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State of Progress of the Modelling Activities

Implementation of SHYFEM for FVG Pilot Area

AdriaClim| PP11 - ARPA FVG | A. Minigher

Internal Meeting - Online | 15th December 2021

European Regional Development Fund

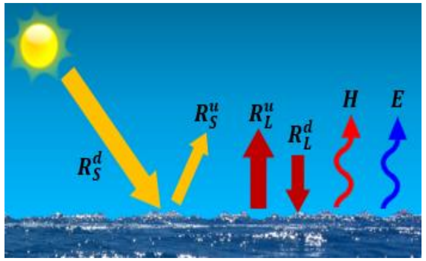
Outline

- **Introduction**
- Current **Problems** & **Solutions**
- **Annual Simulation**
- **Spin-up Time** of the **Modelling System**
- 9th **SISC Annual Conference**
- **Future Developments**

Forcing for SHYFEM

The **dynamics** of the **Pilot Area** (i.e. **Gulf of Trieste** & **Marano and Grado lagoon**) is mainly **determined** by the **interplay** of:

sea surface heat fluxes

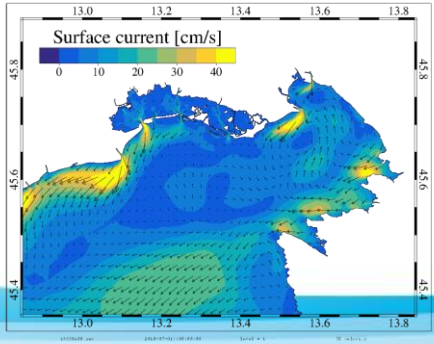


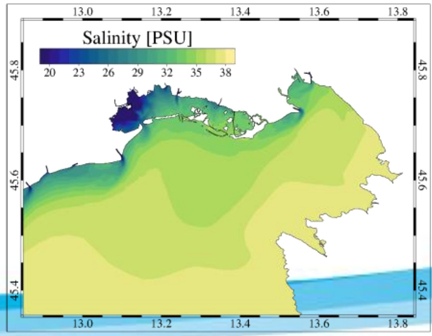
sea surface wind stress

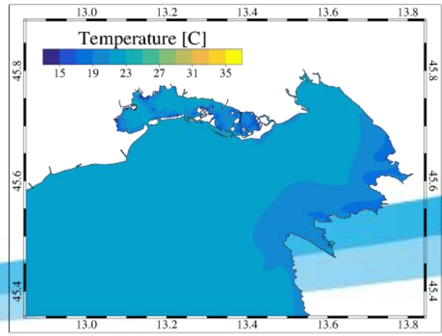
riverine freshwater input

control from Adriatic Sea

S.H.Y.F.E.M
Shallow water Hydrodynamic Finite Element Model







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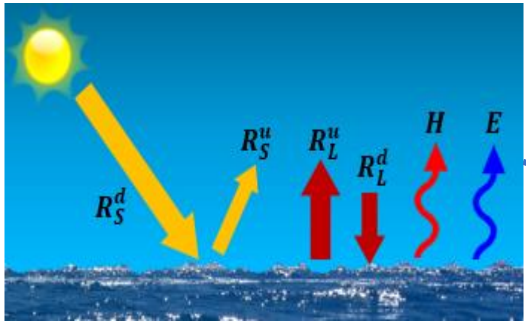
Sea Surface Heat Fluxes – Two Options for SHYFEM

There are **2 options** for **SHYFEM** to compute the sea surface **heat balance**:

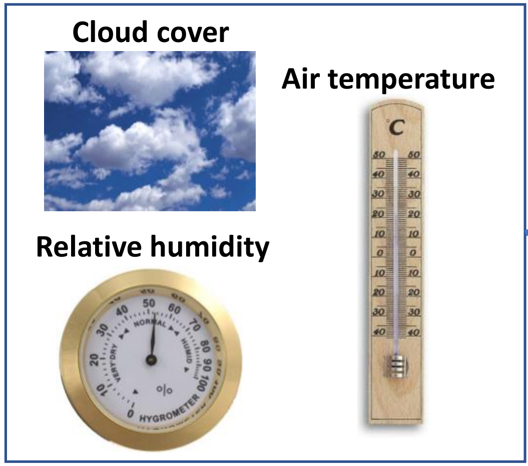
1)

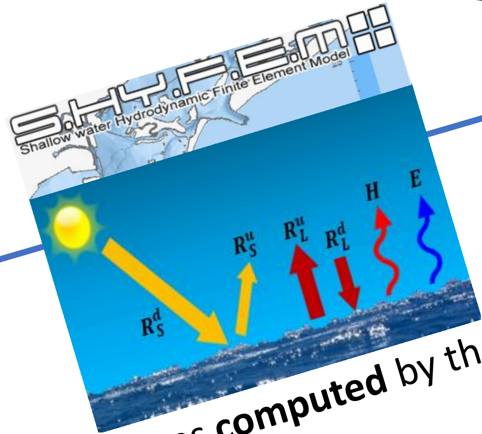


heat fluxes **directly provided** to the model

$$Q_{tot} = Q_s - (Q_l + Q_h + Q_e)$$

2)

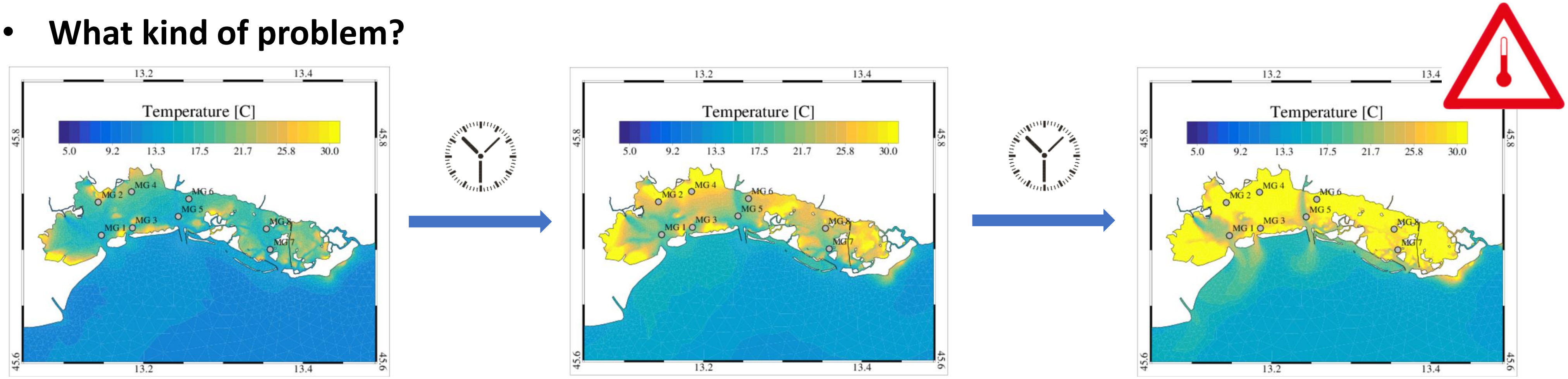




heat fluxes **computed** by the model

Sea Surface Heat Fluxes – Current Problems (1/2)

- **What kind of problem?**



- **What is the cause?**

heat fluxes incorrectly read by SHYFEM – **option 1)**

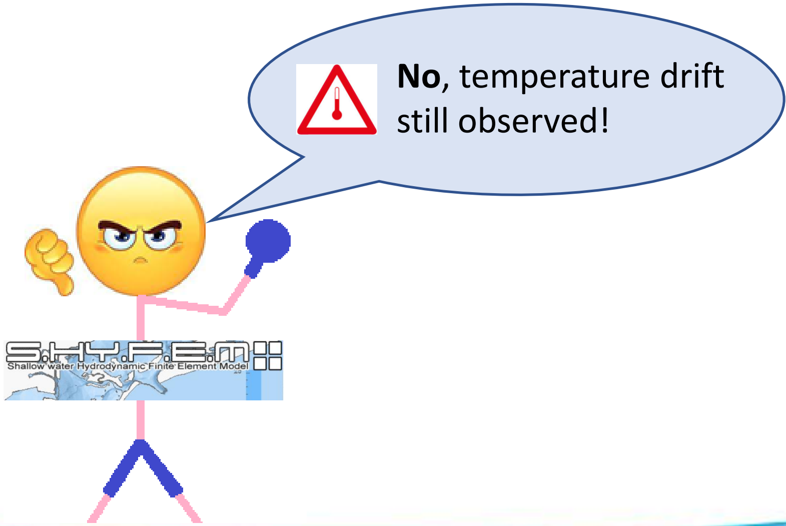
Sea Surface Heat Fluxes – Current Problems (2/2)

- **What is the solution?**

```
cc = max(0.,cc)
cc = min(1.,cc)
rh = max(0.,rh)
rh = min(100.,rh)
```

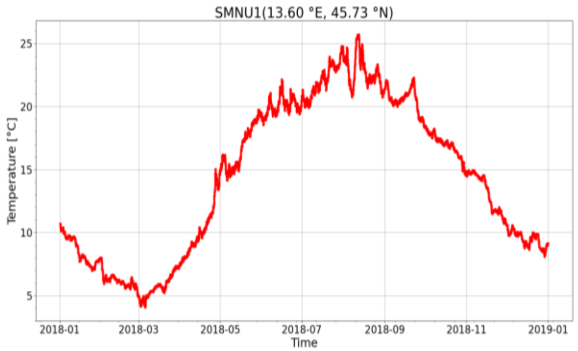
```
! BUG FIX

if ( iheat .ne. 7 ) then
    cc = max(0.,cc)
    cc = min(1.,cc)
    rh = max(0.,rh)
    rh = min(100.,rh)
endif
```

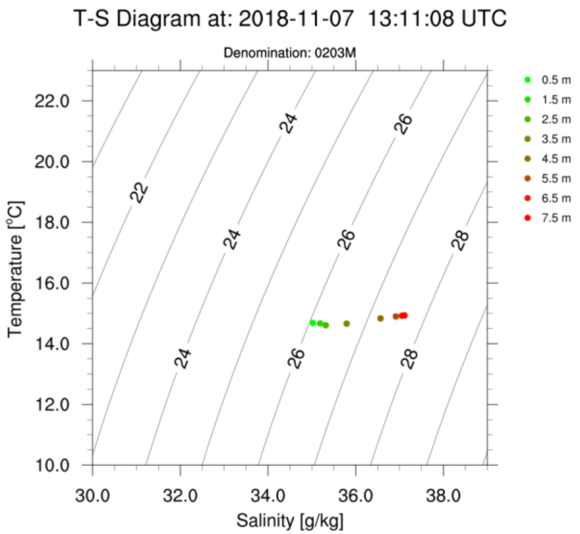
- **All solved?**

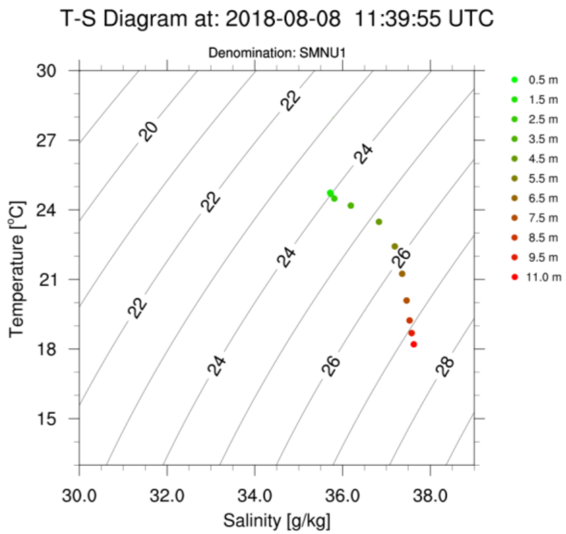


To be continued…

Annual Simulation







By implementing **SHYFEM** with **option 2)**, we performed an **annual** hindcast **simulation** (year 2018):

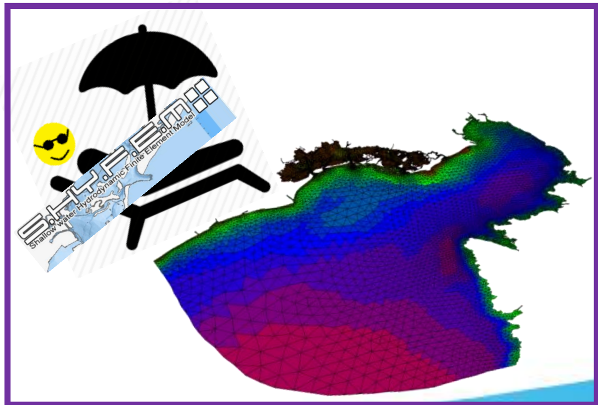
- **benchmark**
- **already subjected** to **validation**
- **big dataset** carrying a lot of information
  - → **1 year** of **hourly** data ($\boldsymbol{T}$, $\boldsymbol{S}$ & $\vec{\boldsymbol{v}}$), in **18˙311** different **locations**
  - → **1 year** of **high frequency** (**15 minutes**) data ($\boldsymbol{T}$, $\boldsymbol{S}$ & $\vec{\boldsymbol{v}}$), in **46** desired **locations**
- important either for **AdriaClim** (starting point for **sensitivity runs**), **CASCADE** (**characterization** of the **Pilot Area**) and **FIRESPILL** (**oil spill** simulations)

Spin-up Time of the Modelling System – Intro (1/2)

- Oceanographic **models** are generally characterized by an **initial time period**, during which they attempt to **stabilize** and **relax** from initial and boundary conditions (**spin-up time**)
- This time period is characterized by **unreliable results** → usually **discarded**
- Its **length** may **depend** on **several factors** (e.g. model and size of the study site)
- An **accurate knowledge** of the **relaxation** of the **modelling system** allows to consider a **tailored** initial time **period to discard**, hence to:

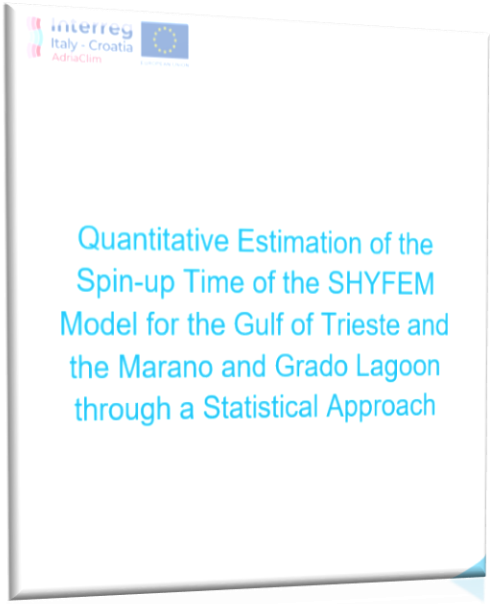
1) save HPC resources

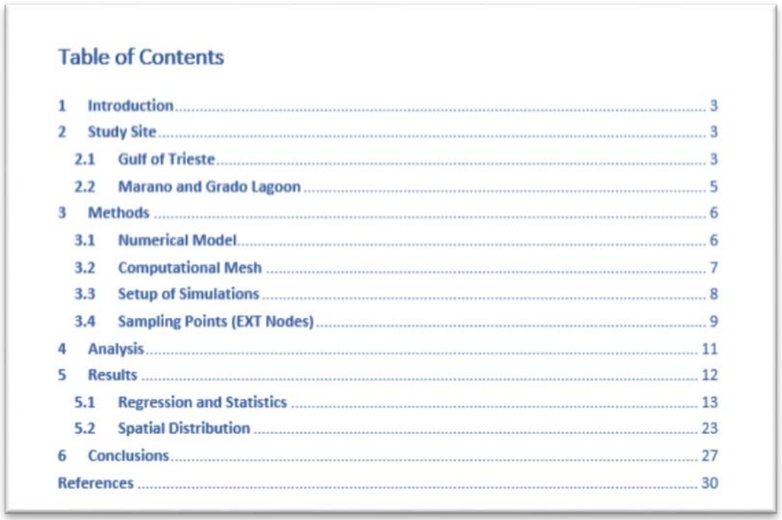
2) ensure the relaxation of the system



Spin-up Time of the Modelling System – Intro (2/2)

- Therefore, we carried out a **detailed study** on the **relaxation** of our modelling system (i.e. **SHYFEM** + **Gulf of Trieste** & **Marano and Grado lagoon**), by means of a **statistical approach**, to obtain a **quantitative** estimation of **spin-up time**





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Spin-up Time of the Modelling System – Methods

- **4 simulations** (hindcast), **sharing** the same **setup** of the model and **input dataset**, but **starting** on **different dates**

Season	Simulation	Start [YYYY-MM-DD]	
Winter	1995F100A1_A020	2018-01-01	$\Delta t = 10\ days$
	1995F100A1_A021	2018-01-11	
Summer	1995F100A1_A022	2018-07-01	$\Delta t = 10\ days$
	1995F100A1_A023	2018-07-11	

- **46 nodes** (of the 3D computational mesh) in which **simulations** are **compared**, **two by two**
- **5 variables** for which comparison is carried out (**sea temperature**, **salinity**, **eastward** and **northward sea water velocity** & **water level**)
- **2 seasons** investigated (**winter** & **summer**)

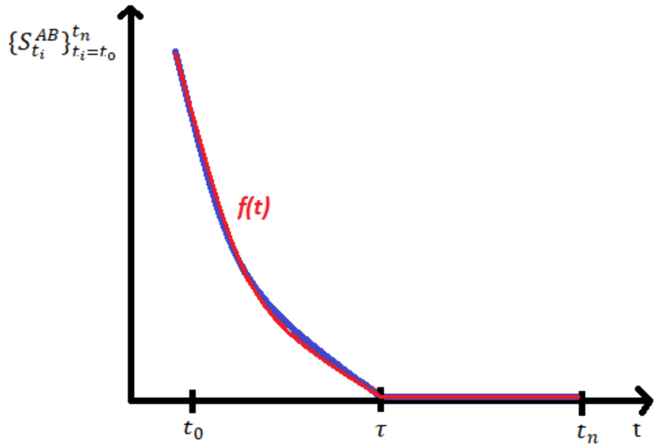
Spin-up Time of the Modelling System – Analysis

- Let $\boldsymbol{A}$ and $\boldsymbol{B}$ be the two **simulations** to be compared, for a **variable** $\boldsymbol{V}$
- Let us compute the **absolute value** of the **difference** between $\boldsymbol{V^A}$ and $\boldsymbol{V^B}$, at **time** $\boldsymbol{t_i}$ ($\in [t_0, t_n]$, i.e. the **time period shared** by A and B):

$$D_{t_i}^{AB} \equiv \left| V_{t_i}^{A} - V_{t_i}^{B} \right|$$

- Let us now **sum** all the **differences**, **from** $\boldsymbol{t_i}$ **onwards**:

$$S_{t_i}^{AB} \equiv \sum_{t=t_i}^{t_n} D_t^{AB}$$



- Finally, let us consider the **time series** $\boldsymbol{\{S_{t_i}^{AB}\}_{t_i=t_0}^{t_n}}$
- We choose the following **regression function**:

$$\boldsymbol{f(t)} \equiv \begin{cases} at^2 + bt + c & t < \tau \\ k & t \geq \tau \end{cases} \quad (k = a\tau^2 + b\tau + c \text{ by continuity})$$

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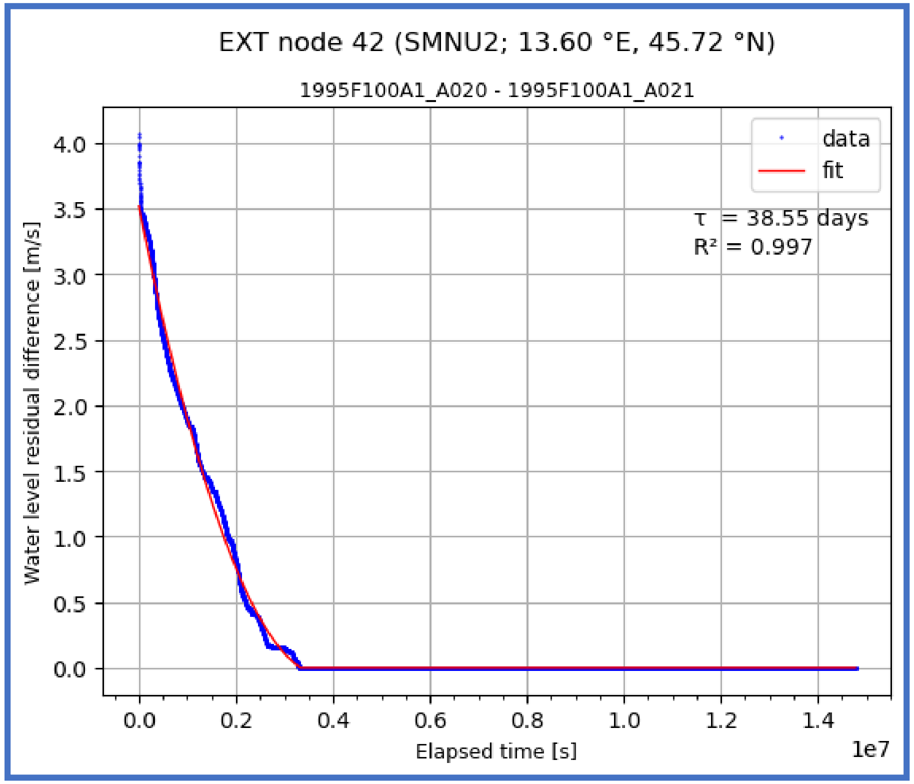
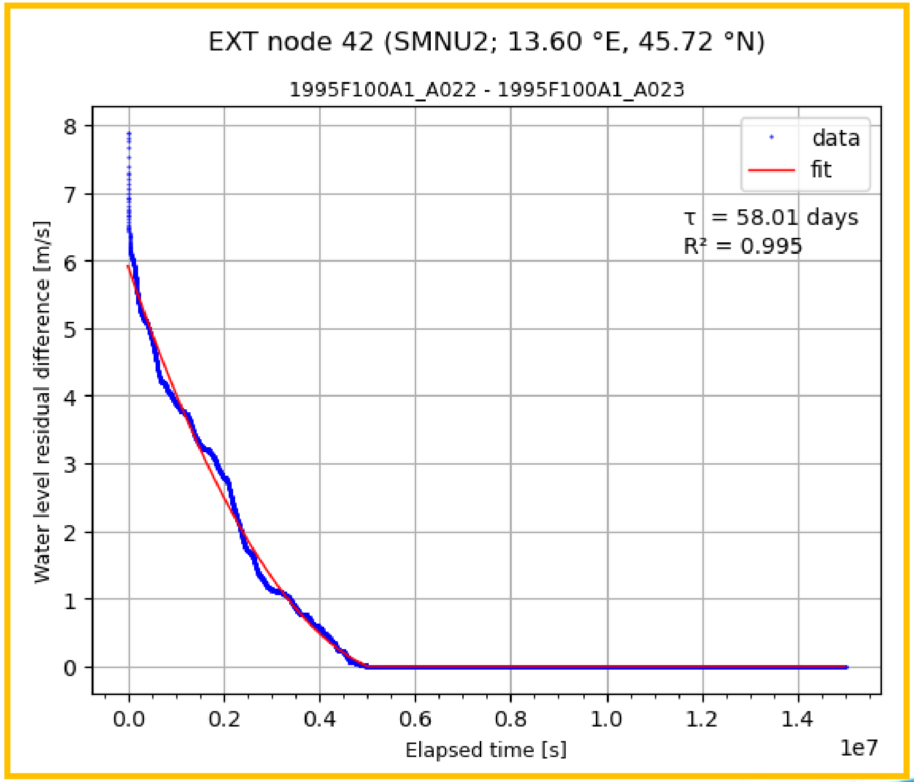
Spin-up Time of the Modelling System – Results (1/2)

Winter



Summer



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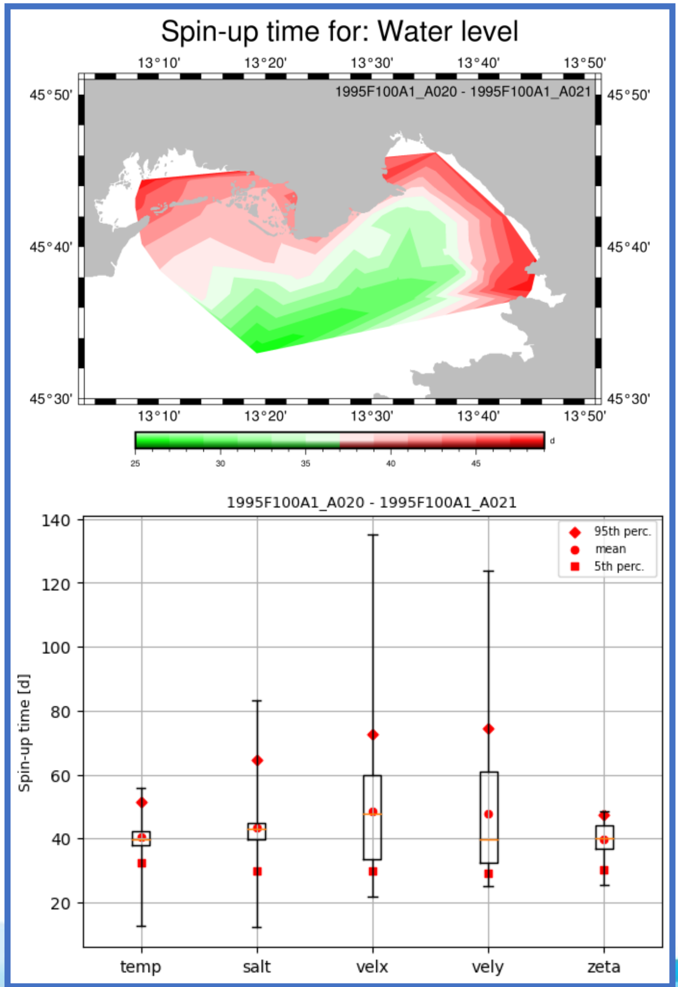
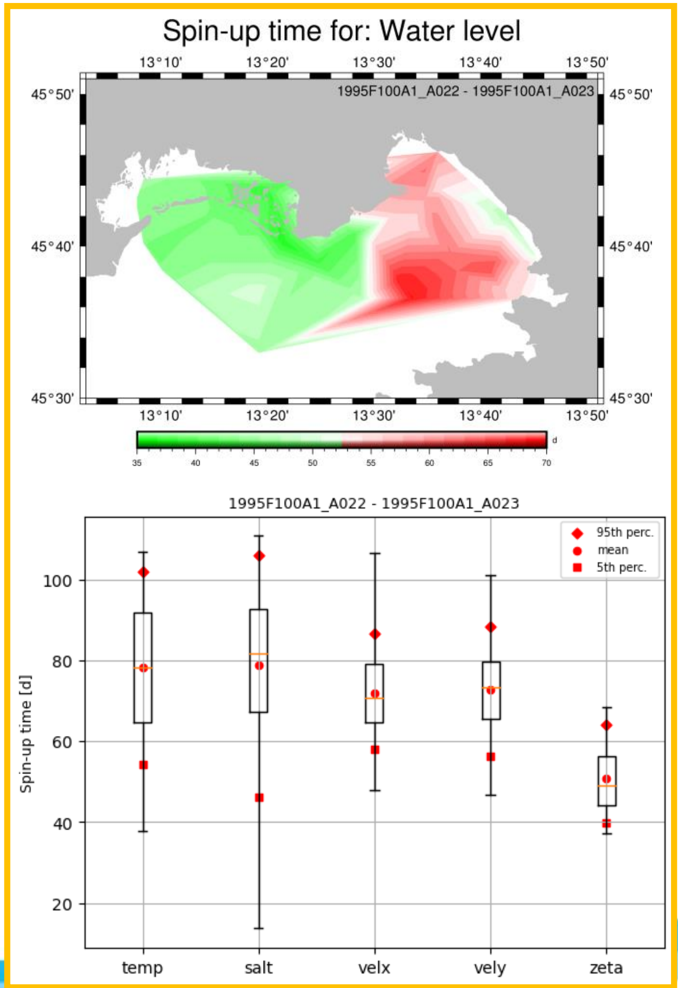
Spin-up Time of the Modelling System – Results (2/2)

Winter



Summer



- **Spin-up** time has a strong **seasonal** and **spatial character**
- **Relaxation** is generally **faster** in **winter**
- **Salinity** and sea water **velocity struggle to relax** completely
- $\tau = \begin{cases} (50 \pm 10)\ days & winter \\ (80 \pm 20)\ days & summer \end{cases}$

9th SISC Annual Conference

A. Acquavita, M. Bagnarol, C. Ferrarin, F. Flapp, D. GIAIOTTI, E. Gianesini, D. Guiatti, S. Martini, E. Marini, A. Minigher, C. Moro, M. Pittis

Towards Local Scale Scenarios of Coastal Climate Change in the Northern Adriatic Area

F. Flapp, L. Gover, E. Sfiligoi, M. Arteni, S. Ursella, D. GIAIOTTI, E. Gianesini, A. Minigher, A. Pividori, M. Bagnarol, S. Martini, A. Acquavita

A Novel Approach in Supporting the Local Authorities to Define Adaptation Actions to Climate Change

3 oral **presentations** at the 9th **SISC** (Società Italiana per le Scienze del Clima) **Annual Conference**, including a study on ***"Recent Trends and Future Perspectives of Upwelling Events in the Gulf of Trieste"***, showing that:

- **upwelling** and **Bora** wind episodes are **strictly related**
- summer **Bora** wind episodes **lasting** more than about **12 hours** effectively **mix** the **water column**
- it is possible to use the **mean sea level pressure gradient** at the **synoptic** scale as **proxy** for the identification of **Bora** wind episodes at the **local** scale
- there were **no trends** in coastal **upwelling** episodes in the **last 19 years** (**same results** for both **summer** and **winter**)
- **downscaling** of **mean sea level pressure gradient** can be used for **climatic projections** of future trends in **coastal upwelling** episodes (**EURO-CORDEX** data, **AdriaClim** project)

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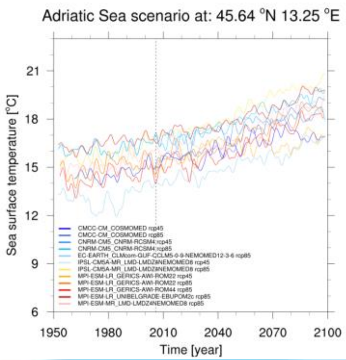
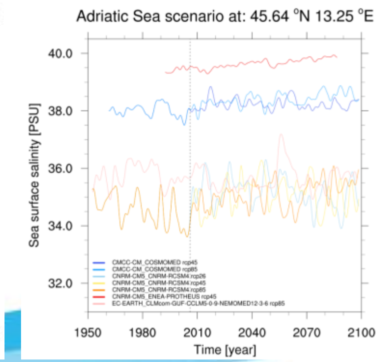
Future Developments

- **Solution** of SHYFEM **problems** with sea surface **heat fluxes**
- **Validation** and **calibration** of SHYFEM through **ARPA FVG** oceanographic **measurement campaigns**
- **Implementation** of the **ARPA FVG** marine **forecasting system** for the Pilot Area
- **Annual Runs** of SHYFEM, for the years 2030, 2040, 2050 etc., starting from:
  1) **CMCC climatic projections** (RCP 8.5)
  2) **perturbed boundary conditions** (and meteorological forcing), according to **MED-CORDEX climatic projections** (RCPs 4.5 and 8.5)





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