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NONLINEAR ANALYSIS OF THE NORTH ATLANTIC (NAO), ATLANTIC MULTIDECADAL (AMO) AND WESTERN MEDITERRANEAN (WeMO) OSCILLATIONS FOR THE COMMON PERIOD 1856-2009

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Three monthly indices of oscillations concerning sea level pressure differences (NAO and WeMO) and sea level temperatures (AMO) are analysed by means of a set of algorithms based on the rescaled analysis (Hurst exponent), the reconstruction theorem (correlation and embedding dimensions and Kolmogorov entropy), predictive instability (Lyapunov exponents and Kaplan-Yorke dimension) and correlation and power spectrum. Whereas WeMO, and especially AMO, indices are characterised by a notable persistence (Hurst exponents clearly exceeding 0.5), NAO index depicts clear signs of randomness, with a Hurst exponent very close to 0.5. The complexity of a predictive scheme is manifested by the high number of nonlinear equations (correlation dimensions from 6.8 to 10.1) which would be required to reproduce the monthly series. The loss of memory of the underlying physical mechanisms governing the indices is especially relevant for NAO and WeMO, with Kolmogorov entropies exceeding 1.0, in comparison with AMO, which is characterised by entropy close to 0.15. Nevertheless, the predictive instability, characterised by the first positive Lyapunov exponents is quite similar for the three indices, with the highest exponent varying within the short 0.13-0.15 interval. The Kaplan-Yorke dimension is also characterised by a similar value for the three oscillation indices, close to 14.5. Autocorrelation and power spectrum, as well as cross-correlation and cross-power spectrum, are characterised by a strong reduction of the spectral content with the increasing analysed frequency, especially for monthly AMO and monthly AMO-WeMO cross-power spectra. Concretely, assuming a decay modelled by a power law, the exponent of this law is 0.07, 0.17 and 1.06 for NAO, WeMO and AMO indices respectively. Relevant spectral amplitudes, exceeding white noise and 95% significant levels of Markovian red-noise contents are detected for WeMO (19 and 51 years), AMO (9, 51 and 77 years) and WeMO-AMO cross-power (51 years). The periodicity of 1 year, as expected, is always detected, being also observed a significant periodicity of 6 months for the monthly NAO. After the computation of the Hausdorff dimension and the comparison with the exponent of the decaying power spectrum with the increasing analysed frequency, signs of fractional Brownian noise behaviour are detected for the three time series. Nevertheless, a time behaviour based on fractional Brownian noise should be discarded after the results of the corresponding simulations.