STATE OF PROGRESS OF THE MODELING ACTIVITIES

SHYFEM and Climate Scenarios

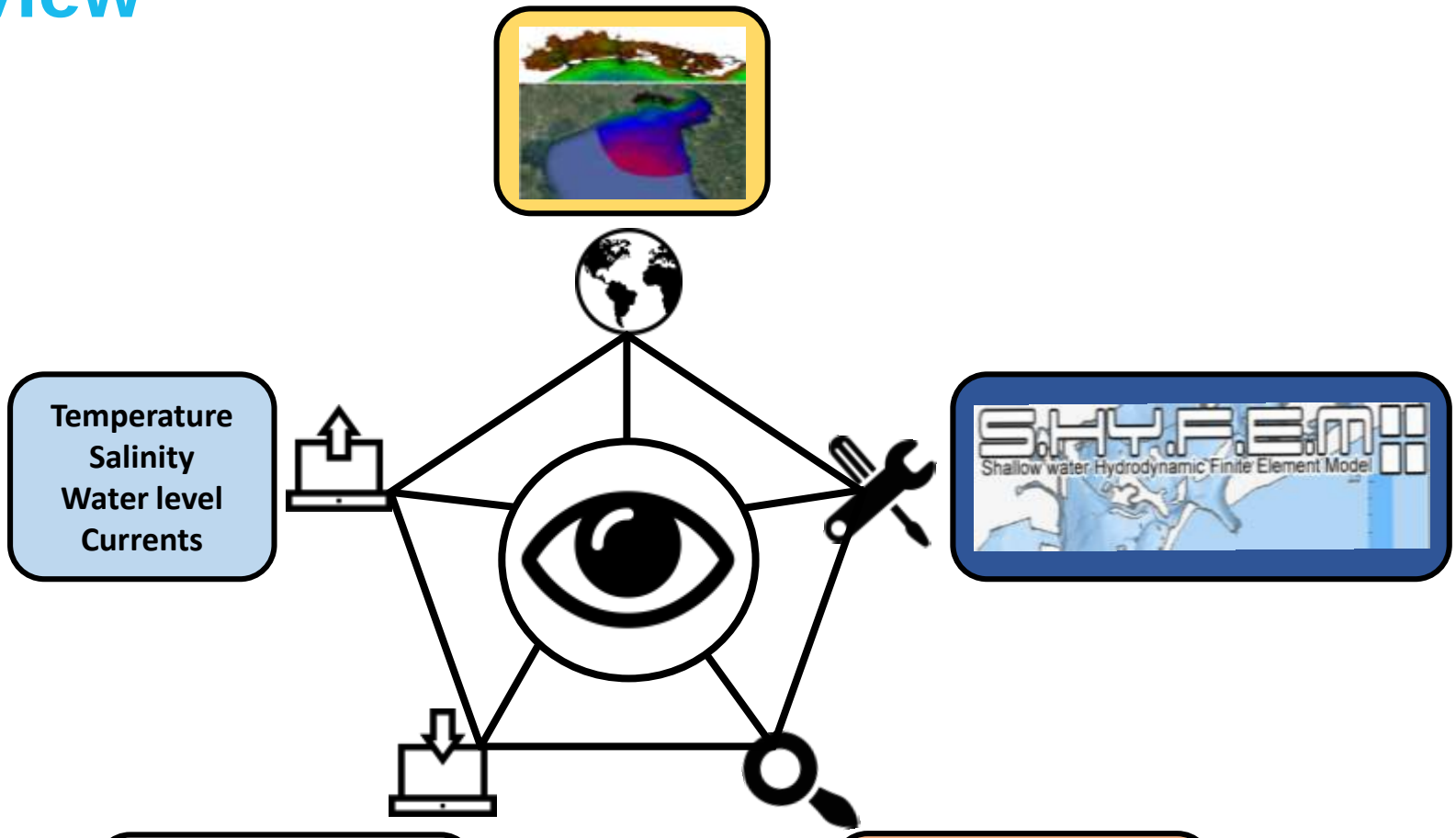
AdriaClim| PP11 | ARPA FVG

Alessandro Minigher

Internal meeting | Palmanova | 12 October 2022

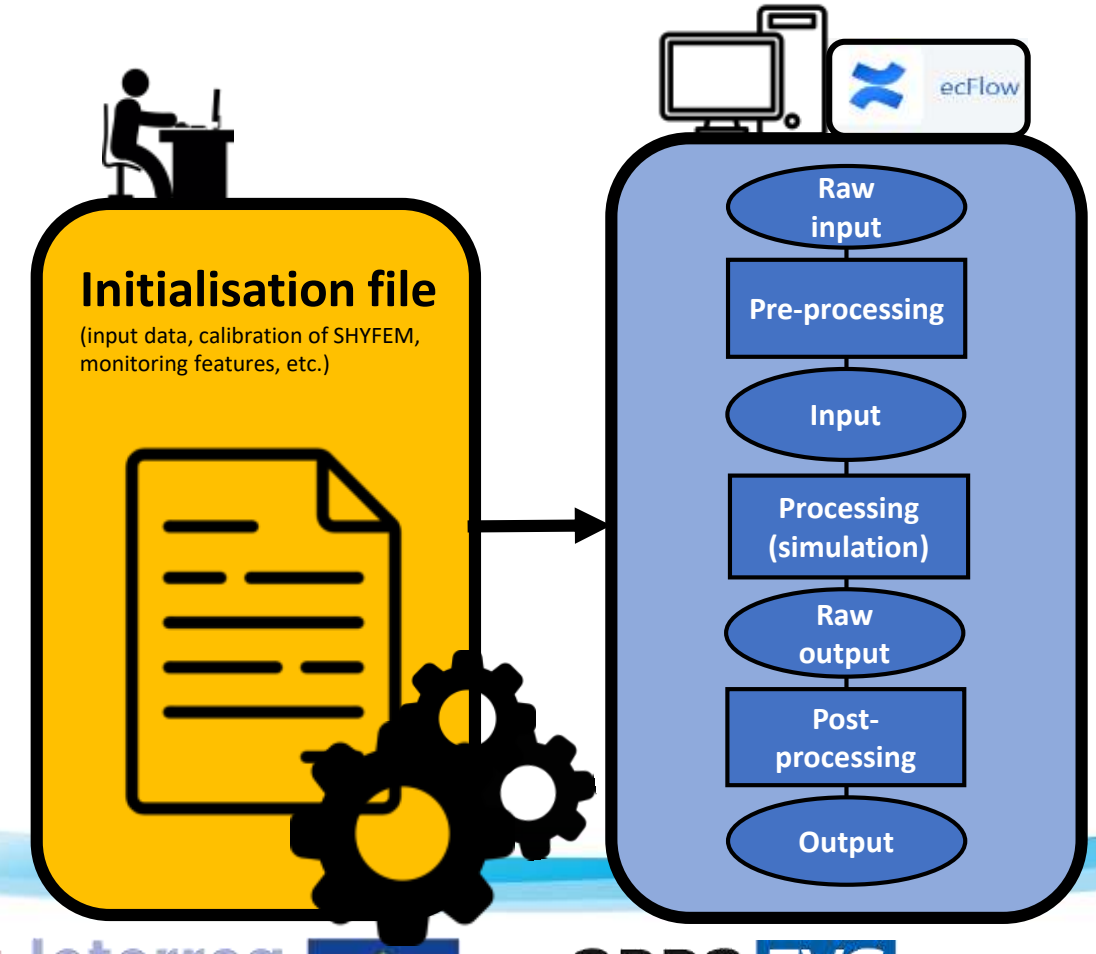
European Regional Development Fund

Overview


Temperature
Salinity
Water level
Currents
SHYFEM
Shallow water Hydrodynamic Finite Element Model
Marine (temperature, salinity, water level, currents)
Meteo (wind, surface pressure, solar radiation, temperature and specific humidity at 2 m, cloud cover, precipitation)
Hydro (rivers' runoff)
From 4 km (open sea) to tens of meters (lagoon channels)

Computational flows: automation of simulations, pre- and post- processing

We adopted an approach that involves the development and use of **computational flows**



ADVANTAGE

Automation
(the user choses the setting, the machine does the rest)

Time saving
(to be employed in other activities)

Monitoring
(web page)

Human errors prevention
(e.g. copy and paste)

Close to operative activities
(e.g. weather forecasts)

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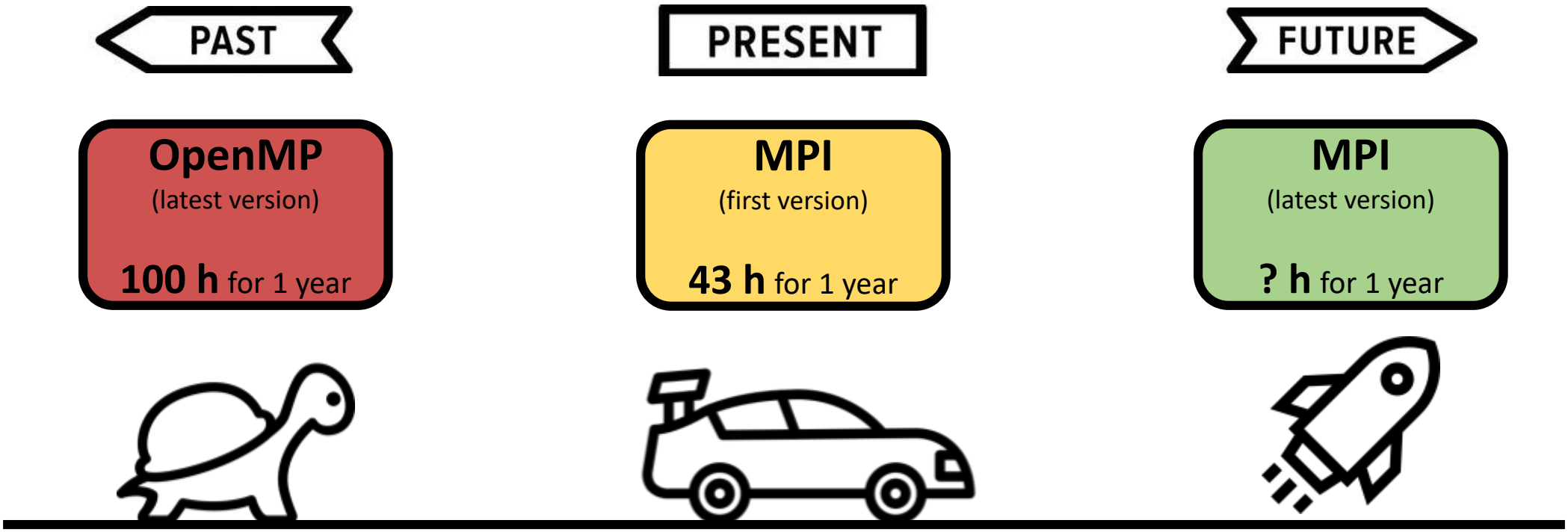
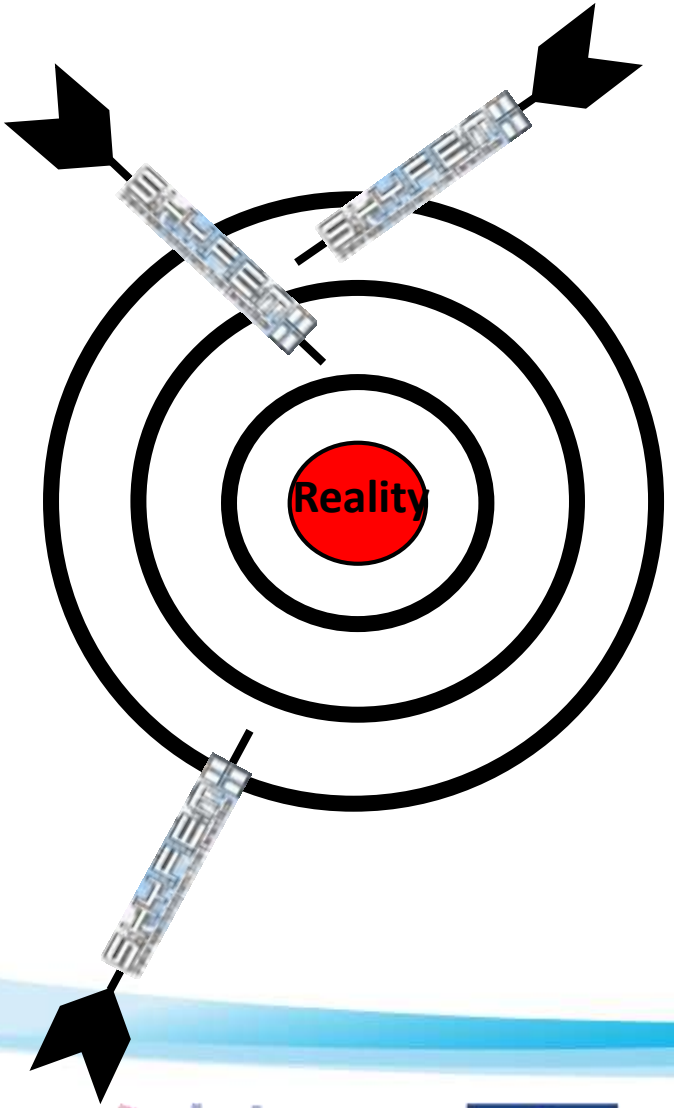
SHYFEM: from OpenMP to MPI



Calibration of SHYFEM: introduction

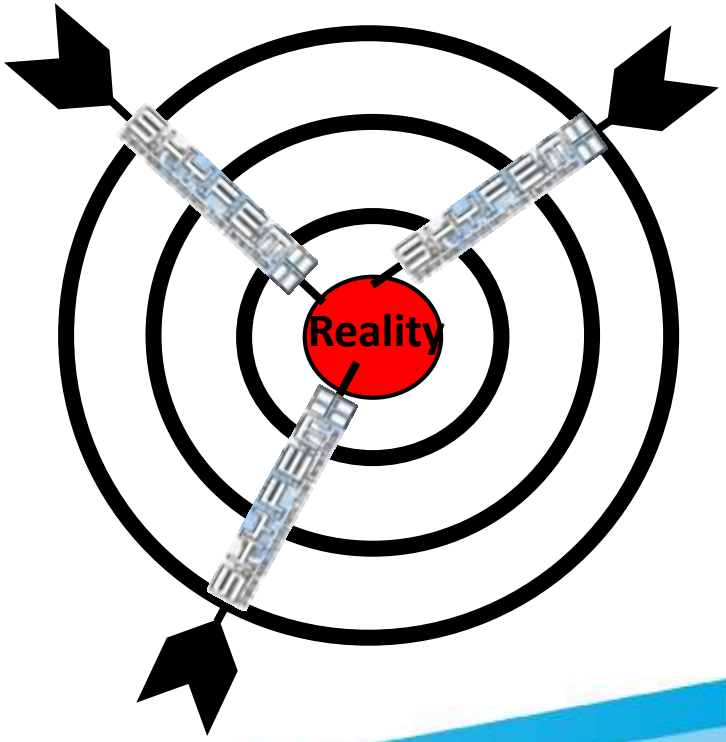


calibrate SHYFEM, i.e. find the best configuration of the model, in order to represent reality

run **multiple simulations**, sharing the **same inputs**, but with **different configurations**

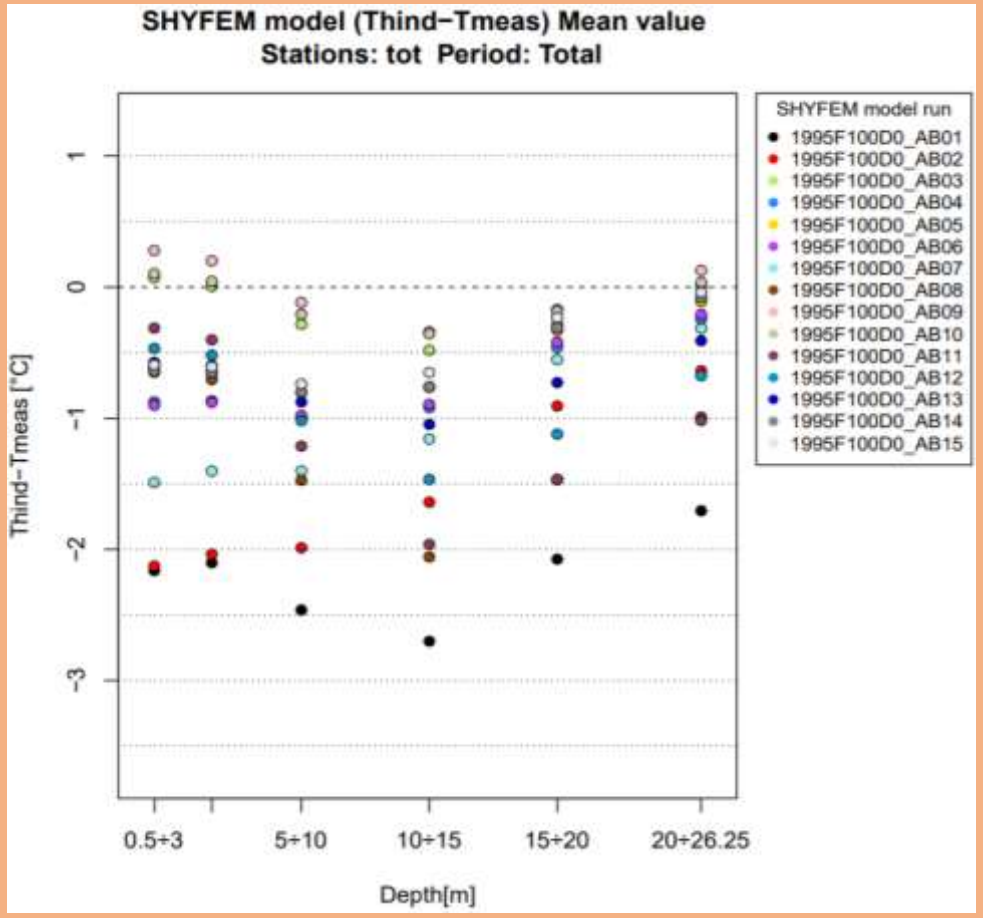
compare **simulations** and **measurements**

Usually, the best simulation (calibration) cannot be found (in absolute sense); it depends on the use of the model

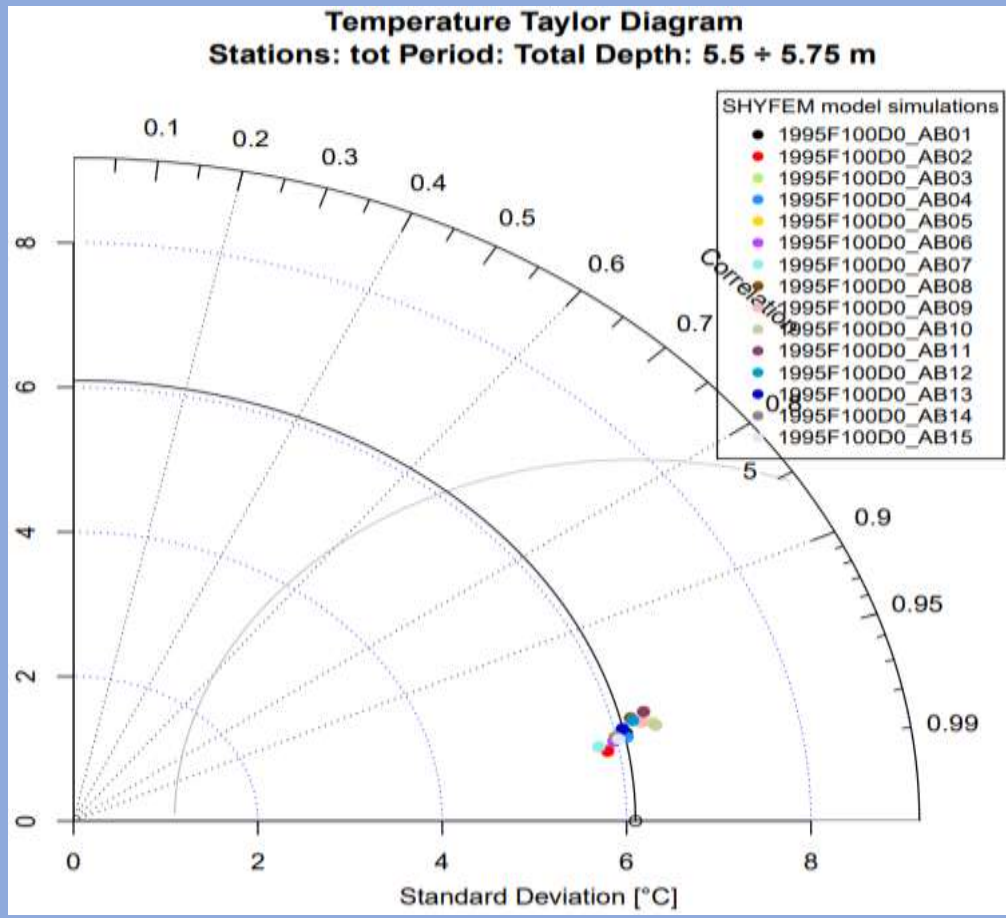


Calibration of SHYFEM: temperature & salinity

Bias

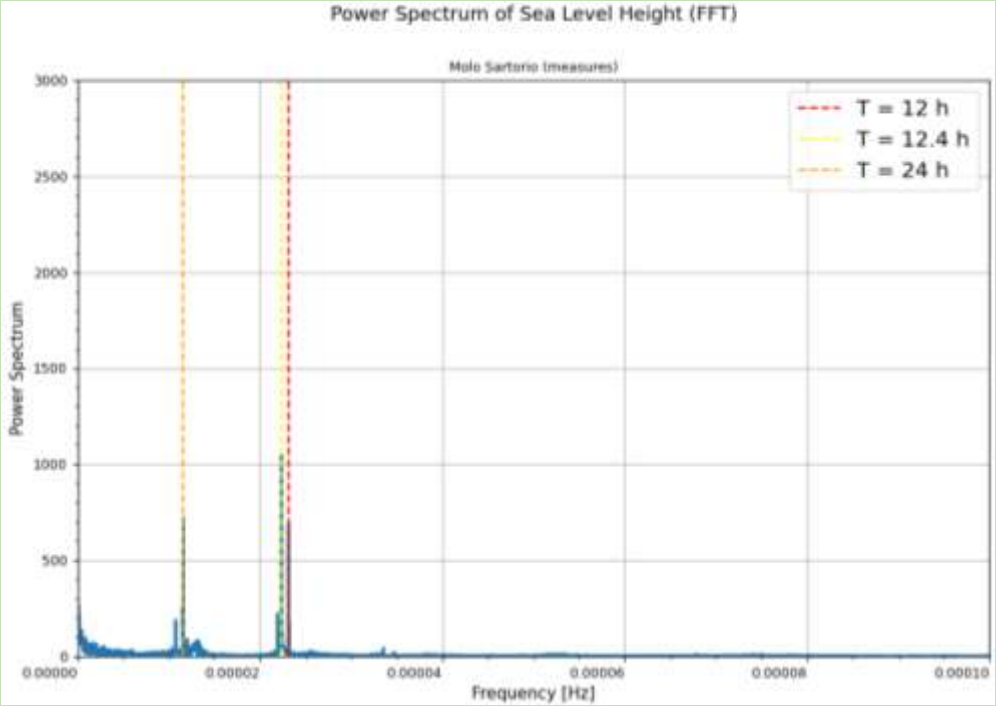


Correlation

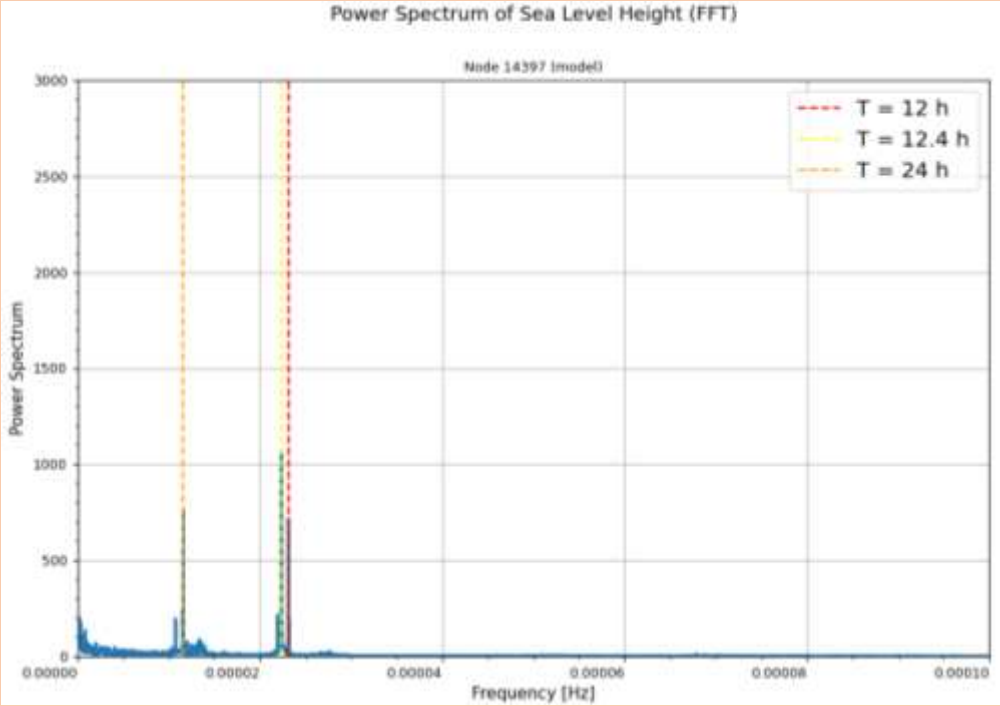


Calibration of SHYFEM: water level

Measurements



Model



T_1 = **12.42 h (M2, principal lunar)**
T_2 = **23.93 h (K1, luni-solar diurnal)**
T_3 = **12.00 h (S2, principal solar)**

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Climate scenarios of Bora episodes: intro

Is there any **trend** in the frequency of **Bora wind** episodes that will blow on the **Gulf of Trieste** in the **XXI century**?

EURO-CORDEX
EUR-11, 0.11°

3 RCPs (2006÷2100)
2.6, 4.5, 8.5

14 simulations
ensemble

Sea level pressure
daily resolution

2 points
A := (13.5653 °E, 45.6182 °N)
B := (16.1323 °E, 47.6575 °N)

Geostrophic wind

$$\vec{v}_g = \frac{\hat{k}}{\rho f} \times \vec{\nabla} p_{BA}$$

Local wind

$$|\vec{v}_g| = a|\vec{v}_l|^2 + b|\vec{v}_l| + c$$

2 wind thresholds
5 m s^{-1}, 10 m s^{-1}

3 seasons
full year (Jan÷Dec), Summer (Jun÷Sep), Winter (Nov÷Feb)

Statistics
ensemble statistics and linear corr. (on episodes n.)

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Climate scenarios of Bora episodes: results

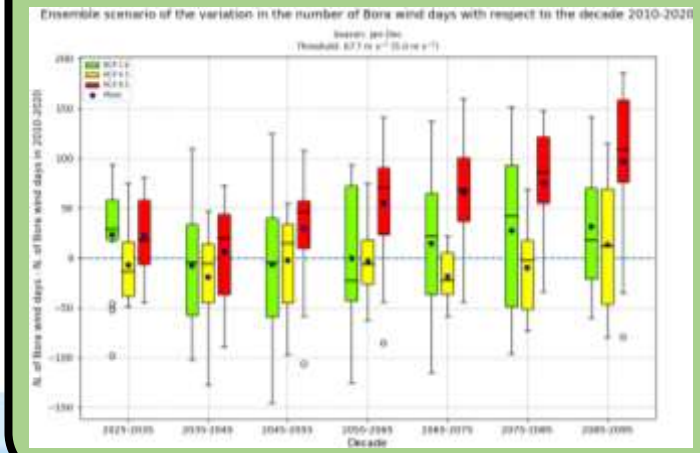
Trends on medians (α=0.05)

5 m s^{-1}

- **RCP2.6**: no trends
- **RCP4.5**: no trends
- **RCP8.5**: **1.5 days year^{-1}** (p-value=0.00)

10 m s^{-1}

- **RCP2.6**: no trends
- **RCP4.5**: no trends
- **RCP8.5**: **0.5 days year^{-1}** (p-value=0.02)



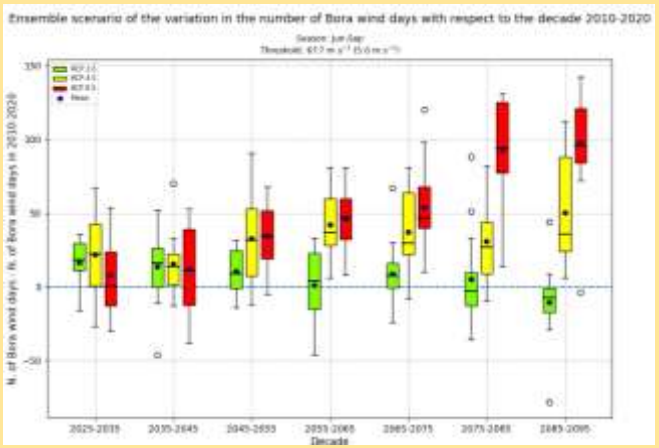
Trends on medians (α=0.05)

5 m s^{-1}

- **RCP2.6**: **-0.4 days year^{-1}** (p-value=0.00)
- **RCP4.5**: no trends
- **RCP8.5**: **1.7 days year^{-1}** (p-value=0.00)

10 m s^{-1}

- **RCP2.6**: **-0.2 days year^{-1}** (p-value=0.01)
- **RCP4.5**: no trends
- **RCP8.5**: **0.6 days year^{-1}** (p-value=0.00)



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- **RCP2.6**: no trends
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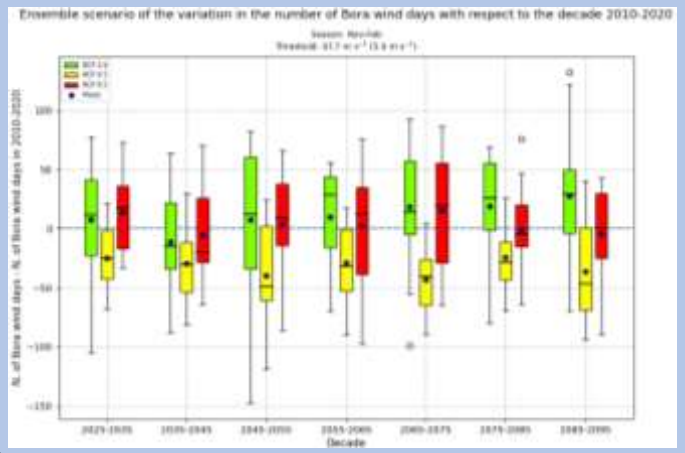
- **RCP8.5**: no trends



Climate scenarios of Scirocco episodes: intro

Is there any **trend** in the frequency of **Scirocco wind** episodes that will blow on the **northern Adriatic Sea** in the **XXI century**?

EURO-CORDEX
EUR-11, 0.11°

3 RCPs (2006÷2100)
2.6, 4.5, 8.5

14 simulations
ensemble

Sea level pressure
daily resolution

2 points
A := (13.2348 °E, 45.6088 °N)
B := (14.4941 °E, 43.0646 °N)

Geostrophic wind
$\vec{v}_g = \frac{\hat{k}}{\rho f} \times \vec{\nabla} p_{BA}$

Local wind
$|\vec{v}_g| = m|\vec{v}_l| + q$

2 wind thresholds
5 m s^{-1}, 10 m s^{-1}

3 seasons
full year (Jan÷Dec), Summer (Jun÷Sep), Winter (Nov÷Feb)

Statistics
ensemble statistics and linear corr. (on episodes n.)

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Climate scenarios of Scirocco episodes: results

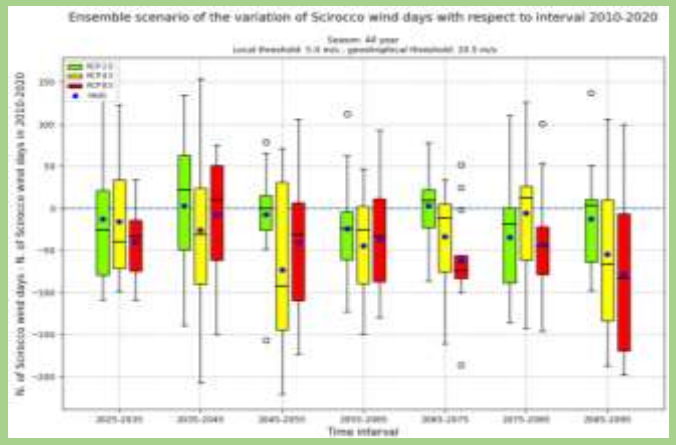
Trends on medians (α=0.05)

5 m s^{-1}

- **RCP2.6**: no trends
- **RCP4.5**: no trends
- **RCP8.5**: **-1.1 days $year^{-1}$** (p-value=0.05)

10 m s^{-1}

- **RCP2.6**: no trends
- **RCP4.5**: no trends
- **RCP8.5**: **-0.5 days $year^{-1}$** (p-value=0.04)



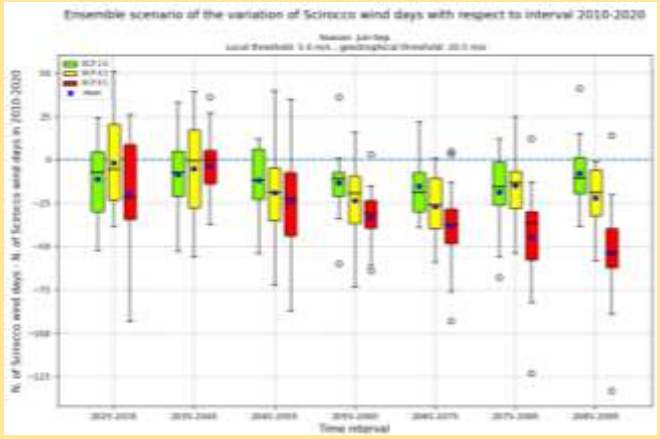
Trends on medians (α=0.05)

5 m s^{-1}

- **RCP2.6**: no trends
- **RCP4.5**: no trends
- **RCP8.5**: **-0.7 days $year^{-1}$** (p-value=0.02)

10 m s^{-1}

- **RCP2.6**: no trends
- **RCP4.5**: no trends
- **RCP8.5**: no trends



Trends on medians (α=0.05)

5 m s^{-1}

- **RCP2.6**: no trends
- **RCP4.5**: no trends
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10 m s^{-1}

- **RCP2.6**: no trends
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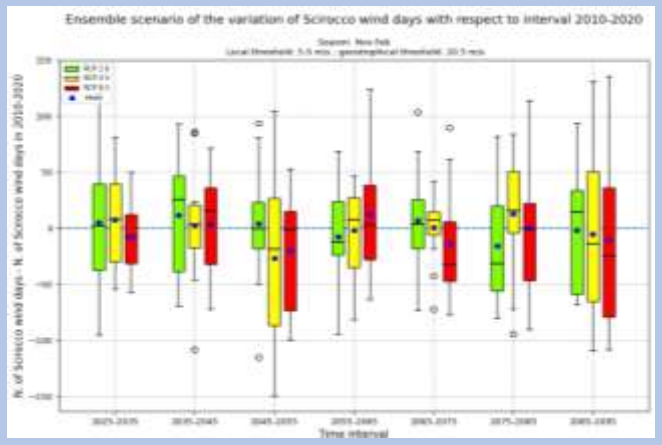
- **RCP8.5**: no trends



Climate sensitivity tests: introduction

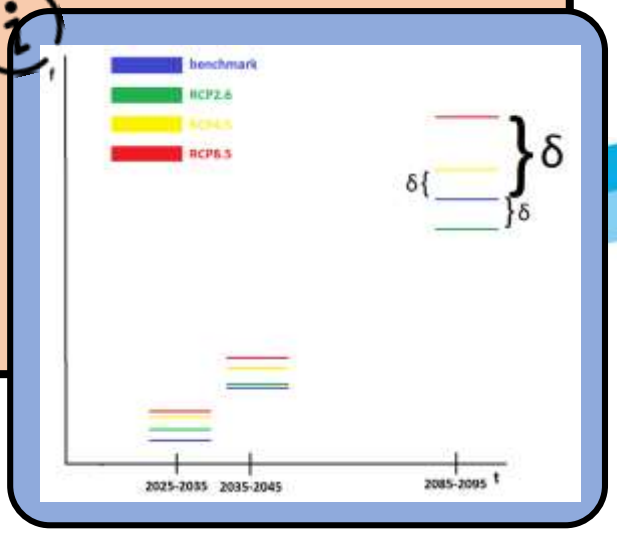
How do the **Gulf of Trieste** and the **Marano and Grado lagoon** respond to **climate variability**, from a physical-oceanographic point of view?

1. **Run** the *best* **historical**, annual **simulation** (**benchmark**)
   - best-calibrated simulation for the year **2018**

2. **Perturb** the **input data** (marine, meteo, hydro) of the benchmark, according to **climate scenarios**
   - **3 meteorological climate scenario** (**1** for each **RCP**) – EURO-CORDEX
   - **5 oceanographic climate scenarios** (**1** for **RCP2.6**, and **2** for **RCPs 4.5** and **8.5**) – MedCORDEX
   - **perturbation** of **meteorological data** (**temperature** and **humidity**) through **monthly, decadal "deltas"**
   - **perturbation** of **marine data** (**temperature**, **salinity** and **water level**) through **monthly, decadal "deltas"**
   - **perturbation** of **hydrological data** (**runoff**) through **monthly, decadal variations** in precipitation paths

3. **Run** the **perturbed simulation**
   - each perturbed simulation is representative of a certain **decade**
   - run as many simulations as the number of decades (**cover the entire XXI century**)
   - run as many simulations as the number of available forcing scenarios (**enrich the ensemble**)

4. **Analyse** the **results** (statistics, graphs, etc.)
   - results have to be considered with respect to the benchmark (**relative results**)



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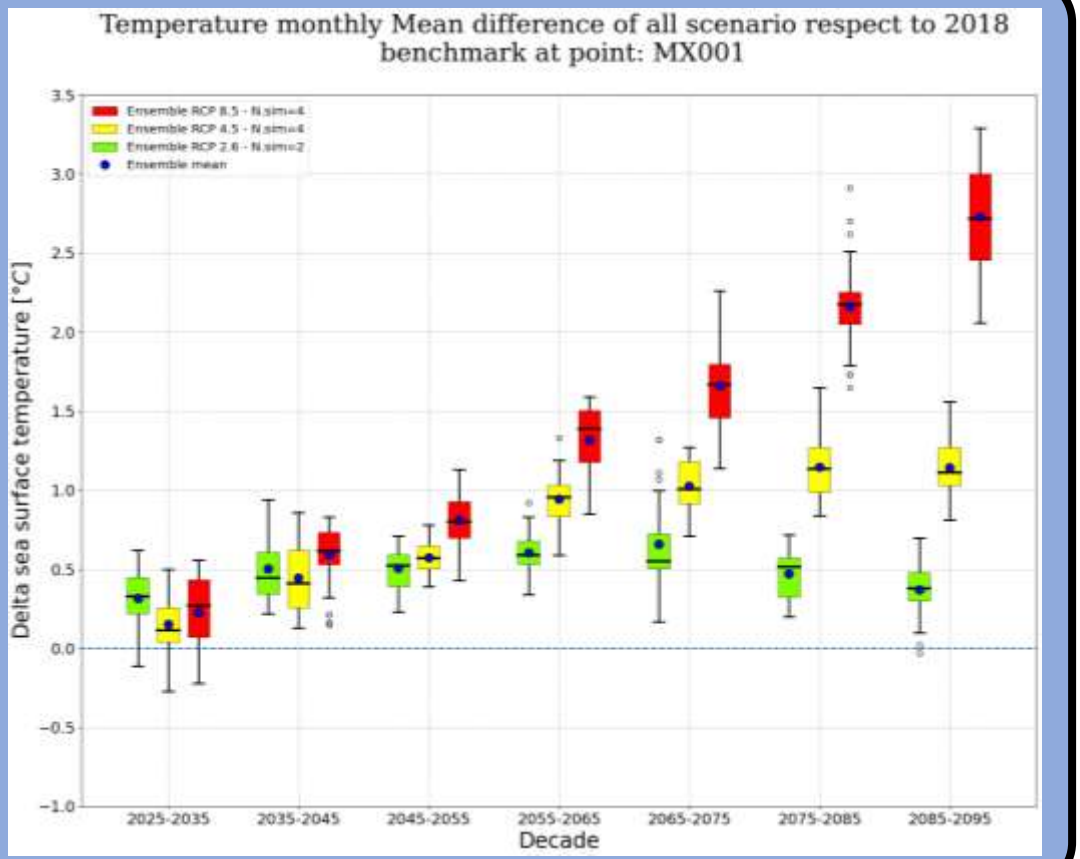
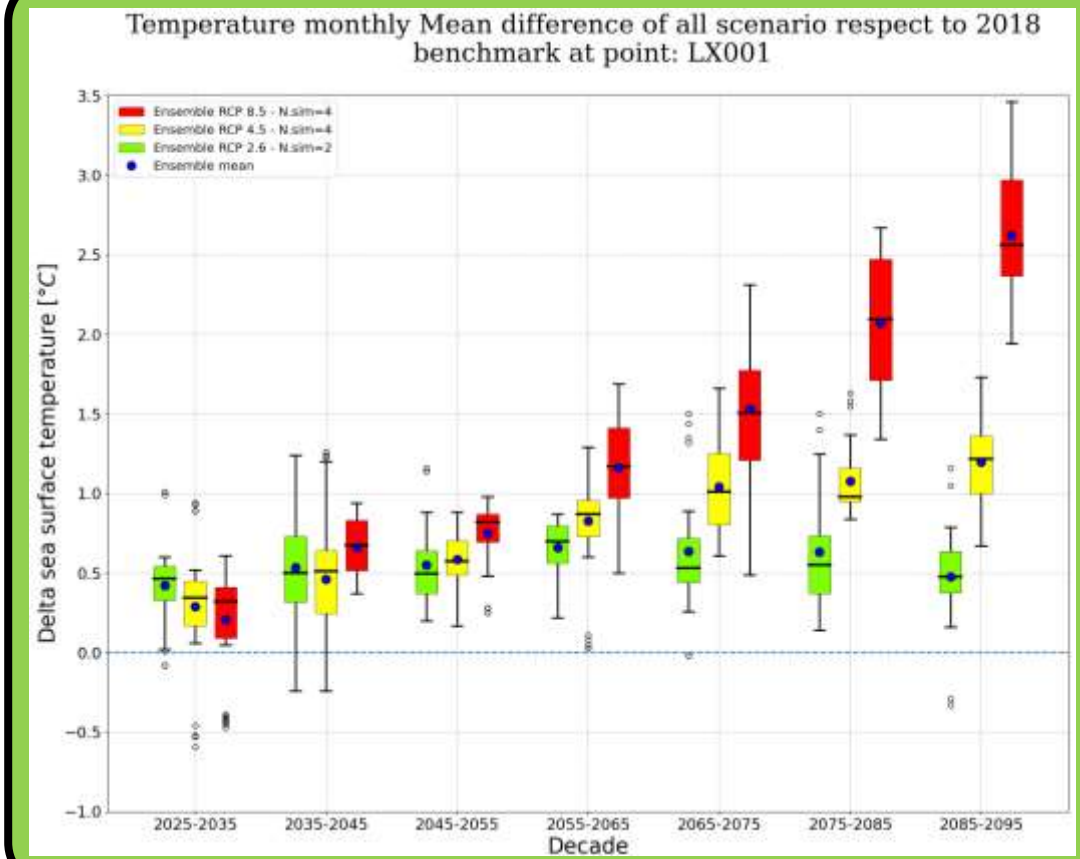
Climate sensitivity tests: (first) results

Open sea

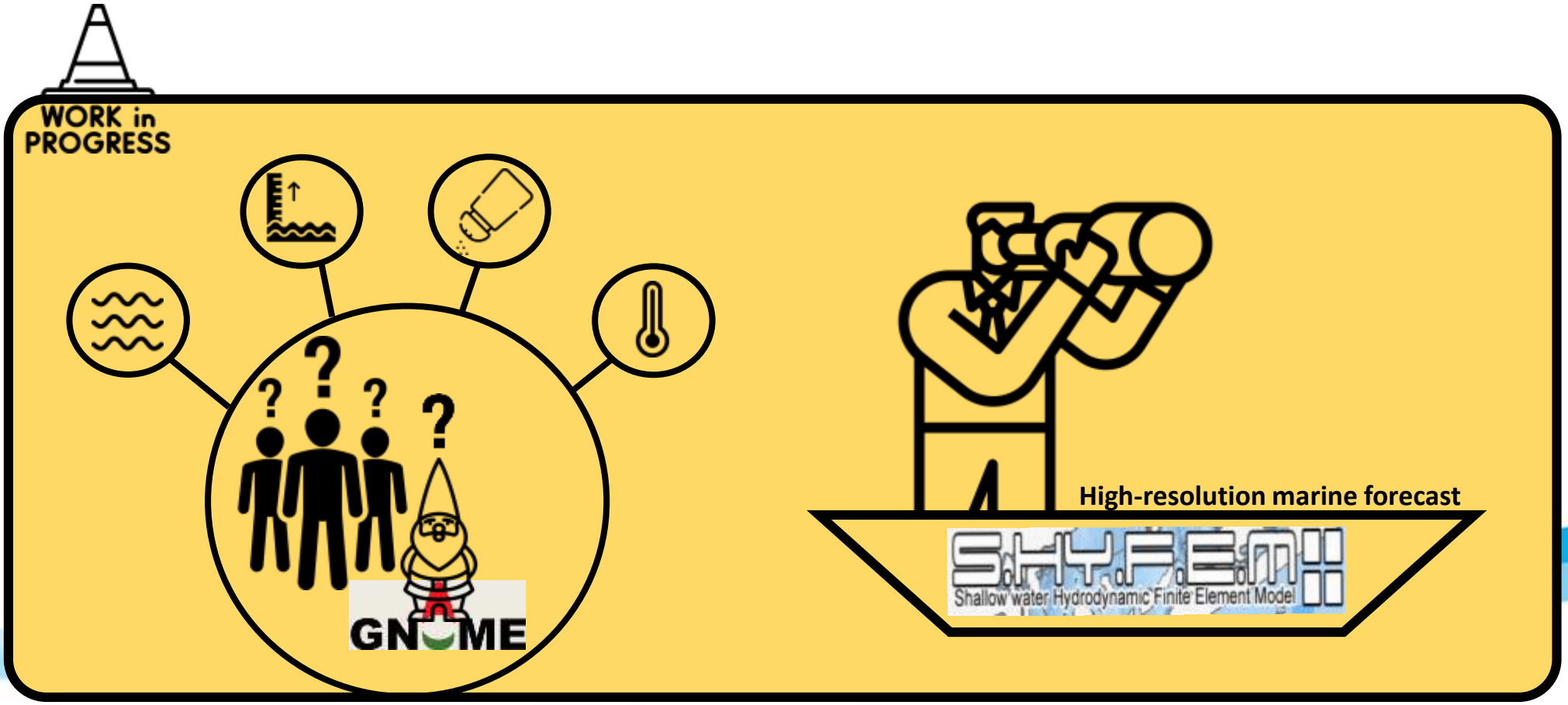


Lagoon



FVG marine forecasting system: in progress

The implementation of ARPA FVG's **high-resolution marine forecasting system** for the Gulf of Trieste and Marano and Grado lagoon is **in progress**



Future developments

- **Enrich the ensemble** of **climate sensitivity tests** with **IPCC**'s **water level** "deltas"

- **AdriaClim**'s **climate scenario**, RCP**8.5** (2006÷2050)

- **Finalize** the development and implementation of **Arpa FVG**'s **high-resolution marine forecasting system** for the Gulf of Trieste and Marano and Grado lagoon

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