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Model expectations for the D/H distribution on Mars as observed by NOMAD

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Abstract

The NOMAD ("Nadir and Occultation for MArs Discovery") spectrometer suite on board the ExoMars Trace Gas Orbiter (TGO) has been designed to investigate the composition of Mars' atmosphere, with a particular focus on trace gases, clouds and dust, and started its science operations in April 2018. One of the primary science objectives of NOMAD is the detailed investigation of semiheavy water (HDO), both in nadir (total columns) and in solar occultation (vertical profiles). Interestingly, NOMAD has the capability to simultaneously retrieve H_2O and HDO, hence the very important D/H ratio. This ratio provides information on cloud formation and atmospheric escape. The GEM-Mars model was recently extended with HDO fractionation. We present some first results that will be useful to guide the interpretation of D/H data from NOMAD.

Introduction

The isotopic composition of fresh water on Earth has been defined by the Vienna Standard Mean Ocean Water (VSMOW), in which the HDO isotopologue of water has a relative abundance (D/H or ½× HDO/H_2O) of 155.76±0.1 ppm (parts per million). In the atmosphere of Mars, D/H has been found to be enhanced by 5-7 times compared to Earth [1, 2 and references therein], indicating a stronger atmospheric depletion of H_2O on Mars compared to Earth. Until now, HDO and D/H have been observed from Earth, and NOMAD will be the first instrument in orbit to provide detailed measurements. D/H fractionation is expected to occur in the Martian atmosphere following two processes: upon condensation/ evaporation of water, where the heavier isotopologue will condense/vaporize at slightly higher temperature, and by photolysis, where HDO has a lower absorption cross-section in the UV [3]. Also, the heavier isotope will escape less readily above the exobase during Jeans escape. Also the D/H ratio in ancient water ice reservoirs, such as the permanent water ice cap, is expected to impact on the atmospheric value [2].

Modeling the D/H ratio on Mars

The GEM-Mars General Circulation Model [4] includes both the formation of water ice clouds and photochemistry. As such, it is well equipped to do simulations of the D/H fractionation. First results will be presented and interesting features will be highlighted. Model expectations will be discussed in view of the observational geometries of NOMAD and if possible compared to first results (which will be presented in Aoki et al., this session). For example, the model can help to understand how representative observed D/H ratios are in the solar occultation mode, where measurements are confined to the terminator and could be affected by morning/evening cloud and fog formation.

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