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Implications of rupture complexity for hazard assessment and forecasting of local and regional tsunami

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Traditionally hazard assessment for tsunami does not take rupture complexity, i.e. the heterogeneity of the slip distribution across the earthquake rupture interface, into account. The authors have demonstrated that the potential extent of inundation will be significantly underestimated if rupture complexity is ignored. For local tsunami it has also been shown that for a target site a strict proportionality between earthquake moment magnitude and inundation extent does not exist. The main difficulty in including the effects of rupture complexity in Probabilistic Tsunami Hazard Assessment (PTHA) for local and regional tsunami lies in the fact that calculations to full inundation need to solve non-linear wave equations. These calculations are so computationally expensive that simulating a statistically significant number of scenarios becomes impractical. The hazard assessment process thus requires a de-aggregation procedure that can rely on simulations based on the linear wave equations alone, to identify scenarios significant enough to be considered for full inundation modelling. We correlate properties of the offshore wave field derived from linear simulations with the extent of inundation derived from non-linear tsunami simulations, allowing us to reduce non-linear calculations in our hazard assessment to a practical number.

The effect of rupture complexity on the tsunami wave field is routinely considered in tsunami forecasting for distant and regional sources. Source models are inverted from DART buoy readings as soon as this information becomes available. However, depending on the location of the earthquake causing the tsunami, DART buoy information will not be provided immediately after the event, which poses a challenge to tsunami forecasting for local and regional sources. We propose a concept of tsunami forecasting for regional tsunami, which also provides probabilistic hazard assessment for the event in question. This approach considers rupture complexity and other uncertainties in the time period between detection of the tsunamigenic earthquake and the delivery of forecasts based on DART buoy information. It allows for more informed evacuation decision making during this period. This concept requires the calculation of multiple potential scenarios while the event unfolds. Thus, software that calculates the tsunami wave field in supra real-time (much faster than the physical manifestation of the tsunami) needs to be employed.

For our study we have used COMCOT (development version, GNS Science) and the fast tsunami simulation program easyWave (kindly provided by Andrey Babeyko, GFZ Potsdam) and integrated both tools into a python based automation framework.