

Toward an AI-enhanced hydro-morphodynamic model for nature-based solutions in coastal erosion mitigation

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Coastal erosion is an increasing challenge, especially with the impact of climate change and stronger storm events. Traditional engineering solutions, such as seawalls, can be effective in the short term, but they are costly and often harm natural ecosystems. Because of this, there is growing interest in nature-based solutions. Seagrass meadows are a promising option, as they can reduce wave energy, slow down currents, and help stabilize the seabed in a more sustainable way.

This study focuses on the coast of Norderney in the German Bight. We use numerical models such as SCHISM-WWM and XBeach to simulate how different seagrass layouts influence erosion during storm events. A total of 180 scenarios were tested, varying both the starting depth and the depth range of the seagrass meadows to capture a wide range of possible conditions.

Since these simulations require significant computational time, we developed an AI-based emulator using a Convolutional Neural Network (CNN). The model is trained on the simulation results and predicts Bed Level Changes, which represent patterns of erosion and deposition. It uses roller energy and flow velocity as inputs and shows high accuracy in reproducing spatial patterns and erosion volumes. This approach allows fast testing of different scenarios and supports the design of effective and sustainable coastal protection strategies.