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Dynamics of equatorial ionosphere/thermosphere and onset of spread F

Takashi Maruyama [1]

[1] Comm. Res. Lab./Hiraiso

We have conducted an extended ionospheric observation on Cebu island (124 deg. E, 10.3 deg. N; 2.4 deg. N in diplatitude), Philippines, in March 1998 using a portable ionosonde as a part of a WestPac ionospheric campaign. Extended observation was also made at Manila station (121 deg. E, 14.6 deg. N; 7.3 deg. N in diplatitude). East-west separation of the two stations is about 350 km.

Significant localization of evening enhancement in the zonal electric fields was observed during the equatorial spread F events. We speculate that this localization may be caused by interaction between the localized wave activity in the thermosphere and the region of evening enhancement that moves westward at 480 m/sec with the sun terminator.

1. Introduction

The equatorial ionosphere often becomes unstable after sunset and plasma bubbles form. The plasma bubbles are observed as intense range-type spread F on the ionogram and cause radio wave scintillations in satellite communication links up to microwaves. A basic mechanism in forming equatorial spread F is gravitational Rayleigh-Taylor (R-T) instability in conjunction with EXB drift instability due to an eastward electric field operated at the bottomside. The eastward electric field pushes up the ionosphere in the direction of EXB drift, which enhances the R-T instability growth rate because of lowered ion-neutral collision frequency at high altitudes. Thus, a strong eastward electric field after sunset, which is known as an evening enhancement, is a key factor in the onset of equatorial spread F and its short-term prediction. Also known is a large day-to-day variability in the evening enhancement of electric fields. Neither the origin nor spatial extent of the variability is well known.

2. Observation

We have conducted an extended ionospheric observation on Cebu island (124 deg. E, 10.3 deg. N; 2.4 deg. N in diplatitude), Philippines, in March 1998 using a portable ionosonde as a part of a WestPac ionospheric campaign. Extended observation was also made at Manila station (121 deg. E, 14.6 deg. N; 7.3 deg. N in diplatitude). East-west separation of the two stations is about 350 km.

One of the largest events was observed on March 9. The ionosphere rose after sunset and reached 300 km by 1100UT (1900LT). After that the ionosphere over both Manila and Cebu started to descend. At Manila the ionosphere continued to descend, while the ionosphere over Cebu turned to rise again. As a result, the difference in the ionospheric height over both stations reached up to 110 km at 1200UT (2000LT). The onset of intense spread F was observed 15 min after the ionosphere started to descend over Manila, while intense spread F over Cebu began when the layer height was at its maximum. A similar event was observed on March 3.

3. Discussion

In the above events, there exists a large westward gradient in the electron density at the bottomside of the ionosphere. In general, thermospheric neutral winds around the sunset hours are eastward with a speed of 100 - 150 m/sec. Under such conditions, the ionosphere is shown to be destabilized by the collision force between the ion and neutral particles. This means that localization of the evening enhancement takes an important role in the generation of spread F. We speculate that this localization may be caused by interaction between the localized wave activity in the thermosphere and the region of evening enhancement which moves westward at 480 m/sec with the sun terminator.

4. Conclusion

The extended observation of the ionosphere at Manila and Cebu both near the magnetic equator has suggested an ionosphere/thermosphere interaction that controls the onset of spread F. For further studies, an ionosonde network along the magnetic equator separated several hundred kilometers apart would be effective. To predict the onset of strong ionospheric scintillations, it is shown that any single ionosonde station is not sufficient to monitor ionospheric conditions.