IS-ENES2 3rd General Assembly
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Reading, England

ENES Climate Data Infrastructure – CDI –

Data and Network – Status / Requirements / Challenges / Roadmap

ENES Data Infrastructure Providers:
BADC/CEDA, CERFACS, CMCC, DKRZ, IPSL, LIU, KNMI, SMHI, UiB, …

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On behalf of and with contributions from ENES Data Task Force
https://redmine.dkrz.de/projects/enes-data-task-force

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IS-ENES2 Achievements

A major outcome of the IS-ENES2 project with respect to data is the establishment of the ENES CDI (Climate Data Infrastructure). The ENES CDI

- was implemented for CMIP5 under IS-ENES2 funding
- is operationally continued for CMIP6 after IS-ENES2 with intutional and national funding
- is coordinated by the ENES DTF (Data Task Force)
- has strong weight in the international ESGF development, maintenance and operation as well as in the CMIP6 data management.
- future development is presently planned in a number of EU proposals in the EOSC (European Open Science Cloud) framework.

ENES CDI: Components

Technical Components:

- Data Nodes
  - Associated (large) storage pools (disk + tape) , long term archival facilities
- Portals
  - Metadata, Search, User-Management, Documentation
  - Higher level services including specific processing services (Climate4Impact)
- Network Infrastructure
- Processing Resources (currently not exposed/connected in an infrastructure, yet need to do so)

Software Components:

- ESGF software stack (data publication, data node, portal)
- Data preparation and data quality control ("cmorization", CMIP / CF compliance, ..)
- Data replication and data cache maintenance ("synda")
- Model / experiment related metadata tools ("es-doc")
- Data related metadata tools ("errata",..)
- Data processing tools and toolboxes ("cdo", "downscaling",..)
- Workflow-enabled big data analytics frameworks ("Ophidia")
- Data identification and data citation infrastructure and tools ("PIDs", "DOIs",..)
- Processing support frameworks ("WPS", ….)

ENES CDI: Components

Non Technical Components:

- ENES Data Task Force
- ENES / ESGF partnership
  - Substantial ESGF infrastructure development done by European ENES partners
  - Representation in ESGF Executive Committee
- ENES / WCRP WIP participation
  - Substantial WIP work done by ENES partners
- Cooperation with / involvement in other data infrastructure projects
  - EUDAT
  - Envri+
  - ICNWG (international network infrastructure team)
  - RDA
  - INDIGO-DataCloud
  - Copernicus

- Funding streams
  - Future European data infrastructure plans (H2020, open science cloud, EINFRA-12, ..)
  - Future national/institutional plans

ENES CDI: Requirements / Challenges

A) <u>Hosting</u> future high volume data projects (CMIP6 …)

- To support data analysis large amounts of data have to be collected and made accessible centrally for data processing at „tier1“ sites (e.g. national data caches)
- Future overall data collection requirements (e.g. to support multi model evaluations) will exceed local storage capacities

→ ENES wide data replication and data collection strategies
→ Sharing data storage responsibilities
→ High bandwidth interconnections between ENES tier1 sites (and to intenational tier1 sites)
→ ENES wide data mangement plans and policies
→ New tools and services to support cross-institutional data management (overall research object (collection) management versus POSIX file/dir + MD management)
→ Follow current / future data object storage and storage cloud approaches

ENES CDI: Requirements / Challenges

B) Data processing and data evaluation support

- Especially tier1 sites need to support „data near processing“
- (Large) compute cluster co-located to large data caches
- Hosting of compute services alongside data services
  (use by specific portals like climate4impact or Copernicus or by end users directly)

→ ENES national compute islands versus a distributed compute infrastructure
(grid experiences → many non technical obstacles .. !!)
→ New code packaging and deployment and hosting solutions (virtual machines on demand, docker, cloud services – new things for HPC centers ..)
→ Code management besides data management:
(code quality assurance, packaging, plugin interfaces, ..)
→ Sustainable compute infrastructure ???
ENES / ESGF strong enough for this ? → collaboration etc. with other efforts !?

ENES CDI: Requirements / Challenges

C) Research object management

- ENES data used over long periods of time and also in interdisciplinary contexts (→ underlying technology changes, volatiale http references, metadata ! ..)
- Foundation needed for sustainable data management services (e.g. persistent data identification independent of file systems, http references, ..)
- Data / metadata / collections → research objects and RO management services
- Support for RO object versioning, replication, provenance, etc. needed

→ ENES / DKRZ driven PID infrastructure for CMIP6 is only the first (small) step
  - → PID management services integration into current data managemen practises at data centers needed
  - → multi faceted challenge to establish sustainable RO management infrastructure in ENES and beyond

→ RDA Europe Call Application (CMCC) for Collaboration Project on RDA PID recommendation adoption (collaboration with DKRZ)

→ Ongoing collaborations in context of EPIC, EUDAT, RDA → H2020, EINFRA-12, … ?!

ENES CDI: Requirements / Challenges

D) Data and Metadata: data infrastructure ingest

- Data homogenization („cmorization“) process not only for model data
- Flexible data quality control tools
- Metadata collection about the data generation context (model, experiment) („es-doc“,..)

→ Flexible community toolset to support groups in data homogenization needed (status: individual cmor or cmor like local adaptations – no real community effort .. many groups e.g. CORDEX start from scratch)

→ Flexible community toolset to support groups in data quality control (work started, integration of cf-check, cmor-check, mip-checks ..)

→ Es-doc toolset sustainability

ENES CDI: Institutional Plans

DKRZ:

- PID, LTA, Data citation, EUDAT, RDA, Replication, ….

BADC:

- Security infrastructure (ESGF AAI), data replication (ICNWG), ….

CERFACS:

- Build on C4I/KNMI portal/services: EUDAT/EGI/RDA (data analytics, e.g. cloud computing+interfacing APIs between infras, workflows, data life cycle), still seeking H2020 appropriate consortium/funding to pursue

IPSL:

- Multi Model Analysis, replication (synda based), analysis workflow, ES-DOC, Errata (PID based), EOSC

KNMI:

- Build on and support C4I with CERFACS/SMHI/WUR/CMCC/…; Host ESGF data node; PerfSonar; ESGC CWT; Work on provenance and indicator metadata;

CMCC:

- CMCC Provides a Tier2 site. It is also committed to develop and maintain the ESGF modules related to the download metrics (IS-ENES2 funded activity). Since 2010, CMCC has been also developing a framework for big data analytics (Ophidia) in close synergy with ESGF. A dedicated cluster will be made soon available for the ESGF-CWT activity. Plans relate to apply to H2020 and Copernicus calls on data-infrastructure topics.

LIU:

- Operate and develop ESGF and MARS infrastructure. Nordic support for ESGF. Operate and deploying iRODS, hosting PID framework services. Involved in EGI, NeiC and ECDS

ENES CDI: Inter-Institutional Plans

CMIP6 ENES cross institutional infrastructure developments, e.g. ESGF

- Replication
- Data network bandwidth
- PID infrastructure
- (Early) data citation
- Errata management
- ES-DOC/CIM and emerging new Metadata & DRS for level-2+ products
- Data provision and processing: ENES & Copernicus; adapt current platform (C4I) and services to new datasets and experiments
- User Support: after IS-ENES2 ??

ESGF CMIP6 Data Publication

Modelling group

Checkpoint D2/M2

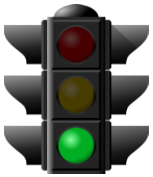
- PID tracking_ID syntax correct
- Citation information complete
- Errata / Annotation available
- Further_info_url correct

ESGF publication

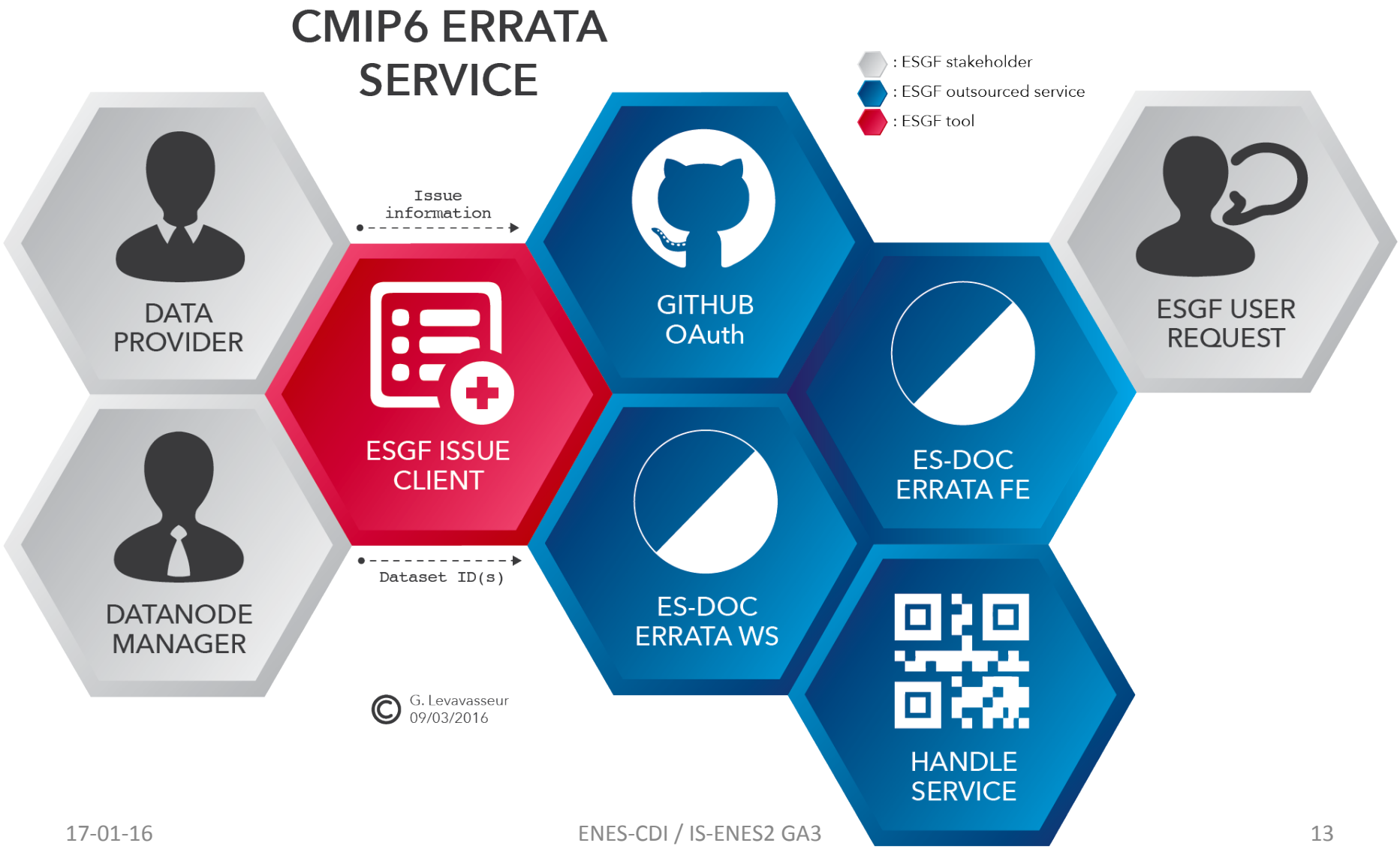
- PID registration
- Citation information confirmation
- File publication
- Errata / Annotation registration
- CIM documents

STATUS flags

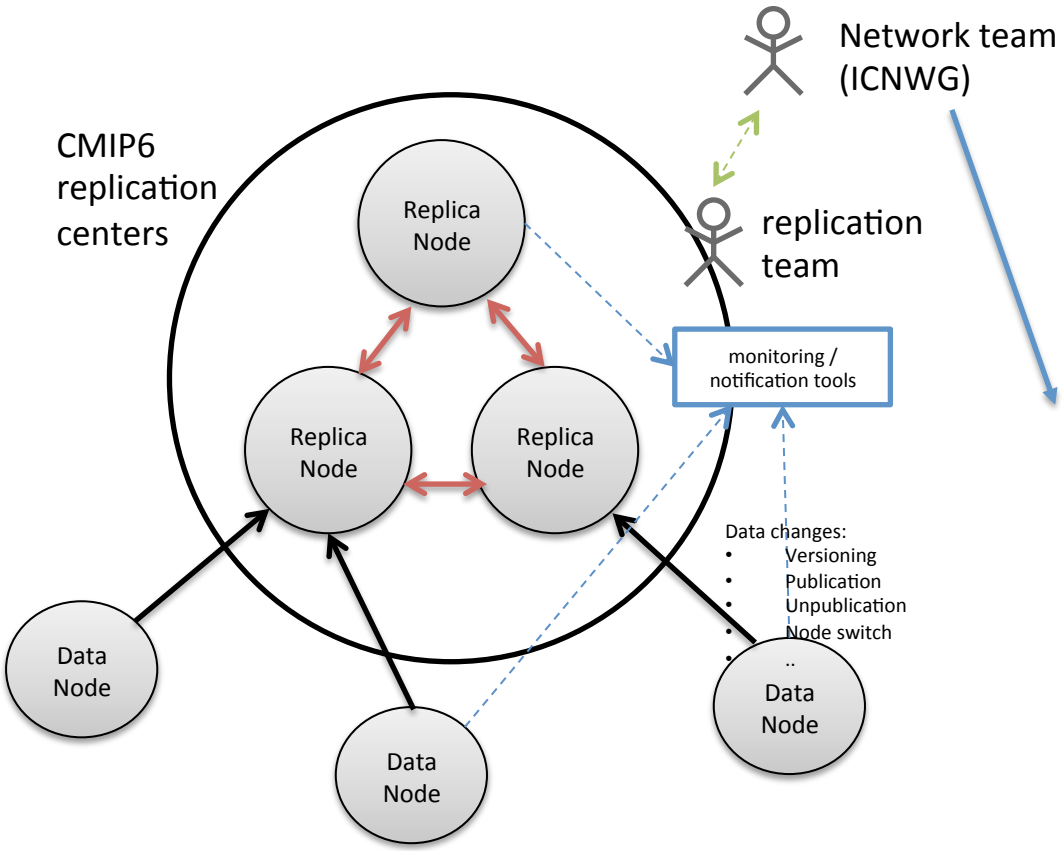
OK!



ESGF CMIP6 ES-DOC Errata Service



ESGF CMIP6 Data Replication



CMIP6 data volume

- 20 – 30 PB compressed NetCDF-4
- WIP suggestion: 2 PB core data for replication

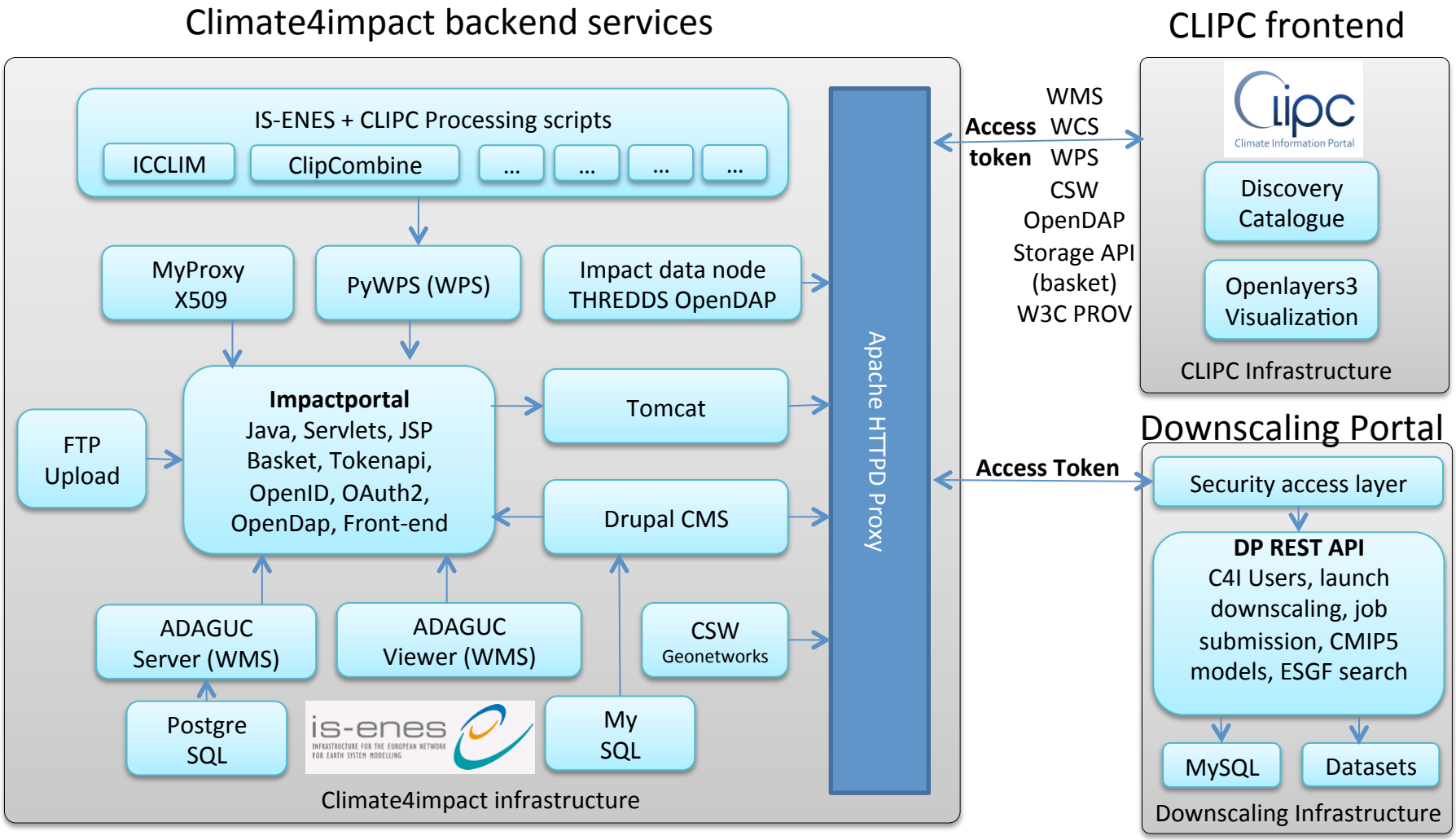
Network bandwidth (ICNWG)

- Theoretical: 10 Gbit/s
- Real: about 1 Gbit/s (local – local)
- Projection: 3 – 5 Gbit/s

Full replication of 2 PB core data

- Real: 26 weeks
- Projected: 9 – 5 weeks

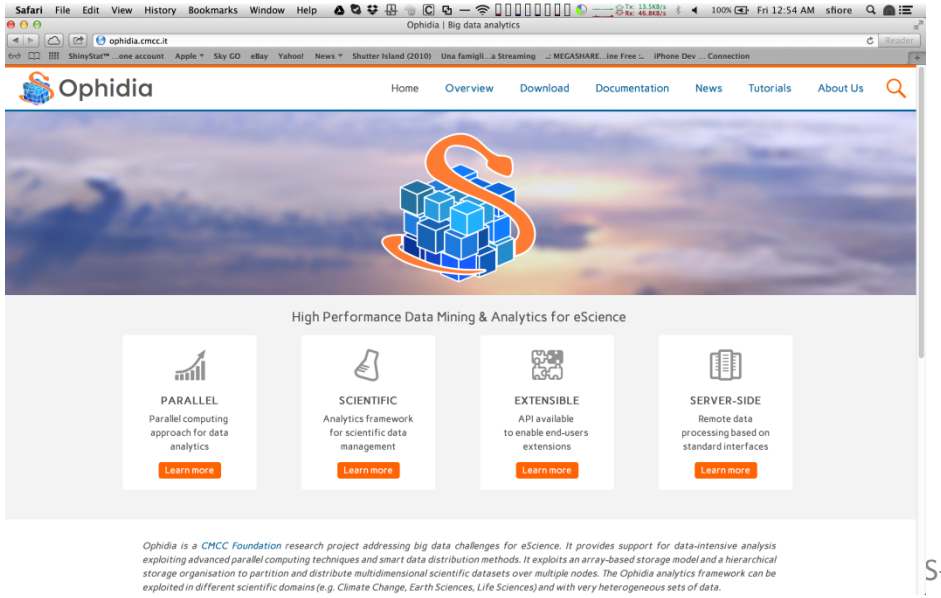
Climate for Impacts Portal (C4I)

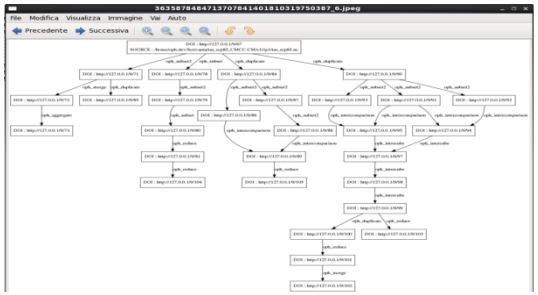


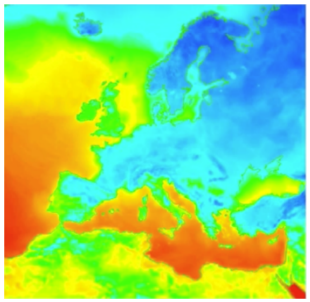
Workflow-enabled big data analytics – Ophidia

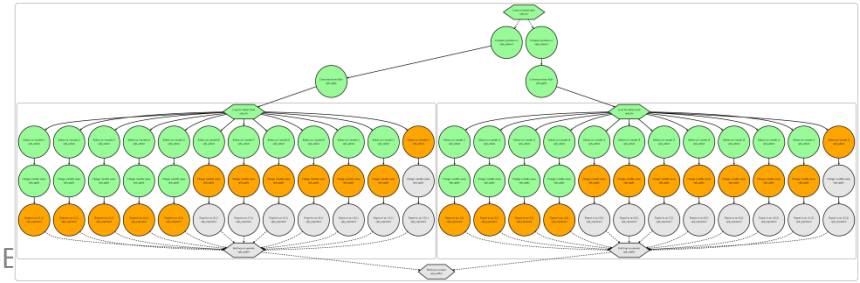
Ophidia is a research project addressing big data challenges for eScience

- It provides support for declarative, parallel, server-side data analysis exploiting parallel computing techniques and database approaches
- It supports end-to-end analytics workflows for eScience
- It has been exploited in **CLIP-C** to process climate indicators in some big data scenarios and in the **INDIGO-DataCloud** to implement distributed, multi-model analytics experiments









ENES CDI: Future Perspectives

Even after end of the IS-ENES2 project the ENES CDI will be coordinated by the ENES DTF to:

- Strengthen ENES data infrastructure "mission statement" and "identity" which is needed to define contour in context of emerging science cloud etc. trends
- Integration into EOSC (European Open Science Cloud)
  - EU pushing the integration of EUDAT, EGI and INDIGO to aim for an operational EOSC by 2020
  - ENES is represented in EUDAT by CERFACS, DKRZ, MPI-M
  - ENES is represented in INDIGO-DataCloud by CMCC
  - Direct integration of ENES partners at institutional level in COPERNICUS, E-INFRA 12A and E-INFRA 21
- Preserve Europe's leading role in ESGF development, maintenance and operation

- Develop strategies to handle huge data volumes (CMIP6: 20 – 30 PB) together with huge numbers of data entities (CMIP6: 50 – 150 Mio)
  - Sharing of data storage responsibilities between European data nodes
  - Federated data processing at storage locations
    - Orchestration of data analytic workflows using data processing near storage, cloud computing (EGI, ...) with local temporary storage (EGI DataHub, ...), using standard interfaces (ESGF API, EUDAT GEF API, ...)
  - Higher level services including specific processing services and intelligent search facilities (Climate4Impact)
  - Network bandwidth on demand
  - Replacement of classical file system by cloud storage of digital objects
  - Alternative data storage and evaluation strategies to adapt data production to IT-prospects