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ARPA FVG

EMS Annual Meeting 2024
UP2.4
Atmosphere-Ocean interactions: open-ocean and coastal processes

A novel approach to generate very high resolution climate scenario for coastal areas

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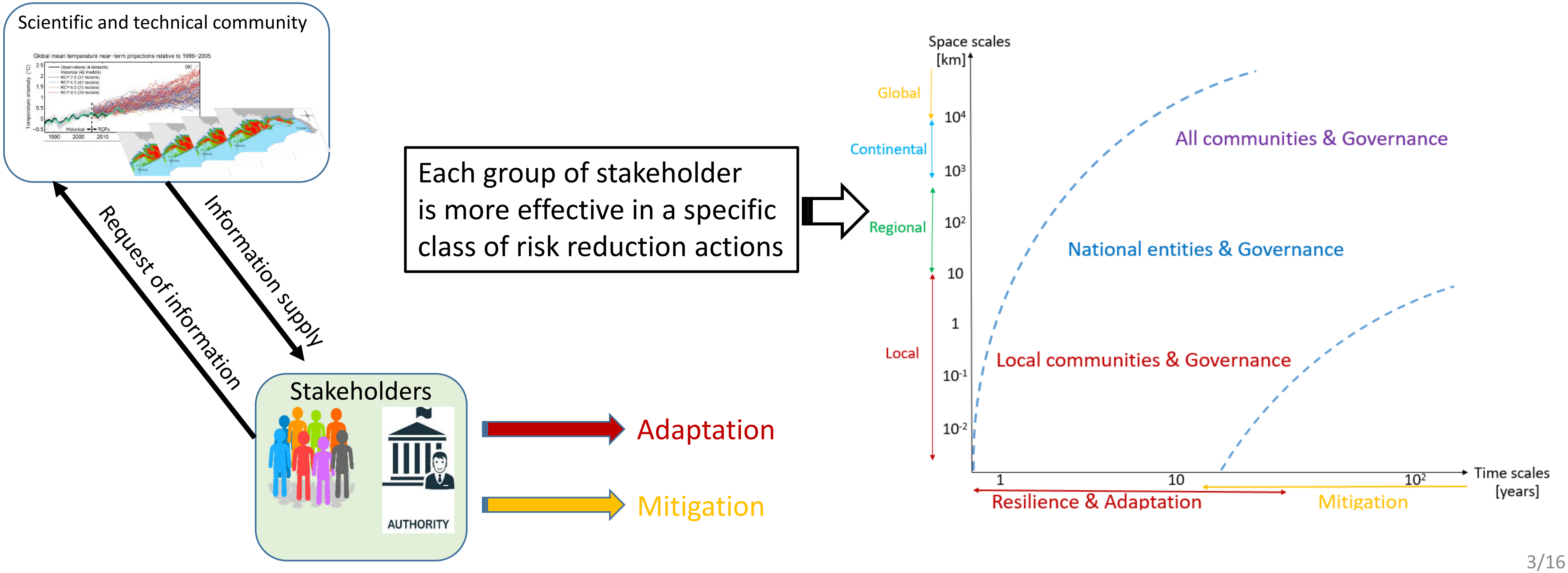
SCREEN CAPTURE WELCOME

Outline

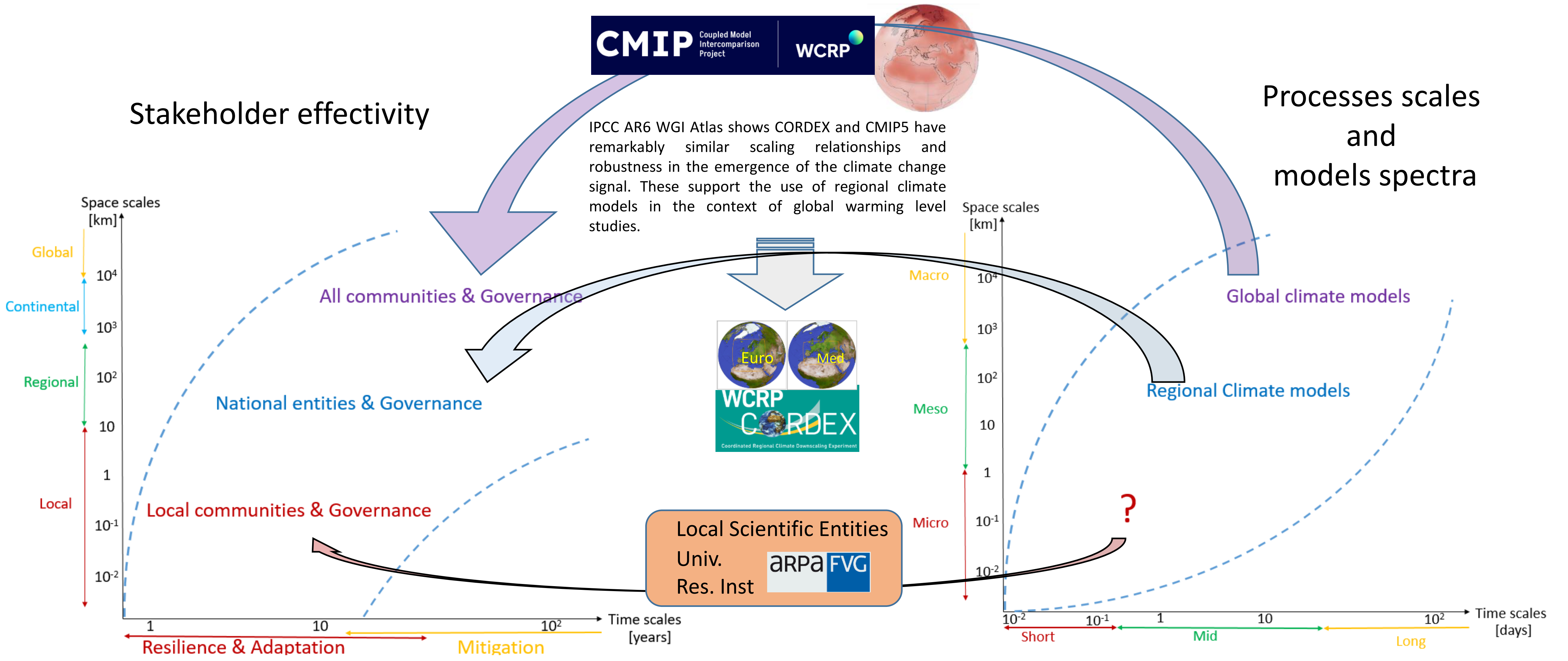
- ❑ Motivations for climate scenarios at local scale
- ❑ Description of the methodology and its advantages
- ❑ Methodology application on the NE Adriatic coasts
- ❑ Some results on climate scenarios in the NE Adriatic coasts
- ❑ Conclusions and perspectives

Climate change, stakeholders requests and stakeholders actions

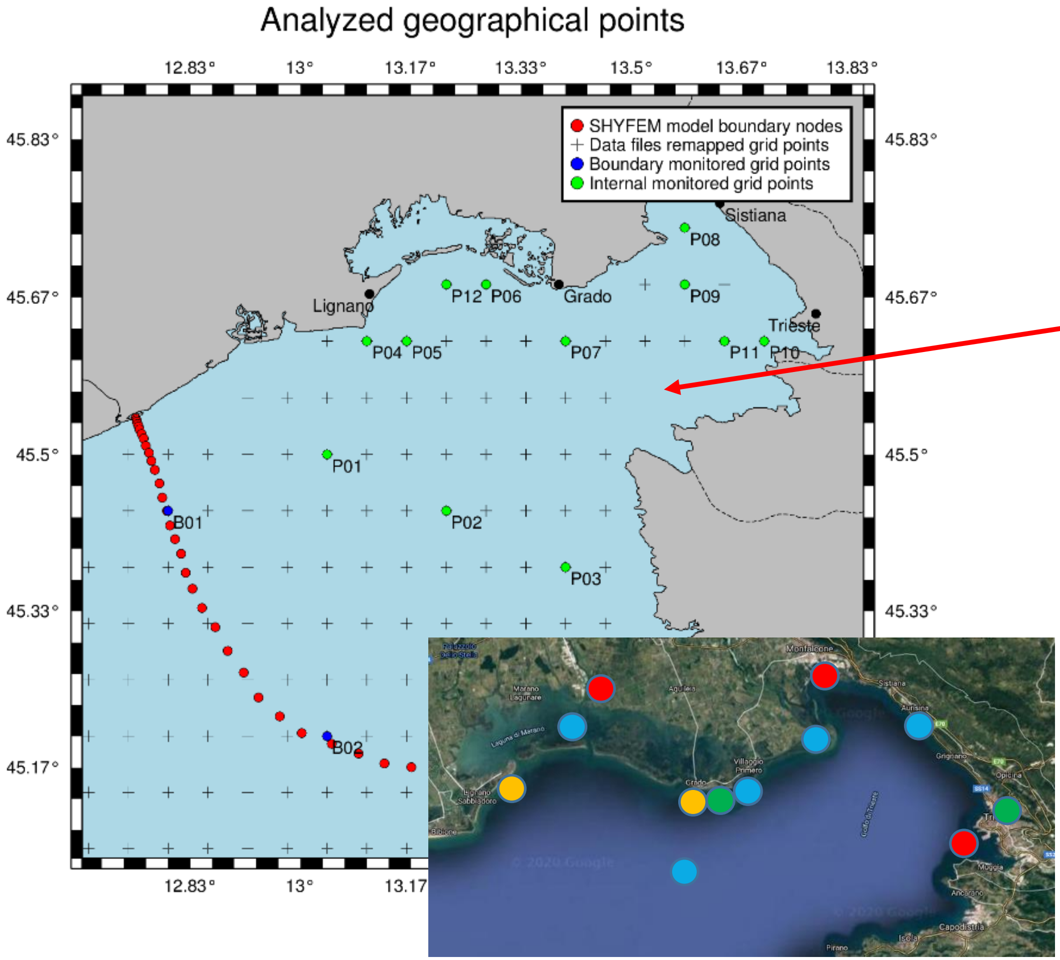
1. "Almost" everybody knows that climate is changing fast and climate change brings hazards, resulting in impacts too.
2. We have found two main approaches to reduce the risks related to climate change { Adaptation / Mitigation }

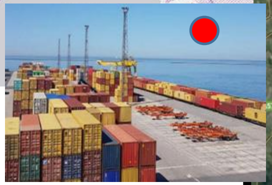


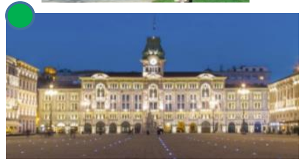
Climate change, stakeholders requests and available information

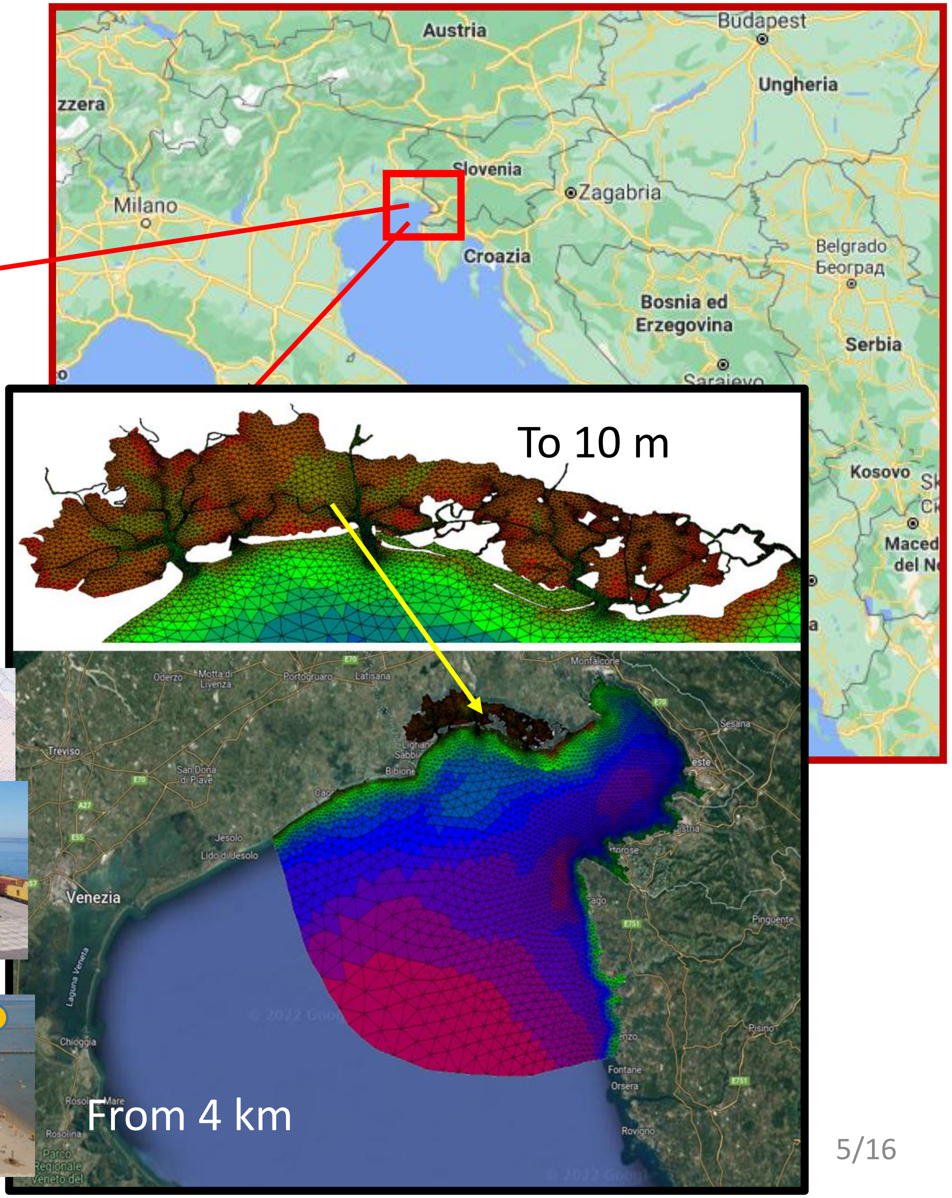


What does it mean small spatial domain and high resolution? NE Italy (sea/air)



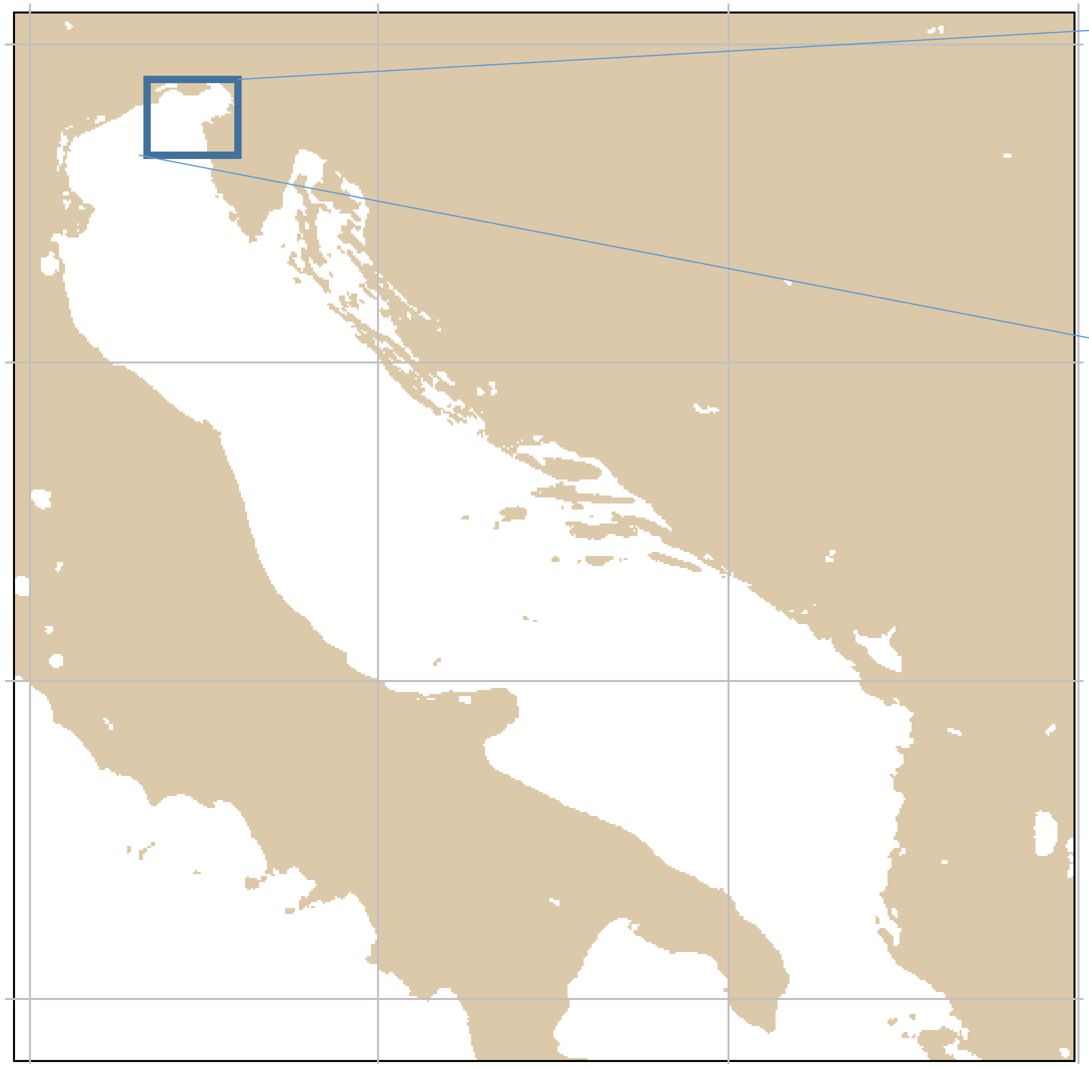


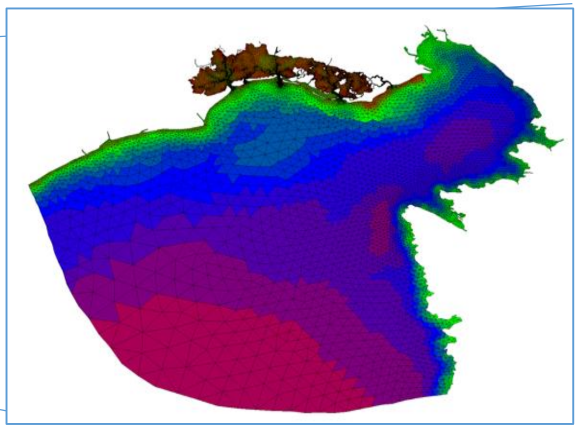




- Relevant ecosystems: Natura 2000 sites
- Important anthropic activities: harbors, tourism, historical sites

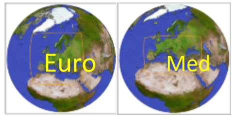
Domain sensitivity from boundary conditions and relaxation times





Important facts

- ❑ The local domain is very small with respect the mesoscale basin
- ❑ Signals at the boundary propagate fast into the domain (temperature, salinity, level, etc.)
- ❑ Relaxation times are very small with respect climate scales
- ❑ Boundary conditions are available



WCRP CORDEX Coordinated Regional Climate Downscaling Experiment

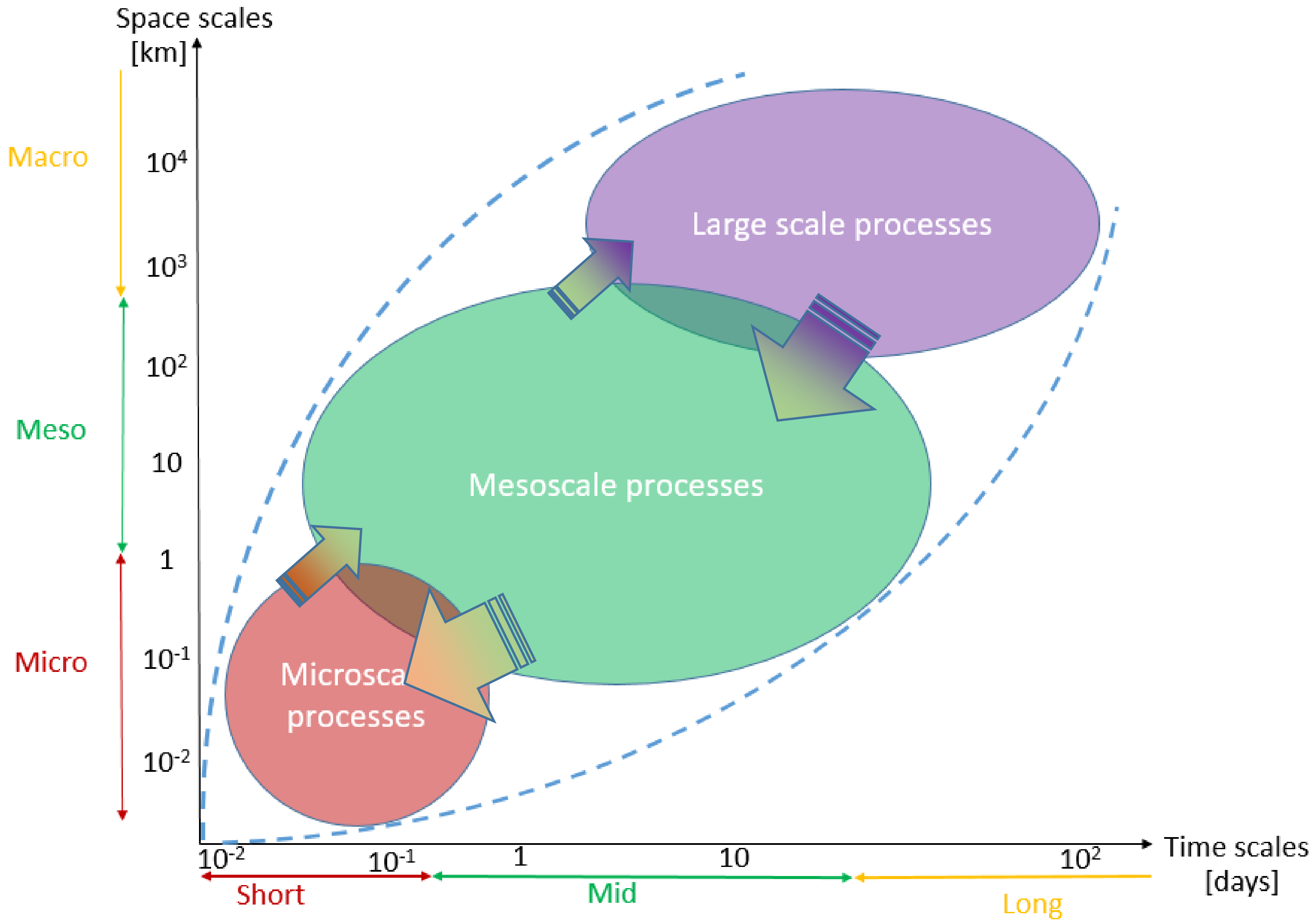
Weakness of feedbacks and one way models interaction (nesting)

- Feedbacks across the scale are the reality.

- For climate downscaling, upward feedback is considered to be significantly weaker than boundary forcing (CMIP5 – CORDEX too)

- One way model nesting is a practical way to transfer the boundary signal to the simulation domain

❑ Required computational and human resources are available in local scientific and technical communities



The novel approach: sensitivity cases to changed boundary conditions and forcing

a) Identify the **model** reproducing the **local scale processes** in your domain.

b) Identify the best **boundary condition and forcing** for the **reference period** (analyses).

c) Generate the **reference** (1 – 10 years) **simulation** on your domain: the benchmark.

d) Select the **ensemble of CORDEX** simulation to be used **as forcing**

e) **Perturb** the best **boundary conditions** with a CORDEX model output according to the Global Warming Levels (GWLs) - intrinsic SSP-RCPs at some lead time.

f) **Generate** the **sensitivity case** run with **perturbed boundaries and forcing**.

g) **Compare** the **sensitivity case** with the **benchmark** (anomalies, gradients, etc.)

h) **Repeat steps e), f) and g) to create the ensembles** of sensitivity cases on your domain

i) Summarize the sensitivity cases **according to Global Warming Levels** (GWLs) - intrinsic SSP-RCPs at some lead time

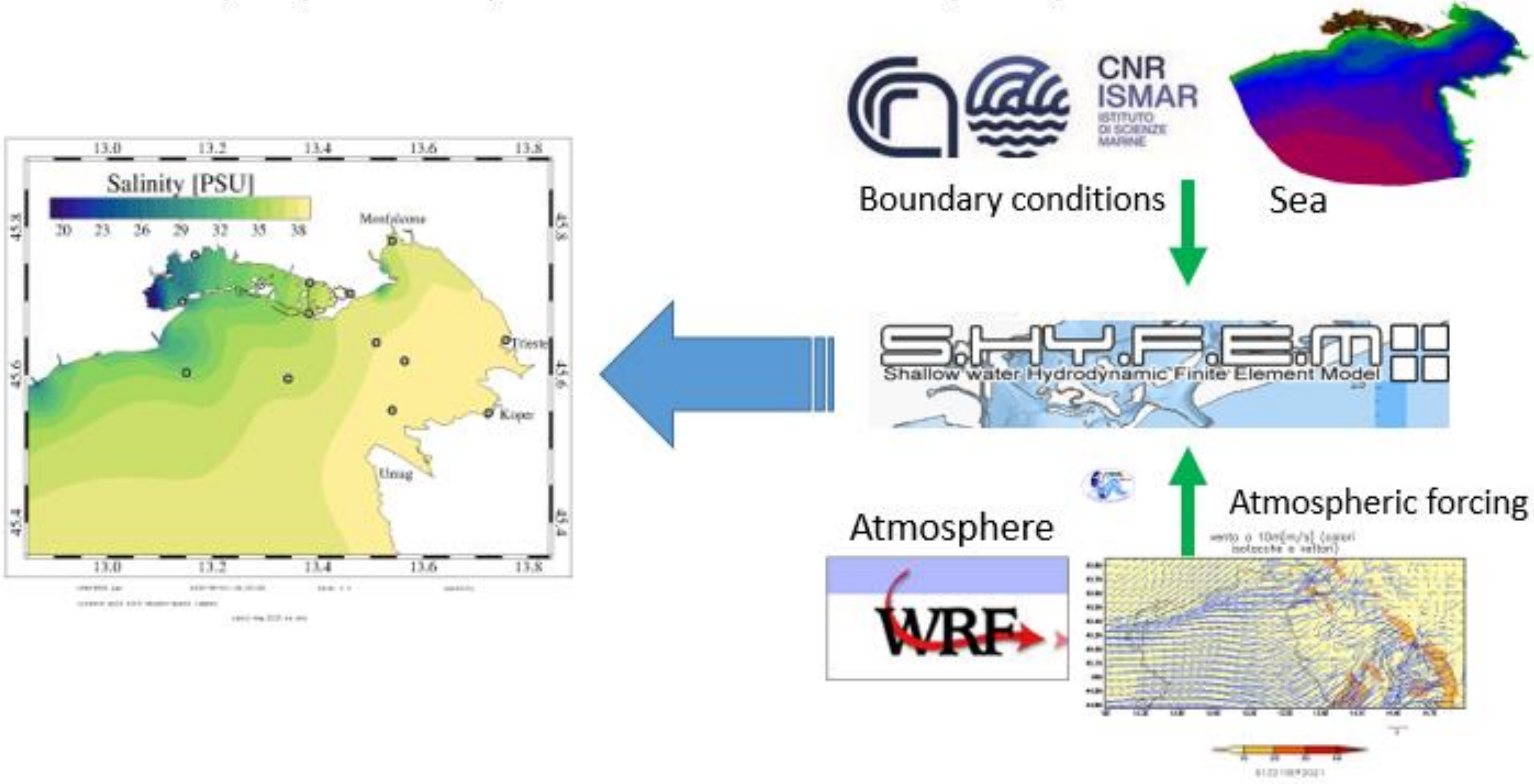
j) **Organize** the huge amount of generated **information** in formats suitable **for stakeholder usage** in the easiest accessible way

Application of the novel approach: model, boundary conditions and forcing

Steps: a), b)

1st release of yearly benchmark simulation (2018)

CNR-ISMAR (PP1) boundary conditions + ARPA FVG (PP11) WRF analyses

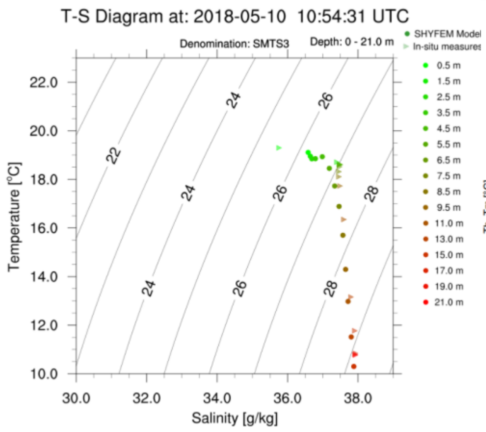


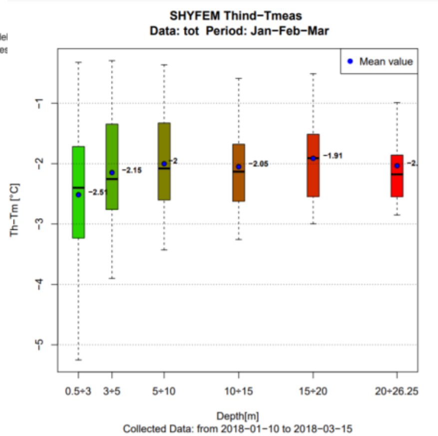
Application of the novel approach: generation of the (validated) benchmark

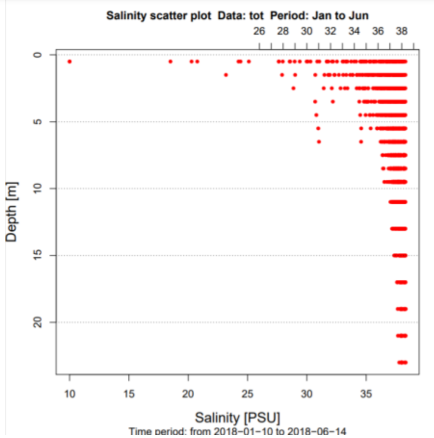
Step: c)

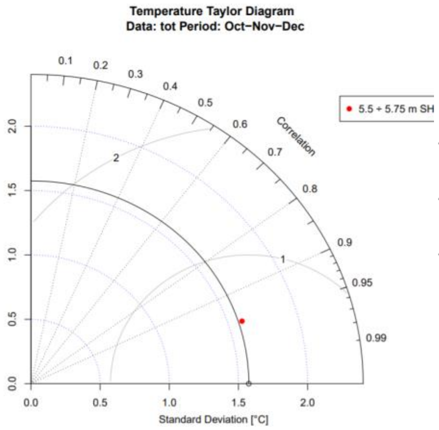
Validated benchmark simulation against ARPA FVG measures

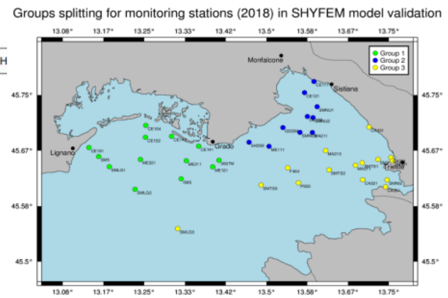
Computational flow development to validate automatically each benchmark and Climate Change sensitivity case simulation











SHYFEM model validation for Northern Adriatic Sea (2018 Period)

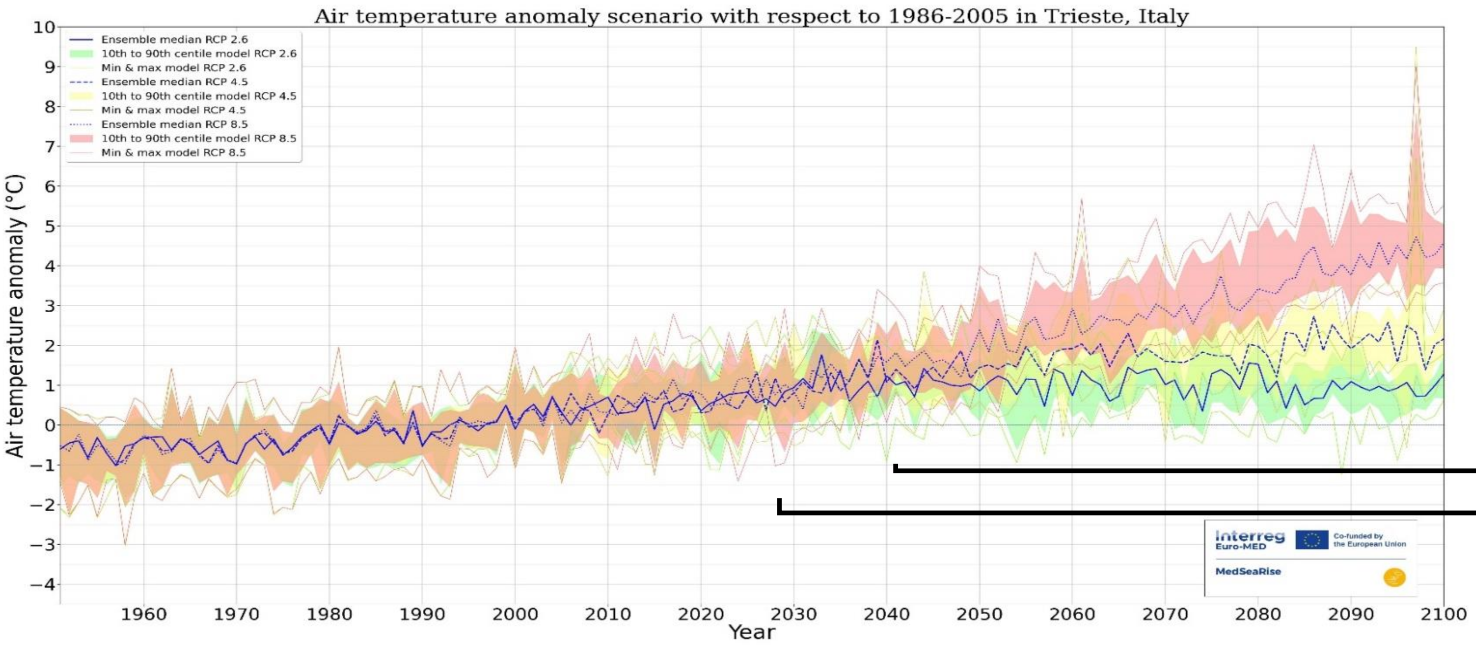
SHYFEM validation results	Jan-Feb-Mar	Apr-May-Jun	Jul-Aug-Sep	Oct-Nov-Dec	First Semester	Second Semester	Annual
TS-Diagrams	Group 1 Group 2 Group 3	Group 1 Group 2 Group 3	Group 1 Group 2 Group 3	Group 1 Group 2 Group 3			
Boxplot	Group 1: Temp Sal Group 2: Temp Sal Group 3: Temp Sal All stations: Temp Sal	Group 1: Temp Sal Group 2: Temp Sal Group 3: Temp Sal All stations: Temp Sal	Group 1: Temp Sal Group 2: Temp Sal Group 3: Temp Sal All stations: Temp Sal	Group 1: Temp Sal Group 2: Temp Sal Group 3: Temp Sal All stations: Temp Sal	Group 1: Temp Sal Group 2: Temp Sal Group 3: Temp Sal All stations: Temp Sal	Group 1: Temp Sal Group 2: Temp Sal Group 3: Temp Sal All stations: Temp Sal	Group 1: Temp Sal Group 2: Temp Sal Group 3: Temp Sal All stations: Temp Sal
Scatter Plot	Group 1: Temp Sal Group 2: Temp Sal Group 3: Temp Sal All stations: Temp Sal	Group 1: Temp Sal Group 2: Temp Sal Group 3: Temp Sal All stations: Temp Sal	Group 1: Temp Sal Group 2: Temp Sal Group 3: Temp Sal All stations: Temp Sal	Group 1: Temp Sal Group 2: Temp Sal Group 3: Temp Sal All stations: Temp Sal	Group 1: Temp Sal Group 2: Temp Sal Group 3: Temp Sal All stations: Temp Sal	Group 1: Temp Sal Group 2: Temp Sal Group 3: Temp Sal All stations: Temp Sal	Group 1: Temp Sal Group 2: Temp Sal Group 3: Temp Sal All stations: Temp Sal
Taylor Diagrams	Temp: 0.5 5.5 9.5 m Sal: 0.5 5.5 9.5 m	Temp: 0.5 5.5 9.5 m Sal: 0.5 5.5 9.5 m	Temp: 0.5 5.5 9.5 m Sal: 0.5 5.5 9.5 m	Temp: 0.5 5.5 9.5 m Sal: 0.5 5.5 9.5 m	Temp: 0.5 5.5 9.5 m Sal: 0.5 5.5 9.5 m	Temp: 0.5 5.5 9.5 m Sal: 0.5 5.5 9.5 m	Temp: 0.5 5.5 9.5 m Sal: 0.5 5.5 9.5 m

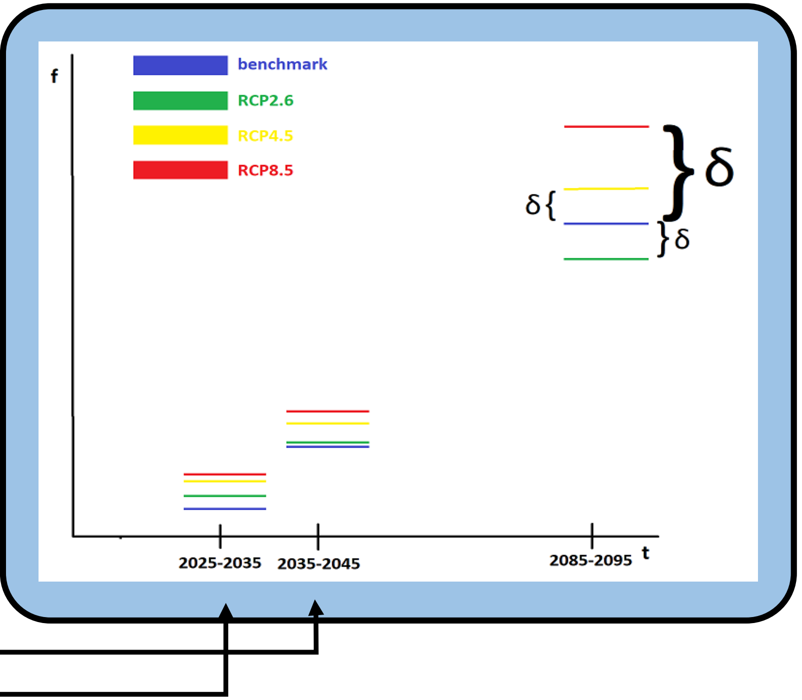
Application of the novel approach: ensemble scenario ad boundary perturbation

- Oceanographic basin scale climate scenarios (e.g. MED-CORDEX)
- Atmospheric forcing synoptic/regional scale climate scenarios (e.g. EURO-CODEX)

Steps: d), e)

Perturbed 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 each **RCP**) – 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





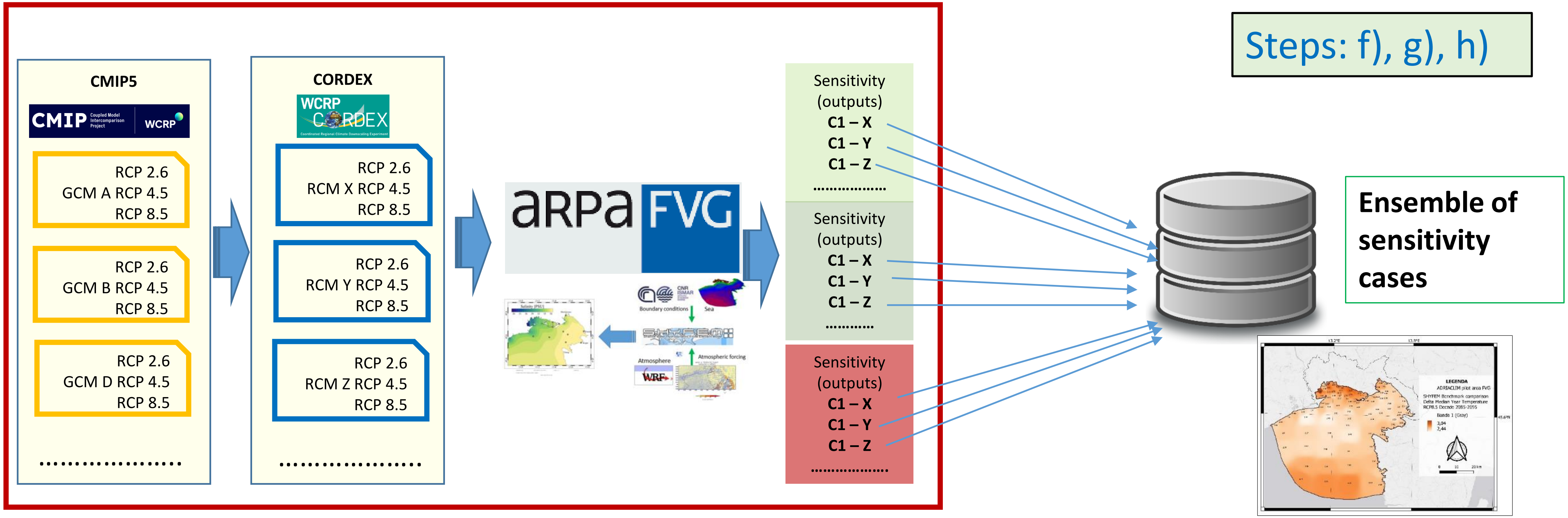
Application of the novel approach: generation of sensitivity cases

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**)

Generate yearly runs
2030, 2040, 2050, …
RCPs 2.6, 4.5, 8.5

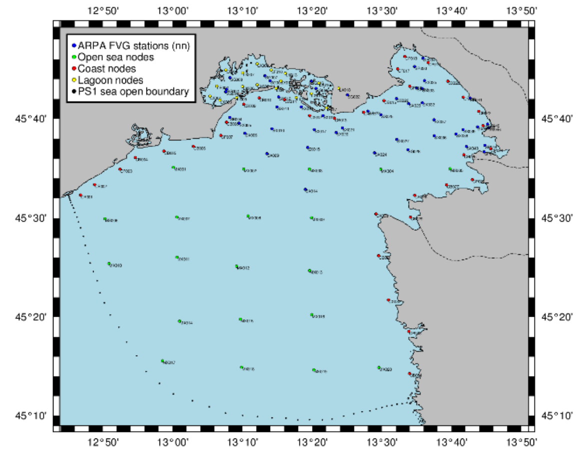
Steps: f), g), h)

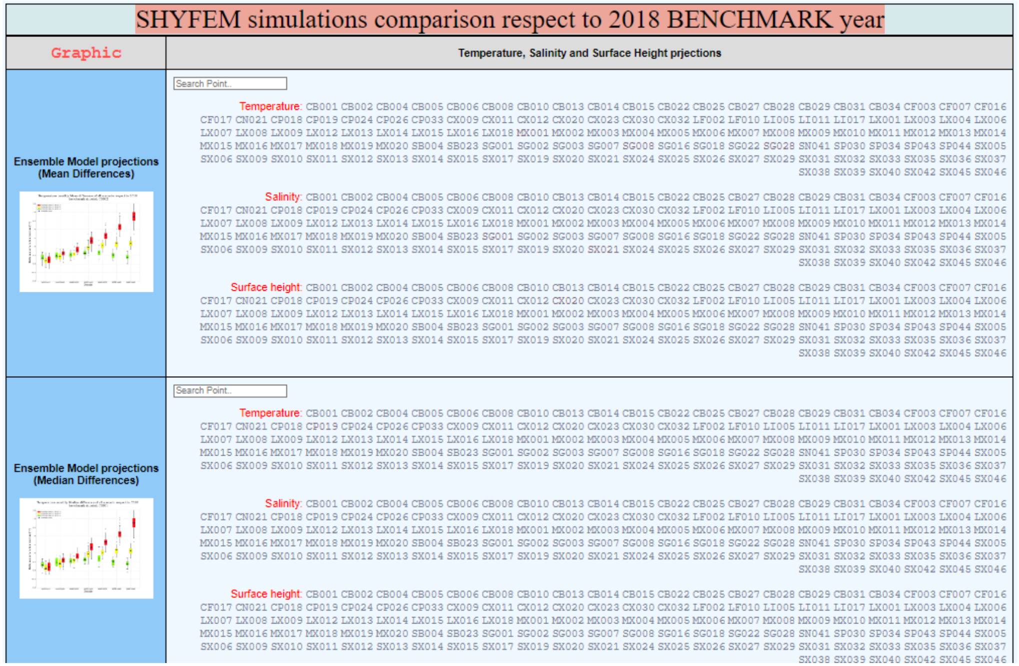


Application of the novel approach: summarize sensitivity case outputs

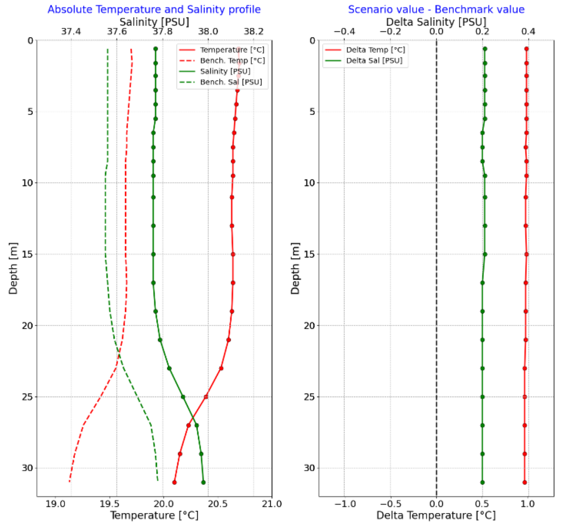
Step: i)

...eling EXT Nodes - ARPA FVG (PP11) Pilot Site (PS1)

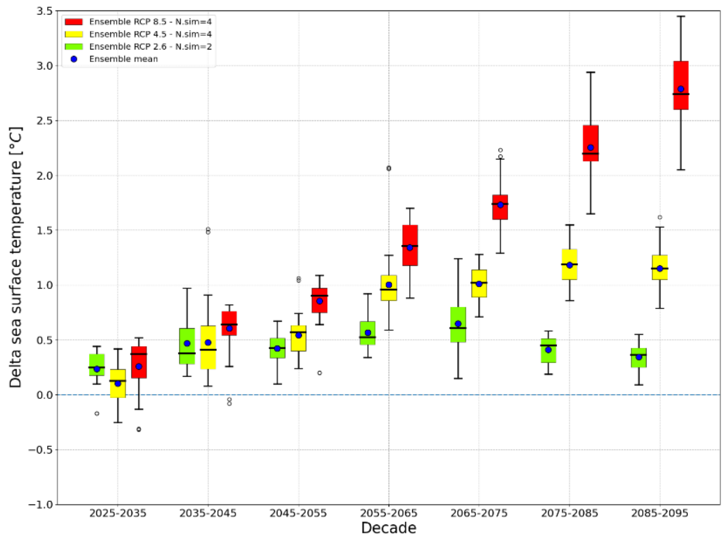




Temperature and Salinity October monthly Mean profiles:
Benchmark=2018, Point=MX015, Serial Code=1997F100D0_D138, RCP=4.5, Period=2075-2085



Temperature monthly Mean difference of all scenario respect to 2018 benchmark at point: SG028

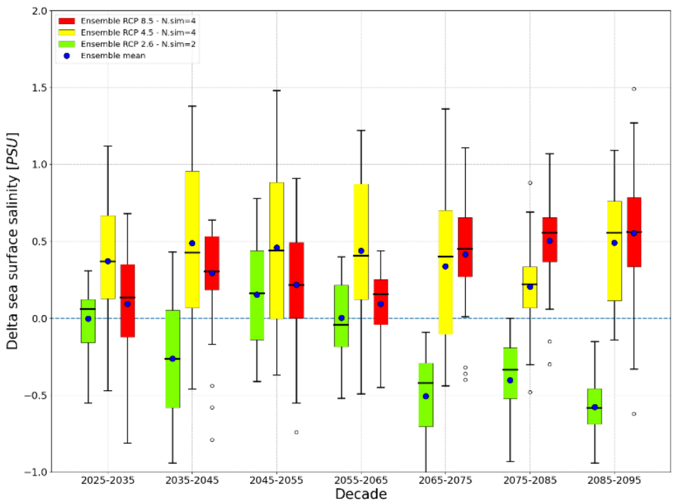


Scenarios available for physical parameters

Open sea and Friuli lagoon

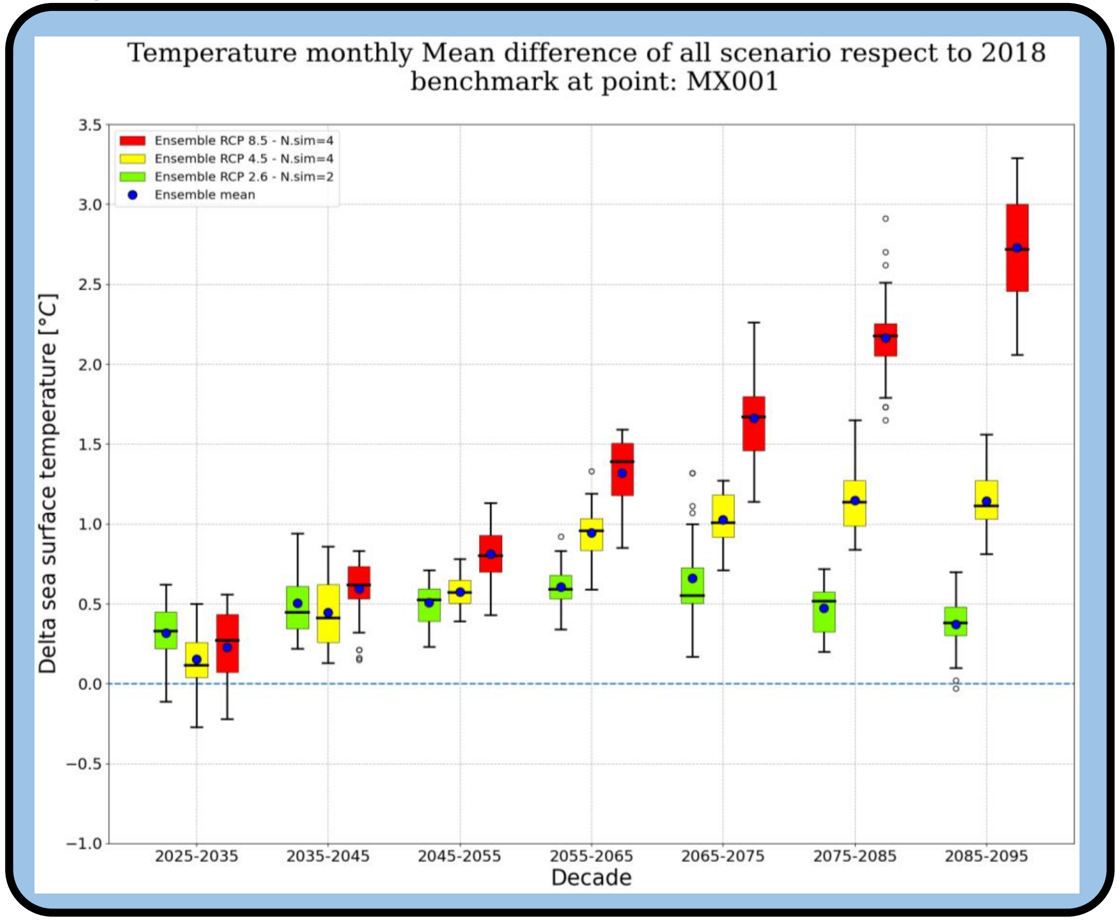
Data available for more than 100 geographical positions.

benchmark at point: SX021

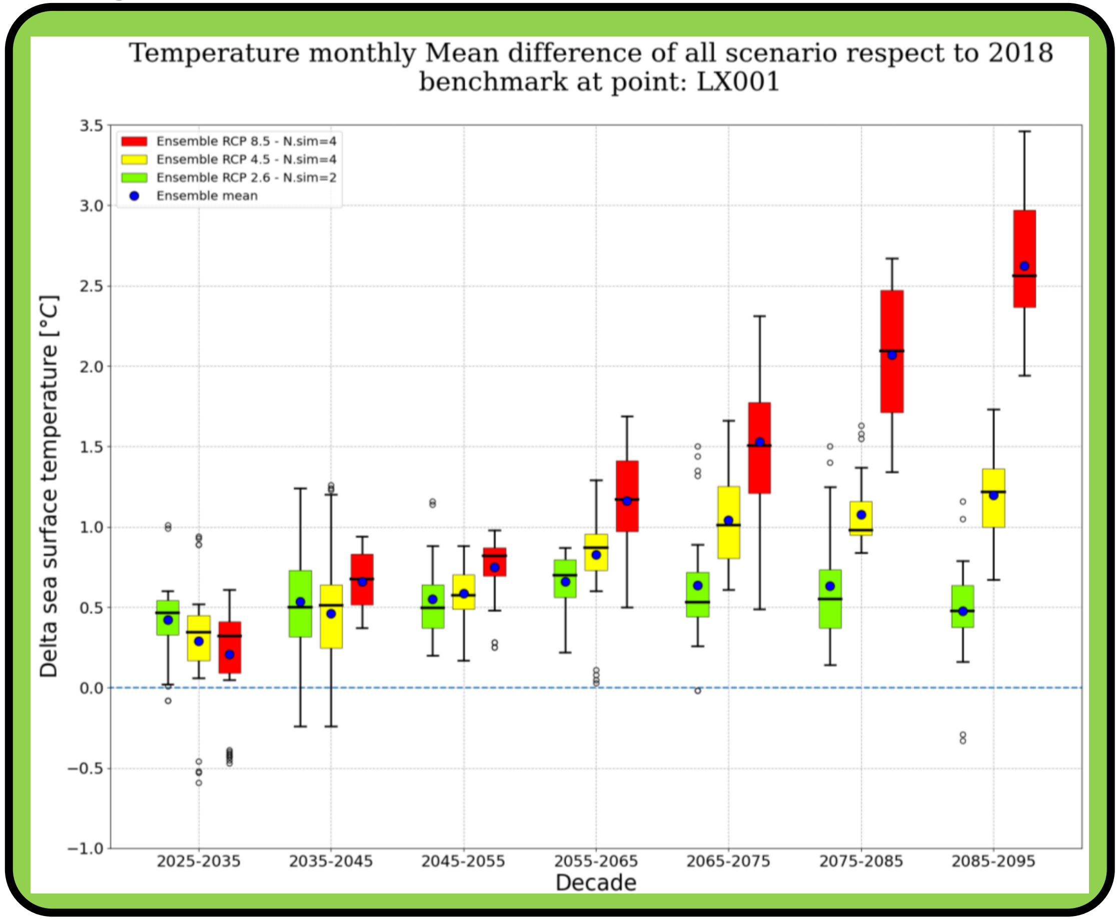


Application of the novel approach: look at the results too!

Open sea



Lagoon



Application of the novel approach: summary of outputs for stakeholders

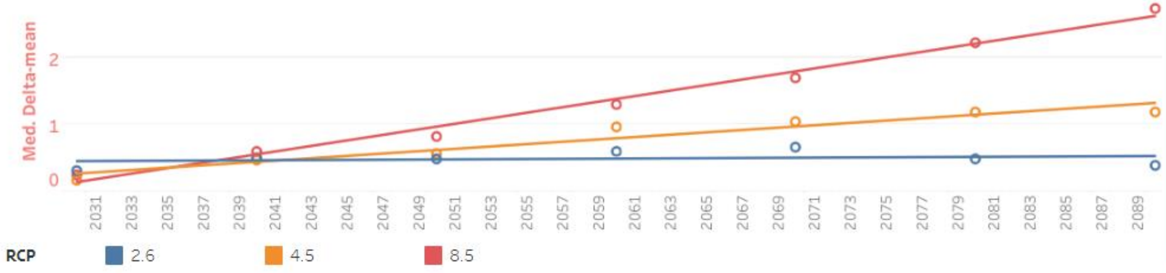
Step: j)

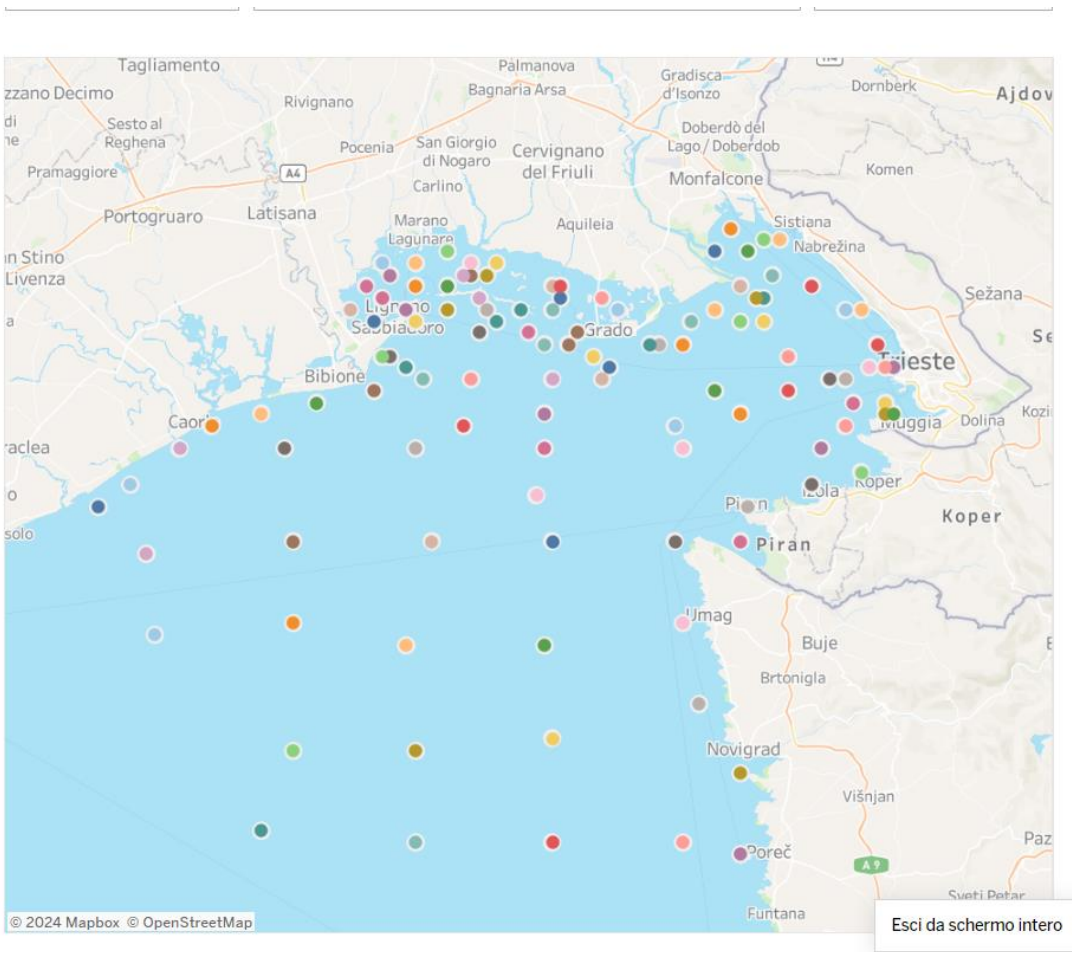
For a large number of geographical points, according to the stakeholder interest, sensitivity cases and related statistics are available as plots, CSV through an easy to access interface
https://public.tableau.com/app/profile/interregithr.arpafvg/viz/AdriaClim_deltaMean/Storia1

Field	2030 gen	feb	mar	apr	mag	giu	lug	ago	set	ott	nov	dic
sal	1.180 0,343	1.180 0,170	1.180 0,110	1.180 0,096	1.180 0,205	1.180 0,285	1.180 0,175	1.180 0,246	1.180 0,237	1.180 0,249	1.180 0,054	1.180 0,211
temp	1.180 0,227	1.180 0,085	1.180 0,143	1.180 0,036	1.180 0,024	1.180 0,245	1.180 0,265	1.180 0,294	1.180 0,343	1.180 0,317	1.180 0,283	1.180 0,303
zos	1.180 -0,002	1.180 -0,013	1.180 0,015	1.180 -0,012	1.180 0,005	1.180 0,002	1.180 0,002	1.180 -0,001	1.180 0,005	1.180 0,010	1.180 0,017	1.180 0,004

Grafico: temp / mese - RCP: Tutti

Grafico: temp / anno - RCP: Tutti





Conclusions and perspectives

- Stakeholders need information for future climate scenarios (air/sea) with a spatial resolution suitable for adaptation actions **at local scale** and to assess the resilience costs.
- High resolution climate scenarios require **local scale processes** (air/sea) to be included.
- Ensembles of secular (classical) air/sea numerical simulations, through the limited area technique, are highly demanding (time and costs) and, at present, they are not performed.
- For **small spatial domains**, the dynamical downscale can be carried out by means of **sensitivity cases** generating **ensembles of simulations** on time windows associated to **global/regional warming levels**.
- Sensitivity cases **approach does not require huge computational and human resources**.
- Sensitivity cases **approach** allows to **generate quantitative information** on future climate **suitable for stakeholders** (local communities and governance entities).

- Assessment of the sensitivity cases approach limits to investigate extreme events frequency has to be conducted (minimal length of the simulation to get the signal of climate change on the frequency).

These results have been achieved thanks to the EU project

MedSeaRise | Interreg Euro-MED Co-funded by the European Union

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