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Modeling the HDO cycle with the LMD Mars GCM

Margaux Vals et al.

Abstract

HDO and the D/H ratio are important in order to understand Mars past and present climate, in particular through ages of the Martian water cycle. We present here further modeling developments of the HD (Forget et al. 1999), in continuation of the work presented by L. Rossi in session TP16 ("Modeling of the Storm on the martian HDO cycle."). These improvements are led with the perspective of comparison provided by the Atmospheric Chemistry Suite (ACS) on board the ESA/Roscosmos Trace Gas Orbiter.

Introduction

The D/H ratio observed in a planetary atmosphere is a proxy for the ratio of the current water reservoir of the planet. The current D/H ratio measured in the Martian atmosphere is at least five that of the Vio (SMOW) (Owen et al. 1988, Encrenaz et al. 2018, Krasnopolsky 2015, Villanueva et al. 2015). This high derived from the HDO/H₂O abundance ratio, is a precious indicator of the large escape of water from time. Apart from the mass difference between both isotopes, the differential escape of H and D comes from H₂O over HDO (Cheng et al. 1999) and the Vapor Pressure Isotope Effect (VPIE) that produces condensation (Krasnopolsky, 2000, Bertaux et al. 2001, Fouchet et al. 2000).

Modeling HDO

Although the version of the model used by L. Rossi et al. comprises the main last developments of the of the water cycle (no radiative effect of clouds, simple conversion from vapour to ice to reach the same consistent comparison with the previous study led by Montmessin et al. 2005. We present here the results with the complete representation of the water cycle, including the activation of the radiative effect (referring to the parametrization of the different processes of formation of the clouds as nucleation of water ice growth, dust scavenging and supersaturation) implemented in the model by Navarro et al. 2016 have been proved to considerably improve the representation of the water cycle in comparison to available

Preliminary results

The reinforcement of the Hadley circulation by the radiative effect of clouds, so as the involvement obviously affect the transport of HDO and its vertical distribution, which directly impacts the D/H ratio in a GCM simulation run over three martian years reveal a persistent behaviour of the D/H cycle. The D/H is close to the one observed by Montmessin et al. 2005, and also by L. Rossi in the abstract sub-emphasis of the latitudinal gradient appearing during the Northern Hemisphere Summer, probably (the) Hadley cell generated by the radiative effect of clouds (see Figure 1). The D/H ratio cycle of the ice phase between what happens during the first and the second part of the martian year. In particular, the high values at the tropics during the Southern Hemisphere spring and summer, while the corresponding amounts of the vapor (respectively around 10~ppb and 5000~ppb), have to be further investigated (see Figure 1). The vertical distribution is also impacted by the modified structure of the clouds led by the integration of the microphysics (see Fig

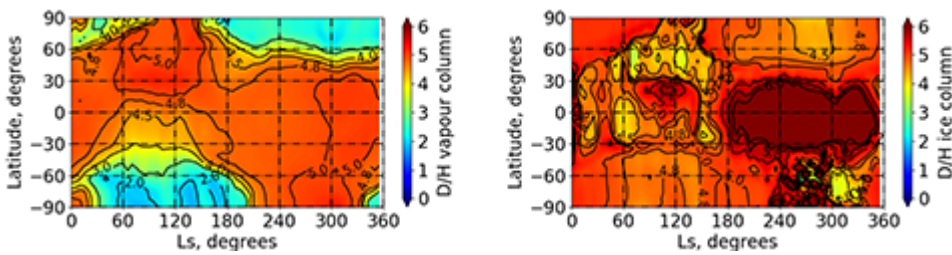


Figure 1: Zonal mean of the integrated column of D/H vapor and ice ratio over a martian year at the L_s (Solar Longitude). GCM simulation run with the radiative active water ice clouds and the microphysics

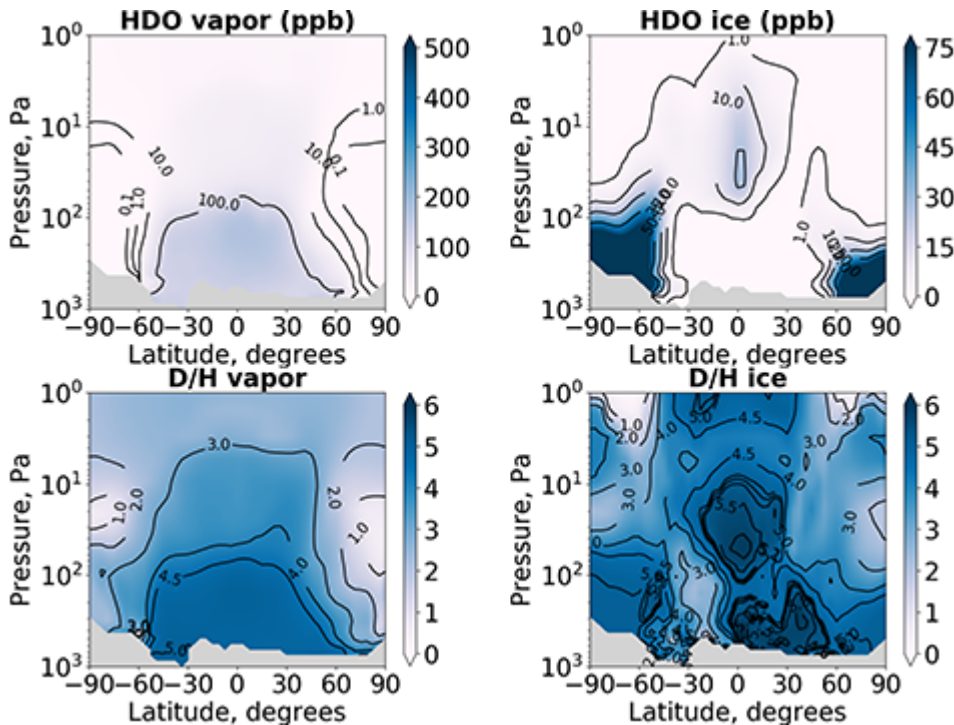


Figure 2: Zonal mean cross sections of HDO vapor, HDO ice, D/H vapor and D/H ice during southern spring

Conclusion

While the results of the simple physics of clouds allow a straightforward analysis of the fractionation regarding H_2O , the last simulations obtained with the microphysics of clouds account for a more realistic cycle and will offer the best basis for interpretation and comparison with the observations. For now,

extend to an altitude of around 120~km and they don't include the parametrizations of the thermosphere (Gonzalez-Galindo et al. 2009) and the photochemistry (Lefèvre et al. 2004, 2008). The ultimate goal is a complete representation of the deuterium cycle, from its source as HDO in the lower atmosphere to the thermosphere.

Results of the last achievements will be presented at the conference.

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