

## Seismic-Perturbed Obliquity Change as a Discrete Trigger Mechanism of El Niño and La Niña Episodes

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**Abstract:** The global climate disruptor El Niño Southern Oscillation (ENSO) is difficult to forecast some years in advance due to lack of understanding of its root cause. An alternative physical mechanism is hereby proposed to describe the nature and sustaining force, and predict the occurrence of El Niño and La Niña phenomena. This is based on the earthquake-perturbed obliquity change model previously proposed as a major mechanism of the global climate change problem. Massive quakes can impart a very strong oceanic force that can move the moon which in turn pulls the earth's axis and change the planetary obliquity. Analysis of the annual geomagnetic north-pole shift and global seismic data revealed this previously undiscovered force. Using a higher obliquity and constant greenhouse gas forcing in the global climate model EdGCM showed that the seismic-induced polar motion and associated enhanced obliquity could be the major mechanism governing the mysterious climate anomalies attributed to El Niño and La Niña cycles. The apparent eastward migration of high SST in the Pacific and the warming of the Indian and Atlantic Oceans south of the equator during ENSO years were correctly simulated by the model. The annual time series of global surface temperatures computed by EdGCM was compared with the observed global temperature and the results showed relatively good agreement. In addition, the heat wave that occurred in Europe during the summer of 2003 and the Russian heat wave of 2010 that killed over 55,000 people appeared to have been correctly simulated with higher obliquity. This study can help affected countries in water shortage contingency planning, disaster mitigation and may help prevent adverse economic and commercial impacts due to ENSO.

**Keywords:** El Niño Southern Oscillation, La Niña phenomenon, massive earthquakes, sea surface temperature, obliquity change, global climate change

### INTRODUCTION

The irregular occurrence and intensity of El Niño Southern Oscillation (ENSO) and La Niña cycles and their impact on the global climate are quite difficult to understand and much more difficult to predict. ENSO is well known to be a major climate disruptor that leads to devastations in agriculture and fisheries, induce natural disasters and adversely affect global economy and public health (McPhaden et al., 2021). This study aims to determine the occurrence and major cause of the El Niño and La Niña phenomena using both statistical analysis of available observations and dynamic model simulations using the EdGCM Global Climate Model ([edgcm.columbia.edu](http://edgcm.columbia.edu)). This model was developed by Chandler et al. (2005) to simulate climate conditions under various global warming scenarios.

The seismic origin of the El Niño phenomenon had been originally proposed by Walker (1988, 1995, 1999) while analyzing the seismicity in the Eastern Pacific Rise and previous ENSO episodes. However, the possible impact of the seismic events on obliquity change was not considered in the analyses. It was concluded that all El Niños since 1964 have been preceded by anomalous seismicity along portions of the East Pacific Rise and this seismicity was found to lead

the extreme lows in ENSO indices by 5-15 months (Walker, 1999). Hence, the El Niño Southern Oscillation was believed to originate from the warming of the overlying seawater by geothermal heat rising from the interior of the planet forced by seismic activities.

Various ENSO trigger mechanisms had been put forward by many authors (McPhaden et al., 2021; Sarachik & Cane, 2010). This study proposes a different physical mechanism and applies statistical analyses of existing datasets and numerical simulation using the EdGCM global climate model to determine its validity. The ENSO driving mechanism proposed here is based on the Earthquake-Perturbed Obliquity Change Model described in Rivera (2011), Rivera & Khan (2012) and Rivera (2019). Earthquakes impart a very strong oceanic force that can perturb the gravitational force between the earth and the moon, move the moon in its orbit, which in turn pulls the earth's axis and change the planetary obliquity. Details of the computations of the increased obliquity due to these forces are shown in the previous studies undertaken by the author.

## METHODS

The years after 1990's showed strong and frequent earthquakes globally. Data on earthquakes were gathered from the National Earthquake Information Center (NEIC) of the US Geological Survey. Furthermore, the NOAA's National Geophysical Data Center ([www.ngdc.noaa.gov](http://www.ngdc.noaa.gov)) published the annual migration of the North Pole. The geographic North Pole is very close to the magnetic North Pole and its annual position can be deduced from the motion of the magnetic North Pole. Polar wander is not a new discovery and had been pointed out earlier by many authors (Chao et al., 1996; Chao & Gross, 2000). The satellite picture released by Earth Shaker Philippines provided by Japan Meteorological Agency during the winter solstice of December 21, 2021 also showed increased tilt or enhanced obliquity of the planet Earth (Fig. 1).

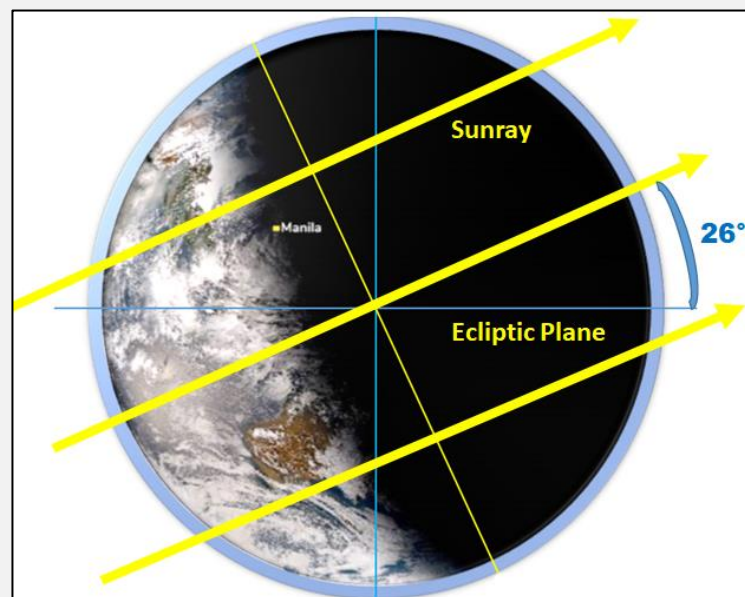


Figure 1. Increased planetary obliquity as observed by JMA satellite taken on December 21, 2021 (5:20PM Manila Time). Enhanced obliquity, greater than the Milankovitch maximum, is now evident.

The ecliptic plane is only approximate but the sun appeared to have moved south. However, it is actually the earth which tilted further away from the sun in boreal winter. The sun is too massive to be moved south of the ecliptic plane by any planet. Note that this was taken at 5:20PM Manila time. At latitude 15 degrees, there is a 10-minute increase in nighttime duration. Assuming an enhanced obliquity of  $27.4^\circ$ , calculation of the sunlight duration showed that it decreased from 11.25 to 11.08 hours during winter, with a gain in nighttime duration of about 0.17

hour or 10.2 minutes for Manila. The winter sunrise is also observed to be later than usual (6:27AM local time) while sunset is earlier (about 5:17 PM). At higher latitudes ( $\geq 40^\circ\text{N}$ ), the nighttime duration increased by over 30 minutes due to greater obliquity.

The exact obliquity is actually higher than  $26^\circ$  now and was measured using compass readings of sunset and sunrise positions and star trail observations to be over  $27^\circ$  now. The star trail observation yielded an obliquity of  $27.7^\circ$  as shown in Fig. 2 below. The increase in daytime duration during summer is also a consequence of the high obliquity leading to an increase in thermal days. The observed deglaciation in both Arctic and Antarctic regions confirms a greater obliquity. Moreover, the extreme cooling during winter and abnormal warming during summer also point to a higher obliquity at present.



Figure 2. Star trail observation in 2021 showing the angle of Polaris where the North Pole points. The latitude of observation was  $13.7^\circ$  but now increased to  $17.9^\circ$  yielding an obliquity of  $27.7^\circ$

Using the annual data on major earthquakes around the globe (unaltered data for the years 1901 to 2013) and the annual magnetic north-pole shift data of NGDC, there appears to be a good correlation between seismicity and the motion of the magnetic North Pole (Fig. 3). The observed magnetic pole shift data were used to deduce the yearly obliquity change. It was shown in Girkin (2005) that the planetary obliquity can exceed the Milankovitch predicted maximum (i.e.  $24.5^\circ$ ) and could reach  $28.4^\circ$ . This was confirmed in the inferred annual obliquity values and satellite observation as shown above where the obliquity is now beyond  $26^\circ$ .

Lin & Qian (2019) proposed that the El Niño-La Niña switching is caused by a forced subsurface oceanic wave propagating from western Pacific to central and eastern Pacific that triggers sea surface temperature anomalies. Accordingly, the subsurface wave is modulated by lunar gravitational force as shown by their analysis of Earth's angular momentum budget and NASA's Apollo Landing Mirror Experiment. Theoretical calculations in Rivera (2011) and Rivera & Khan (2012) showed that the oceanic wave is driven by massive quakes and can perturb the moon in its orbit. This seismic-driven oceanic motion resulted to the increased obliquity of the planet Earth. The mysterious lunar motion in its orbit is a general annual recession as shown and predicted in Rivera (2019). However, within each year, massive quakes from different oceanic coastal

boundaries would propel the moon to move to and from its orbit. For instance, the massive Japan quake of 2011 and its tsunami wave moved the moon closer to the earth as shown by the supermoon that was observed in March 2011. However, the massive Asian quake in the Indian Ocean in December 2004 moved the moon farther away from the earth as shown by the small full moon during the event. It is this recession of the moon that causes the obliquity of the earth to change and increase beyond the Milankovitch prediction by exerting a torque (i.e. a force that causes rotation) on the planet. An obliquity change of 4-degrees within just a period of 20-30 years is considered to be geologically and astronomically very abrupt. The conventional astronomical theory of Milankovitch estimated a 26-41ky periodicity of obliquity.

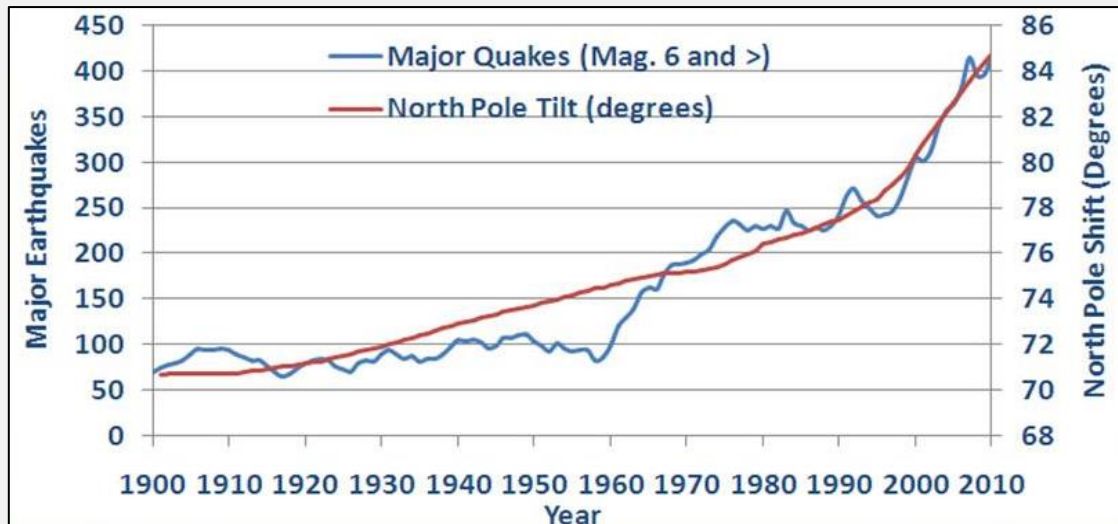


Figure 3. North-Pole shift and strong earthquakes with Magnitude 6.0 and higher

Statistical regression analyses of the mean sea level pressure of Tahiti in the Eastern Pacific and the obliquity change was undertaken using MS Excel Analysis Tool Pack. The Australian Bureau of Meteorology published most climate data even the MSLP data from the French Polynesian station of Tahiti provided by Meteo France. The total solar irradiance data from [Steinhilber et al. \(2009\)](#) were also used in the statistical regression analyses for both sea surface temperature and mean sea level pressure datasets.

To determine the impact of the enhanced obliquity in this study, the global climate model EdGCM was also utilized. It was run to simulate the enhanced obliquity since the 1960s when strong earthquakes started to increase as the global seismic dataset shows.

## RESULTS AND DISCUSSION

### Regression Analysis

The obliquity data deduced from NGDC (i.e. obliquity change + 23.5 degrees) was correlated with the mean sea level pressure in Tahiti (less 990 hPa) and the result showed very good agreement as shown in [Fig. 4](#). The regression analysis resulted in the following statistical equation.

$$\text{MSLP} = 1.089741\text{OBL} \tag{1}$$

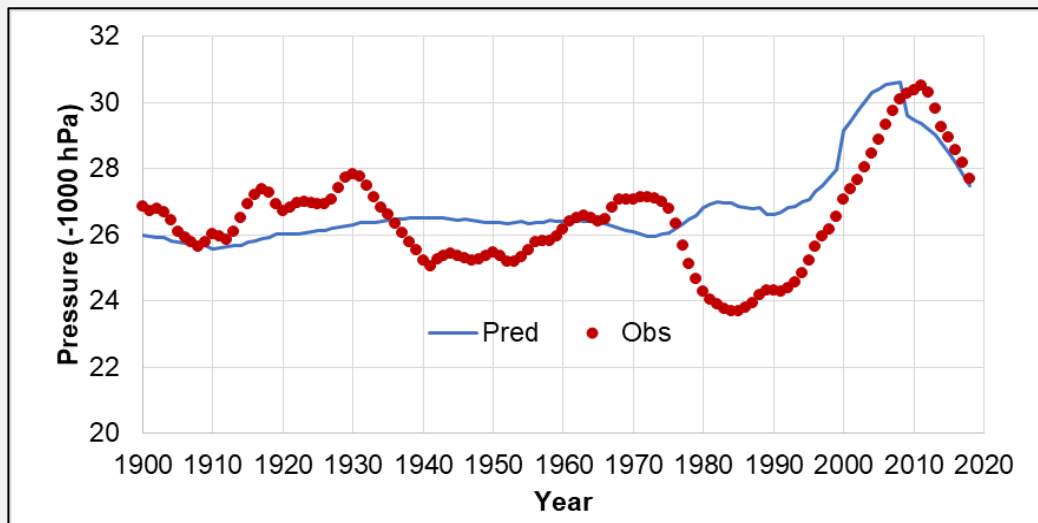


Figure 4. Mean sea level pressure in Tahiti showed very strong correlation with enhanced obliquity

where MSLP is reduced mean sea level pressure in Tahiti and OBL is enhanced obliquity (annual values). The regression analysis yields an  $R^2 = 0.9974$  and a standard error of 1.9328. Note that obliquity change is positively correlated with the pressure in Tahiti. Thus, the enhanced obliquity is a good indicator of the ocean and atmospheric conditions in the eastern Pacific. The effect of solar irradiance appears to be secondary and negatively correlated. In fact, the observed mean sea level pressure in Tahiti can be correlated directly with just the enhanced obliquity with a similarly very high  $R^2$ .

In addition, the observed rainfall in Darwin was found to be positively correlated with the enhanced obliquity with a similarly very high  $R^2$ . It should be noted that the atmospheric pressure in both Darwin and Tahiti stations are used to determine the Southern Oscillation Index (SOI). The anomalous warming of the Southern Pacific Ocean during boreal winters suggest that the enhanced obliquity must have a considerable impact because as the north pole tilts away from the sun, the south hemisphere is exposed to greater absorption of solar radiation. This leads to anomalous warming of the oceans south of the equator during boreal winter. The observed data on global sea surface temperature (SST for the 90S-90N) was analyzed and showed very good correlation with the north-pole shift data and increased obliquity. Hence, the observed data on global sea surface temperature anomaly are primarily governed by annual changes in the north-pole shift or enhanced obliquity, and partly by the annual changes in total solar irradiance. The multiple regression analysis for SST is shown in Fig. 5 with a very high correlation coefficient  $R^2 = 0.9318$  and a standard error of 0.0617. The resulting regression equation is

$$SSTa = 0.053707Obl + 0.424026TSI - 2.88182 \quad (2)$$

where SSTa is the global sea surface temperature anomaly, Obl is annual obliquity deduced from the north-pole shift data of NGDC, and TSI is total solar irradiance. This confirms that the warming of the sea surface is primarily due to the enhanced north-pole shift or increased obliquity. This can be understood if one considers the increased absorption of solar radiation as the planetary obliquity increases as discussed further in Rivera (2011) and Rivera & Khan (2012). The new EPOCH model (Earthquake-perturbed Obliquity Change) described therein showed how the enhanced obliquity can alter the solar absorption on different latitude.

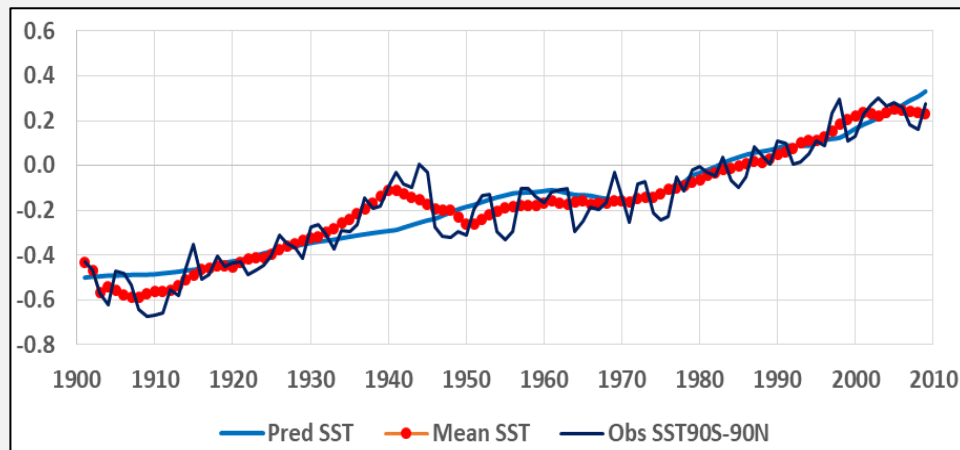


Figure 5. Regression analysis of the mean sea surface temperature anomaly versus enhanced obliquity and solar irradiance

### A Discrete Mechanism of ENSO

The physical driving mechanism of the ENSO phenomenon could be due mainly to earthquake-perturbed obliquity change. For centuries, the obliquity was almost constant and was proposed by Milankovitch to vary from 22.1 to 24.5° with a period of about 26,000 years. However, using a more accurate numerical scheme of the planetary motion involving all the planets, the sun and the moon in a new astrophysical simulation, [Girkin \(2005\)](#) found that the obliquity of the earth may vary from 21° to 28.4°. Using the tsunami generation model in [Rivera \(2006\)](#), the new EPOCH model in [Rivera \(2011\)](#) and the lunar perturbation in [Rivera \(2019\)](#), it was shown that the obliquity would increase due mainly to the action of massive quakes and tsunamis on the lunar orbit. As quakes rock the oceans, the moon responds with an erratic motion, pulling on the earth's axis and causing the obliquity to change. As the moon recedes, it can cause the earth's axis to tilt further, increasing the obliquity. This confirms Walker's initial hypothesis on the probable influence of seismicity in the East Pacific on ENSO occurrence. As the obliquity changed, the sun's declination angle also changed as shown in [Fig. 6](#) below. In particular, the declination angle during the boreal summer months increased. On the other hand, the declination angle decreased during the winter months. This leads to the enhanced warming during summer (El Niño phase) followed by enhanced cooling (La Nina phase).

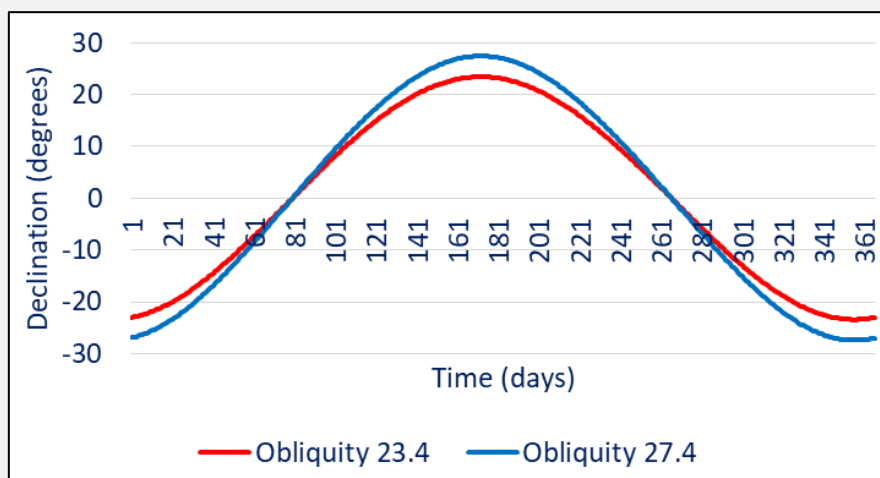


Figure 6. Altered declination angle of the sun due to enhanced obliquity of 27.4 degrees

### Modeling and Simulation of El Niño-La Niña Episodes with EdGCM

The EdGCM model is a research-grade global climate model that simulates and predicts the coupled ocean-atmosphere system in a dynamic way. It was developed by the National Aeronautics and Space Administration (NASA) and Columbia University (USA) to predict future climate conditions under variable scenarios of greenhouse gas forcing. However, in this study the EdGCM was used to predict future climate conditions with constant greenhouse gases but with increased obliquity. The obliquity is assumed to be 28 degrees as the model does not allow annual increments to be made. This was deliberately done to determine the impact of enhanced obliquity on the global climate and the potential occurrence El Niño and La Niña episodes. The episodic El Niño-La Niña events appear to be due primarily to the enhanced obliquity of the planet earth. As the earth tilts further, the oceans and continents gain greater amount of solar radiation during the summer, with corresponding loses during the winter resulting in the abnormal heating and cooling of the Central and Eastern Pacific Ocean. Notice that the initial ENSO indicator is the anomalous warming of the sea surface in the Eastern Pacific Ocean south of the equator during the winter months. This is because the planet tilted away from the sun during winter in the northern hemisphere and this exposes the southern hemisphere to the sun, leading to a gain in the absorbed solar radiation south of the equator. The apparent migration of the high SST from the west to central and eastern Pacific region south of the equator during the strong El Niño of 2010 (top) and 2015 (bottom) are shown in [Figure 7](#) below. As shown, the model was able to simulate the high SST anomalies in the Central and Eastern Pacific Ocean and its apparent migration from west to east.

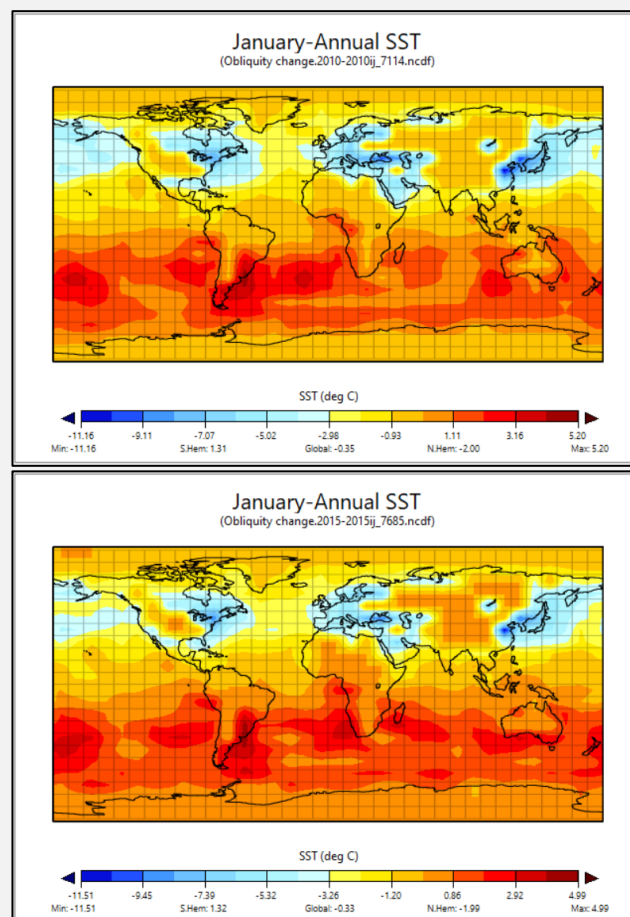


Figure 7. Simulated migration of high SST from west to East-Central Pacific with EdGCM during the intense ENSO of 2010 (top) and 2015 (bottom)

The winter SST anomaly in 2010 intensified until early spring as the earth tilted further. Note that the ocean warming in the Indian Ocean and the Atlantic Ocean which was thought to be a tele-connection of the ENSO in the Pacific was also correctly simulated by the model as the planetary tilt increases. High SST was also simulated by the EdGCM model in the Atlantic Ocean south of the equator. This is mainly due to the positive gain in absorbed solar radiation as the obliquity of the earth increases which had been documented earlier (Rivera 2011, Rivera & Khan 2012).

The initial 50-year run was able to simulate previous El Niño and La Niña years with alternating dips and spikes in the global precipitation and evaporation. This is shown in Fig. 8 below. The simulated troughs in the global rainfall indicate the past occurrence of El Niño years.

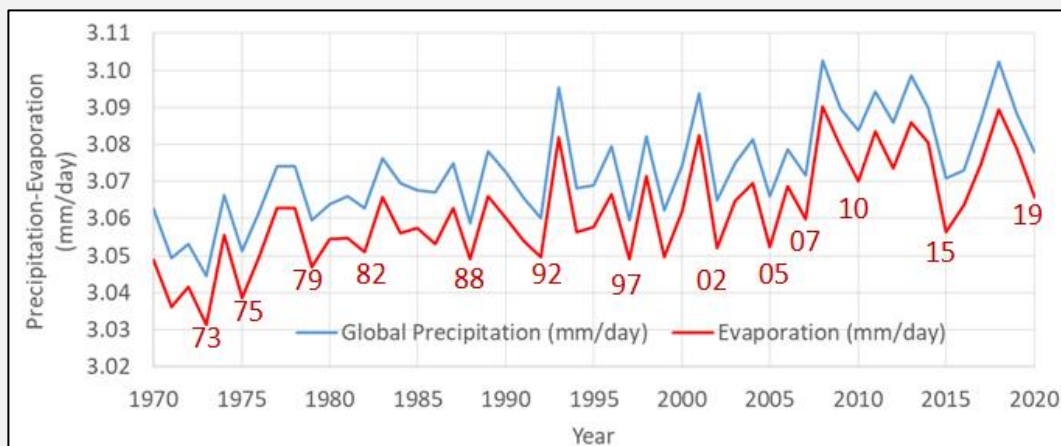
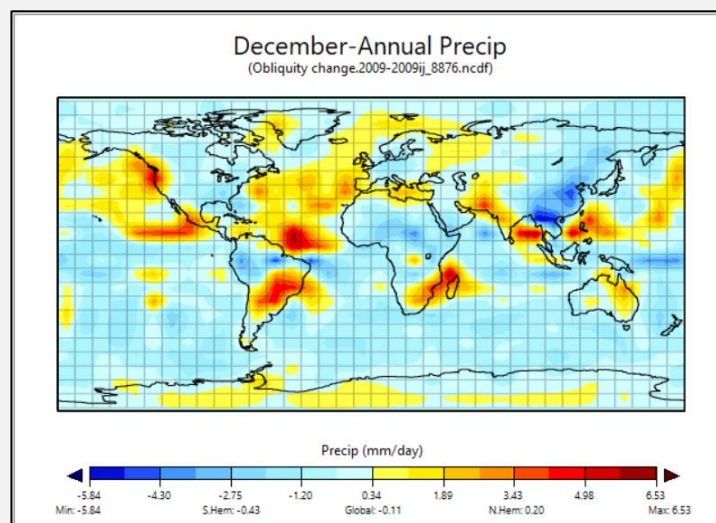


Figure 8. Simulated dips and spikes in the annual global precipitation and evaporation with EdGCM during the ENSO episodes of 1970-2020 using enhanced obliquity

In addition, the model correctly predicts the La Nina episodes with an increase of global average rainfall. The simulated rainfall anomalies for the 2009 and 2021 La Niña episodes (computed from their annual average precipitation) are shown in Fig. 9 below. Note that the rainfall in South America and Southeast Asia especially in the Philippines increased considerably in 2009 (top) and 2021 (bottom).



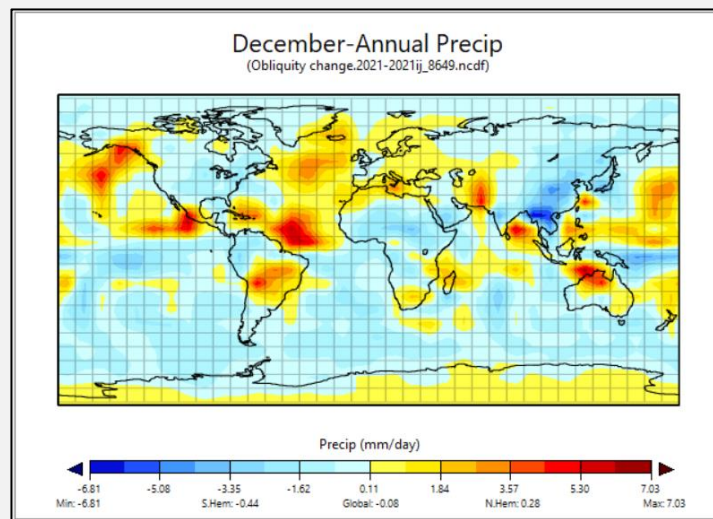


Figure 9. Simulated precipitation anomalies (mm/day) for the 2009 (top) and 2021 (bottom) La Niña episodes

It should be noted that even when the dips in rainfall and the ENSO's are correctly simulated by EdGCM, both rainfall and evaporation rates are still increasing exponentially. The model results showed that the global average precipitation during El Niño-La Niña years yields alternating dips and spikes in global rainfall but with a gradual rise of both parameters. This could have caused the floods in the Eastern Pacific and droughts in the Western Pacific, and a combination of both climate disasters in some countries in the same year. With a successful simulation of the ENSO-La Niña events in the initial 50-year simulation, the climate model was further run until the year 2100 to predict future ENSO episodes. This assumes that there is no abrupt change in the obliquity till the end of this century.

The EdGCM appears to simulate quite well the El Niño-La Niña episodes for the last 50 years, and the predicted future ENSO episodes due to enhanced obliquity could also be correct (Fig. 10). The annual time series of global surface temperatures computed by EdGCM was compared with the observed global temperature and the results showed relatively good agreement (Fig. 11). In addition, the heat wave that occurred in Europe (Russo et al., 2015) during the summer of 2003 and the Russian heat wave of 2010 that killed thousands were correctly simulated with higher obliquity (Fig. 12). Even the recent heat wave of 2021 in North America also appeared in the global climate simulations.

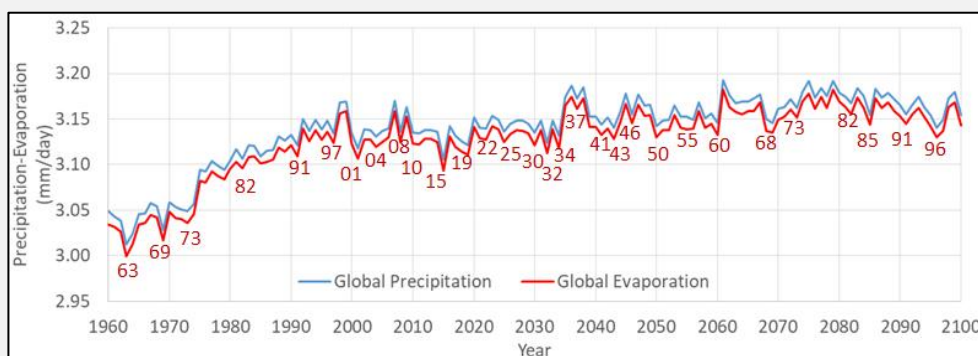


Figure 10. Simulated annual global precipitation-evaporation using enhanced obliquity with EdGCM. El Niño years appear as sudden dip of precipitation due to altered evaporation and solar absorption as the planet tilts further.

Evidently, the submarine quakes in the East Pacific and in other coasts could have a very strong influence on the orbit of the moon. These jolts can generate a very strong oceanic force in the order of tenths of the moon’s gravitational force and that the gravitational weakening produced can drive the moon away and in the process of receding, the moon tilts the earth further (Rivera, 2019).

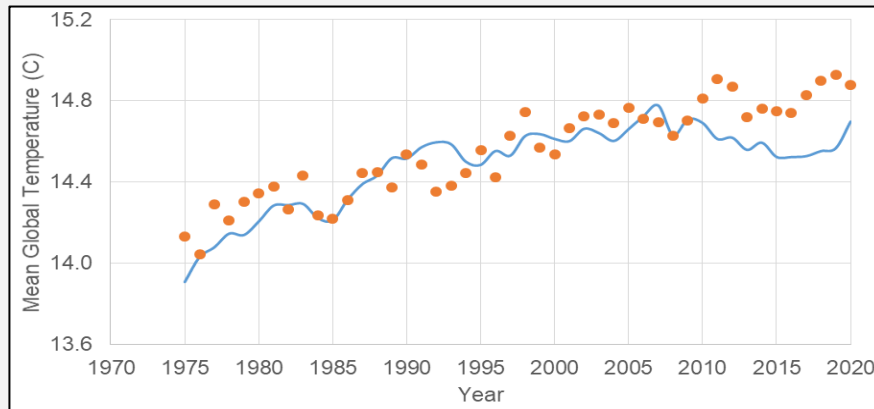


Figure 11. Simulated and predicted global surface temperature using EdGCM with higher obliquity

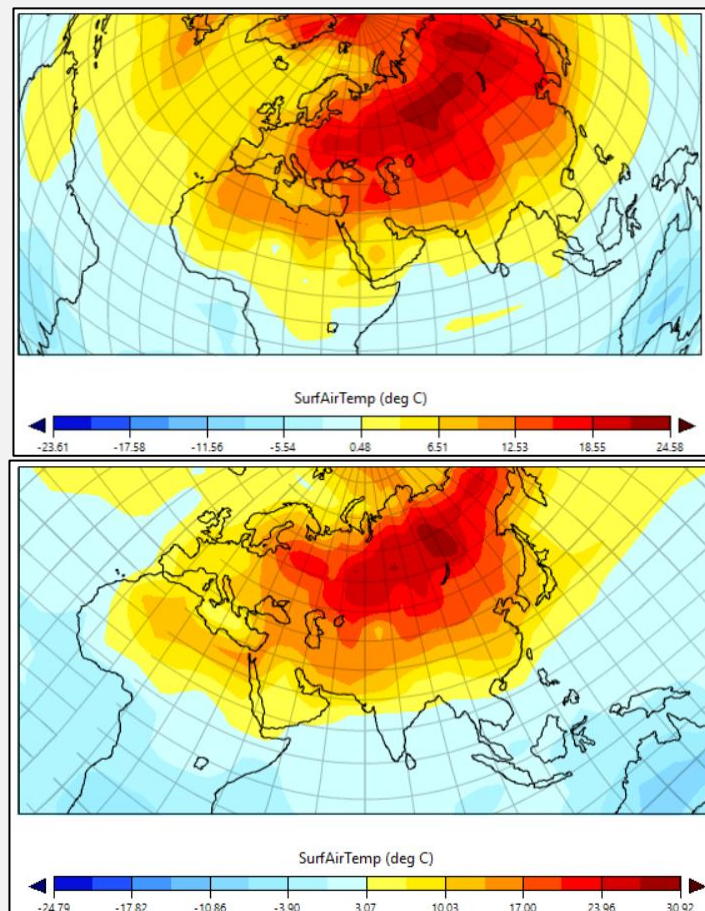


Figure 12. Simulated temperature anomaly during the heat wave in Europe in 2003 (top) and Russia in 2010 (bottom) using EdGCM with higher obliquity

## CONCLUSION AND RECOMENDATION

The model simulations and data correlations showed that the major factor that triggers and sustains El Niño and La Niña episodes is enhanced obliquity driven by seismic-induced lunar motion. This leads to an irregular but continuous variability of oceanic and atmospheric parameters. That the seismic-perturbed lunar motion is in control of the irregular ENSO cycles can be understood when one divides the astronomical unit ( $1.4959787 \times 10^{11}$  m) by the lunar orbital speed (1.022 km/s). This results to a mean periodicity of about 4.6 years which is comparable to the observed (i.e. mean of 2 to 7 years is 4.5 years) periodicity of ENSO. The massive quakes near western coastal areas (i.e. in the Eastern Pacific Rise and elsewhere) could drive the moon away from its normal orbit, and in the process of receding, pulls the earth's axis and enhances the obliquity. A  $4.2^\circ$  increase in the axial tilt of the planet is not much but every small fraction can alter the solar absorption in any latitude. The increase of the planetary obliquity within a few decades leads to a lunar-induced disruption of the oceans causing them to heat up and cool down abnormally, as a recharge mechanism of floods and droughts by altering the atmospheric and oceanic dynamics. As the obliquity increases, the sea surface and subsurface layers become exposed to higher absorption of solar radiation particularly in the southern hemisphere during boreal winter, and this results in global and regional atmospheric rainfall anomalies. As the earth revolves around the sun with increased axial tilt, abnormal cooling in the southern hemisphere during boreal summer will then occur as it loses absorbed solar radiation. A net reduction of absorbed solar radiation also occurs in the equator (Rivera, 2011).

With higher obliquity, SST during boreal winters would be anomalously higher than normal in the southern hemisphere. Then anomalous cooling is expected there during boreal summer. The global climate model EdGCM was able to simulate correctly the apparent eastward migration of the warm sea surface in the Pacific (and Indian) Oceans during the boreal winter conditions of ENSO episodes. This shows that higher obliquity triggers and keeps ENSO going. It is also the most likely mechanism that triggers the Madden-Julian Oscillation, the Pacific Decadal Oscillation and the North Atlantic Oscillation. In addition, the apparent southward intrusion of semi-permanent atmospheric systems like the West Pacific Subtropical High that is linked to ENSO could be dictated by enhanced obliquity with the southward motion of the North Pole that exposes the southern oceans to higher solar absorption during boreal winters. Higher obliquity can also affect the positions of the jet streams during the seasons. Moreover, the migration and intensification of the Inter-Tropical Convergence Zone (ITCZ) further south or north during the seasons could be dictated by higher obliquity. This is due to the enhanced thermal contrast of the oceans and land masses in various latitudes of both hemispheres as they gain or lose absorbed solar radiation with enhanced obliquity.

The model run for the 21st century predicts irregular ENSO episodes with periods from 2-7 years. Since EdGCM was able to predict previous ENSO episodes, it can also be used to predict future ENSO occurrences. The model predicts that El Niño would occur during the years 2025, 2030, 2032, and 2034, while the years 2035-2037 are predicted to be anomalously wet. Finally, it is recommended that the annual planetary tilt or obliquity be measured accurately. In particular, the reference plane of the ecliptic must be established accurately with respect to the equator.

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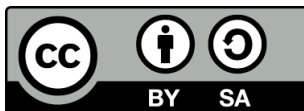
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