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A knowledge discovery approach to explore some Sun/Earth's climate relationships

A. Pou (1) and J. Valdes (2)

(1) Department of Ecology, Faculty of Sciences, Autonomous University of Madrid, 28049-Madrid, Spain (antonio.pou@uam.es), (2) National Research Council Canada, Institute for Information Technology, 1200 Montreal Rd. Bldg M50, Ottawa, ON, K1A 0R6, Canada (Julio.Valdes@nrc-cnrc.gc.ca)

Recent developments in data driven modeling and analysis including computational intelligence techniques may throw new light on the exploration of possible solar activity/Earth's climate relationships. Here we present three different examples of methodologies under development and some preliminary results.

a) Multivariate Time Series Model Mining (MVTSMM) analysis [1] and Genetic Programming were applied to Greenland's CRETE Site-E ice core Delta O18/16 values (1721-1983, one year interval sampling) and with sunspots activity (International Sunspots Number) during the same time span [2].

According to the results (1771 to 1933 period) indicated by the lag importance spectrum obtained with MVTSMM analysis, the sun's activity itself shows high internal variability and is inhomogeneous. The Dalton minimum, a low activity period usually considered to occur between 1790 and 1830, is shown to be a complex structure beginning about 1778 and ending in 1840. Apparently, the system entered a new state in 1912.

In the joint analysis, the analytical tool uses extensively the solar activity data to explain the Delta O18/16 data, showing areas of stable patterns, lag drifts and abrupt pattern disruptions, indicating changes of state in the solar processes of several kinds at different times.

b) A similar MVTSMM analysis was conducted on Central England Temperature (CET) and solar activity data using Group Sunspots Number (GSN) with a useful interpretive span of time from 1771 to 1916. The joint analysis involved large amounts of solar activity variables, except for the 1843-1862 and 1877-1889 periods where the discovered models used much less information from GSN data.

As with the Crete-E/ISN analysis the lag importance spectrum of CET/GSN shows a number of clear discontinuities. A quarter of them are present in both (1778-1779, 1806, 1860-1862, 1912-1913). These experiments were designed for testing methodologies and not for specific hypothesis testing. However, it seems that Delta O18/16 data would more readily respond to solar influences. This raises the suspicion that perhaps they do not only reflect temperatures but also solar activity, as well as other possible factors not directly related to atmospheric temperatures. These methodologies may be useful as exploratory tools, directing the attention to specific areas where further research should be required. This could be the case of the Delta O18/16 data, frequently considered to be a reliable and accurate proxy of temperatures.

c) Another experiment was made using daily maximum temperatures from 10 Spanish meteorological stations for the period 1901-2005 [3]. Using a hybrid procedure (Differential Evolution and Fletcher-Reeves Classical Optimization) it was found that a subset was capable of preserving the 10-dimensional similarity when nonlinearly mapped into 1D. A daily index, F1 was applied to the whole dataset and grouped by years and transformed into a Kolmogorov-Smirnov dissimilarity matrix, space optimized and clustered giving the following landmarks: 1911-12, 1919-1920, 1960, 1973 and 1989. A visual comparison with the aa geomagnetic index may suggest a certain coupling with changes in the magnetic field behavior.

The complexity of the patterns suggest that the possible relationships between Earth's climate and solar activity may occur in much more complex ways than just irradiance variations and simple linear correlations.

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