



NAO influence on European temperature near-decadal variability: Evidence from phases of period 7.8 years oscillatory modes detected by the enhanced Monte Carlo SSA

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Searching for dynamical mechanisms underlying experimental data in order to understand, model, and predict complex, spatially extended and possibly nonlinear phenomena, such as those studied in geophysics, in many cases starts with an attempt to identify trends, oscillatory processes and/or other potentially deterministic signals in a noisy environment. In this paper we show how an extension of the Monte Carlo singular system analysis (MCSSA) in which, in addition to the signal covariance structure, a complexity measure of the SSA modes is tested against surrogate data, can help to detect nontrivial dynamical modes, in particular, irregular oscillations embedded in colored noise or multifractal background. The approach is applied in detecting of period 7.8 years oscillatory modes in long-term monthly near-surface air temperature records from several European locations and in the monthly North Atlantic Oscillation (NAO) index. (Palus & Novotna, *Nonlinear Processes in Geophysics* 11 (2004) 721-729.) These modes are extracted from the raw data (expressed in the SSA/EOF basis), their instantaneous phases are computed and their relations are studied. In particular, it is tested for presence of phase synchronization between the NAO and the temperature oscillatory modes and character of their coupling is studied. Problems in establishing statistical evidence for phase synchronization and coupling asymmetry are discussed. Using an information-theoretic approach for establishing causal relations from phases of interacting oscillators (Palus & Stefanovska, *Phys.Rev.E* 67, 2003, 055201(R).) a

coupling asymmetry and causal information flow are detected from the NAO oscillatory mode to the oscillatory modes extracted from several European temperature records. Thus we have obtained statistical evidence for existence of the period 7.8 years oscillatory modes in the NAO and European temperature variability, as well as for their interaction, namely for the influence of NAO on the temperature variability at this temporal scale.

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