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Slow slip events captured by GNSS along the Central Section of the North Anatolian Fault

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Recent observations suggest that seismogenic faults release elastic energy not only during sudden earthquakes but also aseismically. Slow slip can be persistent, lasting for years, or episodic. Aseismic slip is thought to be influenced by the presence/migration of fluids, stress interactions through fault geometrical complexities, or fault material heterogeneities. However, slow slip events have mostly been captured by regional GNSS networks in subduction zones, and the finest details of the nucleation, propagation, and arrest of such events have not been observed yet. Therefore, continental creeping faults are ideal targets for tackling such observational gaps and focusing on the sub-daily behavior of such slow slip events.

The central segment of the North Anatolian Fault is known to be creeping at least since the 1950s. This region was struck by the Mw 7.3 Bolu/Gerede earthquake in 1944, and since then, no earthquake of magnitude greater than 6 has been recorded. During the 1960s, aseismic slip was discovered as a wall built across the fault in 1957 was being slowly offset. Geodetic studies (InSAR, GNSS, and creepmeters) focused on capturing and analyzing aseismic slip around the village of Ismetpasa. Creepmeter measurements during the 1980s and 2010s, along with InSAR time series analysis, suggest that aseismic slip occurs episodically rather than persistently. However, no permanent GNSS stations were available close enough to the fault to study the details of such slow slip events.

Within the scope of a French-Turkish collaboration, we installed 17 GNSS stations (ISMENET) in 2019 to survey the spatio-temporal evolution of aseismic slip rate and characterize the physical properties of the fault zone. A creepmeter array located in the Ismetpasa village reported the occurrence of a significant slow slip event between December 2019 - January 2020. We analyze the GNSS record to search for small aseismic slip episodes and describe their behavior. We use a combination of Multivariate Singular Spectrum Analysis (MSSA) and Geodetic Template Matching

(GTM) to extract the signature of aseismic slip and characterize its source. Results are compared to creepmeter measurements, as well as the historical earthquakes, fault geometrical complexities, and kinematic coupling. Our results confirm that aseismic slip in the region is not permanent. Therefore, even though the aseismic slip rate in the long-term seems to be constant, such a rate might result from the contribution of many aseismic slip episodes as the one detected in this work.