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Atmospheric and water loss from early Venus

H. Lammer (1), Yu. N. Kulikov (2), H. I. M. Lichtenegger (1), N. Terada (3)

(1) Space Research Institute, Austrian Academy of Sciences, Graz, Austria (helmut.lammer@oeaw.ac.at), (2) Polar Geophysical Institute (PGI), Russian Academy of Sciences, Murmansk, Russian Federation (kulikov@pgi.ru), (3) National Institute of Information and Communications Technology, Tokyo, and Japan Science and Technology Agency, Saitama, Japan (teradan@nict.go.jp)

We investigate how the enhanced radiation and particle envionment of the young Sun could have influenced the evolution of the early Venusian atmosphere. In particular we focus on the dissociation of water and the loss of oxygen by ion pick up processes. For modelling the Venusian thermosphere over its history, we apply a diffusive-gravitational equilibrium and thermal balance model and investigate the heating of the early thermosphere by photodissociation and ionization processes, arising from exothermic chemical reactions and cooling by CO2 IR emission in the 15 mu m band. Our model simulations support an expanded thermosphere for Venus with exobase levels between about 200 km at present and about 2200 km 4.5 Gyr ago. Moreover, our results indicate high exospheric temperatures of more than 8000 K during the early active phase of the young Sun even if we assume a dry CO2 atmosphere with a similar composition to that observed today for Venus. Exospheric temperatures larger than 4000 K lead to diffusion-limited escape and high loss rates for atomic hydrogen dissociated from water. The duration of this blow-off phase for atomic hydrogen depends essentially on the mixing ratios of CO2, N2 and H2O in the early Venusian atmosphere and could last from about 150 to several hundred Myr, resulting in a large thermal loss of water from Venus. We used our model atmosphere density profiles and studied the loss of atomic oxygen pickup ions from Venus' upper atmosphere over time by applying a numerical test particle model. Depending on the solar wind parameters, our model simulations showed that ion pickup by a strong early solar wind on a non-magnetized Venus could erode more than about 250 bar of atomic oxygen ions during 4.6 Gyr, which corresponds to an equivalent mass of one terrestrial ocean.