Observations of the Martian atmosphere by NOMAD on ExoMars Trace Gas Orbiter


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1 day coverage: 
One orbit every ~2 hours 
400 km - 74° inclined

**SO channel**
- Solar occultation
- Composition of the atmosphere
- Dust, clouds
- (SOIR instrument on Venus Express)

**LNO channel**
- Nadir mapping of trace gases
- But also Limb and Solar occultation

**UVIS channel**
- Nadir and Solar occultation
- Ozone, UV level
- Dust, clouds

EGU, 4
Instrument status

- NOMAD was off 2 weeks during the COVID-19 lockdown
- Was successfully restarted on 11 April

<table>
<thead>
<tr>
<th>Nb Observations</th>
<th>Type of Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>4320 (100)</td>
<td>Solar occultation – SO+UVIS (grazing)</td>
</tr>
<tr>
<td>4144</td>
<td>Nadir dayside – LNO+UVIS</td>
</tr>
<tr>
<td>7448</td>
<td>Nadir dayside – UVIS</td>
</tr>
<tr>
<td>81</td>
<td>Nadir nightside – LNO+UVIS</td>
</tr>
<tr>
<td>298</td>
<td>Nadir nightside – UVIS</td>
</tr>
</tbody>
</table>

Up to MTP24
NOMAD: Science Objectives

- Chemical composition
  - Detection of a broad suite of trace gases and key isotopes
    - CO₂, CO, O₃
    - CH₄ related: CH₄, ¹³CH₄, CH₃D, C₂H₂, C₂H₄, C₂H₆, H₂CO
    - Escape processes: H₂O, HDO -> D/H
    - Volcanism related: SO₂, H₂S, HCl

Aoki et al, JGR 2019
NOMAD : Science Objectives

- Mars Climatology & Seasonal cycles
  - 3D spatial & temporal variability of trace gases and aerosols (dust & clouds)

- Climatology of $O_3$ and UV radiation levels

Willame et al, 2017

Ozone column

$O_3$

@ 300 nm

LAT

DUST

LAT

CLOUDS

Willame et al, 2017

EGU, 4 May 2020
NOMAD : Science Objectives

- **Sources & Sinks**
  - Analyse correlation trace gases – dust – clouds – T&P
  - Use GCM for interpretation

*Giuranna et al*, Nature Geoscience 2019

*Neary et al*, GRL 2020
SO & UVIS - Solar occultation

- SO
- UVIS
- CO2

Sun
Mars
UVIS - Solar Occultation

- Determination of transmittance based on Trompet et al. (2016)

@30 km February – July 2019

@40 km

Ls=22, Lat = -81

Piccialli et al, EPSC (2019)
H$_2$O and HDO

S. Aoki, G. Villanueva, G. Liuzzi

Villanueva et al., DPS 2018
Aoki et al., EPSC (2018,2019); JGR (2019)
Dust storm & $\text{H}_2\text{O}$

Global dust storm!
Latitudinal effects

N hemisphere

Aoki et al., JGR (2019)
Dust storm & H$_2$O

Aoki et al., JGR (2019)

N hemisphere

Global dust storm!

Regional dust storm!
Dust storm & H₂O

- Latitudinal variation

Global dust storm

Regional dust storm

Aoki et al., JGR (2019)
CO retrieval

CO - North

Altitude

NH

CO - South

Altitude

SH

Solar longitude

200

300
Dust characterization (Liuzzi et al., JGR 2020)

- Dust loading

- Water ice abundance
  - Altitude of water ice condensation slowly declines (90 -> 50 km)
  - Following the Dust decreases
Dust characterization (Liuzzi et al., JGR 2020)

- Ice particle size

- Dust particle size

EGU, 4 May 2020
GCM simulations to explain high altitude water vapor during 2018 dust storm

Neary et al., GRL 2020
EGU2020: D3010/EGU2020-14498

• Vertical distribution of dust is a key factor for the transport of water vapor through the equatorial hygropause

New profile better matches MCS dust extinction profile
circulation + water vapor

temperature + water ice

higher altitude dust  \(\rightarrow\) warmer temperatures  \(\rightarrow\) fewer water ice clouds

\(\rightarrow\) transport of water vapor to high altitudes
New dust profile better simulates high altitude water during dust storm

NOMAD observations of water vapor profiles

GCM simulation with new dust profile

GCM simulation of non dust storm case
Green line

\[
\frac{I(557.7 \text{ nm})}{I(297.2 \text{ nm})}
\]

- Theoretical calc. (NIST): 16.7
- Average of Obs: 9.4 ± 1.0
- NOMAD: 16.5 ± 1.3

J.-C. Gérard, ULiège
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