MITC-8

Multi-event analysis of STEVE, SAR arc, and red/green arc at subauroral latitudes using ground optical and radio instruments and the Arase and Van Allen Probes satellites

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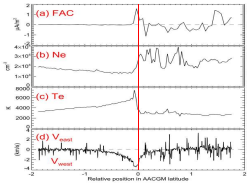
1. Introduction

Strong Thermal Emission Velocity Enhancement (STEVE)

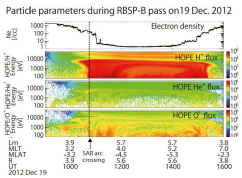
- Atmospheric optical phenomenon that appears with purple emission and observed above picket-fence (green emission). (MacDonald et al., 2018)
- Wide spectrum from 400 to 730 nm (Gillies et al., 2019)
- Optical manifestations associated with SAID in the ionosphere (Chu et al., 2019)



STEVE

Stable Auroral Red (SAR) arc

- 630 nm (red) emission of oxygen atoms at subauroral latitudes
- The SAR arc is caused by Coulomb collisions between cold electrons in the plasmasphere and hot ions in the ring current. (Inaba et al., 2021)



SAR arc

Red and Green arc

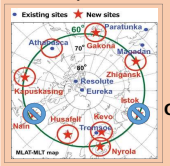
- Arc with red and green emission (Red and green arc) have also been reported. (Mendillo et al., 2016)

For the first time we analyzed multiple cases of STEVE, SAR arc, red and green arcs, an unprecedented number of conjugate events (9 events), and compared the characteristics of magnetospheric plasma and electromagnetic field variation.

2. Instrumentation

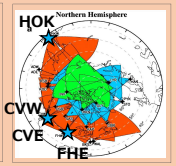
Ground

OMTI's high-sensitivity all-sky camera



Shiokawa et al. (2017)

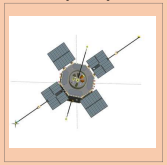
SuperDARN



Nishitani et al. (2019)

Magnetosphere

Van Allen Probes (RBSP)



HOPE, EMFISIS

Miyoshi et al. (2012)

ERG

PWE, MEP-I, LEP-I, MEP-e, LEP-e, EFD, MGF

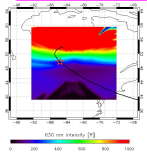
4. Results & discussion

Events analyzed in this study

Analyzed days
ERG : 4436 days
RBSP-A: 3101 days
RBSP-B: 2603 days

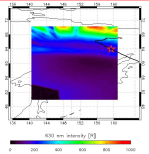
NUM	STA	TIME	DAY	TYPE	SATELLITE
1	KAP	00:57~04:20(UT)	2017/3/22	STEVE	RBSP-B
2	KAP	02:21~04:47(UT)	2017/8/20	STEVE	ERG
3	KAP	03:11~03:41(UT)	2018/9/14	STEVE	RBSP-B
4	MGD	10:45~15:15(UT)	2017/3/27	SAR arc	RBSP-A
5	GAK	6:03~8:48(UT)	2020/1/16	SAR arc	ERG
6	ATH	3:53~8:10(UT)	2021/1/12	SAR arc	ERG
7	ATH	04:45~07:01(UT)	2017/2/17	RED/GREEN ARC	RBSP-B
8	ATH	05:25~07:57(UT)	2018/2/17	RED/GREEN ARC	RBSP-B
9	GAK	3:30~7:20(UT)	2019/2/2	RED/GREEN ARC	RBSP-A

STEVE on 2017/03/22 at KAP



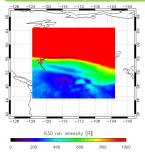
557.7 nm
630.0 nm
486.1 nm
572.5 nm

SAR arc on 2017/03/27 at MGD



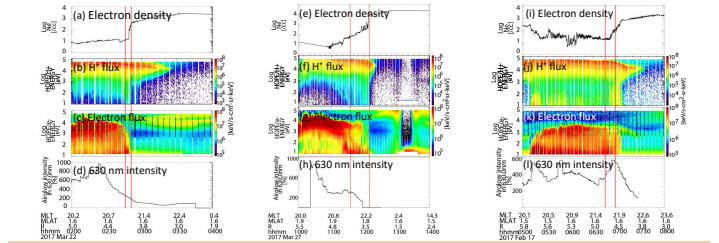
630.0 nm (red)

Red and Green arc on 2017/02/17 at ATH



557.7 nm (green)
630.0 nm (red)

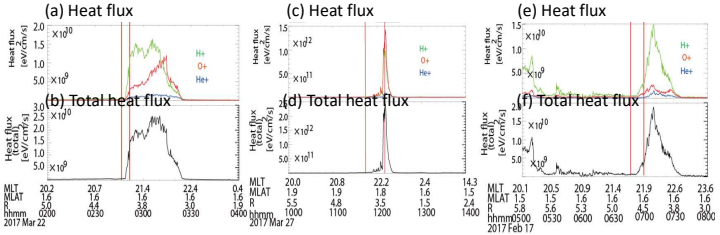
Comparing energy flux data obtained from the satellites



- The arcs occur in the overlap region of the plasmasphere boundary and the ring current.
- The electron energy rises at the arc crossing.

→No clear difference in particle energy or electron density for these three arcs.

Comparison of heat flux

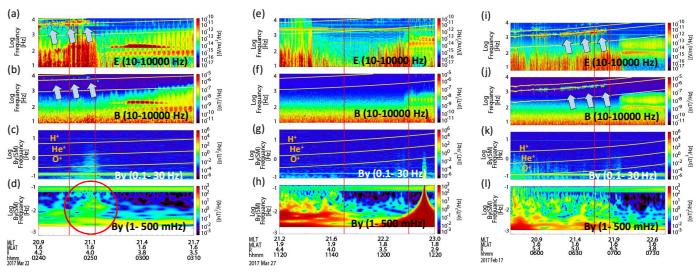


Despite the SAR arc having the weakest airglow intensity, the heat flux is the highest.

→The STEVE and red/green arcs emit light due to factors other than Coulomb collisions.

Comparing electromagnetic waves obtained from the satellites

STEVE on 2017/03/22 at KAP | SAR arc on 2017/03/27 at MGD | Red and Green arc on 2017/02/17 at ATH

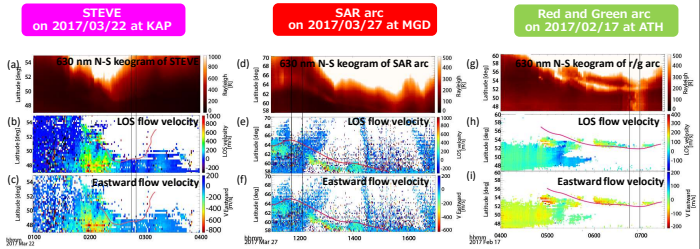


- Chorus waves are observed during a STEVE and a red/green arc.
- The magnetic waves at ~0.001-~0,1 Hz are observed during a STEVE.

→The emission of 557.7 nm is generated by high-energy electron precipitation scattered by pitch angle due to wave-particle interactions.

Comparing plasma flow obtained from the SuperDARN radar

STEVE on 2017/03/22 at KAP | SAR arc on 2017/03/27 at MGD | Red and Green arc on 2017/02/17 at ATH



Westward plasma flow (STEVE : ~600 m/s, SAR arc : ~200 m/s, red and green arc : ~100 m/s) occurs along the arc.

5. Conclusions

We analyzed 9 conjugate observations of STEVE, SAR, red/green using 3 magnetospheric satellites and 7 ground-based all-sky cameras over a four-year period from January 2017 to April 2021.

- Most of the three types of arcs (8/9) had similar source features that their source is in the overlap region between the plasmapause and the ring current.
- Heat fluxes are higher for the SAR arc than for the STEVE and the red/green arc.
- The Chorus waves were observed only in STEVE (3/3) and Red and green arc (3/3) events.
- SuperDARN data showed a strong westward flow in the ionosphere during the STEVE event.

Under conditions of SAR arc generation
Electromagnetic wave occurs → Red/green arc
Strong westward flow occurs → STEVE