Mapping Tectonic Stress Using Earthquakes

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Abstract

Earthquakes occur when the forces acting on a fault overcome its intrinsic strength and cause it to slip abruptly. Understanding more specifically why earthquakes occur at particular locations and times is complex because in many cases we do not know what these forces actually are, or indeed what processes ultimately trigger slip. The goal of this study is to develop, test, and implement a Bayesian method of reliably determining tectonic stresses using the most abundant stress gauges available earthquakes themselves.

Existing algorithms produce reasonable estimates of the principal stress directions, but yield unreliable error bounds as a consequence the weak constraint on stress imposed by any single earthquake, observational errors, and an unavoidable ambiguity in distinguishing between the fault normal and slip vector.

A statistical treatment of the problem can take into account observational errors, combine data from multiple earthquakes in a consistent manner, and provide realistic error bounds on the estimated principal stress directions.

We have developed a realistic physical framework for modelling multiple earthquakes incorporating the effects of fault friction and show how the strong physical and geometrical constraints present in this problem allow inference to be made about the orientation of the principal axes of stress in the earth's crust. We are taking as case studies data from New Zealand, California, and Japan where tectonic stress studies have been complicated by the quality of earthquake observation parameters, and the difficulty of detecting changes in stress or comparing seismological and geodetic observations.