

Tools and technologies for NEMO models: the case of the Generic Interfaces developed in the framework of IMMERSE

Laura Stefanizzi, Stefania A. Ciliberti, Giovanni Coppini



INTRODUCTION

- Within IMMERSE H2020, we contributed on the development on interfaces for the design and implementation of a *seamless interface* for CMEMS users to access and use model & observations products
- This is part of the WP7,T7.3 coordinated by CMCC in collaboration with NOC
- The main objective of this study is to present a numerical prototype that helps to connect CMEMS and Coastal Community, combining NEMO-based tools and custom CMEMS-oriented processing tools for interfacing coastal models with CMEMS (to be possibly used through DIAS)



- IMMERSE Interfaces will be the result of the integration of state-of-the-art procedures and novel ones for building new advanced numerical models based on NEMO



Consolidated Scientific Knowledge:

PyNEMO



National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL



and *Operational Procedures*

...Plus...:

Feedbacks from Experts and Intermediate Users

Preparing interface with
CMEMS Model/Obs
products & with Coastal
Models



Connecting to DIAS for
accessing/online
processing operational
data

Generic Interface



PROTOTYPE TOOLBOX FOR SEAMLESS UPTAKE OF CMEMS PRODUCT IN DOWNSTREAM MONITORING SYSTEM



Copernicus
Marine Service



Model Products

Observations



TOOLBOX

NEMO-based tools



CMEMS-based
processing tools

Webinar on Users
Requirements

Data-driven

Conceptual models

Estuarine and coastal-to-open ocean
unstructured models

Coastal area representation
(HR datasets)

Downstream
Services

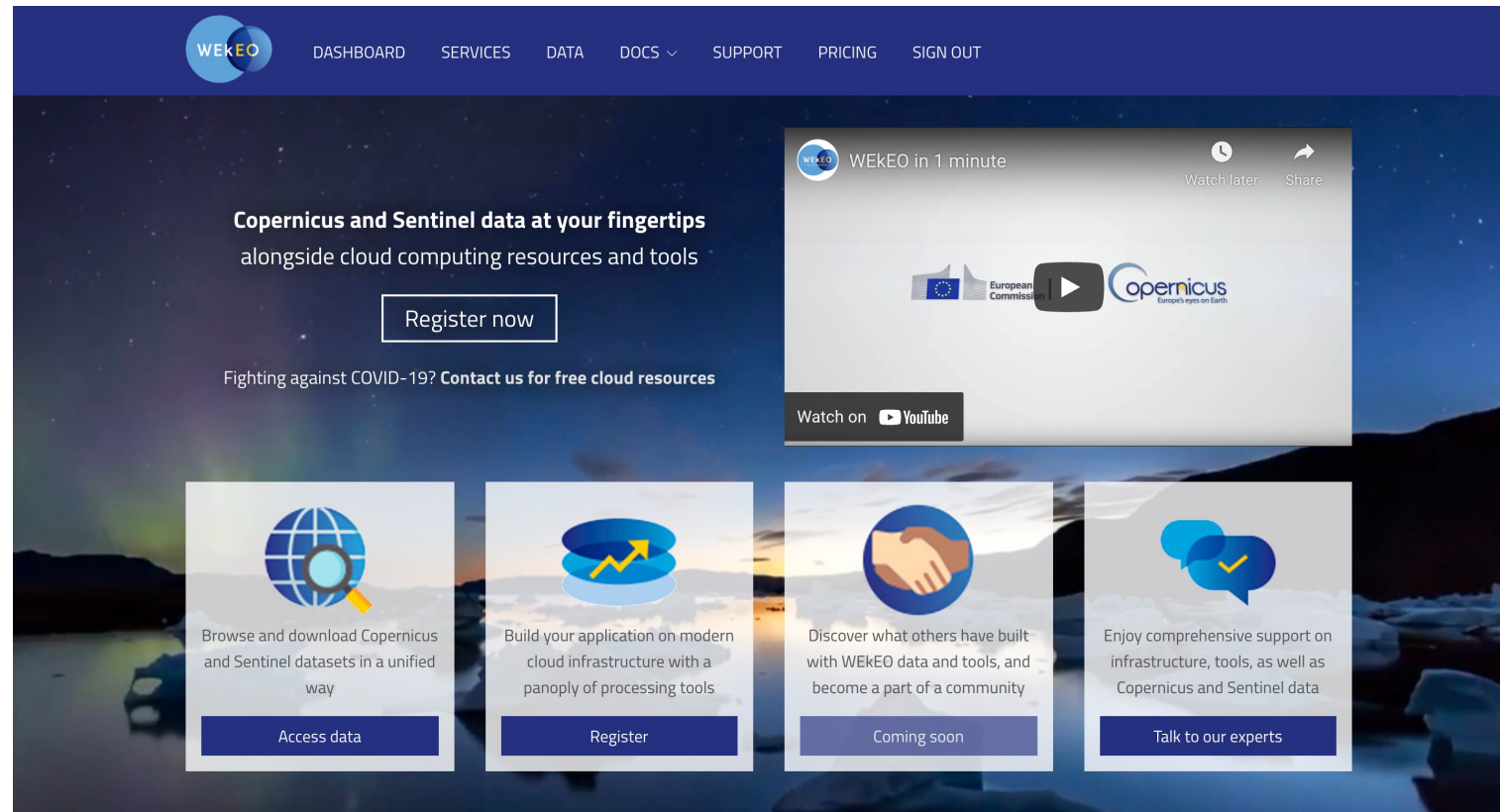
Coastal Models



DIAS
(Wekeo)



WEKEO FOR IMMERSE

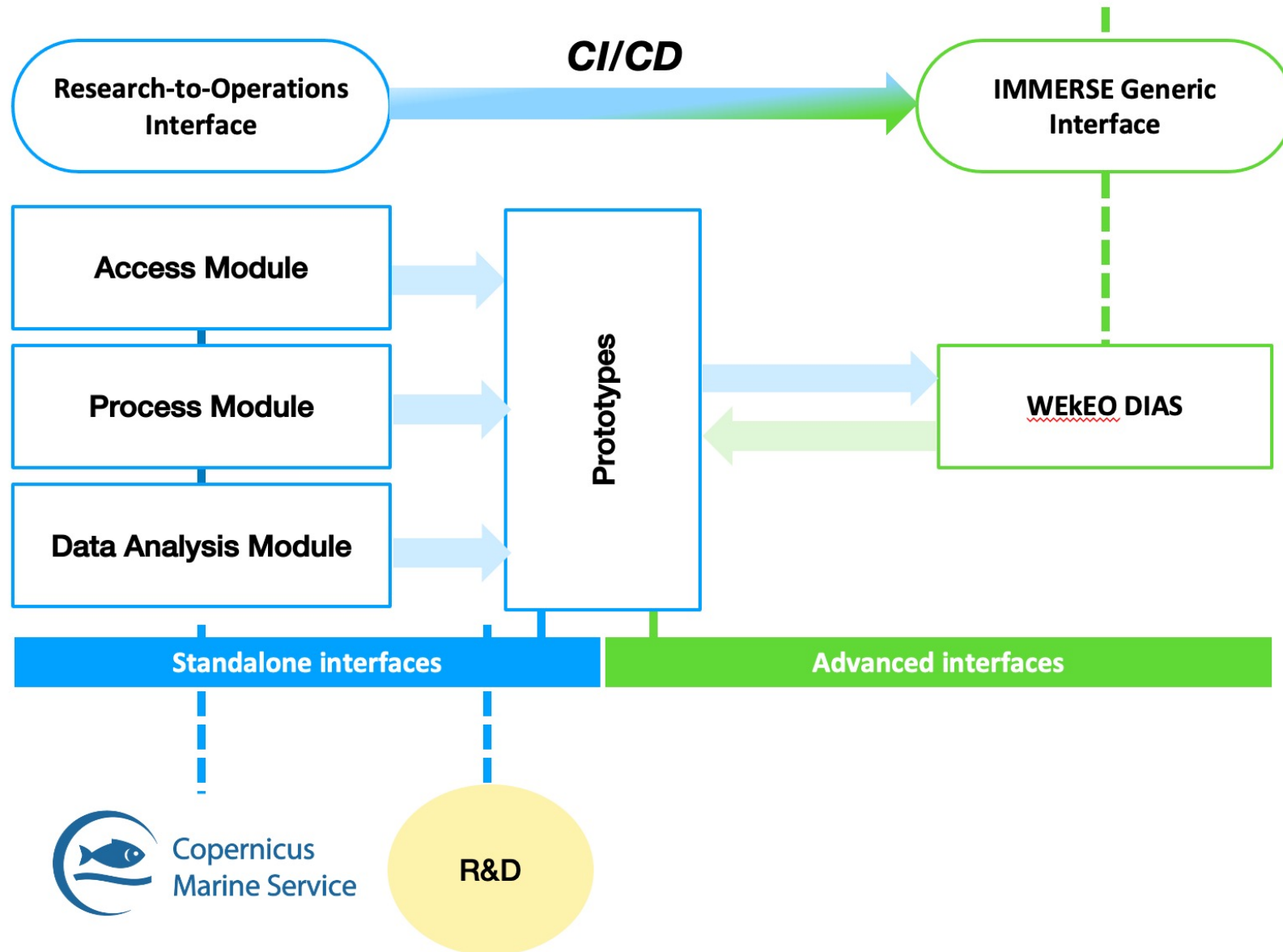


IMMERSE interfaces and WEkEO support:

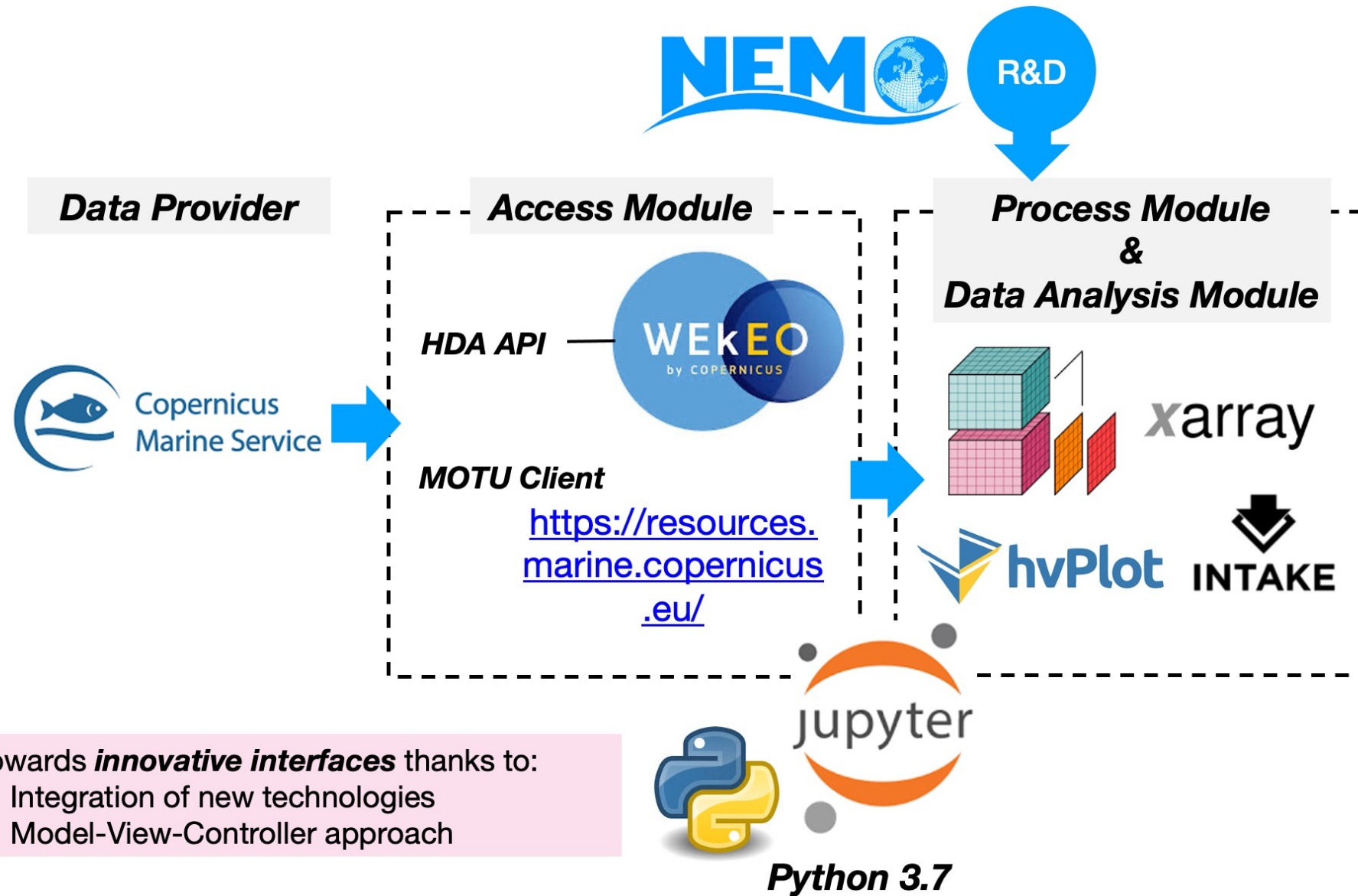
- To access and discover the CMEMS catalogue, including both model and observational data
- To manipulate accessed datasets to extract relevant physical information for a new NEMO-based configuration
- To prepare NEMO set of upstream files and to validate NEMO solution by using CMEMS observational datasets



IMMERSE INTERFACES

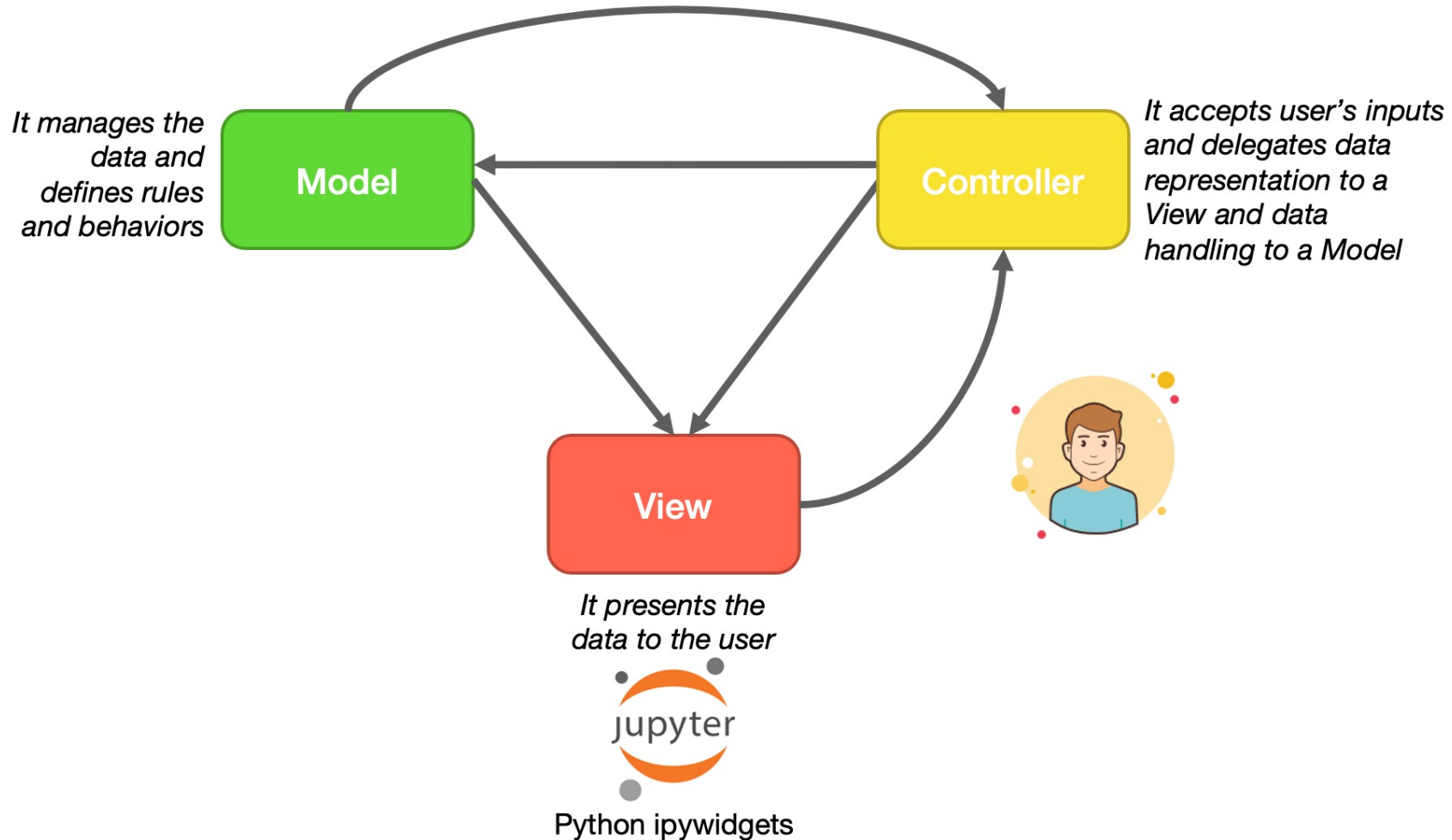


STREAMING DATA DIRECTLY INTO PYTHON



SOFTWARE ARCHITECTURE DESIGN

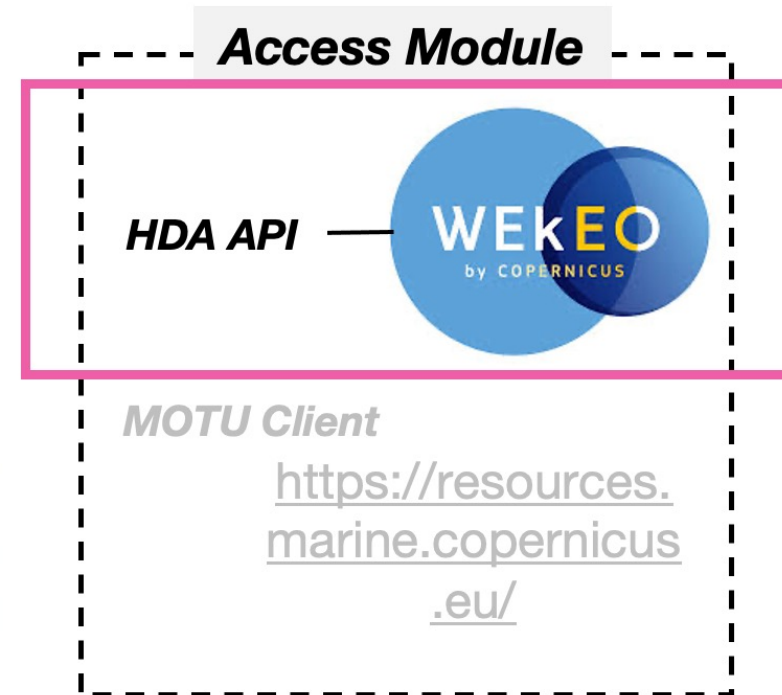
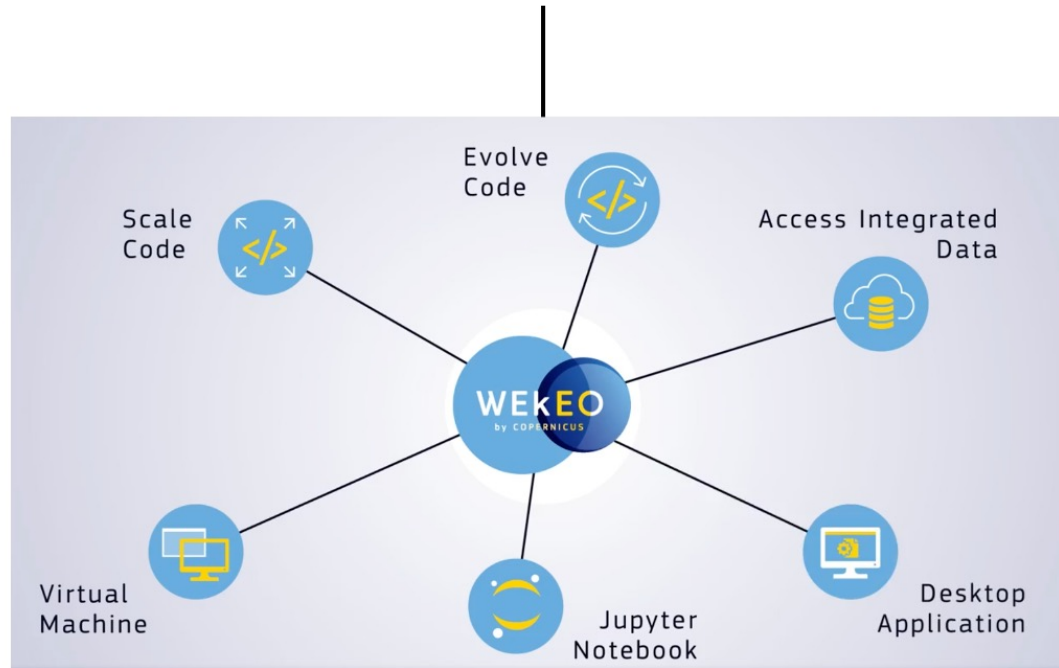
- Since Model, View and Controller are decoupled, each one of the three can be **extended, modified and replaced** without having to rewrite the other two



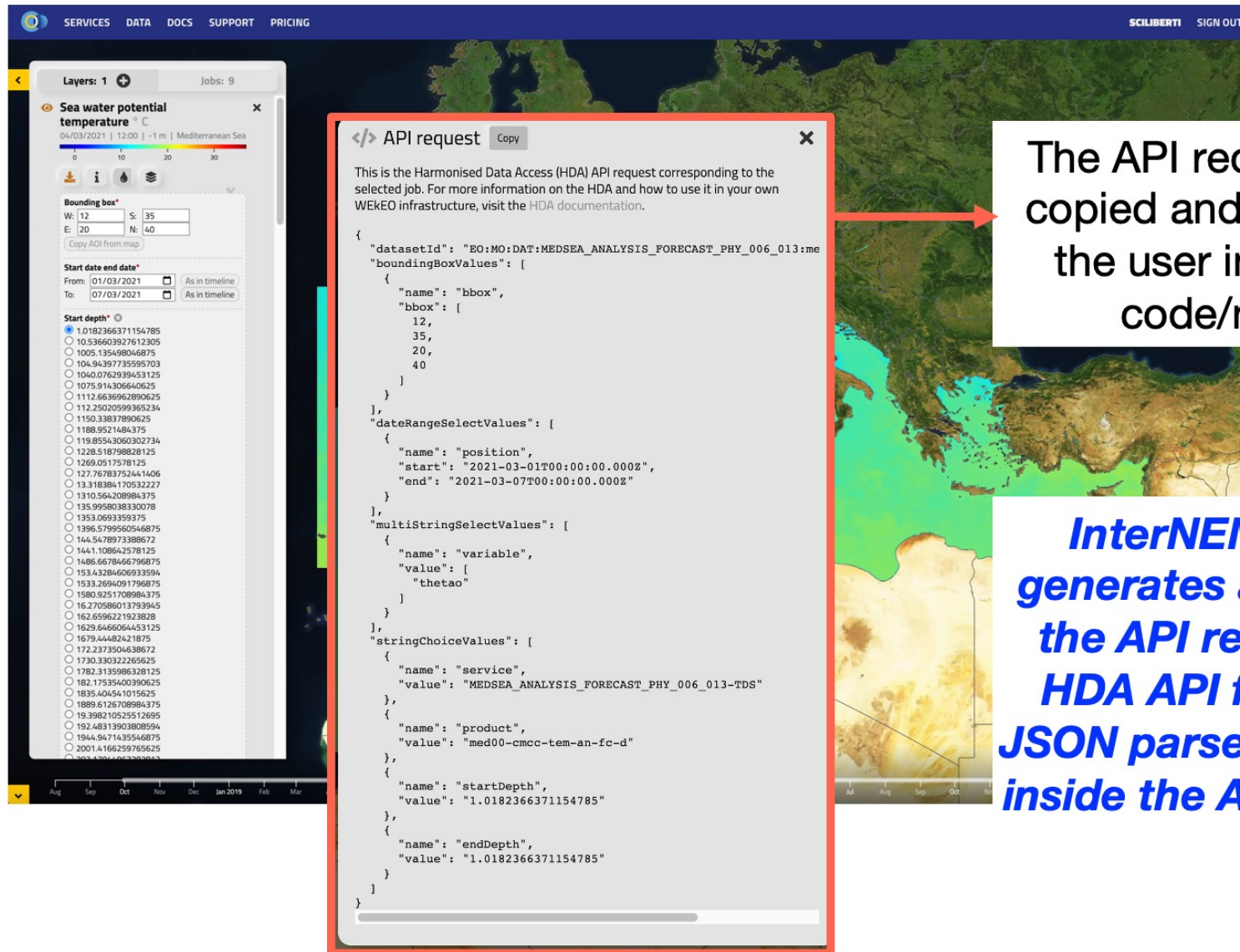
WEKEO HAD API

<https://www.wekeo.eu/hda-api>

The Harmonised Data Access (HDA) API allows uniform access to the whole WEkEO catalogue, including subsetting and downloading functionalities



ACCESS TO WEKEO



The screenshot displays the WEKEO interface. On the left, a sidebar shows 'Layers: 1' and 'Jobs: 9'. The main map area shows a satellite view of the Mediterranean Sea. A 'Sea water potential temperature' layer is active, with a bounding box of W: 12, S: 35, E: 20, N: 40. A list of 'Start depth' values is shown, with the first value selected. An 'API request' window is overlaid on the map, displaying a JSON request for sea water potential temperature data. The request includes parameters for datasetId, bounding box, date range, position, variable, service, product, start depth, and end depth.

```
</> API request Copy X
This is the Harmonised Data Access (HDA) API request corresponding to the
selected job. For more information on the HDA and how to use it in your own
WEKEO infrastructure, visit the HDA documentation.

{
  "datasetId": "EO:MO:DAT:MEDSEA_ANALYSIS_FORECAST_PHY_006_013:me",
  "boundingBoxValues": [
    {
      "name": "bbox",
      "bbox": [
        12,
        35,
        20,
        40
      ]
    }
  ],
  "dateRangeSelectValues": [
    {
      "name": "position",
      "start": "2021-03-01T00:00:00.000Z",
      "end": "2021-03-07T00:00:00.000Z"
    }
  ],
  "multiStringSelectValues": [
    {
      "name": "variable",
      "value": [
        "thetao"
      ]
    }
  ],
  "stringChoiceValues": [
    {
      "name": "service",
      "value": "MEDSEA_ANALYSIS_FORECAST_PHY_006_013-TDS"
    },
    {
      "name": "product",
      "value": "med00-cmcc-tem-an-fc-d"
    },
    {
      "name": "startDepth",
      "value": "1.0182366371154785"
    },
    {
      "name": "endDepth",
      "value": "1.0182366371154785"
    }
  ]
}
```

The API request must be copied and integrated by the user inside his/her code/notebook



InterNEMO instead generates automatically the API request, using HDA API function and JSON parser. This is done inside the Access Module



ACCESS MODULE FOR WEKEO

1

Access Module

This notebook provides the steps for discovering the CMEMS catalogue through Wekeo DIAS.

Importing Modules: the core for the interface is **AMController**, which implements **Harmonized Data Access API** via notebook in an automatic way (<https://www.wekeo.eu/hda-api>)

1. Import Modules

As first step you need to import all modules used in this notebook, implemented in a separate file.

```
In [1]: from AMController import *
import warnings
warnings.filterwarnings("ignore")
```

2

2. Load and Visualize Product Catalog

At now, a partial catalog is visualized.

```
In [2]: c = AMController()
c.display_catalog()
```

Load and Visualize Product Catalogue: it performs the same steps as in the standalone version, but accommodating Wekeo requirements. The **AMController** returns the list of services and products as configured to the user, which may select and load the preferred ones

Services: MEDSEA_ANALYSIS_FORECAST

Products: EO:MO:DAT:MEDSEA_ANALYSIS_FORECAST_PHY_006_013:med00-cmcc-tem-an-fc-m

Load Metadata

Mediterranean Sea Physics Analysis and Forecast

'''Short Description:''' The physical component of the Mediterranean Forecasting System (Med-Currents) is a coupled hydrodynamic-wave model implemented over the whole Mediterranean Basin. The model horizontal grid resolution is 1/24° (ca. 4 km) and has 141 unevenly spaced vertical levels. The hydrodynamics are supplied by the Nucleous for European Modelling of the Ocean (NEMO v3.6) while the wave component is provided by Wave Watch-III; the model solutions are corrected by a variational data assimilation scheme (3DVAR) of temperature and salinity vertical profiles and along track satellite Sea Level Anomaly observations. '''Product Citation:''' Please refer to our Technical FAQ for citing products.<http://marine.copernicus.eu/faq/cite-cmems-products-cmems-credit/?idpage=169>



ACCESS MODULE FOR WEKEO

3

3. Logging in using Wekeo credential

Log in by using your Wekeo User Credential. If you don't have them please visit [here](#)

```
In [3]: c.display_login()
```

Username:

Password:

Copernicus_General_License Terms and Conditions already accepted

Logging using Wekeo credentials: once the user has selected the preferred dataset, before proceeding he/she needs to insert the Wekeo credentials (they can be created though <https://www.wekeo.eu/web/guest/user-registration>)

4

4. Discovery and Download File

Set the parameters for downloading.

You can use the product information visualized in this section to set the parameters needed for downloading.

```
In [4]: c.display_mtd()
```

Bounding Box

Date Range

Variables

Depths

#	lat_min	lat_max	lon_min	lon_max
0	-17.2916660308837890625	45.979167938232421875	36.291667938232421875	30.1875

Discovering and download the product: the controller implements additional functions for visualizing dataset metadata



ACCESS MODULE FOR WEKEO

4

```
In [5]: c.display_download()
```

Lon Min: -17

Lon Max: 15

Lat Min: 30

Lat Max: 40

Date Min: 2018-10-01T12:00:00.000Z

Date Max: 2018-10-30T12:00:00.000Z

Depth Min: 5.464963436126709

Depth Max: 10.536603927612305

☒ bottomT

bottomT

☒ thetao

thetao

Download

The download is launched once the user specifies the preferred bounding box, temporal coverage, layer and variable(s)

```
In [5]: c.display_download()
```

```
17.0&y_lo=15.0&variable=bottomT"
```

```
    }
```

```
  ],
```

```
    "itemsInPage": 1,
```

```
    "nextPage": null,
```

```
    "page": 0,
```

```
    "pages": 1,
```

```
    "previousPage": null,
```

```
    "totItems": 1
```

```
  }
```

```
*****
```

```
Query successfully submitted. Order ID is yYZ8VDPDmmDRIBavVSfqJ3zocbM
```

```
Query successfully submitted. Status is completed
```

```
Downloading
```

```
File size is:      1.16 MB
```

```
[=====]          33.59 Mbps[   1.17] MB downloaded, 33578.16 kbps
```

```
Download complete...
```

```
Time Elapsed: 0.03566799999999981 seconds
```

```
Query successfully submitted. Response is <Response [200]>
```

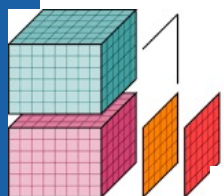
To verify the correctness of the download process, the run process returns a list of messages, including estimation of the file size, processing time and status



Process Module

&

Data Analysis Module



xarray



INTAKE



hvPlot

Subsetting, timeseries,
mean/max/min...

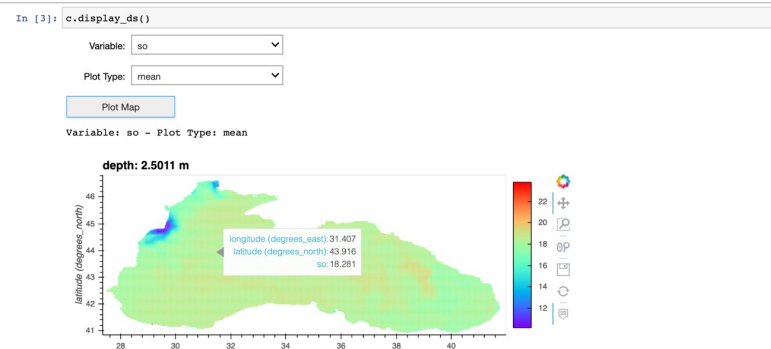
CLASS4

PROCESSING & ANALYSIS

Plot 2D Map

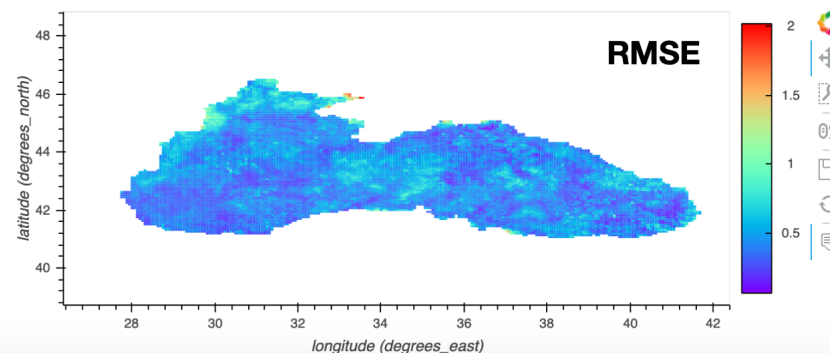
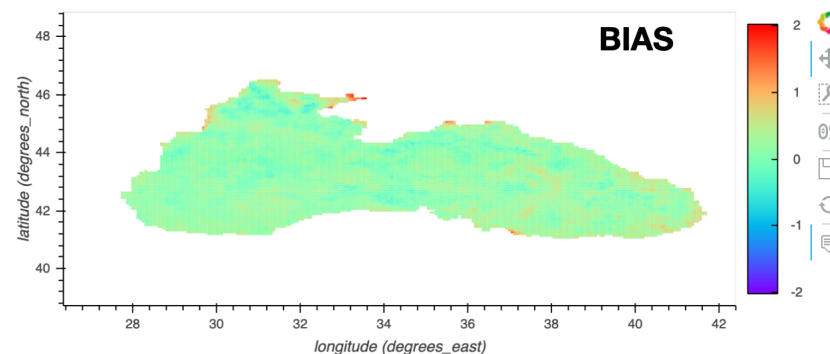
In this section you can plot the 2D map of the variables of interest. In particular, 4 different types of plots are available:

- simple : plot the 2D map of the variable of interest for each timestep and for each depth
- mean/min/max : plot the mean/min/max of the variable in the period of interest



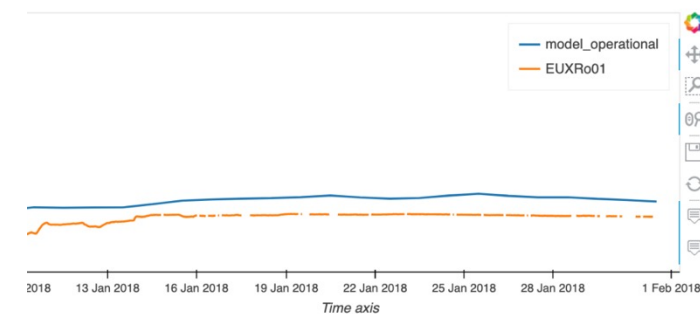
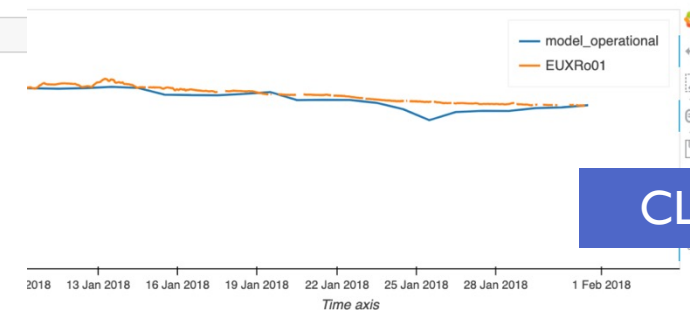
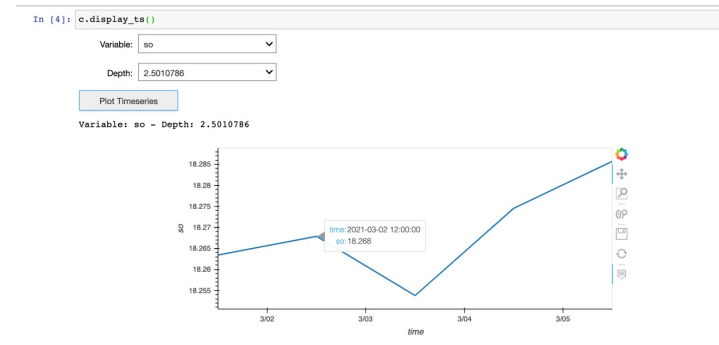
3. Display 2D map

In [3]: `c.display_map()`



Plot Timeseries

In this section you can plot the timeseries of the variables of interest.



CLASS2



CONCLUSIONS

Baseline:

- Centralization: one access point for CMEMS data thanks to WEkEO
 - Integration: Python-based codes and libraries are integrated to develop new interfaces for data access
 - Deployment: multiple architectures / one way to code for continuous integration and continuous development thanks to MVC approach
 - Operations: easy transfer from R&D to operational environment thanks to flexible interfaces able to perform processing and data analysis
-
- Supporting WEkEO for supporting next generation of pre-operational tools able to
 - Facilitate the definition of new NEMO-based configurations as baseline for new developments
 - Enforce the assessment of numerical results thanks to efficient access to observations and model products



REFERENCES

- Useful links:
- Copernicus Marine Environment and Monitoring Service: <https://marine.copernicus.eu/>
- WEkEO DIAS: <https://www.wekeo.eu/>
- Harmonized Data Access API: <https://www.wekeo.eu/web/guest/hda-api>
- InterNEMO: <https://github.com/CMCC-Foundation/immerse>
- PyNEMO: <https://github.com/NOC-MSM/PyNEMO/tree/IMMERSE>
- IMMERSE H2020 Project: <https://immerse-ocean.eu/>





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