ファブリ・ペロー干渉計を用いたサブストームオンセット時の熱圏風変動の解析

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Multi-event study of thermospheric wind variations at substorm onset using an FPI at Tromsoe, Norway

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In this study, we focused on high-latitude thermospheric wind variations near the onset time of isolated substorms. Substorm-related energy inputs from the magnetosphere to the polar ionosphere modify the high-latitude ionosphere and thermosphere. For the first time, this study showed the characteristics of high-latitude thermospheric wind variations at the substorm onset. We also investigated the possibility of these wind variations as a potential trigger of substorm onset by modifying the ionospheric current system (Kan, 1993). A Fabry-Perot interferometer (FPI) at Tromsoe, Norway provided wind measurements estimated from Doppler shift of both red-line (630.0 nm for the F region) and green-line (557.7 nm for the E region) emissions of aurora and airglow. We used seven-year data sets obtained from 2009 to 2015 with a time resolution of 13 min. We first identified the onset times of local isolated substorms using ground-based magnetometer data obtained at the Tromsoe and Bear Island stations, which belongs to the IMAGE magnetometer chain. Totally, we selected 4 red-line events and 5 green-line events taken place at different local times. For all these events, the peak locations of westward ionospheric currents identified by the ground-based magnetometer chain were located at the poleward side of Tromsoe. Then, we calculated two weighted averages of wind velocities for 30 min around the onset time and 30 min after the onset time of substorms. We evaluated differences between these two weighted averages to estimate the strength of wind changes. The observed wind changes at these substorm onsets were less than 49 m/s (26 m/s) for red-line (green-line) events, which are much smaller than the typical plasma convection speed. This indicates that the plasma motion caused by substorm-induced thermospheric winds through ion-neutral collisions is a minor effect as the driver of high-latitude plasma convection, as well as the triggering of substorm onset. The red-line events show increases of eastward winds from the pre-midnight to post-midnight sectors and decreases of northward winds except for the midnight sector. The green-line events show increases of eastward winds from the pre-midnight to post-midnight sectors, and increases (decreases) of northward winds before (after) midnight. We discuss possible causes of these observed wind changes at the onset of substorms based on the mechanisms of thermospheric diurnal tides, arc-induced electric field and Joule heating caused by the auroral activities that were identified by the cross sections of all-sky images, as well as the IMF-associated plasma convection model. From these results, we suggest that the high-latitude thermospheric wind variations at substorm onset are mainly caused by the competition between diurnal tides and plasma convection.