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Impact of seasonal cycle removal on linear and nonlinear time series analysis of geophysical data

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Time series of climatic observables like temperature or precipitation often show a strong seasonal cyclicity dominating the dynamics on longer time scales. However, if one wants to study short-term features of the records, these cycles often counteract the analysis and leads to erroneous results on the short-term features.

In this contribution, we thoroughly compare different approaches for deseasonalising time series, i.e., removing strong regular oscillatory components. The studied concepts include the classical phase-averaging and spectral methods, which assume constant cycle amplitudes, as well as methods for a time-dependent characterisation like smoothing of slow fluctuations, wavelet filtering, singular system analysis, empirical mode decomposition, or other techniques for statistical decomposition of multivariate data.

Whereas simple phase-averaging works surprisingly well in case of many climatological time series, time-dependent methods are potentially superior in terms of the remaining spectral power of the annual cycle frequency and, even more, in case of irregular oscillations like the El Nino phenomenon. In addition to this general observation, we examine the impact of the different deseasonalisation approaches on the results of a variety of linear as well as nonlinear methods of time series analysis, including correlation functions, mutual information, entropy, fractal dimensions, and recurrence quantification analysis. Our corresponding results for different kinds of climatic data allow for classifying the different approaches according to their general performance, as well as methods of time series analysis according to their sensitivity with respect to slow deterministic variations.