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Mega-drought Detection and Prediction in the Central Sierra Derived from the Reconstruction of Mt. Rose SWE Record for Water Years CE 972-CE 2031 Using the Reversal of the Sun's Magnetic Field

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ABSTRACT

We have shown in several previous papers the major driving forces of winter precipitation in the Sierra are the reversal of the sun's magnetic field and a statistically independent "carrier" signal being generated by the Earth's large-scale atmospheric circulation. We present in this paper an extension of our wavelet analysis methods to include the period WY (CE972 to CE2031). We applied our model using a recently published tree ring reconstruction of solar modulation covering the last millennium to reconstruct the Mt. Rose SWE record over the period WY (CE972 to CE1912). We used the ISSN combined with the accepted SSN prediction model for Solar Cycle 25 to estimate Mt. Rose SWE over the period WY (CE972 to CE2031). Our model is confirmed by a high correlation with the Mt. Rose SWE record over the period WY (CE 1913 to CE 2021). The amplitude modulation of the sun's magnetic field, the Gleissberg Cycle (GC), is determined to be a time varying signal that resets approximately every 100 years. In addition, the GC itself has an amplitude modulation with a period of approximately 3,222 years. This is the Hallstatt cycle which has been reported in cosmogenic radioisotopes (^{14}C and ^{10}Be) and in paleoclimate records throughout the Holocene. There is compelling evidence the Hallstatt oscillation is coherent to a repeating pattern of planet motions and is therefore astronomical in origin. The relatively short period of 276 years (ISSN (1755-2031)) selected for our previous papers is less than 10% of the Hallstatt cycle and hence its effect was considered negligible. However, for the longer period considered in this paper, the effects of the Hallstatt cycle had to be included. We report on the mega-drought conditions that were occurring in the Sierra mountains starting with the late 10th century and continuing into the early 13th century. We also present an extension of our model to Cal-Yr. (BCE6755 to CE2025) and predict the next megadrought in the central Sierra will occur at approximately CE 2761

INTRODUCTION

Professor Church of the University of Nevada, Reno over a century ago established the earliest snow courses in the United States in the Sierra mountains above Lake Tahoe, CA,USA, Figure(1),(Church,1937).

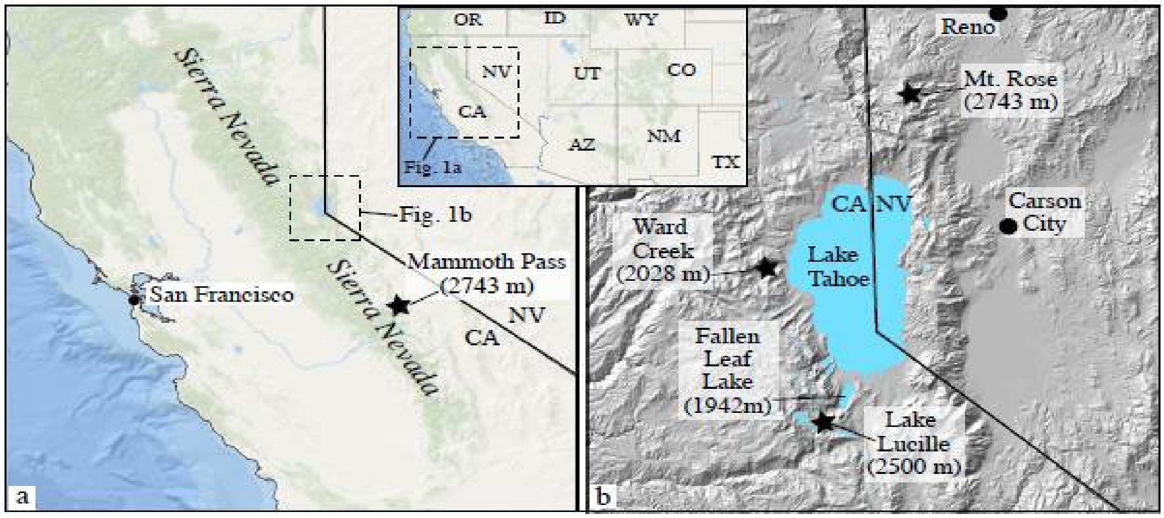
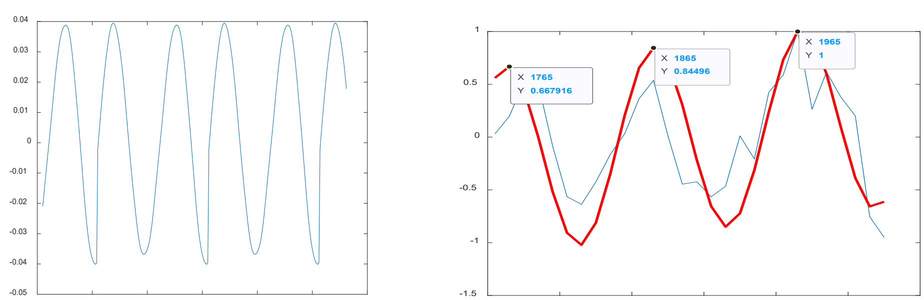


Figure 1 (a) Regional setting. (b) Enlarged map of the Lake Tahoe Basin and surrounding terrain. Snow Water Equivalent sites (SWE) are labeled as black stars.

(Kleppe & Brothers,2017,2018,2019,2021) developed and reported on a model that suggests the major driving forces of winter precipitation, in the form of snow in the central Sierra, are the reversal of the sun's magnetic field and a statistically independent "carrier" signal being generated by the Earth's atmospheric circulation. An essential input to this model is a record of solar activity over the period of interest. The amplitude modulation of the sun's magnetic field, the Gleissberg Cycle (GC), is determined to be a time varying signal that resets approximately every 100 years, Figure (2-a). In addition, the GC has an amplitude modulation with a period of approximately 3,222 years, Figure (2-b). This is the Hallstatt cycle and has been reported in cosmogenic radioisotopes (^{14}C and ^{10}Be) and in paleoclimate records throughout the Holocene,(Dergachev & Vasiliev,2019).



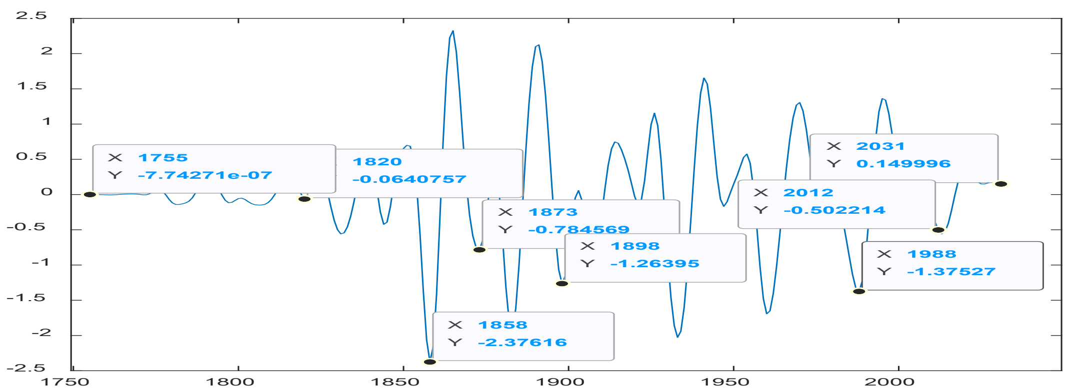
(a) **(b)**

Figure 2a Plot of repeating time varying GC.

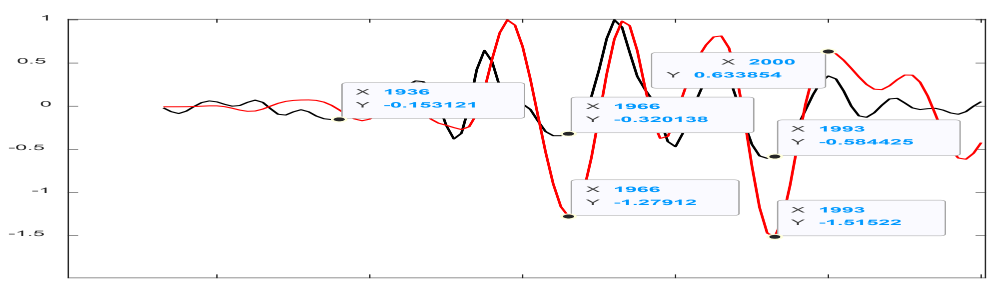
b Hallstatt modulation of the GC (R=0.78)

METHODOLGY and RESULTS

The Kleppe/Brothers model was used to estimate the MRSWE over the extended period WY (CE 1755 to CE2031), (Kleppe & Brothers,2021). This result is shown in Figure (3-a). The model was confirmed by a high correlation (0.7) with the actual Mt. Rose SWE record over the period WY (CE 1913 to CE 2021), Figure (3-b). The result of this reconstruction predicted the ongoing severe drought in the Sierra mountains range would last until the Fall of 2023 or WY 2024.



(a)



(b)

Figure 3a. Estimated MRSWE (blue) 1755 to 2031

b. Actual(black) v Estimated(red) for 1913 to 2020 (R=0.7)

This paper presents an extension of the Kleppe/Brothers model to reconstruct the central Sierra snowpack MRSWE over the time-period WY (CE 972 to CE 2031), and to also reconstruct the megadrought conditions in the central Sierra mountains over the period BCE 6675 to CE 2025. The method requires knowledge of the Hallstatt Cycle for the period of interest. We used a recently published reconstruction of solar activity by month, (Brehm, et al, 2021), for the period CE (972-1913), the ISSN CE (1914-2020), and the NOAA/NWS sunspot prediction model (2021-2031) for our mega-drought analysis (BCE 6675 to CE 2025). Figure (4) shows the reconstruction of the Hallstatt Cycle over the period BCE 6755 to CE 2031 using our data set and the data set from (Wu, et al 2018).

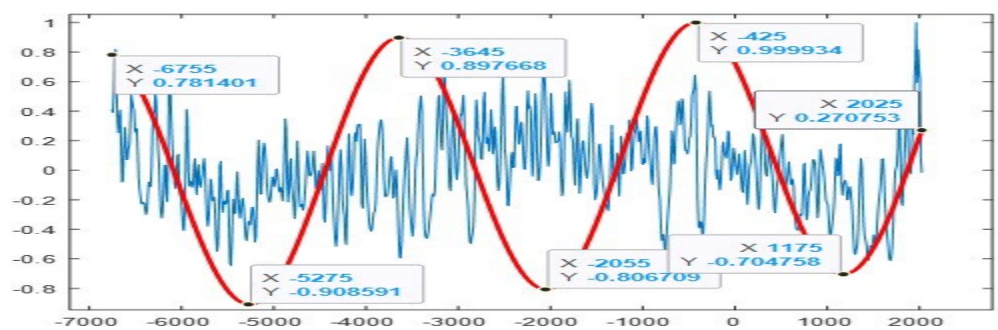


Figure 4 Reconstruction of Hallstatt Cycle with solar modulation (blue) and the reconstructed Hallstatt Cycle (red) .

We confirmed the validity of this reconstruction using data from sediment cores that were taken in the sediment of Fallen Leaf Lake and reported by (Noble, et al ,2015) and (Mensing, et al ,2015). The authors reported finding sedimentation shifts circa BCE 5350, BCE 3050, BCE 1750, and BCE 425 that may reflect major changes in middle Holocene aridity. The mega-drought reported by (Kleppe, et al ,2011) reported the mega-drought period of approximately CE 1052 to CE 1258 with a mid-value of CE 1155.

DISCUSSION AND CONCLUSIONS

The reconstruction of Mt. Rose SWE (red) over the period CE 972 to CE 2031, Figure (5), clearly shows the mega-drought reported in (Kleppe, et al ,2011). The midpoint is CE 1155. The solar modulation data from (Brehm, et al ,2021) are shown in blue.

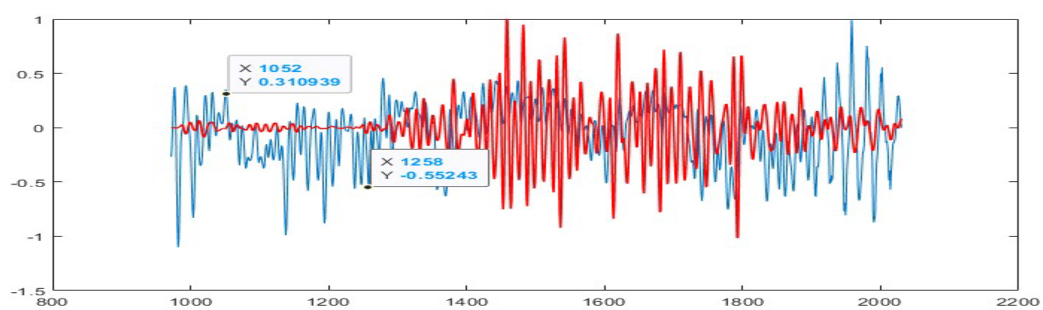


Figure 5 Mt. Rose SWE BCE 6675 to CE 2031 shown in (red) and solar modulation shown in (blue).

It is important to note the solar modulation data (blue) shown in Figure(5) is not directly correlated with the reconstructed SWE(red). One must use the amplitude modulated Kleppe/Brothers model to estimate the SWE. It is also important to note the megadrought CE(1052-1258) is not seen using the model if one ignores the Hallstatt Cycle. The megadroughts appear to occur at the peak values of the Hallstatt Cycle. These values are at the peaks of the absolute value of the demodulated Hallstatt Cycle or approximately every 1586 years. The next mega-drought in the central Sierra is therefore not expected to occur until approximately the year CE 1175+1586 = CE 2761. This should provide sufficient time for appropriate measures to be taken to help mitigate such a wide-spread natural disaster.

There is some question as to origin of the Hallstatt Cycle whether it is astronomically caused or if it is a variation of the geomagnetic field (Scafetta, et al (2016),(Dergachev & Vasiliev,2019). This does not affect our results as either cause would equally affect the amplitude of the Hallstatt Cycle.

It is important to discuss the most probable mechanism for our results. The El Nino Southern Oscillation (ENSO) is one of the most important ocean-atmospheric interactions that produce the snowpack variability in the Sierra. The Sea Surface Temperature (SST) is used to generate the Oceanic Niño Index (ONI) which is one of the oldest indices for monitoring ENSO. The El Nino Modoki (EMI) index is also an important index of SST anomalies averaged over three areas of the tropical Pacific Ocean. The Modoki mode is associated with strong anomalous warming in the Central tropical Pacific and cooling in the Eastern and Western tropical Pacific. The EMI captures the zonal pattern of the Modoki mode. During an El Nino event, the surface waters in the central and eastern Pacific Ocean become significantly warmer than usual. (Kleppe & Brothers ,2019) discussed this in some detail. The modulation of the SST by the reversal of the magnetic field of the sun comes from the modulation of the downward short wave radiation flux, SW↓ and the downward long wave radiation flux, LW↓. The lag-correlation coefficients between EMI and SW↓and LW↓ have been reported by Pinker, et al (2017). The SW↓ flux leads the EMI index by 1 month; and the long wave radiation flux LW↓ also leads the EMI index by 1 month. It is important to note the time series of the radiative fluxes are highly correlated with the time series of the El Nino and the EMI indicating both radiative flux variations have the same solar spectral peaks as the Kleppe/Brothers model.

The basic Kleppe/Brothers model has been extended to other sites throughout the western united states, (Kleppe & Brothers ,2018) and to the use of the Palmer Drought Severity Index (PDSI). However, presently the model use for megadrought detection and prediction has only been applied to the one MRSWE site. More sites are currently being studied. The exact details of how to apply the model can be found in (Kleppe & Brothers, 2017,2018,2019, 2021).

Short-term actuate prediction of drought using the Kleppe/Brothers model is limited by the ability to accurately predict the date of the flip of the magnetic polarity of the sun and to also have an accurate prediction of the intensity of the sun's changing magnetic field over each Solar Cycle.

It is recommended that increased research efforts should be allocated to developing a better understanding of the sun and its Solar Cycles and to developing a better understanding of the relationships between these cycles and climate.

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