Seasonal variations of electron density and ion upflow in the topside ionosphere

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The ionosphere was considered to play a passive role on energy and mass transfers between the magnetosphere and ionosphere. Recent observations, however, have clearly shown that the ionosphere sometimes plays an active role on them, that is, ionospheric electrons being sometimes accelerated to a few keV carrying downward FACs. Such upward electron beams are observed almost exclusively winter, suggesting that the ionosphere is important in their formation. Based on an analysis of data obtained from EISCAT, we present seasonal variations of plasma distributions above E region to understand relationships between poorer electron density and the production of field-aligned electric field in winter. We then show that the occurrence and strength of ion upflows have dependence on season.

The magnetosphere and ionosphere strongly interact each other, exchanging energy in fields and particles. The ionosphere was previously considered to play a passive role on these energy and mass transfers called the M-I coupling. Recent observations, however, have clearly shown that the ionosphere sometimes plays an active role on them. Indeed, observations with the FAST and Freja satellites have shown that ionospheric thermal electrons are sometimes accelerated to a few hundred eV - a few keV carrying downward field-aligned currents. Such upward electron beams are observed almost exclusively in the winter hemisphere, suggesting that the ionospheric conductivity and/or ionospheric electron distribution are important in their formation. The ionospheric conductivity relates to current closure in the ionosphere thus determines the electric field through current closure, while the distribution of electrons in the F region, topside ionosphere and bottomside magnetosphere that carry these downward field-aligned currents is heavily involved in the field-aligned electric field formation. On the other hand, Radar and satellite observations have shown that the ionosphere can be a major source of plasmas for the magnetosphere.

In this paper, mainly based on an analysis of data obtained from the EISCAT radars, we first present seasonal variations (solar zenith angle dependence) of plasma distributions above E region in order to better understand relationships between poorer electron density and the production of field-aligned electric field in winter. We then show that the occurrence and strength of ion upflows has not only dependence on magnetic disturbance such as AE and Dst but also significant dependence on season and/or solar zenith angle. Ion upflows are seen more strongly in winter than in summer under moderate disturbances.