Scale-specific patterns of phase coherence between solar/geomagnetic activity and climate variability

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Detection and extraction of quasi-oscillatory dynamical modes from instrumental records of meteorological variables, climatological proxies and proxies of solar activity, or other geophysical data became a useful tool in analysing variability of observed phenomena reflected in complex, multivariate geophysical signals. Recent development in nonlinear dynamics, namely in chaotic synchronization brought a possibility of novel ways to study relations between such modes representing a part of atmospheric variability and possible external influences. Paluš & Novotná [1] proposed the enhanced Monte Carlo Singular System Analysis (MC SSA) in which, in addition to the signal covariance structure, regularity and predictability of the SSA modes is quantified and tested. Applying the enhanced MC SSA on monthly time series of sunspot numbers, geomagnetic activity aa index, North Atlantic Oscillation (NAO) index and near-surface air temperature from several mid-latitude European stations they detected a number of oscillatory modes, some of them with common periods [2]. Instantaneous phases of the detected modes underwent synchronization analysis. In the case of the modes with the period 7-8y statistically significant phase coherence, beginning from 1950's, has been observed [3]. Here we study scale-specific North Hemisphere patterns of phase coherence between solar/geomagnetic activity and NCEP/NCAR and ERA40 near-surface air temperature. Both the reanalysis datasets provide consistent patterns of areas with marked, statistically significant coupling between solar/geomagnetic activity and climate variability observed in continuous monthly data, independent of the season, however, confined to the temporal scale related to oscillatory periods about 7-8 years [4]. The patterns of coupling between the solar/geomagnetic activity and temperature variability are compared with patterns of coherence between the NAO index and the temperature data. Using the concept of partial phase synchronization [5] we investigate the role of the NAO in transferring solar signatures from the stratosphere to the troposphere.

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References

[1] M. Paluš and D. Novotná, "Enhanced Monte Carlo Singular System Analysis and Detection of Period 7.8 Years Oscillatory Modes in the Monthly NAO Index and Temperature Records", *Nonlin. Proc. Geophys.*, **11**, 721–729 (2004)
[2] M. Paluš and D. Novotná, "Common Oscillatory Modes in Geomagnetic Activity, NAO Index and Surface Air Temperature Records", *J. Atmos. Sol.-Terr. Phys.*, **69**, 2405-2415 (2007)
[3] M. Paluš and D. Novotná, "Phase-coherent Oscillatory Modes in Solar and Geomagnetic Activity and Climate Variability", *J. Atmos. Sol.-Terr. Phys.*, **71**, 923–930 (2009)
[4] M. Paluš and D. Novotná, "Northern Hemisphere Patterns of Phase Coherence between Solar/Geomagnetic Activity and NCEP/NCAR and ERA40 Near-surface Air Temperature in Period 7-8 Years Oscillatory Modes", *Nonlin. Proc. Geophys.*, **18**, 251–260 (2011)
[5] B. Schelter et al., "Partial Phase Synchronization for Multivariate Synchronizing Systems", *Phys. Rev. Lett.*, **96**, 208103 (2006)