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The relevance of the initial thermal state of a fault on its dynamic behaviour

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In the recent years a large emphasis has been given to the thermal properties of the fault zones, as well as to the potential role of the temperature during coseismic slip failures (e.g, Chester and Higgs, 1992). Within the framework of a deterministic description of earthquake faulting on which the present work focuses, the initial state of a fault system (the initial shear stress distribution $\tau 0$ and the initial sliding velocity v0) and the choice of the governing model describing its rheological behavior, play a fundamental role in the description of the earthquake recurrence. In the present work we also explore whether the initial thermal state of the fault (namely the initial temperature T0) can play a role in the determination of the repeated slip failures on the same seismogenic structure. We achieve this goal analyzing the fault dynamics by assuming a rate– state– and temperature–dependent rheology (the Chester–Higgs constitutive model; Chester and Higgs, 1992).
Our numerical results clearly demonstrate that the initial temperature greatly influences the coseismic slip (and thus the earthquake magnitude), the released stress (and thus the radiated energy) and finally the earthquake recurrence. Indeed, one of the main outcome of the present study is that the simulated earthquakes explicitly depend on the assumed initial thermal state of the fault, in that the developed slip is different, as well as the stress drop. Moreover, by changing T0 we have different velocity and traction histories, which in turn cause different values of the temperature change ΔT. Consequently, this affects a persistent feature of the CH law, i.e. Tcycle that is not merely controlled by the governing parameters, such as a, b, L and the external conditions such as σn, but also on T0. In other words, it can be stated that the fault behaves differently depending on its initial thermal state. Finally, our numerical experiments indicate that there is an initial temperature which minimizes Tcycle . Interestingly, this critical temperature does not always coincide with the temperature predicted by the geothermal gradient. In general, we can observe a decreasing seismic cycle for low values of T0 and then an increasing intervent time for high values of T0.
In conclusion, our results can contribute to the lively debate on the deterministic hazard assessment, illuminating that also the temperature field plays a fundamental role in earthquake dynamics, not only because it controls possible phase changes and the chemical environment of the fault zone, but also because it directly affects the response of a brittle fault and earthquake cycles.

Chester, F. M. and H. G. Higgs (1992). Multimechanism friction constitutive model for ultrafine quartz gouge at hypocentral conditions, J. Geophys. Res. 97, B2, 1859–1870.