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Radiative effects of molecules in Jupiter's stratosphere: Development of a code for the implementation to a GCM

T. Kuroda (1), A.S. Medvedev (2) and P. Hartogh (2)
(1) Department of Geophysics, Tohoku University, Sendai, Japan, (2) Max Planck Institute for Solar System Research, Katlenburg-Lindau, Germany (tkuroda@pat.gp.tohoku.ac.jp / Fax: +81-22-795-6406)

Abstract

Here we report the development of a scheme which calculates the radiative effects of molecules for a Jupiter's stratosphere general circulation model (GCM) based on a terrestrial radiation code [1]. We have performed preliminary calculations of heating/cooling rates in Jupiter's stratosphere from 1-D profiles of temperatures and composition, and have got the results comparable to preceding studies [2].

1. Introduction

Jupiter's stratosphere extends for more than 350 km above the visible cloud top, with the pressure range of roughly between 10^3 and 10^{-3} hPa. The main absorber of the solar radiation in these heights is CH_4, while the cooling is created mainly by C_2H_6, C_2H_2 and CH_4. We have calculated the heating/cooling rates by the molecules in solar and infrared wavelengths using the correlated k-distribution approaches [3], which is required for the fast and effective calculations in the GCM.

2. Preliminary calculations

Two vertical temperature profiles between 10^3 and 10^{-3} hPa, which are based on the observations, are provided for the calculations. One of the profiles is from the Galileo Probe [4] (Profile 1), and the other is from the Voyager 1 egress radio occultation [5] and linear extrapolation for upper atmosphere (Profile 2). The vertical distributions of the compositions of C_2H_6, C_2H_2 and CH_4 are required for the calculations, and they are derived from the simulation by a 1-D photochemical model [6] commonly for both temperature profiles. Profiles of temperatures and composition are shown in Figure 1.

The calculations have been performed with 60 layers in vertical. The absorption of solar radiation by CH_4 is calculated with 9 spectral bands between 960 and 9200 cm^{-1}, while the infrared absorption and emission by C_2H_6, C_2H_2 and CH_4 are calculated with 10 spectral bands between 10 and 2000 cm^{-1}. The absorption and emission are calculated using the correlated k-distribution method with 12 k-distribution integration points in each band. The radiative fluxes at the borders of each layer are calculated by the 2-stream adding method [7].

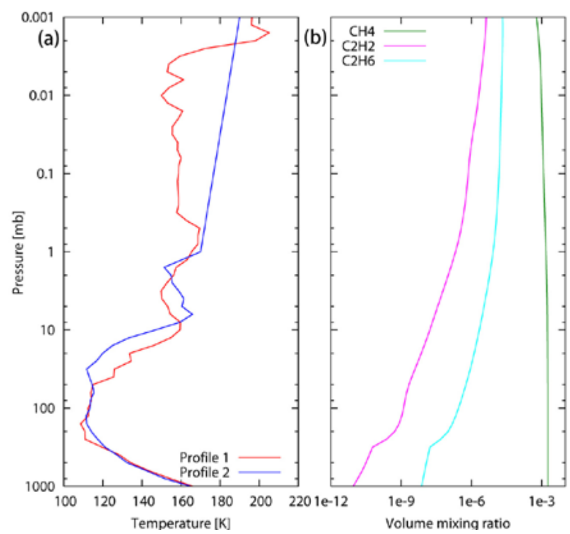

Figure 1: Vertical profiles of (a) temperatures and (b) atmospheric composition used in the preliminary calculations.

3. Results

Figure 2 shows the calculated heating/cooling rates, denoting heating in positive values, for the infrared radiation in each given temperature profile and solar radiation (without dependence on the temperature fields) with solar zenith angle of 0°. These vertical profiles are quantitatively comparable to the previous numerical study based on the smoothed Galileo Probe vertical temperature profile [2].

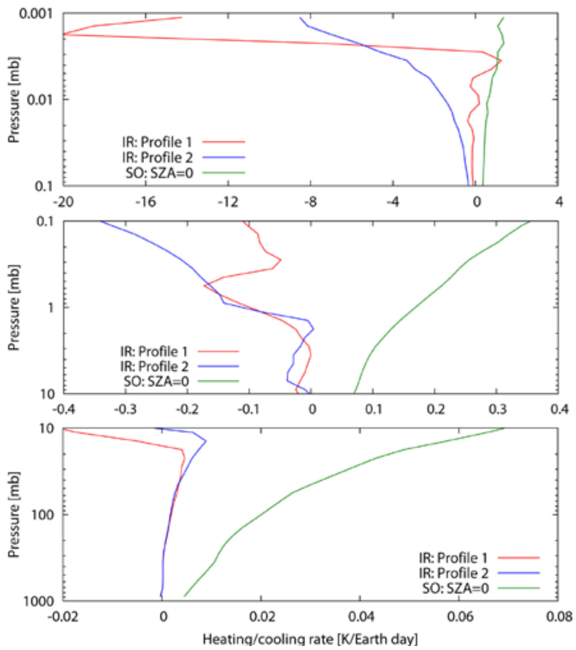

Figure 2: Calculated vertical profiles of heating/ cooling rates [K/ Earth day] for the infrared radiation in each given temperature profile in Fig.1 (red and blue) and solar radiation with solar zenith angle of 0° (green). Positive values denote the heating.

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