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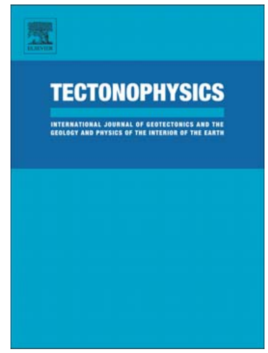

A comparison between rate-and-state friction and microphysical models, based on numerical simulations of fault slip

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A comparison between rate-and-state friction and microphysical models, based on numerical simulations of fault slip

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Abstract

Rate-and-state friction (RSF) is commonly used for the characterisation of laboratory friction experiments, such as velocity-step tests. However, the RSF framework provides little physical basis for the extrapolation of these results to the scales and conditions of natural fault systems, and so open questions remain regarding the applicability of the experimentally obtained RSF parameters for predicting seismic cycle transients. As an alternative to classical RSF, microphysics-based models offer means for interpreting laboratory and field observations, but are generally over-simplified with respect to heterogeneous natural systems. In order to bridge the temporal and spatial gap between the laboratory and nature, we have implemented existing microphysical model formulations into an earthquake cycle simulator. Through this numerical framework, we make a direct comparison between simulations exhibiting RSF-controlled fault rheology, and simulations in which the fault rheology is dictated by the microphysical model. Even though the input parameters for the RSF simulation are directly derived from the microphysical model, the microphysics-based simulations produce significantly smaller seismic event sizes than the RSF-based simulation, and suggest a more stable fault slip behaviour. Our results reveal fundamental limitations in using classical rate-and-state friction for the extrapolation of laboratory results. The microphysics-based approach offers a more complete framework in this respect, and may be used for a more detailed study of the seismic cycle in relation to material properties and fault zone pressure-temperature conditions.

Keywords:
earthquake nucleation, dynamic rupture propagation, microphysics, rate-and-state friction

1. Introduction

The destructive potential of earthquakes poses major societal challenges, and thus calls for a deep understanding of the underlying mechanics for reliable seismic hazard assessment. In order to better apprehend both natural and induced seismicity, much laboratory work is aimed at characterising the frictional behaviour

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