SHYFEM SIMULATIONS
&
SUPPORT TO OCEANOGRAPHIC CAMPAIGNS

AdriaClim| PP11 | ARPA FVG

Internal Meeting | Palmanova (UD) | 24 February 2021

European Regional Development Fund

Training

Internal (by Dario Giaiotti, CRMA-ARPA FVG):

- description of the **working environment**
- management of **HPC workspace**
- …and many others

External (by Francesco de Giorgi, *eXact lab*):

- 10 hours course
- introduction to **C3HPC**
- main **software facilities**
- usage of the ***PBSPro*** job scheduler and introduction to **HPC queues**
- codes **compilation** (serial, parallel – shared & distributed memory): theory and practice
- **Git** & **GitHub**: theory and practice

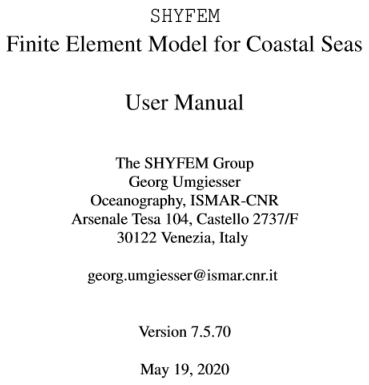
SHYFEM

- Introduction to SHYFEM
- Run Test: Nador Lagoon
- Run Test: Pilot Area

Introduction to SHYFEM

What is SHYFEM?

- **S**hallow water **HY**drodynamic **F**inite **E**lement **M**odel
- programme **package**
- **semi-implicit** time integration
- **2D** or **3D** simulations



SHYFEM
Finite Element Model for Coastal Seas

User Manual

The SHYFEM Group
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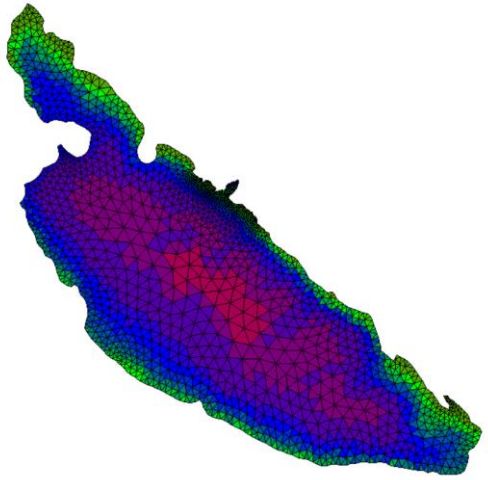
Version 7.5.70

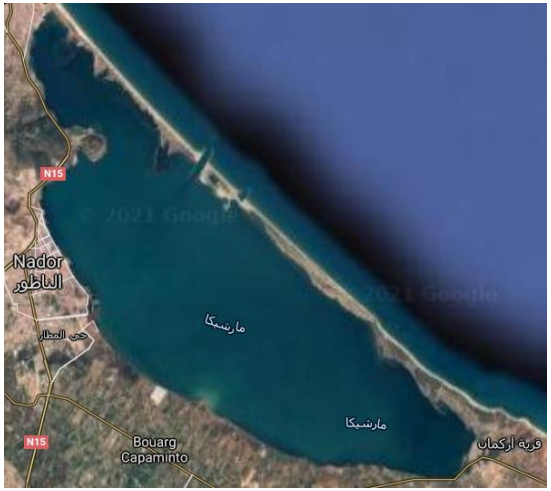
May 19, 2020

What I did?

- **Download** from GitHub
- **Storage** on C3HPC
- **Study** of the manual
- **Installation** of needed **software**
- **Installation** of **SHYFEM**
- **Compilation**
- **Learn** SHYFEM pre- & post-**processing tools**
- **Run tests**

Run Test: Nador Lagoon





First run test:

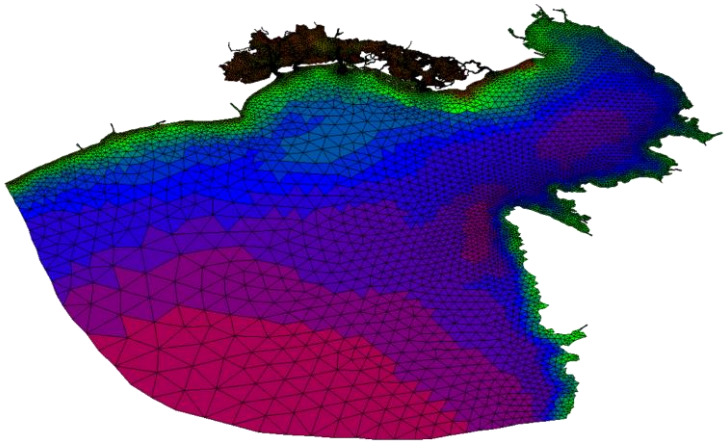
- **Nador** lagoon
- on C3HPC **login node**…
- ..and on C3HPC **queues** ←

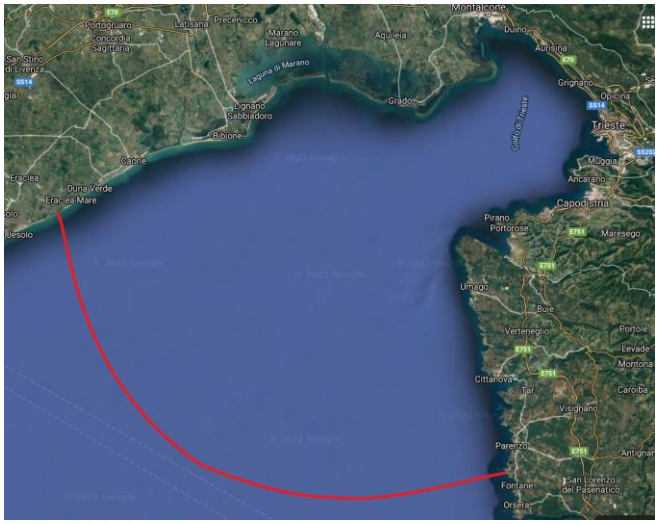
job script

```
# ******************
#  JOB'S DIRECTIVES
# ******************

#PBS -q arpa
#PBS -l nodes=1:ppn=12
#PBS -l walltime=02:00:00
#PBS -N shyfem_job
#PBS -o shyfem_job.out
#PBS -e shyfem_job.err
#PBS -m abe
#PBS -M alessandro.minigher@arpa.fvg.it

# ************
#  ACTUAL JOB
# ************

# Activation of traps and errors in case of undefined variables, and debug

set -e
set -u
#set -x
```

SHYFEM runs as expected

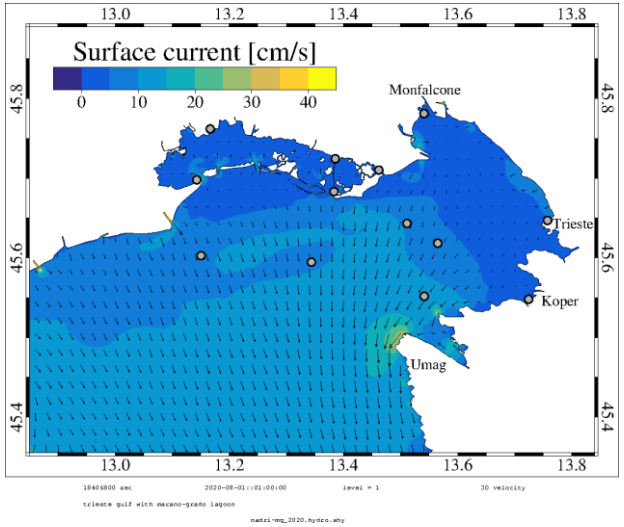
Run Test: Pilot Area, 1





Second run test:

- Gulf of Trieste and Marano-Grado Lagoon → **pilot area**
- **hindcast** (August 2020)
- on C3HPC **queues** → **serial** & **parallel** (shared memory)

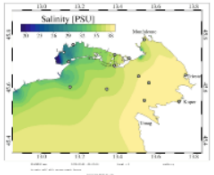


01 August 2020 (01:00) – 31 August 2020 (23:00)

Run Test: Pilot Area, 2

#AdriaClim: Meeting on SHYFEM and First Run Test on Pilot Area

17/02/2021



Mercoledì 3 febbraio, alcuni rappresentanti di ISMAR-CNR e ARPA FVG si sono riuniti in un incontro volto a definire i dettagli delle **simulazioni numeriche** che verranno eseguite mediante il **modello idrodinamico** SHYFEM, nel contesto del progetto **INTERREG IT-HR AdriaClim [1] [2]**.

A seguito di tale incontro, martedì 9 febbraio è stata eseguita la prima simulazione di prova sull'area pilota.

L'introduzione operativa del modello **SHYFEM [3]** nel progetto AdriaClim consentirà di simulare, con elevata risoluzione spaziale, lo **stato futuro del mare di alcune aree costiere del bacino adriatico**, quali ad esempio il golfo di Trieste e la laguna di Marano-Grado, contribuendo al conseguimento degli obiettivi del **WP3**, in particolare delle deliverable 3.3.1 e 3.3.2.

*On Wednesday 3 February, some representatives of ISMAR-CNR and ARPA FVG met in order to define the details of the **numerical simulations** that will be performed by running the SHYFEM **hydrodynamic model**, in the context of the **INTERREG IT-HR AdriaClim project [1] [2]**.*

Following this meeting, the first run test on the pilot area was performed on Tuesday 9 February.

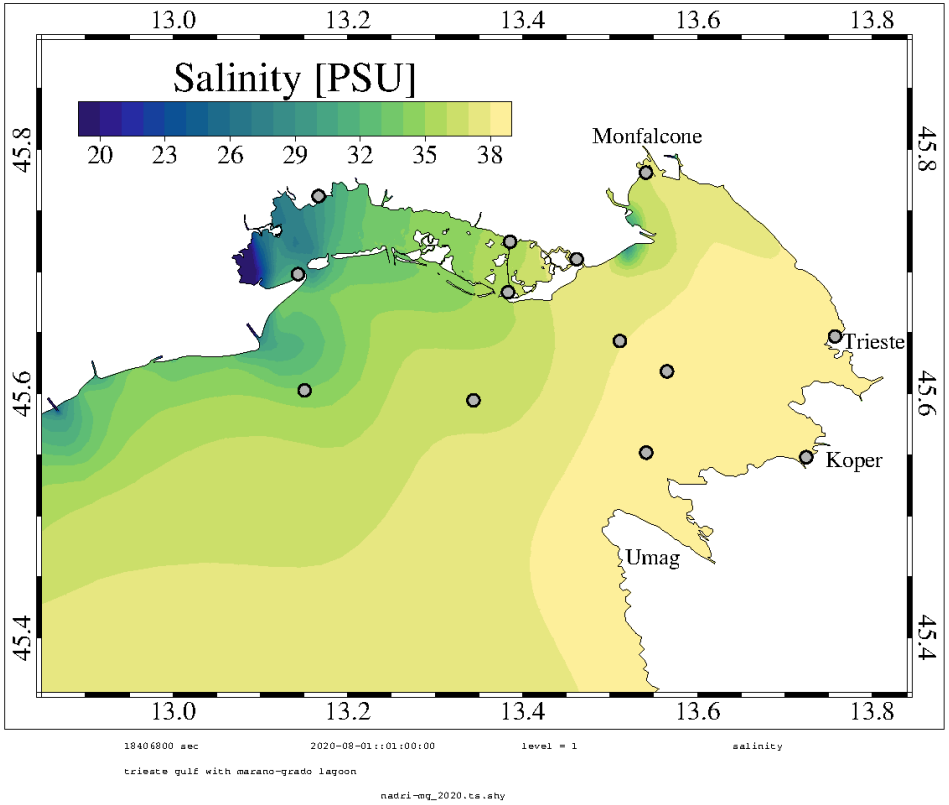
*The operational introduction of the **SHYFEM model [3]** in the AdriaClim project will allow to simulate, with high spatial resolution, **the future state of the sea of some coastal areas of the Adriatic basin**, such as the Gulf of Trieste and the Marano-Grado lagoon, contributing to the achievement of the **WP3** objectives, in particular of deliverables 3.3.1 and 3.3.2.*

Riferimenti/References:

[1] Interreg Italy-Croatia - AdriaClim

[2] ARPA FVG - AdriaClim

[3] S.H.Y.F.E.M



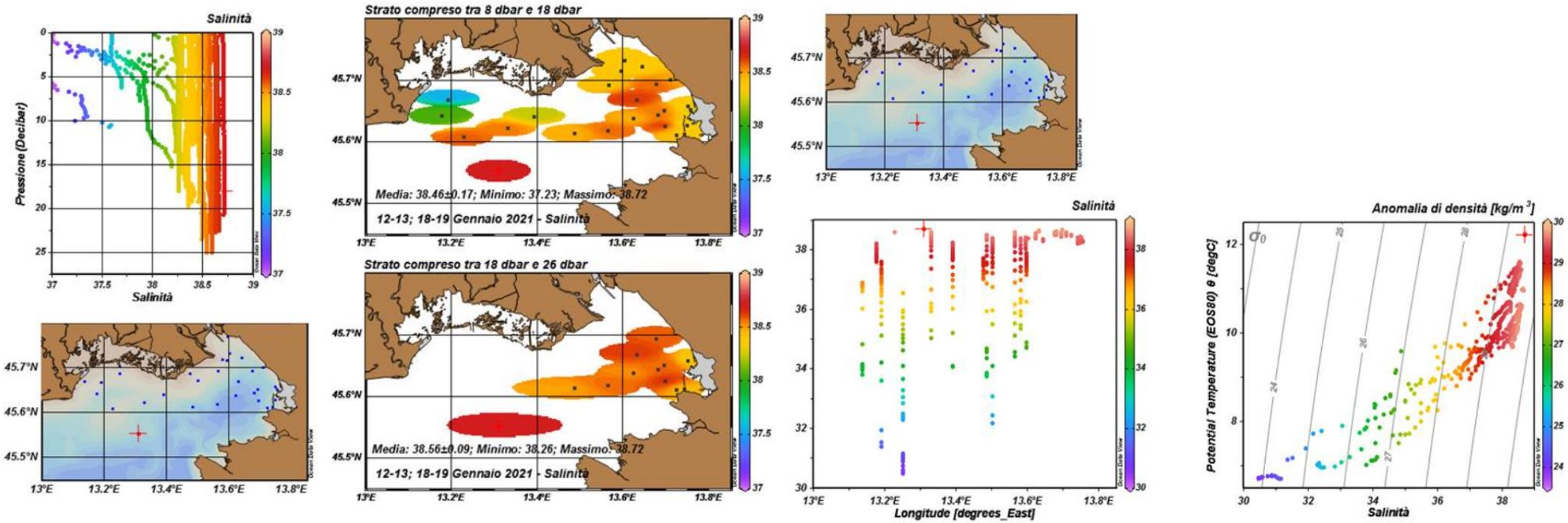
http://www.arpa.fvg.it/cms/istituzionale/servizi/progetti_europei/news/adriaclim_0001_2021.html

NCL SCRIPTS

SUPPORT TO MID-JANUARY OCEANOGRAPHIC CAMPAIGN

- Observed Density Anomaly in the Gulf of Trieste
- What Really Happened?
- Further Support
- NCL Developed Scripts
- STA-QMT & CRMA Cooperation

Observed Density Anomaly in the Gulf of Trieste

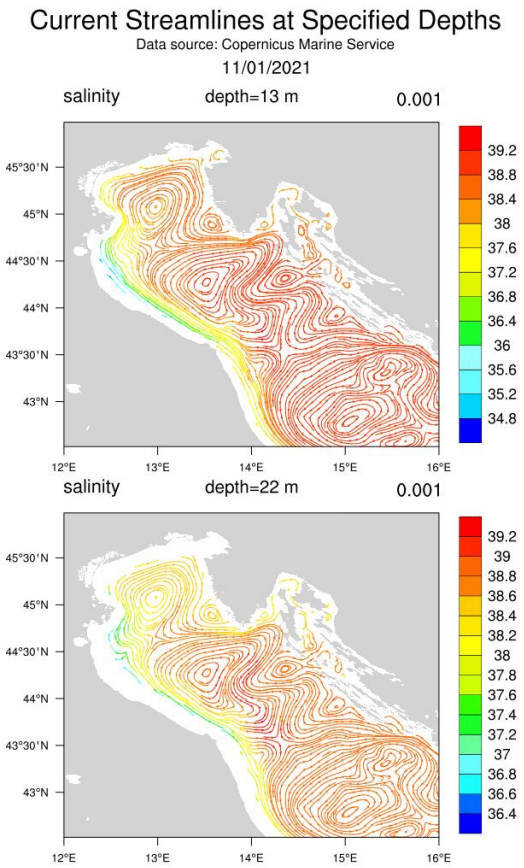


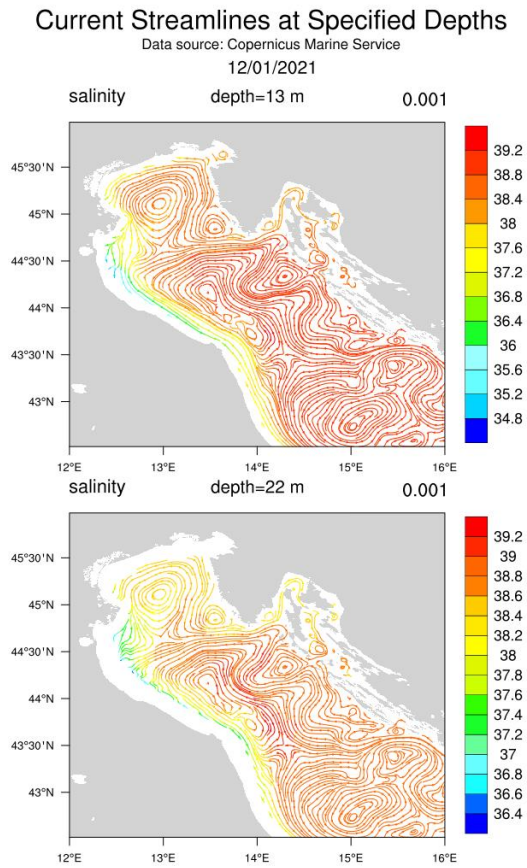
Composed images provided by: **Massimo Celio** (ARPA FVG)

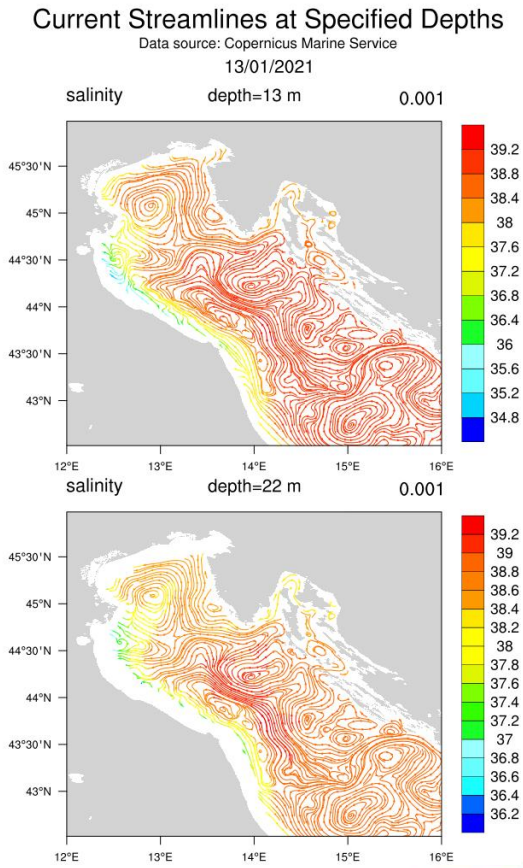
- **mid-January oceanographic campaign** [1]
- **central-eastern** part of **GoT** characterized by rather **high salinity**, especially from 18 dbar to bottom → expected **water input** from **central-southern Adriatic** Sea through the **Croatian coast**

[1] http://www.arpa.fvg.it/cms/hp/news/Bollettino-Stato-oceanografico-ecologico-Golfo-Trieste-Gennaio-2021.html

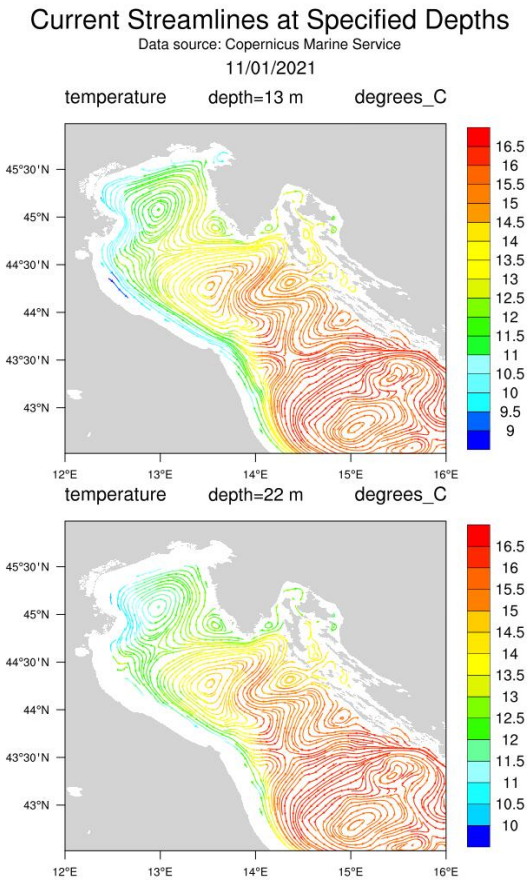
What Really Happened?

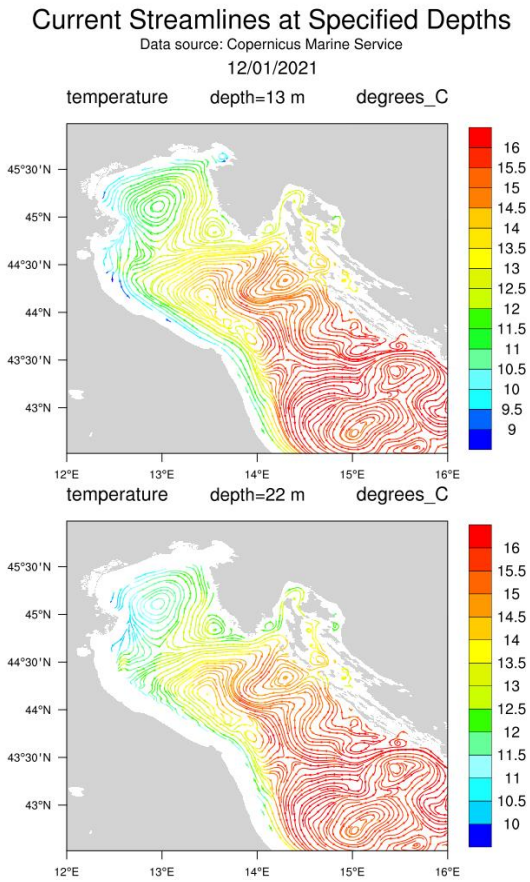


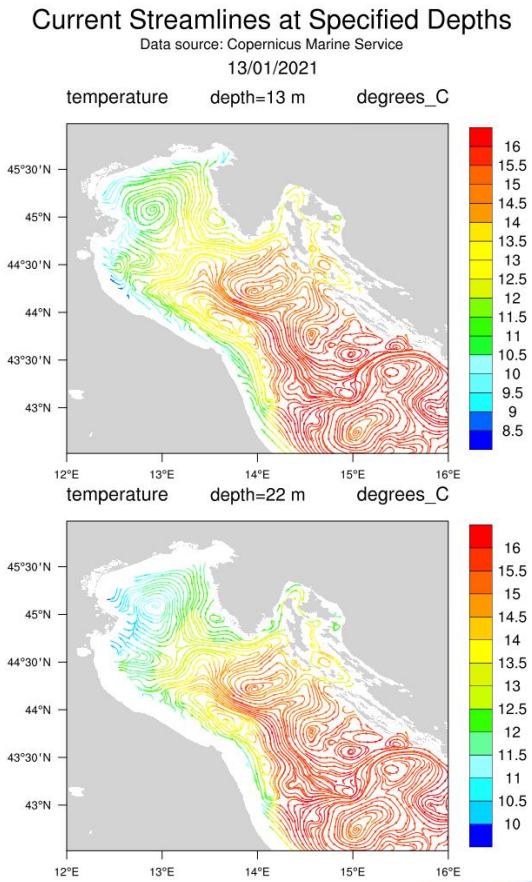




Further Support, 1





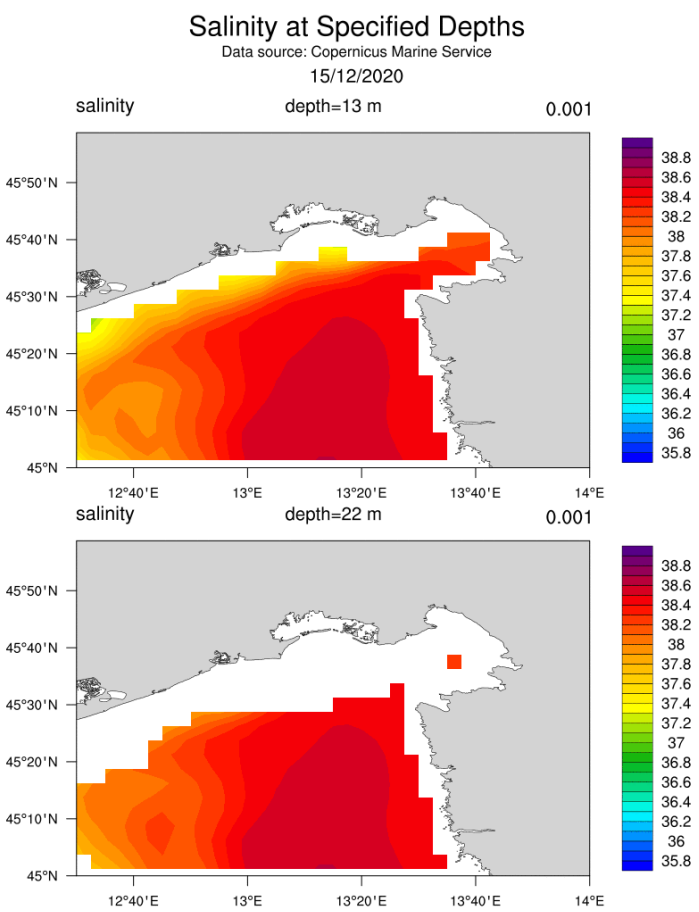


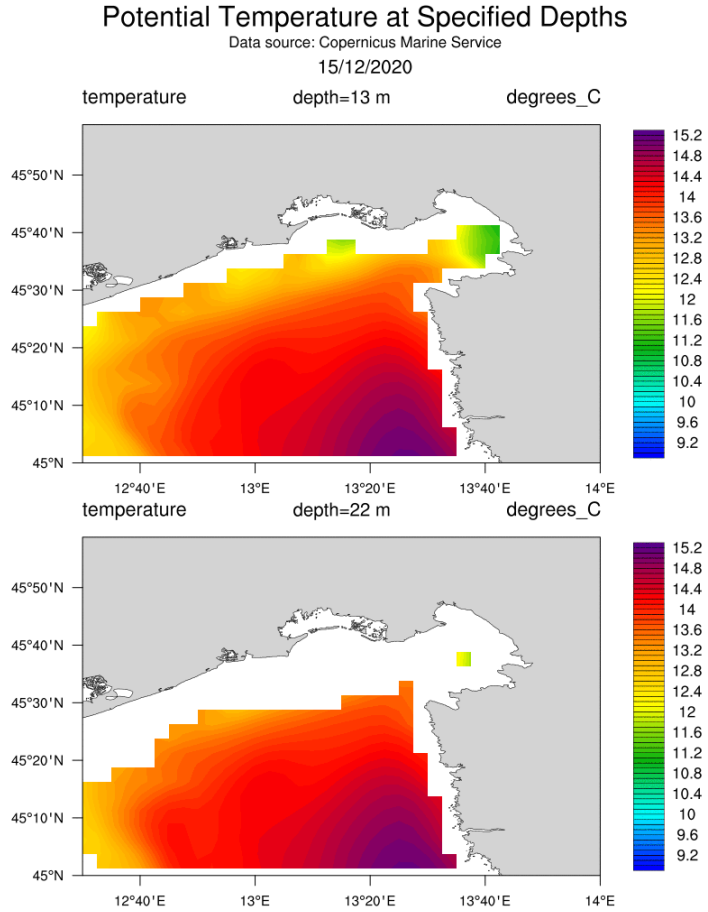
Interreg Italy - Croatia AdriaClim
European Regional Development Fund

EUROPEAN UNION

ARPA FVG
Agenzia Regionale per la Protezione dell'Ambiente del Friuli Venezia Giulia

Further Support, 2





15 December 2020 – 15 January 2021

STA-QMT & CRMA Cooperation

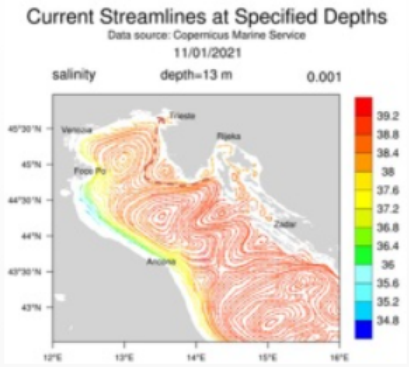
Gennaio 2021: masse d'acqua marina caratterizzate da alta salinità interessano il golfo di Trieste

24/02/2021

A gennaio di quest'anno le masse d'acqua costituenti il bacino del Golfo di Trieste hanno presentato una salinità particolarmente elevata rispetto alla norma.
Nel documento disponibile online Gennaio 2021: masse d'acqua marina caratterizzate da alta salinità interessano il golfo di Trieste vengono presentate sia osservazioni riferite al monitoraggio eseguito da Arpa FVG che il loro confronto con l'analisi della distribuzione delle correnti marine ottenute della modellistica oceanografica.

L'oceanografia del Golfo di Trieste, a causa di molteplici fattori, è estremamente variabile. La posizione geografica del golfo, tratto di mare Mediterraneo incassato tra terre a una latitudine relativamente elevata, la bassa batimetria associata a una morfologia asimmetrica a causa dei fondali occidentali più degradanti rispetto a quelli orientali, le forzanti meteorologiche, tra cui la forte differenza di temperatura tra inverno ed estate e l'azione degli intensi venti orientali (Bora), e, infine, l'afflusso di acque dolci associate alle portate fluviali, fanno si che le caratteristiche oceanografiche del golfo siano particolarmente dinamiche.

- Gennaio 2021: masse d'acqua marina caratterizzate da alta salinità interessano il golfo di Trieste



Distribuzione della corrente marina in relazione alla salinità

Gennaio 2021: masse d'acqua marina caratterizzate da alta salinità interessano il golfo di Trieste

Celio Massimo, Minigher Alessandro

Il monitoraggio svolto nel golfo di Trieste a metà gennaio ha evidenziato la presenza, soprattutto nell'area esterna e centro-orientale del bacino, di una massa d'acqua ad elevata salinità (Fig. 1, 2).

NCL Developed Scripts

```
;**************************************************************************
;
; DESCRIPTION:    this NCL script is inspired by the "iso_1.ncl" NCL script
;                 (NCL Graphics) which can be found at the following link:
;                 https://www.ncl.ucar.edu/Applications/iso.shtml
;                 This script is aimed at drawing a contour (salinity) plot
;                 over a map (longitude and latitude intervals are provided in
;                 the script), using "int2p_n_Wrap" (*) to interpolate
;                 salinity values to user specified depths. This is performed
;                 for each data file specified in an initialisation file.
;                 (*) https://www.ncl.ucar.edu/Document/Functions/Contributed/int2p_n_Wrap.shtml
;
; EXTERNAL CALLS: none.
;
; EXTERNAL FILES: - input NetCDF data files;
;                   (e.g. see in /lustre/arpa/AdriaClim/COPERNICUSData/PSAL)
;                 - initialisation file containing the full paths of the
;                   input NetCDF files to be considered. This file is
;                   formatted as follows:
;
;                   input NetCDF file 1
;                   input NetCDF file 2
;                   ...
;                   input NetCDF file N
;
;
; DEVELOPER:      Alessandro Minigher (alessandro.minigher@arpa.fvg.it)
;                 ARPA FVG - S.O.C. Stato dell'Ambiente
;                 "AdriaClim" Interreg IT-HR project
;
; CREATION DATE:  01/02/2021.
```

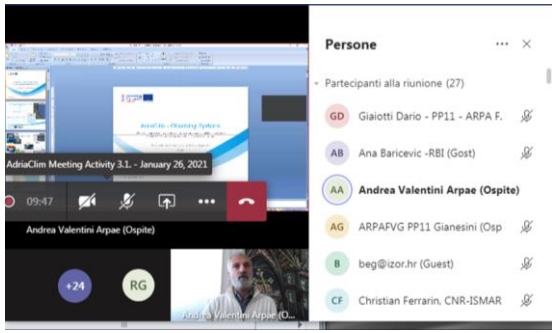
```
; Plot as many subplots as the number of specified depths

do kl=0,dimsizes(zlev_psal)-1

    ; Center string resources

    res@gsnCenterString = "~Z95~depth="+zlev_psal(kl)+" m"

    ; Streamline plot over a map: salinity and potential temperature

    plot_psal(kl) = gsn_csm_streamline_scalar_map(wks_psal,iso_u(0,kl,:,:),iso_v(0,kl,:,:),iso_psal(0,kl,:,:),res)
    plot_temp(kl) = gsn_csm_streamline_scalar_map(wks_temp,iso_u(0,kl,:,:),iso_v(0,kl,:,:),iso_temp(0,kl,:,:),res)

end do

; Draw multiple plots of identical size on a single frame: salinity

gsn_panel(wks_psal, plot_psal, (/2,1/), resP)

; Set text string resources to draw title and subtitles in panel's top
; added space

txres = True                    ; set text resources
txres@txJust = "BottomCenter"   ; set justification point of text item

; Title

txres@txFontHeightF = 0.022                     ; set text height
title = "Current Streamlines at Specified Depths"   ; set title
gsn_text_ndc(wks_psal,title,0.5,0.95,txres)             ; draw title

; First subtitle

txres@txFontHeightF = 0.012                         ; set text height
subtitle1 = "Data source: Copernicus Marine Service"   ; set subtitle
gsn_text_ndc(wks_psal,subtitle1,0.5,0.93,txres)             ; draw subtitle
```

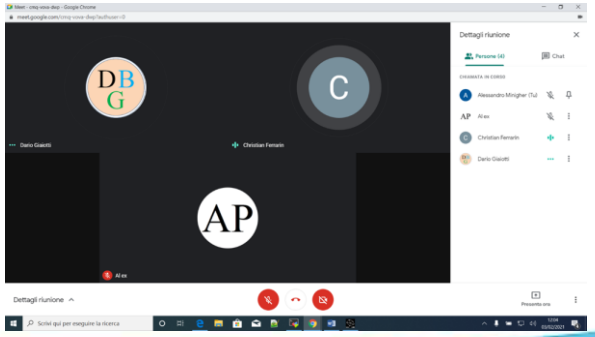
```
; For every data file to be considered

do i=0,dimsizes(input_files)-1

    ; Opening attempt to the i-th external NetCDF file in reading mode

    f = addfile(input_files(i),"r")

    ; Extraction of data to be used

    temp = f->thetao      ; potential temperature
    z_temp = f->depth     ; depth
    time = f->time    ; date and time

    ; Date and time conversions: from "minutes since 1900-01-01 00:00:00" to
    ; "standard" calendar (YYYYMMDD format)

    t = cd_calendar(time,-2)

    ; Year, month and day extraction

    t_split = (/4,2,2/)                     ; string slicing directives
    dt = str_split_by_length(t, t_split)    ; string slicing
    year = tostring(dt(0))                  ; year extraction (to string
                                            ; conversion)
    month = tostring(dt(1))                 ; month extraction (to string
                                            ; convertion)
    day = tostring(dt(2))                   ; day extraction (to string
                                            ; convertion)

    ; Date formatting

    date = day+"/"+month+"/"+year         ; to be used in plot's subtitles
    date_plot = year+"-"+month+"-"+day    ; to be used to rename output immages

    ; Interpolation of data to be plotted to the specified (constant) depths:

    zlev = (/ depth1, depth2 /)                         ; Depth specification
    zlev@units = z_temp@units                           ; Set the specified
                                                        ; depth's units to
```

Meetings & Seminars

Internal to ***AdriaClim***:

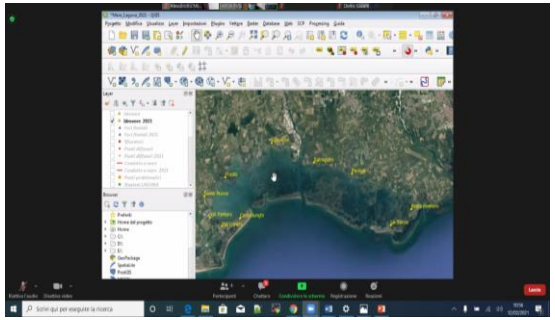
- first **meeting** on **Activity 3.1** → *design and implementation of the observing systems*
- **ISMAR-CNR** → definition of **SHYFEM** simulation **details**





Internal to **ARPA FVG**:

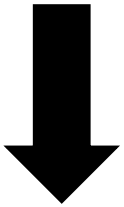
- **CRMA**
- INTERREG IT-HR ***CASCADE*** project → *measurements and model outputs integration*



Future Developments

The **future developments** of these activities are:

- **enhancement** of the **support** to monitoring **campaigns** → **operational service**
- **operational introduction** of **SHYFEM** model in *AdriaClim* (and *CASCADE*) projects → **high resolution simulations** of the future state of the northernmost part of the Adriatic Sea (**Gulf of Trieste** and **Marano-Grado lagoon**)



Protection of **Adriatic Coasts** and **Adaptation** to **Climate Change**

CONTACT INFORMATION

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