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Tsunami Hazards from secondary sources in the Makran Subduction Zone, northwestern Indian Ocean

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We present evidence for hazards from secondary tsunami sources in the Makran subduction zone (MSZ), NW Indian Ocean, by analyzing two tsunami events of November 1945 and September 2013 in this region. We revisited the source of the 27 November 1945 tsunami in the MSZ by analyzing two observed tsunami waveforms in Karachi and Mumbai and coastal deformation data. However, the source model based on far-field tsunami waveforms (Heidarzadeh and Satake 2014, Pure Appl. Geophys., doi: 10.1007/s00024-014-0948-y) produces a maximum coastal runup height of 5-6 m in the near-field; almost half of the observed runup height of 12-15 m. This finding combined with the reports of failure of the trans-oceanic submarine communication cables during this earthquake and tsunami may indicate possibility for submarine landslides triggered by the main shock. Another possibility can be large slip due to splay faults which branch from the plate boundary during large earthquake since many splay faults are present in the seismic profiles of the MSZ. These secondary tsunami sources cannot be estimated from far-field tsunami data. The recent tsunami on 24 September 2013 in the Makran region was triggered by an inland Mw 7.7 earthquake. While the main shock and all aftershocks were located inland, a tsunami with a dominant period of around 12 min was recorded on nearby tide gauges and a DART station. We examined different possible sources for this tsunami including a mud volcano, a mud/shale diapir, and a landslide/slump through numerical modeling (Heidarzadeh and Satake 2014, Geophys. J. Int. 199, 752-766). Only a submarine landslide/slump with a source dimension of 10-15 km and a thickness of around 100 m, located 60-70 km offshore Jiwani (Pakistan) at the water depth of around 2000 m, was able to reasonably reproduce the observed tsunami waveforms. In terms of tsunami hazards, analysis of the two tsunamis shows that the MSZ is posed to potential tsunami hazards from secondary sources such as submarine landslides and splay fault branching from the plate boundary.

Keywords: Northwestern Indian Ocean, Makran subduction zone, Tsunami, Splay faluting, Landslide, Tsunami secondary sources