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Combined Numerical and Machine Learning Approach to Ensemble Storm Surge modeling in the Northern Adriatic

Matjaz Licer (1), Anja Fettich (2), Peter Smerkol (2), Saso Petan (2), and Martin Vodopivec (2)

(1) National Institute of Biology, Marine Biology Station Piran, Slovenia (matjaz.licer@nib.si), (2) Slovenian Environment Agency, Ljubljana, Slovenia

Storm surges are one of the processes in the Northern Adriatic that cause significant risk to local population, economy and cultural heritage. They are notoriously difficult to model and in recent years ensemble approach to storm surge forecasting has proven beneficial. We present a storm surge forecasting system for sea level anomalies (SLA) in the Gulf of Trieste, employing a combined approach of ensemble numerical ocean modeling and machine learning. We use fifty ECMWF ensemble surface fields for winds and mean sea level (MSL) pressure as surface boundary conditions to force a quasi-barotropic (3 vertical s-levels) Adriatic setup of NEMO ocean model. Lateral open boundary conditions to NEMO ocean model come from CMEMS MFS product. The fifty NEMO components, forced by ECMWF ensemble members, are run daily for a 72 hour forecasting period and constitute an ensemble forecast for SLA. Tidal component to SLA is computed using a dedicated run of NEMO on the same numerical grid, initialized to the same thermohaline state, but subsequently forced only with TPXO8 tides at the open boundary. Combined SLA ensemble is then renormalized by a 24-hour running bias removal employing near real-time observations from a tide gauge in the port Koper (Gulf of Trieste). Systematic errors of the forecast are modeled using a machine learning algorithm which employs synoptic-scale atmospheric forecasts over the Adriatic basin as its feature set and Koper tide gauge observations as its target. Modeled error predictions are removed from the forecasting set to produce SLA prediction with a higher forecasting skill.