Simultaneous observation of the SC electric fields with the HF Doppler sounders on the day- and night-sides

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The geomagnetic sudden commencement (SC) is composed of the stepwise increase caused by the magnetopause currents, superimposed by the preliminary impulse (PI) and main impulse (MI) caused by the ionospheric Hall currents at high latitude driven by the dusk-to-dawn and dawn-to-dusk electric fields, respectively. The PI is positive and negative in the morning and afternoon, respectively, and the MI is in opposite direction to the PI. The ionospheric currents decrease their intensity with decreasing latitude because of the geometrical attenuation (Kikuchi et al., 1978), resulting in rare observation of the PI at low latitudes, but the PI appears again at the dayside equator where the ionospheric currents are intensified by the Cowling effect. The SC electric fields have been observed at low latitude with the HF Doppler sounders on both the day- and night-sides simultaneously with the SC at high latitudes and equator, even when the PI and MI are not significant at low latitudes (Kikuchi, 1986). It should be stressed that the HF Doppler sounders have an advantage in detecting the electric field on the nightside where the ionospheric currents are too weak to be detected by the magnetometers. The SC electric fields on the nightside are in opposite direction to those on the dayside, while the electric fields in the evening are in the same direction as on the day with enhanced magnitude three folds as large as those on the dayside (Kikuchi et al., 2016). The local time features with the evening anomaly meet the solutions of the potential solvers (Tsunomura, 1999), suggesting that the electric fields of the PI and MI are potential fields associated with the ionospheric currents supplied by the field-aligned currents in contrast to their wave properties in the magnetosphere. The PI was found to start simultaneously at high latitude and dayside equator within the temporal resolution of the magnetometer data (10s) (Araki, 1977), which suggests that the ionospheric currents are transmitted instantaneously from high latitude to the equator. The instantaneous transmission has been explained by means of the zeroth-order transverse magnetic (TM0) mode waves propagating at the speed of light in the Earth-ionosphere waveguide (Kikuchi and Araki, 1979). The PI and MI electric fields have been well studied as overviewed above, but the local time and latitude features have not been evaluated by simultaneous observations over the globe. In this paper, we report an event analysis to evaluate the local time features of the SC electric fields with the HF Doppler sounders at Prague, Czech Republic, Tucuman, Argentina on the nightside, and at Sugadaira, Japan and Zhongli, Republic of China on the dayside. To identify the polar-equatorial ionospheric currents, we used magnetometer data from College, Alaska and Guam in the western Pacific. We analyzed an SC event that occurred on 17 March, 2015 with the PI starting at 0445:20s UT and reaching the peak at 0446:10s UT simultaneously at high latitude and equator, followed by the MI peaked at 0447:20s UT. The PI and MI electric fields on the dayside are westward and eastward, respectively, and the electric fields are reversed on the nightside. The onset and peak times of the PI electric field were found to be simultaneous on the day- and night-sides within the temporal resolution of data (10s). With the magnetometer data, we confirmed instantaneous transmission of the electric field from high latitude. The latitude dependence of the electric field intensity and the evening anomaly/enhancement remain to be clarified with the HF Doppler sounder observations over the globe.