Time Series Approaches to Understanding Earthquake Dynamics

CHEONG Siew Ann
Division of Physics and Applied Physics
School of Physical and Mathematical Sciences
Nanyang Technological University
cheongsa@ntu.edu.sg

Abstract

To people living in an earthquake-prone region, such abrupt earth crust movements must seem unbearably frequent. In this talk, I will start by asking why large earthquakes are so rare, and suggest that these results from the confluence of many interacting length and time scales. I will then explain how it is possible to extract slow macroscopic dynamics from the high-frequency time series of microscopic variables, through two complementary statistical methods. In the time series clustering method, we compute the normalized or digital cross correlations between microscopic variables over a long-time window. The larger the cross correlation between two time series, the more similar they are statistically. For understanding earthquake dynamics, the microscopic variables we look at can be the GPS coordinates of a network of monitoring stations. The most strongly-correlated stations can be grouped into effective variables, which are self-organized over long length scales. By sliding the long-time window across the data set, we can further determine the long time scales over which effective variables evolve. As an example, I will apply the method to GPS time series data between Oct 2006 and Mar 2008 from the New Zealand network of monitoring stations, to identify a loss-of-correlation precursor signature of a closely-timed pair of large earthquakes in Sep 2007. Then, I will move on to describe the basic ideas behind the time series segmentation method, which is also useful for understanding earthquake dynamics. The method uses recursive entropic segmentation, to identify the number of macroscopic phases represented in the time series, and when phase transitions occur. Since we are only starting to apply this method to geophysical time series data, I will use our work on the US stock markets as an example to illustrate the power of this method.

Biography

Dr CHEONG Siew Ann graduated from the National University of Singapore in 1997 with a BSc (Hons) degree in physics, and obtained his PhD in theoretical condensed matter physics from Cornell University in 2006. He then spent a year and a half as a postdoctoral associate with the Cornell Theory Center, working on biological sequence segmentation, before joining the Nanyang Technological University as an Assistant Professor in Physics and Applied Physics. Besides developing data analysis techniques and modeling frameworks for understanding the dynamics of complex systems such as macromolecules, financial markets, infectious diseases, and earthquakes, he also has research interests in the area of computational physics and condensed matter physics.