サブストームオンセット前後にノルウェー・トロムソのファブリ・ペロー干渉計で観測された下部熱圏風の加速

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Acceleration of the lower-thermospheric wind measured with a Fabry-Perot interferometer around substorm onsets at Tromsø, Norway

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At high latitudes, electromagnetic and particle energies are transferred from the magnetosphere to the ionosphere and the thermosphere. The polar ionosphere and thermosphere act as an energy and particle sink, where the energy is transformed into both heated and accelerated plasmas and neutral particles. The former and latter processes can be regarded as thermal and mechanical energy transformation, respectively. These processes result in wind acceleration of the polar thermosphere in various spatiotemporal scales. In this paper, wind acceleration in the lower thermosphere and magnetospheric energy inputs were studied using data from the European Incoherent Scatter (EISCAT) radar and a Fabry-Perot interferometer (FPI; λ = 557.7 nm) at Tromsø, Norway. In particular, this presentation focuses on substorm onset time. The onset time was decided by the EISCAT-derived electron density at 110 km height or FPI fringe count, which showed abrupt increases due to auroral particle precipitation. A superposed epoch analysis method was applied on the EISCAT-derived ionospheric parameters for ±1 hour at the center of the onset time. The ion temperature at 110 and 250 km heights and the electron temperature at 110 km height showed clear enhancements before the electron-density enhancement by a few tens of minutes. These increases suggest enhancements of the perpendicular electric field, which induces frictional and Joule heating and Farley-Buneman instability, at the outside of poleward edge of aurora. The FPI-derived neutral wind data were also analyzed by the superposed epoch analysis method. Vertical component of the neutral wind velocity increased for periods of enhancements of the ion and electron temperature. At the same time, the horizontal wind velocity changed the direction from southwestward to southward decreasing its magnitude, which means northeastward acceleration. Since presumable directions of the Hall and Pedersen currents around the onset time are westward and southward, respectively, the total ionospheric current is southwestward. In this case statistical result of the southward neutral wind gives positive $\mathbf{U}\cdot(\mathbf{J}\times\mathbf{B})$, which is equal to $\mathbf{J}\cdot\mathbf{E}$ - $\mathbf{J}\cdot\mathbf{E'}$. The positive value suggests that the electromagnetic energy flux ($\mathbf{J}\cdot\mathbf{E}$) originated in the magnetosphere is converted to both Joule heating rate ($\mathbf{J}\cdot\mathbf{E'}$) and Lorentz force ($\mathbf{J}\times\mathbf{B}/\rho$) in the ionosphere/thermosphere. It is thus concluded that both Joule heating process and the Lorentz force come into play for acceleration of the horizontal wind in the lower thermosphere at the substorm onset. However, Joule heating must be a predominant mechanism for the vertical-wind perturbations because Lorentz force acts almost horizontally. In the presentation temporal development of the Joule-heating and Lorentz-force contributions to the wind acceleration will be also addressed.