Implications of the TGO results on potential surface emissions of methane on Mars

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As a potential biomarker, Martian methane has attracted attention through several reports of its detection over the last 15 years. Photochemical models predict that the lifetime of atmospheric methane should be of the order of 300 years, which implies that any detection would point to recent emissions. However, the very existence of this gas has been continuously questioned, in particular because the observed lifetime would be several orders of magnitude shorter than expected. Several fast removal processes have been hypothesized to explain the observations, but none of them has met a large consensus so far. It is in this context that the ESA-Roscosmos ExoMars Trace Gas Orbiter (TGO) mission started its science operations in April 2018. The first highly sensitive measurements of methane in solar occultation were reported last year. No methane was detected over the first months of the TGO mission and an upper limit of 0.05 ppbv was obtained. The implications of this result on the methane problem on Mars will be addressed in this work.

Several model studies investigated the transport of methane in Mars’ atmosphere. In particular, simulations of surface emissions of the gas using General Circulation Models (GCM) for Mars predicted the formation of layers during the first weeks after the release. Therefore, any detection of a layer by TGO would point to a recent emission. As a corollary to this, methane should be found within a few days at higher altitudes after its emission from the surface.

The reported detection limit of 0.05 ppbv is a strong constraint on the background level of methane, i.e. on the total amount of the gas present in the atmosphere for a time exceeding the transport timescale (~3 months). However, locally, the retrieved detection limit from TGO strongly depends on the amount of atmospheric dust and, thus, on several factors such as the season, latitude, and altitude, which makes the problem much more complicated.

Hence, what are the surface emission scenarios that are consistent with the TGO results? To answer this question, a statistical analysis of GEM-Mars GCM simulations including a large range of theoretical lifetimes will be conducted to determine the realms of scenarios in agreement with the multifactor-dependent TGO upper limits. The positive detections reported over the last 15 years will also be discussed in the light of the results obtained from our study.