

Interseismic deformation analysis due to megathrust locking using GNSS Data: A case study of southwestern Pakistan

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Pakistan lies on the region where three plates collide with each other along with a triple junction near Karachi city. In south, the Arabian plate subducts beneath the Eurasian plate off the southern coast of Iran and Pakistan. At the western end of the subduction megathrust, it is connected to the Zagros thrust system of Iran through Minab fault, whereas it is connected to the southern Chaman fault system along with Murray Ridge transtensional zone at its eastern end. The Makran Subduction Zone (MSZ) has produced the world's largest arc-trench gap (500-600 km) and wedge system with splay faults (both on and offshore), having ~7 km thick sedimentary strata. Convergence across the MSZ is complex and poorly understood, yet potentially the largest source of earthquakes and tsunami hazards in the region. The increasing convergence rates between Arabia and Eurasia from west to east across the subduction zone divides the MSZ into eastern and western parts with high and low seismicity, respectively. Historical seismicity shows that the eastern part of MSZ has experienced at least six large earthquakes ($M > 7$) rupturing the plate boundary in the last 500 years, including the tsunamigenic 1945 M8.1 event (the second worst tsunami in the Indian Ocean after 2004 Sumatra tsunami). Following the 1945 earthquake, tsunami runups of up to 15 m were reported at Pasni, 1.4 m at Karachi, and 2 m at Mumbai (Byrne et al., 1992; Heidarzadeh et al., 2008). This zone has the potential to generate 8.7–9.2 (Mw) earthquakes (Smith et al., 2013; Frohling and Szeliga, 2016). We use Global Navigation Satellite System (GNSS) measurements of crustal motion across the Makran megathrust to investigate the fault coupling distribution and fault geometry. Specifically, we estimate the slip deficit rates and width (locking depths) for three sections along the megathrust. Compared with previous studies, we attempt to test a new plate boundary geometry and a different modeling strategy. We use published GNSS data from more than 19 stations in Iran, Pakistan, and Oman, as well as hypocentral positions and seismic data, to build the geometry of the megathrust and a preliminary fault-coupling model for the MSZ. The precise GNSS velocity data show that the entire MSZ is broadly coupled from near the trench to a downdip depth range of 25-35km, although with small information in strike parallel and strike normal directions due to the sparse GNSS network. By modeling the GNSS data, we confirmed the interseismic deformation due to megathrust coupling in the forearc region and its seismogenic potential. We are also working on high resolution Interferometric Synthetic Aperture Radar (InSAR) data sets (SAR sensors of Envisat (2003-2010) and Sentinel-1 (2015-2023) satellites) to update results, which is expected to complement the sparse GNSS stations and produce more detailed locking distribution.