A STUDY OF MAGNETIC FIELD (Bz) AND IONOSPHERIC VARIATION DURING MAGNETIC ACTIVITIES AT LOW LATITUDE

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ABSTRACT

A large foF2 data base was collected for the four magnetic storms occurring in January 10, 1976; April 12-13, 1981; October 29, 1973 and July 8, 1975; for the low latitude station of Manila (14.7^{0}N) in the East Asian sector. Also, plots of D(foF2) deviations versus time (UT) and that of the interplanetary magnetic field component (Bz) versus time (UT) for the low latitude station were analyzed.

From our analysis, it was observed that there is a direct variation between Bz and the F2 region response. Davis et al (1997) have shown that a southward turning with change in Bz of δBz > 11.5nT results in foF2 showing a marked decrease in amplitude reaching a minimum value of 20hrs after the southward turning. It was also observed that there is homogeneity in the response of F2 region at low latitude stations (i.e. foF2 enhancement) irrespective of the period of storm event, but more pronounce during intense storms which was in agreement with Adeniyi, 1986; Mikhailov et al, 1994; who states that the positive phase in most cases (90%) is observed at equatorial latitudes during magnetic disturbances.

Keywords: *Magnetic storm, F2 region, equatorial latitudes, magnetic disturbances, interplanetary magnetic field.*

INTRODUCTION

According to Patrick et al (2001), the earth is surrounded not by vacuum but by a highly dynamic coupled system of plasmas and magnetic fields whose complex interplanetary phenomena constitutes the subject of space weather. However, geomagnetic activity is a measure of the energy which the magnetic field intercept from the passing solar wind and funnels into the magnetosphere (Chaman Lal, 2000). The magnetic reconnection between southwardly directed IMF and northward magnetospheric fields proposed by Dungey (1961) and the viscous mechanism proposed by Axford and Hines (1961) are the two generally accepted modes of solar wind into magnetosphere. According to Gonzalez and Tsurutani (1987), the IMF structures leading to intense magnetic storms have an intense and long duration southward component.

Danilov (2001) reported that the F2 region response to geomagnetic storm called Ionospheric storm is a complex event. It consists of the so-called positive and negative phases, which have very complicated spatial and temporal behaviour. However, the main cause for the positive ionospheric storm phase is an upwelling and equatorward moving of the ionospheric F2 region plasma by thermospheric wind with additional contributions from some other processes while that of negative phase is a combination of the effects of the neutral composition changes.

While negative phases are almost always observed at high latitudes and nearly as often as positive phases at middle latitudes. As for the seasonal preference, negative phases dominate in all seasons except winter when positive phase are more probable. Meanwhile, positive phase sometimes are observed several hours before the beginning of the magnetic disturbance which caused a particular ionospheric storm (Danilov and Belik, 1991).

DATA AND METHOD OF ANALYSIS

In other to study the interplanetary and ionospheric deviation during the storms of January 10, 1976; April 12-13, 1981; October 29, 1973 and July 8 1975 at the low latitude station of Manila (14.70N), the parameters used are the interplanetary magnetic field (Bz) and the hourly values of foF2 obtained from some of the National Geophysical Data Centers SPIDR global network of ionosonde stations and NSSDC Omniweb (http//:nssdc.gsfc.nasa.gov/omniweb) for the East Asian low latitude station of Manila.

The data used for the plot of Bz for each of the storm days spans January 6-12, 1976; April 7-15, 1981; October 24-30, 1973 and July 2-9, 1975. However, the F2 region response to the storms is easily related as D(foF2), the normalized deviation of the critical frequency foF2 from reference.

where D(foF2) = [foF2 – (foF2)ave] / (foF2) ave

Therefore, the data being analyzed consists of D(foF2) of respective hourly values of foF2 of each of the storm days plus two days after each storm occurrence. The reference for each hour is the mean value of foF2 for that hour calculated from the four quiet days preceding the storm.

RESULT AND DISCUSSION

The D(foF2) versus time (UT) plots were presented in figure 1 bringing out the variation in the foF2 region for each of the four storm days in panel (a), (b), (c) and (d) at Manila station. From figure 1(a), the plot showed that the F2 response was more of an enhancement especially starting from around 20:00UT of January 10 through January 12, 1976. This could have been as a result of equatorward winds resulting from traveling ionospheric disturbances and also by an increase in ionization during the equatorward months. This was further buttressed by the Bz plot in figure 2(a) which showed a sharp southward turning around 10:00UT of January 10 reaching a peak value of ~-20n T. at around 20:00UT of the same day, Bz rotates sharply northward and gets to a value of 12.5n T. the IMF leading to intense magnetic storms have intense (>10n T) and long duration (3hr) southward component (Chukwuma, 2003b).

In figure 1(b), there was both enhancement and depletion of the F2 region response due to the storm of April 12-13, 1981. But it was more of an enhancement, and this was evident from the Bz plot of figure 2(b), which also gives an irregular response, but the southward turning of Bz to a maximum value of around -25n T is an indication that this storm is intense. According to Adeniyi, 1986; Turunen and Rao, 1980, during prominent disturbances, negative phase may be observed at equatorial latitudes. This may be due to other ionospheric irregularities, since some positive effects in the F2 response during geomagnetic disturbances may be due to the so-called traveling atmospheric disturbances (TAD) (Prolls, 1995; Mikhailov et al, 1994).

From the plot of figure 1(c), it was observed that, there was no definite pattern until around 22:00UT on October 29 through till around 19:00 on October 30 before the F2 region response begins to deplete. It was noted from the corresponding Bz plot of this storm day in figure 2(c) that the turning of Bz southwardly was more frequent but short lived, before moving northward and then southward again.

The maximum Bz value for this storm event is ~-5n T and a short lived southward component is an indicative that the storm is weak or moderate but not intense.

The D(foF2) plot in figure 1(d) and that of the Bz in figure 2(d) also showed that there was an enhancement in the foF2 region. Figure 2(d) depicts that there was no definite pattern in the direction of the Bz component until around 00:00UT on July 7, when it falls to ~-6n T, rise and fall again and got to a peak value of -7.6 at 18:00UT on July 8; after which it experiences northward turning around 23:00UT on same day, before turning southwardly again reaching a value of -12.7n T on July 8, the storm day at 11:00UT. However, the southward long duration turning is an indication that the storm is an intense one.

Meanwhile, a striking effect on the plot of figure 2 as shown in all the panels is that the positive phase storm which occurred in the daytime is partially caused by absolute density enhancement of all neutral constituents (Nangaladze et al, 2000).

However, on the average it could be said (from figure 1 and 2) that there was an enhancement in the response of F2 region at low latitude station of Manila for the four storm events under investigation.

Liu Libo et al (2002) showed that ionospheric positive phase storm (PPS) may be caused by any of the following factors:

i. Increase in the concentration of neutral atomic oxygen,
ii. Equatorward horizontal neutral winds,
iii. East electric fields to higher level of lower loss and
iv. Particle precipitation.

Also, Chukwuma (2003a) states that the observed decrease in foF2 during the geomagnetic storm of April 12-13, 1981 is related to decrease in [O] / [N_2] at F2 region altitude; and Nangaladze et al (2000) states that the negative storm is a combination of the effects of the neutral composition change.

CONCLUSION

Summarizing, we may draw the following picture on the study Bz and ionospheric variations during the magnetic storms at low latitude that

1. The storms of January 10, 1976, April 12-13, 1981 and July 8, 1975 were intense storms based on their Bz intensity (>10n T) and long duration (>3hr) southward component while that of October 29, 1973 is a moderate one.
2. The predominantly positive phase storm at the three intense storm events is a reflective of their corresponding Bz plot (i.e. there is a direct variation).

3. there was homogeneity in the response of F2 region at low latitude stations (i.e. foF2 enhancement) irrespective of the storm event taking place but more pronounce during intense storm which was in agreement with Adeniyi, (1986); Mikhailov et al, (1994) who states that the positive phase in most cases (90%) is observed at equatorial latitude during magnetic disturbances.
4. that geomagnetic storms should be expected anytime the Interplanetary Magnetic Field (IMF) of the solar wind is southward and the solar wind crosses the earth for long durations of time or in shorter more energetic bursts (Flares/CMEs).

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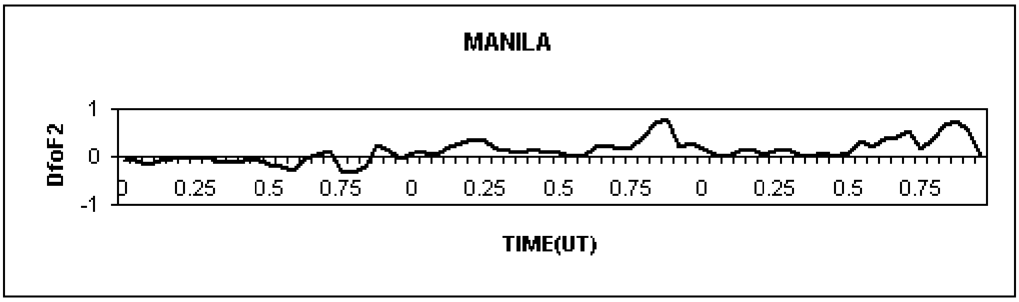
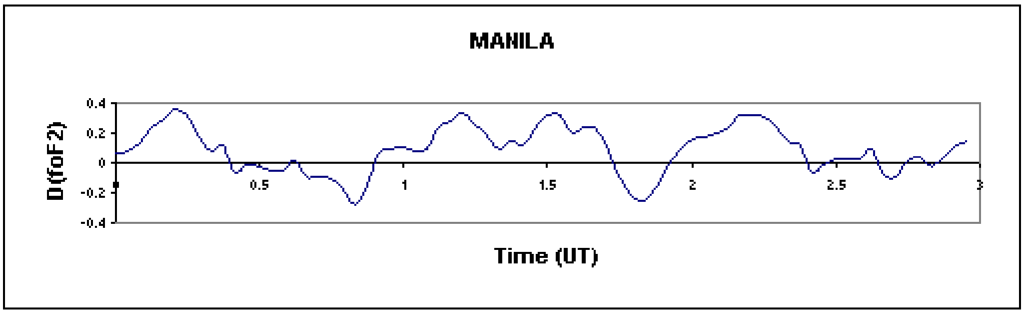
a)



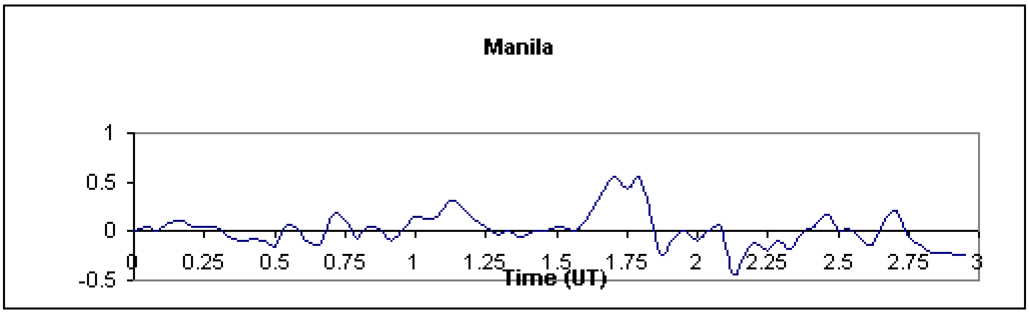
Jan.10-12,1976

b)



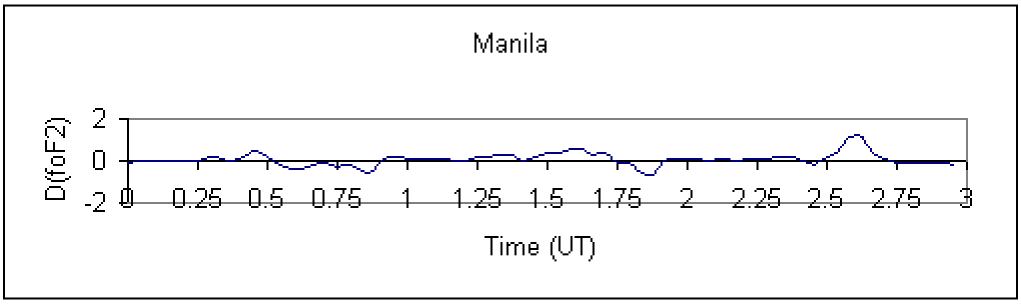
April 12-14, 1981

c)



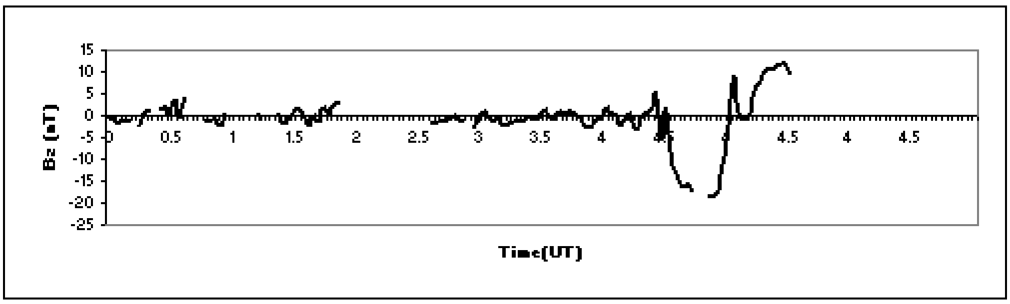
Oct. 29-31, 1973

d)

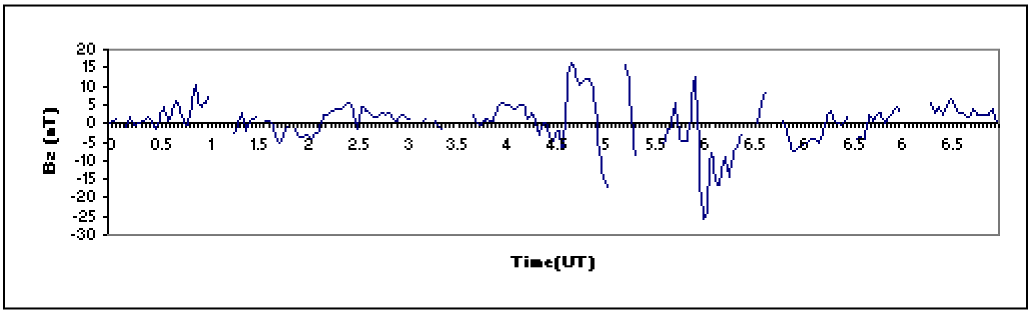


July 8-10, 1975

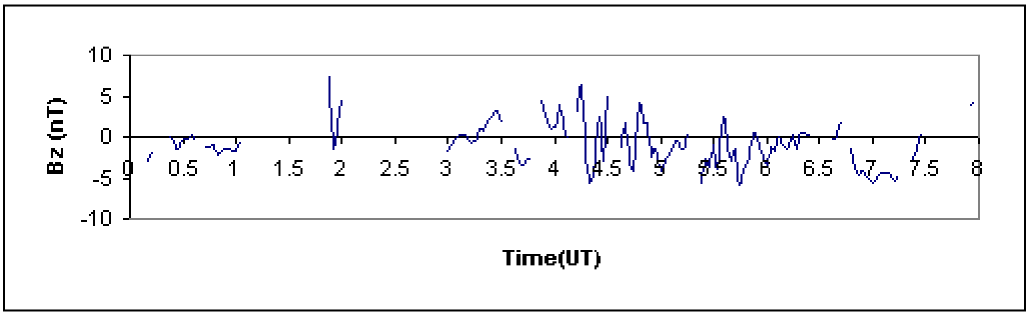
Figure 1: Variations in D(foF2) at station of Manila for the four storm events.



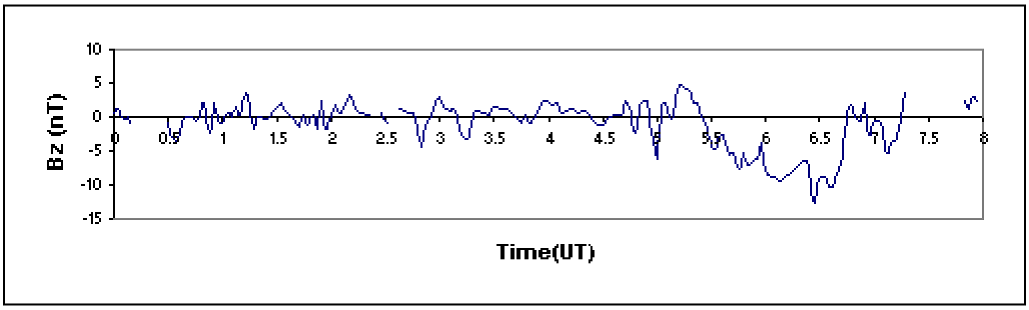
(a) Storm of January 10, 1976 (showing Graph for Jan. 6-12, 1976)



(b) Storm of April 12-13, 1981 (showing Graph for April 7-15, 1981)



(c) Storm of October 29, 1973 (showing Graph for Oct. 24- 30, 1973)



(d) Storm of July 8, 1975 (showing Graph for July 2- 9, 1975)

Figure 2: Magnetic Field component Bz plot for the four storm events against time (UT)