High Perfomance Data Analytics in eScience

Lab Tutorial

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On behalf of the ECAS Team

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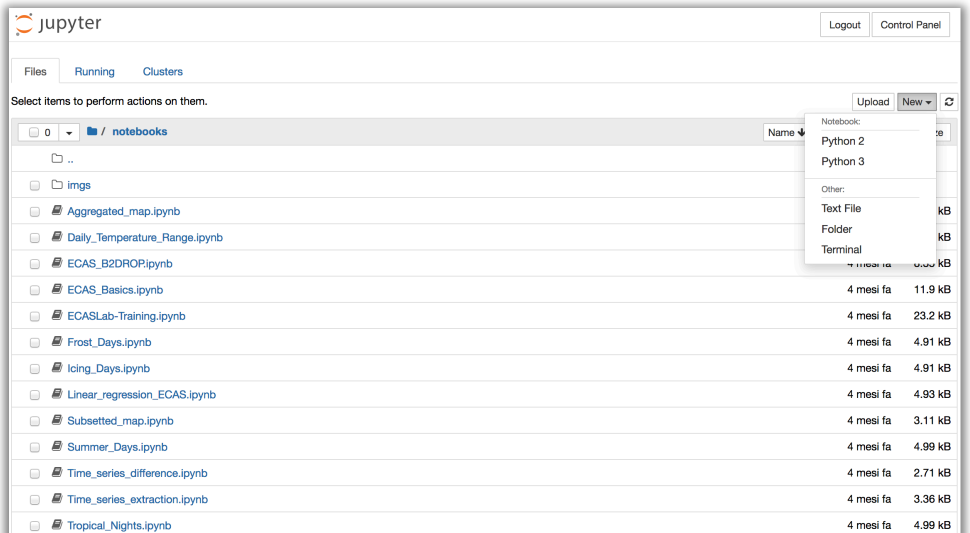
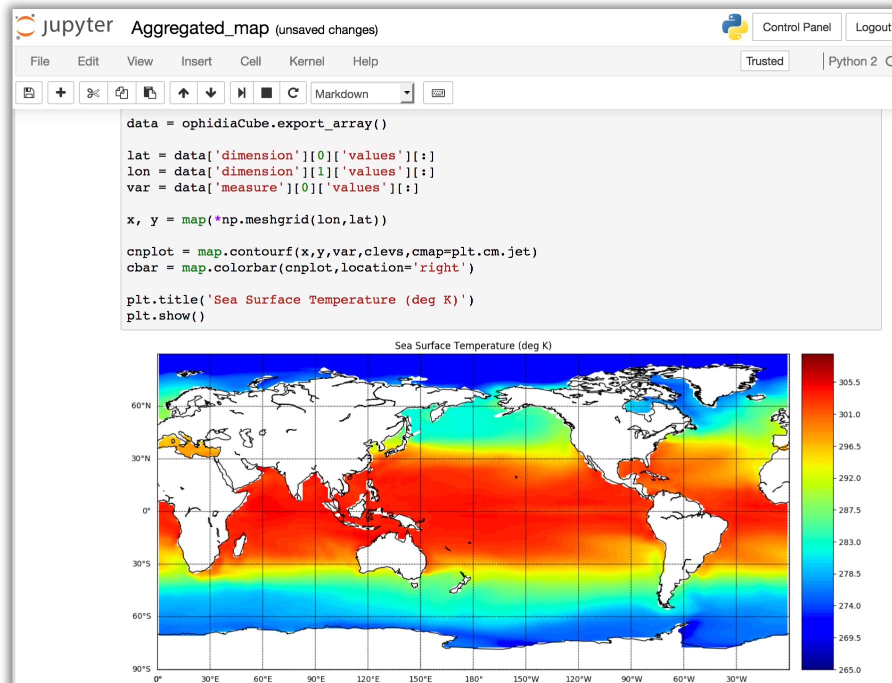
Session outline

- ✔ ***Brief introduction to Jupyter Notebook***
- ✔ ***PyOphidia modules and interface***
- ✔ ***VMI environment for the Virtual Lab***
- ✔ ***Overview of ECASLab @ CMCC***
- ✔ ***PyOphidia notebook demo***

Jupyter Notebook

*“The **Jupyter** Notebook is an open-source web application that allows you to create and share documents that contain live code, equations, visualizations and narrative text. Uses include: data cleaning and transformation, numerical simulation, statistical modeling, data visualization, machine learning, and much more.”* [1]





[1]Jupyter Website: https://jupyter.org/

The PyOphidia library

PyOphidia is a GPLv3-licensed Python module to interact with the Ophidia framework and it implements two main classes:

- **Client class**: supports the submissions of Ophidia commands and workflows, as well as the management of session from Python code (similar to the Ophidia Terminal)
  - It allows to run all the Ophidia operators, including massive tasks and workflows
- **Cube class**: provides the datacube type abstraction and the methods to manipulate, process and get information on cubes objects and it builds on the client class
  - Defines a object-oriented approach allowing to handle a datacube more naturally

While the cube module provides a user-friendly interface, the client module allows a finer specification of the operators.

The PyOphidia library: cube class

PyOphidia Cube class introduces the concept of **cube objects** and supports all the Ophidia operators as **methods.**

To this end, the class defines two types of methods according to the type of operator:

- **Class methods**: concerning the operators which do not refer to a particular cube object (e.g. the oph_list, the operators to manage the file system, etc.)

```
cube.Cube.list(level=2)
```

- **Instance methods**: concern the operators applied directly on a cube object to access and manipulate it (by creating a new cube object)

```
mycube.info()

mycube2 = mycube.reduce(operation='max',ncores=5)
```

The PyOphidia library: cube class

Example of **cube class** usage:

- Load the module and setup a connection to the server instance (similar to client class)

```
from PyOphidia import cube

cube.Cube.setclient(username="oph-user", password="oph-passwd",
                    server="127.0.0.1", port="11732")
```

- The arguments can be automatically inferred by the environment, if setup in the *.bashrc*

```
cube.Cube.setclient(read_env=True)
```

- Once the connection has been setup all the operators can be executed remotely through the related method

```
cube.Cube.list(level=2)
```

The PyOphidia library: cube class

Example of **cube class** usage:

- A cube object can be created in multiple ways. In case of pre-existing cube (pid):

```
mycube = cube.Cube(pid='http://127.0.0.1/ophidia/1/1')
```

- A cube can be also created from a NetCDF file using the constructor function:

```
mycube = cube.Cube(exp_dim='lat|lon',imp_dim='time',ncores=2
          measure='tos',src_path='/path/tos.nc')
```

- or directly using the import method (exactly the same as the previous one):

```
mycube = cube.Cube.importnc(exp_dim='lat|lon',imp_dim='time',ncores=2
                            measure='tos',src_path='/path/tos.nc')
```

- After the processing, the cube can be deleted with the proper method:

```
mycube.delete()
```

The PyOphidia library: cube class

Example of **cube class** usage:

- Once a cube is available in the python code, various operators can be executed to produce new datacubes:

```
mycube2 = mycube.reduce(operation='max',ncores=5)

mycube3 = mycube2.subset2(subset_dims="lat|lon|time", ncores=5,
                          subset_filter="-80:30|30:120|151:240")

mycube4 = mycube3.aggregate(operation='max',ncores=5)
```

- Methods can also be concatenated into a single command:

```
mycube5 = mycube.reduce(operation='max',ncores=5).subset2(
                 subset_dims="lat|lon|time", ncores=5,
                 subset_filter="-80:30|30:120|151:240").aggregate(
                                 operation='max',ncores=5)
```

The PyOphidia library: client class

The client class allows to run the same commands of the cube class with a lower-level interface and supports the execution of massive operators (param. sweep)

- Commands follow the same structure as for the Oph_term (`oph_operator param1=val1;`)

```
from PyOphidia import client
ophclient = client.Client(read_env=True)

ophclient.submit("oph_list level=1", display=True)
```

- Multiple files can be loaded in parallel by specifying a filter on the inputs

```
ophclient.submit("oph_importnc exp_dim=lat|lon;imp_dim=time;ncores=2;
measure=tos;src_path=[path=/path/*.nc]")
```

- The same operator can be run in parallel on multiple input cubes

```
ophclient.submit("oph_reduce2 operation=avg;dim=time;cube=[*]")
```

Ophidia massive operators documentation: http://ophidia.cmcc.it/documentation/users/massive/index.html

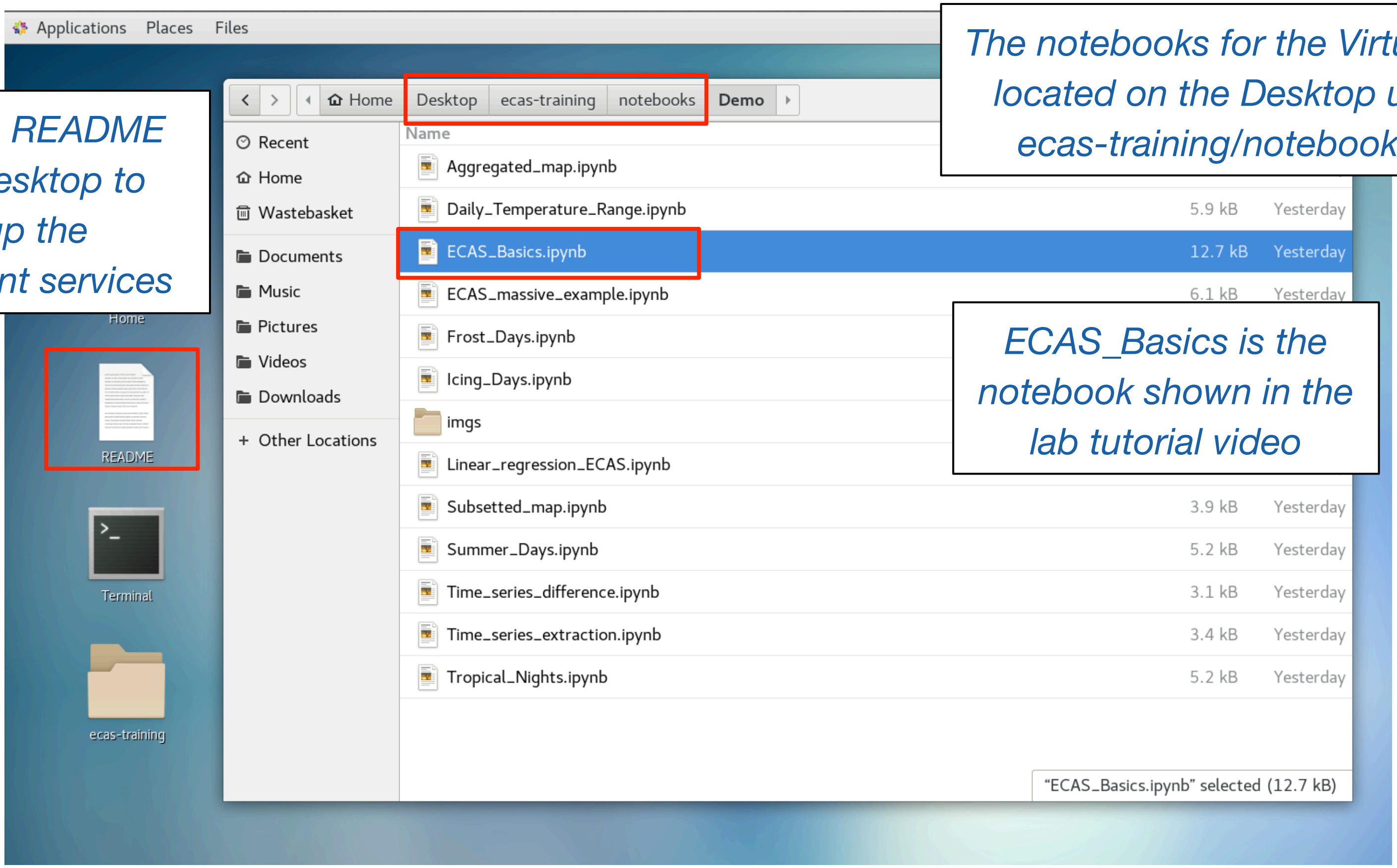
Virtual Lab environment

The pre-installed VMI with the full Ophidia stack and other dependencies for the Virtual Lab is available at: https://download.ophidia.cmcc.it/vmi_desktop/training/OphidiaVMI.ova

*Login and password are both **ophidia**. For additional information refer to the summer school virtual lab instructions.*

Check the README on the Desktop to startup the environment services

The notebooks for the Virtual Lab are located on the Desktop under the ecas-training/notebooks folder



ECAS_Basics is the notebook shown in the lab tutorial video

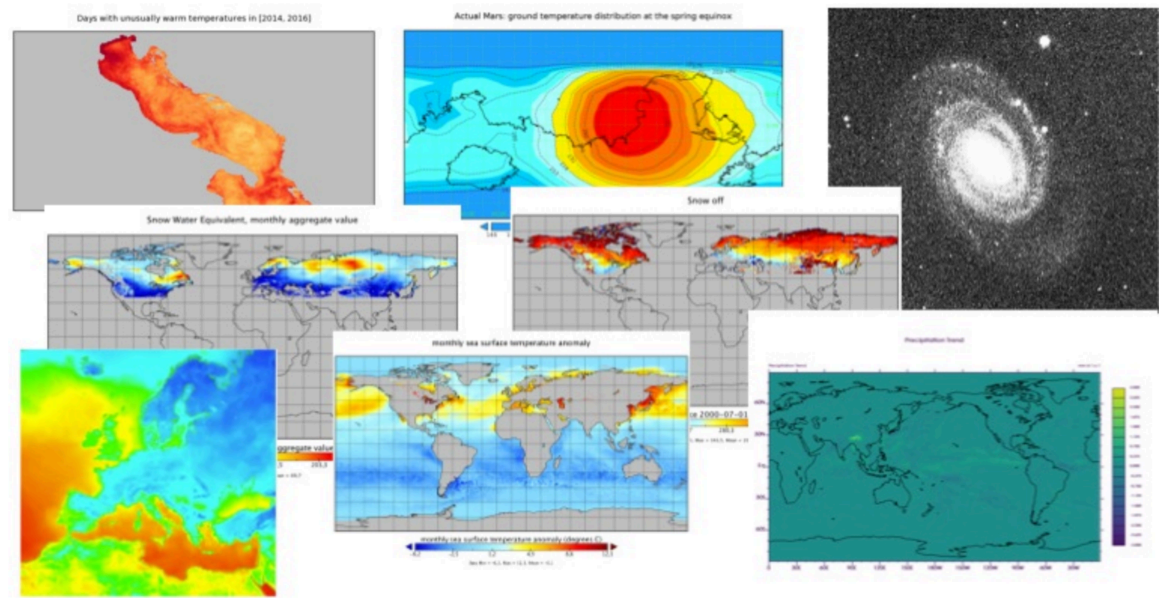
ECASLab @ CMCC

Home TNA Calls Register Login

ECASLab is a scientific data analytics environment built on top of ECAS (the ENES Climate Analytics Service), one of the thematic services included in the EOSC-hub service portfolio.

It provides a scientific environment exploiting a server-side approach and integrating both data and analysis tools to support data scientists in their daily research activities.

ECASLab starts from a previous effort (OphidiaLab, developed at CMCC Foundation) with the main aim of providing a virtualized research environment for researchers. It represents the entry point for users that want to test, train, exploit the ECAS Thematic Service.



A few examples of output related to different analytics experiments implemented in the ECASLab environment.

It consists of several components like an ECAS cluster, a JupyterHub instance jointly with a large set of pre-installed Python libraries for running data manipulation, analysis, and visualization, a data publication service and a tool for the infrastructure monitoring (mainly intended for the administrators).

In order to get started with ECASLab please have a look at the Quick Start section and register here to get an account.

https://ecaslab.cmcc.it/

ECASLab Registration form @CMCC

ecas cmcc

Home TNA Calls Register Login

ECASLab Registration Form

Sign Up!

First Name *

Last Name *

E-mail *

Affiliation *

Country *

IS-ENES3

Training

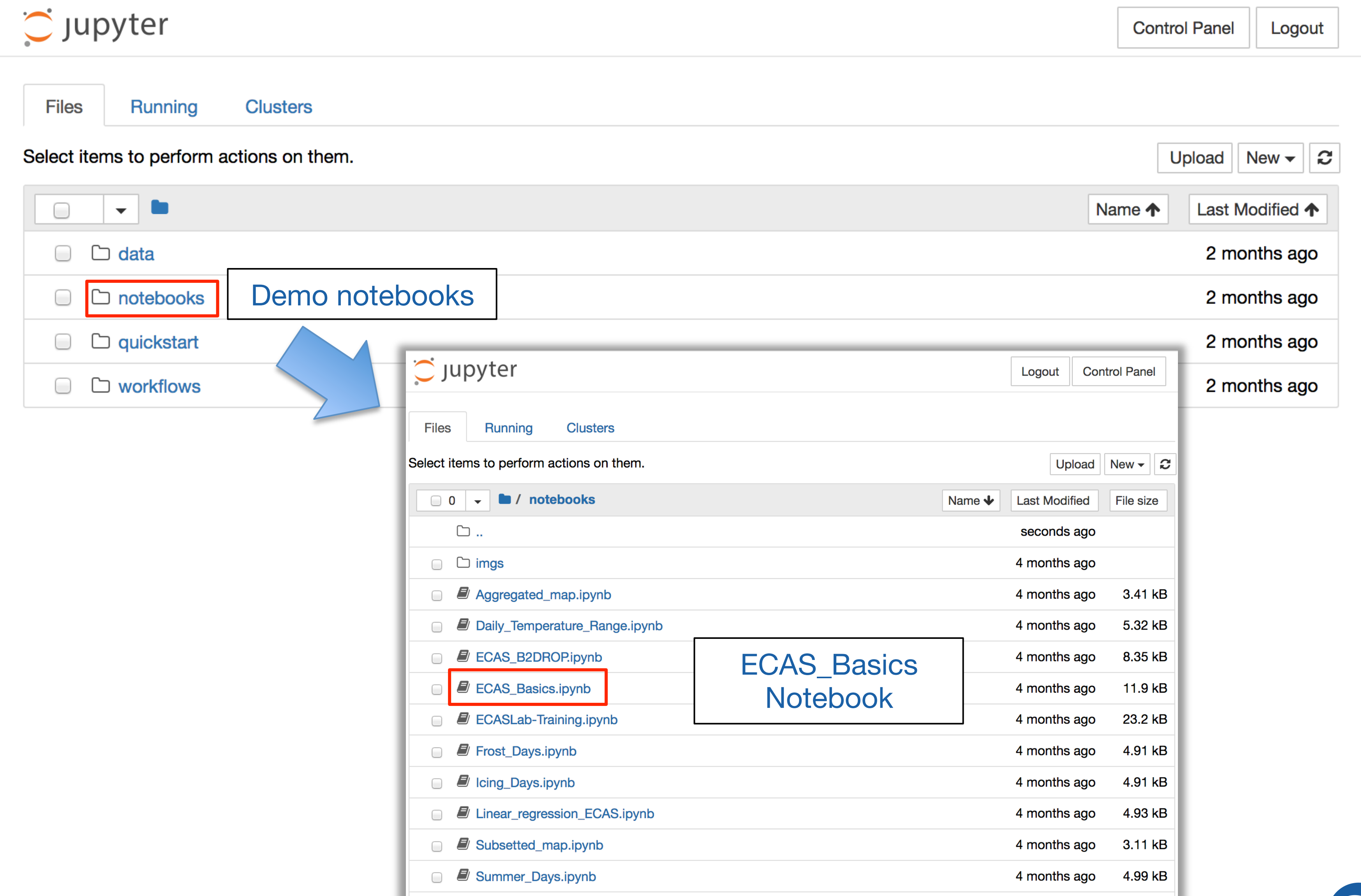
Captcha *

Select IS-ENES3 as project

Specify motivation for requesting access. You can simply type "Training"

https://ecaslab.cmcc.it/web/registration.php

ECASLab JupyterHub service



PyOphidia notebook demo: *ECAS_Basics*

jupyter ECAS_Basics (read only)

Logout Control Panel

File Edit View Insert Cell Kernel Widgets Help Trusted Python 3

Run Markdown

Demo: ECAS/Ophidia simple commands examples

First of all import PyOphidia modules and connect to server (connection details are inferred from the ECAS environment)

In [ ]:
```
from PyOphidia import cube, client
cube.Cube.setclient(read_env=True)
```

Create a datacube from the NetCDF file:

- The file is **data/ecas_training/tasmax_day_CMCC-CESM_rcp85_r1i1p1_20960101-21001231.nc**
- The variable to be imported is **tasmax**
- Data should be arranged in order to operate on time series (**time** dimension)

Note: We are not directly reading the file from the Notebook

In [ ]:
```
mycube = cube.Cube.importnc(
                src_path='data/ecas_training/tasmax_day_CMCC-CESM_rcp85_r1i1p1_20960101-2100123
                measure='tos',
                imp_dim='time',
                ioserver='ophidiaio_memory',
                ncores=2,
                description="Imported cube"
        )
```

Check the datacubes available in the virtual file system

In [ ]:
```
cube.Cube.list(level=2)
```

Links and references

Virtual Lab

- Ophidia Virtual Machine Image: https://download.ophidia.cmcc.it/vmi_desktop/training/OphidiaVMI.ova
- Updated training material: https://github.com/ECAS-Lab/ecas-training/tree/ESiWACE2_SummerSchool_2020

Ophidia

- Ophidia Website: http://ophidia.cmcc.it
- Ophidia Doc: http://ophidia.cmcc.it/documentation

ECASLab

- CMCC ECASLab instance: https://ecaslab.cmcc.it/
- ECASLab registration form @ CMCC: https://ecaslab.cmcc.it/web/registration.php

PyOphidia

- PyOphidia Doc: http://ophidia.cmcc.it/documentation/users/pyophidia/
- PyOphidia repository: https://github.com/OphidiaBigData/PyOphidia

Other software/Python modules used in the examples

- Jupyter Project Doc: https://jupyter.readthedocs.io/en/latest/
- Cartopy Doc: https://scitools.org.uk/cartopy/docs/latest/
- Matplotlib User's Guides: https://matplotlib.org/users/index.html

Thank you!

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esiwace
CENTRE OF EXCELLENCE IN SIMULATION OF WEATHER AND CLIMATE IN EUROPE

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EOSC-hub

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

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Contact us at: ecas-support@cmcc.it

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