300m: Operational products
- 100m: demonstration products 01/19-03/20



Lake Water Quality characteristics

LWQ 100m

LWQ 300m

LWQ 1km

Access

Algorithm

Quality

Application

Technical

Documents

Gallery

Product version	Access	Sensor	Temporal coverage	Spatial information	Timeliness
1	Product portal FTP	Sentinel3 OLCI	May 2016 - present	Global, 1/3km	Within 3 days after the end of the synthesis period
1	Product portal FTP	ENVISAT MERIS	May 2002 - March 2012	Global, 1/3km	Archive only

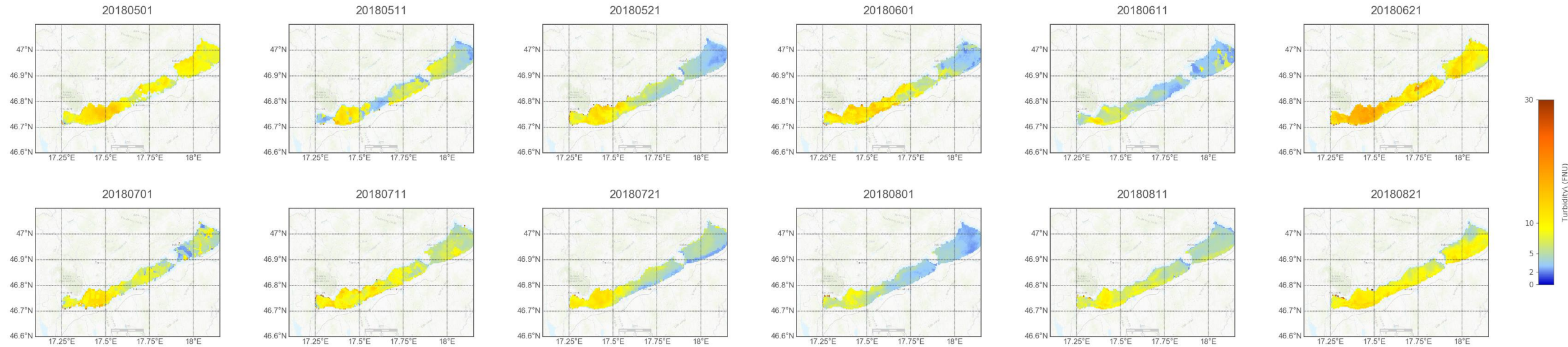
other contributors
0°0'0"O 150°0'0"O

(LSWT)

- Turbidity (TUR)
- Trophic State Index (TSI)
- Lake Surface Reflectances (LSR)

Product Example – Time series Lake Balaton

Lake Balaton - Turbidity



Copernicus Global Land Service, Lake Water Products
Processing: Calimos v 1.1.0, PML, BC
Inputdata: MERIS FRS © ESA
Background: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia,
© OpenStreetMap contributors, and the GIS User Community

Copernicus Marine Service (CMEMS) – Oceans



Marine

- Products

- Chlorophyll-a concentration
- Optical water properties
 - Reflectances, backscattering coefficient, light attenuation coefficient, absorption coefficient

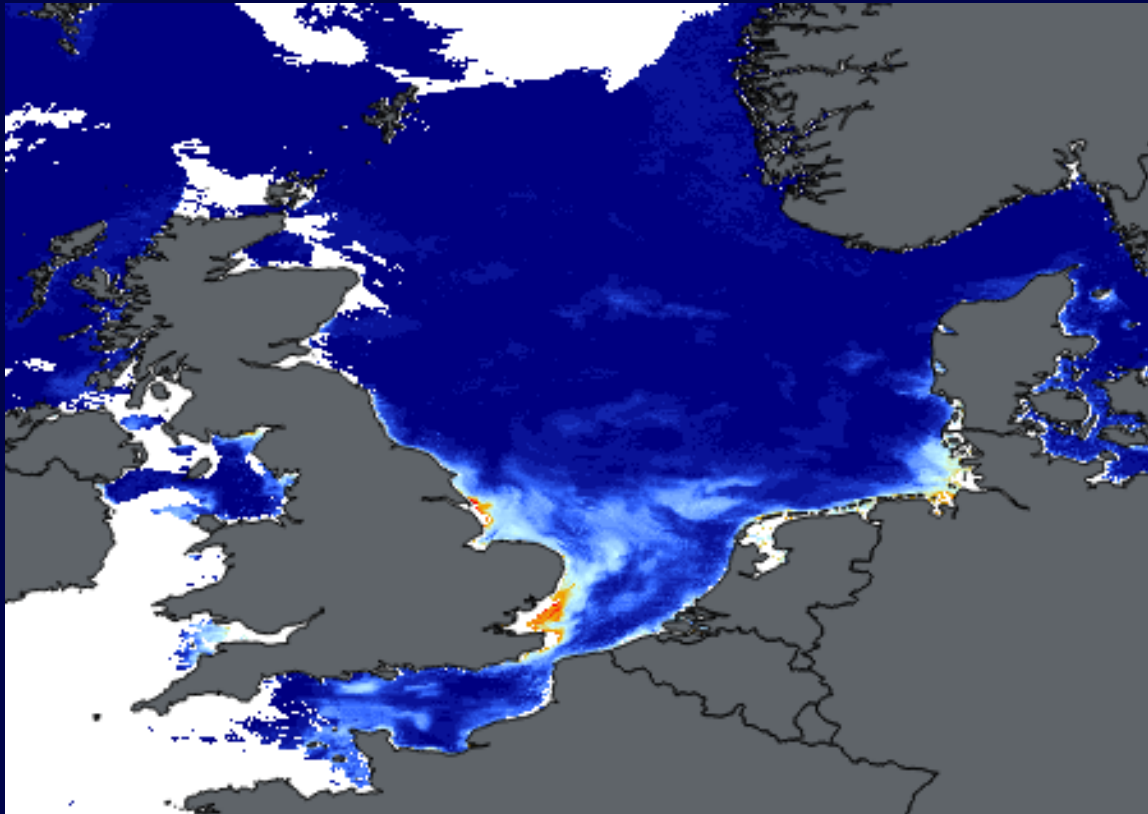
- Characteristics

- Per regional sea + global (see figure)
- Level 3:
 - daily mean
 - 1km x 1km and 4km x 4km
 - New: 100m x 100m based on Sentinel 2 (from 2021)
- Level 4:
 - Gap-filled
 - daily mean, monthly mean
 - 1km x 1km and 4km x 4km
 - New: 100m x 100m based on Sentinel 2 (from 2021)

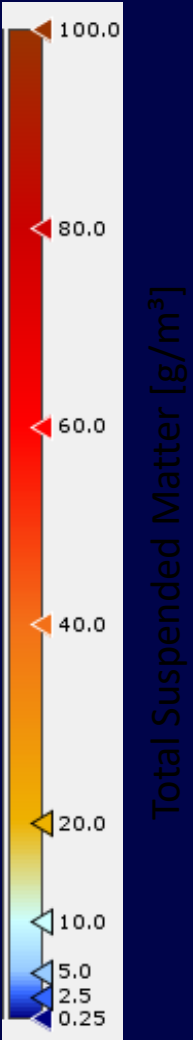
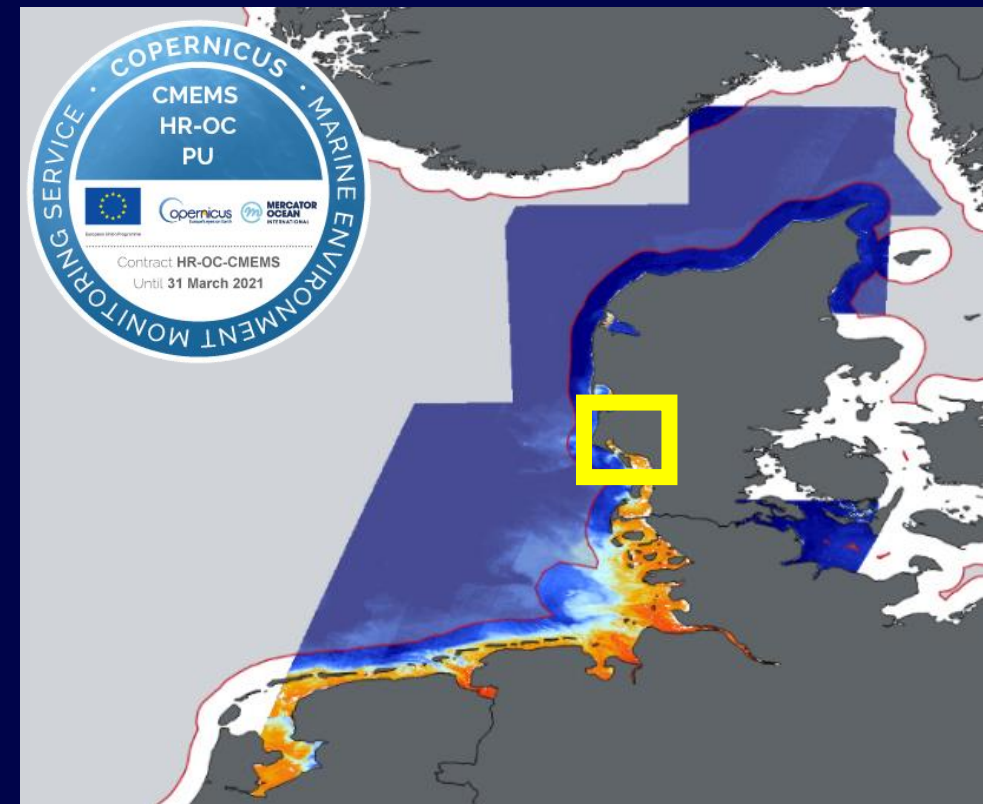


CMEMS TSM Product Example, 22.04.2020

Low Resolution Product (1km)

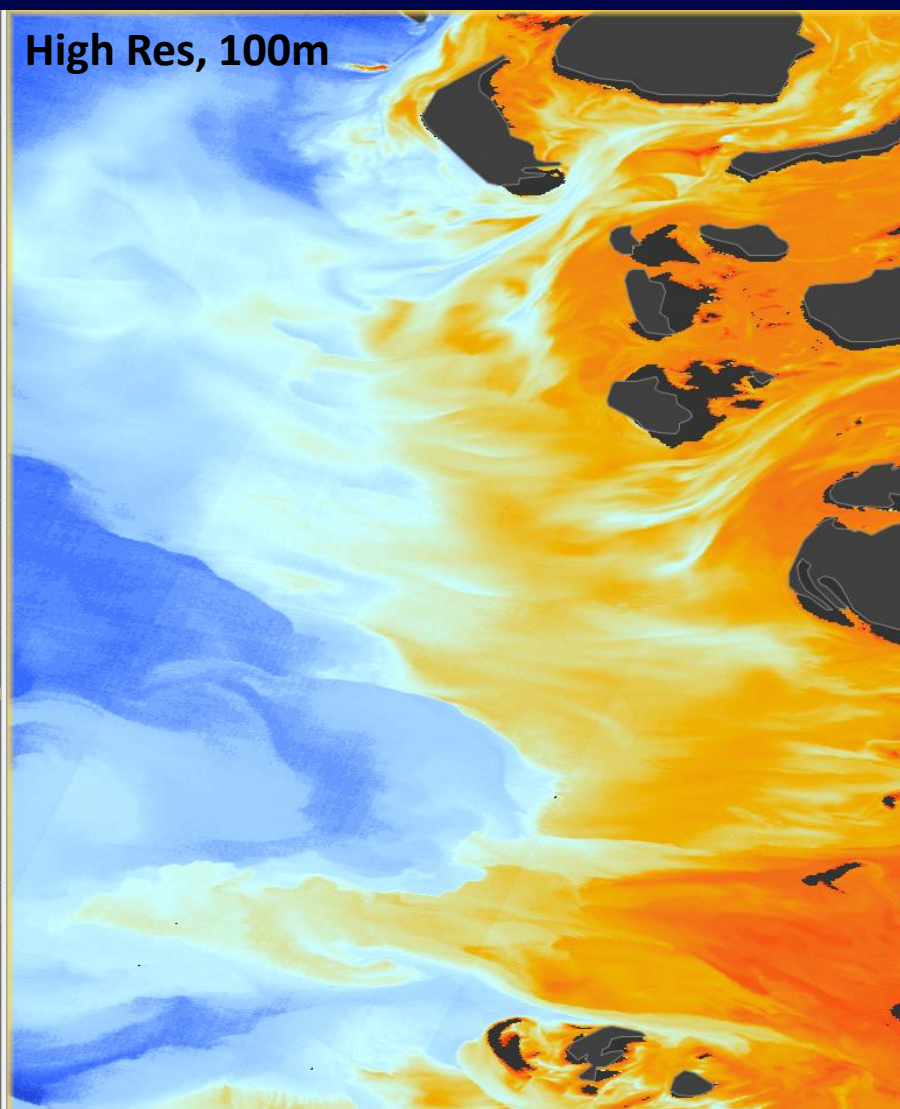
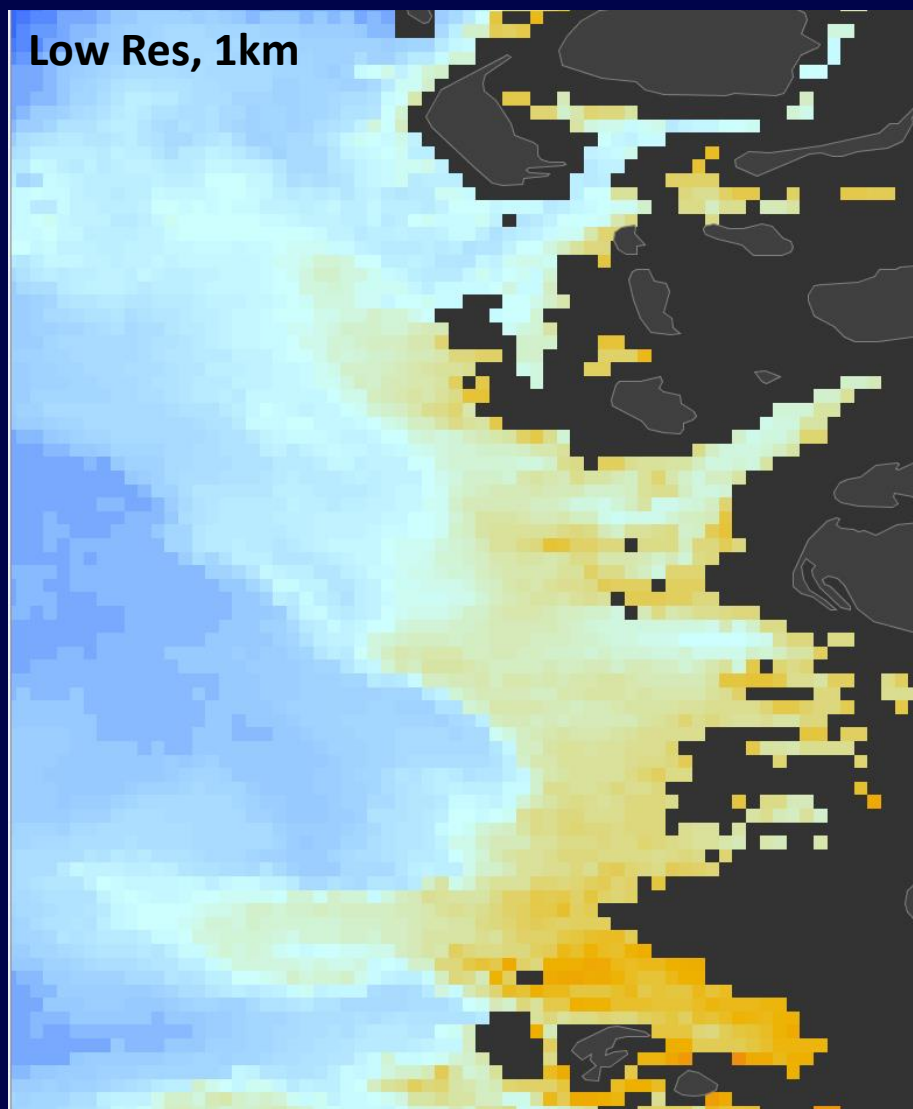


HR-OC Sentinel-2 Product (100m)



New Service, operated by Brockmann Consult, RBINS and VITO under contract of Moi. Operations will start early 2021. Processing performed on CREODIAS

CMEMS TSM Product Example, 22.04.2020



Total Suspended Matter [g/m^3]

SNAP 8

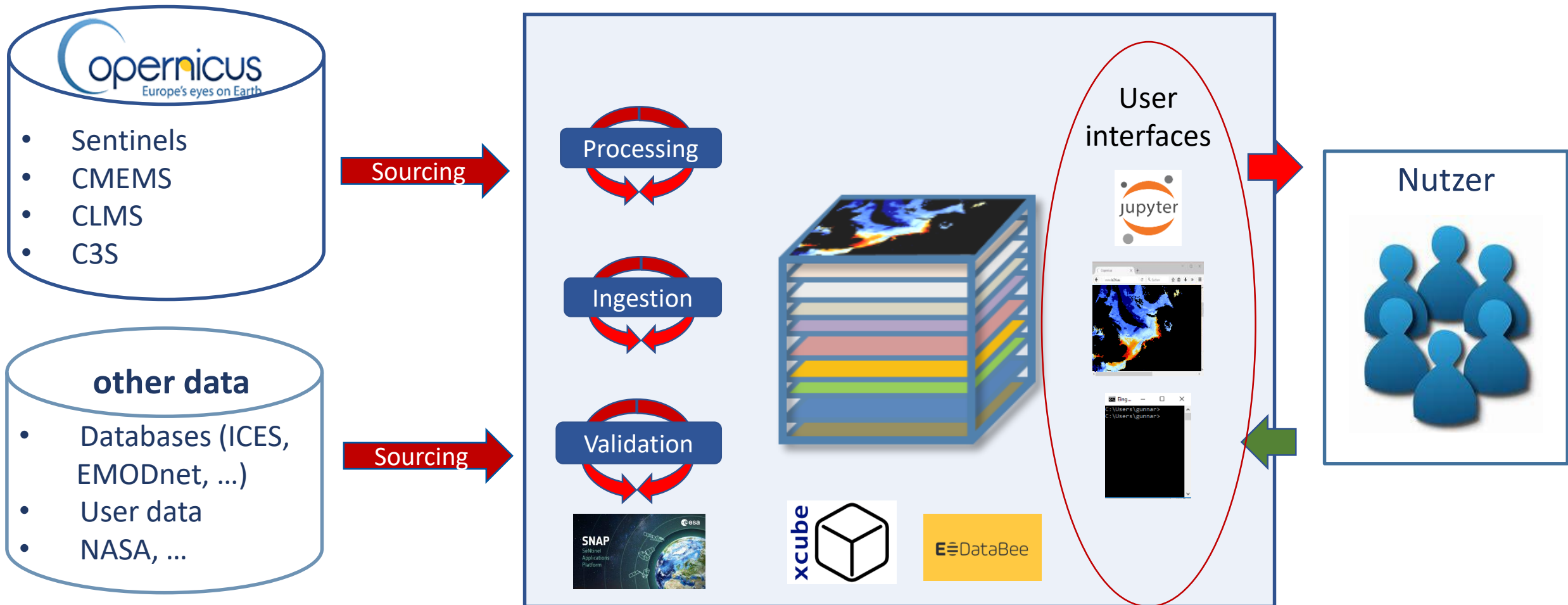
- More than 200 issues addressed
- Highlights:
 - remote data access of data
 - Copernicus Scientific Data Hub (SciHub): for Sentinel-1, Sentinel-2 and Sentinel-3 data
 - Amazon Web Services (AWS): for Sentinel-2 and Landsat-8 data
 - Alaska Satellite Facility (ASF): for Sentinel-1 and ALOS data
 - US Geological Survey (USGS): for Landsat-8 data
 - windowed reading of products
 - IO performance
 - memory management; tile cache operator
 - new implementation of geocoding
 - sensor specific features and improvements: Capella and SAOCOM support, soil moisture, S3 Fire Radiative Power support, S3 oblique view improvements
- Cloud optimised new standard I/O format zarr
 - Cloud optimised
 - Python xarray, dask
 - Directly useable by xcube (next slide)



The screenshot displays the SNAP Product Library interface. On the left, there are search filters for Repository (Scientific Data Hub), Account (carstenbrockmann), Mission (Sentinel2), Satellite (Sentinel-2), Start Date (09-08-2020), End Date (15-08-2020), Product Type (S2MS11C), Cloud Cover, Relative Orbit, Orbit Direction, Product Name, and UTM Tile. The main area shows a list of products with columns for URL, Mission, Acquisition date, and Size. A satellite imagery map of Norway is visible at the bottom left, with a red box indicating the Area of Interest. The right sidebar contains 'Product Library', 'Layer Manager', and 'Mask Manager' tabs. At the bottom, there is a 'Timeline' section with a calendar view showing the current month as August.

ARD in a Datacube

Combination of data and services in data datacube



Datensatz

S2 Trondheimsfjord 32VNR Summer 2018

Variable

suspended particulate matter concentration in seawater generated using Nechad et al, 2010 algorithm



RGB

Ort

Punkt 1

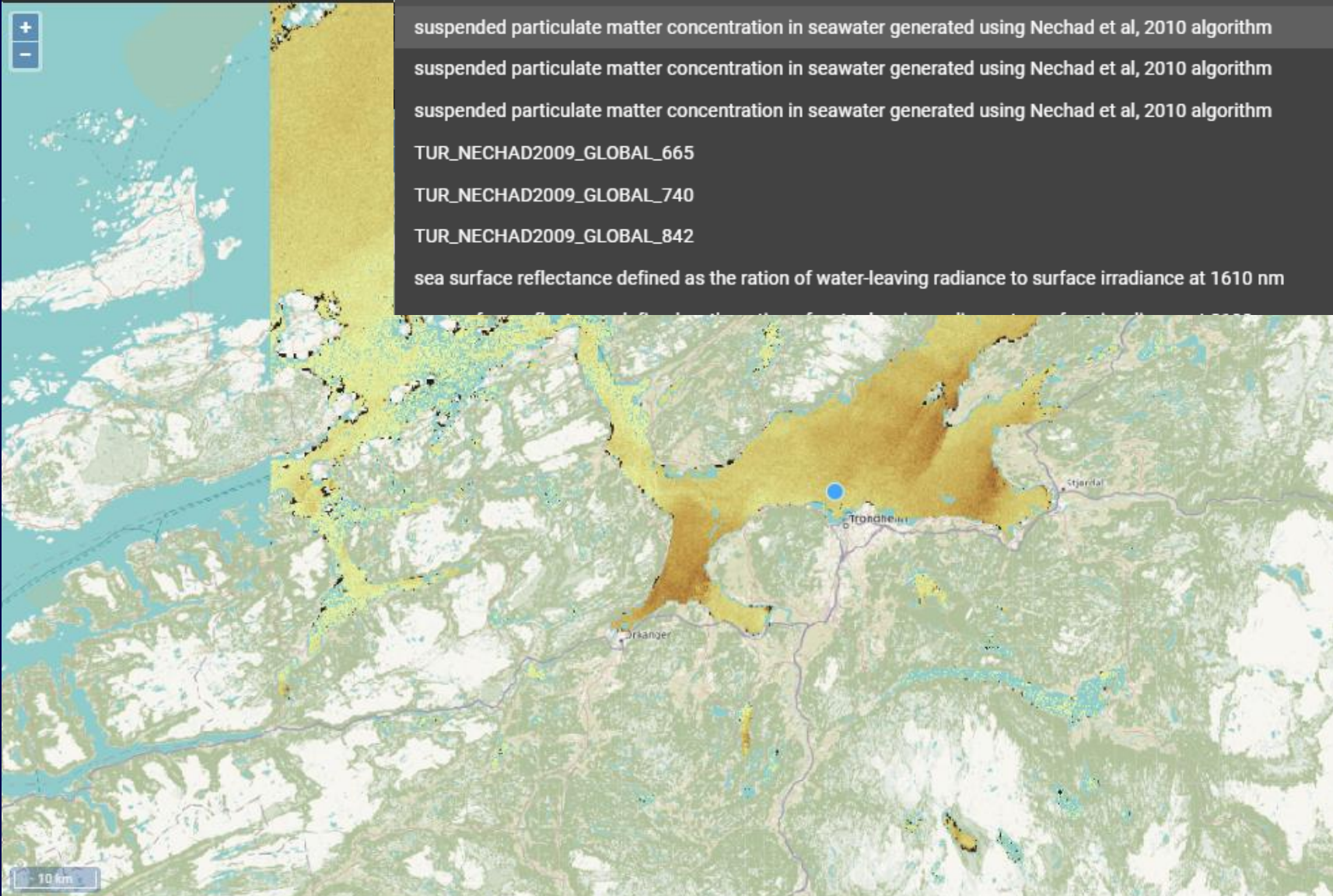
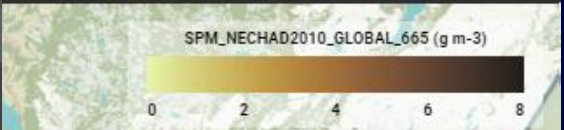


Time (UTC)

2018-06-30 10:50:2



- Chlorophyll-a concentration in seawater, generated by the two-band algorithm from Gilerson et al. (2010)
- Chlorophyll-a concentration in seawater, generated by the two-band algorithm from Gilerson et al. (2010)
- suspended particulate matter concentration in seawater generated using Nechad et al, 2010 algorithm
- suspended particulate matter concentration in seawater generated using Nechad et al, 2010 algorithm
- suspended particulate matter concentration in seawater generated using Nechad et al, 2010 algorithm
- TUR_NECHAD2009_GLOBAL_665
- TUR_NECHAD2009_GLOBAL_740
- TUR_NECHAD2009_GLOBAL_842
- sea surface reflectance defined as the ration of water-leaving radiance to surface irradiance at 1610 nm

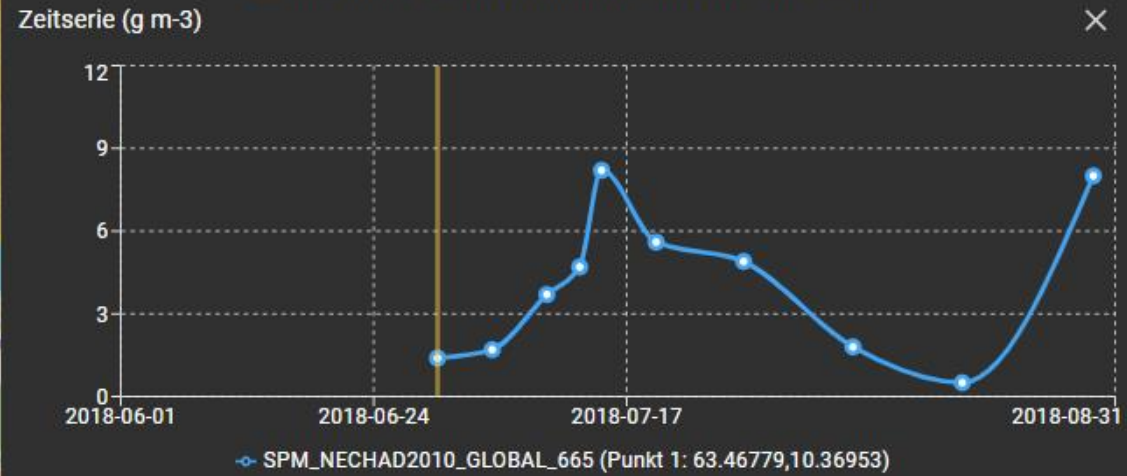
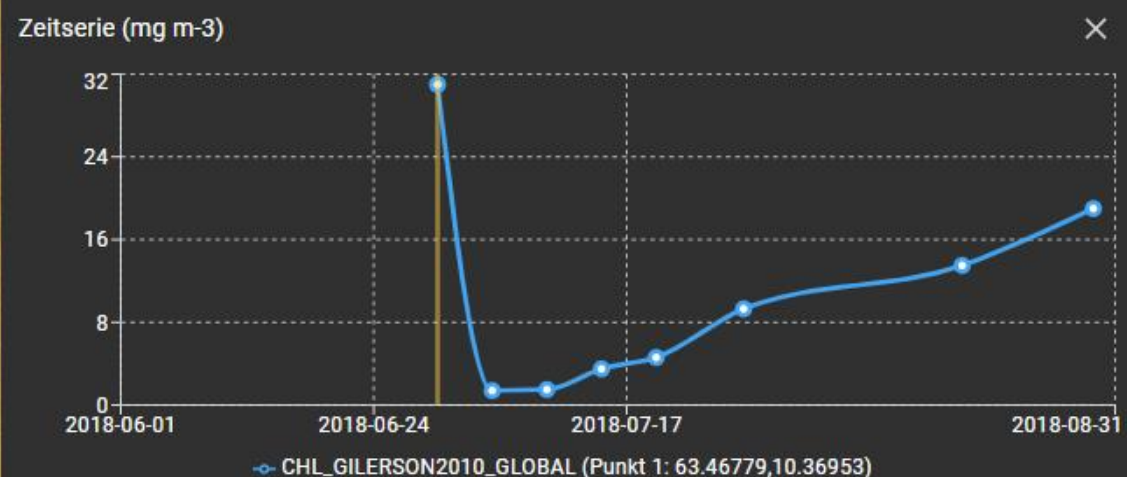
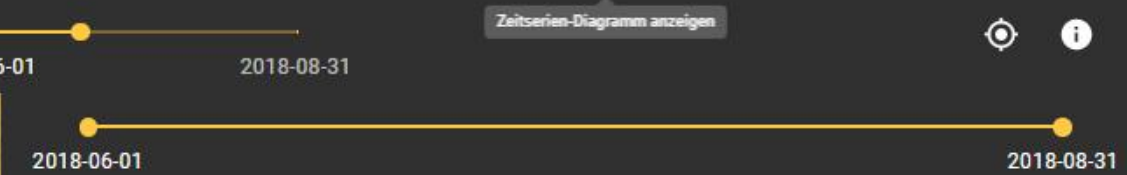
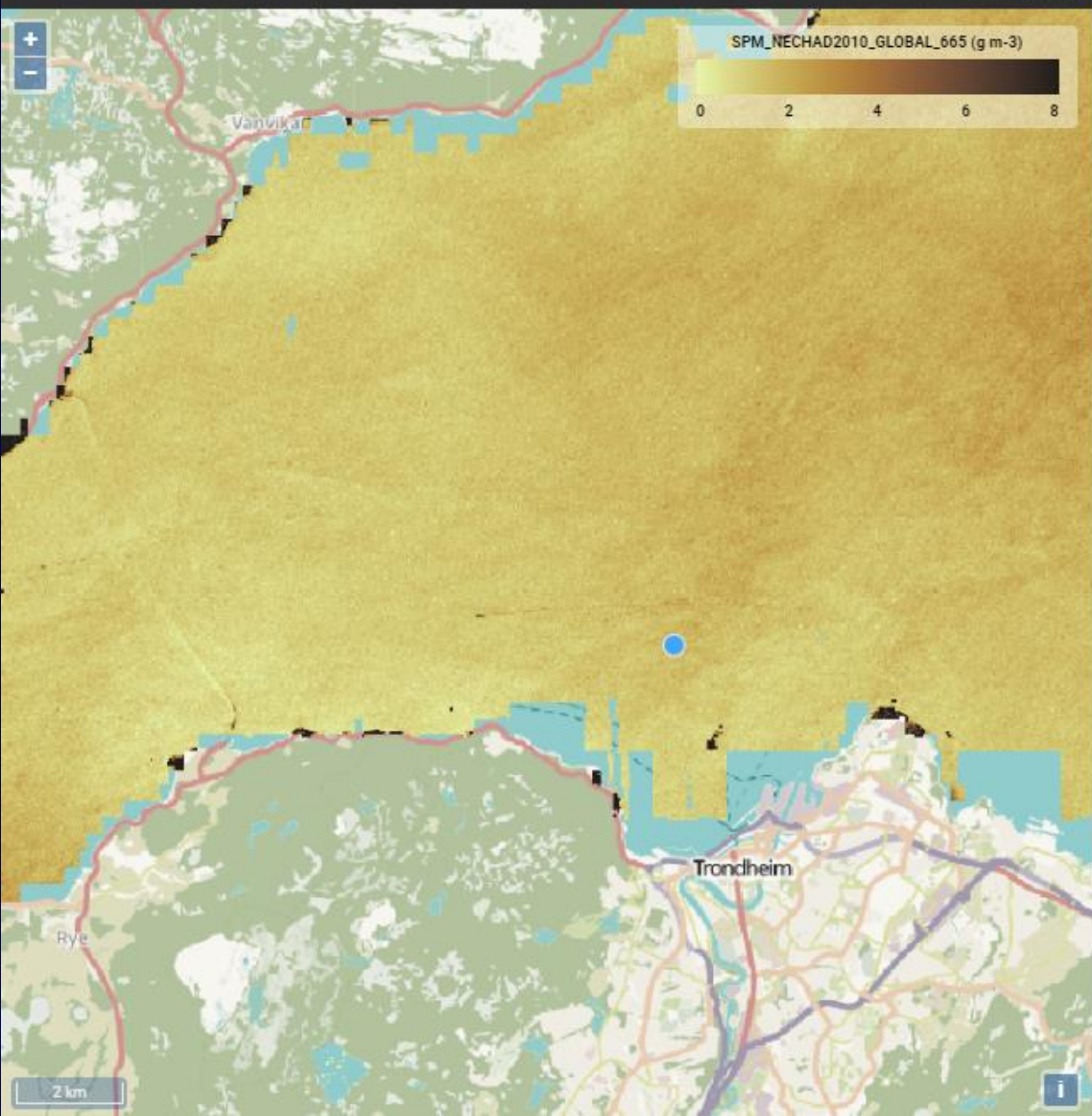


Datensatz S2 Trondheimsfjord 32VNR Summer 2018

Variable suspended particulate matter concentration in seawater generated using Nechad et al, 2010 algorithm

Ort Punkt 1

Time (UTC) 2018-06-30 10:50:27
2018-06-01 2018-08-31



Python API

Using the xcube python API in a Jupyter notebook

```
EDC_demo_phi-week_v1.ipynb X
+ - - - - - Code - - - - - EDC 0.21.2 (Python3)
bbox = x1, y1, x2, y2
spatial_res = 0.00018 # spatial resolution (approx. 20 m in degree)
time_tolerance = '2H'
```

A description about the dataset and the bands may be found here: <https://docs.sentinel-hub.com/api/latest/data/sentinel-2-l2a/>.

Step 3: Setting cube configurations for 2018 summer season (May - August)

```
[6]: cube_config_2018 = CubeConfig(dataset_name = dataset_name,
    band_names = band_names,
    tile_size = tile_size,
    bbox = bbox,
    spatial_res = spatial_res,
    time_range = ['2018-05-01', '2018-08-31'],
    time_tolerance = time_tolerance)
```

Step 4: View bounding box to check selected area

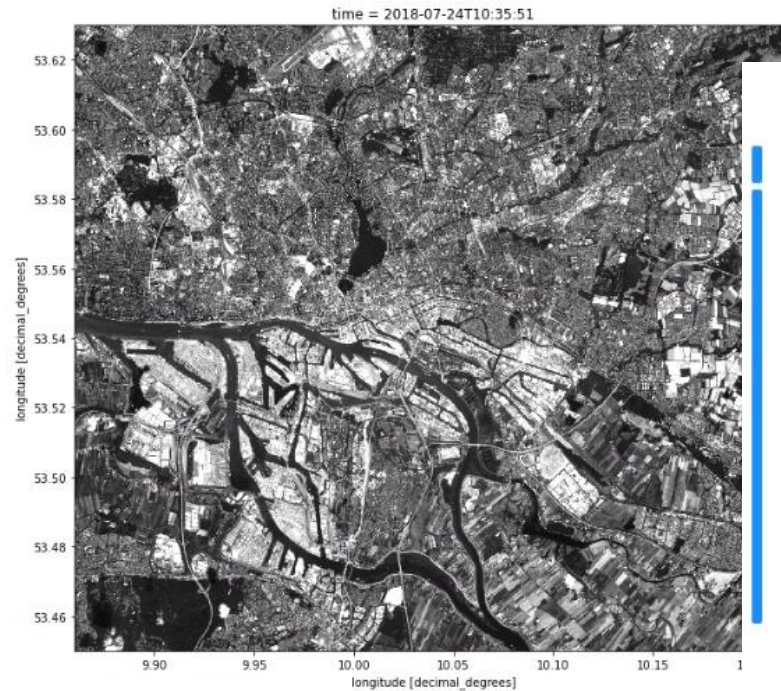
```
[7]: IPython.display.GeoJSON(Shapefile.geometry.box(*bbox).__geo_interface__)
```



Step 5: Open data cube

```
[9]: cube_S2_2018.B04.sel(time='2018-07-25 12:00:00', method='nearest').plot.imshow(vmin=0, vmax=0.2, cmap='Greys_r', figsize=(14, 10))
```

```
[9]: <matplotlib.image.AxesImage at 0x7fec2df57110>
```

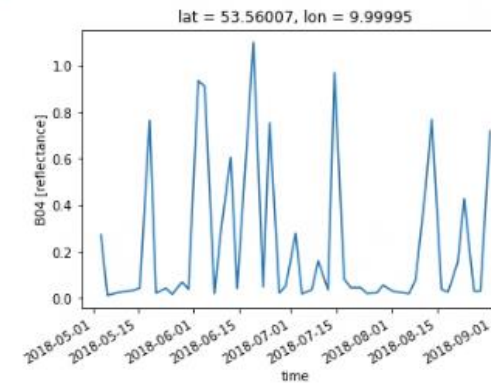


Step 7: Plot a timeseries for a certain location

Step 7: Plot a timeseries for a certain location

```
[10]: cube_S2_2018.B04.sel(lat=53.56, lon=10.00, method='nearest').plot()
```

```
[10]: [<matplotlib.lines.Line2D at 0x7fec2e1f5050>]
```



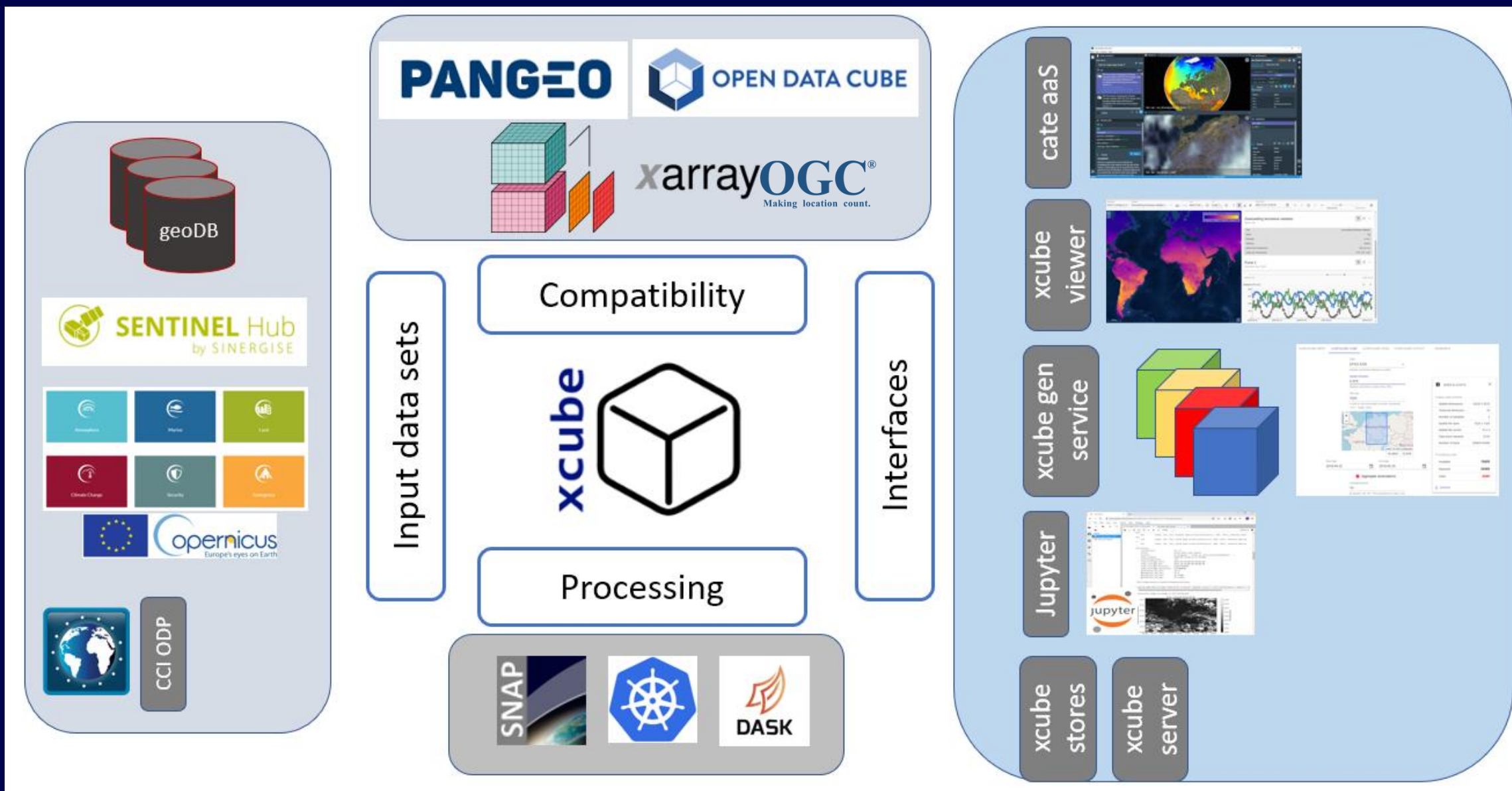
If one wants a subest. e.g. because the region of interest is smaller, this can be achieved by using xcube python api:

```
[11]: # xcube imports
from xcube.core.compute import compute_cube
from xcube.core.maskset import MaskSet
from xcube.core.geom import mask_dataset_by_geometry
from xcube.core.geom import clip_dataset_by_geometry
```

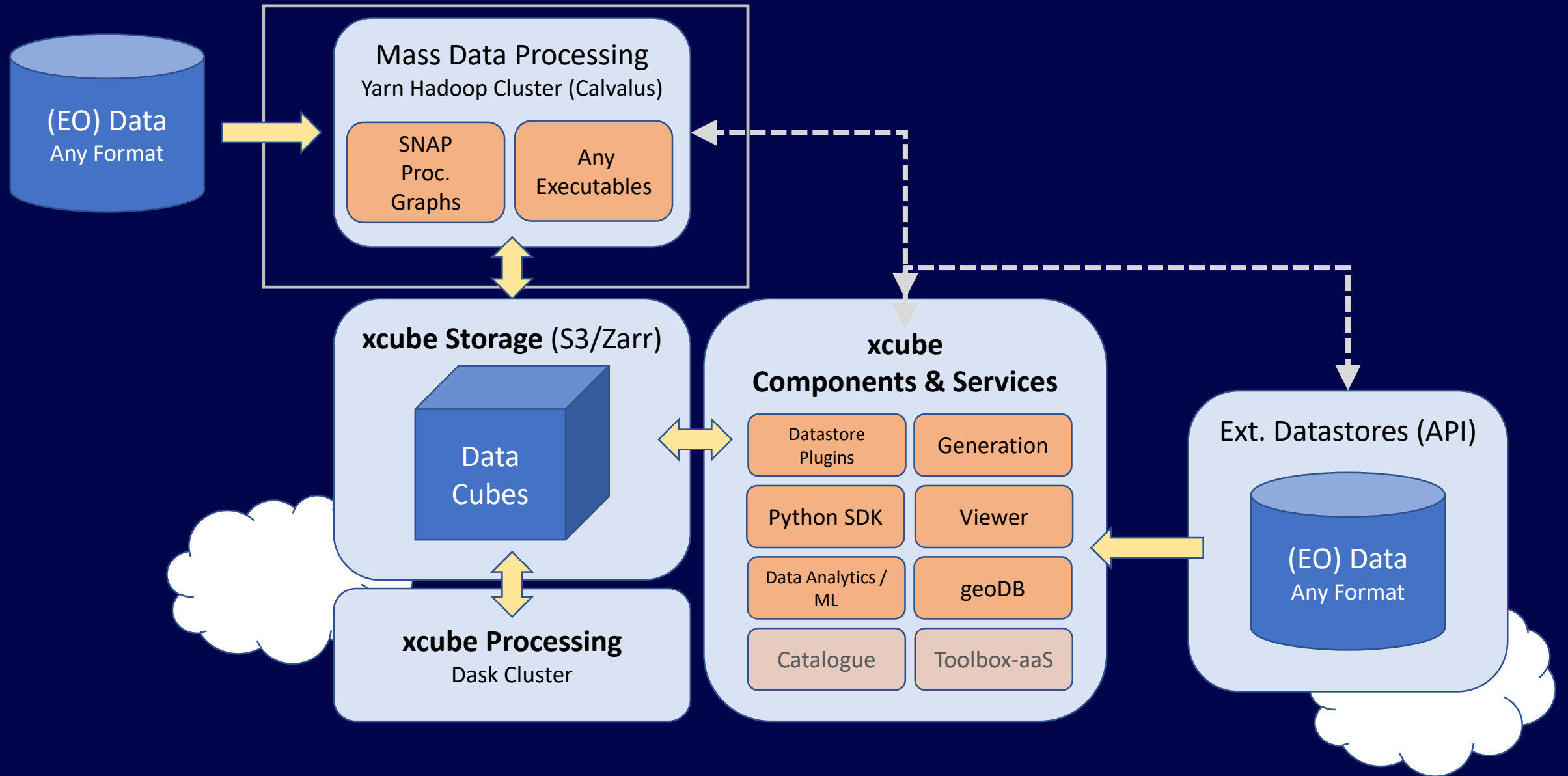
There are two ways of selecting the area of interest:

- By masking - this keeps only the data of the WKT Polygon or shapefile

The xcube Ecosystem

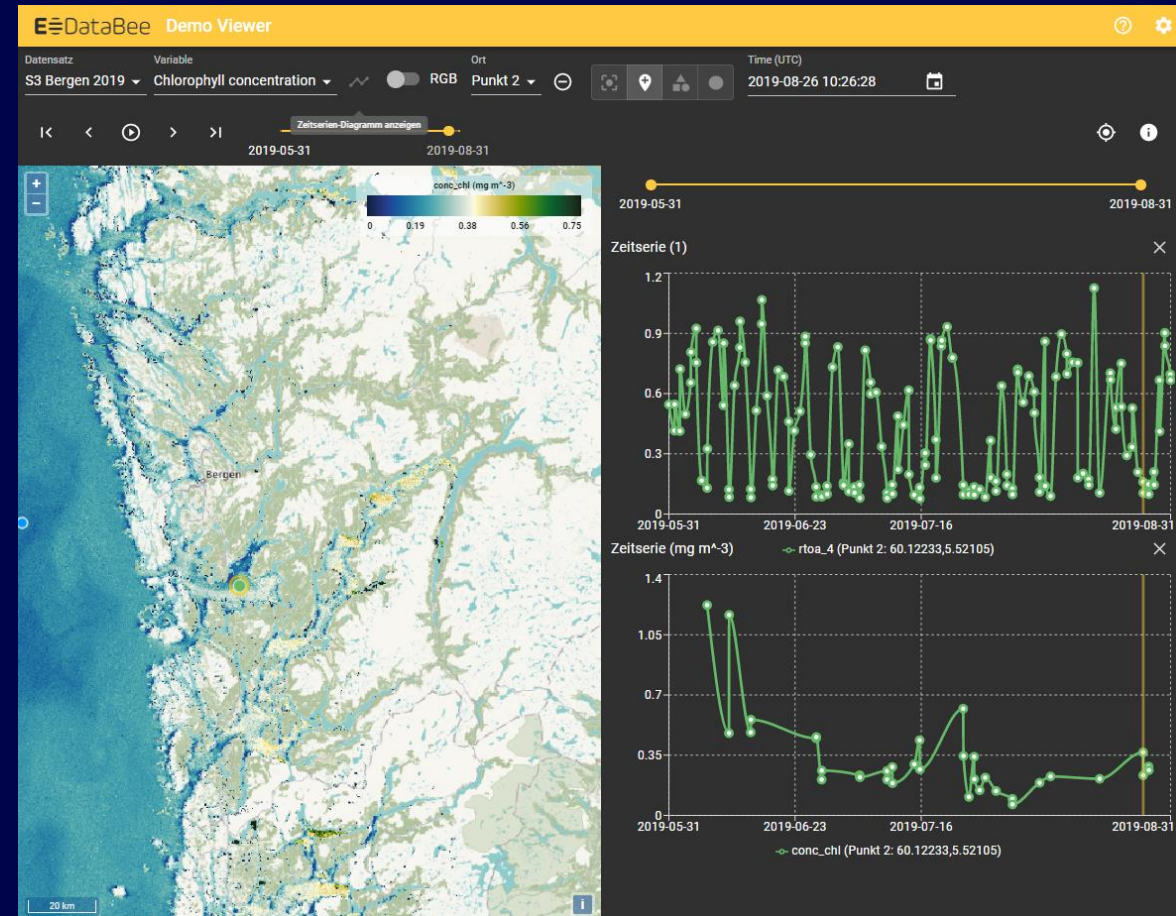


xcube Technical View



eodatabee

- A data cube service providing EO and non-EO data with a focus on water quality products.
- Customisability of the service and unique combination of scientific, regional, and technological competence.
- EODataBee service comprises the following Service Elements:
 - Water quality products
 - Scientific Consultancy
 - Datacube generation, operation, and visualisation service
 - Training
- It is operated by a group of domain expert companies, emerging from EU H2020 project DCS4COP (Brockmann Consult, RBINS, VITO, NIVA, Univ. Hull, Cefas, LOV, Starlab)



Take-home messages

- Analysis Ready Data are satellite data processed to common agreed standards, are provided with meta data and are organised in space and time so that they can be easily used with a minimum of additional user effort.
- EO data users have optimal support for analysis, algorithm development and testing, as well as routine, operational production with SNAP. SNAP 8 comes with new cloud and datacube optimised I/O format (zarr, COG [future])
- xcube ecosystem is an suite of python tools to support ARD.
- eodatabee is offering xcube tailored to water quality products and amended with additional services.