EVALUATING CHANNEL-HILLSLOPE COUPLING ALONG AN EROSION RATE GRADIENT, BOLINAS RIDGE, CALIFORNIA

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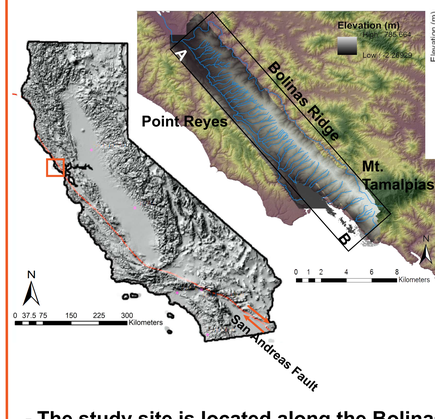
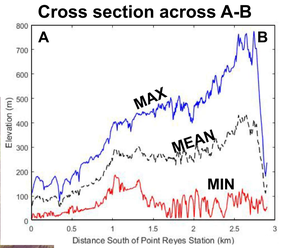
Motivation and Research Questions

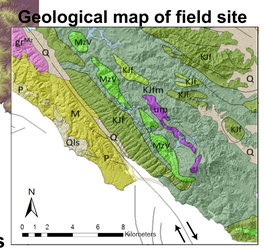
It is reasonably well-established that channels experiencing ongoing rock uplift in tectonically active mountain ranges exhibit a positive scaling relationship between channel steepness (a measure of channel gradient normalized for differences in drainage area, e.g., Kirby and Whipple, 2012) and erosion and/or uplift rate. In nearly all field sites these scaling relationships are non-linear, reflecting the influence of a stochastic distribution of runoff events and a threshold for erosion (e.g., Lague, 2005; DiBiase and Whipple, 2011). Although there is an expectation that transport thresholds may vary with erosion rate, as the caliber of sediment delivered from hillslopes to channels increases, characterization of systematic variations in grain size has proved challenging in most field sites.

Here we address this question by combining topographic analysis of channel and hillslope morphology with quantification of grain size distributions along an apparent erosion rate gradient in coastal Marin County, California.

Field Site



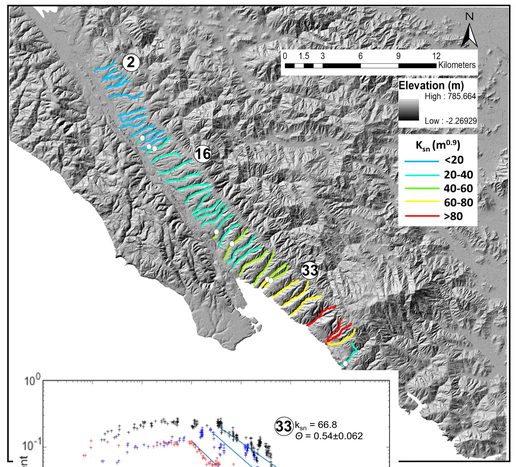




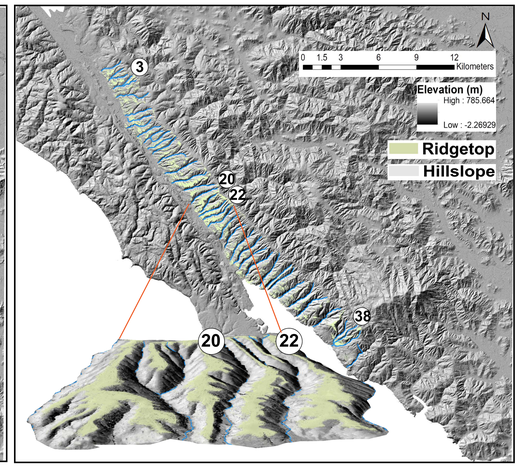
- The study site is located along the Bolinas Ridge, a linear ridge adjacent and parallel to a section of San Andreas Fault, in Marin County, California.
- The elevation increases from north to south
- The ridge is underlain by the Franciscan complex, a melange of lithic-rich sandstones. The mapped lithology appears to be uniform along the Bolinas Ridge (Kirby et al., 2007)

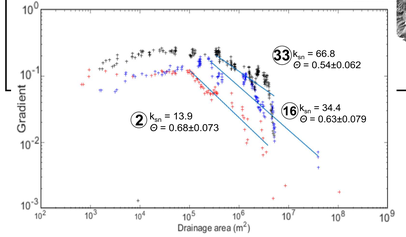
Results:Topographic Analysis

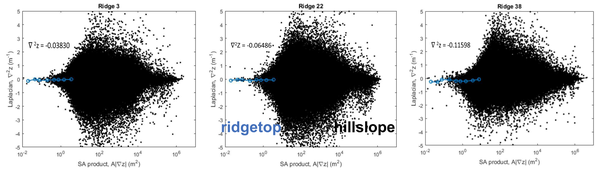
Normalized channel steepness (k_{sn})

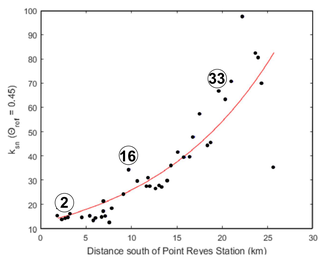


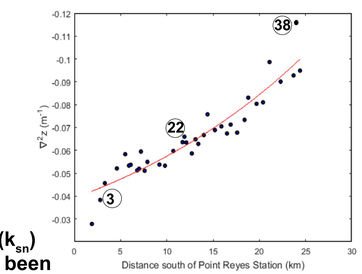
Ridgetop Curvature ($\nabla^2 z$)









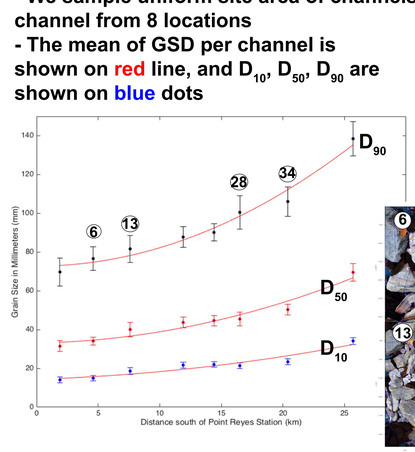


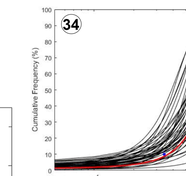
- Normalized channel steepness indices (k_{sn}) derived from slope-area regression have been used to detect zones of differential erosion and/or uplift rate
- k_{sn} systematically increases fourfold to sixfold from north to south along the Bolinas Ridge (similar to Kirby et al, 2007)

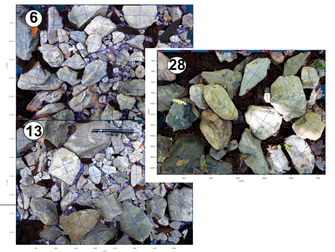
- Ridgetop curvatures have primarily changed when ridges respond to erosion and/or rock uplift
- Plots of curvature($\nabla^2 z$) of elevation against the product of slope and drainage area separate ridgetop and hillslope
- Curvatures of ridgetop as a function of distance negatively increase from north to south
- More upwardly convex ridgetop features toward the south

Results: Grain Size Analysis

- We extract grain size distribution (GSD) plots from a granulometric analyses of top-view photographs of fluvial gravel beds
- We sample uniform site area of channels at 45-50 samples per channel from 8 locations
- The mean of GSD per channel is shown on red line, and D_{10}, D_{50}, D_{90} are shown on blue dots







- Spatial increase in mean grain size suggests variable sediment transport thresholds along the Bolinas Ridge

Preliminary Conclusions

- Systematic adjustment of channel steepness, ridgetop curvatures, and grain size distribution suggests an increase in erosion and /or uplift toward the south
- Covariation of channel steepness and median grain size suggests that thresholds for sediment transport may develop as a consequence of variable erosion rate

References

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