Earthquake Prediction Model IV

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Abstract

The objective of this research was to further continue[1,2,3] analyzing and investigating correlations between astronomical data and earthquakes, with the intended goal of predicting future earthquakes with a greater advanced warning and higher degree of accuracy than current technology. Specifically, it focuses on severe earthquakes that occurred during the last century, with special emphasis on earthquakes of magnitude 7 or higher. This research work has already shown[1,2,3] a correlation between certain inter-planetary configurations (encompassing the relative geocentric positions and angles of all planets) and the occurrence of strong earthquakes. Building on the work done since the last publication[1,2,3], which focused on the validation of data employed from other resources[4] wherever possible and extending the data set to include the earthquakes of magnitude 7 or higher from January 1900 to December 2009, this research attempts to explore if any correlation exists between the declination angles of planets and the occurrence of strong earthquakes of magnitude 7 and higher. The previous work which was based on the longitudinal geocentric angle between each planetary pair included the Model I, the 15-degree multiple angles, the model II, the 12-degree multiple angles and the Model III, the top 16 most frequently occurred angles. This work extends the research by including the top 16 most frequently occurred declination angles for each planetary pair as well as sun's declination angles with every other planet model.

As a result, between the two sets of Model IV, the sun based declination angle model seems to predict earthquake of magnitude 7 or higher with an order of magnitude better than the top 16 most frequently occurred declination angle model. However, compared to the Model III, the performance of both cases of Model IV was about two orders of magnitudes poor. Further research is necessary to build a useful, predictive model that can assess the probability of a given earthquake occurring during a certain time period at a given geographical location on earth. Predicting earthquakes well in advance of the state of the art will promote, protect, and enhance the world economy, potentially saving millions of lives.

Introduction

Although this paper focuses on earthquake prediction, since 1993, the research began by studying the influence of planetary configurations on natural calamities in general. Starting in 2000, these predictions have been made available to the public on a monthly basis at this website[5]. While further research is warranted to include the place and type of natural disaster in the predictions, the time periods for the occurrences of natural disasters have been predicted in monthly columns[5]. Beginning 2006, the research of the natural calamities was more focused on the occurrence of earthquakes. One reason for this was the availability of accurate data on earthquakes from National Earthquake Information Center, United States Geological Survey[6].

There is absolutely no precedent in predicting an earthquake solely based on planetary configuration. An occurrence of an earthquake is a random event and it can sometimes occur more frequently than other times. Since 2006, this research began with the idea that planetary positions along the ecliptic, and therefore, their apparent (geocentric) positions as viewed from earth, may potentially correlate with the occurrence of earthquakes. Based on planetary characteristics and a large amount of earthquake data, several hypotheses were tested to see if these correlations actually exist. The results of this exercise indicated that certain planetary configurations seem to correlate reasonably well with earthquakes. This research has evolved from 15-degree multiple angles (Model I) to 12-degree multiple angles (Model II) and then to the top 16 most frequently occurred geocentric longitudinal angles (Model III). The intent of this paper is to highlight the initial findings of the next model (the model IV) on prediction of earthquakes based on the planetary declination angles.

A declination of a point (or planet) is the angular distance measured in the perpendicular direction towards north or south of the celestial equator. An angular distance measured along the north direction of the celestial equator is positive and the same along the south direction is negative. Thus, when declination of Mars is 22 degrees, it's position with respect to the celestial equatorial plane (which is the same as the extended earth's equatorial plane in infinite direction) is along the arc perpendicular to the earth's equatorial plane measured in degrees is 22. It is same as latitude location on earth's surface, except that it's on the celestial earth's sphere. Thus, Sun's declination on June 21 (Summer solstice) is 23 degrees and 26 minutes and it is -23 degrees 26 minutes on Dec 21 (Winter solstice). Similarly it is zero on the days when the spring (March 21) and the autumn (September 22/23) equinoxes occur as the Sun crosses the celestial equator on those days. It must be recognized that relative to planets the Sun never moves, always fixed. But due to the earth's tilt and the diurnal rotation it appears to move. If the earth's north-South Pole axis was not tilted the Sun declination would always be zero.

Sometimes declination of a planet is referred as declination angle, but mostly it is referred as declination. In this paper it is either referred as declination or declination position. Consider two planets, Jupiter and Venus. Let us say Jupiter's declination position is 15 degree (north) and Venus's declination position is -10 degree (south). Typically an angle is formed by three points. Two points give a straight line; and two straight lines meeting a common point forms an angle. Since the earth is in its equatorial plane, the implicit in the definition of declination angle between Jupiter and Venus is the angle formed between the Jupiter-Earth arc and Venus-Earth arc measured along the perpendicular direction of the earth's equatorial plane. Thus, the declination angle between Jupiter and Venus is 25 degrees (Jupiter is 15 degrees on the north side of the earth's equator and Venus is 10 degrees south side of the earth's equator). In other words, a declination angle between two planets is the difference between their declination (angular difference) positions or the difference between their latitude positions on the celestial sphere. When two planets are said to be in parallel, they are at the same declination (position) and therefore, naturally, the declination angle between them is zero. For contra parallel planets the declination angle will be twice the declination of either planet.

Research Basis - Methodology

As pointed out earlier the bases for this research are the unique planetary declination positions surrounding the earth. Astronomical data provides planetary declination positions as a function of time. It was observed that the declination angles of certain magnitudes between some pairs of planets with respect to the earth appear to correlate with earthquakes. The hypothesis of this research is that the correlations between earthquakes of the past and their corresponding planetary declination angles during those respective periods occur in a statistically significant way.

The Model

The objective for this model development is to predict earthquakes of magnitude 7 and higher based on declination angles between planetary pairs. First a simple model was developed based on the assumption that the earthquake severity depends on the total number of angles ranging from zero degrees to 54 degrees (note that a typical declination range is -23.5 to 23.5 degrees giving a maximum of about a 47 degree declination angle, but with "out of bound planets" the maximum angle can go as high as about 54 degrees) for the top 16 most frequently occurred declination angles for each pair of planets during 1900-2009 for seven and higher magnitude earthquakes. In other words, the more the number of angles the higher the severity of the earthquake. However, it was found that the severity of the earthquake is not necessarily proportional to the number of angles formed. As a result, it became necessary to account for the influence of each individual angle for each pair of planets by weighing them differently. The weighted model is developed using a simple linear regression technique. Thus, in theory there are 45 different pairs of planets (6 outer, 2 inner, Sun and Moon) and 16 distinct declination angles (from 0 degrees to about 54 degrees), making a total of 720 maximum possible unique variables that can influence the earthquake occurrence. An orb of six minutes for each declination angle was employed for the analysis.

Since the Moon's average daily variation is about 2 declination degrees, it can form almost equal number of angles with every other planet during a daily twenty-four hour period. Nonetheless to test the influence of Moon, two sets of models, one with the inclusion of Moon and the other without are developed.

The earthquakes of magnitude 7 or higher that occurred during January1900 – December 2009 were obtained from the USGS[3,5] website. Two data sets of 1900-1972 and 1973-2009 were combined to create one large data set of 1672 points. To avoid the co-linearity in data employed, if there were more than one earthquake of magnitude 7 or higher occurred in one day, the only one with the highest magnitude was selected for that day for this analysis. The accuracy of the data sets was verified against the Centennial Earthquake Catalog[3]. The first step of the analysis was to determine the top sixteen frequently occurred declination angles during the 1900-2009. An example of Neptune-Saturn pair is shown in Figure 1. The top 16 angles for this pair are: 2.6, 0.2, 2.3, 0.8, 10.2, ------- 8.6. And the corresponding frequency of the occurrences of these angles is: 34, 25, 23, 22, 19, -------14 respectively. Thus, for Neptune-Saturn pair, the declination angle of 2.6 degrees occurred 34 times during 1900-2009 for earthquakes of 7 and higher magnitudes. Then computations of angles for all the 45 planetary angle pairs were performed. Using an orb of six minute, the planetary data pertaining to the top 16 angles were extracted for all 45 planetary angle pairs for the model and are listed in Appendix-A. Thus, there are 720 unique variables. A linear model is assumed as follows.

Earthquake Magnitude = Σ Cn * (angle pair)n + constant for n =1 to 720

where Cn is the coefficient of the n^{th} angle pair; and the n^{th} angle pair equals one when true and zero otherwise.

For example, Neptune-Saturn 2.6 declination angle is represented by the $X_{161}{}^{th}$ variable which becomes unity only when the angle between Neptune and Saturn lies between 2.5 and 2.7 degrees. For all other angles between Neptune and Saturn, $X_{161}{}^{th}$ variable equals zero.

A linear regression was performed and all the coefficients were estimated by generalized least squares. A number of coefficients were so small in magnitude that their influence on the model was deemed negligible. The corresponding variables were omitted one at a time and the regression was repeated to confirm that their influence on the model indeed was negligible. As mentioned earlier two sets of the models were developed, one with the inclusion of Moon (referred here as with-Moon model) and the other without Moon (referred here as without-Moon Model). For each of these models, two cases were obtained as follows:

The first case includes all the variables (720 variables for with-Moon Model and 576 variables for without-Moon model)

The second case where the insignificant variables were omitted subject to the criteria of t>=1 where "t" is statistical test that measures the significance of the coefficient. For this case there were 308 variables for with-Moon model and 244 variables for without-Moon model.

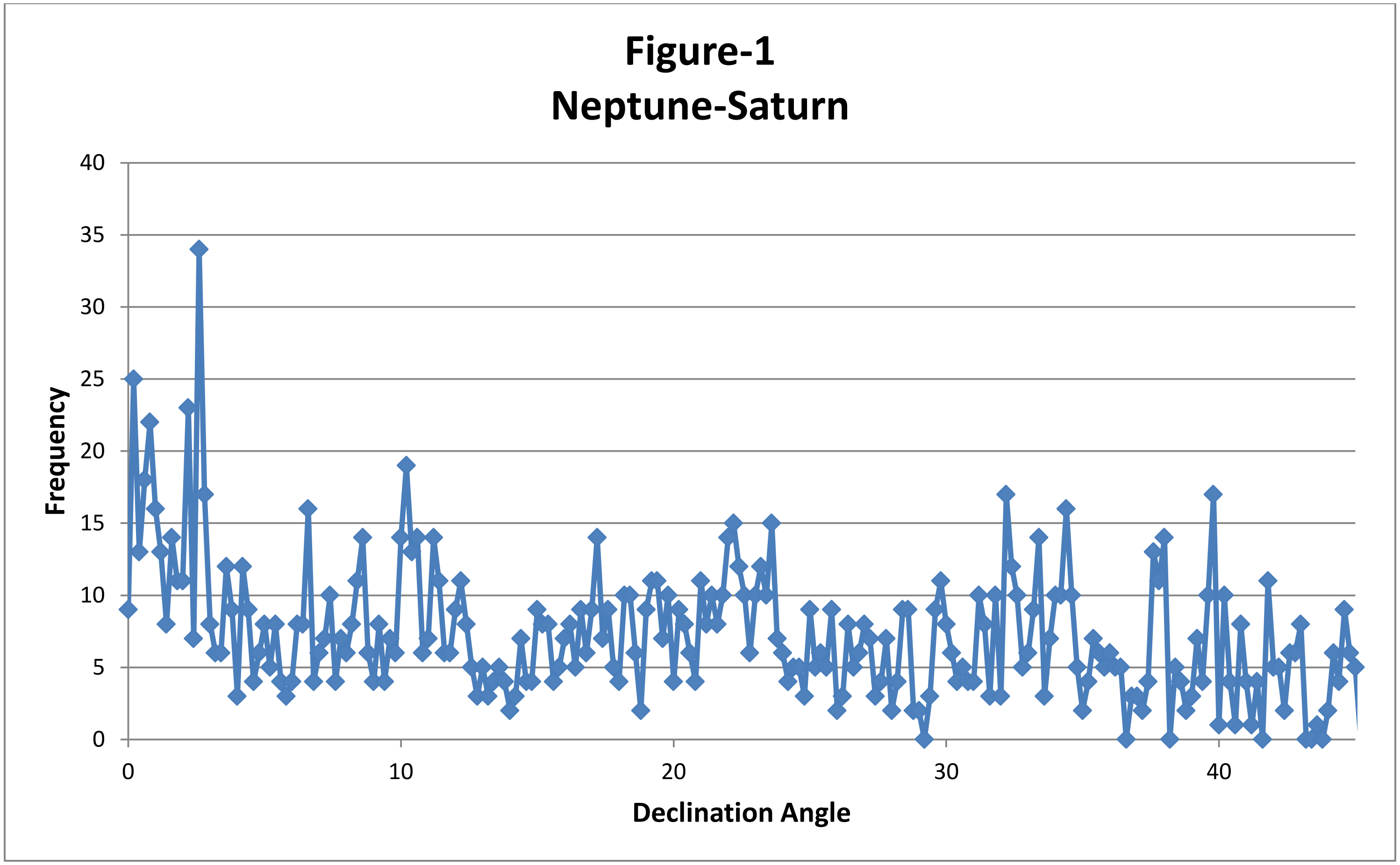
Figure-1
Neptune-Saturn
40
35
30
25
20
15
10
5
0
Frequency
0
10
20
30
40
Declination Angle

A typical set of coefficients of model variables are shown in Table-1 for the 308-variable with-Moon model. There are 45 rows representing planetary pairs and 16 columns for the corresponding angles. Naming of the planetary pairs employ characters Pl, Ne, Ur, Sa, Ju, Mr, Ve, Mc and Su for Pluto, Neptune, Uranus, Saturn, Jupiter, Mars, Venus, Mercury and Sun respectively. Thus, Pl-Ne represents the planetary pair Pluto and Neptune, and Sa-Mc represents the planetary pair Saturn and Mercury.

The value of the constant in the linear equation of these models as calculated by robust linear regression ranged between 7.23 and 7.27. The simulation results showed that the first two models were almost identical in their performance as the successive omission of coefficients of insignificant magnitude did not seem to degrade the model performance while allowing the data noise reduction. The simulated results along with the actual earthquakes are shown in Figure 2 for these models, and although not included in the figure due to space limitation, a similar trend exists for all 1672 data points for each model.

Table-1

308 Variables with Moon Model

Angle #-->	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Angle Pair																
Pl-Ne	0.197	0.2726			-0.173	-0.158	0.1307			-0.091	0.1318	0.1163				
Pl-Ur			-0.08		0.1839		-0.071		-0.074		-0.091	0.1114				0.354
Pl-Sa			-0.155		-0.111			0.2795		-0.075	-0.195				-0.101	-0.239
Pl-Ju				0.1631	0.1028	0.095		-0.108			0.1332	-0.169		0.1251		
Pl-Mr	0.0709							0.06			0.2935	-0.114	0.2173		0.1898	0.1559
Pl-Ve		0.207	0.3603	0.1517	0.092			0.3127				0.1349	0.1697	-0.298	-0.245	
Pl-Mc	0.1525		0.0897					-0.1	-0.285	-0.183	-0.125	0.3508			0.3369	
Pl-Su			0.1894	-0.085	0.1145	-0.111	-0.104	0.243				-0.129	-0.105		-0.155	-0.163
Pl-Mn	0.1337			0.1066		-0.152				0.1994	0.217	-0.145			-0.157	
Ne-Ur	-0.113		0.108	-0.084	0.1888	-0.11	-0.212	-0.132	0.2977				-0.106		-0.197	
Ne-Sa						-0.118	0.5011	-0.184		0.3023			-0.169	-0.226		0.0741
Ne-Ju			0.1748	-0.137		0.245					0.2336	-0.167	0.1903	0.2001	-0.146	
Ne-Mr			0.0973	0.0937	-0.147	0.1383		0.1029		0.0772	0.2292				-0.091	
Ne-Ve							-0.222			-0.098		0.2185		0.1997		
Ne-Mc	-0.108			-0.113	-0.106		0.1769	-0.173				0.2691			-0.193	0.165
Ne-Su		0.0716	0.1112	-0.115	-0.112		-0.085			0.0968			0.1147			-0.126
Ne-Mn		-0.148	-0.108		0.125	-0.223		-0.186			-0.129				-0.089	-0.219
Ur-Sa	0.0786	0.0784		-0.149								-0.094		-0.132	0.0876	
Ur-Ju					0.1791	0.1558					-0.191	-0.135	-0.098	-0.137		
Ur-Mr		-0.19	0.1112	0.1355						0.1			0.217			
Ur-Ve		-0.181	-0.1		-0.25	-0.102	-0.135				-0.144	-0.387	0.227	0.1803	0.1758	0.4025
Ur-Mc			0.1731			-0.152						-0.181			-0.141	
Ur-Su			0.1173						-0.127	0.1836			0.1532	-0.138		-0.241
Ur-Mn	-0.147	-0.079	-0.125	0.1205	-0.11		0.0706	-0.154	-0.171		-0.081	-0.104			0.1167	
Sa-Ju			0.1473			-0.071	0.1752	-0.1				-0.17	-0.124		-0.192	0.1404
Sa-Mr				0.1097		0.1212			0.1165		0.1418	0.1021		-0.104		
Sa-Ve	0.1904	0.1034	-0.175				-0.108		-0.173			0.0989	0.2225	0.1671	0.0986	
Sa-Mc		-0.371				0.3759	0.1522	-0.149		0.0809	0.1304			0.1108		0.1014
Sa-Su				-0.151	-0.089		-0.225	0.149	0.0906	-0.218		0.1432			-0.093	
Sa-Mn				0.163								0.1251	0.2042			-0.133
Ju-Mr		0.1403								0.1444						0.2406
Ju-Ve										-0.124	0.2269		-0.246	-0.122	-0.16	
Ju-Mc			-0.132				0.1504	-0.095			-0.092					
Ju-Sun					0.1719	-0.195			0.1364		-0.101			0.1148	-0.099	
Ju-Mn	-0.115									0.2438	0.1293		0.1494	-0.124		
Mr-Ve		0.2488		0.1178	0.2917	-0.284				0.199			0.1975			
Mr-Mc				0.3091		-0.143	-0.213		-0.14	-0.113	-0.219			0.0975		
Mr-Su		-0.143	0.1112	-0.109	0.0704	0.1225	-0.107		0.2796		-0.092		-0.09			-0.198
Mr-Mn										-0.187			0.0712			
Ve-Mc	0.156	0.0785			0.0905			0.137				-0.227			0.259	0.131
Ve-Su			-0.061								0.073	0.1683				-0.089
Vn-Mn		0.1401					0.1438	-0.104	0.0772					0.1488	0.1245	
Mc-Su	-0.066	0.078	0.0867	-0.076			-0.067							-0.153		
Mc-Mn			0.1253	-0.15				-0.111		-0.124	-0.133	-0.097	0.279	0.1041		
Su-Mn		-0.127						0.1098		-0.085		-0.165		-0.296	0.1225	

It must be noted that one of the limitations of these models is that they only apply over a narrow range of seven and higher earthquake magnitude. Therefore, all predicted values for earthquakes below magnitude seven are irrelevant and meaningless since they can be applicable for the entire lower range of earthquake magnitudes from zero to 6.9. The other important limitation to these models is that they are based on only 1672 data points (since earthquakes of magnitude seven and higher occur about a dozen time per year). Thus, for example, for the model of 308 variables, the ratio of data points to model variables is just above five, and for the one with 244-variable model it is about 7. Consequently, the R-square term, which is a measure of a model fit, varied with decreasing amount of variables from 0.43 to 0.31 indicating a fit not so perfect.

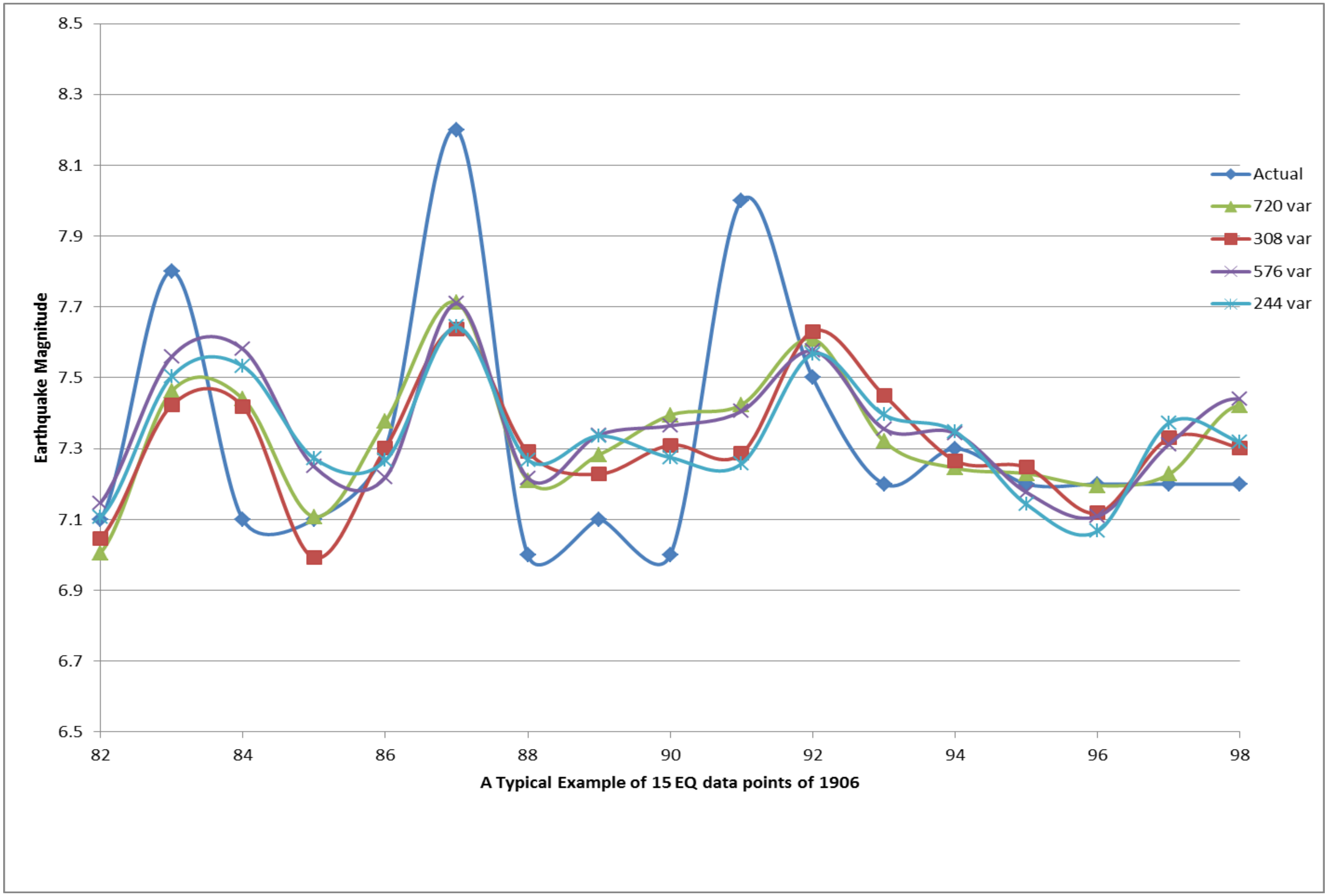

Figure -2: Regressed four Models and the corresponding actual earthquake values of seven and higher

Using Greenwich noontime daily planetary positions, each model was then used to predict the earthquakes for the year 2011-2014. A summary of assumptions reflecting the limitations described above form the basis for the models and are listed below:

1. The predicted earthquakes of magnitude less than 7 are ignored since the model is based on the earthquake data set of magnitude 7 and higher. Thus, the prediction dates of an earthquake of magnitude less than 7 also apply for the dates when earthquake did not occur.

2. As pointed out earlier, in order to determine the influence of angles made by Moon with other planets, two sets of models, with-Moon and the without-Moon were developed. The determination of the angles used for each pair of planets was based on the top 16 most frequently occurred declination angles for earthquakes of seven and higher magnitude during 1900-2009. Thus for each pair of planets, a unique set of 16 declination angles were used in the models.

3. After testing several different orbs for declination angles, a six minute ($1/10^{th}$ of a degree) orb is found to be most satisfactory, and therefore applied for all declination angles.

4. Since the predictions (or simulations) were computed on a daily basis corresponding to Greenwich noon, prediction is assumed to apply for the entire date (12 AM to the next 12 AM of Greenwich Time).

5 The minimum number of declination angles required to meet the criteria of realizing the earthquake of magnitude seven or higher must be higher than the daily average number of angles for that year.

6 The models thus obtained when applied to the daily Greenwich Noon declination angles for planets from the year 2011 to 2014 for earthquake predictions, the predicted resulted seem to overestimate the actual earthquakes about by the amount of their corresponding root mean square errors. Therefore, the predictions were corrected with the root mean square errors which ranged from 0.296 to 0.33.

Although the linear regression was performed using top 16 most frequently appeared declination angles for each planetary angle pair as independent variables, while setting up the equations for each 1672 earthquake data points of magnitude 7 and higher, a care was taken to omit the angle pair (a rare case) if it was not truly independent. For example, consider two planetary pairs: Saturn-Mars and Saturn-Venus. If the declination angle between Saturn and Mars is 10 degrees (as one of the 16 most frequent angles) and the declination angle between the Saturn and Venus is 15 degrees (also as one of the 16 most frequent angles) then the declination angle variable Mars-Venus is omitted if it’s either 5 or 25 degrees as one of the top 16 most frequently occurred angles. It is important to note that the 45 declination angle pairs are based declination position of ten planets. However, because only top 16 declination angles for each pair are considered in the regression analysis, it is possible to have up to 720 (45 times 16) independent variables for all 1672 data points.

Alternatively another hypothesis is formulated with the assumption that the planetary declination angle pairs are based on a one common planet. Thus, for example, if Sun is assumed as a common planet then only the nine planetary declination angle pairs: Sun-Pluto, Sun-Neptune, Sun-Uranus, Sun-Saturn, Sun-Jupiter, Sun-Mars, Sun-Venus, Sun-Mercury and Sun-Moon are considered.

In order to compare this hypothesis against the top 16 frequently occurred declination angles for each of 45 planetary pairs, as before, a linear regression was performed for each common planet case (nine planetary pairs for each common planet case) with top 80 frequently occurred declination angles. The top 80 angles were chosen to have the same total number of 720 variables for comparison. The results showing the R-square term, which is a measure of model fit, are listed in Table-2.

Table-2

Top 80 Declination Angles Models	**R^2 Term**
Pluto based	0.4230
Neptune based	0.4361
Uranus based	0.4177
Saturn based	0.4384
Jupiter based	0.3973
Mars based	0.4395
Venus based	0.4290
Mercury based	0.4427
Sun based	**0.4589**
Moon based	0.4489

As shown in the Table-2, the Sun based model has the highest value of the R-square term, and therefore, the best possible fit Sun based model is chosen for the analysis. The top 80 most frequently occurred declination angles for Sun based model pairs are listed in Appendix-B. The linear regression analysis estimated all the variable coefficients by using generalized least square method. As with the previous model, two sets of models were developed, one with inclusion of Moon (all variables) and the other without Moon. In each of these sets, a number of variables (with very small value of coefficient) were omitted one at a time and the regression was repeated to confirm the influence of the omitted variables was indeed negligible. Thus for each of these two sets two cases were obtained as follows:

The first case includes all 706 variables (note that Sun-Mercury pair only had 66 total angles) for with-Moon model and 626 variables for without-Moon model.

The second case where the insignificant variables were omitted subject to the criteria of t>=1 where "t" is statistical test that measures the significance of the coefficient. For this case there were 344 variables for with-Moon model and 279 variables for without-Moon model.

A typical set of coefficients of model variables are shown in Table-3 for the 626-variable without-Moon model. There are 8 columns representing planetary pairs and 80 rows for the corresponding angles. As before, naming of the planetary pairs employ characters Pl, Ne, Ur, Sa, Ju, Mr, Ve, Mc and Su for Pluto, Neptune, Uranus, Saturn, Jupiter, Mars, Venus, Mercury and Sun respectively. Thus, Pl-Su represents the planetary pair Pluto and Sun, and Sa-Su represents the planetary pair Saturn and Sun.

The value of the constant in the linear equation of these models as calculated by robust linear regression ranged between 7.13 and 7.30. The simulation results showed that the first two models for each case were almost identical in their performance as the successive omission of coefficients of insignificant magnitude did not seem to degrade the model performance while allowing the data noise reduction. The simulated results along with the actual earthquakes are shown in Figure 3 for these four models, and although not included in the figure due to space limitation, a similar trend exists for all 1672 data points for each model.

Table-3

626 Variables Coefficients for Sun based without Moon Model

Angle Pair-->	**Pl-Su**	**Ne-Su**	**Ur-Su**	**Sa-Su**	**Ju-Sun**	**Mr-Su**	**Ve-Su**	**Mc-Su**
Angle #								
1	-0.198	0.0988	-0.028	-0.002	-0.086	-0.003	0.0421	-0.031
2	0.1097	0.0045	-0.13	-0.005	0.0054	-0.128	0.0055	0.1779
3	0.0564	0.0817	-0.119	-0.047	-0.124	-0.018	0.0209	0.0679
4	-0.086	-0.102	-0.074	0.0669	-0.089	-0.166	-0.036	-0.016
5	0.1389	-0.011	-0.097	-0.101	0.1226	0.0523	0.0617	0.1115
6	-0.055	-0.022	0.0029	0.0296	-0.019	0.0788	-0.028	0.0743
7	-0.05	-0.034	0.1031	-0.333	0.1644	-0.029	0.0162	0.017
8	0.2786	-0.166	-0.012	0.0422	-0.164	0.0672	0.0325	-0.009
9	0.0395	0.0125	-0.079	0.1054	-0.02	0.2319	-0.001	-0.008
10	-0.062	-0.042	0.1274	-0.087	-0.021	0.0363	-0.017	0.008
11	-0.13	0.0616	-0.081	0.1371	-0.1	-0.21	0.0252	0.116
12	-0.087	-0.024	0.0978	0.1069	0.0732	-0.098	0.1205	0.0421
13	-0.023	0.0085	0.0218	-0.044	-0.068	-0.163	0.0628	0.0593
14	-0.128	0.0347	-0.059	-0.025	0.0369	0.0037	-0.02	-0.035
15	-0.15	-0.036	-0.065	-0.044	-0.191	0.0098	-0.051	0.0177
16	-0.107	-0.126	-0.161	0.0781	0.0027	-0.144	-0.155	0.0433
17	0.0686	0.0084	-0.02	-0.166	0.1359	-0.04	0.1619	-0.052
18	-0.037	0.0748	0.0063	0.0119	-0.131	-0.091	0.241	0.0399
19	0.0179	0.0499	-0.003	-0.079	-0.053	0.1049	0.1088	0.0904
20	-0.082	-0.124	-0.101	0.001	-0.006	-0.03	0.0326	0.0167
21	0.0259	-0.128	0.2144	0.1996	-0.128	-0.023	-0.046	-0.06
22	0.1427	-0.066	-0.244	-0.139	-0.011	-0.025	-0.125	0.0143
23	-0.007	-0.158	-0.032	-0.132	0.101	-0.09	0.0115	0.028
24	0.1391	0.0195	-0.092	-0.016	-0.12	0.1051	0.0556	0.1236
25	-0.073	0.13	0.1643	-0.09	0.0351	0.0058	0.0043	-0.094
26	0.1895	-0.071	-0.119	-0.161	-0.23	0.0531	0.0987	0.0685
27	0.0417	0.2122	0.0504	0.1176	-0.069	-0.165	-0.174	0.0276
28	0.0436	0.1148	0.0426	-0.129	0.1424	-0.074	0.0065	-0.011
29	-0.08	0.1045	-0.039	0.1216	-0.054	0.0041	0.0642	0.0103
30	0.0705	-0.172	-0.113	-0.173	-0.017	-0.004	0.0718	0.0644
31	-0.088	0.1849	0.0515	0.0323	-0.013	0.027	-0.111	-0.01
32	0.1887	-0.098	0.0062	0.2461	0.0913	-0.059	-0.049	-0.022
33	-0.121	0.2057	0.0097	0.0736	-0.053	0.2845	-0.037	0.0564
34	-0.254	-0.122	0.0215	0.0098	-0.099	-0.055	-0.035	-0.032
35	0.204	-0.107	0.0772	0.1454	-0.138	-0.252	-0.138	0.1957
36	-0.057	-0.079	-0.061	-0.012	0.0548	-0.079	-0.15	-0.003
37	0.0445	0.1513	-0.105	0.0811	-0.15	-0.068	-0.094	-0.122
38	-0.189	-0.09	-0.02	0.0241	-0.019	-0.094	-0.108	0.036
39	-0.098	-0.331	-0.058	0.1198	-0.092	0.2836	-0.027	0.1806
40	0.1456	0.0783	-0.141	-0.019	0.0326	0.1224	-0.126	0.1485

Table-3 (continue)

626 Variables Coefficients for Sun based without Moon Model

Angle Pair-->	**Pl-Su**	**Ne-Su**	**Ur-Su**	**Sa-Su**	**Ju-Sun**	**Mr-Su**	**Ve-Su**	**Mc-Su**
Angle #								
41	-0.209	0.0254	0.1278	-0.034	-0.109	-0.108	-0.035	0.1423
42	-0.014	0.035	0.1691	-0.166	-0.042	0.0544	0.1327	-0.077
43	0.0087	-0.07	0.1881	0.1004	-0.183	0.0684	0.1363	-0.023
44	-0.029	0.1861	0.0365	0.1293	-0.122	-0.034	0.0138	0.2996
45	0.1482	-0.119	-0.006	-0.015	-0.018	-0.028	-0.158	-0.038
46	0.1378	-0.155	-0.117	0.0021	0.1844	0.0281	0.0286	0.1466
47	0.0951	-0.142	0.2115	-0.158	-0.021	-0.039	-0.092	0.1074
48	-0.122	-0.042	0.1697	0.1262	-0.27	-0.153	0.0515	0.0588
49	-0.039	0.0332	0.0687	0.1278	-0.161	0.1103	0.1575	-0.117
50	-0.233	0.1437	-0.029	0.1012	0.1977	0.1052	0.0489	0.027
51	-0.171	0.0384	-0.172	0.3057	-0.139	0.0569	-0.004	0.1661
52	0.0149	0.003	-0.106	0.0701	-0.148	0.1199	0.0401	0.0438
53	-0.005	0.0443	0.0372	-0.041	0.1402	-0.001	0.0127	0.1565
54	-0.035	0.1867	-0.028	0.0917	0.0004	0.1032	0.0005	0.0656
55	-0.004	-0.084	-0.055	0.3696	0.118	-0.105	0.0153	0.0758
56	-0.239	-0.23	0.0434	-0.077	0.1954	-0.011	0.0047	0.0185
57	-0.02	-0.139	0.1183	-0.154	-0.114	-0.027	-0.154	-0.17
58	0.0823	-0.051	-0.064	-0.001	0.361	0.15	-0.323	0.2512
59	-0.043	0.1748	-0.041	-0.021	0.0823	-0.005	-0.045	0.0314
60	0.0287	-7E-04	0.15	-0.104	-0.052	-0.009	-0.183	-0.043
61	-0.244	-0.068	0.0719	0.0426	-0.051	0.3361	-0.115	0.1631
62	0.164	0.1842	-0.101	-0.029	-0.055	0.3235	-0.105	-0.267
63	0.0832	-0.057	0.0553	0.0333	-0.045	-0.015	0.0057	0.0806
64	-0.074	0.2044	0.0885	0.2698	-0.044	-0.052	-0.066	0.1779
65	0.0821	0.157	0.014	0.0257	0.0825	-0.039	-0.189	
66	-0.157	-0.09	-0.037	0.1177	-0.101	-0.347	-0.209	-0.142
67	-0.069	0.0473	0.2339	0.1718	0.0937	0.2787	0.0061	-0.158
68	-0.044	-0.065	-0.088	-0.13	0.0541	-0.078	0.0715	
69	-0.299	-0.126	0.259	0.0069	-0.075	-0.148	0.023	
70	-0.138	-0.003	0.2856	0.0249	-0.127	-0.122	-0.141	
71	0.0723	0.082	-0.276	0.1373	0.0392	-0.192	-0.188	
72	-0.104	0.2363	-0.106	0.11	-0.065	-0.106	0.0345	
73	0.2283	-0.121	0.0077	0.1318	0.038	-0.26	-0.234	
74	0.1461	0.0153	0.4549	0.2325	-0.228	-0.317	-0.097	
75	-0.028	-0.117	0.1146	0.0578	-0.012	-0.116	-0.166	
76	0.0263	-0.305	0.0935	0.2588	0.0821	-0.013	0.1909	
77	0.3455	0.2034	0.0636	-0.135	0.0483	-0.114	-0.246	
78	-0.015	0.0836	-0.169	-0.094	0.0081	0.1718	0.0014	
79	0.5399	-0.08	0.0272	-0.084	-0.027	-0.1	-0.018	
80	0.2109	-0.089	0.2034	-0.06	0.0715	-0.103	-0.041	

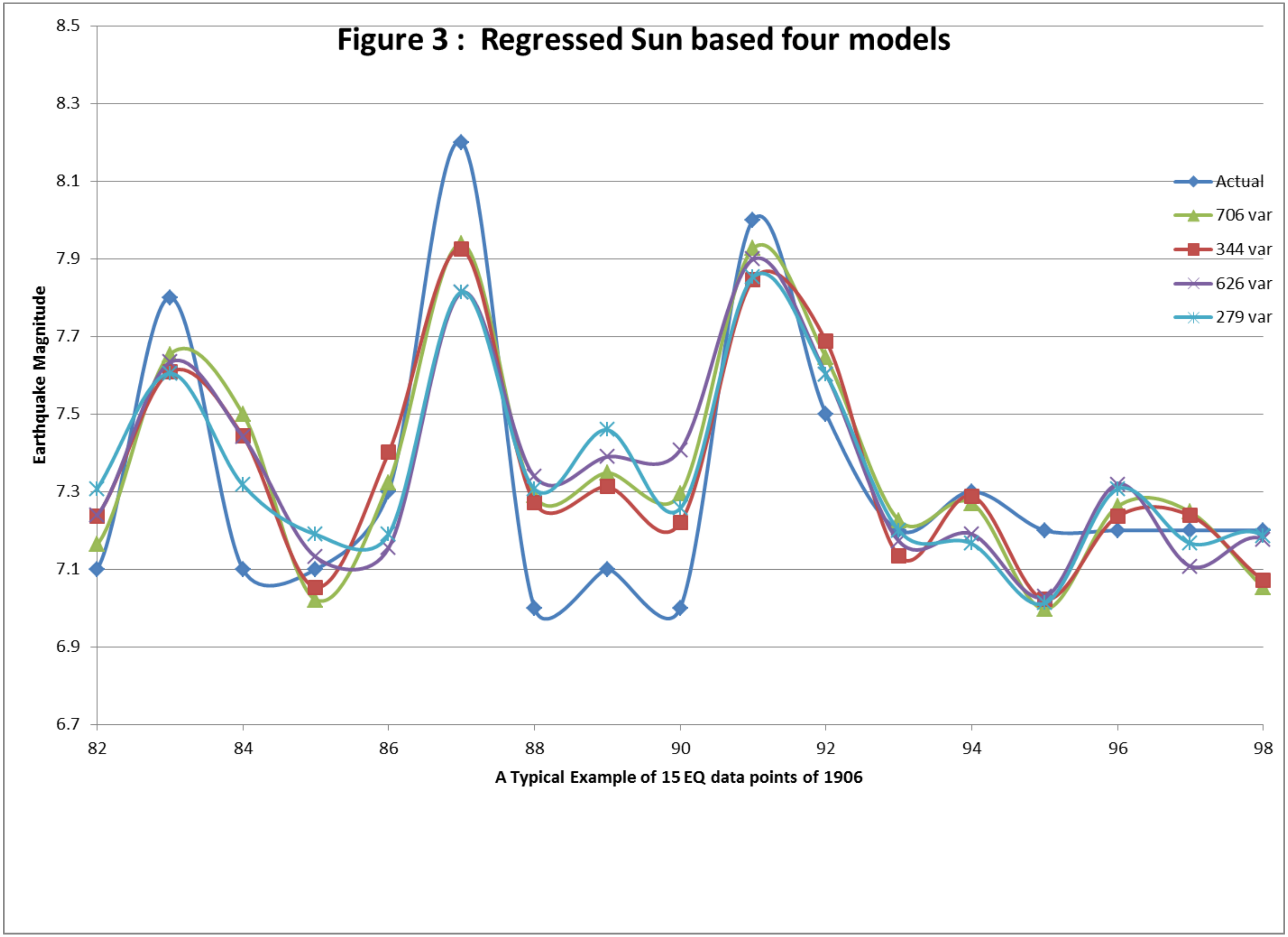
Figure 3 : Regressed Sun based four models
Earthquake Magnitude
8.5
8.3
8.1
7.9
7.7
7.5
7.3
7.1
6.9
6.7
82
84
86
88
90
92
94
96
98
A Typical Example of 15 EQ data points of 1906
Actual
706 var
344 var
626 var
279 var

Using Greenwich noontime daily planetary positions, each sun based model was then used to predict the earthquakes for the year 2011-2014. As for the top 16 most frequently observed angles for each planetary pair model, a summary of assumptions reflecting the limitations described above for the Sun based top 80 frequently observed declination angles form the basis for the models and are listed below:

1. The predicted earthquakes of magnitude less than 7 are ignored since the model is based on the earthquake data set of magnitude 7 and higher. Thus, the prediction dates of an earthquake of magnitude less than 7 also apply for the dates when earthquake did not occur.

2. As pointed out earlier, in order to determine the influence of angles made by Moon with Sun, two sets of models, with-Moon and the without-Moon were developed. The determination of the angles used for each planet with Sun was based on the top 80 most frequently occurred declination angles for earthquakes of seven and higher magnitude during 1900-2009. Thus for each pair of planet with Sun as a common planet, a unique set of 80 declination angles (except of Mercury-Sun only had 66 declination angles) were used in the models.

3. After testing several different orbs for declination angles, a six minute ($1/10^{th}$ of a degree) orb is found to be most satisfactory, and therefore applied for all declination angles

4. Since the predictions (or simulations) were computed on a daily basis corresponding to Greenwich noon, prediction is assumed to apply for the entire date (12 AM to the next 12 AM of Greenwich Time).

5. The minimum number of declination angles required to meet the criteria of realizing the earthquake of magnitude seven or higher must be higher than the daily average number of angles for that year.

6. The models thus obtained when applied to the daily Greenwich Noon declination angles for planets from the year 2011 to 2014 for earthquake predictions, the predicted resulted seem to overestimate the actual earthquakes about by the amount of their corresponding root mean square errors. Therefore, the predictions were corrected with the root mean square errors which ranged from 0.289 to 0.319.

7. It must be noted that the model assumes the dependency on the angles of the planetary pairs with sun as a common planet in those pairs.

Results

As described above, this paper presents Model IV as two separate models, based on declination angle between each planetary pair. The first, the top 16 most frequently occurred declination angles for each one of the 45 planetary pairs for earthquakes of magnitude seven and higher during 1900-2009, and the second one, for the same period during which the earthquakes of magnitude seven and higher occurred, is the top 80 most frequently occurred declination angles for each one of the 9 Sun based planetary pairs with Sun as a common planet in every pair. These models will be referred here as Top 16 all-planet based and the top 80 sun based models. Furthermore each one of these two models there are two sets: with Moon and without Moon model, and each of these four sets have two cases each.

The both models, with two different set each, were tested to predict earthquakes of seven and higher magnitude for the period 2011-2014. For each one of these two models, the best results are provided by the 576 variable no-Moon top 16 all planet based model and the 626 variable no-Moon top 80 sun based model. The dates predicted by these models and the corresponding actual dates on which earthquakes occurred are shown in Figure 4 and are summarized in Table-4 for 2011–2014.

Figure-4 shows that out of the two earthquakes of magnitude 7 and higher that occurred in November 2014, the 576-variable no-Moon top 16 all-planet based model predicts one of them while the 626-variable no-Moon top 80 sun based model accurately predicts both of them. Please note that these models pick 18 and 15 days respectively in November 2014 for the earthquake of magnitude 7 or higher. The previous geocentric longitude based model III picked 14 days for that month and predicted both earthquakes accurately.

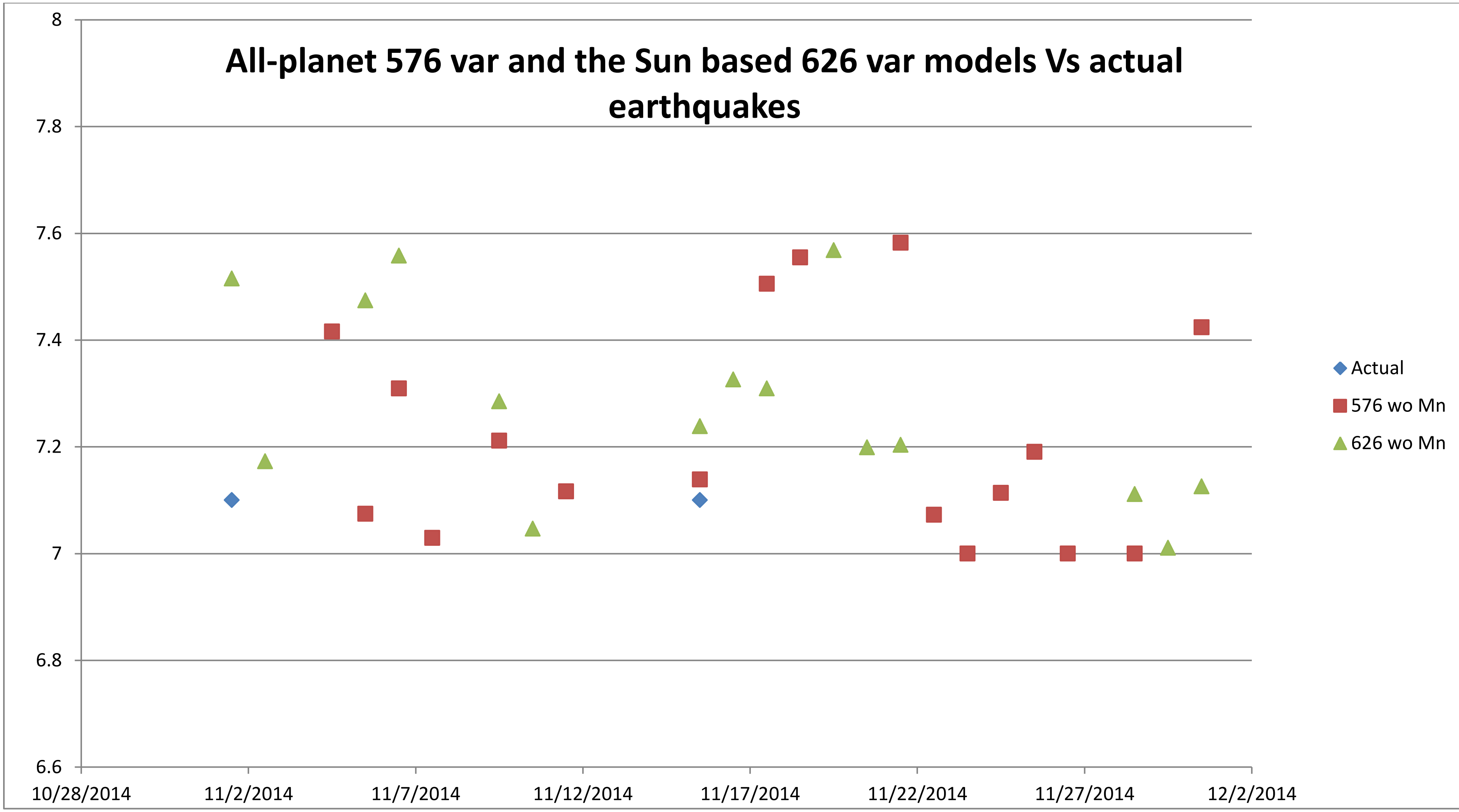

Figure-4 Comparison of 576 top 16 all-planet based and top 80 sun-based variable models predictions and the actual earthquake data for November 2014

Table 4

2011	Model III		Model IV (576 Var) Top 16 all planet based	Model IV (626 Var) Top 80 Sun based
Months	**Prediction Dates**	**Actual Dates**	**Prediction Dates**	**Prediction Dates**
Jan-11	1-6, 12-13, 15-20, 22, 28	**1** (7), **2**(7.2), **13** (7), 18 (7.2)	1-4, 6, 8-12, 14, 16, 18-19, 21-22, 24, 26, 30-31	14-15, 17-18, 22, 24-26, 29-31
Feb-11	1, 6, 8, 14, 16-18, 21-22	None	2, 4, 7, 9, 11-12, 15, 27	2, 4, 9, 12, 17-19, 23
Mar-11	1, 6-8, 11-12, 15, 17-18, 21,26	**9** (7.3), 11(9) Japan	1, 4-5, 9-23, 25, 30	2, 6-9, 15, 18-19, 22, 27, 31
Apr-11	7-9, 14, 25-26	**7** (7.1)	9, 11, 15, 18, 26, 27, 30	2, 6, 15, 17, 30
May-11	1, 3-6, 10, 12, 20-21	None	8, 18, 19	13-14, 18-19
Jun-11	4-7, 10-13, 16, 24, 25, 27	**24** (7.3)	4, 5, 21, 25-26, 29	None
Jul-11	4-7, 10, 13, 15, 19, 21-22, 28, 31	6 (7.6), 10 (7)	1, 3	None
Aug-11	7, 9, 15, 23-25, 27, 29-30	**20** (7.2), **24** (7)	9, 17, 19-20, 23-24, 27	1, 9, 11, 13, 20-21, 23-24
Sep-11	3, 14-15, 18-19, 24, 28,	**3** (7), **15** (7.3)	11-12, 21, 26-28	1, 16
Oct-11	11, 14-15, 24, 31	**21**(7.6), **23**(7.3)	2-3, 5-6, 9-11, 13-14, 17-20, 23-24, 26, 27, 30	3, 9, 11-12, 18-20, 31
Nov-11	6, 10, 14-16, 21-25, 27	None	1, 5, 8, 10, 13-14, 20-21, 24, 30	2, 19
Dec-11	1, 5, 13-16, 18, 21, 23-26, 31	14(7.3)	8, 17, 21	1, 26-27

Table 4 (Continue)

2012	**Model III**		**Model IV (576 Var)** **Top 16 all planet based**	**Model IV (626 Var)** **Top 80 Sun based**
Months	**Prediction Dates**	**Actual Dates**	**Prediction Dates**	**Prediction Dates**
Jan-12	1, 5, 27 and 30	**10**(7.2)	7, 22, 25, 28	12, 15, 18, 21, 28-29
Feb-12	1, 9-10, 14, 17-18, 22-23 and 27	2 (7.1)	3-5, 14	1, 4, 6, 10, 14, 16, 18, 21-22, 24, 26
Mar-12	1, 7-8, 13,15-16, 18, 20-21, 26, 28-31	**20**(7.4), 25(7.1)	25	1, 7, 14, 19, 22, 23
Apr-12	21-22 and 26-27	**11**(8.6), 12(7)	None	3, 7, 9, 11, 13-14, 17, 25
May-12	1, 5 and 19-20	None	20	3, 10, 13, 15
Jun-12	7, 21-22 and 28-29	None	3, 6, 18, 21	1
Jul-12	2, 10-12, 19, 21, 23-24 and 26	None	23, 26	3-4, 13, 28
Aug-12	9-12, 20-23 and 27-29	14(7.7), 27(7.3), 31(7.6)	9	2, 4, 6, 9, 15, 25, 27, 29
Sep-12	11, 14-16, 19, 27, 30	5(7.6), 30(7.3)	21, 23, 27	6, 8
Oct-12	1-6, 9, 12-13, 16-17, 19-22, 24-26, 28 and 30	28(7.8)	21, 26,	1, 3, 5-8, 13, 16-17, 25, 28, 30
Nov-12	2-5, 7, 16, 22, 24 and 30	7(7.4)	14, 16, 22, 26-27	2-5, 8, 13-14, 15, 22, 25-26
Dec-12	1, 7, 13, 20, 23 and 25-27	7(7.3), 10(7.1)	3, 5-6, 8-10, 13-14, 18, 20, 23, 28-31	8-9, 14, 18, 25, 27-28

Table 4 (Continue)

2013	**Model III**		**Model IV (576 Var) Top 16 all planet based**	**Model IV (626 Var) Top 80 Sun based**
Months	**Prediction Dates**	**Actual Dates**	**Prediction Dates**	**Prediction Dates**
Jan-13	1, 3-5, 8, 13-15, 22-25	5(7.5)	2-3, 5-20, 22-23, 25, 27-28, 31	4, 9-10, 12, 14, 16-22, 26, 28-29
Feb-13	2, 10-13, 15, 18 , 25-28	6(8), 8(7.1)	1, 4-5, 8-10, 13, 16-17, 24	2-3, 7-13, 16-18, 20-22, 25-28
Mar-13	1, 7, 10-13, 16-19, 21, 30-31	None	5, 21, 24, 28	8-9, 11-12, 14-15, 18-19, 21, 26, 28, 30-31
Apr-13	5, 8-9, 13-14, 16, 20-21, 25-28, 30	6(7), 16(7.7), 19(7.2)	1, 3, 12, 14-15, 19-20, 22	8-9, 11, 19, 26, 28-30
May-13	1-2, 4, 6-7, 12, 16-18, 20, 23, 29-30	23(7.4), 24(8.3)	11-12, 15-23, 26-27	4, 8, 11-13, 17, 20, 24-26, 28, 31
Jun-13	1, 3, 14, 16, 19, 22-24, 27, 30	None	2-4, 7-8, 11, 15, 18, 20, 25	4-6, 11-13, 27-29
Jul-13	1, 4-5, 7-8, 12-13, 15, 17-19, 23	7(7.3), 15(7.3)	3, 6-9, 11-12, 20-21, 23, 25	6-7, 12, 15-16, 20, 24, 28, 31
Aug-13	1-6, 10, 12, 14, 18, 22, 29-30	30(7)	1, 28	1-2, 9, 16, 23-25
Sep-13	2, 8, 15, 18, 21, 23, 26-28,	24(7.7), 25(7.1)	1-4	4, 5, 7, 14, 16, 24
Oct-13	1, 3, 6-8, 10-13, 16-19, 22, 26, 28, 30-31	15(7.1), 25(7.1)	19	1, 5, 8-10, 12, 14-16, 20, 22-23, 26, 29
Nov-13	3, 7-9, 11-13, 15-18, 23, 25-28	17(7.7), 25(7)	4, 5	2-4, 7, 10, 12-13, 15, 17-19, 23, 28-29
Dec-13	6, 14, 16-17, 20-22, 25-26, 28-29	None	1, 6-7, 9-10, 14, 17, 21, 30-31	3, 5-6, 8, 16, 21

Table 4 (Continue)

2014	**Model III**		**Model IV (576 Var)** **Top 16 all planet based**	**Model IV (626 Var)** **Top 80 Sun based**
Months	**Prediction Dates**	**Actual Dates**	**Prediction Dates**	**Prediction Dates**
Jan-14	4, 19, 24 and 27-28	None	6, 8, 14, 19, 21-28, 31	11, 15, 24-25, 29-31
Feb-14	6, 18-19 and 24	None	2-5, 7, 9, 17-28	1, 5, 7-9, 11, 13-14, 17-19, 21-22, 25, 27
Mar-14	1, 3-5, 8-10, 12-17, 19-28 and 30-31	None	1-2, 9-13, 20-21, 24-25	2, 6, 11, 13, 18, 20, 23, 27, 30
Apr-14	1-3, 7-13, 15, 17-18, 20-21, 26-27 and 30	1(8.2), 3(7.7), 11(7.1), 12(7.6), 13(7.4), 18(7.2), 19(7.5)	3, 17	2, 6, 18, 21
May-14	1, 5, 7-8, 10-15, 17-18, 24, 26 and 31	None	None	1, 7, 8, 10, 29
Jun-14	6-7, 19, 21, 23 and 25-26	23(7.9)	22-23, 27-29	17, 23-24, 26-27
Jul-14	1, 8, 10, 13-20, 22-23, 25 and 28	None	2, 7-8, 13-14, 16-18, 20, 22-25, 27-28	11-12, 24, 30
Aug-14	2, 12, 24-25 and 27-28	None	4-5	1, 6, 21, 27
Sep-14	1-2, 6, 12, 15, 20, 22, 24, and 26-27	None	26	16, 19, 30
Oct-14	8-9, 11-12, 14-15, 17, 19, 20-23, 27-28 and 30-31	9(7), 14(7.3)	12-13, 17-18, 20	1-3, 6, 8-9, 11-12, 14, 16, 18, 26-28, 30
Nov-14	1-2, 5-8, 10, 12, 15-17, 23-24 and 26	1(7.1), 15(7.1)	4-7, 9, 11, 15, 17-19, 21-26, 28, 30	1-2, 5-6, 9-10, 15-17, 19-21, 28-30
Dec-14	3-7, 9-11, 16, 18, 25 and 28-29	None	1-4, 6-11, 14, 16-21, 24-27	1, 5, 9-11, 26, 28, 30

Earthquake Predictions for 2011-2014 of magnitude 7 or higher

The Table 4 lists the prediction dates for Model III and two types (576 variable top 16 all-planet and 626 variable top 80 sun based) of Model IV and the actual dates on which the earthquakes of magnitude 7 or higher occurred for the period starting from January 2011 through December 2014. The first two columns in Table–2 list months and the prediction dates for Model III for the corresponding months. The next column lists the dates on which earthquakes occurred with magnitude shown in the parentheses. If the prediction date matches the actual date, the prediction date is highlighted in red in the prediction column. The last two columns in Table-4 list the prediction dates for two types of Model IV. Again, if the prediction date matches the actual date, the prediction date in these columns is highlighted in red.

As shown in Table-4, the overall monthly predicted dates ranged between 0 to 24 days for both Model III and Model IV with monthly average predicted dates were about the same for both Model III and Model IV. In other words the model rules out, on monthly average basis, between 16 to 22 days.

Model III

Table-5 summarizes the results for the earthquakes of magnitude 7 or higher for Model III. The first two columns in Table-4, the years and the corresponding number of predicted dates are listed. In the next two columns the number of successful predicted earthquakes and the number of earthquakes occurred are shown. The fifth column shows the ratio of predicted days with the total number of days for that year. The last column lists the calculated probability. The probability calculations are based on the binomial distribution probability and are calculated using the Microsoft Excel statistical function BINOM.DIST, according to this function the probability is calculated as:

Calculated probability = 1-BINOMDIST (# of hits-1, actual # of EQs, predicted days/365, TRUE)

Thus, for year 2011 there were 17 earthquakes of magnitude 7 or higher and the 720 variable without-Moon model, by picking 71 days out of 365, correctly predicted 9 earthquakes. The probability of that prediction according binomial probability distribution is 0.2 percent. In other words, there is only 0.2 percent chance to correctly predict 9 out of 17 earthquakes by picking 71 days out of 365.

For each of the four models (or cases), the overall probability of prediction for the four years (2011-2014) is also shown at the bottom of each model. It ranged from 0.4 percent (0.004) to 45 percent (0.45), with the best performance by the 720 variable model no-Moon Model. Note that as the probability number decreases the model performance improves.

Table-5

Model III

(Two sets: with and without Moon Models with two cases each)

Year and Model	P days	No. of Hits	Actual No. of EQs	P days/Total	Probability
					Bionomial
880 Var Model					
2011	108	11	17	0.29589	0.002866
2012	38	3	15	0.103825	0.198989
2013	84	3	17	0.230137	0.786237
2014	98	4	12	0.268493	0.40901
Overall	328	21	61	0.224658	0.022156
410 Var Model					
2011	116	6	17	0.317808	0.467002
2012	96	4	15	0.262295	0.582224
2013	104	7	17	0.284932	0.184442
2014	124	8	12	0.339726	0.021157
Overall	440	25	61	0.30137	0.046638
720 Var wo Mn Model					
2011	71	9	17	0.194521	0.002107
2012	53	3	15	0.144809	0.373061
2013	116	4	17	0.317808	0.839101
2014	104	8	12	0.284932	0.006746
Overall	344	24	61	0.235616	0.004347
280 Var wo Mn Model					
2011	83	4	17	0.227397	0.562633
2012	104	3	15	0.284153	0.84392
2013	104	7	17	0.284932	0.184442
2014	96	3	12	0.263014	0.648549
Overall	387	17	61	0.265068	0.452833

Further, the Model III was improved by combining 410 variable with-Moon model case with the 720 variable without-Moon model case. The results of the combined model are shown in Table 6. The overall probability of the combined model for the four year period is 0.017 percent as opposed to the best performing 720 variable without-Moon model with 0.4347 percent overall probability. This improvement is due to the fact that there was a great deal of overlap for the prediction dates and the only 11 out of 38 earthquakes were predicted by the both model cases.

Table-6

Model III (Combined 410 and 720 variable models)

Year	P days	No. of Hits	Actual No. of EQs	P days/Total	Probability
					Bionomial
2011	135	13	17	0.369863	0.001081
2012	115	6	15	0.314208	0.321263
2013	154	8	17	0.421918	0.431439
2014	162	11	12	0.443836	0.000937
Overall	566	38	61	0.387671	0.00017

Model IV

(Top 16 most frequently occurred declination angles)

Table-7 summarizes the results for the earthquakes of magnitude 7 or higher for Top 16 most frequently occurred declination angles of Model IV. The first two columns in Table-7, the years and the corresponding number of predicted dates are listed. In the next two columns the number of successful predicted earthquakes and the number of earthquakes occurred are shown. The fifth column shows the ratio of predicted days with the total number of days for that year. The last column lists the calculated binomial probability. Thus, for year 2011 there were 17 earthquakes of magnitude 7 or higher, and the 576 variable without-Moon model, by picking 110 days out of 365, correctly predicted 8 earthquakes. The probability of that prediction according binomial probability distribution is 10.7 percent. In other words, there is only a 10.7 percent chance to correctly predict 8 out of 17 earthquakes by picking 110 days out of 365days.

Table-7

(Two sets: with and without Moon Models with two cases each)

Year and Model	P days	No. of Hits	Actual No. of EQs	P days/Total	Probability Bionomial
720 Var Model					
2011	122	6	17	0.334247	0.525559
2012	48	2	15	0.131148	0.603758
2013	98	6	17	0.268493	0.293885
2014	111	1	12	0.30411	0.987103
Overall	379	15	61	0.259589	0.643996
308 Var Model					
2011	114	5	17	0.312329	0.653017
2012	58	1	15	0.15847	0.92483
2013	103	6	17	0.282192	0.340441
2014	111	2	12	0.30411	0.91947
Overall	386	14	61	0.264384	0.774203
576 Var wo Mn Model					
2011	110	8	17	0.30137	0.107008
2012	42	2	15	0.114754	0.52689
2013	99	5	17	0.271233	0.506897
2014	111	3	12	0.30411	0.75691
Overall	362	18	61	0.247945	0.236792
244 Var wo Mn Model					
2011	164	7	17	0.449315	0.7078
2012	84	2	15	0.229508	0.890515
2013	155	7	17	0.424658	0.633086
2014	133	4	12	0.364384	0.691173
Overall	536	20	61	0.367123	0.777431

For each of the four models (cases), the overall probability of prediction for the four years (2011-2014) is also shown at the bottom of each model case. It ranged from 23.7 percent

(0.2367) to 77 percent (0.777), with the best performance by the 576 variable case (23.7 percent) no-Moon Model. Note that as the probability number decreases the model performance improves.

Model IV

(Top 80 most frequently occurred sun based declination angles)

Table-8 summarizes the results for the earthquakes of magnitude 7 or higher for Top 80 most frequently occurred, sun based declination angles of Model IV. The first two columns in Table-8, the years and the corresponding number of predicted dates are listed. In the next two columns the number of successful predicted earthquakes and the number of earthquakes occurred are shown. The fifth column shows the ratio of predicted days with the total number of days for that year. The last column lists the calculated binomial probability. Thus, for year 2014 there were 12 earthquakes of magnitude 7 or higher, and the 626 variable without-Moon model, by picking 94 days out of 365, correctly predicted 6 earthquakes. The probability of that prediction according binomial probability distribution is 6.2 percent. In other words, there is only a 6.2 percent chance to correctly predict 8 out of 17 earthquakes by picking 94 days out of 365days.

For each of the four models (cases), the overall probability of prediction for the four years (2011-2014) is also shown at the bottom of each model case. It ranged from 6.2 percent (0.062) to 77.7 percent (0.776), with the best performance by the 626 variable case (6.2 percent) no-Moon Model.

Table-8

(Sun based -Two sets: with and without Moon Models with two cases each)

Year and Model	P days	No. of Hits	Actual No. of EQs	P days/Total	Probability
					Bionomial
706 Var Model					
2011	86	5	17	0.23561644	0.371213
2012	61	2	15	0.16666667	0.740378
2013	85	5	17	0.23287671	0.360838
2014	75	3	12	0.20547945	0.460997
Overall	307	15	61	0.21027397	0.292076
344 Var Model					
2011	119	6	17	0.3260274	0.496399
2012	96	6	15	0.26229508	0.176748
2013	120	5	17	0.32876712	0.704977
2014	105	4	12	0.28767123	0.469201
Overall	440	21	61	0.30136986	0.273527
626 Var wo Mn Model					
2011	62	4	17	0.16986301	0.324495
2012	80	3	15	0.21857923	0.668299
2013	132	8	17	0.36164384	0.24399
2014	94	6	12	0.25753425	0.061994
Overall	368	21	61	0.25205479	0.068667
279 Var wo Mn Model					
2011	67	2	17	0.18356164	0.84656
2012	69	3	15	0.18852459	0.55773
2013	63	0	17	0.17260274	#NUM!
2014	137	7	12	0.37534247	0.118266
Overall	336	12	61	0.23013699	0.77655

Conclusions

Table-9 summarizes the results for the Model III and two types of Model IV by choosing the best performing model case in each case.

Table-9
(Result Summary)

	P days	No. of Hits	Actual No. of EQs	P days/Total	Probability
					Bionomial
Model III					
Combined 410 and 720 Var					
2011	135	13	17	0.369863014	0.001081403
2012	115	6	15	0.31420765	0.321262502
2013	154	8	17	0.421917808	0.431439292
2014	162	11	12	0.443835616	0.000937109
Overall	566	38	61	0.387671233	0.000170104
Model IV					
All planet top 16 - 576 Var case					
2011	110	8	17	0.301369863	0.107008142
2012	42	2	15	0.114754098	0.526889881
2013	99	5	17	0.271232877	0.506896736
2014	111	3	12	0.304109589	0.756910006
Overall	362	18	61	0.247945205	0.236792127
Model IV					
Sun based top 80 - 626 var case					
2011	62	4	17	0.169863014	0.324495448
2012	80	3	15	0.218579235	0.668298685
2013	132	8	17	0.361643836	0.24399028
2014	94	6	12	0.257534247	0.061993861
Overall	368	21	61	0.252054795	0.06866742

From the results of probability calculations as listed in Table-9, it can be noted that by minimizing the number of prediction days for the same amount of hits (correctly predicted earthquakes) the model performance improves. Alternately for the same amount of prediction dates the model performance improves if the number of hits increases.

It is interesting to note that all the best performing model cases of Model III and Model IV include the without-Moon model cases. The 720 variable without-Moon case in combination with 410 variable with-Moon case for Model III; and 576 variable without-Moon case for top 16 all planet Model IV and 626 variable without-Moon case for sun based Model IV belong to only without-Moon model cases. As indicated earlier in this paper, the fact that Moon's average daily variation is about 2 declination degrees it can form almost equal number of angles with every other planet during a daily twenty-four hour period thereby nullifying influence of Moon is reflected in these model cases.

Compared to the Model III performance, where the combined 410 with-Moon model case with 720 variable without-Moon model case has the probability of 0.017 percent, the best case of top 16 frequently occurred 576 variable without-Moon case of Model IV performed three orders of magnitude poorly with 23.7 percent probability and the best case of top 80 sun based 626 variable without-Moon case of Model IV performed about two order of magnitudes poorly with 6.8 percent probability.

Clearly, the top 16 frequently occurred 576 variable declination angle Model IV with 23.7 percent probability is not significant in correlating the earthquakes of magnitude seven and higher with the declination angles of all planetary pairs. The sun based top 80 frequently occurred declination angle model IV with 6.8 percent probability is at least one order of magnitude better than the random chance (100% probability). In other words, compared to Model III, the Model IV performance is mediocre; and between the two best cases of Model IV, the sun based 626 variable model IV is better than the top 16 frequently occurred 576 variable model.

It is important to recognize that the model performance varies from one year to the next. The performance of Model III is significantly enhanced for 2014 by correctly predicting 11 out of 12 earthquakes by picking 162 days out of 365 for that year.

The model performance for both Model III and Model IV may need to be observed over a long period of time to confirm the consistency of their performance. Nonetheless, the Model III consistently performed better over all the Model IV cases for 2011-2014.

For the model to be applied for earthquakes of magnitude 7 and higher to predict over a narrower range of days would require further improvement and therefore, more research work is warranted. In addition, further research is necessary regarding the locations of earthquakes.

Appendix A

Top 16 most frequently occurred declination angles for all 45 planetary angle pairs

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Pl-Ne		33.6	34	2.8	4.4	8.6	33.8	33.2	34.2	3.2	4.2	5	6.6	35	1.2	3.4	4.6
2	Pl-U		0.4	0.6	38.8	38.6	0.2	0	38.4	2.6	22.2	39	12.6	10.4	14.6	25.2	1.6	4.4
3	Pl-Sa		3.8	36	4.2	4.4	1.2	1.6	44.4	3.2	3.4	35.8	0.2	1.8	7.6	43.4	44.2	1.4
4	Pl-Jup		1	8	1.4	4.2	5.2	6.8	7.6	0.6	5	7.4	7.8	0.4	3.4	1.8	4	4.6
5	Pl-Mr		0.4	1.4	2.2	0.8	2.8	3.6	2.6	0.2	1.2	1.8	3.2	5.4	1	1.6	4	5
6	Pl-Ve		1.2	2.4	3.4	4.2	5.2	1.8	2.6	0.2	0.6	1	2.2	2.8	3.2	6.8	0.4	5.4
7	Pl-Mc		0.2	0.4	1	5.8	0.8	3.6	4.8	10.4	0.6	1.4	2	2.6	3	4.2	6.4	7.6
8	Pl-Sun		0.4	1	1.4	0.8	3	0.2	5.4	1.2	2.2	2.8	2	4	11.6	40.2	0.6	3.6
9	Pl-Mn		2.6	0.2	2.4	9.6	0.8	5.8	3	3.2	3.4	1.4	2	2.8	3.8	4.8	6	6.6
10	Ne-U		1.6	1.4	0.8	45.8	0.2	1	1.2	0.4	0.6	46	45.6	5.8	44.2	26.2	10.2	29.2
11	Ne-Sa		2.6	0.2	2.2	0.8	10.2	0.6	2.8	32.2	39.8	1	6.6	34.4	22.2	23.6	1.6	8.6
12	Ne-Jup		1	1.2	0.8	4.6	7.2	6.6	20.8	2.4	0.6	13.4	0.2	1.4	2.8	3.6	7.6	7.8
13	Ne-Mr		1.4	1.6	3	2.2	3.4	4	8.6	0.6	0.8	2	2.4	0.2	1.8	3.2	5	5.2
14	Ne-Ve		1.8	2.4	3.4	4.4	4.6	0.2	5	15.4	0.4	1	3.2	1.4	2	3	35.6	0.8
15	Ne-Mc		1.8	8	0.2	2	2.4	1.6	2.2	2.8	7.2	31.8	1.2	2.6	3.2	3.4	3.6	7.4
16	Ne-Sun		0.4	1.2	0.2	1	4.4	0.8	1.4	1.6	2.6	3	15.8	0.6	2.4	4.6	6	1.8
17	Ne-Mn		3	2.4	6	1	3.2	5	32.8	0.8	2	2.2	5.8	0.2	0.6	2.6	5.2	6.8
18	Ur-Sa		0.4	31.8	0.2	0.8	0.6	19	1.4	2.4	36	1	29	31.2	39.6	39.8	1.2	3
19	Ur-Jup		0.6	0.2	2.6	0.8	36.8	2.8	16	17.8	0.4	3	17.4	16.6	18.2	46.4	1	17
20	Ur-Mr		0.4	3.2	1.4	19.6	16.4	1	3.8	1.6	3.6	4	0.2	0.6	2.8	5.2	5.4	6.6
21	Ur-Ve		3.2	4.6	7	2.4	3	5.8	9.4	13.4	2.8	7.6	0.2	0.6	0.8	2	2.6	4.2
22	Ur-Mc		2.8	6.6	6.4	1.6	0.4	1	2.2	3	0.2	0.6	4.2	5.6	0.8	1.2	2.6	5.8
23	Ur-Sun		0.2	2	1	1.2	1.8	2.6	3	12.4	0	2.2	2.4	3.2	3.8	1.4	8.2	10.4
24	Ur-Mn		3	0.4	0.6	8	1	2.2	17.6	1.6	1.8	4.6	5	6	10.6	14	2.8	3.2
25	Sa-Jup		0.8	1.4	10.4	1	5.6	23.4	2.4	3.2	8.6	0.4	0.6	3	9.6	6.8	8.8	2.6
26	Sa-Mr		4.2	1.4	2	4.4	7.4	1.2	2.4	5.2	9.4	0.8	4.8	5.8	8.6	1.6	1.8	2.2
27	Sa-Ve		2.8	0.4	4	2.2	2.4	2.6	3.6	3.8	4.2	8.6	0.6	1.4	4.8	5.8	0.2	1.8
28	Sa-Mc		9	2.2	0.8	2.8	4	0.6	1.4	2	2.4	9.4	1.6	2.6	5.8	6.4	11	12.8
29	Sa-Sun		0.8	0.4	0.2	1.4	8.2	2.4	1.8	2	1	0.6	1.2	3.6	3.8	8.6	12.6	2.8
30	Sa-Mn		1.2	4	5.6	1.4	5.2	7.2	21.8	4.2	5.8	29.8	0.4	5.4	6.6	9.6	14	14.8
31	Ju-Mr		1	0.6	1.2	1.6	3.4	1.8	3.2	3.6	1.4	2	10	2.4	5	4.6	6.4	8.4
32	Ju-Ve		2.4	0.6	1.8	0.4	2.2	1	2	1.2	6.4	8.6	15	1.6	3.8	2.8	7.8	4
33	Ju-Mc		1.6	1.4	2	7.6	0.6	3.6	4.4	1.2	2.6	6.2	0.2	5.8	0.4	1	2.2	2.4
34	Ju-Sun		0.6	2.2	0.2	1.4	0.8	2	7.2	0.4	1	1.2	3.8	2.4	2.6	3.6	3	3.2
35	Ju-Mn		4.2	9.4	3	3.4	4.6	6.4	13	3.6	0.2	2	3.8	4.4	5	7	10.6	27.2
36	Mr-Ve		1	3	0.6	1.8	0.8	2.6	4	6.4	0.2	1.6	0.4	3.2	4.6	8.6	10	11
37	Mr-Mc		1.2	0.4	3.2	3.4	1.8	0.8	5.8	3	4.4	4.2	0.2	3.8	5.4	8.6	9	3.6
38	Mr-Sun		0.8	0.2	0.6	1.8	13.8	3.4	3.6	4	4.2	1.2	3.2	4.6	11.6	0.4	1.6	2.4
39	Mr-Mn		4.6	2.2	2.8	3	6	1.2	1.8	9.6	2.4	3.2	4.4	5.4	6.2	7.4	8.8	0.2
40	Ve-Mc		0.4	0.6	3.6	1.6	2	3	1.8	1.2	2.4	2.6	5.2	2.2	0.8	0.2	1	2.8
41	Ve-Su		0.2	0.8	0.4	3.6	0.6	1	1.2	2.6	6.6	1.4	2.8	4.8	1.6	3.2	4.6	4.4
42	Vn-Mn		0.2	1	2.2	4	5.2	4.4	14.8	1.2	1.4	3	6.2	6.8	7.8	18.8	2.8	4.6
43	Mc-Su		1.8	2.6	2.2	1.2	1.4	2.8	2.4	0.8	1.6	3.6	3.4	4.2	0.4	1	5	0.2
44	Mc-Mn		2.8	1.8	3	8.8	3.8	4.4	5.4	13.4	11	18	21	1.4	2.4	5.6	7.4	9.8
45	Su-Mn		2	1.4	3	4.4	5.4	1.2	2.2	2.4	3.8	5.8	7	9.6	2.8	5.2	6	7.6

Appendix B

Top 80 most frequently occurred declination angles for 9 Sun based angle pairs

	Top 80 Sun based Declination Angle Numbers for each pair								
	Pl-Sun	Ne-Sun	Ur-Sun	Sa-Sun	Ju-Sun	Mr-Sun	Ve-Su	Mc-Su	Su-Mn
	1	2	3	4	5	6	7	8	9
1	0.4	0.4	0.2	0.8	0.6	0.8	0.2	1.8	2
2	1	1.2	2	0.4	2.2	0.2	0.8	2.6	1.4
3	1.4	0.2	1	0.2	0.2	0.6	0.4	2.2	3
4	0.8	1	1.2	1.4	1.4	1.8	3.6	1.2	4.4
5	3	4.4	1.8	8.2	0.8	13.8	0.6	1.4	5.4
6	0.2	0.8	2.6	2.4	2	3.4	1	2.8	1.2
7	5.4	1.4	3	1.8	7.2	3.6	1.2	2.4	2.2
8	1.2	1.6	12.4	2	0.4	4	2.6	0.8	2.4
9	2.2	2.6	0	1	1	4.2	6.6	1.6	3.8
10	2.8	3	2.2	0.6	1.2	1.2	1.4	3.6	5.8
11	2	15.8	2.4	1.2	3.8	3.2	2.8	3.4	7
12	4	0.6	3.2	3.6	2.4	4.6	4.8	4.2	9.6
13	11.6	2.4	3.8	3.8	2.6	11.6	1.6	0.4	2.8
14	40.2	4.6	1.4	8.6	3.6	0.4	3.2	1	5.2
15	0.6	6	8.2	12.6	3	1.6	4.6	5	6
16	3.6	1.8	10.4	2.8	3.2	2.4	4.4	0.2	7.6
17	1.6	6.8	1.6	3.2	5.6	2.6	3	4.6	16.6
18	2.6	8.2	4.4	6.2	7.8	6.4	2.2	6.2	20.6
19	6.4	21.8	7.6	2.2	0	5.6	2.4	2	0.4
20	8	30	13.2	2.6	5.8	6.8	3.8	3	0.8
21	6.6	3.2	0.4	3	6.4	9	5.8	7.2	3.2
22	7.2	3.6	0.8	5.2	8.8	11.2	6.2	0.6	3.6
23	7.6	5.6	2.8	17.4	3.4	1.4	8.8	3.2	4.8
24	1.8	14.4	3.6	4.2	4	2.2	4	5.2	10
25	4.4	17.8	4.8	4.6	7.6	2.8	4.2	5.4	12.2
26	4.6	45.4	5.2	5.4	9.6	3.8	5.4	5.8	0.2
27	5.2	2	5.6	5.8	11.2	5	11.2	6	1
28	6.2	2.2	5.8	6.8	11.4	6.6	1.8	6.6	4.6
29	6.8	2.8	6.6	9	11.6	2	8.4	6.8	6.2
30	9.6	3.4	7.2	10	11.8	5.8	0	3.8	6.6
31	12.8	4	7.4	12	12	7.2	6.4	4.4	7.8
32	15.2	4.2	10.8	1.6	13.8	7.4	8	4.8	8
33	42.2	6.6	11.2	5	16	8.6	7.4	7.4	8.2
34	45.8	7.4	13.4	6.6	1.6	13.2	16.6	8.8	8.4
35	5	7.6	14.6	9.4	10.8	3	6	4	10.8
36	7.8	8.8	17.6	12.2	12.8	5.4	10.8	5.6	11.4
37	8.2	12.6	38.4	17	13.4	8	12.6	8.2	12.4
38	16	15	0.6	19.8	15.4	0	17.2	6.4	23.4
39	17	16	4	4.8	17.2	11	5	7.6	35.8
40	19.2	16.2	5	7	19.4	15.8	5.6	7.8	3.4

Appendix B (Continue)

	Top 80 Sun based Declination Angle Numbers for each pair								
	Pl-Sun	Ne-Sun	Ur-Sun	Sa-Sun	Ju-Sun	Mr-Sun	Ve-Su	Mc-Su	Su-Mn
	1	2	3	4	5	6	7	8	9
41	36.8	20.6	6	9.2	22.2	16.2	9	8.4	4
42	37.4	29.4	8	14	4.6	21	9.2	7	5.6
43	38.8	3.8	9.4	15.4	5.2	1	9.4	9	6.4
44	3.4	5.2	9.6	15.6	6	4.4	12.8	12.2	11.6
45	3.8	7.2	11.6	16.6	6.2	4.8	7	0	12.8
46	4.8	9.8	18.8	18.2	8	5.2	9.8	8	13.8
47	5.6	11.4	19	22.6	10.6	6	10.2	8.6	14.2
48	5.8	14.6	24.4	22.8	13.2	7	12	9.6	15.2
49	7	14.8	26.2	30.6	15.2	8.8	2	9.8	15.8
50	10.4	18.2	4.6	36.6	16.6	10.4	6.8	10.2	17.6
51	11.4	19.4	5.4	3.4	16.8	10.8	7.6	12.4	18.6
52	11.8	23.6	6.2	4	19	11.4	8.2	9.2	19.4
53	21.2	25.2	6.4	7.2	31	11.8	10.4	9.4	24.4
54	26.8	32.8	7	7.4	32.4	15.2	10.6	10	4.2
55	34	37	11.4	8	1.8	15.4	11.8	11.2	6.8
56	34.6	39.6	12.2	8.8	4.2	15.6	14.4	11.8	9.2
57	42.6	5.8	12.6	11	5	16	15	12.6	11.8
58	2.4	7.8	13.6	11.2	5.4	20.4	16.8	11.6	15.4
59	4.2	8.4	14.4	11.4	6.6	7.6	7.8	10.4	15.6
60	7.4	11.2	14.8	11.8	8.2	12.4	10	10.6	17.8
61	8.8	13.6	17.2	13.6	8.4	18.4	11	10.8	18.4
62	9.2	16.8	21.2	14.2	9.8	22.6	11.4	12.8	19.6
63	12.2	17.4	22.6	14.8	10.4	27.4	11.6	12	20
64	14	19	24	16.2	12.2	9.8	14	13.2	21.4
65	14.2	21.6	25.6	16.8	15	14	14.8	11.4	23.8
66	19.4	23	34.6	17.2	17.4	14.2	15.4	13	25
67	21.8	36.6	40.4	18.8	18	15	15.8	11	34.4
68	24.2	38	43.6	21.6	19.8	19.6	17		37.6
69	24.4	38.8	4.2	24.2	20.4	19.8	3.4		38.2
70	24.8	4.8	6.8	24.6	22.6	25.4	5.2		38.4
71	25.8	6.2	7.8	31.4	23.6	7.8	7.2		39.8
72	27.6	6.4	8.4	32.6	25.6	8.4	9.6		41.8
73	30.2	9	9.2	39	28.2	9.2	13		0.6
74	30.4	9.2	10.2	5.6	29.4	9.6	13.2		2.6
75	33.4	10.2	13.8	12.4	29.6	10.6	13.8		9.8
76	33.6	10.6	16.2	13	30.4	12.2	16		11.2
77	35.2	11	17	13.8	33.8	16.8	13.6		12.6
78	36	11.6	17.4	15.8	2.8	17.4	16.2		13.2
79	37	13.8	18	18.4	4.4	17.6	12.4		13.4
80	38.2	14	19.6	19.2	4.8	19	16.4		14

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