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Tsunami hazards in Eastern Indonesia from earthquake, landslide and volcanic sources: Seram Island (June 2021) and Molucca Sea (November 2019) tsunamis

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Eastern Indonesia is exposed to significant tsunami hazards induced by its complex tectonic setting characterized by several curved subduction zones, multiple active volcanoes, as well as submarine landslides. Therefore, the region experiences tsunami from various types of sources (earthquake, landslide and volcano). Here, we study the great tsunami hazards in Eastern Indonesia through analyzing two recent real tsunamis that occurred in this region namely the 14 November 2019 Molucca Sea tsunami following an M_w 7.2 earthquake, and the 16th of June 2021 tsunami following an M_w 5.9 earthquake.

For the 2019 Molucca Sea tsunami, we analyzed 16 tide gauge records and 69 teleseismic data to characterize the tsunami and the earthquake. The maximum zero-to-crest tsunami amplitude was 13.6 cm recorded at Bitung. A combination of aftershocks analysis, forward tsunami simulations and teleseismic inversions were applied to obtain the tsunami source. It is found that the best results are obtained using a rupture velocity of 2.0 km/s and a high-angle reverse fault with a dip angle of 55^o. The source model has a maximum slip of 2.9 m, and an average slip of 0.64 m. The seismic moment associated with this final slip model is 7.64×10^{19} N·m, equivalent to M_w 7.2. By comparing the results with other similar events in the region, such as the November 2014 event (Mw 7.1) with a reverse mechanism and a high dip angle of 65^o, we may conclude that the Molucca Sea region is prone to splay faulting.

The 16th June 2021 tsunami was observed on the southern coast of Seram Island following an M_w 5.9 earthquake. The tsunami's maximum wave amplitude was approximately 50 cm on the Tehoru tide gauge whereas the other two nearby stations showed amplitudes of less than 4 cm. Such a relatively large tsunami (50 cm in Tehoru) is normally unexpected from an earthquake of M_w 5.9 having a normal faulting mechanism. It is likely that a plausible secondary tsunami source, such as a submarine landslide, was involved. For the case of the 2021 Seram tsunami, here we apply numerical modelling and bathymetric analysis to examine the veracity of it being generated by a

submarine landslide. Modeling of earthquake sources of the tsunami confirmed that that the simulated tsunamis were only a few centimeters in height and thus cannot reproduce the 50 cm waves observed in Tehoru. However, we were able to reproduce the tsunami observations using potential landslide sources.

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