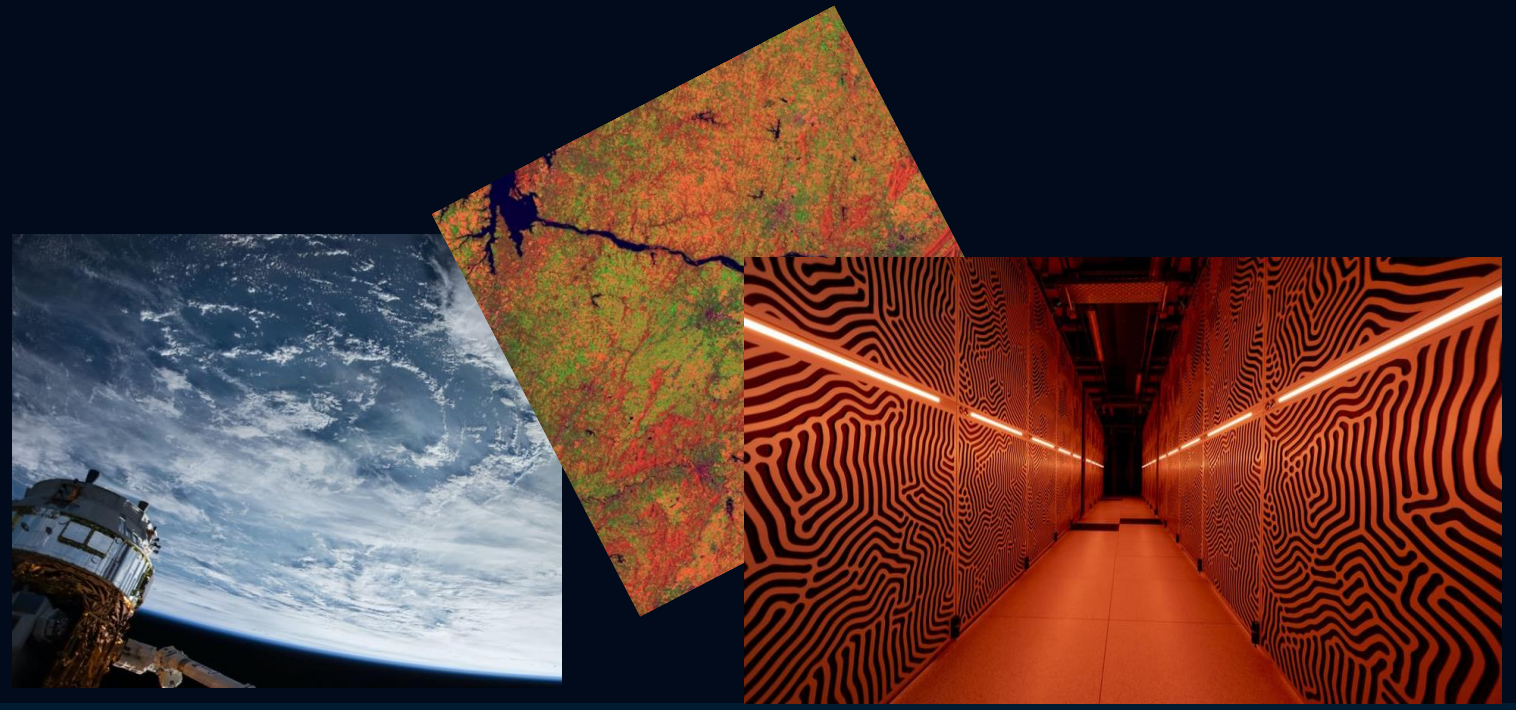


NEXT-GENERATION SUPERCOMPUTING: EUROPE'S ECOSYSTEM FOR AI IN THE EXASCALE ERA

ESA Φnnovation Summit | 25 June 2026 | Frascati, Italy

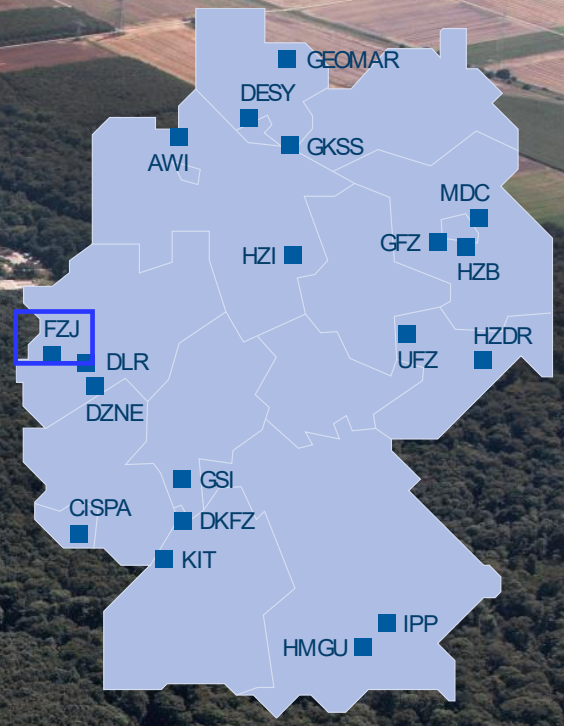
GABRIELE CAVALLARO (WWW.GABRIELE-CAVALLARO.COM)
HEAD OF SIMULATION AND DATA LAB "AI AND ML FOR REMOTE SENSING", JÜLICH SUPERCOMPUTING CENTRE (FORSCHUNGSZENTRUM JÜLICH)
ASSOCIATE PROFESSOR, FACULTY OF ELECTRICAL AND COMPUTER ENGINEERING (UNIVERSITY OF ICELAND)

JÜLICH Forschungszentrum | JÜLICH SUPERCOMPUTING CENTRE

UNIVERSITY OF ICELAND

FORSCHUNGSZENTRUM JÜLICH

HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

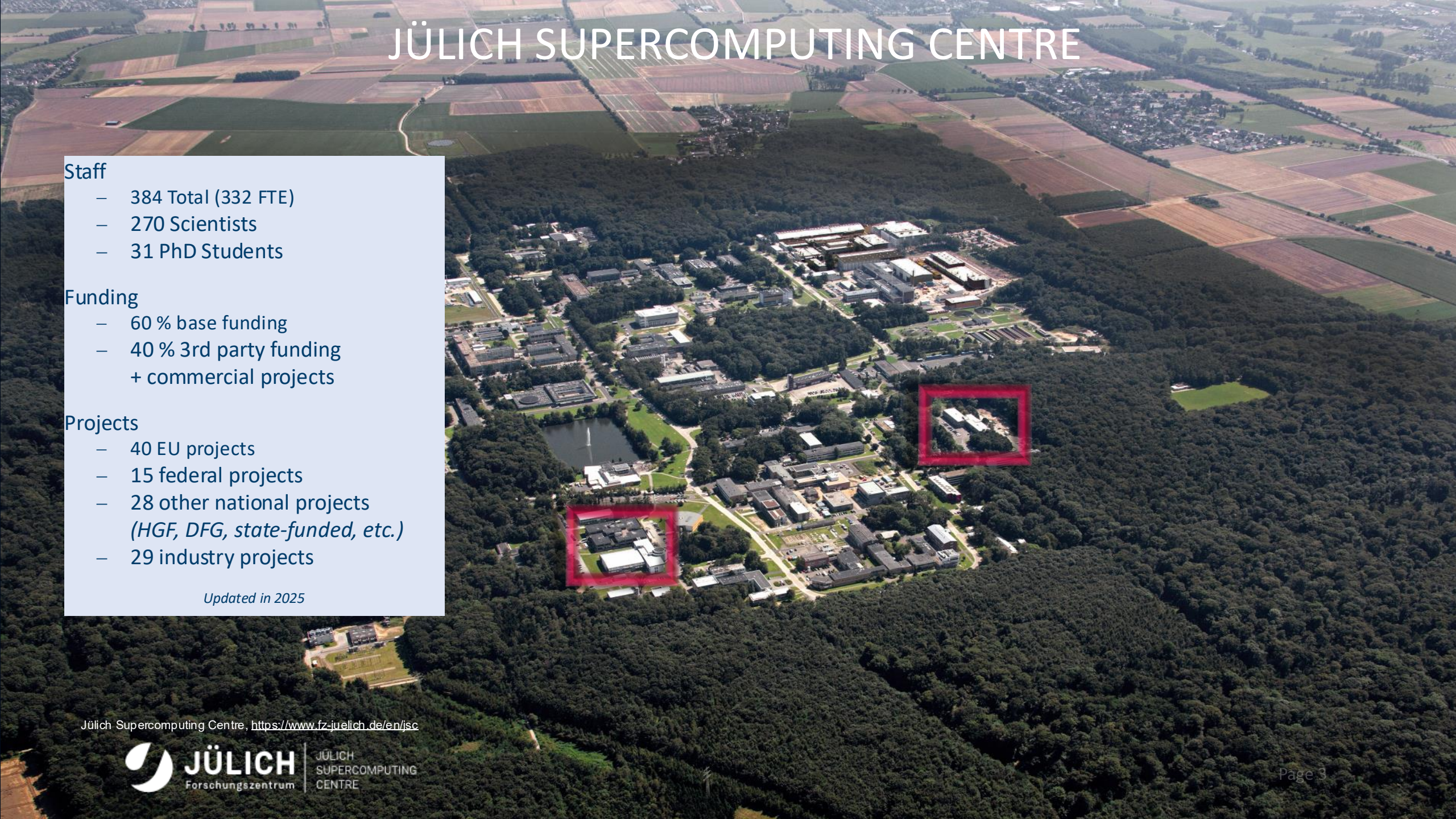


JÜLICH
Forschungszentrum

~7,500
employees

Forschungszentrum Jülich GmbH, https://www.fz-juelich.de/en

JÜLICH SUPERCOMPUTING CENTRE



Staff
- 384 Total (332 FTE)
- 270 Scientists
- 31 PhD Students

Funding
- 60 % base funding
- 40 % 3rd party funding
  + commercial projects

Projects
- 40 EU projects
- 15 federal projects
- 28 other national projects
  (HGF, DFG, state-funded, etc.)
- 29 industry projects

Updated in 2025

Jülich Supercomputing Centre, https://www.fz-juelich.de/en/jsc

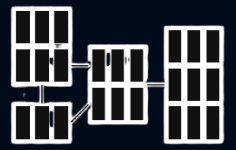
JÜLICH Forschungszentrum | JÜLICH SUPERCOMPUTING CENTRE

JÜLICH SUPERCOMPUTING CENTRE - MISSION

Supercomputing and AI @ Exascale

Future computing technologies

- Quantum Computing, Neuromorphic Computing, Digital Cryo-Computing



Federated infrastructures for data analytics

Provide the most innovative support structures, tools, algorithms and methods

Education of the next generation of HPC / AI / QC specialists

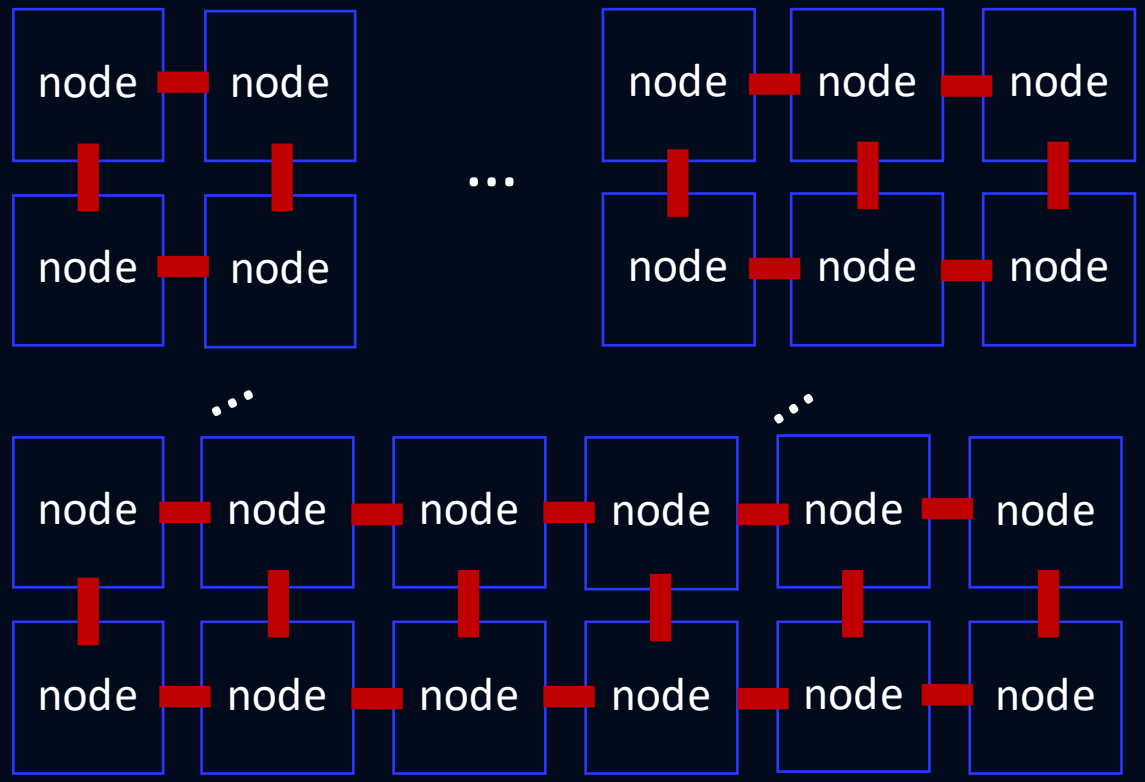
WHAT IS SUPERCOMPUTING?

An Instrument of scientific discovery, like the James Webb telescope but for computational science.

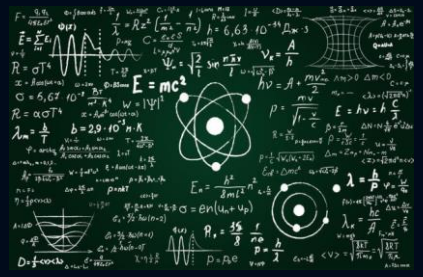
Credit : Prof Jack Dongarra

NASA, James Webb Space Telescope, https://science.nasa.gov/mission/webb/

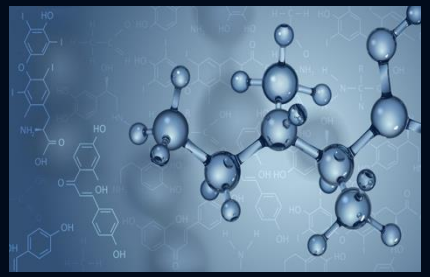
HPC IS USED FOR DATA-INTENSIVE AND COMPUTATION-HEAVY SCIENTIFIC AND ENGINEERING APPLICATIONS



- High number of **compute nodes**
- Vast amounts of memory
- **High-speed interconnects**



Physics



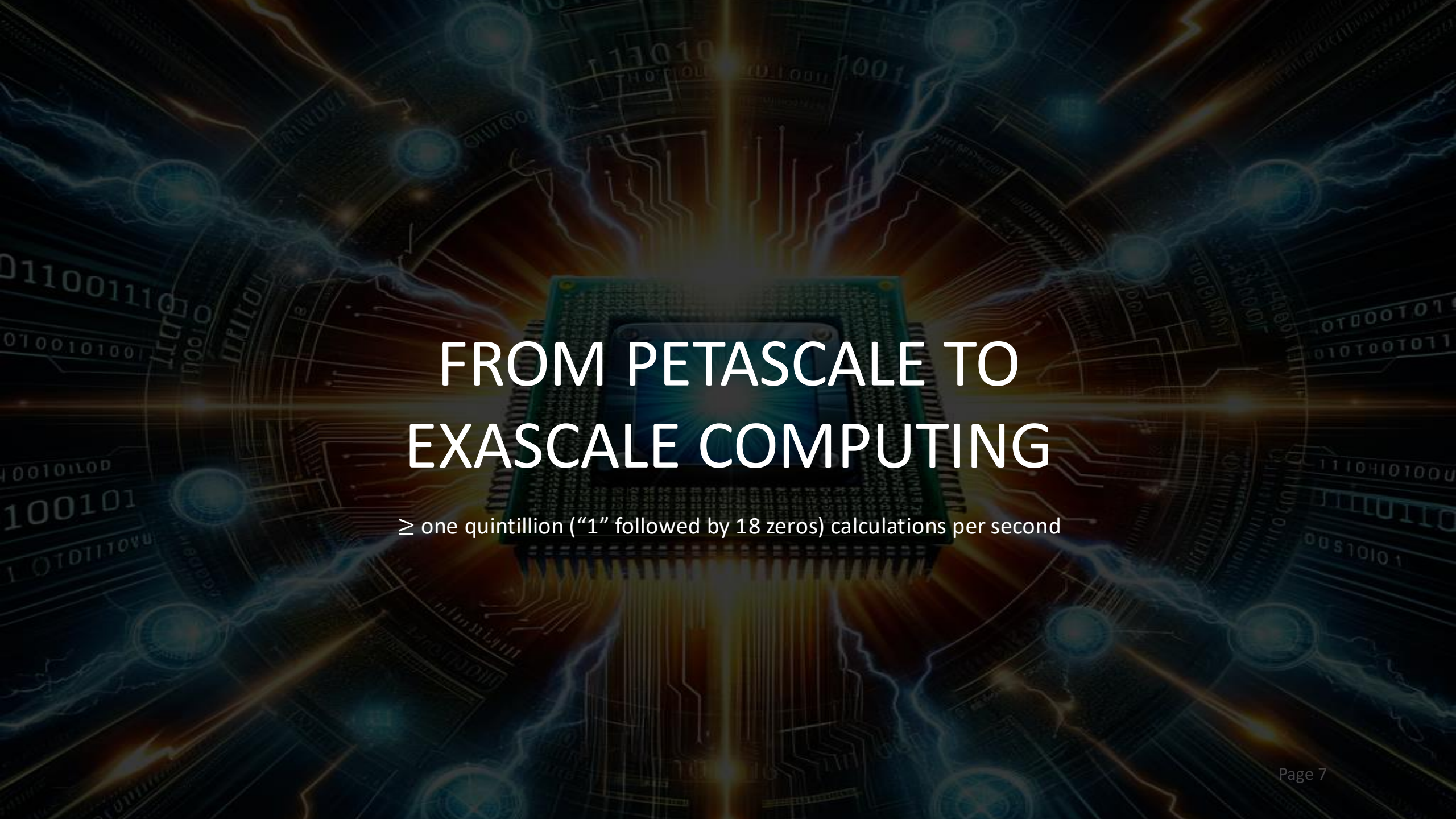
Chemistry

Medicine

...

Climate

Society



FROM PETASCALE TO EXASCALE COMPUTING

≥ one quintillion (“1” followed by 18 zeros) calculations per second


2024-08-15 17:29:56
August 2024
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Forschungszentrum
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SUPERCOMPUTING
CENTRE


April 2025
ESA
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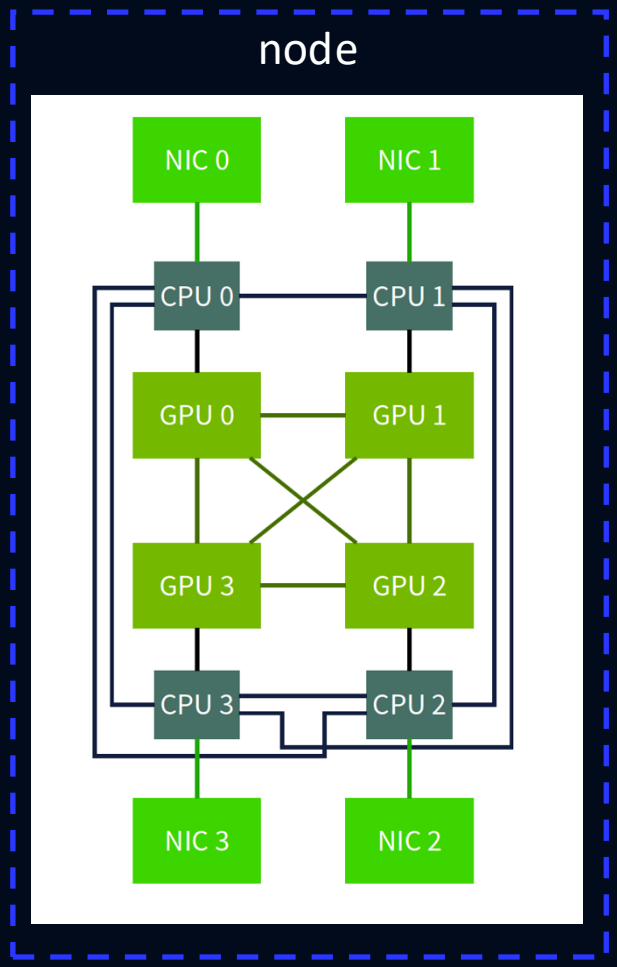
JUPITER BOOSTER

~6000 nodes, ~24 000 GPUs, 224 000 network devices

- GPU : 4 × NVIDIA H100 Hopper flavor 96 GB HBM3 memory per GPU
- CPU: 4 × NVIDIA Grace, 4 × 72 cores; 4 × 120 GB LPDDR5X memory
- Network : 4 × NVIDIA Mellanox InfiniBand NDR200, 4 × 25GB/s

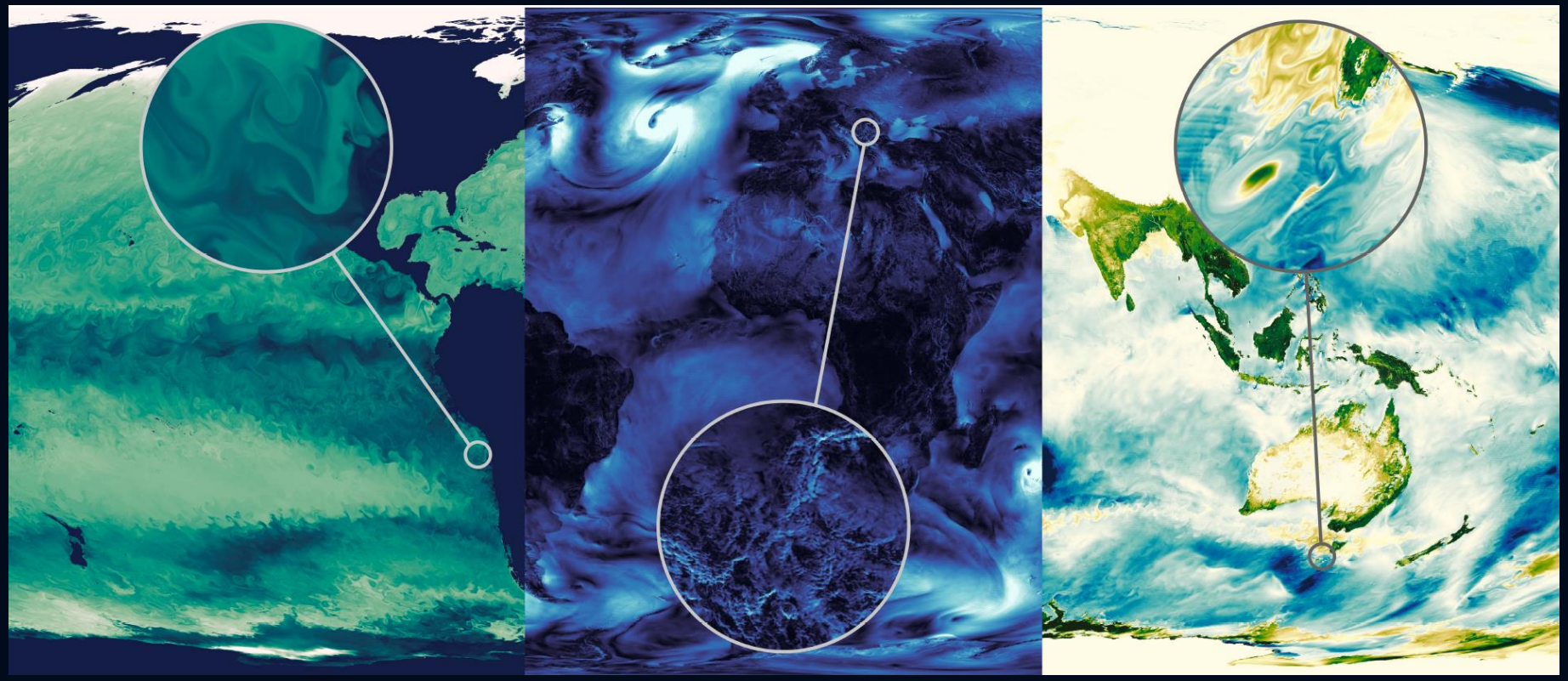


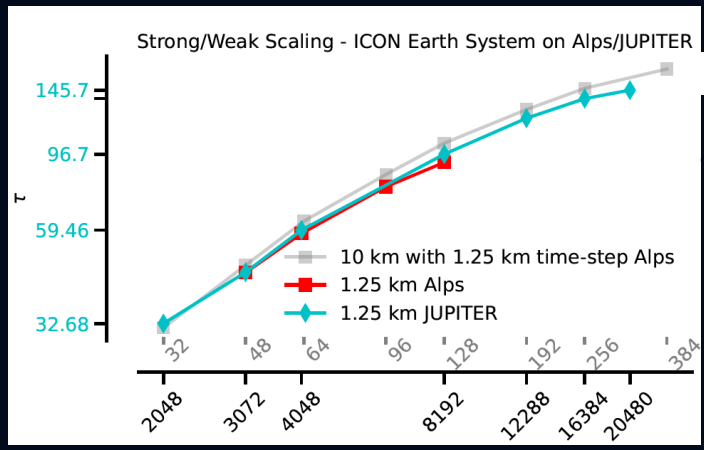
Jülich Supercomputing Centre (Forschungszentrum Jülich), "JUPITER | The Arrival of Exascale in Europe", https://www.fz-juelich.de/en/ias/jsc/jupiter

EXAMPLE APPLICATION: GLOBAL SIMULATION OF THE FULL EARTH SYSTEM AT 1.25 KM GRID SPACING

ACM Gordon Bell Prize for Climate Modelling

- **Task**: Capture the flow of energy, water, and carbon through the atmosphere, ocean, and land components
- **Compute**: 20,480 GPUs on JUPITER alongside 8,192 GPUs on Alps
- **Workflow:** exploiting functional parallelism by efficiently **mapping components to specialized heterogeneous systems**





D. Klocke, C. Frauen, and J. F. Engels et al., "Computing the full Earth system at 1 km resolution," in Proc. Int. Conf. High Performance Computing, Networking, Storage and Analysis (SC'25), 2025, pp. 125–136, http://doi.org/10.1145/3712285.3771789

ACM Gordon Bell Prize for Climate Modelling, https://awards.acm.org/bell-climate

HOW TO APPLY FOR HPC COMPUTE TIME?

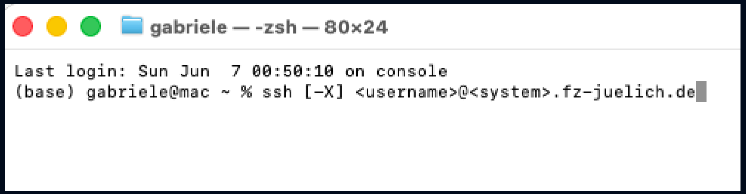
APPLY FOR A PROJECT (COMPUTE TIME)

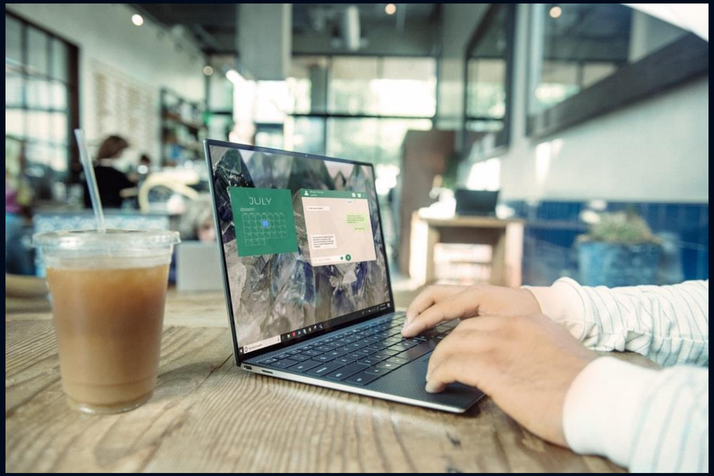
	JUPITER	JUWELS
EUROHPC	**Eligible:** Please see the "Further Information" below. **Available resources:** • JUPITER Booster	—
GCS NIC	**Eligible:** PIs with affiliations of German universities or research facilities **Available resources:** • JUPITER Booster	**Eligible:** PIs with affiliations of German universities or research facilities **Available resources:** • JUWELS Cluster (CPU)

Apply for Computing Time, Jülich Supercomputing Centre (Forschungszentrum Jülich):
https://www.fz-juelich.de/en/jsc/systems/supercomputers/apply-for-computing-time

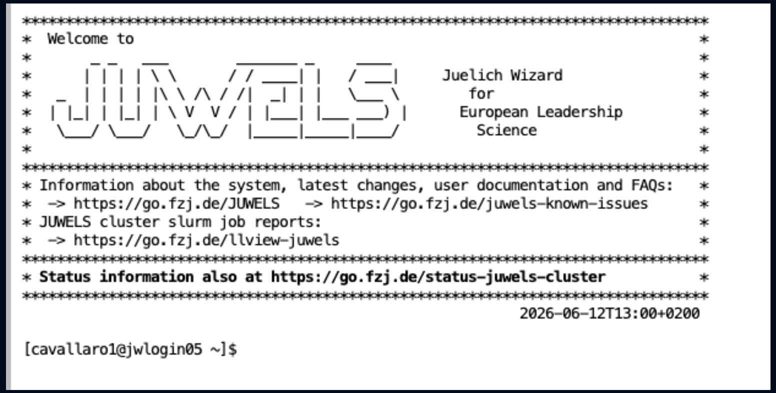
Supercomputers Access Calls, The European High Performance Computing Joint Undertaking (EuroHPC JU):
https://www.eurohpc-ju.europa.eu/supercomputers/supercomputers-access-calls_en

HOW TO ACCESS A SUPERCOMPUTER?





SECURE SHELL (SSH)



Private key

~/.ssh/id_rsa

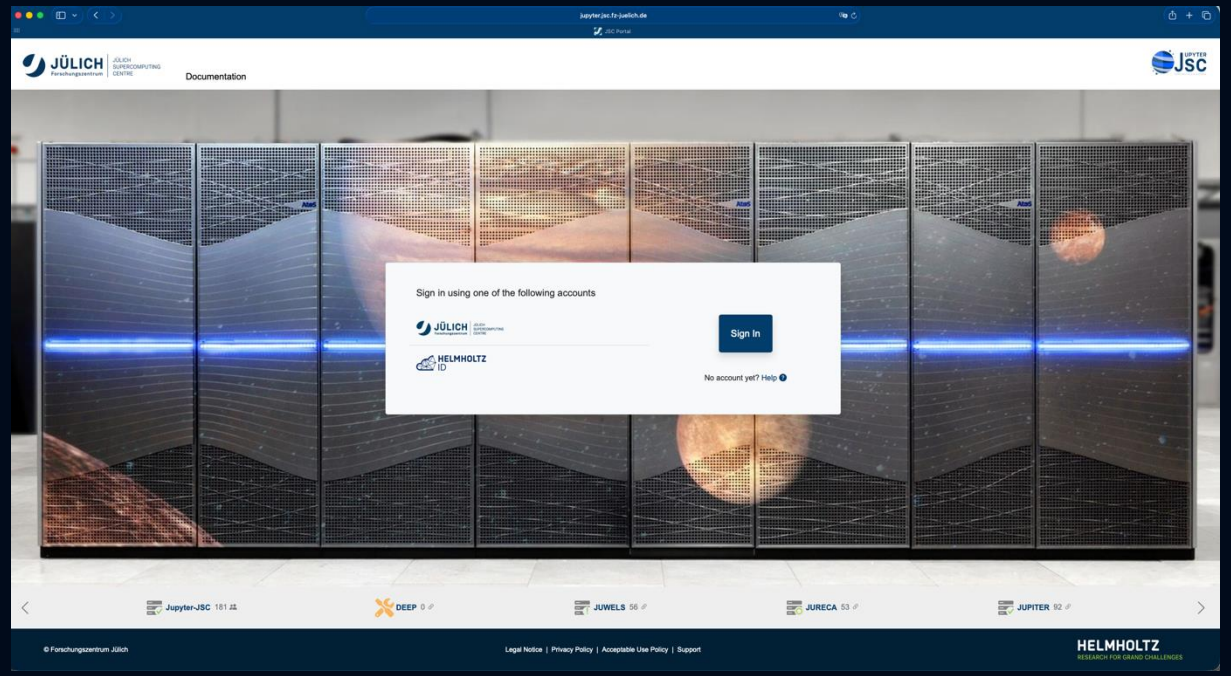
Public key

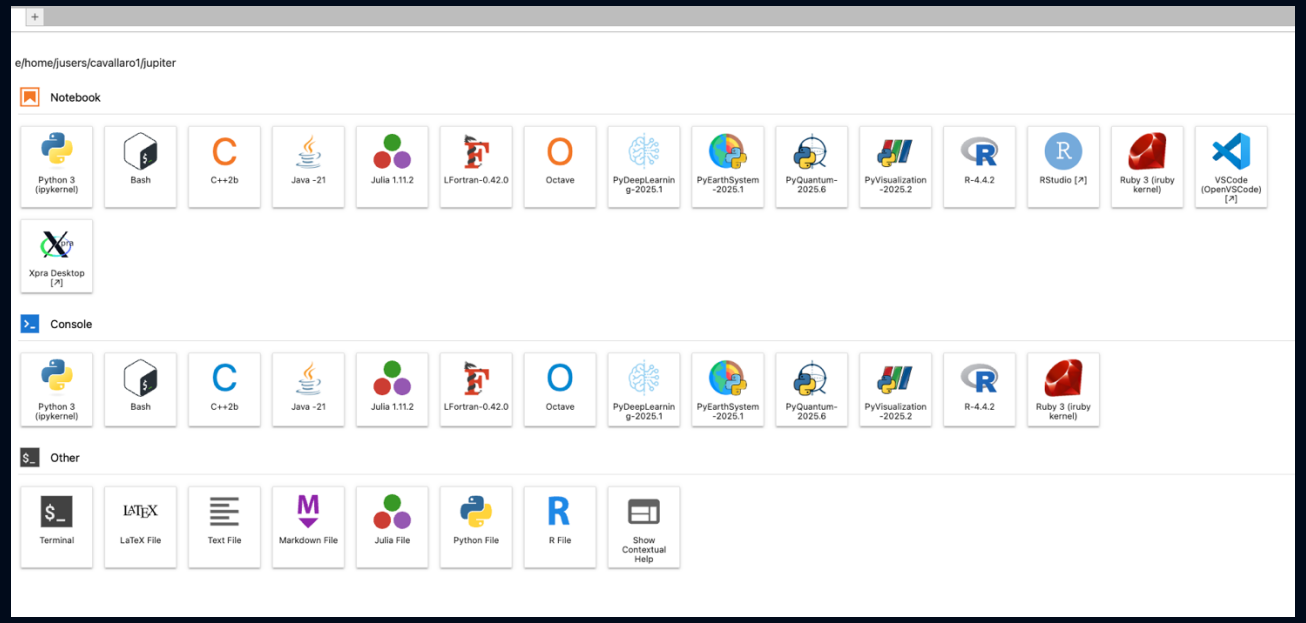
~/.ssh/id_rsa.pub

Public key

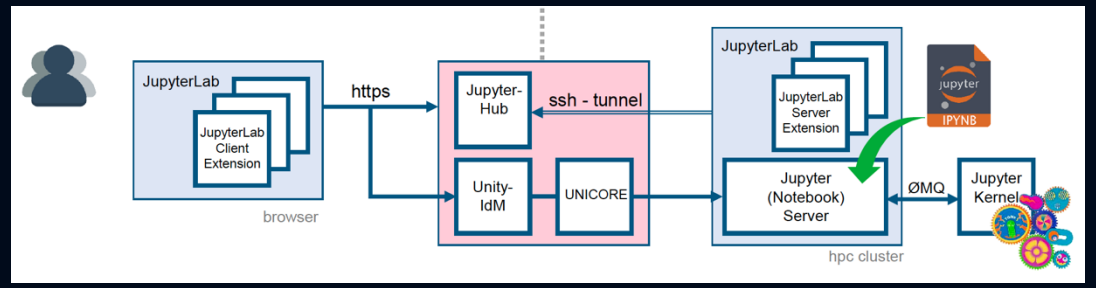
SUPERCOMPUTING IN THE BROWSER

Interactive HPC





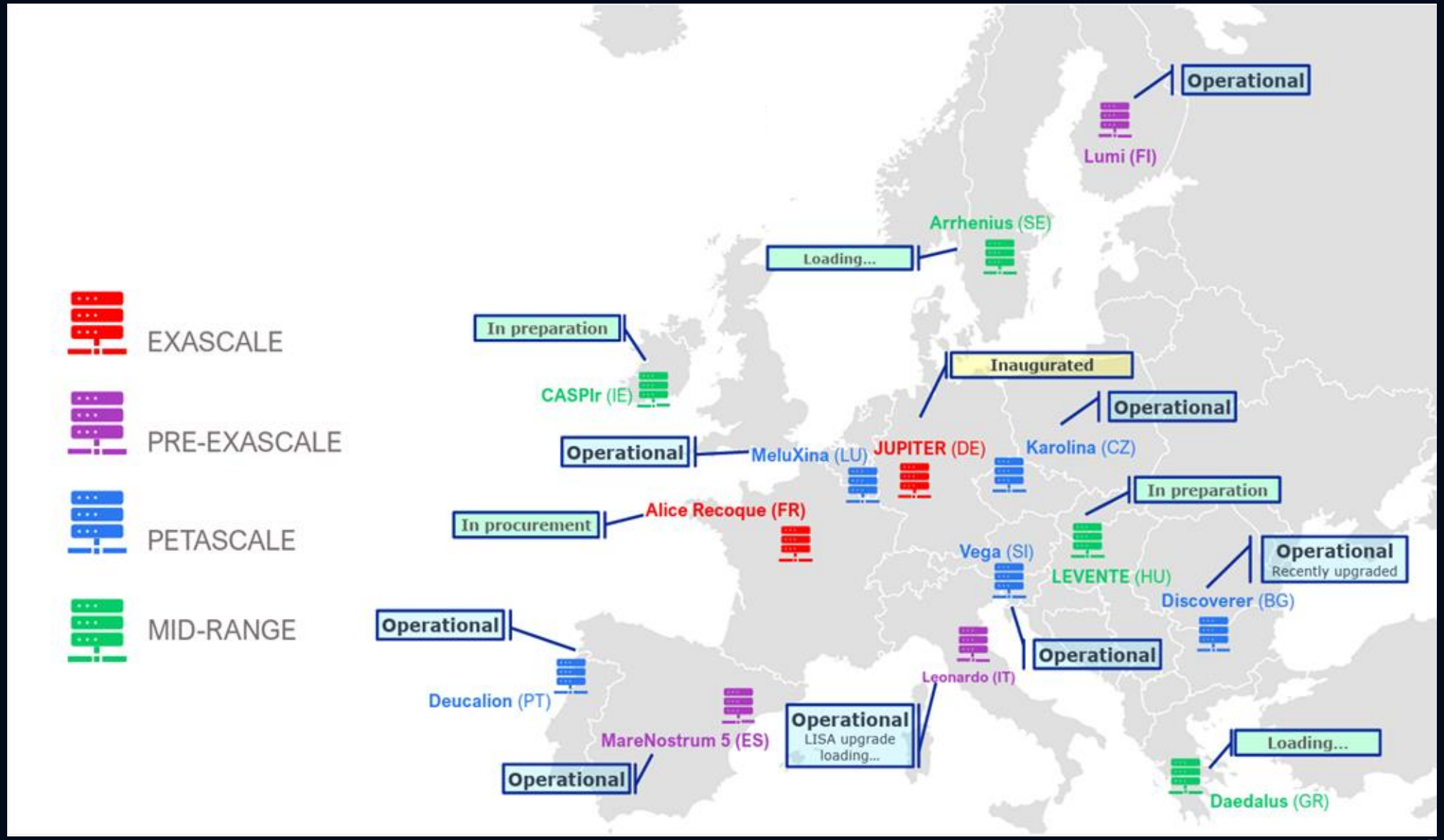
E.g., JupyterLab



Jupyter-JSC, Jülich Supercomputing Centre (Forschungszentrum Jülich):
https://jupyter.jsc.fz-juelich.de/hub/

HOW TO ACCESS MULTIPLE SUPERCOMPUTERS?

EUROHPC SUPERCOMPUTING ECOSYSTEM



European High-Performance Computing Joint Undertaking (EuroHPC JU) https://www.eurohpc-ju.europa.eu/index_en

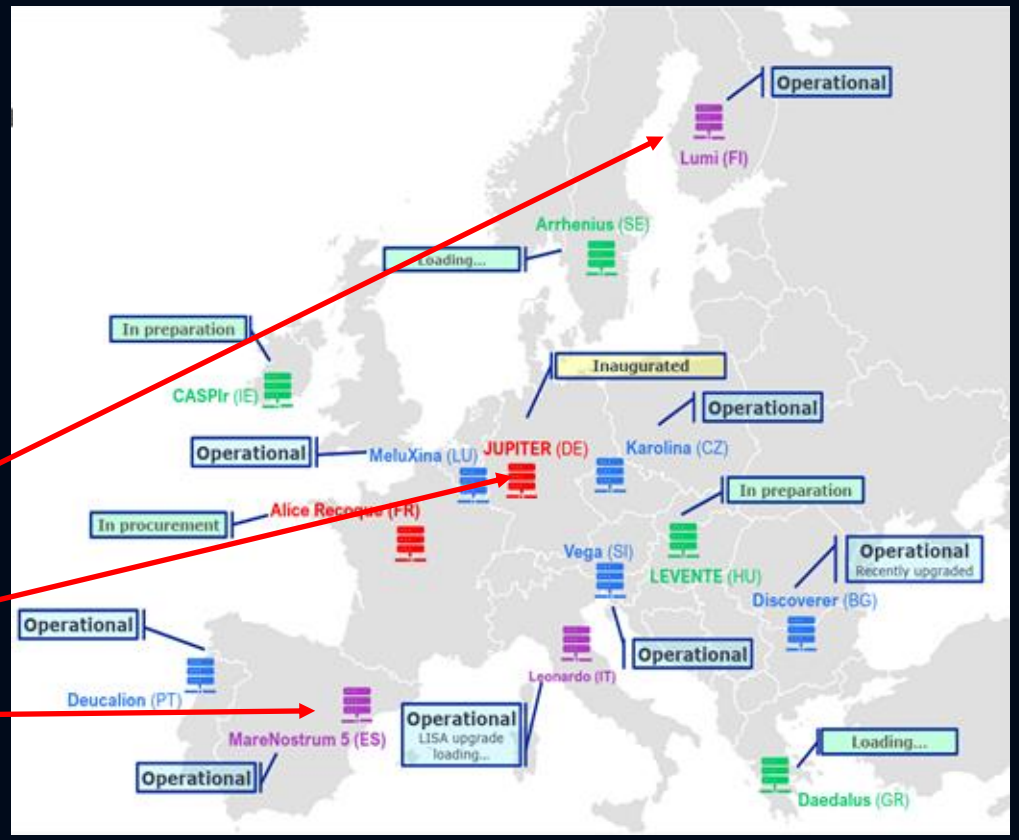
USER JOURNEY

EuroHPC Case

1. Apply for a project (compute time)
2. **Accepted projects are manually transferred to each system**
3. **User is invited to complete a separate registration process at each system**
4. **User uses separate portal and credentials to access and manage project at each System**

...

...



European High-Performance Computing Joint Undertaking (EuroHPC JU)
https://www.eurohpc-ju.europa.eu/index_en

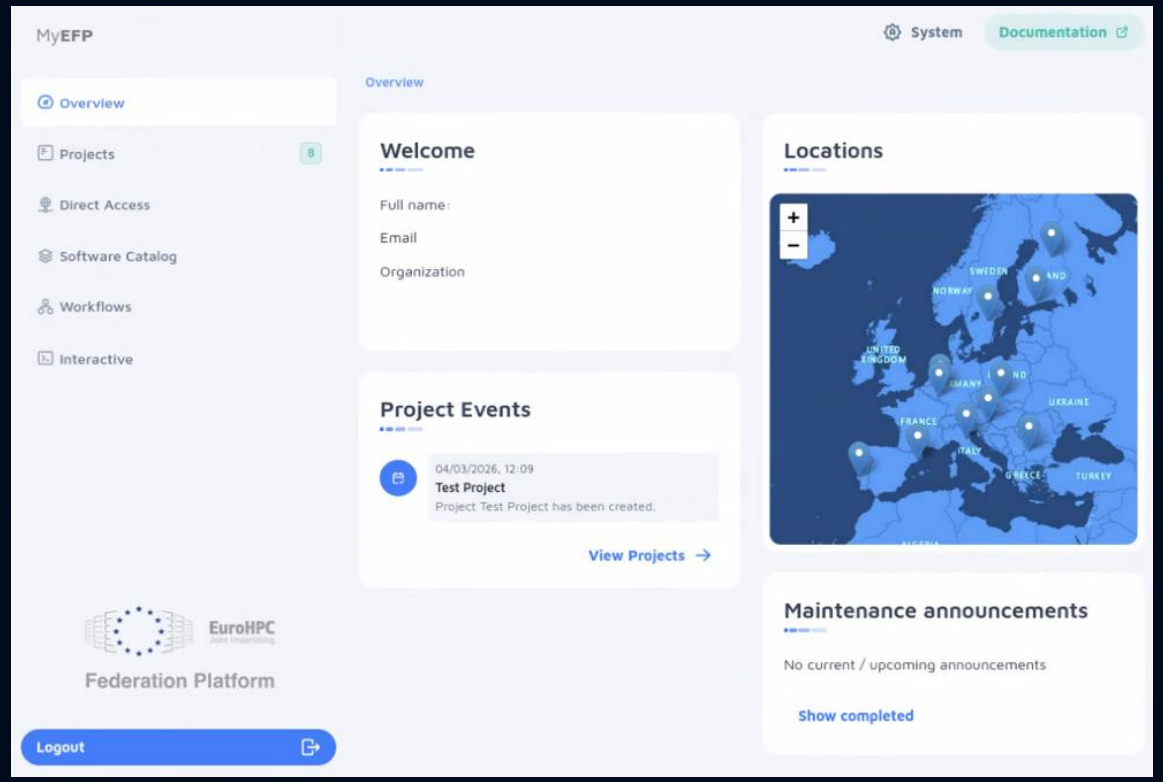
EuroHPC Federation Platform (Alberto Lanzanova, CSC Finland)
https://youtu.be/d6RgvNDz8Ns?si=WdrVf_e6_ep26gfy

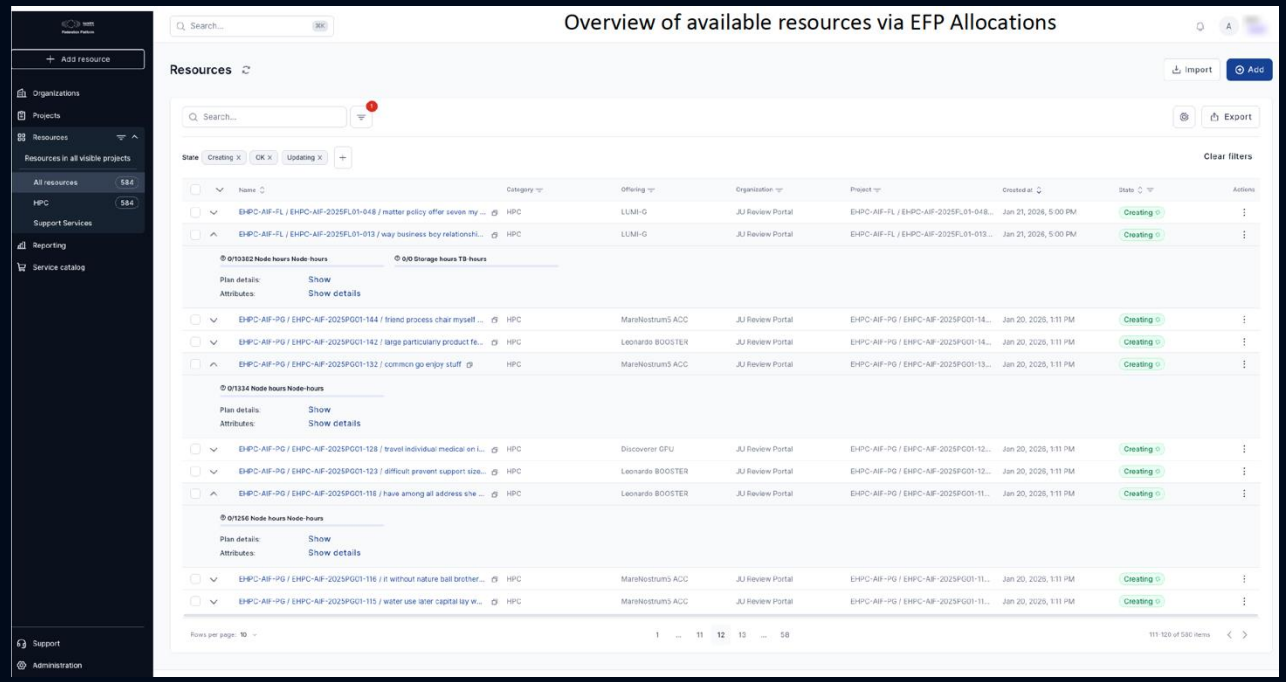
FEDERATION*

*In HPC the need for federation was recognized > 25 years ago ("Grid Computing")

Federated Computing Framework: Paving the Way for a European Collab (ETP4HPC):
https://youtu.be/qvttGnWstCg?si=gT2ZrM7-CrBg5pd0

EUROHPC FEDERATION PLATFORM (EFP)





First release of the EuroHPC Federation Platform to streamline access to Europe's supercomputing resources

Today marks the initial release of the EuroHPC Federation Platform, a unified single access point that transforms how European researchers, businesses and public sector organisations can access EuroHPC systems to advance science and drive innovation.

PRESS RELEASE
15 April 2026 — European High-Performance Computing Joint Undertaking — 4 min read

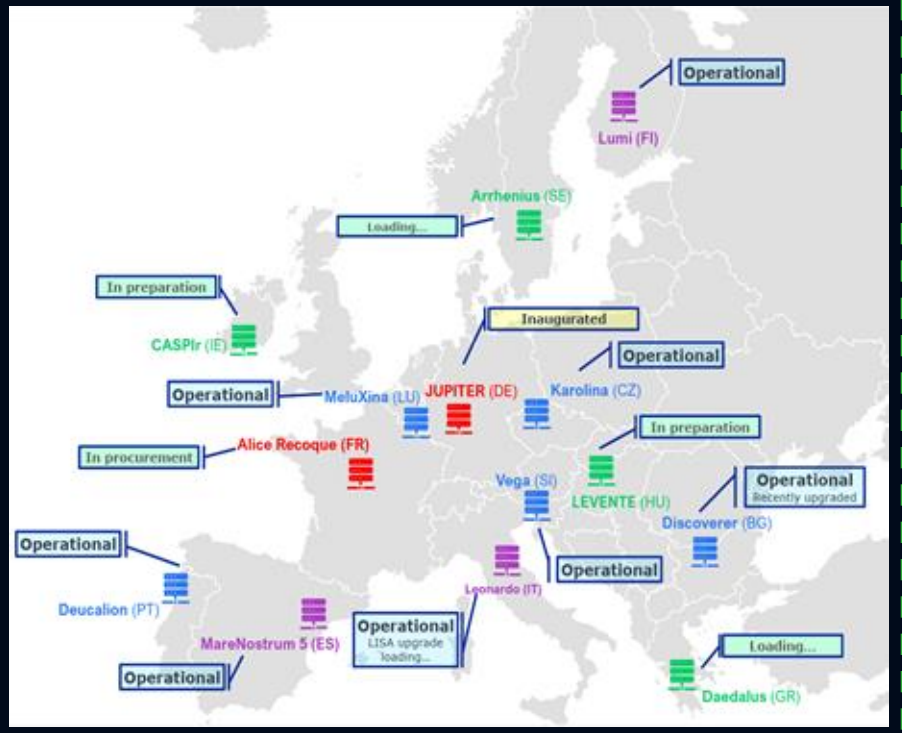
The European High Performance Computing Joint Undertaking (EuroHPC JU): https://www.eurohpc-ju.europa.eu/first-release-eurohpc-federation-platform-streamline-access-europes-supercomputing-resources-2026-04-15_en

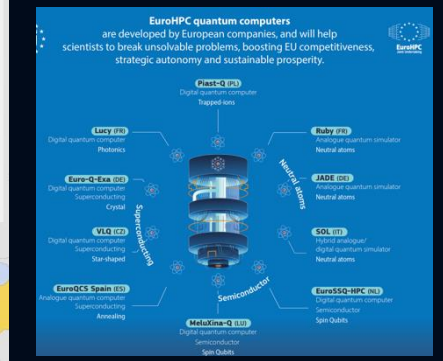
Henrik Nortamo, Balázs Szakmáry (CSC - IT Center for Science), Documentation for EuroHPC Federation Platform, https://docs.my-eurohpc.eu/training/

FUTURE USER JOURNEY

With EuroHPC Federation Platform (EFP)

1. Apply for a project (compute time)
2. **Accepted projects automatically flow to the EFP and to each system**
3. **User is invited to join a project and registers through the EFP**
4. **User manages access and projects using just the EFP**



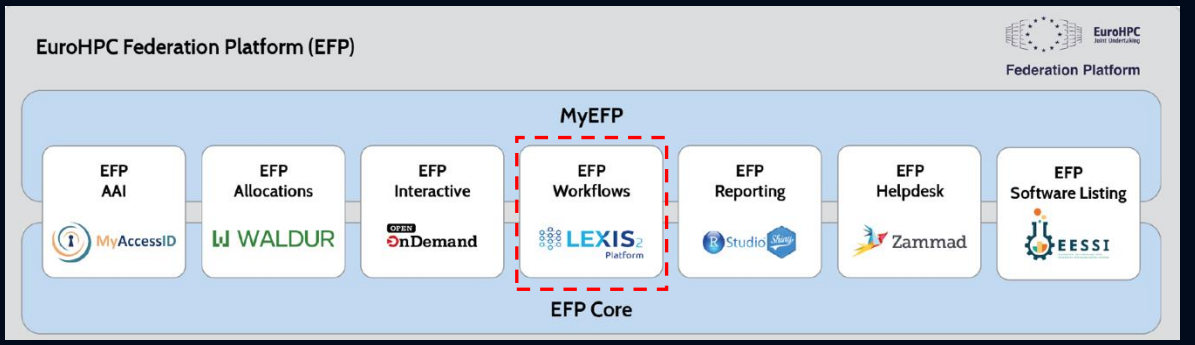


Federation is significantly more challenging today. The environment in which modern federation operates has grown exponentially more complex (exabyte-scale data, extreme hardware diversity, mismatched governance, etc.)

European High-Performance Computing Joint Undertaking (EuroHPC JU)
https://www.eurohpc-ju.europa.eu/index_en

EuroHPC Federation Platform (Alberto Lanzanova, CSC Finland)
https://youtu.be/d6RgvNDz8Ns?si=WdrVf_e6_ep26gfy

WORKFLOWS



Martin Golasowski (IT4I), EFP Workflows, https://docs.my-eurohpc.eu/training/#webinar-5-of-5-efp-workflows

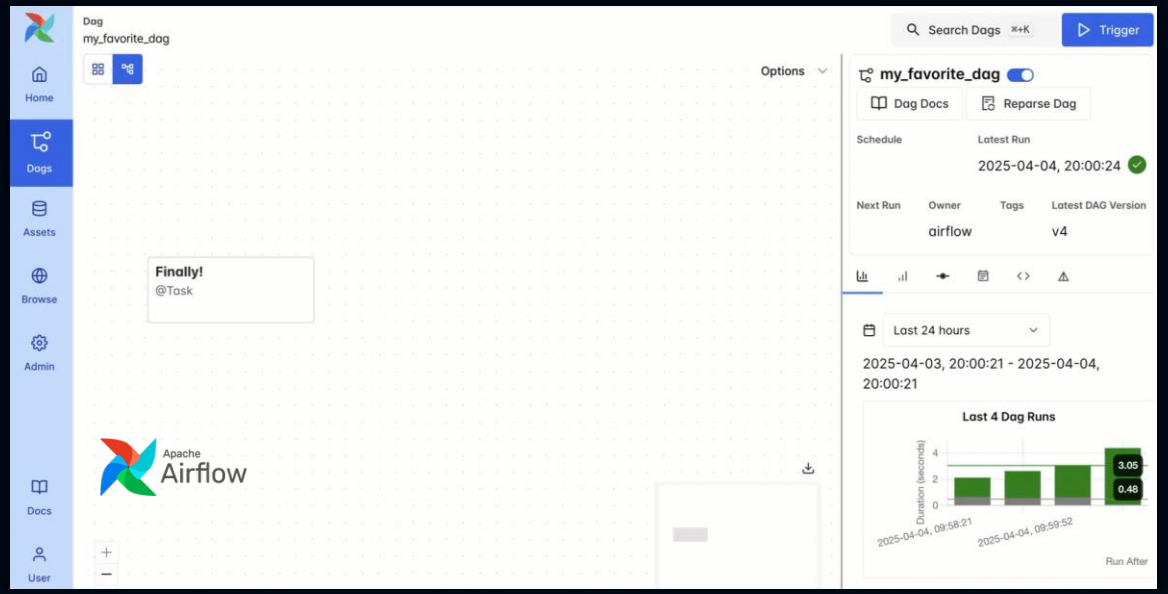
APACHE AIRFLOW

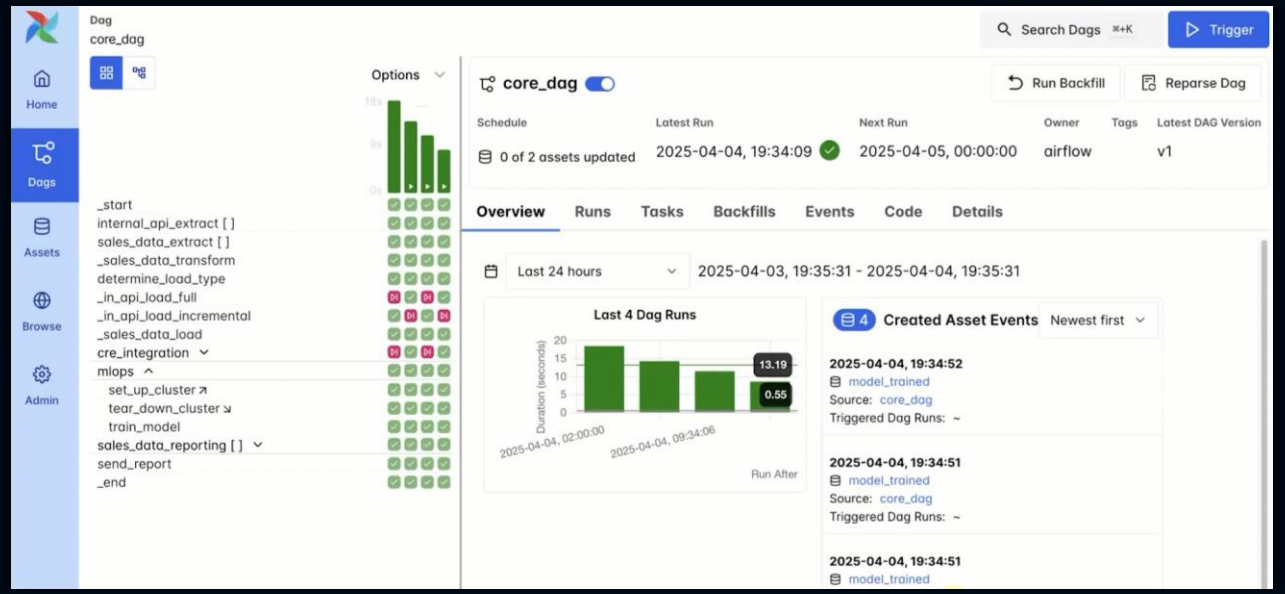
Apache Airflow

Apache Airflow evolves workflow operations **from simple 'light switch' execution to an intelligent management layer** that proactively orchestrates, monitors, and heals.

APACHE AIRFLOW

- **Open-source workflow management platform** used for scheduling and monitoring data pipelines
- It allows users to **programmatically define, schedule, and monitor workflows**
  - Often visualized as Directed Acyclic Graphs (DAGs)
- Widely used for **orchestrating data pipelines**, e.g., Extract, Transform, Load (ETL) processes



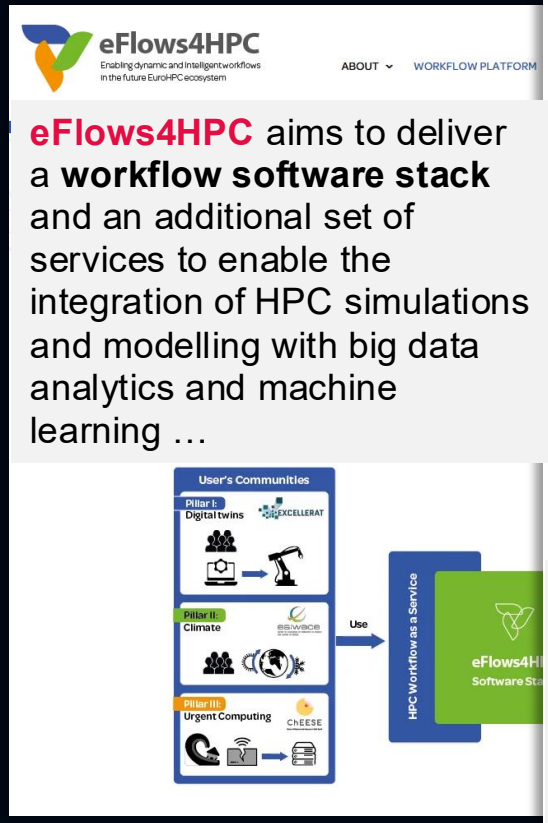


Community-driven with millions of global users and thousands of contributors

Apache Airflow® (v3), https://airflow.apache.org/

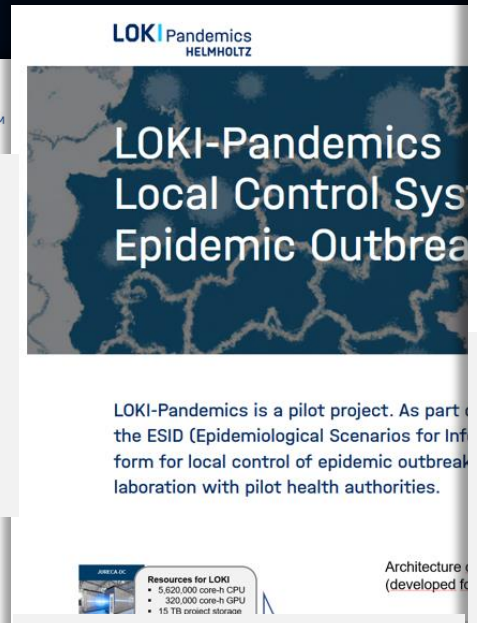
PROJECTS AT JÜLICH SUPERCOMPUTING CENTRE MAKING USE OF APACHE AIRFLOW

2021 - 2024



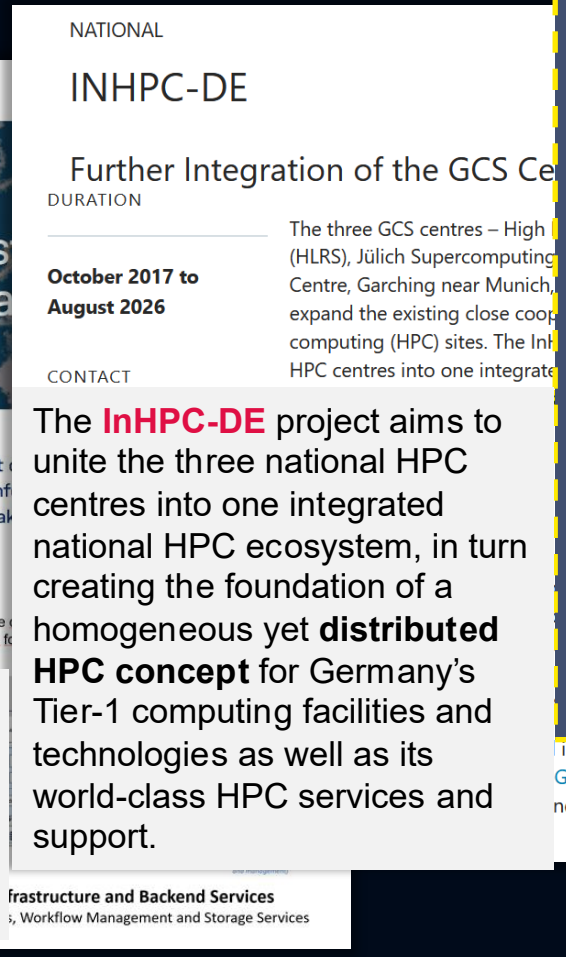
eFlows4HPC aims to deliver a **workflow software stack** and an additional set of services to enable the integration of HPC simulations and modelling with big data analytics and machine learning …

2022 - 2025



The overall objective of **LOKI-Pandemics** is to provide health authorities with a **local control system** for epidemic outbreaks …

2017 - 2026+



The **InHPC-DE** project aims to unite the three national HPC centres into one integrated national HPC ecosystem, in turn creating the foundation of a homogeneous yet **distributed HPC concept** for Germany's Tier-1 computing facilities and technologies as well as its world-class HPC services and support.

2025 – 2027

HIPPO
High Performance Processing Orchestration

- Bridge between DestinE Platform services and heterogeneous compute resources
- Enable new services through federated and efficient HPC orchestration

Destination Earth
Funded by the European Union
Implemented by esa

EDCP-13-DESP Service Integration with HPC resources

HIPPO – BASELINE ACTIVITY AND FOCUS

Prototype access and usage of HPC resources from DestinE Core Service Platform (DESP)

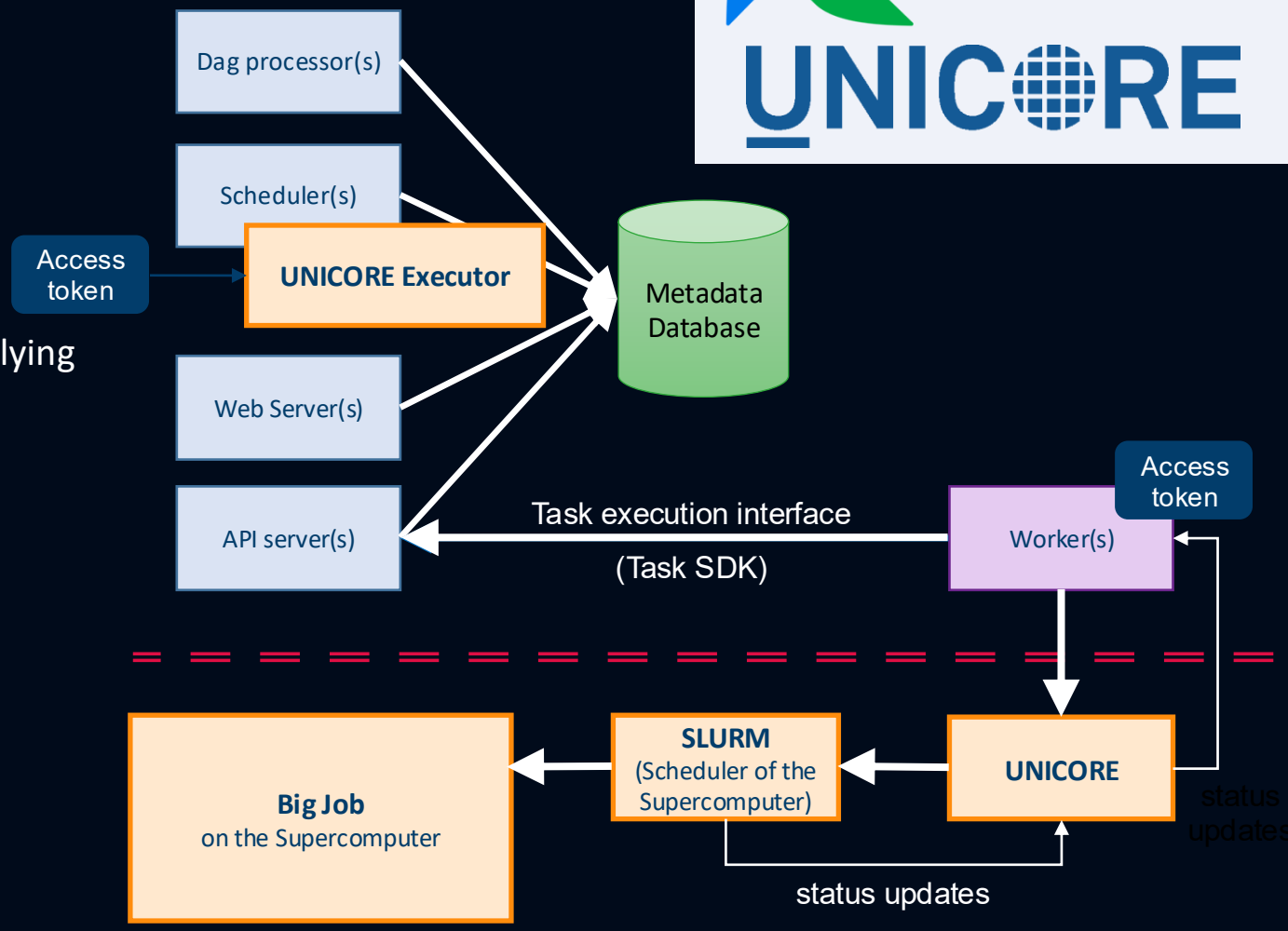
- **Explore different scenarios for fair usage. E,g., enable users to access global climate scenarios then integrate their own local data to build dedicated, localized decision-making tools**

COUPLING HPC TO APACHE AIRFLOW

Airflow-to-UNICORE integration

- UNICORE is a federation middleware system (since 1997)
- Can submit jobs to HPC systems
- **UNICORE executor**: requires the least knowledge of the underlying software architecture of the supercomputer
  - Team Executor Dag-Configuration

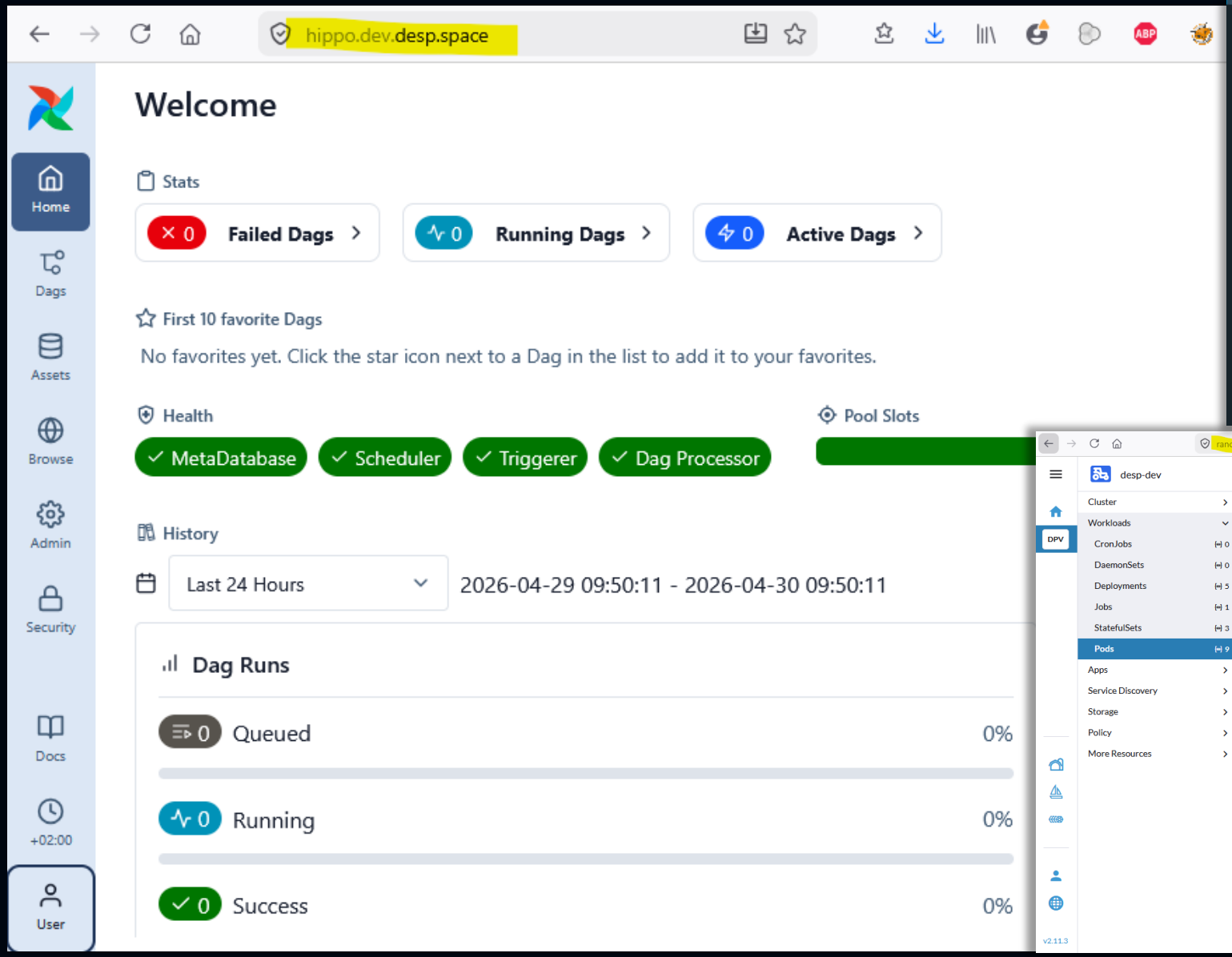
```
@task(
    executor="unicore_executor.UnicoreExecutor",
    executor_config={
        "python_env": custom_python_env,
        "site": "jupiter",
        "Project" : "geofm4eo",
        "Resources" : {
            "Queue" : "booster",
            "Runtime" : "5min"
        }
    }
)
```

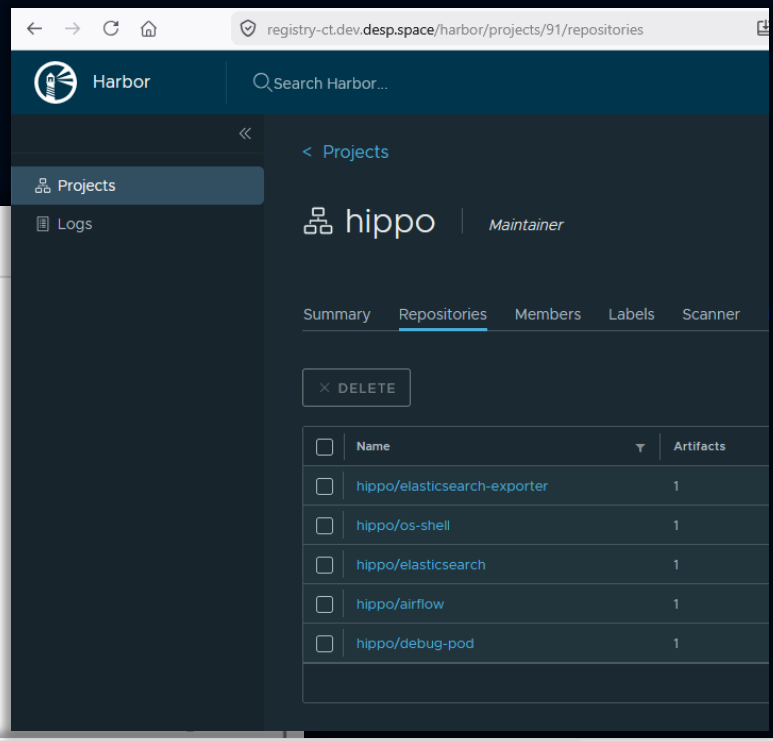


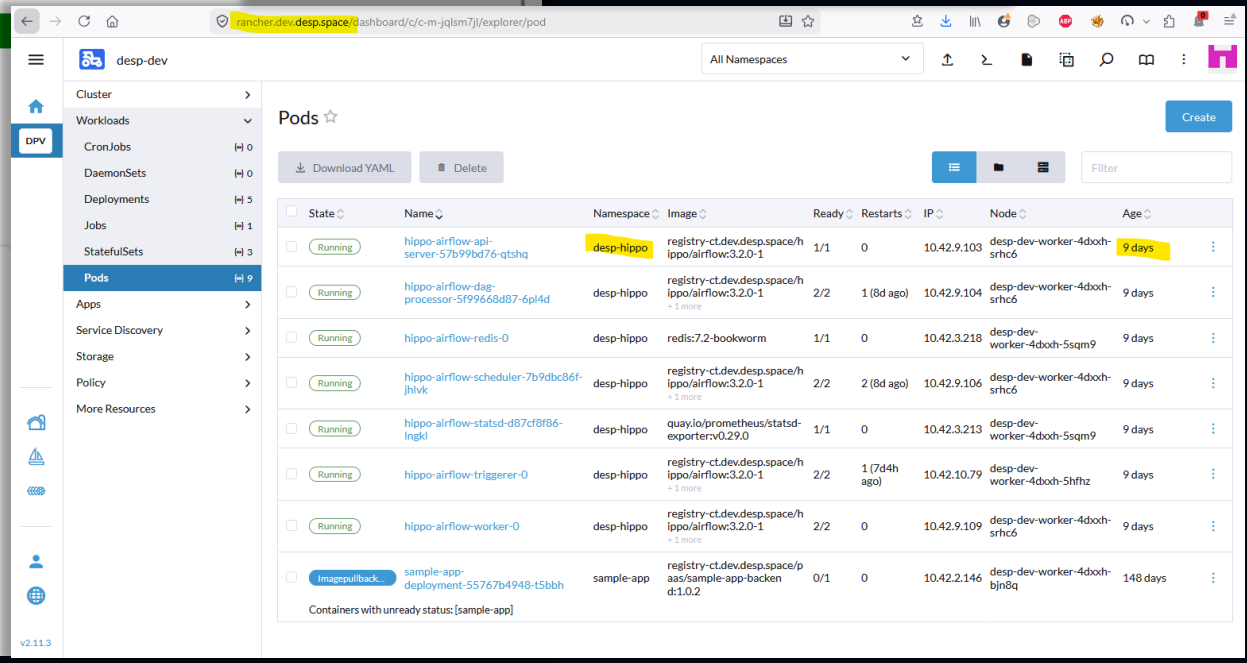
Unicore Airflow Integration, https://github.com/UNICORE-EU/airflow-unicore-integration

DESTINE SERVICE PLATFORM

Current Deployment







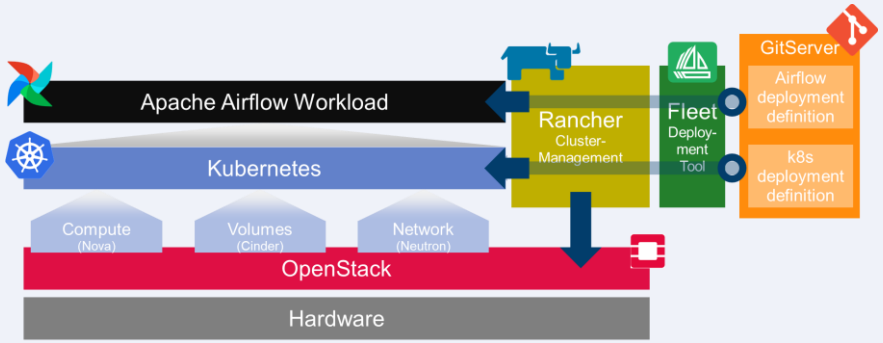
CONCLUSIONS

CONCLUSIONS

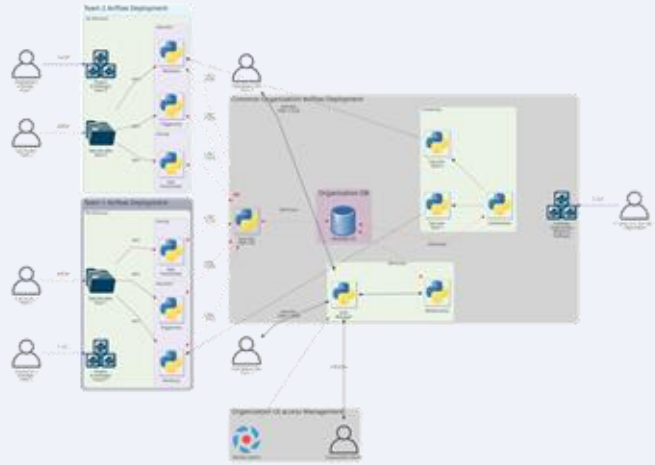
- Airflow isn't just a "task runner“ - it's a management layer ready for HPC

- Extension for HPC-coupling of Apache Airflow via UNICORE
  - Airflow can connect to EuroHPC systems while running in any ecosystem, such as DESP (i.e., outside EFP)
  - It is not intended only for single users

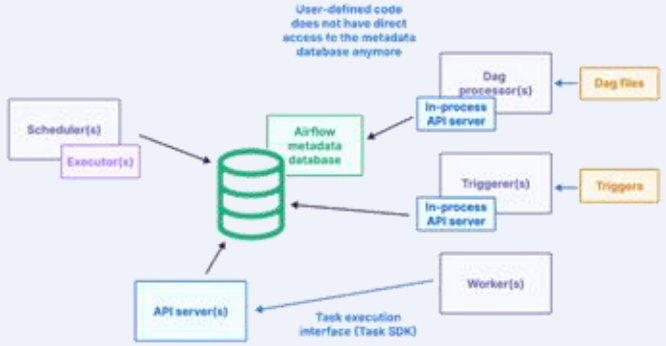
- HIPPO pilots the service implementation needed by DestinE
  - User and service access, workflow execution, reporting, scalability, interoperability and sustainability



Apache Airflow Deployment



Apache Airflow Multi-Team



Apache Airflow Components

THANK YOU FOR YOUR ATTENTION

JÜLICH Forschungszentrum | JÜLICH SUPERCOMPUTING CENTRE

Thanks go to all my colleagues