**Advancing the integration of monitoring and modelling of the physico-chemical and biogeochemical state of the Marano and Grado Lagoon (Italy)**

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This study investigates the physical-chemical and biogeochemical dynamics of the Marano and Grado Lagoon (northern Italy) using a combination of observational data and simulations from the coupled SHYFEM-BFM model. A data assimilation approach is applied to integrate monitoring information into the model, improving the representation of lagoon processes. Model outputs are validated against in situ measurements and previous studies, showing strong agreement for water level and temperature, and good performance for salinity. Dissolved oxygen and nitrate also match observed spatial and seasonal patterns, while chlorophyll-a and phosphate are more variable, with location-dependent discrepancies. These limitations highlight the need for improved monitoring data, which will be provided by the new MALO network developed under the ITINERIS project, and that will contribute to the DANUBIUS infrastructure. MALO includes four instrumented buoys with CTDs measuring temperature, conductivity, pressure, chlorophyll-a, turbidity, and dissolved oxygen. Five ADCPs at lagoon inlets provide current profiles, and a nutrient analyser with integrated CTD complete the system, offering continuous, high-frequency data to strengthen the integration of monitoring and modelling.

A preliminary test of a modified nudging technique within SHYFEM assimilated salinity data from existing probes in the western lagoon, originally installed for hypoxia/anoxia monitoring. While assimilation improved model performance, some discrepancies remained due to probe limitations. Assimilation of higher-quality MALO data is expected to enhance accuracy further once the network is fully operational.

Scenario simulations explored the lagoon’s response to nutrient load variations. Phosphate, nitrate, and ammonia inputs from rivers were altered by ±50%, and additional simulations doubled and quadrupled these inputs. The resulting spatial distributions are compared with literature data, highlighting seasonal ecosystem responses and the lagoon’s sensitivity to nutrient changes. These findings are key for informing nutrient management strategies aimed at achieving water quality targets.

**Keywords: environmental dynamics, numerical simulations, coastal lagoon**