MHD and Hybrid Simulations of the Cold Ion Escape from the Ionosphere of Venus

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Ionospheric flow and escape of cold ions from the ionosphere of Venus are investigated using a global magnetohydrodynamic (MHD) model as well as an electromagnetic hybrid (particle ions and fluid electrons) model. We have developed a three-dimensional, 10-ion-species, comprehensive MHD model that describes the structures, dynamics, and energetics of both the solar wind and the planetary ionosphere. An excellent performance of the model is verified by comparing our numerical results with the Pioneer Venus orbiter observational data. The model shows a complex 3-D flow pattern of the ionospheric plasma, forming large-scale four vortex structures on the nightside and escape channels through the magnetotail region. We also compare our numerical results of the global hybrid simulation with recent observations of the Kelvin-Helmoltz wave-like signatures obtained by the magnetometer onboard Venus Express. We show the importance of the ion kinetic effects on the evolution of the Kelvin-Helmoltz instability especially at the subsolar region of the ionopause and possible impacts on the ion erosion rates.