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Comparison of escape processes in the early atmosphere of Mars

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We study the loss of O and C and hence CO_2 during Mars' history since about 4 Gyr ago due to ion pick-up, sputtering, and photochemical processes. Three points in time corresponding to 1, 3, and 10 times the present solar EUV flux are considered. The production and escape of supra-thermal O and C, whose profiles together with the background atmosphere are used to calculate ionization rates, are simulated with a Monte-Carlo model. The trajectories of the newly created ions are calculated by means of a hybrid code, taking into account the interaction with the magnetized solar wind. We also determine loss rates due to sputtering of the incident O and C ions.

Due to thermospheric heating and related expansion we find that ion pick-up and sputtering loss become the dominant escape mechanisms for EUV fluxes larger than 3 times the present flux. This suggests that up to about 1 Gyr after Mars' origin, the main loss mechanisms are ion pick-up and sputtering processes, whereas loss due to supra-thermal atoms was more efficient during later times. Finally, we compare our loss rates to other model results.