Most probable origin and statistical attribution of the major causes of global mean sea level anomaly and rising tides since the 20th century

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Abstract: The origin of the anomalous global sea level rise (SLR) since the last century is highly controversial and not fully understood. The observed increase of high tides and decrease of low tides in many coastal areas around the world imply that some crucial physical mechanisms that govern the rising sea levels may have been overlooked. The relative contribution of nutation, axial precession, lunar acceleration, Earth's spin and sea surface temperature on sea level anomaly was estimated using multiple regression. A very high relative contribution of the polar migration (49.4%) on the mean sea level rise, followed by axial precession (46.7%) and a secondary contribution of lunar acceleration (3.9%) was found. Sea surface temperature and earth spin rate showed negative correlations with sea level rise. The annual changes of the polar migration, axial precession and lunar acceleration appear to be the dominant physical mechanisms behind the SLR problem. These factors are largely driven by strong earthquakes. The rising oceanic tides in the last century up to the present is largely due to North Pole migration. Apparently, the observed nutation and axial precession are caused by the increased eccentricity of the lunar orbit through changes in the lunar distance and lunar acceleration. Finally, the observed SLR was found to be related to the enigmatic 26-second microseism problem. Using the annual geomagnetic North Pole migration dataset of NOAA-NGDC, the observed frequency of 0.038 Hz was found. This possibly indicates that the planet is gradually tilting as it spins with a concomitant gradual build-up of oceanic pressure and release of magmatic and gas pressure, due to lunar-induced sea level rise and reduced lunar distance.

Key-Words: - Sea Level Rise, Nutation and Precession, North Pole migration, 26-sec microseism

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1 Introduction

The discovery and scientific understanding of global Sea Level Rise (SLR) have evolved over the centuries with significant advancements made in the 19th and 20th centuries. In the early 19th century, systematic measurements of sea levels using tide gauges began (1,2,4,7,8). These early measurements provided the first indications that sea levels were not static but subject to various influences including weather and tidal cycles (5,10,12).

The concept of global sea level change was not well-understood until the mid- to late- 19th century. The British geologist Thomas Jamieson, in the late 1800s, suggested that sea levels had changed over geological time scales due to glacial melting, but comprehensive data were lacking. By the mid-20th century, more accurate and extensive tide gauge records were available, allowing scientists to observe trends over longer periods. In the 1960s and 1970s, researchers began to link sea level rise to global warming and the melting of glaciers and ice caps. One of the pioneering studies was also done by B. Douglas who provided early analysis of 20th-century sea level trends using tide gauge data in the Satellite Era, the launch of satellite missions like TOPEX/Poseidon in 1992 marked a significant breakthrough in the study of sea level rise. These satellites provided precise measurements of sea level on a global scale, confirming that sea levels were rising at an accelerated rate. Subsequent satellite missions (Jason-1, 2, & 3) have continued to improve the accuracy and resolution of sea level measurements.

Modern understanding of sea level rise in the early 21st century from comprehensive analyses combining satellite data, tide gauges, and climate models have provided a clearer picture of the factors driving sea level rise. Presently, most studies highlighted the contributions of thermal expansion, melting glaciers, and ice sheets to global sea level rise (4, 9, 15, 28, 30). Furthermore, (28) uses data from satellite missions such as Jason-3 to update estimates of global sea level rise emphasizing an acceleration in the rate of rise over recent decades. Overall, the understanding of sea level rise has progressed from early observations to sophisticated global monitoring systems, providing robust evidence of ongoing and accelerating global sea level rise.

However, there are indications that some physical mechanisms that could possibly complete our present understanding of the rising tides and sea level changes are lacking in previous studies. The recent findings in (31,32,33) showed that the North Pole tilted and moved abruptly since the last few decades and this could alter the sea levels in various ways including changes in the lunar distance. This hypothesis prompted the present sea level rise investigation.

2 Problem Formulation

The problem of sea level rise has been considered previously to be due mainly to changes in the thermal expansion of oceanic water and melting of Arctic and Antarctic ice sheets and glaciers in higher latitudes. The potential impacts of the axial precession (planetary obliquity) and polar motion have not been considered before and this study investigates their potential contributions to the global mean sea level changes by analyzing existing and publicly available data from the National Oceanic and Atmospheric Administration (NOAA) and its attached agency, the National Geophysical Data Center (NGDC) and the United States Geological Survey (USGS). The polar migration (nutation) dataset was obtained from the International Earth Rotation Service (IERS) in Paris, France (ww.iers.org). This gives the earth orientation parameters since the year 1846 until 2025. Sea level data starting from the early 20th century from various sources including the Australian CSIRO laboratory were also utilized. A gradual but persistent increase in sea level is shown to occur from 5cm in 1900 to 25cm in 2010, and the rate of increase appears to be accelerating (Figure 1).

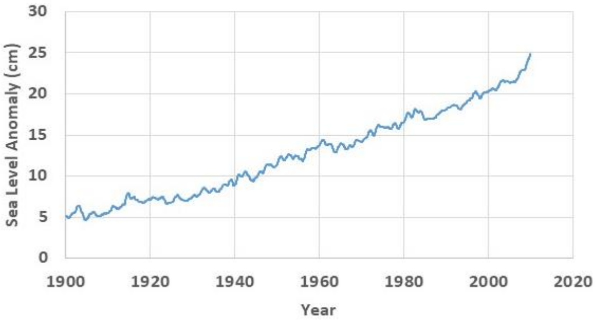

Figure 1. Observed monthly mean sea level rise (CSIRO) since the last century.

The annual changes in the axial precession or planetary obliquity has been documented earlier in (30, 31) using the annual variation of the geomagnetic North Pole shift data of NOAA-NGDC. In addition, the annual lunar acceleration was derived from this dataset. The potential impact of combined ocean thermal expansion and melting of ice sheets is included in this study by using the annual sea surface temperature dataset of NOAA.

The earth's axial tilt or obliquity was previously close to 23.5 degrees. This was based on earlier measurements of the earth orientation parameters in the early 20th century. However, recent measurements showed that the obliquity has increased to about 27.7 degrees (30, 31). The observed planetary obliquity, derived from the NOAA-NGDC geomagnetic pole shift dataset, is shown below (Figure 2). Assuming that the sea surface temperature gives a relative measure of the potential increase of freshwater from melting ice in glaciers and the Arctic and Antarctic ice caps, the observed SST values over the years are also plotted in the figure below. While oceanic thermal expansion and melting of polar ice and glaciers were initially found to be the main driver of sea level rise (13, 15, 17, 25, 26, 33), this parameter was also included in the present analysis.

The annual changes in the y-component of the celestial pole migration was included in this study by using the dataset from the International Earth Rotation Service in Paris, France (www.iers.org). The migration of the North Pole (in milli-arcsecond and degrees of nutation) over the years can be seen in Figure 3. In general, the planetary obliquity (in degrees) has increased as shown in the right. The dataset implies that the North Pole has tilted southwards from its previous position (relative to 1850). The earth's axis is known to undergo nutation (wobble) within a period of 18.6 years due to the orbital declination of the moon. This is much faster than the known axial precession or obliquity change shown by the gradual North Pole motion (with a period normally scaled close to 26,000 years) due to gravitational forces exerted by the planets, the moon and the sun on the rotating Earth.

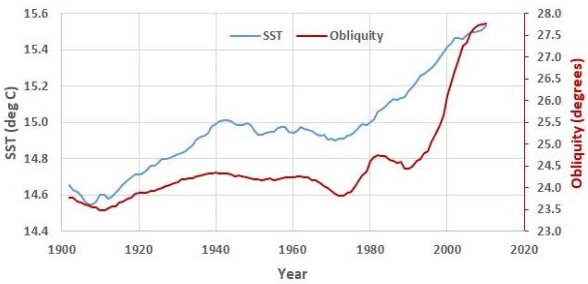

Figure 2. Annual changes in SST and planetary obliquity since the last century.

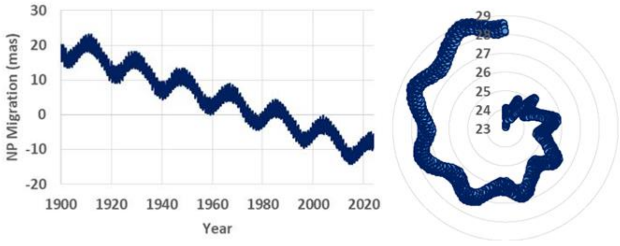

Figure 3. Monthly changes in the North Pole migration (y-component in mas)) and the computed obliquity (in degrees) due to nutation since the last century (www.iers.org).

3 Problem Solution

3.1 Impact of Earth's tilt and polar motion

Aside from the daily rotation of the earth on its axis, there are two possible motions of the earth's axis that define its orientation relative to the sun and the North Star Polaris. The first one is the annual change in the planetary obliquity or axial precession and the second one is nutation or the oscillating wobble of the North Pole. Precession is known to be a long-term and gradual process while nutation is short-term and quite fast. Both of these factors define the orientation of the earth's axis (and its oceans and continents) with respect to the gravitational forces exerted by the moon and the sun. Due to the enhanced axial tilt of the earth and its wobble, the angle between the Moon's orbital plane and the earth's equator has changed. When the moon's declination (i.e. the angle between the moon and the earth's equator) is high, the tidal bulges caused by the moon are not aligned with the equator. This causes the high tides to be more pronounced in the hemispheres and less pronounced at the equator, leading to increased diurnal inequality (the difference in height between successive high tides at a particular location).

The axial tilt and polar migration can influence the amplitude of tides indirectly by affecting the distribution of water masses and oceanic circulation. Changes in ocean circulation patterns can affect the propagation of tidal waves across the oceans. In particular, changes in the magnitude and direction of the Gulf Stream had been shown to occur.

Using the y-component (epsilon denoting obliquity) of the observed polar migration in a statistical regression (using Data Analysis option in MS Excel), the analysis showed very high correlation (Figure 4). This implies that North Pole nutation can already explain over 98% of the observed global mean sea level rise. The annual changes in the y-component (epsilon) of the celestial pole migration was utilized since this is more crucial in determining the orientation of the earth with respect to the gravitational force of the moon and sun.

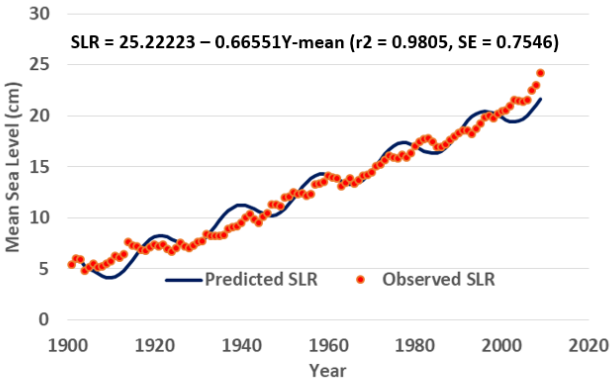

Figure 4. Predicted and observed global MSL using polar migration (y-component).

The North Pole nutation and the earth's axial tilt (obliquity) does indeed affect the oceanic tides. Although they are secondary compared to the primary influence of the gravitational forces of the moon and the sun, when the earth tilts further, the declination angle of the moon slightly changes (assuming that the orbital characteristic of the moon is the same). The moon's orbit is inclined relative to the earth's equator by about 5 degrees. Due to the earth's axial tilt, the angle between the moon's orbital plane and the earth's equator varies over a monthly cycle. When the moon's declination (the angle between the moon and the earth's equator) is high, the tidal bulges caused by the moon are not aligned with the equator. This causes the high tides to be more pronounced in the hemispheres and less pronounced at the equator, leading to diurnal inequality where the difference in heights between successive high tides become more pronounced. This variation actually leads to different tidal patterns, such as mixed tides (two high and two low tides of different heights within a 24-hour period) and diurnal tides (one high and one low tide per day).

The axial tilt can also influence the amplitude of tides indirectly by affecting the distribution of water masses and oceanic circulation. Changes in ocean circulation patterns can affect the propagation of tidal waves across the oceans. There are also possible seasonal variations of the obliquity effect. The earth's axial tilt (which increased from 23.5 to 27.8 degrees) affects the distribution of sunlight on the earth causing the seasons. This variation in solar heating can lead to changes in wind patterns and ocean currents, which can influence the local sea level and tidal patterns. During different seasons, the solar tidal component (the effect of the sun's gravitational force on oceanic tides) can change slightly because the angle at which the sun's gravitational force acts on the earth changes. In addition, when the earth' tilt increases, there is a modified interaction between the earth and gravitational forces of the sun and moon.

During certain times of the year, the alignment of the earth, moon, and sun can lead to larger variations in tidal ranges. For example, during equinoxes, when the Sun is directly over the equator, the solar gravitational force aligns more closely with the lunar gravitational force, potentially enhancing spring tides.

When the planetary obliquity and lunar rate of rotation around the earth are included in the multiple regression, an even higher correlation is found (Figure 5). Note that the y-component of the polar motion was subtracted from year 1900 to get positive values and easily derive its relative contribution to SLR. The result shows that the earth's polar motion and the lunar acceleration largely dictate the observed global mean sea level on the earth's ocean by contributing over 96% to SLR (49.4% from polar migration and 46.7% from earth's tilt). A secondary contribution of about 3.9% comes from lunar acceleration. Even without adding the lunar acceleration, the regression of sea level versus polar migration and obliquity already yields very high r^2 of 0.9952 as shown in Figure 6 below. This also yields a higher relative contribution of polar migration of 54% and a lower contribution of obliquity of about 46%.

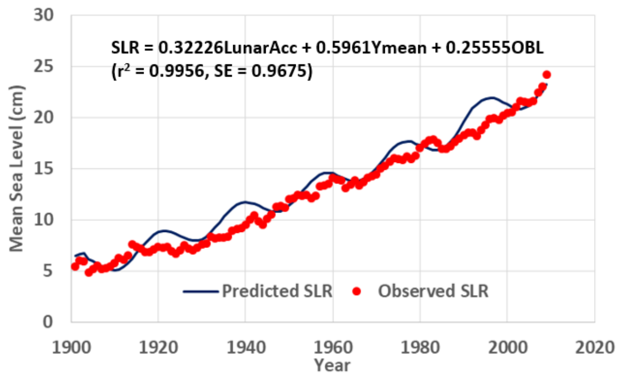

Figure 5. Predicted and observed global MSL (cm) using polar motion, planetary obliquity and lunar acceleration.

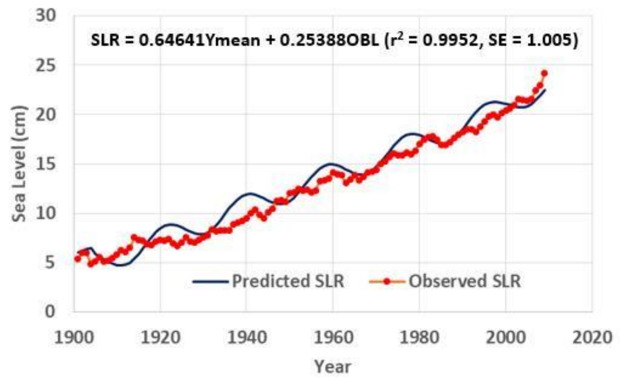

Figure 6. Predicted and observed global MSL (cm) using polar motion and planetary obliquity.

While the earth's axial tilt does not directly cause tides, it influences the distribution and magnitude of tidal forces by affecting the relative positions of the Earth, Moon, and Sun. This results in seasonal variations and diurnal inequalities in tidal patterns. The primary forces driving ocean tides remain the gravitational pulls of the Moon and the Sun, but the Earth's tilt contributes to the complexity and variability of the tides observed at different times of the year and in different locations around the world.

3.2 Impact of massive earthquakes on axial tilting and polar migration

A previous statistical analysis of the impact of earthquakes on the planetary obliquity showed that they are highly correlated (30). To determine whether massive quakes could also correlate with the polar migration, the observed polar migration and the USGS dataset on earthquake events were utilized. Instead of using the quake energy or magnitudes, the number of major quakes was used in this study since they are inter-related. Note that the intensity or strength of an earthquake is normally measured by a seismograph. This device converts the wave energy of an earthquake into a standard unit of measurement like the Richter scale. In this scale, the units of measurement are referred to as magnitudes and the scale is logarithmic with each unit increase in magnitude representing a 10-times increase of energy released. To determine the amount of energy released by an earthquake, the following equation can be used; $E = 1.74 \times 10(5 + 1.44M)$ where the E is energy in joules and M is the Richter magnitude. The use of the number of seismic events in this study is also justified by the conventional Gutenberg-Richter law which shows that the logarithm of the number of earthquakes N is proportional to the magnitude M of the earthquake as in ($\log N = a - bM$) where a and b are constants.

The statistical regression between polar migration and strong earthquakes with ≥M6.0 yields very high correlation with $r^2 = 0.9258$ as shown in Figure 7. Hence, it is highly probable that the influence of Greenland ice loss, postglacial rebound and deep mantle convection are just natural consequences of the presently proposed seismic mechanism. In a gravitational weakening study, (33) showed that massive quakes can alter the moon's orbital motion and eccentricity. As the moon recedes, it appears to pull the Earth's axis as shown in (31, 32). The perturbed lunar motion and concomitant gravitational force most probably also caused the polar migration and observed wobbles of the North Pole as this analysis now showed. Massive seismic forces had potentially led to the observed changes of the planetary obliquity and polar migration.

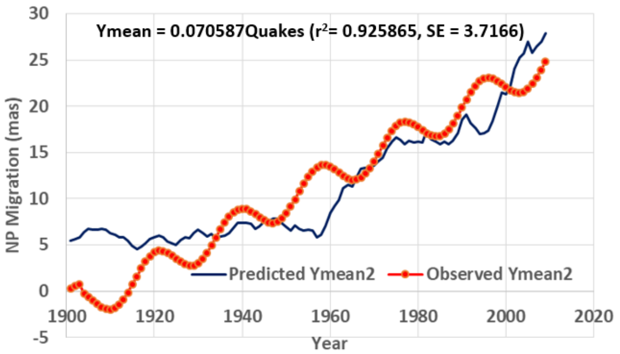

Figure 7. Statistical regression between earthquakes (USGS) and North Pole migration (IERS).

The effect of the lunar distance is very crucial as this governs the lunar tidal force on earth. The tidal force exerted by the moon on the earth's oceans is directly influenced by the distance between the earth and the moon. The gravitational tractive force is inversely proportional to the cube or 4th power of the lunar distance and a small change in the lunar distance has a significant impact on the oceanic tides. This can be seen in the following tidal tractive force equations in spherical coordinates where changes in the earth's obliquity has been included (29):

$$F_{t,r} = 3\frac{GM}{r^4}\left(\frac{3}{2}\sin^2(\theta+\epsilon)\cos 2(\phi+\delta) - \frac{1}{2}\right)$$
$$F_{t,\theta} = -\frac{GM}{r^3}\cdot 3\sin(\theta+\epsilon)\cos(\theta+\epsilon)\cos 2(\phi+\delta)$$
$$F_{t,\phi} = \frac{GM}{r^3}\cdot 3\sin^2(\theta+\epsilon)\sin 2(\phi+\delta) \quad (1)$$

where r is the lunar distance, G is gravitational constant, M is lunar mass, ϴ is colatide, Φ is longitude, ε is obliquity, and δ is the declination angle of the moon which varies when the tilt of the earth changes. Note here that a 7% decrease in lunar distance can result to a very strong increase of about 24-33% in the tidal tractive force. As shown, a slight increase in the obliquity angle (as axial precession and nutation now occur), also increases further the tide-generating force.

While the Newtonian gravitational force is directly proportional to the inverse square of the distance between the moon and the earth's surface, the tide-generating tractive force is inversely proportional to the inverse cube/quartic of the lunar distance. The 1/r3 and 1/r4 relations showed that the tidal force is highly sensitive to changes in the distance between the earth and the moon. Hence, any change in the lunar distance can affect the magnitude of oceanic tides in any location on earth.

Recent observations also confirmed that the lunar distance has changed over the years as shown by frequent super moon occurrences. There is an observed increase in the lunar eccentricity which has no accepted theoretical explanation to date, although this is possibly due to massive submarine quakes (32). In particular, the lunar distance is reduced as the moon comes closer during a lunar month as the orbital eccentricity of the moon increases. Note that when the lunar distance is reduced, the lunar tidal potential increases considerably in an inverse cubic power law. The observed changes in the lunar distance since the start of the millennium is shown in Figure 8 below (values extrapolated from year 2004 to 2000). It can be seen that the average lunar distance is now lower than the accepted average value of 384,400 km. The average distance in the year 2000 is already 383140-km while the average lunar distance in 2025 is about 379,200-km. Hence, the moon is generally closer now than previously thought.

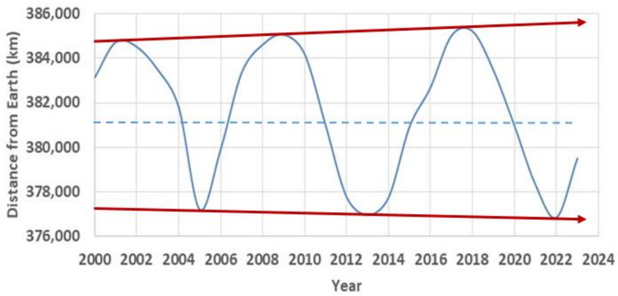

Figure 8. Changing lunar distance (km) since year 2000 (values from www.jgiesen.de).

3.2 Changes on lunar orbital eccentricity and impact of oceanic pressure build-op from SLR

The lunar orbital eccentricity is known to have increased and this has no accepted theoretic al explanation to modern astronomers. We propose that the lunar eccentricity (i.e. deviation from a circular orbit) depends largely on massive tremors on earth. In particular, the eccentricity of the lunar orbit can be derived from (33) as proportional to the number of massive earthquakes as follows;

$$e = 0.0031622776Q_a$$

where e is the lunar eccentricity, Qa is the monthly average of the total number of major earthquakes (M ≥ 6.0) during a lunar orbit. As earthquakes increase in frequency during 1 lunar month, the lunar orbital eccentricity increases. Then as lunar eccentricity is increased, the lunar distance is partly reduced (and partly increased) during a lunar month. When reduced, this greatly increases the gravitational force of attraction exerted by the moon on the oceans.

We analyze the relation of the lunar eccentricity on geomagnetic polar migration using the NOAA-NGDC dataset (1965-2020). We utilize the new Earthquake-Perturbed Obliquity Change or EPOCH model in (31) and the resulting analysis showed a close relation between the computed annual changes in the lunar eccentricity (de/dt) and the estimated geomagnetic jerks (Figure 9).

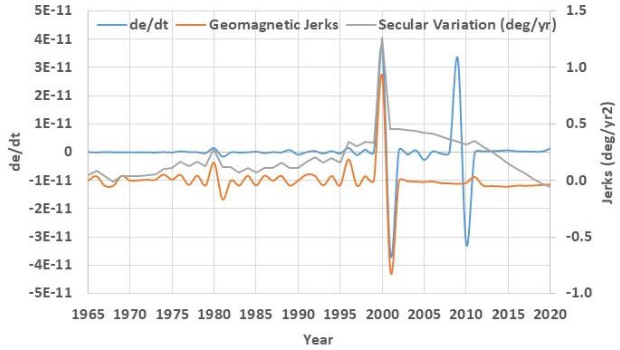

Figure 9. Lunar orbital eccentricity and the geomagnetic North Pole migration (NOAA-NGDC).

Hence, the mysterious geomagnetic jerks may also originate from the increased eccentricity of the moon's orbit.

The gradual obliquity change of the earth possibly due to seismic-driven lunar eccentricity may also govern the enigmatic 26-second microseism which baffles many geophysicists at present. Using the computed change in the lunar distance Δr from the mean earth-moon distance as in (33);

$\Delta r = 5x10^{-6} rQ$

yields a 1,922 m change in the lunar distance. With an average 6 massive earthquakes Q per year (≥M7.5), the lunar distance may change by about 11,532 m. Note that massive quakes exceeding M7.5 can propel the earth to recede from the sun (33) and as the planet recedes from the sun, the earth-moon distance would change as well. Considering that the earth rotates at a speed of about 463.83 m/s in the equatorial Gulf of Guinea, this yields 24.8 seconds which is close to the 26 seconds microseismic pulse of the earth that baffles geologists at present.

Alternatively, using the y-component of the NOAA-NGDC geomagnetic data, the annual distances covered by the geomagnetic North Pole positions over the years were calculated. These are linked to the secular variation of the geomagnetic field (first time-derivative) and may also be related to the origin of the geomagnetic jerks (second time-derivative of the geomagnetic field). Converting these distances into meters (i.e. multiplying by 111,111.1 m/degree) and dividing them by the rotational speed of the earth (close to 463.83 m/s at the equator), the annual variation of the pulse rate of the earth was obtained (Figure 10). From 1855-2025, the computed pulse rate has an average value of 26.3 seconds (or a frequency of 0.038 Hz) while the range was about 10-30 seconds from 1590 to 1950. This is for the y-component of the geomagnetic North Pole. When the geomagnetic South Pole motion is considered, the average distance covered (mean of 8-15 km) divided by the mean rotation rate of the earth also yields about 24.8 sec. These are comparable to the observed gliding pulsation rate from low-frequency tremors recorded by seismometers worldwide. Apparently, the geomagnetic North Pole migration indicates that the planet Earth is tilting gradually with concomitant gradual build-up of oceanic pressure through lunar-induced sea level rise. Note that the hydrostatic oceanic pressure P increases linearly as the ocean depth d increases as in $P = \rho g(d + SLR)$ where SLR is the observed sea level rise, ρ is ocean density and g is gravitational acceleration. The pressure increase due to potential increase in the height of significant waves during stormy conditions was also confirmed by deep-sea observations obtained from NBDC buoys. Given that the global sea level has increased since the 19th century, the total oceanic pressure on the outer core is thus expected to increase considerably. Using a 25-cm SLR at present, the outer core may experience additional pressure loading that amounts to about 1-2 x 1015 N. This may have dangerous consequences on the magma/gas dynamics at the outer core and may induce more volcanic eruptions due to increased pressure on the magma/gas mixture and enhanced lunar gravitational pull as the moon comes closer. With reduced lunar distance and enhanced earth's spin, the total pressure at the outer core might have increased, possibly leading to magmatic intrusion towards the crust and the observed microseism. This may also trigger massive earthquakes as the oceanic and continental plates move relative to each other due to increased torsional force on the crust as the earth's tilt increases. It can potentially redraw the existing world's geography as the lunar orbit becomes erratic with a concomitant change on the formidable gravitational force between earth and moon.

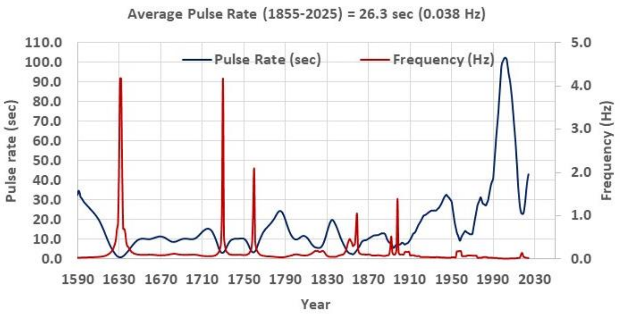

Figure 10. Computed pulse rate (seconds and Hz) from the geomagnetic North Pole migration data of NOAA-NGDC (y-component).

Thus, the gradually changing lunar gravitational force due to changes in the lunar distance propelled by the earth itself (due to episodic massive tremors) may govern the mysterious microseismic activity on earth. Note that there occurs a potential change of oceanic pressure from changing sea levels worldwide as the lunar distance gradually changes each lunar month. This may also govern the dynamic motion of plate tectonics as already pointed out earlier in 2019 (33). This slightly differs from the changing lunar-earth barycenter as posited to be the real mechanism of plate tectonics in the recent study of the Washington University group (Hofmeister and collaborators) in 2022 (45). Accordingly, the changing gravitational pull of the sun on the moon causes dynamic changes on plate tectonic motions. But the sun is too distant to exert a significant force on the moon. In fact, the earth-moon system is moving away from the sun which is attributed by astrophysicists to decreasing solar mass. The present study posits that gravitational perturbations in the earth-moon system caused by the earth itself, through giant quakes and oceanic forces, can either move the moon farther and closer depending on the direction of oceanic force (and torque) relative to the lunar position. Note that the giant quake off the eastern coast of Japan moved the moon closer in 2011, while the moon moved farther during the 2004 Asian quake and giant tsunami off the western coast of Sumatra (33). The increased/reduced size and brightness of the full moon during these events can validate this hypothesis. In addition, the existence of the South Atlantic Anomaly (SAA) and the Indian Ocean Geoid Low (IOGL) could be the permanent marks left by the giant Asian quake in 2004. The associated tsunami-induced torque travelling westward from equatorial Sumatra to Africa possibly created a gravity hole in the Indian Ocean south of Sri Lanka. The clockwise oceanic torque (viewed from North Pole) countered the earth's rotation that enhanced the earth's tilt and made it spin off its axis. When the oceanic torque was generated during the giant tsunami, there must be an associated tremendous oceanic force that dissected the eastern hemisphere and exited near the Atlantic Ocean thereby producing the SAA. This formidable force, directed towards the west hemisphere near South America, had a tremendous force component directed to the moon during that event. In particular, Using the moment magnitude of the giant quake (Mw = 9.3), focal depth (14 km) and water depth (4 km), the total oceanic force exerted by the tsunami was determined to be about 15.7% of the lunar gravitational force (3.137 x 1019 N) with a resultant force equivalent to about 2.162 x 1020 N. This is over 8% stronger than the average gravitational force exerted by the moon on earth. The total oceanic mass perturbed during the tsunami was about 1,200 km × 550 km × 4 km × 1025 kg/m3 or 2.71 × 1018 kg (31, 32). The total mass must have been conveyed towards outer space during that event (i.e. momentum-energy hypothesis in 33). The total hydrogen mass involved in the seawater mobilized by the massive quake was 0.112 times or about 3.03 × 1017 kg (33). This is quite a lot of hydrogen loss during the giant tsunami and could account for the gravity hole in the Indian Ocean and corresponding dent in the magnetic field in the South Atlantic.

The East African Rift, which opened up in 2005 after the 2004 massive quake and tsunami in the Indian Ocean also manifested the strong potential of the enhanced oceanic pressure and force (due to changing lunar distance) in facilitating continental split and drift. Note that the Newtonian gravitational force-law had been modified in (33) to account for the changing lunar distance as in;

$$F = G\frac{Mm}{r_o^{\ 2}}\left(1 - \ln\frac{r_n^2}{r_o^2}\right) \qquad (2)$$

where G is the gravitational constant, M is earth's mass, m is lunar mass, r_o is the average lunar distance and r_n. is the new lunar distance. Here, the reduced lunar distance leads to increased lunar gravitational force F. This may help explain the continental drift theory of plate tectonics and the enhanced motion of the Australian continent and the Hawaiian Islands since the new millennium.

3.4 Impact of massive earthquakes on lunar distance and global sea level anomaly

The number of events of massive earthquakes (≥ M7.5) is highly correlated with the lunar distances computed using the new EPOCH model (31). The resulting analysis showed very close correlation between the two as shown in Figure (11). Note that the estimated lunar distance is increasing since 1970 but it has been decreasing again after 2005. Using Kepler's 3rd law, when the lunar distance is further reduced to about 370,000 km, the lunar orbital period may further decrease to 26 days instead of 27.32 days. This could be the cause of the increased rotation rate of the earth via transfer of angular momentum as observed by earth and planetary scientists at present, potentially reducing the 24-hour diurnal period. In addition, this can increase the number of lunar revolutions around the earth from 13-14 times a year. When the number of massive earthquakes with magnitudes M≥7.5 is considered (smoothed) and correlated with the global sea level anomaly (running average), the resulting regression yields a very high correlation r2 = 0.9659 (Figure 12). The analysis also showed very low p-value and relatively low standard error. This implies that the observed global sea level anomaly is strongly related to the number of strong quakes and frequency of earthquake occurrence. The above analyses showed that strong earthquakes may govern the polar migration and axial precession which in turn govern the observed global sea level rise problem through lunar orbital changes.

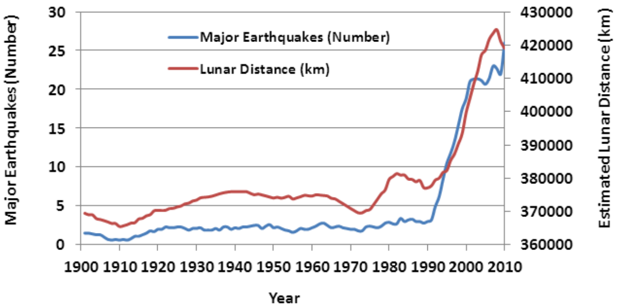

Figure 11. Computed lunar distances and the massive earthquakes since 1900 (USGS).

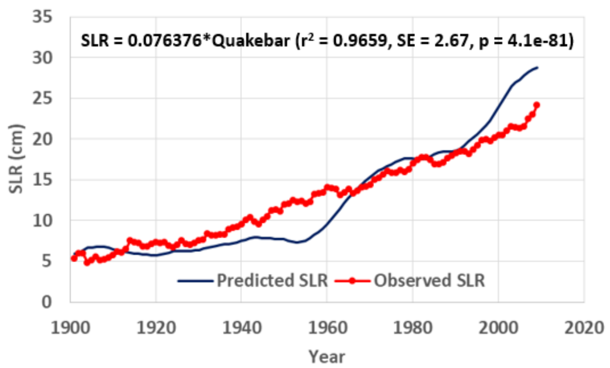

Figure 12. Statistical regression between observed earthquakes and sea level rise.

4 Conclusion

The impact of the polar migration and axial precession (denoted by annual planetary obliquity) of the earth is shown in this study to be the dominant factors causing the observed global sea level anomaly since the last century up to the present. Both of these factors are shown to be dictated by the increasing frequency of massive earthquakes. A very high relative contribution of the polar migration (49.4%) on the mean sea level rise, followed by axial precession (46.7%) and a secondary contribution of lunar acceleration (3.9%) was found in the present study. Sea surface temperature and earth spin rate showed negative correlations with sea level rise. The negative effect of SST implies that thermal expansion of the oceans (in the order of millimeters) is most probably not the real cause of the SLR problem.

The increasing rate of lunar orbital acceleration, though typically considered to be very gradual, can have significant impacts on tidal currents and related oceanographic phenomena. As the lunar orbital speed increases, the oceanic tides may change as well. This change affects the tidal cycle by possibly altering the period between successive high and low tides. The primary tidal constituents such as the semi-diurnal lunar tides are directly related to the lunar orbital rotation period. A faster lunar orbital rate means more tidal cycles within a given period, potentially altering the timing and strength of tidal currents and sea levels.

The changing geomagnetic North Pole migration was utilized to deduce the enigmatic 26 second microseismic tremors which match the observed frequency of 0.038 Hz. Apparently, this indicates that the planet Earth is gradually tilting as it spins with a concomitant gradual build-up of oceanic pressure through lunar-induced sea level rise.

The resonance of tides in ocean basins is also sensitive to the earth's rotation rate. Faster rotation can shift the natural resonant frequencies of these basins. If the tidal forcing frequency aligns with the natural frequency of the ocean basin, it can lead to higher tidal amplitudes (constructive interference). Conversely, if they become misaligned, tidal amplitudes could decrease (destructive interference). These changes in tidal amplitudes would subsequently affect tidal currents, potentially making them stronger or weaker depending on the resonance conditions. Tidal energy dissipation rates are also influenced by the earth's rotation rate. A faster rotation rate can alter the distribution of tidal energy, leading to changes in how energy is dissipated through frictional forces and turbulent mixing in the ocean. This redistribution of energy can modify the strength and patterns of tidal currents, particularly in shallow coastal areas where frictional effects are more pronounced.

Finally, it is recommended that future studies further investigates the impact of the increasing earth's rotation rate on the global sea level changes as there appears to be a very close relation between the observed mysterious low-frequency tremors worldwide with the oceanic pressure build-up that emanates from global sea level rise.

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