Investigating the Spatiotemporal Evolution of midlatitude trough and Subauroral Ion Drifts Using Multiple DMSP Satellites

Hee Chan Cha[1,2], Keiichi Ogasawara[2,1], and Toshi Nishimura[3]

[1]University of Texas at San Antonio, San Antonio, TX, USA

[2]Space Science and Engineering Division, Southwest Research Institute, San Antonio, TX, USA [3]Boston University, Boston, MA, USA

Email: heechan.cha@contractor.swri.org

Introduction

- SAID: localized intense flows embedded within a SAPS channel (Nishimura et al.,2022)
- Representative examples of magnetosphere-ionosphere coupling when an enhanced electric field distorts a geomagnetic field and injects more particles into the inner magnetosphere
- Identified in the dusk-to-midnight sector and related to strong geomagnetic activity

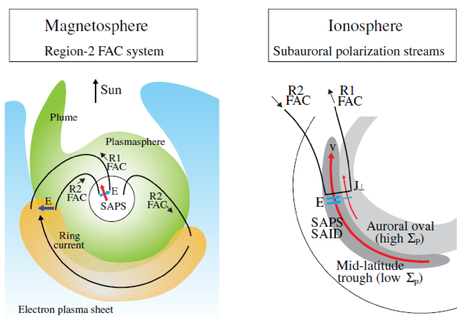

Figure 1. Illustration of the SAPS/SAID formation in the duskside M-I system. SAPS and SAID are collocated in flow channel near equatorward of the auroral oval Nishimura et al. (2021).

Background

- Because of the short time period the low-Earth orbit (LEO) satellites, the same SAID structure can only be measured in every 90 to 100 min
- It is rare to find in-situ studies of SAID and SAPS using multiple observations in time and space
- This study use three DMSP satellites to investigate the evolution of SAID less than 90 min period

Methodology

- Date: June 1st, 2013 (00:00 – 13:00 UT)
- Kp and Dst Indices used to investigate the relationship between a storm period and SAID evolution
- Defense Meteorological Satellites Program (DMSP) F16, F17, and F18 are used
  - F16 (Oct 2003 – 2019), F17 (Nov 2006 - current), F17 (Oct 2009 – current)
  - Special sensor for Ionospheric Electrodynamics and Scintillation (SSIES) that includes ion drift meter (IDM) and the retarding potential analyzer (RPA) data used to investigate the evolution of drift speed distribution and ion density
  - Precipitating energetic particle spectrometer (SSJ/4 and SSJ/5) data used to investigate the evolution of electron and ion precipitation

Summary

- **The spatiotemporal evolution of SAID**
  - During the strongest disturbances period of storm, the SAID event moved to lower latitudes. The width of drift speed distributions was broader in dusk sector than midnight sector. These tendencies correspond to the previous study [Anderson et al., 2001]
  - The latitudinal extent of SAID was broadening as the event progressed for at least 4 hours
- **The midlatitude trough does not always be present with SAID**
  - The SAID event was present without the midlatitude trough at the beginning of storm expansion phase
  - Ion density peak was mostly located in proximity region with the low latitudes edges of electron precipitation
  - The cliff structure near the ion density peak can be inferred as plasmapause according to previous study [Anderson et al., 2008]
  - The plasmapause evolved into the deep trough
  - The formation sequence between the SAID and the midlatitude trough suggest that the formation of SAID may be influenced by features such as the F region density peak or midlatitude trough at lower altitudes, where R1 and R2 Field-Aligned Currents (FACs) are closed

Acknowledgement

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Result (1)

Date : June 01, 2013 (00:00 – 13:22 UT)

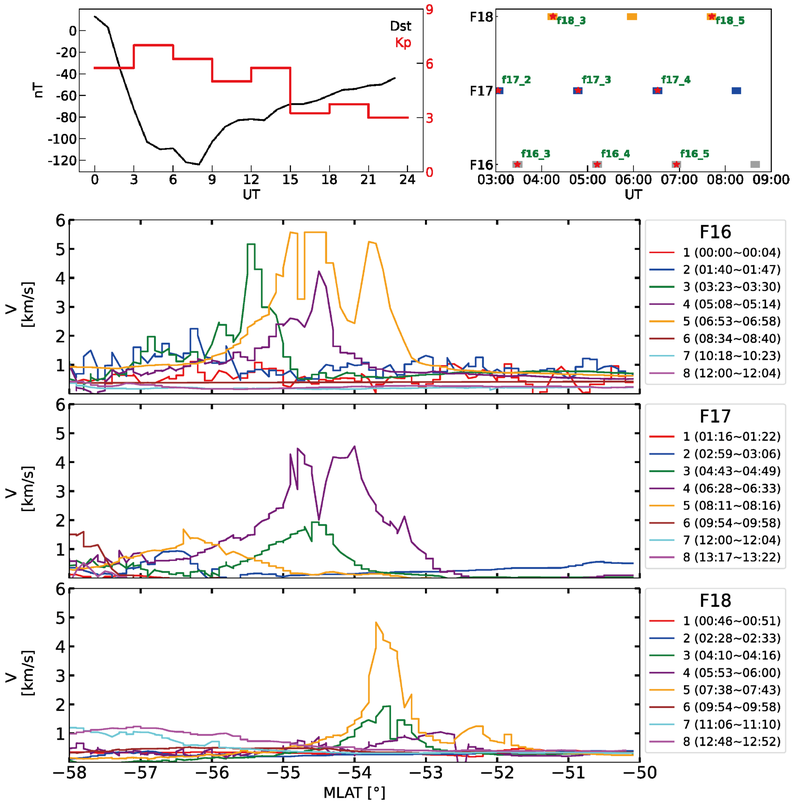

Figure 2. A event summary plots June 1st, 2013. (a) the time profile of Kp (red) and Dst (black) indices during the event from the Kyoto World Data Center for Geomagnetism, (b) periodic coverages of each DMSP spacecraft when they were passing between -58 ° and -50° in MLAT and between 16 hr to 24 hr in MLT. Each bar in the figure presents a distinct orbital interval and red stars mark moments of observed peak SAID peaks, with 'F17_2' denoting the second orbital pass of the F17 satellite through the specified region, (c-e) horizontal drifts of each pass for F16, F17, and F18 between -58 ° and -50° in MLAT. Periods of each interval are shown on the right box.

	F16_3	F16_4	F16_5
$MLAT(°)$	−55.5	−54.5	−54.4
$FWHM(°)$	0.5	0.8	1.7
MLT	19.6	19.1	18.6
$Peak\ Time$	03:28:24	05:12:38	06:56:12
	F17_2	F17_3	F17_4
$MLAT(°)$	−56.5	−54.6	−54.0
$FWHM(°)$	0.5	1.0	1.7
MLT	20.4	19.9	19.4
$Peak\ Time$	03:03:00	04:47:43	06:31:38
	F18_3	F18_4	F18_5
$MLAT(°)$	-53.5	-52.8	-53.7
$FWHM(°)$	0.8	–	0.5
MLT	22.2	22.1	21.9
$Peak\ Time$	04:14:51	05:58:53	07:42:26

Table 1. The SAID location and width observed by F16, F17, and F18 showing basic characteristics of the event. This table presents the information of SAID events observed from F16, F17, and F18 during the strongest disturbances period.

- The SAID event was observed in the dusk sector for at least 4 hours
- The FWHM in the drift speed distribution expanded from 0.5° to 1.7° in MLAT as the event progressed
- The event observed by F16 and F17 showed that the event moved to lower latitudes by 1.1° and 2.5° in MLAT, respectively
- No motion of the SAID event was observed by F18

References

Anderson, P. C., et al. (2001). "Multisatellite Observations of Rapid Subauroral Ion Drifts (SAID)." GRL 106.
Anderson, P. C., et al. (2008). "Observations of the Ionosphere Projection of the Plasmapause." GRL 35(15).
Nishimura, Y., Donovan, E. F., Angelopoulos, V., & Nishitani, N. (2020). *JGR: Space Physics*, *125*, e2020JA028067.
Nishimura, Y., et al. (2021). "Cross-Scale Coupling and Energy Transfer in the Magnetosphere-Ionosphere-Thermosphere System." Pages 1-63,

Result (2)

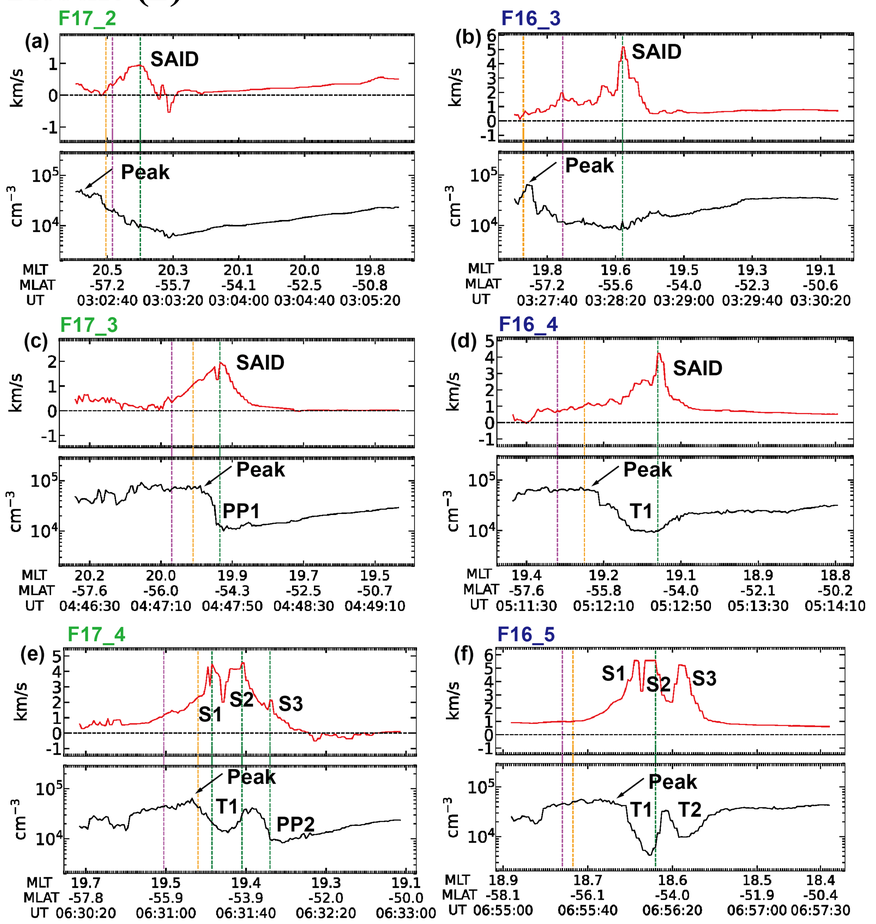

Figure 3. The spatiotemporal evolution of the ion density and horizontal ion drifts for F16 and F17 observations. (a)-(e) the intervals of F16 and F17 in chronological order are presented. The first panel presents the horizontal ion drifts (red line) and the second panel presents the ion density (black line). PP denotes the plasmapause and T1/T2 denotes the density trough. The vertical dashed green line indicates the location where the SAID peak is. The vertical orange and magneta dashed lines indicate the low latitude edges of electron precipitation and the low latitude edges of ion precipitation.

- **F17_2** and **F16_3** (03:02 – 03:30 UT)
  - During the beginning of the storm expansion period
  - SAID was present
  - No midlatitude trough / plasmapause
  - Ion density peak located in proximity region with the LLEEP
- **F17_3** and **F16_4** (04:46 – 05:14 UT)
  - The ionospheric projection of the plasmapause (PP1) appeared in SAID
  - PP1 evolved into the deep ionization trough
  - Ion density peak still located in proximity region with the LLEEP
- **F17_4** and **F16_5** (06:30 – 06:57 UT)
  - SAID developed into triple peaks structure (S1, S2, and S3)
  - T1 remained with the former SAID and it was deepening in the end (F16_5)
  - Another plasmapause (PP2) showed up with SAID peak (S3)
  - Similar to the former interval, plasmapause (PP2) evolved into the another deep trough (T2)