The Occurrence of Plasma Bubble and Its Relation to the Vertical Drift Using ROCSAT-1/IPEI Data

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ABSTRACT

In this paper, the plasma bubbles observations from ROCSAT-1 satellite between January 2000 and May 2004 with longitude limited in 90^{o}E－150^{o}E are used for studying the mechanism of ESF's production at low latitude. The statistical study indicates the occurrence of the plasma bubbles increasing with the solar activity. In the spring and autumn of high solar activity, about 50 percent days have the plasma bubble observed. The bubbles mainly occurred about ±30^o magnetic latitude region, and mainly at the geomagnetic quiet condition, occasionally at storm time. The bubbles during a major-severe storm mainly happened after midnight. The vertical drift observation from ROCSAT-1 satellites indicates there is always a significant polarized eastward electric field associated with the plasma bubbles at pre-midnight. But after midnight the association is seldom happened. At geomagnetic disturbed period, the penetration of the eastern electric field can cause the plasma bubbles after midnight.

1. INTRODUCTION

In the ionospheric low latitudes, there are many scale sized irregularities, in which Equatorial spread F (ESF), is a phenomenon of large scale size irregularities. Because ESF can result in the scattering of radio waves, known as ionosphere scintillation, the study about ESF are concerned by mechanism of ESF's production, such as seed resources to generate the instability and the day to day variability are not well interpreted. The Spread F can be observed by different instruments and have different phenomena. For the space-based measurements, the plasma depletion or plasma bubbles, as a large scale sized ESF, can be detected directly, such as by AE-C, DE-2, DMSP, ROCSAT-1, C/NOFS etc. The plasma drift is very important for the production of ESF. The prereversal enhancement (PRE) of the vertical drift in the postsunset is considered to be related to the production of plasma bubbles (Fejer et al.，1999；Li et al., 2008；Su et al, 2008；Kil et al.，2009). Fejer et al.(1999) suggested that the Rayleigh-Taylor instability could happen with the PRE persisting for more than 30 minutes, and this PRE may just be a daily variation. Kudeki and Bhattacharyya (1999) indicated that the PRE itself is an important mechanism of producing R-T instability. Kil et al.(2009) suggested the relative coefficient between PRE and plasma bubbles is 0.75， and further pointed out that PRE is in favor of producing the R-T instability, but it is not the determination for plasma bubbles. The seed mechanism of producing the R-T, such as the gravitional wave, wind share is still the necessary conditions. Abdu (2001) indicated that the vertical drift is not the only factor for describing the production of plasma bubbles.

The plasma density and drift observations from ROCSAT-1 satellite is a good data resources for studying the occurrence of the plasma bubbles and relations with background drift (Su et al., 2008）. In this paper, we surveyed the occurrence of the plasma bubbles observed from ROCSAT-1 and investigated the vertical drift characteristic during the plasma bubbles. The vertical drifts at pre-midnight and after midnight are compared to know about the different process of producing plasma bubbles. The data sets used in this work are described in section 2. A detailed presentation of the results is given in section 3, and conclusions are presented in the final section.

2. DATA

The data we used is from Taiwan's ROCSAT-1 satellite, which was in a circular orbit at 600 km with an orbital inclination of 35 and provided data from March 1999 to June 2004. Its low-inclination orbit enabled ROCSAT-1 to sample the ionosphere at all local times. The Ionospheric Plasma and Electrodynamics Instrument (IPEI) on board the ROCSAT-1 can measure the ion concentration, ion temperature, and ion drift velocities [Su et al., 1999; Yeh et al., 1999]. In this study, we selected the region longitude from 90^{o}E-150 ^{o}E, and latitude -35 ^{o}N ~35 ^{o}N to analyze the plasma bubble's occurrence. The vertical ion velocities are used to study the PRE.

3. RESULTS

3.1 THE OCCURRENCE OF PLASMA BUBBLES

Figure1 shows occurrence of plasma bubbles in different years. It is obviously that the plasma bubbles observed more frequently in solar high active years. For the seasonal occurrence, the occurrence of plasma bubbles is higher in spring and autumn than that in summer and winter, especially in solar high activity, with about 50 percent days having the plasma bubble observed. The statistic analysis in this paper is consistent with the results reported in other papers (Burke et al.，2004；Gentile et al.，2006；Li et al., 2008; Su et al., 2008；Kil et al.，2009）.

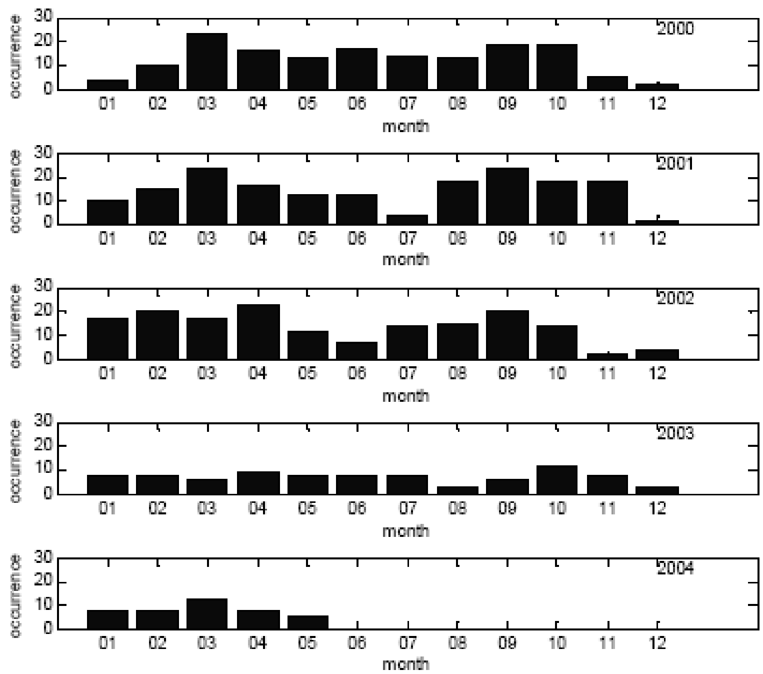

Figure 1. The day numbers with occurrence of plasma bubbles at different years.

3.2 THE VERTICAL DRIFT WITH PLASMA BUBBLES

Figure 2 gives vertical drift observed by ROCSAT-1/IPEI in 2000. The red point is the vertical drift with the plasma bubbles occurred, and the blue point is the drift with no plasma bubble occurred. It is obviously that there is a vertical drift enhancement and disturbance within the plasma bubble at pre-midnight, indicating there is a polarized electric field which producing the R-T instability. However, at post-midnight, there is no significant vertical drift disturbance except in August. The results in other years are similar to that in 2000.

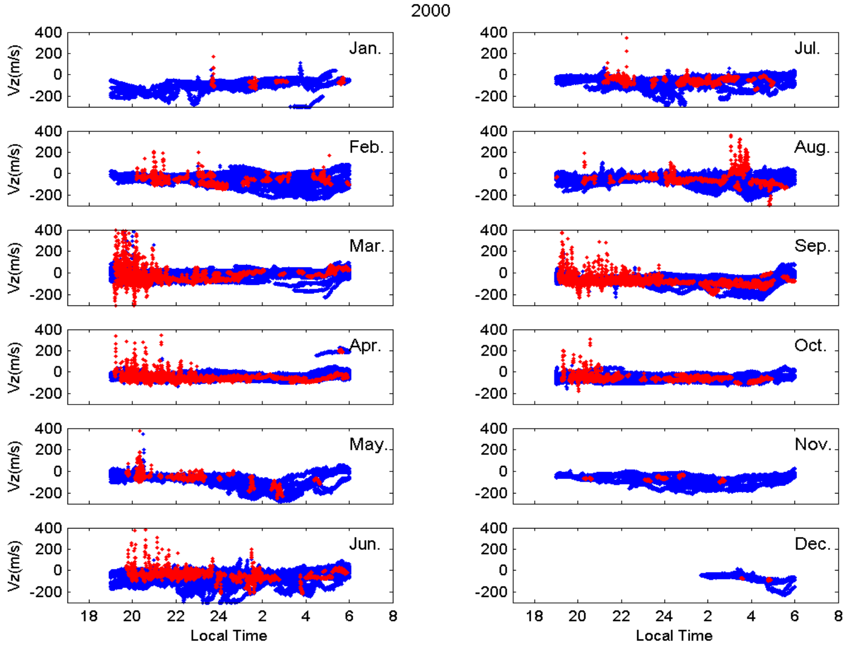

Figure 2. The vertical drift with plasma bubbles in 2000. The red point is the vertical drift with the plasma bubbles observed. The blue point is the drift that no plasma bubble occurred.

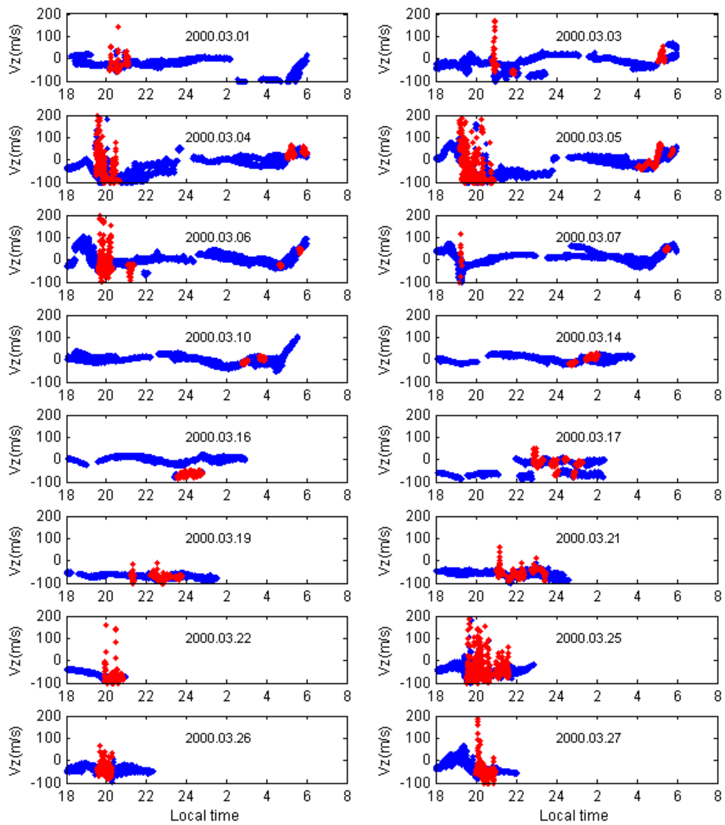

Figure 3. The vertical drift with plasma bubbles in March in 2000.

Figure 3 gives the vertical drift for several days in March, 2000, with plasma bubbles observed mainly at pre-mignight. It is more clearly to see the strong polarized eastward electric field occurred when the plasma bubbles observed at pre-midnight. There is a significant prereserval enhancement (PRE) of the vertical drift observed on March 3-7, March 25 and March 27. But for the plasma bubble on March 22, there is no PRE observed.

Figure 4 shows vertical drift in some specific days which have plasma bubbles occurred at post-midnight. It shows there is no disturbance in vertical drift except on August 12, 2000 with significant disturbance of vertical drift. For other time, there is no such disturbance.

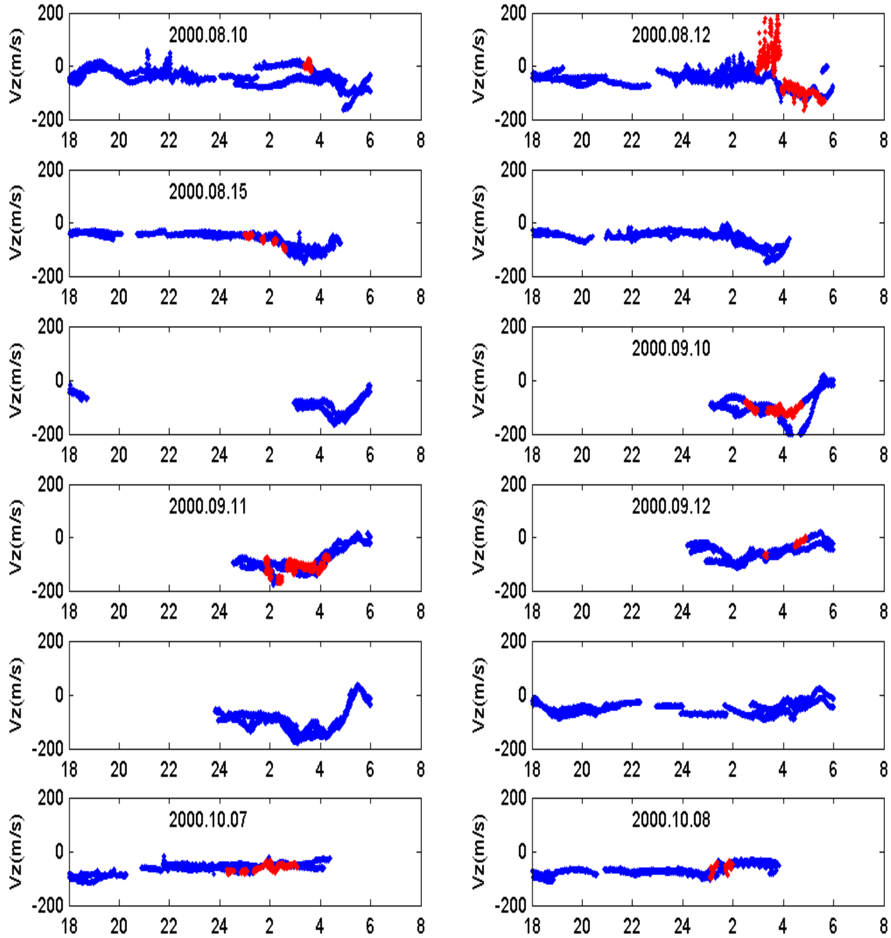

Figure 4. The Same as Figure 3, but for the vertical drift with plasma bubbles occurred in post-midnight.

Further study for the production plasma bubbles on August 12, 2000 is investigated by analyzing the geomagnetic filed conditions in this day. Figure 5 gives the plasma density and vertical drift from IPEI observations. The plasma density shows very large plasma depletions observed. The enhancement of the Vz is associated with the plasma depletions. Figure 6 indicates this plasma bubble event occurred in the periods of a strong geomagnetic storm, with Kp maximum reached 8. The same events observed on March 31,2000, March 31,2001, and Nov.24,2001 etc., which is not shown here. These plasma bubble events may be related to the penetrating electric field during the geomagnetic storm. Fejer (1999) indicated the penetrating electric field could induced the E×B instability, which is responsible for the production of plasma bubbles. Su et al.(2002) analyzed a plasma bubble event during a geomagnetic field on April 6-7, 2000, and showed that the disturbed electric field can lift the plasma upward, and enhance the R-T instability.

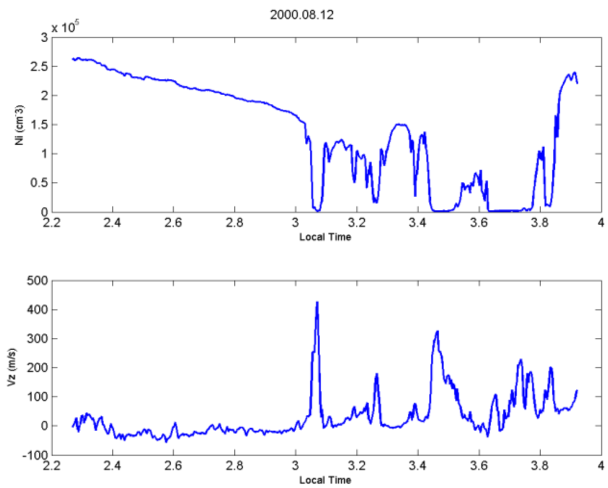

Figure 5. The plasma bubbles and vertical drift on August 12,2000.

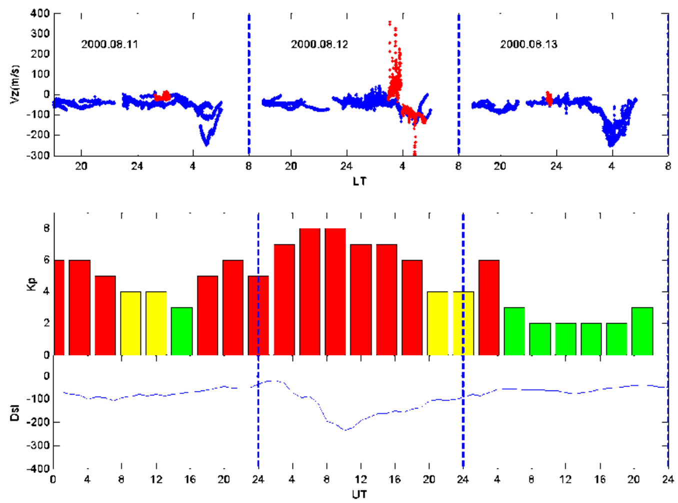

Figure 6. The vertical drift, geomagnetic Kp and Dst indices on August 12, 2000.

We give a statistic result about the geomagnetic index, Ap during the plasma bubble days, as shown in figure 7. Although the plasma bubble mainly happened in Geomagnetic quiet days, there also are plasma bubble events observed for Ap greater than 40. And from figure 7, we can see the post-midnight plasma bubble is more often than pre-midnight during the geomagnetic storm, which matches the history research results (Fejer, 1999).

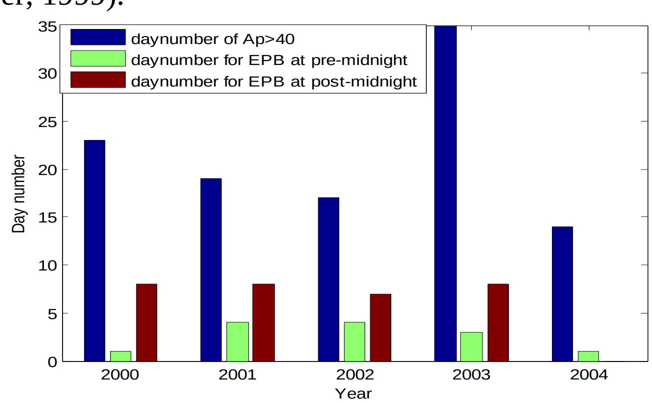

Figure 6. The Ap index in the days with the occurrence of plasma bubbles.

4. CONCLUSIONS

In this paper we have investigated the occurrence of plasma bubbles and the relationship between the vertical drift and the production of plasma bubbles. Our main conclusions are as follows:

1. The occurrence of the plasma bubbles is higher in high solar activity than that in low solar activity. In the spring and autumn of high solar activity, about 50 percent days have the plasma bubbles observed.
2. The pre-midnight plasma bubbles are always associated with polarized electric field.
3. For the post-midnight, the plasma bubbles can be trigged by penetrated eastward electric field during magnetic storm.
4. The pre-reversal vertical enhancement has some connection to plasma bubbles, but it is not the necessary conditions for generating the plasma bubble.

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