Modeling of Jupiter's stratosphere: new radiation code and impacts on the dynamics

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Development of a radiation code

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 atmospheric conditions there are affected by radiative processes by molecules in stratosphere, as well as eddies enhanced from the troposphere. 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, CH_4 and collision-induced transitions of H_2-H_2 and H_2-He.

We have developed a fast radiative scheme for calculating heating and cooling rates by these molecules based on the correlated *k*-distribution approach and suitable for implementation into general circulation models (GCMs) of Jupiter's stratosphere. The results of vertical 1-D calculations showed that the effects of cooling/heating by each atmospheric component are comparable to a preceding study [Yelle et al., 2001] and the temperature of Jupiter's stratosphere is close to radiative-convective equilibrium. Also our results showed that the radiative forcing in the upper stratosphere should be much stronger, which is different from a preceding study which showed that the very long (~10^8 s) relaxation time approximately constant throughout the stratosphere [Conrath et al., 1990]. The radiative relaxation time calculated with our radiation scheme decreased exponentially with height (from 10^8 s near the tropopause to 10^5 s in the upper stratosphere), which is qualitatively consistent with the observations [Simon-Miller et al., 2006].

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Development of a GCM

We have developed a GCM for Jupiter's stratosphere, covering in 10^3–10^{-2} hPa with 41 equally-spaced log-pressure levels. A high resolution in horizontal is required for a Jupiter GCM due to a small Rossby radius of deformation against the radius of planet. The study with Newtonian cooling for radiative parameterization showed that with a large radiative relaxation time (corresponding to Conrath's) the calculation failed very rapidly with temperature dropping continuously, indicating that the assumption cannot sustain convergence of model solutions. With the newly derived vertical profile of relaxation time, simulations converge and produce realistic temperature and wind in Jupiter's stratosphere.

Now the implementation of our radiation code into our GCM is ongoing. Our simulation study will contribute to the preparations for the observations of Jupiter's stratosphere by a sub-millimeter wave instrument onboard the JUICE (JUpiter ICy moons Explorer) spacecraft, JUICE-SWI, which will launch in 2022 and arrive at the Jupiter system in 2030.