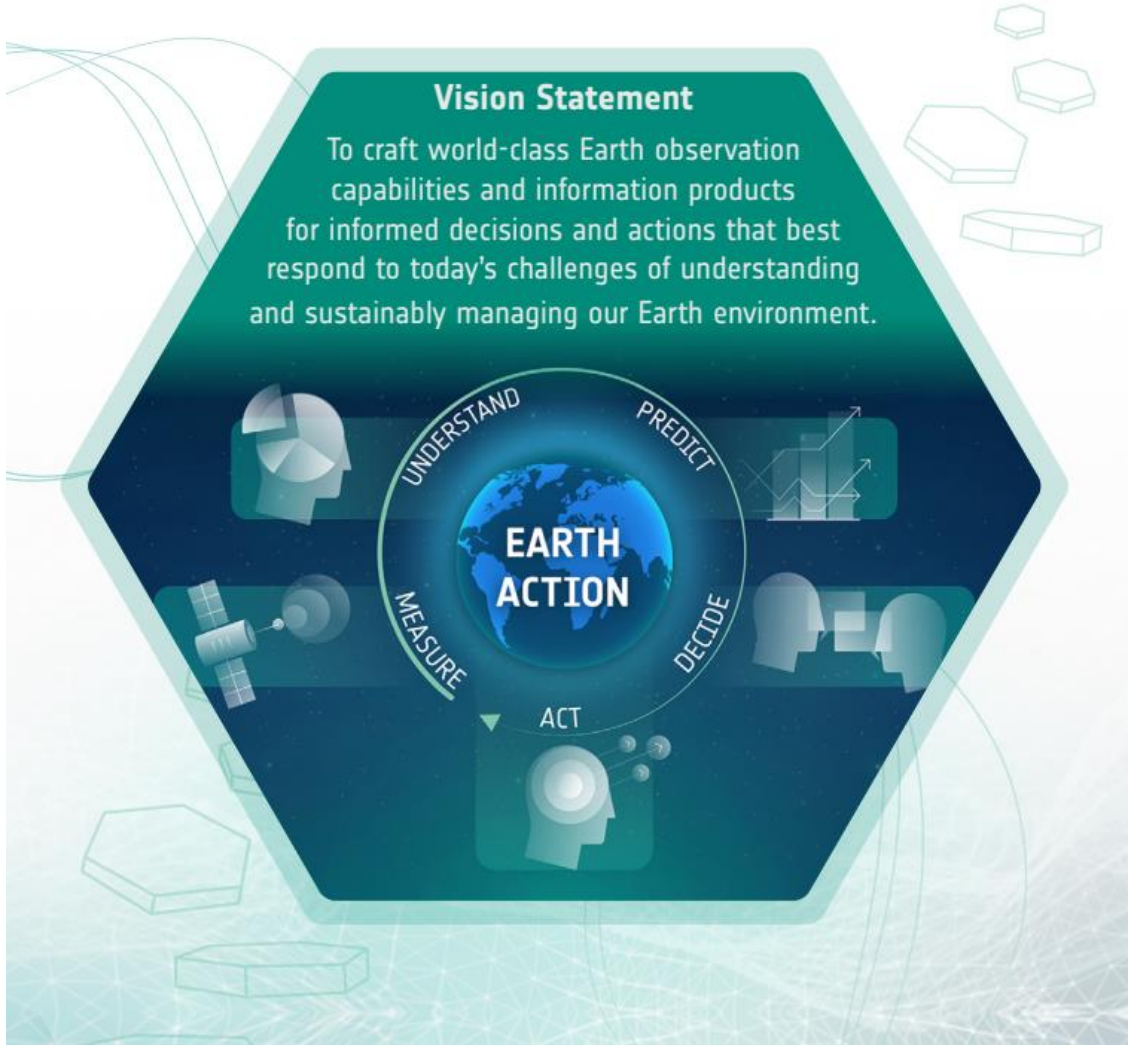
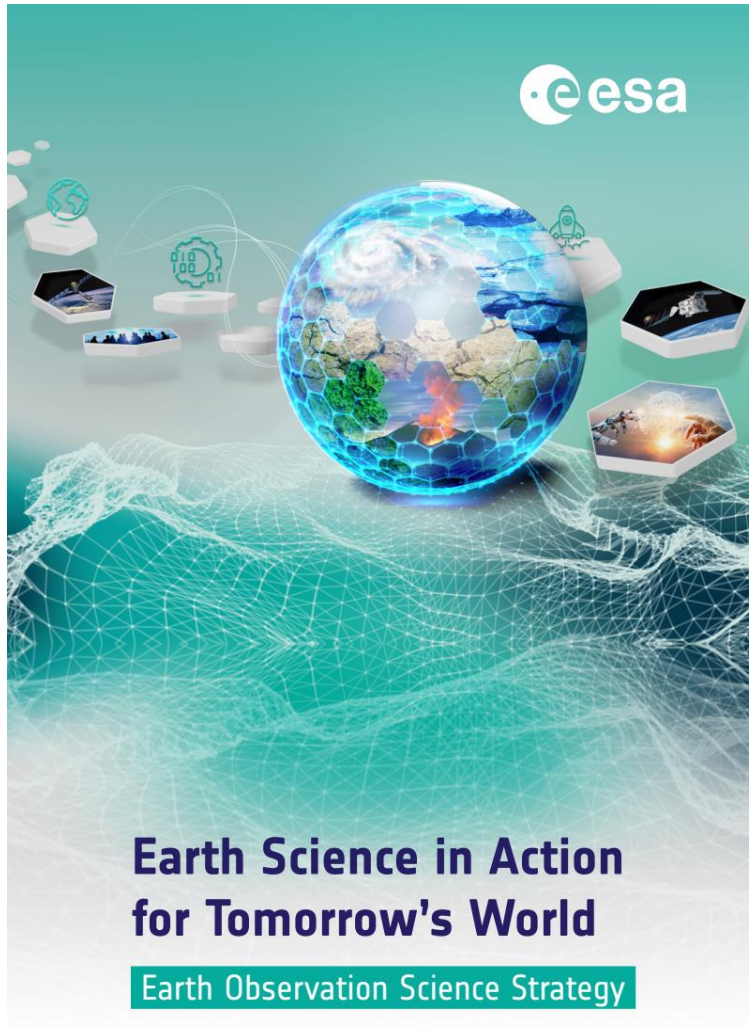
EarthCODE : FAIR & Open Earth System Science for Earth Action

Anca Anghelea
European Space Agency
anca.anghelea@esa.int

What do we mean by Earth Action?



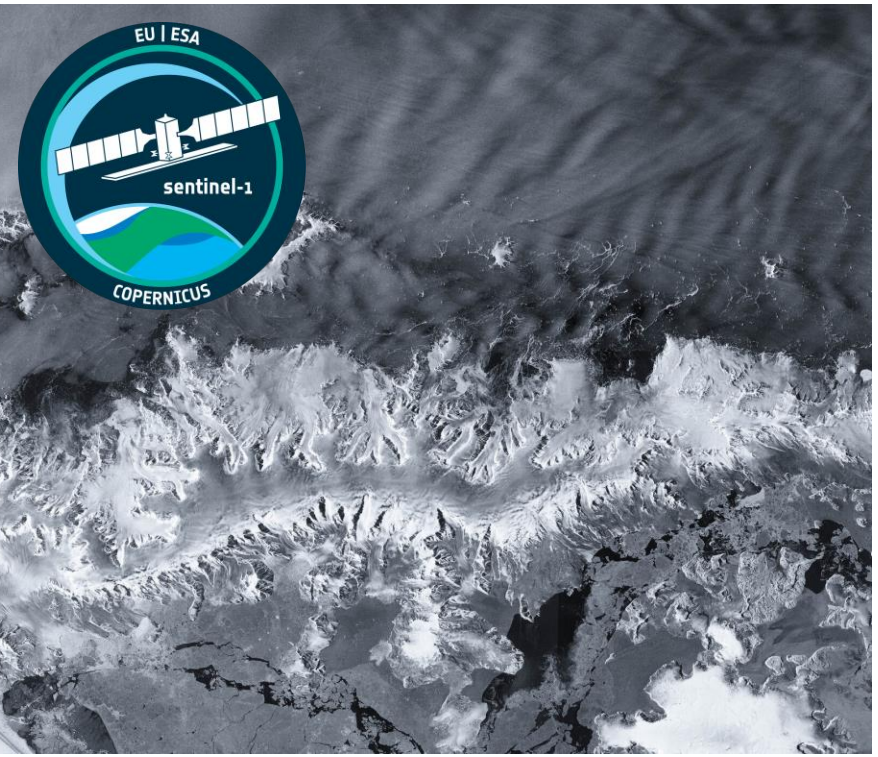


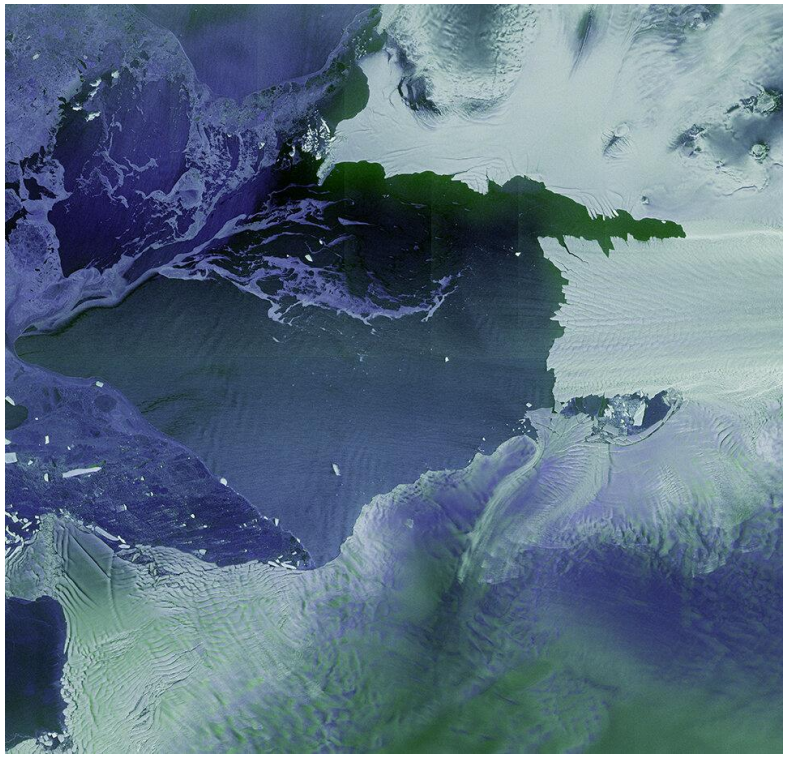
What is the role of Innovation in Earth Action ?

STRATEGIC OBJECTIVE 1: To pursue excellent, innovative, inspirational and impactful frontier science as a primary driver of innovation in EO Programmes and activities.

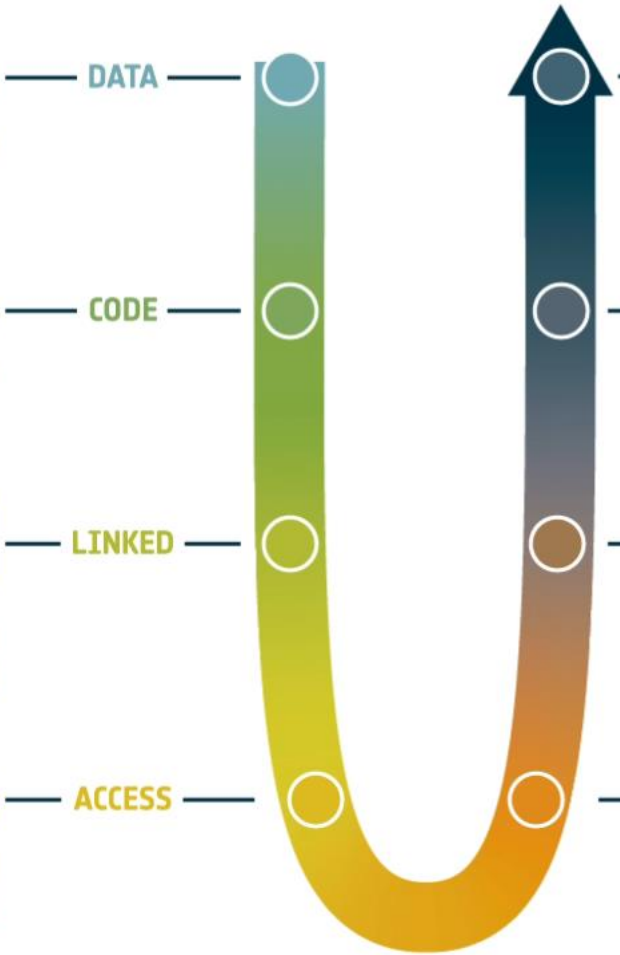
Science as fundament – why make it Open?

STRATEGIC OBJECTIVE 5 : To ensure the EO user community takes full advantage of the scientific opportunities offered by the existing data (including archived and long-heritage) and new missions that will be launched in the 2026–2031 timeframe, to advance understanding of Earth system and maximise scientific return.





EARTH OBSERVATION OPEN SCIENCE AND INNOVATION



Open Data — DATA

Input and output scientific project data

Open-Source code — CODE

Code developed in Earth Science Projects

Linked and executable code & data — LINKED

Data & code used and produced in scientific projects

Open Access — ACCESS

End-to-end open access Workflows and Documentation

COMMUNITY — Community

Open Competitions, Citizen science, new business models, open innovation

PRACTICE — Open Science Practice

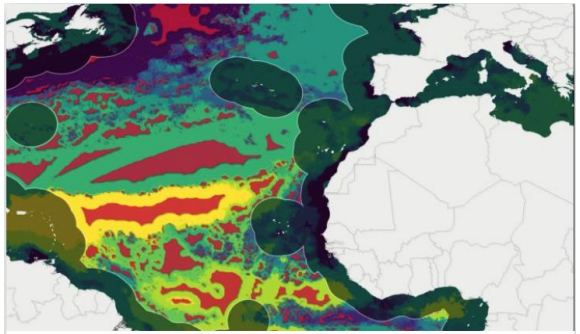
Shared best practice across ESA-funded Science and Innovation activities

EDUCATION — Open Science Education

Education and best prectices for Open Science and Open Source

FAIR — Reproducible on Platforms

End-to-end Reproducible Workflows on various infrastructures

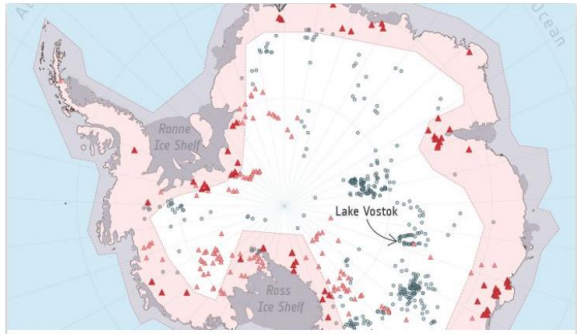


Scientists Users

Protecting ocean biodiversity with satellite data

APRIL 15, 2025

A study, recently published in the Marine Pollution Bulletin, shows that it's possible to safeguard 30 % of the Atlantic Ocean's high-seas biodiversity, without severely disrupting fishing or shipping routes, by harnessing satellite data to define "seascapes" and redirect marine traffic. Using bio-optical information from ESA's Envisat, Copernicus Sentinel-3, alongside NASA's Aqua, OrbView-2 and NOAA-20 satellites, ...

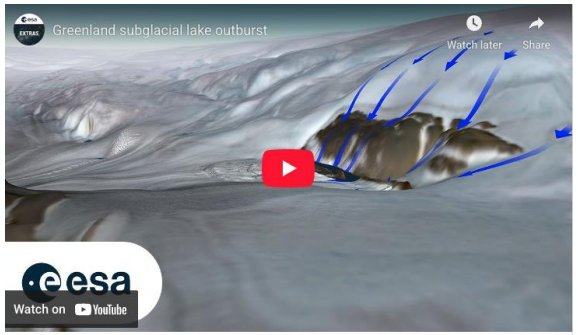


Scientists

85 new subglacial lakes detected below Antarctica

SEPTEMBER 19, 2025

Using over a decade of data from ESA's CryoSat satellite, scientists have identified 85 previously unknown active subglacial lakes beneath Antarctica, bringing the total to 231. These lakes, hidden several kilometres below the surface, periodically fill and drain—movements detected through subtle ice surface height changes measured by CryoSat's radar altimeter. The discovery also adds 12 ...

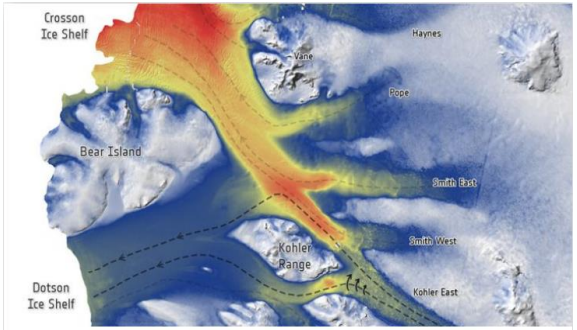


Scientists

Greenland subglacial flood bursts through ice sheet surface

JULY 31, 2025

A new study published in Nature Geoscience reports the first documented case of a subglacial lake draining explosively through Greenland's ice sheet, blasting a roughly 2 km² area and cutting a 85 m-deep crater in July-August 2014. The researchers estimate the event released about 90 billion litres of meltwater bursting upward through nearly 85–90 m of ice. The flood ...

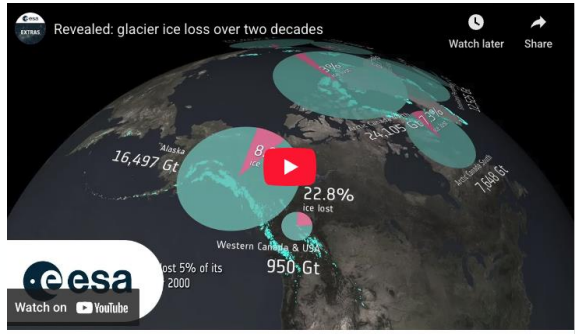


Scientists

Antarctic glacier caught stealing ice from neighbour

MAY 13, 2025

In a surprising discovery, scientists have observed a glacier in West Antarctica rapidly diverting ice from its neighboring glacier, a phenomenon dubbed "ice piracy." This significant shift, previously believed to occur over millennia, has occurred in less than two decades. The study, led by researchers from the University of Leeds and published in The Cryosphere, ...

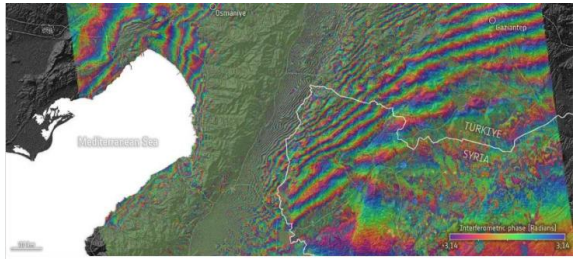


Scientists

Glacier melt intensifying freshwater loss and accelerating sea-level rise

FEBRUARY 19, 2025

A study published today in Nature reports the results of the Glacier Mass Balance Intercomparison Exercise (GlaMBIE) project. It provides the most comprehensive comparison of glacier mass loss estimates to date, integrating multiple satellite and in situ observational techniques, including glaciological measurements, satellite-derived digital elevation model (DEM) differencing, altimetry and gravimetry measurements. By systematically assessing ...



Scientists

Understanding the long-term impact of earthquakes on slopes

SEPTEMBER 23, 2025

When the ground trembles during a powerful earthquake, the danger doesn't end once the shaking stops. Hidden threats like landslides and floods often emerge later, putting lives and infrastructure at risk weeks, months, or even years after the main event. The knowledge gap Collapsed buildings and fast-moving landslides make headlines, but earthquakes destabilise ...

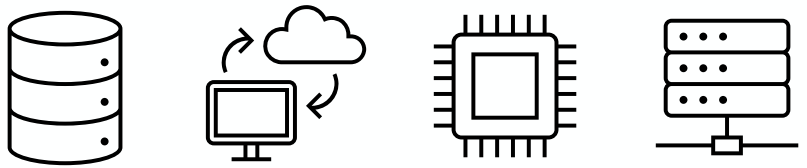
ESA-funded EO science studies resulted in
450+ Scientific Papers
published in the past 3 years only

EarthCODE
aims to make all ESA-funded EO science outcomes **FAIR & Open**

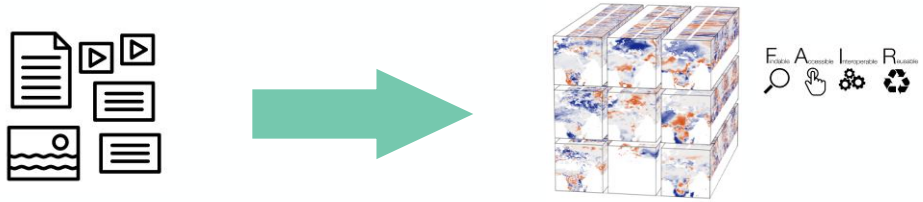
to maximise the impact of science and support **Earth Action**

EarthCODE = **Earth** Science **C**ollaborative **O**pen **D**evelopment **E**nvironment

How does EarthCODE implement the vision?



Integrated cloud-based environments with rich data collections, scalable computing and AI-ready

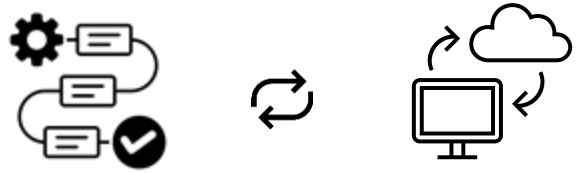


Support to transform the data into cloud-optimized formats, and FAIR-ify data and workflows

STAC

Products with STAC compliant metadata

How does EarthCODE implement the vision?



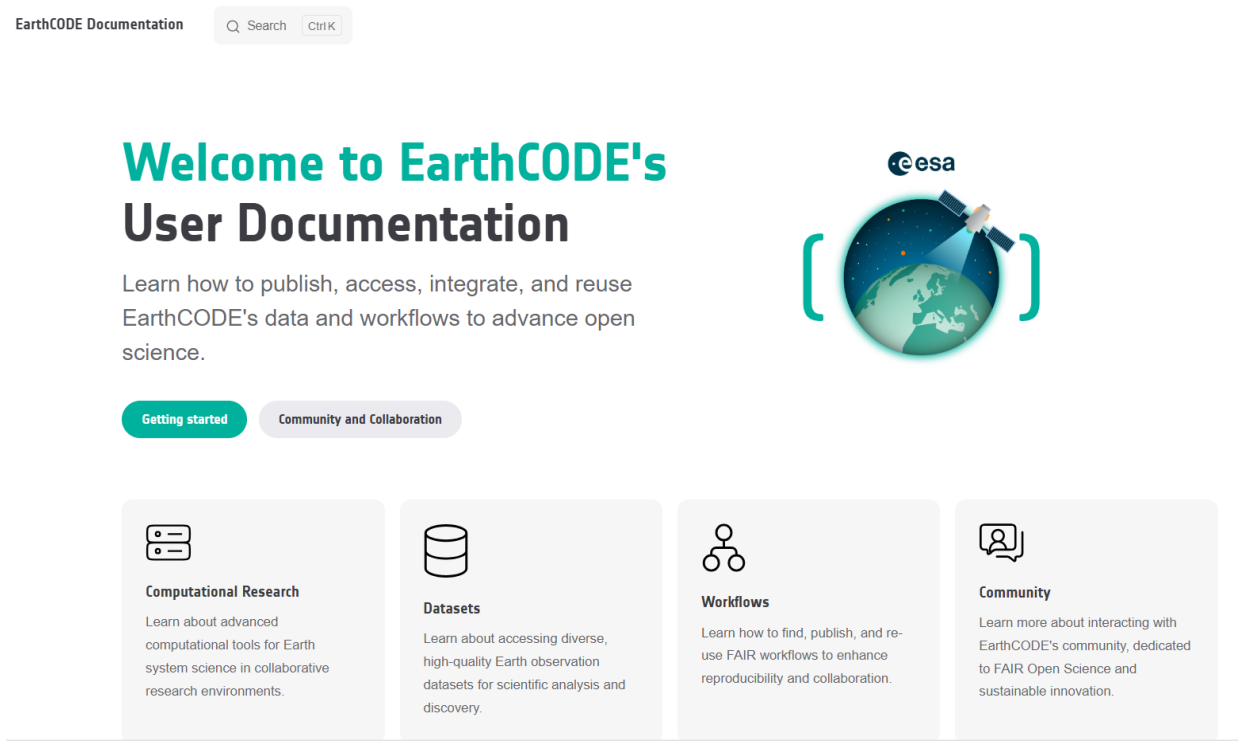
Workflows discoverable in the Open Science Catalogue, and executable on host & compatible platforms

Persistent storage with effective data access mechanisms

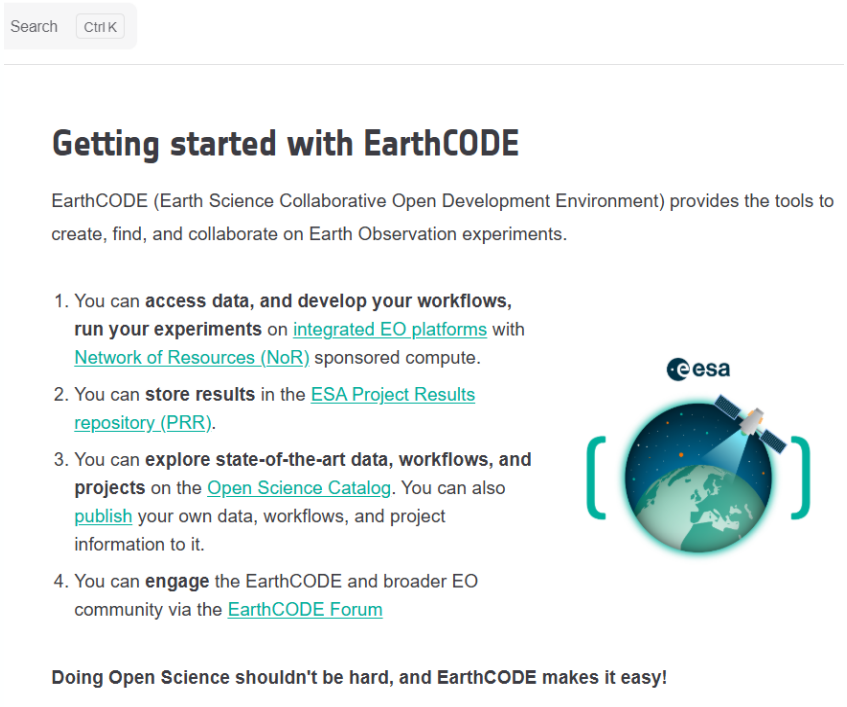
- Sponsored access to cloud computing platforms
- FAIR Data & workflow engineering support for science teams
- Persistent publication + DOI on Open Science Catalogue.
- Long-term storage & preservation in ESA-managed repository.
- A hub to share and discover open data & reproducible methods.
- Visualisation tools for exploration & dissemination of results.

How does EarthCODE implement the vision?

DOCUMENTATION



https://esa-earthcode.github.io/documentation/



https://esa-earthcode.github.io/tutorials/

It's all about Federation, Interoperability, Standards

EURO DATA CUBE

PLATFORM

Euro Data Cube

One-stop-shop for browsing, analysis and processing of EO data, from source up to the final product. A combination of several services: harness the power of the data cube, access and analyse all the most important Earth Observation data in one application

ACCESS →

polar tep

PLATFORM

Polar TEP

The Polar Thematic Exploitation Platform (Polar TEP) provides a complete working environment where users can access algorithms and data remotely, obtain computing resources and tools that they might not otherwise have, and avoid the need to download and manage large volumes of data.

ACCESS →

PLATFORM

DeepESDL

Virtual laboratory providing data, tools, and computational resources to efficiently implement comprehensive processing workflows for Earth System data.

ACCESS →

CDSE

PLATFORM

CDSE OpenEO

Standardised interfaces for easy access and processing of Earth observation data. With its versatile tools, you can effortlessly create new workflows or integrate them into existing ones. Discover how to unleash the full potential of Earth observation data with minimal code and maximum efficiency.

ACCESS →

PANGEO

PLATFORM

Pangeo

Pangeo is first and foremost a community promoting open, reproducible, and scalable science. This community provides documentation, develops and maintains software, and deploys computing infrastructure to make scientific research and programming easier

ACCESS →

COCALC

PLATFORM

CoCalc

Real-time collaboration for Jupyter Notebooks, Linux Terminals, LaTeX, VS Code, R IDE, and more, all in one place. Commercial Alternative to JupyterHub

ACCESS →

CGI

PLATFORM

Insula

The Insula platform acts as a central hub, transforming complex data into meaningful, actionable insights.

ACCESS →

geohazards tep

PLATFORM

Geohazards TEP

The Geohazards Exploitation Platform (GEP) is a cloud-based Earth Observation platform tailored for geohazard monitoring, terrain motion analysis, and critical infrastructure assessment. Operated by Terradue and funded by the European Space Agency, GEP hosts a wide range of processing services that empower users to transform EO data into actionable insights for science, operations, and disaster response.

ACCESS →

- EO Cloud Platforms need to talk to each-other and with the EarthCODE Portal,
- Projects need to publish their heterogenous datasets and workflows in a harmonized way,
- Users need to deal with EarthCODE data in the same way, regardless where originates from,
- Platforms need to be able to execute workflows that did not originate on them,
- Applications need to be able to consume EarthCODE data.

xarray dask jupyterhub STAC

open EO Zarr COG xcube OGC APIs

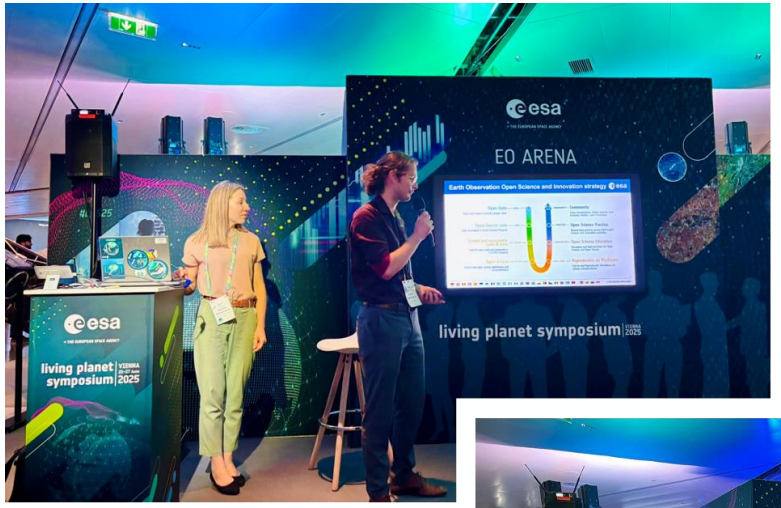
TensorFlow PyTorch python julia

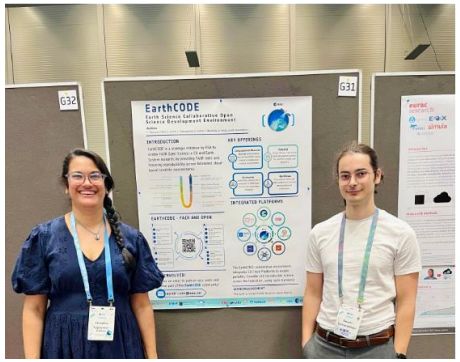
…and FAIR Practice Adoption by the community

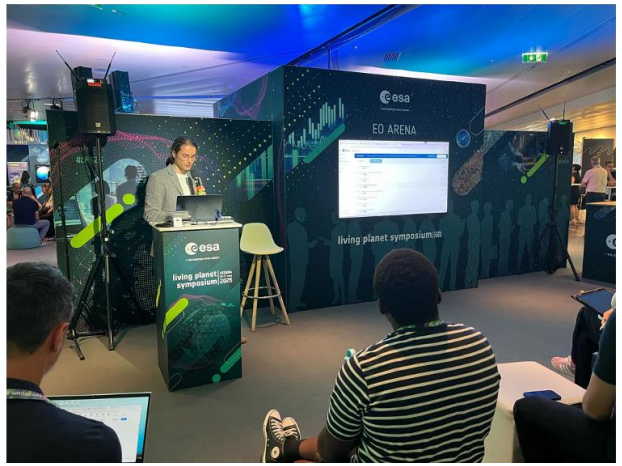
LAMPATA
BRINGING TECHNOLOGY TO THE REAL WORLD

PANGEO

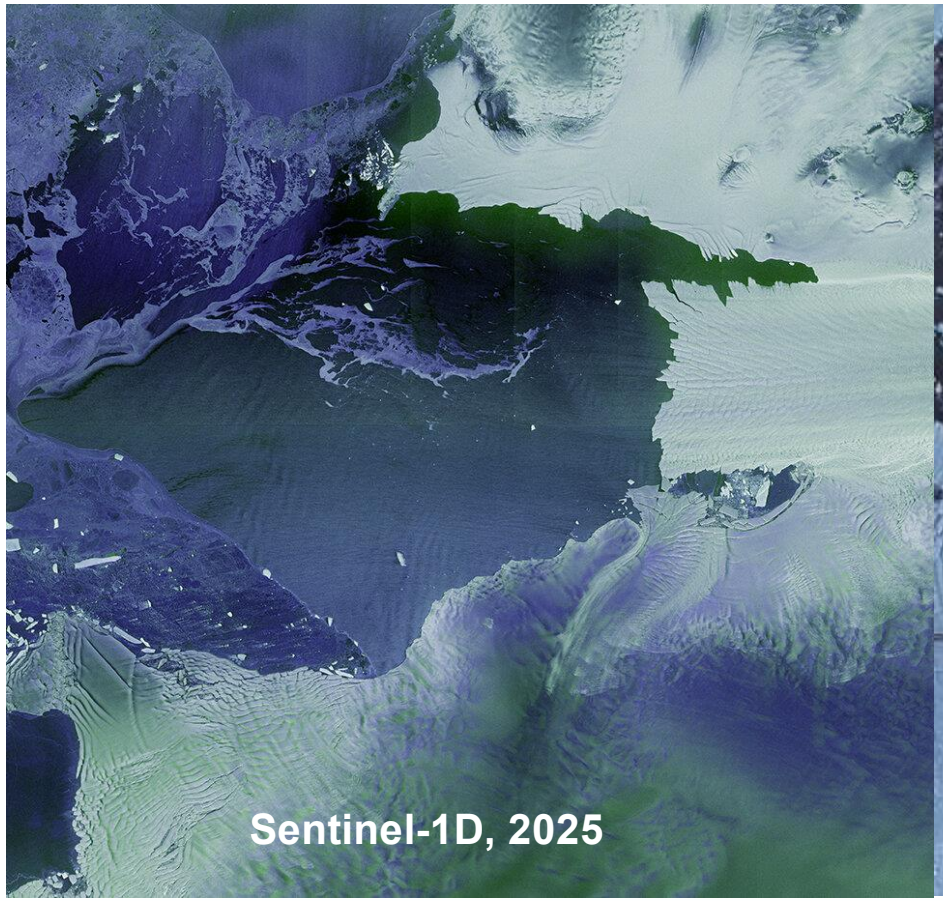
openscapes
openscapes.org

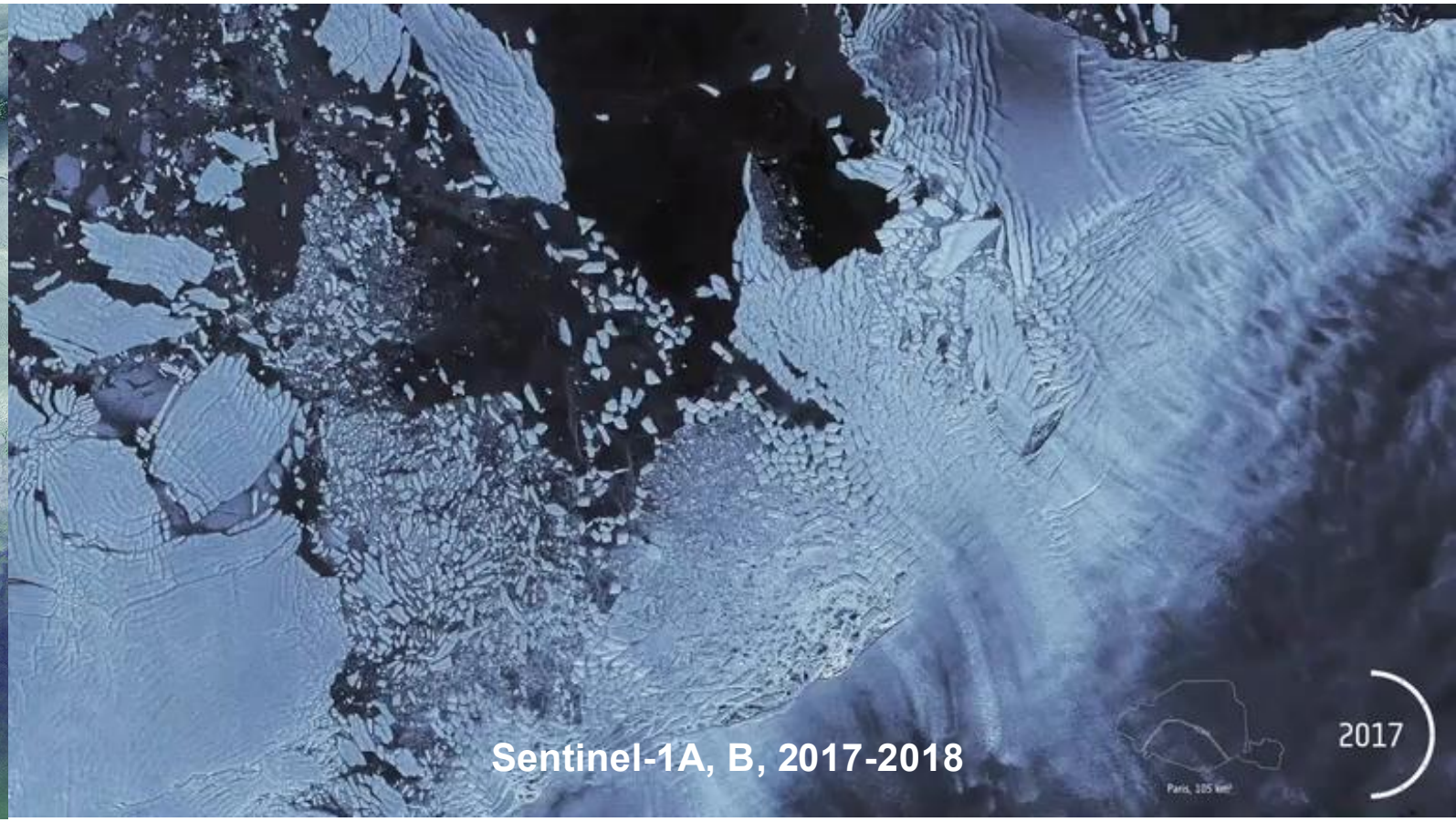






Reproducibility = trust + sustainability





- Continuity of observations
- Continuity of methods (FAIR, long-term availability of the execution environments, with access to the data collections)
- Best Practice in implementing FAIR & Open in the scientific process

EarthCODE Services (upcoming)

1. **Data & Workflow Engineering service** → FAIR-ify geophysical data products and scientific workflows → publication-ready state

2. **Data Update Service** → ensure a scientific production pipeline for geophysical products to offer long time series for the community → “curated data collections”

Offered by the integrated platforms

ESA Polar Science Cluster Antarctic Data Collection

https://s3.waw4-1.cloudferr

- Bedrock
- Ice shelf
- Groundli
- Subglac
- Supragl

•https://s3.waw4-1.cloudfer

- Ice Tem

•https://s3.waw4-1.cloudfer

- Surface

•https://s3.waw4-1.cloudfer

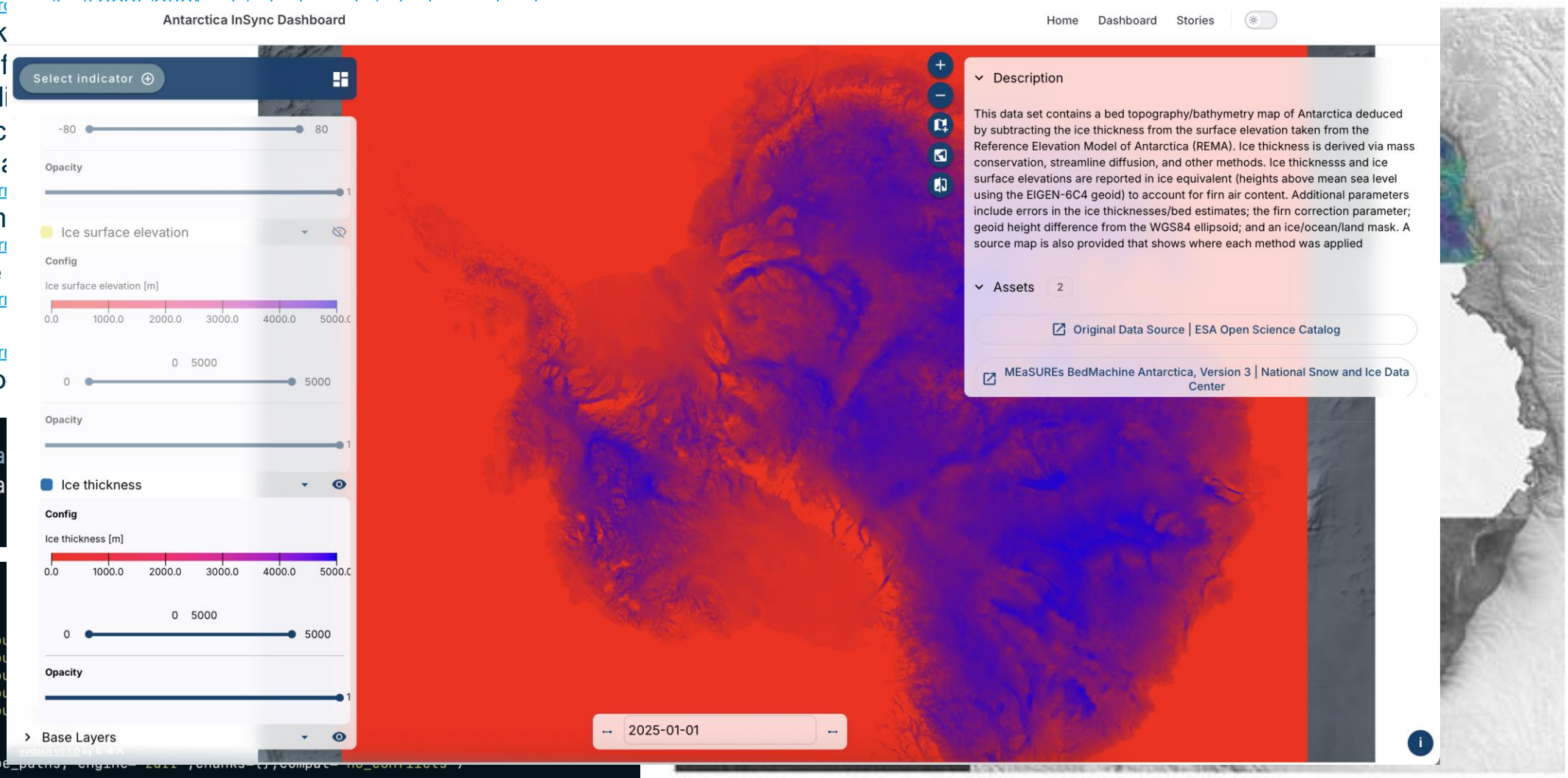
- Calving

•https://s3.waw4-1.cloudfer

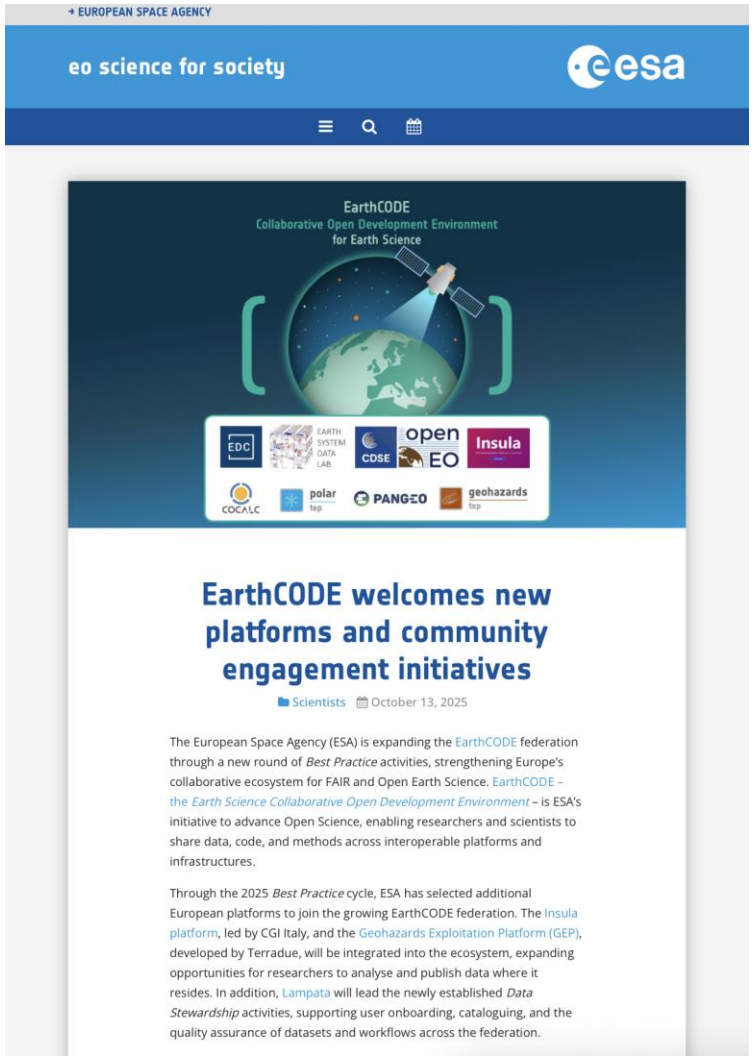
- Ice Velo

```
import xarray a
ds = xr.open_za
ds
```

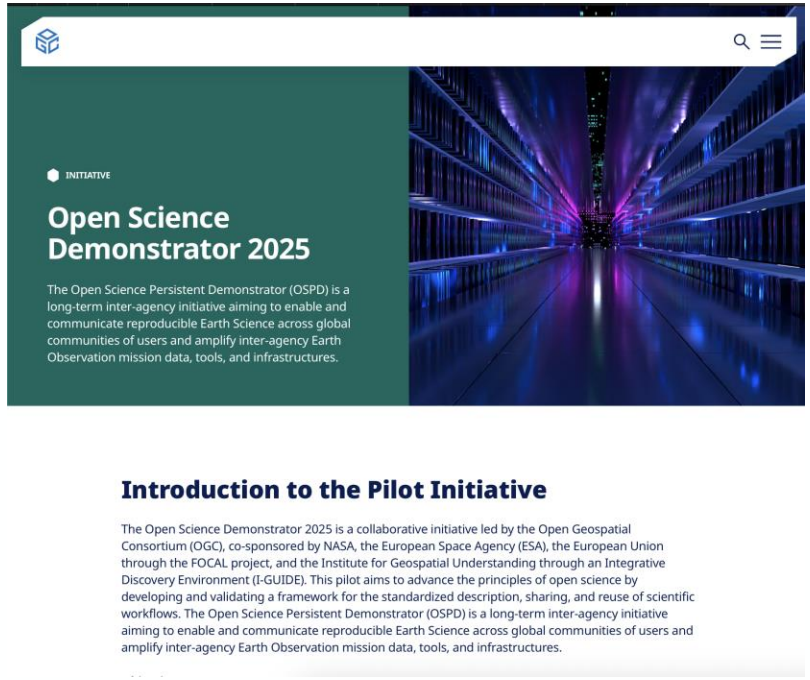
```
import xarray as xr

cube_paths = [
    "https://s3.waw4-1.clou
    "https://s3.waw4-1.clou
    "https://s3.waw4-1.clou
    "https://s3.waw4-1.clou
    "https://s3.waw4-1.clou
]

ds = xr.open_mfdataset(cube_paths, engine="zarr", chunks={}, compat="no_conflicts")
ds
```



Joining the EarthCODE Initiative



- Participate to the yearly **Best Practice Procurements** (ESA ITT, open competition)
- Onboard your Platform Services to the ESA **Network of Resources**



Open Science Persistent Demonstrator (OSPD 2025)

ESA, NASA, OGC

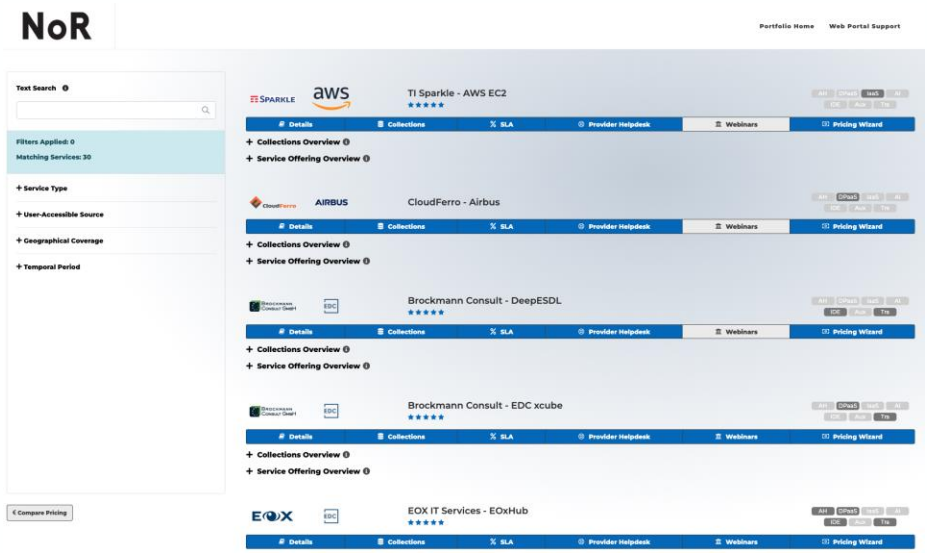
ESA NoR Sponsorship for EarthCODE Platforms

ESA Network of Resources (NoR) Sponsorship

NoR Website: https://nor-discover.org/

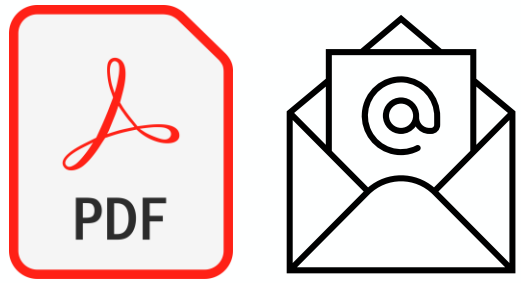
NoR Portfolio: https://portfolio.nor-discover.org

Approval* of sponsorship requests usually within 1 week!



1. **Browse Discovery Portal & select services**

2. **Fill in sponsorship request**



3. **Email to** *Nor-Sponsorship-Requests@esa.int*

** Priority is for integrated platforms, within available budget*

Reach out

earth-code@esa.int

earthcode.esa.int