OpenTopography

Metadata Report

Project Name

Quaternary surface ruptures surveyed with SfM, Panamint Valley, CA

Summary

To identify and map regions of distributed faulting in late Holocene alluvium, we generated 20 high-resolution (0.5 cm), 0.16 km^2 structure-from-motion digital surface models using drone-based imagery. These data were collected, as part of a Master's thesis, to resolve regions that lacked existing lidar coverage, and regions where small (0.5 - 1 m) offsets in young alluvium are poorly resolved by existing 0.5 m NCALM lidar DEMs (Figures 1-2). Data were collected at eight locations, over the course of three field seasons between March – November 2021. Each survey location (Figure 2) was given a unique name identifier based on the region and the survey takeoff/return point: 1) Mama Scarp Wash (MSW), 2) Central Alluvial Fan Wasteland (CAFW), 3) Carbonate Hill (CH), 4) Radio Tower Southeast (RTSE), 5) Radar Tower East (RTE), 6) Radar Tower North (RTN), 7) Radar Tower Southwest (RTSW), and 8) Radar Tower West (RTW). Each survey was collected using a DJI Phantom IV drone, including 6 - 8 targets of known dimensions and locations within the surveyed region, located using an EMLID Reach differential GPS. All surveys were collected using predetermined flight plans and parameters, programmed with DroneDeploy. For DroneDeploy specifications, see "Survey Methods" section below.

Personnel

- PI: Christine Regalla
- Field lead: Aubrey LaPlante
- Field staff: Heather Elliott, Letty Rodriguez, Emma Foley,
- Other team members: Amanda Binkley

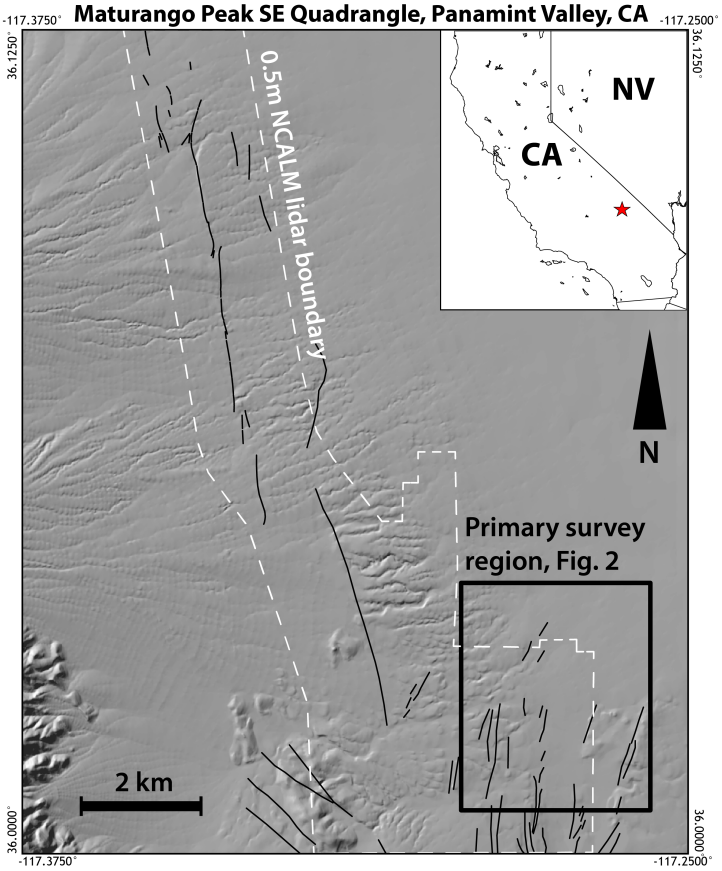

Figure 1: Regional map of the Maturango Peak SE Quadrangle in Panamint Valley, CA. An inset map shows the general location of this quadrangle with respect to California (CA) and Nevada (NV). Active Quaternary faults from the USGS-CA Geologic Survey database are shown with black lines, overlain on a 10m hillshaded DEM of Panamint Valley. The extent of existing 0.5m NCALM lidar is marked by a white dashed line. The primary survey region for this dataset is outlined with a black box. Projection: NAD 1983 UTM Zone 11.

Site Information –

For each survey, the drone takeoff and return point was located on a thin (<1cm) wooden platform of known position, so that a takeoff point could be reoccupied in later flights. Below we note the location of the wooden platform where the drone began and ended each survey. We also note the weather conditions and time of day each survey was collected, including sunrise, sunset, and presence of clouds that may have influenced the existence of shadows. Finally, we state the primary reasons for targeting each survey location and our data collection objectives.

Site 1– Mama Scarp Wash (MSW)

- **Platform location**: 36.01378° N, -117.28662° W
- **Collection:** We collected a single 0.16 km^2 survey (MSW-0321-01) at this site, on March 22, 2021, between 8:48 AM – 8:57 AM.
- **Conditions**: Wind speed ~ 2 mph, 62°F (9AM), clear sunny skies, minor cloud cover in the distance, 23% humidity, 6:50 AM sunrise, 7:03 PM sunset.
- **Objectives:** We targeted this location due to the presence of dozens of scarps crossing mid-late Holocene alluvium. Our objectives with this site were to use higher-resolution drone

imagery to reconstruct piercing lines from bar and swale morphologies. Small lateral (< 1.0m) and vertical (< 0.5m) offsets of piercing lines were difficult to restore in the field and with existing 0.5 m lidar, and we collected this survey to decrease the uncertainty of piercing line reconstructions.

Site 2 – Central Alluvial Fan Wasteland (CAFW)

- **Platform location**: 36.01361° N, -117.28281° W
- **Collection:** We collected five 0.16 km^2 surveys at this site (CAFW-0521-01 through CAFW-0521-05), on May 9th, 2021, between 9:25 AM and 12:30 PM. We took a 50 min break from 10:50 AM – 11:40 AM to let the drone cool down in an ice box.

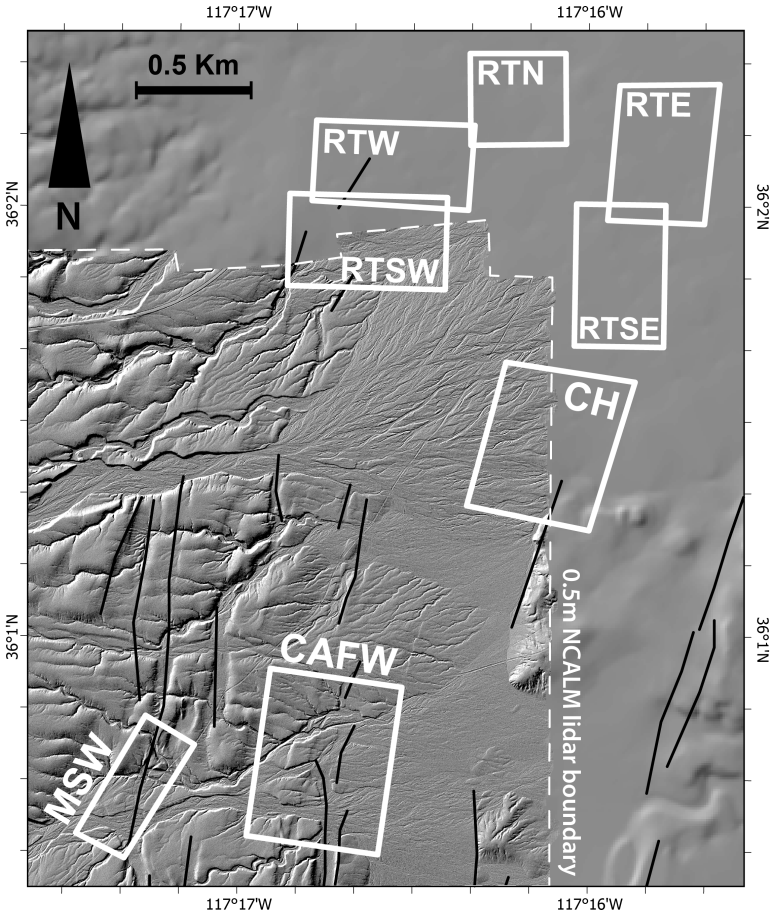

Figure 2: The primary survey region for this dataset. Active Quaternary faults from the USGS-CA Geologic Survey database are shown with black lines, overlain on a 10m hillshaded DEM of Panamint Valley and 0.5m NCALM lidar. The 0.5m lidar boundary is marked by a white dashed line. Eight general surveyed areas that we name in this study are outlined with white boxes: Mama Scarp Wash (MSW), Central Alluvial Fan Wasteland (CAFW), Carbonate Hill (CH), Radar Tower Southeast (RTSE), Radar Tower East (RTE), Radar Tower North (RTN), Radar Tower West (RTW), and Radar Tower Southwest (RTSW). Projection: NAD 1983 UTM Zone 11.

- **Conditions**: Wind speed ~3-6 mph, temperatures between ~86°F (9AM) and 93°F (1PM), clear sunny skies, 6% humidity, 6:24 AM sunrise, 7:18 PM sunset.
- **Objectives:** We targeted this location due to the presence of dozens of scarps crossing mid-late Holocene alluvium. Despite the existence of 0.5m lidar in this survey region, we were having difficulty tracing surface rupture continuity in the field due to the many interfingering alluvial generations with low-relief bar and swale morphologies. Our objectives with this site were to use higher-resolution drone imagery to locate and reconstruct piercing lines from bar and swale morphologies. Similarly to the Mama Scarp Wash region, small lateral (< 1.0m) and vertical (< 0.5m) offsets of piercing lines were difficult to restore in the field and with existing 0.5 m lidar, and we collected this survey to decrease the uncertainty of piercing line reconstructions.

Site 3 – Carbonate Hill (CH)

- **Platform location**: 36.02150° N, -117.26430° W (CH-0521-01 through CH-0521-04), 36.02500° N, -117.27316° W (CH-0521-05)
- **Collection:** We collected four 0.16 km^2 surveys (CH-0521-01 through CH-0521-04) at Carbonate Hill from the first takeoff point, on May 16th, 2021, between 9:05 AM and 12:14 AM. We observed clouds rolling into the valley around 11:00 AM and decided pack up any equipment/targets no longer needed between 11:14 AM – 12:28 PM, in case of a turn in the weather. We obtained a final survey (CH-0521-05) between 12:28 PM – 12:46 PM from a second takeoff location closer to Ballarat road so that we could more easily see the drone during the survey, and to take safety precautions as storm clouds began to approach north of the survey region. At approximately 1:30 PM, as we were leaving the field site, it began lightly raining.
- **Conditions**: Wind speed ~ 6-10 mph, temperatures between ~ 78°F (9AM) to 88°F (1PM), 20-30% humidity, clear sunny skies at 9AM, partially cloudy at 11AM, overcast at 1PM, 6:15 AM sunrise, 7:24 PM sunset.
- **Objectives:** We identified this region as a location where numerous fault scarps in late Pleistocene alluvium project into many generations of interfingered mid-late Holocene alluvium, where we lack 0.5m lidar. We collected these surveys east of the road to strategically avoid power lines and to generate surface models along the eastern boundary of 0.5m lidar. These DSMs surveys helped us distinguish primary boundaries between different generations of alluvial units, and aided in locating and reconstructing piercing lines.

Site 4 – Radar Tower Southeast (RTSE)

- **Platform location**: 36.03053° N, -117.26186° W
- **Collection:** We collected two 0.16 km^2 surveys (RTSE-1121-01, RTSE-1121-02) at Radar Tower Southeast on November 13th, 2021 between 10:16 AM and 11:18 AM.
- **Conditions**: Wind speed 2-4 mph, 80°F, 20% humidity, interspersed clouds, 6:25 AM sunrise, 4:44 PM sunset.

- **Objectives:** We targeted all the radar tower survey regions after mapping and measuring dozens of displacements on many parallel and *en échelon* fault strands in regions such as Carbonate Hill to the south of the radar tower. Our objectives with RTSE and RTE were to extend the mapping of late Holocene ruptures northward, closer to the playa and nearer to the projection of the PVTR with central Panamint fault scarps. RTSE contains primarily interfingered mid Holocene alluvium that we targeted to constrain mid Holocene earthquakes.

Site 5 - Radar Tower East (RTE)

- **Platform location**: 36.03760° N, -117.26757° W
- **Collection:** We collected two 0.16 km^2 surveys at RTE (RTE-1121-01, RTE-1121-02) on November 13th, 2021, between 12:00 PM and 1:01 PM.
- **Conditions**: Wind speed 4 mph, 80°F, 20% humidity, interspersed clouds, 6:25 AM sunrise, 4:44 PM sunset.
- **Objectives:** We targeted all the radar tower survey regions after mapping and measuring dozens of displacements on many parallel and *en échelon* fault strands in regions such as Carbonate Hill to the south of the radar tower. Our objectives with RTSE and RTE were to extend the mapping of late Holocene ruptures northward, closer to the playa and nearer to the projection of the PVTR with central Panamint fault scarps. RTE primarily consists of interfingering, youngest late Holocene alluvium, where we hoped to target offsets associated with the youngest late Holocene ruptures

Site 6 – Radar Tower North (RTN)

- **Platform location**: 36.03760° N, -117.26757° W
- **Collection:** We collected one 0.16 km^2 survey at RTN (RTN-1121-01) on November 13th, 2021, between 2:00 PM and 2:21 PM.
- **Conditions**: Wind speed 1 mph, 87°F, 20% humidity, interspersed clouds, 6:25 AM sunrise, 4:44 PM sunset.
- **Objectives:** We targeted this site to increase the coverage of high-resolution imagery where there is currently a lack of lidar. Faults mapped to the south of Radar Tower North project into this region where we identified many generations of interfingered mid-late Holocene alluvium. This site is ideal to isolate Holocene rupture strands that could not be identified along-strike to the south due to the presence of modern roads, the radar tower, and powerlines along the road that have disrupted the surficial expression of any mid-late Holocene faulting.

Site 7 – Radar Tower Southwest (RTSW)

- **Platform location**: 36.03240808N, -117.2774922W
- **Collection:** We collected two 0.16 km^2 surveys at RTSW (RTSW-1121-01, RTSW-1121-02) on November 14th, 2021, between 9:33 AM and 10:23 AM.
- **Conditions**: Wind speed 0-1 mph, 72°F, 24% humidity, interspersed clouds, 6:26 AM sunrise, 4:43 PM sunset.

- **Objectives:** We targeted this region to extend fault mapping that we had completed to the south of Radar Tower Southwest. We collected these surveys north of Ballarat road and east of the main highway to strategically avoid power lines and to generate surface models along the northern boundary of 0.5m lidar. These DSMs surveys helped us distinguish primary boundaries between different generations of alluvial units that were difficult to identify in the field, and aided in locating and reconstructing piercing lines, particularly where modern construction and ATVs have modified low-relief bar and swale morphologies and surficial expressions of Holocene ruptures.

Site 8 – Radar Tower West (RTW)

- **Platform location**: 36.02975° N, -117.27822° W
- **Collection:** We collected two 0.16 km^2 surveys at RTW (RTW-1121-01, RTW-1121-02) on November 14th, 2021 between 11:33 AM and 12:25 PM.
- **Conditions**: Wind speed ~ 1-4 mph, 80-85°F, 15-20% humidity, interspersed clouds, 6:26 AM sunrise, 4:43 PM sunset.
- **Objectives:** We targeted Radar Tower West due to the lack of lidar, and the observation of ruptures in this region where we identified many generations of interfingered mid-late Holocene alluvium. These DSMs surveys helped us distinguish primary boundaries between different generations of alluvial units that were difficult to identify in the field, and aided in locating and reconstructing piercing lines, particularly where ATVs have made it difficult to trace rupture continuity.

Survey Methods

- **Equipment used**: Imagery was collected using a DJI Phantom IV drone, receiving signals from GPS and GLONASS for positioning, with a 12.4-megapixel camera.
- **GPS solutions**: Each survey contained 6 - 8 targets of known dimensions, which we surveyed using an EMLID Reach differential GPS.
- **Collection methods**: We programmed surveys using DroneDeploy to collect imagery with 75% side-lap and 80% front-lap, at a flight speed of 6 m/s, at a starting height of 75 m from the takeoff point, and a maximum flight height of 102 m. All surveys were programmed to collect imagery along columnar grid paths oriented either parallel or perpendicular to the survey boundaries, and to collect imagery along the entire survey perimeter looking toward (inward to) the survey area.

Products

- **Data processing methods**: We generated dense point clouds and digital surface models using Agisoft Metashape, following the methods described in Reitman et al., (2015), and the USGS UAS Data Post-Processing Guide (Over et al., 2021).
- **Date of dataset processing**: Dense point clouds and DSM rasters were processed over three periods, May 20-28, 2021, July 3, 2021, and December 1-5, 2021.
- **Coordinate system of datasets**: NAD 1983 UTM Zone 11N
- **Spatial resolution**: The horizontal and vertical resolutions of the orthomosaics and DSMs produced using these methods were 2 - 3 cm/px and 5 - 6 cm/px, respectively.
- **Horizontal Accuracy**: Average horizontal uncertainty of this dataset is 0.5 cm (+1.7/-0.5) per meter of horizontal distance.
- **Vertical Accuracy**: Vertical uncertainties of this dataset range between 0.6 - 10 cm.
- **Data formats**: Orthomosaics (.tif) and digital surface model rasters (.tif)

Miscellaneous Data Availability

This dataset was used to reconstruct right-lateral, vertical, and total cumulative displacement of late Holocene earthquakes in the Panamint Valley transtensional relay (LaPlante et al., in review). For access to the raw drone imagery and other orthomosaics that were too large to include in this primary OpenTopography dataset, please contact Aubrey LaPlante (aal382@nau.edu).

Acknowledgements

We would like to acknowledge and thank the many generations of Timbisha Shoshone (Panamint) Tribe members who have acted as stewards of the land and resources within the Death Valley region for centuries. The widespread preservation of the geoheritage of Panamint Valley by the Timbisha Shoshone Tribe, prior to their displacement, allowed us to collect this data and answer our primary science questions. Additionally, we would like to humbly acknowledge the many tribes of Yavapai, Havasupai, Hopi, Hualapai, Kaibab, Navajo, Apache, Paiute, and Zuni descent who have been, and remain, deeply connected to the land and its resources within Flagstaff and Coconino County, AZ. We gratefully acknowledge our continuing partnerships with the ancestral people of the land we reside on, which allowed us to complete this work.

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