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Statistical analysis of long term biological time series: power spectra and bivariate extremes

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We consider 5 long term biological time series: copepod, salps, siphonophors, daphnies and phytoplankton abundance, recorded at fixed locations in the Mediterranean sea and in the Geneva lake. Depending on the time series, there are between 400 and 4000 data points: the sampling period is between one week and one month, and the total sampling time between 25 and 28 years. All these long term biological time series reveal very large fluctuations showing that the characterization of their population dynamics is not an easy task. We have estimated the power spectra of each series, and considered the pdf, especially the extremes.

Power spectra often showed an annual pike superposed to scaling background fluctuations. The extremes revealed in all cases an hyperbolic pdf $p(x) \sim x^{-\mu}$. The tail exponents μ were between 1.4 and 2.9. This is an important characterization of the wildest fluctuations of these series. We also estimated the memory of the time series using the autocorrelation function (the first zero of the latter): this varied between 1.5 and 4 months. For time series recorded at the same location and same times, we applied new analysis techniques to bivariate time series: we characterized bivariate extremes using a polar representation. This new methodology visually showed some functionnal dependences between species.