Characteristics of ion upflows from the low-altitude ionosphere observed by EISCAT

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Molecular ions ($O_2^+/NO^+/N_2^+$) in the magnetosphere have been observed during the magnetic storms [e.g., Klecker et al., 1986]. Recent Arase observations in the ring current revealed that the existence of the molecular ions is a common phenomenon during geomagnetically disturbed period under Dst < -30 nT [Seki et al., 2019]. These molecular ions are considered to originate from the low-altitude ionosphere (altitude < 300 km). In order to escape to the magnetosphere, they thus need to have been transported upward from low-altitude ionosphere below 300 km altitude by some heating processes such as ion frictional heating, electron turbulent heating and small-scale plasma instability. However, what mechanism causes such an ion upflow from the low-altitude ionosphere is not known, because it is difficult to transport molecular ions against dissociative recombination [Peterson et al., 1994]. In this study, we aim at observational investigation of the ion upflow mechanisms based on simultaneous observations by the EISCAT radar and the Arase (ERG) satellite.

Three ion upflow events from the low-altitude ionosphere during geomagnetically disturbed periods (Dst < -30 nT) are analyzed in detail using the EISCAT uhf radar data. These ion upflows have similar features: the upward velocity along the field aligned direction with ion temperature enhancement at 200-400 km altitudes and electron temperature enhancement at 100-120 km altitudes. It indicates that the ion frictional heating caused by strong electric field formed these ion upflows from the low-altitude ionosphere. On the other hand, we found ion upflow events from the low-altitude ionosphere which showed different features from the above three events. Geomagnetic conditions are less active (Dst ~ 0 nT, AE ~ 200 nT) in these latter events. The ion upflows occurred with no significant ion heating but with electron density and temperature enhancement. It suggests that electron heating caused by soft electron precipitation created the second type of the ion upflows from the low-altitude ionosphere.

Keywords: Ion upflow, Molecular ion, Ionospheric heating, EISCAT radar, Arase (ERG) satellite

