Geophysical Research Abstracts,
Vol. 10, EGU2008-A-06456, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-06456
EGU General Assembly 2008

Scale-resolved phase coherence analysis between signals of solar and climatic variability

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Phase-coherent motion of oscillatory components is a common feature of solar activity and climate variability. In this work, we present a wavelet-based framework for studying the synchronicity of oscillations in such natural systems and compare its performance to that of other traditional as well as modern concepts of phase synchronisation analysis.

As a case study, we investigate the coherent activity on both solar hemispheres during the last about 130 years. We show that a significant phase shift between the corresponding records, which varies on long time scales, is a main contributor to the well-known north-south asymmetry. In particular, this phenomenon can be understood in terms of a different phase diffusion of two coupled chaotic oscillators, which evolve coherently in time. The statistical reliability and implications of this result are discussed, with a particular emphasis on the observation of great sunspot minima.

Using the same framework, we reconsider the phase coherence between solar activity and oscillations in different parts of the climate system. In order to explicitly study the temporal variability of both amplitudes and phases, prominent oscillation modes are selected by novel statistical approaches like empirical mode decomposition or singular system analysis. Our corresponding results are critically compared with the findings of other studies published in the recent years.