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Intense current structures observed at electron scales during dipolarization and substorm current wedge formation

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We study multiscale magnetic structures in 14 substorm-related prolonged dipolarization events in the near-Earth magnetotail by using data from the Cluster Inner Magnetosphere Campaign. The dipolarizations were associated with the arrival and braking of multiple Bursty Bulk Flows and Dipolarization Fronts (DFs). The very small separation ($\leq$ electron inertia length, λe) between Cluster-3 and Cluster-4 permits, for the first time, the observation of strong magnetic gradients at electron scales. These structures were transiently ($\leq$ 2s) observed during prolonged dipolarization growth at the leading and trailing edges of DFs. The values of magnetic gradients observed at electron scales are several dozen times larger than the corresponding values of magnetic gradients simultaneously detected at ion scales. These nonlinear features in magnetic field gradients denote the formation of intense and localized ($\sim$a few λe) current structures during the dipolarization and substorm current wedge formation. These observations highlight the importance of electron-scale processes in the formation of a 3D substorm current system.