A dual earthquake and coastal landslides source model for the 2018 Palu tsunami Indonesia

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Introduction

Submarine landslides can cause tsunamis which have a catastrophic impact on coastal areas. As of today, many catastrophic submarine landslide events that generating tsunami have been reported including the landslide-induced tsunami by the Great Japan earthquake on March 2011. The 2018 tsunami triggered by the 7.5 Palu earthquake is a recent example. Due to these landslides, enormous tsunami waves that caused more than 4 m of inundation devastated the City of Palu and the Donggala Regency, resulting in 2,101 deaths. This is a cascading effect of earthquake where a primary hazard (earthquake) cascades to other hazards (landslide).

In this study, we propose a new dual-source model (earthquake + landslide) that couples validated landslide-generated tsunami and earthquake-generated tsunami models for reproducing the 2018 Palu tsunami disaster. The quake and tsunami in Palu in 2018 showed that large strike-slip earthquakes could cause destructive and deadly tsunamis that can have different causes. This research successfully reproduced all significant landslide sites inside Palu bay, as corroborated by earlier marine bathymetric and other studies. Our dual model recreates almost the entire tsunami run-up, especially in the southeast of Palu Bay, which was not reproduced in many previous studies.

Dual source tsunami model (earthquake + landslide)

Fig. 1 show the flow chart of the proposed dual model for 2018 Palu disaster. For landslide model, we used the integrated landslide simulation model (LS-RAPID) version 2.1 which can simulate the initiation and motion of landslides triggered by earthquakes or/and rainfall.

LS-Tsunami was developed to use the landslide motion from LS-RAPID. The method assumed that initial tsunami wave is the same as vertical ground movement and it was similar to an earthquake-generated tsunami. When a landslide mass rapidly enters and travels within a water body, the elevation of the submarine ground surface will be increased and the water mass above the landslide mass will be raised. LS-Tsunami uses these initial wave data to start the simulation model. LS-Tsunami was developed based on the TUNAMI code a well-established and widely used one. It has been transmitted to 19 institutions in 15 nations as of 2003 (Imamura et al. 2006).

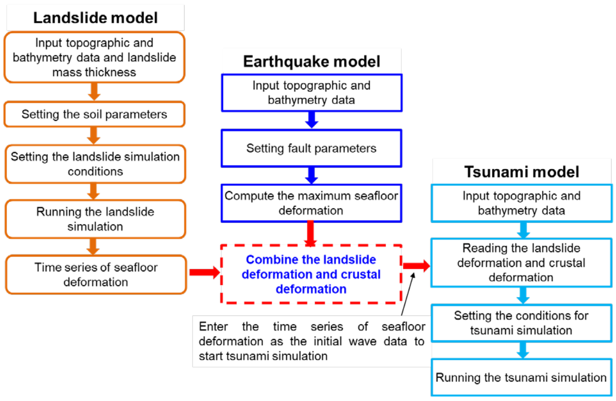

Fig.1 A dual earthquake and coastal landslides sources model

For the seismic source we used the models published by the United States Geological Survey (USGS) and Jamelot et al. 2018. The Okada method (1985) methods was used to computed the vertical deformation of the seafloor. The deformation was used as initial surface deformation in the Ls-tsunami.

Simulation results and Discussion

Fig. 2 shows the simulation result of the tsunami run-up height for the earthquake model only. It is clear to see that the earthquake-induced tsunami modeling cannot fully explain observation data, especially for the South of Palu bay.

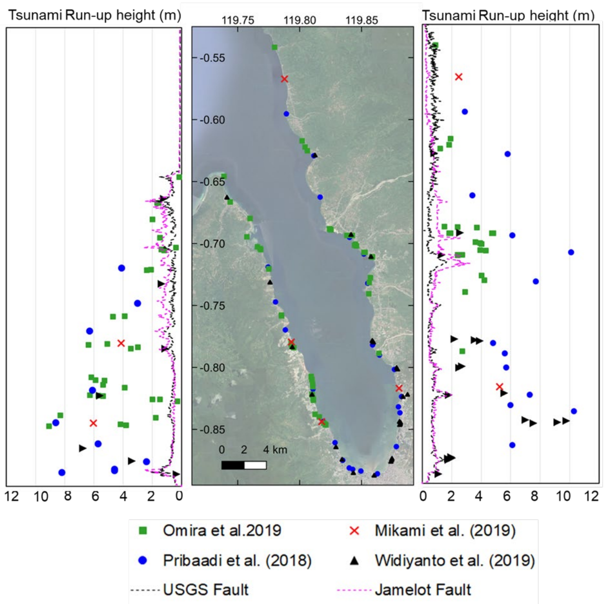

Fig. 2 Tsunami simulation result for only earthquake model

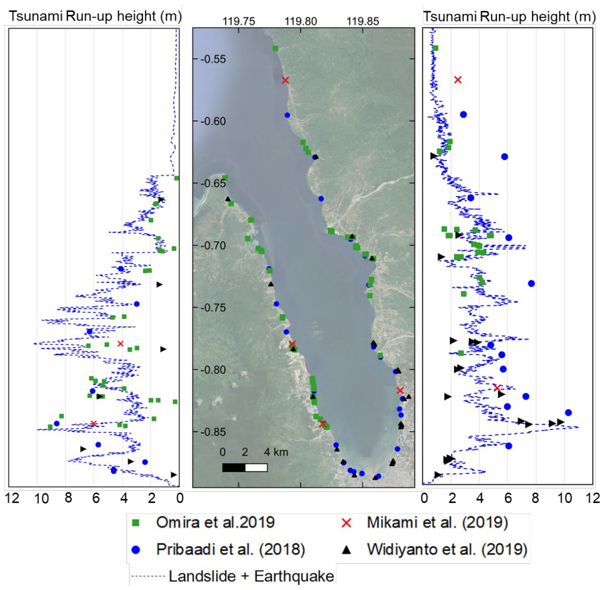

Fig. 3 Tsunami simulation result for dual model (earthquake + landslide)

Fig. 3 shows the simulation result of the tsunami run-up height for the dual model. A numerical simulation of the dual model provided a better match with the tsunami observation records than a simulation based on earthquakes or landslides alone.

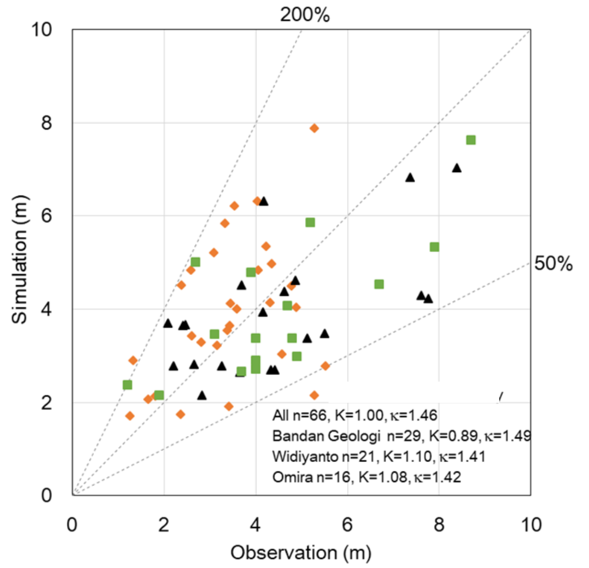

Fig.4 The comparation between simulation results of dual model and observation data

Fig. 4 compare the simulation result and observation data. The Japan Society of civil Engineering recommends values of $0.95 < K < 1.05$ and $\kappa < 1.45$ for the model results to achieve “good agreement”. The K and κ values were used to compare the observed run-up height and flow depth and simulated values. The dual model has K of 1.00 and κ of 1.46, so the simulation result is relative good agreement.

References

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