Exploiting the Model-Context Protocol for Earth Observation Data Access and Workflow Orchestration

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ECMWF

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ECMWF

European Centre for Medium-Range Weather Forecasts (ECMWF)

Inter-governmental Organisation, Established in 1975

- 35 States (23 Member &12 Co-operating States)
- Headquarter in Reading, UK, Offices in Bonn, Germany & Bologna, Italy

Operational Numerical Weather Prediction (NWP) centre

- Research institute and a 24/7 operational service
- Twice daily generation of operational weather forecasts
- Assimilation of 80 million observations/day
- Archive of Petabytes of observations and forecast data

IT infrastructure

- HPC facility globally one of the largest weather sites
- Cloud infrastructure for Copernicus services and the European Weather Cloud
- Climatological data : ~ Exabyte (EB) (daily growth of 300TB)

Some European Initiatives and Projects involving ECMWF

- Copernicus Services (CAMS, C3S and contribution to CEMS) – Earth observation services
- Destination Earth – Digital Twin of the Earth

- **DeployAI**
- **EO4EU**
- BUILDSPACE
- CLIMRES
- MediTwin

DeployAI project

Funded by the European Union

*DeployAI's **vision** is to empower the European AI innovation ecosystem by providing **accessible, ethical, and human-centric AI solutions** that foster collaboration, innovation, and trust across industries, especially **focusing on SMEs and the public sector.***

*DeployAI's **mission** is to deliver a fully operational, production-grade **AI-on-Demand Platform** & a comprehensive **Marketplace,** offering DevOps tools, AI models, real-world use cases, and seamless access to **Cloud and HPC infrastructures**.*

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AI on Demand (AIoD) – High-Level Architecture

AI-on-Demand platform

Sovereign DevOps tools
(AIoD Branded Services)

LowCode AI Application Builder Studio (AI Builder)

- Evaluation Services Model Cards
- Agentic Tools (Paradigm)
- Other, i.e. Sandbox Systems
- Compliance by design

On-Demand DevOps / Kubernetes Infrastructure

CONVOTIS

AI Business Navigator

AIoD European AI Marketplace
(Open Source)

- European AI Startups
- Business AI Applications
- Industrial AI Application
- EU Ecosystem

AIoD Core System
Open-Source eCommerce Platform (VirtoCommerce)

- GenAI Gateway
- Enterprise Portal / APIs

GPU Server

Lumi AI · MELUXINA · IONOS

AI Factories

Lumi AI · MELUXINA

Model API Provider

IONOS · Fraunhofer

- Enterprise Applications
- Industrial Applications

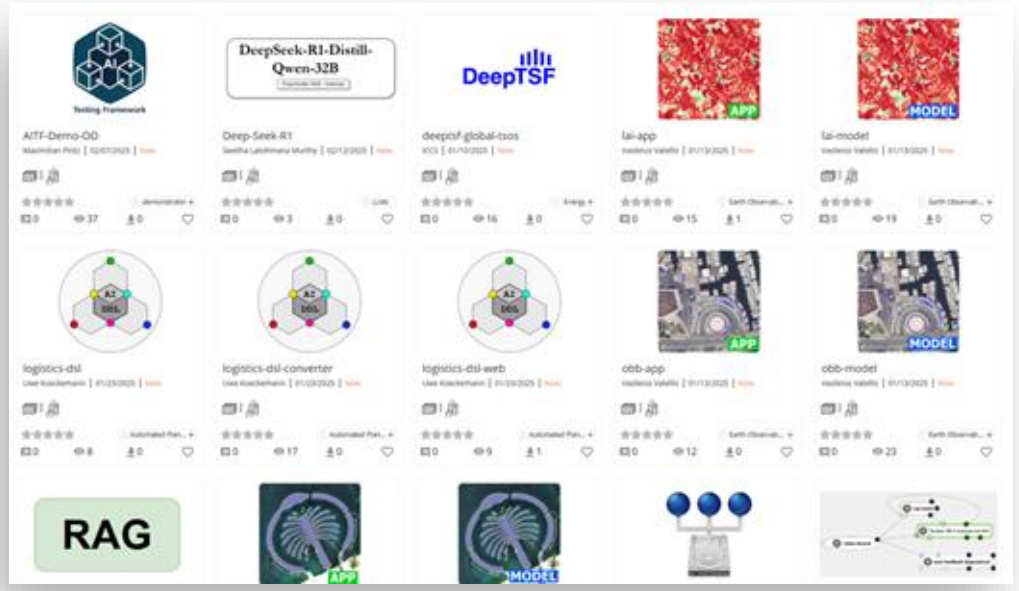
AI Builder

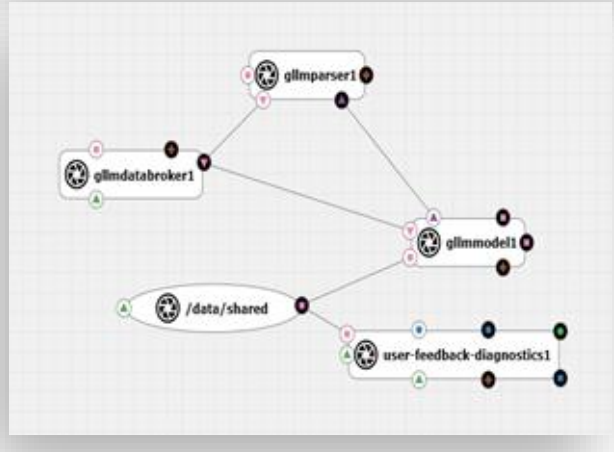
"AI-Builder is a tool for creating workflows from re-usable AI modules"

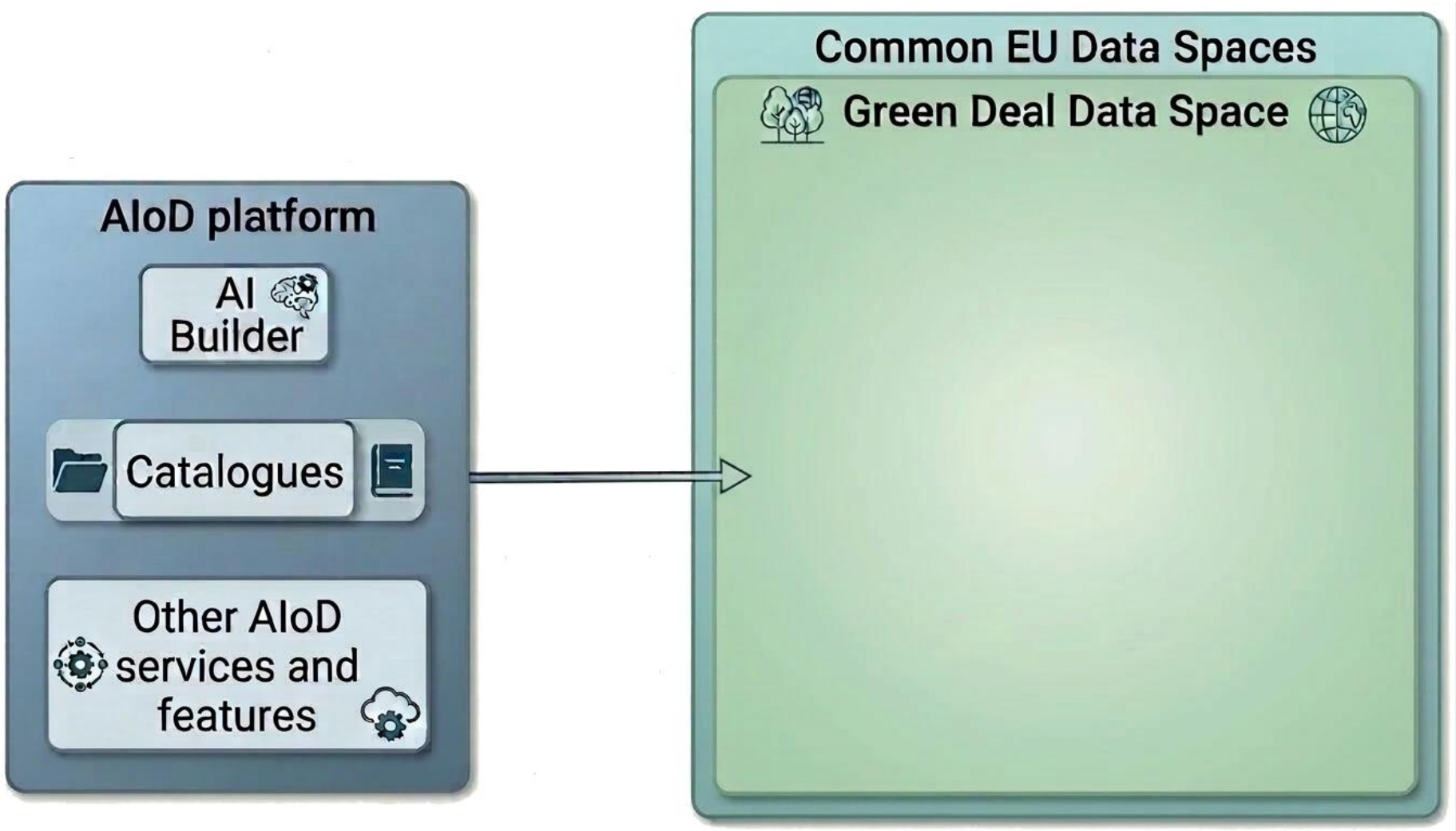
Catalog of AI-Modules

Visual AI-Pipeline Editor

Ability to deploy AI-Pipelines to various execution environments like Cloud or HPC infrastructures

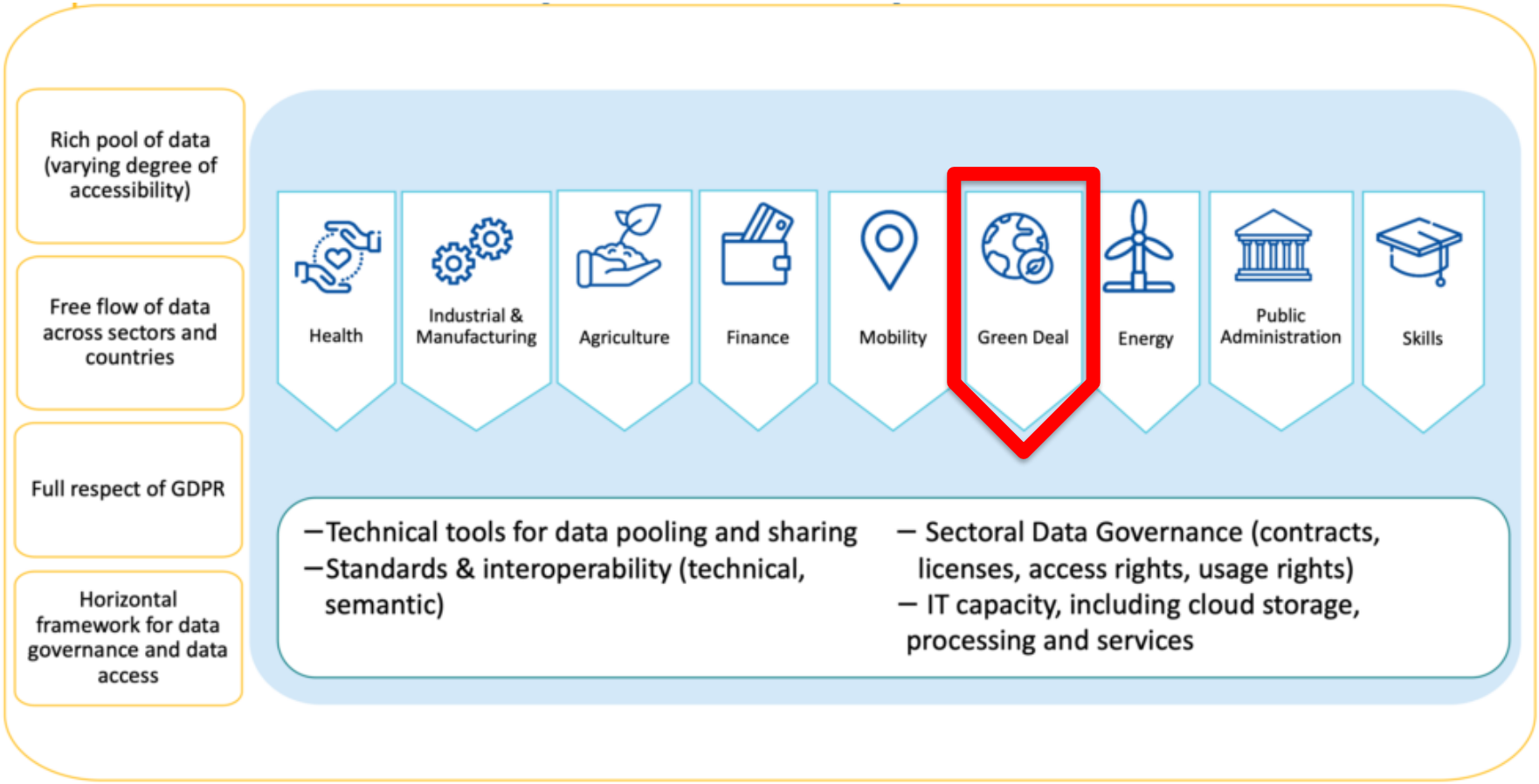





Common EU Data Spaces
Green Deal Data Space
AIoD platform
AI Builder
Catalogues
Other AIoD services and features

Common European Data Spaces

- Common European Data Spaces are secure, interoperable environments that enable data to be accessed, shared, and reused across sectors and borders in a trustworthy way.



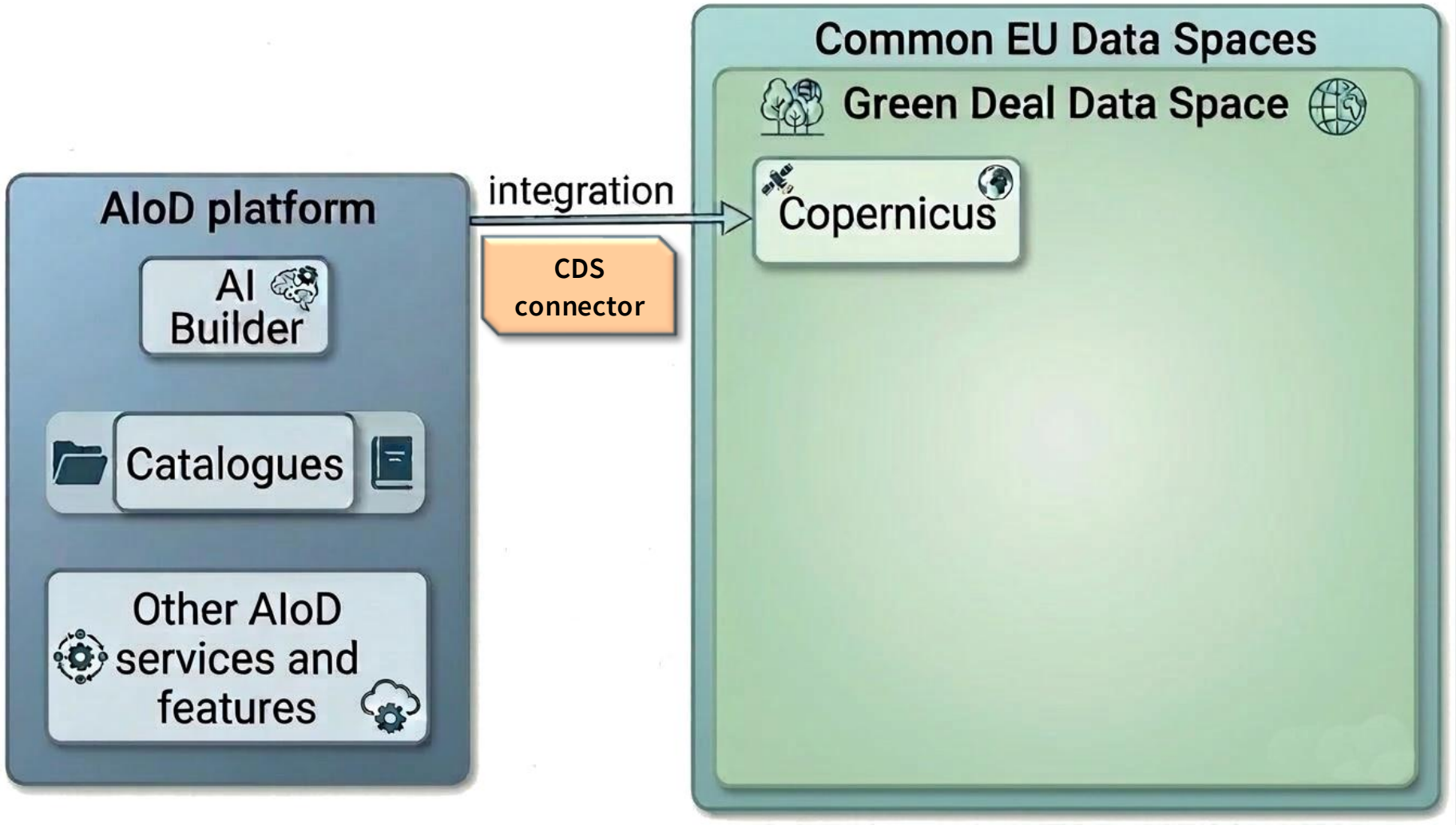
source: https://dataspaces.info/common-european-data-spaces/

Copernicus Climate Data Store Connector (CDS connector)

A gRPC-based service that provides the Copernicus Climate Data Store (CDS) ERA5 data API integrated within AI Builder

Lets users bring their own CDS credentials, submit data pulls, and retrieve outputs in different formats.

Ships with a small web UI for submitting jobs and visualizing results..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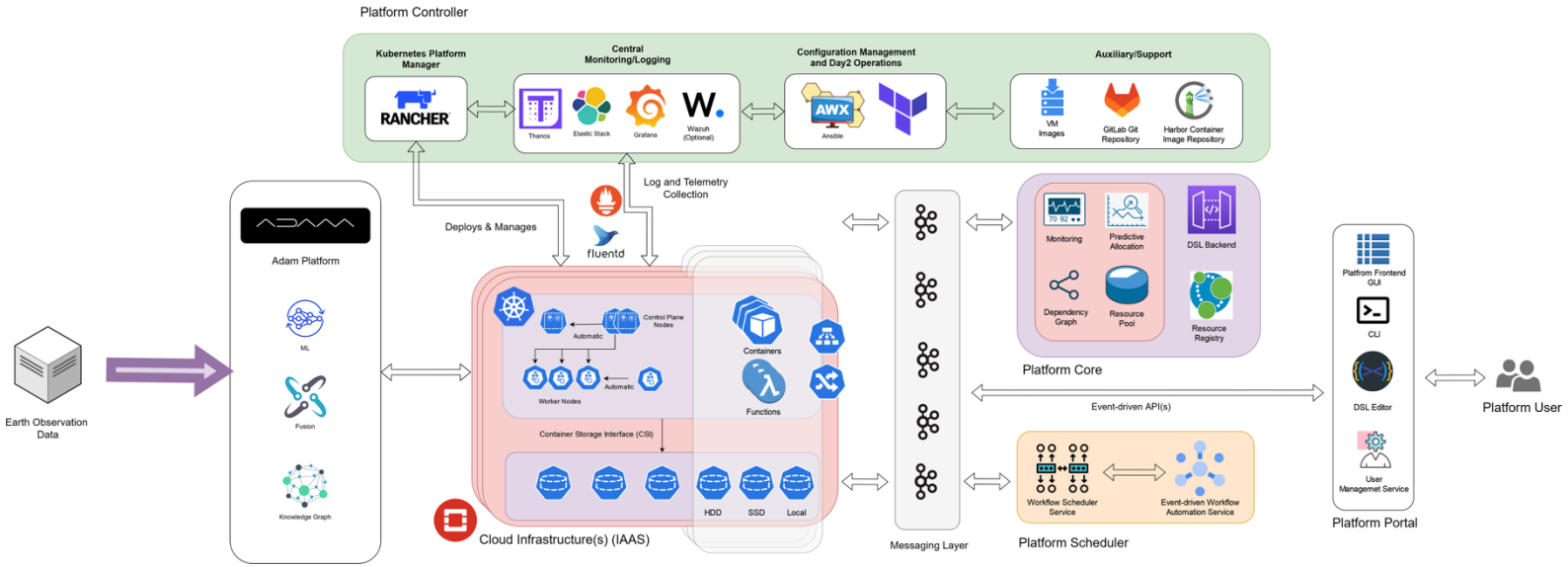
The EO4EU platform

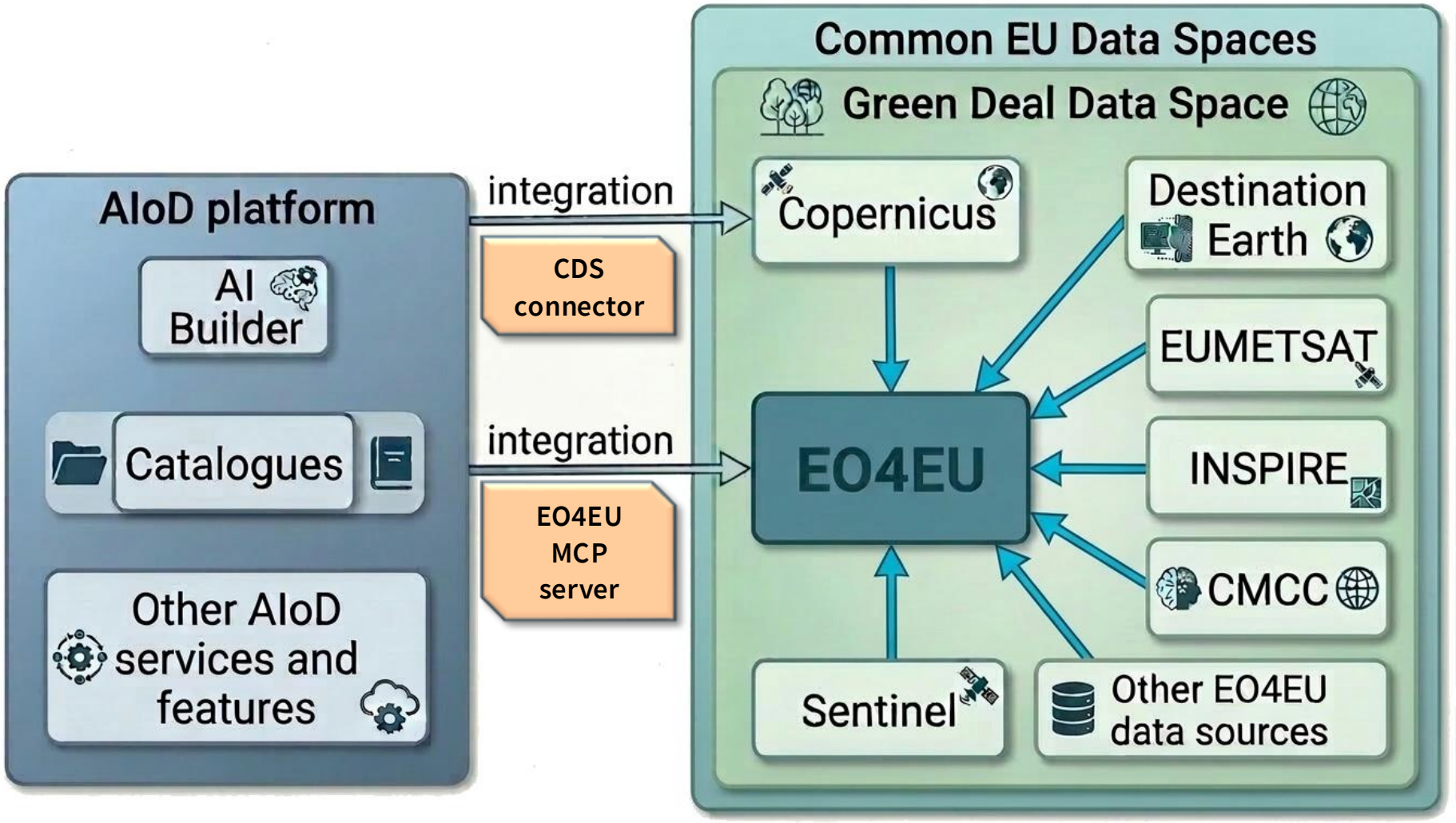
Funded by the European Union

- The EO4EU platform provides users with:
  - A unified access to multiple and heterogeneous Earth Observation data sources, leveraging Knowledge Graphs
  - Workflow-based facilities for data processing, including Machine Learning
  - Advanced visualisation interfaces (e.g. XR), along with a web-based UI and REST APIs



More at https://www.eo4eu.eu/platform

How it all fits together



Model-Context Protocol (MCP)

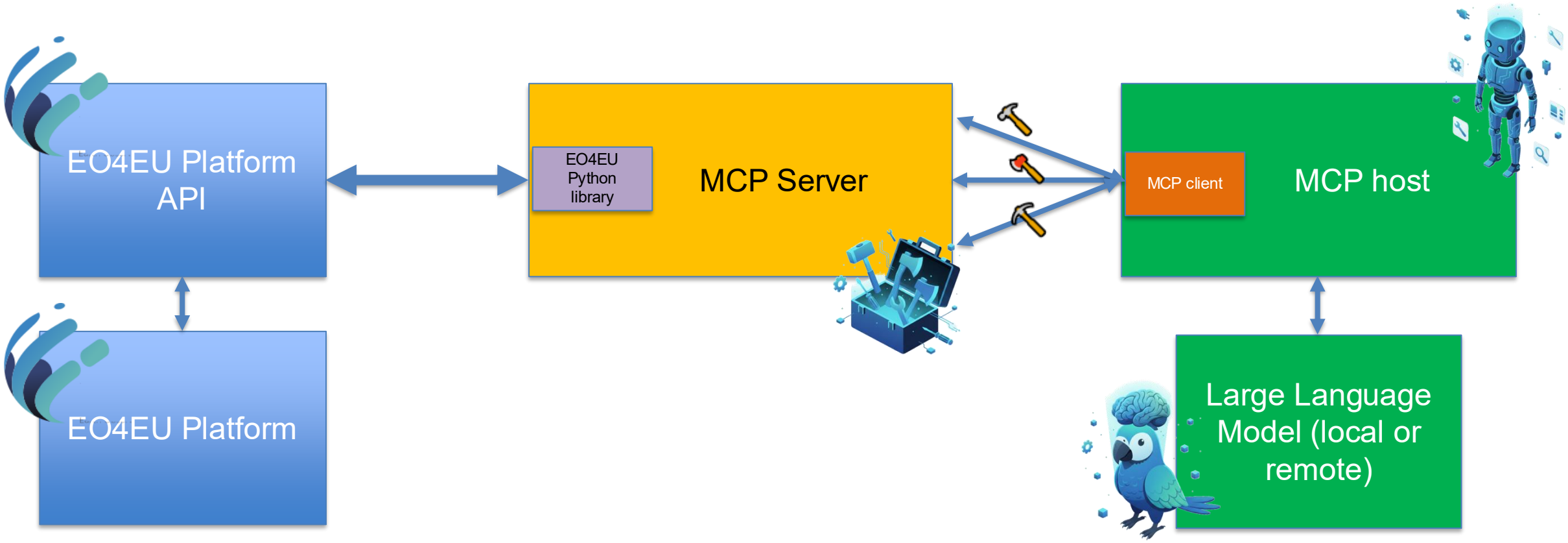
- Open protocol to integrate existing platforms with **Large Language Models (LLMs)**

- Main concept: **make "Tools" available, through a server, to a client LLM**
  - We can think of **tools** as programs/functions which leverage API calls to achieve specific goals
    - Tools come with a use-case oriented description in natural language
  - Based on JSON-RPC

- Why? Just exposing to an LLM existing APIs will not work well:
  - LLMs are bad at choosing from a large set of endpoints
  - API descriptions are not (in general) use-case oriented
  - LLMs need to understand through hints in natural language which tools to select to achieve their goal

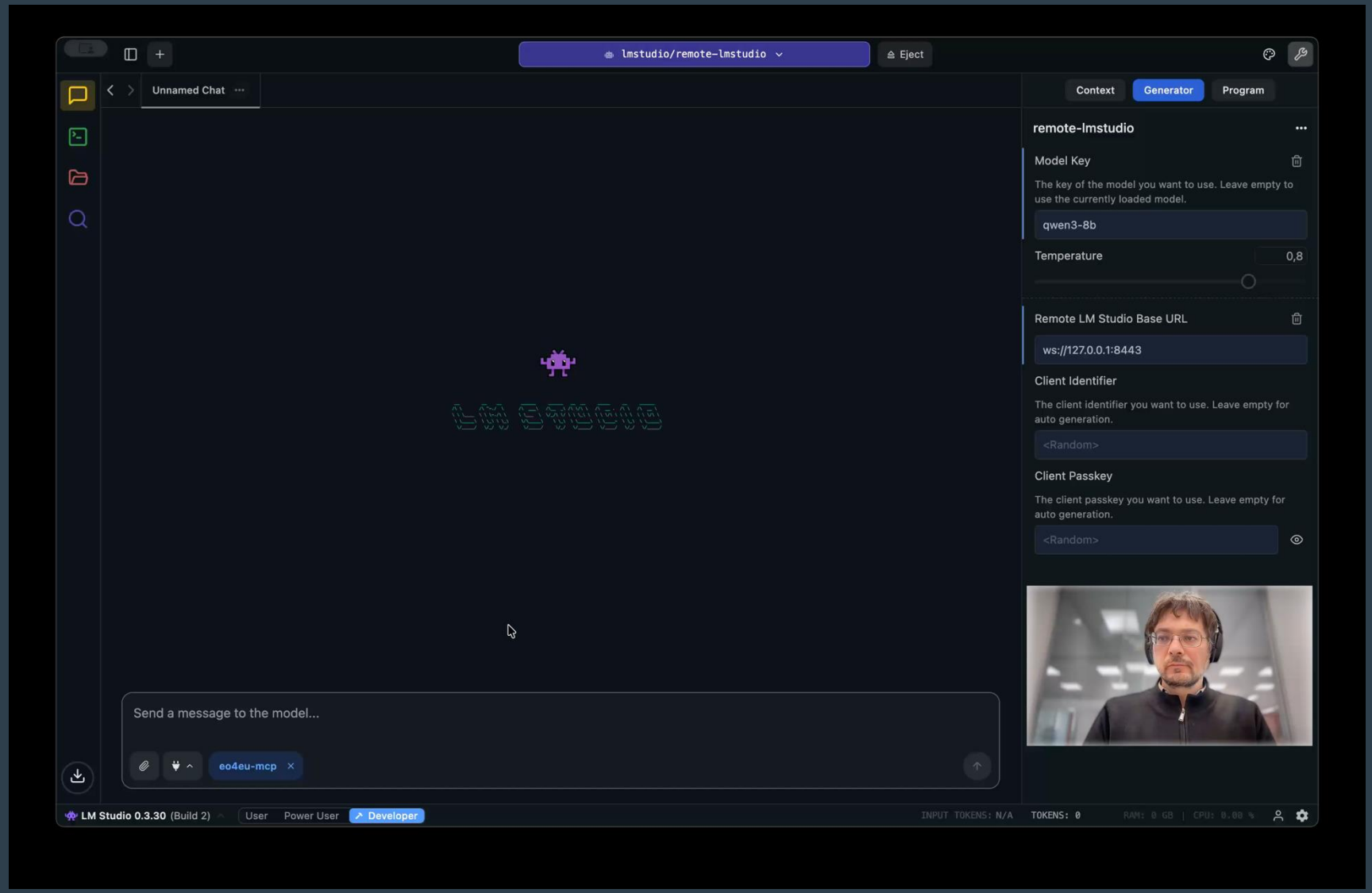
- It's gaining traction, e.g. Docker's MCP hub: **https://hub.docker.com/mcp**

Using MCP to integrate EO4EU and AI tools



Demo

The video shows how the functionalities of the EO4EU platform can be accessed through a chat interface, leveraging an on-premises LLM



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Lessons Learned

- 🔑 LLM context length is key
  - If an API called by the MCP server is very verbose it will eat up context length
    - But: the MCP server can take care of filtering out unnecessary information
  - There should be a 1 to many mapping between MCP tools and API calls
- 🙃 LLMs hallucinate (surprise surprise)
  - This is a technological limitation
  - LLMs loop indefinitely over tools sometimes
- 🔌 Plugging in a different LLM to the same MCP server can change to a significant extent the behaviour of the application

Thank you

FOR YOUR ATTENTION

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