Cumulative offsets revealed by airborne LiDAR along a "creeping" section of the Haiyuan fault, northern Tibetan plateau

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Airborne LiDAR is a powerful and efficient tool for acquiring topographic data with cm- to mm-resolution, a resolution high enough for detailed description of landforms and their small displacements along faults. It is therefore very appealing and increasingly applied to active fault studies worldwide. However, such data is largely lacking in China despite that there are many active faults in the country. We recently acquired ~130 km of airborne LiDAR topographic data in 1 km-wide swath along the Haiyuan fault. LiDAR point cloud obtained has a density of 4-5 pts/m2 on average, sufficient to build 0.5-1 meter DEMs, reveals the Haiyuan fault with unprecedented clarity. The Haiyuan fault is one of the major continental left-lateral faults in northern Tibetan plateau, with repeated large-magnitude earthquakes, the most recent large one being the great 1920 M~8 Haiyuan earthquake with a 230-km-long surface rupture (Zhang et al., 1987). However, the 30 km-long section of fault beyond the western termination of the 1920 rupture behaves differently, with a combination of different modes of slip, from creeping (Cavalier et al., 2008; Jolivet et al., 2014), intense microseismicity, to possibly 1888 Jintai earthquake with estimated magnitude of $6_{3/4}$ - 7. LiDAR data illuminates fine features of the fault geometry, which can be quantified in strike deviation and fault zone width. Numerous offset gullies are delineated, yielding a wide range of offsets, from 50 m to as low as 2 m. The grouping of the smallest offsets, 2-3 m, is the most obvious, despite its small magnitude, lends support to the inference of historical 1888 Jintai earthquake rupturing to the surface (Zhou et al., 1992). Comparing to the Parkfield section of the San Andreas fault, the creeping section of the Haiyuan fault preserves more discrete cumulative offsets, which deserves further discussion in terms of long-term geomorphic imprints of creep versus stick-slip faulting styles.