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Escape of Hot O, C, N, and H atoms for present Mars

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Abstract

Lower energetic neutral atoms which are produced due to photochemical reactions in planetary thermospheres play an important role for the escape of atmospheric species at Mars. The newly photochemically generated energetic neutral atoms, O, C, N, and H are traced from their point of origin up to the exobase or beyond, by using a 3D Monte-Carlo model and the kinetics and transport characteristics of these particles are determined. The simulation includes the collision of the suprathermal particles with the background gas, energy transfer, and the tracing of secondary and cascaded hot atoms, which are generated in collisions of the hot particles with ambient constituents. A non-linear electron dissociative recombination coefficient as well as energy and mass dependent collision cross sections and their corresponding scattering angles are also taken into account. The exosphere density is obtained from the corresponding energy and angular distribution at the exobase by using a test particle model which follows the ballistic trajectories of hot atoms in the exosphere.

In this model we consider inelastic and quenching collisions between the traced hot particle and the ambient neutral atmosphere as well as differential cross sections to determine the scattering angle in the collisions. We also include rotational and vibrational excitation energies for the calculation of the initial energy of the produced hot oxygen, carbon, nitrogen, and hydrogen atoms.

The simulated energy distribution functions for the hot O atoms for high and low solar activity are shown in Figure 1. By integrating the EDFs of the oxygen atoms over energies higher than the escape energy of 1.97 eV (at an altitude of 200 km), the escape flux and also the loss rate are obtained. For low solar activity they are 3.2×10^8 cm^{-2} s^{-1} and 2.5×10^{26} s^{-1}, respectively. For high solar activity the escape flux is 6.6×10^8 cm^{-2} s^{-1} and the loss rate is 5.0×10^{26} s^{-1}. These loss rates are 1 - 3 orders of magnitudes higher than other escape processes like ion pick up of O^+, sputtering of O, cool ion outflow, and ion escape of CO_2^+ and O_2^+ (see Table 1).

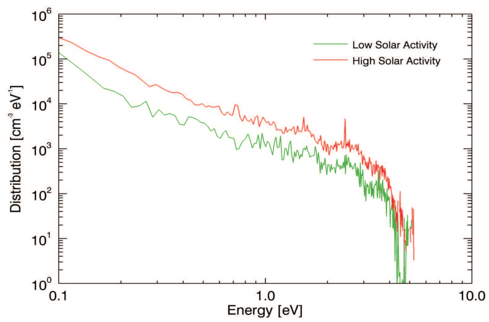

Figure 1: Energy distribution function for hot oxygen atoms for high and low solar activity.

Table 1: Loss rates of other escape processes.

Escape process	Loss rate [s^{-1}]
Ion pick up of O^+	3×10^{24}
Sputtering of O	3.5×10^{23}
Cool ion outflow	$\leq 10^{25}$
Ion escape of CO_2^+ and O_2^+	$\leq 10^{23}$

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