Generation and Propagation of Penetration Electric Fields to the Low Latitude Ionosphere During Substorm and Storms

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The solar wind energy is transmitted to low latitude ionosphere in a current circuit from a dynamo in the magnetosphere to the equatorial ionosphere via the polar ionosphere. During the substorm growth phase and storm main phase, the dawn-to-dusk convection electric field is intensified by the southward interplanetary magnetic field, driving the ionospheric DP2 currents composed of two-cell Hall current vortices in high latitudes and Pedersen currents amplified at the dayside equator (EEJ). The EEJ-Region-1 field-aligned current (R1 FAC) circuit is completed via the Pedersen currents in midlatitude. On the other hand, the shielding electric field and the Region-2 FACs develop in the inner magnetosphere, tending to cancel the convection electric field at the mid-equatorial latitudes. The shielding often causes overshielding when the convection electric field reduces substantially and the EEJ is overcome by the counter-electrojet (CEJ), leading to that even the quasi-periodic DP2 fluctuations are contributed by the overshielding. The overshielding develop significantly during substorms and storms, leading to that the mid and low latitude ionosphere is under strong influence of the overshielding as well as the convection electric fields. The electric fields on the day- and night-sides are in opposite direction to each other, but the electric fields in the evening are anomalously enhanced in the same direction as in the day. The evening anomaly is a unique feature of the electric potential distribution in the global ionosphere. DP2-type electric field and currents develop during the transient/short-term geomagnetic disturbances like the geomagnetic sudden commencements (SC), which appear simultaneously at high latitude and equator within the temporal resolution of 10 sec. Using the SC, we can confirm that the electric potential and currents are transmitted near-instantaneously to low latitude on both day- and night-sides, which is explained by means of the TM_0mode waves in the Earth-ionosphere waveguide.