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High-resolution InSAR rate maps showcase tectonic and anthropogenic processes in the Tajik Basin, Central Asia

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Embedded between the South Tian Shan in the north, the Pamir in the east, and the Hindu Kush in the south, the Tajik basin is a remnant of the Mesozoic-Miocene Tajik-Tarim basin. Since ~12 Ma, ~E-W shortening has been dominating due to the westward collapse of the north-advancing Pamir-plateau, inverting the basin into a thin-skinned, W-convex fold-and-thrust belt detached on Upper Jurassic evaporites. The detachment depth is ~6-8 km b.s.l. under most of the basin, shallowing north towards the Tian Shan. Geologic cross sections yield a maximum of 150 km of E-W shortening, distributed between foreland- and hinterland-vergent fold and thrusts. From the eastern to the western rim of the basin, sparse global positioning (GNSS) rates decay from ~15 mm/yr WNW to 2 mm/yr NNW. Seismicity highlights dextral shear along the ~E-striking Ilyak fault – bounding the basin in the north –, and distributed E-W shortening in the central and eastern Tajik basin and in the foothills of the Hindu Kush. The majority of seismic events occurs below the evaporitic detachment. In 1907, the region was struck by a M_s7.6±0.3 earthquake with a poorly-constrained epicenter, either at the northwestern rim of the basin or more than 200 km farther east at the Pamir's rim.

We present rate maps of the region obtained from Sentinel-1 radar interferometric (InSAR) time-series. The underlying data-base comprises 900+ radar scenes, acquired over 2-4.5 years in two view angles (LOS) on 13 frames. The initial LiCSAR interferograms[1)] and tropospheric delay maps[2)] were created automatically. The LOS rate maps resulting from a small-baseline inversion (LiCSBAS) were Gaussian-filtered both in space and time. Before decomposition to east and vertical rates, the rate maps were tied to a Eurasian-stable GNSS reference frame. The final products span from the western basin to the eastern Pamir, and from the southern edge of the Tian Shan to the northern Hindu Kush, covering an area of 270 000 km^2 with a spatial sampling of ~400 m.

The most reliable results were obtained in the Tajik basin, where the rate maps unveil a combination of basin-scale tectonics, localized halokinesis, effects of extensive irrigation, and seasonal precipitation. Our key findings are: (1) The Tajik basin infill is largely being displaced west as a result of the western collapse of the Pamir. The westward rates decrease away from the

Pamir, reflecting dissipated shortening on thin-skinned structures. (2) A bulk of E-W shortening of ~6 mm/yr is absorbed by the most external Babatag (back)thrust with >20 km of past displacement evidenced by borehole data. (3) The Ilyak fault accommodates ~5-8 mm/yr of dextral slip with eastward increasing values; sharply decaying rates suggest a locking depth of ≤1 km. (4) A strong (>10 mm/yr) uplift and westward motion is associated with the sinistral-transpressive Darvaz fault, bounding the basin against the western Pamir. (5) The highest displacement rates >300 mm/yr are demonstrated over the Hoja Mumin salt fountain.

1) See LiCSAR data portal: https://comet.nerc.ac.uk/comet-lics-portal/
2) See Generic Atmospheric Correction Online Service for InSAR: http://www.gacos.net/