

Sunspots and Mean Magnetic Field: Complex Network Analysis of the Solar Activity

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Various measures of complexity can provide relevant ways to study the complexity in the dynamics of magnetized plasma. In this case, the sun and its behavior will be studied through the use of complex networks. We take two time series associated to solar activity, namely total sunspot [1] and global mean magnetic field [2], taken from 1975 to 2015. Both time series will be analyzed by means of the Visibility Graph (VG) technique [3]. Formally, given a series of data Y_N , it is said that two arbitrary nodes y_a and y_b “see” each other if for every node y_c the relation $y_c \leq y_b + (y_a - y_b) \frac{b-c}{b-a}$ is satisfied. Then, a VG leads to a network, where peaks are the nodes and they are connected if they are visible to each other. The VG allows to study statistical properties of the time series such as reversibility [4], and it has been successfully used to study a variety of physical systems. An interesting result is the metrics “Betweenness Centrality” (BC) that quantifies the frequency at which a node acts as a connecting bridge along the shortest path between any other two nodes. The above, because this method is sensitive for both networks, coinciding maxima of this metric with the maxima of the solar cycle for each time series.

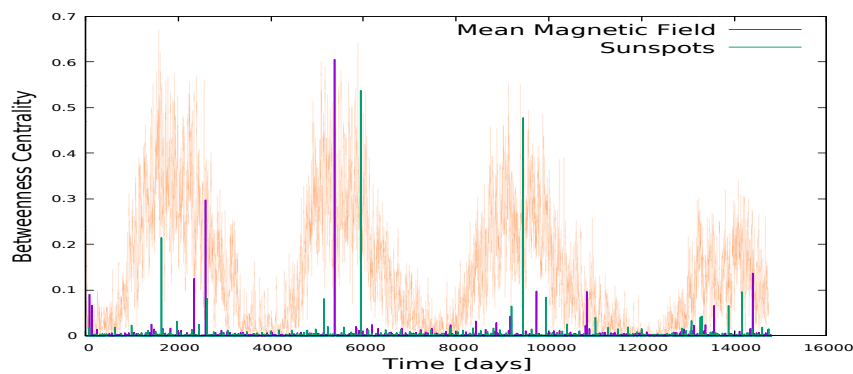


Figure 1: BC for both time series using the VG method. Solar cycle is shown in orange as reference.

References

- [1] Sunspot data from the World Data Center SILSO, Royal Observatory of Belgium, Brussels
- [2] The Wilcox Solar Observatory (WSO) project, <http://wso.stanford.edu>
- [3] Lucas Lacasa, Bartolo Luque, Fernando Ballesteros, Jordi Luque and Juan Carlos Nuno, “From time series to complex networks: The visibility graph”, *Proceedings of the National Academy of Sciences* 105 (2008), no. 13, 4972–4975
- [4] Lucas Lacasa, Angel Nunez, Edgar Roldán, Juan MR Parrondo and Bartolo Luque, “Time series irreversibility: a visibility graph approach”, *The European Physical Journal B* 85 (2012), no. 6, 217