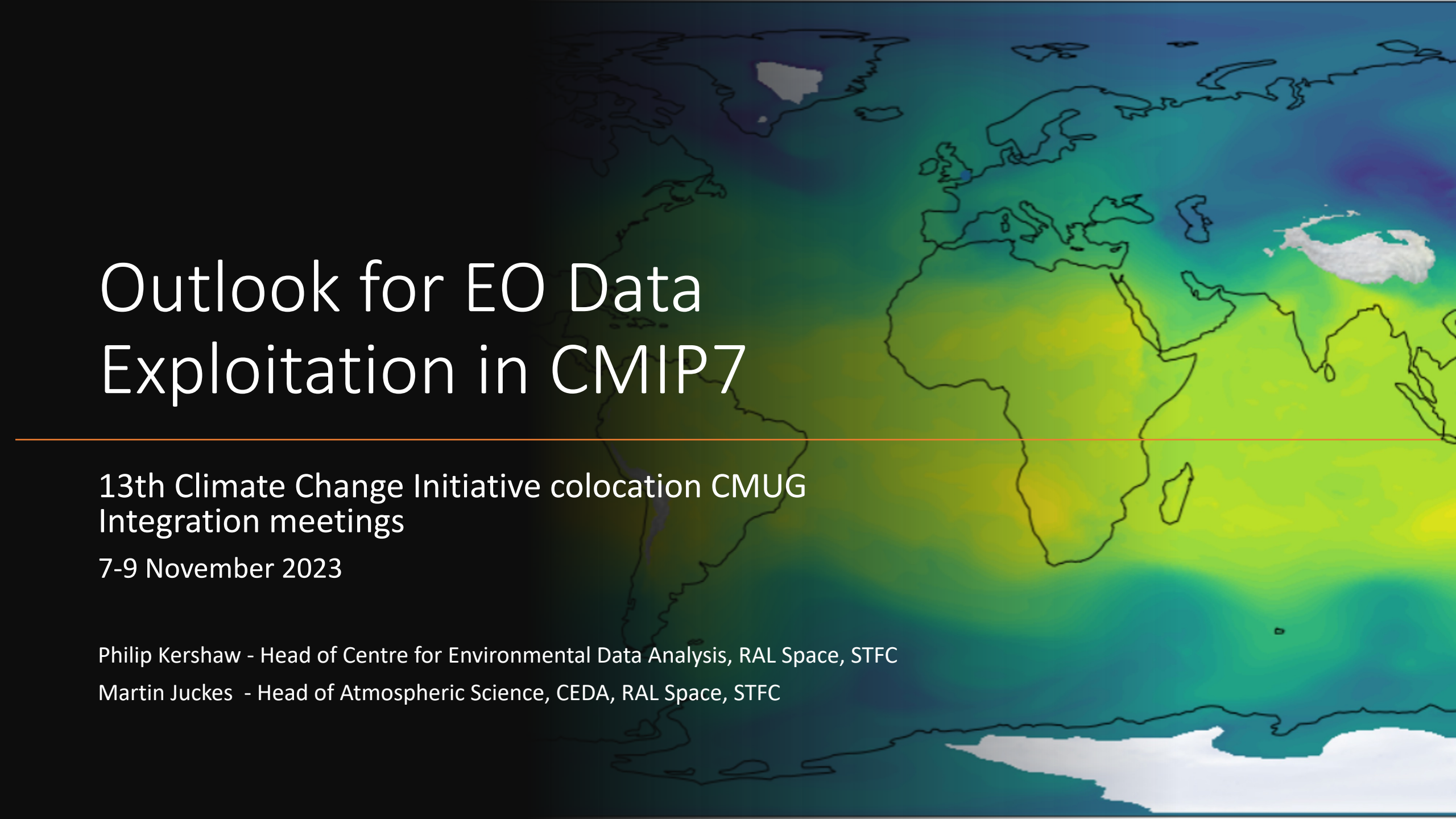


Outlook for EO Data Exploitation in CMIP7

13th Climate Change Initiative colocation CMUG Integration meetings

7-9 November 2023

Philip Kershaw - Head of Centre for Environmental Data Analysis, RAL Space, STFC

Martin Juckes - Head of Atmospheric Science, CEDA, RAL Space, STFC

CEDA, CMIP, WCRP and IPCC

- CEDA's mission: provide data and information services for environmental science on behalf of NERC
- Support climate research -
  - Bringing CMIP and other significant global datasets into our data archive on the JASMIN analysis platform
  - Publishing UK climate simulations and observational datasets to make them accessible to the global scientific and science assessment community
  - Working with peer organisations around the world to create an efficient and scalable global data infrastructure for climate model data (ESGF)
  - Working with the community and peers to establish standards and governance.

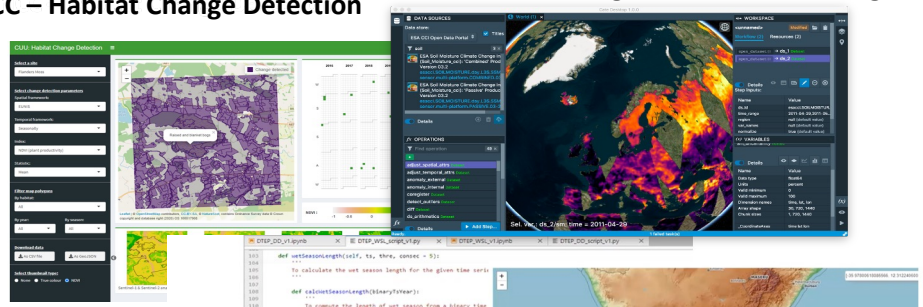
This presentation …

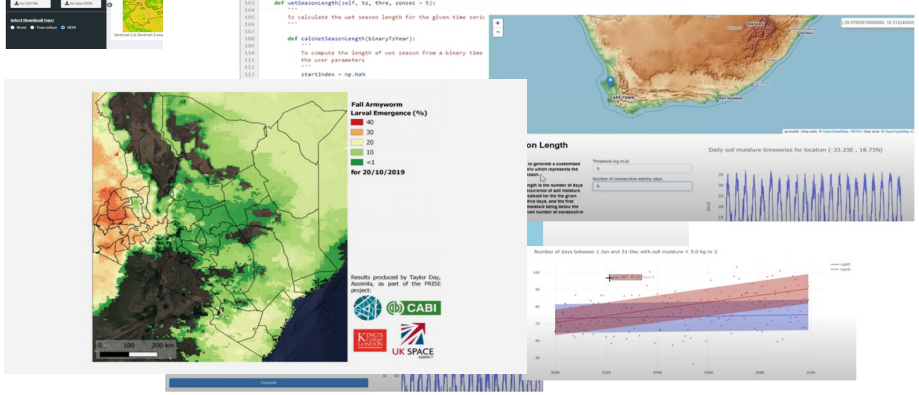
- Data exploitation and the role of data analysis *Platforms*
- Platforms in the wider context of the Earth sciences – their evolution and how they fit into a wider ecosystem of digital infrastructure and services
- Earth System Grid Federation (ESGF) – recent developments
- The EO DataHub –UK initiative to build a new data analysis platform
- Data exploitation in the context of CMIP7, planning, funding, governance
- Thoughts on futures – How does a platform approach best support climate model evaluation taking advantage of EO data

Platform Development Approach

JNCC – Habitat Change Detection

ESA Climate Change Initiative Knowledge Exchange Project





PRISE – Assimila, CABI, KCL, STFC

ESA Digital Twin Earth Climate Explorer - Soil moisture prediction

- Platform: **an underlying software infrastructure** to support the development of applications and web services
- The Platform supports application development through the provision of
  - Hosting – compute and storage (typically cloud)
  - Data
  - Supporting software services and APIs

One example - JASMIN:

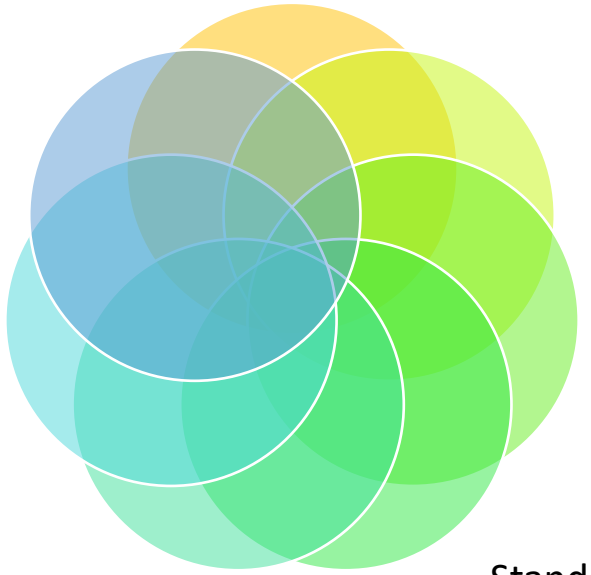
- 10 years' experience with this model serving NERC user community and working with partners in industry and the public sector
- ~40 PB disk and 15k cores

Platforms and Broader International Context

ESA Thematic Exploitation Platforms

Climate Platforms: Pangeo

Copernicus Climate Data Store, DIAS



NERC Digital Solutions Programme, NERC DataLabs

Public cloud offerings: Google Earth Engine, MS Planetary computer, Earth on AWS

Standards: OGC, ESA EO Exploitation Platform Common Architecture

EO DataHub

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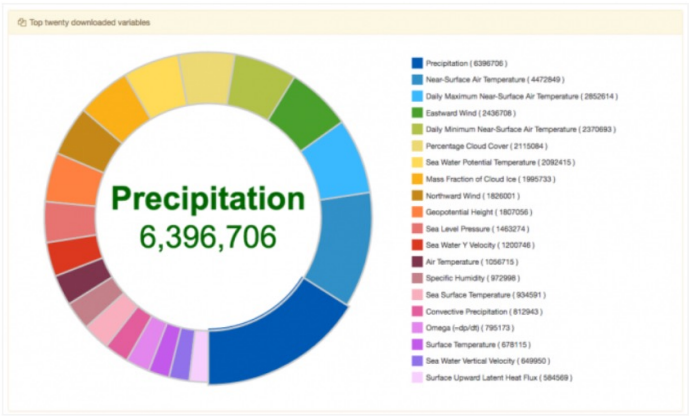
Earth System Grid Federation

37	188	26	15,075,633	1,350,998,839	41.57
Projects	Countries	Data nodes	published datasets	files downloaded	PB downloaded

ESGF Federation

This user interface provides a set of data usage and publication metrics across the Earth System Grid Federation. Statistics refer to the period January 2018 to present.

Data usage



Cross-project and project-specific sections, with a rich set of charts and tables, provide different views about the data downloaded across the ESGF federation.

Data publication

A view of the total amount of data published and available through the ESGF infrastructure gives users an in-depth view about the ESGF data archive.

Ref: http://esgf-ui.cmcc.it/esgf-dashboard-ui/

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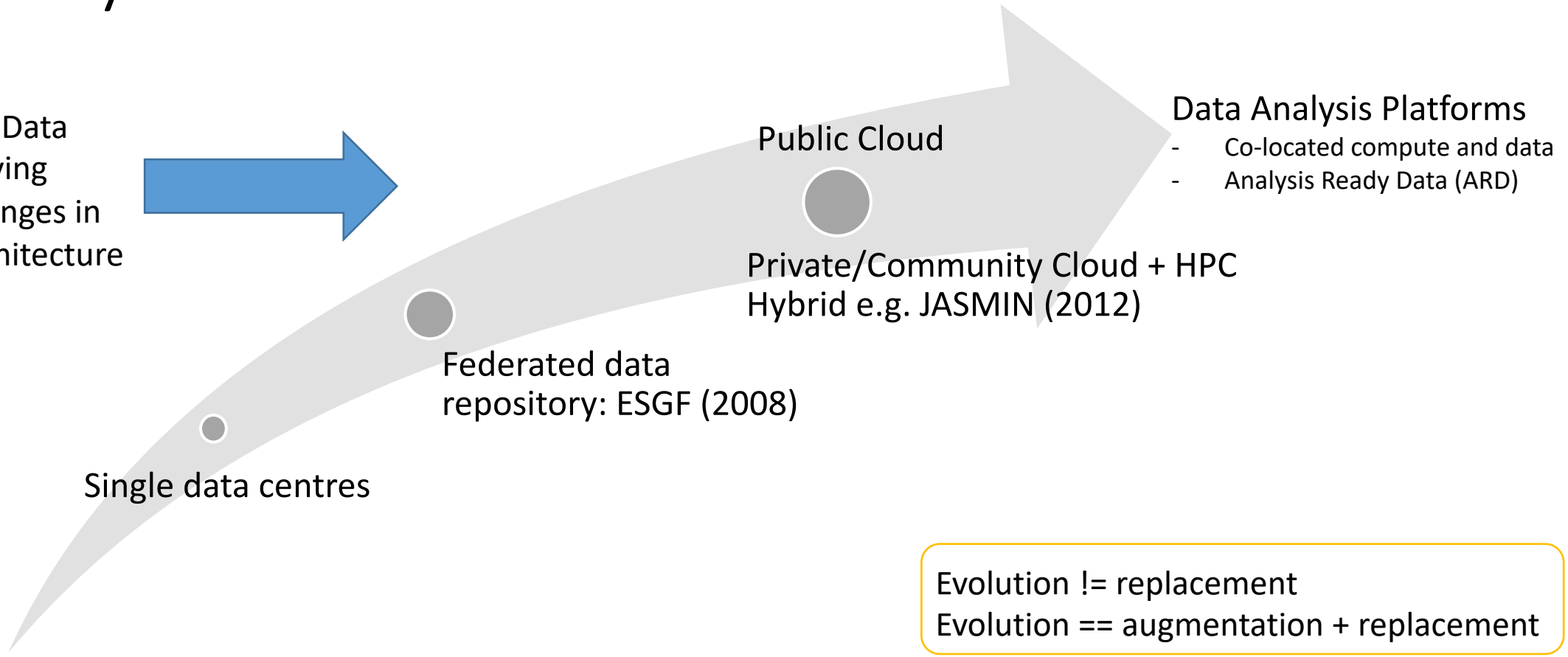
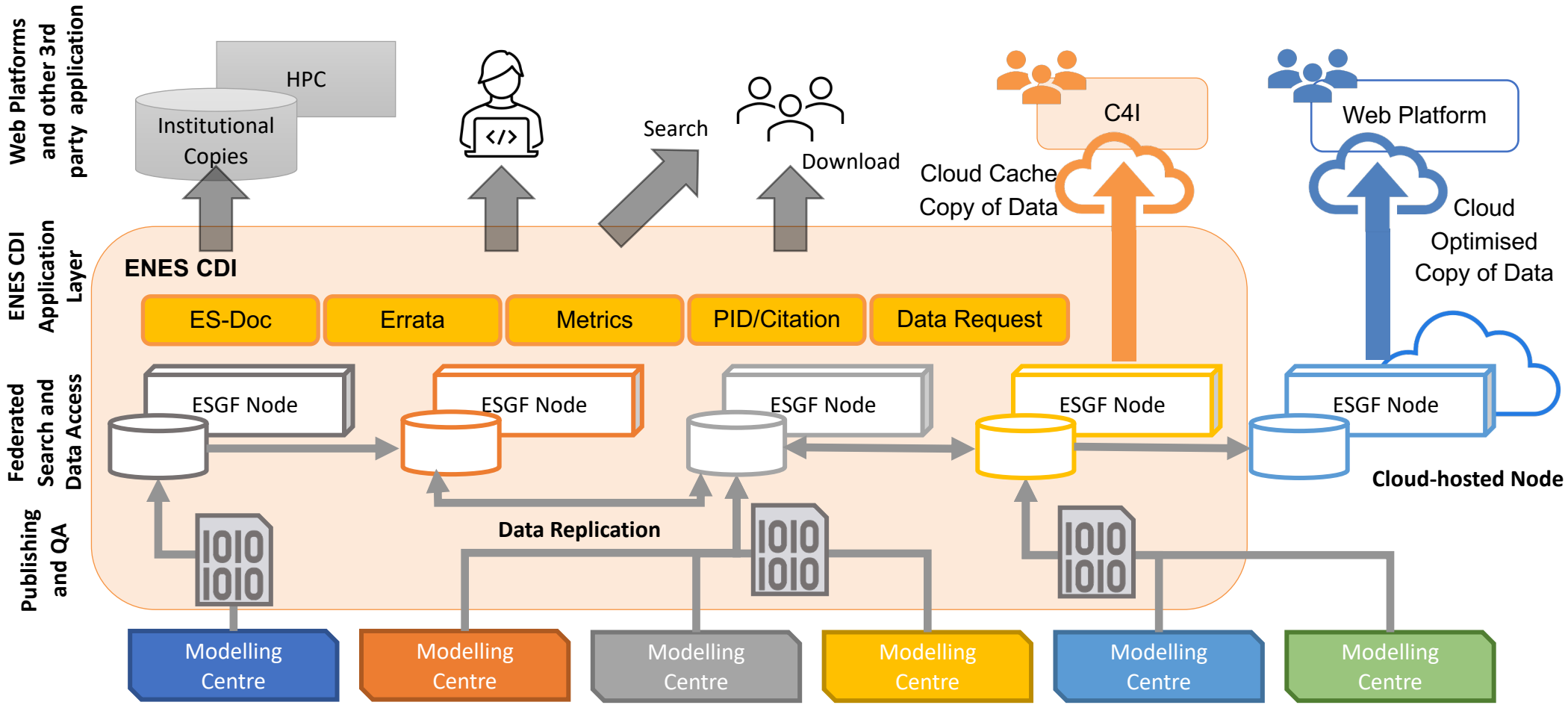
Evolution in architectures for data access and analysis*



Evolution != replacement
Evolution == augmentation + replacement

* Slide from AGU presentation 2020: Cloud futures for CMIP data – evaluating object storage models and re-evaluating federation for data distribution

ESGF and the ENES Research Infrastructure



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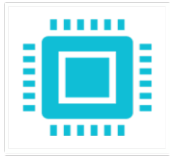
ESGF Development Plans

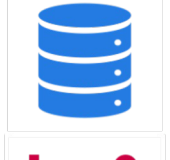


Installation and Systems Administration – Container-based installation developed and being rolled out across the federation

Search Services – new search system under development using Globus (US) and ElasticSearch (Europe). Use common STAC API

Identity and Access Management – uses OpenID Connect / Oauth 2.0 – Globus (US) and EGI Checkin (European) Identity Providers

Compute Services – ENES testbed in operation using web processing service (DKRZ) integrated with web frontend (Climate4Impact)



New modes for data access and storage

Metrics Collection – container-based installation has hooks for linking to CMCC Dashboard

EO DataHub – A new platform for the UK

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Met Office

NPL

CATAPULT
Satellite Applications

UK SPACE AGENCY

- 2-year project, started Feb ‘23 - 10m investment funded from DSIT EO Transitional Package

- Goals:
  - Be a new ‘single point’ EO Data infrastructure, that builds on current UK EO assets and brings together UK EO data offerings from public and commercial centres
  - Enable new EO services and tools to be developed and accessed by the UK EO data community by providing a transformational layer
  - Address key challenges in EO data access and discovery, interoperability, transparency, and trustworthiness
  - Support industry, public sector and academic communities

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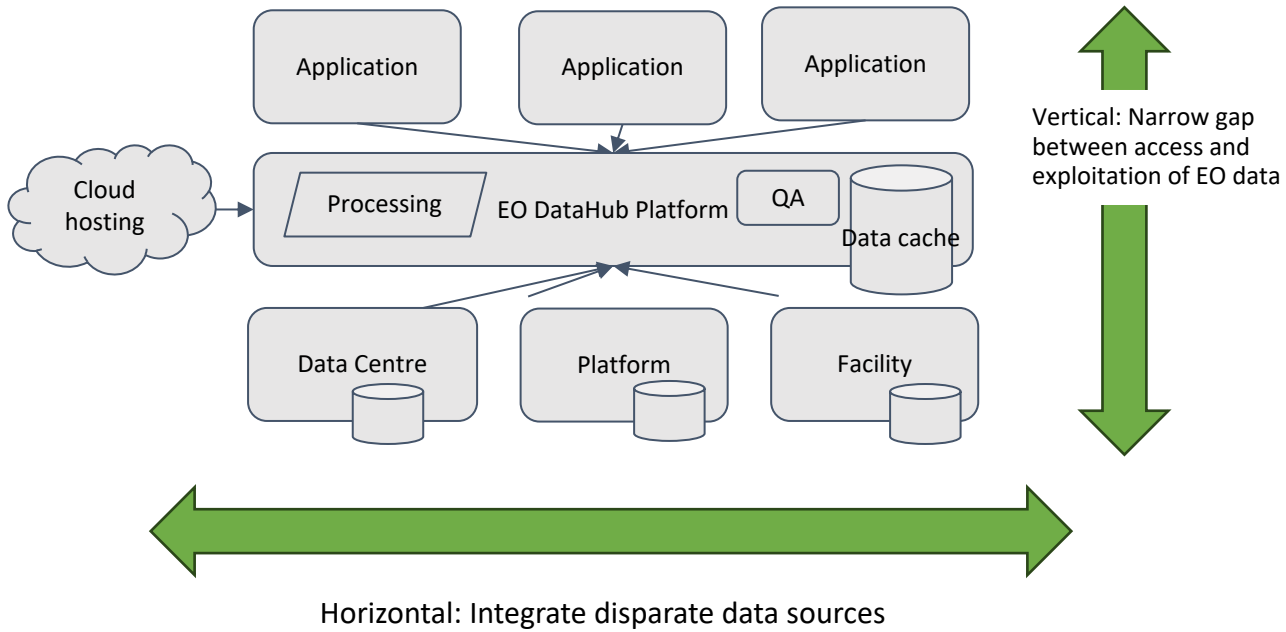
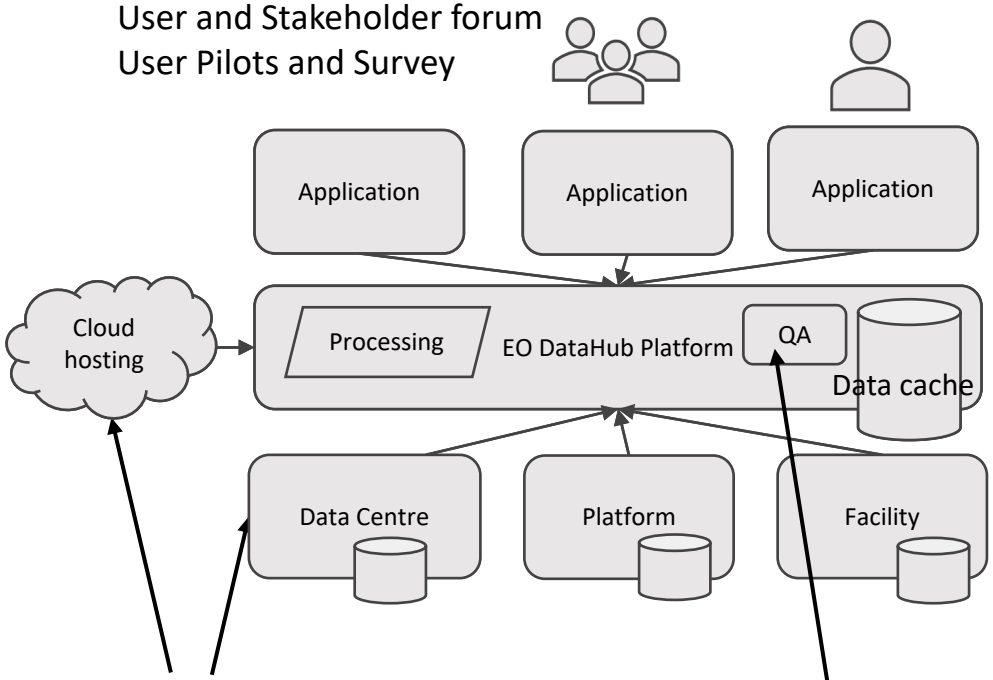
EO DataHub – Architecture Concept



EO DataHub Project Work Areas

User engagement

To inform the overall development esp. Applications
User and Stakeholder forum
User Pilots and Survey



Applications

- ITT will fund development of at least three applications which exploit the Hub Platform
- Themes: Climate, Infrastructure and Utility Systems (Inc. Water & Energy), National Resilience

Hub Platform: software development and operations ITT released

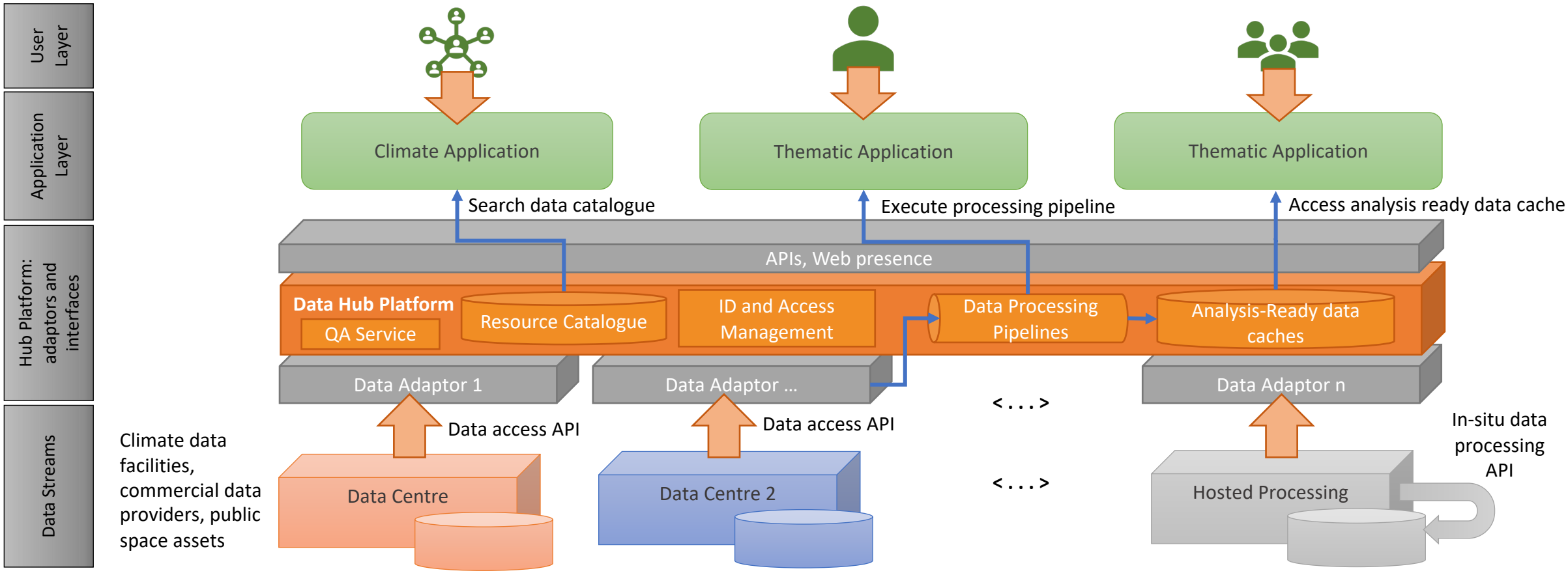
Data Streams: provide data services

- Research community data provider: CEDA – Sentinel, UKCP, CMIP6, CORDEX
- Commercial data provider(s): sourced from ITT to be released – likely hi-res optical and SAR

Hosting: Public cloud + some on-premise for data product generation (***EOCIS Project***)

Quality Assurance: provide quality information to inform users on suitability of data for given purpose

EO DataHub High-Level Architecture



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Core Functional Areas

Data Streams + access interfaces

allow integration of different data providers and production and caching of outputs on the Hub

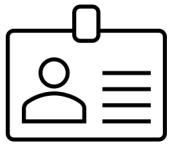
OGC W*S – WMS, DataCubes, Object store – COG, Zarr

Resource Catalogue

support search of data and processing resources

Quality Assurance for data

STAC, OpenSearch, OGC, …



Identity and Access Management, Accounting and Metrics

grant access to secured resources, account and charge for use as required

OpenID Connect, OAuth 2.0, …

Data Analysis, Processing and workflow management

Analyse data, develop and incorporate custom code, execute and integrate into workflows

Jupyter, Dask, CWL, Apache Airflow, …

Web presence

Presentation and glue

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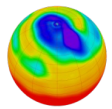

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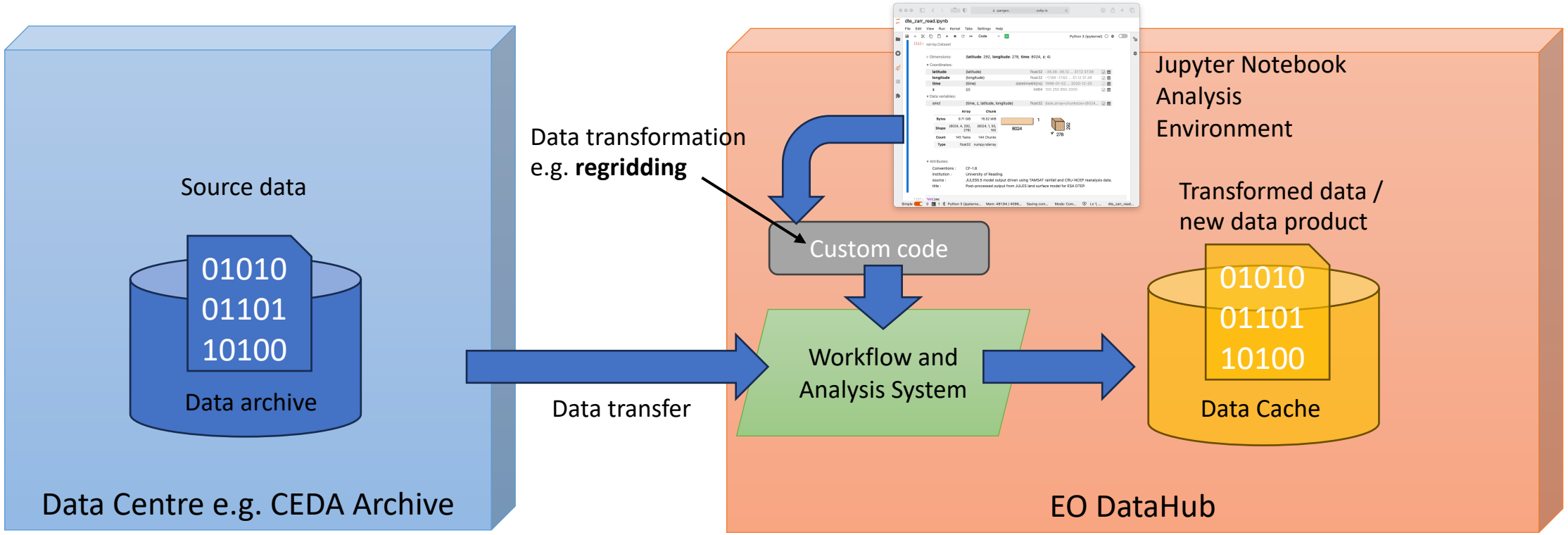
Data Processing to facilitate Data Analysis and Exploitation

- Support for data processing and orchestration of workflows are a core component for an EO Platform

- This is a fundamental capability to support the transformation of source data into forms for further analysis

- Such processing pipelines could be devised to facilitate integration and intercomparison of model outputs and observations

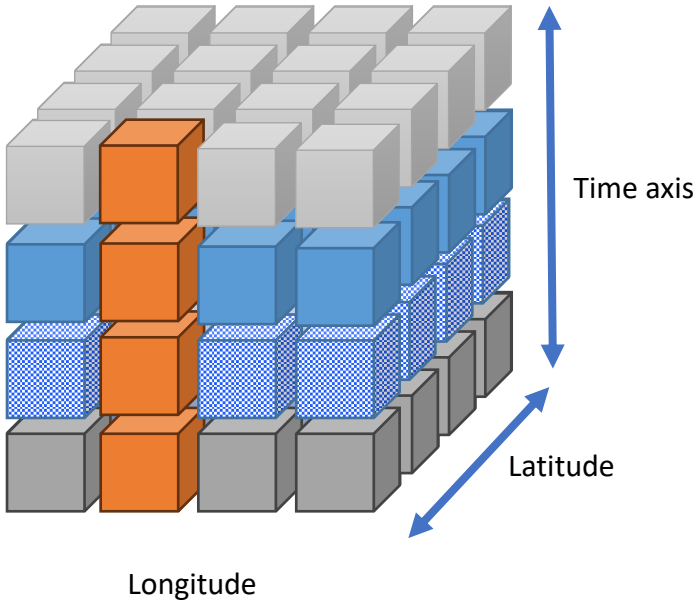
Data Processing to facilitate Data Analysis and Exploitation



Data Formats and Access

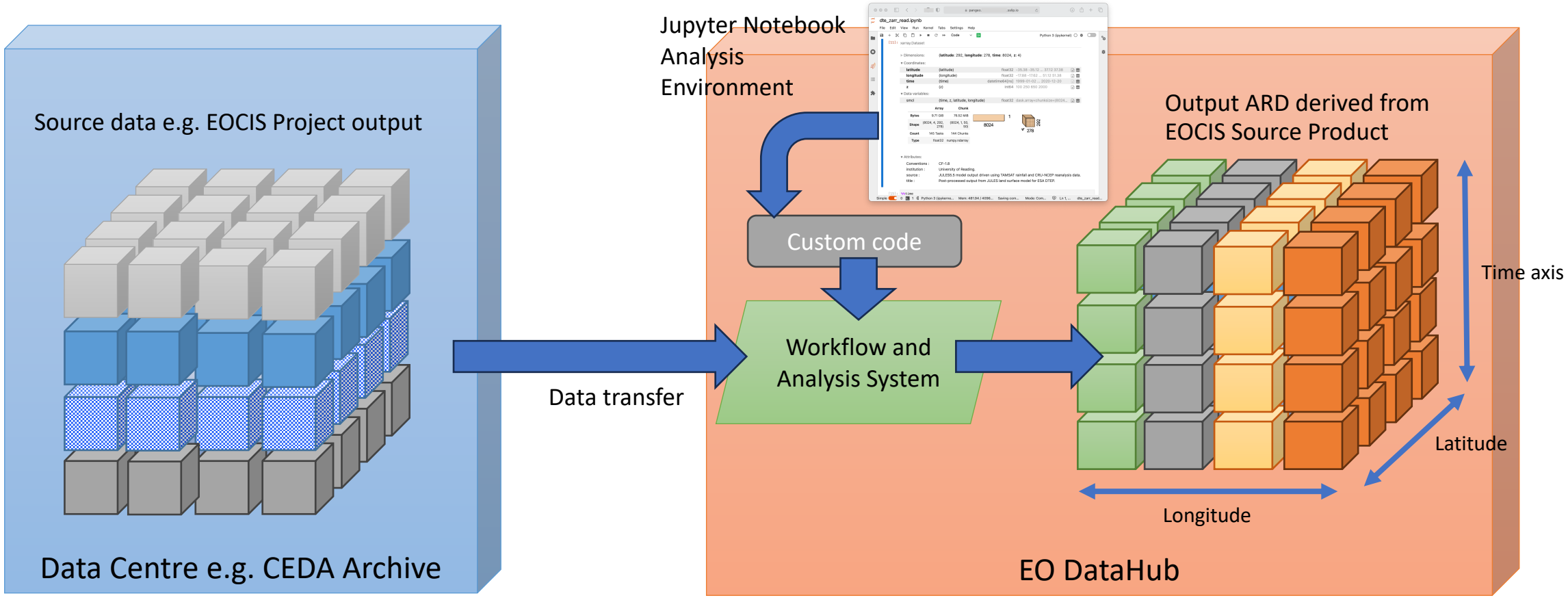
- Analysis-Ready data
- Cloud Optimised GeoTIFF (COG)
  - Popular for EO datasets
  - Enables efficient access of files through the use of HTTP Range GET operations on data stored in object store
- CF-netCDF
  - Predominate standard for climate data
  - Zarr has become popular for cloud storage of netCDF data on object store
  - Kerchunk uses alternative strategy preserving the original netCDF file format but presenting a Zarr compatible interface to consuming client libraries
- Jupyter + xarray + Dask for access and analysis

Data Chunking to optimise read performance



- Example scenario –
- Data processing creates an output file one per time step
  - In the diagram vertically stacked coloured slices as the processing proceeds
- Later, for analysis, a user wants to sample an individual location as a time series (orange vertical)
  - This involves potentially opening hundreds of individual files(!)

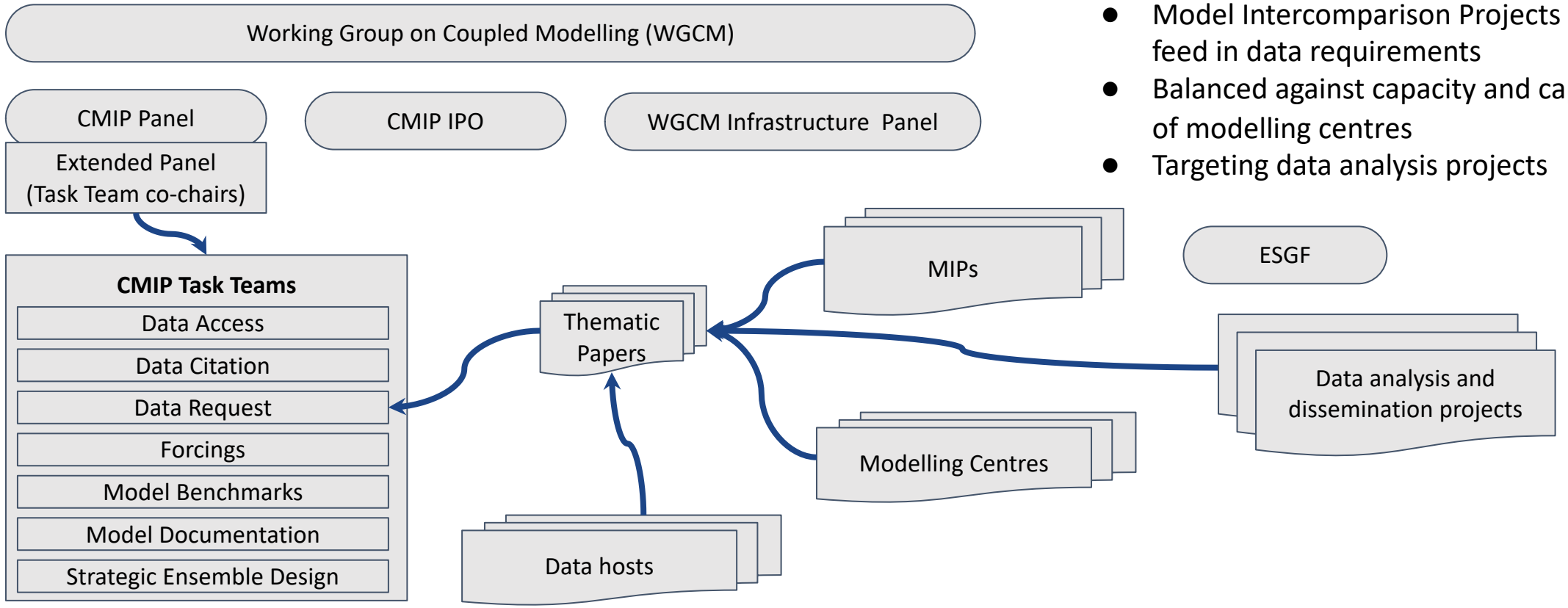
Data Processing Pipeline: rechunking to suit custom data analysis access pattern



EO Data and CMIP7 – Engagement, Processes, and Governance

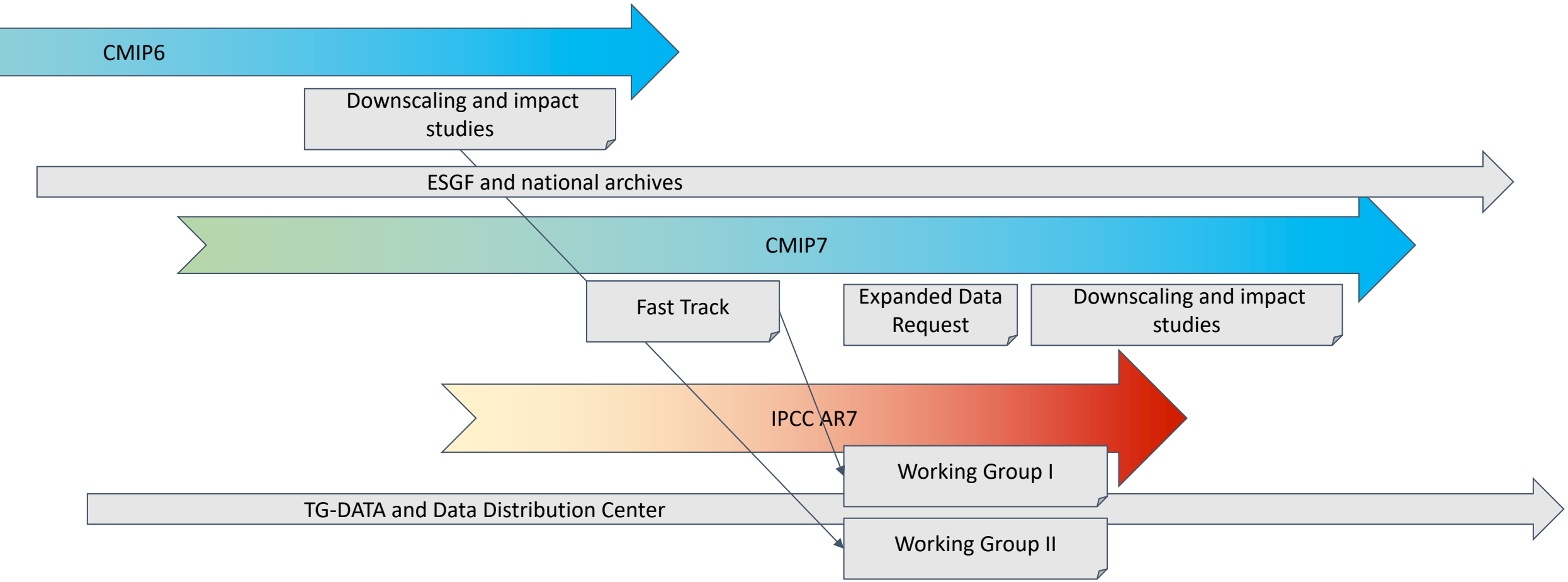
- Effective engagement with the community and participation in the processes and governance for CMIP essential to deliver successful software services
- CMIP has model intercomparison projects that have a targeted focus - this might be an opportunity for specific integration with EO data - in terms of model processes
- How might you do this? - propose a model intercomparison project (MIP)
  - MIPs - need a co-ordinator, needs enough interest from the community

CMIP Data Requirements Workflows

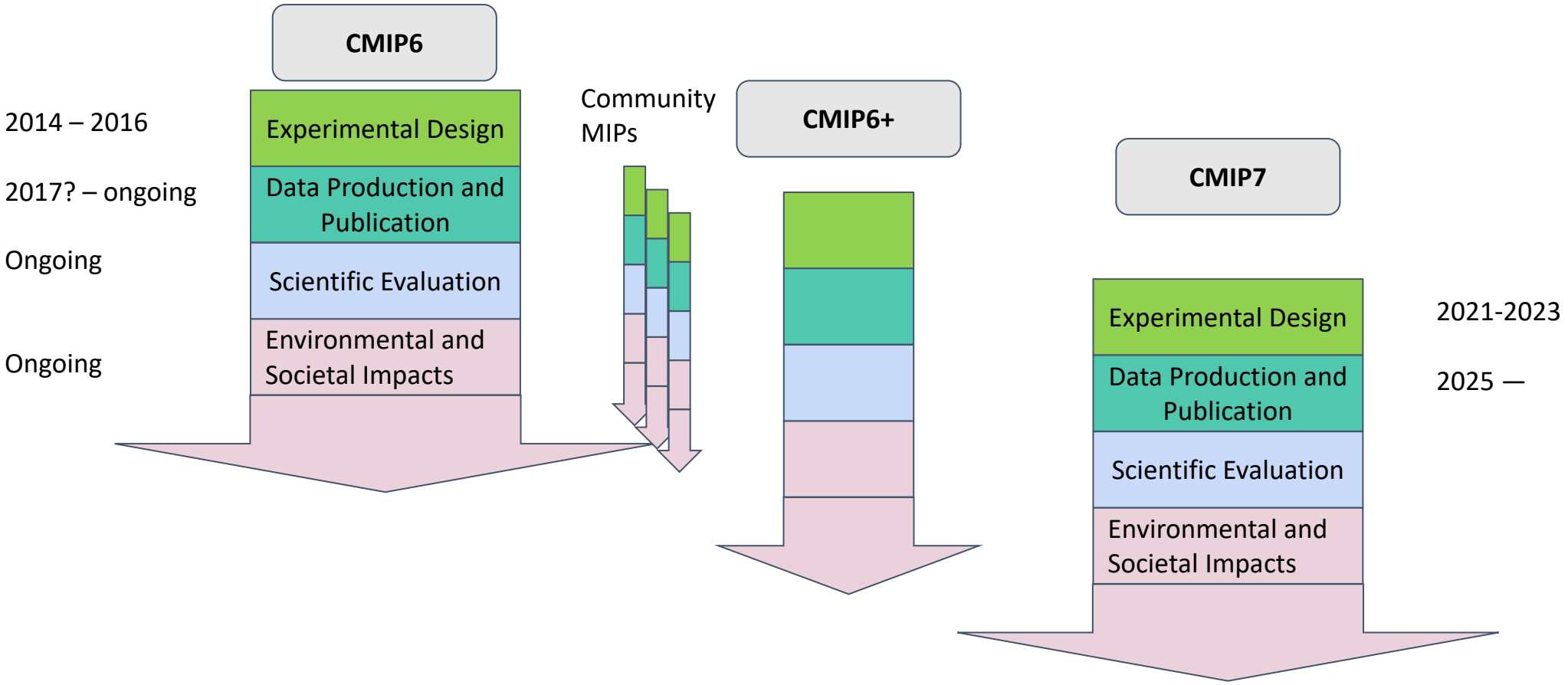


- Model Intercomparison Projects (MIPs) feed in data requirements
- Balanced against capacity and capabilities of modelling centres
- Targeting data analysis projects

Overlapping Phases of CMIP Exploitation



Overlapping Phases of CMIP Exploitation (cont.)



Specific Areas for Potential Engagement

- Supporting evaluation of physical climate simulations for IPCC AR7 WG I – CMIP7 Fast Track
  - Publication of data through Obs4MIPS
  - Developing community tools and platforms
  - Propose a dedicated MIP
- Supporting evaluation of impact modelling in IPCC AR7 WG II – CORDEX downscaling of CMIP6 and distributed community efforts
- Supporting transparency and access to EO Data
- IPCC Task Group on Data (Governance body appointed by IPCC)
- IPCC Data Distribution Centre (Data curation experts funded to work under IPCC governance)

Summary

- New developments in ESGF include a container-based deployment, integration of modern identity and access management and new search services
- ESGF provides the underpinning infrastructure to support a platform-based approach for data analysis
- EO DataHub – new platform which brings together climate model and EO datasets (including new products from EOCIS project)
- New initiatives for interfacing climate models and observations could explore how they might integrate with the CMIP process e.g. initiate a dedicated MIP

Vision for Ecosystem

Leverage platform services to build applications which exploit the model and obs data

Platform provides services for data transformation and exploitation

ESGF underpinning infrastructure + CCI and other EO data sources