ACADEMIA | Letters

Evidence of solar 11-year cycle from Sea Surface Temperature (SST)

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The solar contribution to variation in mean temperatures of the earth during the past has been long debated. The reason for this is evident: a direct sun's influence on global climate parameters would undoubtedly confirm the primary role of the sun in driving the climate in the past, present, and allow us to forecast the future. Once assessed the primary sun's role, other forcings like CO2 or other GHG gases concentration, or other anthropogenic contributions, would need to be reconsidered.

Indeed many scientific studies have shown that changes in solar activity have impacted climate over the whole Holocene period (approximately the last 10,000 years) [1 and references therein],[2]. The high solar activity was the main cause of the well-known Medieval Warm Period, around the year 1000 AD, and the subsequent low levels of solar activity produced the following cold period, now called The Little Ice Age (1300–1850 AD). The sun's role in earth's climate is rationally highlighted in a recent reports of the GWPF [3] and in one recent (2020), very interesting book [1]. Other GWPF reports demonstrate that ocean and natural cycles, and not human activities, may be behind most observed climate changes [4,5]

Even if from 1979 satellite global temperature records are available, direct evidence of the 11-years cycle of solar activity on global temperatures of the last decades has been however rather elusive, although thoroughly investigated.

Nicola Scafetta [6] analyzed in 2009 the cyclic solar contribution to global mean air surface temperature. He employed an empirical bi-scale climate model characterized by both fast and slow time responses to solar forcings : and or . Only a fable 11-year solar cycle signature was evidenced in the major temperature patterns covering years from 1950 to 2009, even if surface temperatures were subtracted by volcano and ENSO signatures.

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Citation: Mazza, D., Canuto, E. (2021). Evidence of solar 11-year cycle from Sea Surface Temperature (SST). *Academia Letters*, Article 3023. https://doi.org/10.20935/AL3023.

More recently (2020) Z.W. Kundzewicz et al. [7] examined the variability of global mean annual temperature and how it is influenced by the rhythm of ocean-atmosphere oscillations. They demonstrated how climate variability is influenced by the 11 different ENSO and IPO indices in Pacific and AMO in the Atlantic, but again no direct ,evident signal of the main solar cycle of 11 years was evidenced.

After having downloaded and analysed hundreds of temperature records of the earth surface, eventually , we found clear evidence for the sun's 11-years cycle signature in some few cases, while for the vast majority of the others this wasn't detectable, buried under other oscillations (seasonal or El-Nino related) or noise. We found that two conditions are the most favourable in finding the proper sun's signature in temperature records: as a rule of thumbs:

1. Focus on the sea surface tropical temperatures, in the range 5°N – 5°S. This is not surprising, there solar rays transfer their energy to surface waters with less reflection or scattering and with an optimum incidence angle.

2. Forget anomalies or indices of whatever type; for our goals this is only data jamming. Look whenever possible to real sea surface temperatures (SST).

After careful analyses of the many temperature records of the whole earth surface temperature, as well as of selected regions, we identified two regions as the most affected by the 11-year solar cycle.

Both of them refer to ocean equatorial regions, known to climatologist as El-Nino-3 and El-Nino-3-4 . All the four El-Nino regions,(1+2), (3) , (3+4) and (4) (see fig. 1) are indeed the subject of extensive Sea Surface Temperature (SST) measurements in order to compute therefrom the ENSO indices used widely by climatologists . But the algorithms used hide the direct evidence of solar signature, while only real temperature data were are therefore the subject of our elaboration. The relevant data sources are listed in references; they are all taken from NOAA Climate Prediction Center (CPC) and from the NOAA Physical Science Laboratory (PSL)

The datasets for all the globe region examined are treated with a technique known as frequency (or Fourier) analysis, as already employed to this purpose [8][9]. NOAA-CPC makes available on the web the monthly records of SST in all the four El Nino regions starting from January, 1982 and the weekly records starting from January 03,1990. NOAA-PSL maintains a collection of monthly datasets for use in climate diagnostics from January,1944.

NOAA-PSL observations are from many different sources including ships, satellites, ground stations, RAOBS, and radar. Currently, PSL makes available datasets to the public in standard netCDF format.

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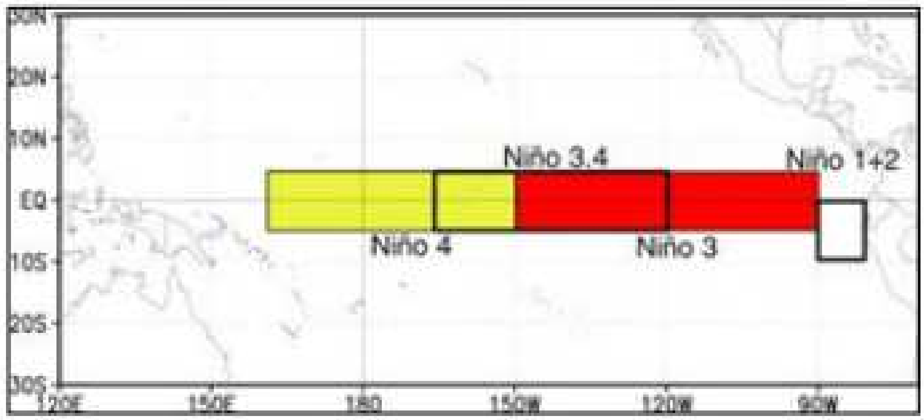

Fig.1 The four El-Nino regions

The region which displays the clearest evidence of the 11-years periodicity in NOAA-CPC weekly and monthly data is without doubt El Nino 4, followed closely by El-Nino 3-4.

In either data the the wide peak in frequency analysis pointing downward corresponds to a period of 11.90 and 11.97 years respectively (Fig.2). The irregular periodicity of El Nino/La Nina cycles in that region is dispersed in the peaks from 3 to 5 years.

The region of El Nino 3.4 displays always a marked peak with 11-years periodicity in both the weekly and monthly data (11.61 and 11.51 years). Again the irregular periodicity of El Nino/La Nina cycles is dispersed in many different peaks ranging from 3 to 5 years, however the sharp peak which appears in both frequency analyses centered around the 11 year period.

Shifting now to the NOAA-PSL data-set (Fig. 3), our frequency analysis can be extended backwards to 1948 also choosing different areas of the ocean. Data range was extended by varying latitude range from 5N-5S (El-Nino-4) up to 10N-10S and 20N-20S. Only frequency analysis for 10N-10S area is reported; being similar to the two other. The three sine-wave deconvolutions (red) are superimposed to the temperature records. Being the timespan longer in this case, the background was interpolated with a second order polynomial. There is also here a clear evidence for temperature oscillation due to solar forcing back to 1948. The amplitude of estimated oscillation is around +- 0.5 °C.

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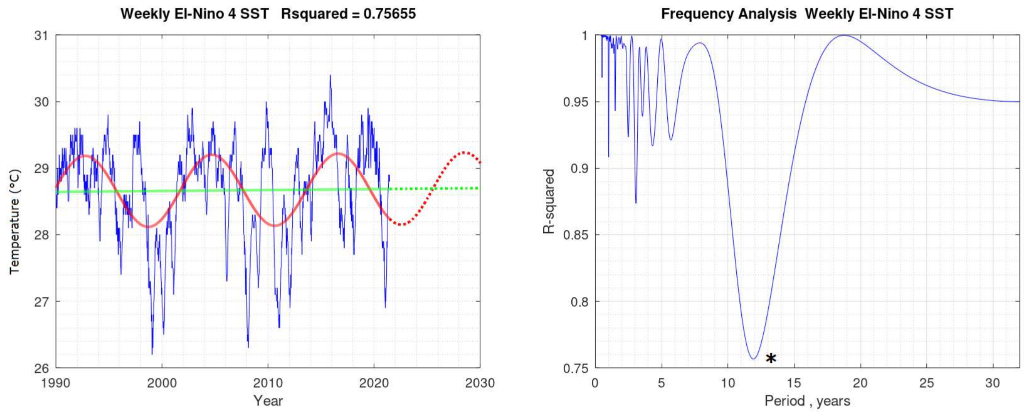

Fig.2 (right) Frequency analysis of the weekly SST records, from 1990 (source NOAA-CPC). (left) Weekly SST records, with linear trend (green) and frequency plot for the peak labelled with * .(red) . Dashed lines refer to extrapolated future trends up to 2030.

A comprehensive figure 4 resumes all the four data records examined , displaying the relative sinewave only, and in comparison with TSI(Total Solar Irradiance, ACRIM) , sunspot number (SISLO, Belgium) and neutron flow (OULU University, Finland), all indicators of solar activity 11-years cycle (Neutron flux is in anti-phase with solar activity, therefore it reaches its maximum when the former is at minimum).

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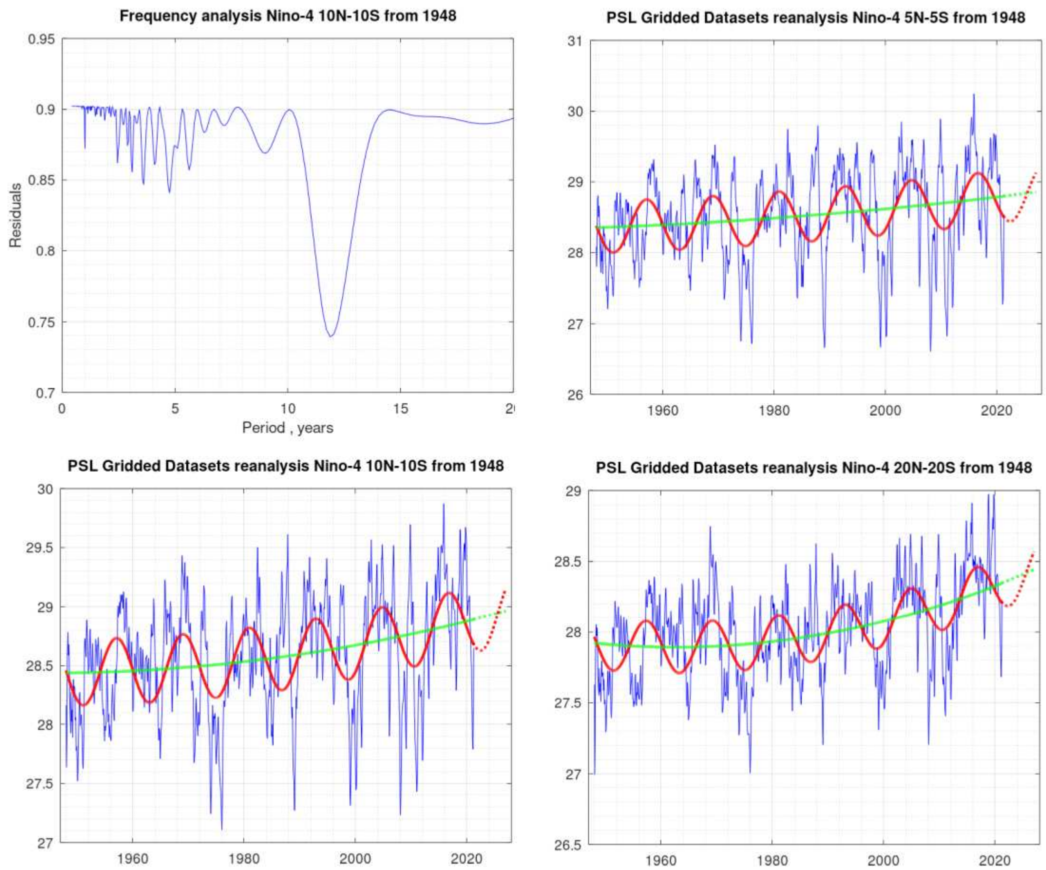

Fig.3 Data from NOAA-PSL from 1948 to June,2021. Area refers to Longitude 160E-150W (El-Nino-4) but to varying latitude range from 5N-5S (El-Nino-4) up to10N-10S and 20N-20S. Only frequency analysis for 10N-10S area is reported.

It is clearly shown that deconvoluted sinewave are correlated in phase with the 11-year solar activity cycle, but they lag usually of 2-4 years on average from the indicators of solar forcing. A possible explanation for the delay could be sought in the ocean water heat capacity and oceanic streams, but further analyses are needed in this respect.

As a clear result of this study, solar 11-year signature is only evident from selected tropical areas of the pacific ocean. As a consequence, by applying the same analysis to global satellite temperature records, (like those from University of Alabama in Huntsville [UAH]) the 11-years periodicity disappears. As a consequence the 3.5 periodicity of El-Nino/La-Nina becomes evident.

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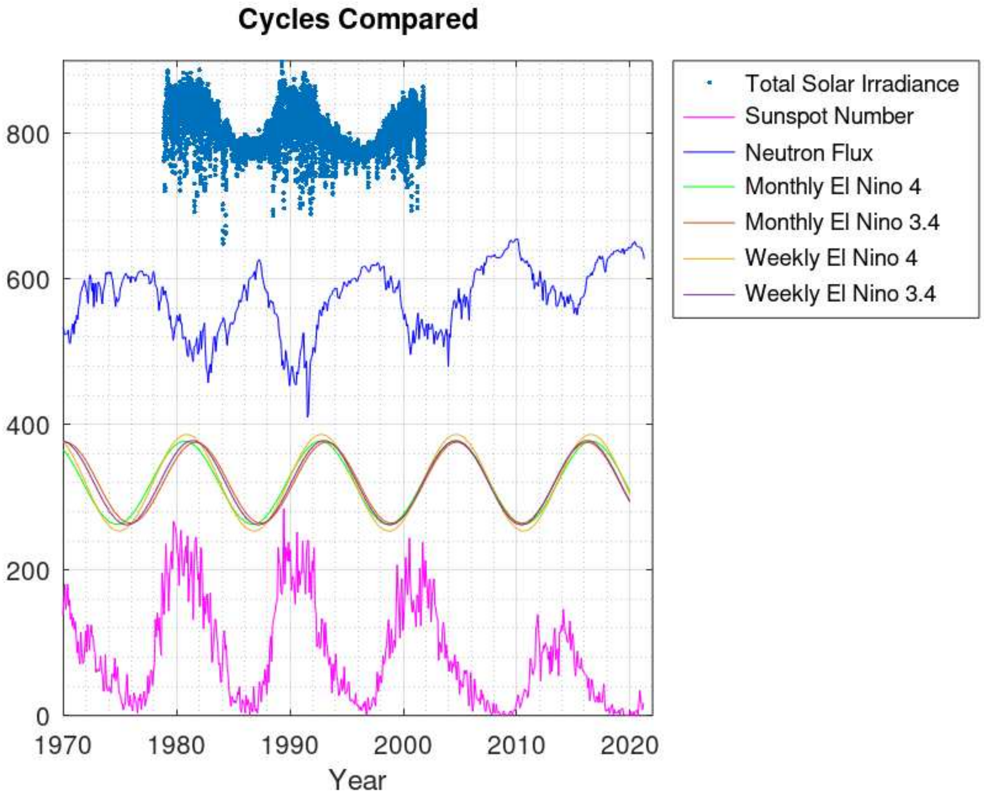

Fig.4 The whole picture of sinewave cycles compared with the main solar forcings (not in scale)

Figure 5 reports the satellite data of global lower troposphere temperature from UAH, University of Alabama in Huntsville. They cannot be used directly, because they are overimposed to a staircase signal (due to the four climate pauses, or stillstands, from 1980) as shown among others by Belolipetsky et al. in 2017 [9]. The four climate pauses are identified by linear interpolation of four temperature tentative sequences chosen by imposing that the interpolating line is horizontal. A unique solution is found, shown in figure by the red segmented line.

Once the four pauses are identified (red in the figure), temperature anomalies are correspondingly detrended, so as they can be analyzed in frequencies , with the results shown in fig.4 bottom left. The most relevant frequency has a period of 3.6 years and corresponds to El-Nino index cyclic variation. No trace, as before explained, of the solar 11-year cycle. The second wide peak centered at 7.5 years could perhaps correspond to the first of the two pe-

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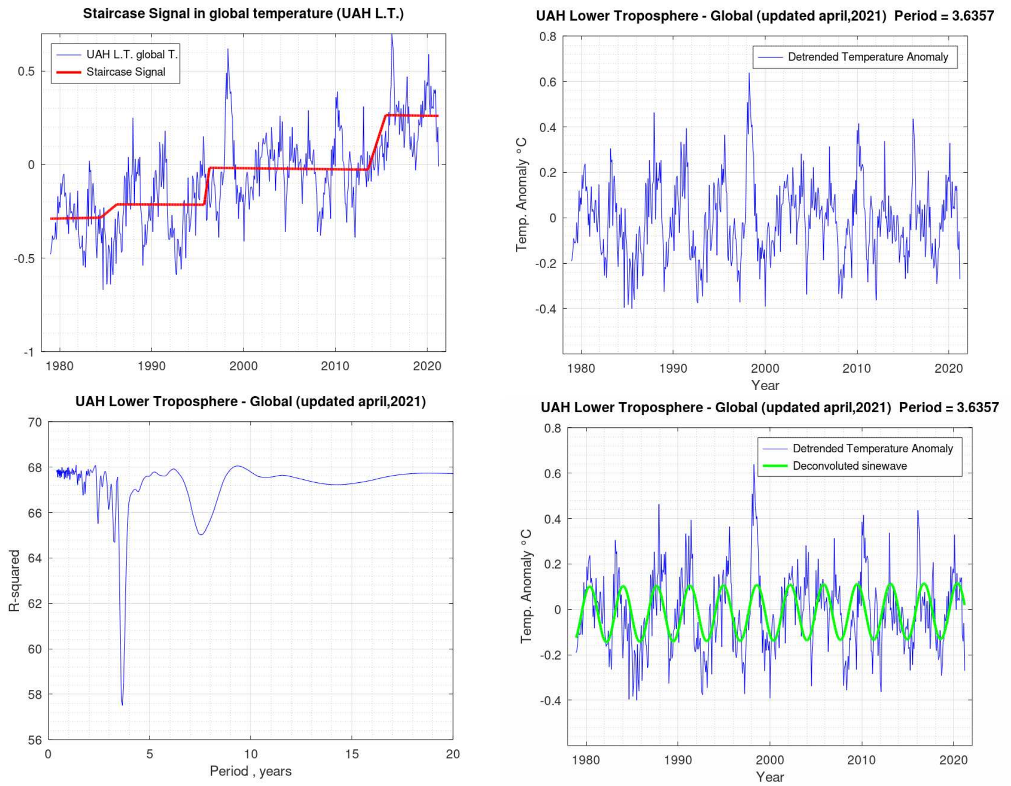

Fig.5 The frequency analysis applied to global lower troposphere anomalies after staircase background id subtracted.

riodicities of Scafetta [6].The final data are plotted in the graph of fig.5 bottom right, with the superimposed sine-wave deconvolution in green, corresponding to a period of 3.6 years (El-Nino periodicity).

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