TELESPAZIO
a LEONARDO and THALES company

EarthCODE reproducible science platform, influenced by EOEPCA+ workflow and data standards

FOSS4G:UK South West 2024

Richard Conway and Garin Smith

Tuesday 12th November 2024

EOEPCA
BETTER ACCESS TO EARTH OBSERVATION

esa

Context – Exploitation Platform

Transforming Data to Actionable Information – value-adding

Virtual analysis environment

Data

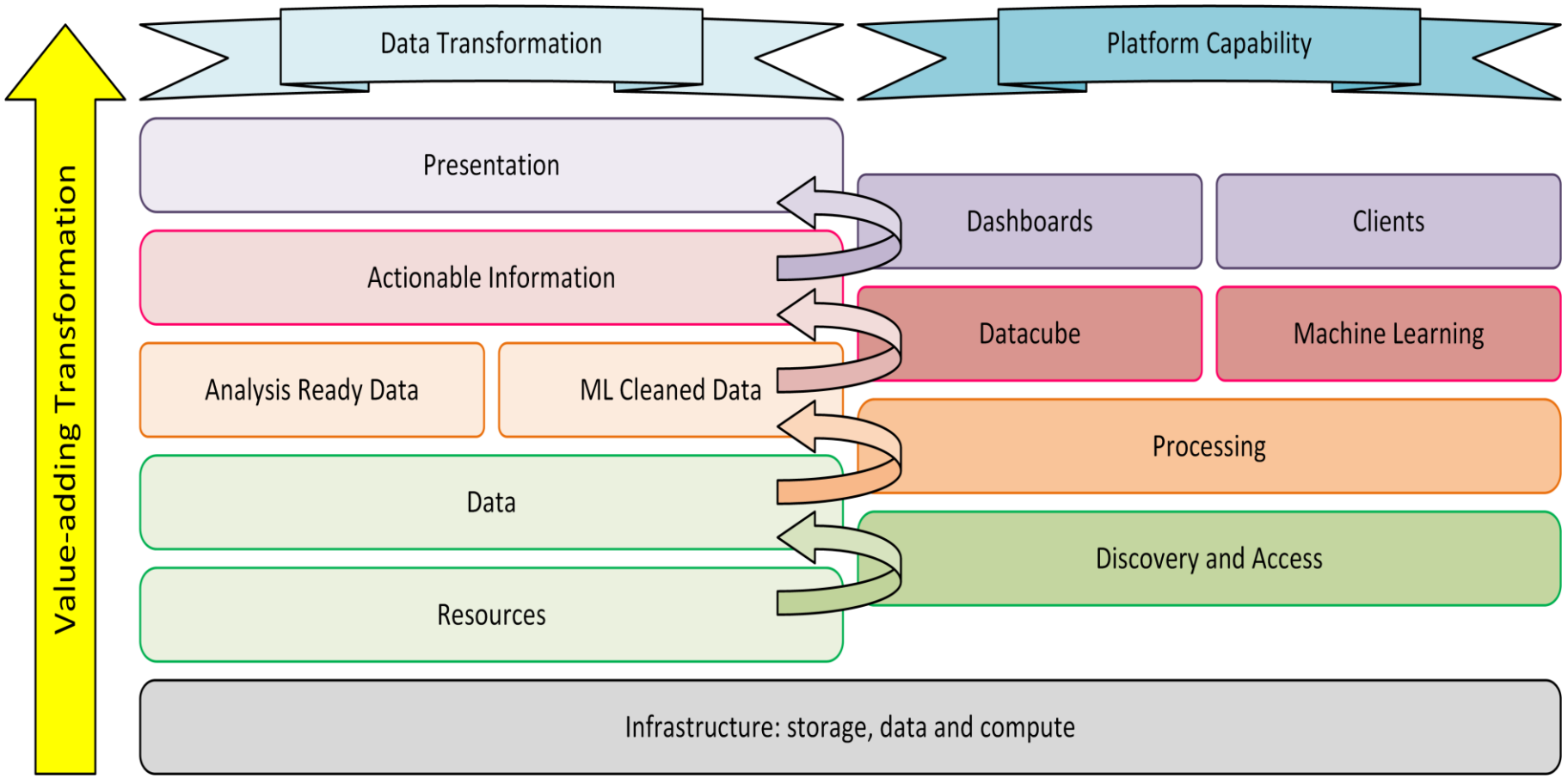
Compute

Tooling

Collaboration

Sharing

Publishing



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Aims and Objectives

Problem

Many platforms in a fragmented ecosystem

Difficult for users to exploit their complementary offerings

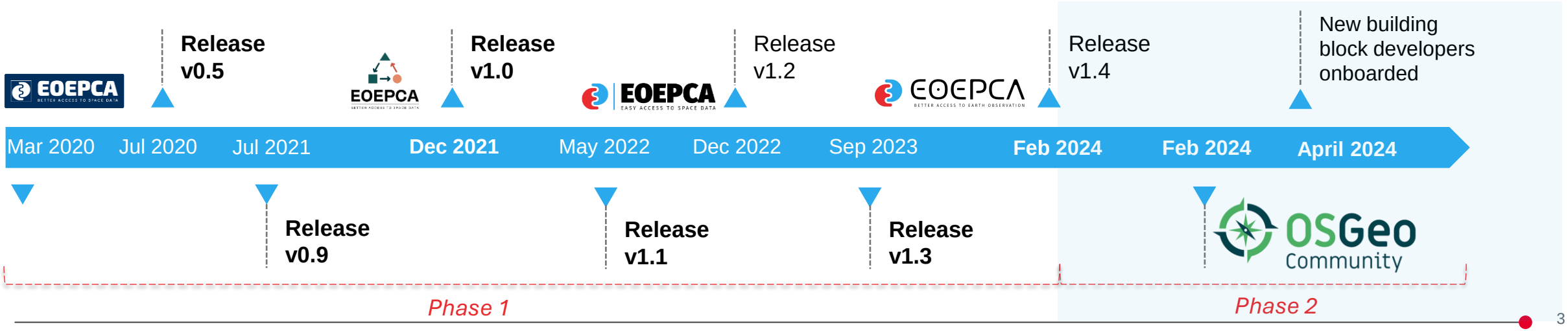
Our Approach

Common Architecture

- **Open Standards**
- Enabling **Federation** among EO cloud platform offerings
- Promote and develop **Interoperability** standards

Reference Implementation

- **Open Source**
- Avoid further fragmentation
- **Reusable Building Blocks**
- Reduce development costs



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Architecture

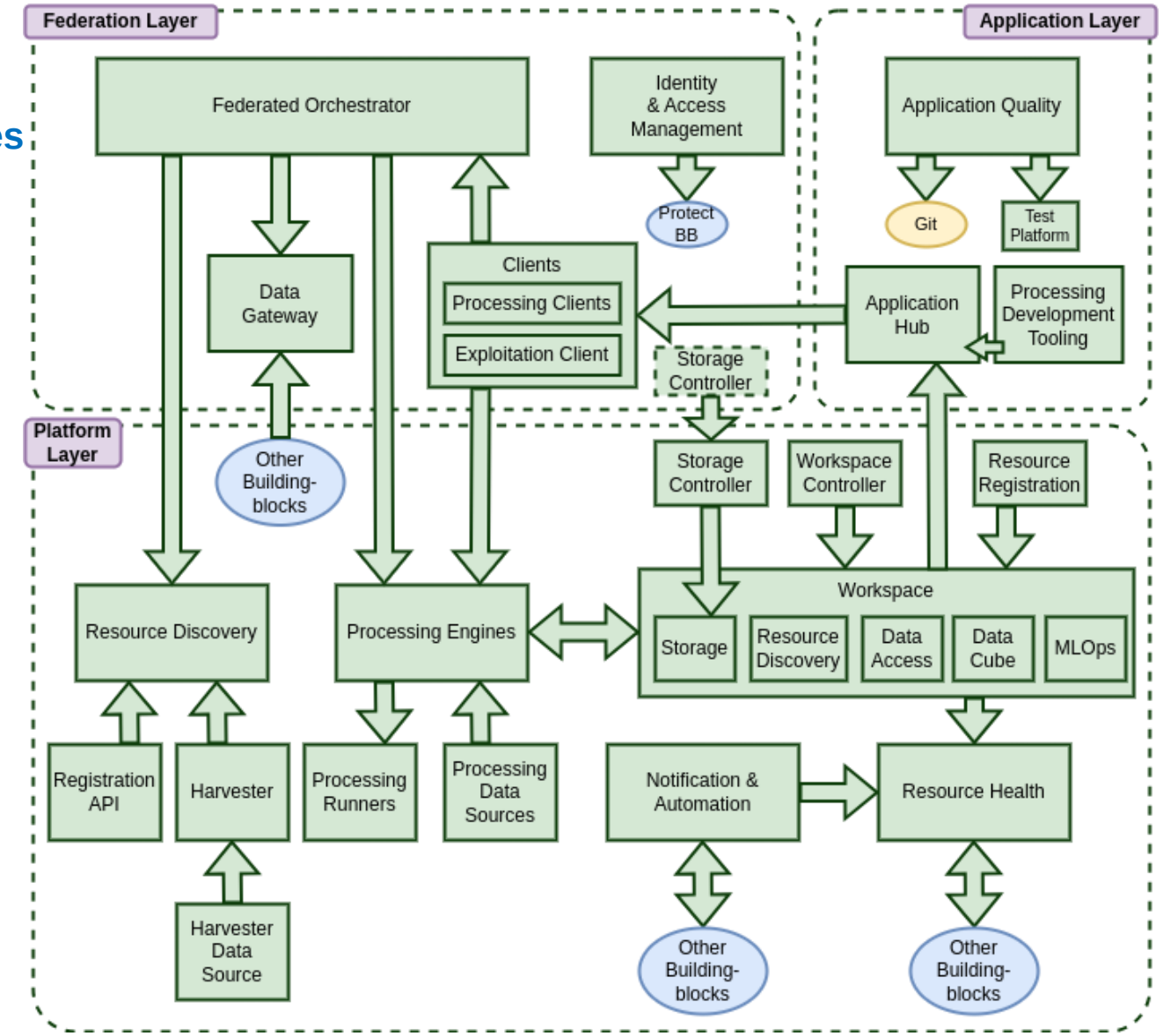
Reference Implementation of the Common Architecture defined by Building Blocks with open standard interfaces

What is a Building Block (BB)?

- Software component that implements a specific platform capability
- Typically provides a service interface (REST API) -> standards
- Dedicated helm chart for each BB – for Kubernetes deployment
- Designed to be used on their own, or in combination as a system
- Open Source

Community Oriented

- Open invitation to engage
  - Use cases and Requirements Definition
  - Co-design and Co-development
  - Adopter
- OSGeo Community project
- OGC – Working Group participation and Testbeds



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User-defined Processing – Processing BB

Bring the processing to the data

Two Approaches

General Purpose Processing

- **OGC API Processes**
- Containerised workflows
- **OGC Application Package**
- Suited to batch processing

Client-oriented Semantics

- **openEO Process Graphs**
- Python, R, JavaScript clients
- Close data integration
- Emerging support for Application Packages

OGC Application Package

- **OGC Best Practice**
- Portable processing workflows
- Common Workflow Language
- Steps: Containerised algorithms

Workflow Runners

- Backend workflow execution
- Extensible integrations…
  - Kubernetes
  - HPC
  - Dask, …

zoo

GeoTrellis

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Platform Resources

stac-fastapi

resources

pycsw

Tiler

datasets

eoAPI

TiPg

pgstac

elasticsearch

Resource Discovery for Reproducible Open Science

- **Resource Discovery BB**
- Workflows, datasets, notebooks, ML models, training data, source repo, documentation, …

Data Discovery & Access

- **Data Access BB**
- Discovery - STAC
- Retrieval and Visualisation - OGC Features, Maps, Coverages

Analysis Ready Data

- **Datacube Access BB**
- Pixel-based access to multi-dimensional data
- **OGC GeoDataCube API**
- Consolidated API for data discovery, access and processing

pygeoapi

Flowable

Ingestion & Harvesting

- **Resource Registration BB**
- API for adding resources of all types
- Data harvesting from external sources

User/Team Resources

- **Workspace BB**
- Collaboration for users and teams
- Storage and shared services
- Integrates with other BBs

vcluster

EOxHub

File Browser

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User Analysis and Exploitation

SharingHUB GitLab jupyterhub DVC STAC

Machine Learning

- **MLOps BB**
- Model Training & Management
- Training data management

Interactive Analysis

- **Application Hub BB**
- Notebooks for Scientific Storytelling
- Dashboards to showcase research outcomes

Application Best Practice

- **Application Quality BB**
- Best practices for Reproducible Open Science
- Static analysis
- Performance tuning

Grafana

Event-driven Behaviour

- **Notification & Automation BB**
- Automated behaviour
- E.g. systematic processing
- Building Block decoupling

Operational Outcomes

- **Resource Health BB**
- Added-value Outcomes
- **Datasets, workflows, applications**
- Automated monitoring and alerts

sonarqube

APACHE JMeter™

Apache Airflow Gatling LOCUST pytest

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Platform Federation

Federated Workflows

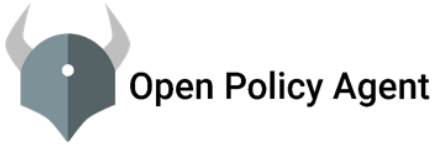
- **Federated Orchestrator BB**
- Cross-platform workflow execution
- Hybrid workflows, combining
  - OGC API Processes
  - Application Packages
  - openEO Process Graphs

Abstract Data Access

- **Data Gateway BB**
- Data source abstraction
  - Data access protocol
  - Authn / Authz
- Python library
- Extensible data providers

Federated User Identity

- **IAM BB**
- Single Sign-on
- External Identity Provider integration



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EOEPCA+: Partner Organisations

DLR

EOX

EOFARM

development SEED

Resource Discovery

Resource Registration

Data Access

Datacube Access

Workspace

TERRADUE

vito

GeoLabs

eurac research

Matthias Mohr Softwareentwicklung

Processing

Application Hub

Federated Orchestrator

Notification & Automation

NOVASPACE

Communications & Outreach

13 Building blocks (and counting) by a variety of developers

werum SOFTWARE & SYSTEMS

IAM

CS a Sopra Steria company

MLOps

Data Gateway

spaceapplications SERVICES

SENSmetry

Application Quality

Resource Health

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EarthCODE

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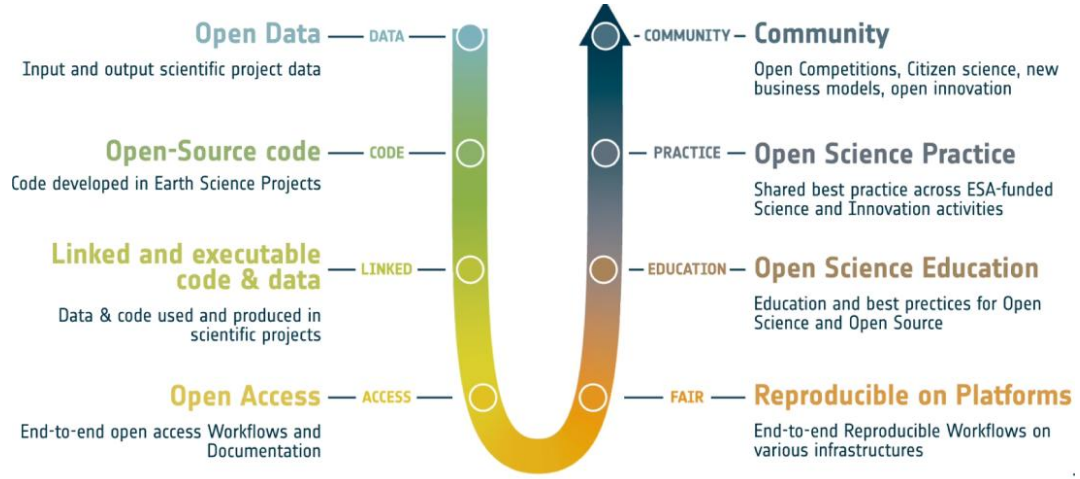
EarthCODE

FutureEO Independent Science Review 2022 recommendations:

More visibility, discoverability and useability of science results, leveraging interoperability and Open Science Tools, and improving communication and community building.

Scientific community feedback at Science Strategy workshop (2023):

ESA to support FAIR and reproducible Open Science practices and complementing the scientific process by Software Development best practice.



Earth Science Collaborative Open Development Environment (EarthCODE) responds to these recommendations

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EarthCODE

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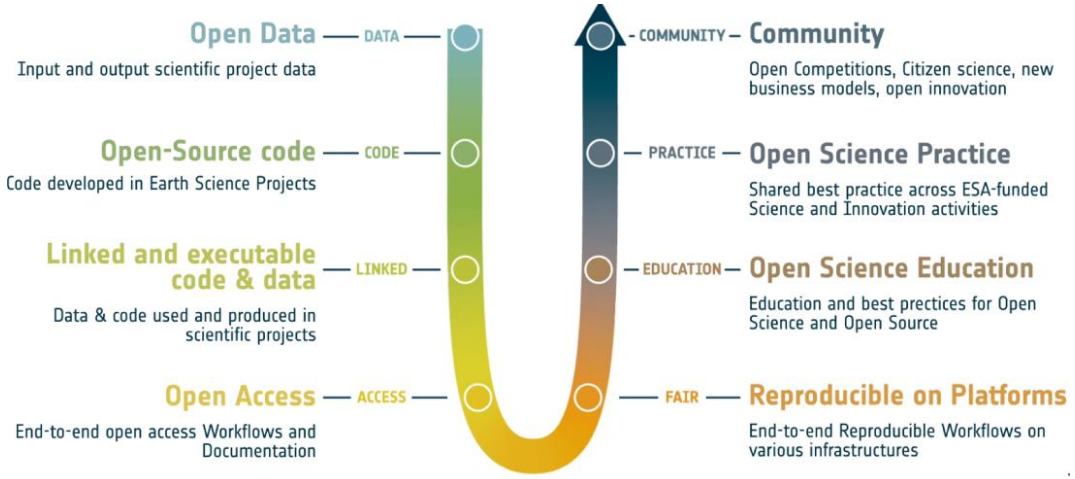

Overall aim of the EarthCODE portal is to help users create scientific workflows for their experiments and publish them to a repository after they have been verified, so that experiments can seamlessly be re-used with the specified data and necessary infrastructure according to FAIR Open Science Principles, engaging with the relevant communities to further science.

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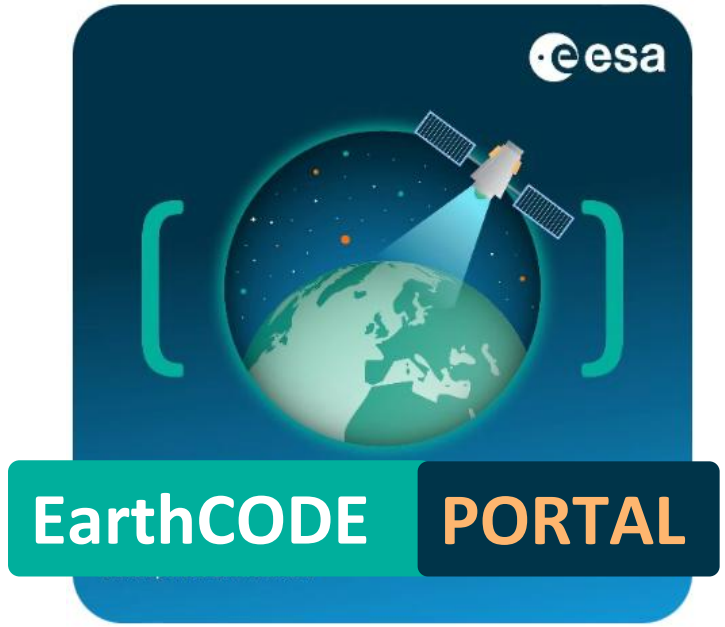
EarthCODE Strategy

- EarthCODE is designed to provide Earth system scientists with computational resources, data management tools, and open science support.



Contributor

user

Catalogue Resources Manage Community

Catalogue

- **Science Data** → Visualise on a web map / import in a dashboard
- **Methods & Workflows** → View / Modify / Use / Execute in a platform
- Papers & Documentation

NoR Sponsorship

Resources

- **EO Platforms** → Develop new methods
- **FAIR Management Tools** → Package your algorithm as a FAIR workflow
- Learning resources

NoR Sponsorship

Manage

- As a PI, manage your project outcomes

Publish your data and workflow

Community

- Discuss on the forum about datasets, methods, etc

Long-term storage in Project Results Repository on **ESA Infrastructure**

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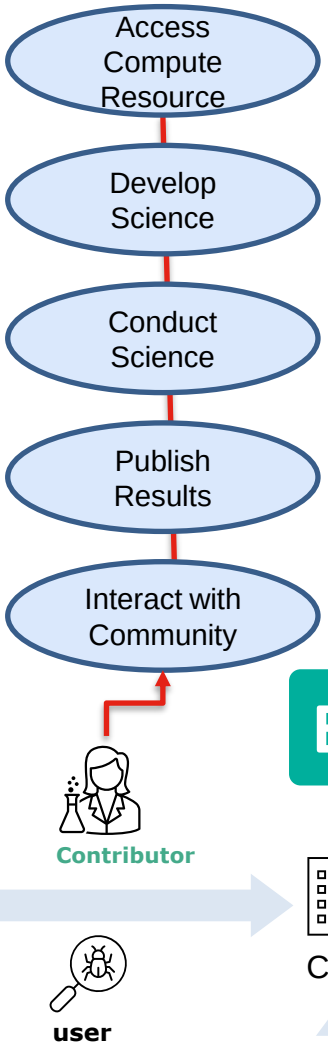
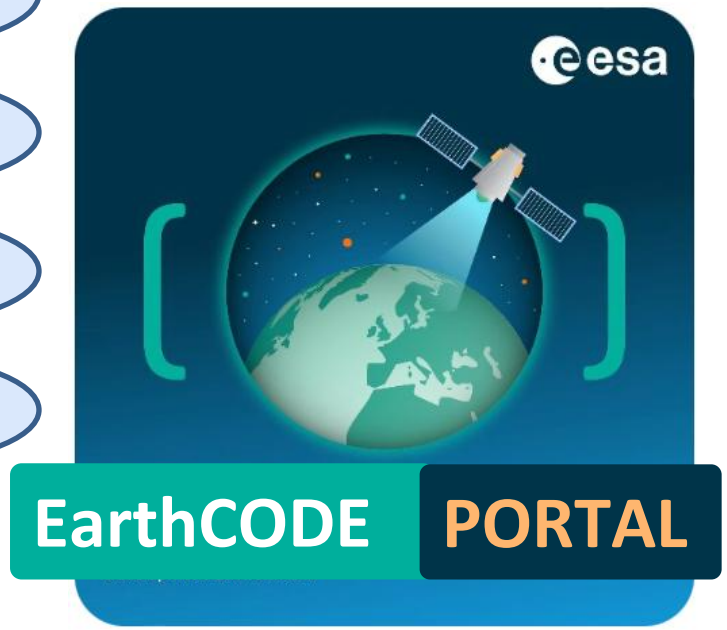
EarthCODE Use Cases





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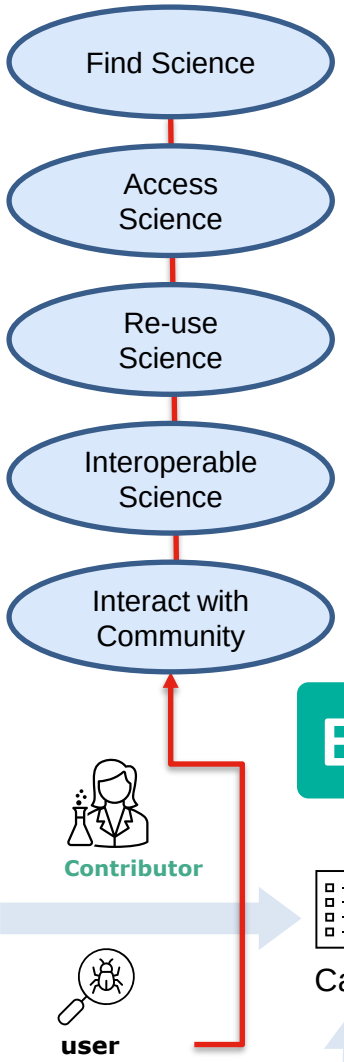

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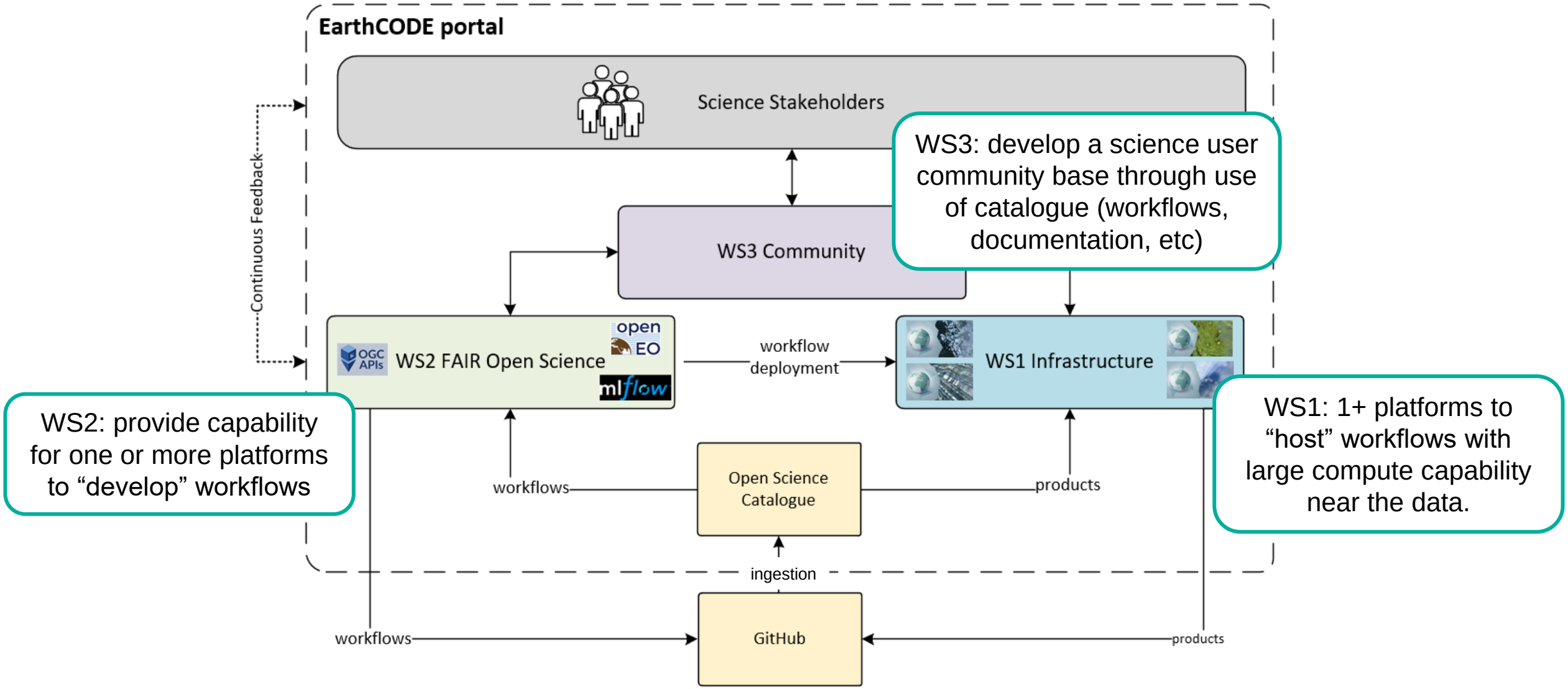
Conceptual Architecture (in support of reproducibility and interoperability)



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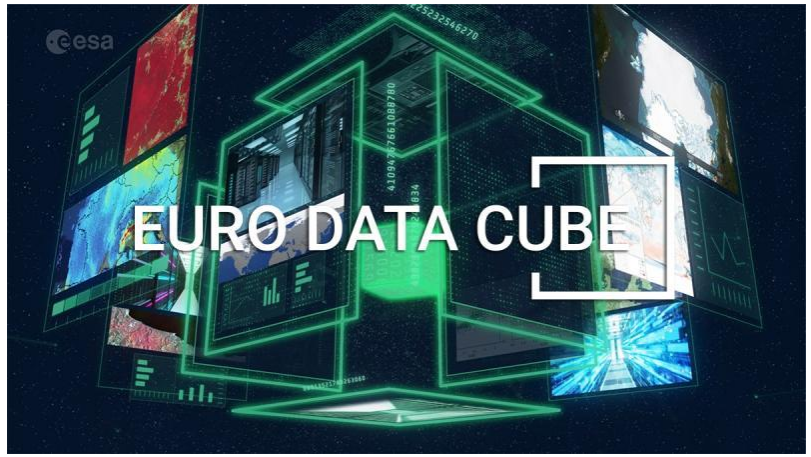
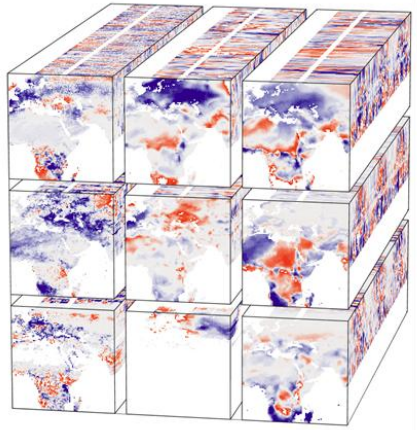
Platforms and Partners





EARTH SYSTEM DATA LAB

EOX

vito Remote Sensing

BROCKMANN CONSULT

Best practise ITT is planned for 2025 to allow more platforms

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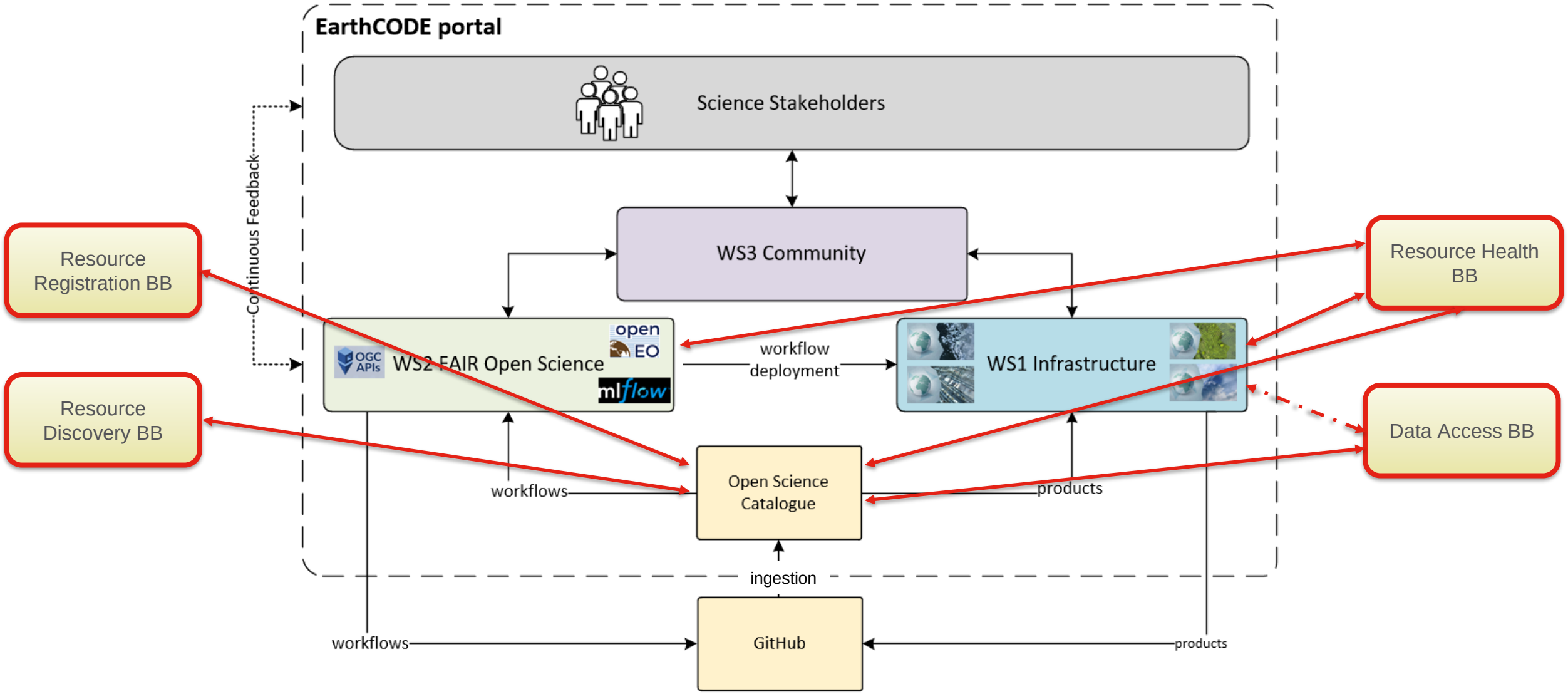

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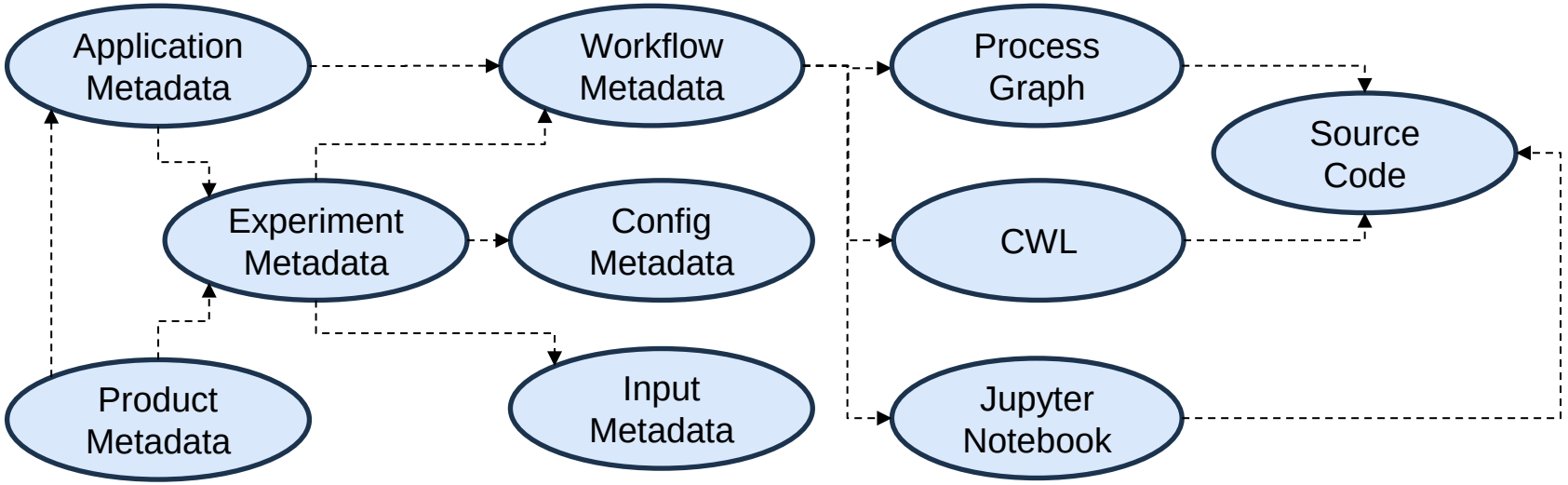
EarthCODE High-level Architecture - Metadata

- Workflow
- Experiment
- Product



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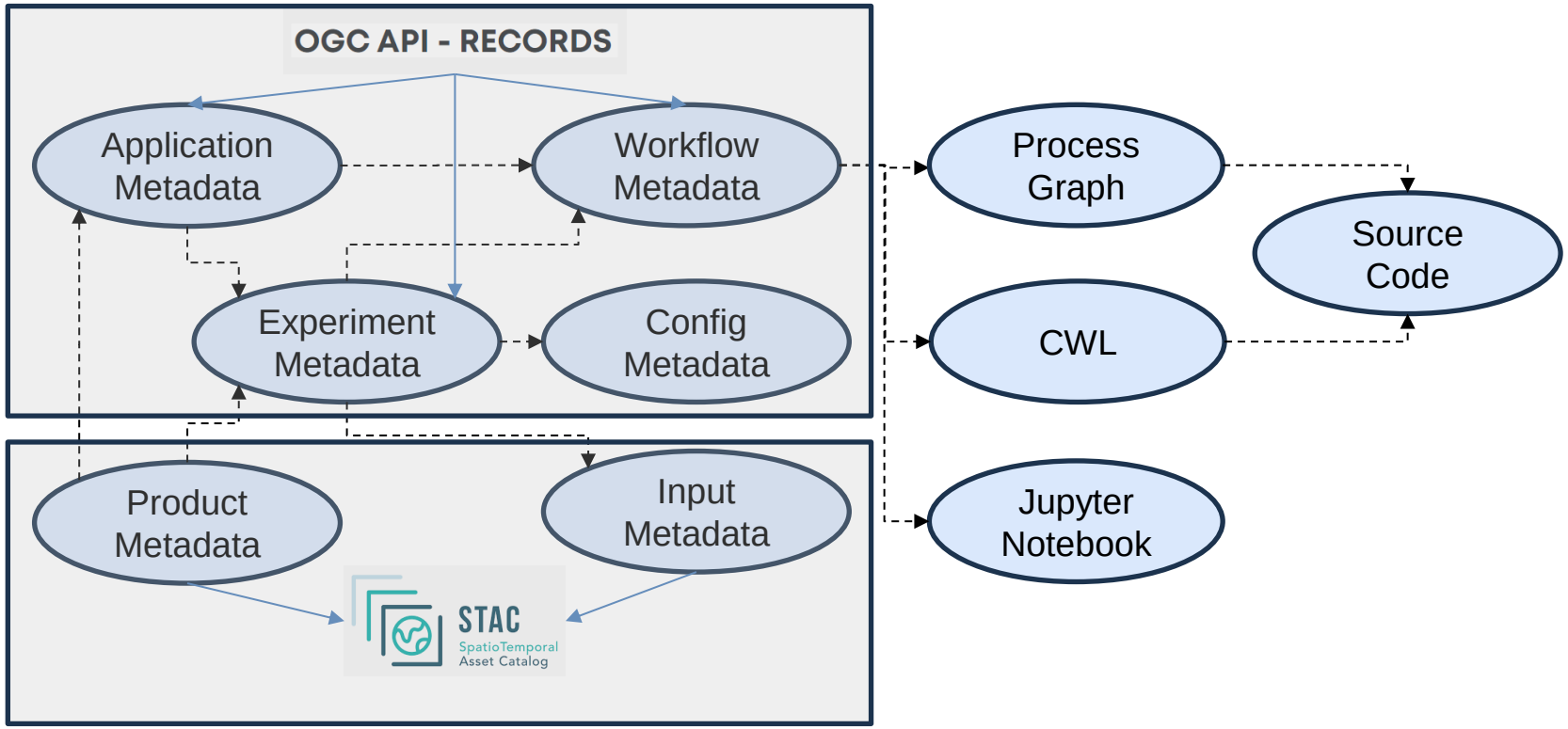
EarthCODE High-level Architecture - Metadata

- Describing Workflows, Experiments and Applications
- Describing Products and Input Data



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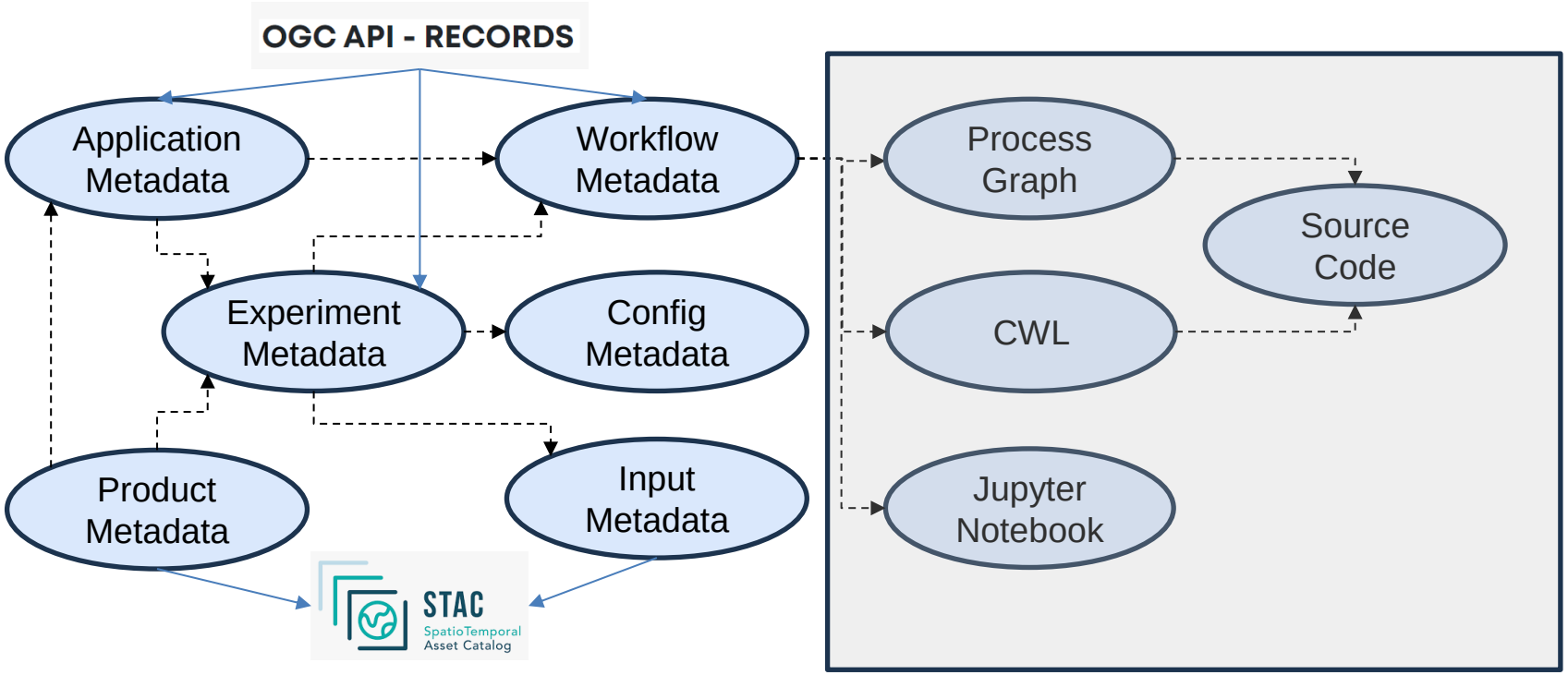
EarthCODE High-level Architecture – Workflow Support

- Find novel ways to convert source code into CWL
- Find novel ways to convert source code into a Process Graph
- Find novel ways to convert source code into other workflows
- Find novel ways to manage data types when using workflows



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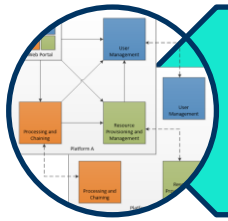
Open Source Software

EOEPCA
BETTER ACCESS TO EARTH OBSERVATION



Web Portal
https://eoepca.org/

GitHub
https://github.com/EOEPCA

Documentation
https://eoepca.readthedocs.io/

EarthCODE

https://earthcode.esa.int/ - EarthCODE Portal

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FOR YOUR ATTENTION

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