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A synthetic study on the feasibility of using geodetic estimates of rigid microplate motions to assess the seismic hazard of crustal faults

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Assessing the hazard of seismogenic faults is typically done by combining geodetic observations collected in the vicinity of the locations of previous large earthquakes with modelling of the co- and post-seismic deformation. Here we explore whether it is feasible to perform a hazard assessment by applying rigid plate dynamics to microplates. We present synthetic numerical experiments that mimic the temporal evolutions of the Euler vector of an idealized microplate subject to the torque-changes arising from the stress build-ups and drop-offs of multiple earthquakes along its margins. We build each test to represent the charging cycle of a single large earthquake of magnitude M_W between 6.5 and 7.5. At the same time, several $M_W < 6.5$ earthquakes occur along the microplate margins - the number and charging time of these are scaled according to the Gutenberg-Richter empirical law. We test two different plate geometries (square and circular) and different values for the viscosities of the asthenosphere and lower upper-mantle, the thickness of the asthenosphere, and the microplate area/thickness. Moreover, we account trade-off between viscosity and thickness of the asthenosphere (whereby the viscosity contrast between the lower part of the upper mantle and the asthenosphere is proportional to the cube of the thickness of the asthenosphere) that has been recently constrained from glacial isostatic rebound modelling. We repeat our tests a statistically-significant number of times (2000 samples) for every set of values, and draw conclusions from the statistics arising from each ensemble of samples. Our tests suggest that the temporal evolution of microplate-boundary stresses associated with the charge of the single large (i.e., $M_W > 6.5$) earthquake impacts on the microplate rigid motion in a way that is very likely (in a statistical sense) to be distinctive, relative to cases where such a large earthquake is removed from the synthetic tests. Specifically, we focus on whether the microplate Euler vector departs from the initial value i) to a degree larger than the typical uncertainty associated with geodetic estimates and ii) for at least $> 90\%$ of the time left until the single large earthquake discharges the accrued energy. We find that in tests featuring one large ($M_W > 6.5$) earthquake, such a kinematic signature is evident already before the 1/10 mark of the remaining time-period. Such an inference holds even when one hypothesises that Euler vector estimates are available for half of the recurrence time of the single large earthquake. Only in synthetic scenarios where the asthenosphere is as viscous as the upper mantle and/or the microplate area grows to around 10^6 km^2 (i.e., almost the area of a small tectonic plate) such a kinematic signature becomes undetectable.