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

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S.1.2 – Climate trends: changes in means and extreme events in observations, simulations and projections

European Regional Development Fund

Outline

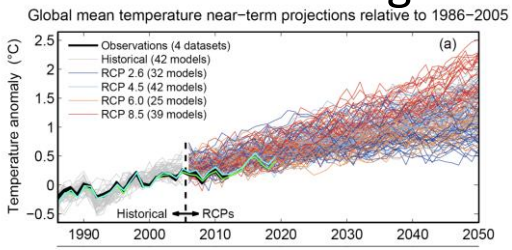
- ❑ The need for simulating climate change at the local scale
- ❑ The role of regional and global forcing at the local scale
- ❑ Local scale versus regional and global scale simulation approaches
- ❑ Issues to face in generating local scale climate change scenarios
- ❑ The Project AdriaClim approach for GoT(1) and lagoon pilot area

(1) GoT (Gulf of Trieste)

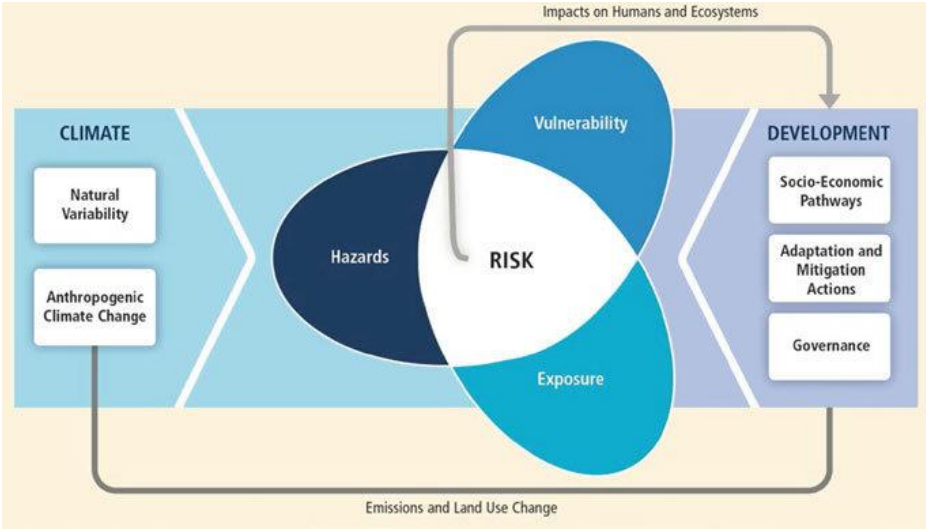
The need for simulating climate change at the local scale

Some facts

1) Plenty of information on climate hazards at the global and continental scales



This information comes from independent sources which allow robustness in the hazard identification.



Such information is suited for:

- **general and common risks** evaluation;
- **global scale mitigation** actions;
- **general and common adaptation** actions

2) Climate change is already impacting some areas with **specific risks** which **magnitude depend on local factors**.

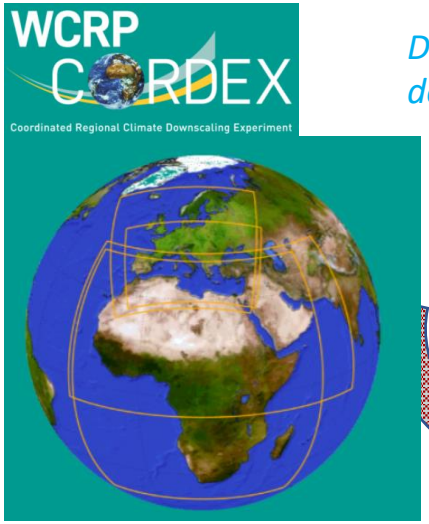
Stakeholders require information on climate related hazards, at local scale, for adaptation actions

What means local scale

The resolution and the domain (scale) required by stakeholder is a function of:

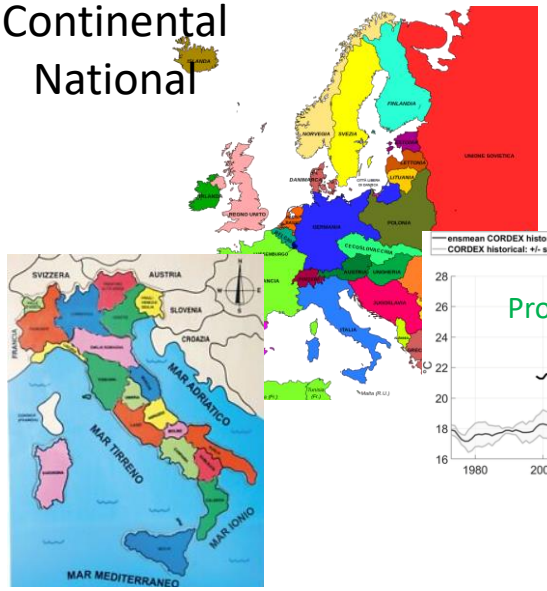
- ❑ stakeholder capacity to define the adaptation plans
- ❑ stakeholder capacity to put in action the adaptation actions

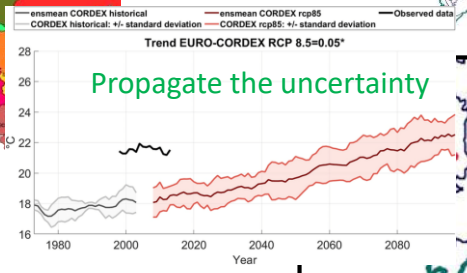
Local scale = f(administrative regions, municipalities, etc. – local policies and local legislation)



Dynamic downscale

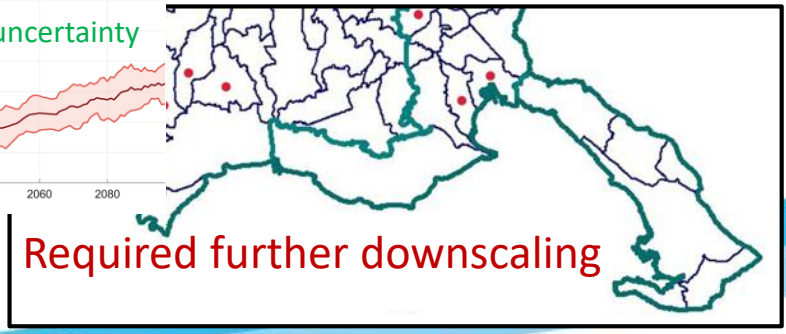
Regional
Continental
National





Propagate the uncertainty

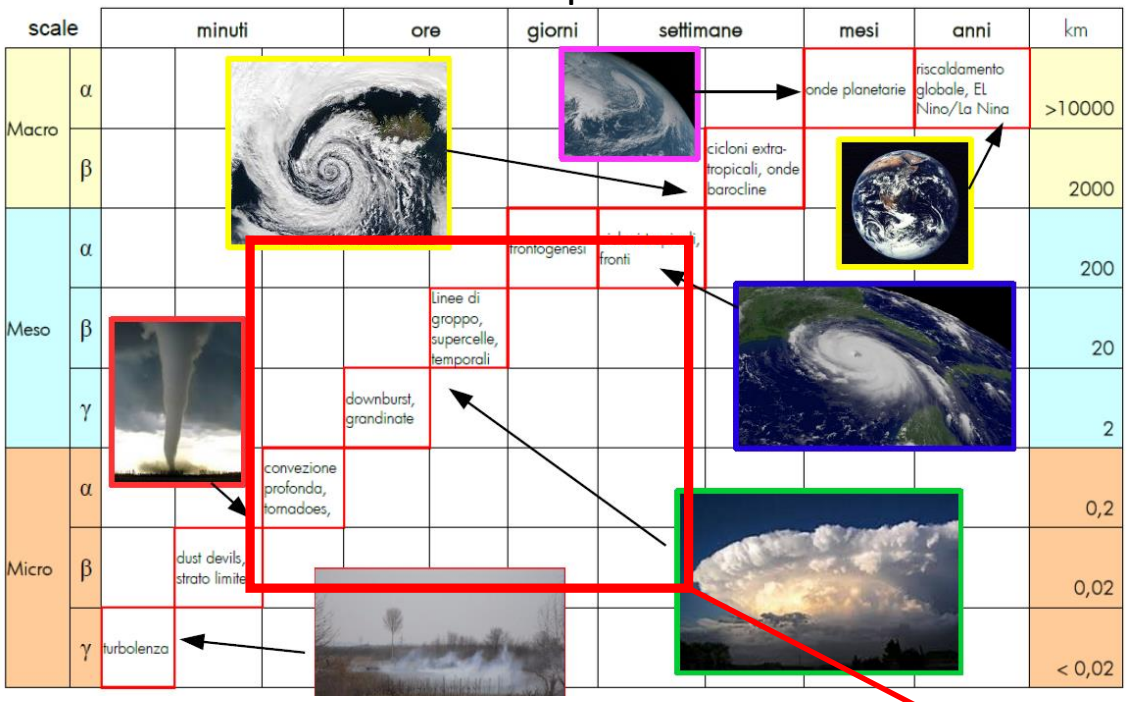
Local
Subnational
Municipality



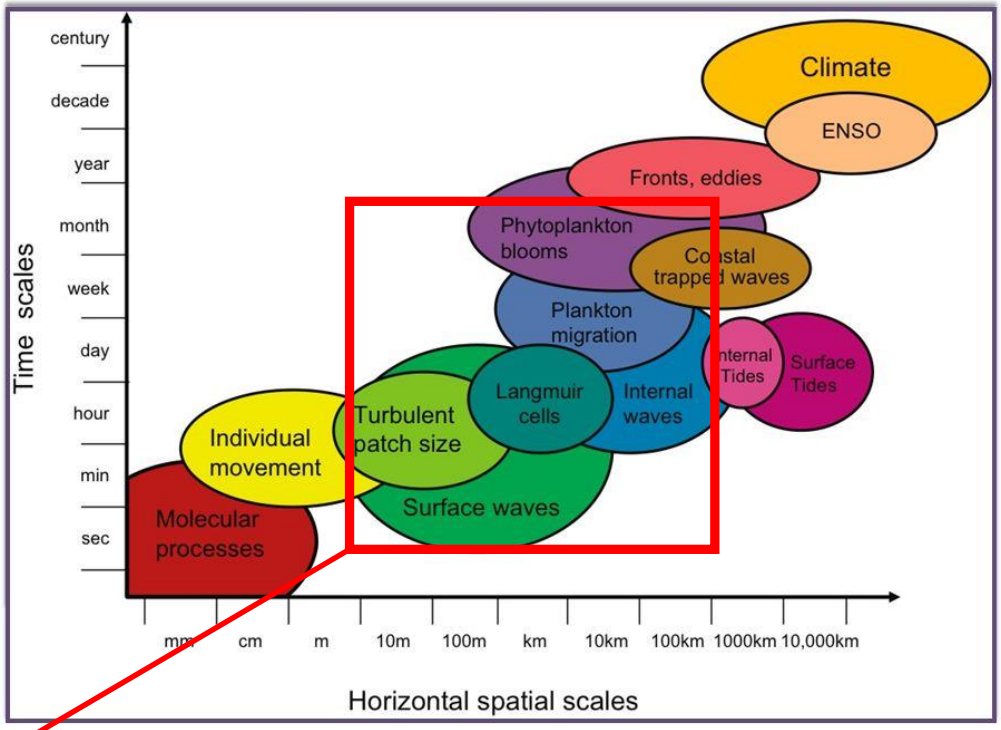
Required further downscaling

Space-time scales and environmental processes

Atmosphere



Ocean

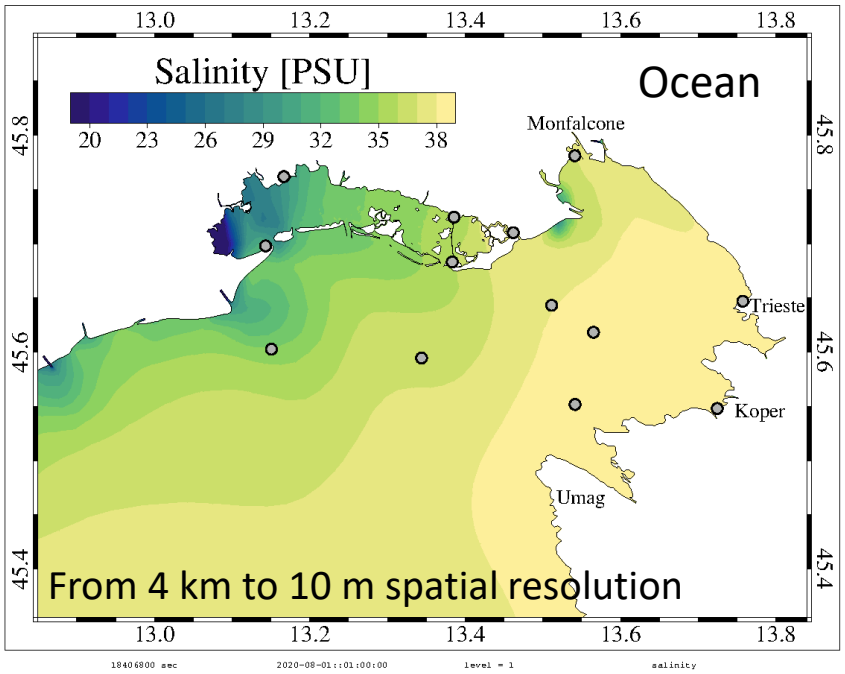


Local scale

Dynamical downscaling requires a range of process and their feedbacks

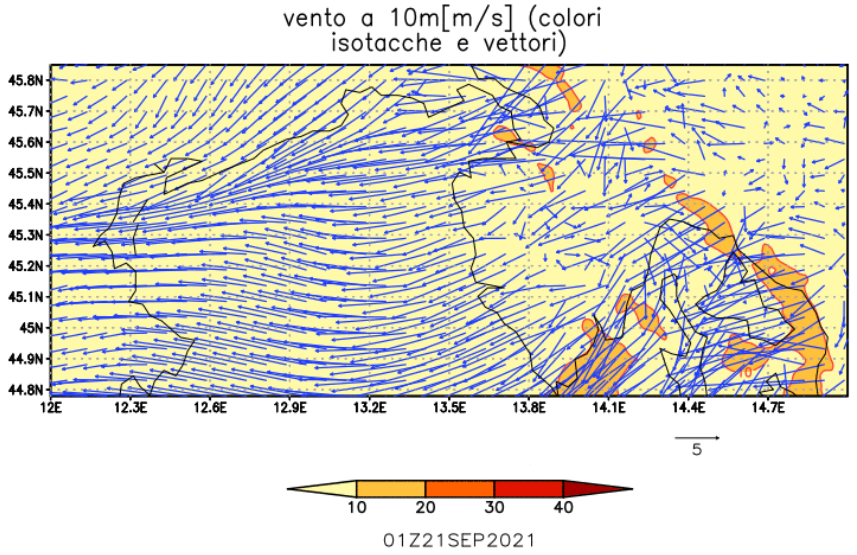
Processes, spatial resolution and numerical models

Models should be able to resolve processes at the local scale



Atmosphere

2 km spatial resolution, 1 hour frequency



S.HY.F.E.M. Shallow water Hydrodynamic Finite Element Model

Ocean

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Pilot area of
Gulf of Trieste + Marano and Grado lagoon

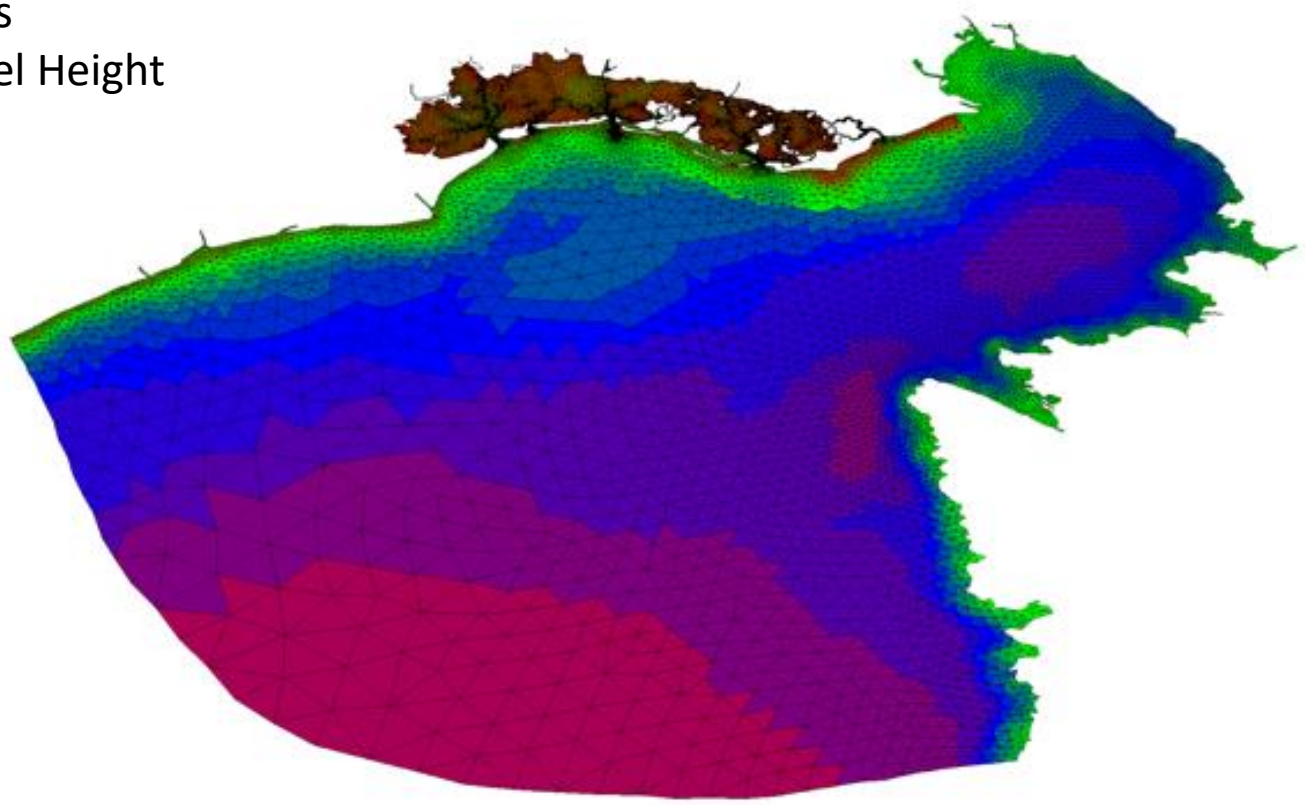
WRF

Atmosphere
(Hindcast)

High resolution ocean simulations: what is needed?

Oceanographic boundary conditions

- Temperature
- Salinity
- Currents
- Sea Level Height



Atmospheric forcing

- Surface winds
- Air temperature
- Energy fluxes
- Sea level pressure

What's available for ocean climate local scale scenarios?

Oceanographic boundary conditions

MED-CORDEX

✓**OCEAN)** NEMO
- 6.5 km horiz res.
- all 71 vertical levels
- daily freq

SIMULATIONS:
✓historical: 1960-2005
✓RCP 4.5, 8.5: 2006-2100

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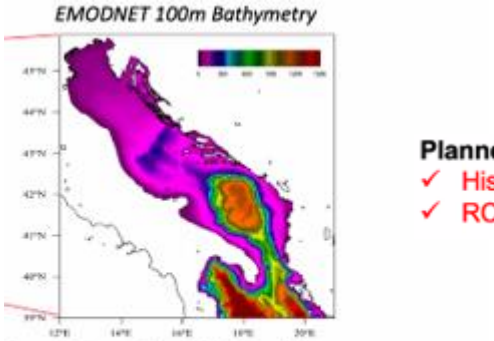


Planned Simulations:
✓ Historical(*) : 1991-2020
✓ RCP8.5(*) : 2021-2050

Spatial Domain of 3 AdriaClim components:
- Ocean model **NEMO (2km and 120 levels)**
- Wave model **WWIII (same grid and res as NEMO)**
- Biochemistry model **BFM (same grid and res as NEMO)**

Atmospheric forcing

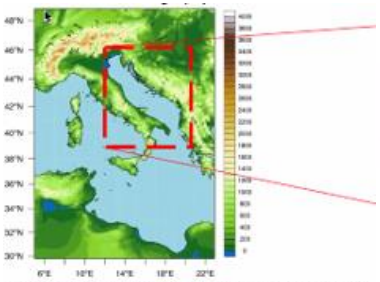
MED-CORDEX andEURO-CORDEX

Spatial resolution:
- EUR-11: 0.11 degree
daily freq

- Hindcast (ERA Interim): 1989 – 2008
- Control: 1951 – 2005 (1981 – 2010, 1951-80)
- Scenario: 2006 – 2100 (2041-71, 2011-40, 2071-2100)

RCP 2.6, 4.5, 8.5

AdriaClim



Planned Simulations:
✓ Historical(*) : 1991-2020
✓ RCP8.5(*) : 2021-2050

Spatial Domain of 3 AdriaClim components:
- Atmospheric model **WRF (6km and 60 levels)**

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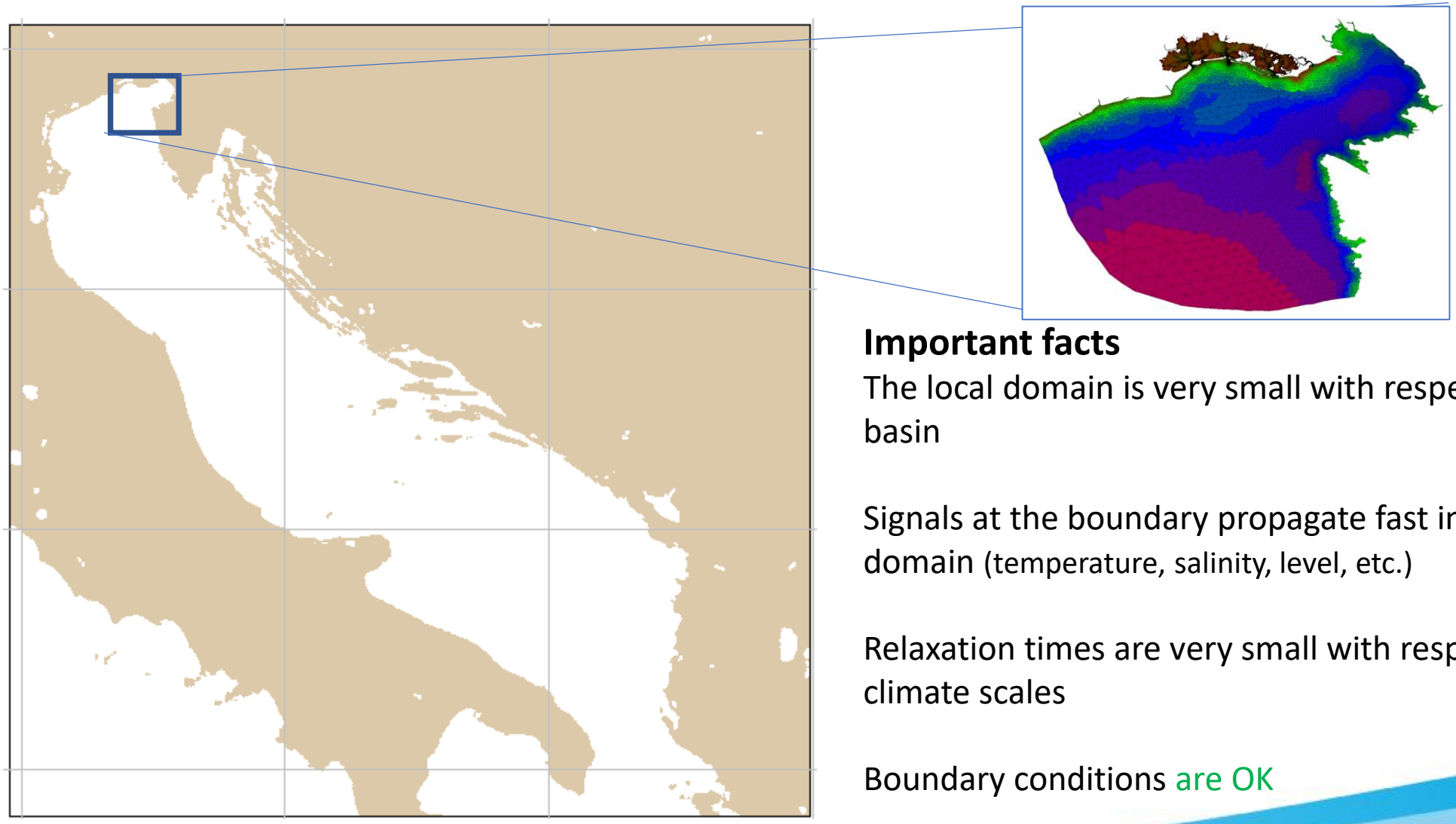
Are boundary conditions suitable for local scale simulation?



Important facts

The local domain is very small with respect the 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 OK

Is atmospheric forcing suitable for local scale simulation?

Important facts

For synoptic to mesoscale atmospheric forcing, it is OK (pressure, energy fluxes, etc.)

For mesoscale to microscale atmospheric forcing, it is not enough (winds, convective precipitation, etc.)

Time response of shallow waters at local scale and mesoscale/microscale atmospheric forcing are comparable.

Atmospheric mesoscale/microscale forcing lead to marine events, embedded into climate

Events are important features of shallow waters and they should be considered in climate scenarios

Issue to face

How to include mesoscale/microscale weather events in atmospheric forcing?

Some patches have to be applied (for the specific domain GoT and its lagoons)

There are important mesoscale forcing that are linked to synoptic scale patterns:

- Strong **Bora wind** events
- Strong **Scirocco wind** events
- Local scale **precipitation and rivers runoff**

Regression functions can transfer future synoptic scale patterns into the local scale

Daily sea level pressure fields	local wind intensity
Daily precipitations	regional scale fresh water flow

Response of the ocean model to a set of local scale forcing allow **to transfer into the future climate scenarios the events thanks** to atmosphere forcing analysis at synoptic/mesoscale (EURO-CORDEX and MED-CORDEX)

For trend analysis of events occurrence and their intensity

Strategy to explore coastal local scale climate scenarios

- ❑ Apply the best hydrodynamic model for ocean shallow waters (e.g. SHYFEM)
- ❑ Use a sets of oceanographic basin scale climate scenarios (e.g. MED-CORDEX)
- ❑ Use a set atmospheric forcing synoptic/regional scale climate scenarios (e.g. EURO-CODEX)

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

Propagation of the long period climate trend into the small domain, to the local scale, as snapshots of climate

Sets of local scale data for **average fields** and **statistic for events** to assess climate hazards

Generate sensitivity cases to atmospheric forcing events

Link synoptic/regional scale fields to local events (2020 – 2100)

Compute statistics of atmosphere-sea events from the whole atmospheric forcing sets

Work in progress in AdriaClim

- Runs for code relaxation time evaulaion and propagation of boundary conditions into the domain
- Generation of reference yearly simulation, to compare scenario simulations
- Definitions of the regression functions that transfer future synoptic scale patterns into the local scale features

Conclusions

- Stakeholders require coastal climate change scenarios with a local scale resolution, both for long term trends and intense episodes. Uncertainty estimates are mandatory.

- The dynamic approach nowadays applied to downscale atmosphere and ocean scenarios, from the global scale into the regional scale, at present is not suitable to downscale regional scenarios into local ones.

- For very small domains of shallow waters, yearly model runs may be enough to propagate the global or regional scale scenario into the domain, at least for the mean values of physical fields.

- Trends in the events frequency and intensity can be approached using model sensitivity runs and functions linking regional climate atmospheric fields to the local scale atmospheric forcing.

The AdriaClim project is applying this strategy for the Gulf of Trieste and its lagoons

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