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Latitudinal dependence of Pc3-4 amplitudes across the dip equator along the 210° Magnetic Meridian

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Abstract

Studying Pc3-4 geomagnetic pulsations at equatorial and very low latitude regions is an important issue to understand their generation and propagation mechanisms. Pc3-4 amplitudes and their latitudinal dependency across the dip equator up to low latitudes (± 25°) are investigated using geomagnetic data simultaneously obtained by the MAGDAS/CPMN stations along the 210° Magnetic Meridian (MM) chain. Forty-five Pc3 events and thirty-two Pc4 events were selected for this study. Our results show a clear dependence of Pc3-4 amplitudes on geomagnetic latitudes. At the dip equator, most of the selected Pc3 events (~75%) showed an enhancement in amplitudes, while the rest (~25%) showed an attenuation. After that, the amplitudes decreased gradually by increasing latitudes. These results suggest mixed generation and propagation mechanisms for the equatorial and very low latitudes Pc3s. For better understanding, the Interplanetary Magnetic Field (IMF) and solar conditions are examined during the selected events. Results indicate that Pc3 events with enhanced amplitudes at dip equator are mainly occurred in daytime with no preference to IMF (magnitude and direction) and solar parameters, which suggests the ionospheric currents model as a generation and propagation mechanism for these events. While the attenuation observed in the other Pc3 events was associated with intense and abrupt fluctuations in the IMF and solar parameters, which in turn suggests the compressional wave model for generating these Pc3 events. On the other hand, these two models can explain the observed enhancement in the Pc4 amplitudes at the dip equator. Therefore, our obtained results clarified the origin of equatorial Pc3-4 pulsations.

Keywords: Geomagnetic pulsations; Equatorial Pc3-4; Pc3-4 amplitudes; Ionospheric currents model; Compressional wave model

1. Introduction

Geomagnetic field variations have a wide range and can be classified into long and short-term variations. The long-term (in terms of thousands to tens of years) variations are generated by the dynamo processes in the Earth's core [Newitt et al., 2009]. On the other hand, solar activity is believed to cause short-term (in terms of several years to a fraction of a second) geomagnetic field variations. In the short-period variations, Solar Wind (SW) and Interplanetary Magnetic Field (IMF) interact with the geomagnetic field. Intense changes in the SW and IMF conditions generate several geomagnetic disturbances due to the Sun-Earth interaction.

Short-term geomagnetic field variations, ranging from ~0.2 to 600 sec, are called Geomagnetic Pulsations (GPs). These GPs are considered magneto-hydrodynamic waves that occur naturally in the magnetosphere. The amplitudes of GPs increase by increasing their time periods (or by decreasing their frequencies). These amplitudes have a wide range that varies from several nano Tesla (nT) for the longest time periods of GPs (~600 sec) to fractions of a nT for the shortest time periods of GPs (~0.2 sec). On the ground, the GPs are observed in geomagnetic data recorded by magnetometers at geomagnetic observatories or stations.

In 1963, the International Association of Geomagnetism and Aeronomy (IAGA) classified GPs using a system depending on their waveform and wave period [Jacobs et al., 1964]. Fluctuations with quasi- sinusoidal waveforms are called continuous Pulsations (Pc), while those with irregular waveforms are called irregular pulsations (Pi). Each major category was divided into period bands which roughly separate a specific type of pulsations [Jacobs, 1970; McPherron, 2005] as presented in table 1. Today it is known that the limits of these bands are not precise.

Wave form	Class	Period (sec)	Frequency (mHz)	Amplitude (nT)
Continuous	Pc1	0.2 – 5	200 – 5000	0.01 – 0.1
	Pc2	5 – 10	100 – 200	0.1 – 1
	Pc3	10 – 45	22.2 – 100	1 – 10
	Pc4	45 – 150	6.67 – 22.2	5 – 50
	Pc5	150 – 600	1.67 – 6.67	50 – 500
	Pc6	> 600	< 1.67	> 500
Irregular	Pi1	1 – 40	25 – 1000	0.2 – 1
	Pi2	40 – 150	6.67 – 25	10- 100
	Pi3	> 150	< 6.67	> 100

Table 1. Classification of geomagnetic pulsations according to the period and frequency of pulsation [modified after Jacobs et al., 1964].

GPs can be generated either internally or externally with respect to the magnetosphere by various types of disturbances [McPherron, 2005]. Also, GPs with different frequencies and characteristics originated in different areas in the Earth's magnetosphere. The ground locations in which these areas can be projected depend on several conditions such as IMF, solar wind parameters, and magnetic field itself. Therefore, characteristics of GPs observed on the Earth's surface contain information not only about their generation but also about the regions through which they have propagated [Bol'shakova and Troitskaya, 1968]. Such information can be very useful for studying various physical processes acting in the Sun-Earth system.

Generally, GPs can be observed in several ways. However, the application of ground-based magnetometer arrays has proven to be one of the most successful methods of studying them. The Pc3-4 pulsations are quasi-sinusoidal variations in the Earth's Magnetic field in the period range 10-45 seconds (Pc3 range), and 45-150 seconds (Pc4 range).

Most research works regarding the characteristics of Pc3-4 had relied on geomagnetic data recorded at middle or high latitudes regions, while the very-low latitudes and equatorial regions had received little attention [Takla et al., 2011]. In addition, studies done at low latitudes regions were based on data acquired at a single geomagnetic station [Saka et al., 1982; Saka and Alperovich 1993] or two geomagnetic stations only, one is located at the geomagnetic equator and the other one is located outside the equatorial region [Sarma and Sastry, 1995]. Therefore, latitudinal dependence of the GPs amplitude at very low latitudes and equatorial regions has not yet been confirmed. Consequently, the source and propagation mechanisms of the equatorial and very low latitude pulsations are not fully understood, and they might be related to either upstream waves or mechanisms of pulsations at higher latitudes [Yumoto, 1986; Feng et al., 1995]. Some studies reported an attenuation in the amplitudes of Pc3 pulsation at the dip equator especially for short period Pc3 pulsations [Yumoto et al., 1985; Itonaga and Kitamura, 1993; Roy and Rao, 1998; Takla et al., 2011, Graziela et al., 2020], while other studies reported Pc3 amplitudes enhancement at the dip equator [Sarma and Sastry, 1995; Matsuoka et al., 1997; Saka et al., 2001; Zanandrea et al., 2004]. The dip equator is an imaginary line that roughly passes through the points where a magnetic needle has no dip. In other words, the points where the geomagnetic field lines are totally horizontal.

Therefore, studying latitudinal variation of the GPs amplitude at very low latitudes and dip equator is very important to identify their source mechanism, i.e., a direct incidence of the compressional waves on the equatorial ionosphere or a leak of the ionospheric currents caused by the pulsations at higher latitudes. The latitudinal dependence of GPs can be studied by a meridional array of geomagnetic stations. Thus, the present study aims to investigate the latitudinal dependence of Pc3-4 amplitudes and their generation mechanisms using simultaneous geomagnetic observations across the dip equator through the MAGDAS/CPMN stations at 210° Magnetic Meridian (MM) as shown in Figure 1.

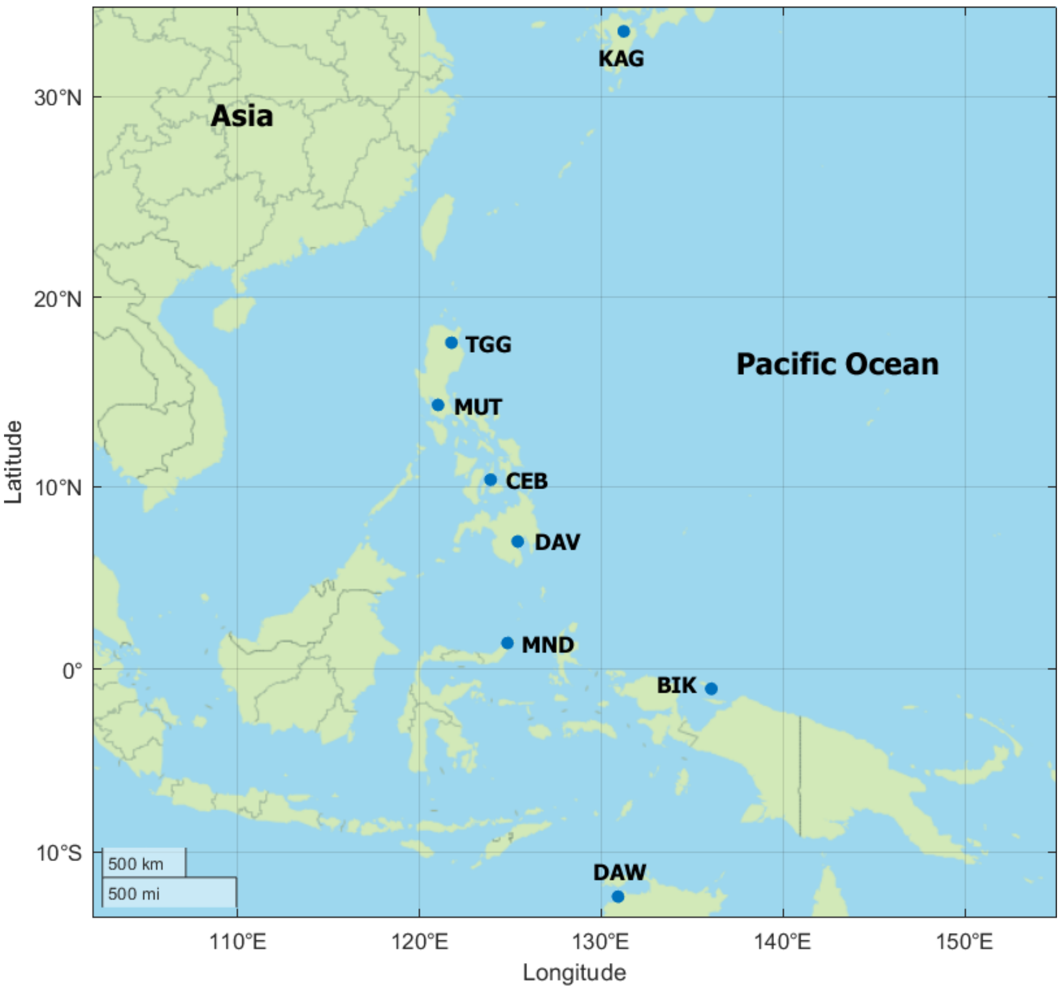

Figure 1. Locations of the geomagnetic stations used in the current study.

2. Instrumentation and data acquisition

MAGDAS and CPMN are global networks of geomagnetic observations that operated by collaborations between the international Research Center for Space and Planetary Environmental Science (i-SPES) [formerly International Center for Space Weather Science and Education], Kyushu University, Japan and institutions in several countries.

The CPMN Project has been started since 1996. The magnetometer system of each CPMN station includes a ring-core type fluxgate magnetometer, a data logging/transfer unit, and a power supply. The maximum sampling interval is 1 second. GPS signals are received to adjust the time-keeping system of the data logger/transfer unit.

On starting the MAGDAS project in 2005, the CPMN was merged into MAGDAS project [Yumoto and the MAGDAS Group, 2006]. Since that time, the MAGDAS/CPMN is considered the generic name of their magnetometer networks. The MAGDAS magnetometer system is based on the CPMN magnetometer system, where it is a fluxgate magnetometer with a ring core that can detect even very small-amplitude geomagnetic disturbances [Yumoto, 1986]. The MAGDAS/CPMN magnetometers have very low noise levels (0.02 nT).

The MAGDAS/CPMN stations are installed along five chains: (1) the 210º MM chain, (2) the dip Equator chain, (3) the 96º MM chain, (4) The South America chain, and (5) Sumatra chain.

3. Pc3-4 events selections

Horizontal geomagnetic north-south (H) and east-west (D) components of geomagnetic field were analyzed using MATLAB scripts prepared for this aim. One day of high resolution (one-second) geomagnetic data consists of 86400 records, which are subdivided into segments with 512 records. The Dynamic Power Spectra (DPS) were calculated by the sliding Fast Fourier Transform technique (512 records, sliding by 5 minutes). Since ground GPs near the dip equator are strongly polarized to the H-component, searching for simultaneous pulsations events was focused on this component.

Two selection criteria are applied to pick the Pc3-4 events. The first one was a visual inspection of DPS plots where a clear intensified activity in the same frequency range is identified as a pulsation event. The second one was the observation of a continuous quasi-sinusoidal wave train resulting from the band-pass filtered geomagnetic data recorded at each station along the examined profile. The selected Pc3-4 events were observed along the selected profile with a good visual similarity in DPS and coherence in the waveform of the band-pass filtered data. Figure 2 presents twelve hours (00:00-12:00 UT) DPS of the H-component recorded on 17 August 2003 at some 210° MM stations. A pulsation event is observed on the ground using the MUT, DAV, and BIK geomagnetic data between 00:00 and 08:00 UT (08:00-16:00 LT).

Forty-five pulsation events (in Pc3 range) were selected for studying the Pc3 amplitudes, and thirty-two pulsation events (in Pc4 range) were selected for the Pc4 amplitudes along the examined profile. The selected events occurred in both daytime and nighttime. The duration of pulsation events was not constant; some events lasted for several minutes while other events lasted for several hours. During some pulsation events, it was difficult to find a good correlation among all stations because some of these stations had momentarily noisy data (perhaps related to human activities near these stations). Therefore, such events were excluded from our results.

4. Data analysis and results

Since the main goal of current research work is to study the equatorial and very low latitudes Pc3-4 and examine their latitudinal dependence, we analyzed one second geomagnetic data recorded in 2003 (a year of high solar activity) and 2008 (a year of low solar activity) at several geomagnetic stations that roughly aligned along the 210° MM. In addition, the effect of equatorial ionosphere on the amplitude of Pc3-4 pulsations at equatorial region is examined through the analysis of these Pc3-4 events. The availability of simultaneous measurements at the 210° MM chain for a long period of time allowed us to study and identify the variation of Pc3-4 amplitudes by a latitudinal profile. Data recorded by an array of MAGDAS/CPMN magnetometers along the 210° MM was analyzed across a profile extending from KAG station, Japan to the DAW station, Australia passing through the dip equator. From North to South, this profile includes the KAG, TGG, MUT, CEB, DAV, BIK, MND, and DAW as shown in Figure 1. The details about the geographic and geomagnetic coordinates of these stations and other information are presented

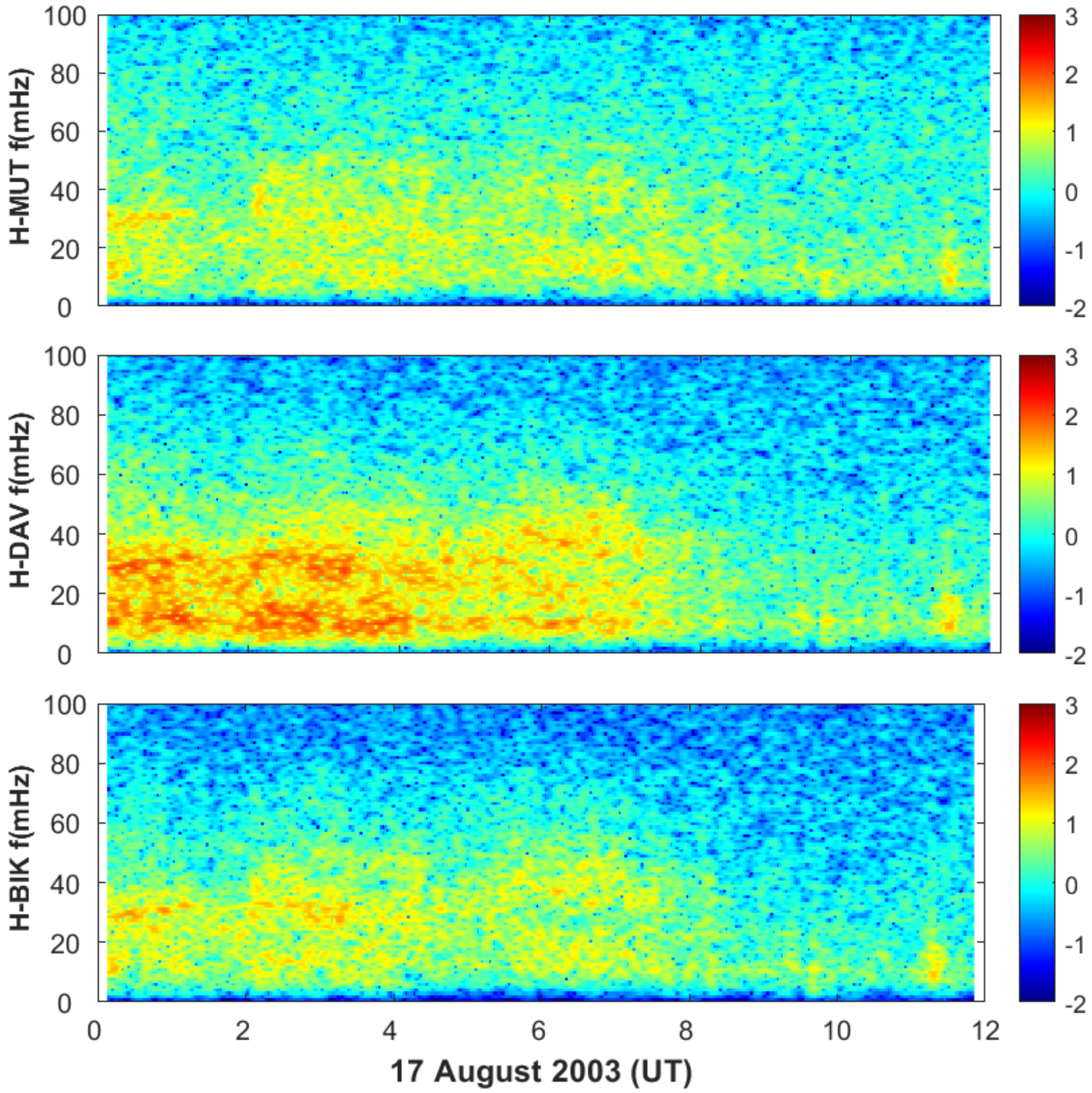

Figure 2. Twelve hours dynamic power spectra of H-components at the MUT, DAV, and BIK stations on 17 August 2003. The dynamic power spectra reveal the occurrence of pulsation activity.

in Table 2. Along this profile, one station is located at the dip equator (DAV, dip lat. = −0.24), while other stations are located at both sides of the dip equator (nearly conjugate points to the north and south). This geomagnetic latitudinal spacing is adequate to detect measurable Pc3-4 amplitude variations with a high degree of waveforms coherence among the examined stations.

From visual inspection of pulsations activity presented in Figure 2, it is clear that the pulsation activity occurred at the examined stations but with different intensities. For examining the Pc3 amplitudes, the H- and D- components were digitally band-pass filtered (a second-order filter) in Pc3 range (20-40 sec). Figure 3 shows the filtered wave packets obtained after applying the band-pass filters for one-hour data of the H- and D-components (05:30-06:30 UT) on 17 August 2003 along a latitudinal profile represented by stations code. Examination of the wave train presented in Figure 3 indicates that the Pc3 amplitude of the H-component is apparently enhanced at the equatorial station (DAV in blue color) compared with the other geomagnetic stations.

On the other hand, another different behavior of the Pc3 amplitudes is presented in Figure 4, in which a clear attenuation in Pc3 amplitude is observed at DAV station (in blue) compared with other stations. It is worth mentioning that the amplitude attenuation increases by decreasing the period range (< 20 sec). After examining the amplitude of the selected Pc3 events, we were able to classify them into two groups. The first one includes the majority of Pc3 events (~75% from the selected Pc3 events), where their amplitudes showed an enhancement at the dip equator station (DAV), while the second group includes the rest of the Pc3 events (~25%) that showed amplitude attenuations at the DAV station.

Station	Code	Country	Geographic		Geomagnetic	
			Lat.	Long.	Lat.	Long.
Kagoshima	KAG	Japan	31.48	130.72	25.13	202.24
Tuguegarao	TGG	Philippine	17.66	121.76	10.26	193.05
Muntinlupa	MUT	Philippine	14.37	121.02	4.95	193.26
Cebu	CEB	Philippine	10.36	123.91	1.06	196.26
Davao	DAV	Philippine	7.00	125.40	−2.22	197.90
Manado	MND	Indonesia	1.44	124.84	−7.80	197.63
Biak	BIK	Indonesia	−1.08	136.05	−9.73	207.39
Darwin	DAW	Australia	−12.41	130.92	−21.91	202.81

Table 2. Information about the MAGDAS/CPMN stations used in the current study.

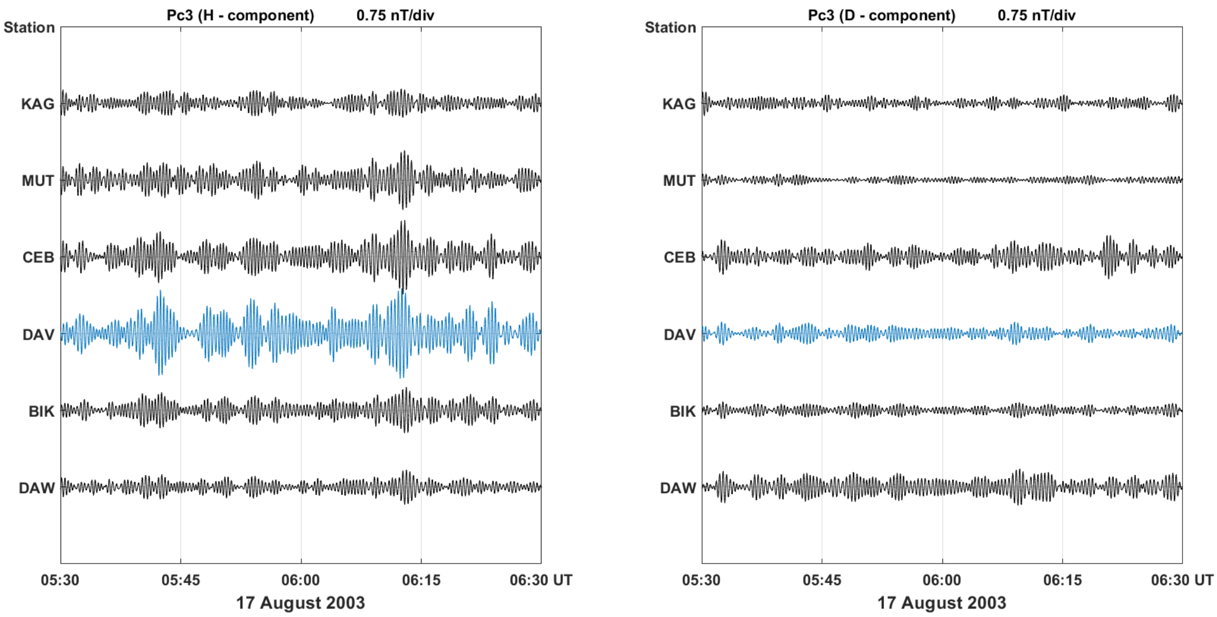

Figure 3. A Pc3 pulsation event (belongs to group 1) observed simultaneously by some geomagnetic stations along the studied profile for one hour on 17 August 2003. The left-side panel for the H-component, while the right-side panel for D-component.

On contrary to H-component, the D-component Pc3 amplitude behaved differently. The amplitude was very small compared with that of H-component (i.e., the Pc3 amplitude ratio D/H at DAV station was less than 0.2) with no systematic variation with geomagnetic latitudes. Therefore, the current study focuses on H-component data only to construct the latitudinal profile.

For the selected Pc3 events, the band-pass filtered data for each Pc3 event is divided into time segments of 10 minutes length. For each time segment, the peak-to-peak amplitudes of wave packets are calculated. In the

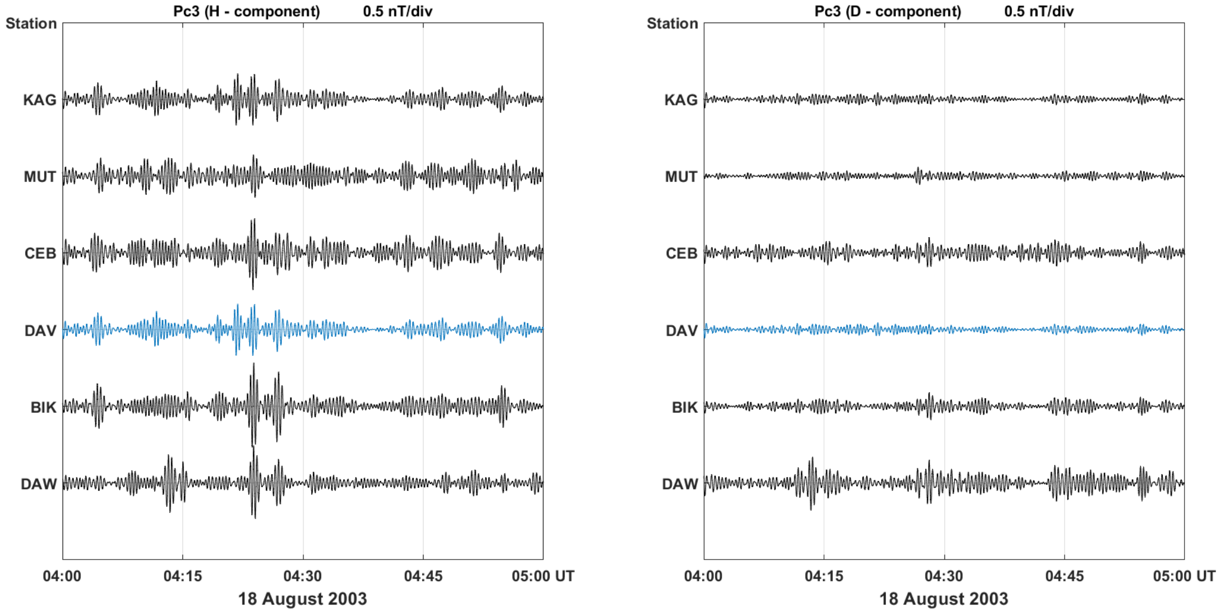

Figure 4. A Pc3 pulsation event (belongs to group 2) observed simultaneously by some geomagnetic stations along the studied profile for one hour on 18 August 2003. The left-side panel for the H-component, while the right-side panel for D-component.

following step, the average Pc3 amplitude is computed for the entire Pc3 event. To track the Pc3 amplitude changes, we calculated the Pc3 amplitude ratio at each station with reference to the geomagnetic station that located at the dip equator (DAV station) as KAG/DAV, TGG/DAV, up to DAW/DAV. Finally, the latitudinal profile of Pc3 amplitude variations was constructed as shown in Figure 5. The examination of calculated ratios along the studied profile indicates distinct latitudinal amplitude variations for the selected Pc3 events. For the Pc3 events with enhanced amplitudes at the DAV station (group 1), the Pc3 amplitudes showed an enhancement at very low latitudes with a peak observed at dip equator station (DAV). After that, the Pc3 amplitudes decreased gradually with increasing station

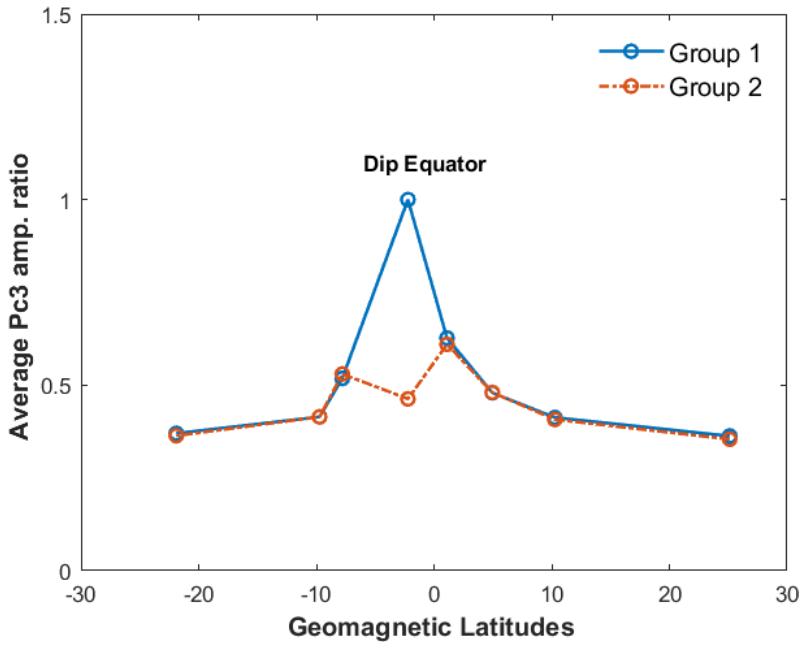

Figure 5. The latitudinal profile of the Pc3 amplitude. The solid curve represents the average amplitude ratios of the Pc3 events (group 1), while the dashed line represents the average amplitude ratios of Pc3 events (group 2).

latitude (up to ≈ ± 25°) as shown in Fig. 5 (solid line). While Pc3 events with attenuated amplitudes at the DAV station (group 2) showed amplitudes enhancement at very low latitudes but with a depression at equatorial station (DAV) and then the Pc3 amplitude decreased gradually by increasing latitude up to ≈ ± 25° as represented in Fig. 5 (dashed line).

The band-pass filter in the period range (70-100 sec) was applied on the H- and D-components of the selected Pc4 events. Figure 6 shows the filtered wave packets obtained after applying the band-pass filter on one hour data of the H-and D-component from 04:00-05:00UT on 29 October 2003 along a profile represented by stations code. The Pc4 amplitude is amplified at dip equator station (DAV in blue). Like the Pc3, the D-component Pc4 amplitudes were smaller than the H-component Pc4 amplitudes. The Pc4 amplitudes of H-component were measured using the same technique previously discussed for Pc3 events. After that, the latitudinal profile of Pc4 amplitude ratios

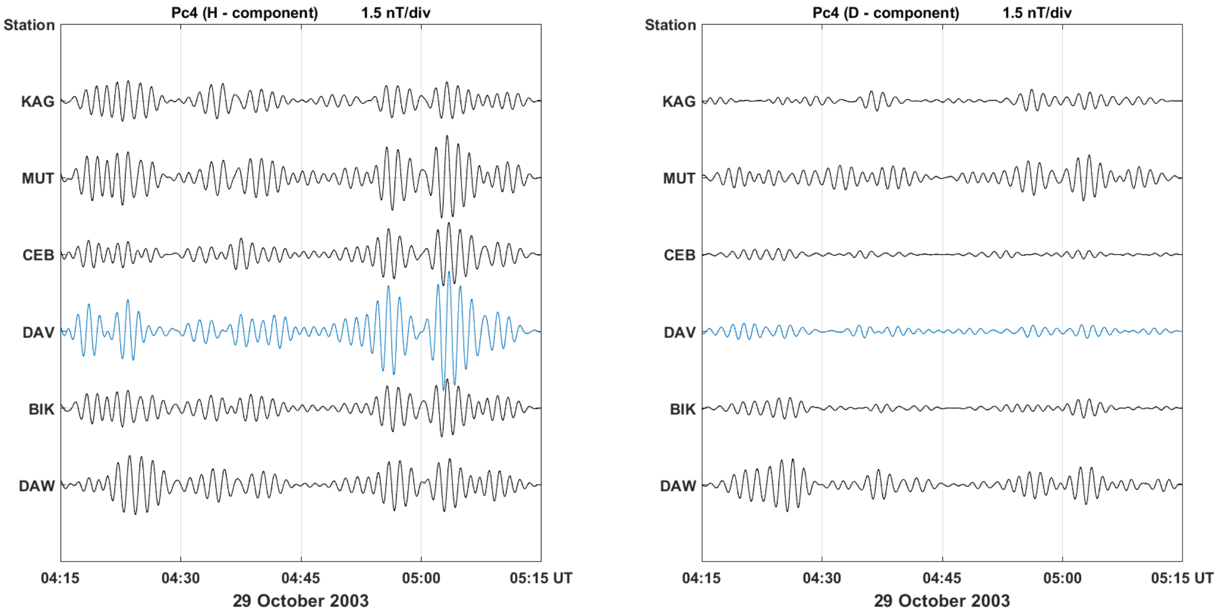

Figure 6. A Pc4 pulsation event observed simultaneously by some geomagnetic stations along the studied profile for one hour on 29 October 2003. The left-side panel for the H-component, while the right-side panel for D-component.

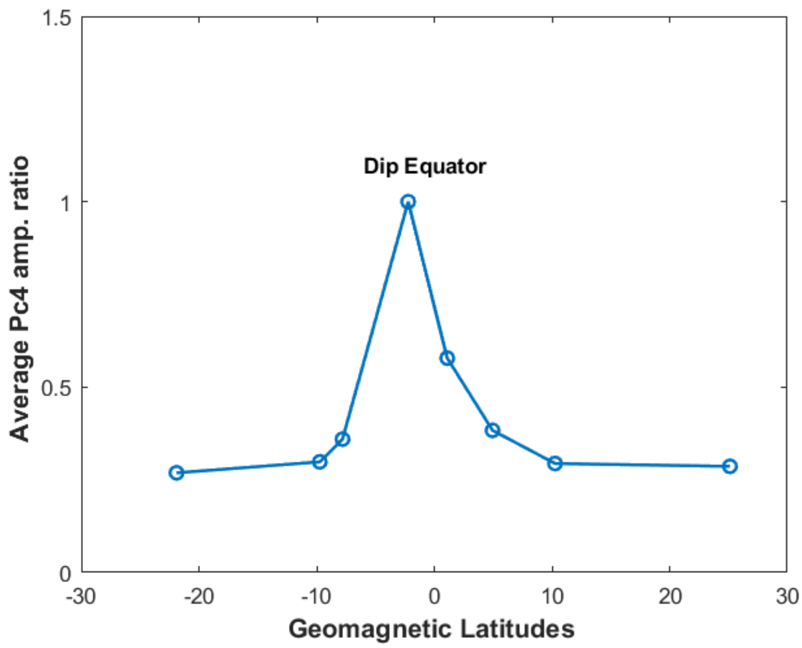

Figure 7. The latitudinal profile of the Pc4 amplitude.

(by using the same procedure for calculating the amplitude ratio of the Pc3 pulsations) was constructed, which also showed an enhancement at very low latitudes with a peak at the dip equator station (DAV). After that, it started to decrease by increasing geomagnetic latitudes (up to ≈ ± 25°) as shown in Figure 7.

Relationships between parameters of the interplanetary medium and GPs were traditionally used as a clue for understanding their physical nature. So, to understand the occurrence of equatorial Pc3-4 pulsations, their generations, and latitudinal dependence, the influence of the IMF and solar parameters on the Pc3-4 activity needs to be examined. Therefore, the current study is extended to investigate the dependence of very low latitude and equatorial Pc3-4 occurrence on solar and IMF conditions. The IMF parameters used for this study are the magnitude of IMF (B), and the north-south component of IMF (Bz), while the solar wind parameters are the solar wind speed (SW) and Electric field (Ey). One-minute interplanetary and solar data were examined and compared with the occurrence of Pc3-4 activity to clarify such a relationship as presented in Fig. 8. This figure shows the geomagnetic pulsations detected at the equatorial station (DAV) during the passage of a high velocity solar wind stream, characterized by variable IMF conditions. The IMF and solar parameter are presented in the upper four panels during 17 August 2003 (UT), while the DPS of the H-components at DAV station is presented in the bottom panel of Figure 8. This figure indicates the occurrence of Pc3-4 activities throughout the day under variable IMF and solar conditions.

Investigating the IMF and solar parameters during the selected Pc3-4 events, shows that most of the Pc3 events (group 1) occurred in the daytime with long durations (in terms of hours) under nearly constant or gradually variable

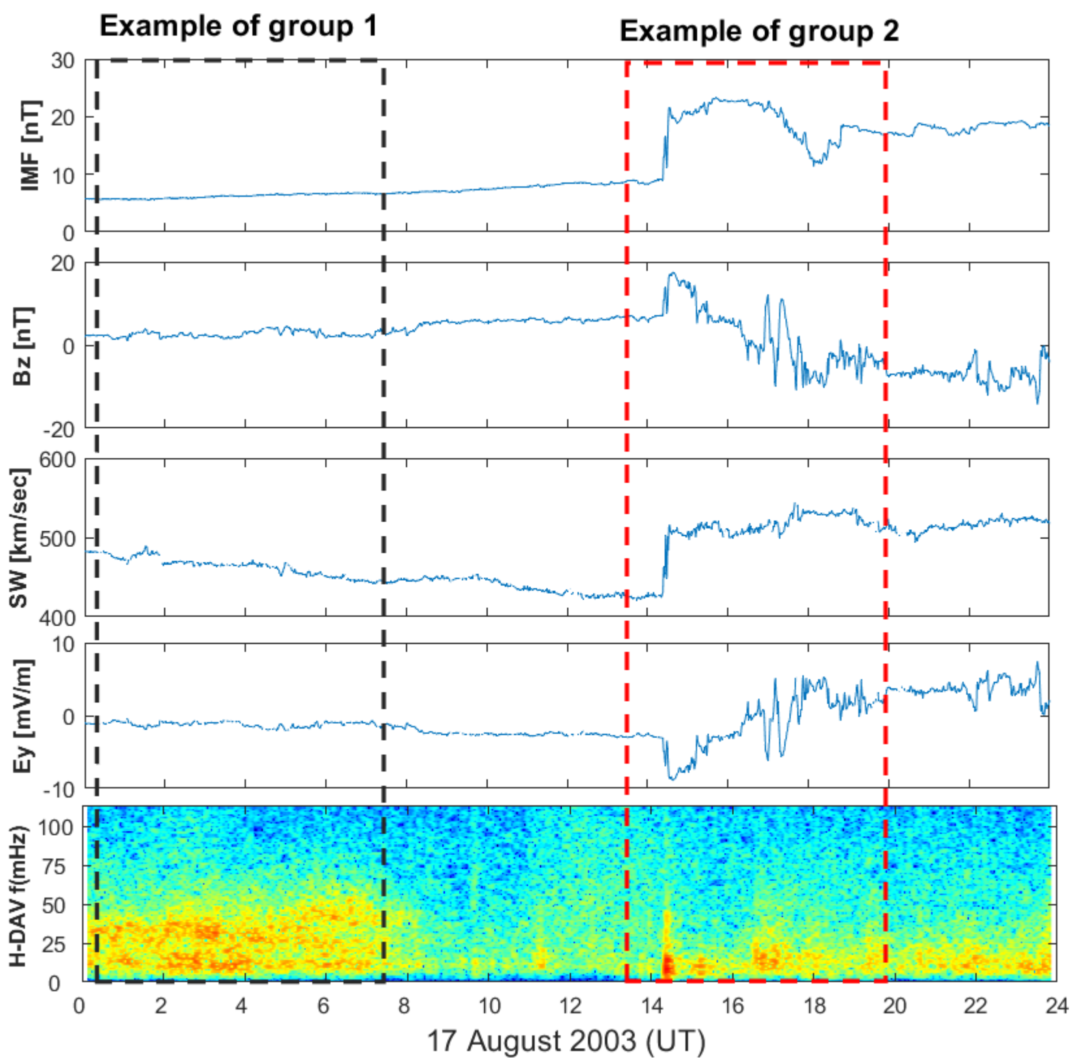

Figure 8. The total magnitude of the IMF (B), north-south IMF (Bz), solar wind velocity (SW) and Electric field (Ey) data during 17 August 2003 (UT) are presented in the upper four panels respectively, while the dynamic power spectra of the H-component recorded at DAV station is presented in the bottom panel. Black and red rectangles indicate two pulsation activities occurred during different IMF and solar conditions.

IMF and solar conditions as presented by black rectangle in Fig. 8, while group 2 Pc3 events occurred with short durations (in terms of minutes) in association with strong and abrupt variations in the IMF (mainly when the IMF is directed southward; $Bz < 0$) and solar parameters as presented by red rectangle in Figure 8. In addition, it is noticed that the frequency of pulsations can relate to the magnitude of fluctuations in the IMF and solar parameters. We observed that strong fluctuations of the IMF not only cause attenuation in the Pc3 amplitudes but also make Pc4 activity dominate over Pc3 activity.

5. Discussion

GPs contain information that can be used to study their generation mechanisms and propagation. Mechanisms proposed for the generation and propagation of equatorial GPs (Pc3-4) have not yet been clearly identified. The observations show that continuous pulsations having the same frequency range may have different characteristics. These observations suggest the existence of different generation mechanisms for GPs. Moreover, a detailed tracking of latitudinal variations of Pc3-4 amplitudes at equatorial, very low and low latitudes has not yet been proven. Consequently, in this study, changes in the Pc3-4 amplitudes are investigated using data acquired by a meridional magnetometer profile (eight geomagnetic stations) roughly located at the 210° MM across the dip equator (within $\pm 25°$).

The results of current study indicated that Pc3 amplitudes have two patterns of variation at the equatorial region. Most of the studied Pc3 events showed an enhancement of the Pc3 amplitudes at very low latitudes with a peak at the geomagnetic equator region (Group 1). On contrary, other Pc3 events showed a depression at the dip equator (Group 2). This observation indicates mixed generation mechanisms for the equatorial Pc3 at the 210° MM. While the Pc4 amplitudes are enhanced at the equatorial and very low latitudes.

In addition, the results of group 1 agree with the outcome of previous works that reported an equatorial enhancement of the pulsation amplitude (about 2-3 times bigger compared with reference stations outside the equatorial region) close to local noon [Sarma and Sastry, 1995; Zanandrea et al., 2004]. Moreover, the observed attenuation of the Pc3 amplitude at the dip equator region (group 2) also agrees with the outcome of research work reported by some researchers [Itonaga and Kitamura, 1993; Itonaga et al., 1998; Takla et al., 2011).

Our results can be explained by considering the generation and propagation mechanisms reported by Yumoto [1986], who proposed two models for the generation and propagation mechanisms of the equatorial and low latitudes Pc3-4 pulsations observed by ground geomagnetic measurements. The first model is the ionospheric currents model in which the Alfvèn waves (the surface waves generated by the Kelvin-Helmholtz instability) propagating horizontally in the high-latitude ionosphere generate large-scale ionospheric current oscillations there. These electric currents leak to the low latitude and generate Pc3-4 pulsations near the dip equator [Yumoto et al., 1986; Tanaka, 2004]. The second model is the compressional upstream waves model, in which the compressional waves generated on the bow shock travel along the equatorial region of the magnetosphere across the ambient magnetic field lines, arrive at the equatorial ionosphere and couple with the magnetic perturbations on the ground through the ionosphere (direct transmission).

Furthermore, it is widely recognized that the ionospheric conductivity above equatorial and very low latitude regions is very high. Effects of this enhanced conductivity mainly appear during daytime on the dip equator and can be extended to a narrow latitude range $\pm 3°$ [Chapman, 1951; Rastogi and Trivedi, 2009]. This enhanced current is known as the Equatorial ElectroJet (EEJ). The effect of the EEJ appears as a significant increase of amplitude in the horizontal component of diurnal quiet-time geomagnetic variations, and in a wide range of short-period fluctuations (GPs), which can be observed within a few degrees of latitude on the ground. Consequently, the enhancement observed in the Pc3 amplitude (Pc3 events belong to group 1) at the very low latitudes and equatorial region can be explained according to the first model (ionospheric currents model) in which an equatorial enhancement in the Pc3 amplitude can be generated due to the concentration of ionospheric currents at the dip equator and superposition of the EEJ effect. On the other hand, the attenuation observed in Pc3 amplitudes (Pc3 events belong to group 2) at the dip equator can be explained by the shielding effects connected with the second model (compressional upstream waves model). Where the high-conducting equatorial ionosphere opposes the propagation of the compressional waves and behaves as an obstacle in their propagation way, for more details, see Yumoto et al. [1985] and Yumoto [1986].

It was previously reported that the occurrence and intensity of some pulsation activities are linked with external sources with respect to the magnetosphere such as the IMF and solar wind parameters [Greenstadt et al., 1979].

The direction of IMF plays an important role in controlling these pulsations [Bolshakova and Troistakaya, 1968; Takahashi et al., 1984]. Statistical studies indicated that the Pc3-4 wave periods (frequencies) are correlated with the magnitude of the IMF (B) while the occurrence rate of GPs is dependent on the orientation of interplanetary field [Greenstadt et al., 1980; Russell et al., 1983]. In addition, the solar wind velocity controls some properties of Pc3-4 pulsations [Saito, 1969; Singer et al., 1977]. Furthermore, the upstream waves are generally controlled by the IMF and solar wind parameters and their transmission into the Earth's magnetosphere can be linked to IMF conditions. Hence, we examined the IMF and solar parameters during the selected Pc3-4 events to clarify the source of the equatorial Pc3-4 pulsations (groups 1 and 2).

The obtained results indicated that Pc3 events of group 1 had long durations and mainly occurred during daytime with no preferences to the IMF (magnitude and direction) and solar conditions (mainly under invariable IMF and solar conditions or with gradual changes), see Figure 8 (black rectangle). Since high latitude pulsations did not show dependence on solar and IMF parameters [Sutcliffe et al., 2013], our results can support the ionospheric currents model (Model 1) to be the source for Pc3-4 events belong to this group. In which the high latitude oscillations leak to the low latitude and generate Pc3-4 pulsations near the dip equator. While the Pc3 events of group 2 had short durations and occurred during abrupt and strong IMF (almost when $Bz < 0$) and solar fluctuations that lasted for short times. Since the amplitudes of Pc3 events in group 2 were connected to IMF and solar parameters, the obtained results suggest the compressional upstream wave (Model 2) as a possible source of Pc3-4 events belong to this group. In conclusion, the obtained results indicate a mixed generation mechanisms for the equatorial Pc3-4 at the 210° MM.

6. Summary and conclusion

In the current study, high-resolution geomagnetic field measurements (1-sec data) recorded at the equatorial, very low and low latitudes regions along the 210° MM were analyzed to study the variation of Pc3-4 amplitudes across the dip equator and try to understand their source origin. Results of data processing and analysis indicate that the amplitudes of Pc3-4 vary strongly with latitude. At equatorial and very low latitudes, the Pc3 amplitude intensifications are observed in the H-component. Most of the studied Pc3 events (~75%) showed a peak at the dip equator, while other Pc3 events (~25%) showed attenuation at the dip equator. This observation suggests that the Pc3s can have more than one generation and propagation mechanisms which are the ionospheric currents model that led to an equatorial enhancement and the compressional upstream waves model with attenuation related to shielding effect as reported by Yumoto [1986]. On the other hand, the Pc4s showed amplitude enhancement at the equatorial and very low latitudes region which can be explained by the above two mentioned models.

For better understanding of the generation mechanism and the influence of IMF and solar conditions on the occurrence of Pc3-4 events, we compared Pc3-4 events with the IMF and solar parameters. This investigation indicated that the Pc3s enhancement (group 1) was observed without any preference conditions in IMF and solar parameters while the attenuation of the Pc3 amplitude (group 2) mainly occurs in connection with strong variations in the IMF and solar parameters and also with Bz directed southward. This observation is a remarkable finding, where it strongly supports the idea that Pc3 events belong to group 1 are generated by the model 1, while the Pc3 events belong to group 2 are generated by model 2.

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