

A correlation between AKR-like emissions and field-aligned currents

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Abstract

In this study, we searched for and analysed cases of co-occurrence of the growth of the density of field-aligned currents (FAC) and AKR-like emissions.

Several cases have been found in which the occurrence of AKR-like emission corresponds to an increase in FAC density. We can infer that FACs accompany the AKR-like emissions, but not necessarily the presence of these currents does imply the existence of these emissions in the entire latitudinal/longitudinal range for which FACs are observed.

There would probably be more such coincidences if there were more close flybys/orbit intersections of the Swarm and Vernov satellites. Observations fall between August and December of 2014 (mid-24th solar cycle).

1 Introduction

Field-aligned currents, flowing along geomagnetic field lines, provide electrodynamic coupling of the solar wind–magnetosphere–ionosphere–thermosphere system. Auroral Kilometric Radiation (AKR) is a natural radio emission in the frequency range ~ 30 –800 kHz generated in the auroral zones at magnetic latitudes larger than 65° and altitudes from 5000 km to 15000 km [1, 5, 6]. AKR-like emission is a component of Auroral Kilometric Radiation typically observed at Earth's sub-auroral region at much lower altitudes [1, 3].

In our study, we observed cases of AKR-like emissions related to AKR whose generation occurs at significantly higher altitudes. At the same time as the AKR-like emissions, we observed field-aligned currents generated in the vicinity of Auroral Kilometric Radiation sources. Possibly FACs could affect the transfer of the energetic electron beams (generating the AKR) that influence the production of AKR-like emissions.

FACs were in previous works indicated as role-playing processes for AKR emissions [2, 7]. According to these findings, we tried to investigate the possible relationship between FACs and AKR-like emissions. To do this, we searched the available data and checked whether there were simultaneous AKR-like emissions and changes in the density of field-aligned currents. For several close flybys, cases were found where both AKR-like emission and FAC density increase occurred.

2 Data

The data about AKR-like emissions come from the Vernov satellite, whose orbit was at an altitude from 640 to 830 km and an inclination of 98.4° .

The data about field-aligned currents density are from Swarm satellites A and C, whose orbit is at 462 km and at 87.35° inclination angle, and Swarm B at a higher orbit of 511 km and at 87.75° inclination angle. They are available via the online Swarm data portal as Level 2 data products.



Figure 1. Visualization of Vernov spacecraft (left) and Swarm satellites (right).

3 Methodology

All AKR-like emissions, obtained from RELEC data (specifically Radio Frequency Analyser (RFA)) onboard the Vernov satellite, were examined (more than three hundred cases) and their occurrence (geomagnetic latitude and longitude, time) was compared with the occurrence of FACs' density growth in the same time and in the same (or very close) latitude and longitude.

4 Results

Below we present some of the found cases and two examples of close flybys during which the co-occurrence of AKR-like emission and increase of FAC density took place.

The upper plot in Figures 2, 3, and 4 show the AKR-like emission from the Radio Frequency Analyser (RFA) instrument (RELEC instrumentation), lower plots show field-aligned current density (negative - upward current, positive - downward current) from Swarm A (red) and C (blue) or B (green), the black lines indicate the overlapping area of emissions and currents. Figures 5 and 6 present parts of the orbits of the mentioned satellites when they intersected.

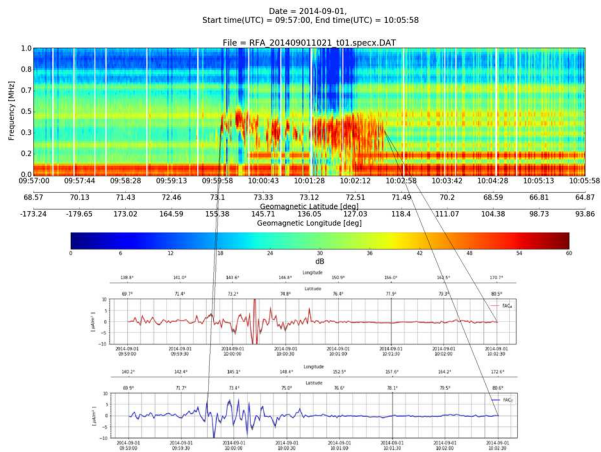


Figure 2. AKR-like emission, and corresponding field-aligned currents density on September 1, 2014.

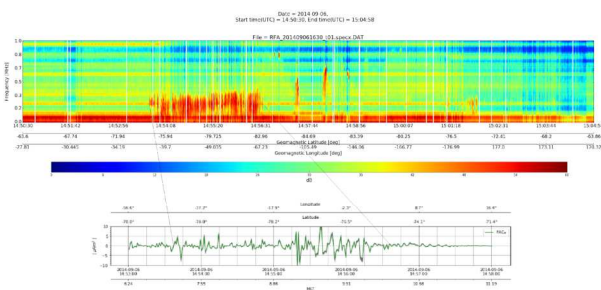


Figure 3. AKR-like emission and corresponding field-aligned currents on September 6, 2014.

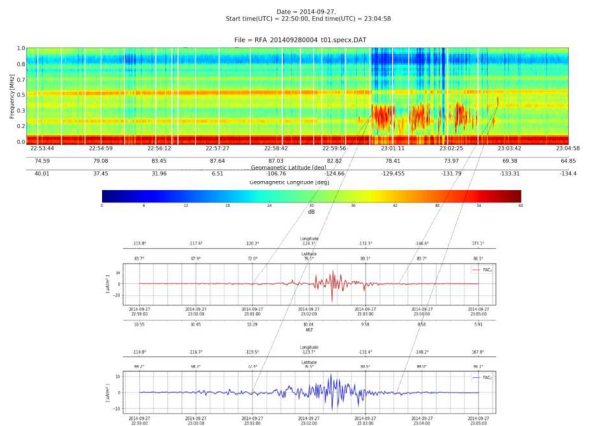


Figure 4. AKR-like emission and corresponding field-aligned currents on September 27, 2014.

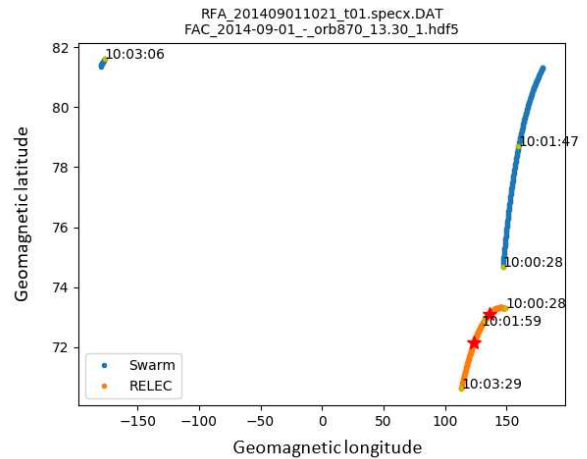


Figure 5. Close flyby of Swarm A and C satellites (blue) and Vernov spacecraft (orange) on September 1, 2014, when there occurred both AKR-like emission and an increase of field-aligned current density (Fig. 2). Red stars indicate the start and end of the AKR-like emission.

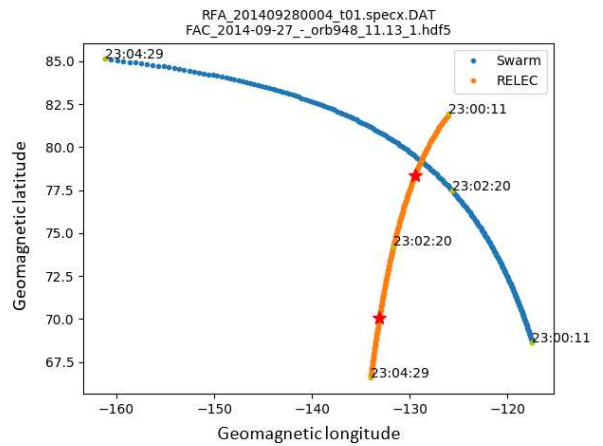


Figure 6. The intersection of orbits of Swarm A and C satellites (blue) and Vernov spacecraft (orange) on September 27, 2014, when there occurred AKR-like emission and field-aligned current density growth (Fig. 4). Red stars indicate the start and end of the AKR-like emission.

5 Conclusions

For several cases where the coincidence in time and location occurred, the co-occurrence of AKR-like emission and field-aligned current density growth was found.

In some of the studied instances, the geomagnetic latitude and longitude range of the AKR-like emission overlaps the geomagnetic latitude and longitude range of the field-aligned current density increase. However, it is often observed that the area of current density growth occupies a bigger (or sometimes smaller) range than the AKR-like emission. We can infer that, conceivably, there is a correlation between FACs and AKR-like emissions, but there is probably an additional factor controlling the range of radio emissions. Positions of respective satellites do not

need to coincide precisely due to possible sub-ionospheric propagation of AKR-like emissions [4] - these emissions can be observed at some distance from FACs.

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