AUTHOR´S COMMENT IN RESPONSE TO ESD-2021-84-RC1.

Cuernavaca, Morelos, Mexico January 14th, 2022.

Dear paleoclimate colleagues:

It is for me a great opportunity to comment (with discussions and additional verifications) my work (esd-2021-84) that presents several important and objective elements of the lagged and recurrent climate hypothesis (LRCH) that could support the development of a consequent (novel & needed) scientific theory of climate. Although the proposed LRCH could not be considered a scientific hypothesis, it provides several important elements to develop, first a scientific hypothesis, and later, a scientific theory.

Taking into account the anonymous reviewer comment (RC1), it is possible to extend and better define a supporting argumentation (written and graphically) of my work (esd-2021-84). Although, the RC1, after to argue about a supposed theory proposed, pointed out: “the present work cannot be considered appropriate to be published in the scientific journal ESD”, let me say that: *I do not agree with this veredict***.**

The written argumentation, to support my work (esd-2021-84), is the following:

1. Earth´s climate (EC) processes are complex. The EC is linked not only to terrestrial processes, but also to cosmic processes. Then, EC should be considered an open process, that, at least, requires the amplest spatial and temporal frames of references for solar and lunar millenial scale influences. [Note: The orbital (or planetary) forcing of climate, devoted to oscillations greater than 20 Kyr, that were proposed by Milankovitch (1931) required more than three decades to be accepted].
2. In order to disentangle the climate complexity, firstly, I have developed a work about a multi-millenia scale solar recurrent pattern (Sánchez-Sesma, 2016; hereafter SS16). This paper published in 2016 in ESD, detects, through Fourier Analysis, a recurrent pattern. This recurrence was empirically validated both, with independent isotopic and climate records (in quantity and quality), and with a gravitational model based on objective solar system dynamics (Horizon system/JPL/NASA). Although this published work has been referred by several works (vgr;Viaggi et al., 2021), however it is possible to present additional verifications (see them below).
3. Secondly, in my work ESD-2021-84, I have developed an integrated empirical explanations of some climate processes, over the last millennia. These explanations are based both on the solar recurrences detected and also on their lagged influences associated with ocean circulation. The well-known (but not fully applied in climate) “ocean conveyor belt” (OCB) concept was considered as the main part of my work. In this comment I have presented additional evidences (see them below for different scales and different oceans).

Previously to present my detailed argumentation, and to mention that all the corrections related to the RC1 document, will be considered in the final version of this work, I would like to make a final comment: “*This work is about three geophysical science processes. One is the multi-millennial potential planetary forcing of the Sun, which generates a quasi-deterministic recurrences that, as the orbital forcing which generates recurrent changes in the Earth's orbit, also generates (by an unknown mechanism) recurrent solar forcing. Another is the lagged responses, characteristic not only in mechanical and thermal processes, but also in climate processes, where the orbital influences generate lagged responses. And another is about the development of geophysical sciences, that required long-term processes to update and change accepted models.”*

In order to support my written argumentation, additional evidence that support the LRCH is presented. In the following detailed information, analysis and/or explanations are provided:

a) The existence of recurrence in solar activity was analyzed in a specific paper at ESD. However there are several important aspects to be remarked. In SS16 there are: 1) a recurrent gravitational possible forcing that suggests the generation of solar activity long-term changes, 2) several verifications that the solar recurrent pattern persists since geological eras. Additionally, there are recent studies that provide more reconstructions (Vaggio, 2021).
b) A muti-scale (geological, millennial, decadal, and annual) analysis of the lagged climate processes in the Equatorial Pacific, and a detailed lagged processes between Equatorial sea surface temperatures between Pacific & Indian oceans over the last centuries.
c) Two additional verifications of the lagged solar influences, one for the Arctic and another for the tropical climate.
d) An additional GT scenario for the 21st century is presented. It is based on a Northern Sweden isotopic record that leads global temperature by more than 250 years.

Finally, as my work provide elements to support another climate explanation than that provided by the the current “anthropogenic global warming” (AGW), it is important to emphasize three simple facts, that question the AGW theory (see below). These facts are about the relative occurrence of CO2: a) One covering the last 50 Kyr, shows the relative leads of CO2 respect Antarctic climate, that changes to relative lags when volcanic activity increases since the last glacial maximum; b) Other covering the Holocene, shows the CO2 variations explained as a lagged response to solar variations; and c) Other covering the last decades, shows the monthly occurrences of CO2 changes after its solar forcing occurrences.

A. Verification of solar recurrences (with a pattern of 9.5 Ky) and their influences on climate

Several verifications of solar recurrences are presented here.

1) The last geomagnetic reversal (GMR) has been an interesting event. Ueno et al., 2019 have collected and integrated climate information in order to analyze the associated anomalies caused by this GMR event. Figures A1 and A2 show comparisons of extrapolated TSI (SS16) with two climate proxy records, along 19 and 18 Kyr, from NW Pacific and N Atlantic, respectively. These figures show excellent matches with the TSI extrapolated around 80 times 9.5 Kyr back in time.

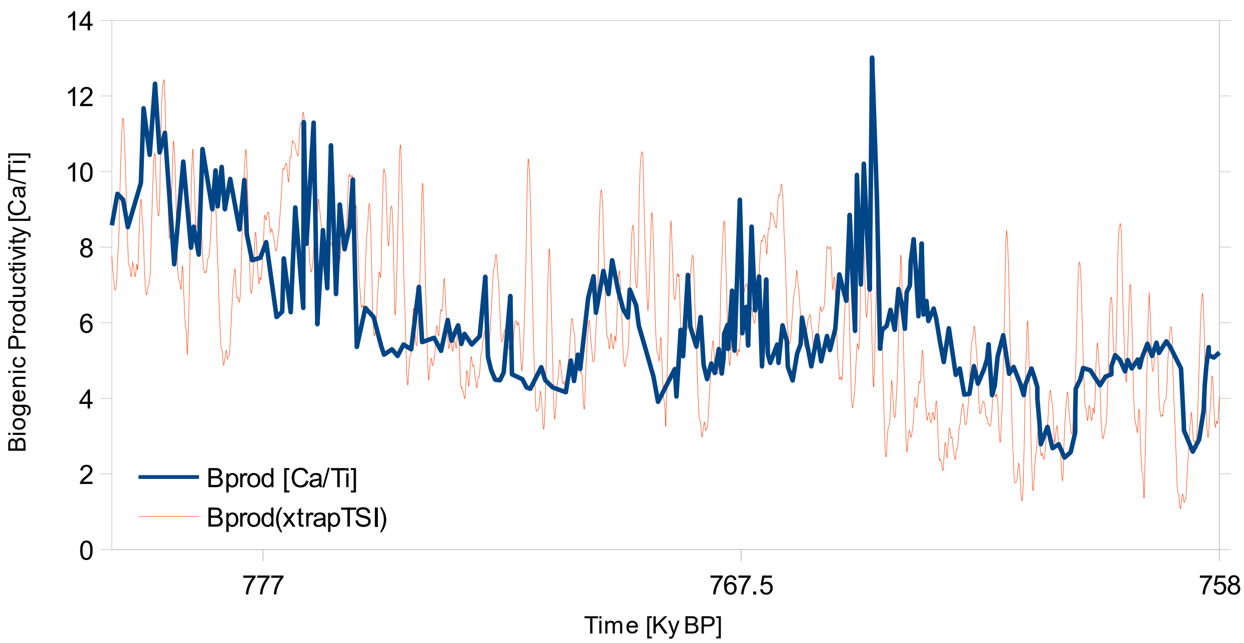


Figure A1. Comparisons of extrapolated TSI (SS16) with a climate proxy record of biogenic productivity from NW Pacific ocean [Ueno et al., 2019].

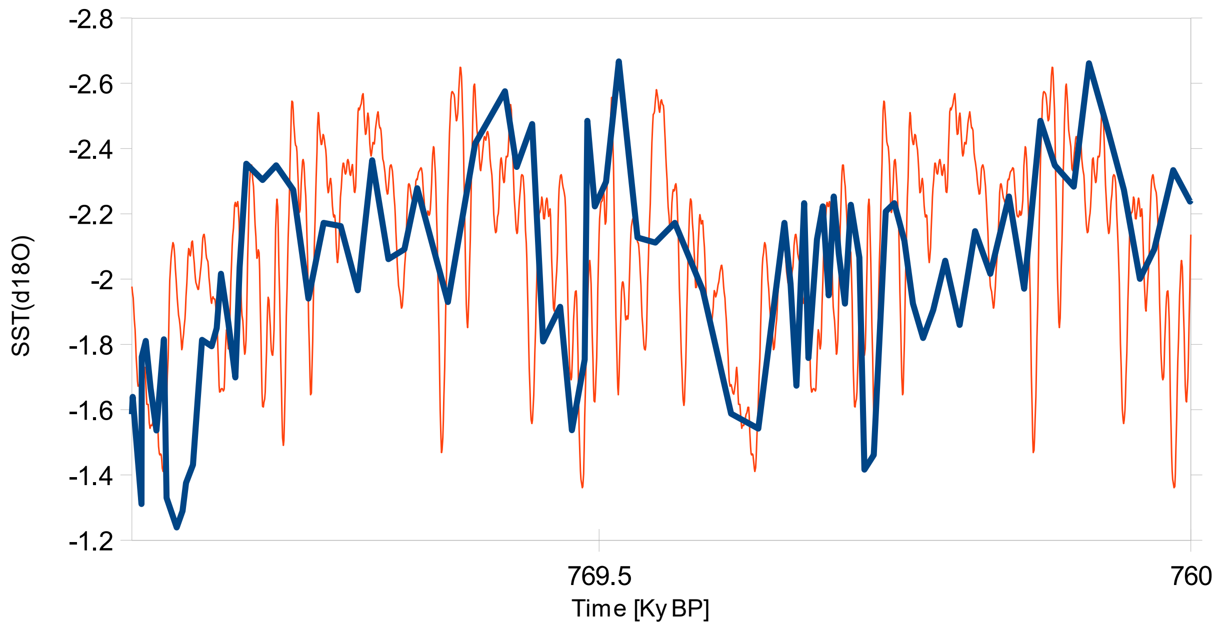


Figure A2. Comparisons of extrapolated TSI (SS16) with a climate proxy record of SST from N Atlantic ocean [Ueneo, et al., 2019].

2) Another comparison is based on the reconstructed Greenland temperatures (Clark et al., 2020) for the NEEM (Greenland) ice-core site (dark blue line, gray shading is uncertainty). The comparison with the TSI (SS16) extrapolated back in time (13 times of 9.5 Kyr) let us estimate a lag of around 3900 years.

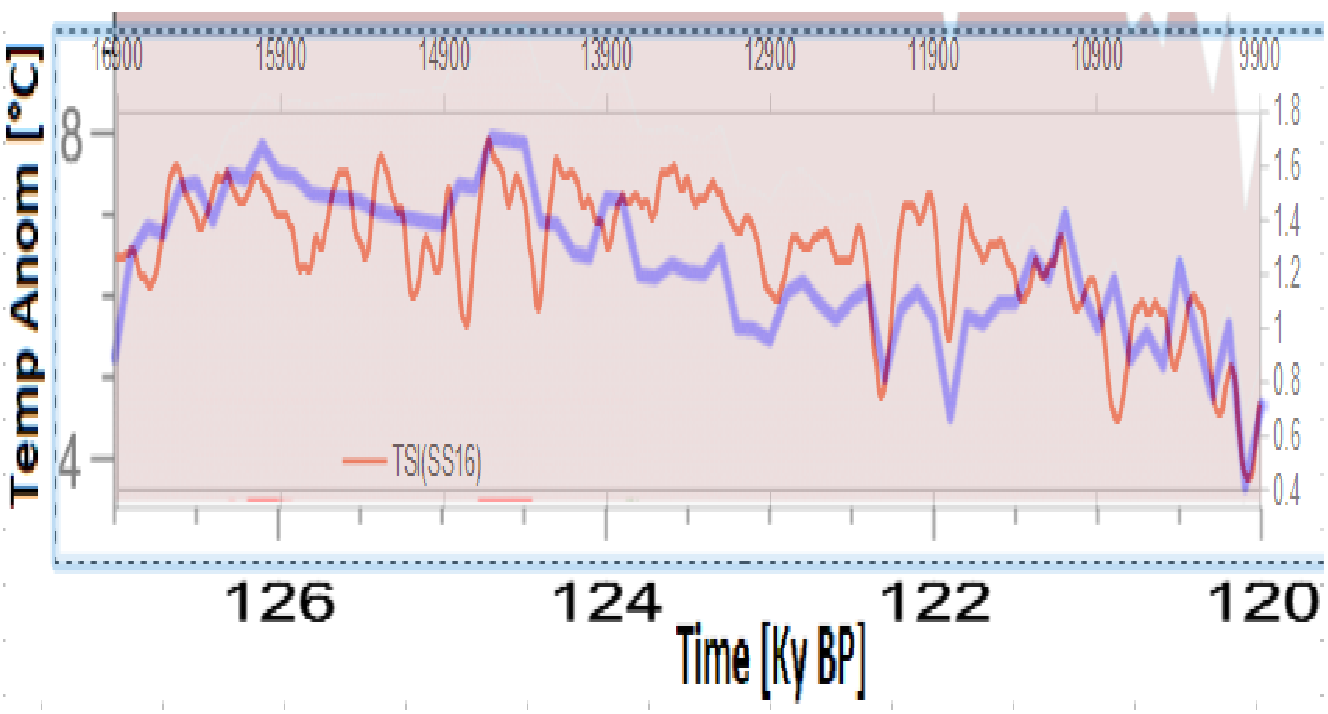


Figure A3. Solar pattern explaining Greenland temperatures (GrT) over the last interglacial (Clark et al., 2022). Solar pattern of 9.5Kyr with a temporal time of 13400 yr BP, that matches GrT at 123.5 Kya (13 times 9.5 Kya) is implying a GrT lag, respect TSI, of around 3.9 Kyr.

3) Another important set of independent evidences for the TSI recurrences of around 9.5 Kyr, is developed byViaggi et al. (2021). They have presented a comparison of sub-Milankovitch cycles (in kyr) identified in the EPICA records by the singular spectrum analysis (SSA) with other signals and their interpretation (forcing) from literature. In Table 1, the part of his table showing periods between 8.8 and 10 kyr (for 7 signals [EPICA δD, EPICA CO2, EPICA CH4, Indian Ocean δ18O, Rhythmites cyclostratigraphy, Rhythmites (coupled thickness and magnetostratigraphy), Rock magnetic cyclostratigraphy] and 3 forcings [Planetary beat on Sun, Nonlinear Milankovitch oscillator, Combination tones of Milankovitch cycles]), is the following:

Table 1. Comparison of Sub-Milankovitch cycles detected in Antarctic ice-cores and other parts of the world, and their estimated forcing (recorted from Viaggi [2021])

SIGNAL	AGE	SUB-MILANKOVITCH CYCLE		
EPICA δD m	Middle Pleistocene-Holocene	13	9.2	5.7
EPICA CO2 m	Middle Pleistocene-Holocene	13	9.8	5.9
EPICA CH4 m	Middle Pleistocene-Holocene	13	9.0	5.4
Indian Ocean δ18O f	Late Pleistocene	12.8–13	9.1–9.3	5.6–5.9
Rhythmites cyclostratigraphy k	Paleozoic	11.0–12.7	8.9–9.2	4.7–6.0
Rhythmites (coupled thickness and magnetostratigraphy) l	Late Carboniferous-Early Permian	11.1–13.6	8.8–10	5.1–6.2
Rock magnetic cyclostratigraphy g	Early Triassic	12.3–12.6	8.9–10.0	4.7–5.6
FORCING	**AGE**	**SUB-MILANKOVITCH CYCLE**		
Planetary beat on Sun	–	–	9.6 **a**	4–5 **n**
Nonlinear Milankovitch oscillator f	–	12.4–13	9.0–9.5	5.5–5.8
Combination tones of Milankovitch cycles	–	10–12 **h**	9.2 **l**	6–7 **h**

NOTES
a Sánchez-Sesma (2015, 2016).
b Dergachev (2004); Xapsos and Burke (2009); present study from data of Vieira et al. (2011) and Steinhilber et al. (2012); Usoskin et al. (2016); Usoskin (2017).
c Creer and Tucholka (1983); Hagee and Olson (1989); Gogorza et al. (2000).
d Viaggi (2018).
e Rodrìguez-Tovar and Pardo-Igùzquiza (2003).
f Pestiaux et al. (1988).
g Wu et al. (2012).
h Da Silva et al. (2018).
i Mayewski et al. (1997).
j Olsen and Hammer (2005).
k Elrick and Hinnov (2007).
l Franco and Hinnov (2012); Franco et al. (2012).
m This work (Viaggi, 2021)

It is important to mention that the average value of the periods analyzed by Viaggi (2021), shown in Table 1, is 9.35 Kyr.

4) Another qualitative comparison is developed with 14C isotopic anomalies measured from Greenland ice cores by Lal et al. (2005). The authors of this work, have pointed out: “The observed variation in cosmic ray flux at the polar site is best attributed to changes in solar activity resulting in variable modulation of terrestrial cosmic ray flux.” The comparison with the extrapolated TSI (SS16), and the 14C anomalies after to be adjusted both through a linear transformation and a bias of 1800 yrs, is shown in Figure A4 with a very good qualitative agreement.

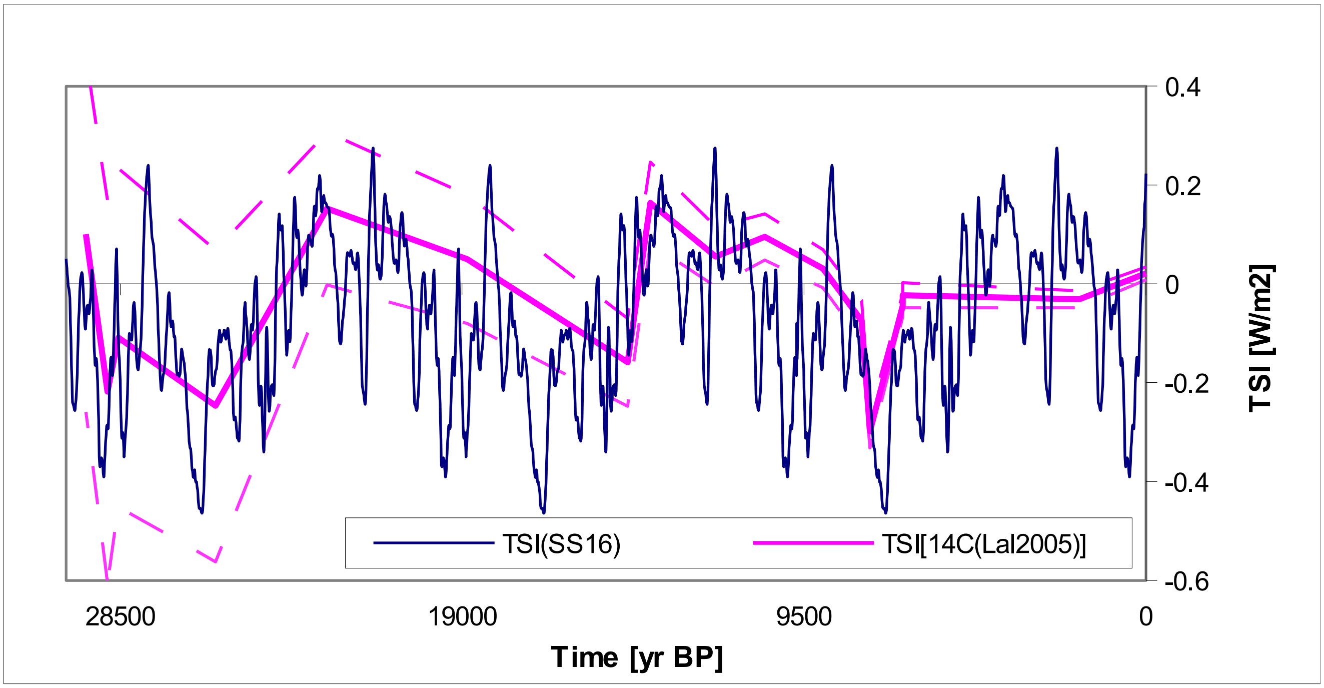


Figure A4. A comparison of 14C local production anomalies measured from Greenland (Lal et al., 2005), with the extrapolated TSI (SS16). The results of 14C after to be linearly transformed and a bias of 1800 yrs, shows a qualitative agreement between these records.

B. Comparison of phase lags between west and east Equatorial Pacific SST, in the geological, millennial, multidecadal, and annual scales; and a detailed analysis of lags between coral reconstructed records from east Equatorial Pacific, west Equatorial Pacific and west Indian, over the last four centuries.

Four forcing periods were considered: 9 Myr, 9.5 Kyr, 80 and 1 yrs. The corresponding graphical analysis are displayed in Figures B1- B4.

For the geological scales, based on Fox et al. (2000), a 0.8 Myr lag is estimated between west Equatorial Pacific SST and east Equatorial Pacific SST. It is shown in a comparison of SST for east and west Eq. Pac. It is shown in Figure B1.

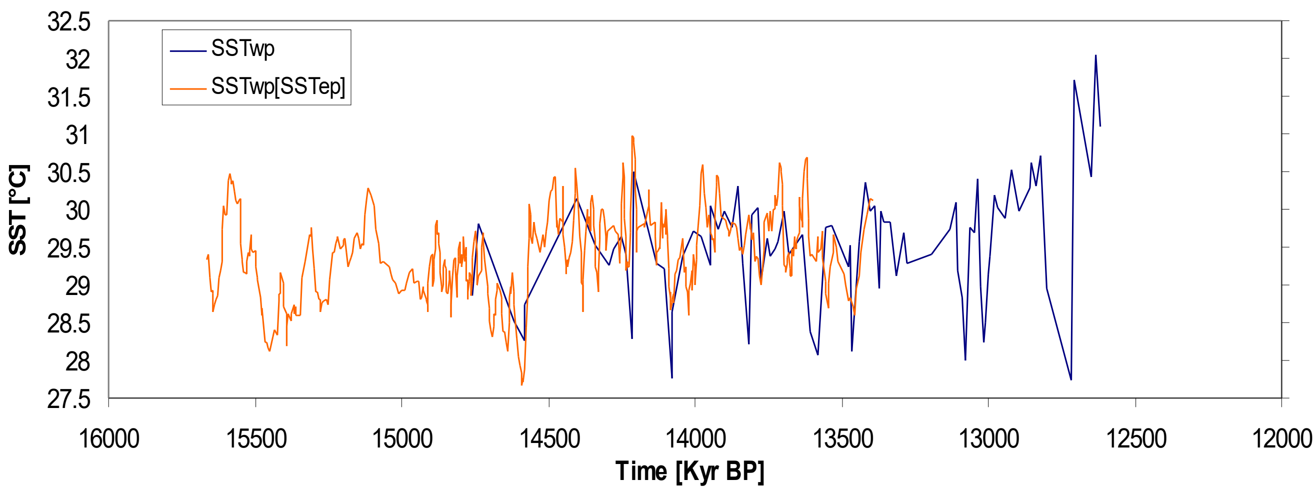


Figure B1

For the millennial scales, based on Lea et al., 2000 and Lea et al., 2006, a 0.9 Kyr lag is estimated between west Equatorial Pacific SST and east Equatorial Pacific SST. It is shown in Figure B2.

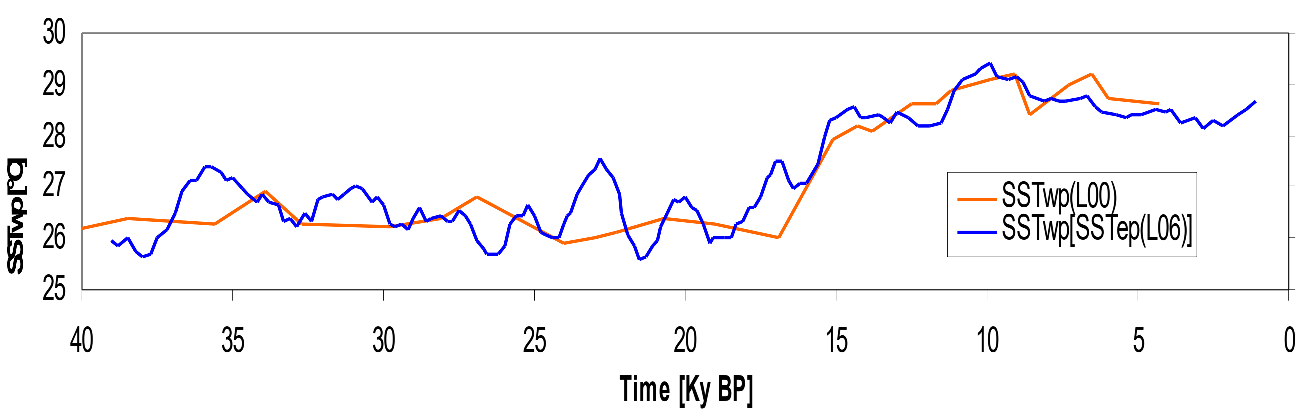


Figure B2

For the decadal scales, based on the NOAA´s data, a lag of 12 years is estimated between Niño 4 in the west Equatorial Pacific SST and Niño 12 in the east Equatorial Pacific SST. It is shown in Figure B3.

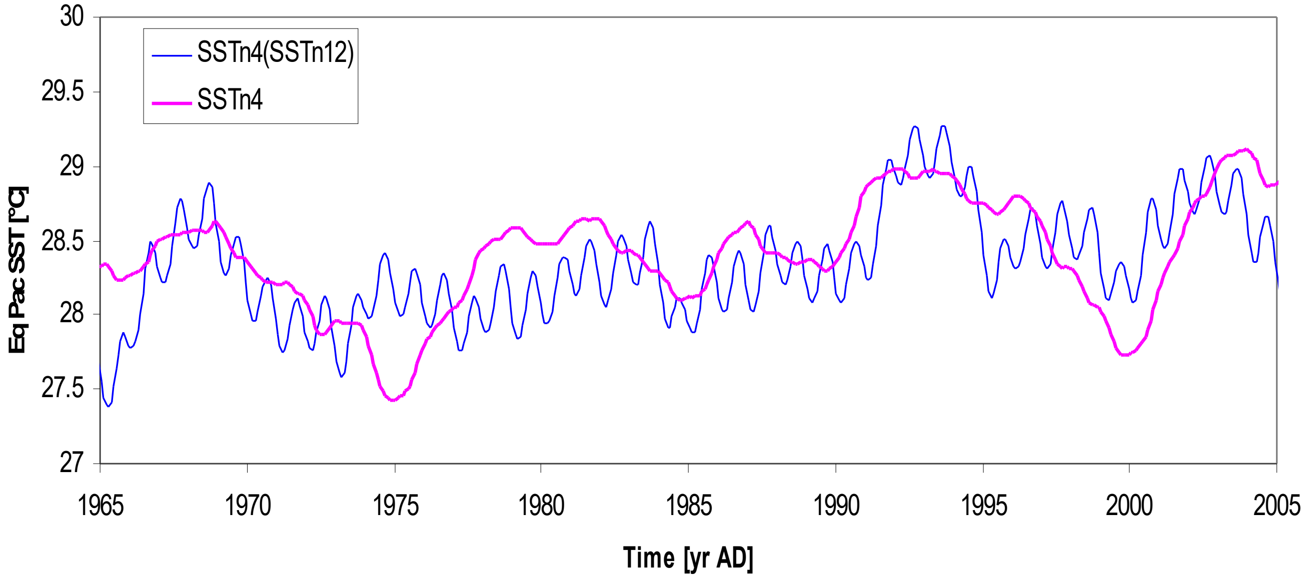


Figure B3

For the annual scales, based on the NOAA´s data, a lag of 3.5 months is estimated between Niño 4 in the west Equatorial Pacific SST and Niño 12 in the east Equatorial Pacific SST. It is shown in Figure B4.

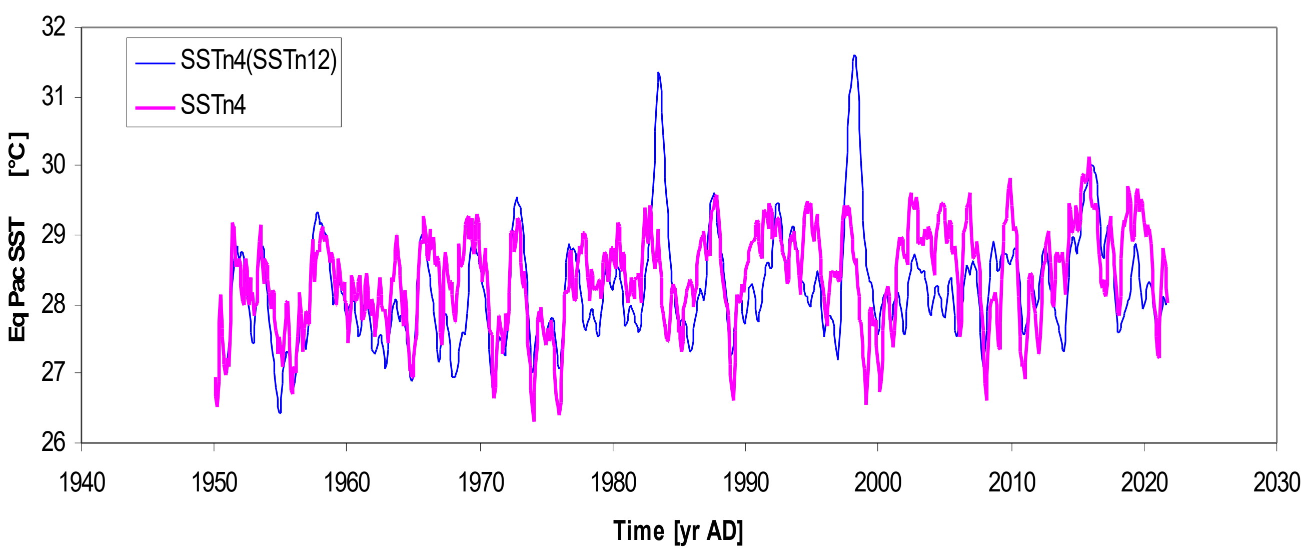


Figure B4

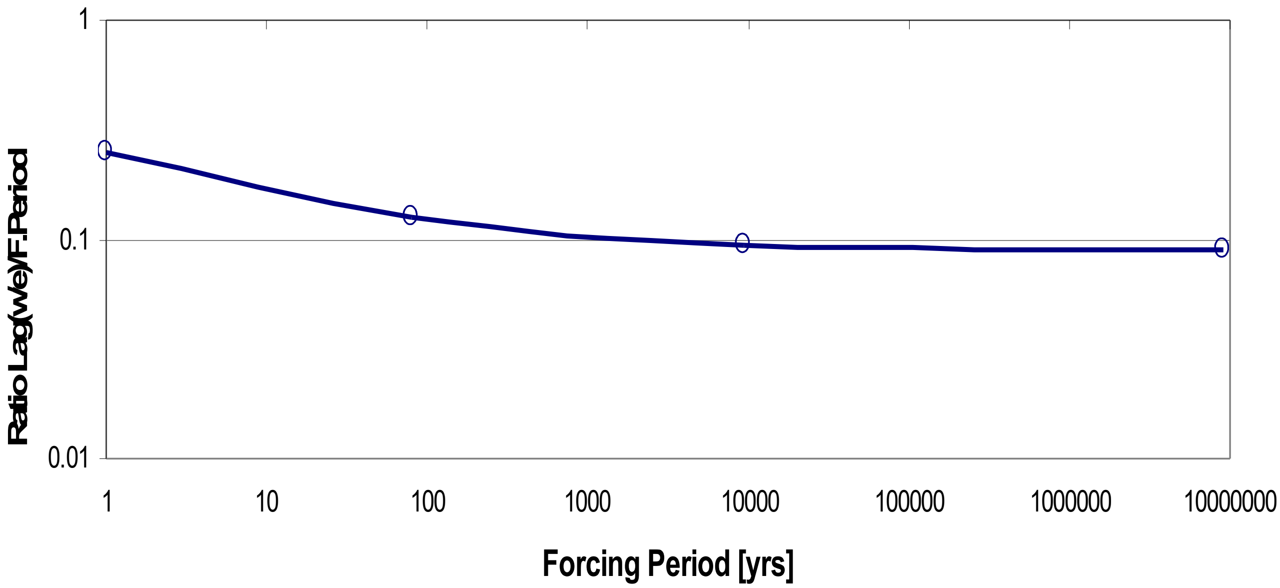
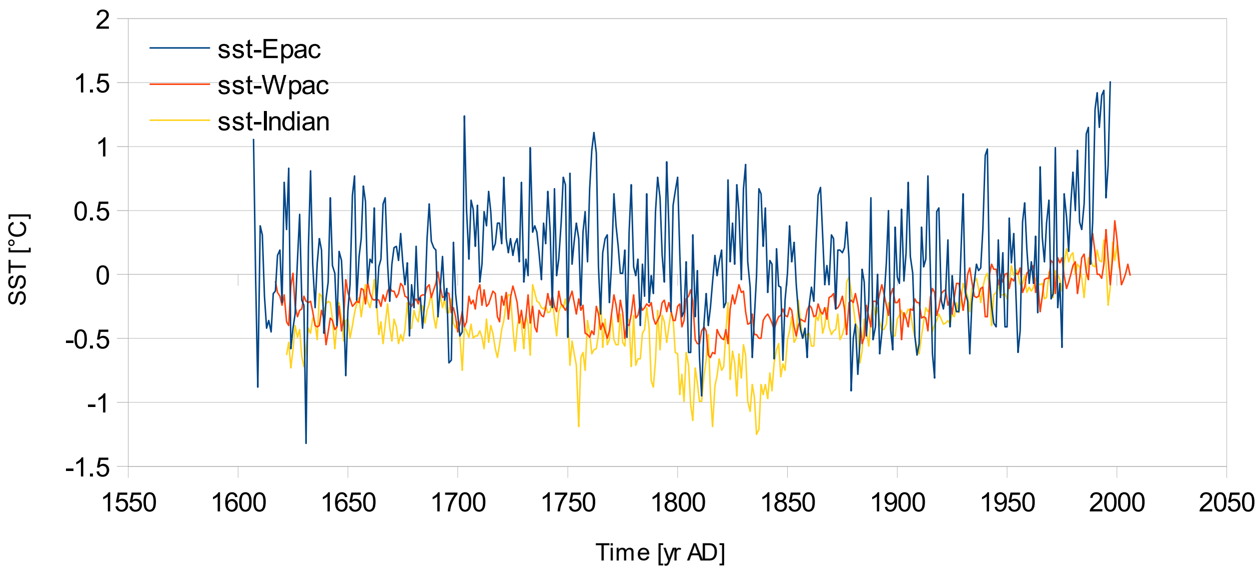
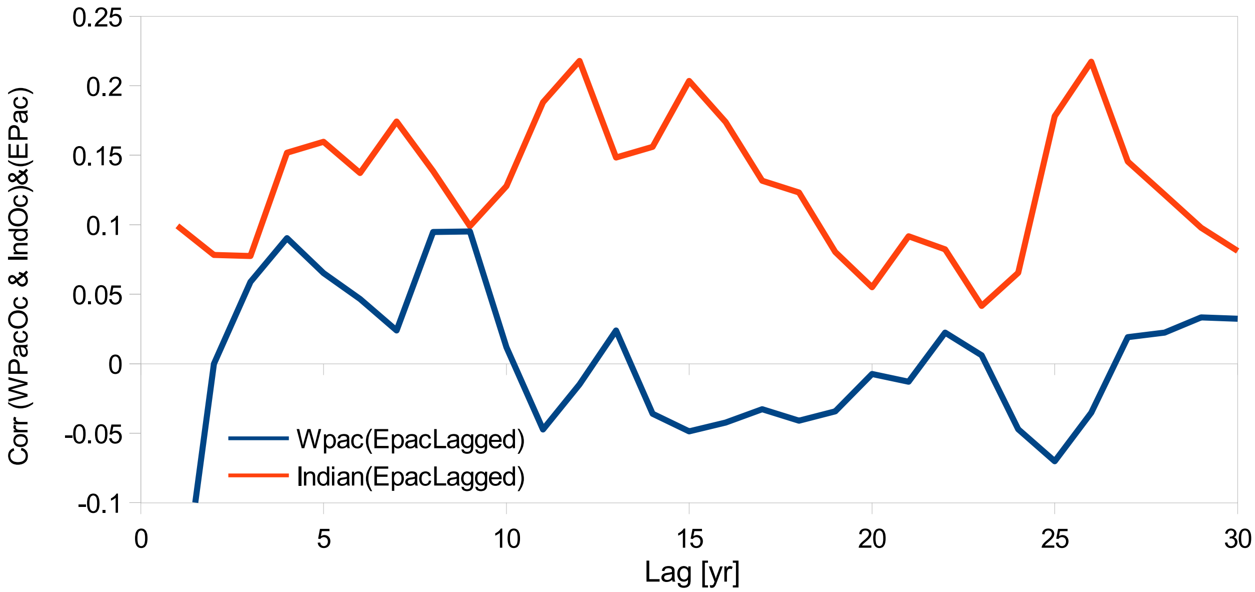


Figure B5: Ratio between West Pac SST lags respect East Pac SST and their forcing periods. Forcing periods were four 9 Myr, 9.5 Kyr, 80 and 1 yrs. See the four correspondent graphical analysis in Figures A1- A4.

Tierney et al. (2015), integrated SST reconstructions based on coral information coming from East Pacific, West Pacific and Indian Oceans, over the last four centuries. These records and their relative lags are displayed in Figure B6. The detrended correlations show their maxima, of smoothed values, for Epac lags of around 7 and 13.5 yr, for best matches for Wpac and Indian records, respectively.



a)



b)

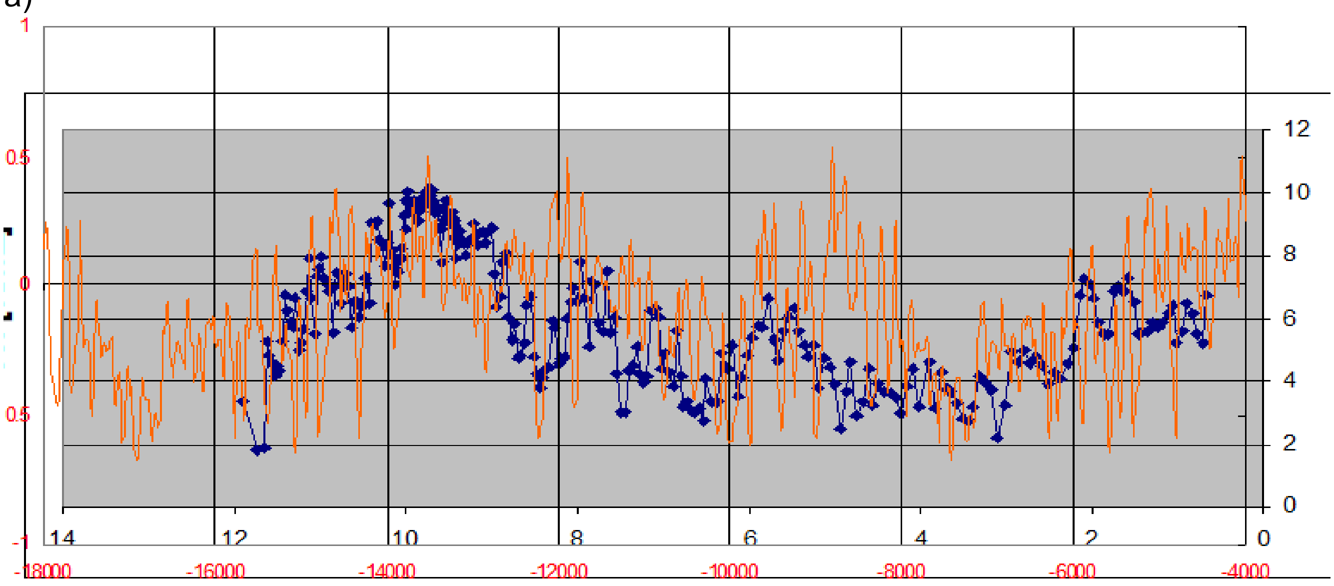
Figure B6: Cross-correlation analysis of east and west Pacific, and west Indian SST records, with different lags over the last centuries. a) records from Tierney et al., 2015; b) detrended correlation for different lags of the East Pacific SST record.

C. Additional verifications of lagged influences on climate

Two additional verifications of solar lagged explanations of an arctic and a tropical climatic records.

1) One verification is based on the Barents sea (BS) climatic indexes, that appears to be happen around 250 years before global temperature. This lead of the BS justify an analysis based on a Northern Sweden cave that helps to provide an experimental GT forecast. It support another independent GT forecast (see below).

a)



b)

Figure C1. Barents sea (BS) SST records over the last 12 Kyr. a) Map showing the BS in the eastern side of the Arctic ocean entrance (north of Norway Sweden and Finland); b) The Holocene SST reconstructed at BS compared with its model based on lagged TSI.

2) Another verification of the lagged climate response is developed with Madagascar and Magdalene Islands hydroclimate records which lag TSI by around 3600 years. These records show an African monsoon onset several centuries earlier than the East Asia Summer monsoon (previously analyzed lags).

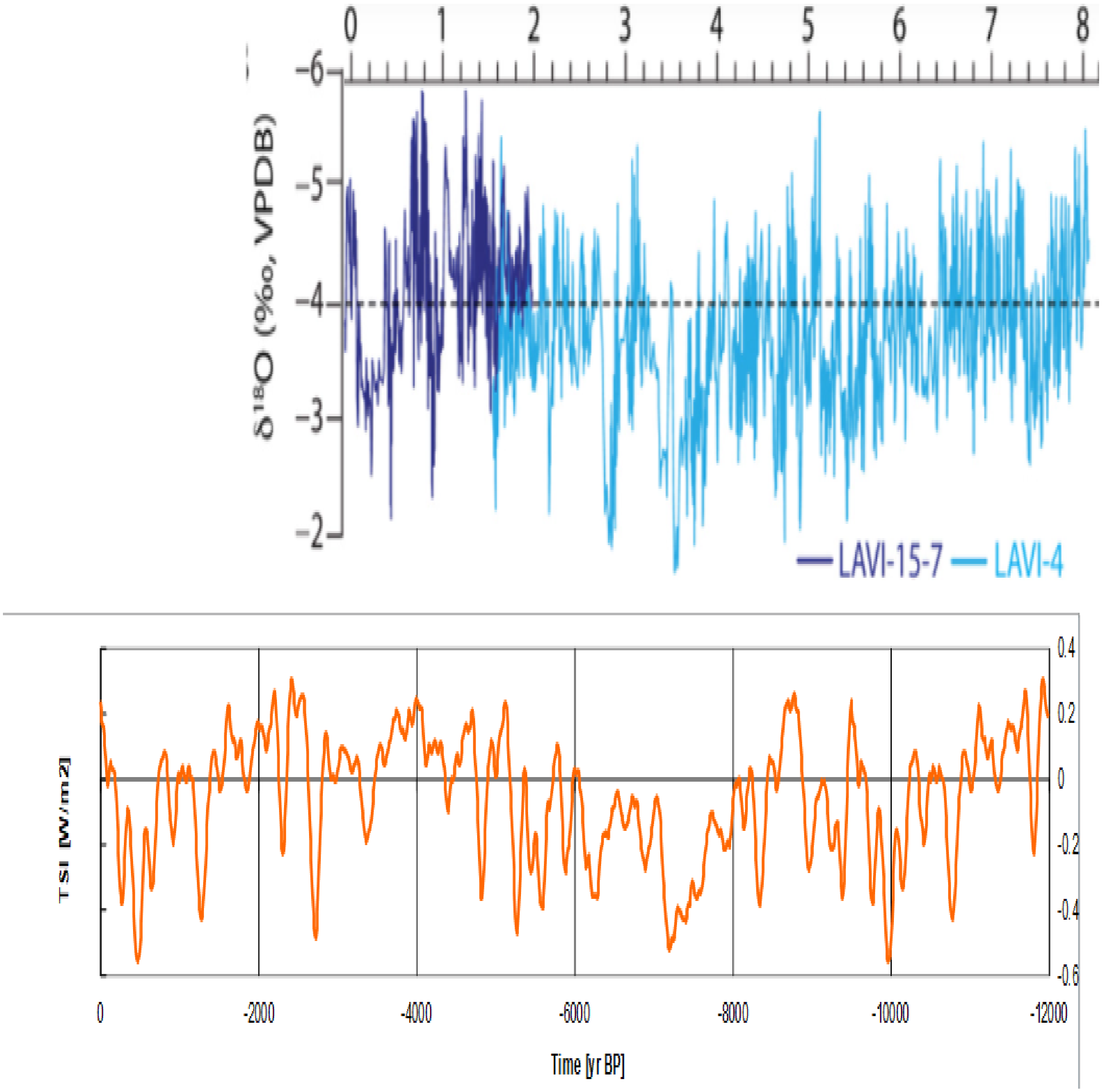


Figure C2. Isotopic oxygen anomalies (upper graph) from a cave in Madagascar and Mascarene Islands (Li et al., 2020) lags TSI record (lower graph) by around 3600 years.

D. Explanations and additional verification of the GT 21st Century forecast

The importance of my work (ESD-2021-84) for the past global climate (expressed in five modelling records) is very important. However, the consequences of this work for the future global temperatures (GT) are of paramount importance. In order to better support the GT decomposition and amplification, here we present an explanation of a kind of “resonance” between volcanic activity and the GT residual after to be considered the solar and lunar lagged influences.

Here, the amplification of 40% of the residual component of global temperature (GT minus the solar and tidal (NASA) component (GT res1b)] is explained. This amplification, could be considered as a resonant response to lagged volcanic activity. The component GT res1b and the lagged global volcanism (Sigl et al, 2005) over the last millennium were displayed in Figure D1. The global volcanic activity, after being adjusted linearly to GT values and lagged 80 yrs presents recurrences of about 180 years that can, after 4 cycles, generates a resonance over the GT res1b component.

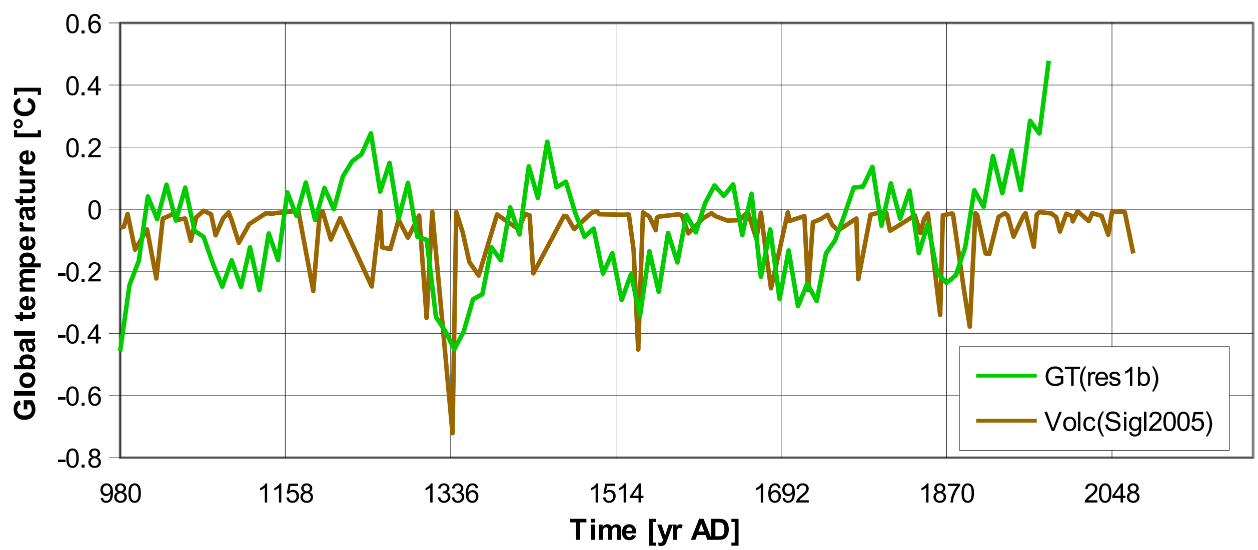
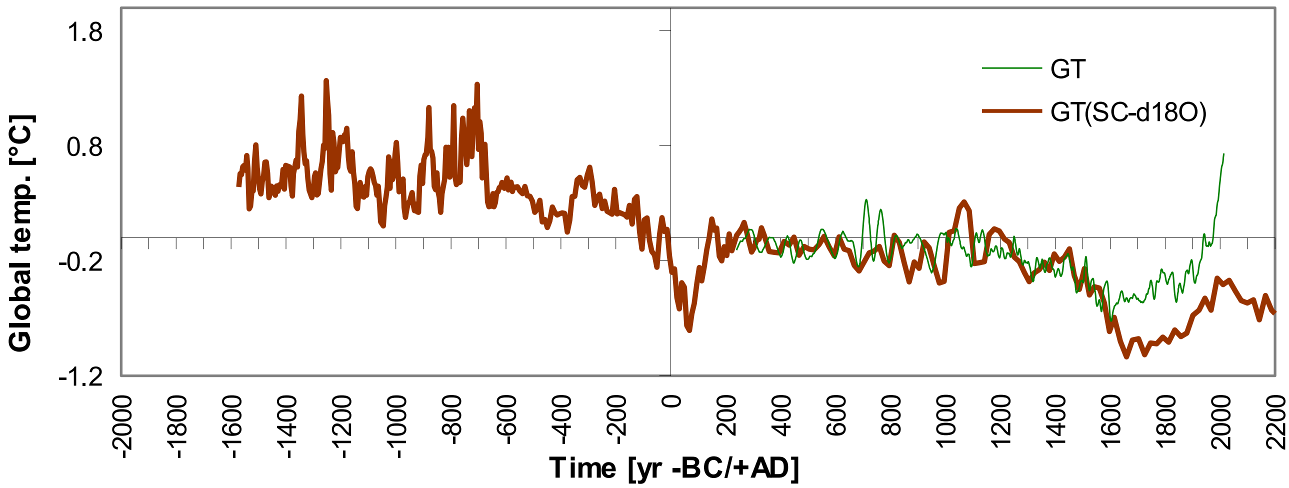


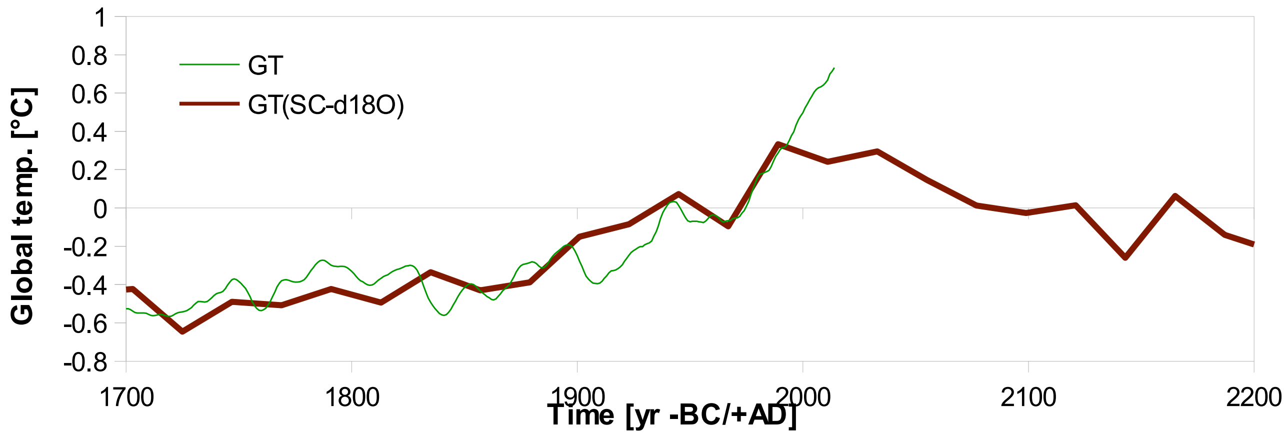
Figure D1. The residual global temperature (GT- solar-tidal) and lagged volcanic activity. The volcanic activity is lagged 80 yrs and has the recurrence of 178 yrs, with a consequent potential to generate a resonance for the GTres1b.

Given the mentioned importance of the GT forecast, an independent verification of the GT forecast is also provided. This independent verification of the 21st century GT forecast is based on independent information coming from the isotopic content of calcites of a cave located in Northern Sweden.

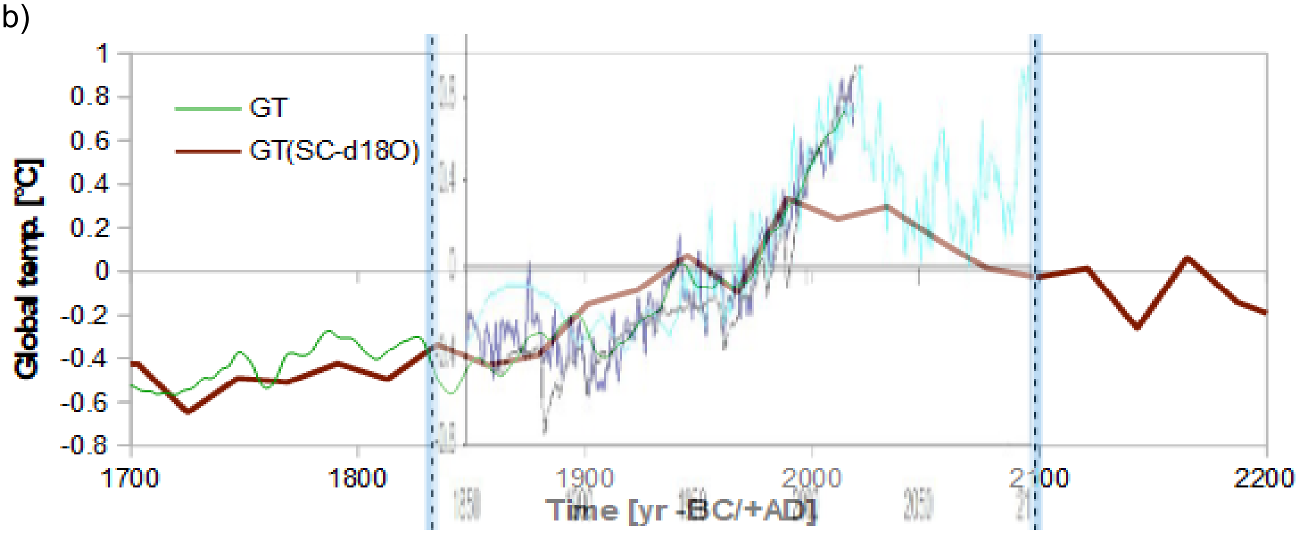
In order to support the GT forecast developed in this work, an independent forecast was evaluated. This GT forecast is based on information coming from isotopic anomalies of a northern Sweden cave over the Holocene. Figure D2 shows this forecast and a comparison with the previous forecast.



a)



b)



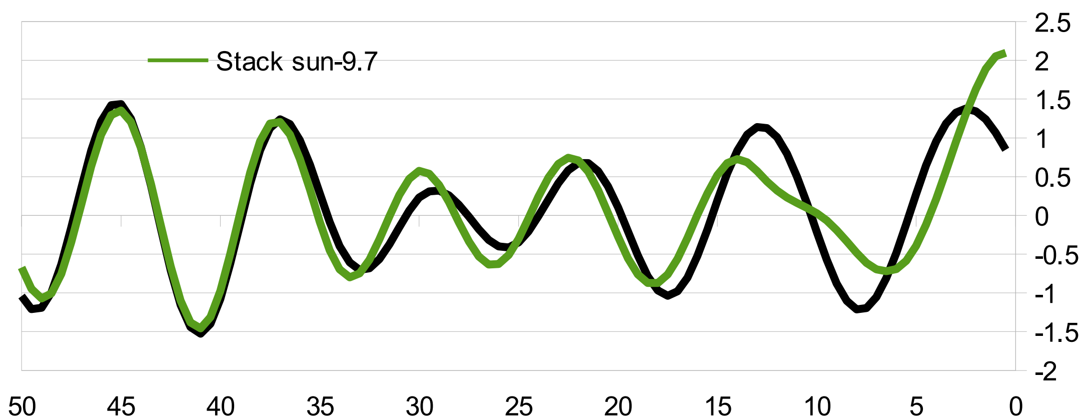
c)

Figure D2. Another GT forecast and its comparison. a) The isotopic record from calcites of a Northern Sweden cave over the last 4000 years lagged 270 years and adjusted to the GT record (integrated in this work). b) A zoom of these records but with adjusted only with the last 300 years: and c) the previous graph b) with the superimposed graph of the GT record forecasted previously in this work

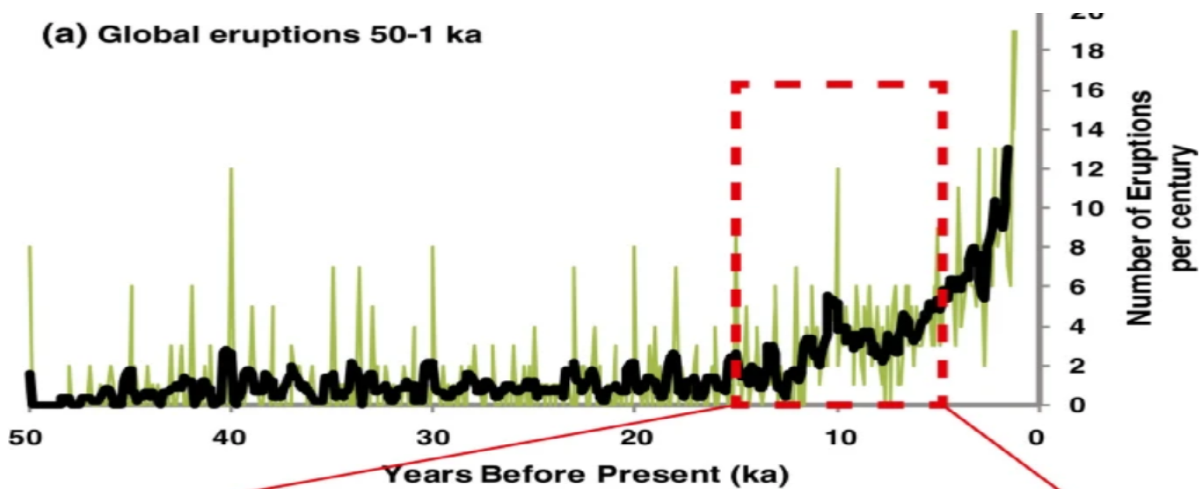
E. Analysis of CO2, solar activity and climate

Finally, a long-term analysis of the CO2 records **are** presented. This analysis shows two important aspects of CO2, relative ocurrences and potential causes: a) over the last 50 Kyr, the usual occurrence of CO2 previous to climate variations, when volcanic activity is below normal, and the contrary when volcanic activity is above normal, **b) over the Holocene, and c) over the last 60years** where the solar lagged influences on **CO2 records that explains their** variations.

Based on two studies developed in the last decade, Viaggi 2021 and Brown 2014, an analysis of the occurrences of CO2 relative to Earth´s climate is developed. Figure E1 shows the relative ocurrences of CO2 and climate variations filtered around 9.7 and 9.8 Kyr oscillations (Viaggi et al., 2021). Fig E1a clearly show a predominant occurrence of Climate before those of CO2. However when volcanic activity, reconstructed by Brown et al. (2014) and shown in Fig E1b, is above normal the CO2 occurs before climate variations. These facts emphasize the thermal oceanic origin of CO2.



a)



b)

Figure E1. Climate, CO2 and volcanism variations over the last 50 Kyr. a) The CO2 and climate variations filtered around 9.7 and 9.8 Kyr oscillations (Viaggi et al., 2021), clearly show a predominant occurrence of Climate before those of CO2; and b) global volcanic activity reconstructed by Brown et al. (2014).

It is also explored the possibility that solar activity generates lagged influence on the atmospheric CO2 content. **Figure E2 and E3 displays CO2 and solar lagged variations over the Holocene and the last 60 years, respectively**.

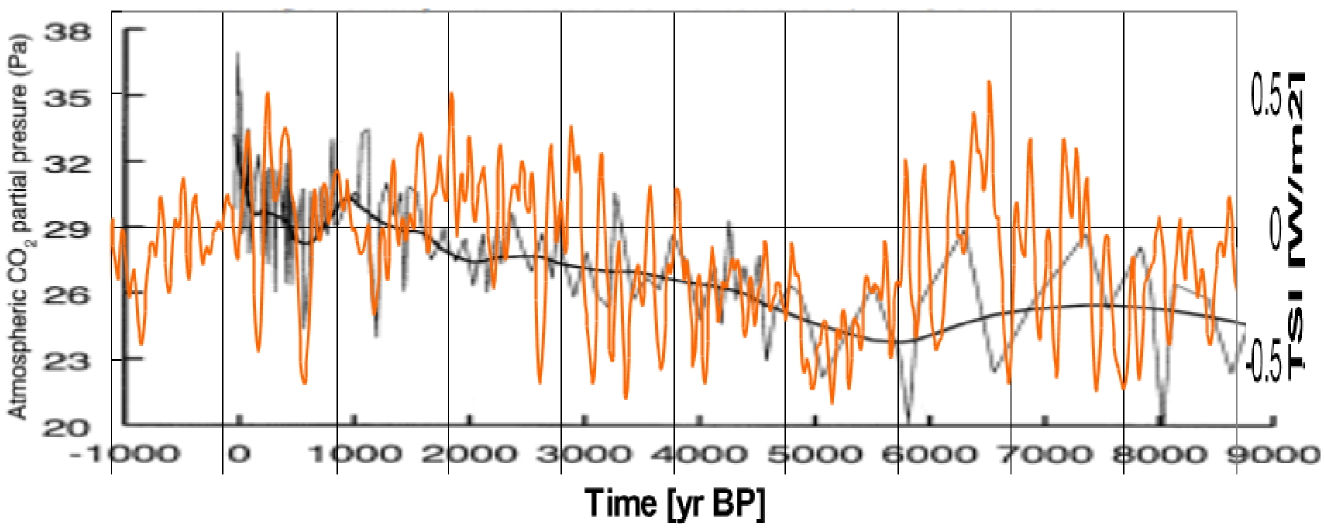


Figure E2. A comparison over the Holocene of CO2 (Royer et al., 2001) and solar lagged variations (SS16), with lags greater than 2000 years.

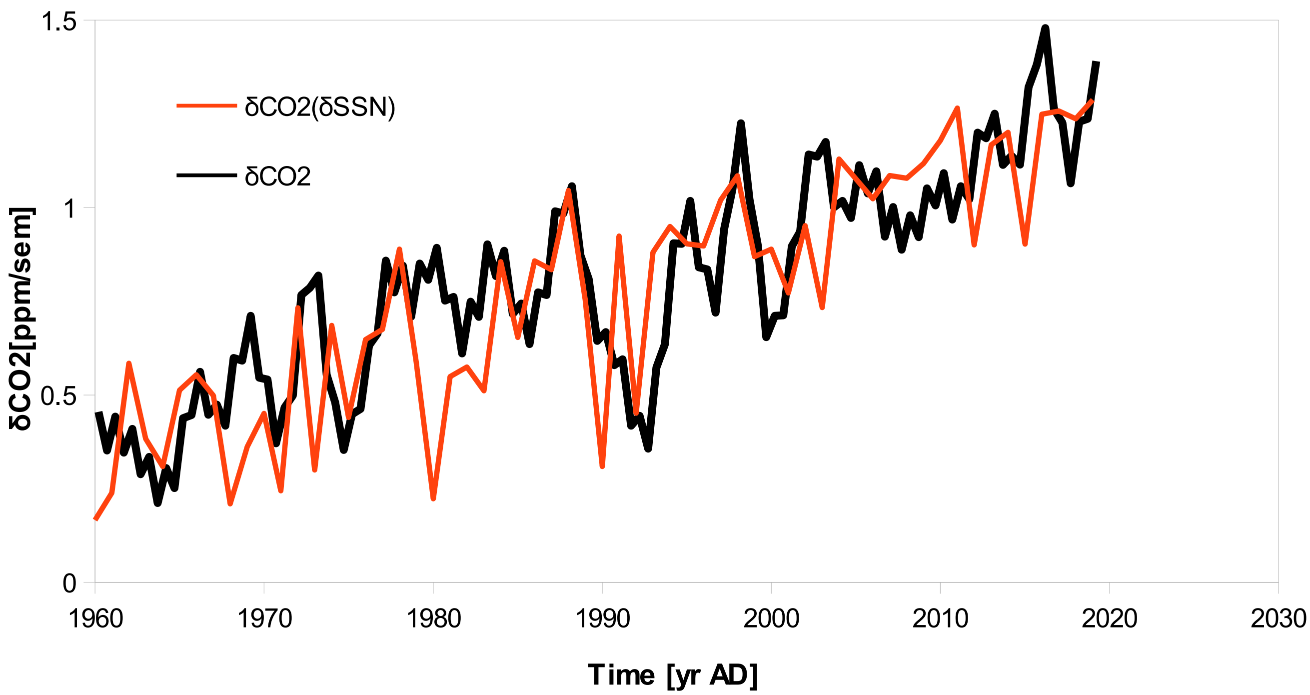


Figure E3. CO2 variations and its solar model over the last 60 years. CO2 changes are monthly registered at Mauna Loa Hawaii, by NOAA & SIO, and its model based on solar activity (SSN) is lagged half a year.

The obtained results of CO_2, depicted in Figures E1, E2 and E3, strongly suggest: with a relative lead/lag influenced by volcanic activity, with a very good match with solar lagged influences, around 2100 yrs later, and with a lagged solar influences on atmospheric CO_2 changes measured in Mauna Loa Hawaii, respectively.

All these characteristics suggest that the causes of CO_2 variations are of solar origin with different thermal and circulation mechanisms.

REFERENCES

Brown et al.: Characterisation of the Quaternary eruption record: analysis of the Large Magnitude Explosive **Volcanic** Eruptions (LaMEVE) database. Journal of Applied Volcanology 2014, 3:5

Clark, P.U., He, F., Golledge, N.R. et al. Oceanic forcing of penultimate deglacial and last interglacial sea-level rise. Nature 577, 660–664 (2020). https://doi.org/10.1038/s41586-020-1931-7

Fox, L. R., Wade, B. S., Holbourn, A., Leng, M. J., & Bhatia, R.: Temperature gradients across the Pacific Ocean during the middle Miocene. Paleoceanography and Paleoclimatology, 36, e2020PA003924. https://doi.org/10.1029/2020PA003924, 2021.

Lal, D., A.J.T. Jull, D. Pollard, and L. Vacher. 2005. Evidence for large century time-scale changes in solar activity in the past 32 Kyr, based on in-situ cosmogenic 14C in ice at Summit, Greenland. Earth and Planetary Science Letters 234, pp. 335-349.

Lea, D. W., Pak, D. K., Spero, H. J.: Climate impact of late quaternary equatorial Pacific sea surface temperature variations. Science 289, 1719–1724, 2000.

Lea D. W., et al., Paleoclimate history of Galápagos surface waters over the last 135,000 yr. Quat. Sci. Rev. 25, 1152–1167, 2006.

Li, Hanying, Sinha, Ashish, Anquetil André, Aurèle, Spötl, Christoph, Vonhof, Hubert B., Meunier, Arnaud, Kathayat, Gayatri, Duan, Pengzhen, Voarintsoa, Ny Riavo, Ning, Youfeng, Biswas, Jayant, Hu, Peng, Li, Xianglei, Sha, Lijuan, Zhao, Jingyao, Edwards, R. Lawrence, & Cheng, Hai.: A multimillennial climatic context for the megafaunal extinctions in Madagascar and Mascarene Islands. Science Advances, 6 (42). https://doi.org/10.1126/sciadv.abb2459, 2020

Risebrobakken, Bjørg; Dokken, Trond; Smedsrud, Lars Henrik; Andersson, Carin; Jansen, Eystein; Moros, Matthias; Ivanova, Elena V (2011): Early Holocene temperature variability in the Nordic Seas: The role of oceanic heat advection versus changes in orbital forcing. Paleoceanography, 26(4), PA4206, https://doi.org/10.1029/2011PA002117. DATA: Risebrobakken, Bjørg; Dokken, Trond; Smedsrud, Lars Henrik; Andersson Dahl, Carin; Jansen, Eystein; Moros, Matthias; Ivanova, Elena V; Sarnthein, Michael (2019): Calculated foraminiferal temperatures, and relative abundance, sediment core GIK 23258-2. PANGAEA, https://doi.org/10.1594/PANGAEA.904941,

Royer D.L., et al. 2001, **CO2** variations Earth Science Reviews 54, pp 349-392

Sundqvist, H. S., Holmgren, K., Moberg, A., Spo¨ tl, C. & Mangini, A.: Stable isotopes in a stalagmite from NW Sweden document environmental changes over the past 4000 years. Boreas, Vol. 39, pp. 77–86. doi:10.1111/j.1502-3885. 2009.00099, 2010

Tierney, J. E., N. J. Abram, K. J. Anchukaitis, M. N. Evans, C.Giry, K. H. Kilbourne, C. P. Saenger, H. C. Wu, and J. Zinke (2015), Tropical sea surface temperatures for the past four centuries reconstructed from coral archives, Paleoceanography, 30, 226–252, doi:10.1002/2014PA002717.

Ueno, Y., Hyodo, M., Yang, T. et al. Intensified East Asian winter monsoon during the last geomagnetic reversal transition. Sci Rep 9, 9389 (2019). https://doi.org/10.1038/s41598-019-45466-8

Viaggi P. (2021) Quantitative impact of astronomical and sun-related cycles on the Pleistocene climate system from Antarctica records. Quaternary Science Advances, Volume 4, October 2021. Supplementary data set: https://ars.els-cdn.com/content/image/1-s2.0-S2666033421000162-mmc1.xlsx [Original data from: Past Interglacials Working Group of PAGES (2016), Interglacials of the last 800,000 years. Rev. Geophys. 54:162–219, https://doi.org/10.1002/2015RG000482]