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Single and multi-spacecraft analysis of the electric field at the dipolarization front

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Using Cluster data, we investigate the electric structure of a dipolarization front (DF) – the ion inertial length scale boundary in the Earth's magnetotail formed at the front edge of an earthward propagating flow with reconnected magnetic flux. We estimate the current density and the electron pressure gradient throughout the DF by both single-spacecraft and multi-spacecraft methods. Comparison of the results from the two methods shows that the single-spacecraft analysis, which is capable of resolving the detailed structure of the boundary, can be applied for the DF we study. Based on this, we use the current density and the electron pressure gradient from the single-spacecraft method to investigate which terms in the generalized Ohm's law balance the electric field throughout the DF. We find that there is an electric field at ion inertia scale directed normal to the DF; it has a duskward component at the dusk flank of DF but a dawnward component at the dawn flank of DF. This electric field is balanced by the Hall (j×B/ne) and electron pressure gradient terms at the DF, with the Hall term being dominant. Outside the narrow DF region, however, the electric field is balanced by the convection (Vi×B) term, meaning the frozen-in condition for ions is broken only at the DF itself. In the reference frame moving with the DF the tangential electric field is zero, indicating there is no flow of plasma across the DF and that the DF is a tangential discontinuity. The normal electric field at the DF constitutes a potential drop of $\sim$1 keV, which may reflect and accelerate the surrounding ions.