openEO platform & the EO platform ecosystem

Patrick Griffiths
ESA EOP-SDD

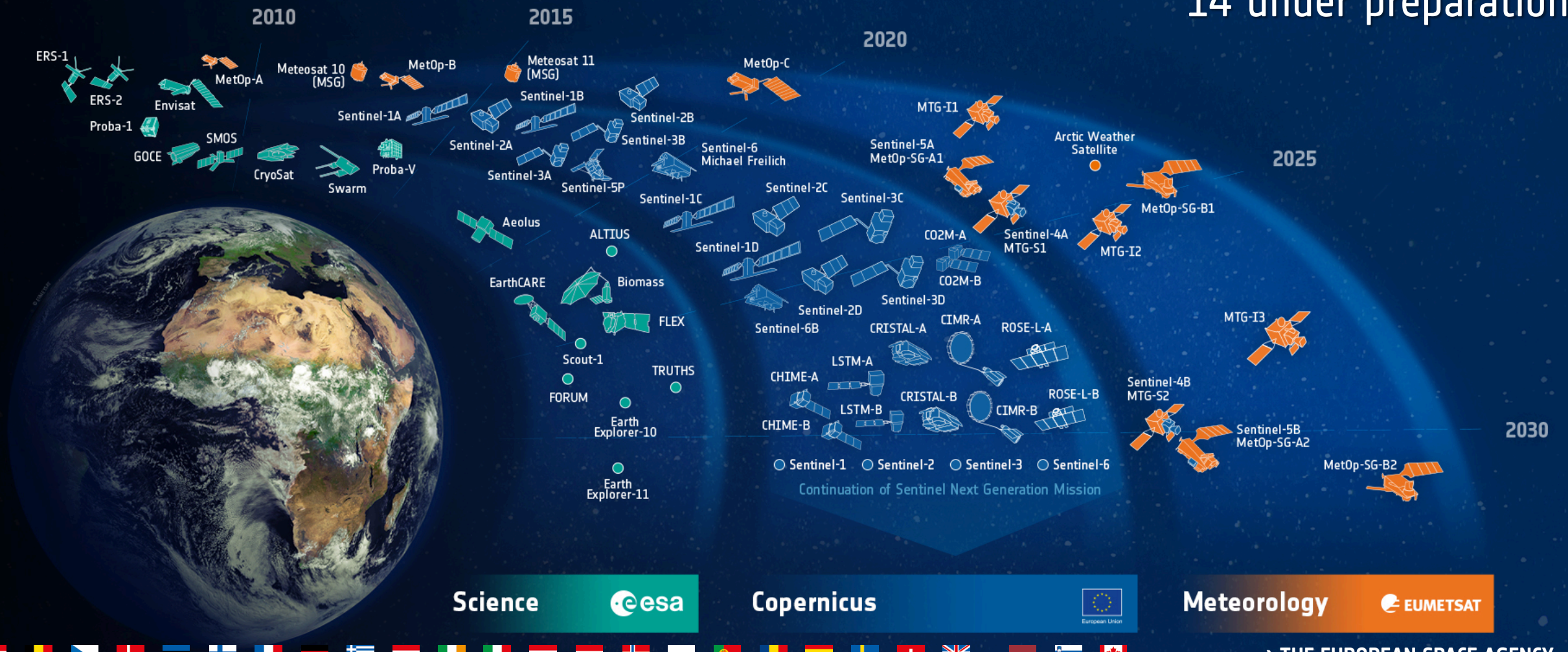
10/06/2021
EODC Forum 2021

ESA EO Vision:

Taking the Pulse of our Planet

ESA-Developed Earth Observation Satellites

16 in operation
38 under development
14 under preparation

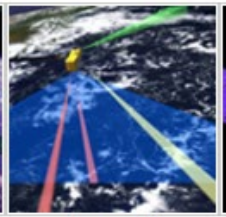


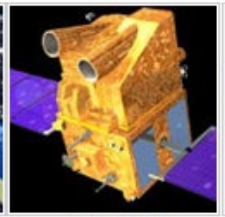
Science esa | Copernicus European Union | Meteorology EUMETSAT

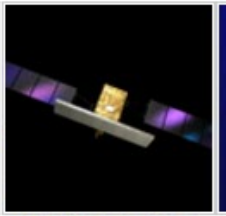
→ THE EUROPEAN SPACE AGENCY

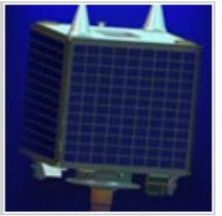
Third Party Missions

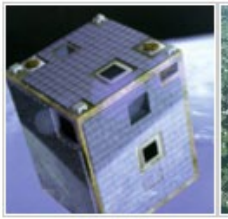

ALOS

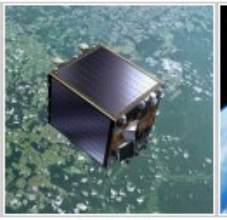

Aura OMI


CartoSat-1

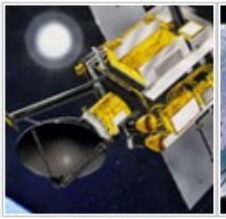

COSMO-SkyMed

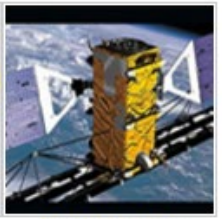

Deimos-1


Proba-1


Proba-V


QuickBird

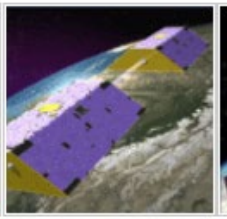

QuikSCAT

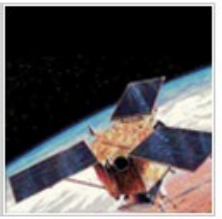

RADARSAT-2


Deimos-2

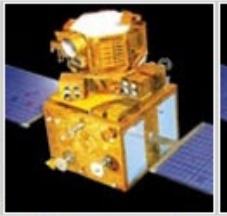

GeoEye-1

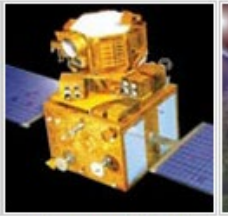

GOSAT

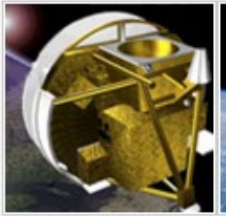

GRACE


IKONOS


RapidEye


ResourceSat-1


ResourceSat-2


SciSat-1/ACE


SeaSat

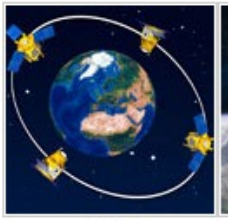

IRS-1C


IRS-1D

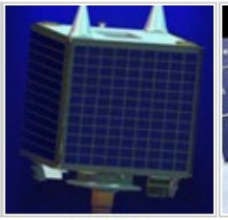

JERS-1

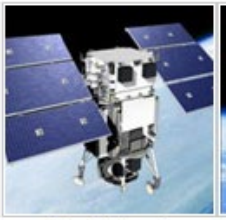

KOMPSAT-1


KOMPSAT-2


SPOT


TerraSAR-X and TanDEM-X

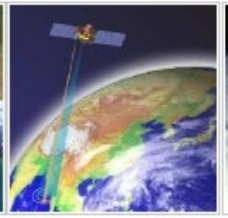

UK-DMC

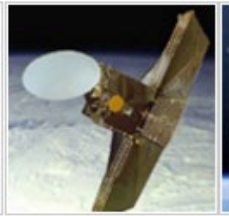

WorldView-1

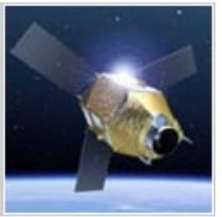

WorldView-2

Landsat TM/ETM


Landsat OLI/TIRS


OceanSat-2

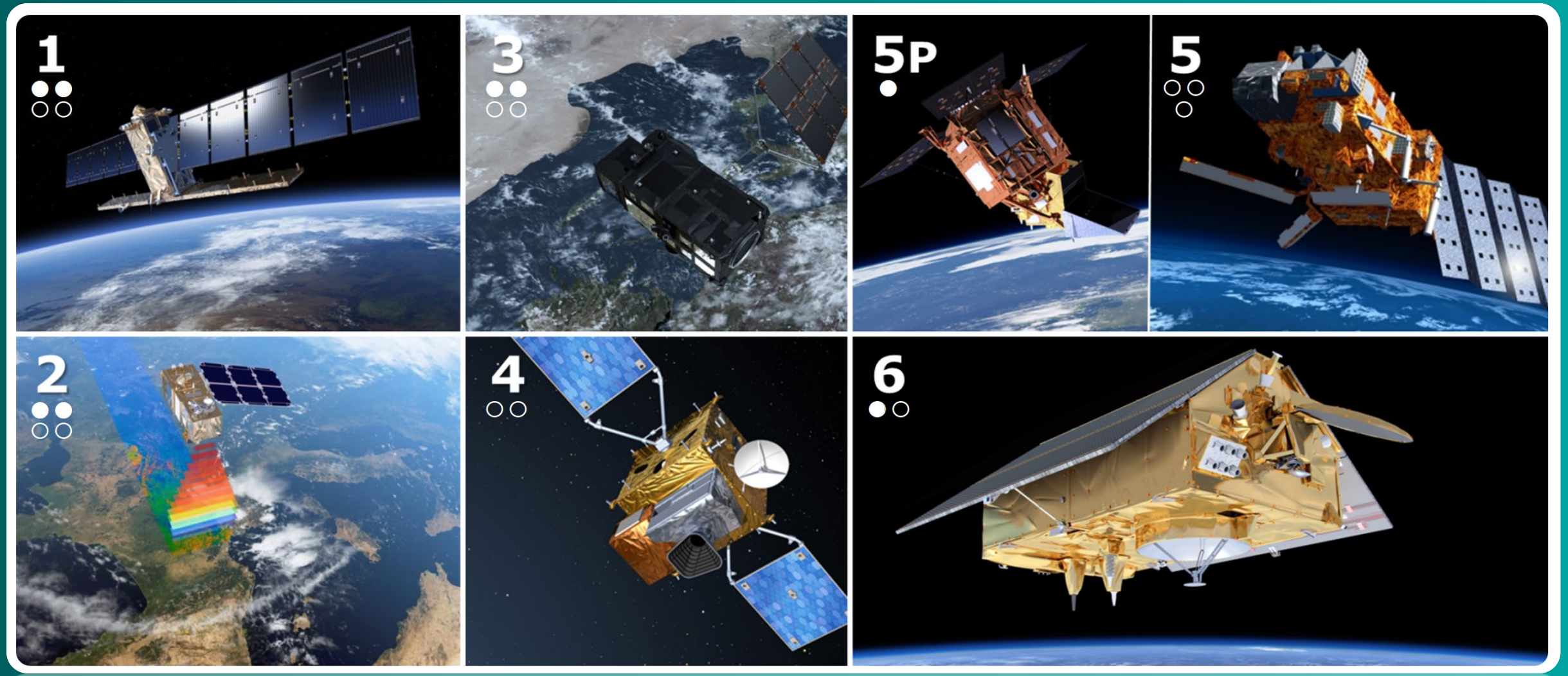

Odin


Pleiades-HR


WorldView-3

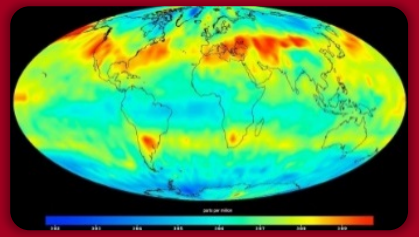
The Big Data Revolution

Copernicus is the largest producer of EO data in the world



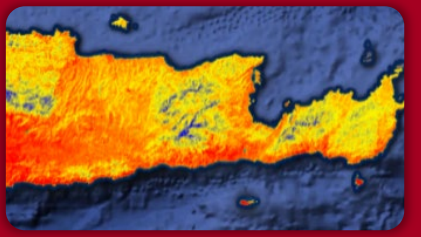
Copernicus Sentinel Expansion Missions

CO2M - Anthropogenic CO_2 Monitoring



Causes of
Climate Change

LST – Land Surface Temperature Mission

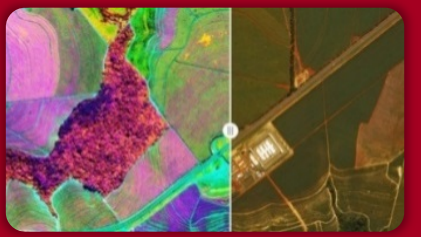


Agriculture & Water
Productivity

CRISTAL – Polar Ice & Snow Topography

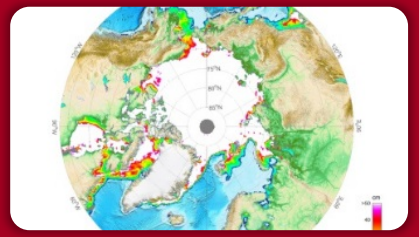
Effects of
Climate Change

CHIME – Hyperspectral Imaging Mission



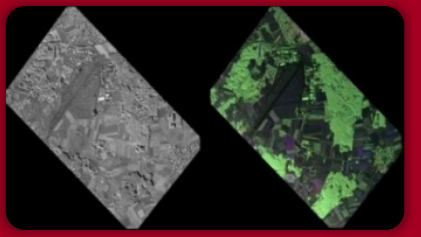
Food Security, Soil,
Minerals, Biodiversity

CIMR – Passive Microwave Radiometer



Sea: Surface Temp.
& Ice Concentration

ROSE-L – L-band SAR Mission

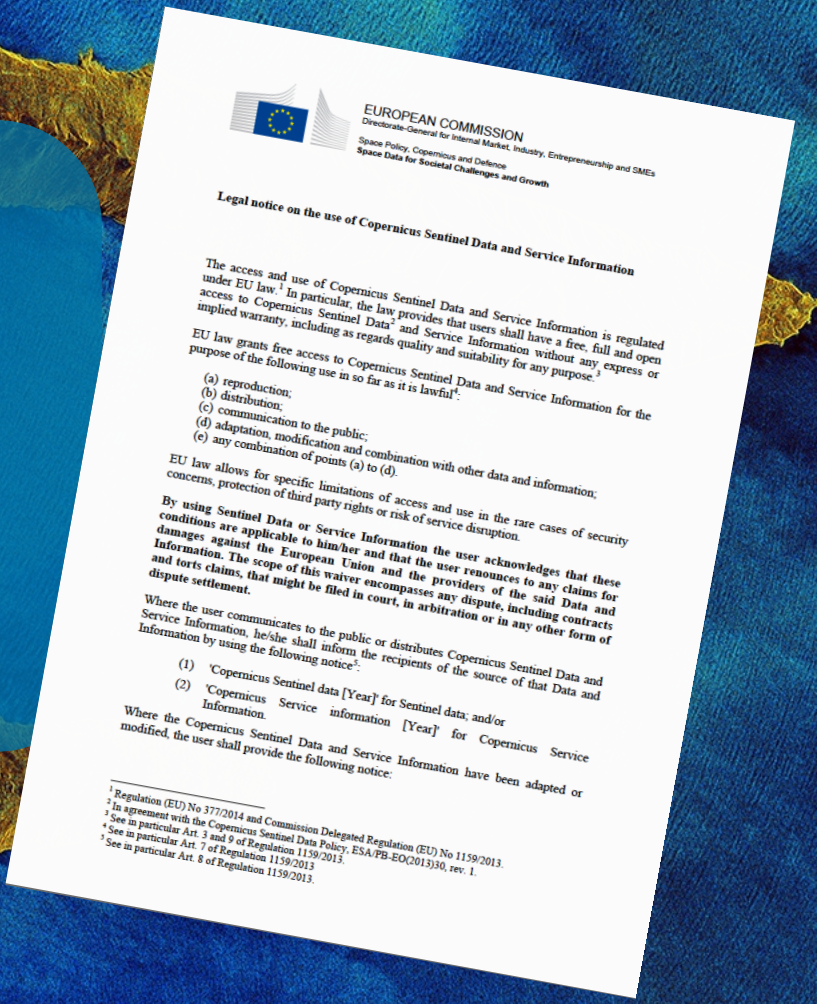


Vegetation & Ground
Motion & Moisture

Copernicus Sentinel Data Policy

Sentinel data are available:

- ✓ **Free, Full and Open***
- ✓ **Over very long term**
- ✓ **Systematically, Operationally**



EUROPEAN COMMISSION
Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs
Space Policy, Copernicus and Defence
Space Data for Societal Challenges and Growth

Legal notice on the use of Copernicus Sentinel Data and Service Information

The access and use of Copernicus Sentinel Data and Service Information is regulated under EU law.[1] In particular, the law provides that users shall have a free, full and open access to Copernicus Sentinel Data[2] and Service Information without any express or implied warranty, including as regards quality and suitability for any purpose.[3]

EU law grants free access to Copernicus Sentinel Data and Service Information for the purpose of the following use in so far as it is lawful[4]:

(a) reproduction;
(b) distribution;
(c) communication to the public;
(d) adaptation, modification and combination with other data and information;
(e) any combination of points (a) to (d).

EU law allows for specific limitations of access and use in the rare cases of security concerns, protection of third party rights or risk of service disruption.

By using Sentinel Data or Service Information the user acknowledges that these conditions are applicable to him/her and that the user renounces to any claims for damages against the European Union and the providers of the said Data and Information. The scope of this waiver encompasses any dispute, including contracts and torts claims, that might be filed in court, in arbitration or in any other form of dispute settlement.

Where the user communicates to the public or distributes Copernicus Sentinel Data and Service Information, he/she shall inform the recipients of the source of that Data and Information by using the following notice[5]:

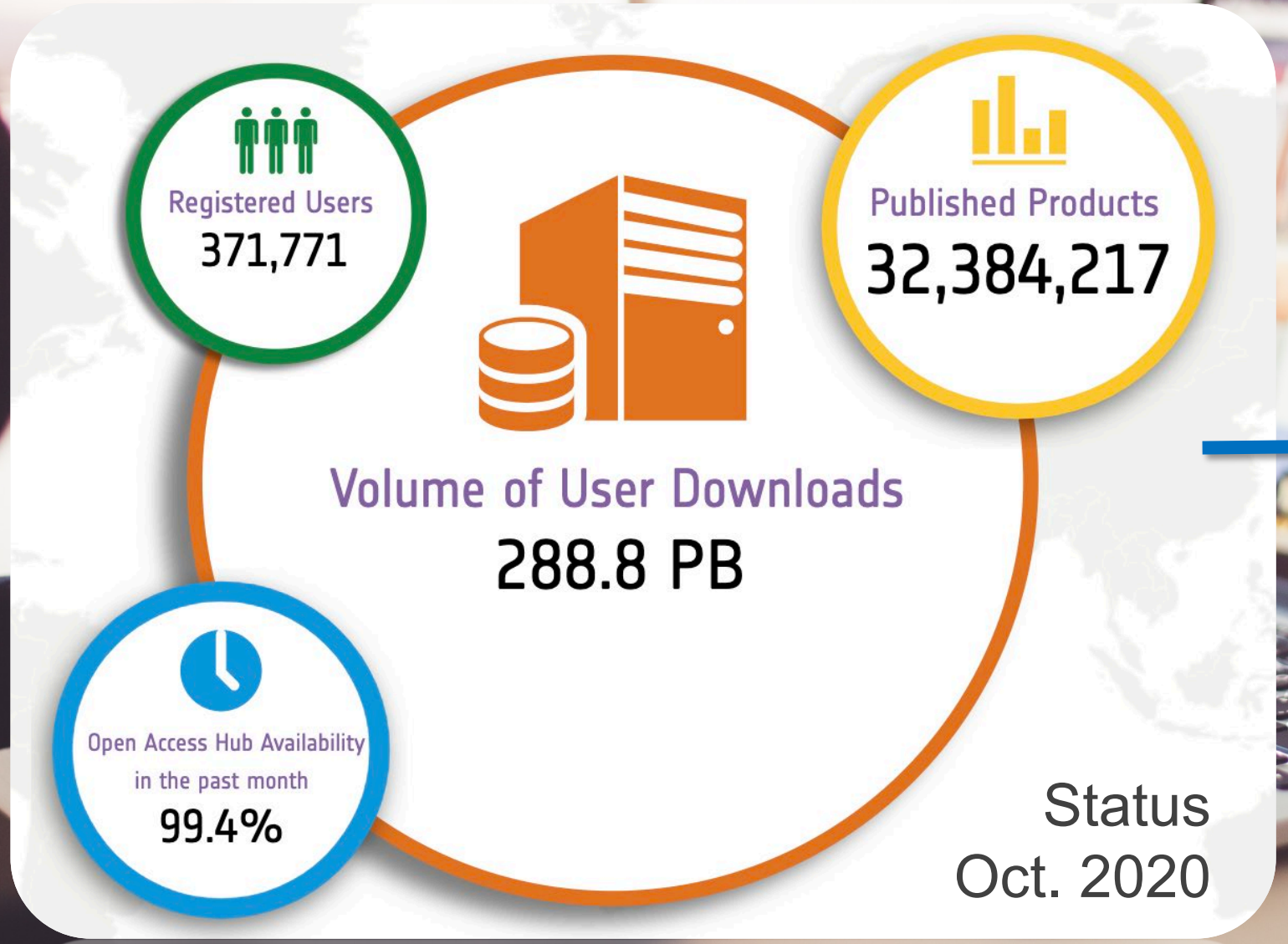
(1) 'Copernicus Sentinel data [Year]' for Sentinel data; and/or
(2) 'Copernicus Service information [Year]' for Copernicus Service Information.

Where the Copernicus Sentinel Data and Service Information have been adapted or modified, the user shall provide the following notice:

[1] Regulation (EU) No 377/2014 and Commission Delegated Regulation (EU) No 1159/2013.
[2] In agreement with the Copernicus Sentinel Data Policy, ESA/PB-EO(2013)30, rev. 1.
[3] See in particular Art. 3 and 9 of Regulation 1159/2013.
[4] See in particular Art. 7 of Regulation 1159/2013
[5] See in particular Art. 8 of Regulation 1159/2013.

* **ESA Sentinel Data Policy** (Sep 2013) and **EU Delegated Act** on Copernicus Data and Information Policy (Dec 2013)

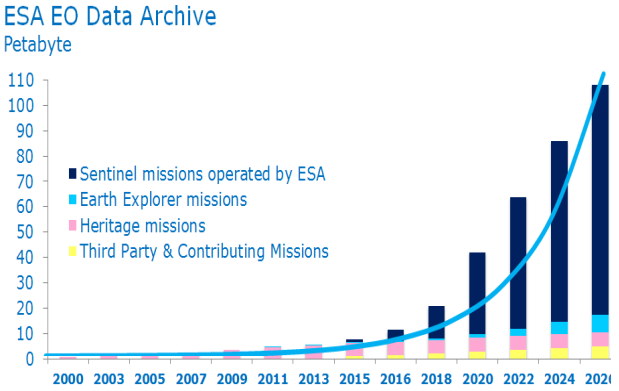
Sentinel Users and Data Access



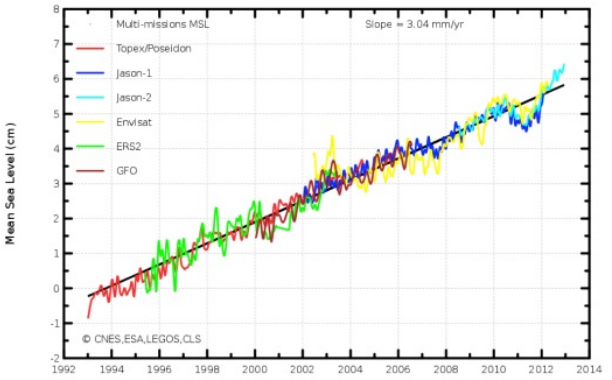
Sentinel access through:

- EU/ESA Copernicus Open Access Hub
- 6 Copernicus services
- 18 ESA Member State hubs
- NASA, NOAA, USGS, Geoscience Australia
- Commercial hubs

Big Data Challenges



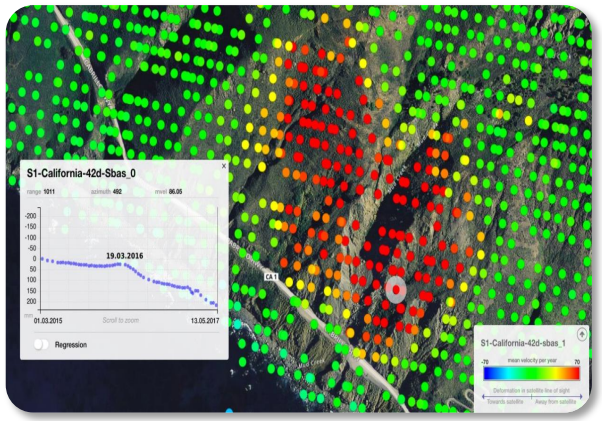
Data volume



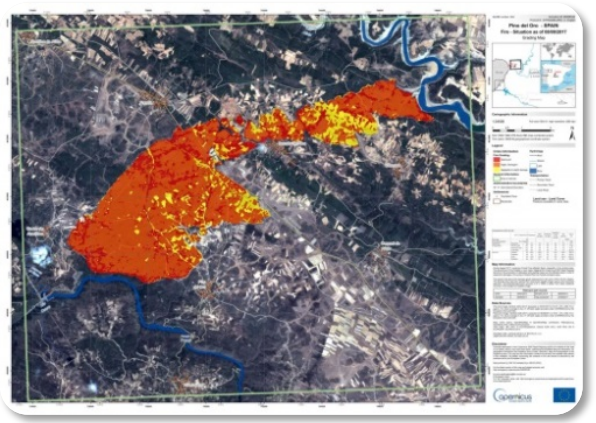
Data continuity

Data sharing

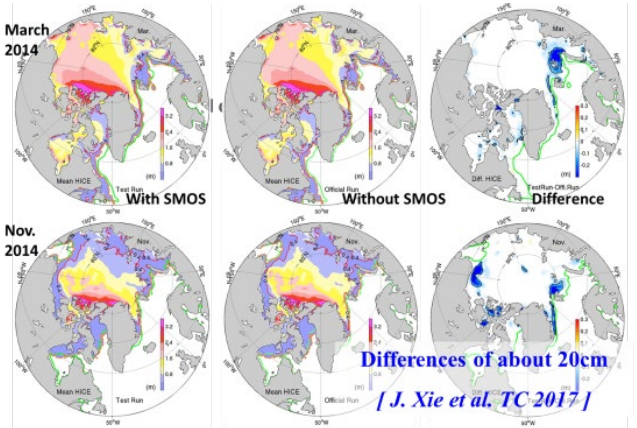
Data quality



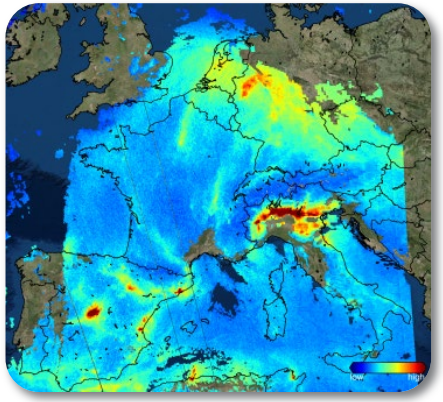
Innovation



Timeliness



Mission synergies



Diversity

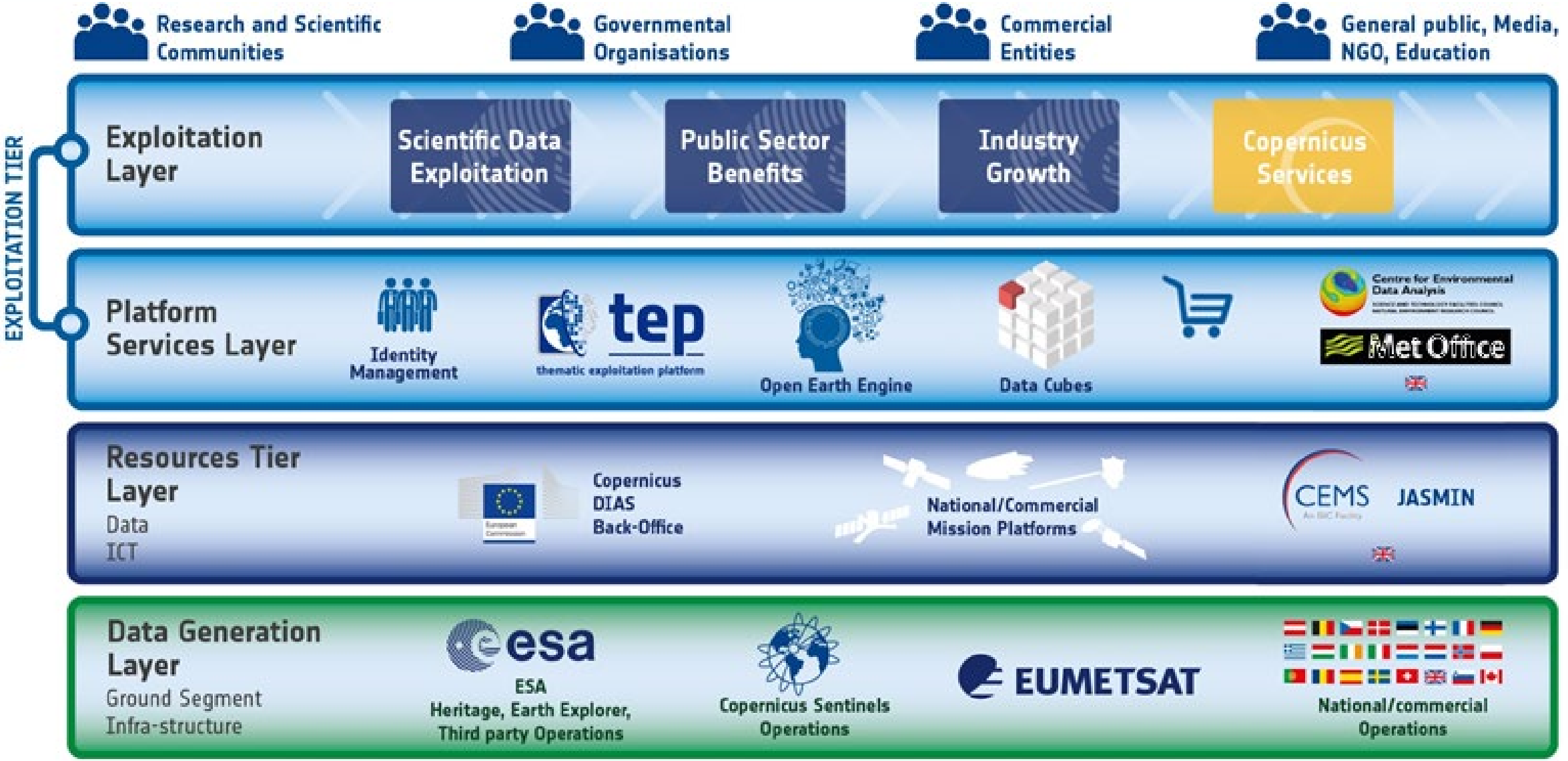
"Move the algorithm/user to the data"

http://storyofchange.net

DIAS – Creating an EO Data Ecosystem

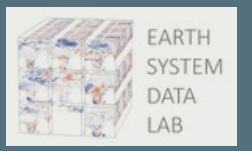
- Copernicus **D**ata and **I**nformation **A**ccess **S**ervices
- Common DG-GROW-ESA approach to EO data exploitation with Copernicus at its core
- Create & enable European EO Data ecosystem for research & business
- Started in June 2018

EO Platform Ecosystem



EO Browser

Ocean Virtual Lab



esa

geohazards tep

coastal tep

forestry tep

hydrology tep

polar tep

urban tep

food security tep

ASB

UP 42

ELLIP

Google Earth Engine

CubeWerx

mundi WEB SERVICES
Algo Hosting

openEO Platform

jupyterhub

EURO DATA CUBE

EOxHub

The EO Information Factory

xcube

SENTINEL Hub

CLEOS

EOPORT
Near real time earth observation services

ADAM

JASMIN

TERRA SCOPE

CloudSigma

mundi WEB SERVICES

T-Systems

eodc

VIENNA SCIENTIFIC CLUSTER

WEkEO

CODE-DE

CREODIAS

CloudFerro

ONDA

OVHcloud

sobloo

orange

OneAtlas

MAXAR GBDX

planet.

Earth on aws

aws

The prevailing capability gap

Some observations:

- → EO paradigm change has not been completed (mentally, technologically)
- → European EO data is not primarily exploited in European platforms
- → European capabilities suffer from fragmentation
- → Data science and EO science/value-adding are increasingly converging
- → Open source libraries and tools are becoming more capable and dominant

The prevailing capability gap

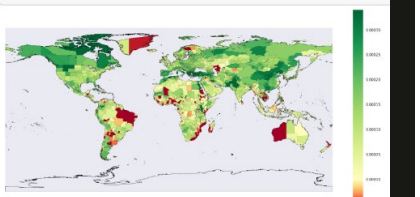
- EO communities (scientists, value adders, etc.) expect intuitive coding interfaces rather than complicated web APIs and engineering standards

jupyter nbviewer

JUPYTER

In [32]:

```
!mkdir GAUL2013
!hdfs dfs -copyToLocal /tapdata/GAUL2013/GAUL1* ./GAUL2013/
def plot_map(zones_trend, lllon=-180, lllat=-90, urlon=180, urlat=90):
    fig = plt.figure(figsize=(20,10))
    ax = fig.add_subplot(111)

    map = Basemap(llcrnrlon=lllon, llcrnrlat=lllat,
                  urcrnrlon=urlon, urcrnrlat=urlat,
                  resolution='c',
                  projection='cyl')

    #map.drawmapboundary(fill_color='aqua')
    #map.fillcontinents(color='#ddaa66', lake_color='aqua')
    #map.drawcoastlines()

    map.readshapefile('./GAUL2013/GAUL1', 'GAUL1')

    patches = []
    colors = []
    for info, shape in zip(map.GAUL1_info, map.GAUL1):
        zone_trend = zones_trend.get(info['ADM1_CODE'])
        if zone_trend is not None:
            patches.append( Polygon(np.array(shape), True ))
            colors.append(zone_trend)

    vmax = np.percentile(colors, 95)
    vmin = np.percentile(colors, 5)
    midpoint = 1 - vmax/(vmax + abs(vmin))
    colormap = shiftedColorMap(plt.get_cmap('RdYlGn'), midpoint=midpoint, name='shifted')

    pc = PatchCollection(patches, cmap=colormap, linewidths=1., zorder=2)
    pc.set_array(np.array(colors))
    pc.set_clim([vmin, vmax])
    ax.add_collection(pc)
    plt.colorbar(pc)

    plt.show()
```



land.copernicus.eu

```
<wps:ProcessOfferings xmlns:wps="http://www.opengis.net/wps/2.0" xmlns:xsi="http://www.w3.org/2001/XMLS
  <wps:ProcessOffering processVersion="1.1.0" jobControlOptions="sync-execute async-execute" outputTra
    <wps:Process>
      <ows:Title>org.n52.wps.server.algorithm.SimpleBufferAlgorithm</ows:Title>
      <ows:Identifier>org.n52.wps.server.algorithm.SimpleBufferAlgorithm</ows:Identifier>
      <wps:Input minOccurs="1" maxOccurs="1">
        <ows:Title>width</ows:Title>
        <ows:Identifier>width</ows:Identifier>
        <ns:LiteralData xmlns:ns="http://www.opengis.net/wps/2.0">
          <ns:Format default="true" mimeType="text/plain"/>
          <ns:Format mimeType="text/xml"/>
          <LiteralDataDomain>
            <ows:AnyValue/>
            <ows:DataType ows:reference="xs:double"/>
          </LiteralDataDomain>
        </ns:LiteralData>
      </wps:Input>
      <wps:Input minOccurs="1" maxOccurs="1">
        <ows:Title>data</ows:Title>
        <ows:Identifier>data</ows:Identifier>
        <ns:ComplexData xmlns:ns="http://www.opengis.net/wps/2.0">
          <ns:Format default="true" mimeType="application/vnd.google-earth.kml+xml" schema="http://sch
          <ns:Format mimeType="text/xml; subtype=gml/3.1.1" schema="http://schemas.opengis.net/gml/3.1
        </ns:ComplexData>
      </wps:Input>
      <wps:Output>
        <ows:Title>result</ows:Title>
        <ows:Identifier>result</ows:Identifier>
```

http://opengeospatial.github.io

The prevailing capability gap

- Many EO users do not want to worry about or pre-specify their ICT needs in terms of VM specs for cloud based processing and analytics of EO data;

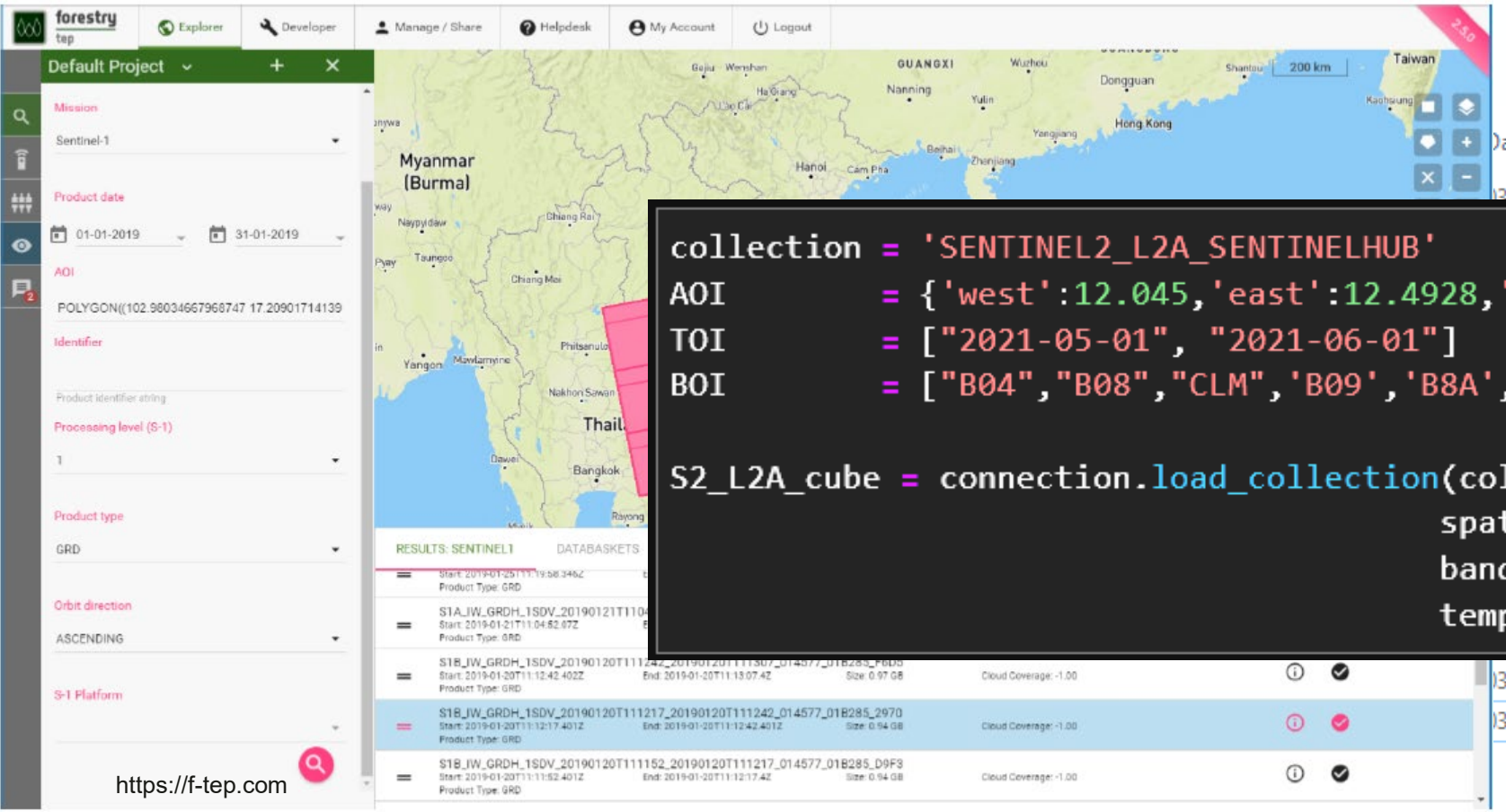
Elastic Cloud Server | On demand virtual machines [5] sobloo.eu/sites/default/files/Cloud Services

***Discount pricing applies on longer or combined subscriptions**

Product	vCPU	RAM (GB)	€ / Hour	€ / Month [1]
High performance				
Paris - cc3.large.4 (2 vCPU, 8GB RAM)	2	8	0,1081 €	70,27 €
Paris - cc3.xlarge.4 (4 vCPU, 16GB RAM)	4	16	0,2162 €	140,54 €
Paris - cc3.2xlarge.4 (8 vCPU, 32GB RAM)	8	32	0,4324 €	281,08 €
Paris - cc3.4xlarge.4 (16 vCPU, 64GB RAM)	16	64	0,8649 €	562,16 €
Paris - cc3.8xlarge.4 (32 vCPU, 128GB RAM)	32	128	1,7297 €	1 124,32 €

The prevailing capability gap

- File based data access limits productivity and lowers scientific value of EO data repositories

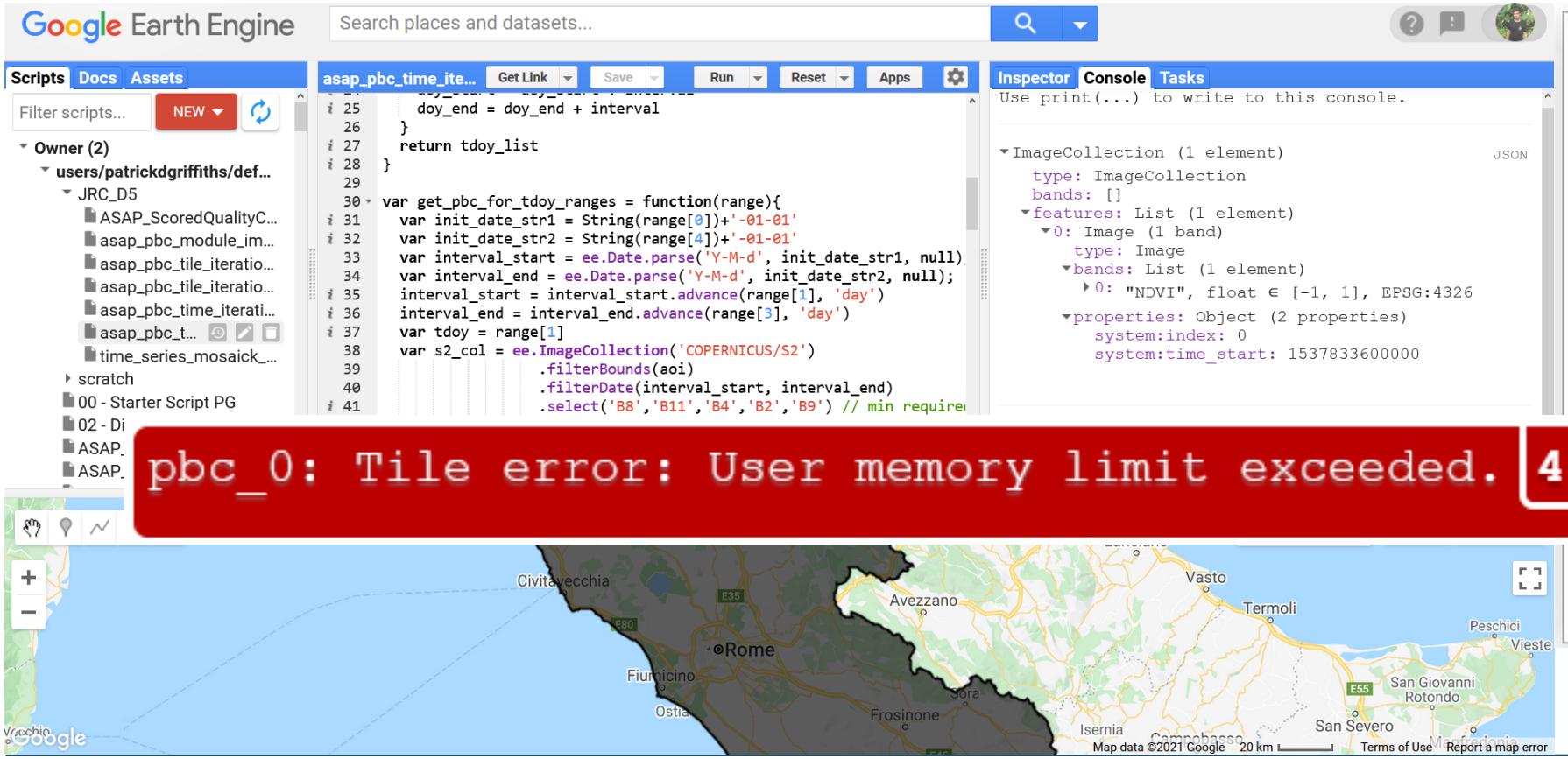



```
collection = 'SENTINEL2_L2A_SENTINELHUB'
AOI        = {'west':12.045,'east':12.4928,'south':41.894,'n
TOI        = ["2021-05-01", "2021-06-01"]
BOI        = ["B04","B08","CLM",'B09','B8A','B11']

S2_L2A_cube = connection.load_collection(collection,
                                         spatial_extent=AOI,
                                         bands=BOI,
                                         temporal_extent=TOI)
```

Date modified	Type	Size
	IrfanView JP2 File	3,069 KB
	IrfanView JP2 File	93,802 KB
	IrfanView JP2 File	93,415 KB
	IrfanView JP2 File	95,053 KB
	IrfanView JP2 File	26,692 KB
	IrfanView JP2 File	28,426 KB
	IrfanView JP2 File	29,274 KB
	IrfanView JP2 File	104,198 KB
	IrfanView JP2 File	29,795 KB
	IrfanView JP2 File	3,062 KB
	IrfanView JP2 File	1,719 KB
	IrfanView JP2 File	26,913 KB
03/10/2018 22:51	IrfanView JP2 File	26,540 KB
03/10/2018 22:52	IrfanView JP2 File	122,424 KB

The prevailing capability gap

- Users require ability to manipulate individual pixels as well as a straight forward mechanism for running large-scale / continental processing tasks

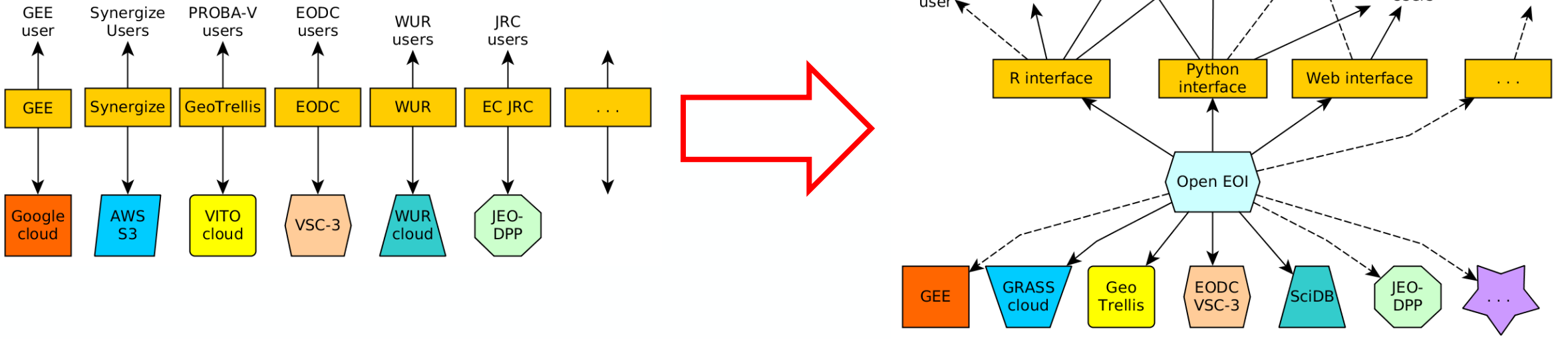


Enter: openEO platform

openEO Platform

H2020 openEO

- Foundational work on interconnecting clouds, EO data and processing;
- Conceptually well aligned with ESA Open Earth Engine Tender;



Transition from H2020 towards operational service

openEO develops an open API to connect R, python, JavaScript and other clients to big Earth observation back-ends in a **simple** an **unified** way.

FUNDING

openEO is an **H2020** project funded under call EO-2-2017: EO Big Data Shift, under grant number **776242**. The project runs from Oct 2017 to Sept2020.

openEO platform - Key concepts driving development

Key concepts for addressing the **capability gap**:

- **Abstracting complexity**: intuitive analytics & programming libraries, dynamic resource allocation, federated cloud environments (EODC, TerraScope, CreoDIAS, EuroDataCube);
- **Providing transparency**: Transparency of source code, scientific integrity & reproducibility, clarity & prior estimation of costing, confidentiality of IPR;
- **Pixel to continental scalability**: pixel-level data access, scalable “building block” processes, clear roadmap for continental-global scale processing;

openEO platform – ESA hopes & expectations

- Continuous increase of useful and innovative processing and analytic functionality:
  - ❖ 9 Use cases planned + additional activities
  - ❖ Resulting building blocks for the community
  - ❖ User algorithm hosting via UDFs (?)
- Active community engagement:
  - ❖ Collaboration, sharing and co-creation of code, data and workflows
  - ❖ Respond to changing community requirements
- Establish openEO platform as a viable alternative:
  - ❖ Business model and license packages to match community requirements
  - ❖ Implement key concepts & demonstrate technical excellence

openEO platform

→ Key note on openEO platform during EO Platforms session: 14/10/2021, 14:50

→ Phi week side event with public launch of openEO platform, hands-on workshop, best-ideas competition

Thank you for listening

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