Holocene return-times of Himalayan mega-quakes: dating and Lidar-imaging of uplifted fluvial terraces on the Main Frontal Thrust hanging-wall.

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For the past 40 years, trenching has been the workhorse of Paleo-Seismology. It is particularly useful across strike-slip faults along which, in shallow excavations, sequences of more than 10 large events may be documented. It is also instructive across normal faults, where the deepening footwalls provide traps for post-seismic deposits. But it has been far less informative across thrust faults, due to limited footwall subsidence and near-surface hanging-wall folding (e.g., El-Asnam 1980; Chi-Chi, 1999; Muzaffarabad, 2005…). Typically, the number of paleo-events identified in thrust trenches rarely exceeds 2. Across megathrusts, where individual great earthquakes can produce > 15-25 m and 5-7 m of slip and vertical throw, respectively, trenching becomes an almost fruitless approach, even with the use of civil-engineering drilling techniques. This has hindered understanding the history of great earthquakes along the Himalayan front. Specifically: rarely more than one large event is exposed in trenches across the Main Frontal Thrust (MFT); the last 4 historical mega-quakes were long deemed blind; and ^{14}C dates in trenches hundreds of km apart have been audaciously inferred to attest to single event rupture lengths > 600-800 km!

As an alternative paleo-seismological tool, we tested the potential of fluvial terrace uplift on the MFT hanging-wall to record repetitive co-seismic throw during great earthquakes. Using 100 km-long, high-resolution (~ 4 points/m^2) Airborne Lidar swath's data along the thrust makes it possible to assess the geomorphic effects of surface faulting with regionally homogeneous, unparalleled precision (< 0.5 m). In eastern Nepal, at 7 different sites along the Siwalik front, 5 to 7 distinct terrace surfaces appear to have been successively uplifted, each time by 5 to 8 meters, to maximum heights of 45/55 m above present-day riverbeds. This implies the occurrence of 5 to 7 great earthquakes with average co-seismic throws of ~ 6.5±1.5 m depending on local thrust dip (20-40°). Radiocarbon and cosmogenic ^{10}Be dating of the terraces suggest that, during the last ~ 4500 years, great MFT earthquakes with near-characteristic slip returned every ~ 700-800 years on average. In Assam, along the Abor and Mishmi range-fronts, the same "above ground" approach helps resolve long-standing quandaries on the source and repeat time of events comparable to the great 1950 earthquake. Large-scale Lidar surveys and accurate dating of uplifted terraces may thus be the most promising way to elucidate the long-term history of megathrust earthquakes.