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ML Surrogate for Tsunami Forecasting and Hazard Assessment in Eastern Sicily

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Addressing the challenges associated with the high computational cost of tsunami inundation simulation has been a persistent issue, particularly in capturing earthquake source uncertainty and solving the nonlinear shallow water equations on high-resolution grids. This study aims to alleviate this computational burden by leveraging machine learning surrogates. Further, evaluating these ML models is often hindered by their black-box nature and the limited size of training and testing datasets, posing challenges for practitioners. We propose an encoder-decoder neural network where offshore tsunami waveforms and local co-seismic deformation fields serve as the basis for predicting high-resolution inundation maps at 10m grids. The model is applied to the coastal region of Catania in Sicily, Italy, integrating diverse earthquake scenarios from a large simulation dataset of 53,550 tsunamigenic events in the Mediterranean Sea. We adopt a pretraining-fine-tuning approach for building the machine learning surrogate and address crucial questions regarding the efficient selection of training scenarios, model design, and training. Leveraging this large simulation dataset, we identify specific locations, scenarios and model conditions where the machine-learning surrogate demonstrates sufficient accuracy and reliability. This provides an efficient mechanism for long-term tsunami hazard assessment or urgent tsunami prediction in real-time situations.