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Towards data assimilation in the Probabilistic Tsunami Forecasting digital twin

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Probabilistic Tsunami Forecasting (PTF) uses the initial magnitude and location of a seismic event to forecast the tsunami intensity at coastal locations as a probability distribution (Selva et al., 2021). The PTF workflow can be summarized in the following steps: 1) select the ensemble of scenarios and the probability of a scenario coinciding with the actual earthquake; 2) for each scenario, compute a tsunami intensity measure (e.g., maximum inundation height) at coastal locations of interest – either by running shallow water tsunami propagation models with the code Tsunami-HySEA, or by retrieving it from a precomputed database of scenarios; 3) combine the intensity measure with scenario probabilities to compute hazard curves; 4) convert the probabilities into alert levels according to a predefined rule; and 5) visualise the results. More recently, developments in the context of the eFlows4HPC project have allowed for the possibility of updating the probabilities of the ensemble elements based on new data (focal mechanism and sea level data) to make the forecast more precise and/or reduce the uncertainties. Building on these new developments, we present the first results using an even more general PTF workflow here, implementing dynamically the assimilation of new data, such as new estimates of the earthquake magnitude and location, focal mechanism, GNSS displacements, and sea level data. In particular, new estimates of the source will be used to compute a new ensemble, new probabilities, and will trigger Tsunami-HySEA simulations of the new scenarios in the ensemble. If sea level and/or GNSS data are available, we compute the misfit between the data and the results of the simulations to further update the probabilities and reduce the overall uncertainty in the forecast. We use the 2020 Samos earthquake as a first test of the new workflow that includes data assimilation, but further testing will be done for other events in the Mediterranean Sea and Pacific Ocean. Implementing a continuous update of the results within the above outlined dynamic workflow triggered by the arrival of new data represents a crucial element in transforming the PTF into a digital twin.

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