Effects of dust storms and supersaturation on the water cycle using DRAMATIC MGCM

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There is little water on Mars today, mainly formed as ice in the polar cap [1]. However, mineralogical observations suggest that liquid water existed approximately 3.5~3.8 billion years ago [2]. The past Martian water has likely been transported to the upper layers, photodissociated by ultraviolet light, and escaped into space [3]. Although the amount of water in the present atmosphere is small, on the order of μm in terms of precipitable water [1], the water cycle structure is a key to understanding atmospheric escape and climate change on Mars. Atmospheric escape and climate change have been studied based on spacecraft observations and climate model development. As for the climate model, the improvement of schemes for Mars-specific physical processes such as Global Dust Storms (GDS) [4] and supersaturation events [5] will be essential to improve the reproducibility of the simulations.

In this study, we compare simulations of MGCM (the Mars General Circulation Model), named DRAMATIC(Dynamics, RAdiation, MAterial Transport, and their mutual InteraCtions)[6] with observations of atmospheric water vapor mixing ratio in MY34 by ExoMars TGO and discuss the impact of supersaturation phenomena on the water vapor. Referring to the observation results of [7] that showed supersaturation occurred in the upper atmosphere, we compared the observation with the modeling results for the saturated water vapor pressure in three patterns: (i) no change, (ii) 10 times greater than the case (i) for global uniformity, and (iii) 10 times greater than the case (i) for Ls less than 180 degrees for an altitude of 60 km and Ls greater than 180 degrees for an altitude above 80 km. The results of (ii) are consistent with the observation [8] that showed water vapor reaching an altitude of over 100 km during GDS, while the results of (iii) remain at an altitude of around 70 km and not significantly different from (i). This result may be because in (ii) cloud condensation was suppressed, and water vapor content increased at all altitudes. In contrast, in (iii), all condensation occurred below the altitude where supersaturation occurred. We raised the maximum altitude of dust distribution to fit the GDS observation [4] and performed (iii) again, resulting in an increase in atmospheric temperature and successfully transporting water vapor up to altitudes around 90~100 km.

Since accurate reproduction of supersaturation requires detailed cloud microphysics [9] and the saturation ratio varies with atmospheric conditions such as temperature change and water vapor transport [10] , the saturated water vapor pressure modeling in this study is not optimized to reproduce real supersaturation. In future studies, we plan to implement a cloud microphysics scheme to adjust the saturation ratio to reproduce cloud formation and water vapor distribution more realistically and improve dust's vertical distribution. In this presentation, we will report on the current status of our study.

[1] Lasue et al.,2013 [2] Ribring et al.,2006 [3] Jakosky,2021 [4] Kass et al.,2019 [5] Maltagliati et al.,2011 [6] Kuroda et al.,2005 [7] Fedorova et al.,2022 [8] Aoki et al.,2019 [9] Navvaro et al.,2014 [10] Fedorova et al.,2020

Keywords: Mars, supersaturation, GCM

