SUBSTORM ENTROPIES

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The specific entropy ($s = p/\rho^{\gamma}$) and total entropy ($S= p^{1/\gamma}V$) of the plasma sheet during substorm are investigated with DMSP observations using a method that assumes ion isotropy (as also assumed in the derivation of $S== p^{1/\gamma}V$) and empirical magnetic field models that capture the expected characteristics of substorm phases. Earthward reductions of S are found during quasi-steady periods (e.g., growth phase) as well as during the transition from growth to expansion phases. During quasi-steady periods, (a) S and flux tube contents (N) decrease moderately at midtail, but more steeply at the inner edge of the plasma sheet; and (b) s appears roughly conserved in the X or convection direction, but closer to Earth, there is a duskward heat flux. Both (a) and (b) suggest that curvature/gradient drifts can play a significant role in the S and N losses. On the other hand, during the transition from growth to expansion phases, S is reduced by an order of magnitude earthward of 20 Re, which can be attributed mainly to the reduction in V from the dipolarization after onset. However, s is roughly conserved. This result is consistent with a mechanism that reduces the flux-tube volume/content without significantly alterings. Recent MHD/PIC simulations of magnetic reconnection indicate that s tends to be conserved except in the small dissipation region, but the change in the field-line topology for a reconnected field line can lead to a reduction in S with the remainder contained in a plasmoid that forms tailward of the X-line.

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