Slow and regular earthquakes interact near Istanbul

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Installation of a strainmeter for a GONAF borehole in Turkey. Complementary to classical seismometers, these devices can also measure slow deformations in the subsurface down to the dimension of an atomic diameter (10^{-10} m). Credit: Marco Bohnhoff, GFZ

Earthquakes typically last only a few seconds, although sometimes the shifts in the subsurface occur in slow motion. Understanding these 'slow quakes', known as 'slow slip events', and their interplay with the short—sometimes violent—tremors is critically important to define the seismic hazard and subsequent risk. An international group led by Patricia Martínez-Garzón, Junior Group Leader at the GFZ German Research Center for Geosciences, has now published a study in the journal *Seismological Research Letters* in which they investigate this interplay of different seismic events near the metropolis of Istanbul with its millions of inhabitants.

A suspicious calm in the 'seismic gap'

The Armutlu Peninsula is currently the most seismically active area directly south of the densely populated Istanbul megacity. The region is part of the North Anatolian Fault, separating Eurasia from the Anatolian plate. This fault is an active tectonic plate boundary known to generate destructive earthquakes causing large numbers of casualties. The last such major earthquake occurred in 1999 near Izmit resulting in almost 20,000 fatalities. A portion of the fault, running between Istanbul and Armutlu, is currently identified as a "seismic gap" because there is a suspicious calm there, so to speak. The region is therefore considered overdue to produce a major earthquake.

Observation of slow quakes

In this region, slow earthquakes could be first identified in 2019 thanks to special borehole strainmeter instruments deployed by researchers from the GFZ German Research Centre for Geosciences, in collaboration with the Turkish Disaster and Emergency Management Presidency (AFAD) and the UNAVCO institute from US. To further study the interaction between slow slip events and "regular" earthquakes

in the region, a dense temporary seismic network "SMARTnet" was deployed in the Armutlu Peninsula, as part of the GONAF Plate Boundary Observatory.

Framing a regular M_W 4.6 earthquake in December 2018, another 30-day lasting slow slip event was now recorded, activating the shallower portion of the same small fault. After that, the fault continued to be seismically active during an entire year, with more than 1000 earthquakes located on the same fault section.

Higher seismicity rates after larger earthquake

The recent study in *Seismological Research Letters* reports on these observations and discusses that the larger seismicity rates during the year after the MW 4.6 event are promoted by the occurrence of the slow slip event, as well as the re-distribution of stresses after the main rupture. "The strainmeters near the active fault allowed to identify the slow slip signal that presumably occurred at shallow depth level and that released an amount of energy equivalent to that of a magnitude 5.5 earthquake, but distributed over weeks, not seconds," says Dr. Martínez-Garzón, lead-author of the study.

Exact role of slow quakes still to be clarified

How the slow slip event could have affected the state of stress along nearby faults remains yet to be investigated in detail. Prof. Marco Bohnhoff, head of the GONAF observatory and a co-author of the study states: "How the slow and fast earthquakes interact remains to be understood in detail. In any case, our results will allow to better quantify the regional seismic risk, in particular for the 15-million population center of Istanbul in the light of the pending big one."

More information: Patricia Martínez-Garzón et al, Near-Fault Monitoring Reveals Combined Seismic and Slow Activation of a Fault Branch within the Istanbul–Marmara Seismic Gap in Northwest Turkey, *Seismological Research Letters* (2021). DOI: 10.1785/0220210047

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