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Characteristics of auroral occurrence at Jang Bogo Station, Antarctica

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Abstract

Jang Bogo Station (JBS) is located at the magnetic latitude of about 80 deg, which mostly belongs to the polar cap region but closely approaches to the auroral oval in the morning sector. In order to observe the auroral activity over the JBS, we have been operating visible auroral All-Sky Camera (ASC) since 2018. Using the auroral image data from the ASC for 6-year winter period of 2018-2023, we produced auroral occurrence maps to investigate the characteristics of the auroral occurrence over the JBS including its variations with local time, magnetic activity index (Kp), and Interplanetary Magnetic Field (IMF). The produced auroral occurrence maps indicate that JBS is mostly located at the polar cap region but becomes close to the auroral oval at the magnetic local morning sector. In particular, the auroral occurrence maps indicate that the JBS seems to be located at the cusp region near the magnetic local noon. The auroral occurrences also show complex variations with Kp index and IMF conditions. Furthermore, the characteristics of the auroral occurrence over the JBS may allow us to investigate the behaviors of the polar cap boundary with the magnetic activity in the magnetic morning and noon sector.

Data used in this study

- Visible aurora images have been observed by Aurora All-sky camera (ASC) over the JBS (AACGM latitude : 79.87S, AACGM longitude : 53.56W), Antarctica during 2018-2023.
- Aurora ASC over the JBS operates from late evening (21 MLT) to the local noon (13 MLT) in terms of magnetic local time during the winter period of April to September. (Figure 1)
- The aurora images for auroral occurrences has 1-min intervals and 5-sec exposure time except 2020 (2020-06-03 ~ 2020-12-31 : 10-sec exposure time).
- The F10.7 and Kp index data are obtained from NASA' OMNIWeb Data Explorer during 2018-2023.
- The Interplanetary Magnetic Field (IMF) data is obtained from High Resolution OMNI (HRO) solar wind magnetic field data at the Earth's Bow Shock Nose for 2018-2023 were used to classify aurora images according to IMF conditions. The IMF data were time shifted to the Cusp Ionosphere (CI) by considering the transit time from Bow Shock (BS) to CI (τ_{BS-MP} ~ 9 min, τ_{MP-CI} ~ 2 min).

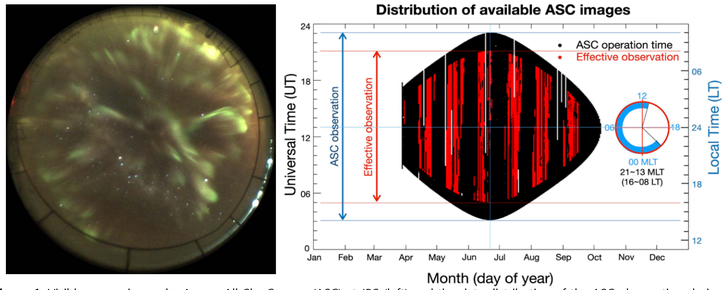


Figure 1. Visible aurora image by Aurora All-Sky Camera (ASC) at JBS (left) and the data distribution of the ASC observation during nighttime condition in 2018 at Jang Bogo Station (JBS) (right). The red shaded area of the entire operation time indicates the effective observation times and periods used for the analysis (Jee et al. 2021).

Characteristics with solar cycle and magnetic activity

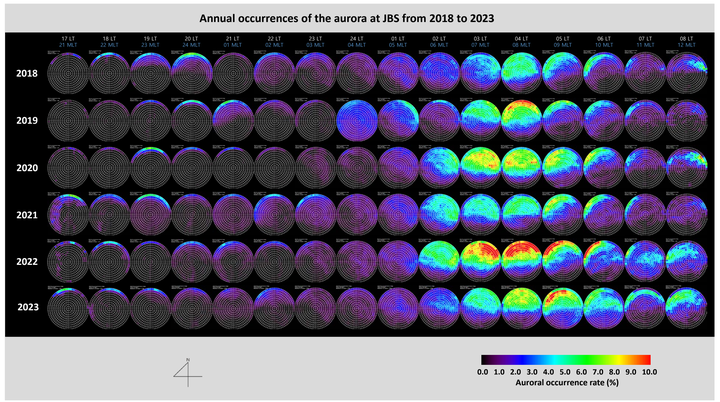


Figure 2. Annual auroral occurrences over the JBS from 2018 to 2023. The center of each circle is the zenith of JBS.

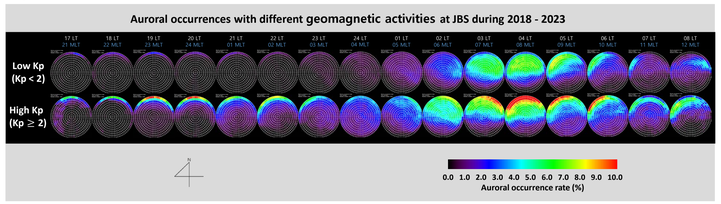


Figure 4. Auroral occurrences with geomagnetic quiet condition (top) and geomagnetic disturbed conditions (bottom) for nighttime at JBS from 22 MLT (18 LT) to 12 MLT (08 LT) during 2018-2023.

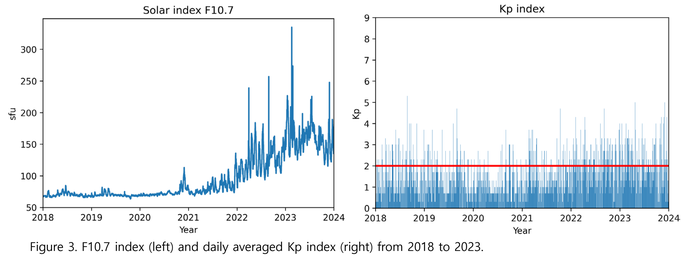
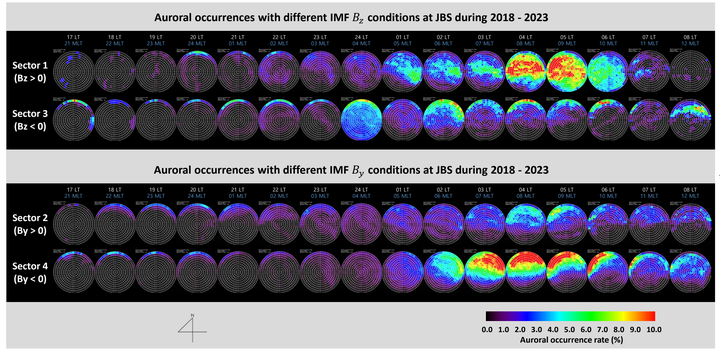


Figure 3. F10.7 index (left) and daily averaged Kp index (right) from 2018 to 2023.

- The auroral occurrence barely appears in the North of the JBS in the evening (22-03 MLT) but it begins to spread poleward and cover nearly the entire sky over the JBS in the MLT morning sector (07-09 MLT).
- The auroral occurrence rate tends to increase as the solar F10.7 index increases, but it is not very clear.

- We classified the aurora images with Kp index : Kp < 2 (Low Kp) and Kp ≥ 2 (High Kp).
- The auroral occurrence is largely enhanced with Kp and the sky coverage also expands poleward for entire local time sector.
- The latitudinal variations of the auroral occurrence tend to be steeper for high Kp, in particular at around 08 MLT.
- The auroral occurrence at the cusp is enhanced and slightly moved to lower latitude for high Kp.

Characteristics with IMF



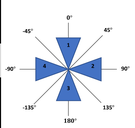


Figure 5. The auroral occurrences with IMF B_z conditions (top) and IMF B_y conditions (bottom) over the JBS from 2018 to 2023. (left) and the sectors classified with IMF clock angle (right).

- We also classified the aurora images into 4 IMF clock angle sectors with the magnitude of IMF greater than 1 nT.
- In Sector 1 (B_z > 0), the occurrence is broadly spread over the zenith while it tends to be enhanced only in the equatorward edge in Sector 3 (B_z < 0) except for 04 MLT.
- This result seems to be associated with the high-latitude reconnection for B_z > 0 (rather than low-latitude reconnection for B_z < 0).

- The auroral occurrence is much greater in Sector 4 (B_y < 0) than in Sector 2 (By > 0) but further investigation seems to be required.

Discussion and Conclusion

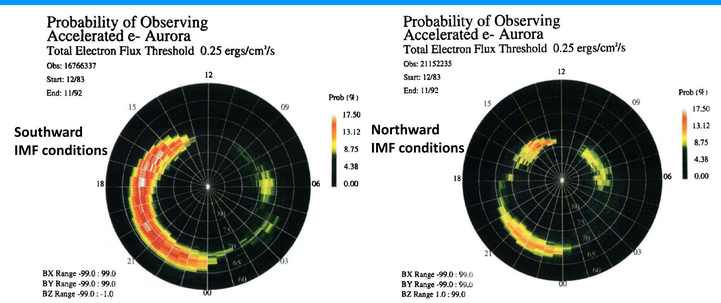


Figure 7. The probability of observing auroral electron acceleration events with energy flux above 0.25 $erg\ cm^{-2}\ s^{-1}$ as a function of MLT and MLAT based on the full set of 1.5 × 10^8 individual electron spectra for southward (left) and northward (right) IMF conditions (Newell et al. 1996).

- The auroral occurrence rate at JBS was observed to be largest in the MLT morning sector (~ 0600-0900 MLT).
  - JBS closely approaches to or within the auroral oval in this morning sector.
  - With regard to B_z dependency, our result seems to show the "morning warm spot" which is larger for Northward IMF in the MLT morning sector.
- The auroral precipitation in the MLT morning sector may primarily be supplied by drifting electrons from the central plasma sheet (Newell et al. 1996).