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Observations of ion outflows at high-latitudes derived from ground-based radar and spacecraft measurements

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The escape of heavy ions from the upper atmosphere is an important process through which planetary atmospheres are lost, and plays a crucial role in determining the mass and energy density of the overlying magnetosphere. This additional mass affects the transport of magnetospheric energy from the ring current by MHD waves. Detailed observations of such outflow events are required in order to establish the physical processes - such as energy input from precipitating electrons, the convection electric field and wave-particle interactions - that can accelerate the heavy ions so they can overcome the effects of gravity. An important question to be addressed is whether the main cause of the initial ion upwelling is ion frictional heating or ambipolar electric fields set up by electron precipitation into the ionosphere, and whether this population is subsequently accelerated by some form of wave-particle interaction.

A number of conjunctions between incoherent scatter radars and the FAST satellite (over the whole life-time of the spacecraft) have been examined in order to characterise the conditions required for ionospheric upwellings detected by the radars to become ion outflows identified by FAST. The radars offer a unique diagnostic of ionospheric composition and vertical motion, and their observations are essential in order to resolve the question of what is the dominant mechanism leading to upwellings and whether these events are directly related to the outflows observed.