Evolution of the 1999 Hector Mine Earthquake surface rupture: a decadal view

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We report on the first ever decadal scale repetition of a high density 3D aerial laser scan covering practically all of a large earthquake surface rupture. The scan was acquired by the National Center for Airborne Laser Mapping (NCALM) on May 27, 2012 along a 50 km stretch of the surface rupture of the October 16, 1999 Mw 7.1 Hector Mine Earthquake. This new scan averages 1.100 m total width, overlapping with and significantly increasing the breadth of a previous LiDAR scan acquired on April 19, 2000 by the USGS and Aerotech, LLC. Together, the two data sets comprise a 4D (12 year) snapshot of the post-event landscape evolution of a well-defined fault scarp and its immediate environs as well as a test case for characterization of the interplay between landscape evolution through time andseismic features made visible in LiDAR DEMs. We investigate a 2 km long focus zone of the Lava Lake fault where it cuts through Neogene volcanic rocks in the Bullion Mountains, a sparsely vegetated area which contains both the maximum horizontal offset measurements from field study and April 2000 LiDAR DEMs and the highest density of April 2000 LiDAR DEM offset measurements.

After gridding both the 2000 and 2012 point cloud data for this zone into exactly congruent 0.5 m resolution DEMs we directly subtracted the two raster DEMs. This new raster elucidated specific and quantifiable areas of erosion and aggradation and shows that no measurable post-seismic slip has occurred within the focus zone during the interscan period. Within the focus zone, 28 offset measurements were made previously using the LaDiCaoz Matlab script by others at the USGS and Caltech. We revisit these 28 measurement locations and find that in roughly half of the locations the same geomorphic features used to measure offset in the April 2000 data are clearly identifiable in the 2012 data. We investigated the locations of the three largest offsets made in the April 2000 dataset (over 600cm), we find that each is complicated by the geomorphology of its specific locale.

Key Points

- No offset (>13 cm resolution) is measurable along the Hector Mine rupture during the 12 year interscan period
- Quantifiable erosion and aggradation in washes
- Identical offset geomorphic features are present and measurable in both data sets

Figure 4. Hillshade plots of focus zone LiDAR DEMs (May 12, 2012 right) and April 2000 (left). Key features are highlighted in black. Yellow boxes show locations of LiDAR offset measurements from Chen et al (in review). Orange/black triangles are locations of field measurements (Treiman et al, 2002). Black crosses are locations of two datasets made in the exact locations of offset measurements made by Chen et al (in review). Offset measurement values are shown in Figure 5. Hillshade difference raster (center) and hillshade of the 2000 LiDAR data (left) and 2012 (right). Hillshade parameters are azimuth 45°, sun angle 30°. Fault detail is highlighted by yellow and blue lines.

Figure 5. Horizontal displacement is along-strike distance. Field measurements are shown in green (Treiman et al, 2002). LiDAR measurements done by others are shown in red (Treiman et al, in review). Colored circles and triangles represent new offset measurements (this study) made in both DEMs. Inset chart shows these measurements and proximal LiDAR field measurements made by others (Treiman et al, 2002; Chen et al, in review). Field measurements are shown in red (Chen et al, in review).

Figure 6. Very similar offset measurements of the exact same geographic features displayed by the 1999 Hector Mine earthquake surface rupture made on DEMs derived from aerial LiDAR scans acquired 12 years apart. April 2000 data; May 2012 data; offset shown in inset. Black lines are the offset measurements made by others (Treiman et al, 2002). Yellow box shows extent of measurement zone in Figure 5. Hillshade parameters are azimuth 45°, sun angle 30°. Field detail is taken from Chen et al (in review).