Nonlinear Dynamics, Poor Data, and What to Make of Them?

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The analysis of univariate or multivariate time series provides crucial information to describe, understand, and predict variability in the geosciences. The discovery and implementation of a number of novel methods for extracting useful information from time series has recently revitalized this classical field of study. Considerable progress has also been made in interpreting the information so obtained in terms of dynamical systems theory.

In this talk we will describe the connections between time series analysis and nonlinear dynamics, discuss signal-to-noise enhancement, and present some of the novel methods for spectral analysis. These fall into two broad categories: (i) methods that try to ferret out regularities of the time series; and (ii) methods aimed at describing the characteristics of irregular processes. The former include singular-spectrum analysis (SSA), the multi-taper method (MTM), and the maximum-entropy method (MEM). The various steps, as well as the advantages and disadvantages of these methods, will be illustrated by their application to several important climatic time series, such as the Southern Oscillation Index (SOI), paleoclimatic time series, and instrumental temperature time series. The SOI index captures major features of interannual climate variability and is used extensively in its prediction. The other time series cover interdecadal and millennial time scales.

The second category includes the calculation of fractional dimension, leading Lyapunov exponents, and Hurst exponents. More recently, multi-trend analysis (MTA), binary-decomposition analysis (BDA), and related methods have attempted to describe the structure of time series that include both regular and irregular components. Given enough time, I will try to give a feeling for how these methods work, and how well.

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