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Varied Types of Subauroral Polarization Streams

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Abstract

Subauroral polarization streams (SAPS) are narrow channels of strong westward ion flows in both the subauroral ionosphere and the conjugated inner magnetosphere in the nightside during geomagnetic storms and substorms. The SAPS exhibit different types of structures like single-peak, double-peak, multi-peak, and oscillation structures. The SAPS are closely related with ionospheric conductivity and region-2 field-aligned currents. The existence of multiple types of SAPS likely indicates precipitations from different magnetosphere-ionosphere coupling dynamics.

1. Introduction

The subauroral polarization streams (SAPS) are prominent phenomenon during storms and substorms in the nightside subauroral ionosphere [1]. It refers to an intense ion convection zone with latitudinally narrow and longitudinally elongated rapid westward ion drifts or equivalent strong poleward electric fields. The generation and evolution of SAPS largely depend on both the conditions of solar wind and interplanetary magnetic field (IMF) and the status of the inner mangetospheric convections [2]. It is usually believed that SAPS are formed when the separation between the electron and ion inner boundaries of the ring current (RC) extends down to the subauroral region of low ionospheric conductivity and strong electric fields occur to ensure the current continuity. Many characteristics of the SAPS, such as the global occurrence based on the statistics of many individual events, long-term variabilities, hemispheric asymmetries [3, 4, 5], electromagnetic wave structures [6], double-peak signatures [7], and evolution patterns during intense storms and quiet-time substorms [2] have been reported based on space-based observations in the ionosphere and the magnetosphere or ground-based radar observations. In this work we will show different types of SAPS structures observed by the Defense Meteorological Satellite Program (DMSP) satellites in the ionosphere. Possible magnetosphere-ionosphere couplings will be discussed.

2. Observations

2.1 Type 1: Single-peak SAPS

Figure 1a shows a typical SAPS structure often reported in literature, which we call single-peak structure. From top to bottom shown are the ion drift velocity (red for horizontal drifts with negative for westward and blue for vertical drifts with positive for upward), the precipitating electron number flux, the precipitating ion number flux, the total ion density, and the field-aligned currents (FAC, estimated from the perturbation magnetic field measured by the magnetometer onboard DMSP satellites with positive for downward region-2 FAC) observed by DMSP satellite. The V-shaped peak is located equatorward of the equatorial boundary of auroral oval. The velocity peak is generally located in the ionospheric density trough and is associated with a peak in region-2 FAC. It is suggested that the main driver of the single-peak structure of SAPS is the single-peak downward region-2 FAC which is generated by the plasma pressure gradient at the inner boundary of the plasma sheet.

2.2 Type 2: Double-peak SAPS

Figure 1b shows the double-peak structure of SAPS with the same formats as those in Figure 1a. The double-peak structure of SAPS usually exists for several minutes to tens of minutes during the evolution of SAPS. It is generated from the single-peak SAPS during more disturbed periods. It is suggested that the double-peak region-2 FAC, which is likely associated with plasma instability developed during the interaction between the hot plasma sheet ions and cold plasmaspheric plasma, might be the main driver of the double-peak SAPS.

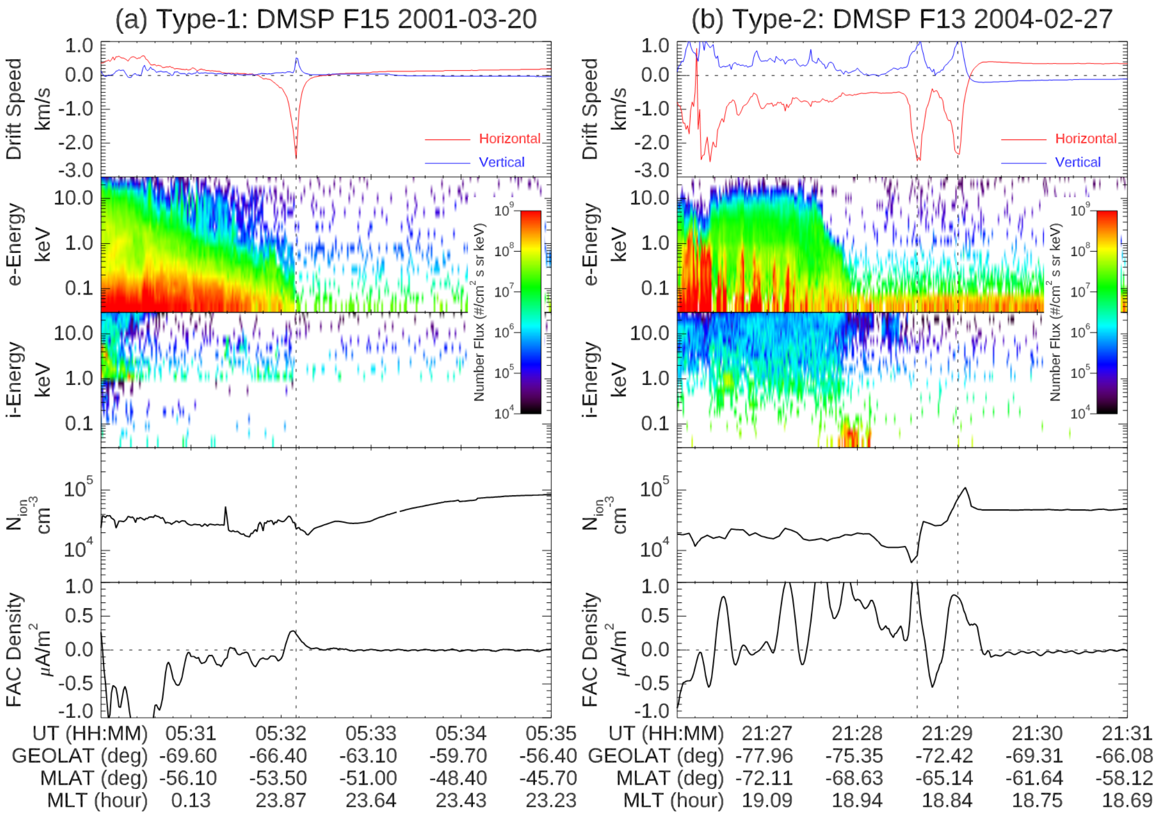

Figure 1. (a) Single-peak SAPS observed by the DMSP F15 satellite on 20 March 2001. **(b)** Double-peak SAPS observed by the DMSP F13 satellite on 27 February 2004. The two vertical lines indicate the two westward ion drift peaks of the event.

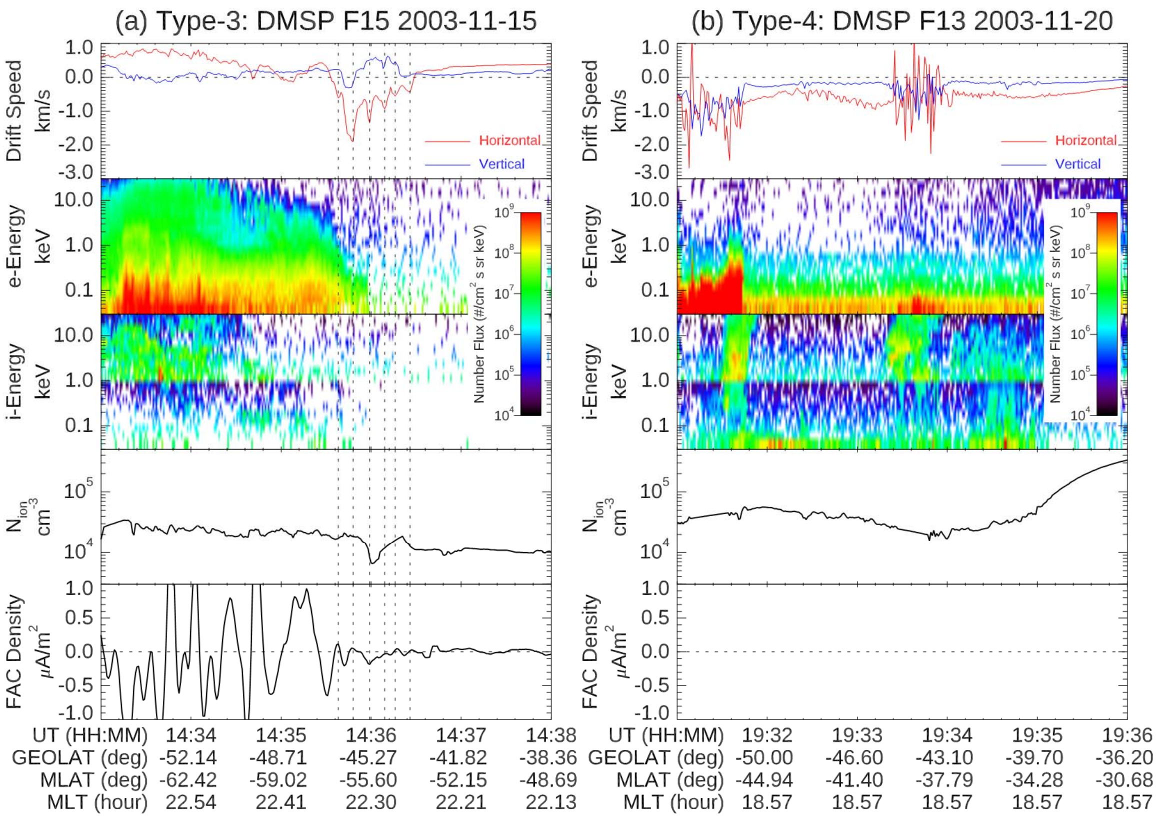

Figure 2. (a) Multi-peak SAPS observed by the DMSP F15 satellite on 15 November 2003. **(b)** SAPS oscillation observed by the DMSP F15 satellite on 15 November 2003. Note that the magnetometer data during this period is unavailable.

2.3 Type 3: Multi-peak SAPS

The third type of SAPS structure exhibits multiple peaks as shown in Figure 2a with the same formats as those in Figure 1. Such multi-peak structure is similar to the electromagnetic wave structures reported by Mishin et al [6]. No clear multilayer structure of FAC is found in the SAPS channel in this event. Such multi-peak structure might be attributed to the Alfvènic perturbations [6].

2.4 Type 4: SAPS Oscillation

During some severe geomagnetic storms, strong oscillations are often observed in the SAPS channel during its evolution, as shown in Figure 2b with the formats the same with those in Figure 1. Such strong oscillations might be related with the deep penetration of plasma sheet ions [8] and the polar cap patch transportation [9].
These instructions provide guidance and a template for the preparation of a Summary Paper for the URSI Flagship Meetings.

3. Conclusion

During different levels of storms/substorms, the evolutions of SAPS exhibit different patterns. Apart from the regular single-peak structure, other interesting structures are also found to be related to different solar wind and geomagnetic conditions. The other three types of structures are just the intermediate states of the SAPS. Their occurrences depend on the solar wind and interplanetary magnetic fields, the large-scale convection in the magnetosphere, the plasma sheet injections, and the ionospheric feedbacks. Thus, different types of SAPS structures may reflect different magnetosphere-ionosphere couplings. The details of this work will be shown in our presentation of the meeting.

4. Acknowledgements

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5. References

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