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Cold Ion Escape from the Martian Ionosphere - 2005-2014

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It has always been challenging to observe the flux of ions with energies of less than 10eV escaping from the planetary ionospheres. We here report on new measurements of the ionospheric ion flows at Mars by the ASPERA-3 experiment on board Mars Express. The ion sensor IMA of this experiment has in principle a low-energy cut-off at 10eV but in negative spacecraft charging cold ions are lifted into the range of measurement but the field of view is restricted to about 4x360 deg. In a recent paper Nilsson et al. (Earth Planets Space, 64, 135, 2012) tried to use the method of long-time averaged distribution functions to overcome these constraints. In this paper we first use the same method to show that we get results consistent with this when using ASPERA-3 observations only. But then we can show that these results are inconsistent with observations of the local plasma density by the MARSIS radar instrument on board Mars Express. We demonstrate that the method of averaged distribution function can deliver the mean flow speed of the plasma but the low-energy cut-off does usually not allow to reconstruct the density. We then combine measurements of the cold ion flow speed with the plasma density observations of MARSIS to derive the cold ion flux. In an analysis of the combined nightside datasets we show that the main escape channel is along the shadow boundary on the tailside of Mars. At a distance of about 0.5 R_M the flux settles at a constant value which indicates that about half of the transterminator ionospheric flow escapes from the planet. To derive the mean escape flux we include all combined observations of ASPERA-3 and MARSIS from 2005 to 2014.

Possible mechanism to generate this flux can be the ionospheric pressure gradient between dayside and nightside or momentum transfer from the solar wind via the induced magnetic field since the flow velocity is in the Alfvénic regime.