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Wavelet variance analysis for gappy time series

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The wavelet variance decomposes the variance of a time series on a scale by scale basis and hence has considerable appeal when physical phenomena are analyzed in terms of variations operating over a range of different scales. The wavelet variance also provides a simple useful alternative to the spectral density function and is a useful measure of variability for intrinsically stationary processes with infinite variance. Applications for the wavelet variance include the analysis of time deviations in atomic clocks, subtidal sea level fluctuations and vertical shear in the ocean. The usual wavelet variance estimator is based upon the nonboundary coefficients from the maximal overlap discrete wavelet transform (MODWT), which is designed for use with regularly sampled observations. In practice, time series collected in the geosciences often deviate from regular sampling either by having missing observations ('gaps') amongst otherwise regularly sampled observations or by being irregularly sampled. In this work estimators of the wavelet variance are proposed that are appropriate when the observed time series is 'gappy', i.e., is sampled at regular intervals, but certain observations are missing. The proposed estimators are not based explicitly upon any interpolation scheme, are unbiased and collapse to the usual MODWT estimator in the gap free case. The large sample properties of these estimators are derived under the assumptions that the underlying gap-free process is Gaussian and that the mechanism generating the gaps is a binary-valued stationary process independent of the Gaussian process and satisfying certain weak regularity conditions. The proposed methodology will work well in many practical applications as long as the number of samples in the series isn't too sparse.