Enhanced Storm Surge Prediction in Hong Kong Coastal Waters Using Deep Learning Methodology

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This study presents a sophisticated deep learning model designed for the prediction of frequent storm surge water levels along the Hong Kong coastline. Utilizing the Convolutional Long Short-Term Memory (Conv-LSTM) method, the model incorporates U and V wind fields, surface pressure fields, and tidal station water levels from around Hong Kong as inputs to forecast imminent storm surge water levels. To enhance the model's predictive capabilities, we integrate the Physics-Informed Neural Network (PINN) methodology. The model's efficacy was assessed using extensive historical datasets comprising wind fields, pressure fields, and tidal station water levels, collected from 11 test sites within the study area. These datasets were instrumental in training and validating the model. A comparative analysis of various predictive methods revealed that the hybrid Conv-LSTM-PINN approach outperformed others in prediction accuracy. Notably, the Conv-LSTM-PINN method demonstrated superior accuracy in forecasting near-term storm surge water levels on the test site dataset. This method marked a significant advancement over the standalone Conv-LSTM approach, yielding enhanced prediction precision and reduced error margins. This improvement in predictive accuracy offers crucial support for disaster management authorities, enabling more effective responses to storm surge emergencies. Furthermore, the study delves into the influence of different meteorological factors on storm surge levels. Our analysis indicates that U and V wind fields and surface pressure fields exert a considerable influence on storm surge water levels, whereas the impact of tidal station water levels is comparatively lesser. These insights contribute to a deeper understanding of the mechanisms driving storm surge events and offer valuable guidance for future research in this domain.