Neutral-ion coupling in the auroral ionosphere during magnetospheric substorms

*Lei Cai[1,2], Shin-ichiro Oyama[2], Anita Aikio[2], Heikki Vanhamaki[2], Ilkka Virtanen[2]

1. Ionospheric Physics Unit, Univ. of Oulu, Finland, 2. Institute for Space-Earth Environmental Research, Nagoya University, Japan

At high latitudes, the coupled ionosphere-thermosphere system is highly affected by interactions between the solar wind and the magnetosphere. The magnetospheric energy can be efficiently transferred into the ionosphere during magnetospheric substorms, via electromagnetic energy exchanges and auroral precipitation. Due to substorm energy input, ion-drag force and pressure gradient produced by Joule heating can become dominate forces that control the thermospheric wind. Although a few studies have shown that thermospheric dynamics can be strongly affected by auroral activities, it is still unclear that how the ion-neutral coupling process depends on different substorm phases. In addition, the variation of the thermospheric wind may be affected by the location of the substorm onset in respect to the observation site.

To investigate the questions above, we used measurements from 2009 to 2016 by ground-based instruments installed in northern Scandinavia, including European Incoherent Scatter (EISCAT) radars, Fabry-Perot Interferometer, all-sky cameras, and magnetometers. Those instruments provide an opportunity to measure several ionospheric and thermospheric key parameters such as plasma density, electric field, conductivities, equivalent currents, and the neutral wind. We studied the substorm evolution of thermospheric winds by analyzing individual events and by statistical methods. In the evening sector, the neutral wind has a typical westward acceleration during the substorm growth phase, mainly due to the strong ion-drag force associated with the equatorward motion of the enhanced eastward electrojet. The westward acceleration is terminated at a time close to substorm onset. During the expansion phase, the the wind changes from westward to eastward. The transition time from westward to eastward depends on the longitudinal location of the onset. During the evolution, mesoscale disturbances were often observed, which are affected by the local auroral activity. We will discuss the physical mechanisms that cause the wind accelerations by analyzing the relative importance between ion-drag force and Joule heating.

Keywords: ionosphere-thermopshere coupling, substorm, neutral wind, equivalent current, auroral activity

