Plasma Bubble Rise Velocity Estimated from EAR Observation and High-Resolution Bubble Model

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Equatorial plasma bubbles (EPBs) are 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 EPBs from the space weather point of view. Especially, it is crucial to understand how fast EPBs evolve from initial seeding into very turbulent structures that cause scintillation.

The observation of EPBs with the 47-MHz Equatorial Atmosphere Radar (EAR) in West Sumatra, Indonesia (0.20S, 100.32E, 10.36S dip latitude) has been conducted since 2001, and its unique observational data have been archived for about 15 years. The EAR detects coherent backscatters from 3-m scale ionospheric irregularities. Since the plasma density depletions inside EPBs are filled with small-scale irregularities, EAR echoes can be regarded as a tracer of EPBs. In addition, the rapid beam steering capability of the active phased array system of the EAR makes it possible to observe spatial and temporal evolution of EPBs even under a rapid growth phase. The rise velocity of EPBs can then be estimated from the multi-beam observation by tracing the head of EAR echoes.

EPBs tend to occur around sunset time due to the prereversal enhancement of eastward electric field. In addition, they occasionally appear to grow around midnight when the background ionospheric condition turns to be suitable for the EPB growth. The estimated rise velocity of the EPBs observed by the EAR around sunset was about 200m/s, while the rise velocity around midnight was less then 100m/s. To confirm these results, numerical simulation with the High-Resolution Bubble model was conducted under sunset and midnight conditions. The rise velocity of simulated EPBs is roughly consistent with the EAR observation. It is observed that the rise velocity is sensitive to background eastward electric field and the amplitude of initial seeding.