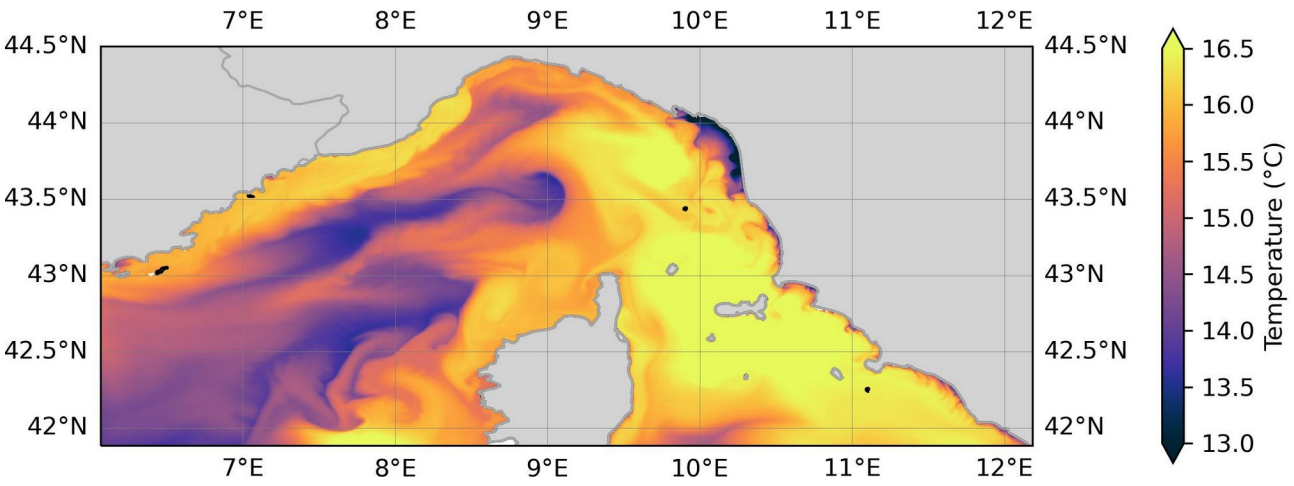
MANUAL FOR DATA_MED TOOLS

Contibutor : Clément Fontana



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contact : cfontana [a] ogs.it

1 Introduction

This document presents the architecture and instructions to process oceanographic model outputs and data in the Mediterranean Sea using the MITgcm model.

Using other models remain possible through simple nomenclature/format conversion. Contact me for any questions.

2 General arborescence

```
├── config
├── datasets
│   ├── ARGO
│   ├── BOUSSOLE
│   │   └── data
│   ├── CMEMS
│   ├── DVM
│   │   └── data
│   ├── DYFAMED
│   │   ├── data
│   │   ├── dyfamed-buoy
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├── gallery
├── meteo
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├── modules
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```

3 Setup

git clone git@github.com:cfontana00/DATA_MED

Required Python toolbox

Core : numpy, scipy, cartopy, matplotlib, xarray

Optional : copernicusmarine (CMEMS), cdsapi (ECMWF)

Environment variables

$ set $DIR/modules to your PYTHONPATH in ~/.bashrc

$ export env variable DATA_MED_DIR as /path/to/DATA_MED

$bash

Create your own configuration file

$ cd config

$ cp config_TEMPLATE.json config_MYCONFIG.json

$ cp variables_mit_TEMPLATE.dat variables_mit_MYCONFYG.dat

(Tag MYCONFIG can be anything)

4 Parameters description

Tune your config_MYCONFIG.json file considering parameters below

```
"_____":"GENERAL PARAMETERS",

"date_ini":"2021-12-11",                    # Initial date of model data
"date_end":"2021-12-12",                    # Final date of model data
"outdir":"/path/to/OUTPUT_SMP",             # Directory containing outputs
"diagdir":"/path/to/diags/dir",             # Directory to save diagnostics files
"rm_boundary":"no",                         # Remove boundaries
"damping":20,                               # Number of pixels to remove


"_____":"RIVER PARAMETERS",
"french_list":["Argens","Var"],                          # French rivers list (see README)
"italian_list":["Arno","Magra","Ombrone","Serchio"],     # Italian  rivers list (see README)
"river_ini":"2021-01-01",                                # River initial date
"river_end":"2021-12-31",                                # River final date

"_____":"METEO PARAMETERS",
"meteo_ini":"2015-03-10",                    # Starting date for meteo data processing
"meteo_end":"2015-03-11",                    # Ending date for meteo data processing
```

```
"day_cycle":2,                                  # Number of days per cycle
"n_cycle":3,                                    # Number of cycles
"imin":"500",                                   # I index minimum cut
"imax":"600",                                   # I index maximum cut
"jmin":"350",                                   # J index minimum cut
"jmax":"450",                                   # J index maximum cut

"_____":"ARGO",

"argo_ds":"phy",                                # Argo data set (phy or bgc)

"_____":"DYFAMED PARAMETERS",
"some_par":"some_par",              # To be defined

"_____":"BOUSSOLE PARAMETERS",
"some_par":"some_par",    # To be defined


"_____":"PLOT PARAMETERS",

"resol":"10m",                          # Cartopy coast/land resolution
"fig_proj":"ccrs.PlateCarree()",        # Cartopy projection
"fig_sx":"8",                           # Horizontal 2D figure size
"fig_sy":"8",                           # Vertical 2D figure size
"fig_fmt":"jpg",                        # Output figure format
"fig_res":"300",                        # Output figure resolution
"tight":"False",                        # Crop white space (time-consuming)
"fig_tck_size":"10",                    # Figure tick size
"fig_tcklbl_size":"10",                 # Figure tick label font size
"fig_lbl_size":"10",                    # Figure label font size
"cb_fraction_2D":"0.02",                # Python colorbar fraction parameter
"cb_pad_2D":"0.12",                     # Python colorbar pading parameter

"fig_sx_sat":"7",                       # Same as above but for model/sat comparisons
"fig_sy_sat":"4",
"fig_tck_size_sat":"4",
"fig_tcklbl_size_sat":"4",
"cb_pad_sat":"0.12",
"cb_fraction_sat":"0.02",
"cb_pad_sat":"0.04",
"cb_tck_size_sat":"4",
"cb_lbl_size_sat":"6",
```

```
"with_currents":"False",              # Configuration specfic, do not use
"with_whales":"True",                 # Overlap currents on maps


"_____":"SECTION PLOT PARAMETERS",

"fig_secx":"8",                       # Horizontal in-depth section figure size
"fig_secy":"4",                       # Vertical in-depth section figure size
"sec_lon1":"8.5",                     # Longitude starting point for section
"sec_lat1":"43.",                     # Latitude starting point for section
"sec_lon2":"10.",                     # Longitude ending point for section

"sec_dep":"600",                      # Maximum depth for section
"sec_resH":"0.05",                    # Horizontal resolution for interpolation
"sec_resV":"1",                       # Vertical resolution for interpolation
"cb_fraction_sec":"0.025",            # Python colorbar fraction parameter for section plot
"cb_pad_sec":"0.06",                  # Python colorbar padding parameter for section plot

"_____":"TRANSECT PLOT PARAMETERS",

"trans_ini":"2015-04-01",             # Initial date for transect
"trans_end":"2015-04-19",             # End date for transect
"trans_depth":200,                    # transect depth
"trans_resV":1,                       # transect vertical resolution
"trans_name":"eddy",                  # transect name for backup
"trans_file":"/DISK2TB/DATA/eddy.dat", # daily position of transect


"_____":"PROFILE PLOT PARAMETERS",

"fig_prox":"4",                       # Horizontal profile figure size
"fig_proy":"8",                       # Vertical profile figure size
"col_bcg":["g","b","r"],              # Colors
"col_phy":["b","r"],                  #  ( /!\ refer to the argo_ds parameters tuning)

"_____":"INTERPOLATION PARAMETERS",
"dump":"0.05",                # Margin kept around point to fasten interpolation (5/10 grid points)
"itp_meth":"nearest",         # Interpolation method, set nearest for tests, or linear
```

The configuration is read dynamically and its variables are global inside the system once loaded

5 Variable options description

$ cp /config/variables_mit_TEMPLATE.dat /config/variables_mit_MYCONFIG.dat

Description	Name	File tag	Colormap	Log plot	Limit mode	Plot min value	Plot max value	Label	Units
Options				True/ False	set/auto				
Example	Chl	PFTC	cmc.imola	True	Set	0.05	0.25	Chlorophyll	mg.m-3

6 Plot directory routines

This directory contains routines to perform plots. Diagnostics arborescence is automatically created and name of file saved prompted.

=> *Routine make_plot_2D.py :*

Description : Plot 2D spatial maps on the domain

Arguments : *configuration_name variable_name z-level*

 Bash utilization with *make_plot_2D.ksh*

=> *Routine make_plot_section.py :*

Description : Plot vertical section on the domain

Arguments : *configuration_name variable_name direction coordinate_value*

direction argument can be horizontal or vertical

If *direction* is horizontal, routine plots the section from '*sec_lon1'* to '*sec_lon2*' at latitudinal '*coordinate_value*'
If direction is vertical, routine plots the section from '*sec_lat1'* to '*sec_lat2*' at longitudinal '*coordinate_value*'

 Same possible bash utilization as *make_plot_2D.py*

7 RIVERS datasets routines

This routine create river runoff input files at the MITgcm format

The data can be downloaded from https://www.hydro.eaufrance.fr/ for french rivers and http://www.sir.toscana.it/consistenza-rete for italian ones.

 Get csv files from both sites and save them as *rivername*.csv in the /datasets/RIVERS/data

$ python3 read_rivers.py NWMED

=> **produces** MITgcm ready to read files in /diagdir/MYCONFIG/RIVERS/

The routine raises an error if data are not continuous. In this case you must pre-process the data (*e.g.* interpolation/climatology) and save the processed file in data_modif/rivername_modif.csv

 The routine checks for existence of the file *_modif.csv before reading the original one.

8 METEO routines

ECMWF toolbox

These routines download and process CERRA data from :

https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-cerra-single-levels?tab=overview

Tune "METEO PARAMETERS" section in your configuration file

Get the data :

Go to DATA_MED/meteo/ECMWF

Run :

$ python3 get_data.py MYCONFIG

The routine download data between “meteo_ini” and “meteo_end”, months are fully download regardless the defined day of the date

=> NetCDF files are **stored** in diagdir/MYCONFIG/METEO

Two methods are then available to create atmospheric forcing files.

The first method create one unique file for each variable and over the whole period defined by parameters “meteo_ini” and “meteo_end” (Method 1 below).

The second method creates separate files over temporal cycles starting on “meteo_ini”(Method 2 below), this method is adapted for long simulations that have to be performed in several runs.

Method 1 :

Run : $ python3 process_data.py MYCONFIG

Method 2 :

Run : $ ./run_cycles.ksh MYCONFIG

 **Files storage** :

=> Interpolated NetCDF files are **stored** in diagdir/MYCONFIG/METEO/ITP_NC

=> Interpolated binary files are **stored** in diagdir/MYCONFIG/METEO/ITP_BIN

Binary files are ready to be read by MITgcm

 So far, longitude/latitude 1-D array are read from an output file :

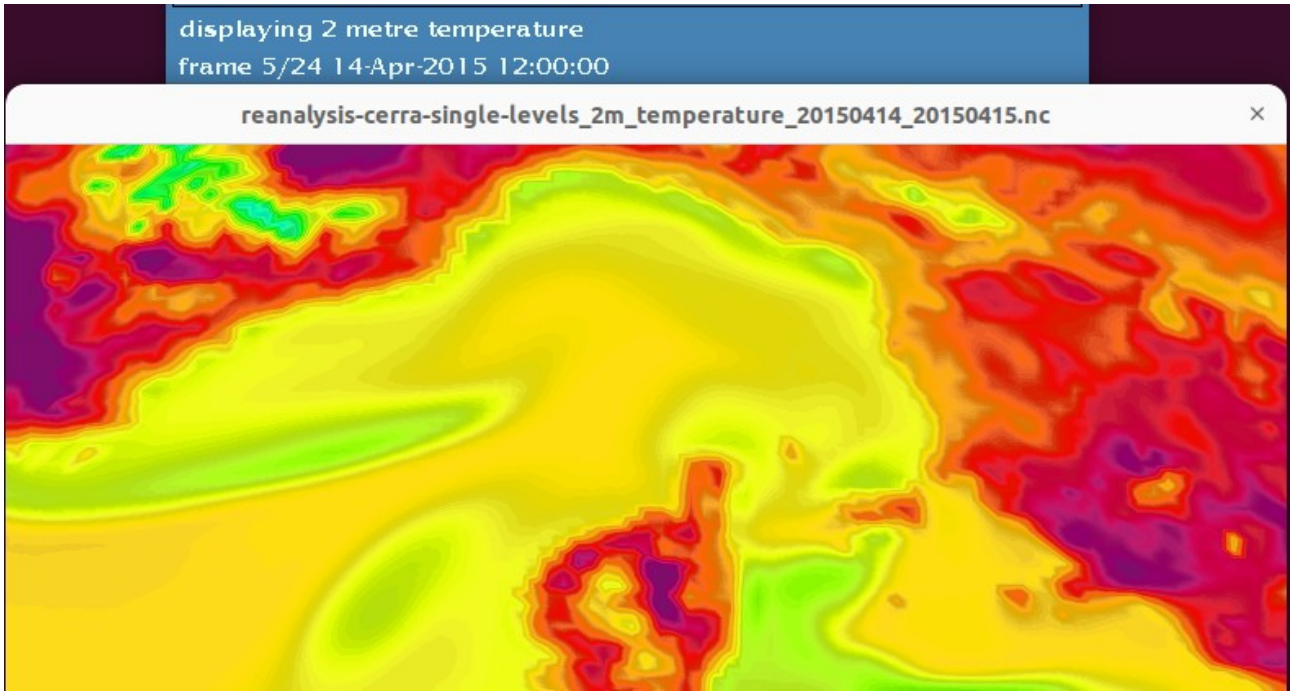
lon,lat,levels = load_coords()

 # Mesh model lon/lat

LAT,LON = np.meshgrid(lat,lon)

TO DO : For a first model initialization, modify this section to read lon/lat elsewhere (bathy, mask …) if outputs are not found.

Example :



9 ARGO

⚙ Comparison with Argo data, the module **needs argopy installed** (https://argopy.readthedocs.io/en/latest/)

Tune in configuration file “argo_ds” to “phy” (physical Argo TS) or “bgc” (biogeochemical Argo)

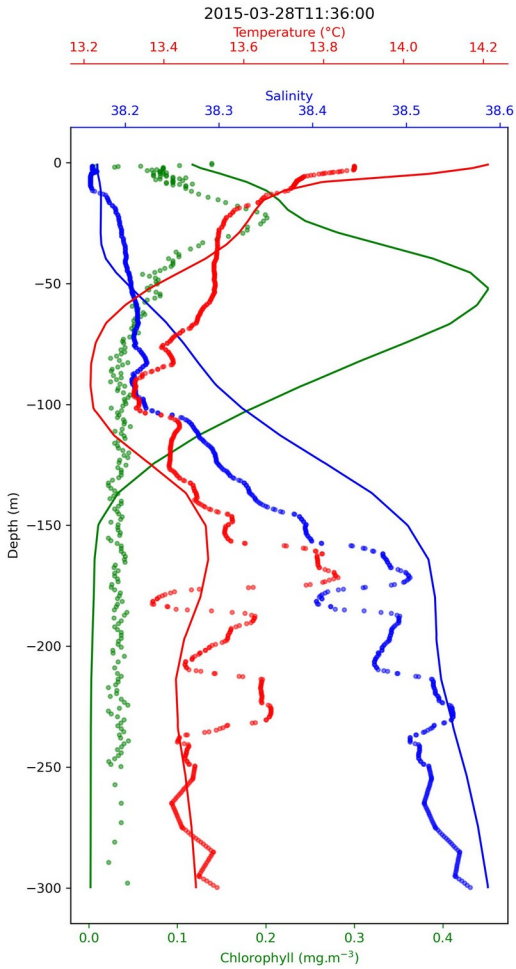
Run :

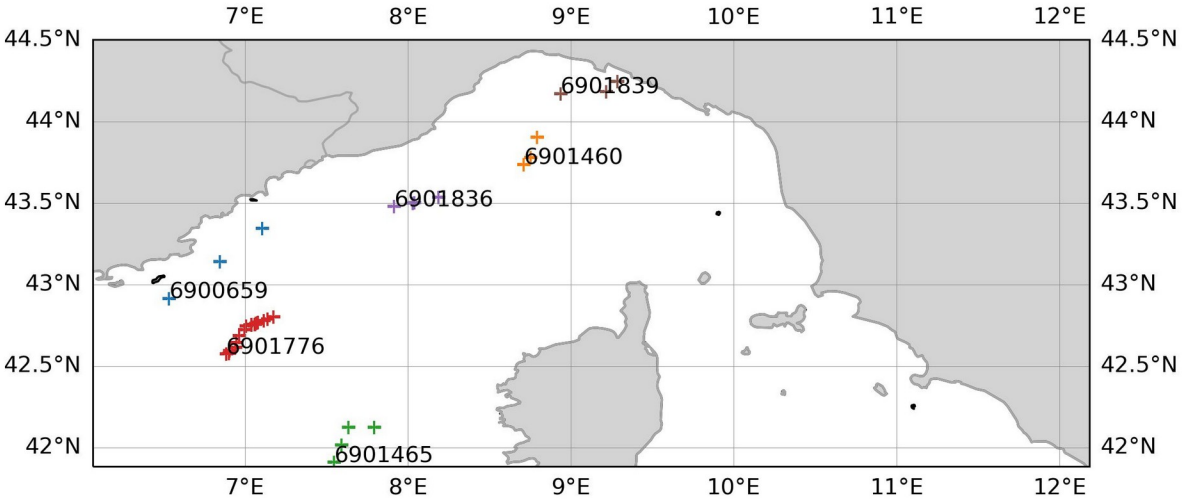
$ python3 get_data.ksh MY_CONFIG

$ python3 compare_argo.py MY_CONFIG

Data and graphs stored in diagdir/ARGO/MY_CONFIG

Example :





10 CMEMS

Copy the file /config/cmems_TEMPLATE to /config/cmems_MY_CONFIG.

The satellite CMEMS products can be changed there if necessary.

Go to /datasets/CMEMS

Get the data by :

$ python3 get_data_sat.py MY_CONFIG *var*

Interpolate data on model grid by

$ python3 interp_cmems.py MY_CONFIG *var*

Do the plot by tuning the *_sat plotting parameters of the configuration file and running in /plot :

$ python3 plot_data_vs_sat.py MY_CONFIG *var* CMEMS

plot_data_vs_sat.py compute mean averaged times-series but this can be also done with

$ python3 compute_data_vs_sat.py MY_CONFIG *var* CMEMS

Without producing the plot (faster)

Compare data/model time series with :

$ python3 MY_CONFIG *var* CMEMS

File storage

=> Data files are **stored** in diagdir/MY_CONFIG/CMEMS/data

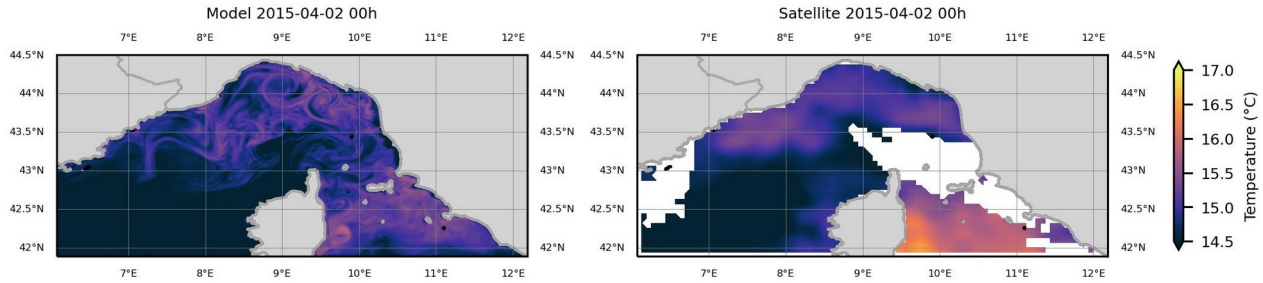
=> Interpolated files are **stored** in diagdir/MY_CONFIG/CMEMS/*var*/ITP_NC

=> Interpolated files are **stored** in diagdir/MY_CONFIG/CMEMS/*var*/ITP_NC/PLOT

=> Time series files and plots are **stored** in diagdir/MY_CONFIG/CMEMS/*var*/ITP_NC

where *var* stands for chl or thetao

Example :



11 Test data set

You can perform tests using MITgcm NetCDF outputs available here :
https://drive.google.com/drive/folders/1zeqUdXv5-6zCRw_ok9OOMxth2WrHNgRl?usp=sharing

Just set the *outdir* and *diagdir* variables in your configuration file.

12 Create your own directory

You can easily access existing functions and create your own directory to process data.
For an example of use :

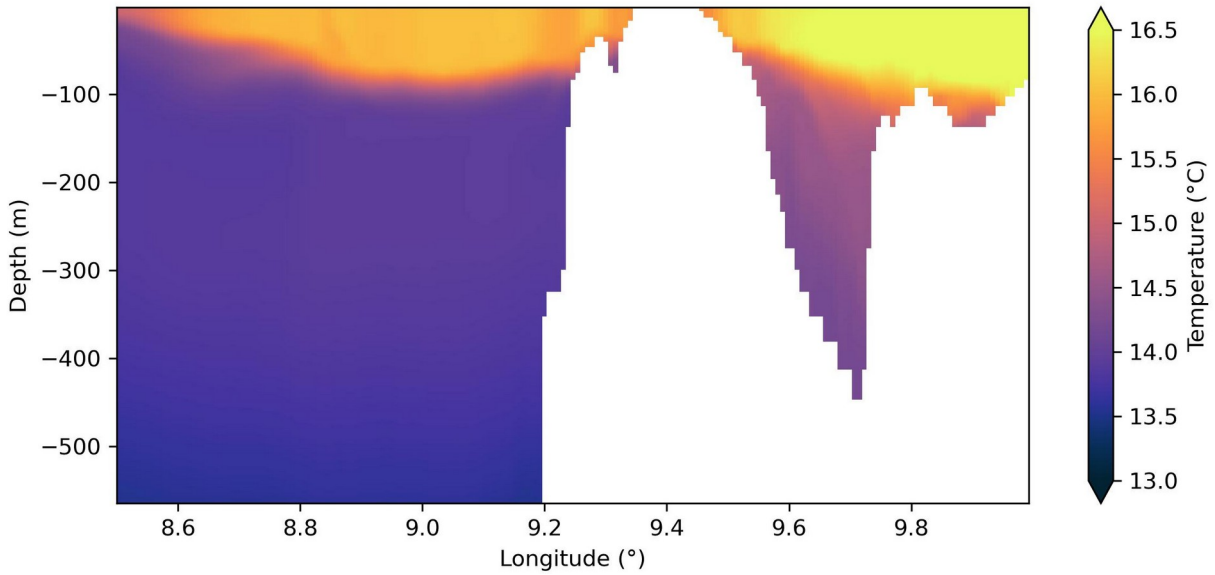
$ cd datasets/MY_NEW_DATA
$ python3 my_new_routine.py MYCONFIG

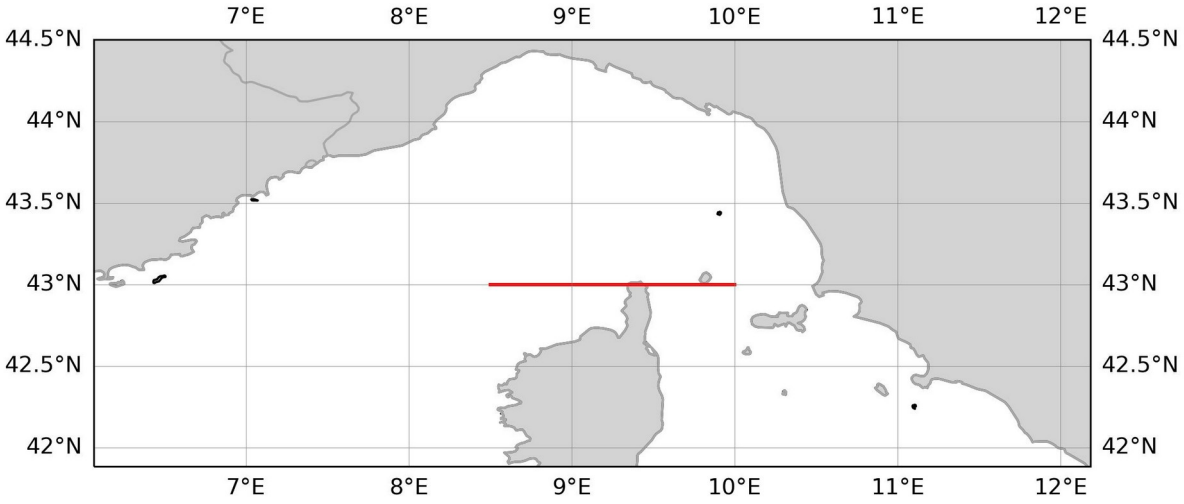
TIPS :

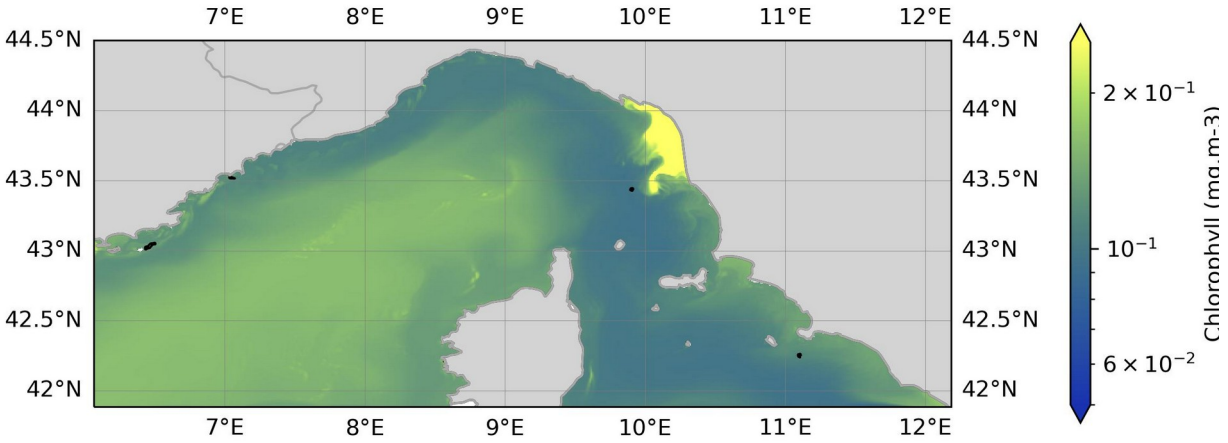
- You can add your own configuration parameters in a file /config/config_CUSTOM.json and load it using load_config(CUSTOM) in your routines. We could include them in the general file later.
- You can also create your own functions in /modules and load them as others.
- Check for /module/fun_* for already existing functions (e.g. *write_nc*, *savefig* in fun_io.py)

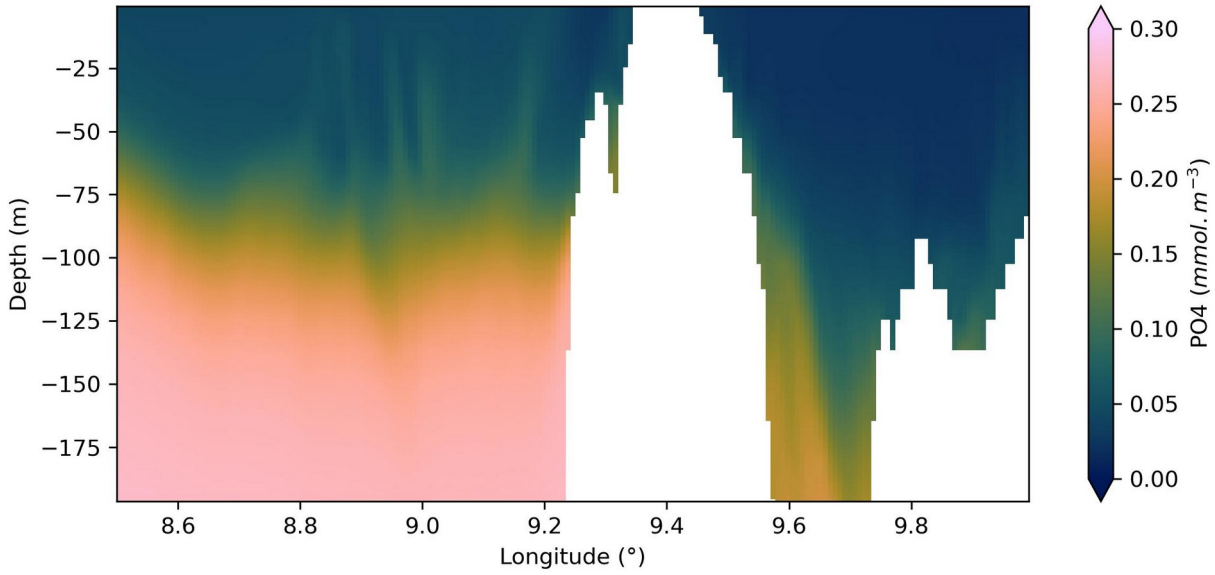
ENJOY !

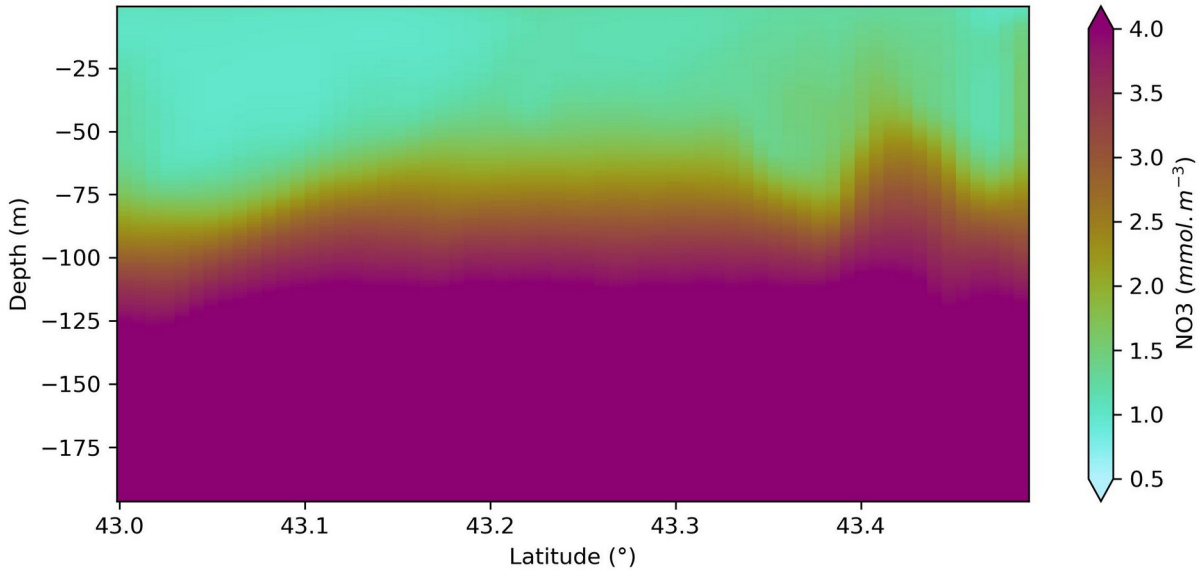
13 Gallery


Depth (m)
−100
−200
−300
−400
−500
8.6
8.8
9.0
9.2
9.4
9.6
9.8
Longitude (°)
16.5
16.0
15.5
15.0
14.5
14.0
13.5
13.0
Temperature (°C)


7°E
8°E
9°E
10°E
11°E
12°E
44.5°N
44°N
43.5°N
43°N
42.5°N
42°N


7°E
8°E
9°E
10°E
11°E
12°E
44.5°N
44°N
43.5°N
43°N
42.5°N
42°N
2×10^{-1}
10^{-1}
6×10^{-2}
Chlorophyll (mg.m-3)


Depth (m)
−25
−50
−75
−100
−125
−150
−175
8.6
8.8
9.0
9.2
9.4
9.6
9.8
Longitude (°)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
PO4 (mmol. m−3)


Depth (m)
−25
−50
−75
−100
−125
−150
−175
43.0
43.1
43.2
43.3
43.4
Latitude (°)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
NO3 (mmol. m−3)