SYMPOSIUM OP'24 ADVANCING OCEAN PREDICTION SCIENCE FOR SOCIETAL BENEFITS

5.6 - Digital twins

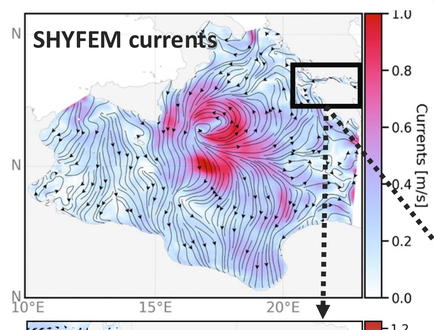
INTEGRATED MODELLING FRAMEWORK FOR NATURE-BASED SOLUTIONS TOWARD A DIGITAL TWIN OF THE COASTAL OCEAN

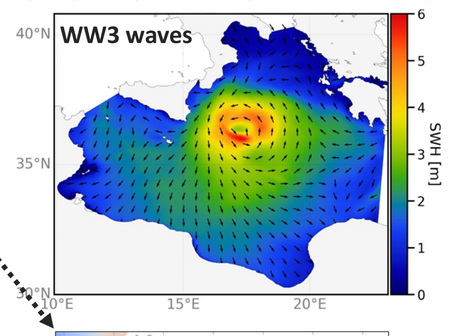
Abstract

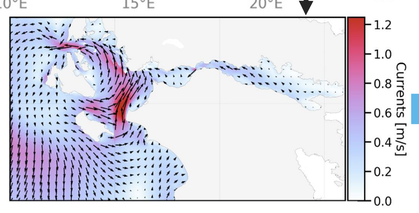
Coastal regions, rich in infrastructure, ecosystems, and cultural heritage, are highly vulnerable to climate change impacts such as sea level rise and increasing extreme events. Storm surges, driven by waves and currents, are primary causes of coastal erosion and inundation. Beyond traditional seawalls and groins, nature-based solutions (NBS) have emerged as sustainable alternative, with seagrasses offering significant coastal protection among the various ecosystem services they offer.

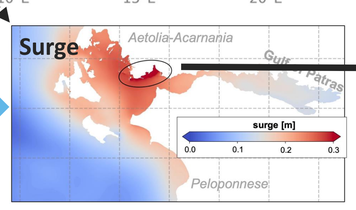
This study aims to investigate the impact of seagrass meadows on physical oceanic variables related to currents, waves and sediment transport using a coastal ocean digital twin (cDTO). Seagrass is modelled within a 3D unstructured grid, accounting for plant flexibility and seasonal growth cycles. In applying this model to the Lazio coast (Tyrrhenian Sea) the synergistic integration of observed seasonal variability in the numerical model proved essential for achieving realistic results, revealing an additional mean monthly wave height variation of up to 10% influenced by seasonal growth patterns, aside from the 20-40% wave damping capability of seagrass. The integration of circulation, waves, sediments, vegetation and flooding models is depicted, with various applications onto real-world scenarios, to illustrate and showcase the holistic approach in building cDTO.

STORM SURGE MODELLING AND FORECASTING OF MEDITERRANEAN TROPICAL-LIKE CYCLONE. MEDICANE IANOS TEST CASE





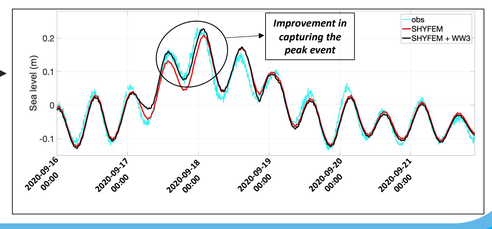




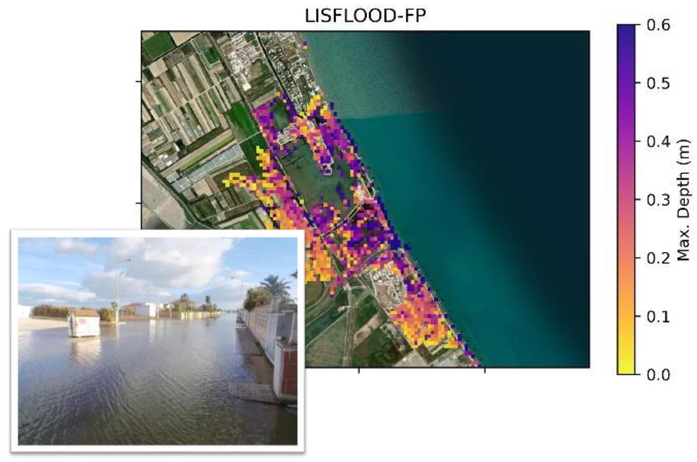
Model Improvement

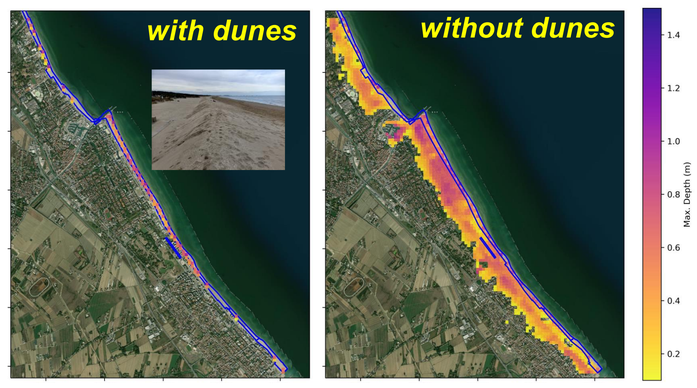
	W-C	W-0	Difference [%]
Bias	-0.202	-0.215	-6%
RMSE	0.33	0.341	-3%
SI	0.128	0.129	-1%
ρ	0.95	0.95	/
Slope	0.93	0.95	+2%

Model SSH VS Tide Gauge

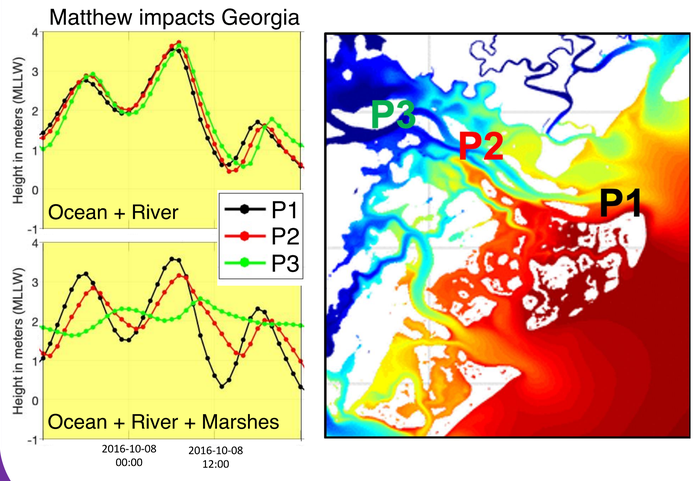


DOWNSTREAM MODEL FOR FLOODING AND CAPACITY OF WHAT-IF SCENARIOS PRODUCTION

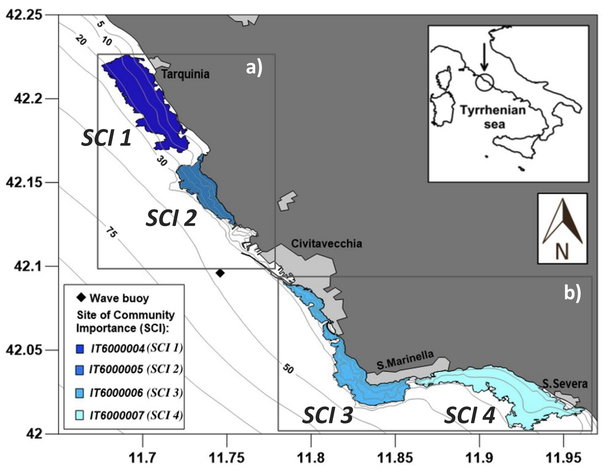




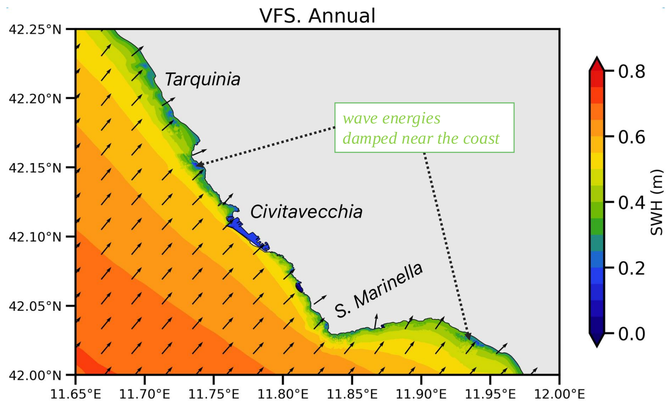
Inclusion of marshes allows to account the peak reduction due to the natural expansion of the flow in river banks and land, well evident going upstream in urban area



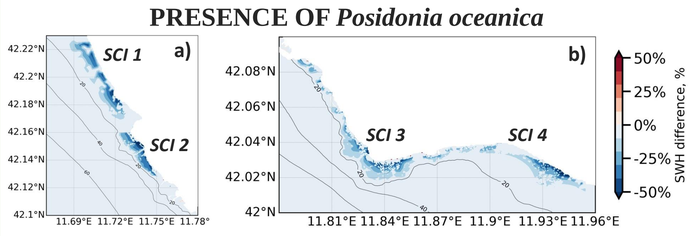
SYNERGETIC INTEGRATION OF VEGETATION DATA WITHIN NUMERICAL WAVE MODEL



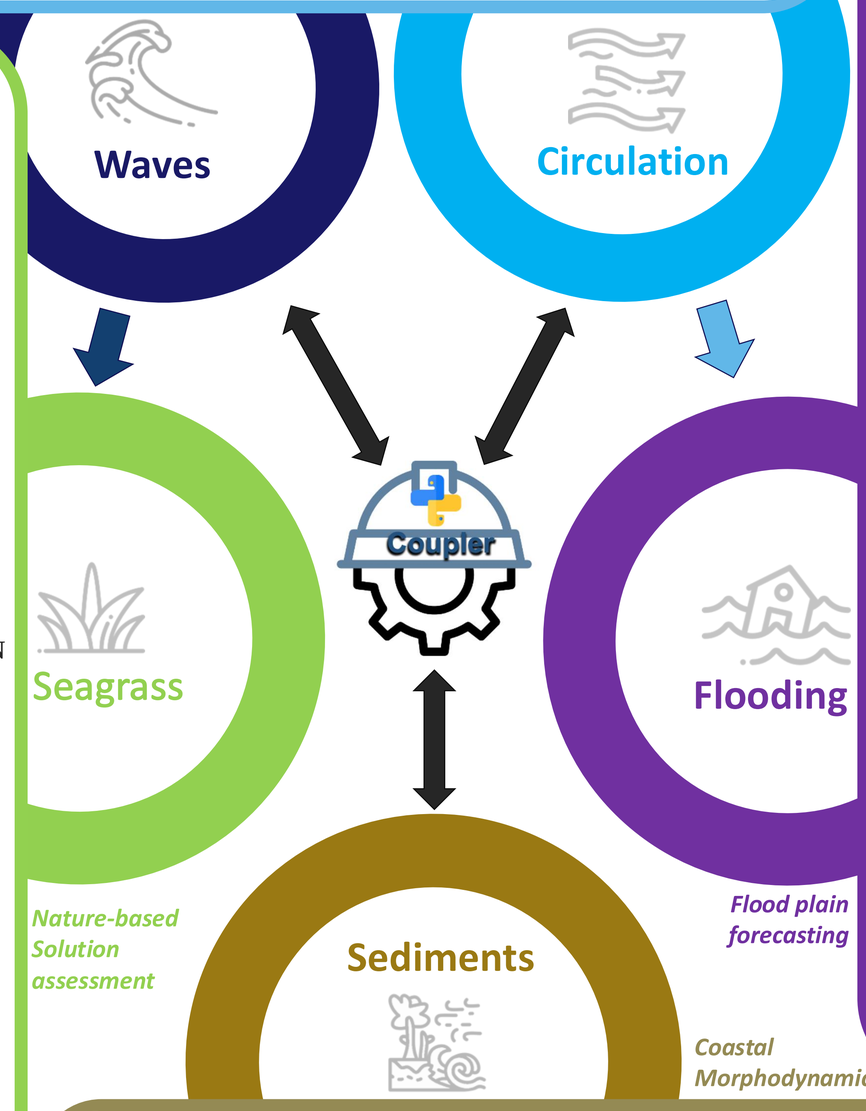
WAVE DYNAMICS AND THE IMPACT OF VEGETATION ON WAVE HEIGHT IN CIVITAVECCHIA



ANNUAL MEAN WAVE DAMPING DUE TO THE PRESENCE OF *Posidonia oceanica*



Restoration and reimplantation



SHYFEM-MPI – MORPHODYNAMICS MODEL

MODEL VALIDATION. TIDAL INLET

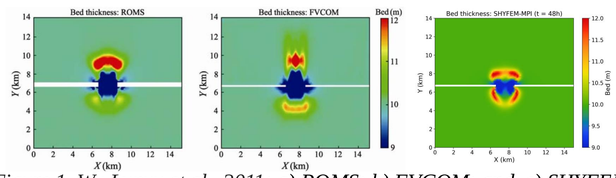


Figure 1. Wu Lunyu et al., 2011: a) ROMS; b) FVCOM; and c) SHYFEM-MPI

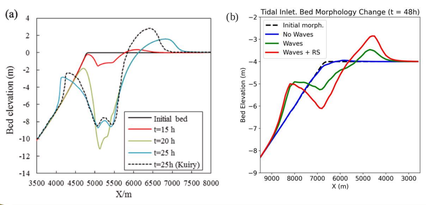
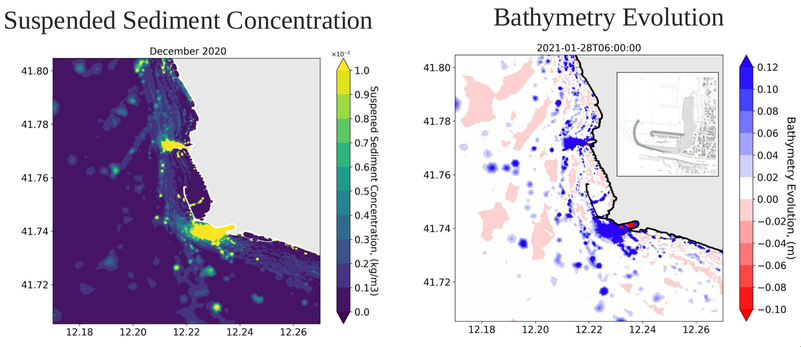


Figure 2.
a) He Ma et al., (2024).
b) SHYFEM - MPI

PRELIMINARY RESULTS FOR FIUMICINO COASTAL REGION, ITALY



Authors

Ivan Federico[1], Seimur Shirinov[1,3], Salvatore Causio[1], Simone Bonamano[2], Nicolás Biocca[1], Viviana Piermattei[1], Jacopo Alessandri[3], Italo Lopes Dos Reis[3], Lorenzo Mentaschi[3], Giovanni Coppini[1], Marco Marcelli[2], Nadia Pinardi[3]

[1]*CMCC Foundation - Euro-Mediterranean Center on Climate Change, Italy*
[2]*Laboratory of Experimental Oceanology and Marine Ecology, Tuscia University*
[3]*Department of Physics and Astronomy, University of Bologna*

cmcc Centro Euro-Mediterraneo sui Cambiamenti Climatici

Ocean Predict In partnership with unesco Intergovernmental Oceanographic Commission

2021 2030 United Nations Decade of Ocean Science for Sustainable Development