While geomagnetic storms can be driven by interplanetary coronal mass ejections (ICMEs) and high speed streams (HSSs), the magnetospheric response varies depending on the driver. For example, electron and ion temperatures measured at geosynchronous orbit increase during both types of storms, but the temperature increase is much larger during HSS-driven storms [Denton et al., 2006]. For HSS-driven storms, ion temperatures measured at geosynchronous orbit increase sharply at the time of convection onset and remain elevated for the duration of the HSS-driven event [Denton and Borovsky, 2008]. These hot ions are convected to the inner magnetosphere where they can drive the ring current. Global ion temperature maps can be created using TWINS ENA measurements to study where ion heating occurs and how these hot ions move throughout the magnetosphere during storms.

TWINS Measurements and Ion Temperature Calculation

The measured ENA intensity, \( I_{ENA} \), is related to the ion intensity, \( n_{ion} \), by

\[
I_{ENA}(E) = \int n_{ion}(z^*) \sigma_{\xi}(z^*) d(\xi z^*),
\]

where \( z^* \) is along the LOS, and \( \sigma_{\xi} \) is the energy-dependent charge exchange cross-section. The integral over \( z^* \) accounts for the attenuation of ENAs due to additional collisions or ionization along the path from the origin of the ENA to the instrument. This integral is approximately zero for optically thin regions such as the plasma sheet. The contribution to the high energy portion of the spectrum (energies much greater than the ion temperature) is dominated by emission from the hottest region along the LOS [McHarg, 1987]. Thus, we approximate the integral by the peak value at location \( z^* \) of the integrated ion temperature, \( T_{z^*} \), obtained as shown in Figure 1. The integral is over the peak value at location \( z^* \) of the integrated ion temperature, \( T_{z^*} \).

We assume the hottest point along the LOS occurs near the equatorial plane. Thus, the measured ENA fluxes are mapped along the LOS to the equatorial plane. This algorithm is used because the fixed angular resolution of the instrument yields a FOV that increases as a function of distance from the Earth, if the instrument location falls outside of a modeled magnetosphere boundary [Shue et al., 1991]. The flux is calculated using the square of the LOS magnitude for each pixel. An exponential fit to the scaled measurements yields an effective ion temperature for the hottest region along the LOS.

**22 July 2009 HSS-driven Storm**

For the 22 July 2009 storm, six 48 sweep (1-3/2 hour) intervals during the main phase were studied. Hot ions first appear in the duskward region of the nightside soon after the time of convection onset (00:49 UT, using the Auroral Boundary Index). The hot ions then move toward the day side across the midnight meridian. A region of cooler temperatures on the dayside inside of geosynchronous orbit is evident throughout the main phase. These results are consistent with average ion temperatures at geosynchronous orbit from a superposed epoch analysis of HSS-driven storms by Denton and Borovsky [2009]. Early in the main phase of the storm, the hot ions were dominant in the dawnward side of the magnetosphere. Early in the main phase of the storm, these hot ions were convected Earthward. A cooling of the entire magnetosphere was observed during the 11:38 – 12:07 UT interval, then the temperatures increased again over the following hours. This is in contrast to the average behavior for HSS-driven storms described by Denton and Borovsky [2009] where the ion temperatures remain elevated for the duration of the high speed stream. The fluctuations in ion temperatures. Some features similar to the 22 July 2009 storm were observed. For example, a region of hot ions in the post-noon sector is apparent toward the end of the main phase in each storm. During this time in both storms, the pre-noon sector is populated by cooler ions.

**Discussion**

Projection to the Equatorial Plane

We assume the hottest point along the LOS occurs near the equatorial plane. Thus, the measured ENA fluxes are mapped along the LOS to the equatorial plane (GSM coordinates) that is divided into a grid of 0.5 x 0.5 bins. For each pixel in an ENA image, the intersection of the associated FOV (FOV) with the GSM coordinates is calculated. The ENA flux multiplied by the square of the LOS magnitude for that pixel is divided among the FOV bins in amounts proportional to the fractional area of the FOV that intersects each bin. This algorithm is used because the fixed angular resolution of the instrument yields a FOV that increases as a function of distance from the Earth, if the instrument location falls outside of a modeled magnetosphere boundary [Shue et al., 1991].

The measured ENA intensity, \( I_{ENA} \), is related to the ion intensity, \( n_{ion} \), by

\[
I_{ENA}(E) = \int n_{ion}(z^*) \sigma_{\xi}(z^*) d(\xi z^*),
\]

where \( z^* \) is along the LOS, and \( \sigma_{\xi} \) is the energy-dependent charge exchange cross-section. The integral over \( z^* \) accounts for the attenuation of ENAs due to additional collisions or ionization along the path from the origin of the ENA to the instrument. This integral is approximately zero for optically thin regions such as the plasma sheet. The contribution to the high energy portion of the spectrum (energies much greater than the ion temperature) is dominated by emission from the hottest region along the LOS [McHarg, 1987]. Thus, we approximate the integral by the peak value at location \( z^* \) of the integrated ion temperature, \( T_{z^*} \), obtained as shown in Figure 1. The integral is over the peak value at location \( z^* \) of the integrated ion temperature, \( T_{z^*} \).

For the 2 May 2010 storm, twelve 24 sweep (~1/2 hour) intervals during the main phase were studied. During this storm, the hot ions were dominant in the dawnward side of the magnetosphere. Early in the main phase of the storm, these hot ions were convected Earthward. A cooling of the entire magnetosphere was observed during the 11:38 – 12:07 UT interval, then the temperatures increased again over the following hours. This is in contrast to the average behavior for HSS-driven storms described by Denton and Borovsky [2009] where the ion temperatures remain elevated for the duration of the high speed stream. The fluctuations in ion temperatures. Some features similar to the 22 July 2009 storm were observed. For example, a region of hot ions in the post-noon sector is apparent toward the end of the main phase in each storm. During this time in both storms, the pre-noon sector is populated by cooler ions.