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Martian exobase temperature inferred from radio occultation measurements

S. Kazeminejad (1, 2) , **H.I.M. Lichtenegger** (2), H. Lammer (2), Yu.N. Kulikov (3), G. Kirchengast (1) and S.J. Bauer (1)

(1) Institute for Geophysics, Astrophysics, and Meteorology, University of Graz, Universitätsplatz 5, A-8010 Graz, Austria, (shahin.kazeminejad@gmx.at, gottfried.kirchengast@uni-graz.at, siegfried.bauer@uni-graz.at), (2) Space Research Institute, Austrian Academy of Sciences, Schmiedlstrasse 6, A-8042 Graz, Austria, (herbert.lichtenegger, helmut.lammer@oeaw.ac.at), (3) Polar Geophysical Institute (PGI), Russian Academy of Sciences, Khalturina Str. 15, Murmansk, Ru-183010, Russian Federation, (kulikov@pgi.ru)

The thermospheric heating processes and the formation of the ionospheres of terrestrial planets like Venus, Earth and Mars are mainly controlled by the solar X-ray and Extreme Ultraviolet radiation (0.1 - 100 nm). Lyman-alpha airglow observations by several Mars missions yield exospheric temperatures up to about 350 K. There is much evidence however, that these exospheric temperature estimates are to high. The reason for that comes mainly from to the fact that hot neutral hydrogen particles may have contaminated the used data. Our study compares the ionospheric data obtained by radio occultation measurements of various spacecraft. Several various data sets were obtained during different solar activity periods can study the behavior of the dependence between the neutral temperature at the exobase, obtained from a Chapman ionospheric profile near the ionospheric peak, and the solar 10.7 cm radio flux ($F_{10.7}$). The exobase temperatures obtained by our method during low, medium and high solar activity periods result in exobase temperatures between 180 K – 250 K but never reach a value of about 350 K. We show model simulations of hot hydrogen atoms, which are produced via photo-chemical reactions in the Martian ionosphere and suggest that one can consider three hydrogen populations in the Martian exosphere environment: the bulk atmospheric hydrogen, a low very low energetic neutral hydrogen atoms (VLENAs) and at high altitudes energetic neutral hydrogen atoms (ENAs), which are cur-

rently observed by Mars Express' ASPERA-3 instrument. To test our assumptions we compare our results to known measurements of ionospheric profiles, corresponding solar $F_{10.7}$fluxes and in-situ obtained Pioneer Venus Orbiter (PVO) neutral gas temperatures at the exobase level of Venus. We find a very good agreement between the temperatures obtained by our model and the PVO observations. Thus, our study provides important results in the field of comparative planetology and helps to obtain good estimates of the Martian exobase temperature over the whole solar cycle, which has so far (in contrast to Venus) not been directly measured. Furthermore, our study contributes significantly to the overall analysis and understanding of the Mars Express mission data because the Japanese Nozomi spacecraft, which was equipped with a mass spectrometer allowing to infer the Martian exosphere temperature, failed.