Penetration of the convection and overshielding electric fields to low latitude during quasi-periodic DP2 fluctuations

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It seems established that the convection electric field penetrates to the equator with no significant shielding during the DP2 fluctuation event with periods 30-60 min (Nishida, 1968) and even during the storm main phase continuing over several hours (Huang et al., 2007). On the other hand, shielding became effective in 17 - 20 min during the substorm growth phase (Somajajulu et al., 1987; Kikuchi et al., 2000). To demonstrate that the shielding/overshielding electric field exists at the equator even for the short duration event, we analyzed equatorial DP2 fluctuations of 30 min period caused by fluctuating IMF Bz, together with the convection map in the polar ionosphere and electric potentials of the R1 and R2 field-aligned currents calculated by the comprehensive ring current model (CRCM). It is found that the DP2 magnetic fluctuations at the equator were caused by alternating eastward and westward electrojets in association with the southward and northward IMF, respectively. SuperDARN convection map consisted of large-scale two-cell convection vortices associated with the R1 FACs during the period of the eastward equatorial electrojet, while the two-cell convection pattern was greatly distorted with a reversed vortex at the equatorward side during the period of the westward electrojet. The CRCM with the fluctuating IMF as an input provided an electric potential pattern dominated by the R2 FACs for the period of the westward electrojet. The observations and simulation results suggest that the overshielding electric field dominated even for the short-period (30 min) DP2 fluctuation events, when the R1 FACs decreased because of the northward turning of the IMF. The shielding electric field grows/decays following the growing/decaying convection electric field with time lag of some tens of min. Therefore, the overshielding electric field appears at the equator, whenever the convection electric field decreases irrespective of the period of the fluctuations. This scenario well explains the continuous penetration of the main phase electric field (Huang et al., 2005) and overshielding electric field during early recovery phase of the storm (Kikuchi et al., 2008).