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New generation of tsunami hazard assessment for southern Iran

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Abstract

We reassess the tsunami hazards associated with the Makran subduction zone (MSZ) offshore southern coasts of Iran and Pakistan based on the lessons learned from the large Japan earthquake and tsunami on March 11, 2011. The large M9+ earthquake offshore northwestern Japan surprised many seismologists and caused extreme destruction and death toll because no one was prepared for such an extreme earthquake and tsunami. This event showed that earthquakes larger than what we expected normally from subduction zones can occur in world's subduction zones, and hence we may take into account worst-case scenarios for tsunami hazard assessment. In this study, based on historical earthquakes in the MSZ, we defined a worst-case scenario earthquake for the region and then calculated the distribution of tsunami heights along the southern coast of Iran bordering the Indian Ocean. Our scenario earthquake is an Mw 9 earthquake which is capable of rupturing the full length of the plate boundary along the MSZ. The resulting tsunami can produce wave heights up to 15 m along the coastlines of the region which is more than twice larger than the values calculated in the framework on the first generation of tsunami hazard assessment for the region. The results may help to understand the effects of an extreme tsunami and earthquake in the region. The 2011 Japan tsunami taught us that we have to be prepared for worst-case scenarios.

Keywords: Makran subduction zone, southern coast of Iran, Tsunami, tsunamigenic earthquake, worst case-scenario.

1. INTRODUCTION

Recent M9+ tsunamigenic earthquakes on March 11, 2011 offshore northwestern Japan and on December 26, 2004 offshore Indonesia demonstrated that earthquakes greater than we anticipated can occur. Paleoseismological studies made on the Indian Ocean coasts after the December 26, 2004 (M 9.1) earthquake and just before the 2011 Japan M9 earthquake showed that such gigantic earthquakes have occurred several hundred to a thousand years ago. Studies of the world's other subduction zones have shown that typical recurrence interval of M9+ earthquakes is several hundred years. The main lesson learnt from the recent M9+ earthquakes is that we have to be prepared for worst-case tsunami scenarios that may happen once in several hundred years.

Here, we investigate tsunami hazards associated with a worst-case scenario earthquake from Makran Subduction Zone (MSZ) on southern coast of Iran. With a total length of about 900 km, MSZ is located at the northwestern Indian Ocean which is the result of the subduction of the Arabian plate beneath the Eurasian plate at a subduction rate of around 2 cm/yr (Fig. 1). Makran was responsible for a large earthquake and tsunami on November 27, 1945 which caused a death toll of around 4000 people. A total length of about 200 km of the plate boundary was ruptured during the 1945 earthquake whose magnitude was calculated as Mw 8.1 by Byrne et al., (1992) [1]. This earthquake was the maximum recorded earthquake in the MSZ. Makran sometimes was known as a forgotten subduction zone in terms of tsunami hazard assessment (Emile A. Okal, 2006, personal communications). However, some authors worked on its tsunami hazards in recent years [e.g., 2, 4, 5, add 6]. As discussed by Heidarzadeh et al., (2008, a) [5], Makran differs from other subduction zones in view of some tectonic characteristics; for example there is no trench at the location of the subduction zone which possibly can be attributed to its extremely low subduction angle, and that its subduction rate of 2 cm/yr is significantly lower than that of other world's subduction zones [5].