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Modeling tsunami generation and propagation: Insights from sensitivity analysis of landslide parameters at Stromboli

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Understanding the generation of tsunamis from landslides at volcanic islands is crucial due to their infrequent, yet potentially catastrophic, impact on coastal communities. We present a sensitivity analysis of the effects of different rheological and geometrical landslide parameters on the generation and propagation of tsunamis in the near field. In particular, we employed the MultiLayer-HySEA model to simulate tsunamis generated by landslides occurring along the northwestern flank of the Stromboli volcano, specifically in the area known as Sciara del Fuoco, which is considered most prone to instability. This shallow-water model implements a two-way coupling between a granular material layer representing the landslide and 3 fluid layers representing the water. The parameters investigated include the initial position, density, volume, and shape of the landslide, as well as its friction angles and water-landslide friction coefficients. We varied each landslide parameter to examine its effect on the tsunami wave height and energy at specific locations. We found that the principal parameters of the synthetic waveforms and the landslide volumes are logarithmically correlated when considering subaerial landslides, while they correlated linearly when considering submarine landslides. We than explored the effect of the other source parameters on such analytical relationships. Based on the variability observed in waveform characteristics, we suggest a ranking of importance for the source characteristics that contribute significantly to the uncertainty/variability of the model output. Our study aligns with previous predictions at Stromboli and offers a valuable tool for reconstructing the source parameters of tsunamis based on proximal sea-level measurements, enabling rapid forecasting of subsequent impacts around the volcanic island.