Exploring deep learning approaches to predict hourly evolution of surge levels

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In order to better understand current coastal flood risk, it is critical to be able to predict the characteristics of non-tidal residuals (from here on referred to as surges), such as their temporal variation and the influence of coastal complexities on the magnitude of storm surge levels. In this study, we use an ensemble of Deep Learning (DL) models to predict hourly surge levels using four different types of neural networks and evaluate their performance. Among deep learning models, artificial neural networks (ANN) have been popular neural network models for surge level prediction, but other DL model types have not been investigated yet. In this contribution, we use three DL approaches - CNN, LSTM, and a combined CNN-LSTM model - to capture temporal dependencies, spatial dependencies and spatio-temporal dependencies between atmospheric conditions and surges for 736 tide gauge locations. Using the high temporal and spatial resolution atmospheric reanalysis datasets ERA5 from ECMWF as predictors, we train, validate and test surge based on observed hourly surge levels derived from the GESLA-2 dataset. We benchmark our results obtained with DL to those provided by a simple probabilistic reference model based on climatology. This study shows promising results for predicting the temporal evolution of surges with DL approaches, and gives insight into the capability to gain skill using DL approaches with different Architectures for surge prediction. We therefore foresee a wide range of advantages in using DL models for coastal applications: probabilistic coastal flood hazard assessment, rapid prediction of storm surge estimates, future predictions of surge levels.