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New insights into present-day deformation of the Makran subduction zone, Iran, from continuous GPS: Impact of the Saravan intra-slab earthquake in 2013 and first evidence of silent earthquakes.

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The Makran subduction zone (MSZ) along the SE Iranian and Pakistan coast accommodates ∼30 mm/yr of northward motion of the Arabian oceanic plate with respect to Eurasia. It is seismically silent, with only some rare earthquakes of Mw > 6 recorded since the last century. Therefore, aseismic motions and slow slip events (SSE) are expected in the MSZ. Only now, sufficient measurements of the Iranian permanent GPS network run by the National Cartographic Center of Iran are available to provide evidence for eventual transient motions in the Iranian part of the MSZ.

Ten years of continuous GPS measurements at 9 stations in the Iranian Makran allow to establish the interseismic velocity field. It shows that seismic coupling of the subduction interface decreases from west to east and from south to north, from 61% to 5%. A simple 1D model in an elastic half space fits the GPS displacements in average with a subduction interface dipping weakly by 5° and with low coupling of 10% from 50 km to 350 km from the trench.

The permanent GPS data monitored the Saravan earthquake in southeast Iran (Mw 7.7, 16/04/2013), an intra-slab earthquake with a normal faulting mechanism at 50 km depth in the MSZ. Co-seismic displacements of the GPS stations are compared to model predictions of surface displacements, computed considering a dislocation consistent with the CMT mechanism. The closest GPS station SRVN 60 km south of the epicenter improves the exact location of the earthquake, but the GPS network is too sparse to distinguish new details of the earthquake mechanism. Some stations show distinct pre- and post-seismic velocities. In particular, the post-seismic velocity of SRVN indicates higher coupling of the subduction interface after the intra-slab event than before (increase from 5% to 23%). While in South American subduction zones these intermediate depth intra-plate earthquakes have the reputation to precede a large inter-plate event with decreasing the inter-plate coupling (c.f. Chili Tarapaca 2005 - Iquique 2014 earthquake sequence), the increase of coupling in the weakly coupled MSZ might bring the subduction interface closer to a classical inter-plate event as well.

Until today, no shallow inter-plate event occurred, but the GPS data indicate a horizontal offset of 2.3 cm at the CHBR station close to the Makran coast, during a data gap between 2013 and 2015. No instrumental changes affected the station during this time interval, and the horizontal offset is directed in exactly the opposite direction as the interseismic motion, convincing us that we might observe here the first evidence of a SSE in the MSZ. The surface offset of 2.3 cm corresponds to 5-7 cm of slip of a 50x50 km patch on the subduction interface, yielding an equivalent magnitude Mw 6.4. Thus, the occurrence of SSEs could explain the lack of classical seismic activity in a part of the MSZ. However, the observed spatio-temporal variability of coupling throughout the MSZ could limit the extent and the recurrence time of SSEs and leave place for classical earthquakes.