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Heating and acceleration of escaping planetary ions

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The magnetic field of the Earth acts like a shield against the solar wind, leading to a magnetopause position many planetary radii away from the planet, in contrast to the situation at non- or weakly magnetized planets such as Mars and Venus. Despite this there is significant ion outflow due to solar wind interaction from the cusp and polar cap regions of the Earth's ionosphere. Effective interaction regions form, in particular in the ionospheric projection of the cusp, where ionospheric plasma flows up along the field-lines in response to magnetospheric energy input. Strong wave-particle interaction at altitudes above the ionosphere further accelerates the particles so that gravity is overcome. For the particles to enter a direct escape path they must be accelerated along open magnetic field lines so that they cross the magnetopause or reach a distance beyond the region of return flow in the tail. This return flow may also be either lost to space or returned to the atmosphere. Throughout this transport chain the heating and acceleration experienced by the particles will have an influence on the final fate of the particles. We will present quantitative estimates of centrifugal acceleration and perpendicular heating along the escape path from the cusp, through the high altitude polar cap/mantle, based on Cluster spacecraft data. We will open up for a discussion on the benefits of a ponderomotive force description of the acceleration affecting the ion circulation and escape. Finally we will compare with the situation at the unmagnetized planets Mars and Venus and discuss to what extent a magnetic field protects an atmosphere from loss through solar wind interaction.