Characteristics of auroral vortices observed by multiple imagers and EISCAT radar

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We investigated temporal, spatial, and energy characteristics of a series of eastward-moving mesoscale auroral vortices in discrete arcs observed by multi-point monochromatic (427.8nm) imagers in Fennoscandia at 22:15-22:20 UT on March 14, 2015. We reconstructed 3D distributions of the auroral vortices (corresponding to horizontal 2D distributions of precipitating electron energy) at high temporal resolution from the multiple images recorded at a 2 second interval by three all-sky EMCCD imagers and at a 5 second interval by four wide-view CCD imagers. The reconstructed 3D distributions of the optical emission were quantitatively compared with height profiles of ionospheric electron density along a magnetic field line simultaneously observed by EISCAT the UHF radar at Tromso, Norway.

The height profile of the 427.8nm emission was very similar to that of the electron density, however, the electron density estimated from the 427.8nm emission using empirical atmosphere models was about 2.5 to 3 times smaller than that observed by the EISCAT UHF radar. The difference between the electron density estimated from the optical emission and that observed by EISCAT radar may be caused by an uncertainty of some atmospheric parameters derived from empirical models, for example, an effective recombination coefficient. Furthermore, we could capture the horizontal structure of precipitating electron energy at high temporal resolution for the first time by taking advantage of the ground-based network observation. The average energy of precipitating electrons was higher around the center of the vortices than the other location of the discrete arcs, and the high-energy region moved with eastward moving vortex structures. The spatial and energy distribution of precipitating electrons was essentially consistent with the so-called inverted-V type auroral electron precipitation, which has often been observed above the discrete aurora by many low-altitude polar-orbiting satellites. In addition, the relation that total energy flux and average energy of precipitating electrons was consistent with the Ohm's law along a magnetic field line, i.e., the field-aligned current (FAC) is proportional to the field-aligned potential difference. We discuss the dynamics of the auroral vortices in terms of the magnetosphere - ionosphere coupling.