Spectra of the geomagnetic field diurnal variations

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SUMMARY

Spectral analysis of the 3 components of the geomagnetic field time series with the discreteness of 60 s (Intermagnet data) has been made by the Fast Fourier Transform, and an average-annual and average-seasonal amplitude spectra have been obtained over periods from 300 s to 5 × 10^6 s. The spectrum consists of a continuous part and narrow lines at the diurnal period T_1 = 86400 s and its harmonics with periods T = T_1/n, where n = 2-7. The subject of this work is the diurnal line of the spectrum and its harmonics located in the interval of periods 10,000–100,000 s. The spectra were studied at 50 world-wide distributed observatories and the following results were obtained. The representation of harmonics through spectral lines makes it possible to identify two phenomena. At the near-to-pole high geomagnetic latitudes ±79-90°, only the daily harmonic T_1 is observed, harmonics of higher orders are absent. In this zone, the horizontal component is much larger than vertical one which is in good agreement with the quasi-uniform current layer in the polar cap ionosphere. An interesting new scientific result is the widening of the diurnal harmonic spectral line from September to February at all studied observatories. This is not a seasonal variation, since it is equally observed in both the northern and southern hemispheres, in which the seasons are in antiphase. We can assume that this phenomenon is associated with a certain orientation of the Earth in outer space relative to some factor that changes the daily spectral line to a wider one. The absolute motion of the Earth, formed by the hierarchy of cosmological rotations, is proposed as such a factor.

Keywords: diurnal geomagnetic variations, harmonics of diurnal variations, absolute motion

1. INTRODUCTION

During our study of variations of the VTF (vertical transfer function) we examined the coherence parameters of the 3 components of the geomagnetic field and found maxima in both input and multiple coherences at the harmonics of the diurnal period. To understand the result, we determined the spectra of the geomagnetic field and found some non-described (as far as we know) phenomena that we would like to present now.

2. METHODICS

The program using FFT (Fast Fourier Transform) algorithm has been applied to processing of the 3 components of the geomagnetic field time series with the discreteness of 60 s (Intermagnet data). Consequently an average-annual and an average-seasonal amplitude spectra have been obtained over periods from 300 s to 5 × 10^6 s. The spectrum consists of the continuous part and narrow lines at the diurnal period T_1 = 86400 s and its harmonics with periods T = T_1/n, where n = 2-7. The presentation of the harmonics of diurnal variation through spectral lines makes it easy to track the presence or absence of specific harmonics in the geomagnetic field, their amplitude and width of the lines.

3. RESULTS

32 Intermagnet observatories in the North American region (including Honolulu and west Greenland) were processed, 12 of which are presented in Figure 1. All spectra reveal well known regularity: the amplitude of the geomagnetic field grows with an increase of period. However, in the vicinity of the diurnal period, a more or less flat maximum of continuous spectra is usually observed, while at the diurnal period itself an intense line is always presented. From the entire spectrum, only harmonics of the daily period will be considered. Therefore, in all figures the scale of periods is limited to interval 10000-100000 s.

In the closest to the geomagnetic pole observatories THL, ALE, RES (Figure 1) and MBC (φ_m=79.85°), only a single diurnal line T_1=86400 s without higher harmonics is observed (we neglect the second harmonic, which is an order smaller and appears in few components). Horizontal components' amplitude is much bigger than vertical one at these 4 observatories.

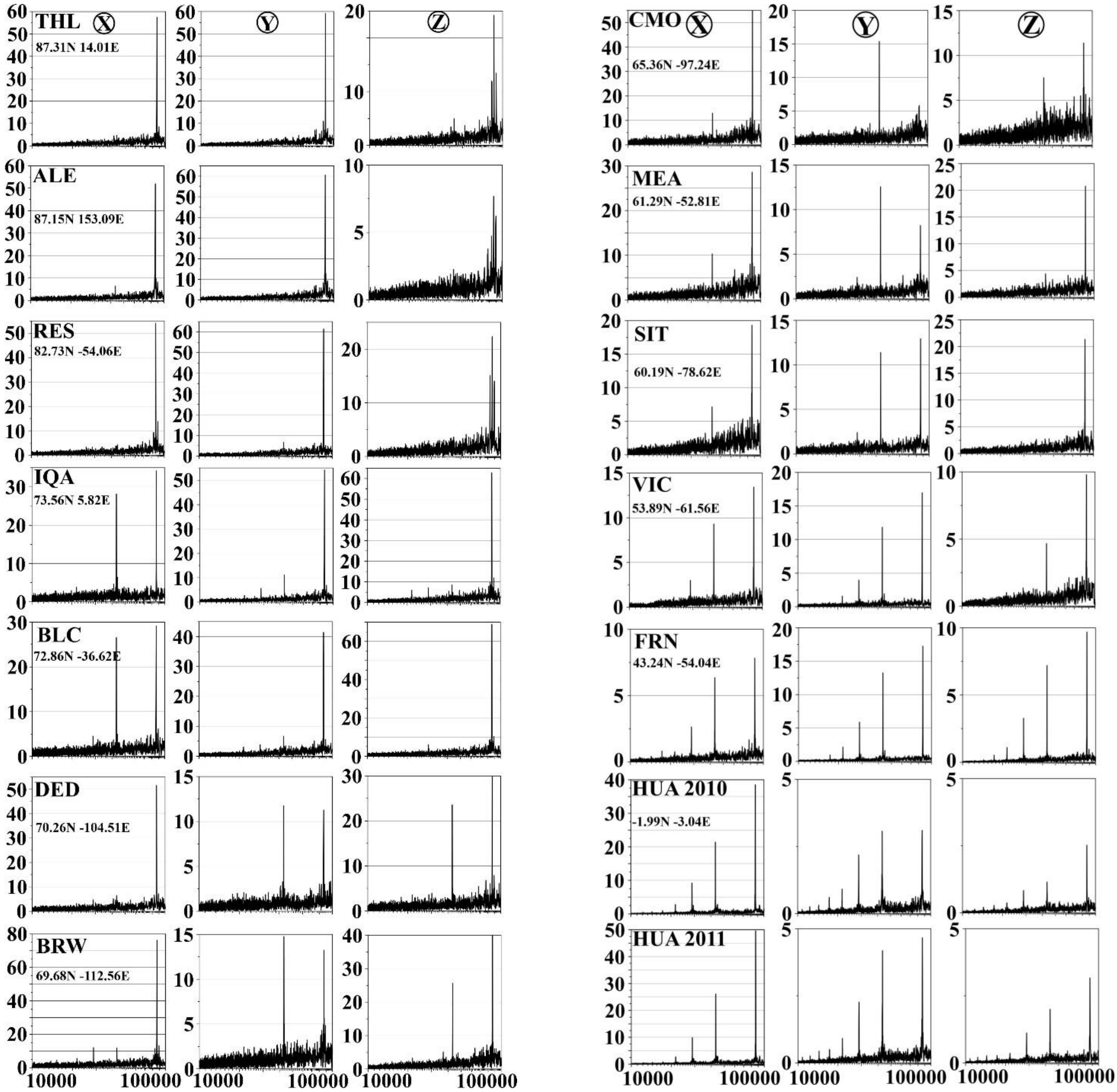

Figure 1. Annually averaged spectra of the geomagnetic field for the year 2001 at 12 North American observatories and for the years 2010 and 2011 at the equatorial observatory HUA in South America. The abscissa axis shows the periods from 10000 to 100000 s with a logarithmic scale, and the ordinate axis shows the amplitude in nT with a linear scale. In the left frame there is the international code of the observatory and its geomagnetic coordinates. X, Y, Z – northern, eastern and vertical components

Next 9 observatories are located in aurora zone or near its border. In Figure 1 this zone is represented by four observatories with typical behavior. In IQA and BLC at X the first and second harmonics are of nearly equal value, at Y and Z the first harmonic predominates. In DED and BRW at X, the first harmonic with large magnitude (especially in BRW) predominates. At Y the second harmonic is a little more than the first one. At Z the second harmonic is a little less than the first one. Higher order harmonics are small or absent in the aurora zone.

In the middle latitudes 40 – 65° next 13 observatories are located. In CMO and MEA at X and Z the first harmonic dominates, at Y the second harmonic dominates. In SIT and VIC everything is as in previous two observatories but at Y component the second harmonic is a little less than the first one. Beginning with STJ (φ_m=56.68°), predominance of the Y amplitude over the X and Z amplitudes is formed, which is well known for the mid- and low-latitude Sq-variations. This can be seen in FRN graphs, at which also the «right» change of the harmonics' amplitudes is observed: the higher the harmonics' order the less its amplitude. In Y and Z 5 harmonics are seen, in X component – all 7.

In the low latitudes 20 – 39° the last 6 observatories are located. In TUC (φ_m=39.57°) and DLR (φ_m=37.95°) a deflection from the «right» order is observed at X component: the first harmonic amplitude is less than the second harmonic. The last two observatories SJG (φ_m=27.92°) and HON (φ_m=21.58°) have the «right» order of all 7 harmonics.

At the equatorial observatory HUA in South America, annually averaged spectra for the years 2010 and 2011 have the «right» order of harmonics. HUA is located under equatorial electrojet where X component is strongly enlarged, while Y and Z are small.

Next, we will consider the average seasonal spectra in HUA for 2009-2011 (Figure 2). Season 1: December-February (winter in the northern hemisphere, summer in the southern hemisphere), season 2: March-May, season 3: June-August, season 4: September-November. The letter W denotes local winter, S – local summer in Figures 2 and 3. The same data is given in Figure 3 for observatories presenting high and middle geomagnetic latitudes of both hemispheres.

Comparing annual and seasonal spectra, it can be seen that the first one has regular distribution of the harmonics, while the second one has irregular chaotic harmonics' distribution for different 3 month intervals. A rather surprising result is the widening of the diurnal harmonic spectral line from September to February and the absence of the widening from March to August for all three considered years 2009-2011 at all five observatories.

4. DISCUSSION AND CONCLUSION

We found 2 unknown (as far as we know) phenomena:

4.1. The absence of higher order harmonics except intense T_1 at the near-to-pole observatories. We processed the Antarctic observatories and also found the predominance of the T_1 with relatively small second harmonic T_2:

VOS (φ_m=-88.36°) T_1: X≈55nT, Y≈60nT, Z≈10nT
T_2: X≈Y≈12nT, Z≈0
DMC (φ_m=-84.04°) T_1: X≈Y≈42nT, Z=12
T_2: X=Y=9nT, Z≤1nT
SBA (φ_m=-78.91°) T_1: X≈Y≈36nT, Z≈20nT
T_2: X≈Y≈6nT, Z≈4nT
DRV (φ_m=-74.10°) T_1: X=41nT, Y=45nT, Z=37nT
T_2: X=11nT, Y=10nT, Z=12nT

In VOS and DMC we see strong dominance of T_1 over T_2 and the horizontal component over vertical one. The same pattern is evident for northernmost THL, ALE and RES (φ_m>82°). In SBA (φ_m= -78.91°) and MBC (φ_m=+79.93°), the horizontal field

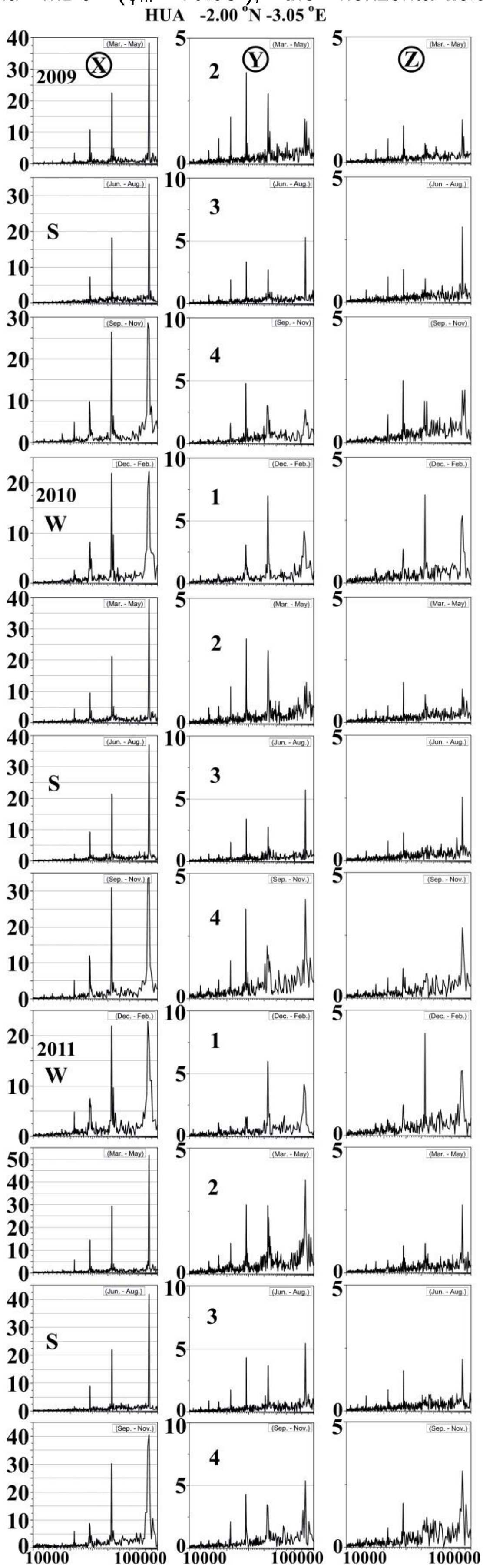

Figure 2. Average seasonal spectra in **HUA**

dominance becomes less pronounced. Therefore, the zones of T_1 and horizontal field dominance are located from the geomagnetic poles to latitudes ±79°. Approximately in the same area, the spreading currents of polar ionospheric electrojets acquire the structure of a quasi-homogeneous layer (Nishida, 1978) which creates at the Earth's surface geomagnetic field of the same structure as we described above.

4.2. The maxima of input and multiple coherence at the daily period and its harmonics indicates that all three components of the natural geomagnetic field are mutually correlated at the daily period and its harmonics contained in the spectrum.

4.3. Widening of the daily line T_1 of the seasonal average spectra from September to February and the absence of the widening from March to August for all considered years at all studied observatories. This is not a seasonal variation, since it is equally observed at observatories in both the northern and southern hemispheres, where the seasons are in antiphase. We can assume that this phenomenon is associated with a certain orientation of the Earth in outer space relative to some factor that creates the line's widening. The absolute motion of the Earth (Rokityansky, 2008), formed by the hierarchy of cosmological rotations, detected from dipole anisotropy of the cosmological background radiation, is presumed as such a factor. The line's widening should be investigated additionally.

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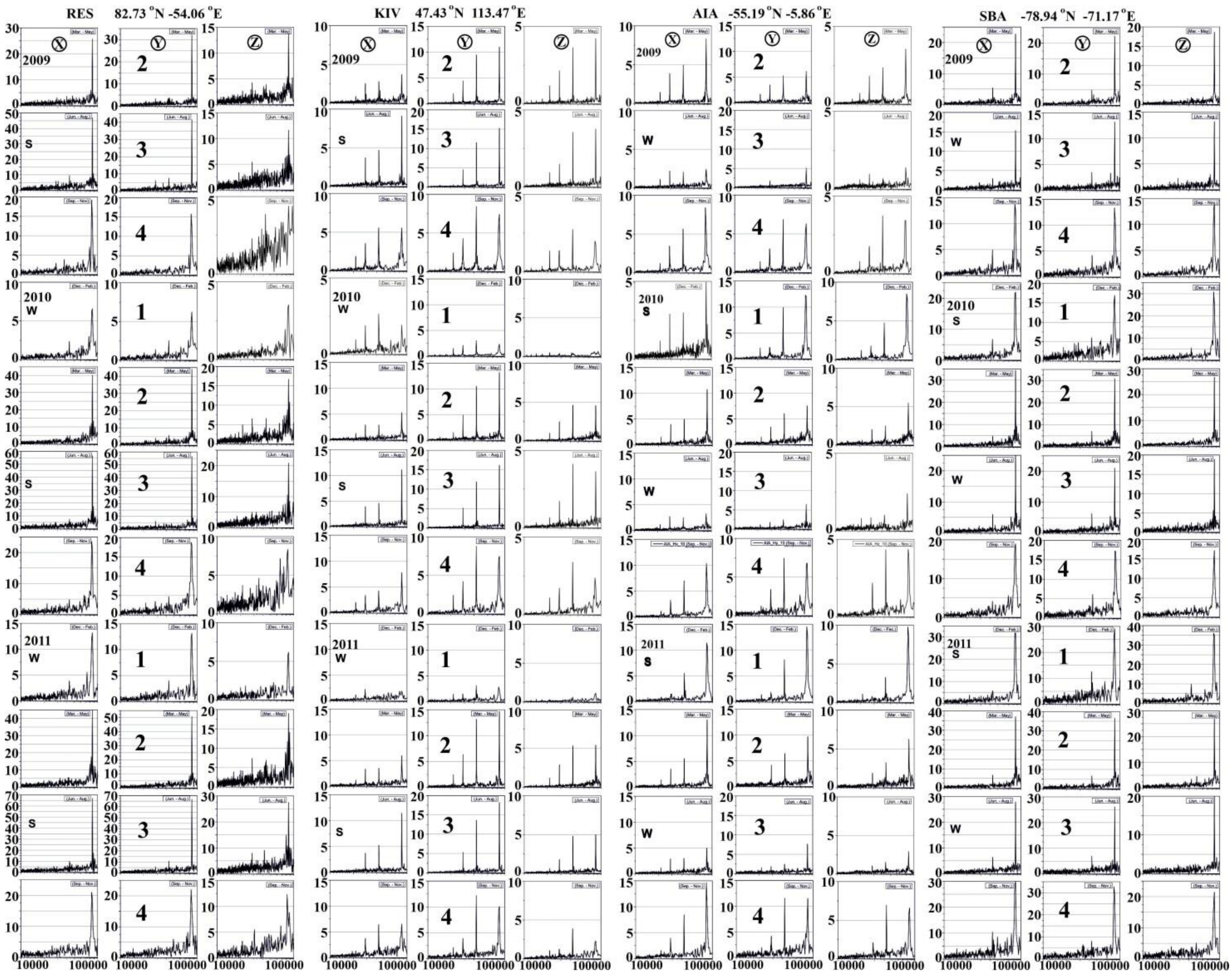

Figure 3. Average seasonal spectra in **RES, KIV, AIA** and **SBA**.