Development of multi-scale numerical simulation model for the study on ionospheric disturbances

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The ionospheric disturbance called plasma bubbles that occurs in the equatorial ionosphere has an irregular plasma density structure, so it degrades radio wave propagation from various satellites. Although plasma bubbles have been observed for more than 80 years, the generation mechanism has not been clarified and the prediction of plasma bubble occurrence is quite difficult. In this study, we have developed a new simulation model for studying plasma bubbles. Models that simulate the ionosphere can be roughly categorized into two types: the global ionosphere model and the local ionosphere model. There is a trade-off between computational domain and resolution. The High-Resolution Bubble (HIRB) model, which is one of the local ionospheric models, can reproduce plasma bubbles in 1 km resolution, but the simulation domain is limited to a narrow wedge region. The model developed in this study is a multi-scale numerical model which covers the whole longitude with a high resolution domain in the dusk region. The new model has the advantages of both global and local models and compensates both disadvantages. In the multi-scale simulation model, plasma bubbles are generated in the high-resolution domain and penetrate into the topside ionosphere. Although the resolution is not as high as the HIRB model, the generated plasma bubbles contain irregular plasma density structures. Plasma drift velocity simulated in the new model are consistent with observations in the all local time region. It indicates that the global simulation is well performed as well as the plasma bubble generation. In this study, the new simulation model has been developed to simulate the plasma bubble generation and global plasma drift velocity in the whole longitude with a multi-scale grid system. Since it is possible to express the plasma bubble more delicately by increasing spatial resolution, the performance of the new simulation will be greatly improved by parallel computing.

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