Comparing Tail Dynamics Using TWINS and THEMIS

Joel Tibbetts[1, 2], Amy M. Keesee[1, 2], Roxanne Katus[3], Christine Gabrielse[4], Jiang Liu[5], Xu Zhang[5], Anusree Devanandan[1, 2]

[1]*Institute for the Study of Earth, Oceans and Space, University of New Hampshire,* [2]*Department of Physics and Astronomy, University of New Hampshire*

[3]*Department of Mathematics, Eastern Michigan University*

[4]*The Aerospace Corporation*

[5]*University of California, Los Angeles*

SM42E-2215

AGU Fall Meeting 2022

CENTER FOR GEOSPACE STORMS

TWINS-THEMIS Comparison Intervals

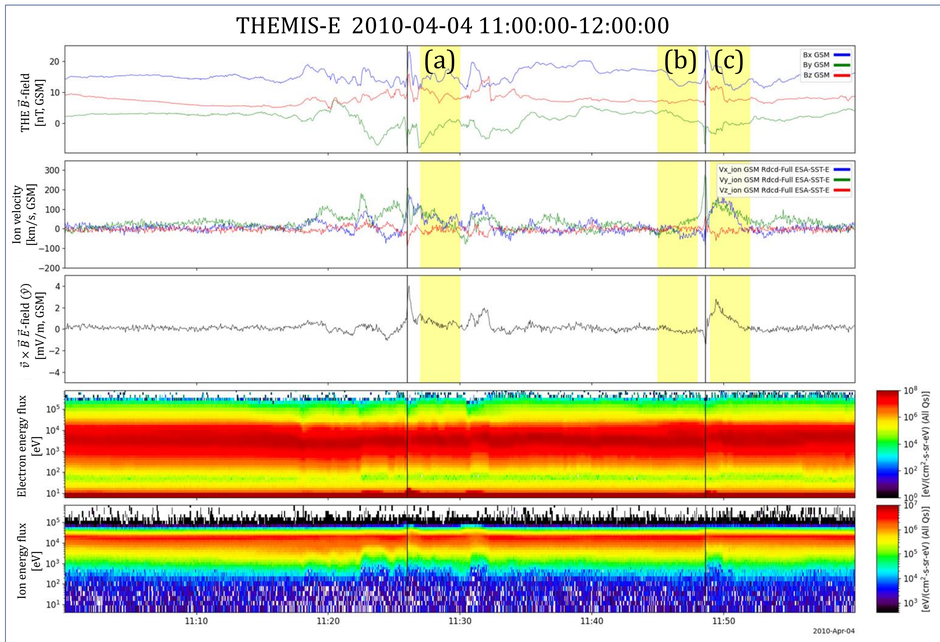
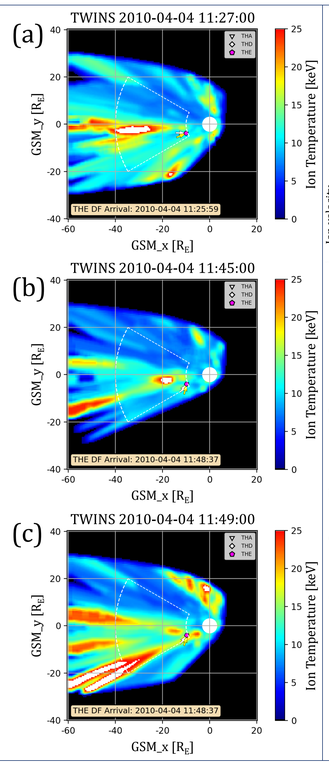
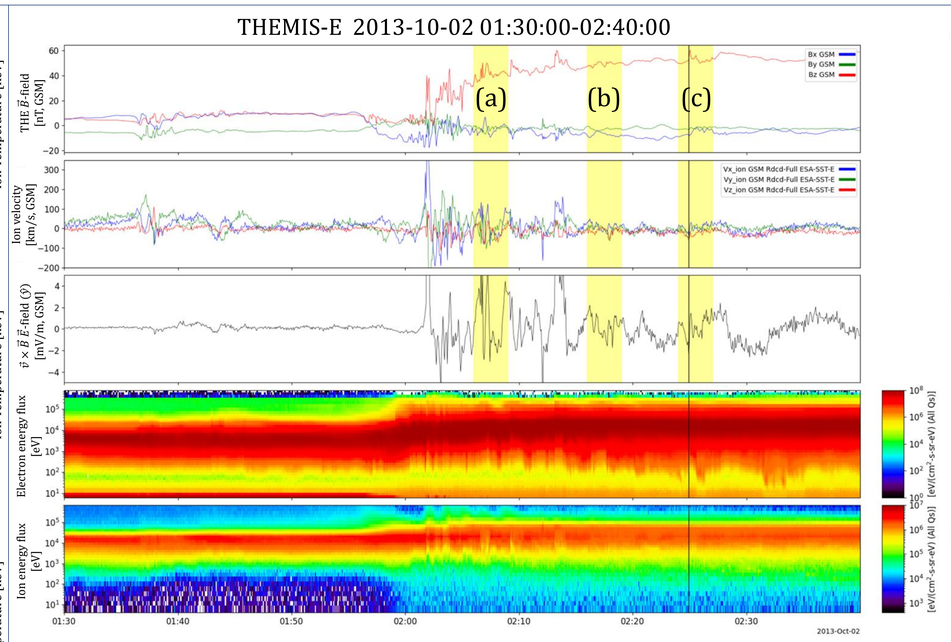


Figure 1. THEMIS-E data taken on 04 April 2010 between 11:00 – 12:00 UT. Vertical lines at 11:25:59 and 11:48:37 indicate the arrivals of dipolarization fronts (DFs) detected by THEMIS. Highlighted intervals (a-c) correspond to 3-minute ion temperature maps from TWINS (right), showing regions of ion energization near THE around the DF arrival times.





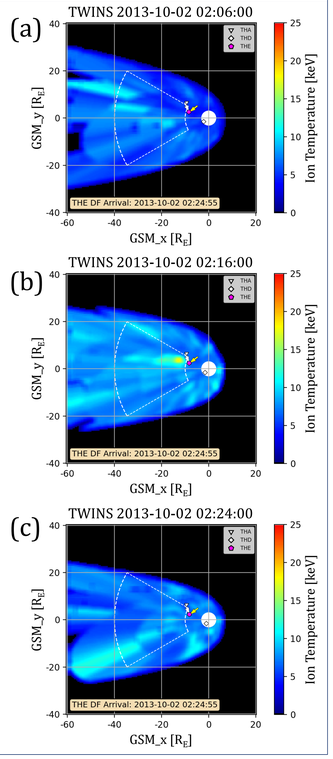


Figure 2. THEMIS-E data taken on 02 October 2013 between 01:30 – 02:40 UT. Vertical line at 02:24:55 indicates the arrival of a DF detected by THEMIS. Highlighted intervals (a-c) correspond to 3-minute ion temperature maps from TWINS (right). Note the lack of ion energization in the TWINS maps around the DF arrival (c) and larger dipolarization (a, b).

Introduction

- Mesoscale magnetotail dynamics are a critical element of understanding and predicting what occurs in the magnetosphere during geomagnetic storms and substorms.
- Ion temperature maps calculated from the Two Wide-Angle Imaging Neutral-Atom Spectrometers (TWINS) Energetic Neutral Atom (ENA) imagers were created for storms that occurred 2009-2017 in the database described by Keesee et al., 2020.
- An algorithm developed by Dr. Katus and Dr. Keesee allows for automated detection of flow channels based on associated ion heating by analyzing a region between 10-40 R_E in the magnetotail in ion temperature maps created from TWINS ENA data.
- This algorithm was used to identify intervals with significant ion heating in 3-minute TWINS data and validated against a list of known dipolarizing flux bundles (DFBs) recorded by THEMIS (Liu et al., 2013, Zhang et al., 2019). This process is detailed in Keesee et al., 2022.
- Here, we present a comparison of TWINS ion temperature maps to in situ THEMIS data around times of DFB detections from THEMIS, with the goal of investigating temporal and spatial differences in observations of these structures.

Results and Discussion

- The figures above show two case studies of THEMIS-E data alongside TWINS ion temperature maps generated during intervals from the DFB event list of Liu et al., 2013 and Zhang et al., 2019.
- TWINS maps show x-y locations of the THEMIS spacecraft associated with dipolarization fronts (DFs) marked in magenta, with white and yellow arrows indicating directions of front normal and front velocity vectors, respectively.
- Results of this study thus far have produced numerous examples of strong agreement between TWINS and THEMIS in detections of tail activity, with most instances of DFB signatures from THEMIS (based on B_z) being accompanied by ion energization in TWINS data in the minutes leading up to/following an event (see **Figure 1**).
- These regions of ion energization are often found close to the location of THEMIS.
- Other intervals, such as the one shown in **Figure 2**, do not show signs of significant ion energization in TWINS maps close to the time of DF arrivals in THEMIS data.
- Intervals with these discrepancies in timing suggest new questions regarding TWINS measurements.
- These “cold” intervals may be explained by an excess of oxygen neutrals increasing the flux in the lowest energy bins of the TWINS ENA spectra.

Future Work

- Verifying the accuracy of the TWINS measurements will involve a statistical study of error sources from the TWINS ENA instrument along with a simulation-based analysis of the instrument.
- Future studies will include analysis of intervals with ion diffusion regions (IDRs) identified in MMS data by Rogers et al. in the “IDR alphabet” list (2019, JGR), looking for conjunctions between MMS IDRs, TWINS, and dipolarization/injection signatures in RBSP data.
- We also hope to compare TWINS ENA data to both simulations and other sources of in situ measurements to determine for which intervals oxygen may be contributing to unexpectedly “cold” temperature maps.

Acknowledgements

Funded by NASA Awards 80NSSC19K0755; 80NSSC20K0701; 80NSSC22K0802.
We acknowledge the substorm timing list identified by the SOPHIE technique (Forsyth et al., 2015), the SMU & SML indices (Newell and Gjerloev, 2011); and the SuperMAG collaboration (Gjerloev et al. 2012).
We acknowledge Jiang Liu for the THEMIS DFB list.
Solar wind, IMF, and geomagnetic indices were obtained from OMNIWeb (omniweb.gsfc.nasa.gov).
This work is supported by the NASA DRIVE Science Center for Geospace Storms (CGS) under Cooperative Agreement 80NSSC22M0163.

References

- Keesee, A. M., Katus, R., Tibbetts, J., Liu, J., Zhang, X., & Sorathia, K. A. (2022). Automated detection algorithm for mesoscale heated regions in TWINS ion temperature maps. *Journal of Geophysical Research: Space Physics*, 127, e2022JA030464. https://doi.org/10.1029/2022JA030464
- Keesee, A., et al. (2014), Regions of ion energization observed during the Galaxy-15 substorm with TWINS, J. Geophys. Res. Space Physics, 119, 8274–8287, doi:10.1002/2014JA020466.
- Forsyth, C., Rae, I. J., Coxon, J. C., Freeman, M. P., Jackman, C. M., Gjerloev, J., & Fazakerley, A. N. (2015). A new technique for determining Substorm Onsets and Phases from Indices of the Electrojet (SOPHIE). Journal of Geophysical Research: Space Physics, 120, 10,592–10,606. https://doi.org/10.1002/2015JA021343
- Gjerloev, J. W. (2012), The SuperMAG data processing technique, J. Geophys. Res., 117, A09213, doi:10.1029/2012JA017683.
- Liu, J., Angelopoulos, V., Runov, A., and Zhou, X.-Z. (2013), On the current sheets surrounding dipolarizing flux bundles in the magnetotail: The case for wedgelets, J. Geophys. Res. Space Physics, 118, 2000– 2020, doi: 10.1002/jgra.50092.
- Newell, P. T., and J. W. Gjerloev (2011), Evaluation of SuperMAG auroral electrojet indices as indicators of substorms and auroral power, J. Geophys. Res., 116, A12211, doi:10.1029/2011JA016779.