Ophidia big data analytics framework

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on behalf of the Ophidia Team

Climate Information Portal

is-enes
INFRASTRUCTURE FOR THE EUROPEAN NETWORK FOR EARTH SYSTEM MODELLING

Earth System Grid Federation ESGF

INDIGO - DataCloud

cmcc
Centro Euro-Mediterraneo sui Cambiamenti Climatici

EUBRA BIGSEA

The Ophidia project

Ophidia (http://ophidia.cmcc.it) is a CMCC Foundation research project addressing big data challenges for eScience

It provides support for declarative and server-side data analysis exploiting high performance computing paradigms and database approaches

Exploits a multidimensional data model providing the data cube abstraction for access and analysis of scientific n-dimensional data

Ophidia

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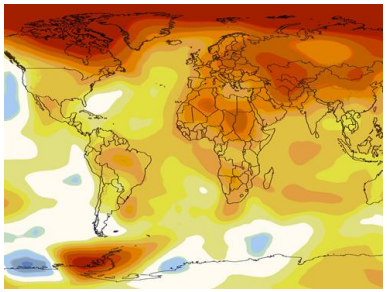
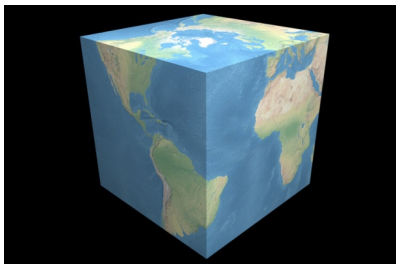
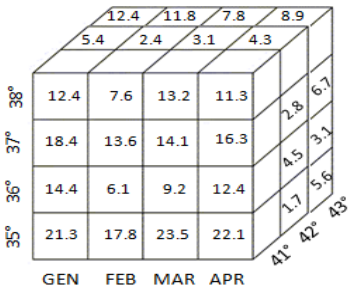
Paradigm shift from client- to server-side

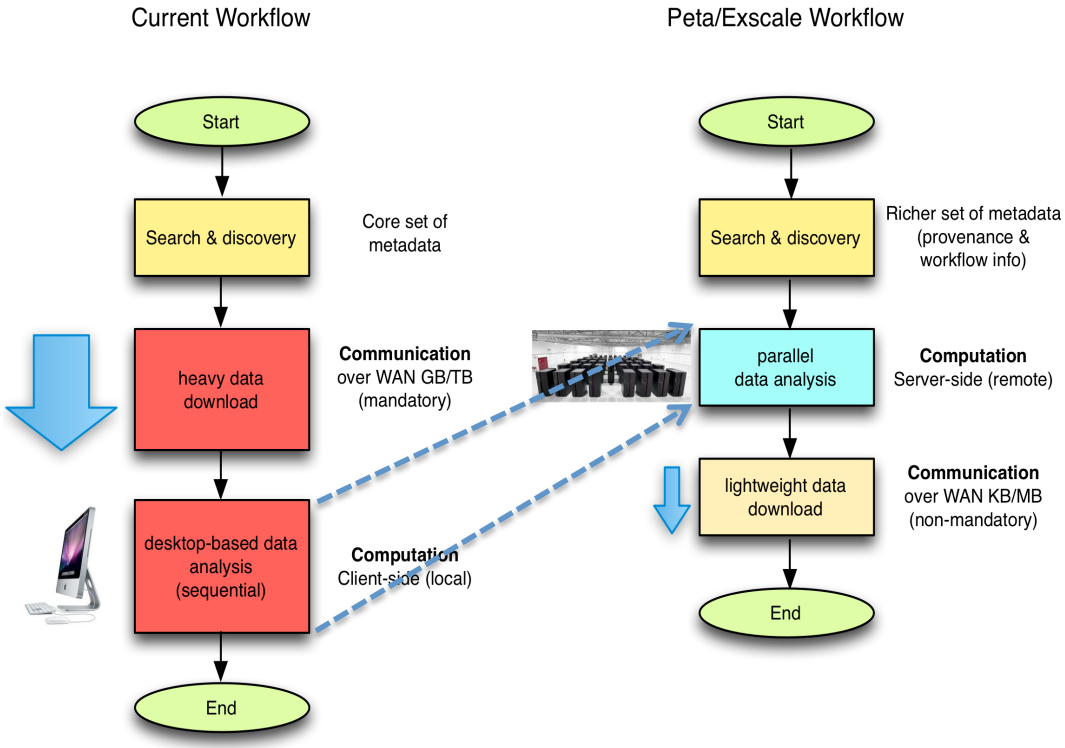
Volume, variety, velocity are key challenges for big data in general and for climate change science in particular. Client-side, sequential and disk-based workflows are three limiting factors for the current scientific data analysis





Earth System Grid Federation ESGF





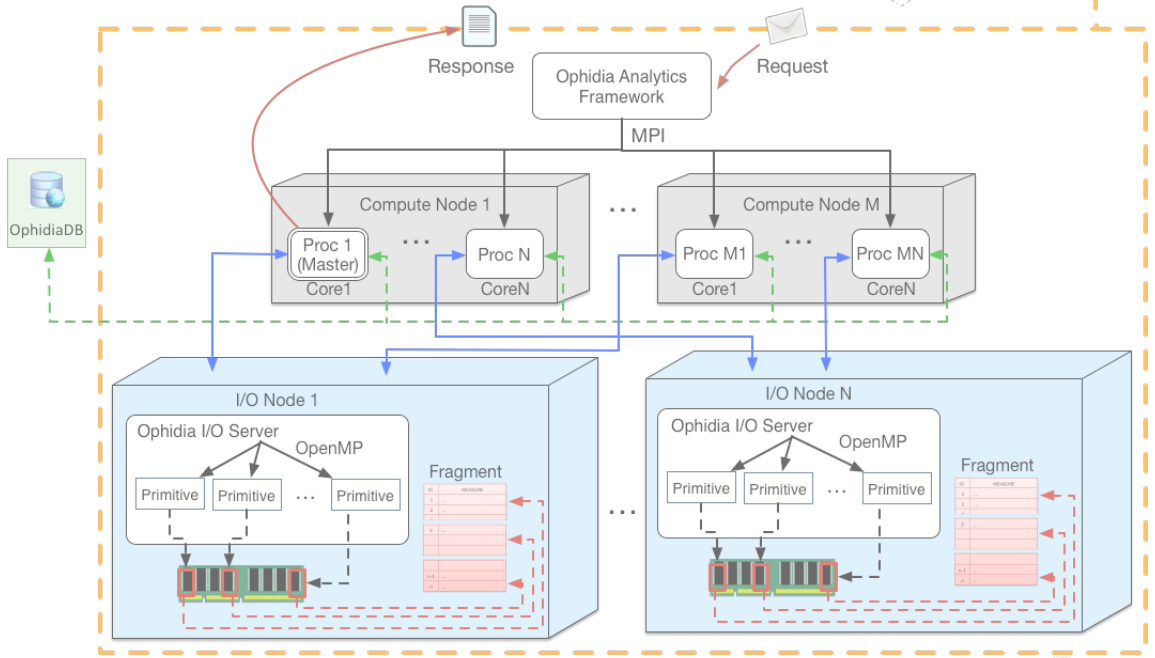
*S. Fiore, A. D'Anca, C. Palazzo, I. Foster, D. N. Williams, G. Aloisio, "**Ophidia: toward bigdata analytics for eScience**", ICCS2013 Conference, Procedia Elsevier, Barcelona, June 5-7, 2013*

Ophidia Architecture: end-user view

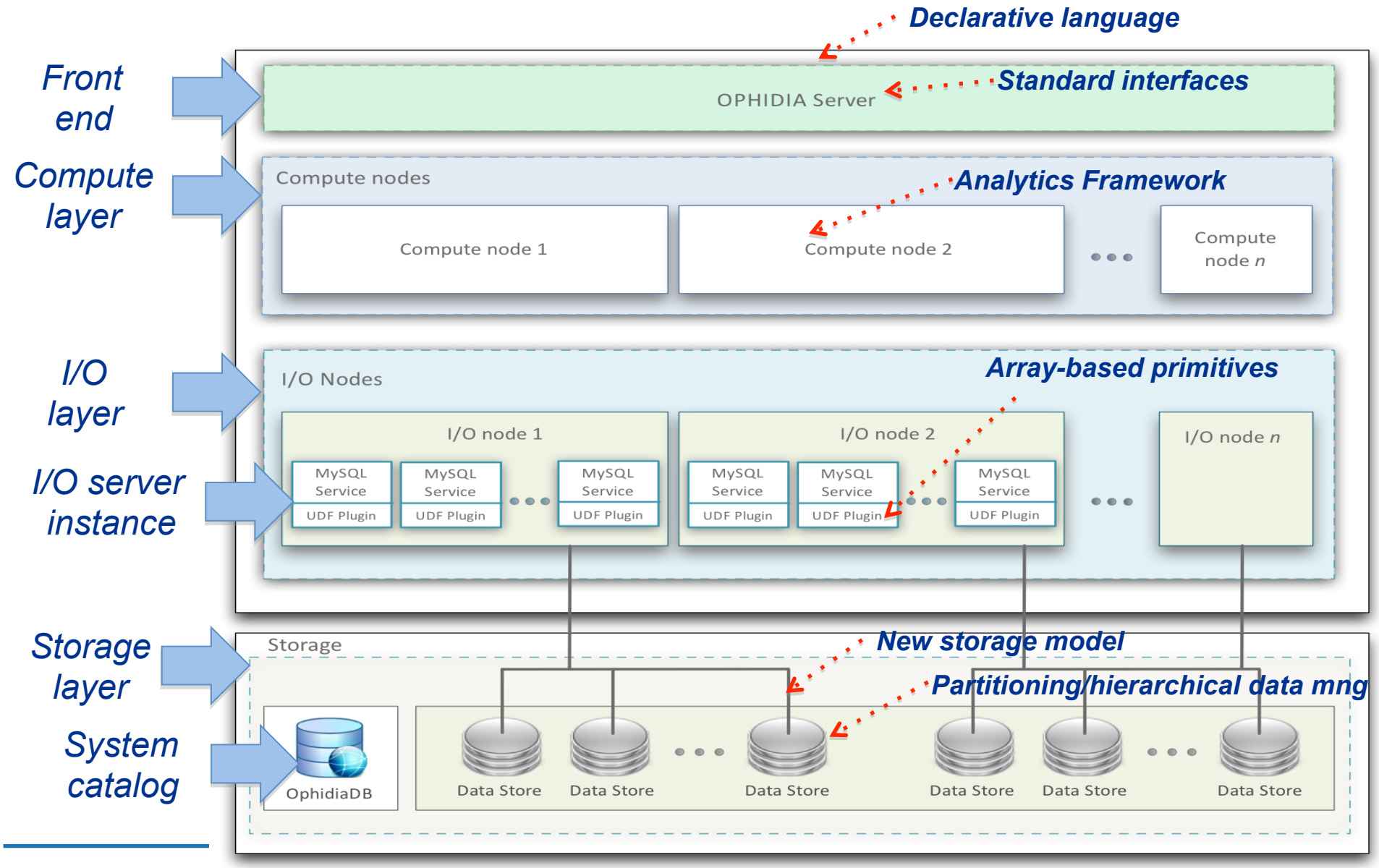
***Oph_Term**: a commands interpreter with no GUI (like bash), serving as a client for the Ophidia framework*

***Ophidia framework**: Server-side processing*

*Through the **oph_term** we "send" commands to the **framework***



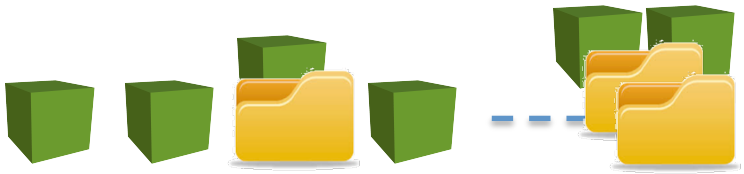
Ophidia Architecture (sw stack view)



Ophidia in a nutshell

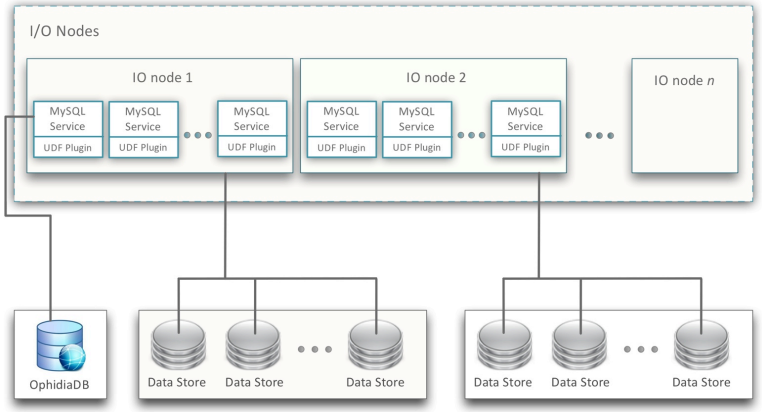
- ✔ *Big data stack for scientific data analysis*
- ✔ ***Features:*** *time series analysis (array-based analysis), data subsetting (by value/index), data aggregation, model intercomparison,* ***OLAP****, etc.*
- ✔ *Use of parallel operators and parallel I/O*
- ✔ ***Support for complex workflows / operational 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*

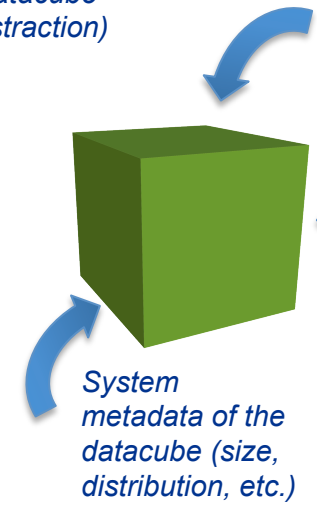
Data abstraction: cube space perspective (OLAP)



User perspective (datacube abstraction)

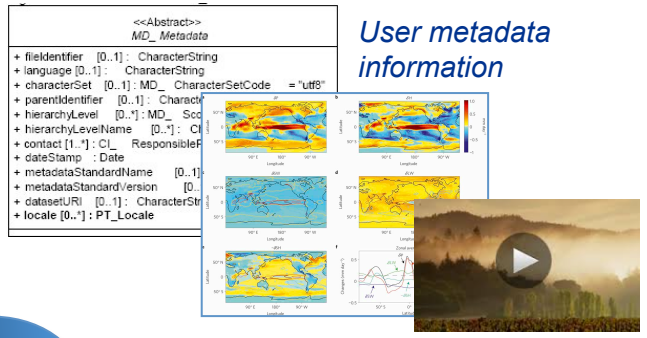
System perspective (internal storage representation)





System metadata of the datacube (size, distribution, etc.)

User metadata information



Metadata provenance

```
--> https://ophidia.cmcc.it:8443/162/169 (ROOT)
  ├─ https://ophidia.cmcc.it:8443/162/170 (oph_reduce)
  │    └─ https://ophidia.cmcc.it:8443/162/171 (oph_merge)
  │         ├─ https://ophidia.cmcc.it:8443/162/172 (oph_aggregate2)
  │         └─ https://ophidia.cmcc.it:8443/162/173 (oph_rollup)
  │              ├─ https://ophidia.cmcc.it:8443/162/174 (oph_reduce)
  │              └─ https://ophidia.cmcc.it:8443/162/175 (oph_reduce)
  ├─ https://ophidia.cmcc.it:8443/162/176 (oph_aggregate)
  └─ https://ophidia.cmcc.it:8443/162/177 (oph_aggregate)
```

Manage the Ophidia file system

CMD	BEHAVIOR
cd	change directory
mkdir	create a new folder
rm	remove an empty folder or hide (logically delete) a container
ls	list subfolders and containers in a folder
mv	move/rename a folder or a container
…	…

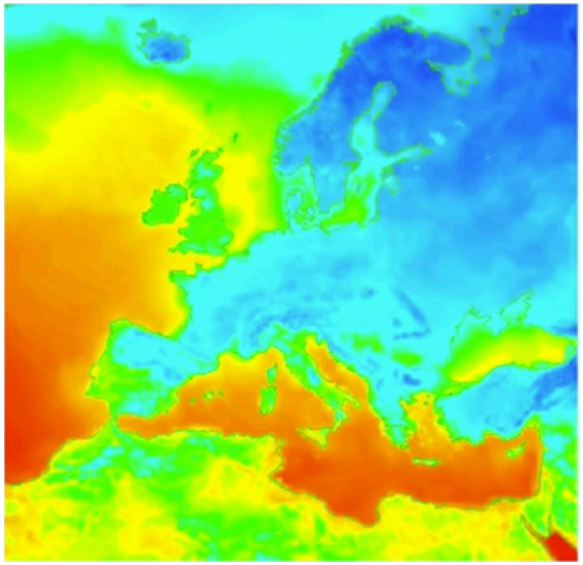
Metadata associated to the datacubes

TYPE	CONTENT
Text	Plain text metadata
image	Binary string representation of an image
video	Binary string representation of a video
audio	Binary string representation of an audio stream
url	Text representing an URL

Search & Discovery

Experiment: climate indicators processing

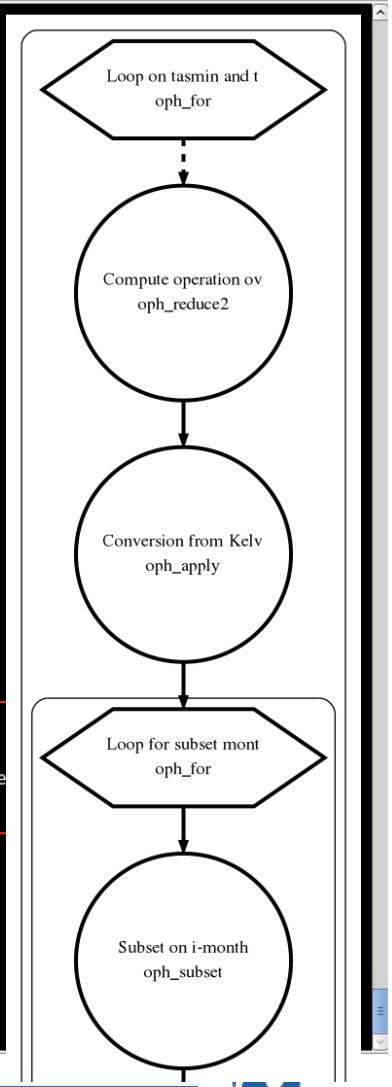
- ✔ *In the CLIPC project, processing chains for data analysis are being implemented with Ophidia to compute **climate indicators***
- ✔ ***First set of indicators** includes: TNn, **TNx**, TXn, **TXx***
  - ✔ *Input files: 12GBs (TasMin & TasMax)*
  - ✔ *Workflows have been already implemented*
- ✔ ***Parallel approach***
  - ✔ *Inter-parallelism & Intra-parallelism*



Workflow JSON representation

ophrpm@ophidiarpm:~/workflow

```
"tasks": [
    {
        "name": "Loop on tasmin and tasmax cubes",
        "operator": "oph_for",
        "arguments": [ "name=cube","counter=1:2", "values=${1}|${2}", "parallel=yes" ]
    },
        {
                "name": "Compute operation over time",
                "operator": "oph_reduce2",
                "arguments": [
                        "cube=@{cube}",
                        "dim=time",
                        "concept_level=M",
                        "midnight=00",
                        "operation=$3",
                        "container=tmp"
                ],
                "dependencies": [
                        { "task": "Loop on tasmin and tasmax cubes" }
                ]
        },
        {
                "name": "Conversion from Kelvin to Celsius degrees",
                "operator": "oph_apply",
                "arguments": [
                        "query=oph_sum_scalar('oph_float','oph_float',measure,-273.15)"
                ],
                "dependencies": [{
                        "task": "Compute operation over time",
                        "type": "single"
                }]
        },
        {
                "name": "Loop for subset months",
                "operator": "oph_for",
                "arguments": [ "name=index","counter=1:12", "values=Jan|Feb|Mar|Apr|May|Jun|Jul|Aug|Sep|Oct|N
                "dependencies": [ { "task":"Conversion from Kelvin to Celsius degrees", "type": "single" } ]
        },
                {
                        "name": "Subset on i-month",
                        "operator": "oph_subset",
                        "arguments": [
                                "subset_dims=time",
                                "subset_filter=&index:12:end"
                        ],
                        "dependencies": [
--More--(65%)
```



Workflow submission

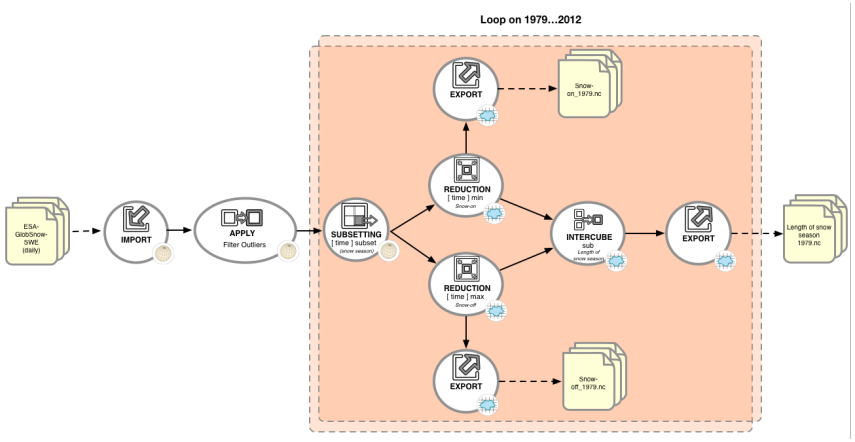
ophrpm@ophidiarpm:~/devel/oph-client/res | ophrpm@ophidiarpm:~/workflow

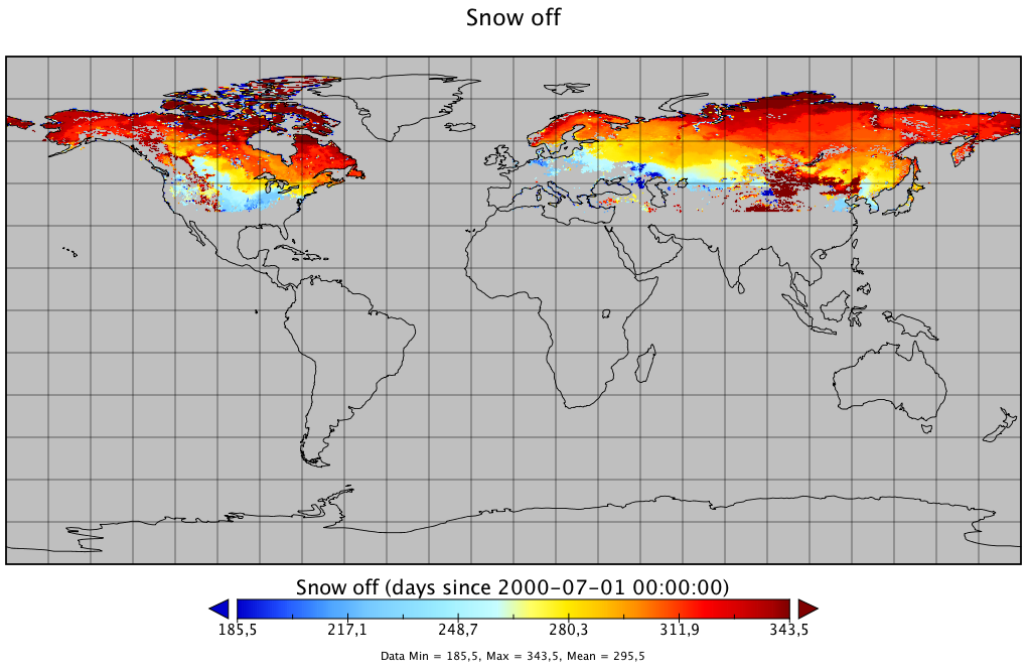
```
[37..6380] >>
[37..6380] >> ./Tind_loop.json http://193.204.199.174/ophidia/29/2046 http://193.204.199.174/ophidia/30/2047 max
[JobID]:
http://193.204.199.174/ophidia/sessions/376699238311302232511449455166146380/experiment?247#3144

[37..6380] >> view 247
[247] ./Tind_loop.json http://193.204.199.174/ophidia/29/2046 http://193.204.199.174/ophidia/30/2047 max [http://193.204.199.174/ophidia/sessions/376699238311302
232511449455166146380/experiment?247#3144]

[Response]:
Workflow Status
---------------

OPH_STATUS_COMPLETED

Workflow Progress
-----------------

+==========================+======================+
| NUMBER OF COMPLETED TASKS | TOTAL NUMBER OF TASKS |
+==========================+======================+
| 82                       | 82                   |
+==========================+======================+

Workflow Task List
------------------

+==========================================================+======================+========+=======+===========+============================+=====+=============+
| OPH JOB ID                                               | SESSION CODE         | WORKFL | MARKE | PARENT MA | TASK NAME                  | TYP | EXIT STATUS |
|                                                          |                      | OW ID  | R ID  | RKER ID   |                            | E   |             |
+==========================================================+======================+========+=======+===========+============================+=====+=============+
| http://193.204.199.174/ophidia/sessions/37669923831130   | 37669923831130223251 | 247    | 3145  | 3144      | Loop on tasmin and tasmax  | SIM | OPH_STATUS_ |
| 22325114494551661463 80/experiment?247#3145              | 1449455166146380     |        |       |           | cubes                      | PLE | COMPLETED   |
|----------------------------------------------------------|----------------------|--------|-------|-----------|----------------------------|-----|-------------|
| http://193.204.199.174/ophidia/sessions/37669923831130   | 37669923831130223251 | 247    | 3146  | 3144      | Compute operation over ti  | SIM | OPH_STATUS_ |
| 22325114494551661463 80/experiment?247#3146              | 1449455166146380     |        |       |           | me (1)                     | PLE | COMPLETED   |
|----------------------------------------------------------|----------------------|--------|-------|-----------|----------------------------|-----|-------------|
| http://193.204.199.174/ophidia/sessions/37669923831130   | 37669923831130223251 | 247    | 3147  | 3144      | Compute operation over ti  | SIM | OPH_STATUS_ |
| 22325114494551661463 80/experiment?247#3147              | 1449455166146380     |        |       |           | me (2)                     | PLE | COMPLETED   |
|----------------------------------------------------------|----------------------|--------|-------|-----------|----------------------------|-----|-------------|
| http://193.204.199.174/ophidia/sessions/37669923831130   | 37669923831130223251 | 247    | 3148  | 3144      | Conversion from Kelvin to  | SIM | OPH_STATUS_ |
| 22325114494551661463 80/experiment?247#3148              | 1449455166146380     |        |       |           | Celsius degrees (1)        | PLE | COMPLETED   |
|----------------------------------------------------------|----------------------|--------|-------|-----------|----------------------------|-----|-------------|
| http://193.204.199.174/ophidia/sessions/37669923831130   | 37669923831130223251 | 247    | 3149  | 3144      | Conversion from Kelvin to  | SIM | OPH_STATUS_ |
| 22325114494551661463 80/experiment?247#3149              | 1449455166146380     |        |       |           | Celsius degrees (2)        | PLE | COMPLETED   |
|----------------------------------------------------------|----------------------|--------|-------|-----------|----------------------------|-----|-------------|
```

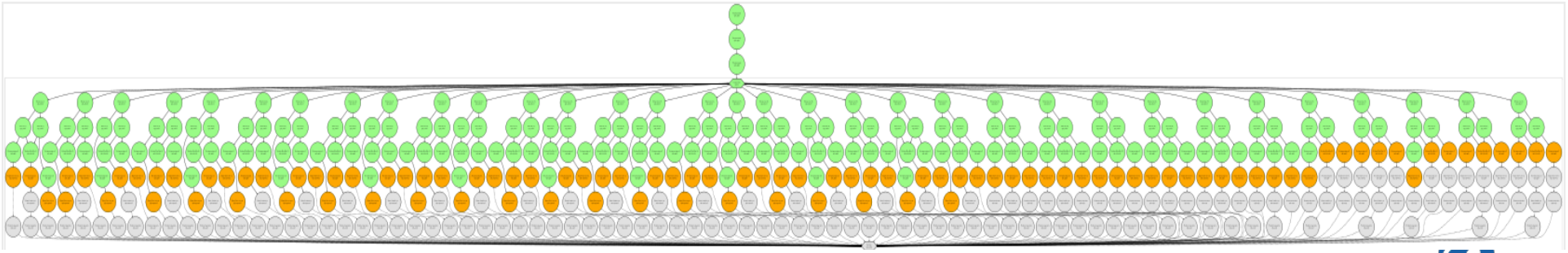
Tier1 indicators using Ophidia

Snow on/off – Length of snow season

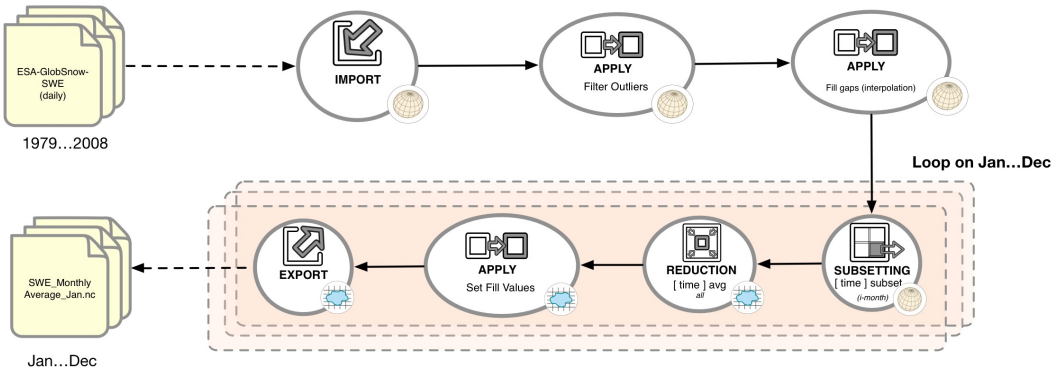
- ✔ *Dataset time range: 1979-2012*
- ✔ ***50 GB** of input data*
- ✔ ***434 tasks** performed*
- ✔ *99 NetCDF output files*





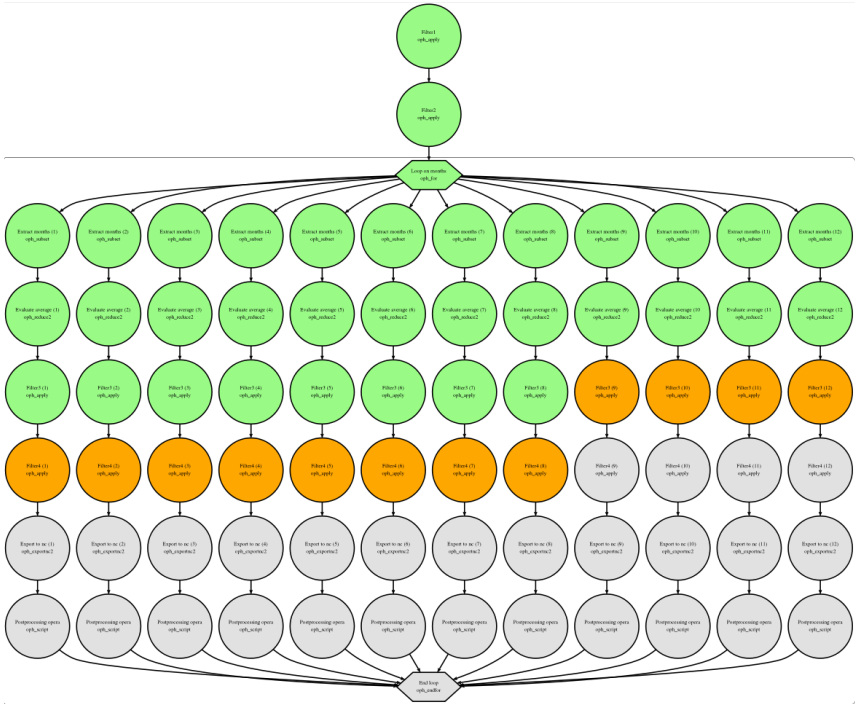


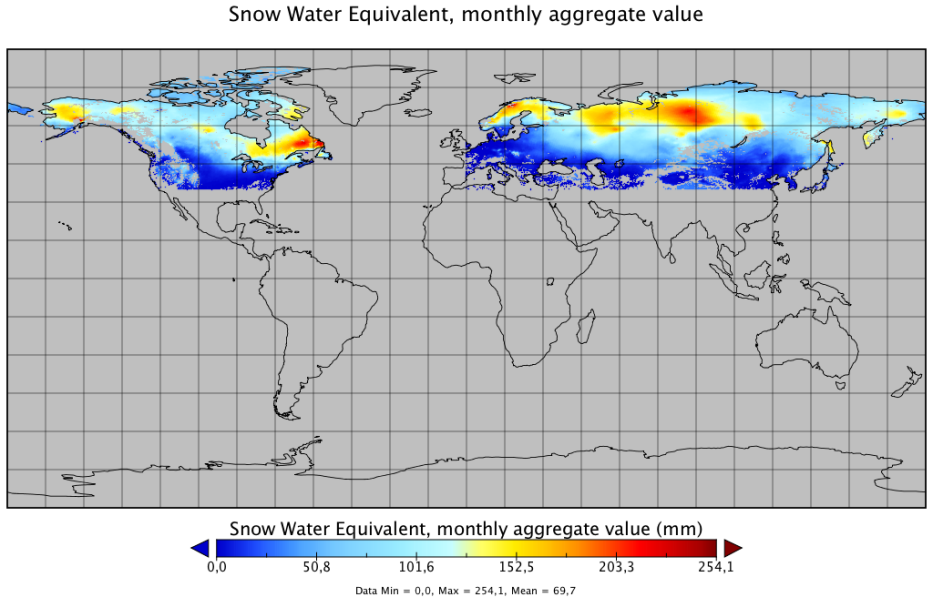
Tier1 indicators using Ophidia



SWE monthly average

- ✔ *Dataset time range: 1979-2008*
- ✔ ***1.7 GB** of input data*
- ✔ ***76 tasks** performed*
- ✔ *12 NetCDF output files*



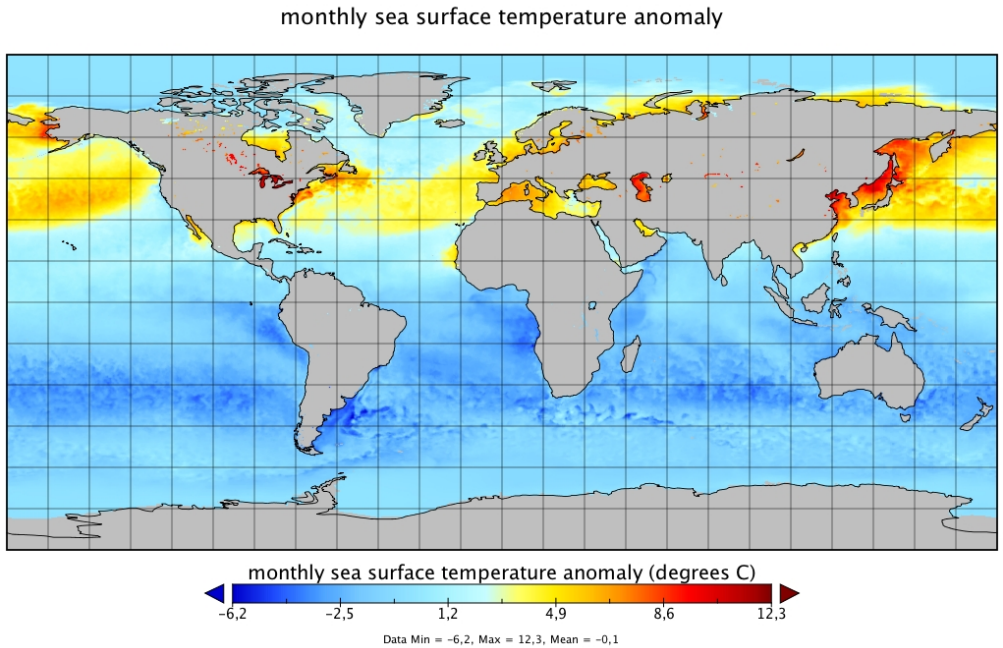


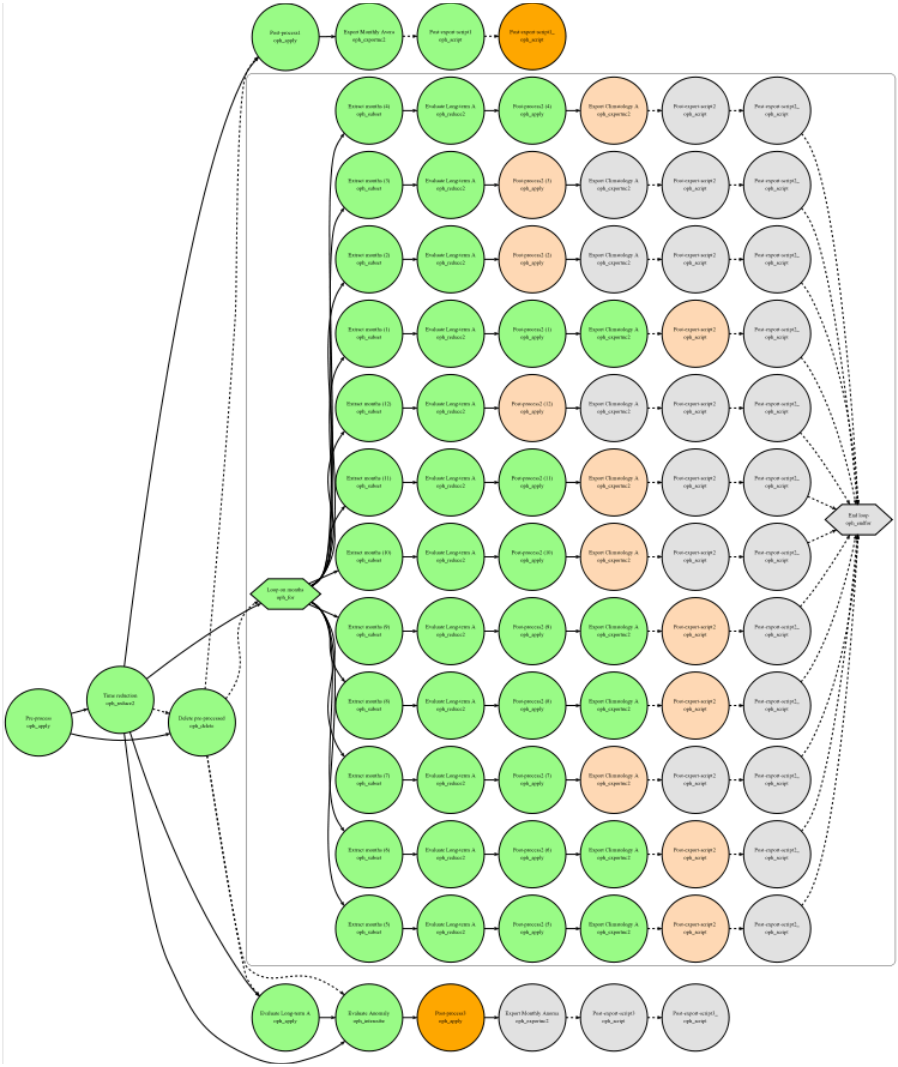
Tier1 indicators using Ophidia

Climate Information Portal

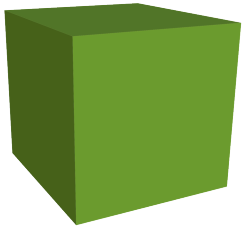
SST mean, anomaly, climatology mean

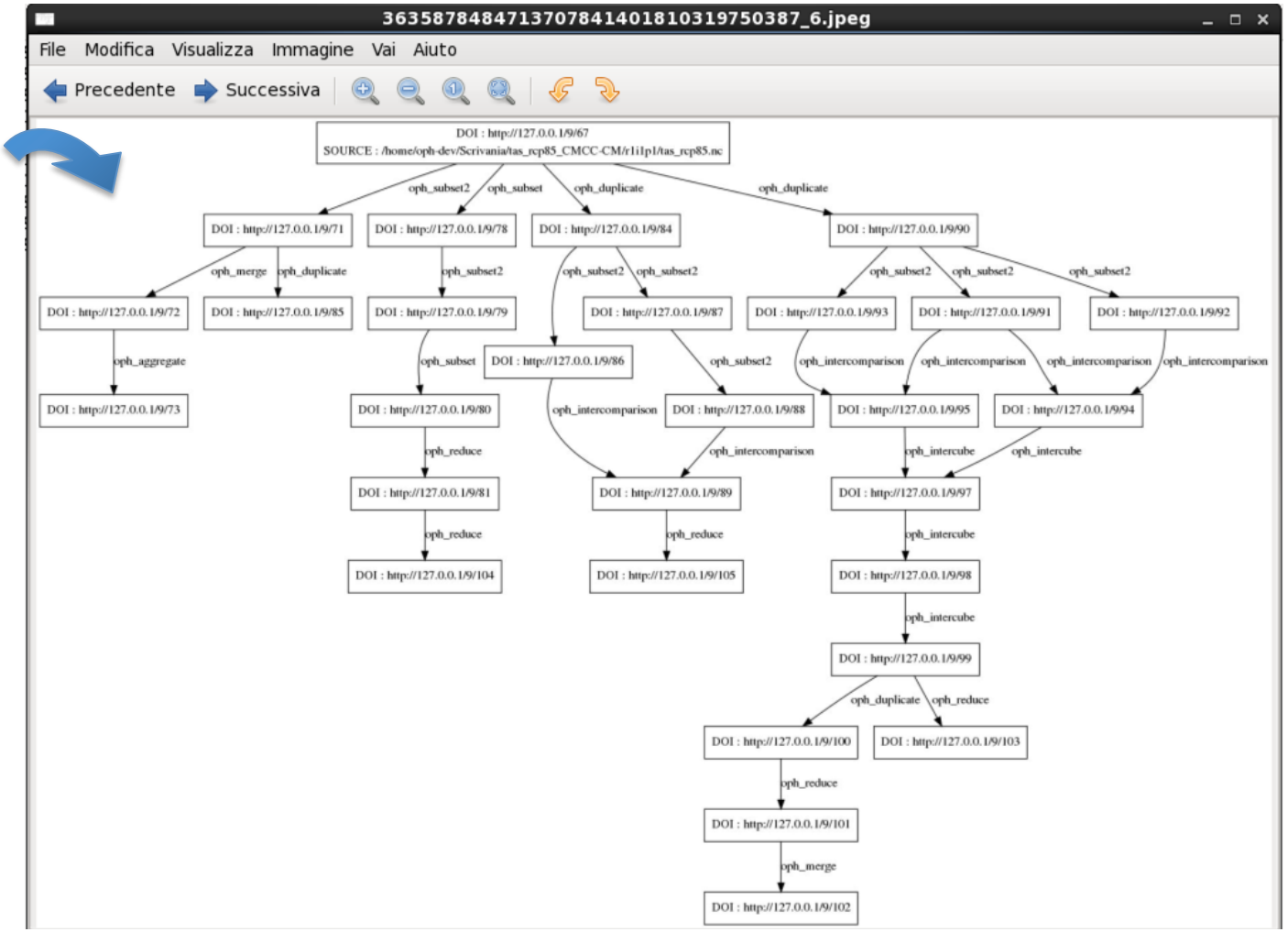
- ✔ *Dataset time range: 1991-2010*
- ✔ ***350GB** of input data*
- ✔ ***87 tasks** performed*
- ✔ *Expected 12x51MB + 2x12GB of output files*





Provenance management (PID-based)





RDA proposal submitted on extending Ophidia with **RDA PID recommendation** (collaboration with DKRZ)

RESEARCH DATA ALLIANCE

Ophidia & INDIGO-DataCloud

INDIGO - DataCloud

- **An H2020 project** approved in January 2015 in the EINFRA-1-2014 call
  - 11.1M€, 30 months (**from April 2015 to September 2017**)
- **Who**: **26 European partners** in 11 European countries
  - Coordination by the Italian National Institute for Nuclear Physics (INFN)
  - Including developers of distributed software, industrial partners, research institutes, universities, e-infrastructures
- **What**: **develop an open source Cloud platform** for computing and data ("DataCloud") tailored to science.
- **For**: **multi-disciplinary scientific communities**
  - E.g. structural biology, earth science, physics, bioinformatics, cultural heritage, astrophysics, life science, climatology
- **Where**: deployable on **hybrid (public or private) Cloud infrastructures**
  - INDIGO = **IN**tegrating **D**istributed data **I**nfrastructures for **G**lobal Expl**O**itation
- **Why**: answer to the technological **needs of scientists** seeking to easily exploit distributed Cloud/Grid compute and data resources.

Testbed environment for running multi-model experiments (precipation trend analysis)

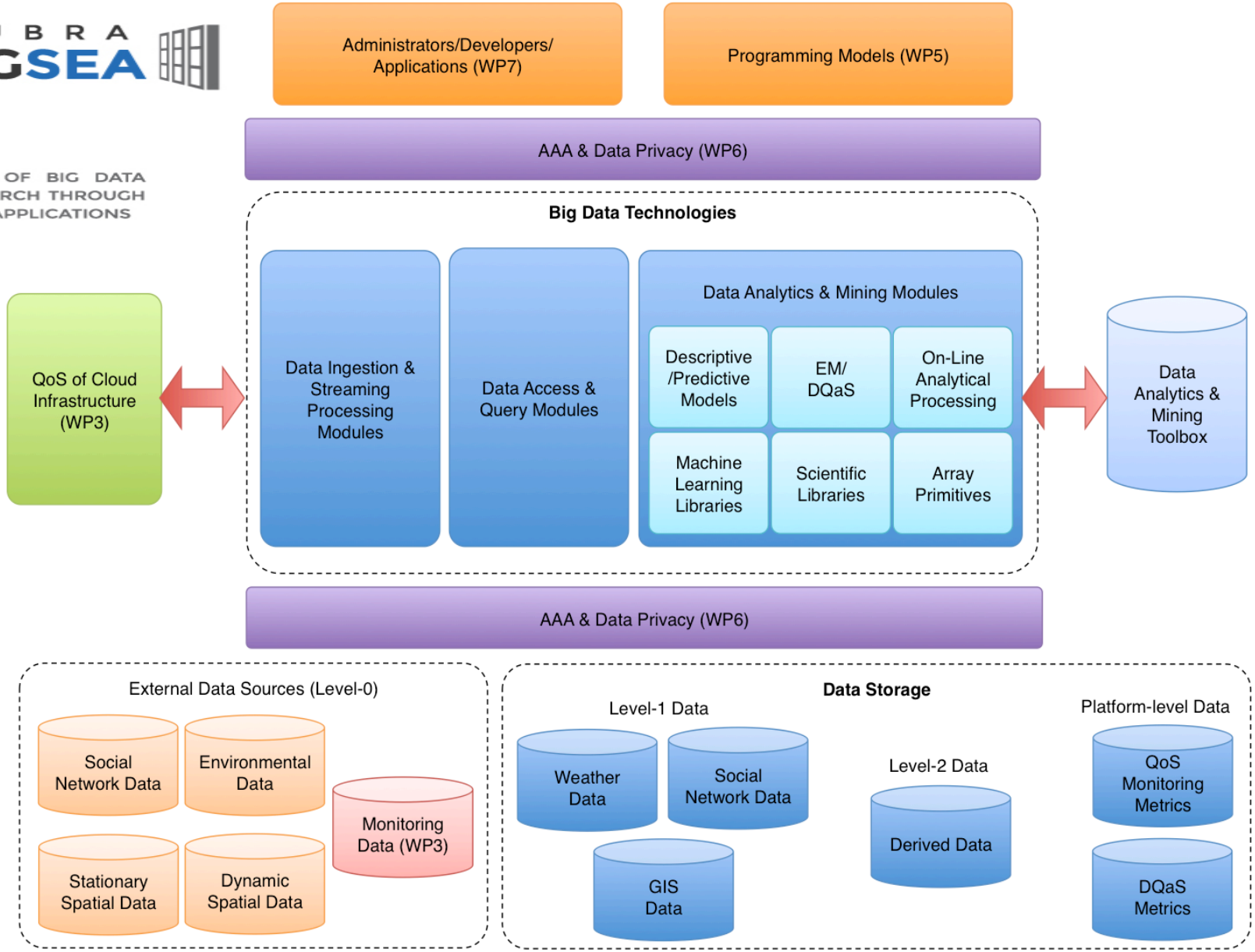
INDIGO - DataCloud

More on this topic in the afternoon talk at 5.30pm

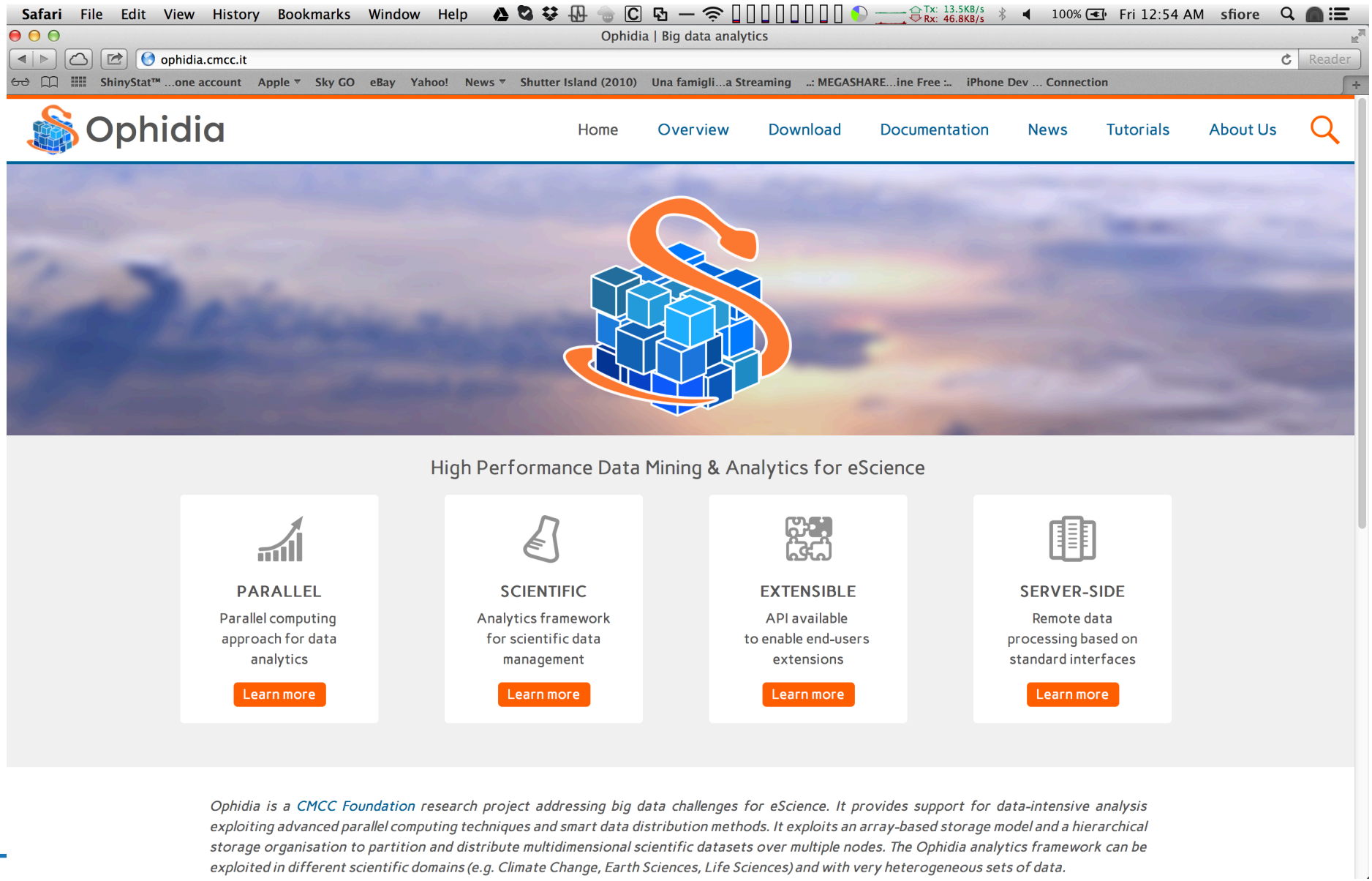
BIGSEA: cloud and QoS based vertical and horizontal elasticity for big data systems

EUBRA BIGSEA

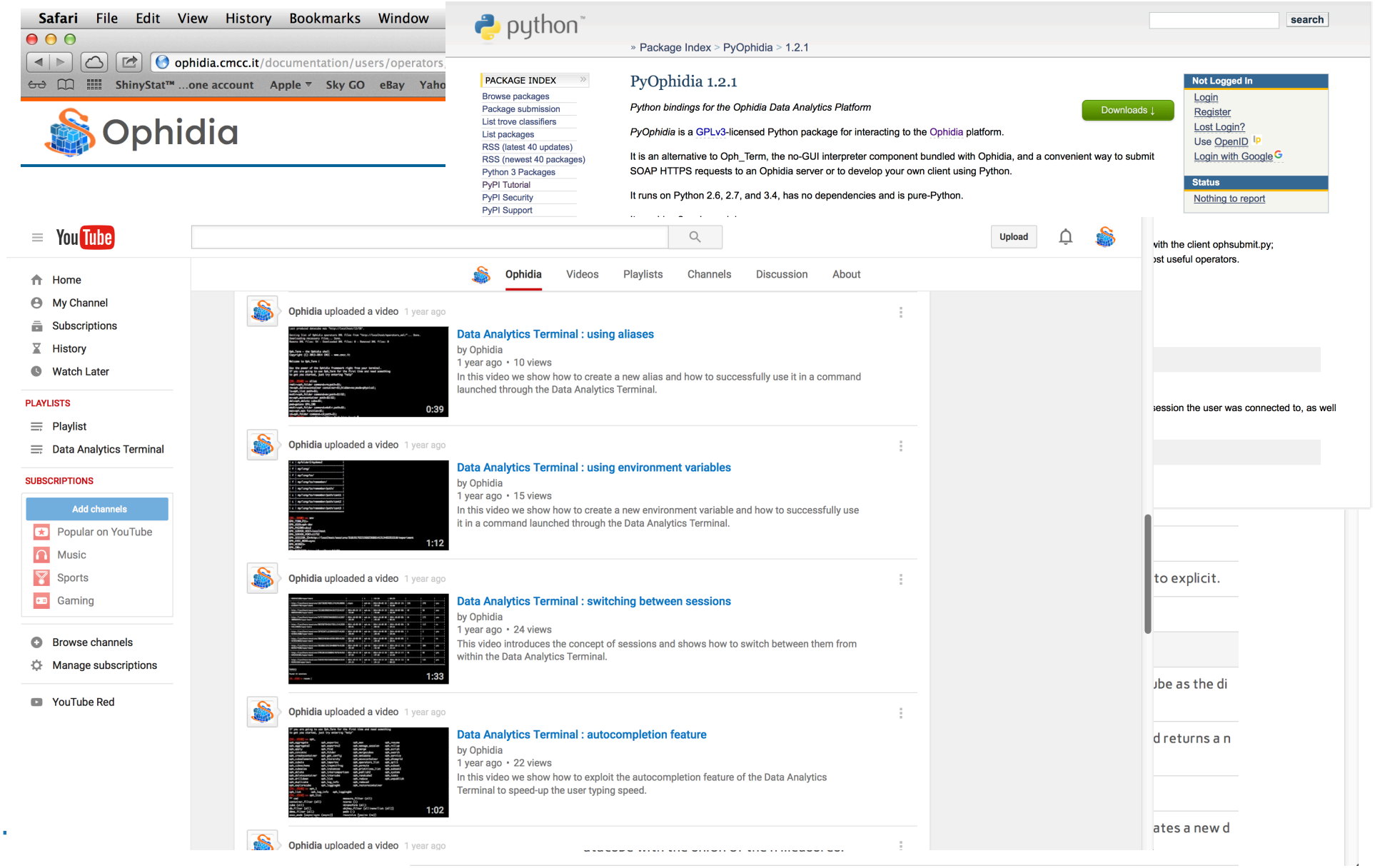
EUROPE - BRAZIL COLLABORATION OF BIG DATA SCIENTIFIC RESEARCH THROUGH CLOUD-CENTRIC APPLICATIONS



Resources (http://ophidia.cmcc.it)



Resources (II)



Thanks

http://ophidia.cmcc.it

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www.youtube.com/user/OphidiaBigData