Wavelet Spectral Analysis for Irregularly Sampled Astromonical Time Series

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Examples of irregularly sampled time series abound in many areas of science, but their analyses introduce numerous statistical challenges. For example, the standard wavelet variance analysis, which has emerged as an accepted statistical approach for studying the variability of time series, is intended to be applied only to regularly sampled time series, and can not easily cope with irregular or unevenly sampled data. After a brief review of the existing approaches to analysis of irregularly sampled time series, we will explore two new statistical approaches to this problem. First, we will discuss approximate scale-based analysis of variance for time series based upon the so-called Slepian wavelets. In many ways, this approach is comparable to the multitaper spectral approach based on the notion of generalized Slepian sequences and others. Slepian wavelets arise as eigenfunctions of an energy maximization problem in a pass band of frequencies. For irregularly sampled time series data, we will extend the notion of dyadic scales, and derive corresponding statistical theory for Slepian-based wavelet variances. We will show via a simulation study how our method adapts to sampling times with mild irregularities. Second, we will consider a general framework for estimating wavelet variances for irregularly sampled time series. Here, we will extend the work of Mondal and Percival (2010), and propose new inference procedures. We will demonstrate potential use of our methods on a light curve data from variable stars. If time permits, we will discuss situations where wavelet approaches might have an edge over more traditional spectral approaches, such as the famous Lomb-Scargle periodogram, the multitaper spectral analysis, and the work of Masry.

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