Earth Syst. Dynam. Discuss.,
doi:10.5194/esd-2016-38-AC3, 2016

Earth System Dynamics Discussions
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Interactive comment on "The Earth's climate system recurrent & multi-scale lagged responses: empirical law, evidence, consequent solar explanation of recent CO_2 increases & preliminary analysis" *by* J. Sánchez-Sesma

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Received and published: 30 November 2016

Initial Declaration This paper has presented an integration of Earth's climate information over the last millennia and its preliminary analysis, to be discussed, and then improved. In particular, this paper presents evidences of the climate lagged responses both in external and internal forcing (volcanoes, carbon cycle and oceanic transports) and the most important climate variables (Continental Tropical Climate [CTC], Atlantic Meridional Overturning Circulation [AMOC], Sea Level [SL], Ice Raft Debris [IRD] and northern hemisphere and global temperatures [NHT & GT]) in order to better under-

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stand and consequently to better model their associated climatic processes and mechanisms.

General Response Thanks to comments and critics, the final version will show, with better structure and information, how the Earth's climate is influenced by the oceanic transport with consequent lagged influences. However, in response to the comments received, in this first reply I will focus on reinforcing the two key points on which my work is based, through new contributions that provide greater solidity, consistency and clarity to the ideas presented in my research.

PART A: Solar recurrences. During recent decades, a great amount of new geophysical and astronomical information has provided us with objective elements to refine our conception of solar dynamics. On the one hand, isotopic information from polar and deep sea sediments has provided a great amount of detailed information for indirect solar activity estimations. On the other hand , solar dynamics simulations, motivated by space explorations, have reconstructed and forecasted millennia scale movements, velocities, and accelerations for the main objects of the Solar System. With these two different but complementary types of information, we have detected low-frequency common variations between solar activity and solar movements. Specifically, in the supplements and based on independent data, we verify the existence of a multi-millennia solar recurrent pattern detected by Sánchez-Sesma (2016a). It is based on data previously published on atmospheric 14C from the Cariaco basin sediments accumulated over the last 60,000 years (Hughen, 2004). Although we have provided [in Appendixes A and B of Sánchez-Sesma (2016a)] further verification, testing and analysis of solar recurrent patterns since geological eras, and their potential gravitational forcing, in this supplementary information, motivated by reviewers 1 and 2, we present additional evidences of: a) the existence of multi-millennial ($\sim$9500-yr) scale solar oscillations, and b) their recurrences. These verified solar recurrent oscillations have also provided additional support not only for the consequent multi-millennial-scale experimental forecast, suggesting a solar decreasing trend toward Grand (Super) Min-

imum conditions for the upcoming period, 2050-2250 AD (3750-4450 AD), but also for the terrestrial responses analyzed by Sánchez-Sesma (2016b).

PART B: Lagged responses in climate and its Power Law. Even when humans were not impacting the environment, Nature was expressed in dynamic and changing forms. Geology and Biology have shown that Nature's changes usually happen slowly over long time periods that exceed the life span of humans. So, in most cases, we do not see long-term changes in Nature. These unseen changes at one level can influence other levels, cascade down or up levels, reinvigorating or destroying processes that are represented in power-law equations. These power-law equations have been developed as the simplest scale invariant equations in astronomy (Nottale, 1997). In the beginning these equations provided solutions, and a large part of the research on this subject was devoted to the calculation of numerical values of the exponents, but now astronomical researchers know they must go beyond such an approach, and look for the fundamental physical principles that may allow us to really understand how the power-law works (Nottale, 1997). Motivated by these astronomical experiences, and in order to explore deeper in climatic processes, we need as a first step to not only look for these Power-Laws, but also to (accept) analyze these relationships between geophysical scales and processes. We add new information and propose a different approach to analyze the Power-Law variations of the forcing period/response lag (P/L) relationships across different scales. In supplements (one to complement Appendix A), we have applied a second approach to the power law variations of the climatic lagged responses. To do so, we evaluate the Northern hemisphere temperature lag with respect to the annual solar cycle forcing, evaluate a complementary and independent model of the power law based on independent and complemented information, and compare the new approach with the previous approach. The consequent lag associated with the 9.5-kyr solar forcing is 1540 yrs, which is almost 3% lower than the 1586 yrs estimated with the first approach. This reduction, obtained in the second approach, implies a better comparison with other lags associated with the 9.5-kyr, with their mean average ratio changeing from 0.937 in the first approach, to 1.032 in the second ap-

proach, implying a reduction to almost half of the differences (6.3 to 3.2 %) to the ideal ratio 1. This supplement will be included in Appendix A.

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Please also note the supplement to this comment:
http://www.earth-syst-dynam-discuss.net/esd-2016-38/esd-2016-38-AC3-supplement.zip

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