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A waveform skewness index for measuring time series nonlinearity and its applications to the ENSO–Indian monsoon relationship

Justin Schulte et al.

Correspondence to: Justin Schulte (jschulte972@gmail.com)

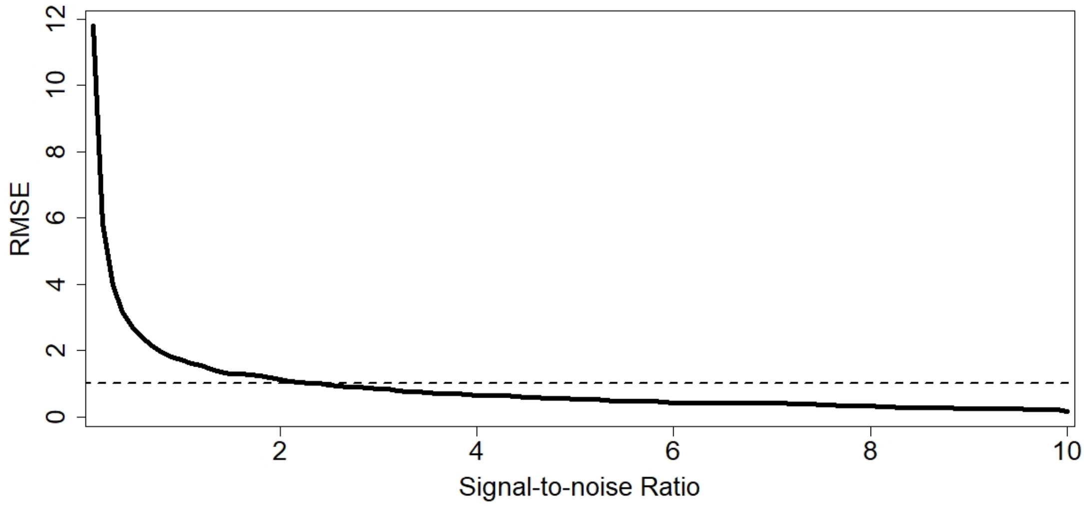

Figure S1. The normalized root mean square error calculated beween the waveform skewness time series of a signal and the wavelet skewnss time seires of the signal after it has been contaminated by Gaussian white noise. In this case, the uderlying signal with standard deviation σ_2 and *y*(*t*) = 0.85 is $X_2(t)/\sigma_2$ (see Eq. (11) in main text) and the contamimated signal is $X_3(t) = \frac{X_2(t)}{\sigma_2} + \frac{W(t)}{n\sigma_w}$, where *W*(*t*) is Gaussian white noise, σ_w is the standard deviation of the Gaussian white noise, and *n* is the signal-to-noise ratio. The normalized root mean square error was calculated by dividing the root mean square error by 0.85, which is the waveform skewness of the signal. As shown in the figure, deviations from the waveform skewness time series of the signal become larger than the wave form skewness of the signal around *n* = 2.5.

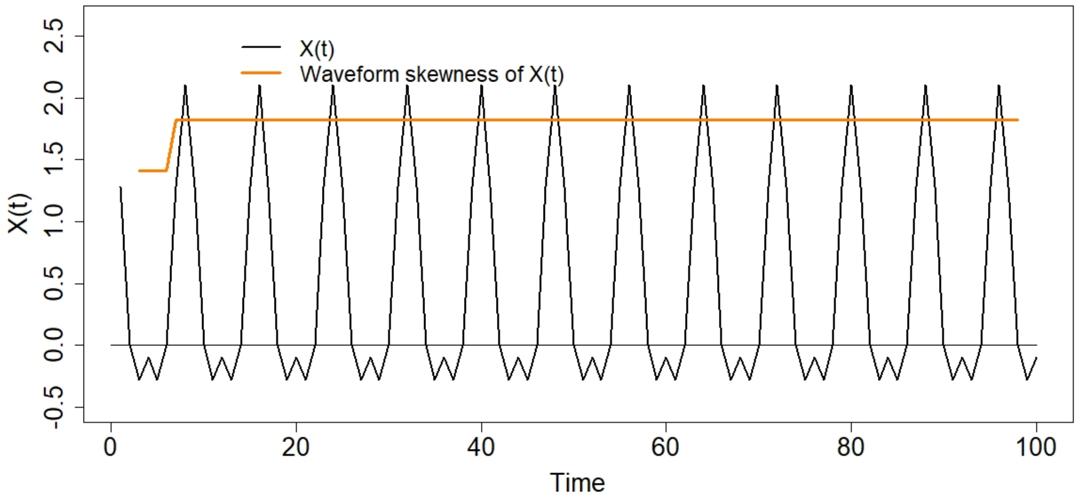

Figure S2. The waveform skewness of the time series $X(t) = \left(cos\left(\frac{2\pi}{8}t\right) + 1.1\right) cos\left(\frac{2\pi}{8}t\right)$ whose amplitude changes are correlated to changes in its phase.