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Using rigid microplate motions to detect the stress buildup preceding large earthquakes: a feasibility test based on synthetic models

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Assessing the temporal evolution of stresses along seismogenic faults is typically done by combining geodetic observations collected near the locations of previous large earthquakes with modeling of the interseismic, coseismic, and postseismic deformation. Here we explore whether it is feasible to link the charge phase of large earthquakes to rigid microplate motions, which can be inferred from geodetic observations that are instead collected further away from crustal faults. We use numerical simulations of the dynamics and associated kinematics of an idealized, rigid microplate subject to stress buildups and drop-offs from a series of earthquakes. Simulations span the charging cycle of a single $6.5 < M_W < 8$ earthquake. Several $M_W < 6.5$ earthquakes distributed according to the Gutenberg-Richter law occur meanwhile. We use large ensembles of simulations featuring randomly-generated earthquake hypocenters and make statistical assessments of the fraction of model time needed for the microplate motions to depart from the initial one to a degree that is larger than typical geodetic uncertainties, and for at least 90% of the remaining time before the large earthquake occurs. We find such a fraction (i) to be only one tenth in simulations that do feature a large earthquake, (ii) to be longer in simulations that do not, and (iii) to remain small for realistic microplate geometries and asthenosphere viscosity/thickness values. Our inferences hold also when we simulate geodetic time series shorter than the large-earthquake cycle, and even when we assume that only half of the stress buildup affects the microplate rigid motion.