Latitude and local time variations of stormtime electric fields as observed with HF Doppler sounders and SuperDARN

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Penetration of electric fields during the intense geomagnetic storm on 22-23 June, 2015 was investigated using HF Doppler sounders (HFDs) on the day- and night-sides and SuperDARN at high- and mid-latitudes. ACE observed that the southward interplanetary magnetic field (IMF) decreased to -30 nT at 1801 UT, lasting 70 minutes concurrently with a sudden increase of the solar wind dynamic pressure. A storm sudden commencement (SC) was observed at 1833 UT by the HFDs at 7 stations in Japan (0330 MLT), Zhongli, Taiwan (0230 MLT) and Prague, Czech (1930 MLT), and midlatitude SuperDARN radar in Hokkaido, Japan. The electric field of the main impulse (MI) of the SC and the succeeding storm main phase was westward with the intensity decreasing from 7.8 mV/m at Oarai (27.3 degrees GMlat) to 2.0 mV/m at Zongli (15.4 degrees GMlat) in the post-midnight, whereas that was eastward of 1.2 mV/m at Prague (50.0 degrees GMlat). The multi point observation of HFD showed that the eastward convection electric field expanded into the evening hour 1830-1930 MLT. The global magnetometer networks, NICT chain, INTERMAGNET and SuperMAG, showed that the DP2 currents developed from high latitude to the equator on both the day- and night-sides during the storm main phase. The DP2 currents should be driven by the dawn-to-dusk magnetospheric convection electric field as detected by THEMIS near the magnetopause in good correlation with the DP2 ionospheric currents. On the other hand, midlatitude SuperDARN radars in the American sector observed anti-sunward plasma flows at latitudes lower than 47 degrees GM latitude after 2010 UT, equatorward of the expanded dusk convection cell, indicating that the overshielding occurred due to the northward excursion of the IMF. It is remarkable that the overshielding caused westward counterelectrojet (CEJ) at the dayside equator and eastward equatorial electrojet (EEJ) on the nightside. Based on the HF radio and magnetometer observations, we suggest that the intense convection /overshielding electric field penetrated near-instantaneously to the mid- and low-latitudes and cause the EEJ/CEJ on both the day- and night-sides during the geomagnetic storm.