Geophysical Research Abstracts
Vol. 19, EGU2017-18866, 2017
EGU General Assembly 2017

Period and amplitude of non-volcanic tremors and repeaters: a dimensional analysis

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Since its relatively recent discovery, the origin of non-volcanic tremor has been source of great curiosity and debate. Two main interpretations have been proposed, one based on fluid migration, the other relating to slow slip events on a plate boundary (the latter hypothesis has recently gained considerable ground). Here I define the conditions of slip of one or more small asperities embedded within a larger creeping fault patch. The radiation-damping equation coupled with rate-and-state friction evolution equations results in a system of ordinary differential equations. For a finite size asperity, the system equates to a peculiar non-linear damped oscillator, converging to a limit cycle. Dimensional analysis shows that period and amplitude of the oscillations depend on dimensional parameter combinations formed from a limited set of parameters: asperity dimension Γ, rate and state friction parameters $(a,\ b,\ L)$, shear stiffness of the medium G, mass density ρ, background creep rate $\dot{V}$ and normal stress σ. Under realistic parameter ranges, the asperity may show (1) tremor-like short period oscillations, accelerating to radiate sufficient energy to be barely detectable and a periodicity of the order of one to ten Hertz, as observed for non-volcanic tremor activity at the base of large inter-plate faults; (2) isolated stick-slip events with intervals in the order of days to months, as observed in repeater events of modest magnitude within creeping fault sections.