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Energy budget of the coupled ionosphere and thermosphere around the cusp region

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The ionosphere and thermosphere are the region where the energy originated from the solar wind finally dissipates through the Joule heating, the work done by Ampere force, and the direct heating by particle precipitation. Ground-based and satellite observations have revealed that the electromagnetic energy dissipation has a significant role for dynamics, composition change and the energy budget in the ionosphere-thermosphere (IT) system. Various ionospheric phenomena have been observed in the cusp and polar cap region. The details of the thermospheric variations concerned with the ionospheric phenomena are, however, still unknown. EISCAT Svalbard Radar (ESR) was founded in 1996 and is located at Longyearbyen; (75.3 MLAT; MLT=UT+ about 3hours), Svalbard, Norway. The ESR together with the mainland EISCAT radars can cover a wide region from the auroral oval to the cusp and polar cap region. The purpose of this study is to evaluate the electromagnetic energy dissipation rates in the cusp and the polar cap region and to understand their roles in the IT system. In order to investigate the dissipation processes of the electromagnetic energy in the IT system around the cusp region, electromagnetic energy transfer rate (EETR), Joule heating rate (JHR) and passive energy deposition rate (PEDR) were evaluated using the ESR data.

Two periods were selected for detailed analysis. The first period was the time interval 0400-1200 UT (0700-1500 MLT) on September 22, 1998 when solar activity was moderate (F10.7=141.1*10^-22[W/m^2/Hz]) and geomagnetic activity was quiet (Kp=1_+). During this period, the ESR was located equatorward of the polar cap or cusp region. The second period is the time interval 0400-1200 UT on March 9, 1999 when solar activity was moderate (F10.7=127.1*10^-22 [W/m^2/Hz]) and geomagnetic activity was relatively high (Kp=3_+). The ESR was located in the plasma mantle region in this case. The values of PEDR per unit mass were evaluated at the altitude range between 92 and 672 km for both periods of September and March. Enhancements of the southward component of the electric field caused increase of PEDR per unit mass. The maximum values of PEDR per unit mass were 5-10 times as large as the heating rate due to absorption of solar EUV emission.

The effect of the neutral wind on JHR was investigated in the case of September 22, 1998 in the altitude range between 98 and 116 km with a resolution of about 3 km. The contribution of the neutral wind to JHR was also strongly dependent on the wind field driven by various forces, e.g., tides and ion drag. When the eastward component of the neutral wind due to the semidiurnal tide was enhanced in the time interval 0440-0528 UT at 98 km altitude, the value of mechanical energy transfer rate was positive and larger than JHR. When the northward component of the neutral wind due to the ion drag was enhanced in the time interval 0556-0628 UT above 110 km altitude, the value of mechanical energy transfer rate was negative. The values of JHR and PEDR were almost the same in the two cases of September and March.