Improved NLTE model for the IR CO_2 bands emission in the Martian atmosphere

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Radiative transfer in the IR ro-vibrational bands of CO_2 is an important factor in establishing the structural and dynamical properties of the entire Martian atmosphere. Also, the emissions in some of the CO_2 bands are used for remote sensing of the atmosphere during spacecraft missions to Mars. So these reasons require more sophisticated models of populations of the excited vibrational states of the CO_2 molecules. A model for solving the problem of radiative transfer in the CO_2 bands under non-local thermodynamic equilibrium (NLTE) in the Martian atmosphere has been further developed. In comparison to the previous version of our model [1], the main improvements are as follows. 1) Radiative transfer in the near-infrared CO_2 bands within the $5 \div 1.02$ μm spectral range was considered with exact treatment of overlapping over frequency of ro-vibrational lines. 2) The IR spectral line radiation absorption due to dust aerosols, whose optical depth can be significant during Martian global dust storms (GST), was taken into account for the first time. 3) The set of the V-V and V-T processes of CO_2 molecular vibration energy exchange during collisions between different species of the Martian atmosphere has been renewed as well as the rate constants of these processes. The NLTE populations of more than 300 excited states of 7 isotopes of CO_2 with vibrational energy up to 9500 cm^{-1} are calculated using the Accelerated Lambda Iteration technique with relative error not worse than 10^{-5}. The effects of the above mentioned improvements on the CO_2 vibrational state populations as well as on the radiative cooling/heating rates in the IR CO_2 bands are demonstrated for different conditions in the Martian atmosphere including GST.

[1] Ogibalov, V.P., and Shved, G.M. // *Solar System Res.*, **Vol. 37**, No. 1, pp. 23-33, 2003.