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Feasibility of acoustic monitoring of strength drop precursory to earthquake occurrence

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Rate- and state-dependent friction law (RSF), proposed on the basis of laboratory experiments, has been extensively applied to modeling of earthquake stick-slip cycles. A simple spring-slider model obeying RSF predicts a significant decrease of the frictional strength Phi (the state of contact) that is localized within a few years preceding the earthquake occurrence. On the other hand, recent laboratory experiments successfully monitored the history of the strength by simultaneously measuring P-wave transmissivity |T|across the frictional interface using a 1MHz transducer. This suggests a possibility of earthquake forecast by monitoring the strength of a natural fault by acoustic methods.

The present paper explores the feasibility of such monitoring in the field on the basis of the physics of RSF combined with the linear slip model (LSM) employed in the classical acoustic methodology for monitoring an imperfectly welded interface. The characteristic frequency f_c, around which |T|(or reflectivity |R|) has a good sensitivity to the interface strength, is shown to be proportional to the strength and inversely proportional to the representative scale of real contacts.For natural faults f_c is estimated to be 1 to 100Hz, which is practicable in the field. The changes of |T|and |R|depend on the ratio of the strength drop to the absolute strength level, the latter of which is not constrained by RSF simulations. Expected changes in wave amplitude in the preslip period would be several percent for strong faults and several tens percent for weak faults, which may be detectable by acoustic methods such as seismic reflection surveys.

Keywords: fault strength, earthquake cycle, rate- and state-dependent friction, precursor, linear slip model, acoustic monitoring