Statistical Properties of Tail Ion Diffusion Regions Measured with the Magnetospheric Multiscale Mission

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Abstract

We present statistical observations of eight Ion Diffusion Regions (IDRs) in the geomagnetic tail, as observed by the Magnetospheric Multiscale Mission (MMS) during the Phase 2B tail campaign (≈01 May 2017 — 30 Septermber 2017). These IDRs were identified by applying an automated algorithm which made selections based on six key parameters of reconnection diffusion regions, applied in three stages. Comparison of these key parameters within this set is provided and also compared against the average properties of IDRs described in previous literature.

Methodology

The search for Ion Diffusion Regions is taken in three stages. The first stage looks for correlated reversals in B_Z and ion V_X, occurring $\leq$90 seconds apart. The second stage looks for *i)*$|\vec{E}| \geq 10mV$ where a low-pass filter of 1Hz has been applied to $\vec{E}$ to reduce false positives due to wave activity; and *ii)*a guiding center expansion parameter $\delta_i \geq 1.0$, both coinciding with the reversal in B_Z. The third stage looks for *i)*Hall $\vec{E}$ and *ii)*$\vec{B}$ in the neighborhood of the reversal in B_Z, again taken to be within 90 seconds. To maintain consistency with previous studies, GSM coordinates have been used throughout this study.

The above algorithm is applied to data using an automated code developed in IDL in 24hr increments which return 3-minute spans which the code identifies as possible IDRs for further study. Supplementary code then generates survey plots of the identified intervals and reports basic properties to a CSV file.

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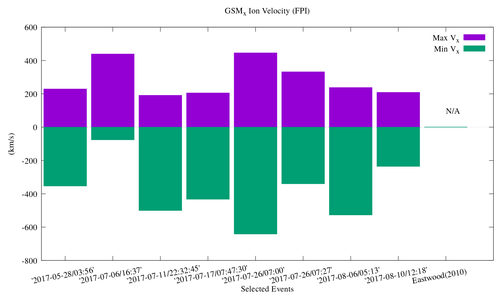
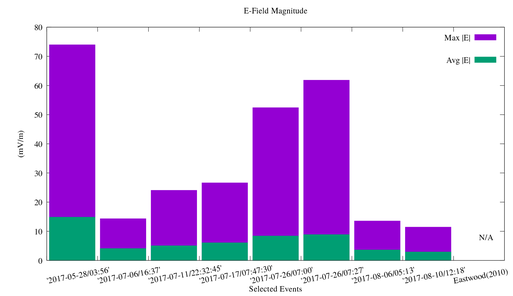
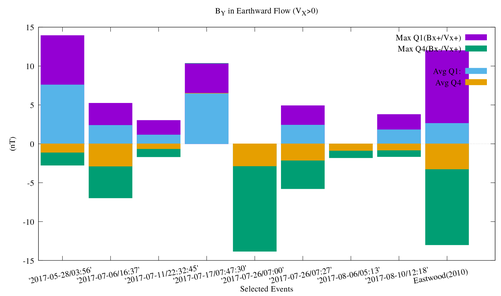
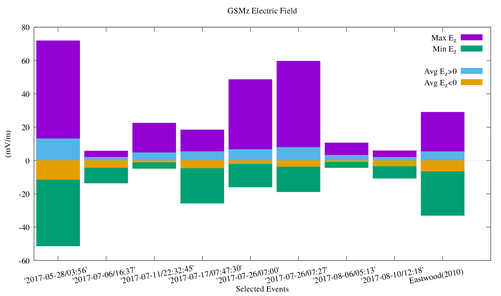
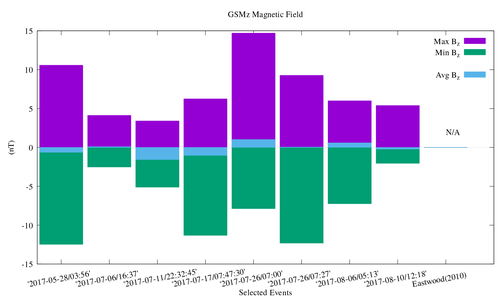
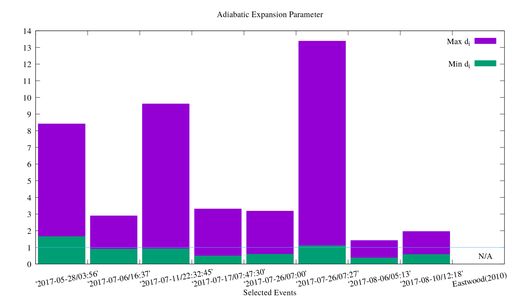


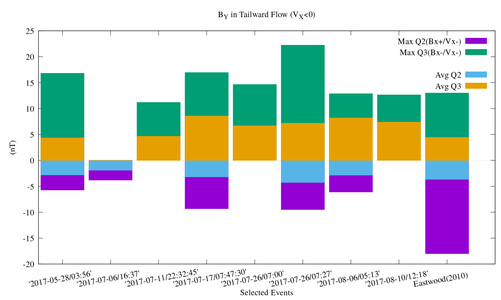


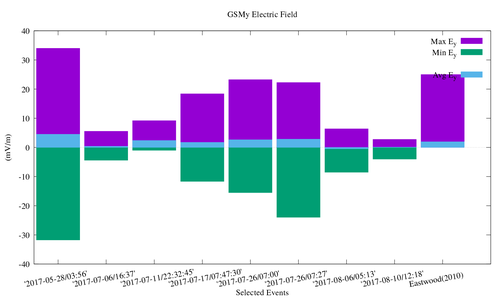




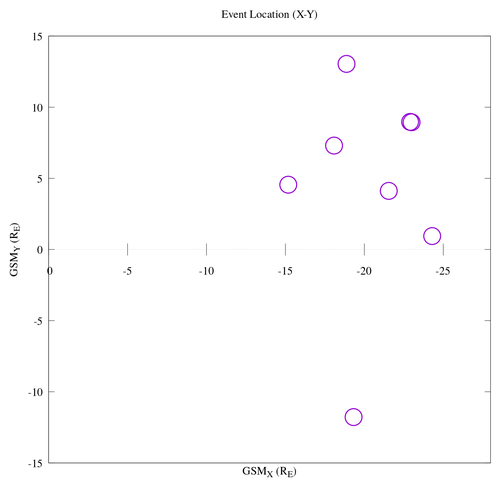




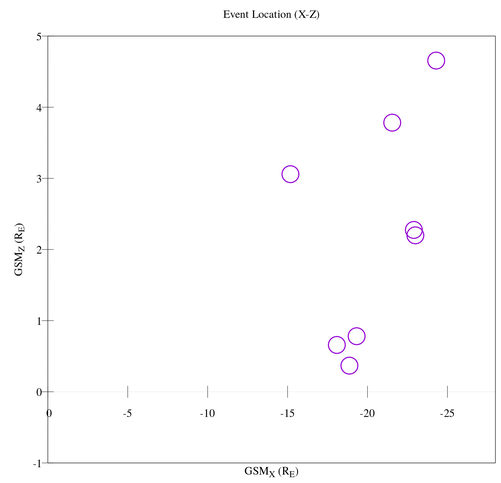




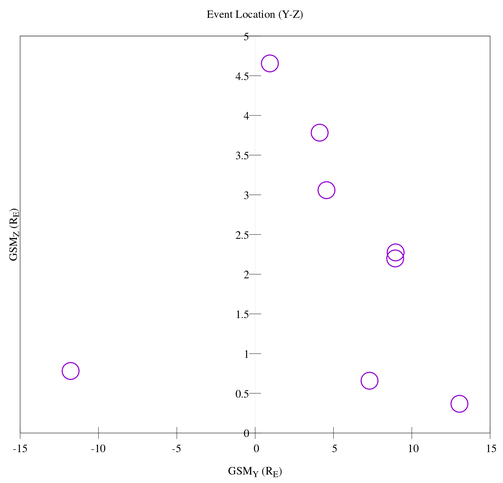
Stage 1 Criteria: *The above plots show the statistical properties of $V_{i,X}$ and B_Z components in the neighborhood around the reconnection site. Asymmetries in the offsets may indicate significant structure velocity. Similar asymmetries or a non-zero average value of B_Z may indicate a guide field in the $\hat{z}$.*



Stage 2 Criteria: *These plots show statistical properties of the electric field magnitude as well as the guiding center expansion coefficient. Minimum values of δ_i are also shown. Many good examples of reconnection display not only a high value for δ_i near the X–line, but also moderate to large values throughout the neighborhood surrounding it.*



Out-Of-Plane (Hall) Magnetic Fields: *Detection of the quadrupolar Hall magnetic field is one half of the third stage in our IDR detection algorithm. Properties of the out-of-plane magnetic field are divided into the four regions of the Hall model. Not all quadrants were observed by MMS for some events.*



Normal (Hall) and Out-Of-Plane $\vec{E}$: *Hall electric fields were determined by being sign anti-correlated with B_X while $\delta_i \geq 1$. Comparison with the measured $|\vec{E}|$ implies that the Hall $\vec{E}$ is the dominant component of the electric field near the X–line.*

Highlights

- Used automated, stepwise algorithm to identify 8 IDRs in MMS data during Phase 2B
- Statistical properties of these events compared to those observed by Cluster
- Algorithm development continues
- Investigation will continue during Phase 3D

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