Spatiotemporal variation of precipitating electron energy in auroral vortices

*Yoshimasa Tanaka[1], Yasunobu Ogawa[1], Akira Kadokura[1], Kirsti Kauristie[2], Carl-fredrik Enell[3], Urban Braendstroem[4], Tima Sergienko[4], Bjorn Gustavsson[5], Daniel Whiter[6], Alexander Kozlovsky[7], Hiroshi Miyaoka[1], Mike Kosch[8]

1. National Institute of Polar Research, 2. Finnish Meteorological Institute, 3. EISCAT Scientific Association, 4. Swedish Institute of Space Physics, 5. The Arctic University of Norway, 6. University of Southampton, 7. Sodankyla Geophysical Observatory, 8. South African National Space Agency

We investigated dynamic vortex structures in discrete arcs observed by multi-point monochromatic (427.8nm) imagers in Northern Europe at 22:15-22:20 UT on March 14, 2015. We applied auroral computed tomography method to the multiple images taken at 2 second interval by three all-sky EMCCD imagers and at 5 second interval by four wide-view CCD imagers, and reconstructed a 3D distribution of auroral emission and a horizontal 2D distribution of energy of precipitating electrons. The reconstructed 3D distribution of the auroral emission was compared with height profiles of ionospheric electron density along a field line simultaneously observed by EISCAT UHF radar at Tromso, Norway.

The analysis results are summarized as follows. (1) Averaged energy of auroral precipitating electrons was higher around the center of auroral vortices than the other location of the discrete arcs. (2) Total energy flux of precipitating electrons was proportional to the square of the averaged energy. (3) The shape of height profiles of the 427.8nm emission was very similar to that of the electron density profiles. (4) The electron density estimated from the 427.8nm emission by using empirical atmosphere models was about 2.5 to 3 times smaller than observed by EISCAT UHF radar. The result (1) is consistent with the Ohm's law along a field line, i.e., the field-aligned current (FAC) is proportional to the field-aligned potential difference. If the discrete arcs were caused by electron precipitation from the auroral acceleration region (AAR) where the Ohm's law is satisfied, the electron energy (proportional to the potential difference) should have been high around the center of vortex where FAC is large. The result (2) strongly supports this inference. As for the item (4), the difference between the electron density estimated from the optical emission and that observed by EISCAT radar may be explained by an uncertainty of some atmospheric parameters derived from empirical models, in particular, an effective recombination coefficient. We discuss the dynamics of the auroral vortices in terms of the magnetosphere –ionosphere coupling.

Keywords: auroral vortex structure, precipitating electron energy, tomography analysis, EISCAT radar, magnetosphere - ionosphere coupling

