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Earthquake rate models considering seismicity and fault moment release: Evaluation of reliability and skill for California and Europe.

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A basic component of any Probabilistic Seismic Hazard Assessment is an earthquake source model that defines earthquake activity rates, i.e. the occurrence rates of events as a function of space, time and magnitude. Such earthquake rate forecasts can be compared with seismicity following the period of data these models have been developed from.
We present a novel earthquake source model that applies the kernel-smoothing method to both past earthquake locations and slip rates on mapped crustal faults. The resulting rates are mainly driven by the data, being independent of expert elicited delineation of seismic source zones. Our forecast relies on the assumption that the occurrence of past seismicity is a good proxy to forecast future seismicity, and that future large-magnitude events occur more likely in the vicinity of known faults. We show that the optimal weighted sum of the corresponding two spatial densities depends on the magnitude range considered. The final annual rate of our forecast is purely driven by a maximum likelihood fit of activity rates to the catalog data, whereas its spatial component incorporates contributions from both, earthquake and fault moment-rate densities.
We show applications of the model to Californian and European data. In both regions we performed retrospective and pseudo-prospective likelihood consistency tests to underline the reliability of our approach using the testing algorithms applied in the Collaboratory for the Study of Earthquake Predictability (CSEP). We comparatively tested our model's forecasting skill against classical area source models and find a statistically significant better performance for testing periods larger than 15 years using m>=5 earthquakes as target events.
Our findings underline that such a data-driven approach is a valid alternative to partly expert-driven area source zonations and thus contributes to assess epistemic uncertainties in the occurrence of earthquake activity. Our model constitutes one branch of the earthquake source model logic tree of the European seismic hazard model released by the EU-FP7 project Seismic HAzard haRmonization in Europe (SHARE). We further show an adaption of our approach to Switzerland, where little is known about crustal fault sources. Our model will be integrated into the logic tree of source models for the revision of the probabilistic seismic hazard model for Switzerland in 2014.