From catalogs, earthquake geology data, and trench data to recurrence models: a Bayesian perspective.

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We developed a Bayesian framework for computing the combination of recurrence models that best represents our knowledge using prior beliefs updated by 3 distinct datasets: the catalog of large earthquakes (CLE), the earthquake geology data including dated cumulative offsets, fault length, and expected range of slip per full-segment events, and trench data. Our method determines the relative weights of the parameters of each model, and the relative weights of the models themselves, in an objective fashion, once the datasets and the priors are chosen, thus ensuring reproducible results.

Fitzenz et al., 2010 and in press 2012 showed such a framework developed for faults that are known to experience full-segment events each time they have a very large earthquake. We do not suppose that the slip is always the same, or that it propagates always in the same direction.

We report on the data that proved most influencial (both on the parameter space and on the relative weight associated to each model) in our case study of the Dead Sea Fault (DSF) in Jordan, to encourage their integration in the databases on active faults that are being developed for other faults such as the different segments of the North Anatolian Fault system. Our first step was to couple a non-informative prior on each model parameter space to the catalog of large earthquakes. Going beyond the historical record thanks to archeological records proved very valuable; We compared observed and synthetic dated cumulative offsets simulated using each candidate recurrencemodels, a distribution of plausible slip per event, and a minimum and maximum allowed slip rate. The 6 dated cumulative offsets (over a total of 47,000 yrs) proved very discriminant, in particular in cases where they evidence changes in fault slip rates over short time periods (e.g., by a factor of 3 in about 4 inter- event times, in the case of the Jordan Valley Fault); We showed how a Bayesian analysis of the trench data incorporates the candidate model that is thought to explain the interval of time between consecutive events. It has to be built using an algorithm that goes from each ”observation”, i.e., the uncertain date of the event and its order in the sequence, to the ”true” inter- event time (that we do not know) and the next observation, through the recurrence model.

In our method, we need either the ”raw” data, i.e., the radiocarbon dates of all samples used and the location of the event in the stratigraphy, or the probability density functions for the observed event dates, but only if they are reported in their full complexity and if they derive only from the calibration of one pair of radiocarbon ages.

In summary, we recommend that 1) historical and archeological data; 2) long cumulative slip histories; and 3) trench data, be reported with the uncertainties on the age and the slip when applicable (interval when defined by bounds, mean and standard deviation of known pdfs, or discretization of non-parametric pdfs, depending on the method to extract the age). In particular, raw radiocarbon layer ages can be reported as a mean and std dev, and complex calibrated earthquake dates (from oxcal or other softwares) should be sampled (e.g., every 5 years) and full tables should be stored together with the current version of the calibration curve.

Finally, more work is needed to define proper priors, and to model the relationship between cumulative slip and co-seismic slip, in particular when the fault behavior is more complex.