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An efficient scheme for calculation of the non-LTE infra-red radiative cooling/heating rates in the Martian GCM

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The non-LTE infrared radiation plays a crucial role in the physical processes of the Martian atmosphere. The 15 μm CO_2 band is the main cooling factor of the middle atmosphere. The absorption of near infra-red solar radiation is an important heating factor. The middle and upper atmosphere are significantly influenced by the absorption of the infrared radiation originating in the lower atmosphere.

Accurate calculations of the non-LTE cooling/heating (CH) require a self-consistent solution of the ro-vibrational relaxation problem and the radiative transfer equation for a very large number of ro-vibrational lines (line-by-line (LBL) approach, [Lopez-Puertas and Lopez-Valverde, 1995], [Gusev and Kutepov, 2003]) and, therefore, is very time consuming. On the other hand, schemes based on the cooling-to-space approximation, although fast, do not provide the desired accuracy of the CH calculations.

We developed a new efficient and accurate routine for calculating the non-LTE CH in the Martian atmosphere. This routine:

- relies on the exact accelerated lambda iteration (ALI) solution of the vibrational non-LTE problem in CO_2 [Gusev and Kutepov, 2003];
- utilizes opacity distribution function (ODF) technique [Mihalas, 1978]; ODF approach allows [Kutepov et al., 2004] treating each ro-vibrational band as a single line of a special shape whose variation with respect to pressure and tem-

perature is parameterized. Compared to the standard LBL approach the ODF method provides an acceleration of the calculations by a factor close to the number of lines in the band;

- accounts for the absorption and transformation of the near-IR solar radiation;
- allows varying all input collisional rate and spectroscopic parameters;
- calculates CH with a prescribed accuracy (as determined by comparison with the elaborated reference data) by utilizing the optimized sets of vibrational levels and bands.

New routine is about 1×10^5 times faster than the LBL approach when reproducing CH data with 10% accuracy. This allowed us to implement it into the Circulation model of Martian atmosphere developed in the Max-Planck Institute for Solar System Research [Hartogh et al, 2005], and to run it at the computers with moderate performance.

The results of the exact accounting for the non-LTE CH during the long-term GCM calculations will be presented.

References

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