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Simulation study of Jupiter's stratosphere: development of a new radiation code and impacts on the dynamics

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We have developed a new radiation code of radiative heating and cooling for Jupiter's upper troposphere and stratosphere (10^3 to 10^{-3} hPa) suitable for general circulation models (GCMs). It is based on the correlated k-distribution approach, and accounts for all the major radiative mechanisms in the Jovian atmosphere (heating due to absorption of solar radiation by CH_4, and cooling in the infrared by C_2H_6, C_2H_2, CH_4 and collision-induced transitions of H_2-H_2 and H_2-He). The code can be applied for Saturn and extrasolar gas giants. Vertical 1-D calculations using this code demonstrated that temperature of Jupiter's stratosphere is close to radiative-convective equilibrium, and that the radiative relaxation time decreases exponentially with height (from 10^8 s near the tropopause to 10^5 s in the upper stratosphere). The latter differs from the study of Conrath et al. (1990), which showed the very long ($\sim 10^8$ s) relaxation time approximately constant throughout the stratosphere. Our calculations with the GCM show that the radiative relaxation time suggested by Conrath et al. (1990) is too long, and cannot sustain convergence of model solutions. With the newly derived vertical profile of relaxation time, simulations converge and produce realistic temperature and wind in Jovian stratosphere.

Keywords: Jupiter, Stratosphere, Atmospheric radiation, Atmospheric dynamics, Gas giants, JUICE