Comparison of Enhancement in Energetic Neutral Atoms and Aurora All Sky Images

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Introduction

- Magnetosphere-Ionosphere Coupling is an integral part of earth's space environment, and understanding the interacting system is of great importance.
- One of the physical phenomena of the coupling is the formation of aurora. The correlation between Ion enhancement and aurora brightening is being examined, to get a better understanding aurora formation.
- Below is an example of ion temperature and aurora map, where regions of ion enhancement can be correlated with aurora brightening.
- In an effort to better understand the relationship between ion enhancement and aurora brightening, correlation between particle dynamics from the Van Allen Probes and ion temperature increase in localized spatial and temporal regions in the magnetotail are examined, during both storm time sub-storm time events.

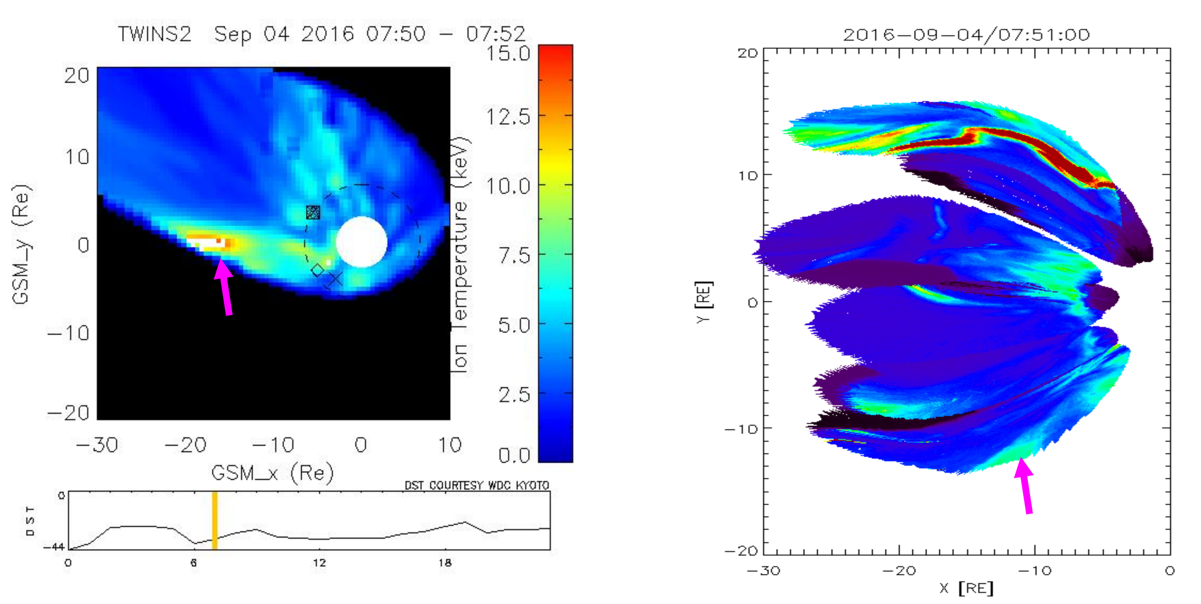


Fig 1: The two plots show a correlation between Ion enhancement and aurora brightening. With the square dots on the ion temperature map indicating locations of the Van Allen Probes(VAP), and the dashed circle showing geosynchronous orbit

Methodology

- Energetic Neutral Atoms (ENA) are formed by a charge exchange collision with neutral atoms in the exosphere, thereby becoming neutral and non interactive with the magnetic field.
- Using ENA and the equation below, a map of the ion temperature of the magnetotail can be generated.

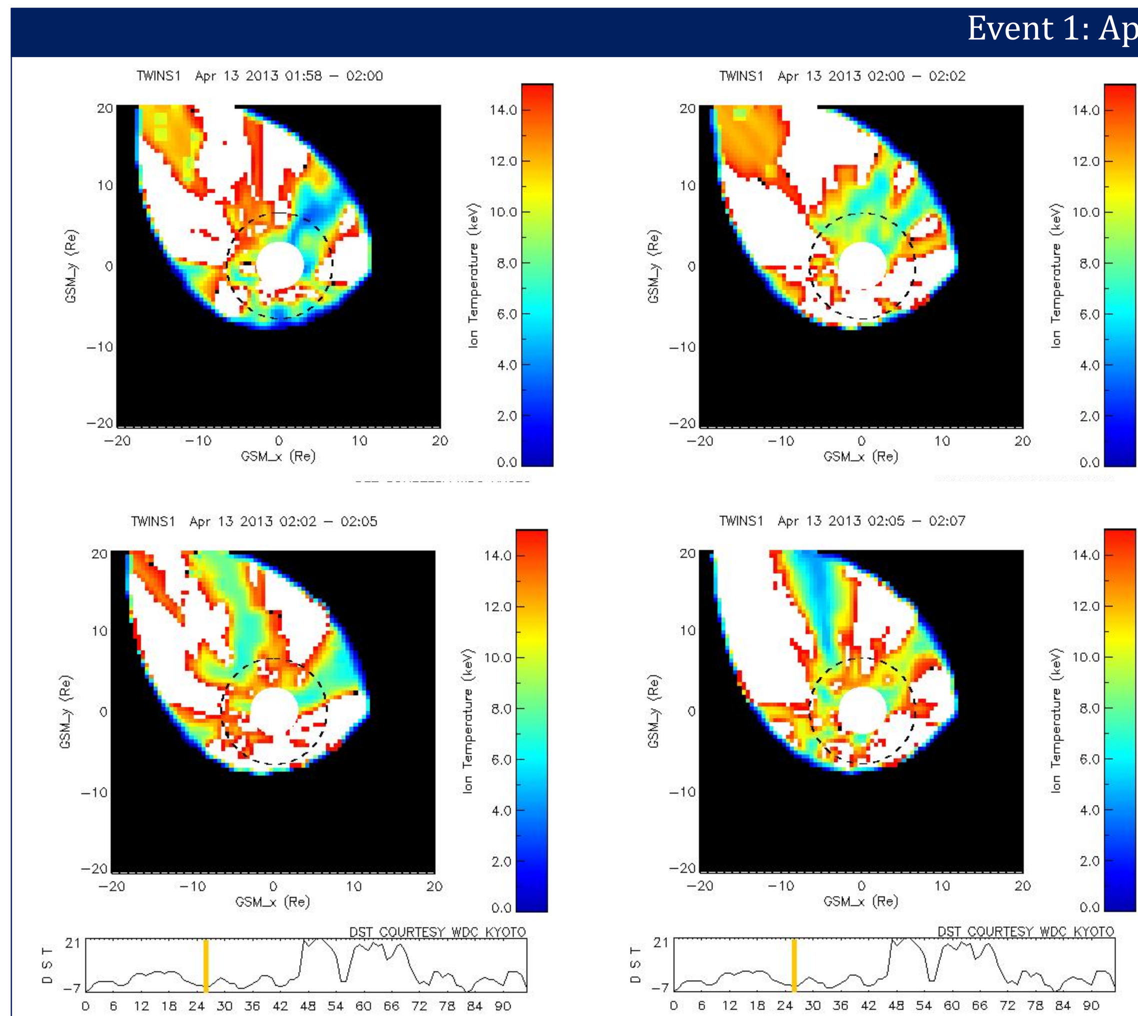
$$j_{ENA}(E,\vec{u}) = \sigma_{cx}(E)\int (n_n(z) j_{ion}(z,E) \exp[-\int \alpha(l)dl]\, dz$$

- This can be simplified further assuming a j_{ion} follows a Maxwellian distribution, to get:

$$\frac{j_{ENA}}{\sigma_{cx}(E)E} \approx \frac{\xi n_n(z^*) n_i(z^*)}{\sqrt{2m_i}(\pi T_i(z^*))^{\frac{3}{2}}} \exp\left(-\frac{E}{T_i(z^*)}\right)$$

- The ENA flux is mapped along the line-of-sight to an equatorial plane grid, then this equation is used to produce a temperature map.
- The temperature map is correlated with Ion plots for events where the Two Wide-Angle Imaging Neutral-atom Spectrometer (TWINS) and the Van Allen Probes (VAP) spacecraft overlap.

Event 1: April 13, 2013 (Sub-storm)



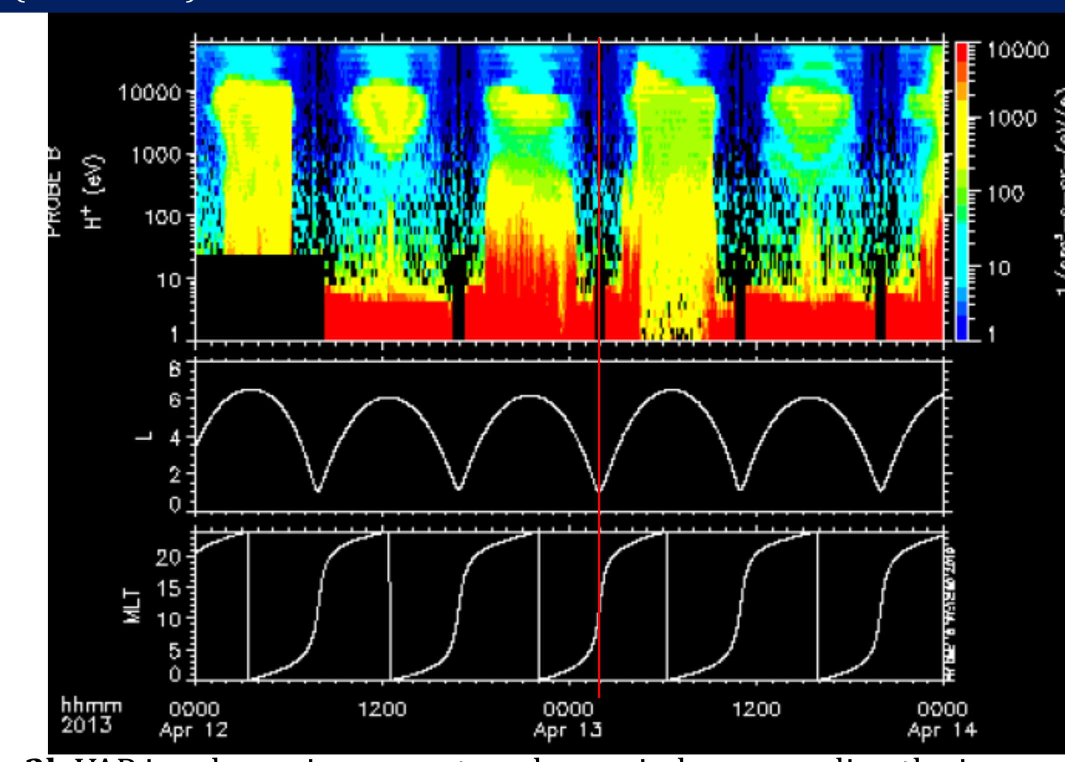
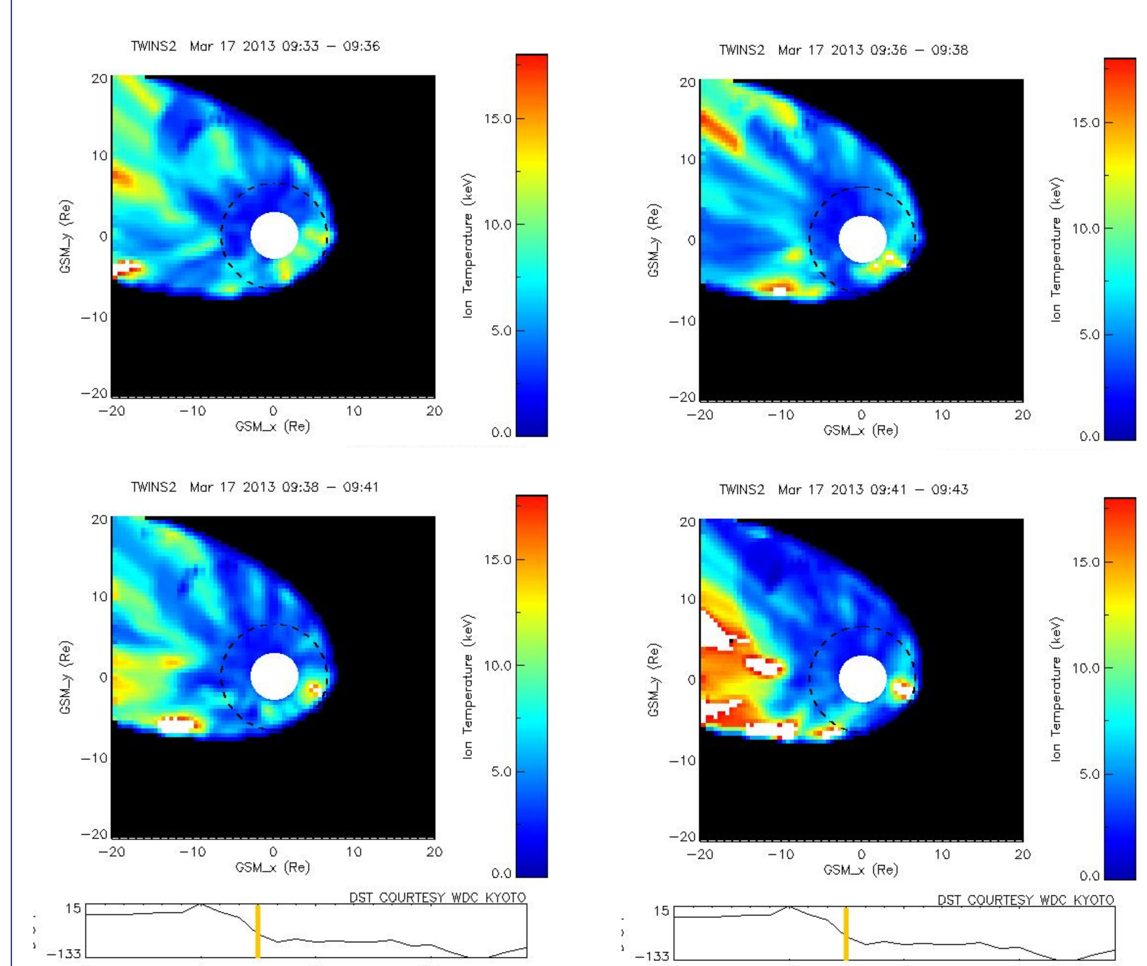


Fig 2b VAP ion dynamics over a two day period, surrounding the ion temperature increase. There is some movement of the proton ions to a lower L value. The red vertical line indicates the approximate time of the TWINS intervals from Fig 2a.

Fig 2a: TWINS 1 Ion Temperature map from 1:58am to 2:07 am, with a time interval of approximately 3 minutes

Event 2: March 17, 2013 (Storm)



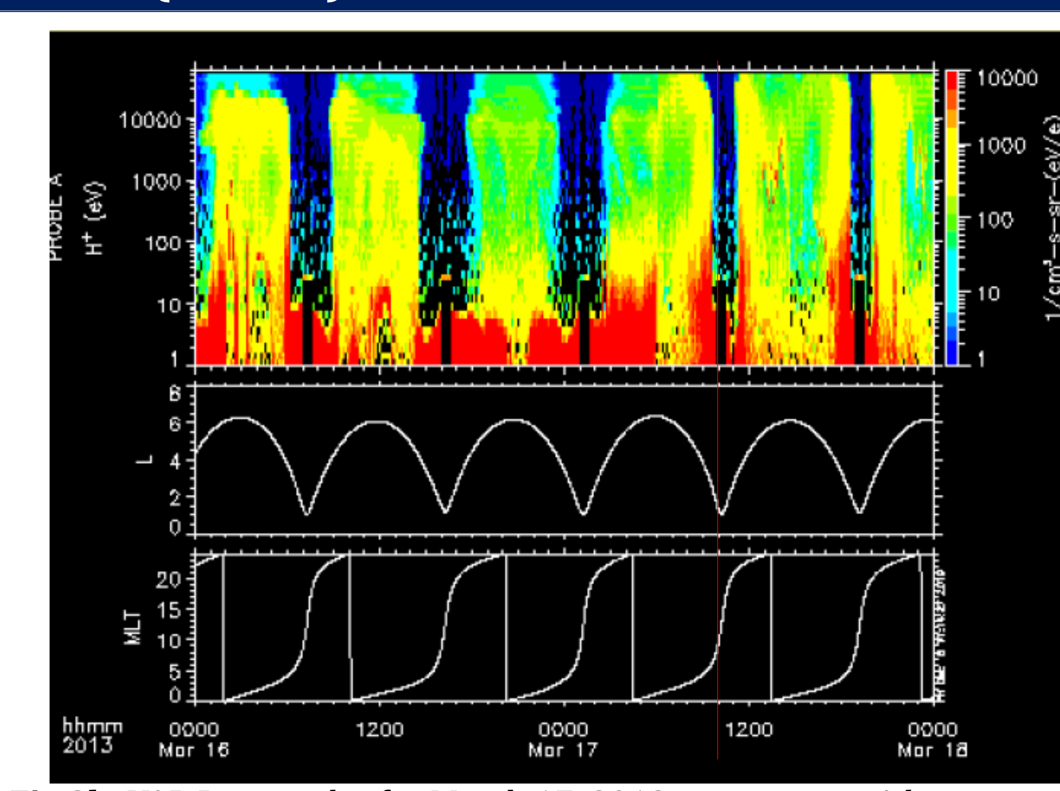


Fig 3b: VAP Proton plot for March 17, 2013 storm event. A better correlation between Ion temperature increase and ion dynamics can be seen.

Fig 3a: TWINS 2 Ion Temperature map from 9:33am to 9:43am, with a time interval of approximately 3 minutes

Event 3: March 17, 2015 (Storm)

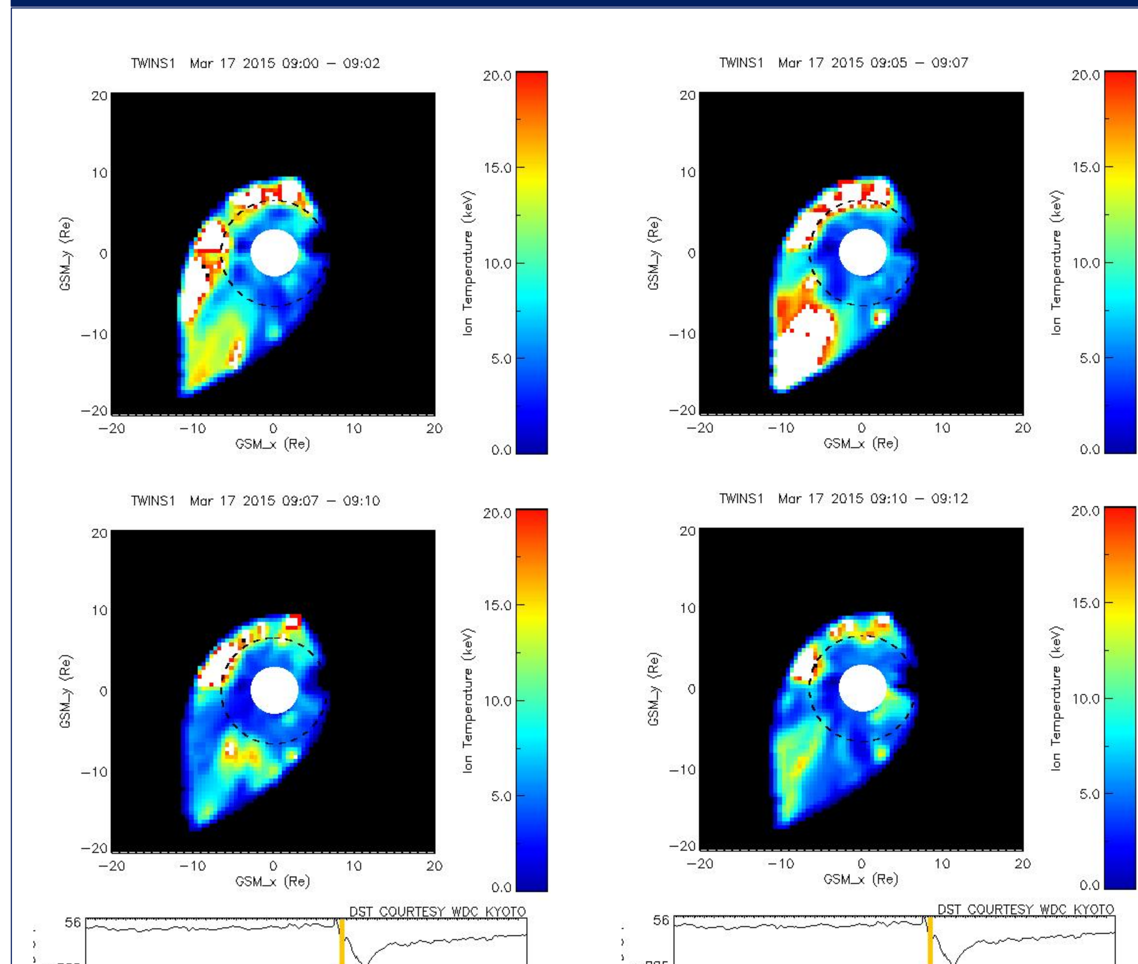


Fig 4a: Ion temperature map of the March 17, 2015 storm time events. Going from 9:00 am to 9:12 am, with a time interval of approximately 3 minutes

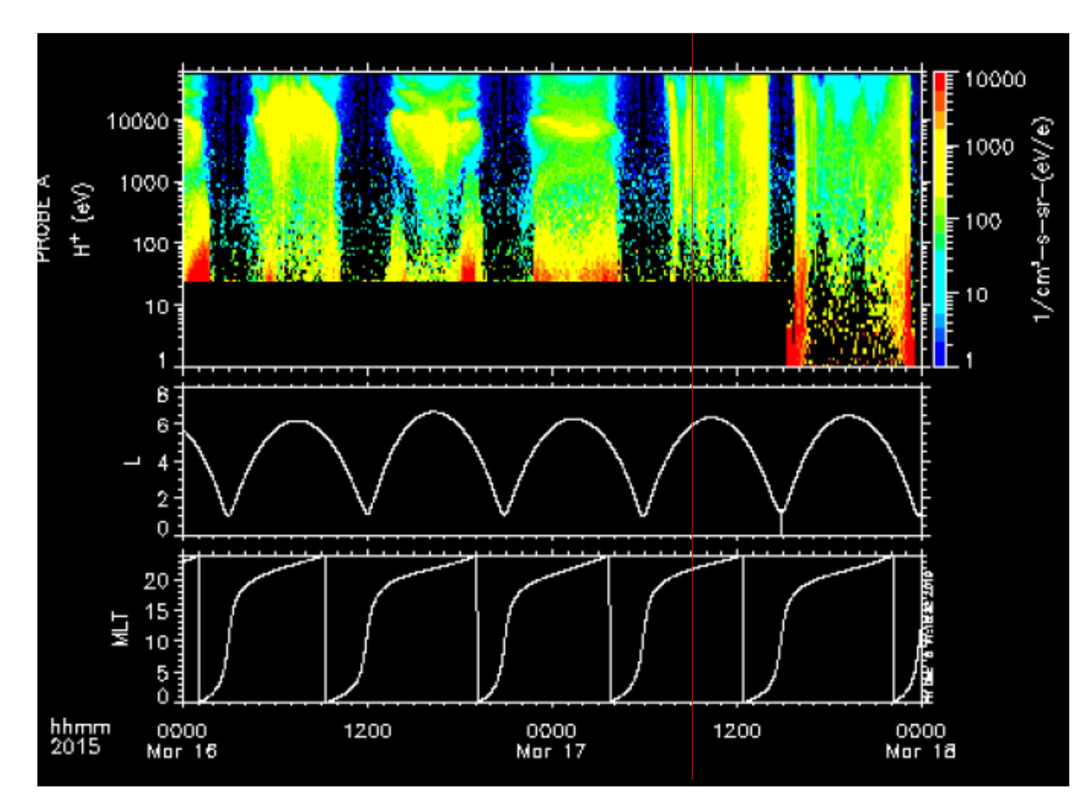


Fig 4b: VAP Proton plot for March 17, 2015 storm event. Similar to the March 17, 2013 storm time event, a better correlation between ion dynamics and temperature increase can be seen from the plot, where the ion density shifted to the lower L values after the temperature increase.

Data

- TWINS ENA data was used in the production of the ion temperature map.
- Van Allen Probe (VAP) Helium, Oxygen, Proton, and Electron (HOPE) mass spectrometer data is used to identify dynamics.
- The Time History of Events and Macroscale Interactions during Substorm (THEMIS), All Sky Imager (ASI) data was used in the generation of the Aurora map.

Results

- Ions density shifted significantly from high L shell values to lower L shells after ion temperature increase, during storm time events.
- Minimal decrease in L shell values of the ion densities during sub-storms.
- There seem to be a correlation between ion dynamics and temperature increase during storm time events, but not so much in sub-storms in the magnetotail.

Conclusions

- The correlation between ion temperature increase and ion dynamics in the magnetotail was examined.
- The ion temperature and ion dynamics seem to be more correlated during storm time events, and less so, during sub-storm events.
- Further course of action includes an alternate Ion temperature map, based on a magnetic field mapping. Improved spatial mapping may help in comparing the Ion temperature enhancements and inner magnetosphere ion dynamics, and understand the underlying physics behind Aurora formation

Acknowledgements

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