Solar quiet (Sq) and conductivity-depth structure of Asia sub-region using solar quiet field variation

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Abstract. The study used some selected magnetic field records to establish the equivalent external and internal ionospheric current system for the moderate solar quiet year 2012. The month-by-month behaviour of the equivalent current for both external and internal current appears stronger in local summer months (May-August) and weaker in local winter months (November-February). The current vortex appears earlier in local summer than in local winter months and disappeared in December. In each of the month, the latitudinal position of the internal Sq current vortex appeared at a considerable higher latitude than the external. A regression line fitted to the estimated conductivity values gives a profile that starts at 0.02 S/m at a depth of about 30 km and rose gradually to about 0.03 S/m seen at ~120 km depth. Consequently the conductivity profile increases significantly to about 0.07 S/m at depth of about 400 km followed by a sharp steep increase through the transition zone and reached its peak value ~0.3 S/m at depth of about 770 km. An evidence of discontinuity was observed at depth of about 370-440 km and 603-671 km. The sharp steep increase in conductivity profile at depth of about 400 km may be due to phase change of the mantle minerals from olivine to spinel structure.

1. Introduction

The daily geomagnetic field variations at the Earth surface has quite a number of sources which are of external and internal origin to the Earth surface. The field produce by these sources are generally time dependent and changes slowly with latitudes depending on the magnetic activity on the outer space. According to the classical dynamo theory, the main source of the daily geomagnetic field is the electric current flowing at an altitude (90-150 km) in the E-region of the ionosphere generated by the motion of conducting particles across the Earth’s main magnetic field, [1]. When magnetic disturbances are absent, the current generated is known as solar quiet (Sq) current and the field produce is known as solar quiet (Sq) field. The sensitivity of the Sq current amplitude to solar activity is different from one season to another such that its strength has an annual variation with higher intensity in summer at mid-latitude region and a semi-annual variation in which it is strongest in equinox at equatorial low latitude, e.g [2] The variability of the Sq current system has been attributed to variation in the ionospheric conductivity, [3]. In a different study, [4] attributed the variability of the Sq current to variation of the tidal and prevailing winds in the upper atmosphere. The equivalent Sq current system during the sunlight hours has two current vortices (one on each hemisphere) centred on the local noon. The current flow in the northern hemisphere is counter-clockwise and clockwise in the southern hemisphere, e.g [5]. The fluctuating current cause a corresponding currents to flow into the conducting Earth structure. The magnitude, direction and depth at which the induced component of the Sq current penetrate is determine by the effective wavelength of the source current and the distribution of electrically conducting materials within the Earth’s interior, [6]. The primary aim of this study is to
investigate the month-by-month behaviour of the equivalent Sq current system and to estimate the general conductivity profile of the upper mantle beneath Asia sub-region

2.0 Sources of Data
In the data selection, the first criteria adopted to ensure good and quality data are used was to select days in which the geomagnetic disturbance index Kp values are not greater than 3 as earlier suggested by [7]. These groups of quiet days were obtained as published by Geoscience Australia Catalogue at [8]. These days have least solar-terrestrial magnetic disturbances, thus represent the Sq fields generated by dynamo currents in the E region of the ionosphere. The data set used in this study are the International Real-time Magnetic Observatory Network (INTERMAGNET) data for the year 2012. The observatories had their sample records available in minute average values and the original recordings of the field across all the stations were in Universal time (UT) and are all converted to local time. The intermagnet data are recorded as orthogonal north, east and vertically downward components field as X, Y and Z and the X and Y are transformed to their respective northward (H) and eastward (D) coordinate system using the relation given in [9]. The magnetic stations used span from the magnetic equator to high latitude region and table 1.0 shows the list of the stations used in the analysis.

Table 1.0: List of INTERMAGNET data stations and their coordinates system used in the study

| Name                  | Code | Geographic | Geomagnetic |
|-----------------------|------|------------|-------------|
| Dalat                 | DLT  | 11.94      | 2.60        |
| Phu thuy              | PHU  | 21.03      | 10.78       |
| Zhaoqing              | GZH  | 22.00      | 12.74       |
| Kanoya                | KNY  | 31.42      | 20.50       |
| Kakioka               | KAK  | 36.63      | 27.37       |
| Beijing Ming Tom      | BMT  | 40.30      | 30.04       |
| Changchum             | CNH  | 44.08      | 31.00       |
| Memenbetsu            | MMB  | 43.91      | 35.35       |
| Irkutsk               | IRT  | 52.27      | 41.84       |
| Parantuka             | PKT  | 52.97      | 46.10       |
| Magadan               | MGD  | 60.05      | 53.49       |

3.0 Method of Data Analysis
The analysis started by assuming that as the Earth rotates around the sun and the magnetic observatories across the latitudes are riding with the Earth under a fixed subsolar ionospheric current system. These magnetic observatories sampled the behaviour of the field source current and the current induced to flow in the conducting Earth beneath the observatories. The Sq field variations at any of the latitude in 24 hours represented the measured field through 360° of a sphere. [6] Called this technique "cloning" a sphere from a longitudinal "slice" sample.

Next, a hemispheric mirror modelling technique was applied. This model utilizes the field values of the hemisphere that is of primary interest in the study to create a secondary hemisphere in the opposite hemisphere. This was achieved by simply assuming that the H-field variation in the secondary hemisphere is similar to the primary hemisphere but its D and Z component are caused to be oppositely directed by simply changing the appropriate sign of the two (D and Z) components so as to conform to the reversed source-current vortex as extensively discussed by [6]. In the mirror hemisphere, the variations of the Sq field formed for the three orthogonal components from the primary one were shifted by 6 months such that the summer hemisphere of the primary stations corresponds to the winter hemisphere of the secondary hemisphere. In a similar way, for each day the harmonic coefficients for an analysis sphere was created with field values at all 2.5° latitude
increments, pole to pole as input parameter to the SHA analysis. At this stage, a complete sphere has
been successfully created consisting of the primary and secondary hemisphere and the outcome of the
analysis was strictly apportion to the primary region.

[10], and [9] estimated the spectral contributions to the Sq field and found that only the 24-, 12-, 8-
and 6-hr harmonics components are of larger size to contribute significantly to the Fourier analysis.
The higher magnitudes is due to the effect of Earth’s rotation and not on the characteristics of the
signal at any given day. On the basis of this that we determine the 24-, 12-, 8-, and 6-hourly Fourier sine and cosine coefficients for each station and component from the detrended Sq field
records. The annual and semi-annual Fourier components of 12 (months) daily coefficients in each
year were also determined at each 2.5° geomagnetic latitude increments from the geomagnetic equator
to northward and southward poles as earlier suggested by [10] The Fourier coefficients obtained were
stored in a file and these values represent the year’s Sq field variations for each component. For any
geomagnetic component W (H, D and Z), the Sq field could be constructed from:

\[ \Delta W = \sum_{m=1}^{\infty} \left\{ C_m \cos(15mt) + S_m \sin(15mt) \right\} \]  

where \( \Delta W \) represent the changes for the H, D or Z field component from the daily mean value of the
surface field records. The t is the local time (LT) in hours at the stations, while \( C_m \) and \( S_m \) are the
cosine and sine amplitude coefficients as given in the equation below;

\[ C_m = A_m^0 + \sum_{\ell=1}^{\infty} \{ A_m^{Q\ell} \cos(30MQ) + B_m^{Q\ell} \sin(30MQ) \} \]  

(2)

\[ B_m = B_m^0 + \sum_{\ell=1}^{\infty} \{ A_m^{Q\ell} \cos(30MQ) + B_m^{Q\ell} \sin(30MQ) \} \]  

(3)

where m is the order from 1-4 for the 24-, 12-, 8-, and 6-hours spectral components. Q is 1 for annual
and 2 for semi-annual, while M is the decimal month (represented as 0.00 for January 1 and 12.00 for
December 31). The As and Bs are the Fourier amplitude coefficients and the mainline letters are the
annual and semi-annual coefficients. Any linear trend on the recorded Sq field variation that will
introduce some errors in the sinusoidal amplitude coefficients was removed before the Fourier analysis
was performed. The file containing each of the 40 Fourier coefficients representing each of the three
orthogonal field directions were carefully arranged according to geomagnetic latitudes of the stations
used in the analysis for smoothing. The global observations of Sq fields are more symmetric with
respect to geomagnetic axis than the geographic and this cause the SHA coefficients series for the Sq
to converge more easily and rapidly with geomagnetic expansion. Therefore, the analysis in this study
will proceed with the geomagnetic coordinate system.

When V is determined from the magnetic field record about the Earth, analyses shows that most of
the contributions comes from the internal part of the magnetic potential function expansion. The magnetic potential of the quiet field obtained from the daily mean values recorded in universal time
(UT) from the external source current and the internally induced current is expressed as;

\[ V_{\text{ext}} = R_E \sum_{n=1}^{\infty} \left( \frac{r}{R_E} \right)^n \sum_{m=0}^{n} \left[ a_n^{me} \cos(m \phi) + b_n^{me} \sin(m \phi) \right] P_n^m(\cos \theta) \]  

(4)

\[ V_{\text{int}} = R_E \sum_{n=1}^{\infty} \left( \frac{R_E}{r} \right)^{n+1} \sum_{m=0}^{n} \left[ a_n^{mi} \cos(m \phi) + b_n^{mi} \sin(m \phi) \right] P_n^m(\cos \theta) \]  

(5)

Where C, \( \theta \), a, r, \( \phi \) represent constant of integration, geomagnetic colatitude, geocentric distance,
Earth’s radius and local time of the station. It is obvious from equation 9 and 10 that two magnetic
potential components are attributed to external and internal sources. The magnetic potential \( V_{\text{ext}} \) increases with increasing \( r \)-indication of increase field strength as the height increases from the
surface. On the other hand, the \( V_{\text{int}} \) increases with decreasing \( r \)-indication of increase field strength with depth from the ground. The \( a_n^{me}, b_n^{me} \) and \( a_n^{mi}, b_n^{mi} \) correspond to the Gauss coefficient with e and i indicating external and internal field sources. It is apparent in equation 4 and 5 that the
longitudinal dependence of both magnetic field potential are given by Fourier series, while its
latitudinal dependence is represented by a series of Schmidt quasi-normalized associated Legendre
functions \( P_n^m(\cos \theta) \). This function can be estimated using the following recursive formula as provided in [9]
\[ R_n^m = \sqrt{n^2 - m^2} \]  
(6a)

\[ P^0_0 = \cos(\theta) = 1; \quad P^1_0 (\cos\theta) = (\cos\theta) = \sin(\theta) \]  
(6b)

\[ P^m_n (\cos\theta) = \frac{\sqrt{2m-1}}{\sqrt{2m}} \sin(\theta) P^{m-1}_{m-1}; \quad (\cos\theta) P^{m-1}_{m-1}; \quad \text{for } m > 1, n = m \]  
(6c)

\[ P^m_n (\cos\theta) = \frac{(2n-1) \cos \theta}{\sin \theta} \left( R^m_n - P^{m-1}_{n-1} \right) f \]  
(6d)

Equation (6e) is undefined at the poles (for \( \theta = 0 \) or 180°).

To determine the spherical harmonic Gauss coefficients, the following values were first obtained;

\[ a_n^m = \frac{2n+1}{4(n+1)} \left( \sum_{0}^{180} X^m c \frac{dP^m_n}{d\theta} \sin \theta + Y^m s m P^m_n \right) \Delta \theta \]  
(7a)

\[ b_n^m = \frac{2n+1}{4(n+1)} \left( \sum_{0}^{180} X^m c \frac{dP^m_n}{d\theta} \sin \theta + Y^m c m P^m_n \right) \Delta \theta \]  
(7b)

\[ C_n^m = \frac{1}{4} (2n + 1) \sum_{0}^{180} Z^m c r^m_n \sin \theta \Delta \theta \]  
(7c)

\[ d_n^m = \frac{1}{4} (2n + 1) \sum_{0}^{180} Z^m s r^m_n \sin \theta \Delta \theta \]  
(7d)

where \( X^m c \) and \( Y^m s \) represent the cosine and sine coefficients of the Fourier component m of the northward (\( \Delta H \)) field change at colatitude (\( \theta \)). The \( \Delta \theta \) in these equations is the step increment which is equivalent to 2.5° (\( \Delta \theta = 2.5° \)) used in the analysis. \( \theta \) is the geomagnetic colatitude.

The spherical harmonic Gauss coefficient for the external and internal is then computed using the equations below;

For the external part

\[ a_n^{me} = \frac{[n+1] a_n^m + c_n^m]}{2n+1} \]  
(8a)

\[ b_n^{me} = \frac{[n+1] b_n^m + d_n^m]}{2n+1} \]  
(8b)

The internal part is given as;

\[ a_n^{mi} = \frac{[n_a_n^m - c_n^m]}{2n+1} \]  
(9a)

\[ b_n^{mi} = \frac{[n_b_n^m - a_n^m]}{2n+1} \]  
(9b)

The potential function was separated into external and internal source contributions. With reference to Gauss coefficients, the external fields in the orthogonal directions (with X pointing geomagnetic northward, Y eastward and Z vertically downward) may be reconstructed from the external spherical harmonic analysis as series of Fourier cosine and sine of the terms;

\[ X^m c (\theta) = \sum_{n=m}^{12} a_n^{me} \frac{dP^m_n}{d\theta} \]  
(10a)

\[ X^m s (\theta) = \sum_{n=m}^{12} b_n^{me} \frac{dP^m_n}{d\theta} \]  
(10b)
\[ Y^m_c(\theta) = -\frac{m}{\sin \theta} \sum_{n=m}^{12} b_n^m \frac{dP_n^m}{d\theta} \]

(10c)

\[ Y^m_s(\theta) = -\frac{m}{\sin \theta} \sum_{n=m}^{12} a_n^m \frac{dP_n^m}{d\theta} \]

(10d)

\[ Z^m_c = \sum_{n=m}^{12} n a_n^m p_n^m \]

(10e)

\[ Z^m_s = \sum_{n=m}^{12} n b_n^m p_n^m \]

(10f)

where \( X^m_c, Y^m_c \) and \( Z^m_c \) are the Cosine coefficients of the external orthogonal field components and \( X^m_s, Y^m_s \) and \( Z^m_s \) are the Sine coefficients. For the internal horizontal component the \( e \) may be replaced by \( I \) and its vertical internal component is expressed as;

\[ Z^m_c(\theta) = -\sum_{n=m}^{12} (n+1) a_n^{mi} p_n^m \]

(11a)

\[ Z^m_s(\theta) = -\sum_{n=m}^{12} (n+1) b_n^{mi} p_n^m \]

(11b)

The sphere in which the spherical harmonic analysis is carried out was spherically created to accommodate the boundary conditions of the Gauss method.

The equivalent current function \( J(\phi) \) in Amperes (A) for any hour of the day \( \phi/15 \) is expressed as;

\[ J(\phi) = \sum_{m=1}^{4} \sum_{n=n(m)}^{12} \{ U_n^m \cos(m\phi) + V_n^m \sin(m\phi) \} p_n^m \]

(12)

The external current is expressed by;

\[ U_n^m = -K n^{n+1} a_n^{mi} \left( \frac{a}{R} \right)^n \]

(13a)

\[ V_n^m = -K n^{n+1} b_n^{mi} \left( \frac{R}{a} \right)^{n+1} \]

(13b)

Where \( K = \frac{5R}{2\pi} \) and \( R \) is the Earth radius given in kilometres, \( a \), is the radius of the sphere of the equivalent current location. Throughout the study, \( a \), is assumed to be approximately equal to \( R \) so that the ration \( \frac{a}{R} \) and \( \frac{R}{a} \) becomes 1 and the factor was omitted.

### 4.0 Conductivity of the Earth’s upper mantle

[11] Provided set of equations for profiling the conductivity with a transfer function equivalent to a substitute conductor. This method required external and internal spherical harmonic coefficients at a given location as input parameters. [12] Modify Schmucker’s transfer function. The generalized form of Schmucker’s transfer function \( C_n^m \) as modify by Campbell and Anderssen is expressed as;

\[ C_n^m = Z - iP \]

(14)

The transfer function for a substitute conductor given in equation (1) has a complex number in which the real (\( Z \)) and the imaginary (\( P \)) part expressed as;

\[ Z = \frac{R}{n(n+1)} \left( A_n^m [n a_n^m e^{-(n+1)a_n^m}] + B_n^m [n b_n^m e^{-(n+1)b_n^m}] \right) \]

(15a)

\[ P = \frac{R}{n(n+1)} \left( A_n^m [n b_n^m e^{-(n+1)b_n^m}] - B_n^m [n a_n^m e^{-(n+1)a_n^m}] \right) \]

(15b)

The \( R \) is the radius of the Earth expressed in kilometres; hence the \( Z \) and \( P \) are expressed in kilometres. The coefficient \( A_n^m \) and \( B_n^m \) are obtained using the spherical harmonic coefficients for the external and internal field given below;

\[ A_n^m = a_n^me + a_n^{mi} \]

(16a)
\[ B_n^m = b_n^{me} + b_n^{mi} \]  
16b)

For each \((m,n)\) set of spherical harmonic coefficients, the depth (in km) to the uniform substitute was estimated using the relation

\[ d_n^m = Z - P \]  
17a)

And has a substitute –layer conductivity \((\text{S/m})\) given by;

\[ \sigma_n^m = \frac{5.4 \times 10^4}{m(\pi P)^2} \]  
(17b)

The ratio of the internal to the external components of the quiet field variation \(S_n^m\) is given as;

\[ S_n^m = u + iv \]  
(18a)

Where

\[ u = \frac{(a_n^{me})(a_n^{mi})+(b_n^{me})(b_n^{mi})}{[(a_n^{me})^2+(b_n^{me})^2]^{1/2}} \]  
(18b)

\[ v = \frac{(b_n^{me})(a_n^{mi})-(a_n^{me})(b_n^{mi})}{[(a_n^{me})^2+(b_n^{me})^2]^{1/2}} \]  
(18c)

The validity of equation (a) and (b) is bounded by three conditions: the first condition is given by;

\[ 0^\circ = \text{arg}(C_n^m) \geq -45^\circ \]  
(19a)

The second condition is that

\[ 80^\circ = \text{arg}(S_n^m) \geq 10.5^\circ \]  
(19b)

The third is that the SHA amplitudes (equation 12) not be small because the relative error in the SHA coefficients increases with decrease in amplitudes of the coefficients. Hence the amplitude is set at;

\[ [(A_n^m)^2 + (B_n^m)^2]^{0.5} \geq G_m \]  
(19c)

5.0 Results and Discussion

Figures 1and 2 shows the month-by-month equivalent external and internal Sq current system. It is obvious from these figures that the external and internal equivalent currents are characterized by a single daytime current vortex at mid-latitude that appears stronger in northern summer months (May-August) and weaker in northern winter (November-February). The maximum intensity of the external current reached \(12.6 \times 10^4\)A in June and its minimum 4.4 \(\times 10^4\)A is seen in November. The internal Sq current has its maximum amplitude value -6.2 \(\times 10^4\)A in June and its minimum -2.2 \(\times 10^4\)A appeared in November. The structure and strength of the Sq current system are primarily controlled by the neutral tidal winds and the conductivity in the dynamo region of the ionosphere. Modelling the Sq current system at different solar epoch, [13] found that changes in ionospheric conductivity cause a corresponding changes in the Sq current intensity. This account for the maximum intensity of the Sq current system observed in northern summer month (June) in the present study. Apart from the intensity of the external Sq current, the latitudinal position of the current vortex shows that it varies on monthly basis.
For example, the latitudinal position of the externalSq current vortex ranged between 23° and 25° seen between April to August as depicted in figure 1. During these periods, the internalSq current vortex moves poleward relative to the external vortex. It ranged between 25° and 28° seen between April to September as shown in figure 2. In each of the month, the latitudinal position of the internal Sq current vortex appeared at a considerable higher latitude than the external. Figures 1 and 2 also show that the current vortex appear earlier in local summer months (May-August) than in local winter months (November-February). This variation in the position of the Sq foci has been largely attributed to interhemispheric field-aligned current (IHFACs). [14] earlier suggested that the field-aligned current of the current vortex produce an eastward geomagnetic field that advances the equivalent current vortex in the summer hemisphere and delays the vortex in the winter hemisphere. The consequences is that the intensity of the Sq current vortex appears at earlier local time in summer than in winter as obvious in the present study. This could be the main reason for the Sq current whorl appearing at later hour of the day in northern winter months. If in deed the noontime southward flow of FACs is responsible for the northern eastward displacement of the Sq current whorl, then it has a shorter time considering the months of later occurrence of Sq current whorl, while the northward flow has longer period of about 6-months. This difference may likely reflect local effect of the upper mantle conductivity upon the induced currents in the Earth’s interior.

Figure 1.0 Equivalent external Sq current system in 2012
During times when the external Sq current was minimum in northern winter, the daytime current in November appears very weak with its vortex at a considerable lower latitude (25°) and disappeared in December. The internal Sq current vortex was also observed to disappear in December. This implies that the disappearance of Sq vortex is a consequence of weaker daytime Sq current. This result is in sharp contrast with the early findings of [2] that did not observe any disappearance of the Sq vortex focus in their winter months. However, the present result is consistent with the India-Siberia region reported by [16]. These authors observed disappearance of Sq vortex focus in their winter months. In a similar study by [17], they found for the Central Asia Sq focus vortex magnitude to reach about 16.8 x 10^4 A in June and July and virtually disappeared in December and January. The disappearance of sq current vortex particularly in winter months indicates the existence of significant changes in the summer-winter variation pattern of the Sq current system.

Figures 3 show the mantle electrical conductivity-depth profile of Asia sub-region during moderate and low solar activity year 2012. The blue dotted points are the computed conductivity values. The locally weighted regression fitting to the conductivity values is given.
by the solid line computed using the best Lowess technique. A small group of about 3 conductivity values at depth range between 200 and 400 Km are observed in figure 3. It is not certain whether these are real or outliers or perhaps there are times when the varying source Sq field is inducing a response from a small scale, high conductivity anomaly at these locations. Similar effect was earlier observed in the India-Siberia region by [18]. Apart from these small groups of conductivity values, generally the scattered points are much concentrated within the first few kilometres down to a depth of about 450 km and with increasing depth, the density of the scattered points decreases to a depth of about 770 km.

Figure 3. Mantle electrical conductivity-depth profile computed from the monthly spherical harmonic analyses of the Sq fields applied to the equivalent substitute conductor technique. The points that is indicated by * the computed values while the solid line through the points is a locally weighted regression fitting of the computed conductivity values.

These points resulted from series of factors among them includes; error incurred from the field measurements, error from spherical harmonic analysis (SHA) fitting, various sources of currents. The noise in the original data and the effect of lateral inhomogeneity also constitute an error that is very difficult to evaluate accurately, hence what could actually be termed an error is in the measurement of the regression fitting for the scattered conductivity values. It is obvious from both figure 4 that the profile shows downward increase in conductivity with depth from the crustal surface deep down into the lower mantle in consistent with earlier result of [6] that observed conductivity profile to the lower mantle depth beneath Australian region. This downward increase in the conductivity profile is no surprise since for a given earth’s interior the temperature increases with depth, it is expected for the electrical conductivity to increase accordingly. The gradual increase at depth range between 30 and 120 km indicate the existence of weak conductivity zone. This observation is in Sharp contrast with the South American sector that showed highest conductivity profile at this depth range suggesting lateral inhomogeneity between the continents. However, the present result is Consistent with East Asia and African observation by [19] and also Malaysian region by [20]. Since the electrical conductivity within few kilometres of the crust depends on the amount of interstitial water that is present, it is likely the weak conductivity may be due to dehydration of the crust through metamorphic process as earlier identified by [21]. A sudden increase in conductivity from 0.03 to 0.04 S/m at depth range between
120 and 270 km correspond to the asthenosphere with global seismic low velocity and high electrical conductivity, e.g. [22]. A sharp steep increase in conductivity was observed at depth of about 400 km with corresponding magnitude of 0.07 S/m and increases steeply to about 0.15 S/m at depth of 600 km and continued until it reached about 0.3 S/m at depth of 770 km with no indication of levelling off. The sharp steep increase at depth of 400 km may be due to phase change of the mantle materials from olivine to spinel structure as earlier as earlier discussed by research workers e.g. [18]. The high electrical conductivity profile at depth between 400 and 600 km correspond to the mantle transition zone identified with high electrical conductivity, e.g. [20]. The mantle transition zone has been identified as the most likely important water reservoir on Earth due to its ability to store water content of more than 2 wt%, [23]. The enhanced conductivity profile in the transition may likely be influence by the presence of water. The discontinuity profile observed at 370–440 km is likely associated to the transformation of α-phase of olivine to β at high temperature and pressure, [24] while the dissociation of γ is ascribed to the seismic discontinuity at 603–671 km, [25]. The γ-phase split into perovskite and magnesiowustite at the transition zone and even beyond, [26].

6.0 Conclusion

The monthly behaviour of the external and internal Sq current system appears stronger in local summer months (May-August) and weaker in local winter months (November-February). The current vortex appears earlier in local summer than in local winter months. In each of the month, the latitudinal position of the internal Sq current vortex appeared at a considerable higher latitude than the external. An evidence of discontinuity was observed at depth of about 370-440 km and 603-671 km. The sharp steep increase in conductivity profile at depth of about 400 km may be due to phase change of the mantle minerals from olivine to spinel structure.

Acknowledgements

The results presented in this paper rely on data collected at magnetic observatories. The authors are grateful to the national institutes that support them and INTERMGNET for promoting high standard magnetic observatories.

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