The Ophidia big data analytics framework

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On behalf of the Ophidia Team

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Outline

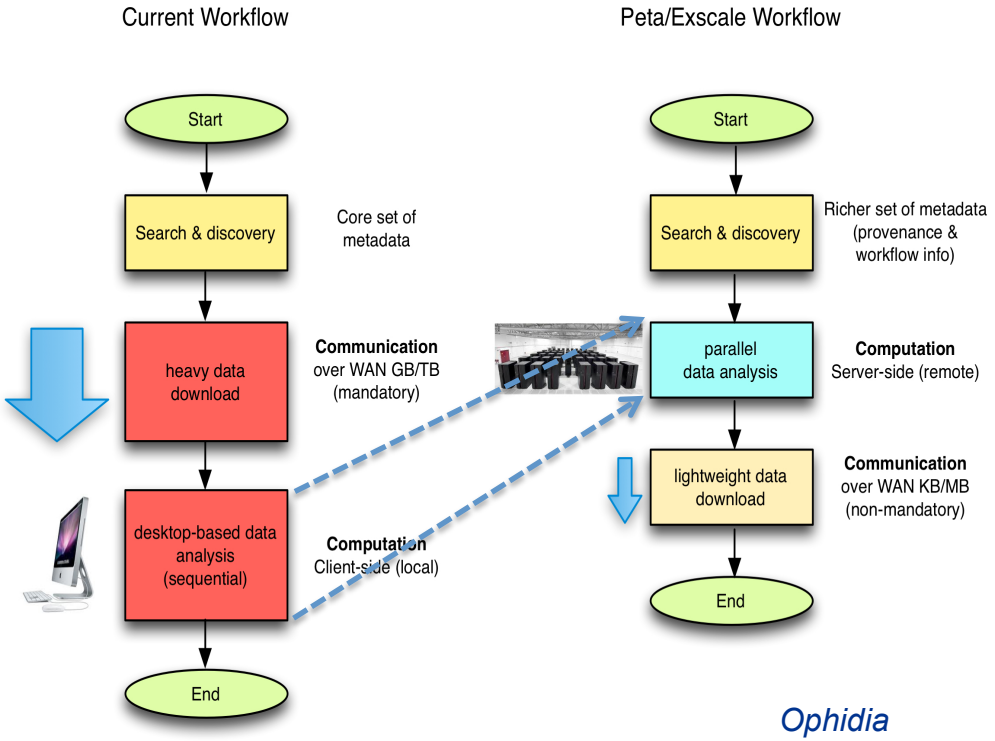
- ✔ *Ophidia introduction*
- ✔ *Workflows support*
  - ✔ *Climate indicators processing*
  - ✔ *Fire danger analysis*
  - ✔ *Cloud-based use case on climate change and biodiversity*
  - ✔ *Climate Model Intercomparison Data Analysis case study*
- ✔ *Modularity, extensibility & programmatic access*
- ✔ *Conclusions*

The Ophidia Project

Ophidia is a research effort carried out at the ***Euro Mediterranean Centre on Climate Change*** *(CMCC) to* address "big data" challenges, issues and requirements for climate change data analytics.

Requirements

- *Time series analysis*
- *Data subsetting*
- *Model intercomparison*
- *Multimodel means*
- *Massive data reduction*
- *Data transformation*
- *Climate change signal*
- *Maps generation*
- *Ensemble analysis*
- *Worflow support*
  - *Tens, hundreds of tasks*
- *Metadata management support*



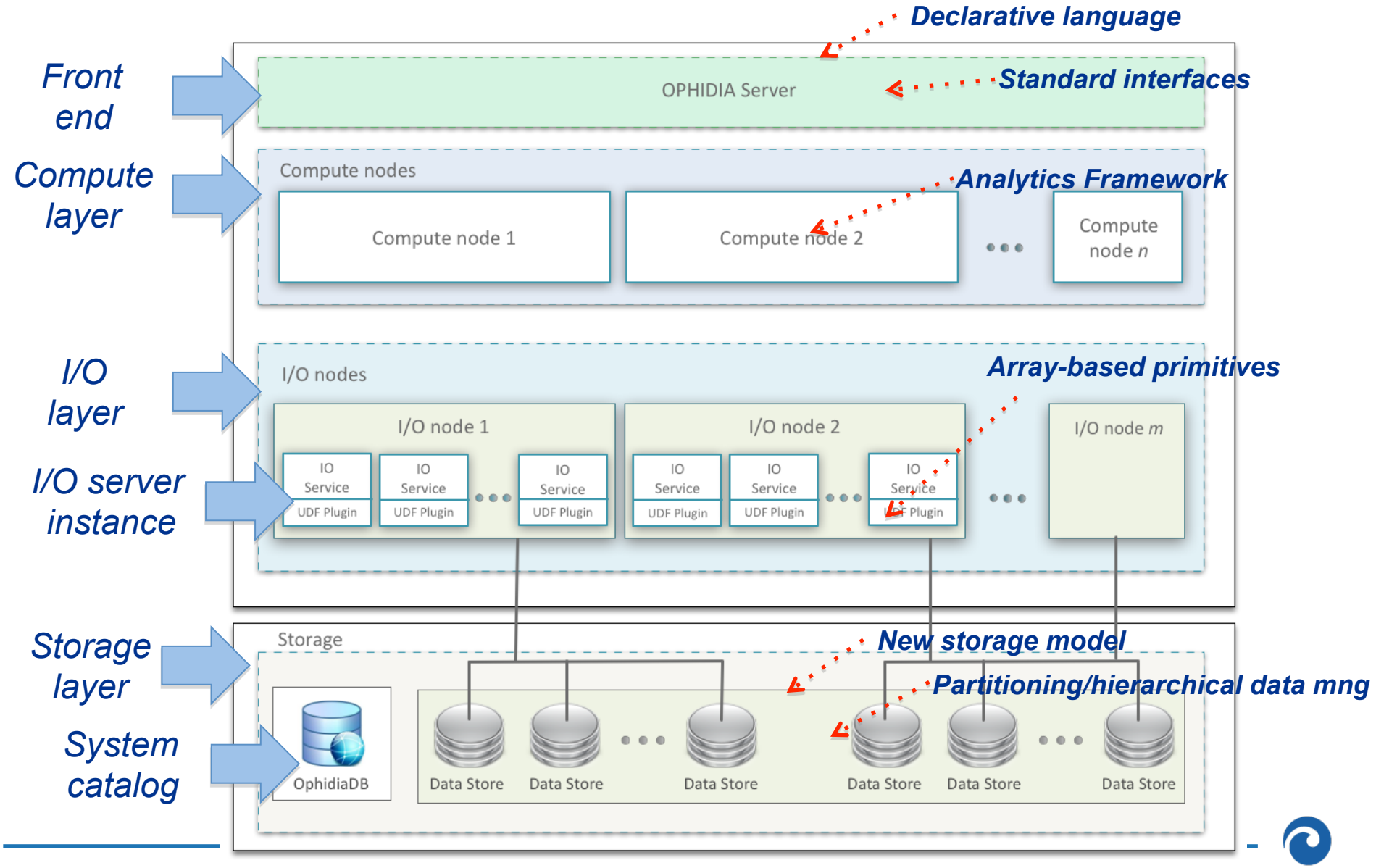
Ophidia
http://ophidia.cmcc.it/

*S. Fiore, A. D'Anca, C. Palazzo, I. Foster, D. N. Williams, G. Aloisio, "Ophidia: toward bigdata analytics for eScience", **ICCS2013 Conference**, Procedia Elsevier, Barcelona, June 5-7, 2013*

Ophidia in a nutshell

- ✔ *Big data stack for scientific data analysis*
- ✔ *Use of parallel operators and parallel I/O*
- ✔ *Support for complex workflows / operational chains*
- ✔ *Extensible: simple API to support framework extensions like new operators and array-based primitives*
  - ✔ *currently 50+ operators and 100+ primitives provided*
- ✔ *Multiple interfaces available (WS-I, GSI/VOMS, OGC-WPS).*
- ✔ *Programmatic access via C and Python APIs*
- ✔ *Support for both batch & interactive data analysis*

Ophidia Architecture v0.1



Storage model (dimension-independent) & implementation
Array-based support and hierarchical storage

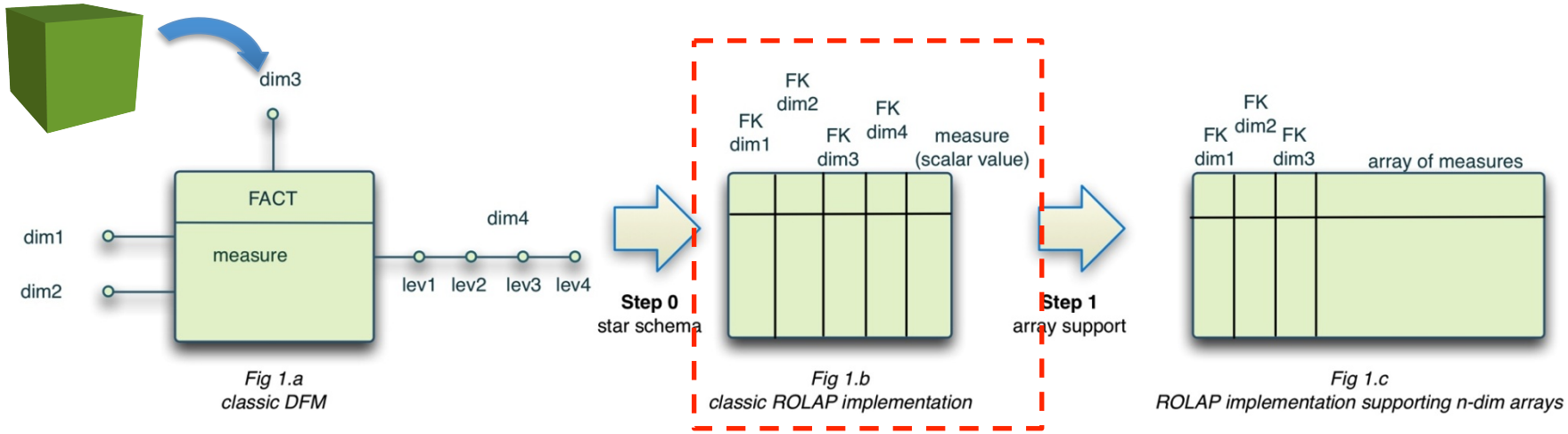


Fig 1.a
classic DFM

Fig 1.b
classic ROLAP implementation

Fig 1.c
ROLAP implementation supporting n-dim arrays

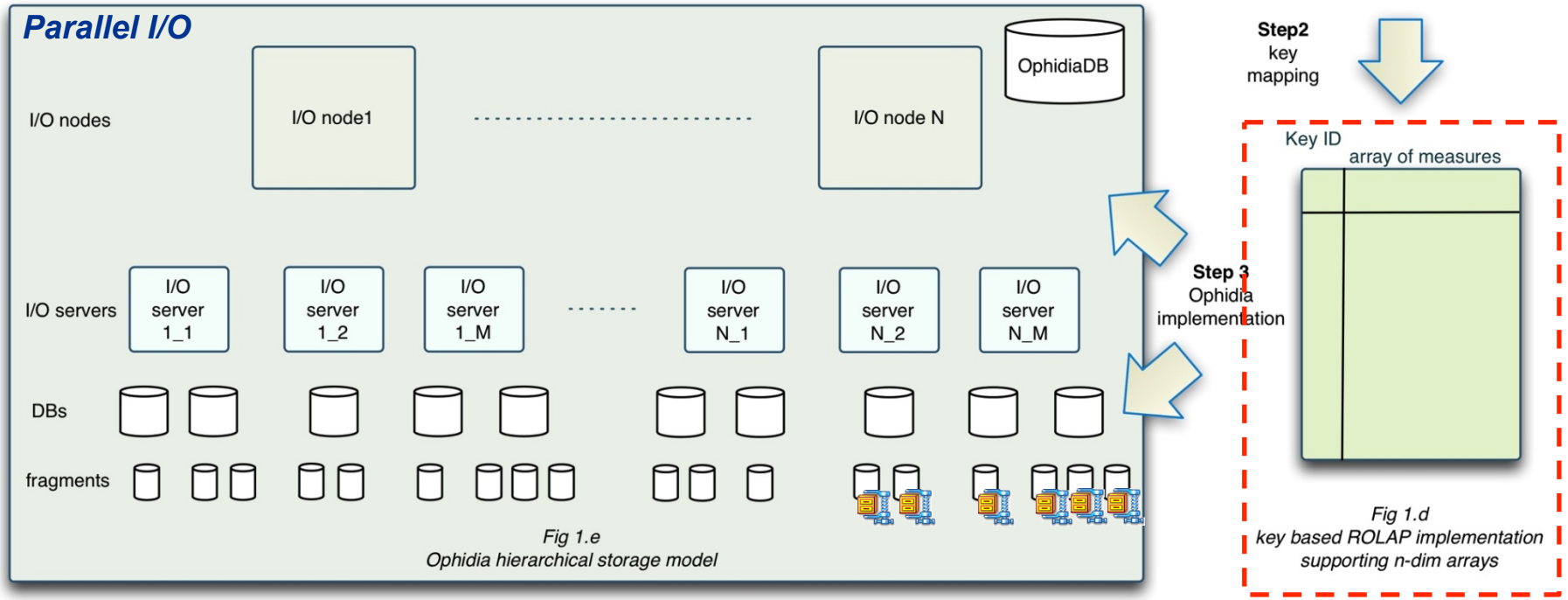
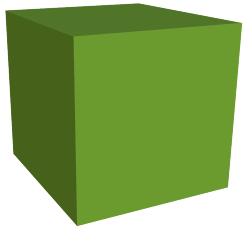
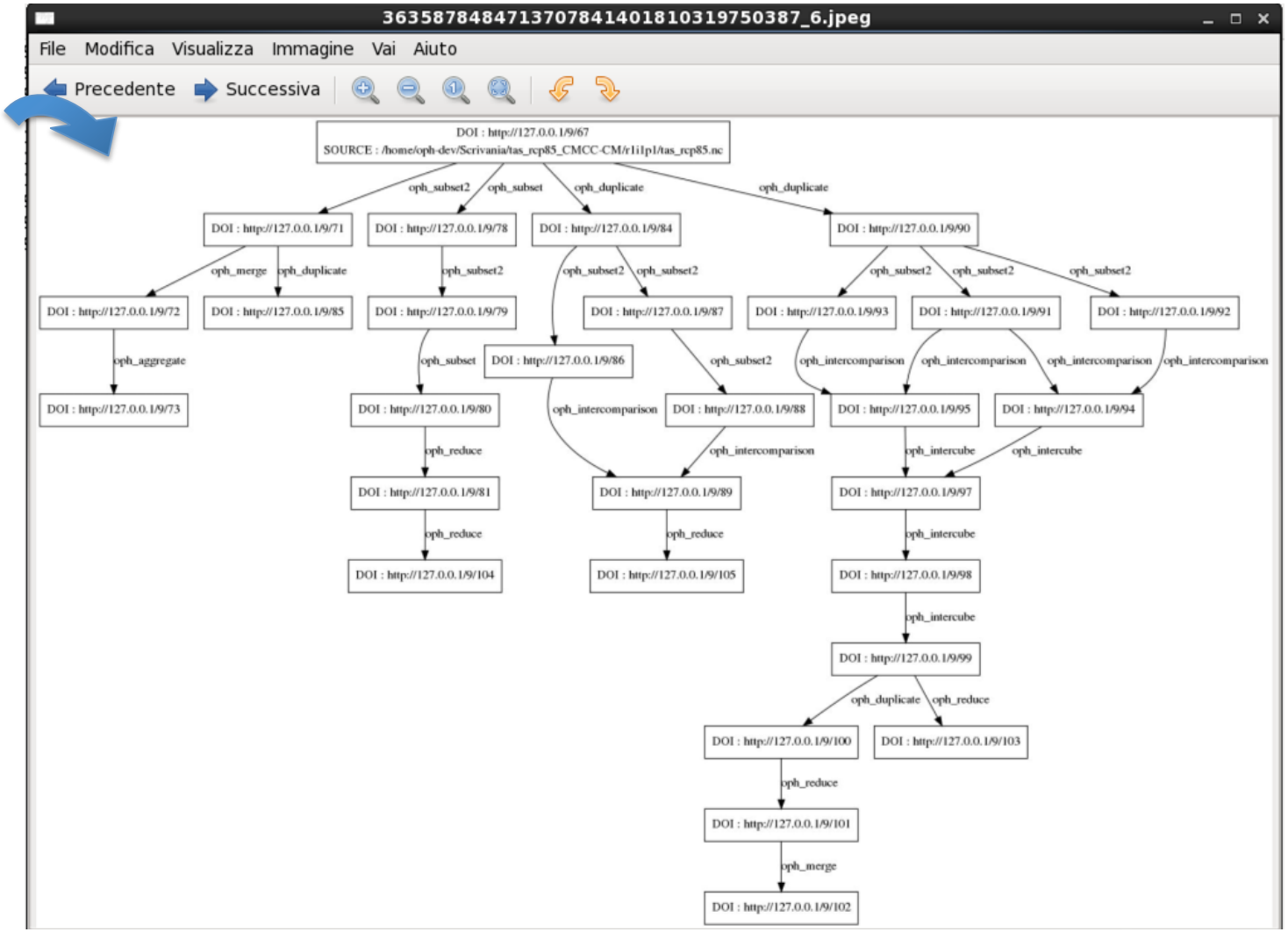


Fig 1.e
Ophidia hierarchical storage model

Fig 1.d
key based ROLAP implementation
supporting n-dim arrays

Provenance and PID





The analytics framework: datacube operators (about 50)

OPERATOR NAME	OPERATOR DESCRIPTION
Operators "Data processing" – Domain-agnostic	
OPH_APPLY(*datacube_in*, *datacube_out*, *array_based_primitive*)	Creates the *datacube_out* by applying the *array-based primitive* to the *datacube_in*
OPH_DUPLICATE(*datacube_in*, *datacube_out*)	Creates a copy of the *datacube_in* in the *datacube_out*
OPH_SUBSET(*datacube_in*, *subset_string*, *datacube_out*)	Creates the *datacube_out* by doing a sub-setting of the *datacube_in* by applying the *subset_string*
OPH_MERGE(*datacube_in*, *merge_param*, *datacube_out*)	Creates the *datacube_out* by merging groups of *merge_param* fragments from *datacube_in*
OPH_SPLIT(*datacube_in*, *split_param*, *datacube_out*)	Creates the *datacube_out* by splitting into groups of *split_param* fragments each fragment of the *datacube_in*
OPH_INTERCOMPARISON (*datacube_in1*, *datacube_in2*, *datacube_out*)	Creates the *datacube_out* which is the element-wise difference between *datacube_in1* and *datacube_in2*
OPH_DELETE(*datacube_in*)	Removes the *datacube_in*

Data processing (parallel operators, MPI & OpenMP based)

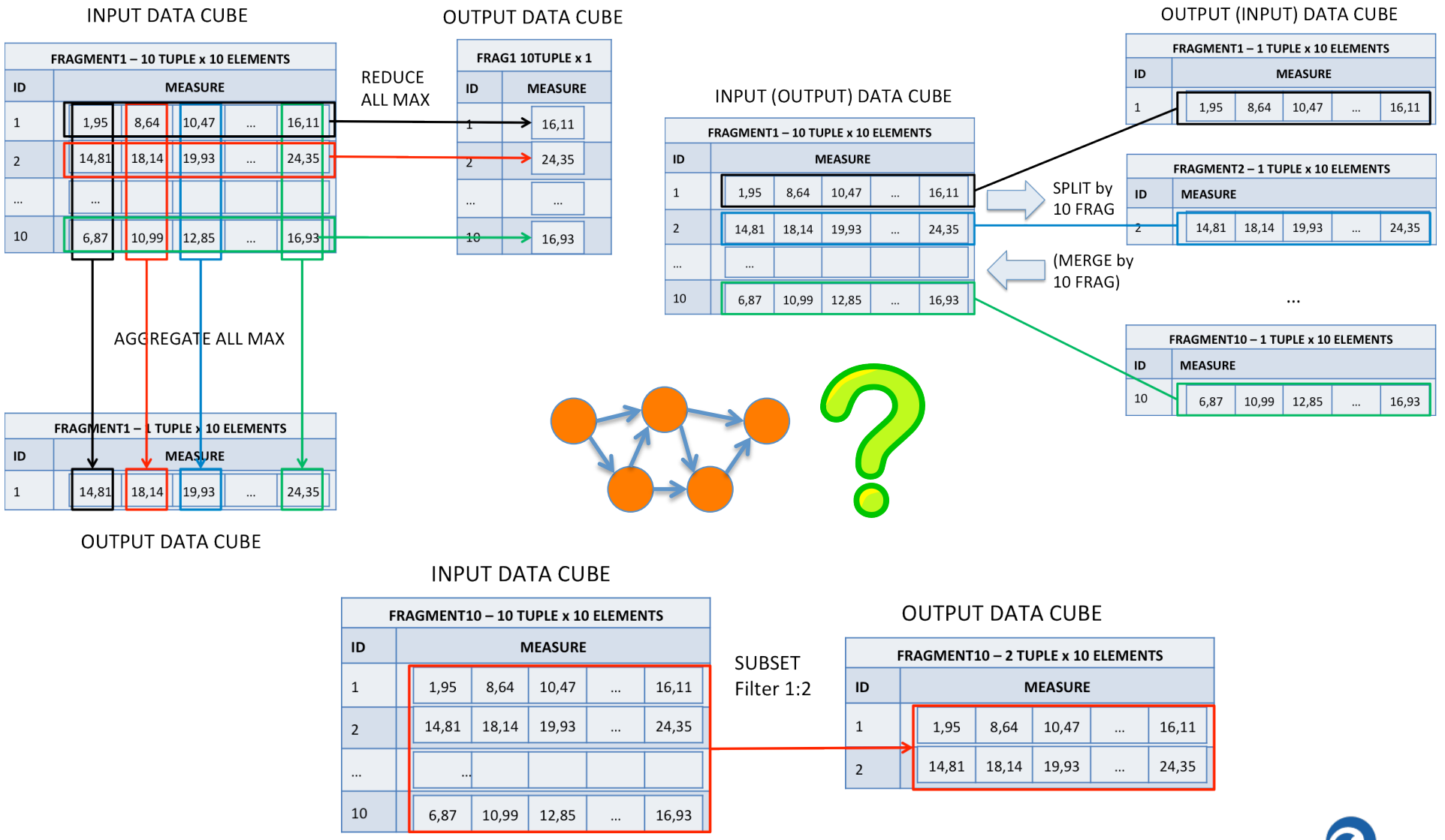
Import/Export (parallel operators)

Data Access (sequential and parallel operators)

Metadata management (sequential and parallel operators)

OPERATOR NAME	OPERATOR DESCRIPTION
Operators "Data processing" – Domain-oriented	
OPH_EXPORT_NC (*datacube_in*, *file_out*)	Exports the *datacube_in* data into the *file_out* NetCDF file.
OPH_IMPORT_NC (*file_in*, *datacube_out*)	Imports the data stored into the *file_in* NetCDF file into the new *datacube_in* datacube
Operators "Data access"	
OPH_INSPECT_FRAG (*datacube_in*, *fragment_in*)	Inspects the data stored in the *fragment_in* from the *datacube_in*
OPH_PUBLISH(*datacube_in*)	Publishes the *datacube_in* fragments into HTML pages
Operators "Metadata"	
OPH_CUBE_ELEMENTS (*datacube_in*)	Provides the total number of the elements in the *datacube_in*
OPH_CUBE_SIZE (*datacube_in*)	Provides the disk space occupied by the *datacube_in*
OPH_LIST(void)	Provides the list of available datacubes.
OPH_CUBEIO(*datacube_in*)	Provides the provenance information related to the *datacube_in*
OPH_FIND(*search_param*)	Provides the list of datacubes matching the *search_param* criteria

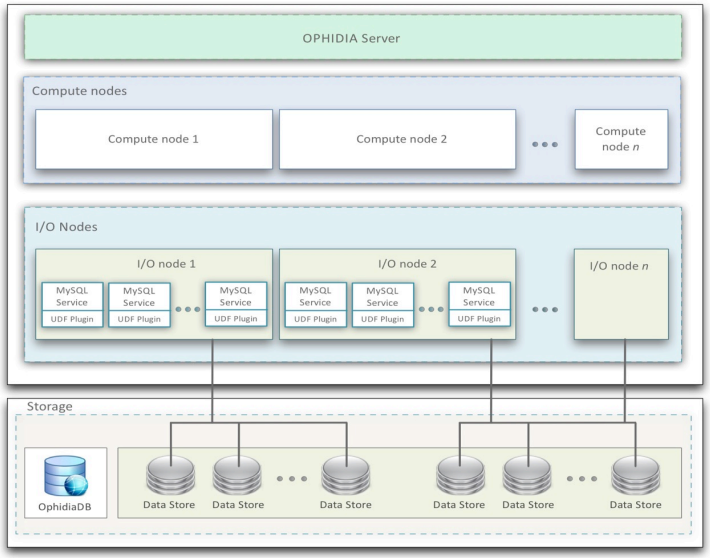
The analytics framework: datacube operators



How to submit a workflow: the Ophidia Terminal

- The Ophidia terminal provides an effective and lightweight way to interact with the Ophidia server
- Bash-like env. (commands interpreter)
- Terminal with history management, auto-completion, specific environment variables and commands with integrated help
- Easy installation as an only one executable using a small number of well-known and open-source libraries
- Simple enough for a novice and at the same time powerful enough for an expert

Let's consider a use case on climate indicators implemented in the CLIP-C project



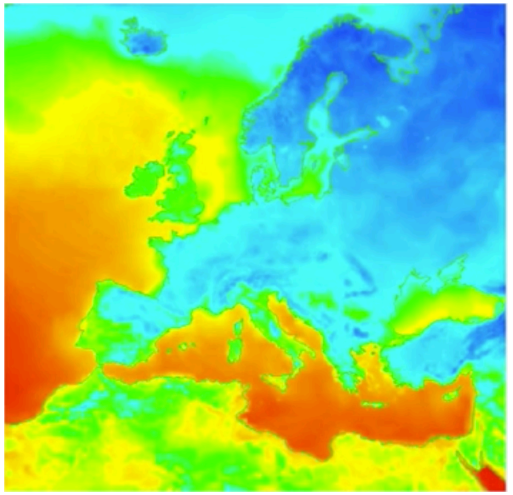
Use case on climate indicators processing

Climate Information Portal

- ✔ *In the CLIPC project, processing chains for data analysis are being implemented with Ophidia to compute **climate indicators***

- ✔ ***First set of indicators** includes: TNn, **TNx**, TXn, **TXx***
  - ✔ *Input files: 12GBs (TasMin & TasMax)*
  - ✔ *Workflows have been already implemented*
  - ✔ *Demo on Thrursday*

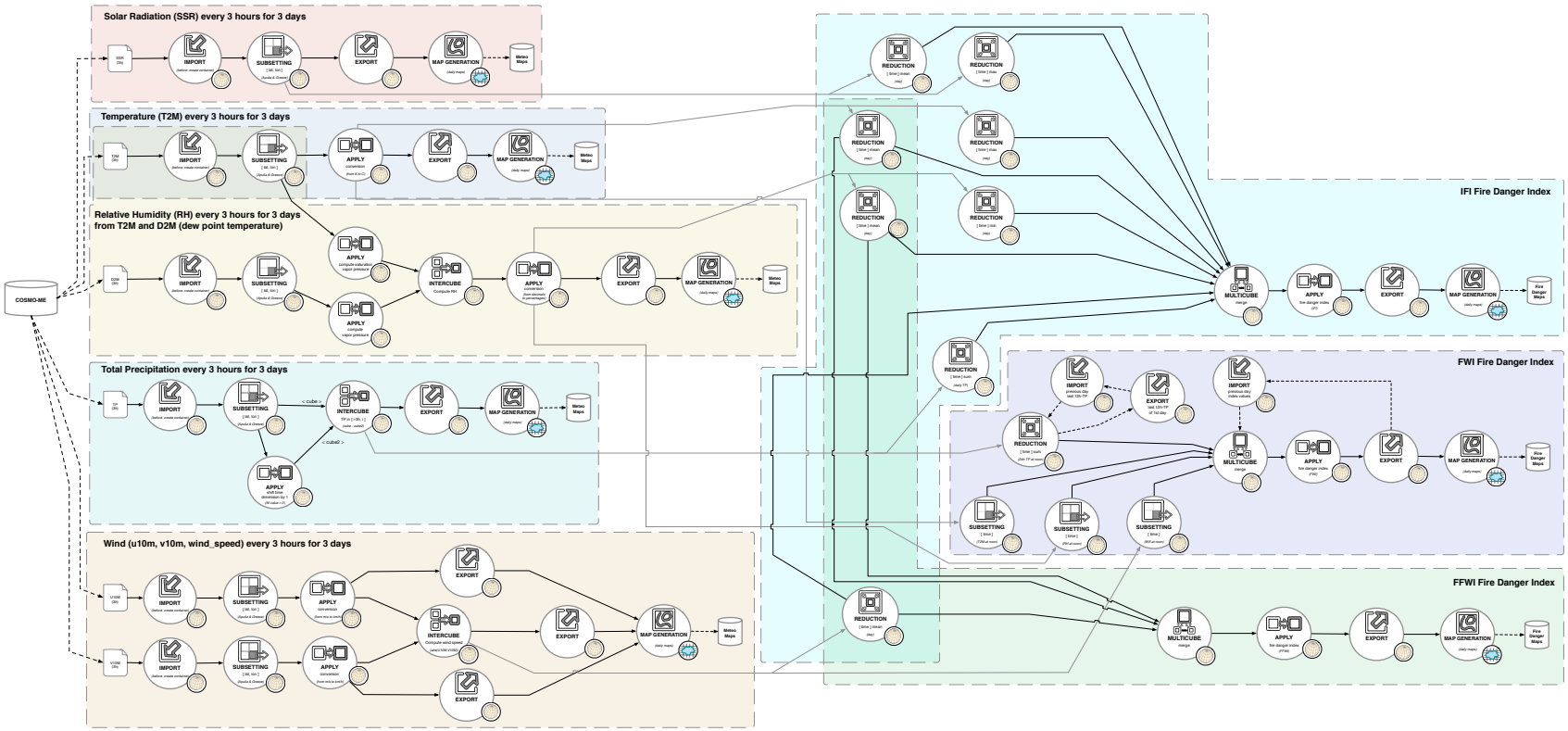
- ✔ ***Parallel approach***
  - ✔ *Inter-parallelism & Intra-parallelism*



See the demo on Thursday

Operational FIre Danger preventIon plAtform

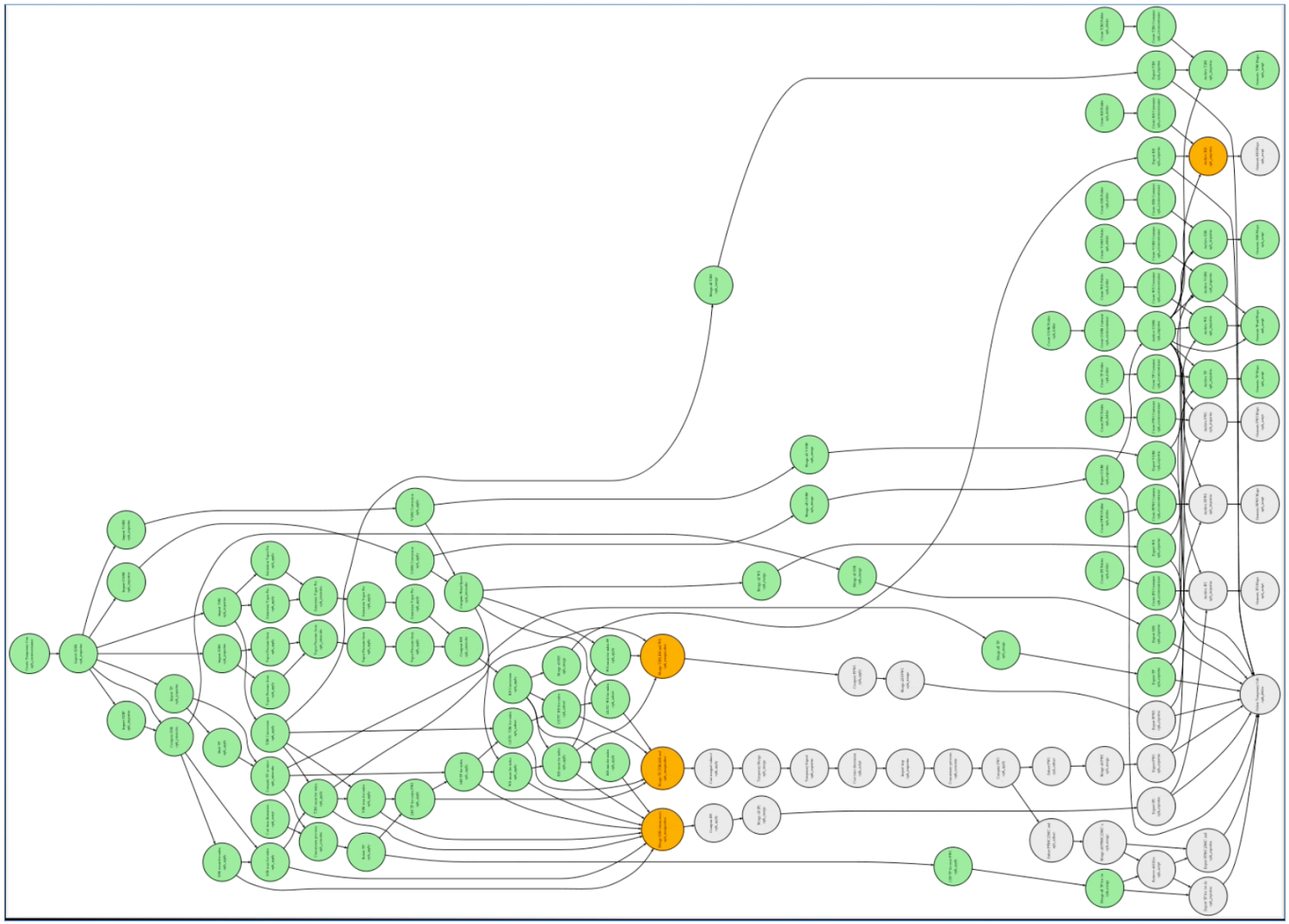
OFIDIA main objective is to build a **cross-border operational fire danger prevention infrastructure** that advances the ability of regional stakeholders across Apulia and Ioannina Regions to **detect** and **fight forest wildfires**



OFIDIA: Operational FIre Danger preventIon plAtform

Co-ordinator: Prof. G. Aloisio (CMCC)
Website: http://www.ofidia.eu/

Workflow runtime execution (fire danger analysis)



https://www.youtube.com/watch?v=vxbYF1Zhpuc&feature=youtu.be

EUBrazilCC project

EU Brazil Cloud Connect
EU Brazil Cloud Computing for Science

- ✓ *The main objective is the creation of a **federated e-infrastructure for research using a user-centric approach**.*
- ✓ *To achieve this, we need to pursue three objectives:*
  - ✓ *Adaptation of existing applications to tackle new scenarios emerging from cooperation between **Europe** and **Brazil** relevant to both regions.*
  - ✓ *Integration of frameworks and programming models for **scientific gateways** and **complex workflows**.*
  - ✓ ***Federation of resources**, to build up a **general-purpose infrastructure** comprising existing and **heterogeneous resources***
  - ✓ ***Data analytics workflows** on heterogeneous datasets including **climate**, **remote sensing** data and **observations** (e.g. NetCDF, LANDSAT, LiDAR)*

EU Brazil Cloud Connect
EU Brazil Cloud Computing for Science

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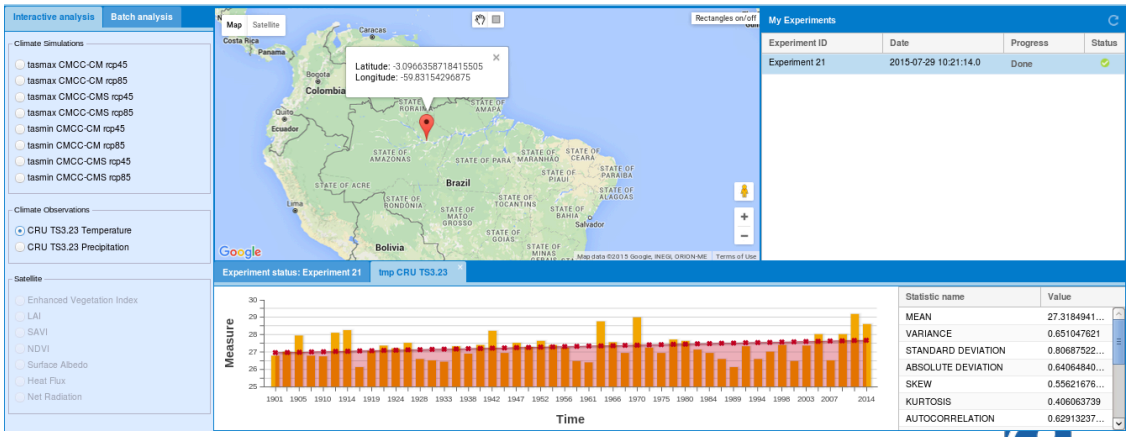
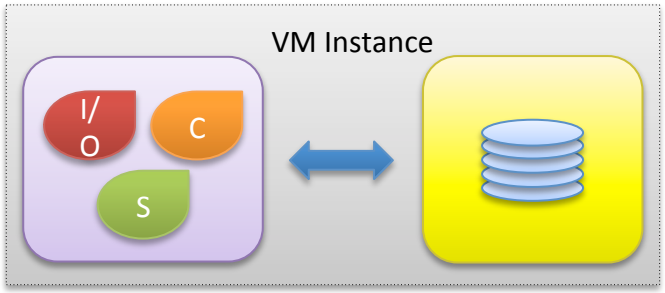


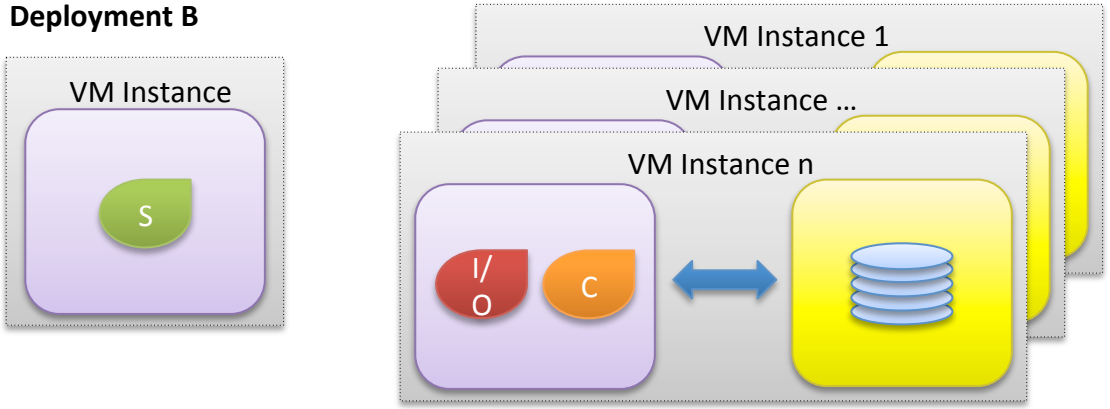
Cloud-based deployment scenarios

EU Brazil Cloud Connect
EU Brazil Cloud Computing for Science

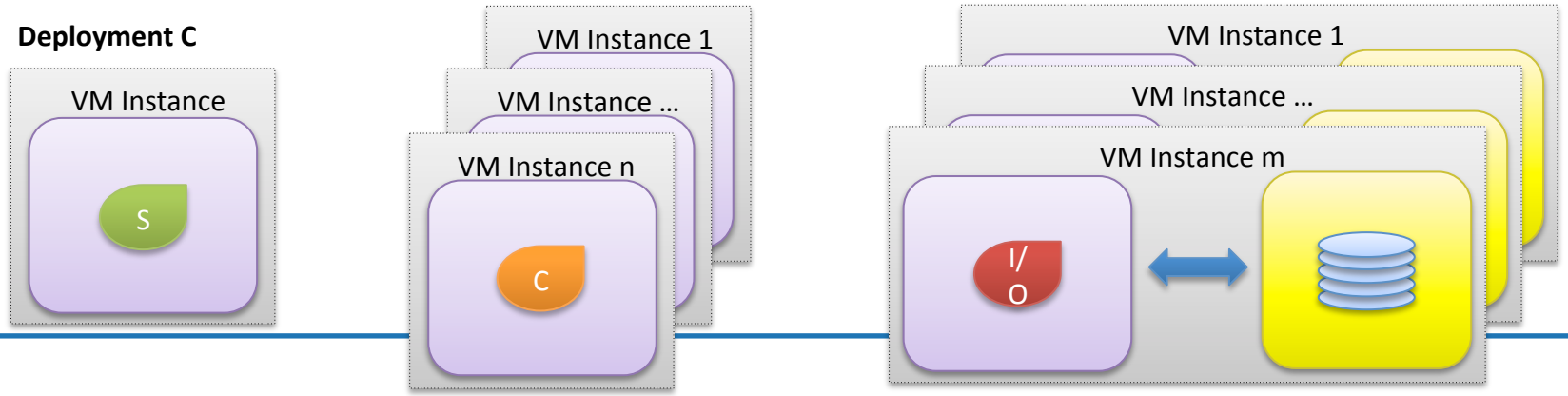
Deployment A



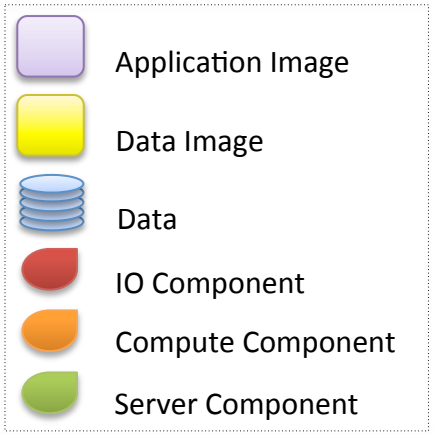
Deployment B



Deployment C



Legend



INtegrating Distributed data Infrastructures for Global ExplOitation

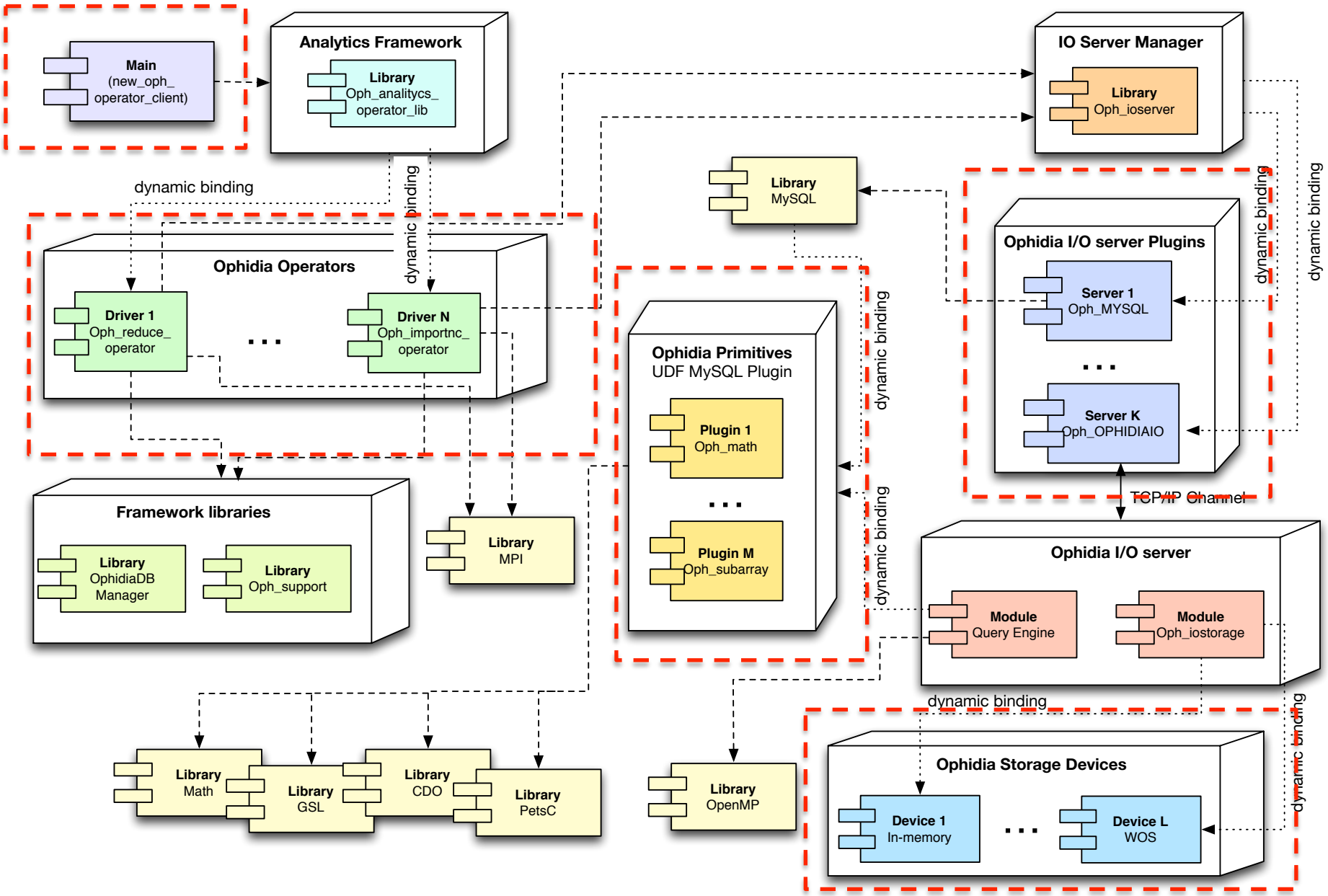
- ✔ **INDIGO-DataCloud** is a project approved within the **E-INFRA-1-2014** call of the **Horizon 2020** framework program of the European Community.
  - ✔ It aims at developing a **data/computing platform** targeting **scientific communities**, **deployable on multiple hardware** and provisioned over **hybrid** (private or public) **e-infrastructures**.

- ✔ It aims at targeting multiple case studies related to different domains

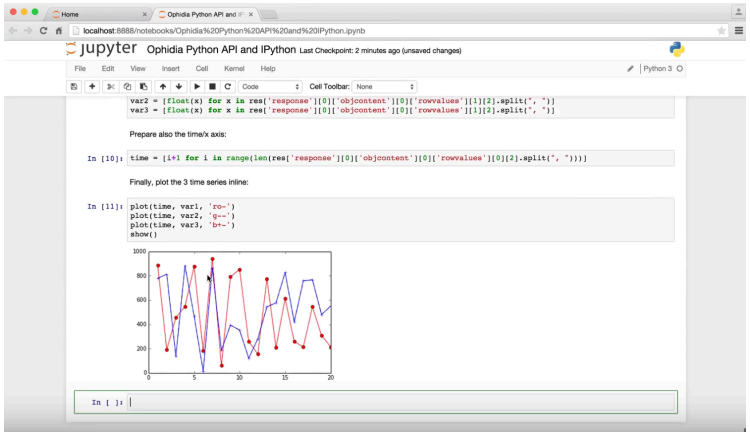
- ✔ Key points for the "*Climate Model Intercomparison Data Analysis*" case study:
  - ✔ **Interoperability** with application domain specific software and services will be addressed (e.g. IS-ENES/ESGF) – Link to the ESGF-CWT activity
  - ✔ **Server-side and parallel** approach for large scale data analysis
  - ✔ **Two-level workflows** to fully address the case study requirements
  - ✔ **Multi-site experiment** to demonstrate the feasibility of the approach at the federation level

Co-ordinator: Dr. Davide Salomoni (INFN)
Technical Director: Giacinto Donvito (INFN)
Website: https://www.indigo-datacloud.eu/

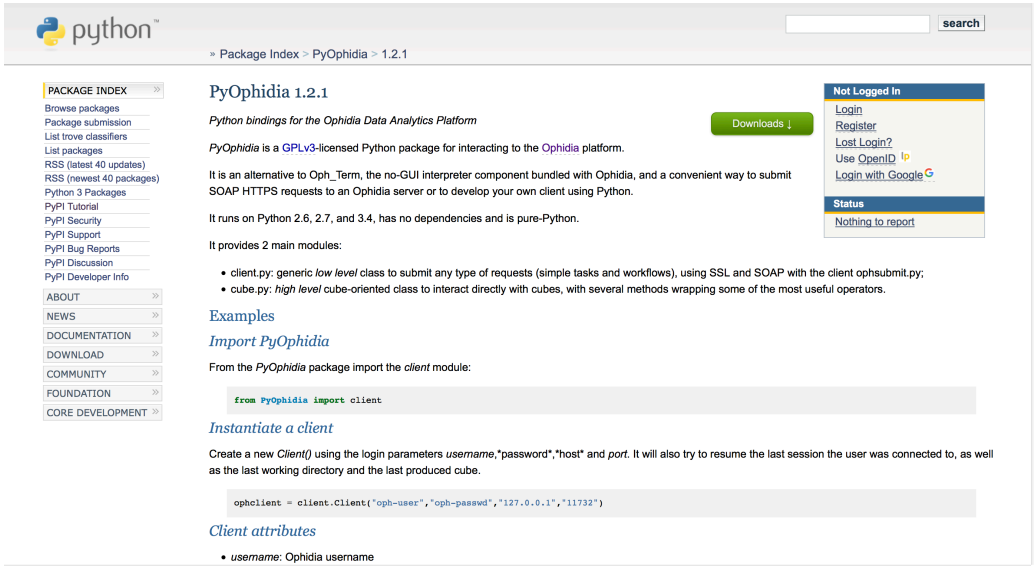
Modularity and extensibility: APIs and dynamic bindings



Programmatic access through the PyOphidia class



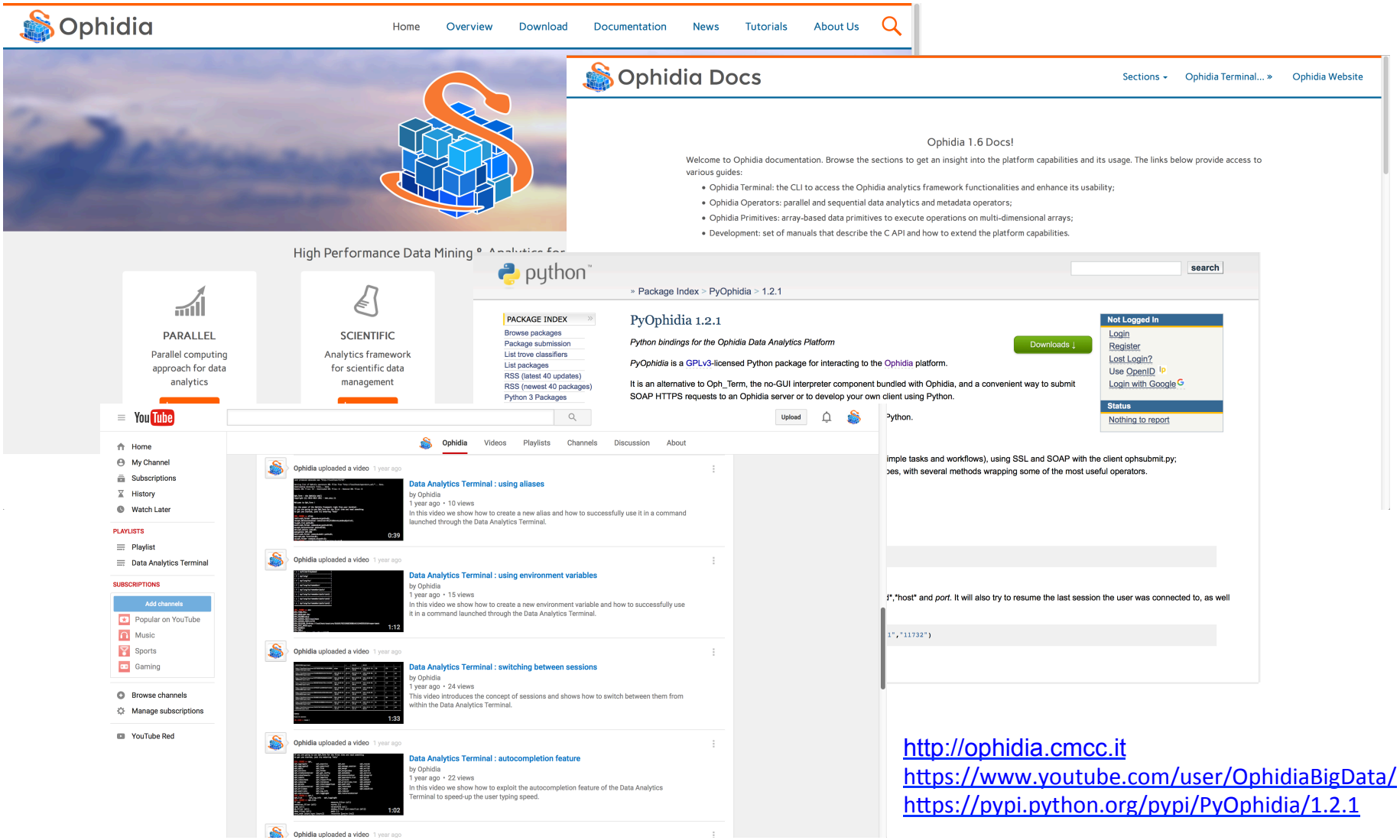
https://pypi.python.org/pypi/PyOphidia/1.2.1



https://www.youtube.com/watch?v=8pcrBXboF6U&feature=youtu.be

- ✓ **PyOphidia** provides a Python interface to submit commands to the Ophidia Server and to retrieve/deserialize the results
- ✓ Two classes implemented:
  - ✓ **Client class**: connect to the server, navigate into the ophidia file system, submit workflows, manage sessions, etc.
  - ✓ **Cube class**: manipulate cubes (reduce, subset, operations between cubes, intercomparison, etc.), get information on cubes (schema, dimensions, metadata, etc.)

Useful resources



http://ophidia.cmcc.it
https://www.youtube.com/user/OphidiaBigData/
https://pypi.python.org/pypi/PyOphidia/1.2.1

Conclusions

- ✔ *Ophidia is a big data analytics framework for eScience*
  - ✔ *OLAP approach for big data – multidimensional data model*
- ✔ *Multiple use cases for data analysis in different domains/contexts have been implemented*
  - ✔ *Sea situational awareness, fire danger prevention, climate indicators, couple model intercomparison data analysis, biodiversity and climate change*
- ✔ *It provides access via CLI (end-users) and API (devel users)*
- ✔ *Programmatic access via C and Python APIs*
- ✔ *Several deployment scenarios in the cloud have been implemented*
  - ✔ *Mainly in the EUBrazilCC project*
  - ✔ *Publication of the VMIs on the EGI AppDB expected before the end of the year (final testing are ongoing)*
- ✔ *Roadmap towards ESGF: WPS support already available*
- ✔ *Official Release v1.0 is coming: January 2016*

Thanks

http://ophidia.cmcc.it

@OphidiaBigData

www.youtube.com/user/OphidiaBigData

Do you want to join us?