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Three-dimensional high-resolution plasma bubble modeling

YOKOYAMA, Tatsuhiro[1*] ; SHINAGAWA, Hiroyuki[1] ; JIN, Hidekatsu[1]

[1]National Institute of Information and Communications Technology

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 known as a evolution of the generalized Rayleigh-Taylor instability. Numerical modelings of the instability on the equatorial two-dimensional plane have been conducted since the late 1970's, and the nonlinear evolution of the instability has been clearly presented. Recently, three-dimensional (3D) modelings became popular tools for further understanding of the development of EPB such as 3D structure of EPB, meridional wind effects and gravity wave seeding. One of the biggest advantages of the 3D model is that the off-equatorial E region which is coupled with the equatorial F region can be included in the model. It is known from observations that the conductance of the off-equatorial E region controls the growth rate of the Rayleigh-Taylor instability, that is, sudden decrease of the E-region conductance around the sunset accelerates the evolution of the instability. We have developed a new 3D high-resolution model for EPB, and studied internal structure of EPB and the contribution of the off-equatorial E region. As it is necessary to use high-order numerical schemes to capture sharp plasma density gradient of EPB, we adopted the CIP scheme which can keep the third-order accuracy in time and space. The simulated EPB has asymmetrical density gradients at east and west walls, and the growth rate changes significantly depending on the condition of the off-equatorial E region. In the future, we will integrate the high-resolution model into whole atmosphere-ionosphere coupled model (GAIA) to study the growth of EPB under the realistic background conditions.

Keywords: plasma bubble, equatorial spread F, equatorial ionosphere, numerical simulation