Lower-thermospheric wind variations in auroral patches during the substorm recovery phase

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Responses of the polar thermosphere and ionosphere to geomagnetic substorms have been widely investigated by many researchers. Representative mechanisms that may cause such variations are thermal energy dissipation by the Joule and particle heating processes and momentum transfer by the Lorentz force. The mechanisms and thermospheric/ionospheric responses have been studied by analyzing data mainly at the expansion phase or around the substorm onset. In contrast the substorm recovery phase has had little focus for most researchers. A motivation for this work is spontaneous and dramatically large variations of density, temperature, and dynamics in the thermosphere and ionosphere at the substorm recovery phase.
At the substorm recovery phase, measurements of the lower-thermospheric wind with a Fabry-Perot interferometer (FPI) at Tromsø, Norway found the largest wind variations in a night during appearance of the auroral patches. Taking into account magnetospheric substorm evolution of plasma energy accumulation and release, the largest wind amplitude at the recovery phase is a fascinating result because it is generally assumed that the energy dissipation at the recovery phase is smaller than that at expansion phase and onset. The results are the first detailed investigation of the magnetosphere-ionosphere-thermosphere coupled system at the substorm recovery phase using comprehensive data sets of solar wind, geomagnetic field, auroral pattern, and FPI-derived wind.
This study used three events in November 2010 and January 2012, particularly focusing on the wind signatures associated with the auroral morphology, and found three specific features: (1) wind fluctuations that were isolated at the edge and/or in the darker area of an auroral patch with the largest vertical amplitude up to about 20 m/s and with the longest oscillation period about 10 minutes, (2) when the convection electric field was smaller than 15 mV/m, and (3) wind fluctuations that were accompanied by pulsating aurora. This approach suggests that the energy dissipation to produce the wind fluctuations is localized in the auroral pattern. Effects of the altitudinal variation in the volume emission rate were investigated to evaluate the instrumental artifact due to vertical wind shear. The small electric field values suggest weak contributions of the Joule heating and Lorentz force processes in wind fluctuations. Other unknown mechanisms may play a principal role at the recovery phase.

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