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Global ionospheric currents driven by Region-2 field-aligned currents during substorms

Kumiko Hashimoto[1*], Takashi Kikuchi[2], Tsutomu Nagatsuma[3]

[1]Kyushu University of Health and Welfare, [2]Nagoya University STEL, [3]NICT

The dawn-to-dusk convection electric field increases during the growth phase of substorms, driving DP2 currents composed of two-cell current vortices in high latitude and leading to an increase in the eastward electrojet (EEJ) at the dayside dip equator. During the expansion phase, electric field and currents are reversed in direction to the normal DP2 currents at subauroral to equatorial latitudes when the convection electric field reduces abruptly. The reversed current at the dayside dip equator appears as a counterelectrojet (CEJ) and causes an equatorial enhancement of the negative bay in the afternoon sector [Kikuchi et al., 2000]. In this study, by using magnetometer array data and SuperDARN (Super Dual Auroral Radar Network) convection maps, we deduce that the reversed electric field and currents often develop at the onset of substorms when the convection electric field increases and the auroral electrojet (AEJ) continues to move equatorward. These observations imply that the Region-1 and Region-2 field aligned currents (R1 and R2 FACs) increase in the afternoon sector concurrently with the current wedge responsible for the positive bay at midnight. The substorm-associated R2 FACs are strong enough to cause the reversed current at the subauroral latitude and the CEJ at the equator. We also deduce that the dayside equatorial CEJ begins simultaneously with the midnight positive bay while the positive bay onset is delayed by several minutes as the station departs from the midnight meridian. These observations suggest that the unloading process begins in the near-Earth magnetotail with the intensification of the asymmetric ring current that is responsible for the equatorial CEJ and R2 FACs on the dayside.

Keywords: substorm, Region-2 field-aligned current, Overshielding electric field, equatorial counter electrojet, substorm current