R009-27
Zoom meeting D ：11/2 AM1 (9:00-10:30)
10:00〜10:15

CO2近赤外吸収と渦拡散強度による火星熱圏構造への影響

#中山 陽史 [1), 関 華奈子 [2), 中川 広務 [3), 品川 裕之 [4), 寺田 直樹 [5)
[1 東京大学,[2 東大理・地球惑星科学専攻,[3 東北大・理・地球物理,[4 情報通信研究機構,[5 東北大・理・地物

Effects of the CO2 near-IR absorption and strength of eddy diffusivity on the Martian thermosphere

#Akifumi Nakayama[1),Kanako Seki[2),Hiromu Nakagawa[3),Hiroyuki Shinagawa[4),Naoki Terada[5)
[1The University of Tokyo,[2Dept. Earth & Planetary Sci., Science, Univ. Tokyo,[3Dep. Geophysics, Grad. Sch. Sci., Tohoku Univ.,[4NICT,[5Dept. Geophys., Grad. Sch. Sci., Tohoku Univ.

The temperature and compositional structure in the thermosphere have a crucial importance of the evolution of planetary atmosphere via the atmospheric escape because the temperature and composition at the thermosphere would determine the supply rate of gas to the exosphere. On the other hand, CO_2 dominated atmosphere is popular not only for the planets in the Solar system but also for water-rich terrestrial exoplanets in the habitable zone [e.g. Nakayama et al. 2019]. Thus, we discuss uncertainty of numerical modeling and consistency to observations for the CO_2-rich Martian thermosphere because recent MAVEN observations provide enough knowledge of the Martian thermosphere. In generally, the structure of the thermosphere is known to be determined by complex processes, such as photo- and thermo-chemistry, radiative cooling, and mixing and separation via molecular and eddy diffusion. In particular, we have no enough knowledge of the effect of strength of eddy diffusion on the temperature structure, although there are some studies to discuss the effects on compositional structure [e.g., Nier & McElroy 1977]. On the other hand, CO_2 near-IR absorption has an important role to the temperature structure of CO_2-rich atmosphere [e.g., Bougher & Dickinson 1988]. Although previous study adopted the band model, such as k-distribution method, for the radiative transfer [Bougher et al. 2015], we need to determine the absorption and heating profile, using line-revolved method because teneous upper atmosphere only absorb strong absorption lines. In this study, we evaluate effects of the CO_2 near-IR absorption and strength of eddy diffusivity on the structure of the Martian thermosphere.

We develop the thermosphere model based on Johnstone et al. (2018). This model estimates steady-state thermospheric structure, considering photo- and thermo-chemistry, molecular and eddy diffusion, non-LTE radiative cooling, and CO_2 near-IR absorption. For the near-IR absorption, we adopt the Line-by-line (LBL) method using HITRAN2012 database [Rothman et al. 2013]. We assume present Martian condition for UV spectrum and temperature and composition at the lower boundary. We adopt the scaling law for eddy diffusivity derived by Krasnopolsky et al. (1986) and vary its strength by an order of magnitude. For the LBL method, we vary wavenumber resolution from 1 to 0.01 cm^{-1} to evaluate the impact on the heating profile.

We found the numerical method of near-IR absorption and eddy diffusivity affect temperature structure in the thermosphere located typically from 100 to 200km. Both give temperature difference of typically 20K at the exobase. In particular, the LBL method provide different absorption and heating profiles from those estimated by k-distribution method. In addition, the higher wavenumber revolution of the radiative transfer, the higher heating rate around exobase is because strong and fine absorption lines are absorbed in the upper part of the thermosphere. Our results indicate the importance of eddy diffusivity and line-resolved near-IR absorption for the CO_2-rich thermosphere with relative weak UV irradiance, like the present Martian thermosphere.

Reference:

Bougher, S. W., & Dickinson, R. E. (1988). Journal of Geophysical Research: Space Physics, 93(A7), 7325-7337.
Bougher, et al. (2015). Journal of Geophysical Research: Planets, 120(2), 311-342.
Nier, A. O., & McElroy, M. B. (1977). Journal of Geophysical Research, 82(28), 4341-4349.
Johnstone et al (2018). Astronomy & Astrophysics, 617, A107.
Krasnopolsky, V.A., 1986. Photochemistry of the Atmospheres of Mars and Venus. Springer-Verlag, Berlin.
Nakayama et al (2019). Monthly Notices of the Royal Astronomical Society, 488(2), 1580-1596.
Rothman et al (2013). Journal of Quantitative Spectroscopy and Radiative Transfer, 130, 4-50.