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Storm-time RC ion distribution and evolution retrieved from TWINS ENA by differential voxel CT technique

Wei-Nan Yan, Shu-Ying Ma, and Liang Xu

Wuhan University, China, College of Electronic Information, Wuhan, China (syma@whu.edu.cn, 86-27-68778923)

The quantitative retrieval of the 3-D spatial distribution of the parent energetic ions of ENA from a 2-D ENA image is a challenge task. The Two Wide-angle Imaging Neutral-atom Spectrometers (TWINS) mission of NASA provides an unique opportunity to retrieve the 3-D distribution of ions in the ring current (RC) by using a volumetric pixel (voxel) CT inversion method. In this study the voxel CT method is implemented for a series of differential ENA fluxes at different energy levels ranging from 5 to 80 keV obtained simultaneously by the two satellites of TWINS flying on two widely-separated Molniya orbits during the main phase of the magnetic storm of 24-25 October 2011 with minimum Sym-H index of -160 nT. The data were selected to span a period of about 50 minutes during which a large substorm was undergoing its expansion phase first and then recovery. The ENA species of O and H are distinguished for lower energy-mass ratio in some time- segments by analyzing the signals of pulse heights of second electrons emitted from the carbon foil and impacted on the MCP detector in the TWINS sensors. In order to eliminate the possible influence on retrieval caused by instrument bias error, a differential voxel CT technique is applied. To weaken the influence of low altitude emission (LAE) produced by ion precipitation, a correction is made for the ENA intensity along the line-of-sight that run deep into the high latitude atmosphere, invoking the so called thick-target approximation. The flux intensity of the ENAs' parent ions in the RC has been obtained as a function of energy, L value, MLT sector and latitude, along with their time evolution during the storm-time substorm expansion phase. Forward calculations proved the reliability of the retrieved results. It shows that the RC is highly asymmetric with a major concentration in the midnight to dawn sector for equatorial latitudes. The ion flux spectra undergo dramatic changes from pre-storm to the main phase. Besides, halfway through the substorm expansion there appeared a large enhancement of equatorial ion flux at lower energy-mass ratio (2.7 keV/amu) in the later afternoon to dusk ranging from L=2.5 to 7, of which the inner part in the afternoon shows more abundant oxygen ions than hydrogen. Whether the abundant oxygen comes directly from the ionosphere and whether it relates with plasmaspheric plume are worthy of further study.

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