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B Periodogram analysis

Periodograms were calculated using the Discrete Fourier Transform for the simulations and the Lomb-Scargle periodogram (Lomb 1976) for the GPDD. Periodogram powers were calculated at frequencies $f_o, \dots, f_o(M/2-1)$, where M is the length of the time series and f_o is the reciprocal sampling duration, or fundamental frequency. The white noise power was estimated from the mean periodogram power, which is equivalent to a least squares fit (Horne and Baliunas 1986; Lancaster and Šalkauskas 1986). The OUSS parameters s_o, λ and ε^2 were estimated through a maximum-likelihood fit to the periodogram, using the ALGLIB library (Bochkanov 2013). The likelihood function was approximated by

$$L(p_1, .., p_n) = \prod_{k=1}^{n} \exp\left[-p_k/s(f_k)\right]/s(f_k), \tag{B.1}$$

where $p_1, .., p_n$ are the periodogram powers calculated from the time series for any considered frequencies $f_1, .., f_n$, and $s(f)$ is the expected periodogram power at frequency f (see Appendix A). Eq. (B.1) assumes the periodogram powers $p_1, .., p_n$ to be uncorrelated and is thus only exact in the limit of infinitely long time series. If not mentioned otherwise, we considered all available periodogram frequencies.

False alarm probabilities (FAP) were estimated using at least 10^4 random periodograms (Bernoulli trials) of the fitted OUSS model, emulated by exponentially distributed numbers as outlined in the main article. At these sample sizes, the Bernoulli estimator has a standard deviation of at most 0.005 (and below 0.0025 if FAP < 0.05). Local P-values (i.e. of non-global periodogram peaks) were calculated using the formula

$$P = 1 - \left[1 - e^{-s_\mathrm{p}/s(f_\mathrm{p})}\right]^N, \tag{B.2}$$

where N is the number of considered frequencies, s_p is the periodogram power at the considered frequency f_p and s is given in appendix A. Note that different normalization conventions for periodograms will lead to rescaled estimates for s_o and ε^2, but this has no effect on the estimated FAP.

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