ANALYSIS OF INTERPLANETARY PHENOMENON, GEOMAGNETIC AND IONOSPHERIC RESPONSE ASSOCIATED WITH THE STORM OF JULY 8, 1975, IN THE EAST ASIAN SECTOR

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Abstract

A study is made of the moderate geomagnetic storm of July 8, 1975 (Dst_{min} *=-60 nT) and its associated ionospheric storm using solar wind parameters and foF2 data obtained from ionosonde stations in East Asian longitudinal sector. The storm was found to be a double step storm with the first* Dst_{min} *resulting mainly from ring current injection due to increase in solar wind density while magnetospheric convection electric field played the leading role in the development of the second* Dst_{min}*. The analysis of the interplanetary and foF2 data show that the appearance of positive storm before the beginning of the geomagnetic disturbance in the mid-latitudes and the occurrence of strong negative phase at the low latitude station of Manila is due to the penetration of interplanetary electric field. Furthermore, available results presented ionospheric response features that bear similarity in form and magnitude with those that are due to intense storms. This suggests that a moderate storm is capable of generating ionospheric storms which are of comparable magnitude with those resulting from intense geomagnetic storms.*

Keywords: *Geomagnetic storm, solar wind, plasma sheet density, ring current, ionospheric storm.*

1. **Introduction**

Investigations into the origin and nature of geomagnetic and ionospheric storms have continued to engage the attention of scientists who constitute the space weather community for example Blagoveshchensky et al (2003) ; Borovsky et al. (1998) ; Boudouridis et al (2005) ; Buonsanto and Fuller-Rowell (1997) ; Danilov, A. D (2001) ; Davies et. al. (1997) ; Gonzalez et al. (1994, 1998, 2001, 2002) ; Huang, et al. (2004) ; Kamide et al. (1998a, b); Kozyra et al. (2002) Nielsen and Honary (2000) ; Strickland et al. (2001); Viera et al. (2001); Wang et al.(2003) and references therein. This is because magnetic storms can adversely affect the space environment causing disruption of satellite operations, communications and navigation systems, and electric power distribution grids leading to a variety of socioeconomic losses; magnetic storms could as well endanger human life or health.

Geomagnetic storms can be classified as follows: weak (-30nT > Dst_{min} >-50 nT), moderate (-50 nT > Dst_{min} > - 100 nT) and intense (Dst_{min} < - 100 nT) (Gonzalez et al., 1994; Kamide et al., 1998a; Viera et al., 2001). However, a survey of available literature shows that investigations into intense magnetic storms appear to predominate in space weather studies. This situation probably arises from the notion that intense storms are more likely to have negative effects on satellite navigation, communication, and power systems. But weak and moderate storm have recently been mentioned in the explanation of some unresolved problems in ionospheric physics. For example, following the suggestion by Danilov (2001) that the appearance of positive storm before the beginning of a geomagnetic disturbance in the mid-latitudes and the occurrence of strong negative phase at the equator are two of the acute unsolved problems in ionospheric physics, Chukwuma (2006) investigated these phenomena using f_oF2 data obtained, from a global network of ionosonde stations, during the intense geomagnetic storms of the maximum phase of solar cycle 22 in 1989 and the intense geomagnetic storm of April 1-2, 1973. His results show that the existence of positive storms at mid-latitude stations of the East Asian sector and the American sector, and the appearance of strong negative storm at the low latitude station of Manila prior to the intense storm of April 1-2, 1973 are associated with the moderate storm with *Dst* = -60 nT which occurred at 20:00 UT on March 31, 1973. While the positive storms at Slough (54.4 ° N) and Uppsala (59.86 ° N) and a negative storm at Ouagadougou (12.4 ° N) prior to the October 1989 storm was due to the moderate storm with *Dst* = -66 nT that occurred at 8:00 UT on October 19, 1989. These results appear to suggest that the interplanetary structures and magnetospheric processes that result in moderate storms and their associated ionospheric storms need to be investigated; more so that the aforementioned positive ionospheric storm effects in the middle latitude is an indication of enhancement of F2 region electron density and directly results in increase in HF radio wave absorption as implied in the relation (Schwentek, 1976):

$$A \propto \int_0^h N v dh . \qquad (1)$$

where A is HF radio wave absorption, v the collision density and *h* the height of reflection. Enhanced HF radio wave absorption results in shortwave fadeouts while the depletion of *foF2* as indicated by the existence of negative storm will also affect HF transmission in that the level of efficiency of the F2 region for total reflection (Rawer, 1976; Schwentek, 1976) of HF radio wave will be reduced.

Furthermore, it's instructive that we find out if weak and moderate magnetic storms are capable of generating ionospheric storms which are of comparable magnitude with those resulting from intense geomagnetic storms.

In this work, we present the results of an investigation into the moderate geomagnetic storm of July 8, 1975 and its associated ionospheric storms in the East Asian longitudinal zone. Assured that investigations into geomagnetic storms, in regards to existing literature, are still work-in-progress, we will in this paper attempt an explanation of the roles played by solar wind structures: proton density, solar wind speed, IMF B_z component and interplanetary electric field in the generation of the present moderate magnetic storm, and its associated ionospheric storm.

2. Data and Method of Analysis

The data used in this study consists of:

1. Interplanetary data: solar wind proton density N_{sw}, solar wind flow speed V_{sw}, interplanetary electric field E_y and magnetic field B_Z component. These hourly data were obtained from NSSDC's OMNIWeb Service (http://nssdc.gsfc.nasa.gov/omniweb).
2. Geomagnetic data: These are hourly values of the low-latitude magnetic index, *Dst*, and were also obtained from NSSDC's OMNIWeb Service (http://nssdc.gsfc.nasa.gov/omniweb). The *Dst* index is an important parameter that is a measure of disturbances of the ring current during geomagnetic storms. The ring current is significantly enhanced during storm times, and the westward ring current decreases the northward component of the Earth's surface magnetic field.
3. The Ionospheric data: These are hourly values of *foF2* obtained from some of the National Geophysical Data Centre's SPIDR (Space Physics Interactive Data Resource) a network of ionosonde stations located in the East Asian sector: Yakutsk, Khabarovsk, Wakkanai, Akita, Kokubunji, Yamagawa, Okinawa and Manila. Table I lists these ionosonde stations as well as the difference

between LT and UT in hours for each station. The present study is concerned with variations in *foF2* due to the intense geomagnetic storm of July 8, 1975. However, the F2 region response to geomagnetic storms is most conveniently described in terms of *D*(*foF2*) , that is the normalized deviations of the critical frequency *foF2* (Chukwuma, 2003b):

Table I: Ionosonde stations.

Station	Geographic co-ordinates		Geomagnetic co-ordinates		Difference between LST and UT (in hours)
	φ	λ	φ	λ	
Yakutsk	62.0°N	129.6°E	51.21 °N	195.0°E	+9
Khabarovsk	48.5°N	135.1°E	38.12 °N	201.4 °E	+9
Wakkanai	45.4°N	141.7°E	35.58 °N	207.4 °E	+9
Akita	39.7°N	140.1°E	29.78 °N	206.9 °E	+9
Kokubunji	35.7°N	139.5°E	25.75 °N	206.8 °E	+9
Yamagawa	31.2°N	130.6°E	21.28 °N	207.4 °E	+9
Okinawa	26.3°N	127.3°E	15.50 °N	196.6 °E	+8
Manila	14.7°N	121.0°E	3.62 °N	191.2 °E	+8

$$D(f_oF2) = \frac{f_oF2 - (f_oF2)_{ave}}{(f_oF2)_{ave}} \qquad (2)$$

Hence, the data that was analysed consists of *D*(*foF2*) of respective hourly values of *foF2* on July 7-8, 1975. The reference for each hour is the average value of *foF2* for that hour calculated from the five quiet days, July 2-6, 1975, preceding the storm. The use of *D*(*foF2*) rather than *foF2* provides a first-order correction for temporal, seasonal and solar cycle variations so that geomagnetic storm effects are better identified. Furthermore, the criterion used in selecting the stations is such that storm variations represented real changes in electron density not simply redistribution of the existing plasma (Chukwuma, 2003b; Soicher, 1972).

Given that the aim of this work is in part to show if the magnitude of the respective positive and negative ionospheric storms resulting from a weak/moderate are comparable with those resulting from intense magnetic storm, the ionospheric storms are defined by changes in *D*(*foF2*) of more than 10% (Danilov, 2001), while changes of *D*(*foF2*) of ~ 30% are regarded as intense or large (Huang et al., 2002 and references therein).

3. **Results**

Geomagnetic and Interplanetary Observations

The composite diagram in Figure 1 presents from top to bottom the low latitude magnetic index, *Dst*, and the solar wind parameters: IMF B_z component, proton density, N_{sw}, solar wind density speed, V_{ssw}, and the interplanetary electric field E_y plots for July 7-8, 1975. The parameters are plotted against Universal Time (UT).

Figure 1(a) shows that *Dst* index had positive values until ~17:00 UT on July 7 when it depressed into negative values, signalling the storm commencement. *Dst* decreased steadily to attain moderate storm values with *Dst* = -52 nT at 3:00 UT on July 8 before reaching Dst_{min} =-60 nT at 5:00 UT. Thereafter, *Dst* began to recover gradually. The *Dst* index experienced a small inflection at ~12:00 UT. The *Dst* starts to decrease but recovers again reaching *Dst* =-26 nT at 14:00UT before decreasing sharply to Dst_{min}

=-49 nT at 16:00 UT. *Dst* index recovered immediately getting to -24 nT at 23:00 UT. This is a moderate double step storm (Kamide et al., 1998a). According to Kamide et al. (1998a) and Kozyra et al. (2002), double-step storms result from successive imparts of different regions of southward IMF B_Z on the magnetosphere. The first impact triggers a magnetic storm, which does not have time to recover before the second impart begins and results in a second decrease in *Dst* index that is usually deeper than the first although the magnitude of the second interval of southward B_Z is, in general, not significantly different from the first interval. However, it is important to observe that the magnitude of *Dst* decrease of the main phase of the second step is lesser than that of the first. Kamide et al. (1998a) had reported, without comments on any causative mechanism, that there are cases, constituting a very small fraction (8.5%) of all storms, of double step storms where the second peak is less pronounced than the first. This characteristic of some storms need an explanation.

The B_z plot (Figure 1(b)) shows B_z with positive values for the interval 0:00-10:00 UT on July 7. For a northward IMF there will be no significant convection in the magnetosphere. B_z turned southward at ~10:00 UT and decreased with fluctuation to B_z = -9.3 nT at 3:00 UT on July 8. Thereafter, B_z became less negative for six hours reaching B_z = -6.5 nT at 9:00 UT. However, note that the northward turning of the IMF B_z became incomplete as B_z deceased abruptly at the hour and attained a value of B_z = -12.6 at 11:00 UT, thereafter it started to increase and was northward at ~18:00 UT.

The V_{sw} variations (Figure 1(c)) show V_{sw} decreasing steadily in magnitude from 376 kms^{-1} at 0:00 UT on July 7, with intermittent swings, until it reached 342 kms^{-1} at 5:00 UT on July 8. Thereafter it decreased sharply to 331 at 6:00 UT before increasing to 347 kms^{-1} at 8:00 UT. At 10:00 UT, V_{sw} had decreased to 340 kms^{-1}. The V_{sw} plot appears to indicate an increase in the solar wind speed in the interval 11:00-15:00 UT but this was short-lived as this period was immediately followed by a slow stream solar wind.

The Figure 1(d) presents the proton density variations for July 7-8, 1975. The plot shows N_{sw} increasing in magnitude from 13.9 cm^{-3} at 0:00 UT to 20.6 cm^{-3} at 2:00 UT and then decreased rather sharply to 6.2 cm^{-3} at 5:00 UT on July 7. N_{sw} was nearly steady at about 6.2 cm^{-3} until 10:00 UT when it started to increase sharply reaching 14.8 cm^{-3} at 13:00 UT. N_{sw} decreased sharply to 9.1 cm^{-3} at 14:00 but thereafter began to increase rather steadily to reach 21.5 cm^{-3} at 4:00 UT on July 8. The solar wind density decreased again to 18.2 cm^{-3} at 6:00 UT before increasing to the peak value of 27.4 cm^{-3} at 10:00 UT. The large increases in the proton number density at 4:00 and 10:00 UT on July 8 respectively would have indicated in part the arrival of a shock in the interplanetary medium (Nielsen and Honary, 2000; Strickland et al., 2001) but the absence of a fast stream at these times following the slow upstream solar wind, as seen in Figure 1(c), will preclude a shock.

Figure 1(e) presents the interplanetary electric field E_y. The plot shows that with the exception of an inflection that occurred at 13:00 UT on July 7, E_y increased steadily from 0.18 mV/m at 10:00 UT to 2.68 mV/m at 18:00 UT. Thereafter E_y experienced intermittent fluctuations before attaining the peak value of 4.41 mV/m at 11:00 UT on July 8 and immediately decreased rather sharply to negative values at 19:00 UT.

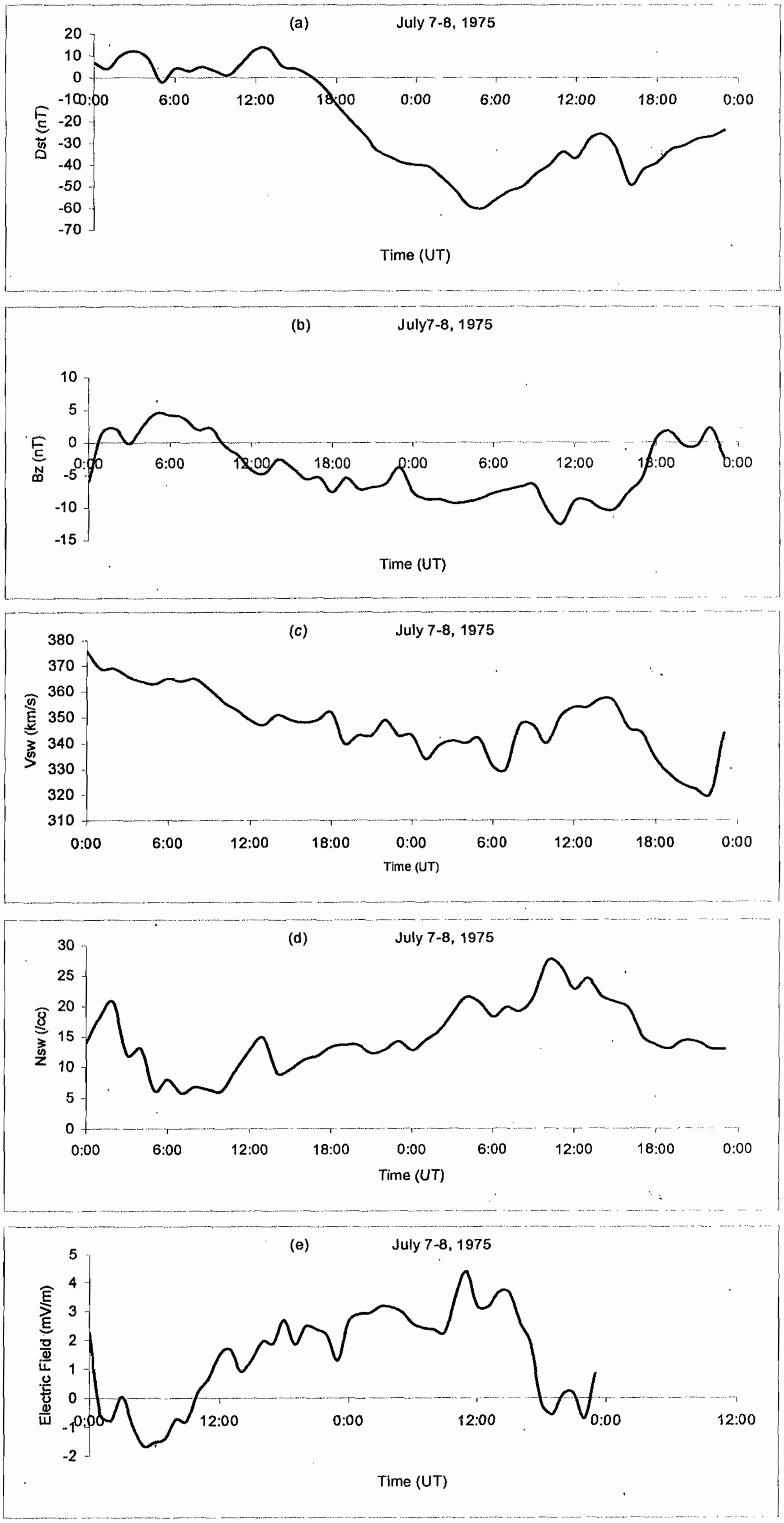

Fig. 1: Composition of interplanetary and geomagnetic observations for July 7-8, 1975.

4. Ionospheric Response

Figure 2(a) shows the *D(f_oF2)* variations at the high latitude station of Yakutsk for July 7-8, 1975. The *D(f_oF2)* plot shows that in the interval 0:00-12:00 UT on July 7, the ionosphere at this station was characterized by intermittent positive storms. However from~14:00 UT, f_oF2 began to suffer depletion resulting in a negative storm which occurred between 16:00 and 23:00 UT. The station also recorded another positive phase between 3:00 and 10:00 UT on July 8 with peak electron density enhancement of 19% and 20% respectively at 4:00 and 7:00 UT. At 11:00 UT, *D(f_oF2)* began to depress rather sharply to attain 44% depletion at 14:00 UT. *D(f_oF2)* tried to recover but depressed abruptly to 55% at 16:00 UT. Thereafter *D(f_oF2)* started to recover, reaching 12% depletion at 23:00 UT.

The ionospheric response at Khabarovsk for the period under investigation, as shown by Figure 2(b), appears characterized by the existence of positive storm. Intermittent positive phases occurred in the interval 12:00-15:00 UT on July 7 and from 23:00 UT on July 7 to 14:00 UT on July 8. However, there were two negative phases; the first occurred in the period 18:00 and 21:00 UT on July 7 and the other at 17:00 on July 8 when f_oF2 suffered 20% depletion.

Figure 2(c) shows that the ionosphere at Wakkanai also appears characterized by positive storm in the period July 7-8, 1975. Intermittent positive phases occurred in the interval 10:00-15:00 UT on July 7 and from 22:00 UT on July 7 to 10:00 UT on July 8. However the ionosphere recorded a negative storm with 16% depletion in f_oF2 at 15:00 UT on July 8.

Figure 2(d) shows that positive storm was the dominant ionospheric feature at Akita during the period under investigation. However, between 18:00 and 21:00 UT on July 7 the ionosphere recorded a negative storm with peak depletion in f_oF2 of 25% at 21:00 UT. Note also the 12% depletion of f_oF2 that occurred 22:00 UT on July 8.

Figure 2(e) shows the *D(f_oF2)* plot for Kokubunji for July 7-8, 1975. The *D(f_oF2)* variations shows the existence of a negative phase in the interval 3-5:00 UT on July 7 which was closely followed by intermittent positive phases. f_oF2 decreased briefly to 12% at 16:00 UT before recovering to quiet conditions at 19:00 UT. Thereafter f_oF2 decreased sharply to a negative storm with 38% depletion of f_oF2 at 23:00 UT. Paucity of data would not allow comments for the period between 23:00 UT on July 7 and 3:00 UT on July 8, but available data shows the existence of discontinuous positive phases in the period 12:00-19:00 UT on July 8.

The ionosphere at Yamagama (Figure 2(f)), in the hours 4:00-11:00 UT on July 7 appears dominated by positive storms with respective peak enhancement of 31% and 21% in f_oF2 at 5:00 and 11:00 UT. However, beginning from ~14:00 UT on this day f_oF2 started to decrease, depressing in two sharp steps to -29% indicating a strong negative storm. Thereafter, f_oF2 began to recover, registering an inflection at 22:00 UT and attained quiet conditions at ~2:00 UT on July 8. The quiet conditions lasted until 6:00 UT before the ionospheric response recorded a negative storm which lasted between 8:00 and 10:00 UT. The period was trailed by a positive phase with f_oF2 enhancement of ~15% in the interval 13:00 – 17:00 UT, and a strong negative storms with maximum depletion of 25% in f_oF2 at 19:00 UT.

Figure 2(g) presents the *D(f_oF2)* variations at Okinawa for July 7-8, 1975. It's apparent from the plot that the ionospheric response at this station, for July 7-8, appears characterized by the existence of strong sporadic positive storms with respective peak enhancement of 39%, 30%and 43% in f_oF2 at 4:00, 11:00 and 20:00 UT on July 7, and 30% increase in f_oF2 at 14:00 UT on July 8. However, negative phases were recorded respectively at 13:00 and 23: 00 UT on July 7 with 14%, and 17% depletion in f_oF2, while a strong negative storm, with 30% depletion in f_oF2, occurred at 10:00 UT on July 8.

Figure 2(h) shows the ionospheric response at the low latitude station of Manila. The *D(f_oF2)* variations show a positive phase which appear to have commenced at ~7:00 UT on July 7 and after an inflection at 9:00 UT experienced an abrupt increase in f_oF2 which lead to 51% enhancement in f_oF2 at 11:00. Thereafter f_oF2 decreased sharply and as a consequence the ionosphere recorded a negative storm whereby f_oF2 was depleted by ~ 40% for two hours beginning from 14:00 UT. f_oF2 tried to recover but suffered two consecutive sharp depletions which resulted in the large negative storm that occurred between 20:00 and 21:00 UT. The depletion in f_oF2 in the interval is ~50%. The plot further shows a rapid enhancement in f_oF2 at ~22:00 UT which lead to a positive storm in the hours between 23:00 UT on July 7 and 2:00 UT on July 8 before assuming quiet conditions which lasted until 5:00 UT. f_oF2 increased again at 6:00 UT reaching ~30% enhancement at 9:00 UT before decreasing abruptly to non-storm magnitudes albeit briefly, after which it experienced a rather rapid enhancement. At 15:00 UT f_oF2 had recorded an increase 56% but then decreased abruptly leading to the peak depletion of 62% in f_oF2 at 21:00 UT.

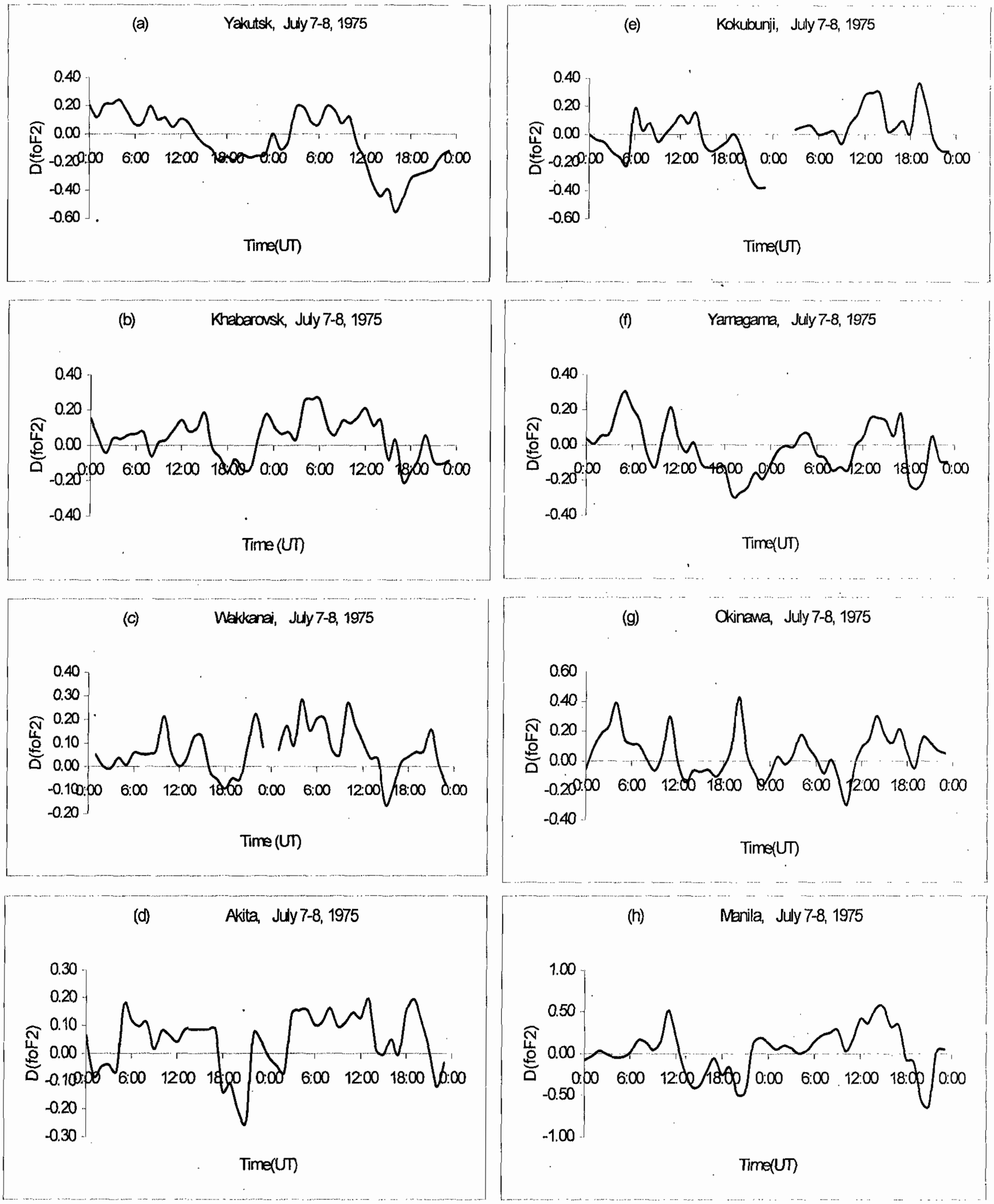

Fig. 2: Variations in $D(foF2)$ for ionosonde stations in East Asian longitudinal sector for July7-8, 1975.

5. **Discussion**

McPherron (1997) has shown that most of the variance in *Dst* is caused by the solar wind. The first main phase of this storm appears explained by the increasing southward B_z and increasing solar wind density. Observe that after some initial sharp fluctuations in the interval 0:00-14:00 UT on July 7, N_{sw} began a rather steady increase at ~15:00 UT. The Dst_{min} at 5:00 UT on July 8 appears a direct result of an enhanced solar wind density at 4:00 UT which drove, under southward B_Z conditions, the plasma sheet density leading to the injection of the ring current. Borovsky et al. (1997, 1998) have shown that the solar density and the near-earth plasma sheet density are highly correlated and an enhanced solar wind density would positively cause the ring current build up. And given that the ring current gives the main contribution to the *Dst* index (Wang et al., 2003, and references therein), any ring current build up would consequently decrease the *Dst* index. The *Dst* recovery in the interval 5:00-14:00 UT appear triggered by decreasing B_z in the interval 5:00-9:00 UT and was sustained by V_{sw} low of the prevailing slow solar wind stream. A less southward IMF will cause a reduction in the convection electric field (Huang, 2004) as shown in Equation (3).

$$E_y = V_{sw}B_s = \begin{cases} |V_{sw}B_z| & B_z \prec 0 \\ 0 & B_z \geq 0 \end{cases} \qquad (3)$$

According to Kamide et al. (1998b), there is the overwhelming evidence that the solar wind dawn-to-dusk electric fields E_y directly drive magnetospheric convection. The simulations of Ebihara and Ejiri (2000) also show that the major variation of storm time *Dst* is mainly due to the changes in the magnetospheric convection electric field and plasma sheet plasma density. The main phase of the second step of the storm was due to increase increases in both southward B_z and the solar wind speed at 15:00 UT on July 8. Observe that the magnitude of *Dst* decrease of the main phase of the second step is lesser than that of the first. This is apparently due to the abrupt large decrease in the solar wind speed immediately after 15:00 UT coupled with decreasing solar wind density as indicated by the proton density plot. Decreasing solar wind density would result in a decrease in ring current injection.

It is important to point out that even though the B_z values in the period 10:00 - 16:00 UT on July 8 appear to have presented an essential condition which would allow mass, energy and momentum to be transferred from the solar wind to the Earth's magnetosphere through magnetic reconnection (Dungey, 1961) and result in an intense storm, this didn't occur because of the prevailing relatively weak convection electric field resulting from slow solar wind stream. Figure 1(c) shows existence slow solar wind stream throughout the July 7-8, 1975. The present result appears to suggest that the solar wind speed is an important factor of dawn-dusk convection electric field. Chukwuma (2006) has shown that the geomagnetic storm of July 13-14, 1982 became intense despite the prevailing relative weak southward B_z. The present result and that of Chukwuma (2006) do not support the suggestion by Tsurutani et al. (1992) that it is the extraordinarily high southward B_z rather than high V_{SW} that is the dominant part of the electric field.

In view of the present result, it might be convenient to suggest that the first Dst_{min} resulted mainly from ring current injection due increase in solar wind density while the magnetospheric convection electric field played the leading role in the development of the second Dst_{min}.

The present moderate storm could be assumed to have commenced at ~17:00 UT on July 7. Analysis of the *D(foF2)* plots in Figure (2) shows that with the exception of the mid latitude station of Kokubunji all the stations recorded the appearance of positive storm before the beginning of the geomagnetic disturbance in the mid-latitudes and the occurrence of strong negative phase at the low latitude station of Manila. Danilov (2001) had listed the appearance of positive storm before the beginning of a geomagnetic disturbance in the mid-latitudes and the occurrence of strong negative phase at the equator as two unsolved problems. Furthermore, the plots indicated the absence of equatorward shift in the negative phase from the high latitudes to lower latitudes, as well as the absence of concomitant decrease in amplitude of the negative phase (maximum absolute value of *D(foF2)* with equatorward shift.

Blagoveshchensky et al. (2003) had observed the existence of positive storms at mid-latitude stations of the European sector prior to the May 15, 1997 storm (*Dst*= 115 nT) and suggested that the occurrence of the positive storm can be explained by an increase of the K_p index to 3^+ hours to the storm commencement. This explanation is considered insufficient because Davies et. al. (1997) have shown that K_p rises before the southward turning of B_z. Chukwuma (2006) also observed the phenomena respectively in 69% and 16% of the plots analyzed for the April 1-2, 1973 storm (*Dst* =-211) and October 1989 storm(*Dst* =-266 nT). The aforementioned phenomena during the April 1-2, 1973 storm (*Dst* =-211) are associated with the moderate storm with *Dst* = -60 nT which occurred at 20:00 UT on March 31, 1973 when the southward B_z = -7.0 nT, while that of the October storm was due to the moderate storm with *Dst* = -66 nT that occurred at 8:00 UT on October 19, 1989 when southward B_z = -4.2 nT. These results appear to underscore the role of moderate storms in the generation of the aforementioned positive phases.

While we may not in this paper explain the mechanism responsible for any of the aforementioned phenomenon during the period prior to 10:00 on July 7 when B_z was positive, it is important to note that the positive phase that preceded the present storm, from Table 1, occurred during the daytime. A widely accepted mechanism for daytime positive storm phase at mid latitudes is equatorward wind disturbances that can uplift the F region plasma. Another mechanism proposed by Fuller-Rowell et al. (1994) and Rishbeth et al. (1998) is related to changes in the mean molecular mass. Enhanced heat inputs in the auroral zone during storms cause upwelling and drive the equatorward winds that carry away energy absorbed by the upwelling. This energy is released by the compressional heating due to downwelling at lower latitudes. The upwelling, equatorward winds, and downwelling cause increases in the N_2/O ratio at high latitudes and decreases in the N_2/O ratio at low latitudes (Huang et al., 2005a). Although there is no measurement of molecular mass in the present study, the positive phase may not be caused by a decrease in the N_2/O ratio for the following reasons. The energy transfer is carried by equatorward neutral winds. It will take several hours for the disturbance winds originating in the auroral zone to reach mid latitudes to cause the decrease of mean molecular mass. In contrast, the observed daytime positive phase started to occur prior to the storm commencement, and any variations of molecular mass caused by storm-associated wind at middle latitudes could not have been generated. Furthermore, we want to suggest the absence of strong equatorward winds during the present storm because the daytime positive phase occurred nearly at the same time at both the high- and mid- latitude stations, and there is the absence of equatorward shift in the negative phase from the high latitudes to lower latitudes. Note also the absence of concomitant decrease in amplitude of the negative phase (maximum absolute value of *D(foF2)* with equatorward shift.

According to Huang (2005a), the only process that can quickly propagate from high to low latitudes without obvious delay is the penetration of electric fields. Enhanced ionospheric electric fields associated with IMF orientations have important effects on the ionospheric electron density. According to Foster and Rich (1998) and Huang (2005a), the eastward electric field will cause increases in the mid latitude ionospheric electron density by moving the ionospheric F region plasma to high altitudes with lower recombination and decreases in the equatorial ionospheric electron density by strengthening the fountain effect.

According to Huang et al. (2005b), interplanetary electric field E_y penetrates to the low latitude ionosphere during the main phase of magnetic storms. Figure 1(b) shows that the values of southward B_z that preceded the commencement of the moderate storm at 3:00 UT on July 8 are through the interplanetary electric field E_y, going by the results of Chukwuma (2006) and references therein, capable of causing the aforementioned features. Figure 1(e) presents the interplanetary electric field E_y for July 7-8 and note that the storm time E_y is enhanced. Huang et al. (2005b) have shown that the interplanetary electric field is well correlated with eastward electric field in the equatorial ionosphere, also when the IMF turns southward and remains stably southward for several hours, the dayside eastward ionospheric electric field at low latitudes is enhanced throughout the entire interval of southward IMF. Observe that presently B_z was southward throughout the duration the day time positive phase at mid latitudes and negative phase at the low latitude station of Manila occurred.

6. Conclusion

We have studied the moderate geomagnetic storm of July 8, 1975 and its associated ionospheric storm using *foF2* data obtained from ionosonde stations in East Asian longitudinal sector. The storm was found to be a double step storm with the first Dst_{min} resulting mainly from ring current injection due to increase in solar wind density while magnetospheric convection electric field played the leading role in the development of the second Dst_{min}.

The analysis of the interplanetary and *foF2* data show that the appearance of positive storm before the beginning of the geomagnetic disturbance in the mid-latitudes and the occurrence of strong negative phase at the low latitude station of Manila are due to the penetration of interplanetary electric field. Also available results presented ionospheric response features that bear similarity in form and magnitude with those that are due to intense storms. This suggests that a moderate storm is capable of generating ionospheric storms which are of comparable magnitude with those resulting from intense geomagnetic storms.

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