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Bi-spectral Analysis of the El-Niño index and its stochastic modeling

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ENSO is highly nonlinear and non-Gaussian. Some of its features, however, may be approximated by a linear or quasi-linear process. We assess the different features of ENSO by analyzing the bispectra of El-Niño index observed over a period of 102 years. 2D-Fourier bispectra B(f1,f2), are computed using the bicorrelation (or lagged skewness) sk(t1,t2)=E[x'(t)x′(t+t1)x′(t+t2)]. The largest and statistically significant contributions to B(f1,f2) occur for frequency pairs (f1,f2), corresponding to: (5.3yr, 34yr), (5.3yr, 3.6yr) and (4.9yr, 4.9yr), all of them peaking in the power spectrum. The integrated bispectrum, i.e. the 2D-integral of B(f1,f2) yields the El-Niño positive skewness sk(0,0)=0.23. A test of nonlinearity is assessed through the Hinich test: Hi(f1,f2)=|B(f1,f2)|**2/[S(f1)S(f2)S(f1+f2)]. Under the null hypothesis of linearity, Hi(f1,f2) is constant and proportional to the square of sk(0,0) and the bi-spectrum depends only on S(f). The test is performed to check the nature of the 2D spectral 'islands' for linearity. Low-order autoregressive processes, forced by non-Gaussian additive and/or multiplicative noise are fitted to the data, and we look for triadic frequency resonances (f1,f2,f1+f2). This would improve stochastic modelling of El-Niño. Application to other SST indices are also performed with particular focus on possible nonlinear correlations and teleconnections are also discussed. Publication supported by FCT- project UID/GEO/50019/2019 - Instituto Dom Luiz.