Abstract:
Fault scarps degrade over time, and their geomorphic forms may provide information of relative activity of surface processes or formation ages. The recent advances in remote sensing techniques and high-resolution topographic data allow us to accurately characterize the profile shape of fault scarps and to examine the spatial variations within a knick zone. Our goal is to compare the quality of two types of high-resolution topographic data, estimate relative degradation stages along a fault system, and understand factors that can complicate the interpretation of scarp shapes in terms of time-dependent erosion processes. We examined fault scarps near the Dragon’s Back Pressure Ridge in the Carson Range, CA. The structure includes a system of normal faults which developed in the Mesozoic sedimentary unit on the northeastern side of the Indian-Andes Fault. In March 2016, we used a Phantom 4 Drone with a Colibri camera and took 150 aerial images of a graben on the northern extent of the Dragon’s Back. The graben of interest lies northeast and lies on a flat terrace with a slope of about 1% to the south-west. We ortho-rectified and stacked the drone images using Agisoft, and generated a 1m-resolution DEM through Cloud Compare. The slope and mean height of the drone DSM were then corrected using LiDAR data acquired in 2005 by BLM/DEQ, accessed through OpenTopography. We extracted 10 profiles from the fault on each side of the graben, and analyzed the topographic profiles using a scarp diffusional model adjusted by a Gaussian function with constants. We estimate three model parameters: the regional slope, the scarp height, and the degradation coefficient (A2 value which represents relative geomorphic ages (Cox et al. 1984; Nash et al. 1994). We found that the scarp downslope (southern scarp) presents less degradation (A2<10 for the scarp upslope (northern scarp, A2>40). These different geomorphic ages could be caused by several factors including the relative orientation of the scarp to the regional slope, vegetation density, and different formation ages. Our study showed that surface processes influenced by regional setting and local climate can produce apparently different geomorphic ages of fault scarps according to current fault diffusion models.

PROFILES FROM DRONE SOUTH SCARP

North Scarp

South Scarp

DISCUSSION

The drone point cloud was constructed with medium-quality in Agisoft and converted into a 1m-resolution DEM using bats. The drone point cloud was then corrected to match the LiDAR point cloud’s elevation and location using Cloud Compare. The DEM generated from the drone is comparable to the DEM generated from LiDAR. Important differences between the drone and LiDAR DEMs:

- The drone captures the top of the vegetation and all optical topography. Depending on the LiDAR dataset, the points can be classified and ground points in vegetation can be separated.
- Small features such as the channels seem sharper in the drone.
- GPS coordinates used to georeference the drone data are not accurate as LiDAR, which is why we needed to post-process in Cloud Compare.
- With more time and battery power, the drone flight could have been longer and captured more images. The flight was about 10 minutes with 1 battery and only got 185 image points. The point cloud was also only created with Medium-resolution for the sake of CPUs.

We discuss three possible explanations for the apparent older northern scarp and younger southern scarp:
- Orientation in respect to slope: the southern scarp is dipping in a direction opposite to the regional slope and therefore receives less runoff than a scarp dipping in the same direction as the regional slope.
- Orientation in respect to sun: the north-facing scarp receives less sun illumination. Therefore, humidity in the soil may be more favorable for vegetation growth, which protects the surface of the scarp from erosion. We attempted a radiometric difference vegetation index (NDVI) analysis however, since our area of interest is not very large, the MODIS ASTER (MASTER) data resolution (11m) was too rough. A much more precise NDVI would be needed with accurate atmospheric correction and higher resolution satellite data.
- The northern scarp may have actually formed earlier but has been truncated.

The exact origin date of the graben is unknown. The mean age acquired from our data is 4.7 Ma for the south scarp and 4.4 Ma for the north side. This translates to 543 and 1029 years respectively using 86.4 ± 0.8 m/yr from Arraweetah et al. (1998). More work can be done to investigate the shape of the graben (the apparent “step” in the middle portion), the vegetation, and the surrounding area (the northern scarp of the graben continues to the north but the southern scarp is truncated by a channel). This study shows the potentiality of drones in acquiring high resolution data. Drone flights are cheaper and post-processing software are often open-source.

REFERENCES
2. LiDAR data from OpenTopography.com

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