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Summary

The mid-infrared channel of the Atmospheric Chemistry Suite (ACS) [1] onboard ESA's Trace Gas Orbiter (TGO) has performed a sensitive search of methane in the Martian atmosphere using the solar occultation technique for more than two Mars years (four terrestrial years). The first two reports [2,3] have concluded on the global absence of methane detection above a mean level of 50 then 20 parts-per-trillion-per-volume (pptv), contrasting with the 0.4 to 45 ppbv concentrations reported from Earth-ground-observations, Mars orbiters, and from Mars' surface by the Curiosity rover [5,6,7,8,9]. Here we present an update of the ACS methane search compiling all the ACS data collected up to summer 2022.

Introduction

For several decades, methane on Mars has been the subject of a continuous and intense search for it may resonate with an ongoing geophysical or biogenic activity on a planet that has long been perceived as inert. After a succession of failed attempts and positive detections between 2004 and 2019 [4,5,6,7,8,9,21,22], TGO started its trace gas detection mission in April 2018 and has continued since then. With its two separate state-of-the-art infrared spectrometers specifically conceived to achieve outstanding detection performances [1,10] for the ultra-sensitive search of a list of trace gases, including methane, TGO was aimed at confirming the presence of methane at Mars, or alternatively to establish the smallest upper limits possible. The Atmospheric Chemistry Suite (ACS) developed by IKI with the support of CNES is one of the spectrometers of TGO. Together with NOMAD, they offer a complementary access to the entire wavelength range from UV to thermal IR. They are also both observing the mid-IR range and therefore provide a redundant and thus reliable exploration of the presence of a variety of trace gases. Among the greatest achievements of these two experiments, we shall mention the joint observation of HDO and H_2O [11,12], the discovery of HCl [13,14,15], the close and joint monitoring of water and ozone [16,17,18], as well as the first CO profiles [19].

Method

The mid-infrared range, in particular the region around the fundamental 3.3 μm band of the C-H bond, provides the most sensitive way to detect methane and higher-order hydrocarbons (Fig. 1).

With ACS, this spectral region has been explored around Mars during the last four years and has revealed an absence of methane above a limit of 20 pptv (Fig. 2), while NOMAD similarly established such limit to 60 pptv [20].

The technique of solar occultation is known to be more sensitive than nadir since the Sun is a source at Mars that is ~600 000 times brighter that Mars itself. While the ubiquitous atmospheric dust prevents observing the near-surface region, the high-resolving power (30 000) and its high Signal-to-Noise Ratio (~10 000 at low level of dust) compensate for this limitation. We attempt to detect CH_4 using the R2 region which features the most intense individual lines of the band system. This region was backed up by parallel search in three other regions to have confirmation in case of a positive detection.

Results

With two Martian years of survey, the dataset consists of more than 1 000 individual altitude profiles. Since [3], improvements in the data processing have been implemented. This 4-year dataset will be presented along with its implications in regard to other observational studies and model attempts to explain reconcile the various observations.

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