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Analysis and modelling of a 9.3 kyr palaeoflood record: correlations, clustering, and cycle

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Here we provide a methodology to analyse and model the properties of correlation, clustering and cyclicity of an environmental time series. We use as our case study 771 palaeofloods, a unique and extensive record which occurred over a period of 9.3 kyr in the Piànico–Sèllere Basin (southern Alps) during an interglacial period in the Pleistocene (sometime between 780 to 393 ka). Long-range correlations are studied by applying power-spectral analysis and detrended fluctuation analysis (DFA) to the number of floods per decade, revealing weak but significant long-range correlations. Clustering is examined by describing the one-point probability distribution of the inter-flood intervals, finding that the palaeofloods cluster in time as they are Weibull distributed with a shape parameter k_W = 0.78. Finally, we investigate cyclicity and find a period of about 2030 years. Using these characterizations of the correlation, clustering, and cyclicity in the original palaeoflood time series, we create a model by applying peaks over threshold (POT) to the superposition of a fractional Gaussian noise (FGN) with a 2030-year periodic component. We use this model to create 2,600,000 synthetic realizations of the same length as our original palaeoflood time series, but with varying intensity of periodicity and persistence, and find optimized model parameters that are congruent with our original palaeoflood series. A key finding of analysis is that neither fractional noise behaviour nor cyclicity is sufficient to model frequency fluctuations of our large and continuous palaeoflood record, but rather a model based on both fractional noise, superimposed with a long-range periodicity is necessary. We believe that our method adds to the literature on appropriate modelling of the correlation, clustering and cyclicity properties of environmental time series.