

## ***Interactive comment on “Transfer Entropy between South Atlantic Anomaly and Global Sea Level for the last 300 years” by Saioa A. Campuzano et al.***

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Dear reviewer,

Thank you very much for your comments.

We agree that in this work we analyse the same two time series proposed by De Santis et al. (2012) to study the possible connection between the climate and the geomagnetic field. However, there are two new aspects which are worth pointing, that indicate this paper is an important advance with respect the previous one.

The first aspect is that, while in the 2012 paper the authors studied the possible correlation on the long trend of the time series, in the present work we filter this long trend

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and analyse shorter scales. From this point of view, our study completes the previous one, confirming the connection.

The second aspect, and this is the most important part of the paper (and justifies the given title), is that we have used a new statistical tool that is able to measure the independence between two time series, and, in case of some dependence, also the direction of the information flow. This concept is important and new in the field. Transfer entropy does not simply establish correlations. For example, if two time series were completely correlated, the reported value of the transfer entropy could be zero. This means that both series are independent, i.e. the knowledge of one of this series does not improve the knowledge of the other one. Otherwise, when a series is depending on the other, the transfer entropy provides a measure of this dependence, together with the flow of information, i.e. knowing the behaviour of one time series makes possible a reliable prediction on the evolution of the other one. Therefore, the use of the transfer entropy provides a new dimension in the study of the connection between the climate and the geomagnetic field, because it implies, if there exists, an information flow between the two time series, and is able to distinguish the sense of this flow, an innovative property of the method.

The reviewer points out that "the proposed mechanisms need to be quantified in a manner making them available for direct physical test including, for example predictions that can be tested. In the present paper no way forward is presented by which the claimed superiority of the presented statistical tool can be used to distinguish between the proposed mechanism". The reviewer also claims that we do not provide "a clear demonstration of how the presented statistical tool can be used to distinguish between the proposed physical mechanisms in the paper". We do not agree with him/her. The response is in the capacity of the transfer entropy to distinguish the sense of the information flow. In the analysed case study, we have shown that the sense of the information goes from SAA to GSL time series. This would discard any physical mechanism in which the climate controls the geomagnetic field and support the mechanisms caused

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by the presence of the SAA. In addition, the outcome of this work suggests interactions between the two time series of anomalies, not only at the long-term trend, but also at a time scale lower or equal to one year. This indicates that, if we are right, the SAA anomalies add great predictability to the GSL anomalies and therefore, it would be expected that a future SAA anomaly (taking into account our selected trend) generates a GSL anomaly with a time lag of one year or less. Hence, any physical mechanism proposed to explain this relation should act within this time interval, excluding many other mechanisms with longer time lags. In order to clarify these points in the manuscript, we propose adding this paragraph in the Discussion section of the paper.

To summarise, we cannot yet establish which the physical mechanism that explains this connection is, but we believe that we are able to point out, with a 90% of confidence level, the sense of this mechanism (and the time interval in which should act), and this is an important advance in the field. Our study is a significant step forward in understanding the complex phenomenon that produces the present increase of GSL, and its possible connection with the present geomagnetic field, characterised by a comparable complexity.

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