Auroral Occurrences and Field-Aligned Currents Observed over the Jang Bogo Station, Antarctic

Yujin Cho(yujincho@kopri.re.kr)[1,2], Geonhwa Jee[1,2], Young-Bae Ham[1,2] , Hyuck-Jin Kwon[1], Jaeheung Park[2,3]

[1]*Korea Polar Research Institute*, [2]*University of Science and Technology*, [3]*Korea Astronomy and Space Science Institute*

Abstract

Energetic particles precipitating from the magnetosphere along the magnetic field lines excite and ionize the neutral particles in the Earth's atmosphere, and the excited particles release their energy in the form of light, which is known as the aurora. The dominant precipitating particles being responsible for the generation of the aurora are electrons, and the downward electrons constitute upward Field-Aligned Currents (FACs) between the ionosphere and the magnetosphere. In 2018, Aurora All-Sky Camera was installed at Jang Bogo station (JBS) in Antarctica for monitoring auroral activities in visible frequency range with color CCD and it has been continuously operated since then. At the location of JBS, the auroral occurrence shows significant MLT (Magnetic Local Time) variations with the highest occurrence rate in the MLT morning sector, which may imply that JBS is located in the boundary region between the polar cap and the auroral oval. In our previous study, we examined the temporal and spatial distributions of auroral occurrence. In this presentation, we compared the results of the distributions of auroral occurrence with satellite's in-situ measurements of the Field-Aligned Current (FAC) in order to investigate the relationship between the auroral occurrence and the FACs.

Auroral Occurrences over JBS

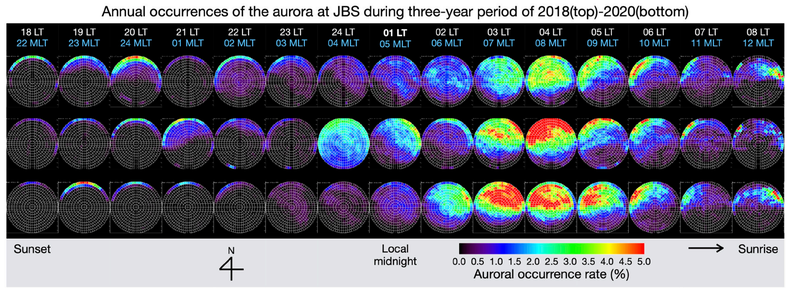


Figure 1. Auroral occurrences calculated from the auroral recognition procedures with expanded elevation angle 10° and with increased cell number of 400 during three-year period of 2018 (top) to 2020 (bottom). (Jee et al. 2021).

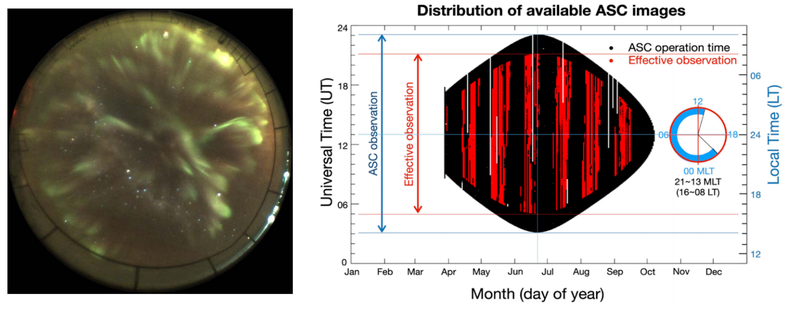


Figure 2. Visible aurora image by Aurora All-Sky Camera (ASC) at JBS (left) and the data distribution of the ASC observation during nighttime condition in 2018 at Jang Bogo Station (JBS) (right). The red shaded area of the entire operation time indicates the effective observation times and periods used for the analysis (Jee et al. 2021).

- Statical distribution of the auroral occurrence over the JBS (AACGM latitude : 79.87S, AACGM longitude : 53.56W), Antarctica during 2018-2020 shows the highest occurrence in MLT morning sector, which may imply that the JBS is located in the boundary region between the polar cap and the auroral oval and approaches closest to the auroral oval in the MLT morning (Jee et al. 2021). (Figure 1)
- The electrons precipitating into the ionosphere along the magnetic field lines are known to generate aurora and these downward electrons constitute upward Field-Aligned Currents (FACs).

Region1 FACs is known to exist at the poleward latitude of the auroral oval, but Region2 FACs exist at the equatorward part of the auroral oval: Therefore, the FACs should also change with in association with the variations of the auroral oval.

Data used in this study

- Visible aurora images have been observed by Aurora All-Sky Camera(ASC) at JBS (AACGM latitude : 79.87S, AACGM longitude : 53.56W), Antarctica since 2018.
- Aurora All-Sky Camera at JBS operates during nighttime from late evening (21 MLT) to the local noon (13 MLT) during the winter period of April to September. (Figure 2)
- The ASC has been collecting auroral images with 1-min intervals with 5-sec exposure time but the exposure time was increased to 10 seconds on June 3, 2020 to enhance the intensity of the captured auroral images (Jee et al. 2021).
- FACs data with 1-sec interval were obtained from the SWARM Alpha (A) satellite during 2018-2020. The FAC current density, j_{FAC}, is calculated as $j_{FAC} = -\frac{j_{IRC}}{\sin I}\ [\frac{\mu A}{m^2}]$ where j_{IRC} is the radial current.
- SWARM A satellite at about 460 km altitude makes roughly 15 orbits per day and covers all the 24-hr local time sector in about 133 days.

Distribution of FACs in MLT

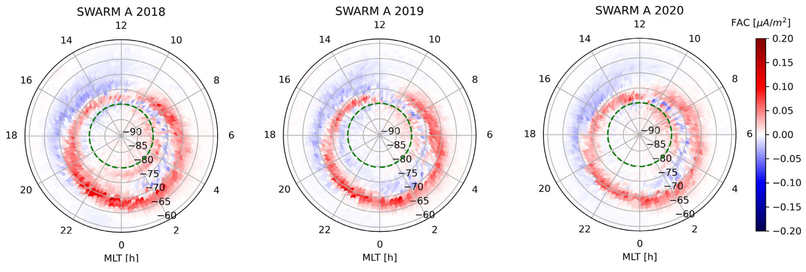
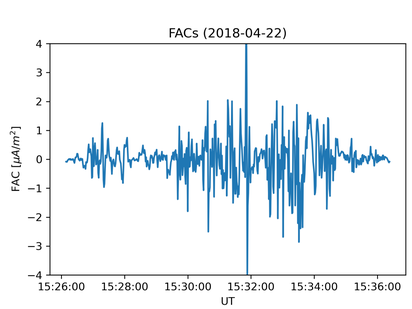


Figure 3. Statistical distributions of FACs data from SWARM satellite A during 2018 to 2020

- Statistical distributions of FACs data are presented from 2018 to 2020 (Figure 3). The data used in the distribution is the bin-averaged median values of FACs for SWARM A satellite, with a grid resolution of 1° MLAT × 0.25 MLT.
- In the dawn (dusk) sector, downward (upward) FACs are dominant at higher latitude (Region 1), while upward (downward) FACs are dominant at lower latitude (Region 2).
- In the MLT morning sector (07-09 MLT), where the auroral occurrence is observed to be maximum in JBS, it can be seen that the auroral occurrence rate is expanded in the poleward direction. Since it is the electrons generating the aurora observed at JBS and they constitute the upward FACs (Region 1), it can be expected that the boundary between the upward FACs (Region 1) and the downward FACs (Region 2) should also move toward the higher latitude in the MLT morning sector.

Relation of FACs and aurora



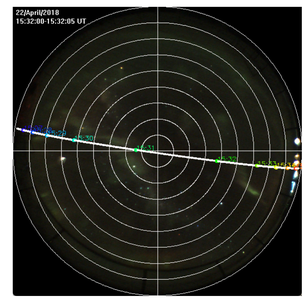


Figure 4. Variation of FACs when aurora occurs in April 22, 2018 (left) and the AASC image with satellite orbit from 2018-04-22 15:32:00 to 15:32:05

- Variations of FACs are observed by SWARM A satellite passing over JBS in April 22, 2018 when the aurora also occurred along the satellite trajectory (Figure 4)
- It seems that the variation of FACs is related the occurrence of the aurora.

Summary and Conclusion

- As the auroral occurrence expands to the poleward direction in the MLT morning sector at JBS, it is expected that the distribution of upward FACs also moves toward higher geomagnetic latitude in the MLT morning sector.
- Considering the simultaneous observations of the FACs and auroral occurrence near the JBS, the auroral occurrence seems to be related with FACs.
- With further analysis of the FACs and auroral occurrences at JBS, the relation between the FACs and the poleward boundary of the auroral oval may be identified.

References

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