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Surface release of methane on Mars: A model study in the framework of the future NOMAD mission

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Abstract

Two connected tasks are tackled in this work in order to provide useful information for the highly sensitive NOMAD solar occultation channel [1] on the future ExoMars Trace Gas Orbiter mission. Firstly, an analysis of potential chemical by-products of methane is carried out using a 1D model for atmospheric chemistry. Secondly, we aim to investigate the time and space evolution of methane after different surface release scenarios using a 3D Global Circulation Model (GCM) for the atmosphere of Mars (GEM-Mars), focusing specifically on the vertical distribution of methane.

1. Introduction

In the past decade, the detection of methane (CH_4) in the atmosphere of Mars has been reported several times [2, 3, 5, 8, 9]. These observations have strongly drawn the attention of the scientific community and triggered a renewed interest in Mars as their implications for the geochemical or biological activities are remarkable. However, given that methane is expected to have a photochemical lifetime of several centuries, the relatively fast loss rates of methane estimated from Earth-based measurements remain unexplained [6]. Although this gave rise to objections against the validity of those observations [11], recent in situ measurements [9] confirmed that methane is being occasionally released into the atmosphere from an unknown source (possibly from the ground). This is in this context that we present a model study of the behaviour of methane plumes and some preliminary results on the chemistry of methane in the atmosphere of Mars.

2. Chemistry of methane

Ten years ago, a chemical scheme involving methane and related compounds was proposed [10]. Photolysis and oxidation of methane (see Figure 1) leads to the production of several organic species of which the most important ones are formaldehyde (CH_2O), methanol (CH_3OH), and ethane (C_2H_6). In this work, all those reactions were implemented in a 1D model for atmospheric chemistry initially developed by A. García Muñoz [4]. A discussion will be held about the CH_4 loss reactions and the production of related species in the framework of the future NOMAD mission.

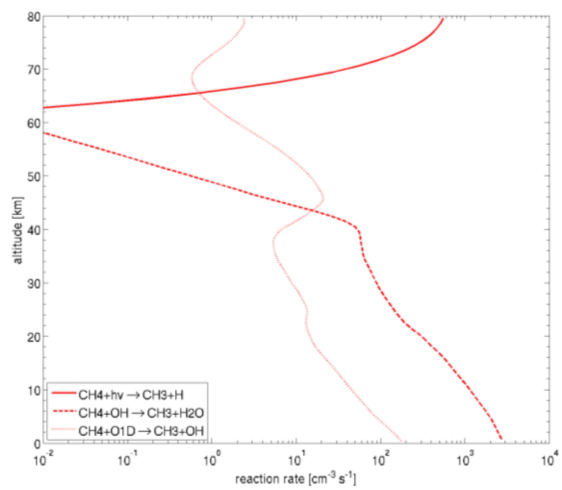

Figure 1. Rates of methane loss reactions as function of the altitude.

3. Surface release of methane

Mischna *et al.* (2011) investigated the behaviour of methane plumes formed in the Martian atmosphere [7]. Following on from that work, a 3D General Circulation Model for the atmosphere of Mars (called GEM-Mars) is used, paying specific attention to the evolution of the vertical distribution of methane after different surface release scenarios.

A few days after its release from the ground, methane is not uniformly dispersed into this atmosphere but can rather form layers at altitudes as high as 25-30 km (see Figure 2).

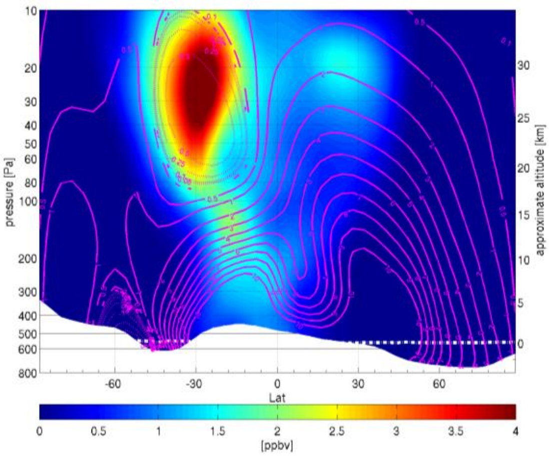

Figure 2. Zonal mean of methane mixing ratio 13.5 days after an instantaneous release at the equator. Contours in magenta represents the uniform values of the mass stream function.

4. Summary and Conclusions

This work in progress aims to develop a GCM (GEM-Mars) in order to support the future NOMAD mission. Two linked aspects are addressed: i) the chemistry of methane on Mars; ii) the evolution of methane in the atmosphere after surface release. We specifically put in evidence the remarkable formation of layers. This is relevant for the highly sensitive IR solar occultation of NOMAD with high vertical resolution.

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