Eigenpattern Analysis of Geophysical Data Sets– Applications to Southern California

K.F. Tiampo (University of Colorado)
kristy@caldera.colorado.edu
J.B. Rundle, W. Klein, and S. McGinnis

Abstract

Earthquake fault systems are now thought to be an example of a complex nonlinear system (Bak, 1987; Rundle, 1995). Under the influence of a persistent driving force, the plate motions, interactions among a spatial network of fault segments are mediated by means of a potential that allows stresses to be redistributed to other segments following slip on another segment. The slipping segment can trigger slip at other locations on the fault surface whose stress levels are near the failure threshold as the event begins. In this manner, earthquakes occur that result from the interactions and nonlinear nature of the stress thresholds. This spatial and temporal system complexity translates into a similar complexity in the surface expression of the underlying physics, including deformation and seismicity. Specifically, the southern California fault system demonstrates complex space-time patterns in seismicity that include repetitive events, precursory activity and quiescence, as well as aftershock sequences. Our research suggests that a new pattern dynamic methodology can be used to define a unique, finite set of seismicity patterns for a given fault system (Tiampo et al., 2002). Similar in nature to the empirical orthogonal functions historically employed in the analysis of atmospheric and oceanographic phenomena (Preisendorfer, 1988), the method derives the eigenvalues and eigenstates from the diagonalization of the correlation matrix using a Karhunen-Loeve expansion (Fukunaga, 1990, Rundle, et al., 1999).This Karhunen-Loeve expansion (KLE) technique may be used to help determine the important modes in both time and space for southern California seismicity as well as deformation (GPS) data. These modes potentially include such time dependent signals as plate velocities, viscoelasticity, and seasonal effects. This can be used to better model geophysical signals of interest such as coseismic deformation, viscoelastic effects, and creep. These, in turn, can be used for both model verification in large-scale numerical simulations of southern California and error analysis of remote sensing techniques such as InSar.