ANALYSING THE SPATIO-TEMPORAL LINK BETWEEN EARTHQUAKE OCCURRENCES AND ORBITAL PERTURBATIONS INDUCED BY PLANETARY CONFIGURATION

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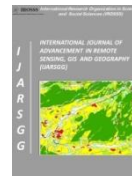Jeganathan Chockalingam

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ANALYSING THE SPATIO-TEMPORAL LINK BETWEEN EARTHQUAKE OCCURRENCES AND ORBITAL PERTURBATIONS INDUCED BY PLANETARY CONFIGURATION

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ABSTRACT: The study has analysed the spatio-temporal positions (helio-centric and geo-centric) and configurations of all the planets on every day basis over the whole year 2015. Gravitational forces are invisible and undetectable, and hence it is very difficult to map the presence of these forces. The study has made a bold attempt in conceptualising indirect way of detecting spatial locations and understanding these gravity forces through earth quake events. The study has found that there are very clear evidences of planetary configuration creating hotspots of orbital perturbations which in-turn has some effect on Earth's orbital path which finally results in Earthquakes. The study analysed 10 different planetary configurations. The study claims that there are local gravitational interactions amongst bigger planets (Jupiter, Saturn, Uranus, Neptune) which creates an invisible resultant gravity vectors (IRGV) which acts as imperceptible planetary force when an inner planet crosses them. The study has estimated the locations of those invisible forces and analysed their links with major earthquakes (>6.0 only). This study has revealed that whenever Earth crossed these IRGVs invariably there were major EQs , and other inner planetary crossings as well showed similar results. Mercury and Moon being the fastest moving objects in the sky they act as catalyst when there is other planetary perturbing configuration. Overall the explanation capabilities of each of possible configurations were critically cross checked and hope that the study will give a New Dimension in the field of Earthquake, Gravity anomalies and their prediction. Finally, the study predicted the sensitive days for the year 2016 and researchers may validate our concepts and results based on actual ground shaking.

KEYWORDS: Planets, Gravity Vectors, Solar System, Planetary configuration, Earth Quake, Spatio-Temporal.
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1. INTRODUCTION: The word "Earthquake" (EQ) refers to shaking of ground, and the effect of this shaking can vary from local to global scale causing enormous damage to life, economy and society as a whole. Earthquake has been one of the most intriguing and challenging process for the researchers as they could not really understand the causes of its occurrence though the technology has advanced so much to map the occurrence pattern around the world. Scientists feel that Earthquake mechanism is not that simple otherwise it would have been predicted long back. However, all great scientific inventions have simple concepts at its core, but it will become simple only when somebody throws light in that angle. There are so many theories and hypothesis about earthquake and its pre-cursor behaviour, and there has been random success but till today there is no consistent short-term/long-term prediction by any single group around the world which proves the incomplete understanding about this phenomena. It is possible that these hypotheses are just a piece in a big puzzle and unless until we accept all the pieces and try to arrange them systematically the whole picture will not be revealed. Continuous failure in earthquake prediction has affected the confidence of funding sources in promoting research behind this important global disaster. In this regard, the current study aim to provide one important decisive piece in this complex puzzle which may turn out to be the only pre-cursor piece which can give us predictive warning at different time scale starting from seconds to years ahead, and most importantly this pre-cursor is consistently quantifiable and can be tested on any planet across the universe.

The most accepted geological theories behind earthquake refer to tectonic movement induced stress building upon rocks beyond the elastic limit and volcanic eruptions as the major causative drivers. The most recent and promising pre-cursor field is "seismo-electro-magnetic" signals. Researchers have observed measurable surge/noises in the earth's and ionosphere's electromagnetic energy before a major earthquake. Some of the tested pre-cursor signals in this field includes Ultra Low Frequency (ULF) magnetic field, Total Electron Content (TEC) changes in ionosphere, noises in communication signals across wide frequencies (which can be observed in mobile network, TV and GPS signals etc.), sudden bright light emission from ground, Thermal/Infra-red anomalies (observed from satellite), mass changes (from GRACE), sudden Linear Cloud surge, changes in animal behaviour, etc. These

anomalies are explained through various theories such as Piezo-electric effect, vapourisation of fluids, electro-magnetic emissions, resistivity anomalies, ULF & VLF-VHF, piezo-magnetism, semi-conductor effect, magneto-hydrodynamic, gravity and Geoidal variation, solar polar magnetic anomaly [1- 14]. Again the pattern is random and hence still elusive, and most importantly these are symptoms and the real cause is still not identified. There are many more interesting works such as Tong [15] discussed various issues related to abnormal animal behaviour before earthquakes; Calais and Minster [16] studied ionospheric perturbations in GPS signals due to earthquaks.; Tronin [17] and Saraf and Choudhury [18] studied satellite based thermal anomaly as pre-cursor for earthquake prediction; Shou [19] and Guangmeng and Jie [20] attempted earthquake prediction based on cloud patterns in satellite images; Avasthi [21] proposed an active seismograph based on real-time observation about rock properties for early detection of Earthquakes. Ramanamurthy [22] have given a detailed review about various techniques, developments and references in the earthquake prediction research and provided suggestions for pre-disaster management strategy. Jordan [23] and Babat [24] discussed various issues, riddles and ridicule surrounding earthquake prediction, and they stressed for integration of diverse ideas and people without bias so as to find viable solution with the ultimate aim of saving human lives. Also reader may visit the "QuakeFinder" webpage for more detailed information about various techniques and associated references, and other general articles (such as "http://www.yourarticlelibrary.com/earthquake/earthquakes-prediction-9-methods-to-predict-earthquake/13915/").

The major difficulty in the earthquake prediction is that most of the processes are either happening under the ground or beyond the sky and science has not advanced enough to see/map through the solid rocks miles beneath. In order to accurately map such under-ground processes across the earth we need a huge network of sensors placed very deep down which is tedious and costly but indirect methods using networked-sensors on the ground surface are being used in USA. Today nothing is technologically impossible, and hence only thing required is a systematic inter-country collaboration and international funding and monitoring mechanism. Anyway, many individuals/organisations across the world are putting real effort, and the day is not far to conquer this phenomena. This study hope to provide one vital pre-cursor and test new paradigm related to Earthquake which could be a path breaking long-term pre-cursor, if it works.

2. HYPOTHESIS and OBJECTIVE:
The current study attempts to understand the possible link between earthquake occurrences and the planetary alignments/configuration/geometry. It is important to re-iterate here that the study is not related to astrology but rather astronomical and geometrical analysis. Authors have been observing the earthquake occurrence patterns (using the last 100 years of EQ data provided by USGS) and various unexplained phenomena over earth surface and as well as the planetary configuration. Years of critical thinking has been consolidated in this paper.

Many authors have talked about planetary influence on the earth, but our work differs from them and the most fundamental assumption in our study is that Earthquake is the result of perturbation in the earth's orbital path while moving around the Sun. Raman [25] discussed various planetary conjunctions from the point of view of Astrology in predicting weathers and earthquakes. Venkatanathan et al. [26,27] discussed about alignment of Sun and Moon with Earth affecting the gravity on earth and associated changes the rotational speed and angular momentum of earth in relation to earthquake. Their theory is partially true because earthquakes does happen during non-alignment dates as well, and hence we need a more detailed analysis. In this study, we propose that the orbital path traversed by the Earth has lot of gravitational undulations causing minor perturbations (horizontal/vertical), and these undulations are caused by the varying net gravitation interactions due to differences in the positional configuration of all the solar-system planets. In addition, the major cause for earthquake is due to changes in the movement pattern of molten outer core. Just like a road having lot of pot holes will result in bumpy ride in a car, our earth also get perturbed during its movement around Sun, and our study hypothesize that the major earthquakes and the major volcanic eruptions are the results of these sudden perturbations and the same logic is applicable to all the planets. Right now there is no mechanism to monitor the tremors on other planets but in the future our hypothesis can be tested on other planets as well.

Given the limited/no experimental capacity at our end, in our study we have taken a completely different dimension in testing and detecting potential timing of occurrence of these orbital gravity undulations through planetary configuration and its association with earthquake occurrences which is, so far, not seen in other studies. Since the planets are on constant move the net gravitational force at any given place in the solar system does not remain constant just like ripples on the water surface. Hence, it need a finer outlook to indirectly detect these effects and current study provides one such indirect measurement and predictive scenario. It is important to note here that we are not talking about gravitational force acting on earth due to other individual planets, but rather we are addressing the changes in the gravitational field (net gravitational force at a given point of time at a given place) in the solar system space. There are 100s of minor earthquakes occurring all over the earth every day, and hence our aim is to predict only Major Earthquakes (magnitude greater than 6 in Richter Scale) and their timing association with gravity perturbations induced by planetary configurations. Our study aim to forecast EQ sensitive days in terms of DOY well in advance, and do not aim to predict the geographic locations of EQ on Earth.

In our approach Earth is considered as a Point in Space and tries to understand the effect of planetary configurations on EQ occurrences from the perspective of perturbations in the orbital path. This approach can be tested on any planet and forecast can be made for any number of years at different time sampling rates (day/hour/minute/seconds).

3. METHODOLOGY: In order to test our hypothesis, the astronomical ephemeris data about helio-centric and geo-centric positions of every planet at a daily interval (at 00:00hours) was collected. We have considered 8 planets (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune) and Sun as the fulcrum point for helio-centric, and Earth as center for geo-centric. Pluto is not considered in this study due to its distance and size. But Moon is considered as a separate special case due to its proximity to Earth as well as due to its well established link to ocean tides and biological influence. It is important to analyse the possible influence of individual planetary configuration as well as in combination with other additional configurations, and hence, we segregated the whole process into smaller processes and analysed the combination in terms of 10 Broad Possible variables (i.e., angle influence, pull-force influence, Jupiter-Saturn Gravity influence, Jupiter-Uranus Gravity influence, Jupiter-Neptune Gravity influence, Saturn-Uranus Gravity influence, Saturn-Neptune Gravity influence, Uranus-Neptune Gravity influence, Net-gravity influence, Moon Influence) and finally integrated all the forces to derive overall influence scenario on a given day. These smaller processes are addressed as questions below.

3.1 WAS THERE ANY EARTHQUAKE IF A PLANET CROSSES ANY OTHER PLANET'S HELIO-CENTRIC POSITIONAL VECTOR? The logic behind this question is that the force acting on a stretched string will be altered if the string is disturbed by any means. We need to find out (a) when is this stretched string altered to the maximum and (b) is there link to earth process due to this cross-cutting. Under this question we have tried to estimate whether on a given day is there any planet crossing the Straight-line connecting Sun and other Planet? and this crossing is termed as "Cross-Cutting Configuration (variable 1)".

Since there are 8 planets (say N) and hence there are 56 possible combinations [N * (N-1)] , and if we remove the redundancies then there will be 28 possible combinations (i.e., angle between Planet A vs B is same as Planet B vs A, and hence only one count is made to remove the redundancy). In order to answer this question we need to find out the angle between the heliocentric positional vector of a planet with respect to other planet's vector. Using the positional vector of each planet, the angle between vectors of all planets with respect to all other planets were calculated at daily interval. A simple Vector calculation can be done as follows:

Fig I: Example Alignment and separation angles between Planets A, B, C.
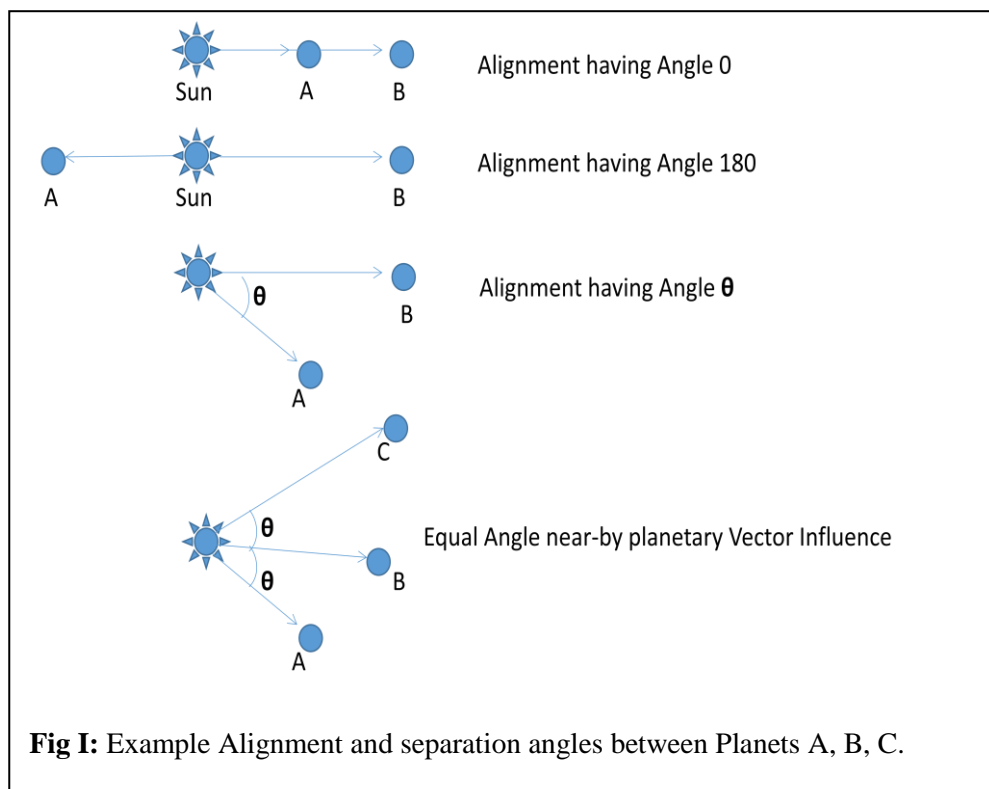
Every planet is under the influence of gravitational force with reference to Sun, and this gravitational force is a vector quantity having both magnitude and direction. Hence, based on vector algebra it is possible to calculate angle between two vector forces (i.e., **θ)**, and the unit of these forces are in Newton. One can easily test these equations

considering any two points 2-dimensional cartesian coordinates (in a Graph paper), and find out the angle between these two points from origin (i.e., at [0,0]).

We have estimated the helio-centric angles under this analysis, and the values of angle will range between 0 to 180 (**Figure 1**): 0 meaning the alignment of a planet "A" with other planet "B" is a straight line and located in the same direction from Sun (i.e., like Sun-PlanetA-PlanetB or Sun-PlanetB-PlanetA) and 180 meaning alignment in the opposite direction (i.e., PlanetA-Sun-PlanetB in straight line but located at both the sides of Sun). If the time-gap in ephemeris collection (i.e., sample rate) is coarse then some times the separation angle would not reach 0 as the inner planets like Mercury, Venus and Moon move faster and hence one has to be careful in detecting the crossing point, and for accurate detection the sample rate can be increased to hourly interval but this will increase the computational cost. In our case we have used daily time-rate at the first iteration. We have also collected the earthquake occurrence information and analysed the correlation with timing of every planets crossing-cutting configuration.

3.2 WAS THERE ANY EARTHQUAKE IF A PLANET COMES IN-BETWEEN ANY TWO NEAR-BY POSITIONAL VECTORS? Since gravitational field exists all over the solar system, there can be local influences/variations when there are more planets in a nearby area w.r.t. a particular planet. In the previous case the influence of two planetary vectors were studied. Now we will look into three-planetary vector interaction. We want to test whether any such local influence exist in terms of earthquake occurrence. In this regard, we have estimated a time at which Angle of separation of a planet with other two planets is same (assuming the maximum influence at the middle point) (Refer last figure in **Figure 1**). We term such scenario as "Pull-Force Configuration", and as said earlier from the 22 possible combinations we can derive 52 non-redundant pull-force configuration per day (it can be calculated per hour/minute/second).

3.3 WAS THERE ANY EARTHQUAKE IF A PLANET CROSSES A NET-GRAVITY VECTOR OF JUPITER AND SATURN? In the previous case we have assumed an equal gravitational influence from nearby two planets without considering their distance and amount, and hence it may not be revealing correct scenario. Hence, we wanted to test local influence of bigger planets in reference to the location of their net gravitational vector force. Here the first step was to calculate net gravitation force between Jupiter and Saturn, and its resultant directional vector at every day interval. Then each inner planet was tested for their crossing of this resultant vector. **Figure 2** explains this in a diagrammatic way.

$$\cos\theta = (\ u \cdot v\ ) / (||u||\ ||v||\ ) \qquad\qquad \text{(Eqn. 1)}$$

where

$u \cdot v$ means "dot product of the vectors" = x1x2+y1y2+z1z2

$||u||$ means "the length of vector u" $= \sqrt{x1^2 + y1^2 + z1^2}$)

$||v||$ means "the length of vector v

(x1,y1,z1) & (x2,y2,z2) are the positional components of 3-Dimenstional vectors u & v respectively.
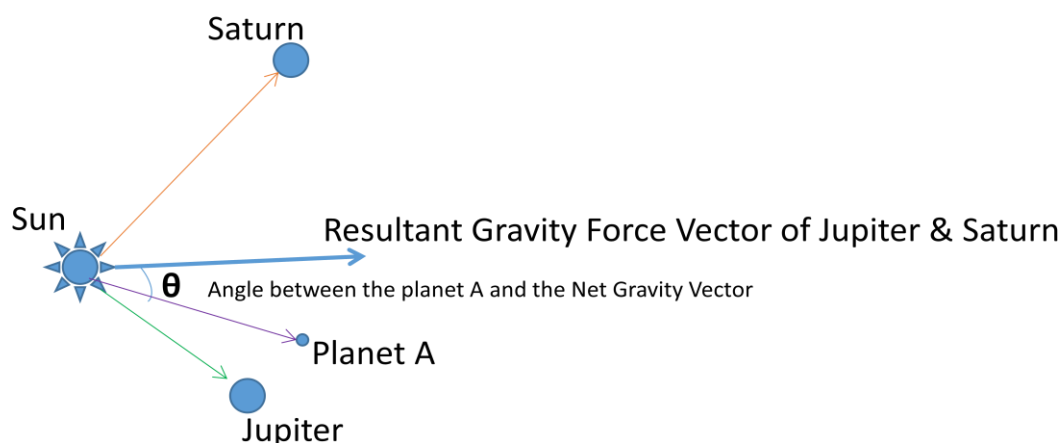

Fig II: Angular concept between a planet and Jupiter-Saturn resultant Gravity vector.

Jupiter and Saturn being the Heaviest planets in our solar system. It is highly expected that the gravity force field of the solar system is maximum altered by these two planets. It is also a fact that the centrifugal force exerted by these two planets are maximum and hence they play a tug-of-war and there has to be a resultant force vector due to these two forces. Authors assumes that gravitational undulation/ripples may exist in-between these two planets across solar system space, and its effect will be maximum along the direction of resultant vector and any inner planet crossing this region will invariably creates a local ripples and its orbital movement is affected due to perturbation. Depending upon the angular separation between Jupiter and Saturn the effect of resultant vector will vary and the maximum consequence can be observed when they are together or separated by 180 degree. In order to analyse this hypothesis at first we have estimated the gravitational forces acting on these two giant planets (every day basis) and then their resultant direction, and finally the angle made by a planet with reference to their resultant vector. From this angle we have estimated the timing at which the angle is minimal (i.e., 0 or close to 0) or maximum (i.e., 180 or close to 180) and tried to establish a correlation with major earthquake occurrences. Jupiter-Saturn orbital conjunctions spread over 11 years (timing between two successive togetherness) and sun-spot cycle also follows a 11 year cyclical maximum, and hence there may be a potential link between these two phenomena. Sun spots results in some magnetic anomalies affecting ultra violet and x-ray which in turn affect earth's upper atmosphere. However current study do not want to indulge in sun-spot and Jupiter-Saturn link, but rather focus was made only on earthquake occurrences.

Apart from Jupiter and Saturn, the next two bigger planets are Neptune and Uranus, and hence authors also wanted to test the influence of combination of these 4 bigger planets (Jupiter-Uranus, Jupiter-Neptune, Saturn-Uranus and Saturn-Neptune) towards earthquake occurrences and research questions can be as follows:

Was there any Earthquake if a planet crosses a net-gravity vector of Jupiter and Uranus?
Was there any Earthquake if a planet crosses a net-gravity vector of Jupiter and Neptune?
Was there any Earthquake if a planet crosses a net-gravity vector of Saturn and Uranus?
Was there any Earthquake if a planet crosses a net-gravity vector of Saturn and Neptune?
Was there any Earthquake if a planet crosses a net-gravity vector of Uranus and Neptune?

3.4 WAS THERE ANY EARTHQUAKE IF A PLANET CROSSES A NET-GRAVITY VECTOR OF SOLAR SYSTEM? Finally, we wanted to test the effect of a planet crossing net-solar-system gravity vector. At first individual gravitation forces (example F1 and F2 forces in Figure 3) were calculated for each planet based on Newton's gravitational model. Secondly the angle of separation (θ) was estimated using Equation (1), and thirdly net force (F) and directional information (α) between planets were calculated iteratively one by one (using Equation 2 & 3) so as to arrive at resultant-Solar System Gravitational Force Vector and its direction. Finally, 8 individual angular information derived for each planet w.r.t. resultant vector was analysed to find out the timing at which a particular planet crosses this vector. Then the relation between earthquake occurrence and timing of crossing was tested. An example to calculate the resultant vector between any two vector force is explained in Figure 3.

Resultant Force:

$$F = F1^2 + F1^2 - 2 * F1 * F2 * COS\ \beta \qquad\qquad \textbf{Eqn. (2)}$$

where

F2^2

$$\beta = (180 - \theta)$$

Direction of Resultant Force:

$$\alpha = arcsine(\frac{F1}{F} * Sin\ \beta\ ) \qquad\qquad \textbf{Eqn. (3)}$$

(a) Force F2 θ Force F1

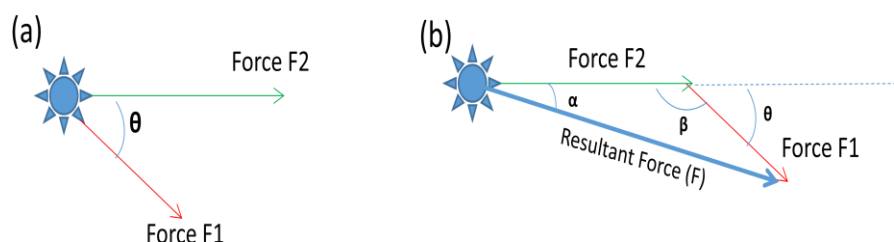(b) Force F2 α β θ Resultant Force (F) Force F1

Fig III: Vector Forces (a) and their resultant force Vector Estimation (b).

3.5   WAS THERE ANY EARTHQUAKE IF EARTH-MOON VECTOR CROSSES A GEO-CENTRIC POSITIONAL VECTOR OF A PLANET? In the previous questions we did not address the influence of Moon, if any. To answer this final question we have transformed all our Helio-centric coordinates to Geo-centric coordinates, and estimated the angle between Earth-Moon positional vector with all other planet's geocentric positional vectors. Then analysed the relationship between earthquake occurrence and moon association. Though it is obvious that we do not claim any major orbital perturbation influence from Moon alone.

4. RESULTS AND DISCUSSION: There are many tools available in the internet to calculate the planetary ephemeris (such as NASA ephemeris generator [http://new-pds-rings-2.seti.org/tools/], French IMCCE ephemeris web server [http://vo.imcce.fr/webservices/miriade/]). In our study we have used IMCCE ephemeris data. The model used to generate the data followed INPOP13C planetary theory, Mean J2000 coordinates, heliocentric equatorial rectangular coordinate system. Data was generated at daily interval considering the base time as 00:00 Hours. The helio-centric spatio-temporal rectangular positional information of inner planets (upto Saturn) are depicted using ArcMap software is provided in **Figure IV**. Since Mercury and Venus moves faster the time-legend colours for initial months would not be visible.
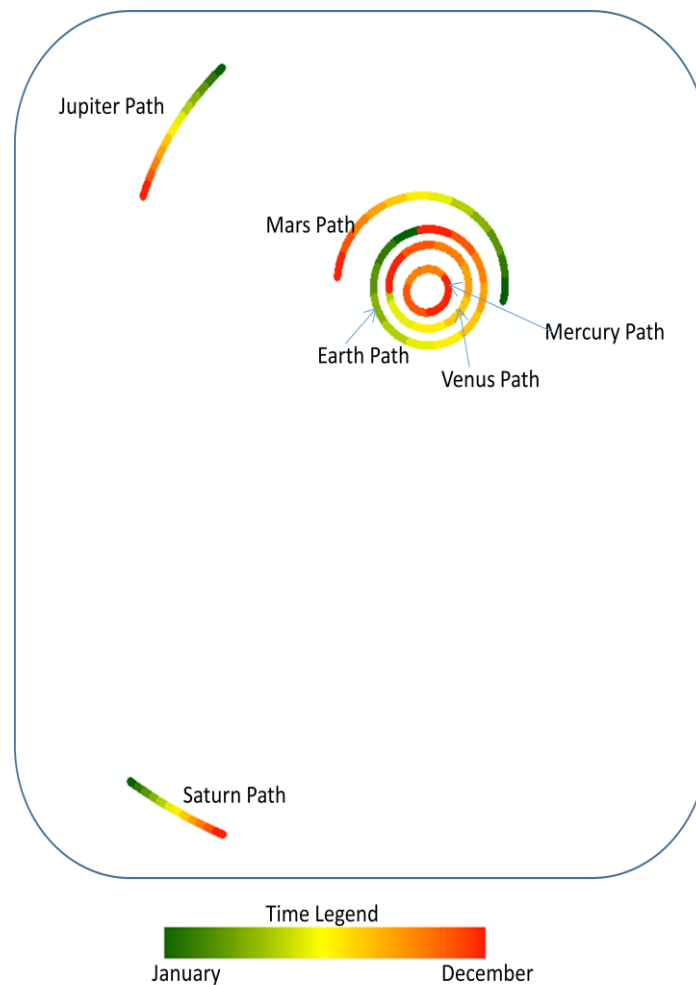

Fig IV: Helio-centric spatio-temporal positions of different planets (upto Saturn) in 2015.

4.1 INFLUENCE OF TWO-PLANETARY CROSSING: We have calculated the angle made by Sun-Planet vector with all other planets, and only 22 non-redundant combinations from inner planets were analysed in detail. Bigger planets crossing takes long years due to their distances and orbital period, and only one crossings between Jupiter and Neptune happened in 2015 and hence other crossing-combinations are not shown. It must be noted that angle between Planetary vectors A and B is same as that of B and A (for example Earth-Sun-Jupiter angle will be same as Jupiter-Sun-Earth) and this will help to remove redundancy. The results from the observation and analysis are depicted in Figures V, VI, & VII. The angle made by each planet with other planet on every Day of Year (DOY) in 2015 is efficiently depicted using 4 graphs (Figs. VIa, VIb, VIIa, VIIb). From the 365 days particular DOY is assumed to be sensitive towards earthquake occurrence if the angle made by the sun-planet vector with other planetary vector is less than 1 degree or greater than 179degree.

Table I provides the DOY of crossing from every planetary combination during the year 2015. Also the near-by DOY where Earthquake with magnitude greater than or equal to (>=) 6.0 occurred during this crossing were provided for checking the link between these two events. It was observed that earthquakes of magnitude >= 6.0 in Richter scale occurred on 108 different days (totalling 145 EQ incidences). Out of these 108, only 22 days were having exact match (i.e., one or more planetary crossing configuration on that EQ day). Hence, at the very first outlook one can simply reject the planetary crossing hypothesis as it's explanation capability is only 21%. But if we consider ±1 day and ±2 day (level of deviation) then there were 57 and 76 matching incidences having 52% and 70% explanation capability, respectively. On the other view instead of seeing in terms of day if we see in terms of events (cluster of days during which a planetary configuration is observed), there were 48 days (27 clusters; continuous days form a cluster) having same side crossings (θ < 1degree) with 18 clusters having earthquake occurrences (66% match), and 42 days (28 clusters) having opposite side crossings (ie., θ >179deg) with earthquake events in 21 clusters (75% match) in 2015.

Planetary Crossing	2015 DOY of crossing (θ < 1deg)	2015 DOY of crossing (θ > 179deg)	Nearby DOY for EQ >= 6.0 (when θ < 1deg)	Nearby DOY for EQ >= 6.0 (When θ > 179deg)
EARTH.cs.MER	30,151,273	100,322	28,149,150,269	97,322
EARTH.cs.VEN	225,226,227	NIL	224,225,227	-
EARTH.cs.MARS	NIL	164 to 167	-	163,168
EARTH.cs.JUP	37,38,39	239,240	33,42,44	236,244
EARTH.cs.SAT	143,144	334,335	142,144	331
EARTH.cs.URA	285,286	96,97	284,287	97
EARTH.cs.NEP	244,245	57,58	244	58
MERCURY.cs.VEN	123,281	54,358	121,125,284	52,358
MERCURY.cs.MARS	6	45,154,258	7	44,155,259
MERCURY.cs.JUP	210	176,266	210	176,265,267
MERCURY.cs.SAT	237,326,	284	236,325	284
MERCURY.cs.URA	11	45,133	7	44,132
MERCURY.cs.NEP	355	NIL	353,354	-
VENUS.cs.MARS	30,31,356,357	201,202	28,33,353, 354,358	199
VENUS.cs.JUP	115,116,351, 352	234	114,115,116,118, 351,353,354	236
VENUS.cs.SAT	177,178	64,293	176,181,182	62,65,293
VENUS.cs.URA	36,262	148	33,261,262	149
VENUS.cs.NEP	11,12,237	124,349,350	236	125,351
MARS.cs.JUP	332 to 337	NIL	330,331,338	-
MARS.cs.SAT	NIL	122,123, 124,125	-	121,125
MARS.cs.URA	43 to 46	NIL	42,44,47	-
MARS.cs.NEP	NIL	328,329, 330,331,332	-	328,330,331
JUP.cs.NEP	NIL	293 to 322	-	11 earthquakes of magnitude > 6.5 during 293 to 322

Table I: Possible Planetary crossings, Earthquake Occurrences and their DOY in 2015.

.cs. represents 'crossing'

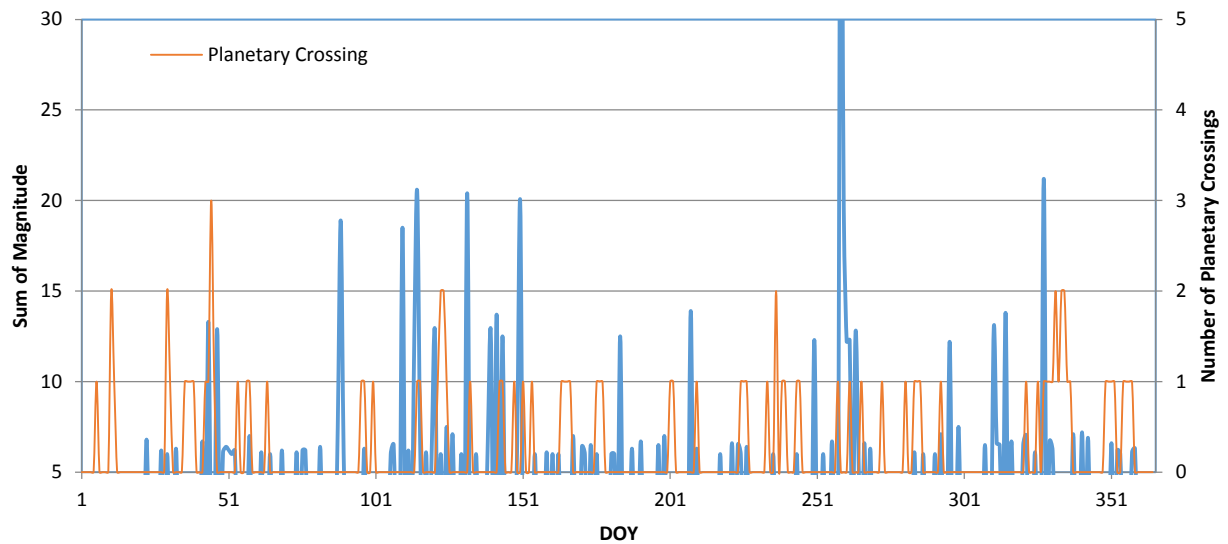MER-Mercury; VEN-Venus; JUP-Jupiter; SAT-Saturn; URA-Uranus; NEP-Neptune

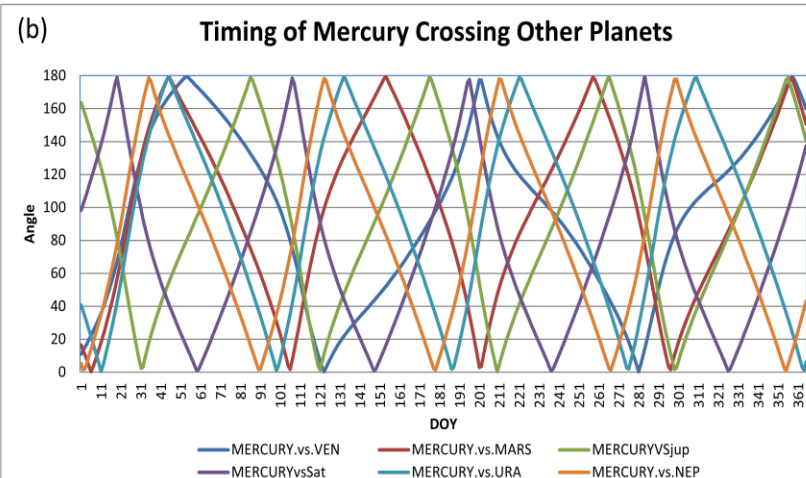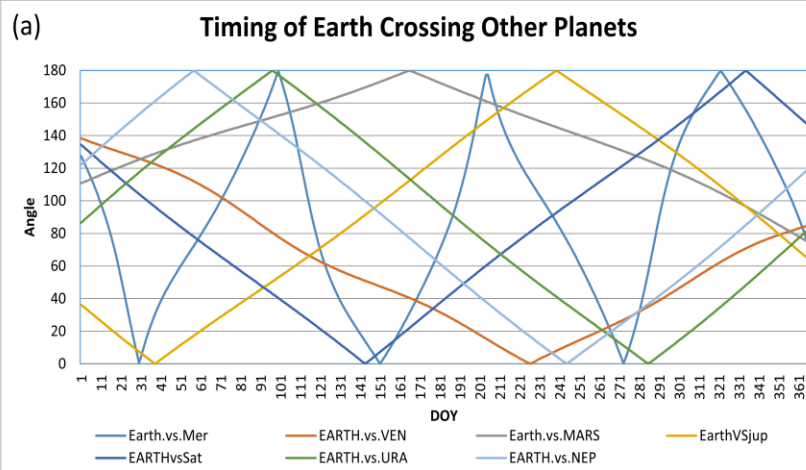**Fig V**: Checking the link between planetary crossing and earthquake occurrences

Fig VI: Timings of Earth (a) and Mercury (b) Crossing other planets.

Just as an example, it is interesting to observe the EQ events near 24th November (DOY 328). There were continuous big earthquakes on this day (2 EQS of magnitude 7.6 and one EQ of 6 magnitude) (Refer Fig V) and during DOY 325 to 337 there were many major earthquakes. Interestingly. it was observed that majority of the inners planets were crossing majority of the bigger planets during this period (Ear.cs.Sat; Mer.cs.Sat; Mar.cs.Nep; Mar.cs.Jup; See Table I for details).

Though there seems to be some link, from the **Figure V** it can be observed that there were some EQ events which did not have any same-day planetary crossings (for example see around DOY 68 to 90 and 301 to 310) and as well as there were many planetary crossings which only induced few EQs (see near DOYs 230 to 250). But there is another way of looking at these gaps. Few days before every major earthquake (see the cumulative sum of earthquake's magnitude on every DOY in **Figure V** (primary y-axis)) there has been clusters of planetary induced perturbations (secondary y-axis). In fact there are only two EQ incidences (around 30th March -DOY89 and 7th November DOY311) which really were not explained by this two-planetary crossing phenomena. Hence It would be interesting to analyse these gaps to get further understanding and to check whether the coincidences were accidental match or has any other explanation.

From **Table I** it is very clear that on the nearby days of planetary crossings there were big EQ events and hence it can be concluded at the first level that though planetary crossing is able to explain 50 to 75% of EQ incidences the remaining incidences need to be explained further and hence in our study we went further looking for other possible planetary configurations.
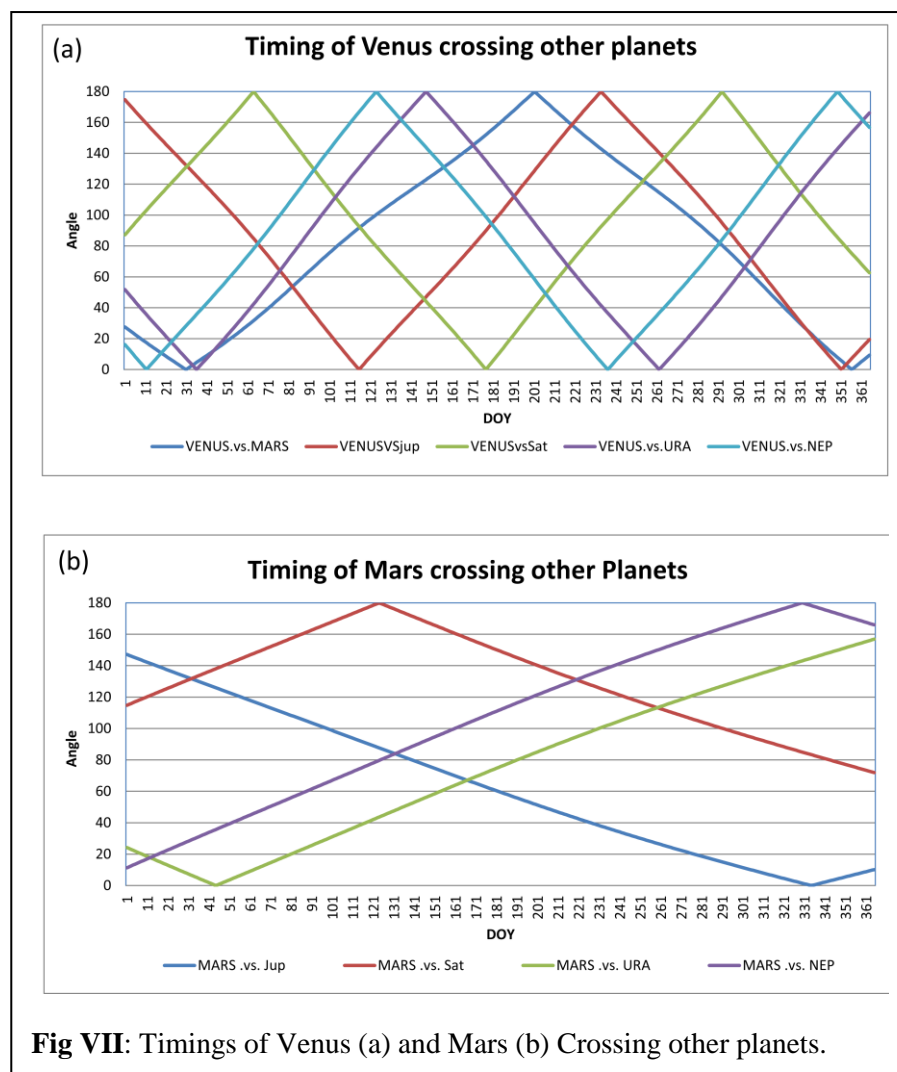

Fig VII: Timings of Venus (a) and Mars (b) Crossing other planets.

4.1.1 EFFECT OF MARS: From **Figures VI (a) & (b)** it can be observed that, in 2015, Earth and Mars did not cross each other on the same side, but rather on the opposite side on the DOYs 164 to 167 (see Green line in VI a) and interestingly there were earthquakes on 163 and 168, the days just before entering and just after exiting this configuration. The similar pattern of EQ occurrences at one day before entering and one day after exiting the Mer-Mars crossing was observed. From **Table I & VI b**, we can infer that Mercury had crossing with Mars in same side on 6th and opposite side on 45, 154, 258, and very interestingly there were earthquakes on the DOYs 7, 44,155,259.

From **Figures VII(a) & (b)** it can be observed that Venus and Mars crossed each others on DOYs 30,31,356,357 (when θ<1deg) and earthquakes were observed on DOYS 28,33,353,354,358. The Ven-Mars crossing on opposite side happened on DOYs 201,202 and earthquake occurred on 199. In case of Venus there was ±2 day delay between EQ occurrences, but in case of Earth and Mercury the delay was ±1 day. Mars crossed Jupiter during DOYs 332 to 337 and there were earthquakes on 330, 331, 338 with the same pattern of -1 day delay pre entry and +1 day delay post exist. Similar pattern is observed in case of Uranus and Neptune.

4.1.2 EFFECT OF MERCURY: Though Mercury had so many crossings in **Figure VI (b)** but in the **Table I** one can only see few crossings. This is because our condition of crossing angle is very less (just 1 degree as we were expecting a perfect crossing). But, Mercury's orbital period is 88 days and hence it crosses each planet very fast (on an average it crosses 4deg per day). Our observation interval was 24 hours (i.e., per day level) and hence Mercury's angle variation in 24hour period is much greater than our thresholds of <1deg in the same side and >179deg on the opposite side. Hence we re-estimated the DOYs with higher threshold as θ < 5deg or θ>175deg only for Mercury. With this condition correct crossing days were revealed (See **Table II**). The nearby DOYs of earthquake occurrences were also provided beneath each configuration (in italics) for comparison.

Pattern	2015 DOY of crossing (θ < 5deg)	2015 DOY of crossing (θ > 175deg)
MERCURY.cs.EAR	30,31,149,150,151,152,153, 272,273,274 *(28,33,149,150,155)*	99,100,101,204,205,319, 320,321,322,323,324 *(97,321,322,325)*
MERCURY.cs.VEN	122,123,124,280,281,282 *(120,121,125,284)*	51,52,53,54,55,56,57,201,202, 357,358,359,360 *(50,51,52,,58,199,358)*
MERCURY.cs.MARS	5,6,7,105,106,201,202,296,297 *(7,107,199,296,299)*	44,45,46,152,153,154,155, 257,258,259,357,358,359 *(44,47,150,155,256,259to262,358)*
MERCURY.cs.JUP	31,32,120,121,209,210,211,299,300 *(33,120,121,208,210,299)*	85,86,87,175,176,177, 265,266,267,355,356 *(88to90,174,176,264,265,267,354,358)*
MERCURY.cs.SAT	58,59,60,61,147,148,149,150, 236,237,238,239,325,326,327 *(58,62,149,150,236,325,328)*	19,107,108,195,196,284 *(107,197)*
MERCURY.cs.URA	10,11,12,99,100,187,188, 275,276,363,364 *(97,188)*	44,45,46,132,133,134,220,221,222, 309,310,311 *(44,47,132,222,308,311)*
MERCURY.cs.NEP	2,3,90,91,178,179, 266,267,268,354,355,356 *(88,89,90,176,181,264,265,267,269, 353,354,358)*	35,36,123,124,211,212,299,300 *(33,125,210,299)*

Table II: Mercury's Planetary crossings, Earthquake Occurrences and their DOYs in 2015
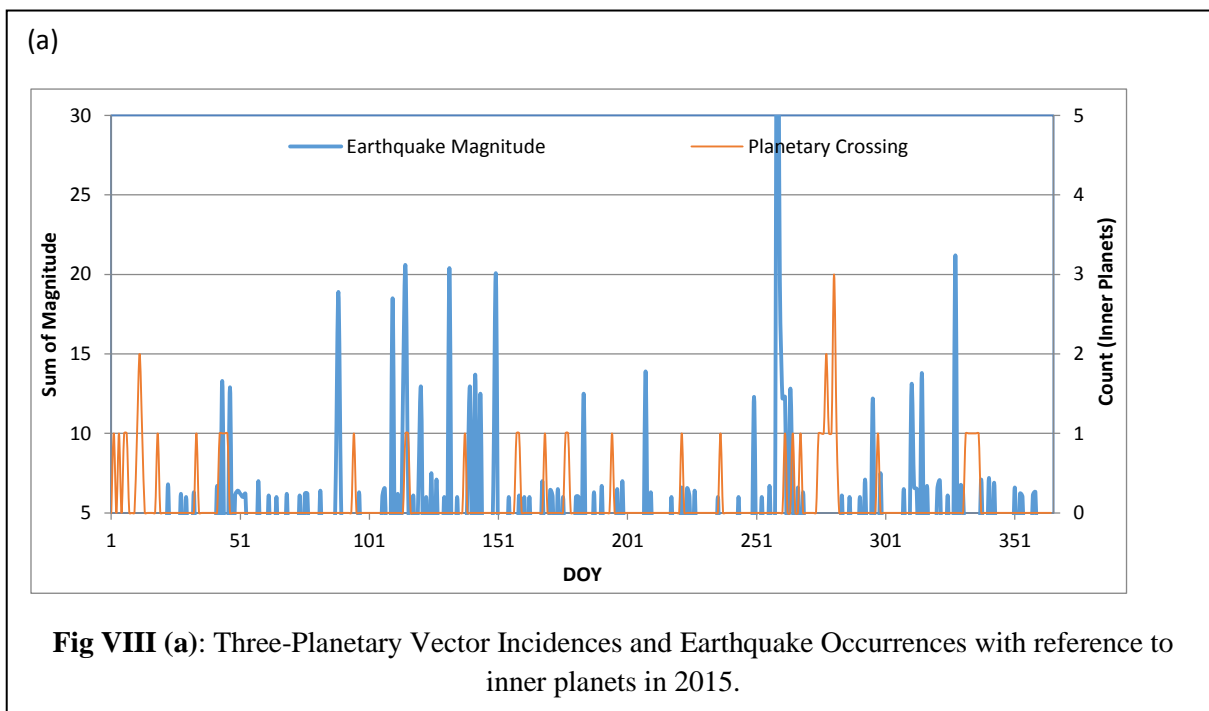(Note: The DOY given in the parenthesis are the actual EQ DOYs)

From **Table II** it can be observed that Mercury crossings with bigger planets have consistently contributed for EQ incidences. For example, Mer-Nep, Mer-Ura, Mer-Sat, Mer-Jup crossings (±1 day tolerance) have strong link with ground EQ events. It was observed that the gaps which were not explainable with 1deg threshold (especially for Mercury) got revealed better with 5degree threshold. User may look into big EQ events on 27th and 29th July (DOY 208, 210) and from Table II it can be observed that during DOY 209 TO 211 Mercury was crossing Jupiter. Also, it is important to note here that Jupiter crossed Neptune in the opposite side during 20th October to 20th November and these period have seen many major EQ events. This Jup-Nep configuration stretched the gravity along their alignment and during which if any inner planets cross these planets they will further disturb the gravity which in-turn will induce gravity ripples, perturbing earth's orbital movement and causing EQs. One can imagine a stone thrown over still water creating ripples and Mercury exactly act as stone (due to its speed) on gravity lake.

In our study we have kept the time-tolerance of 2 days from the crossing event while comparing with earthquake occurrences. In most of the cases we found links (except few) but one has to be careful in deriving any conclusion based on single configuration. The perturbation will be more if there are more such crossing configurations. Just as a sample case we discussed effect of Mars and Mercury with ground occurrences, and **Figures VI and VII** provides us more information than just crossing. One can also analyse what happens if there are clusters of planetary crossing or crossings having equal angle from each other. Reader is left to explore these figures to derive further inferences in addition to what is said above. Overall it is observed that whenever some inner planets cross

Major planets there is a possibility of perturbation on the solar system gravitational field which potentially perturb the earth's orbit (depending upon Earth's distance from such disturbances). Such perturbation could possibly alter the circulation pattern of molten outer core and its consequent impact/pressure on the crust may contribute towards major earthquakes and creates other symptoms of anomalies on earth surface.

4.2 INFLUENCE OF THREE-PLANETARY INTERACTION: In the previous case we considered angle between only two planetary vectors and one angle. Here, we have analysed three planetary vectors together and two angle of separation. For example if Earth is at an angle 10degree from Jupiter in one side and Mars at 10degree from Jupiter on other side then there will be interactions from 5 planetary vectors (i.e., Sun-Earth, Sun-Mars, Sun-Jupiter, Jupiter-Earth and Jupiter-Mars), and there is no way we can measure this. So, we wanted to test this interaction indirectly based on angular separation. Is there any specific EQ incidences at some angle in such three-planetary configuration. We hypothesis that there may be some local alterations in the gravity field due to this configuration and we quantified number of such incidences and its respective DOY and correlated with EQ incidences. Under this test, we grouped the planets into two categories: (a) inner/smaller planets - consisting of Earth (Ea), Mercury (Me), Venus (Ve) and Mars (Ma), and (b) outer/bigger planets - consisting of Jupiter (Ju), Saturn (Sa), Uranus (Ur), Neptune (Ne).

In this analysis, we estimated the angle of separation of a planetary vector with other two planetary vectors at every day interval (sampling at 00:00 hours/day). In this manner there will be 52 non-redundant combinations from the point of view of inner planets (21,15,10,6 combinations from Earth, Mercury, Venus and Mars respectively). Importantly angle of separation must be less than or equal to 45degree so as to logically avoid wider angles. For example, if we want to test the influence of Sun-Earth and Sun-Mercury with all other planets (i.e., 3rd vector) having Earth either in the Middle or on one side (i.e., considering Earth as Reference planet) then there would 6 possible combinations such as (1) Ea-Su-Me vs Ea-Su-Ve, (2) Ea-Su-Me vs Ea-Su-Ma, (3) Ea-Su-Me vs Ea-Su-Ju, (4) Ea-Su-Me vs Ea-Su-Sa, (5) Ea-Su-Me vs Ea-Su-Ur, (6)Ea-Su-Me vs Ea-Su-Ne. To detect EQ influencing planetary configuration based on 3 planetary vectors we have used two conditions: (a) the angle made by each planetary vector with a reference planetary vector must be <= 45deg, and (b) their differences must be <= 1degree (For example if Ju-Su-Me is 25 degree and Ju-Su-Ea is 25.5deg then both the conditions are obeyed as their individual angles are less than 45 deg and their difference is 0.5deg and in such case we assume it as EQ influencing configuration. On the other hand if if Ju-Su-Me is 65 degree and Ju-Su-Ea is 65.5deg then the first condition is not obeyed though the second condition is obeyed and it will not be considered as EQ inducing configuration).

Fig VIII (a): Three-Planetary Vector Incidences and Earthquake Occurrences with reference to inner planets in 2015.

There are 24 non-redundant combinations for the Bigger Planets having 6 combinations each. For example; in Case of Jupiter as Reference planet the combinations would be (1)Ea-Su-Ju vs Ju-Su-Me, (2) Ea-Su-Ju vs Ju-Su-Ve, (3) Ea-Su-Ju vs Ju-Su-Ma, (4) Me-Su-Ju vs Ju-Su-Ve, (5) Me-Su-Ju vs Ju-Su-Ma, (6) Ve-Su-Ju vs Ju-Su-Ma. The count of how many planetary configurations obeying those 2 conditions was calculated for all possible combinations at daily interval. The DOY with a count is cross-checked with EQ incidences (**Figure VIII (a) & (b)** reveals the everyday relationship). It was observed in 2015 that there were 47 configurations w.r.t inner planets and 30

interactions w.r.t Bigger planets. The DOYs of these incidences were cross checked with EQ occurrences and the accuracy of exact match, ±1day, ±2days range were 17%,38%,57% in case of inner planets and it was 6%, 40%, 60% in case of bigger planets.
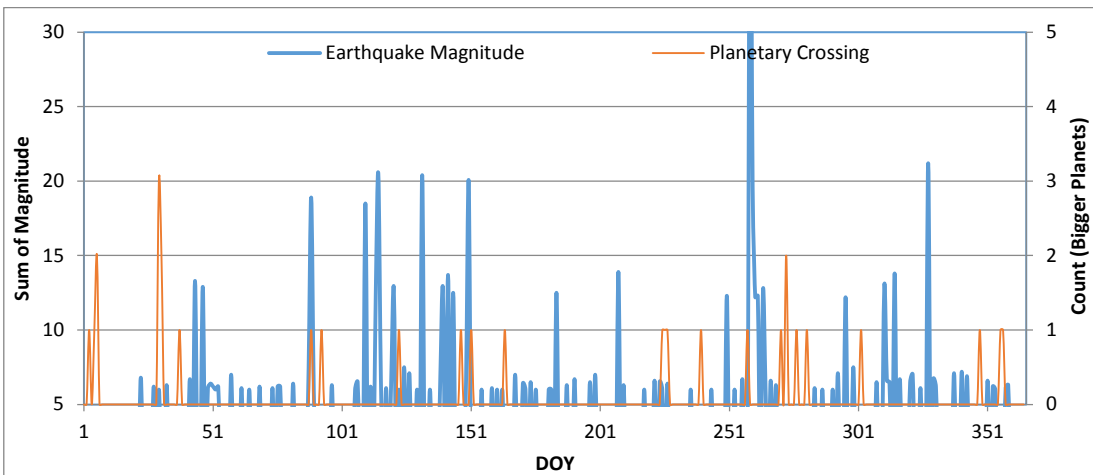

Fig VIII (b): Three-Planetary Vector Incidences and Earthquake Occurrences with reference to bigger planets in 2015.

Reference Planet	2015 DOYs (when θ on both sides <= 45deg and difference <= 1deg)	2015 Earth Quake DOYs (EQ >= 6.0)
Earth	159,160,170,178,179,238,263,266,269, 276 to 283	159,161,171,181,236,265,267,269,284
Mercury	3,5,7,8,12,13,96,116,117,139,196,223,279,299	7,97,114to116,118,139,197,222,224,299
Venus	20,35,44to47,333to338	44,47,331,338
Mars	13,14	NIL
Jupiter	30,89,123,302,348,356,357	28,88,89,90,121,125,354,358
Saturn	147,151,164	149,150,163
Neptune	3,5,6,30,31,225,226,227,240,258,273	7,28,33,224,225,227,256,259
Uranus	6,30,31,38,93,271,273,277,281	7,28,33

Table III: Three Planet incidences, Earthquake Occurrences and their DOYs in 2015
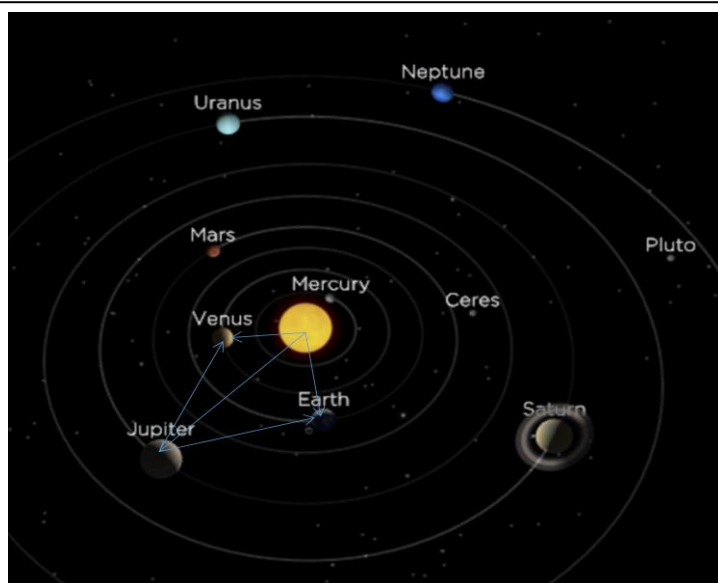

Fig IX: Planetary positions and Three-Planetary Interaction scenario on DOY 88 (29th March 2015) inducing 7.5 magnitude EQ.

EQ incidences during DOY 88,89,90 (29th to 31st March 2015) could not be explained based on 2 planetary crossings though there was a crossing of Mercury with Neptune (refer Table II). It is not natural to expect a gravitational ripple due to Mercury crossing because on that DOY it was located very far from earth. The only logical explanation could be through three planetary interactions. Figure VIII (b) showed some 3-planetary interaction w.r.t. bigger planets during DOY89, and from Table III one can observe that on DOY 89 there was interaction with Jupiter. From our calculations we found that Sun-Earth and Sun-Venus vectors were located at equal angle (~43degree) from Sun-Jupiter vector and **Figure IX** provides the spatial view of these interactions.

Also if one examines continuous EQ events during DOY259 to 262 (16 to 19th September 2015) it will be clear from **Table III** that on DOY 258 there was a Neptune related three-planetary interaction having Sun-Mer, Sun-Ven vectors located at equal angle (~30deg) from Sun-Nep vector. Other possible two planet crossing was between Mer-Mar at opposite side during DOY 257-259, and Earth crossing UNGV (see later section 4.3 Table IX). Hence it can be said whenever there is a combination of interactions between planetary vectors there is a possibility of big EQs.

There were some EQ events which could not be explained even after considering the three planetary interactions. For example continuous earthquakes during DOY 114 to 116 (one with magnitude 7.8 on DOY 115). The nearest planetary crossings were by Mercury-Mars on DOY 105-106 which already has link to EQ on DOY106, and another opposite crossing of Mercury-Saturn on DOY 107-108 which also has link to EQ on 107, and hence these crossings may not be the direct cause for DOY114-116 events. In order to address those un-explained EQ events we did further analysis considering Gravity interactions amongst bigger planets which is discussed in the subsequent sections.

4.3 INFLUENCE OF RESULTANT GRAVITY VECTOR USING BIGGER PLANETS

4.3.1 JUPITER-SATURN INFLUENCE: Jupiter and Saturn are the heaviest planets in our solar system, and it would be interesting to see whether their net gravity vector had any influence on orbital perturbation induced Earthquakes. In this regard, at first we estimated the gravitational forces acting on these two planets (based on Newton's equation) on every day basis, and calculated information about resultant gravity vector (like position, direction and magnitude) (as explained in **Figures II & III**). Finally the angle (θ) made by each inner planetary vector with respect to this resultant Jup-Sat gravity vector (JSGV) was calculated. The DOY in which the inner planets cross (same side or opposite side) this resultant JSGV was estimated (**Table IV** provides the results).

In 2015, it was observed that Earth & Venues crossed this JSGV only once, Mercury crossed 4 times, and Mars crossed once in the opposite direction (180deg to JSGV). There was a major earthquake on DOY 115 (25th April 2015) and that was a period when Earth was crossing the resultant JSGV and this event could not be explained any other means.

From **Table IV** it is clearly visible that whenever an inner planet cross this resultant JSGV there was a major earthquake. The explanation capability of this phenomena is very high towards EQ occurrence. This is a Major finding in our work which is not revealed in any studies so far because this resultant vector is an INVISIBLE entity and it cannot be directly observed, and hence this has been a big HIDDEN ENTITY which got revealed in our study.

Reference Planet	2015 DOYs ($\theta < 1$deg)	2015 DOYs ($\theta > 179$ deg)	2015 Earth Quake DOYs (EQ >= 6.0)
Earth	112,113 (22nd, 23rd April)	306,307 (2nd, 3rd Nov)	112,114,115,116 (22, 24, 25, 26th April,2015); 308 (4Nov)
Mercury*	49,138,227,316	13,14,102,191,279	47, 49 to 53,139, 140, 225, 227, 315, 317; 191
Venus	158,159	44,45,275	159;42,44
Mars	NIL	66 to 69	65,69

Table IV: DOY of Inner Planets crossing resultant Jup-Sat Gravity Vector (JSGV) in 2015
(* for Mercury $\theta <2$; $\theta > 177$ deg was considered.)

The positional vector of this resultant JSGV is completely different from the middle point between Jupiter and Saturn. For example, Earth crossed the middle point of Jupiter and Saturn (i.e., angle made by Sun-Ear vector with Sun-Jup and Sun-Sat must be same) on DOY 92, 93 (i.e., 2nd, 3rd April, 2015) and it has to be kept in mind that there were no big earthquakes during this period. The EQ on 29th March was already explained in earlier sessions (see Fig. IX). Hence, it is very important to consider resultant gravitational vector information between major planets. A detailed DOY wise angle made by all the inner planets with JSGV is shown **in Fig X**.
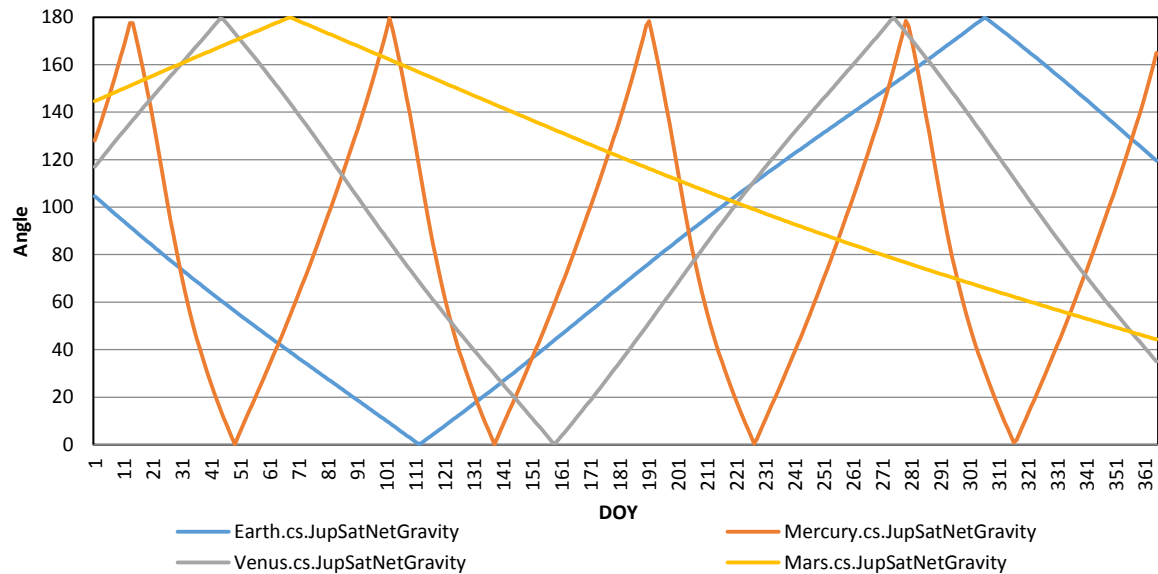
Fig X: Angle between Inner Planets with Jupiter-Saturn Resultant Gravity Vector

4.3.2 JUPITER-URANUS INFLUENCE: Resultant gravity vector of Jupiter-Uranus (JUGV) was analysed and the results are shown in Table V. It is very interesting to note that when Earth was crossing JSGV on DOYs 112-113, the JUGV was located just at the opposite side and hence there has been two invisible gravitational forces acting opposite to each other on this DOY which could have resulted in occurrence of 10 earthquakes (>6 magnitude) within a span of 10 days, and there were 4 earthquakes with the magnitude greater than 6.6, and one very high earthquake (magnitude 7.8) on 25th April, 2015 in Nepal. So one should not consider a particular planetary configuration on a stand-alone mode but rather should also look into other major influencing configurations.

Reference Planet	2015 DOYs (θ < 1deg)	2015 DOYs (θ > 179 deg)	2015 Nearby Earth Quake DOYs (EQ >= 6.0)
Earth	297 to 299	111,112	296,299; 112,114,115,116
Mercury*	14, 102, 190, 278	49,50,137,138,225,226,313,314	191;49 to 53, 139, 224, 225, 227, 311, 312,313,315
Venus	45,46, 270,271	157	44,47,269; 159
Mars	68 TO 71	NIL	69

Table V: DOY of Inner Planets crossing resultant Jup-Ura gravity vector (JUGV) in 2015.
(* for Mercury θ <2; θ > 177 deg was considered.)

On 26th October 2015 (DOY 299) there was an earthquake event with magnitude 7.5, and coincidentally Earth was crossing the JUGV on this period (See **Table V**). But, interestingly nothing happened when Mercury crosses this vector. However, when Mercury crosses this vector in the opposite direction (θ > 178 deg) then there were very clear EQ occurrences. Venus and Mars also showed clear relationship with EQ incidences during February, March September (Refer **Table V** for exact dates).

In a similar way we analysed Sat-Ura, Jupiter-Neptune, Sat-Nep gravity vectors and related results were shown in the **figures XI, XII.** Reader may relate these graphs with EQ incidences.
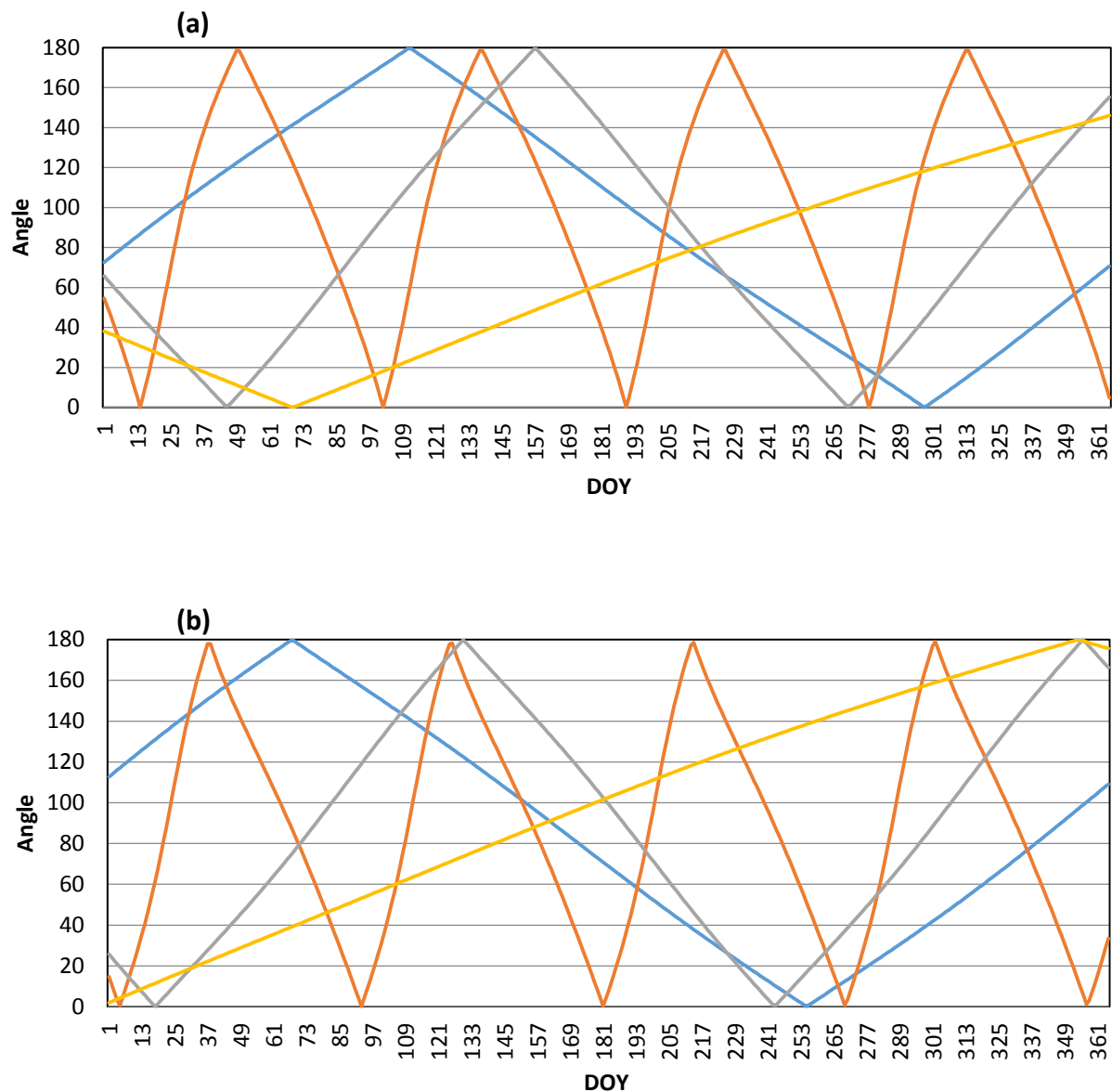
Fig XI: DOY-wise Angle between Inner Planets and Jupiter-Uranus Resultant Gravity Vector (a) and Saturn-Uranus Gravity Vector (b) (*Blue-Earth, Red-Mercury, Grey-Venus, Orange-Mars*).

Reference Planet	2015 DOYs (θ < 1deg)	2015 DOYs (θ > 179 deg)	2015 Nearby Earth Quake DOYs (EQ >= 6.0)
Earth	254 to 256	67,68	256; 69
Mercury*	5,93,181,269,357	37,126,214,302	181,182,269,358,359;125,127,
Venus	18,243	130,356	244; 130,354,358
Mars	NIL	352 to 356	354,358

**Table VI: DOY of Inner Planets crossing resultant Sat-Ura gravity vector (SUGV) in 2015.**
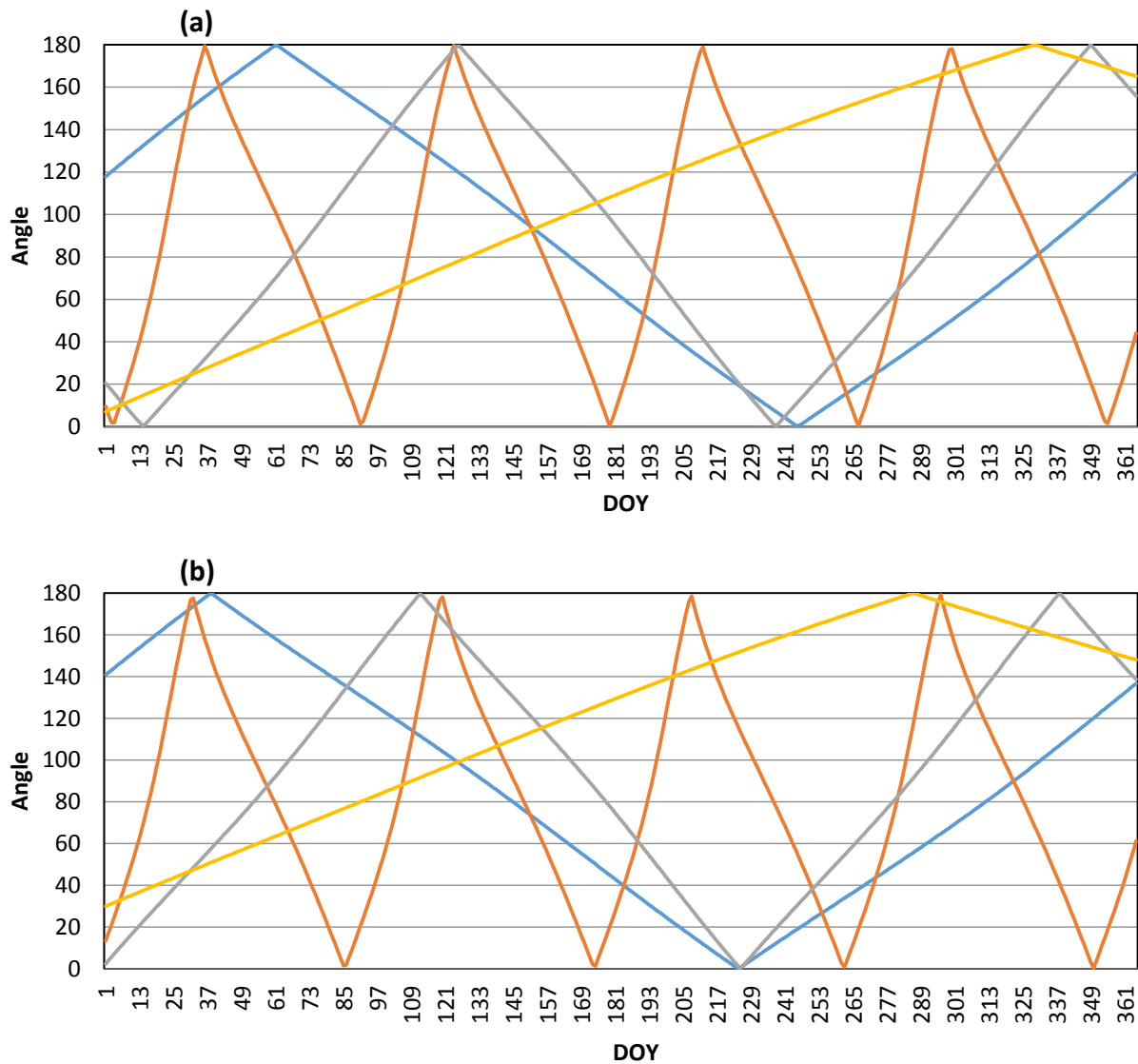
Fig XII: DOY-wise Angle between Inner Planets and Jupiter-Neptune Resultant Gravity Vector (a) and Saturn-Neptune Gravity Vector (b) (*Blue-Earth, Red-Mercury, Grey-Venus, Orange-Mars*).

Reference Planet	2015 DOYs (θ < 1deg)	2015 DOYs (θ > 179 deg)	2015 Nearby Earth Quake DOYs (EQ >= 6.0)
Earth	245,246	61,62	244;62
Mercury*	4,91,179,267,355	36,124,212,300	90,267,354;123,125,299
Venus	14,238	125,126,349	125,351
Mars	NIL	327 to 331	328

Table VII: DOY of Inner Planets crossing resultant Jup-Nep gravity vector (JNGV) in 2015.

Reference Planet	2015 DOYs (θ < 1deg)	2015 DOYs (θ > 179 deg)	2015 Nearby Earth Quake DOYs (EQ >= 6.0)
Earth	224,225	38,39	224,225,227
Mercury*	85,174,262,350	32,120,208,296	174,259to262, 351; 33,120,121, 208, 296
Venus	225	112,338	224; 112, 338
Mars	NIL	284to288	284

Table VIII: DOY of Inner Planets crossing resultant Sat-Nep gravity vector (SNGV) in 2015.

Reference Planet	2015 DOYs (θ < 1deg)	2015 DOYs (θ > 179 deg)	2015 Nearby Earth Quake DOYs (EQ >= 6.0)
Earth	260,261	72 to 74	259 to 262; 74
Mercury*	6,94,182,270,359	38,39,127,215,303	182,269,359;127
Venus	21,247	133,134,359	23;132,358,359
Mars	5to7	365	NIL

Table IX: DOY of Inner Planets crossing resultant Ura-Nep gravity vector (UNGV) in 2015.

(* for Mercury θ <2; θ > 177 deg was considered.)

It is important to analyse the **Tables IV, V, VI, VII, VIII & IX** together before making any conclusion. Generally, user make an observation of a single configuration and reject when there is no earthquake. But one has to see the combination of multiple configurations during a period. Importantly, first preference must be given to direct crossing (i.e., θ < 1 deg) for explaining any EQ event. From the above **Tables** it can be seen that whenever Earth cross any of these resultant gravity vectors of bigger planets there has been big earthquakes without fail. When Venus and Mars crossed this SUGV on opposite side during DOY 352 to 356 (see Table VI) there were 5 big earthquakes (>6 magnitude) during 351 to 359. Is it an accidental coincidence?. Similarly out of 5 crossings by Mercury, 3 resulted in big earthquakes. However one may argue that Mercury crossing on DOY 93 did not result in any EQ, why?. Here comes the broad observation. Mercury crossed Jupiter on opposite side during DOY 85 to 87 (Table II), Mercury crossed SNGV on DOY 85 (Table VIII), and three planetary interaction (Fig. IX) on DOY 89. Hence, there were so many celestial push and pulls and consequently there were major earthquakes before few days from the DOY 93. Importantly one should not expect an exact day match as there were cases having ±1 or 2 days sensitivity but most of them have immediate effect.

On 3rd, 5th & & 7th MAY 2015 (DOY 123, 125 &127) there were earthquakes of magnitude 6, 7.5 & 7.1 respectively. Interestingly Mercury was crossing (a) SNGV on DOY120, (b) JNGV on 124, (c) SUGV on DOY126 and (d) SSGV on DOY125, in the opposite side (SSGV is discussed on section 4.4). Also Mars was crossing Jupiter in the opposite side during DOY122 to 125, and Venus was crossing Neptune on DOY 124 and JNGV on DOY125,126 in the opposite. Also major event on DOY 259 (16th Sep) has clear evidence of Earth Crossing UNGV. Reader may also look in to 11th November (DOY 315) EQ events. There was a direct crossing by Mercury w.r.t JSGV and also it crossed JUGV in the opposite direction on DOY314. There seems to be so many gravitational hurdles at certain places and sometimes in clusters at few places in the solar system space, and it was found that more the crossing of inner planets more the earthquakes.

Due to Mercury's faster movement it creates more possibility to cross these resultant gravity vectors (of bigger planets) very often and hence most of the time the mercury crossings (on same side as well as at opposite side) contributed towards EQ, and this can only be explained in terms of Gravitational interactions. Overall it was observed that explanation capability (i.e., accuracy) of JSGV, JUGV, SUGV, JNGV and SNGV w.r.t. crossings by (a) Earth is 100%. (b) Mercury is 62%, (c) Venus is 85% and (d) Mars is 100%. For Mercury the accuracy of match varies with each RGV as its accuracy is 87.5% for SNGV. Opposite side crossing of Venus with these GVs have 100% link with EQs.

4.4 INFLUENCE OF RESULTANT SOLAR SYSTEM GRAVITY VECTOR: As explained in Section 3.4 the resultant-Solar System Gravity Vector (SSGV) and its direction, and the angle made by each planet with SSGF was calculated on everyday basis over the whole year 2015 (see Figure XIII). The DOY of crossings of inner planets are provided in Table IX for ready reference and also the earthquake events during near-by crossing days were provided for comparison for understanding predictive ability.

Reference Planet	2015 DOYs (θ < 1deg)	2015 DOYs (θ > 179 deg)	2015 Nearby Earth Quake DOYs (EQ >= 6.0)
Earth	250,251	65,66	250;65
Mercury*	4,92,180,268,356	37,125,212,213,301	181,182,267,269; 125,210,299
Venus	17,240,241	128, 352	; 127, 353
Mars	NIL	340 to 343	; 341, 343

Table X: DOY inner Planets crossing resultant Solar System gravity vector (SSGV) in 2015.

(* for Mercury θ <2; θ > 177 deg was considered. See reason in section 3.1.2)

Fig XIII: Angle between Inner Planets with Solar-System Resultant Gravity Vector
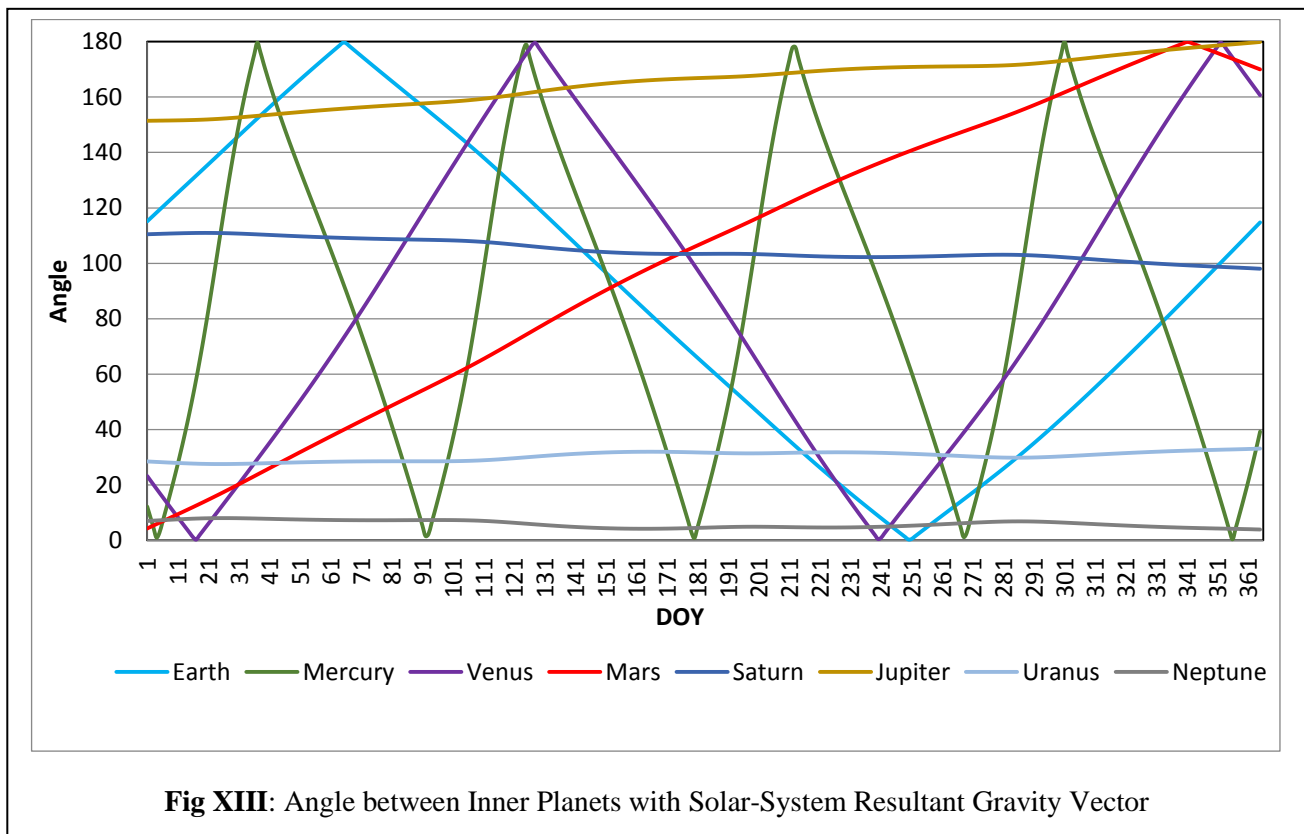
Please look into the earthquake events on 6th March, 7th September, 7th December, 9th December, 2015 (DOY 65, 250, 341, 343). When we searched all other possible configurations in the previous sections none could explain these events. Interestingly when we analysed the crossings w.r.t. SSGV we found that on DOY250 Earth was crossing SSGV, and as well as on DOY 65. The only other crossing was from Venus with Saturn. Similarly there were two big EQs (M7.2 and M6.9) during Mars crossing in opposite side on DOY 341, 343 (see Table X) which were not revealed in previous sections/variables. However Mercury's crossing did not result in earthquake all the time (only 50% link). Venus did not have any effect during same side crossing but had 100% effect in the opposite side. The bigger planets contribute more towards resultant SSGV and their translational movement is slow, but their effect seems to be very minimal. Also, there were no crossing of SSGV by Saturn, Uranus and Neptune in 2015. Jupiter was crossing SSGV during late 2015 and early 2016 and there were observable EQs whenever some other influencing configuration occurred.

4.5 INFLUENCE OF MOON: As explained in Section 3.5, the geo-centric positions of all the planet on everyday in 2015 was estimated. The timing of crossing of Earth-Moon vector w.r.t all the planets were estimated (when θ<6deg and θ>174deg) (see **Table XI**). Since Moon moves fast (~12deg per day) it crosses each planet atleast once every month and hence we kept the angle tolerance accordingly in selecting sensitive DOYs. Also, only the earthquakes which happened within ±1 day from crossing is considered while analysing Moon effect.

It was observed that Moon alone cannot create perturbation in the orbital path of Earth, and hence it can only act as catalyst. In this regard it would not be correct to link every earthquake with Moon crossing. However the catalyst effect is proved by linking moon crossing with other crossings. For example on the DOYs 23,47,49,77,139,140,197,259,315; 33,62,125,127, 181,244,330 there were earthquakes and interestingly there were Moon-Sun crossings (i.e., New Moon or Full Moon day) but there were other configurations (see all previous tables) which need to be considered first before incorporating Moon's role. The Timing of crossing of Earth-Moon vector w.r.t. other EQ inducing configuration would help in accurate prediction of earthquake location, but this research did not attempt to predict geographic locations and definitely there is a hope.

Planets	2015 DOYs (θ < 6 deg)	2015 DOYs (θ > 174 deg)
Moon.cs.Sun	21,50,79,109,138,168,197,227,256, 286,316,345	5,35,65,94,95,124,154,183,242, 271,300,330
Moon.cs.Mer	22,48,78,139,166,196,229, 258,315,347	7,34,62,63,94,126,153,181,213,244, 271,330,361
Moon.cs.Ven	22,52,82,112,142,200,227,253, 282,312, 342	7,37,68,98,128,157,186,214,240,268, 297,327,356
Moon.cs.Mars	23,52,81,110,139,196,225,254, 283,311,340	9,38,67,96,125,154,183,240, 269,326,354
Moon.cs.Sat	44,71,126,153,180,207,235,262,290,317,345	2,29,84,111,166,193,220,247, 275,330,358
Moon.cs.Jup	8,35,62,89,117,144,172,200,227,228, 255,283,311,338	22,49,104,131,159,186,214,242,297, 325,352
Moon.cs.Ura	53,108,163,190,217,245, 272,327,354	13,40,67,95,122,149,150,177,204, 232,259,286,313,340
Moon.cs.Nep	23,78,133,160,187,215,242, 297,324,351	10,37,64,92,119,146,174,201,228, 255,283,310,337,364

Table XI: All Possible crossings by Moon in 2015.

4.6 PREDICTING EARTHQUAKE EVENTS IN 2016: For the benefit of humanity we wanted to provide the DOYs in 2016 where each of the above discussed configuration occurs and these DOYs are sensitive for major Earthquakes, and scientists can look for pre-cursor events on the Earth surface during these periods so as to save lives with advance warning. User may give first priority to resultant gravity vector influence from bigger planets (tables XV to XXI) as their influence especially when earth crosses will have more confidence towards EQ occurrence, and then user may refer to Table XIV. Finally user may refer to Table XII and XIII for further dates.

Planetary Crossing	2016 DOY of crossing (θ < 1deg)	2016 DOY of crossing (θ > 179deg)
EARTH.cs.MER	131,256	83,189,301
EARTH.cs.VEN	NIL	158,159,160
EARTH.cs.MARS	142,143,144,145	NIL
EARTH.cs.JUP	68,69,70	270,271,272
EARTH.cs.SAT	155,156	345,346
EARTH.cs.URA	289,290	101,102
EARTH.cs.NEP	246,247,248	59,60,61
MERCURY.cs.VEN	61,352	119
MERCURY.cs.MARS	29,133	NIL
MERCURY.cs.JUP	24,203,293	80,170
MERCURY.cs.SAT	50,139,228,317	361
MERCURY.cs.URA	87,175,263	33,121
MERCURY.cs.NEP	78,166,254,342	287
VENUS.cs.MARS	331,332	152,153
VENUS.cs.JUP	222	105,341
VENUS.cs.SAT	41,42,270,271	157
VENUS.cs.URA	123,124,350	9,10,236

VENUS.cs.NEP	97,98,323	210
MARS.cs.JUP	NIL	356,357,358,359
MARS.cs.SAT	165,166,167	NIL
MARS.cs.URA	NIL	56,57,58,59,60
MARS.cs.NEP	309,310,311	NIL

Table XII: All possible Planetary crossings and their DOY in 2016.

Pattern	2016 DOY of crossing (θ < 5deg)	2016 DOY of crossing (θ > 175deg)
MERCURY.cs.EAR	14,15,128,129,130,131,132,133, 255,256,257,363,364	82,83,84,189,299,300,301,302,303,304
MERCURY.cs.VEN	58,59,60,61,62,63,64,193,194,351,352,353	117,118,119,120,121,122,273,274
MERCURY.cs.MARS	28,29,30,131,132,133,134,135, 241,242,243,244,347,348	89,90,186,283,284
MERCURY.cs.JUP	23,24,25,113,114,202,203,204,292,293,294	79,80,81,169,170,171,259,260,348,349
MERCURY.cs.SAT	49,50,51,138,139,140,227,228,229,316,317,318	7,8,96,184,272,273,361
MERCURY.cs.URA	86,87,174,175,176,263,264,351,352	32,33,34,120,121,122,208,209,210,211, 297,298,299
MERCURY.cs.NEP	77,78,79,165,166,167,253,254,255,341,342,343	22,23,110,111,198,199,286,287,288

Table XIII: Mercury's Planetary crossings and their DOYs in 2016.

Reference Planet	2016 DOYs (when θ on both sides <= 45deg)
Earth	24,95,112,115,126,127,133,139,151,152,165,166,167, 200,215,240,246,247,254,260,263,268,269
Mercury	34,36,40,41,42,79,215,242,249,259,347,350
Venus	15,21,248,293,296,309,310,311,326,343
Mars	83,84,85,239,240,343,344
Jupiter	20,29,33,41,42,209
Saturn	47,61,131,133,142,143,144,145,159,242
Neptune	256,272,273,320,331,332,337,338,352
Uranus	256,267,322,331,332,351,352,354,358

Table XIV: Three Planet incidences and their DOYs in 2016

Reference Planet	2016 DOYs (θ < 1deg)	2016 DOYs (θ > 179 deg)
Earth	128,129	322,323
Mercury*	40,41,130,219,308	3,92,180,269,357
Venus	24,255	140,141,
Mars	111to115	NIL

Table XV: DOY of Inner Planets crossing resultant Jup-Sat Gravity Vector (JSGV) in 2016.

Reference Planet	2016 DOYs (θ < 1deg)	2016 DOYs (θ > 179 deg)
Earth	111,112	295,296
Mercury*	1,89,177,352	36,37,124,212,299,300
Venus	129,130,353	16,17,240,
Mars	NIL	79 to 82

Table XVI: DOY of Inner Planets crossing resultant Jup-Ura Gravity Vector (JUGV) in 2016.

Reference Planet	2016 DOYs (θ < 1deg)	2016 DOYs (θ > 179 deg)
Earth	258,259	70,71
Mercury*	80,169,257,345	25,113,201,289,290
Venus	104,330	216,217
Mars	327 to 329	NIL

Table XVII: DOY of Inner Planets crossing resultant Sat-Ura Gravity Vector (SUGV) in 2016.

Reference Planet	2016 DOYs (θ < 1deg)	2016 DOYs (θ > 179 deg)
Earth	242,243	58,59
Mercury*	77,165,253,341	22,23,110,198,286
Venus	96,320,	207,208
Mars	301 to 303	NIL

Table XVIII: DOY of Inner Planets crossing resultant Jup-Nep Gravity Vector (JNGV) in 2016.

Reference Planet	2016 DOYs (θ < 1deg)	2016 DOYs (θ > 179 deg)
Earth	227 to 229	41,42
Mercury*	73,161,249,338	19,107,195,283
Venus	86,312	199
Mars	280to283	NIL

Table XIX: DOY of Inner Planets crossing resultant Sat-Nep Gravity Vector (SNGV) in 2016.

Reference Planet	2016 DOYs (θ < 1deg)	2016 DOYs (θ > 179 deg)
Earth	263 to 265	76,77
Mercury*	82,170,258,346	26,27,114,115,202,203,290,291
Venus	108,333,334	220
Mars	335 to 338	1 to 4

Table XX: DOY of Inner Planets crossing resultant Ura-Nep Gravity Vector (UNGV) in 2016.

Reference Planet	2016 DOYs (θ < 1deg)	2016 DOYs (θ > 179 deg)
Earth	245,246,247	59,60,61
Mercury*	78,166,254,343	23,110,111,198,199,287
Venus	98,324,325	209
Mars	311,312,313,314	59,60,61

Table XXI: DOY of inner planets crossing resultant Solar System gravity vector (SSGV) in 2016.
(* for Mercury θ <2; θ > 177 deg was considered.)

5. CONCLUSION AND RECOMMENDATION: The study analysed 10 different configurations based on vector algebra in terms of single, double and triple planetary vectors, influence of inner planets and bigger planets. The DOYs of different configurations were validated over different months and many repeating configurations were tested, and found that there is a definite relationship between EQ occurrences and resultant gravity vectors. More the number of possible crossings more the intensity and frequency of EQs. We estimated the total sum of magnitudes of earthquakes in different months and noticed that May and November was the most quaked months in 2015 with total sum of magnitudes 138.2 and 106.8, and if consider 20th to 20th period between months then Apr-May (143.8) and Aug-Sep (127.4) were the most quaked period, and 16th September was the most quaked day with the total sum of magnitude 46.3. We noticed many perturbation inducing configurations during these periods and associated planetary configurations were revealed in the results and discussion sections. Predicted DOYs for the year 2016 will further add value to our study, and researchers are requested to keep an eye (looking for precursors on the ground) during those days to pin-point ground location to save lives. Overall, the bigger planets play a major role in setting up the stage and inner planets play a spoil sport using that stage which result in earthquakes, and the study revealed the hidden nature of this play and associated dates w.r.t EQ. For prediction, we recommend that researcher should give first priority to resultant gravity vector influence, followed by three-planetary interaction and finally to planetary crossings. Only when other configurations are strong then Sun-Moon conjunction will play a strong catalytical role.

Study restricted itself to time-sampling of one day due to huge amount of calculations involved. One may argue that the study did not check the hypothesis in other years. Indeed, the hypothesis was based on our observations of previous 100 years of earthquakes, and finally the consolidated ideas were tested over 2015. Also, one has to remember that a planetary configuration is a repeating cycle and we get enough such cycles in one year. So, every hypothesis was tested at all those repeating periods in 2015 which itself is a proof of testing at different time period. The authors recommend that our hypothesis can be experimentally checked by sending satellites (such as GRACE type) to those RGV locations in space to understand the orbital perturbation effect. Also one can look into past inter-planetary satellite travel data for any deviation in their path while crossing such RGVs or any other influencing configuration. Also, we recommend that during those perturbations the orbital path of satellites moving around the Earth may also get disturbed and there may be unexplained deviation on those DOYs. The study recommends for detailed observation of Earth's molten outer core as its movement pattern may have a role in geoidal variation, earthquakes and volcanic eruptions as well as inducing local changes in the global circulation pattern.

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