

## Study on ion upflow based on high latitude IS radars and future EISCAT\_3D Study on ion upflow based on high latitude IS radars and future EISCAT\_3D

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An important phenomenon of magnetosphere-ionosphere coupling is the formation of upwelling ions in the topside polar ionosphere. These upflows can be a significant loss of atmospheric gasses into interplanetary space and a significant source of magnetospheric plasma, which may also affect the dynamics of the magnetosphere. Key processes for upward ion flows in the topside ionosphere are suggested to be frictional heating, ambipolar diffusion driven by a heated electron gas, and transverse ion acceleration produced by plasma waves. It is critical to determine the relative importance of the different mechanisms in operation and to understand the 3D distribution and composition of the upflowing ions and neutrals. Moreover, there are several transitions of upflowing ions, for examples, from chemical to diffusion dominance at 500-800 km altitude, from subsonic to supersonic flow at 1000-2000 km altitude, and from collisional to collisionless region at 1500-2500 km altitude.

The ion upflows have been investigated with incoherent scatter (IS) radars at high latitude. Future EISCAT\_3D is one of the most suitable measurements to investigate such transitions because of its wider height coverage (up to about 2000 km) along the field line. EISCAT\_3D will have more transmitter power density and higher sensitivity than those of the current IS radars at high latitude, and will give information of accurate thermal ion velocity, upward flux, and ion composition (O<sup>+</sup>, H<sup>+</sup>, and hopefully NO<sup>+</sup>). A combination of the EISCAT\_3D, ground-based optical instruments, and in-situ measurements is definitely essential to solve several key questions of ion upflow and outflow study. In this paper, we show potential investigations of ion upflow and outflow using the EISCAT\_3D, and also discuss a desirable combination of the EISCAT\_3D and its related observations for the ion upflow and outflow study.

Keywords: EISCAT, incoherent scatter, EISCAT\_3D, upper atmosphere