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Science objectives of the NOMAD spectrometer on ExoMars Trace Gas Orbiter

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1. Introduction

The "Nadir and Occultation for MArs Discovery" (NOMAD) instrument on ESA and NASA's ExoMars Trace Gas Orbiter (EMTGO) will conduct a spectroscopic survey of the Martian atmosphere in the infrared (IR) and UV/visible spectral regions, both in solar occultation and nadir looking modes (see: Vandaele, A.C., same session). In the IR wavelength domain, the spectral resolution (~0.15 cm^{-1}) surpasses those of previous surveys of Mars by more than an order of magnitude, this channel's heritage derives from the SOIR instrument with proven success on ESA's Venus Express mission [1]. An additional light-weight channel UVIS extends the survey to UV and visible wavelengths with a 1-2 nm resolution. NOMAD will search for active geology, volcanism and life by looking for the atmospheric markers of these processes on Mars, confining the source regions, and providing crucial information on the nature of the processes involved. NOMAD will also extend the survey of major climatology cycles of Mars.

2. NOMAD Science objectives

The objectives of EMTGO mission are [ESA-NASA AO 2010; 2], in brief: detection of a wide range of trace gases, characterization of their spatial and temporal distribution, and localization of source and sink regions, the latter also includes high-resolution imaging.

The list of NOMAD target species includes: CO_2 (incl. $^{13}CO_2$, ^{17}OCO, ^{18}OCO, $C^{18}O_2$), CO (incl ^{13}CO, $C^{18}O$), H_2O (incl. HDO), HO_2, O_3, NO_2, N_2O, CH_4 (incl. $^{13}CH_4$, CH_3D), C_2H_2, C_2H_4, C_2H_6, H_2CO, HCN, OCS, SO_2, HCl, and H_2S.

The scientific objectives of NOMAD can be summarized in three categories, consistent with EMTGO's mission objectives:

2.1 Advancing the knowledge about the chemical composition of the Martian atmosphere

The photochemical stability of the Martian atmosphere is assumed to be achieved by the recycling of CO back into CO_2 through the interaction of odd hydrogen species (HO_x) originating from H_2O photolysis. But HO_x radicals have never been measured directly on Mars. NOMAD offers the potential to measure HO_2 both in the vertical and in nadir.

In the past decade several positive detections of CH_4 were reported both from Earth [3, 4] and from Mars orbit [5], which hint at geophysical activity, exogenous input or biological activity. Also observational evidence that the methane destruction occurs on timescales orders of magnitude shorter than expected, has not yet been understood [6]. NOMAD will evaluate the CH_4 presence in the Martian atmosphere to below ppb level, and to pinpoint its origin and destruction, NOMAD will measure methane isotopologues and trace gases related to possible methane production and destruction processes.

Atmospheric markers of other geophysical activity such as volcanism and outgassing have so far not been detected, and predicted abundances for gases related to such activity are very low [7]. A survey at high spectral and spatial resolution from Mars orbit may detect locally enhanced levels e.g. at active vents not detectable by earlier surveys.

2.2 Extending Mars climatologies and refining seasonal cycles

NOMAD will continue and extend the monitoring of the major seasonal cycles on Mars which were done by successive space missions in the past decade. NOMAD will be able to measure a high variability in local times, sampling basically all local times on the dayside hemisphere in the nadir mode. NOMAD will also extend the survey to more species (see list above), including isotopologues such as HDO.

2.3 Searching and identifying sources and sinks of the Martian atmosphere

Correlations between trace gases observed by NOMAD and dust, clouds and atmospheric state variables provided by other EMTGO instruments will be studied in order to understand the interactions which control the abundances of these gases: e.g. (photo-)chemical processes and processes related to dust and/or ice, such as heterogeneous chemistry, phase transitions, or interaction with the regolith. In the case of outgassing, sources must be localized. Global circulation models will provide critical support to this search.

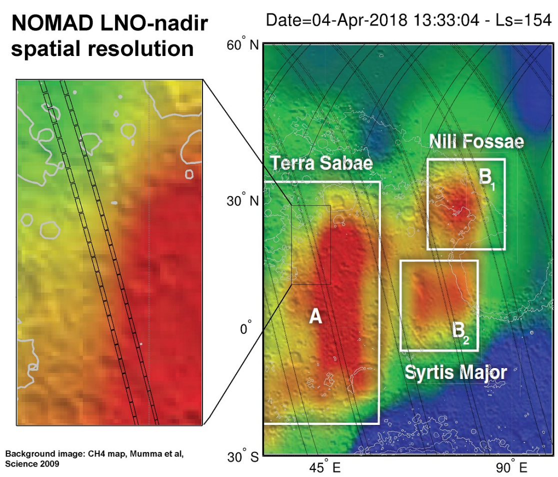

Figure 1: Simulation of NOMAD LNO nadir coverage accumulated over 4 consecutive sols around Ls=154°. The orbits are superimposed on the CH_4 data collected by Mumma et al. [2009] and give an idea of NOMAD's sampling capacities over possible gas emission plumes. The small rectangles that compose the tracks indicate the real-size footprint.

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