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Using Artificial Intelligence for estimating the Responses of coastal lagoons to Climate Change

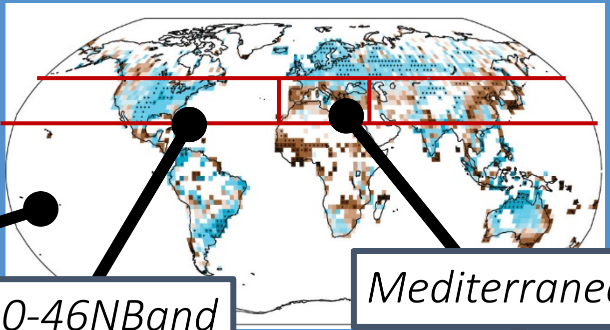
LifeWatch ERIC

NATIONAL BIODIVERSITY FUTURE CENTER

UNIVERSITÀ DEL SALENTO
L'Ateneo tra i due mari

CNR ISMAR
ISTITUTO DI SCIENZE MARINE

SPECIFICITY OF CLIMATE EVOLUTION IN THE MEDITERRANEAN REGION

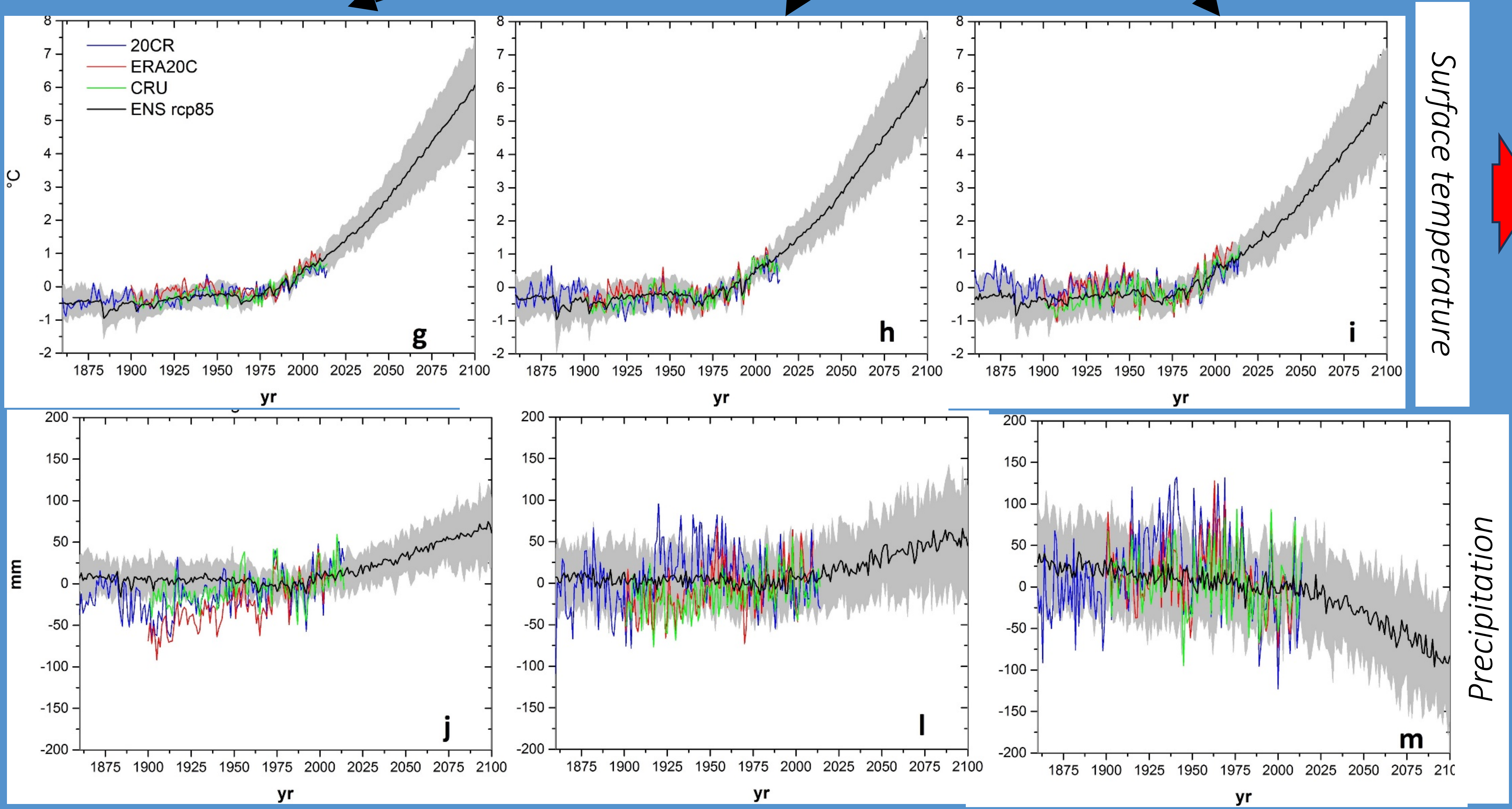


values in these graphics consider <u>only land points</u>
(Lionello and Scarascia, 2018)

Global

30-46NBand

Mediterranean

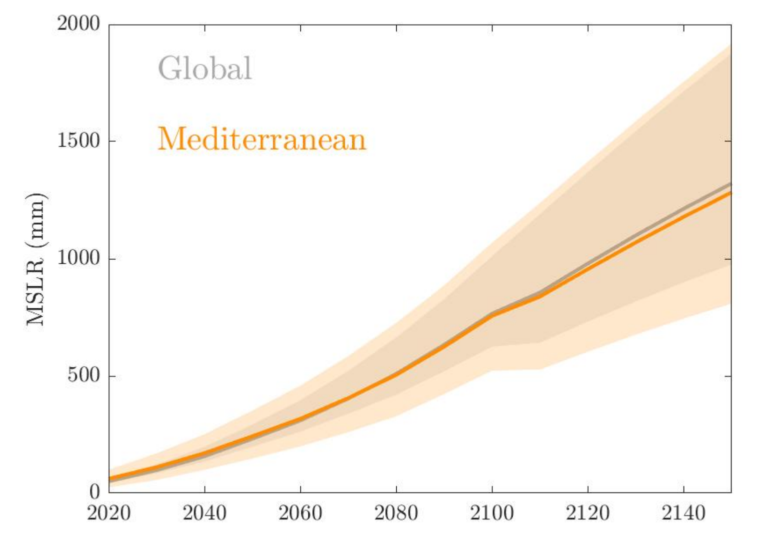


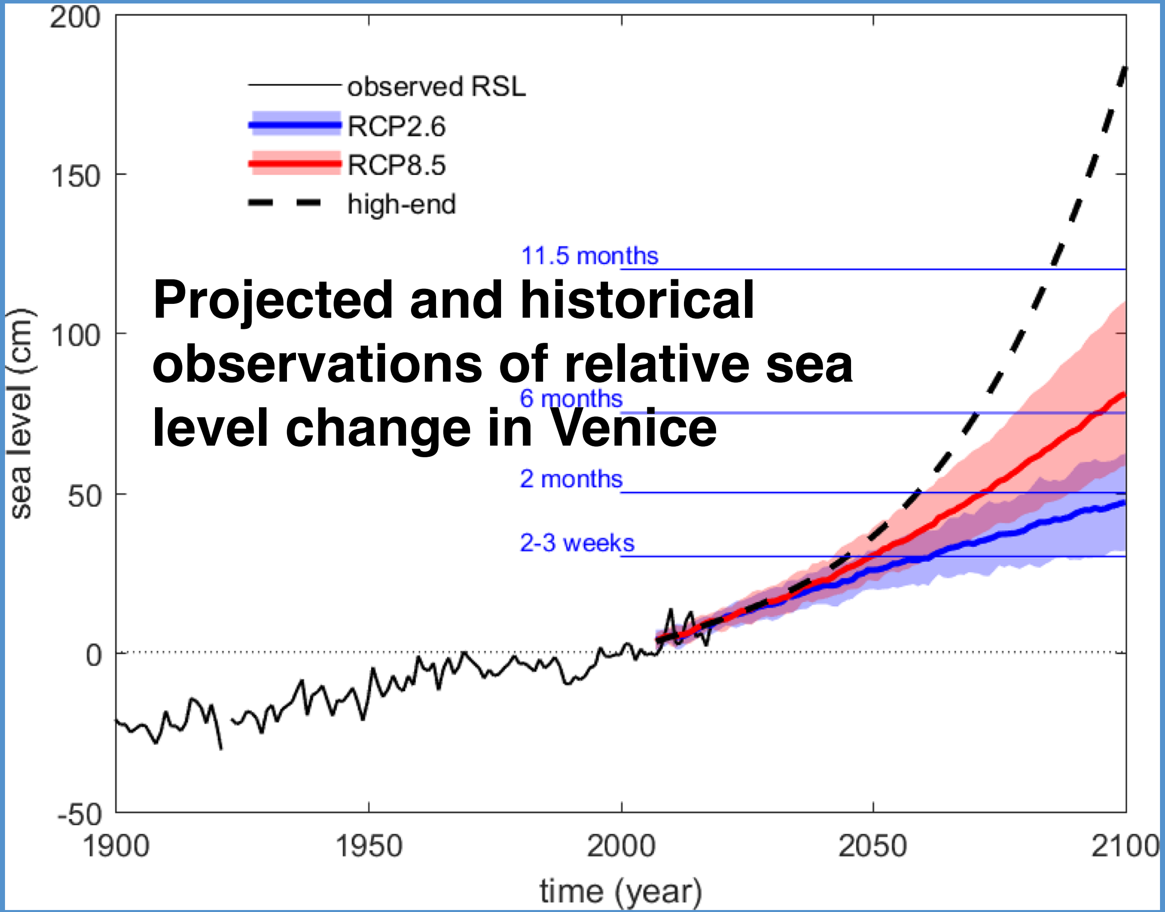
Very large warming <u>in summer</u>

Precipitation decrease

Regional sea level rise

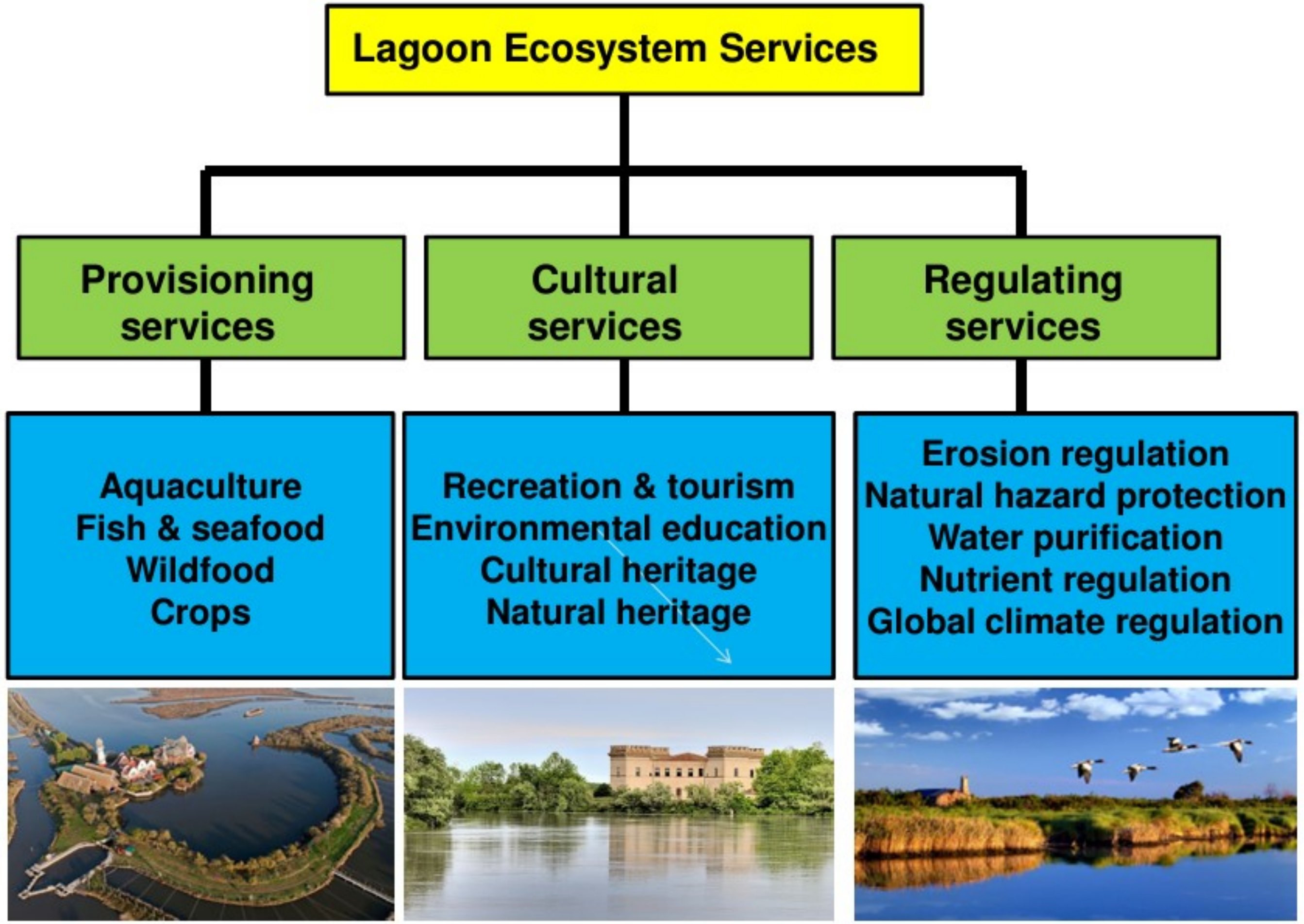
Comparison between global and Mediterranean mean sea level projections





Projected and historical observations of relative sea level change in Venice with respect to the 2000–2007 average. Projections are based on Representative Concentration Pathway 2.6 (RCP2.6; low emission scenario) and RCIP8.5 (strong emission scenario), and a high-end scenario illustrating a plausible evolution obtained by combining the highest estimates of all individual contributions to relative sea level rise (shading – 5–95 percentile range; line – median).

Coastal lagoons play a very important role ……



Ecosystem services: contribution of ecosystem structure and function to human well-being

… but their evolution and consequent risks are not comprehensively assessed

From IPCC AR6 WGII, chapter 3
Cooley et al., 2022: Oceans and Coastal Ecosystems and Their Services. In: ClimateChange 2022: Impacts, Adaptation and Vulnerability. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 379–550, doi:10.1017/9781009325844.005

Estuaries, Deltas and Coastal Lagoons

- ✓ *[….] were impacted for much of the 20th century primarily by non-climate drivers (very high confidence) [….]nevertheless, the influence of climate-induced drivers has become more apparent over recent decades (medium confidence)*
- ✓ *Drought and freshwater abstraction can reduce freshwater inflows to estuaries and lagoons, increasing salinity […]   Changes in freshwater input and SLR, combined with land-use change, can alter inputs of land-based sediments, causing expansion or of intertidal habitats. The same phenomena alter salinity gradients, which are the primary drivers of estuarine species distributions (high confidence*
- ✓ *Warming and MHWs will enhance stratification and deoxygenation in shallow lagoons (medium confidence) and will continue to drive range shifts among estuarine biota (medium confidence), resulting in extirpations where thermal habitat is lost and potentially generating new habitat for warm-affinity species (limited evidence, medium agreement)*

<u>Project objectives</u>

- *Construction of physical/environmental scenarios of coastal lagoons related to Climate Change projections*
- *Assessment of the response of lagoon biodiversity to the physical/environmental scenarios.*

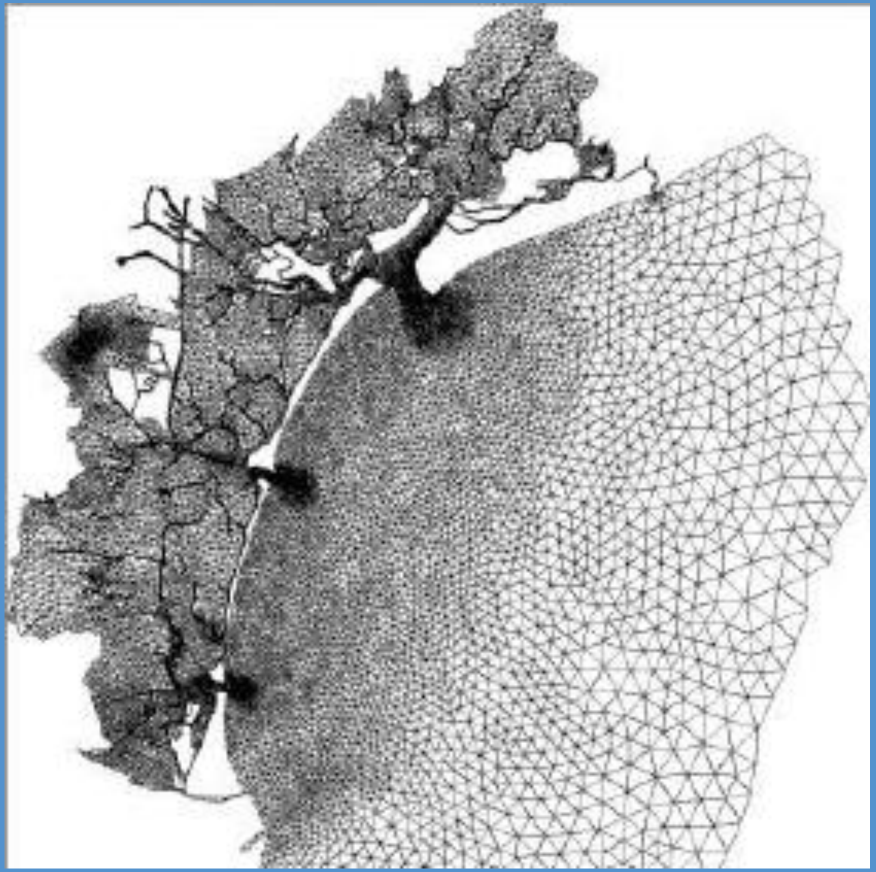
<u>This presentation</u>

- *Initial results considering the physical aspects using selected stations in the Venice lagoon*

The description of coastal lagoon with systems dynamical models is problematic and very difficult to be achieved for a large set of lagoons

↓

Artificial intelligence (neural networks) is used as a suitable alternative to expensive dynamical modelling and to compensate for knowledge gaps



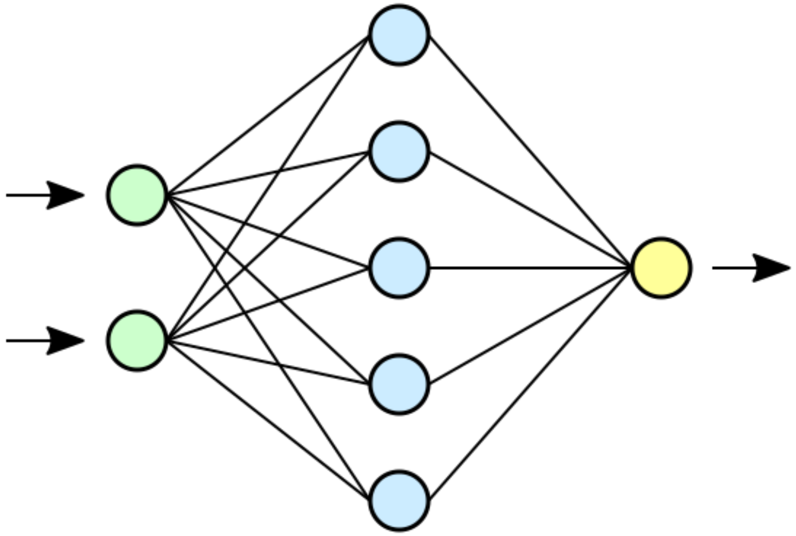
Umgiesser G. et al. "A finite element model for the Venice Lagoon. Development, set up, calibration and validation." *Journal of Marine Systems* 51.1-4 (2004): 123-145.

neural network modelling of coastal lagoon salinity and temperature

Application of neural networks to model physical/environmental time series

- by combining field observations with reanalysis data (**training and validation**)
- by forcing the neural network with climate model results (**projections**)

- *10 m u wind component*
- *10 m v wind component*
- *2 m air temperature*
- *Soil level temperature*
- *Precipitation*
- *Humidity*
- *Offshore Sea level*
- *Offshore salinity*



- *Salinity*
- *Temperature*

- *3 level of neuron (intermediate level for internal patterns recognition)*
- *5 neurons for each level*
- *2 bias neurons*

TRAINING: 2000-2001

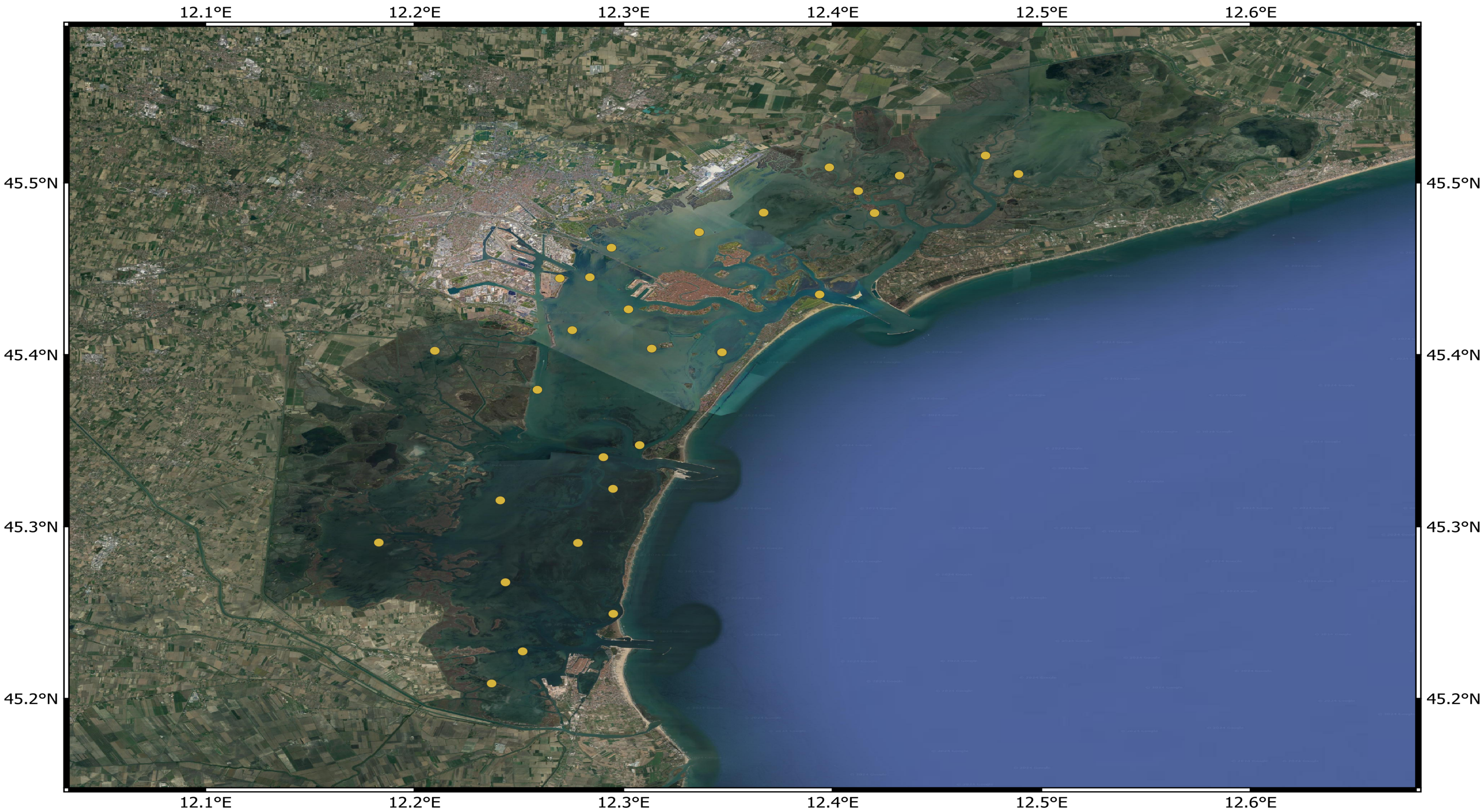
VALIDATION: 2002-2003

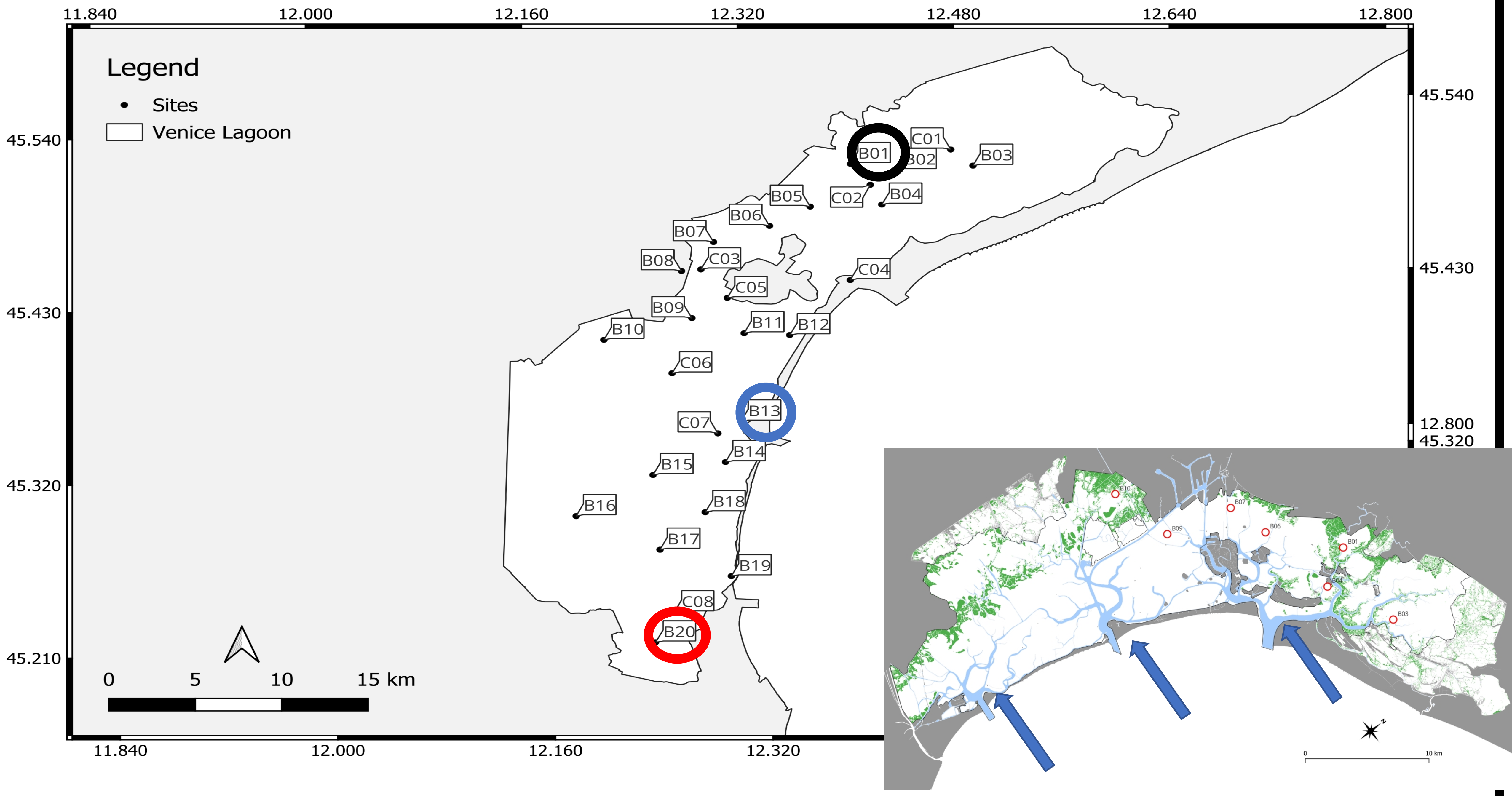
- UERRA regional reanalysis for Europe on height levels from 1961 to 2019 (copernicus.eu)
- 7 selected stations in the Venetian Lagoon

(dati forniti da MAGISTRATO ALLE ACQUE DI VENEZIA, Campagne periodiche di misura della qualità delle acque MELa1

PROJECTIONS SET: 2004-2100

- CSIRO-Mk3-6-0 (CSIRO, Australia) RCP 8.5

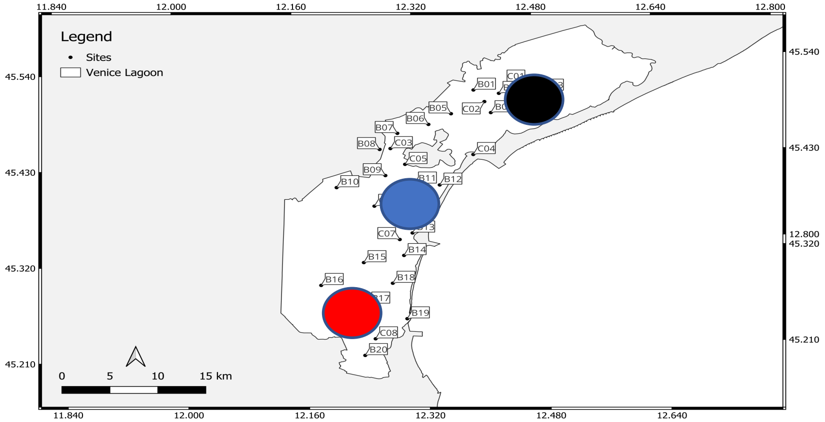


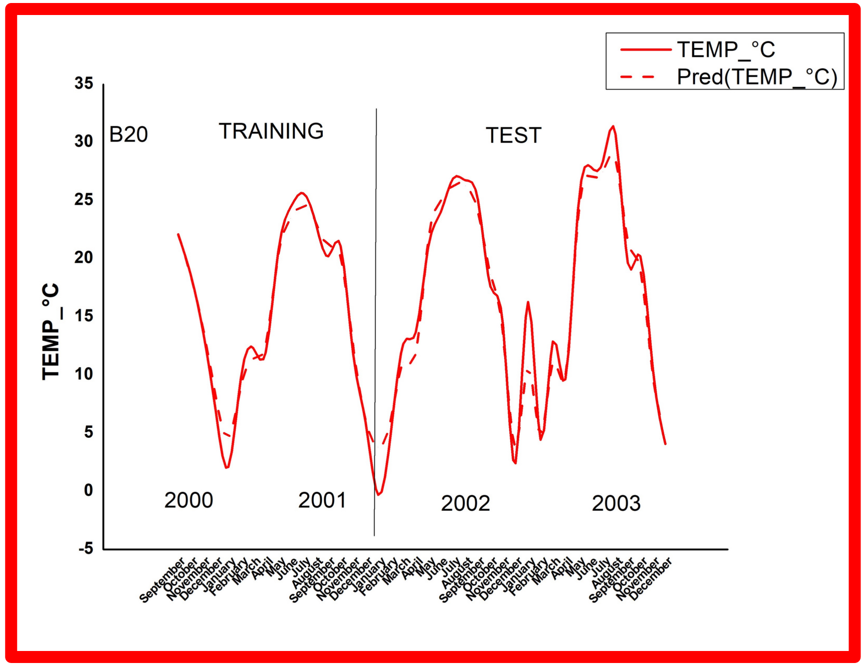


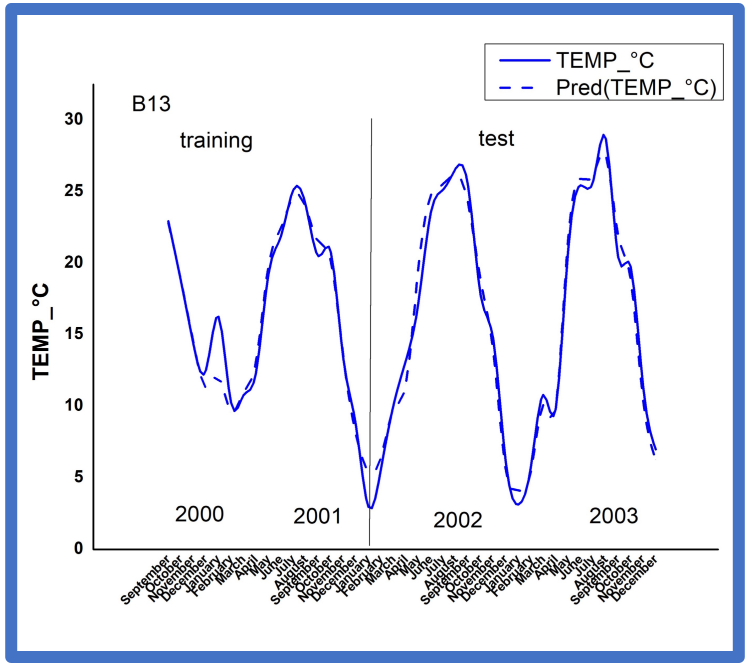
11.840
12.000
12.160
12.320
12.480
12.640
12.800
45.540
45.430
45.320
45.210
12.800
45.320
Legend
Sites
Venice Lagoon
C01
B01
B02
B03
B05
C02
B04
B06
B07
B08
C03
C04
C05
B09
B10
B11
B12
C06
B13
C07
B14
B15
B16
B18
B17
B19
C08
B20
0
5
10
15 km
B10
B07
B09
B06
B01
B03
0
10 km

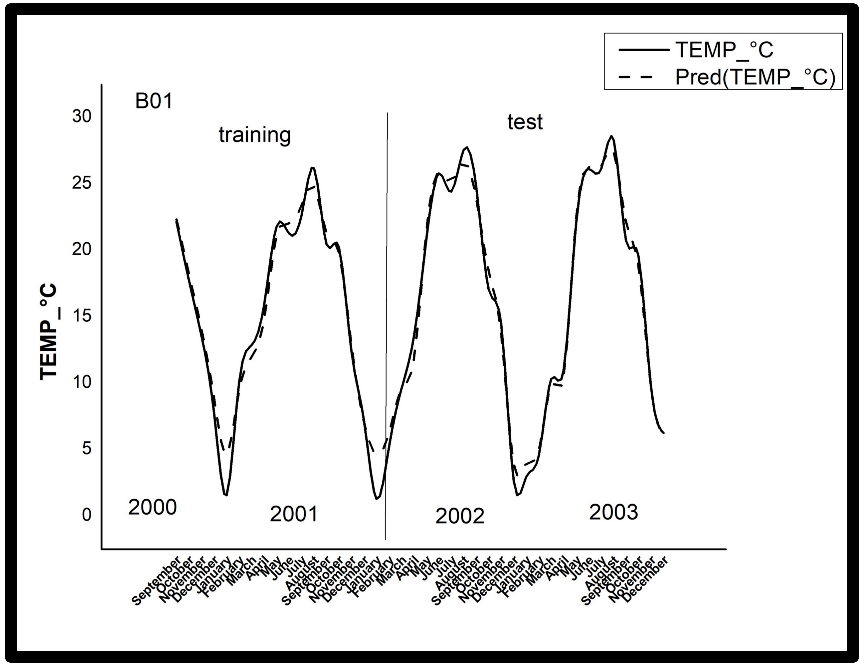
temperature

Training 2000-2001
Test 2002-2003



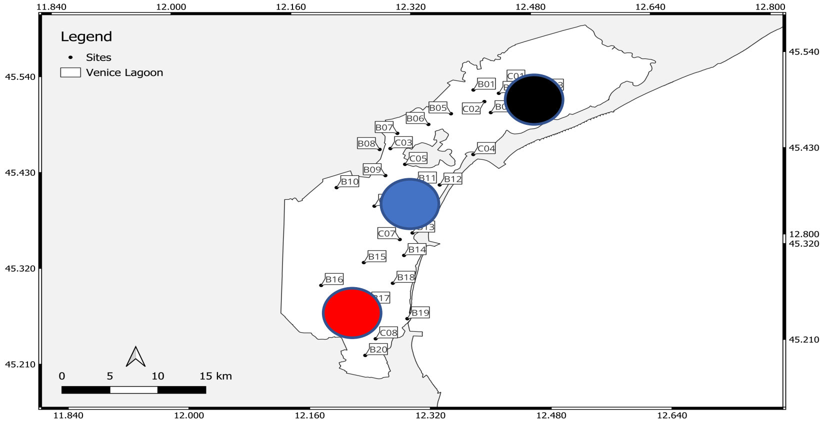


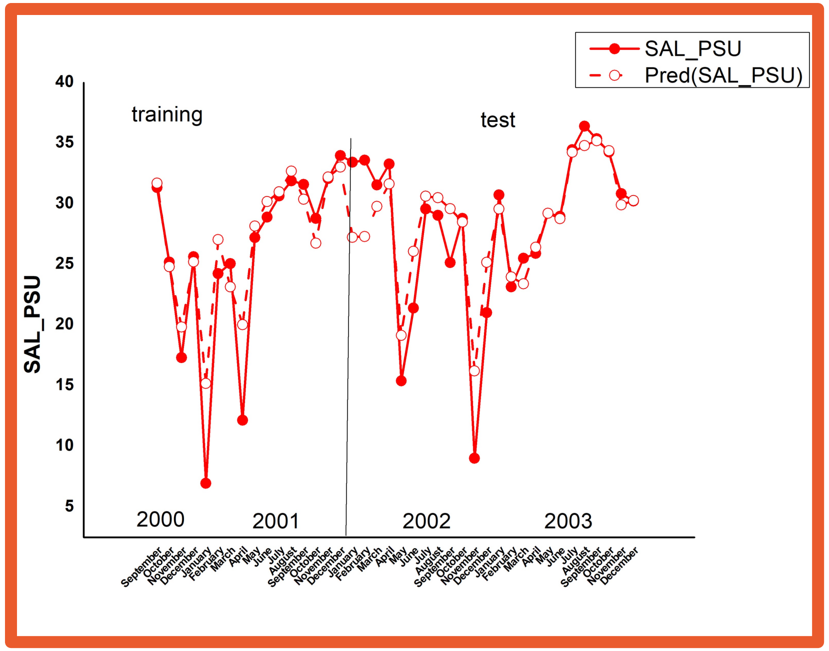


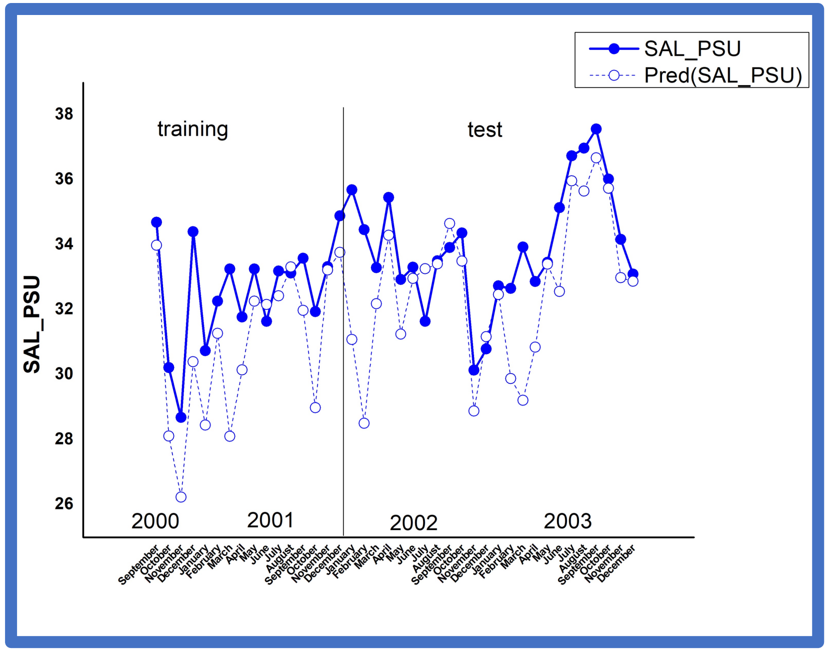


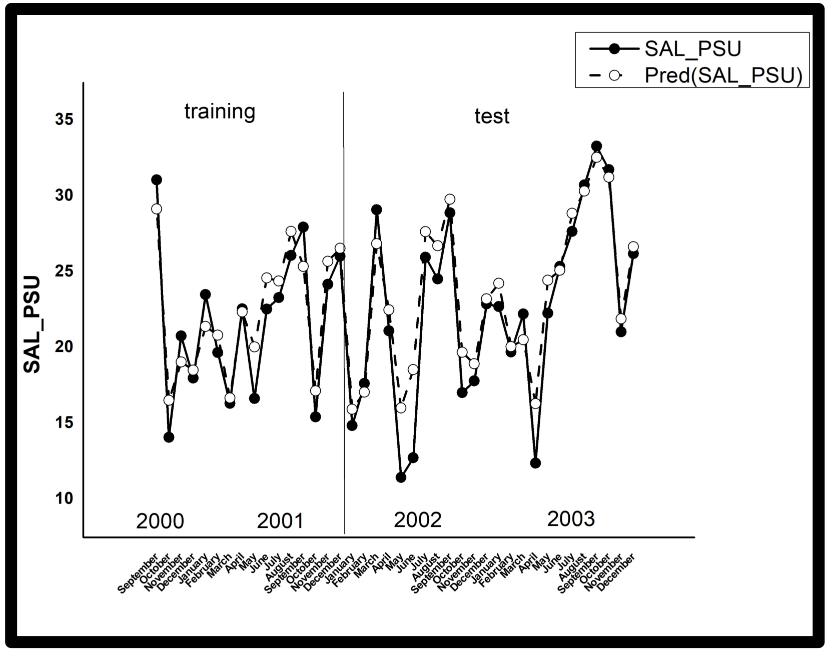
Salinity

Training 2000-2001
Test 2002-2003



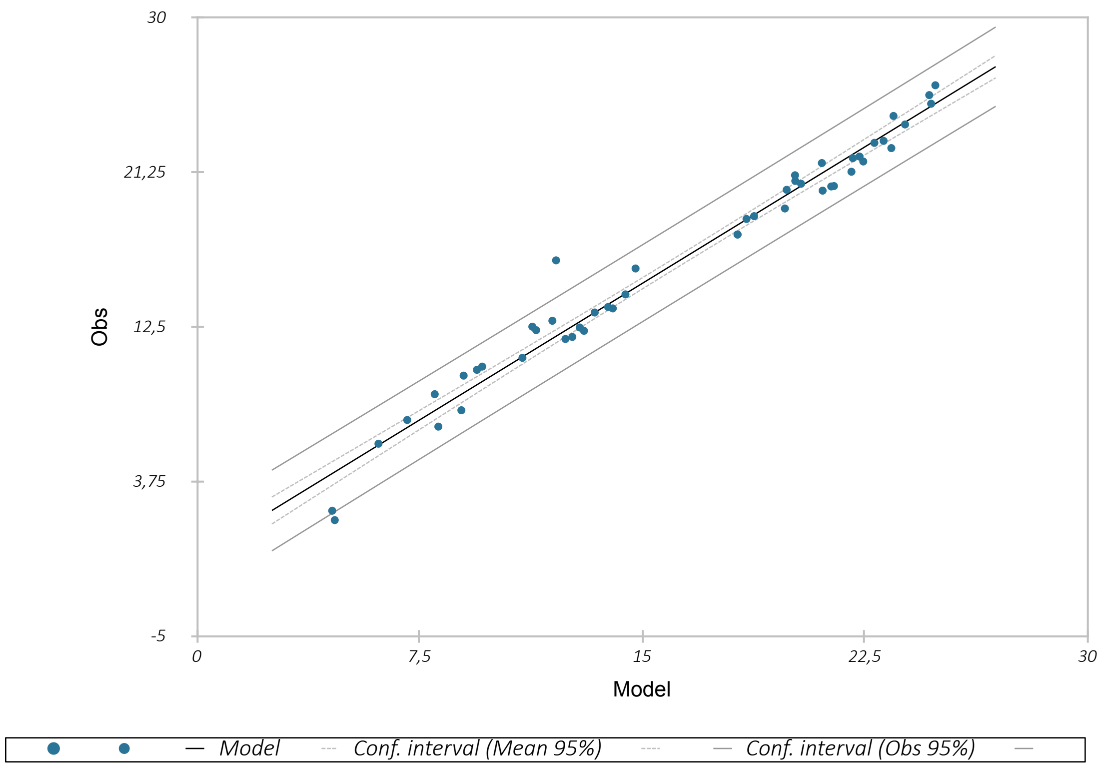




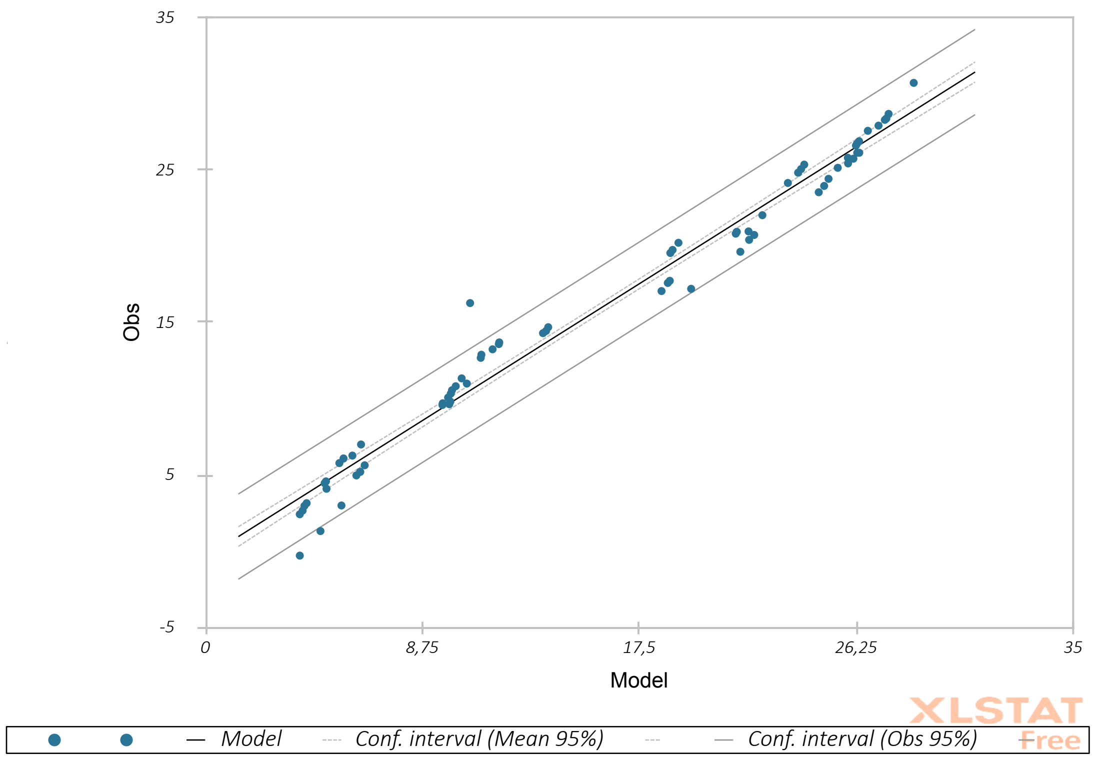


Scatter plot: monthly average Temperature (°C)

Training (2000, 2001)

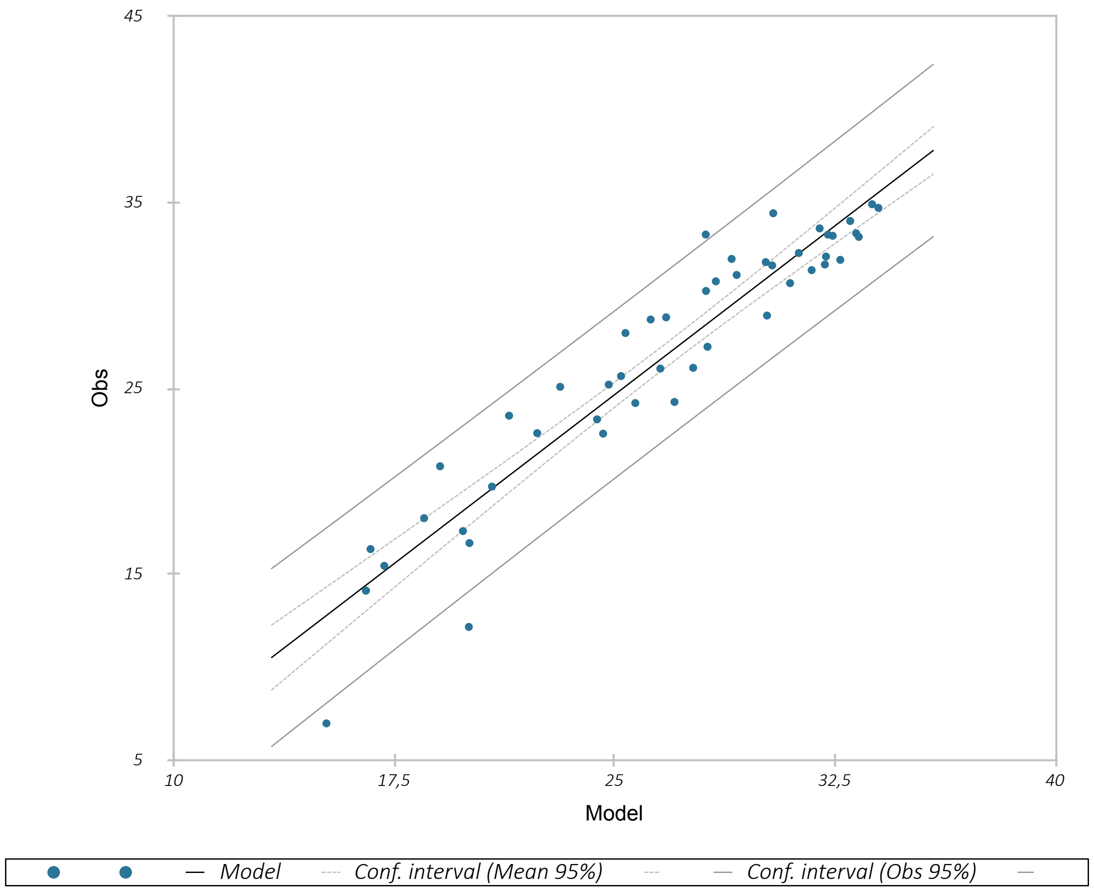


Validation (2002- 2003)

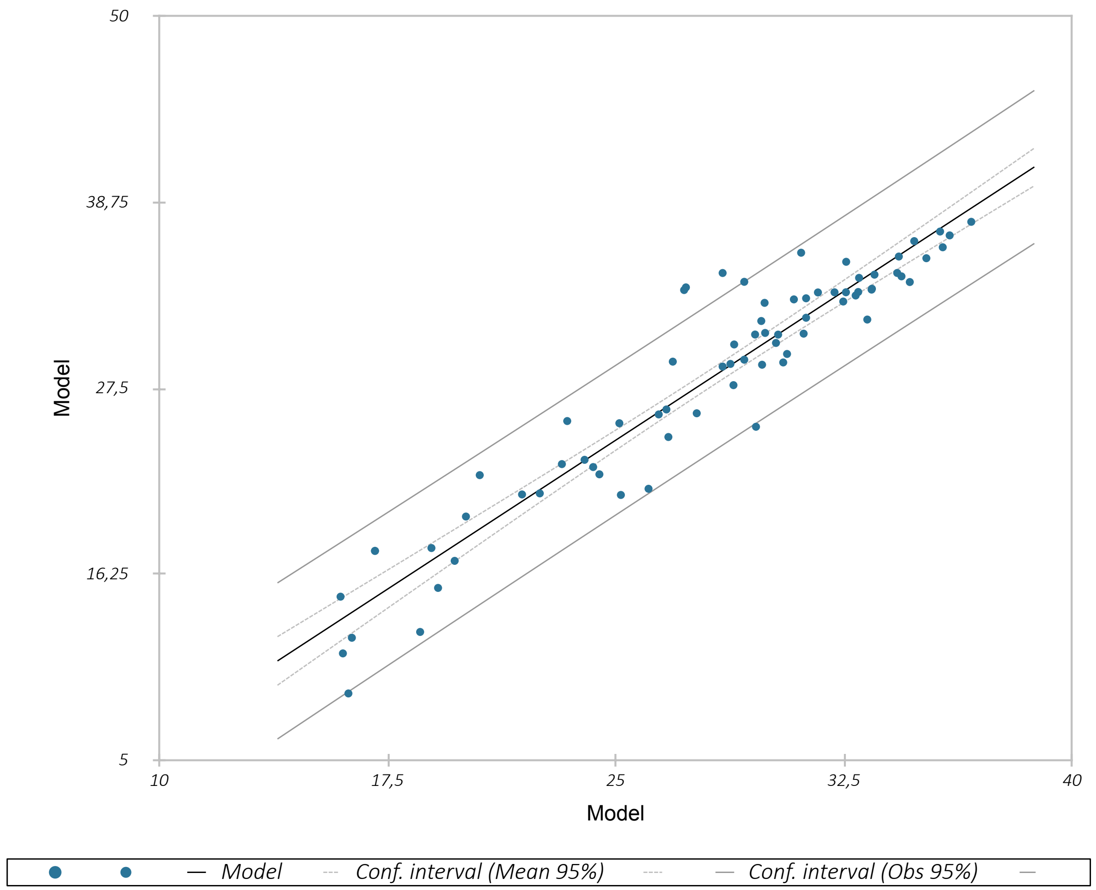


Scatter plot: monthly average Salinity (psu)

Training (2000, 2001)

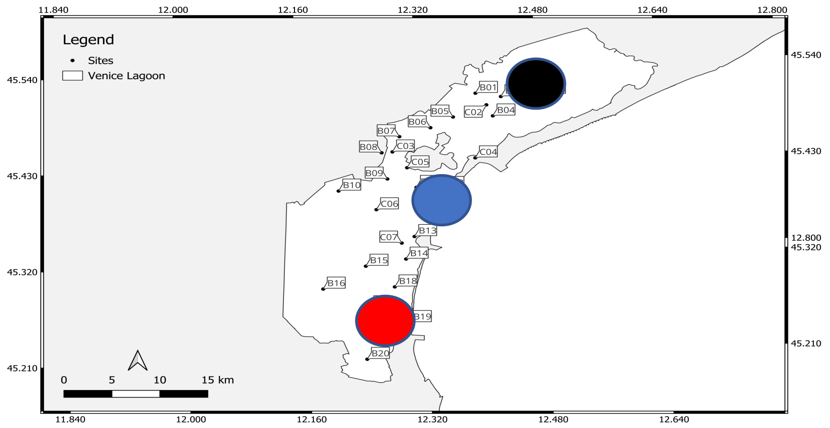


Validation (2002-2003)

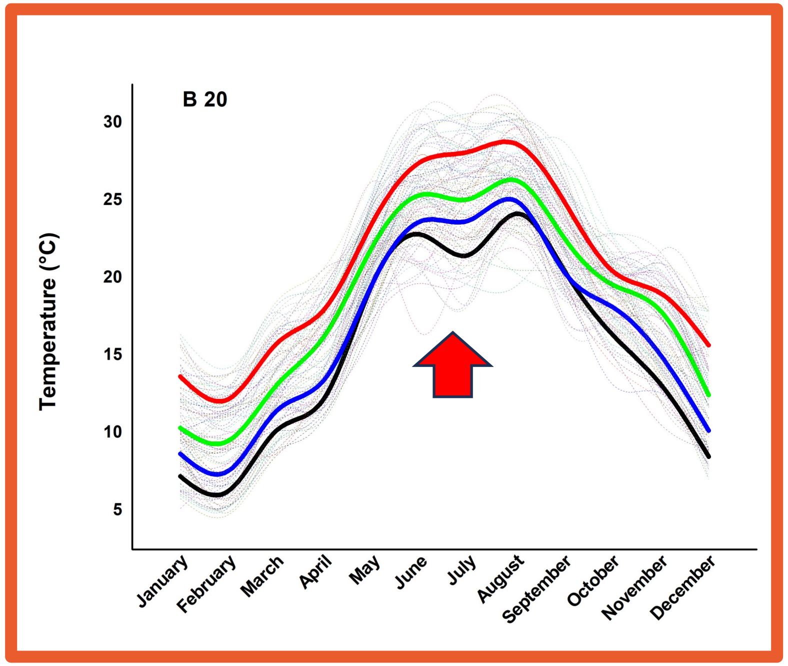


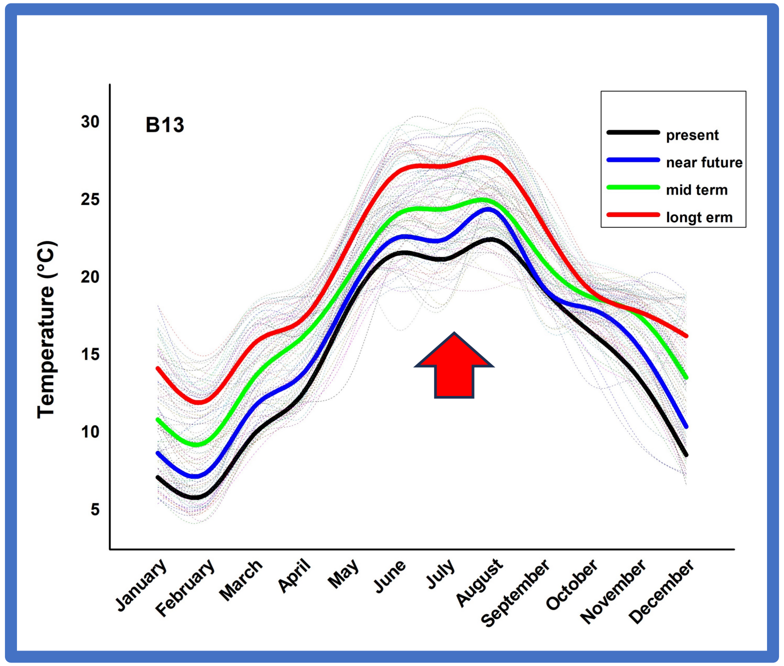
temperature projections for the Venice lagoon

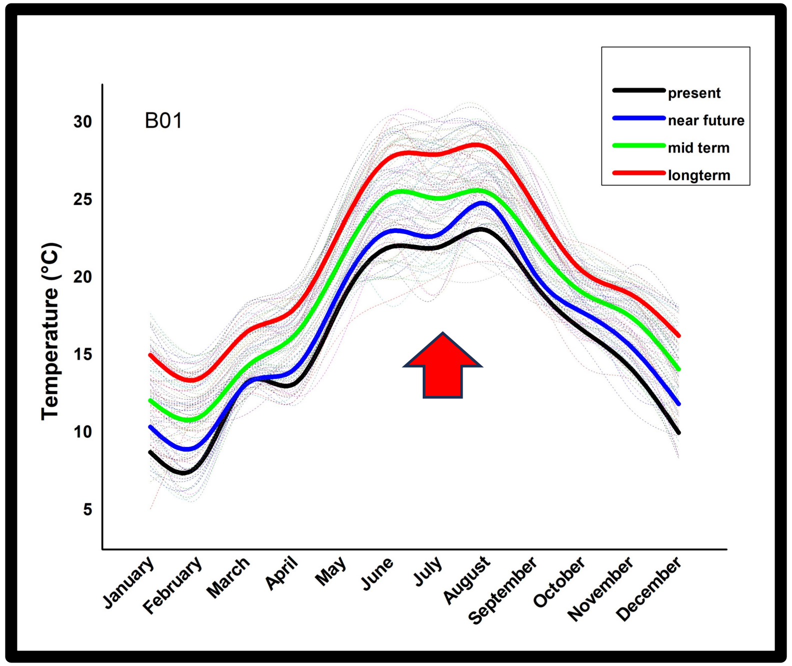
Long-term 2081-2100
Mid- term 2041-2060
Near-term 2021-2040
Present 1995-2014



Overall warming in all areas and seasons

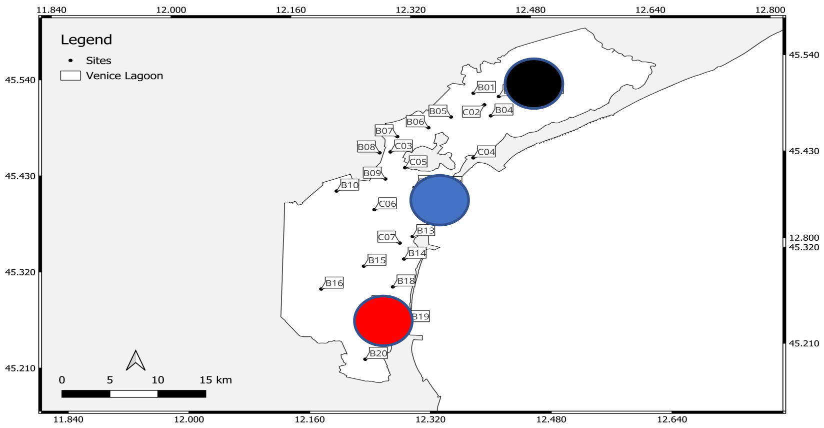




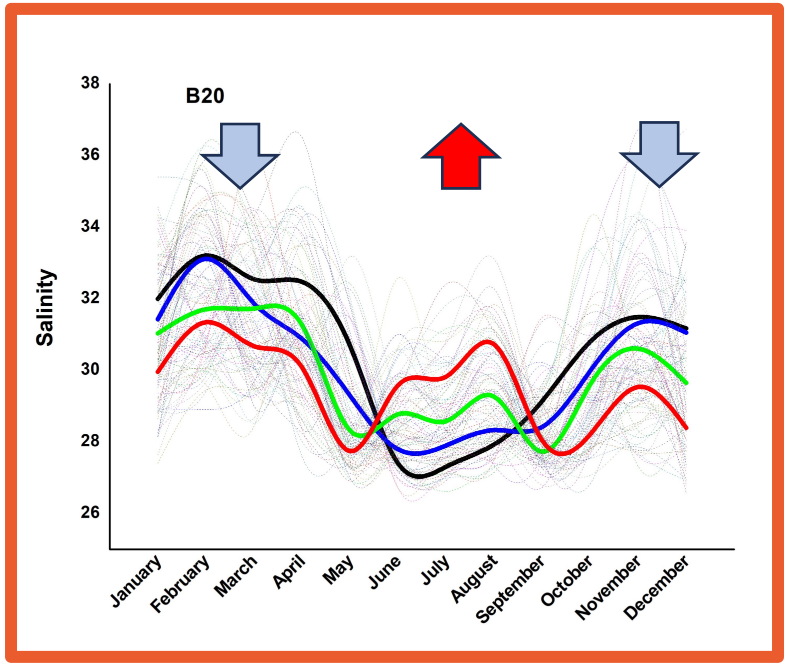


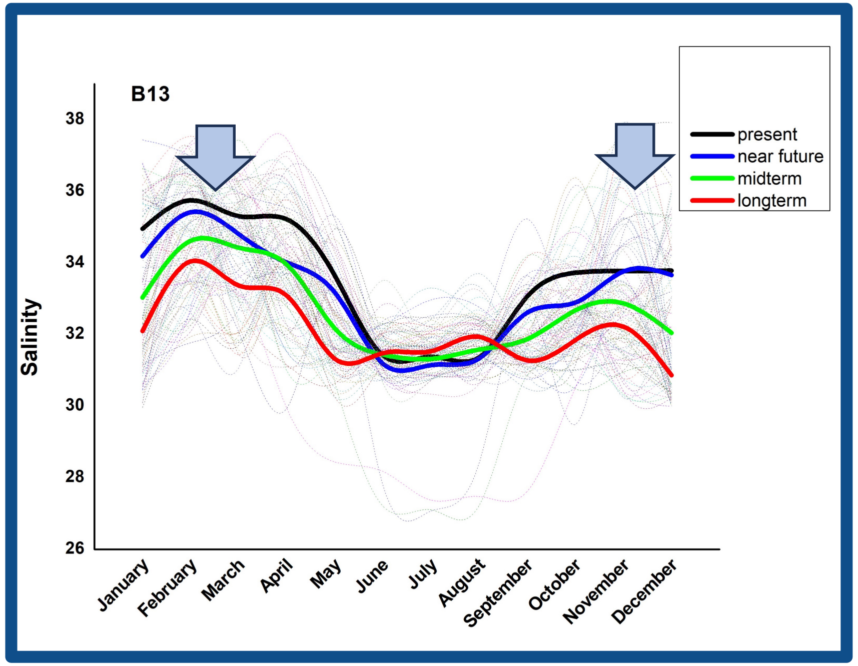
Salinity projections for the Venice lagoon

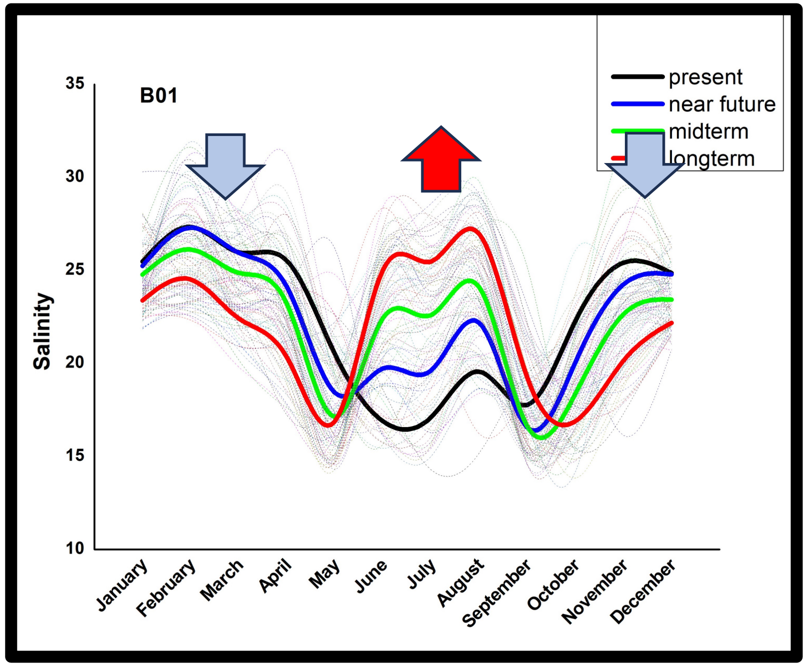
Long-term 2081-2100
Mid- term 2041-2060
Near-term 2021-2040
Present 1995-2014



Fresher/saltier cold/warm season but in summer in areas where tidal forcing is strong







Conclusions

- *promising results: the neural networks seems capable to model the variability of temperature and salinity of the lagoon and to produce sensible projections*
- *Present expectations warmer lagoon, saltier in summer and fresher in winter (reduced amplitude of the salinity cycle) then present (WARNING: based only on one model)*

Future work

- *Model refinement (optimization of driver selection, addition of offshore salinity)*
- *Identifying a suitable model ensemble for exploring the projections and to estimate future evolution with its uncertainty*
- *Exploring a meaningful range of different climate scenarios*
- *Extending the analysis the whole Venice lagoon*
- *including a representative set of lagoon along the Mediterranean coastline*

LifeWatch ERIC 2024 Thematic Service Workshop Series

Thank you for your attention!

Any questions?

Taxonomy | Brussels, Belgium, 30 January 2024

Climate Change Impact on Biodiversity Patterns | Lecce, Italy, 21-22 February 2024

Animal Movement and Biologging | Ostend, Belgium, 22 March 2024

Biogeography | Bologna, Italy, 4-5 April 2024

Biodiversity Observatory Automation | Ljubljana, Slovenia, 11 April 2024

Habitat Mapping | Aveiro, Portugal, 3 May 2024