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Marker formation vs. marker offset – on the resolution potential of tectono-geomorphic records

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Understanding the recurrence and actual size of large and damaging earthquakes is an important step towards mitigating the hazard of future seismic events. Coseismically displaced geomorphic and stratigraphic markers are commonly utilized to constrain the recurrence history of surface-rupturing events. An underlying assumption of this approach is that the formation of new geomorphic markers is (distinctly) more frequent than the occurrence of surface-rupturing earthquakes that will disrupt and offset them (the markers). If this assumption is valid, then the offsets that are caused by individual earthquakes can be distinguished, providing valuable information on the causative earthquake size and its variability. Many of the currently existing earthquake recurrence models, such as the characteristic, the uniform-slip, and the variable-slip earthquake model were formulated following this general approach and the underlying assumption. However, whether this assumption is valid or not is essentially never tested or questioned.

How sensitive are those recurrence models with regards to the validity of the afore-mentioned assumption that marker formation is more frequent than marker offset? Could it be that the observed recurrence characteristics represent the properties of climatic forcing rather than tectonic activity? To address this question, I utilize a statistical model in which I create markers and then displace them by sampling from a number of different probability distributions for marker formation and offset. In doing so, I create a library of recurrence patterns in which the corresponding patterns depend on timing and relative strength of marker formation and marker offset events.

In my presentation I compare these model results with reported earthquake recurrence data (i.e. slip accumulation patterns). This comparison indicates that the surface displacement of ground-rupturing earthquakes is required to exhibit some form of “characteristic” behavior (with regards to slip-per-event) in order to re-create the frequently observed, quasi-characteristic recurrence patterns. These patterns are not readily formed when marker formation is less frequent than their offset, particularly when earthquake surface slip along a given fault section follows a power-law or similar relationship. Given the results of this analysis, it appears that the assumption that marker formation occurs more frequently than marker offset is generally valid.