

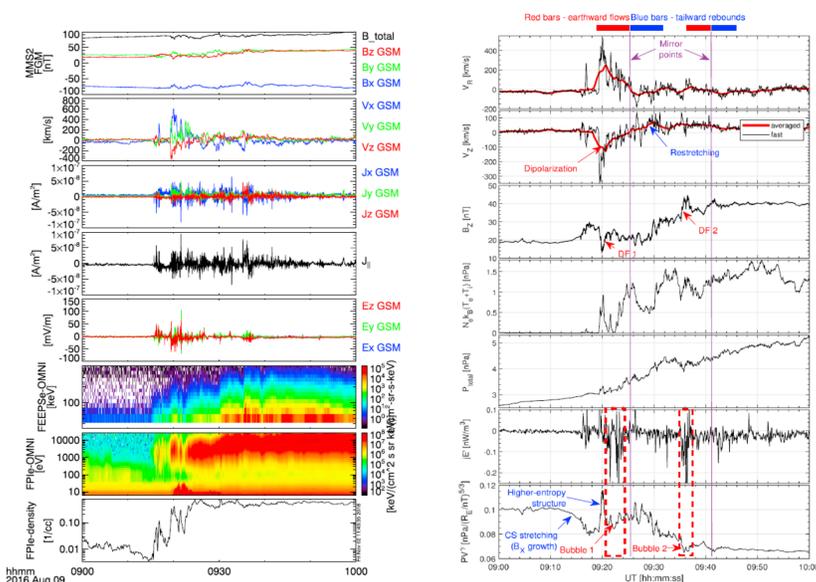
SM13D-3325 - CONTINENT-WIDE R1/R2 CURRENT SYSTEM AND OHMIC LOSSES BY BROAD DIPOLARIZATION-INJECTION FRONTS

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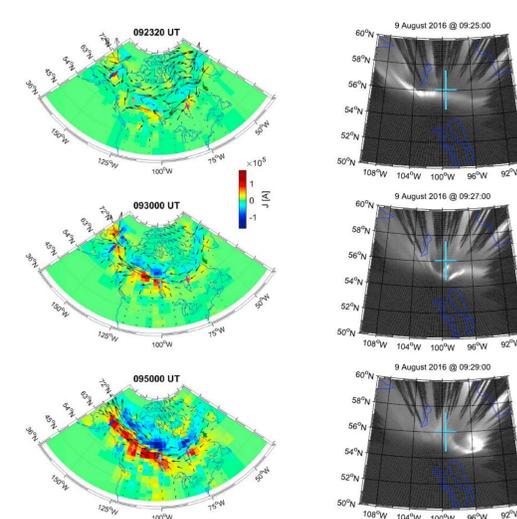
We employ Magnetospheric Multiscale, Geostationary Operational Environmental and Los Alamos National Laboratory satellites, as well as the ground magnetometer networks over Greenland and North America to study a substorm on 9 August 2016 between 9 and 10 UT. We found that during the substorm two earthward flows, whose dipolarization-injection fronts exceeded 6.5 and 4 Earth's radii (R_E) in Y_{GSM} , impinged and rebounded from Earth's dipolar field lines at $L = 6-7$ downtail, where L is the McIlwain number. The impingements and rebounds ended with a substorm current system of downward R1 and upward R2 currents, which grew to azimuthally cover the whole North American continent. At the fronts, regions of enhanced negative $\mathbf{j} \cdot \mathbf{E}$ were formed and peaked toward the end of the impingements. These regions appeared to be conjugate with eastward moving aurora (along the growth phase arc and together with eastward drifting energetic electrons at geosynchronous equatorial orbit), which manifests ionospheric Ohmic losses.

Earthward Flows and Tailward Rebounds



- ✓ Both dipolarization-injection fronts rebounded from the Earth's dipolar field lines
- ✓ The fronts exhibited signatures of bubbles (flux tubes with lower entropy) and were associated with negative $\mathbf{j} \cdot \mathbf{E}$ (generator)

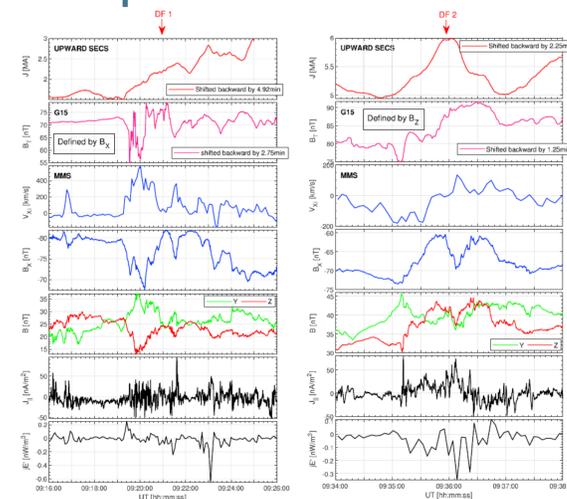
Ionospheric Substorm Current System



- ✓ Ionospheric downward R1 and upward R2 currents grew significantly in the course of the substorm
- ✓ Auroral arc that was observed near the GOES-14 footprint around the time of the first DI front's passing by the probe

Plasma Sheet-Ionosphere Current Circuit

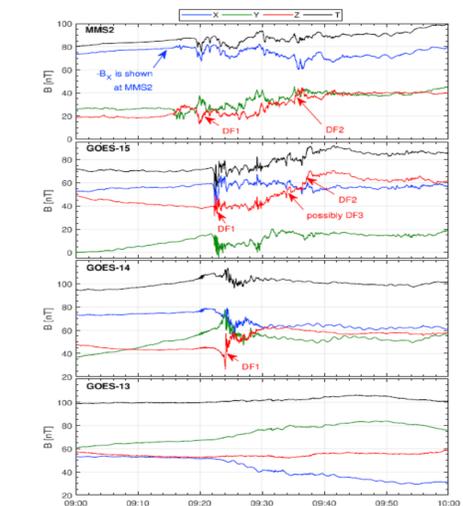
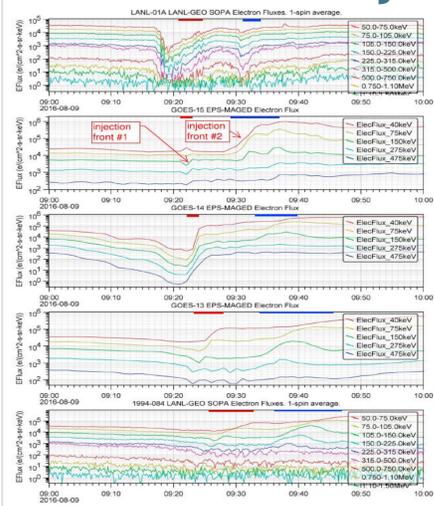
- ✓ The R1/R2 currents were initiated by the first DI front.
- ✓ The R1/R2 currents were contributed by the second DI front causing a significant local current disturbance.
- ✓ At the fronts, negative $\mathbf{j} \cdot \mathbf{E}$ indicated negative energy dissipation - consistent with the Joule heating in the ionosphere.



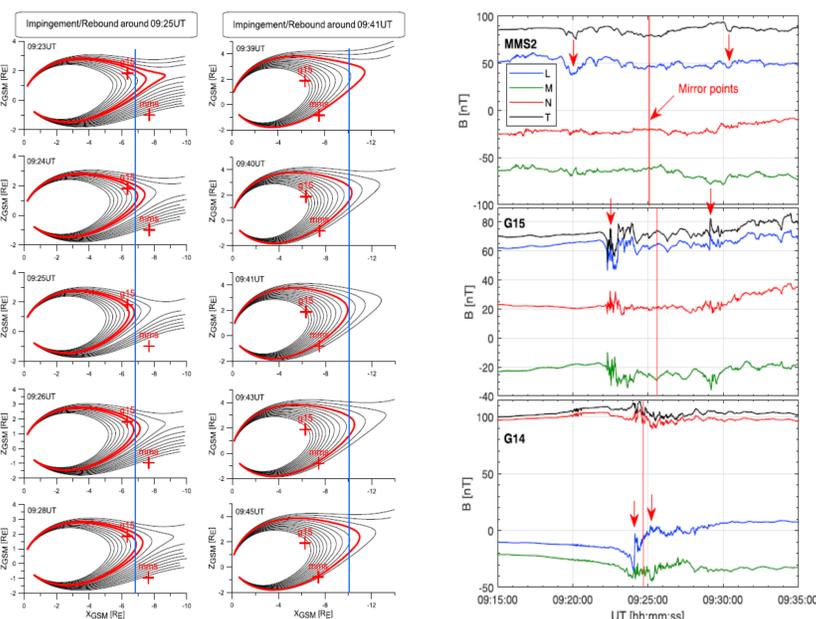
Key Points:

- Two broad (6.5 and 4 R_E in Y_{GSM}) dipolarization-injection fronts impinged and rebounded from Earth's dipolar field lines near GEO during the same substorm
- Downward R1 and upward R2 currents grew to azimuthally cover the whole North American continent in the course of the substorm
- Regions of negative $\mathbf{j} \cdot \mathbf{E}$ (generator) peaked toward the end of the impingements and were conjugate to R2 auroral current (load)

Two Injections at GEO



- ✓ Two broad (6.5 and 4 R_E in Y_{GSM}) dipolarization-injection fronts were observed by GOES and LANL in the course of a significant substorm



- ✓ The rebounds were seen in the field line reconstruction using the AM03 model
- ✓ MMS and GOES-15 and -14 probes observed remnants of the dipolarization-injection fronts during rebounds

