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The Climatic Role in Formation of Fault-Offset Geomorphic Features: Reliable Measurements for Slip-Per-Event Studies

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Analyses of active fault zones have burgeoned with the availability of high-resolution topographic data. Airborne and terrestrial light detection and ranging (LiDAR) datasets are now publicly available via web-based repositories such as www.opentopography.org and provide a means to remotely analyze fault-offset geomorphic features. Because these features (e.g., stream channels and alluvial bars) can be preserved in a landscape for centuries or more, it is important to understand the frequencies and conditions under which they form and to determine whether these conditions are the result of a localized storm event or a more widespread climate signal. Typically, slip-per-event studies in southern California along the San Andreas and San Jacinto Faults have assumed that channels form locally and more frequently than the surface-rupturing earthquakes that offset them; clusters of similarly displaced stream channels are attributed to the number of earthquakes that have occurred since channel formation. In an effort to test this widely accepted hypothesis, we present new measurements of fault-offset stream channels for the creeping section of the central San Andreas fault (SAF) where large ground rupturing earthquakes are not expected. Analysis of Northern California EarthScope LiDAR Project data for small-scale fault-offset geomorphic features has initially revealed 41 offset stream channels with a minimum offset magnitude of $\sim$5 m, however, several 2-3 m offsets are present. However, in an area with steady aseismic creep, one would expect a completely random distribution of offset channel magnitudes if channel formation is localized and random. The noticeable 5 m minimum-offset cluster throughout the creeping SAF suggests that for this entire area, channel formation is systematic. We suggest that widespread, climate-driven channel incision events control channel formation in central and southern California and that they are manifest as clusters of offset magnitudes in the creeping section of the SAF. Proper analysis of these and other offset features can provide key information about the earthquakes themselves. To that end, we are conducting an ongoing study that tests the repeatability of LiDAR-based offset measurements made by users of various skill levels. Measurements are made on LiDAR derived surface renderings (i.e. hillshades, digital elevation models, and contours) of offset features from various geographic regions and span a range of complexity: paper image and scale, the Google Earth ruler tool, and a MATLAB GUI for calculating backslip required to properly restore tectonic deformation. Initial results indicate that standardizing measurement and reporting methods is crucial to reducing variability. While measurements can be highly variable for inexperienced users, more practice with any measurement method can significantly increase consistency. The more a user is forced to define fault and feature elements, the greater precision for a given measurement.