EPSC Abstracts
Vol. 6, EPSC-DPS2011-487, 2011
EPSC-DPS Joint Meeting 2011

Enhanced atmospheric oxygen outflow on Earth and Mars driven by a corotating interaction region

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Abstract

Solar wind controls non-thermal escape of planetary atmospheric volatiles, regardless of the strength of planetary magnetic fields. For both Earth with a strong dipole and Mars with weak remnant fields, the oxygen ion (O+) outflow has been separately found to be enhanced during corotating interaction region (CIR) passage. To discern the role of terrestrial dipole in protecting planetary volatiles, here for the first time, we compared the enhancements of O+ outflow on Earth and Mars to a CIR which passed by in January, 2008 when Sun, Earth and Mars were approximately aligned. The CIR propagation was recorded by STEREO, ACE, Cluster and Mars Express (MEX). During the CIR passage, Cluster observed enhanced flux of upwelling oxygen ions above the Earth's polar region, while MEX detected increased escape flux of oxygen ions in the Martian magnetosphere. We found that, under a solar wind dynamic pressure increase by 2-3 nPa, the rate of increase in Martian O+ outflow flux was one order higher than those on Earth, thus the dipole effectively prevents coupling of solar wind kinetic energy to planetary ions. Surprisingly, as response to the same part of the CIR body, the rate of increase in Martian O+ outflow flux was on the same order as for Earth. We suggest that, besides existence of a dipole field, the distance to the Sun is also crucially important for planetary volatile loss in our inner solar system.