サブストーム時における太陽風から電離圏に至るエネルギーの流れ：MHD シミュレーション

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Energy flow from solar wind to ionosphere during substorm: Global MHD simulation

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The ultimate source of the energy involved by magnetospheric disturbances is the solar wind. When a large amount of the solar wind energy enters the magnetosphere, magnetospheric disturbances, such as a substorm, occur. Using global magnetohydrodynamics (MHD) simulation, we investigated the flow and conversion of the energy originated in the solar wind for substorms under different solar wind conditions, specified by the southward component of interplanetary magnetic field (Bs), the solar wind velocity (Vsw), the solar wind density (Nsw). We defined a solar wind effective cross-sectional area in which all the integral curves of the Poynting flux (S-curve) entering the magnetosphere pass through. About 33-88% of the magnetic energy entering the magnetosphere is converted from the solar wind kinetic energy. Since the contribution from the solar wind kinetic energy is large, the intake magnetic energy is not simply proportional to $VswBs^2$ (Poynting flux), nor $NswVsw^3$ (kinetic energy flux). The effective area decreases with Bs, Vsw, and Nsw, which also makes the relationship between the solar wind parameters and the intake magnetic energy complicated. The stored energy and the released energy in the lobe are also found to depend on the solar wind parameters, suggesting that the loading-unloading processes are also regulated by the solar wind condition. The ionospheric Joule heating rate is well correlated with the intake magnetic energy at onset, and during the substorm expansion. This can be explained by the simulation result that both the directly driven and unloading processes are regulated by the solar wind condition.