Open Journal of Earthquake Research, 2019, 8, 267-298
https://www.scirp.org/journal/ojer
ISSN Online: 2169-9631
ISSN Print: 2169-9623

Sun-Moon-Earth Interactions with Larger Earthquakes Worldwide Connections

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How to cite this paper: Hagen, M. and Azevedo, A. (2019) Sun-Moon-Earth Interactions with Larger Earthquakes Worldwide Connections. *Open Journal of Earthquake Research*, **8**, 267-298.
https://doi.org/10.4236/ojer.2019.84016

Received: September 1, 2019
Accepted: November 8, 2019
Published: November 11, 2019

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Abstract

The aim of this paper is to investigate the effects on Moon-Earth gravitational variations and Moon phases during three Solar Cycless (SC22, SC23, SC24). The first part defines gravitational forces as a force that creates an oscillation when the moon is reaching the Perigee, the smallest distance between the Moon and Earth during its rotational movement around Earth. It has a small amplitude and large period. Unlikely other authors, we do not find a direct connection between the Moon phases and big earthquakes worldwide. The study is performed through the three Solar Cycless, which refers to the variation in the Sun's magnetic field. However, a strong indication appeared that almost the totality of the largest quakes studied happened preferentially at the subduction zones, in the Southern Hemisphere. In this research we apply experimental data to find the tide force, and the Perigee position is an experimental value. Other parameters are experimental, such as the length of Solar Cycless, the Moon's phases connected to each earthquake where M ≥ 7.5. The calculations use regression in time to find the results. Our model considers in the regression the period 1986-2018.

Keywords

Solar Cycless, Moon-Earth Gravitational Forces, Larger Earthquakes

1. Introduction

This paper is a continuation of former research on the gravitational force variation of Moon-Earth and how it would influence the rise of worldwide earthquakes. In our former paper [1] has been verified that Moon-Earth has a gravitational force that varies during the month when the Moon is at the Perigee.

This force creates a wave with a small variation in amplitude and a large period, which has been calculated as well. The period analyzed was shorter than in the present study 1996-2008. The results have indicated that apparently the gravitational moon variation effects more subduction zones, and several locations which occur more earthquakes in the period studied. We also studied the possible correlation between Moon phases and earthquakes searching the historical earthquakes catalog 1700-2016. The results showed the largest earthquakes often surge at subduction zones. However, it does not have any relation with Moon phases, New Moon or Full Moon.

In the paper after that, [2] we have added the Sun to the interactions with Moon-Earth and earthquakes. The Solar Cycless comprehends a period of eleven years it was the next implicit variable used. The period analyzed for this search was 1996-2016, it included two Solar Maxima that could indicate the presence or absence of influence or not in the enhancement of quakes.

Other such studies examined the development of earthquake events during the seasons. To do this, we needed to divide the Global research into Northern and Southern Hemispheres since the seasons occur differently in each hemisphere. It was found to the Northern Hemisphere there was a slight increase in the earthquakes during Spring and Summer [3].

The present research considers three Solar Cycless, the gravitational force oscillation is calculated for each cycle, which could be a possible correspondence of large earthquakes for each maximum of the gravitational force.

Next, we ascertain a possible connection with Moon phases New or Full, which are supposed to influence the larger earthquakes that occur worldwide for each Solar Cycles, as defined under moon cycles. Larger earthquakes magnitudes depend on the region in which they are happening. During this first approach we consider the magnitudes where $M \geq 7.5$.

For these earthquakes, the following set of data includes dates, location, magnitudes, moon phases, and hemisphere, fit into each cycle, SC22, SC23, and SC24. The results show an oscillation between the moon and earth, which mainly affects the tidal waves in the subduction zones.

We will present the data set for each section studied, explaining what the explicit and implicit sets are. Our data is composed of experimental data collected from different catalogs for Solar Cycless [4], [5]; perigee/apogee data sets [6] [7], and, earthquakes [8] [9] [10]. In the case of earthquakes, it is possible to check the events in at least three worldwide catalogs.

2. The Perigee Force Variation

The lunar orbit around the Earth is elliptical therefore twice monthly is considered to be at the Perigee (closest to the Earth) and twice at the Apogee (the furthest from Earth). The force among the two bodies is

$$F = G\frac{Mm}{r^2} \tag{1}$$

In Equation (1), M is the Earth's mass, m is the moon's mass, $G = 6.67 \times 10^{-11}$ $N \cdot m^2 \cdot kg^{-2}$ are all constants, and the only variable is r^2 which is the Earth-Moon distance. This variable is collected from the catalog [6] which also gives the value of the moon phases New Moon and Full Moon. Since the New or Full Moon sometimes are not closer to the earthquake occurrence, we also used [7].

The variation of the distance between the Earth and Moon gave a Perigee force during three Solar Cycless. The maximum $F = 2.32 \times 10^{20}$ N and the minimum is $F = 2.14 \times 10^{20}$ N.

Several times the maximum values occurred near the Full or New Moon, but this was not a rule. The minimum values also occurring during the First or Third quarter. Therefore, there is not a real connection that the Full or New moon is attaching events at the Perigee position. The development of the force at the Perigee position shows an oscillation corroborated for each cycle searched.

We constructed **Tables 1-3**, for the moon cycle and the respective Solar Cycles, shown in **Figures 1-3**. In the figures, the maximum value corresponds to the maxima of the tidal force generated by the Equation (1).

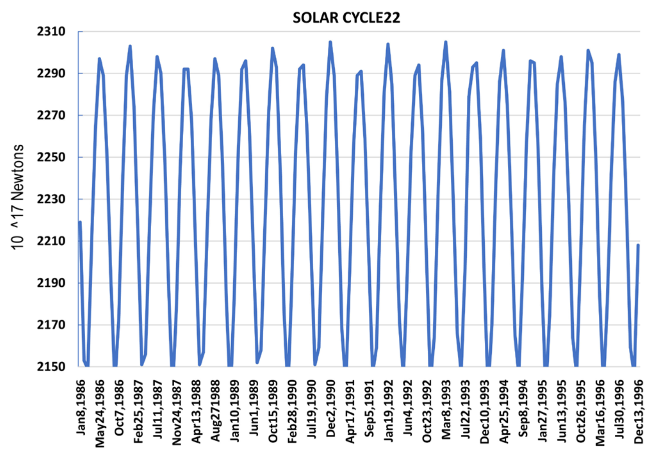

Figure 1. SC22, the perigee variation force 1986-1996. The force is displaying a wave, with small amplitude and large period.

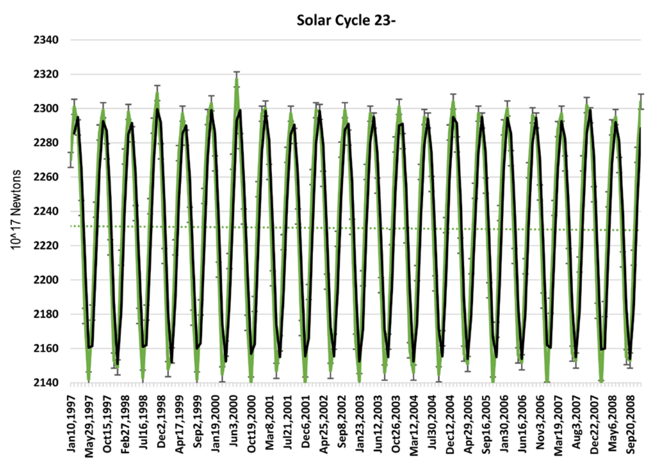

Figure 2. Perigee force variation during Solar Cycles 23.

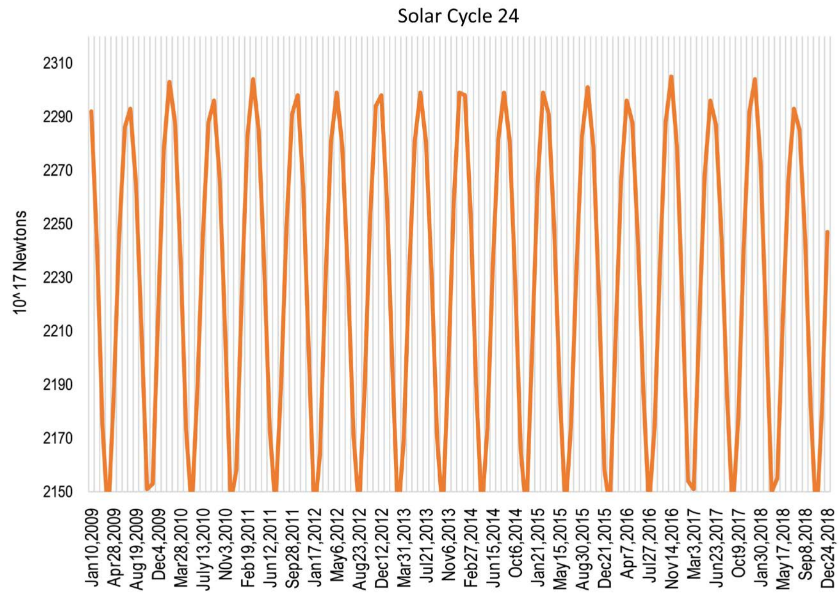

Figure 3. Perigee force variation at Solar Cycles 24.

The variations of force among Earth and Moon could possibly explain the shallow moonquake occurrences. There are four types of moonquakes [11].

Deep moonquakes have a depth of nearly 700 km below the surface of the moon. Meteor impacts, two-week-long thermal moonquakes, and when the darkness covers half of the moon, the temperatures can fall to −240 degrees Fahrenheit.

When that same surface makes its return to sunshine, the temperature swings wildly back to +250 degrees Fahrenheit. When the frozen crust suddenly expands, it can cause a moonquake. Shallow Moonquakes are the most powerful and the most worrisome for researchers and those eager to colonize the moon. Of the four types of quakes, these are the ones that could do some real damage.

The variation in gravitational force and oscillations created will affect the moon surface. This oscillation happens throughout the years and has a small amplitude and, large periods. The moon surface variation has different temperatures in a small period that causes cracks and fractures in its surface. This probably affects all the body since when it contracts, the temperatures fall and when it dilates it rises. It would be a cause of shallow earthquakes on the moon.

According to the references, they only happened 28 times period 1972-1977, when seismological events were observed from the instrument astronauts left behind. The magnitude of quakes observed could reach M5 [11].

1) Solar Cycless, Perigee Variation, Large Earthquakes

In order to understand our calculations, first we calculated the moon cycles and its variations by the variable r, into a Solar Cycles [12]. The Sun rotation magnetic field creates a giant helicoidal field that is sent through space and hit the Earth's rotational and oscillating magnetic field. Induced currents will be created parallel to this magnetic field lines according to Faraday-Maxwell equations.

The following lists are the calculation of tide forces by each perigee position by month and year. We constructed **Figures 1-3** in the text, with the data below.

Table 1. Perigee position distance, and Fg variation. **Figure 1** is constructed with those values corresponding Solar Cycles 22

SC 22	
Perigee	**F_g (10^17 N)**
Jan. 8, 1986	2219
Feb. 4, 1986	2153
Mar. 1, 1986	2149
Mar. 28, 1986	2211
Apr. 25, 1986	2265
May 24, 1986	2297
Jun. 21, 1986	2289
Jul. 19, 1986	2249
Aug. 16, 1986	2190
Sep. 12, 1986	2142
Oct. 7, 1986	2172
Nov. 4, 1986	2237
Dec. 2, 1986	2289
Dec. 20, 1986	2303
Jan. 28, 2987	2274
Feb. 25, 1987	2214
Mar. 24, 1987	2151
Apr. 18, 1987	2156
May 15, 1987	2216
Jun.13, 1987	2270
Jul. 11, 1987	2298
Aug. 8, 1987	2290
Sep. 6, 1987	2249
Oct. 4, 1987	2187
Oct. 30, 1987	2139
Nov. 24, 1987	2177
Dec. 22, 1987	2245
Jan. 19, 1988	2292
Feb. 17, 1988	2292
Mar. 16, 1988	2266

Continued

Apr. 13, 1988	2207
May 10, 1988	2151
Jun. 4, 1988	2157
Jul. 2, 1988	2215
Jul. 30, 1988	2268
Aug. 27, 1988	2297
Sep. 25, 1988	2289
Oct. 23, 1988	2246
Nov. 20, 1988	2181
Dec. 16, 1988	2135
Jan. 10, 1989	2182
Feb. 7, 1989	2249
Mar. 8, 1989	2292
Apr. 5, 1989	2296
May 4, 1989	2263
Jun. 1, 1989	2206
Jun. 28, 1989	2152
Jul. 23, 1989	2158
Aug. 19, 1989	2216
Sep. 16, 1989	2272
Oct. 15, 1989	2302
Nov. 12, 1989	2293
Dec. 20, 1989	2244
Jan. 7, 1990	2175
Feb. 2, 1990	2138
Feb. 28, 1990	2190
Mar. 28, 1990	2253
Apr. 25, 1990	2292
May 21, 1990	2294
Jun. 21, 1990	2261
Jul. 19, 1990	2205
Aug. 15, 1990	2151
Sep. 9, 1990	2159
Oct. 6, 1990	2220
Nov. 3, 1990	2278
Dec. 2, 1990	2305
Dec. 30, 1990	2289
Jan. 28, 1991	2236

Continued

Feb. 25, 1991	2168
Mar. 22, 1991	2141
Apr. 17, 1991	2194
May 15, 1991	2253
Jun. 13, 1991	2289
Jul. 11, 1991	2291
Aug. 8, 1991	2259
Sep. 5, 1991	2203
Oct. 2, 1991	2147
Oct. 27, 1991	2159
Nov. 24, 1991	2224
Dec. 22, 1991	2281
Jan. 19, 1992	2304
Feb. 17, 1992	2285
Mar. 16, 1992	2230
Apr. 13, 1992	2171
May 8, 1992	2145
Jun. 4, 1992	2195
Jul. 2, 1992	2253
Jul. 30, 1992	2289
Aug. 27, 1992	2294
Sep. 25, 1992	2261
Oct. 23, 1992	2202
Nov. 19, 1992	2143
Dec. 13, 1992	2164
Jan. 10, 1993	2232
Feb. 7, 1993	2287
Mar. 8, 1993	2305
Apr. 5, 1993	2281
May 4, 1993	2227
May 31, 1993	2166
Jun. 25, 1993	2147
Jul. 22, 1993	2197
Aug. 19, 1993	2279
Sep. 16, 1993	2293
Oct. 15, 1993	2295
Nov. 12, 1993	2259
Dec. 10, 1993	2194
Jan. 6, 1994	2138

Continued

Jan. 31, 1994	2170
Feb. 17, 1994	2237
Mar. 28, 1994	2286
Apr. 25, 1994	2301
May 24, 1994	2275
Jun. 21, 1994	2224
Jul. 18, 1994	2165
Aug. 12, 1994	2146
Sep. 8, 1994	2197
Oct. 6, 1994	2257
Nov. 3, 1994	2296
Dec. 2, 1994	2295
Dec. 30, 1994	2254
Jan. 27, 1995	2188
Feb. 23, 1995	2138
Mar. 20, 1995	2175
Apr. 17, 1995	2239
May 15, 1995	2285
Jun. 13, 1995	2298
Jul. 11, 1995	2276
Aug. 8, 1995	2225
Sep. 5, 1995	2164
Sep. 30, 1995	2146
Oct. 26, 1995	2201
Nov. 23, 1995	2265
Dec. 22, 1995	2301
Jan. 19, 1996	2295
Feb. 17, 1996	2249
Mar. 16, 1996	2183
Apr. 11, 1996	2141
May 6, 1996	2181
Jun. 3, 1996	2242
Jul. 1, 1996	2286
Jul. 30, 1996	2299
Aug. 27, 1996	2276
Sep. 24, 1996	2223
Oct. 22, 1996	2159
Nov. 16, 1996	2146
Dec. 13, 1996	2208

Table 2. Perigee position distance, and Fg variation. Figure 2 is constructed with these values. Solar Cycles 23.

SC23	
Perigee	F_g 10^17 N
Jan. 10, 1997	2270
Feb. 7, 1997	2301
Mar. 8, 1997	2289
Apr. 5, 1997	2242
May 5, 1997	2179
May 29, 1997	2142
Jun. 24, 1997	2181
Jul. 21, 1997	2241
Aug. 19, 1997	2286
Sep. 16, 1997	2299
Oct. 15, 1997	2275
Nov. 12, 1997	2219
Dec. 9, 1997	2153
Jan. 3, 1998	2149
Jan. 30, 1998	2213
Feb. 27, 1998	2272
Mar. 28, 1998	2298
Apr. 25, 1998	2285
May 24, 1998	2239
Jun. 20, 1998	2179
Jul. 16, 1998	2143
Aug. 11, 1998	2181
Sep. 8, 1998	2243
Oct. 6, 1998	2290
Nov. 4, 1998	2309
Dec. 2, 1998	2275
Dec. 30, 1998	2214
Jan. 26, 1999	2148
Feb. 20, 1999	2156
Mar. 20, 1999	2219
Apr. 17, 1999	2274
May 15, 1999	2297
Jun. 13, 1999	2283
Jul. 11, 1999	2238
Aug. 7, 1999	2178
Sep. 2, 1999	2142
Sep. 28, 1999	2184
Oct. 26, 1999	2249

Continued

Nov. 23, 1999	2295
Dec. 22, 1999	2303
Jan. 19, 2000	2268
Feb. 17, 2000	2206
Mar. 14, 2000	2145
Apr. 8, 2000	2160
May 6, 2000	2211
Jun. 3, 2000	2269
Jul. 1, 2000	2317
Jul. 30, 2000	2281
Aug. 27, 2000	2237
Sep. 24, 2000	2175
Oct. 19, 2000	2139
Nov. 14, 2000	2186
Dec. 12, 2000	2253
Jan. 10, 2001	2297
Feb. 7, 2001	2300
Mar. 8, 2001	2263
Apr. 5, 2001	2201
May 2, 2001	2147
May 27, 2001	2163
Jun. 23, 2001	2222
Jul. 21, 2001	2273
Aug. 19, 2001	2297
Sep. 16, 2001	2284
Oct. 14, 2001	2237
Nov. 11, 2001	2172
Dec. 6, 2001	2139
Jan. 2, 2002	2193
Jan. 30, 2002	2260
Feb. 27, 2002	2299
Mar. 28, 2002	2298
Apr. 25, 2002	2259
May 23, 2002	2199
Jun. 19, 2002	2147
Jul. 14, 2002	2164
Aug. 10, 2002	2224
Sep. 8, 2002	2276
Oct. 6, 2002	2299
Nov. 4, 2002	2283
Dec. 2, 2002	2231

Continued

Dec. 30, 2002	2164
Jan. 23, 2003	2141
Feb. 19, 2003	2201
Mar. 19, 2003	2263
Apr. 17, 2003	2297
May 15, 2003	2293
Jun. 12, 2003	2255
Jul. 10, 2003	2197
Aug. 6, 2003	2146
Aug. 31, 2003	2164
Sep. 28, 2003	2225
Oct. 26, 2003	2279
Nov. 23, 2003	2301
Dec. 22, 2003	2281
Jan. 19, 2004	2226
Feb. 16, 2004	2159
Mar. 12, 2004	2146
Apr. 8, 2004	2204
May 6, 2004	2263
Jun. 3, 2004	2295
Jul. 1, 2004	2293
Jul. 30, 2004	2256
Aug. 27, 2004	2198
Sep. 22, 2004	2145
Oct. 18, 2004	2166
Nov. 14, 2004	2232
Dec. 12, 2004	2286
Jan. 10, 2005	2304
Feb. 7, 2005	2279
Mar. 8, 2005	2220
Apr. 4, 2005	2157
Apr. 29, 2005	2151
May 23, 2005	2208
Jun. 23, 2005	2252
Jul. 21, 2005	2297
Aug. 19, 2005	2293
Sep. 16, 2005	2255
Oct. 14, 2005	2194
Nov. 10, 2005	2139
Dec. 5, 2005	2171
Jan. 1, 2006	2239

Continued

Jan. 30, 2006	2289
Feb. 27, 2006	2300
Mar. 28, 2006	2271
Apr. 25, 2006	2214
May 22, 2006	2156
Jun. 16, 2006	2152
Jul. 13, 2006	2208
Aug. 10, 2006	2264
Sep. 8, 2006	2296
Oct. 6, 2006	2293
Nov. 3, 2006	2251
Dec. 2, 2006	2188
Dec. 28, 2006	2136
Jan. 22, 2007	2185
Feb. 19, 2007	2242
Mar. 19, 2007	2288
Apr. 17, 2007	2297
May 15, 2007	2268
Jun. 12, 2007	2214
Jul. 9, 2007	2157
Aug. 3, 2007	2153
Aug. 31, 2007	2209
Sep. 28, 2007	2268
Oct. 26, 2007	2302
Nov. 24, 2007	2296
Dec. 22, 2007	2250
Jan. 19, 2008	2182
Feb. 14, 2008	2137
Mar. 10, 2008	2183
Apr. 7, 2008	2247
May 6, 2008	2289
Jun. 3, 2008	2295
Jul. 1, 2008	2267
July 29, 2008	2212
Aug. 26, 2008	2155
Sep. 20, 2008	2153
Oct. 17, 2008	2213
Nov. 14, 2008	2273
Dec. 1, 2008	2304

Table 3. Perigee position distance and Fg variation. **Figure 3** is constructed with these values. Solar Cycles 24.

SC24	
Perigee day	**F_g (10^17 N)**
Jan. 10, 2009	2292
Feb. 7, 2009	2242
Mar. 7, 2009	2175
April. 2, 2009	2139
Apr. 28, 2009	2186
May 26, 2009	2246
Jun. 23, 2009	2286
Jul. 21, 2009	2293
Aug. 19, 2009	2265
Sep. 16, 2009	2210
Oct. 13, 2009	2151
Nov. 7, 2009	2153
Dec. 4, 2009	2217
Jan. 1, 2010	2278
Jan. 30, 2010	2303
Feb. 27, 2010	2288
Mar. 28, 2010	2237
Apr. 24, 2010	2173
May 20, 2010	2143
Jun. 15, 2010	2188
July. 13, 2010	2246
Aug. 10, 2010	2288
Sep. 8, 2010	2296
Oct. 6, 2010	2267
Nov. 3, 2010	2209
Nov. 10, 2010	2146
Dec. 25, 2010	2158
Jan. 22, 2011	2226
Feb. 19, 2011	2283
Mar. 19, 2011	2304
Apr. 17, 2011	2285
May. 15, 2011	2234
Jun. 12, 2011	2173
Jul. 7, 2011	2145
Aug. 2, 2011	2189

Continued

Aug. 30, 2011	2249
Sep. 28, 2011	2291
Oct. 26, 2011	2298
Nov. 23, 2011	2264
Dec. 22, 2011	2201
Jan. 17, 2012	2141
Feb. 11, 2012	2164
Mar. 10, 2012	2230
Apr. 7, 2012	2281
May 6, 2012	2299
Jun. 3, 2012	2279
Jul. 1, 2012	2231
Jul. 29, 2012	2171
Aug. 23, 2012	2143
Sep. 19, 2012	2189
Oct. 17, 2012	2252
Nov. 14, 2012	2294
Dec. 12, 2012	2298
Jan. 10, 2013	2259
Feb. 7, 2013	2195
Mar. 5, 2013	2140
Mar. 31, 2013	2169
Apr. 27, 2013	2232
May. 27, 2013	2281
Jun. 23, 2013	2299
Jul. 21, 2013	2281
Aug. 9, 2013	2232
Sep. 15, 2013	2170
Oct. 10, 2013	2142
Nov. 6, 2013	2195
Dec. 4, 2013	2259
Jan. 1, 2014	2299
Jan. 30, 2014	2298
Feb. 27, 2014	2255
Mar. 27, 2014	2190
Apr. 23, 2014	2142
May 18, 2014	2173

Continued

Jun. 15, 2014	2235
Jul. 13, 2014	2282
Aug. 10, 2014	2299
Sep. 8, 2014	2281
Oct. 6, 2014	2229
Nov. 3, 2014	2165
Nov. 27, 2014	2142
Dec. 24, 2014	2201
Jan. 21, 2015	2265
Feb. 19, 2015	2299
Mar. 19, 2015	2291
Apr. 17, 2015	2248
May 15, 2015	2187
Jun. 10, 2015	2143
Jul. 5, 2015	2174
Aug. 2, 2015	2234
Aug. 30, 2015	2283
Sep. 28, 2015	2301
Oct. 26, 2015	2279
Nov. 23, 2015	2225
Dec. 21, 2015	2158
Jan. 15, 2016	2144
Feb. 11, 2016	2207
Mar. 10, 2016	2267
Apr. 7, 2016	2296
May 6, 2016	2288
Jun. 3, 2016	2245
Jul. 1, 2016	2187
Jul. 27, 2016	2144
Aug. 22, 2016	2174
Sep. 18, 2016	2237
Oct. 16, 2016	2288
Nov. 14, 2016	2305
Dec. 12, 2016	2279
Jan. 10, 2017	2220
Feb. 76, 2017	2154
Mar. 3, 2017	2151
Mar. 30, 2017	2213

Continued

April 27, 2017	2269
May 26, 2017	2296
Jun. 23, 2017	2287
Jul. 21, 2017	2245
Aug. 18, 2017	2185
Sep. 13, 2017	2142
Oct. 9, 2017	2177
Nov. 6, 2017	2242
Dec. 4, 2017	2292
Jan. 1, 2018	2304
Jan. 30, 2018	2273
Feb. 27, 2018	2212
Mar. 26, 2018	2150
Apr. 20, 2018	2155
May 17, 2018	2214
Jun. 14, 2018	2267
Jul. 13, 2018	2293
Aug. 10, 2018	2285
Sep. 8, 2018	2244
Oct. 5, 2018	2182
Oct. 31, 2018	2138
Nov. 26, 2018	2179
Dec. 24, 2018	2247

$$\mathcal{E} = -\mathrm{d}\Phi/\mathrm{d}t \tag{2}$$

In the equation Φ is the flux of the magnetic field, and $\mathcal{E}$ is the electromotive force (EMF). Therefore, Sun, rotating its axis in connection with Earth's magnetic field the Birkeland currents [13], [14], [15] and [16]. During a Solar Cycles, the Birkeland currents intensities will increase during a solar maximum for each cycle or if exceptional Coronal Mass Ejections, X flares or solar storms occur, enhancing the parallel currents and auroral lines **Figure 4**.

Previously we pointed out that solar storms and induced currents at the magnetosphere and ionosphere from such interaction would disturb not only the magnetosphere, but also the Earth's surface.

The Earth field is squeezed when Solar Wind speeds increase. The solar wind velocity varies in range of 300 - 800 km/s. Those variations affect the Earth's magnetic field with strong geomagnetic storms.

Overall, the disturbances by the Sun's magnetic field rotation creates a changing magnetic field; therefore, inducing an EMF around Earth's field lines or parallel currents. It is easier to detect this in the Earth's pole. The Earth's rotation

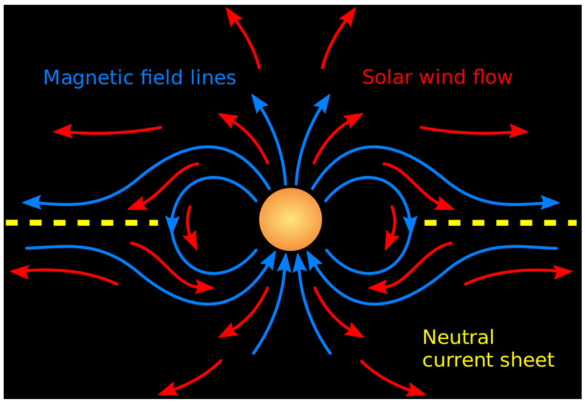

Figure 4. This file is ineligible for copyright and therefore in the public domain because it consists entirely of information that is common property and contains no original authorship. The sun magnetic field lines, it varies with the solar wind speed and rotation on its axis.

also makes the dipolar magnetic field rotates. The interplanetary field is one Gauss double of the Earth's magnetic field on average. The interaction between both magnetic fields, the rotation of both bodies, and the Solar wind speed variations enhances the currents, which is known as aurora borealis.

The current intensity is enhanced by Solar wind speed variations during Coronal Mass Ejects and X flares directed toward the Earth's magnetosphere, [17].

The Solar Cycless are the Sun's magnetic field moving in a cycle. Most of the Solar Cycless are approximately eleven years, at which point the Sun's magnetic field completely flips, north and south poles exchange places. The sunspots are caused by the Sun's magnetic fields, and its varying activity during the cycles.

The beginning of a Solar Cycles is a minimum, when the Sun has the least sunspots, as we are having now in the middle of 2019. Over time, solar activity will rise, and the number of sunspots will increase. Solar Cycless have been observed since 1755 which is considered Solar Cycles 1.

Here, we are working with the following Solar Cycless; Solar Cycles 22, 1986-1996; Solar Cycles 23; 1996 (June)-2008, and Solar Cycles 24; 2008 (January)-2019 (possible end cycle). From the three pictures, we observed the Moon, when at the Perigee creates an oscillation with a period range of 52,080 hours-54,000 hours. The moon's speed around Earth is 3883 km/h and generate a wavelength that varies between -1.94×10^7 km - 2.05×10^7 km. It is possible to research if this wave would influence the rise of earthquakes.

The middle of the Solar Cycles is the solar maximum, or when the Sun has the most sunspots. As the cycle ends, it fades back to the solar minimum, and then a new cycle begins. In this paper, the calculations of moon forces are through of three Solar Cycless. Solar Cycless will give the interaction between the variations in the solar magnetic field and possible connections with the Moon and the Earth through earthquakes. The maximum of the first Solar Cycles analyzed (1986-1996) was July 1989. Comparing this with the data from the earthquakes, the data shows only two big earthquakes for this year; one in May 20, the other on Dec. 12 both during the Full moon. For the Solar Cycles 23 (1996-2008), the maximum occurred in March 2000, when the following quake events occurred May 25, May 28, June 18, November 16, November 17, all, during the Full moon. During the Solar Cycles 24 (2008-2019 September) the maximum occurred on April 2014, when five events occurred, four in April, two under the New Moon, and two during the Full Moon and one in June, under the New Moon. Therefore, the variation of the Sun magnetic field, through its cycle, showed to be stronger during the Full Moon. Examining **Tables 1-3** the events occurred at the years of Maximum Solar activity and most of the New or Full moon events occurred before the earthquakes.

Here we can determine that the activity of large earthquakes will appear most at the Full moon at the maximum of Solar Cycless. Our research indicates that the Solar Magnetic Force is much more important to events on Earth than the gravitational ones between the Sun-Earth interactions. The Sun has a large and helicoidal field; the magnetic field in average on the Sun is around 1 Gauss. It is twice as strong as the average field on the surface of Earth (0.5 Gauss). This paragraph shows that if there is any stronger interaction between Sun-Earth it will be more in their magnetic field variation.

2) Larger Earthquakes, Moon Phases

There are four moon phases: new moon, full moon, first quarter and third quarter, and the phases in between. In this part of our research, we consider only New or Full Moon, the difference between the data and the possible connection with a large earthquake event. In the paper, [1] an extensive study was done to determine if any Moon phase was more likely to happen an earthquake M > 4.5. At a full moon, the Earth, Moon, and Sun are in approximate alignment, just as with the New Moon, however, the moon is on the opposite side of the earth. Therefore, the entire sunlit part of the moon is facing us. To figure out if the importance of these two phases, our **Tables 1-3** are constructed for each Solar Cycles; 22, 23 and 24, and the quakes searched have a magnitude M ≥ 7.5 worldwide. Besides, the day, location and, magnitude are determined by the Moon phase on the day it happened and, also the Hemisphere. [18] The hemisphere is important for greater earthquakes since we showed in a former paper that the larger earthquakes are taking place at subduction zones which are located more at the Southern Hemisphere. The next three Tables show small differences found in the data set.

Next **Table 4** defining the largest earthquakes which occurred during the SC 22.

Table 4, Solar Cycles 22 results show that quakes with magnitudes M ≥ 7.5 more often occurred in the Southern Hemisphere (55%), than in the Northern Hemisphere (45%), **Figure 5**. Southern Hemisphere had 10% more events, located in the subduction zones. See the earthquakes above M7.8 highlighted in pink. The moon phases show that 48% occur near the Full Moon, and 52% at the New Moon, as in **Figure 6**. The number of total events analyzed during SC22 was the smallest from the three cycles, only 44 larger quakes occurred at total.

Table 4. This table is showing the events of the earthquakes during period 1986-1997 (Solar Cycles 22) magnitudes M > 7.5, the locations, and the closest Moon phase at the time (Full or New), also the Hemisphere in which it occurred.

Data	Location	Mag	Moon phase	Hemisphere
July 5, 1986	Aleutian Islands	8	July 7, New	North
August 14, 1986	Molucca Sea	7.5	Aug. 19, Full	South
October 20, 1986	Kermadec Is	7.5	Oct. 17, Full	South
Mar. 6, 1987	Chile coast	7.6	Feb. 28, Full	South
November 30, 1987	Alaska	7.8	Nov. 30, New	North
June 3, 1988	Alaska	7.8	May 27, New	North
August 10, 1988	Solomon Is	7.8	Aug. 9, Full	South
November 6, 1988	China	7.7	Nov. 9, New	North
May 23, 1989	Macquarie Is	8.1	May 20, Full	North
Dec. 15, 1989	Philippines	7.6	Dec. 12, Full	South
Mar. 3, 1990	Fiji Is	7.6	Feb. 25, New	South
April 5, 1990	Mariana Is	7.6	Mar. 26, New	North
April 18, 1990	Indonesia	7.8	Apr. 10, New	South
July 16, 1990	Philippines	7.7	July 8, New	South
Dec. 30, 1990	New Britain	7.5	Dec. 31, Full	South
Apr. 22, 1991	Costa Rica	7.6	Apr. 14, New	North
June 20, 1991	Indonesia	7.5	Jun. 12, New	South
Dec. 22, 1991	Kuril Is	7.5	Dec. 21, Full	South
Oct. 2, 1992	Nicaragua	7.7	Sep. 26, New	North
Dec. 12, 1992	Indonesia	7.8	Dec. 9, Full	South
January 15, 1993	Japan	7.5	Jan. 8, Full	North
June 8, 1993	Russia	7.5	Jun. 4, Full	North
July 12, 1993	Japan	7.7	July 19, New	North
August 8, 1993	Mariana Is	7.5	Aug. 2, Full	North
Mar. 9, 1994	Fiji Is	7.5	Mar. 12, New	South
Jun. 2, 1994	Java (South)	7.8	May 25, Full	South
June 9, 1994	Bolivia (North)	8.2	Jun. 9, New	South
Oct. 4, 1994	Kuril Is	8.2	Oct. 5, New	North
Dec. 28, 1994	Japan	7.7	Jan. 1, New	North
May 16, 1995	Loyalty Is	7.7	May 14, Full	South
July 30, 1995	Chile coast	8	Jul. 27, New	South
Aug. 16, 1995	Solomon Is	7.6	Aug. 10, Full	South
Oct. 9, 1995	Jalisco, Mx	7.9	Oct. 8, Full	North
Dec. 3, 1995	Kuril Is	7.6	Dec. 7, Full	North
Jan. 1, 1996	Minahasa Pen	7.9	Jan. 5, Full	South

Continued

Feb. 17, 1996	Indonesia	8.1	Feb. 18, New	South
June 10, 1996	Aleutian Islands	7.6	Jun. 16, New	North
June 17, 1996	Flores sea	7.7	Jun. 16, New	South
Nov. 12, 1996	Peru coast	7.5	Nov. 11, New	South
April 4, 1997	Sta Cruz	7.7	Apr. 7, New	South
Nov. 8, 1997	China	7.5	Nov. 14, Full	North
Dec. 12, 1997	Russia	7.8	Dec. 14, Full	North

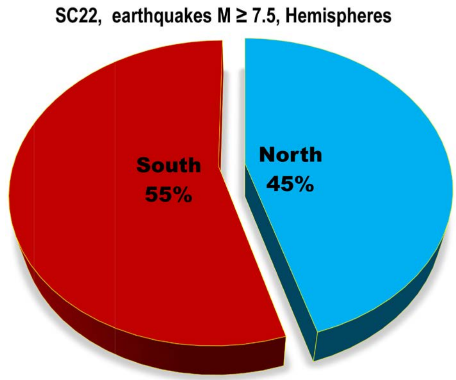

Figure 5. Solar Cycles 22, the occurrence of quakes M ≥ 7.5, by hemisphere.

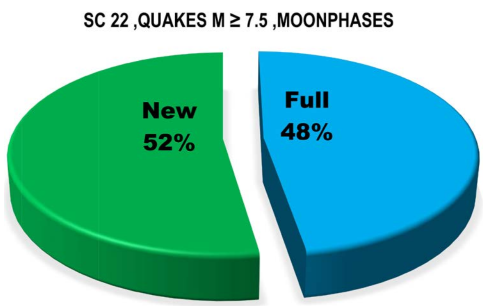

Figure 6. Solar Cycles 22, earthquakes M ≥ 7.5 and the full or new moon occurrences.

The quasi-totality of larger events occurred at the subduction zones most frequently on the Pacific side. Pacific side is the location of most of the subduction zones if compared with Mediterranean. Rare occurrences on the Mediterranean subduction zones point out other diverse mechanisms, more than just the one discussed in this paper [18], [19].

Nevertheless, happened some exceptions to subduction zones occurred on the Myanmar-China border (1988), magnitude M7.7. Another one in Kizan (1997), M 7.5, and the last one in Northern Bolivia (1994), M8.2, at a location in a rupture point depth of 631.3 km below the surface. The conclusion for this Solar Cycless examining larger earthquakes indicates a possible connection between the tidal variation but not a strong bond with the Moon Phases.

There is no evidence that New or Full Moons would increase such events, at this point. Neither the Perigee variation enhances the frequency or magnitude of such earthquakes. Instead, the variation of the tidal wave boosts the possibility of events in such regions with a delayed time to take effect on the earthquake surge. As observed, seldom times it will happen during the perigee when the moon is closest to the Earth (two times). Southern Hemisphere occurrences are more frequent since the world presents huge rupture points in South America where the depths of earthquakes are below 600 km another one near the Fiji Islands (depths bigger than 700 km) as it will be explained in a subsequent search.

Table 5 belongs to the Solar Cycles 23 and defining the largest earthquakes occurred into the period 1997-2008. There are 63 events in total with M ≥ 7.5 showing similar results from Table 4 (SC22). In this table, an occurrence at the Southern Hemisphere for larger quakes happened 54% Figure 7. From those quakes, relevant difference as New Moon had 53% quakes, at Full 47% tremors as shown at Figure 8. Earthquakes above or equal M7.8 are highlighted in green, Table 5.

Table 6 refers to the events to Solar Cycles 24, the last Cycle analyzed, we also highlighted the events M ≥ 7.8 in yellow. This Cycle had a total of 66 tremors M ≥ 7.5 almost the same number of tremors as in the Cycle 23. Here the percentage of quakes that happened at the Southern is double of the Northern, see Figure 9. Figure 10 shows 57% of earthquakes happened at the New Moon.

If it is considered the period 1986-2018 the earthquakes M ≥ 7.5 happened 59% at the Southern Hemisphere and, 55% during the New Moon. Next, it is a study for the largest earthquakes and their occurrences by magnitude, phase and hemisphere.

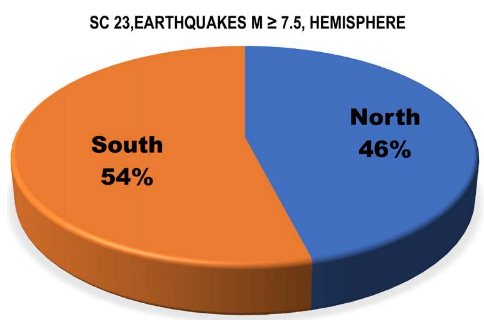

Figure 7. SC23 showing the percentage of M ≥ 7.5 earthquakes in each Hemisphere.

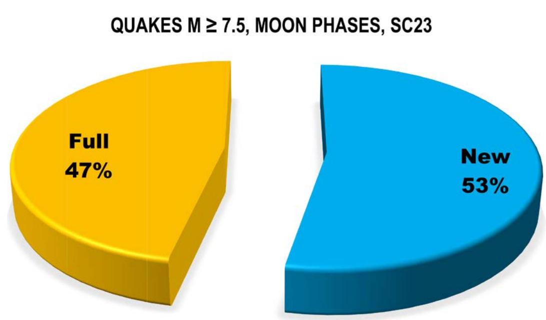

Figure 8. Solar Cycles 23 and the relation between quakes M ≥ 7.5 and moon phases.

Table 5. Belongs to the period defined as the Solar Cycles 23, and the largest earthquakes occurred at the period.

Data	Location	Mag	Moon phases	Hemisphere
Nov. 12, 1996	Peru	7.7	Nov. 8, New	South
April 21, 1997	Sta Cruz Is	7.7	April 20, Full	South
Oct. 14, 1997	Fiji	7.8	Oct. 16, Full	North
Nov. 8, 1997	Xizang	7.5	Nov. 14, Full	North
Dec. 5, 1997	Kamchatka	7.8	Nov. 30, New	South
Jan. 4, 1998	Loyalty Is	7.5	Dec. 29, 1997, New	South
Mar. 25, 1998	Balleny Is	8.1	Mar. 13, Full	North
May 3, 1998	Taiwan	7.5	Apr. 26, New	South
Nov. 29, 1998	Banda Sea	7.7	Nov. 19, New	North
Aug. 17, 1999	Turkey	7.6	Aug. 11, New	North
Sep. 20, 1999	Taiwan	7.7	Sep. 9, New	North
Sep. 30, 1999	Mexico	7.5	Sep. 25, Full	South
Nov. 26, 1999	Vanuatu	7.5	Nov. 23, Full	North
Mar. 28, 2000	Japan	7.6	Mar. 20, Full	South
May 25, 2000	Indonesia	7.6	May 18, Full	South
June 18, 2000	Indian ocean	7.9	Jun. 16, Full	South
Nov. 16, 2000	Papua	8	Nov. 11, Full	South
Nov. 16, 2000	Papua	7.8	Nov. 11, Full	South
Nov. 17, 2000	Papua	7.8	Nov. 11, Full	North
Jan. 1, 2001	Phil	7.5	Dec. 25, 2000, New	North
Jan. 13, 2001	El Salvador	7.7	Jan. 9, Full	North
Jan. 26, 2001	India	7.7	Jan. 24, New	north
June 23, 2001	Peru	8.4	June 21, New	South
July 7, 2001	Peru	7.6	July 5, Full	South
Oct. 19, 2001	Banda Sea	7.5	Oct. 1, New	South
Nov. 14, 2001	China	7.8	Nov. 1, Full	North
Mar. 5, 2002	Phil	7.5	Feb. 27, Full	North
19 Aug., 2002	Fiji	7.7	Aug. 8, New	South
19 Aug., 2002	Fiji	7.7	Aug. 8, New	South
8 Sep., 2002	N Guinea	7.6	Sep. 7, New	North
10 Oct., 2002	Indonesia	7.6	Oct. 6, New	South
3 Nov., 2002	Alaska	7.9	Nov. 4, New	North
22 Jan., 2003	Mexico	7.6	Jan. 18, Full	North
15 July, 2003	Carls. Ridge	7.6	July 13, Full	North
4 Aug., 2003	Scotia Sea	7.6	July 29, Full	South
25 Sep., 2003	Japan	8.2	Sep. 26, New	North

Continued

17 Nov., 2003	Alaska	7.8	Nov. 9, Full	North
11 Nov., 2004	Indonesia	7.5	Nov. 12, New	South
23 Dec., 2004	Macq. Is	8.1	Dec. 26, Full	South
26 Dec., 2004	Sumatra	9.1	Dec. 26, Full	North
28 Mar., 2005	Indonesia	8.6	Mar. 25, Full	North
13 June, 2005	Chile	7.8	June 6, New	South
9 Sep., 2005	Papua	7.6	Sep. 3, New	South
26 Sep., 2005	Peru	7.5	Sep. 18, Full	South
8 Oct., 2005	Pakistan	7.6	Oct. 3, New	North
27 Jan., 2005	Banda Sea	7.6	Jan. 29, New	South
20 Apr., 2006	Russia	7.6	Apr. 13, Full	North
3 May, 2006	Tonga	8	Apr. 27, New	South
17 July, 2006	Java	7.7	Jul. 11, Full	South
15 Nov., 2006	Kuril Is	8.3	Nov. 20, New	North
13 Jan., 2007	Kuril Is	8.1	Jan. 19, New	North
21 Jan., 2007	Molucca Sea	7.5	Jan. 19, New	South
1 Apr., 2007	Solomon Is	8.1	Apr. 2, Full	South
8 Aug., 2007	Indonesia	7.5	Jul. 30, Full	South
15 Aug., 2007	Peru	8	Aug. 12, New	South
12 Sep., 2007	Indonesia	8.4	Sep. 11, New	South
12 Sep., 2007	Indonesia	7.9	Sep. 11, New	South
28 Sep., 2007	Japan	7.5	Sep. 26, Full	North
14 Nov., 2007	Chile	7.7	Nov. 9, New	South
9 Dec., 2007	Fiji	7.8	Dec. 9, New	South
12 May, 2008	China	7.9	May 5, New	North
5 July, 2008	Okhotsk Sea	7.7	Jul. 3, New	North

Table 6. Larger earthquakes ($M \geq 7.5$) during the Solar Cycles 24, data, location, moon phase (new/full) and hemisphere. The data highlighted are $M \geq 7.8$.

Data	Location	Mag	Moon phase	Hemisphere
Jan. 3, 2009	Indonesia	7.7	Dec. 27 (08), New	South
Mar. 19, 2009	Tonga	7.6	Mar. 11, Full	South
July 15, 2009	New Zealand	7.8	Jul. 7, Full	South
August 10, 2009	India	7.5	Aug. 6, Full	North
Sep. 29, 2009	Samoa Is	8.1	Sep. 18, New	South
Sep. 30, 2009	Indonesia	7.6	Sep. 18, New	South
Oct. 9, 2009	Vanuatu	7.7	Oct. 4, Full	South
Oct. 7, 2009	Sta Cruz Is	7.8	Oct. 4, Full	South

Continued

Feb. 27, 2010	Chile	8.8	Feb. 28, Full	South
Apr. 6, 2010	Indonesia	7.8	Mar. 30, Full	South
Jun. 12, 2010	India	7.5	Jun. 12, New	North
Jul. 23, 2010	Philippines	7.6	Jul. 26, Full	South
July 23, 2010	Philippines	7.5	Jul. 26, Full	South
Oct. 25, 2010	Indonesia	7.8	Oct. 23, Full	South
Mar. 3, 2011	Japan	9.1	Mar. 4, New	North
Mar. 11, 2011	Japan	7.9	Mar. 4, New	North
Mar. 11, 2011	Japan	7.7	Mar. 4, New	North
July 6, 2011	Kermadec Is	7.6	Jul. 1, New	South
Apr. 11, 2012	Sumatra	8.6	April 6, Full	South
April 11, 2012	Sumatra	8.2	April 6, Full	South
Aug. 14, 2012	Sea of Okhotsk	7.7	Aug. 17, New	North
Aug. 31, 2012	Philippines	7.6	Aug. 31, New	North
Sep. 5, 2012	Costa Rica	7.6	Aug. 31, New	North
Oct. 28, 2012	Canada	7.8	Oct. 20, New	North
Jan. 5, 2013	Alaska	7.5	Dec. 28, Full	North
Feb. 6, 2013	Solomon Is	8	Feb. 10, New	South
Apr. 16, 2013	Iran	7.7	Apr. 10, New	North
May 24, 2013	Sea of Okhotsk	8.3	May 25, Full	North
Sep. 24, 2013	Pakistan	7.7	Sep. 19, Full	North
Nov. 13, 2013	Scotia Sea	7.7	Nov. 17, Full	South
Apr. 1, 2014	Chile	8.2	Mar. 30, New	South
Apr. 3, 2014	Chile	7.7	Mar. 30, New	South
Apr. 12, 2014	Solomon Is	7.6	Apr. 15, Full	South
Apr 19, 2014	Papua	7.5	Apr. 15, Full	South
Jun. 23, 2014	Alaska	7.9	Jun. 27, New	North
Mar. 29, 2015	Papua	7.5	Mar. 20, New	South
Apr. 25, 2015	Nepal	7.8	Apr. 18, New	North
May 5, 2015	Papua	7.5	May 4, Full	South
May 30, 2015	Japan	7.8	Jun. 2, Full	North
Sep. 16, 2015	Chile	8.3	Sep. 13, New	South
Oct. 26, 2015	Afghanistan	7.5	Oct. 27, Full	North
Nov. 24, 2015	Peru	7.6	Nov. 25, Full	South
Nov. 24, 2015	Brazil	7.6	Nov. 25, full	South
Mar. 2, 2016	Indonesia	7.8	Mar. 9, New	South
Apr. 16, 2016	Ecuador	7.8	Apr. 7, New	South
July 29, 2016	Mariana IS	7.7	Jul. 19, Full	North

Continued

Nov. 13, 2016	N. Zealand	7.8	Nov. 14, Full	South
Dec. 8, 2016	Solomon Is	7.8	Nov. 29, New	South
Dec. 17, 2016	Papua	7.9	Dec. 14, New	South
Dec. 25, 2016	Chile	7.6	Dec. 29, New	South
Jan. 22, 2017	Papua	7.9	Jan. 11, New	South
Jul. 17, 2017	Russia	7.7	Jul. 9, New	North
Sep. 8, 2017	Mexico	8.2	Sep. 6, New	North
Jan. 10, 2018	Honduras	7.5	Jan. 2, Full	North
Jan. 23, 2018	Alaska	7.9	Jan. 17, New	North
Feb. 22, 2019	Papua	7.5	Feb. 15, New	South
Aug. 19, 2018	Fiji	8.2	Aug. 11, New	South
Sep. 6, 2018	Fiji	7.9	Sep. 9, New	South
Sep. 28, 2018	Indonesia	7.5	Sep. 25, Full	South
Dec. 5, 2018	N. Caledonia	7.5	Dec. 7, New	South
Feb. 22, 2019	Ecuador	7.5	Feb. 19, New	South
May 14, 2019	Papua	7.6	May 18, New	South
May 26, 2019	Peru	7.5	May 18, New	South

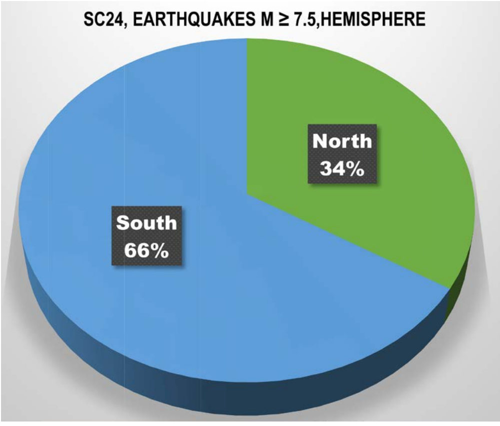

Figure 9. Solar Cycles 24 showing the relation North/south hemisphere for earthquakes $M \geq 7.5$.

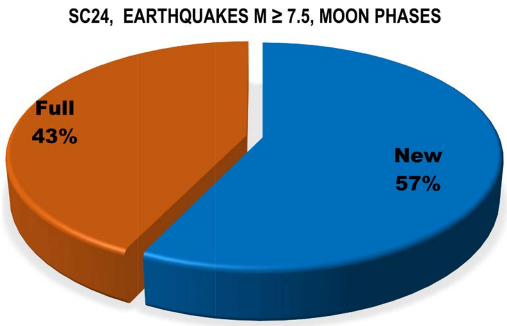

Figure 10. It is the percentage of events that occurred at the full or new moon. Earthquakes $M \geq 7.5$, during the Solar Cycles 24.

3. Solar Cycles 22, Solar Cycles 23, Solar Cycles 24, Comparisons with Data

The data set for three Solar Cycless, make it possible to find out how much the gravitational force of Moon-Earth variation and the tectonics influence on subduction zones can increase the number of events during these periods. Initially we considered larger events the earthquakes M ≥ 7.5 separating by cycles.

Comparing the events found the Solar Cycles 22 has the smallest number of larger events. During Solar Cycles 22, 44 larger events, Solar Cycles 23, 63 larger events, and Solar Cycles 24, 66 larger events occurred. Solar Cycles 24, presenting double the number of tremors at the Southern Hemisphere than the other two cycles. Also, the quakes happened with more frequency at or close to the New Moon. Therefore, there is the Solar Cycless maximum, Moon Phases (New or Full), and the correlated variation on the tidal forces as we did at the first part of this paper. All these variables appear to be correlated to the of subduction zones locations. Full moon looks to be important during the Solar Cycles maximum, when the biggest events occurred at the subduction zones and tightly correlated with this phase.

Largest (M ≥ 7.8) Earthquakes vs. Moon Phases, Hemispheres

The latest results from Section 3 showed that earthquakes tend to appear in the Southern Hemisphere during the new moon. The goal now is to study what happens to the highest magnitude earthquakes that occurred in the last three cycles over a period between 1986-2018. We extracted the highlighted data from the last three Tables 4-6 and constructed three new ones.

Tables 7-9 are earthquakes with magnitude M ≥ 7.8 for each cycle studied. The tables show the date they occurred, the locations, hemisphere magnitude, with a difference as the exact moon phase nearest the occurred earthquake.

Table 7 displays the largest earthquakes M ≥ 7.8 during the Solar Cycles 22. The column for the Moon phases, showing the closest phase to the event, two events occurred at the 1st Q, five at the New moon, two at the 3rd Q and four at the full Moon. Therefore, the New moon is still the phase when more events happened for this Cycle.

Table 8, the relation between the Moon phases and the earthquakes are the following, four at the 1st Q, five at the 3rd Q, five at the Full moon, and nine at the New moon. On this cycle the New moon has a higher occurrence than the other three phases, SC23.

Table 9 is the last cycle studied or SC24 displaying the major events with the same parameters analyzed for the other two cycles. In this cycle the moon phases are six for New and 3rdQ, and eight for Full and 1st Q.

Analyzing the moon phases for the entire period 1986-2018 the totality of earthquakes happened according to the moon phases 1st and 3rd Q had 14 and 13 largest events respectively, full moon, 17 events, and New moon 20 events it means that largest events happened most at the New Moon, 31% followed by the Full Moon 27%.

Table 7. Showing the parameters for the largest earthquakes on the cycle SC2, M ≥ 7.8.

Data	Location	Mag	Moon phase	Hemisphere
Nov. 30, 1987	Alaska	7.8	Nov. 28, 1st Q	North
Aug 10, 1988	Solomon Is	7.8	Aug. 12, New	South
May 23, 1989	Macquarie Is	8.1	May 20, Full	North
April 18, 1990	Indonesia	7.8	Apr. 18, 3rd	South
Dec. 12, 1992	Indonesia	7.8	Dec. 9, Full	South
Jun. 2, 1994	Java (South)	7.8	Jun. 1, 3rd	South
June 9, 1994	Bolivia-North	8.2	Jun. 9, New	South
Oct. 4, 1994	Kuril Is	8.2	Oct. 5, New	North
July 30, 1995	Chile coast	8	Jul. 27, New	South
Oct. 9, 1995	Jalisco, Mx	7.9	Oct. 8, Full	North
Jan. 1, 1996	Minahasa Pen	7.9	Dec. 28, 1st Q	South
Feb. 17, 1996	Indonesia	8.1	Feb. 18, New	South
Dec. 12, 1997	Russia	7.8	Dec. 14, Full	North

Table 8. Showing the major events M ≥ 7.8 occurred worldwide for the SC23. Here the major events at the Northern Hemisphere happen during the minimum of the cycle, or 2003-2007.

Data	Location	Mag	Moon phases	Hemisphere
Dec. 5, 1997	Kamchatka	7.8	Dec. 7, 1st Q	South
Mar. 25, 1998	Balleny Is	8.1	Mar. 28, New	North
June 18, 2000	Indian ocean	7.9	Jun. 16, Full	South
Nov. 16, 2000	Papua	8	Nov. 18, 3rd Q	South
Nov. 16, 2000	Papua	7.8	Nov. 18, 3rd Q	South
Nov. 17, 2000	Papua	7.8	Nov. 18, 3rd Q	North
June 23, 2001	Peru	8.4	June 21, New	South
Nov. 14, 2001	China	7.8	Nov. 15, New	North
3 Nov., 2002	Alaska	7.9	Nov. 4, New	North
25 Sep., 2003	Japan	8.2	Sep. 21, Full	North
17 Nov., 2003	Alaska	7.8	Nov. 20, Full	North
23 Dec., 2004	Macq. Is	8.1	Dec. 23, New	South
26 Dec., 2004	Sumatra	9.1	Dec. 23, New	North
28 Mar., 2005	Indonesia	8.6	Mar. 25, Full	North
13 June, 2005	Chile	7.8	June 15, 1st Q	South
3 May, 2006	Tonga	8	May 5, 1st Q	South
15 Nov., 2006	Kuril Is	8.3	Nov. 17, 3rd Q	North
13 Jan., 2007	Kuril Is	8.1	Jan. 11, 3rd Q	North

Continued

1 Apr., 2007	Solomon Is	8.1	Apr. 12, Full	South
15 Aug., 2007	Peru	8	Aug. 12, New	South
12 Sep., 2007	Indonesia	8.4	Sep. 11, New	South
12 Sep., 2007	Indonesia	7.9	Sep. 11, New	South
12 May, 2008	China	7.9	May 12, 1st Q	North

Table 9. Displaying the data for earthquakes M ≥ 7.8 during the SC24.

Data	Location	Mag	Moon phase	Hemisphere
July 15, 2009	New Zealand	7.8	Jul. 15, 1st Q	South
Sep. 29, 2009	Samoa Is	8.1	Sep. 26, 1st Q	South
Oct. 7, 2009	StaCruz Is	7.8	Oct. 4, Full	South
Feb. 27, 2010	Chile	8.8	Feb. 28, Full	South
Apr 6, 2010	Indonesia	7.8	Apr. 6, 3rd Q	South
Oct. 25, 2010	Indonesia	7.8	Oct. 23, Full	South
Mar. 3, 2011	Japan	9.1	Mar. 4, New	North
Mar. 11, 2011	Japan	7.9	Mar. 12, 1st Q	North
Apr. 11, 2012	Sumatra	8.6	Apr. 13, 3rd Q	South
April 11, 2012	Sumatra	8.2	Apr. 13, 3rd Q	South
Oct. 28, 2012	Canada	7.8	Oct. 29, Full	North
Feb. 6, 2013	Solomon Is	8	Feb. 3, 3rd Q	South
May 24, 2013	Sea of Okhotsk	8.3	May 25, Full	North
Apr. 1, 2014	Chile	8.2	Mar. 30, New	South
Jun. 23, 2014	Alaska	7.9	Jun. 27, New	North
Apr. 25, 2015	Nepal	7.8	Apr. 25, 1st Q	North
May 30, 2015	Japan	7.8	Jun. 2, Full	North
Sep. 16, 2015	Chile	8.3	Sep. 13, New	South
Mar. 2, 2016	Indonesia	7.8	Mar. 1, 3rd Q	South
Apr. 16, 2016	Ecuador	7.8	Apr. 14, 1st Q	South
Nov. 13, 2016	N. Zealand	7.8	Nov. 14, Full	South
Dec. 8, 2016	Solomon Is	7.8	Dec. 7, 1st Q	South
Dec. 17, 2016	Papua	7.9	Dec. 14, Full	South
Jan. 22, 2017	Papua	7.9	Jan. 19, 3rd Q	South
Sep. 6, Full	Mexico	8.2	Sep. 6, New	North
Jan. 23, 2018	Alaska	7.9	Jan. 24, 1st Q	North
Aug. 19, 2018	Fiji	8.2	Aug. 18, 1st Q	South
Sep. 6, 2018	Fiji	7.9	Sep. 9, New	South

Tables 6-8, for SC22, SC23 and SC24 results, resumed in Figure 11. Figure 11 represents the three tables, (Tables 7-9) for the biggest earthquakes worldwide M >or equal 7.8. Observe Tables 7-9 are the biggest earthquakes worldwide for each cycle we searched. Analyzing the three cycles by Hemisphere and Moon Phases, for the largest earthquakes, the results are the following; the biggest occurrences are in the Northern Hemisphere for SC22 (57%), to SC23 was at the Southern Hemisphere (53%) and for SC24 at the Southern Hemisphere (65%). It pointed out the earthquakes likely to happen more at the Southern hemisphere with a small discrepancy on the SC22. The same analysis for the Moon phase for the largest events showing a growth of events in conjunction with a New Moon. The New Moon appears in 57% (SC22), 59% in (SC23) and 78% (SC24%). Considering the entire period 1986-2018, for earthquakes M ≥ 7.8 we obtained to the Moon phases is 31% for New Moon and 27% for Full moon. The Southern Hemisphere has 60% of occurrences for earthquakes with the highest magnitudes for the period 1986-2018.

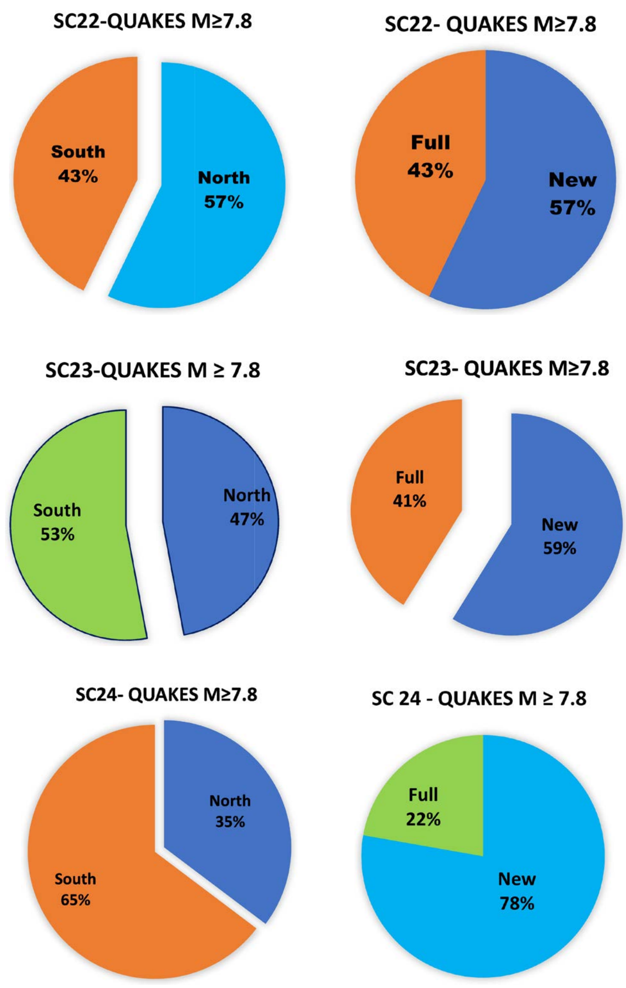

Figure 11. It shows the relationship for Tables 7-9 into cycles, SC22, SC23, and SC24. The events are occurring most at the Southern Hemisphere at the New Moon phase with magnitudes M ≥ 7.8.

4. Results Discussion

The first part of this paper calculated an oscillatory force between Moon-Earth that is created with the variation of the Perigee position twice or three times by month. Our results find an oscillatory tidal force varying during the last three Solar Cycless. Those cycles were defined within the period 1986-2019, one Solar Cycles is defined in periods of 10 - 11 years. The gravitational force Moon-Earth is an oscillation that has maximum and minima when the distance between the two bodies is at the perigee or the minima. Our next step was to associate the evolution of these oscillations and the largest earthquakes happened into the period 1986-2018.

The Moon phases are cyclical as well, and each month there is the occurrence of Full, first quarter, third quarter and New Moon. The rotational movement of the Moon around the Earth is stable, systematically along the months, and the variation for the perigee is small. Our results pointed out that gravitational force Moon-Earth has small growths during some periods and decreases if the distance between the two bodies increases. The disruption of the external parameters happens during Solar Storms, Coronal Mass Ejection or a geomagnetic storm towards the day magnetosphere, when the Solar wind speed sudden increases.

If the solar wind is strong enough or if the magnetic field inside the wind cancels the magnetic field of the Earth, some plasma can get through. Strong bursts of solar wind can squeeze the Earth's magnetosphere compressing until it bounces back like a vibrating rubber ball. Those abrupt external variations would disturb the earthquakes occurrence, as explained in [1]. The explanation for our results that the largest earthquakes happened during the New Moon at the Southern Hemisphere, is that at the New Moon the gravitational forces Sun-Moon are aligned with the Earth increasing the effects of both bodies. At the Southern Hemisphere is the location with the majority of the subduction zones easily influenced by the tidal forces from the Sun-Moon during this period.

The occurrences of earthquakes are always higher at the Southern Hemisphere, particularly in the last cycle SC 24 the proportionality was 66% of events were at the Southern. Examining the next search about the causality of New or Full Moon occurrence for larger earthquakes $M \geq 7.5$ it is found that for all cycles, the incidence of events on the New moon is above 50% in relation to Full Moon.

A last remark is about the influence of the Sun on Earth that remains into the electromagnetic force interactions between the two bodies rather than gravitational ones.

5. Conclusion

Our conclusions point out that Sun-Moon-Earth may interact with each other influencing the largest earthquakes. However, those larger events mostly showed to be dependent in the area searched. It is contingent on the tectonics, fabric, and zones involved in the study. The locations more susceptible to the Moon-Earth relations are in the Southern Hemisphere. The presence of the subduction is important, and most are located in the Northern or Southern Pacific. However, there is a very deep subduction location at the Southern Pacific, as in Fiji with 700 km depth. Finally, the influence of external variables, such as Sun-Earth, Moon-Earth or Sun-Moon-Earth is subtle and is dependent from the location where the event happened. A next study could be developed to understand the importance of Moon gravitational forces for earthquakes with smaller magnitudes as M ≥ 5 or for shallow earthquakes.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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