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A statistical study of auroral upward field-aligned current using THEMIS electron data

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Using plasma sheet electron density and temperature obtained from the electrostatic analyzer (ESA) onboard the THEMIS-D satellite from Nov. 2007 to Jan. 2010, we have statistically investigated thermal current and conductivity to find where and when the field-aligned potential difference is formed. The thermal current (j_{th}) represents the field-aligned current carried by magnetospheric electrons without field-aligned potential difference, and can be estimated from the field-aligned current ($j_{||}$) which was introduced by Knight (Planet. Space Sci., 1973). The Knight relation for the field-aligned current assumes a Maxwellian distribution of magnetospheric electrons in the plasma sheet, while the THEMIS electron data do not show a single Maxwellian. Therefore, we have also examined thermal current by integrating the downward electron flux without the Maxwellian assumption. Through a comparison of the thermal current with the typical auroral current, which is shown by Iijima and Potemra (JGR, 1976), we can roughly estimate the magnitude of the field-aligned potential difference. We found that in the dawn side inner magnetosphere (source of the region 2 upward field-aligned current), both of the thermal currents with/without the Maxwellian assumption are comparable to or higher than the typical auroral current, particularly during active time (AE $>$ 100 nT). On the other hand, in the dusk side outer magnetosphere (source of the region 1 upward field-aligned current), both thermal currents are smaller than or comparable to the typical auroral current. It means that the potential difference may be necessary in the dusk region 1 current. In case of the field-aligned potential difference is formed, the field-aligned current is on the relation $j_{||}=KV_{||}$, where K is the conductivity that represents the efficiency of the upward field-aligned current. This relation was shown by Lyons (JGR, 1980). From the relation between the typical auroral current and the conductivity estimated by our study with Maxwellian assumption, we conclude that 1-10 kV of the filed-aligned potential difference is necessary on the dusk side region 1 upward field-aligned current.

Keywords: Field-Aligned Current, Plasma Sheet, Field-Aligned Potential Difference