

# 1. Scientific motivation

Despite the attention devoted to "Acqua Alta" floodings in the Venice Lagoon [Ferrarin 2024], there is no reliable method to model and predict the local effects of Mose barriers on an urban/regional scale and at short timeframes (e.g., days). errarin 2024]: Ferrarin C., Bonaldo D., Bergamasco A., Ghezzo M., Sea level and temperature extremes in a regulated Lagoon of Venice, tiers in Climate, 5, 2024, https://www.frontiersin.org/journals/climate/articles/10.3389/fclim

# 2. Summary and outlook

- Include the MoSE regulated barriers in the modelling chain, allowing for simulations/forecasting that, at run-time, can activate/deactivate these barriers. Develop a simplified Immersed Boundary (IB) condition [Peskin 1972, Mittal
- 2003] module to integrate the presence of the barriers. Demonstrate the capacity of storm surge forecasting in Venice through a synergistic modelling chain approach - from the regional scale of the Mediterranean Sea to high-resolution local urban scale.

is around heart valves: A numerical method, Journal of Computational Physics, 10, 2, 1972,

## **3. Inclusion of MoSE barriers in the modelling chain**

## SHYFEM-MPI

It is a message passing interface parallelization upgrade [Micaletto 2021; Verri 2023] of the SHYFEM 3D finite element hydrodynamic model [Umgiesser 2004; Cucco 2005], designed to solve the Navier–Stokes equations by applying hydrostatic and Boussinesq approximations. The model is based on an unstructured Arakawa B computational grid with triangular meshes [Bellafiore 2010] allowing an accurate description of irregular coastal boundaries.

## Development of Immersed Boundary (IB) conditions in SHYFEM-MPI

- The computational elements and nodes within the  $\Gamma_{\rm IB}$  domain are excluded from the calculation of the equations of motion whenever the immersed boundary is activated by imposing a zero-velocity condition  $\circ$   $\overline{\mathrm{u}}(\overline{\mathrm{x}})=\overline{\mathrm{0}}$  ,  $\overline{\mathrm{x}}\in\ \Gamma_{\mathrm{IB}}$
- The elements of the  $\Gamma_{nIB}$  domain, which share an edge with the obstacle are subject to a free-slip boundary condition  $\circ \frac{\partial \overline{u}}{\partial n} = 0$ ,  $\overline{x} \in \Gamma_{nIB}$

## Validation with tidal inlet idealized testcase



[Cucco 2005]: Cucco A., Umgiesser G., Modeling the Venice Lagoon residence time, Ecological Modelling, 193, 1–2, 2006, https://doi.org/10.1016/j.ecolmodel.2005.07.043 [Bellafiore 2010]: Bellafiore D., Umgiesser G., 2010, Hydrodynamic coastal processes in the North Adriatic investigated with a 3D finite element model, Ocean Dynamics, 255-273, 60, 2, https://doi.org/10.1007/s10236-009-0254-x

# Storm surge forecasting in Venice: what-if scenario with MoSE barriers

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The analysis and forecast data used to initialize and force the SHYFEM-MPI through the Copernicus Marine Service [Clementi 2022].





## Case study

4 main events were recorded during the period of November 22–26, 2022, the most intense one occurred on the 22/11/2022 [Mel 2023].



Mel R. A., Coraci E., Morucci S., Crosato F., Cornello M., Casaioli M., Mariani S., Carniello L., Papa A., Bonometto A., Ferla M. Insights on the Extreme Storm Surge Event of the 22 November 2022 in the store s Venice Lagoon. Journal of Marine Science and Engineering, 11(9), 2023, https://doi.org/10.3390/jmse11091750



