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Spectral Analysis of Equatorial Plasma Bubbles Obtained by High-Resolution Bubble Model and C/NOFS Satellite

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Extended Abstract

Equatorial plasma bubble (EPB) is a well-known phenomenon in the equatorial ionospheric F region. As it causes severe scintillation in the amplitude and phase of radio signals, it is important to understand and forecast the occurrence of EPB from a space weather point of view. The development of EPB is presently believed as an evolution of the generalized Rayleigh-Taylor instability. It has been proposed that large-scale wave structure (LSWS) at the bottomside of the F region should be an important seeding of EPB. However, it is quite difficult to observe the evolution of EPB from a specific LSWS structure. Therefore, numerical modeling is a powerful tool to study the condition of EPB occurrence and day-to-day variability. In order to simulate the instability in the equatorial ionosphere, a 3D high-resolution bubble (HIRB) model with a grid spacing of as small as 1 km was developed. The HIRB model solves continuity, momentum, and current divergence-free equations numerically in a three-dimensional magnetic dipole coordinate system. Using the HIRB model, nonlinear growth of EPB from LSWS-like seeding, formation of very turbulent internal structures such as bifurcation and pinching [1], and the east-west asymmetry of EPB [2] have been presented.

Recent upgrade of the HIRB model has made it possible to conduct the simulation with sub-kilometer grid spacing. Once EPB penetrates into the topside ionosphere, turbulent internal structures become very significant. From the preliminary spectral analysis of higher-resolution simulation results, we obtain power law characteristics of turbulent structures of simulated EPBs. There are two power law components with a break point at around a few km wavelengths. The power law characteristics are consistent with past in situ observations such as the C/NOFS satellite to some extent. For more detailed analysis, wavelet-based analysis can be applied for the turbulent structures of the simulated EPB [3], and the results can be compared with the same analysis applied for C/NOFS satellite data. Such spectral information may be useful for quantitative evaluation of radio wave scintillation intensity. In the near future, HIRB model may be able to directly resolve Fresnel scale of GPS frequency band (300-400m), so that the effects of EPB on radio wave propagation could be evaluated without any assumption.

References

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