

The influence of atmospheric loss processes to the evolution of the Martian atmosphere and water inventory

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We apply a diffusive-gravitational equilibrium and thermal balance model for high X-ray and EUV flux values which can be expected after the Sun arrived at the Zero-Age-Main-Sequence for the study of the radiation impact on the CO₂-rich Martian thermosphere due to photodissociation and ionization processes, exothermic chemical reactions and cooling by CO₂ IR emission in the 15 micro-m band. Our results show, that during the Noachian epoch high XUV fluxes between 10 to 100 times that of the present Sun were responsible for much higher temperatures of the early Martian thermosphere-exosphere environment. We found that the exobase level could expand to an altitude which was about 10 times that of the present one of about 200 km (4.5 Gyr ago). In order to study the effect of high XUV fluxes and the part of the upper atmosphere which could have been lost to space over the planet's history, we apply a global 3-D magnetohydrodynamic (MHD) simulation model of the solar wind interaction with the extended upper atmosphere. Furthermore we study the possible protection of the early Martian atmosphere and its water inventory by an intrinsic magnetic field against ion pick up by the solar wind plasma of the young active Sun. If one assumes that impact erosion was nearly in balance with impact atmospheric delivery, our results would favour a weak early dynamo with a magnetic moment less than 0.1 that of the present Earth combined with a higher heating efficiency in the thermosphere, or a late onset of the Martian dynamo at least after about the first 150 to 200 Myr after the planet's origin. In such cases the XUV heated and expanded

upper atmosphere could have lost, depending from the solar wind mass flux of the young Sun from several bar up to several tens of bar.