The NOMAD instrument on board ExoMars: heritage from previous missions towards breakthrough science

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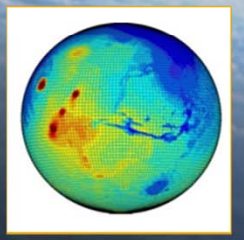
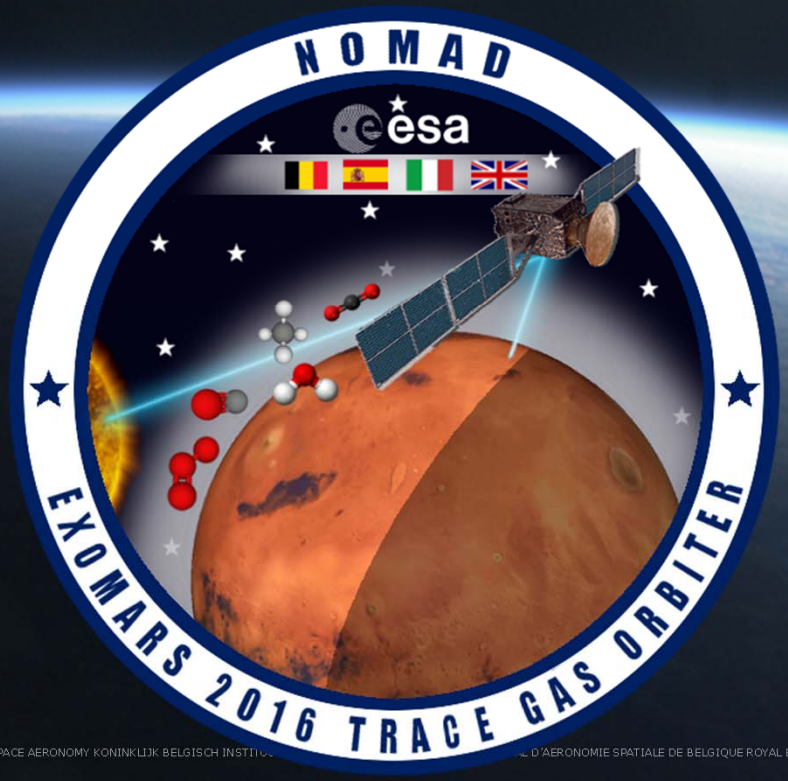
Open University





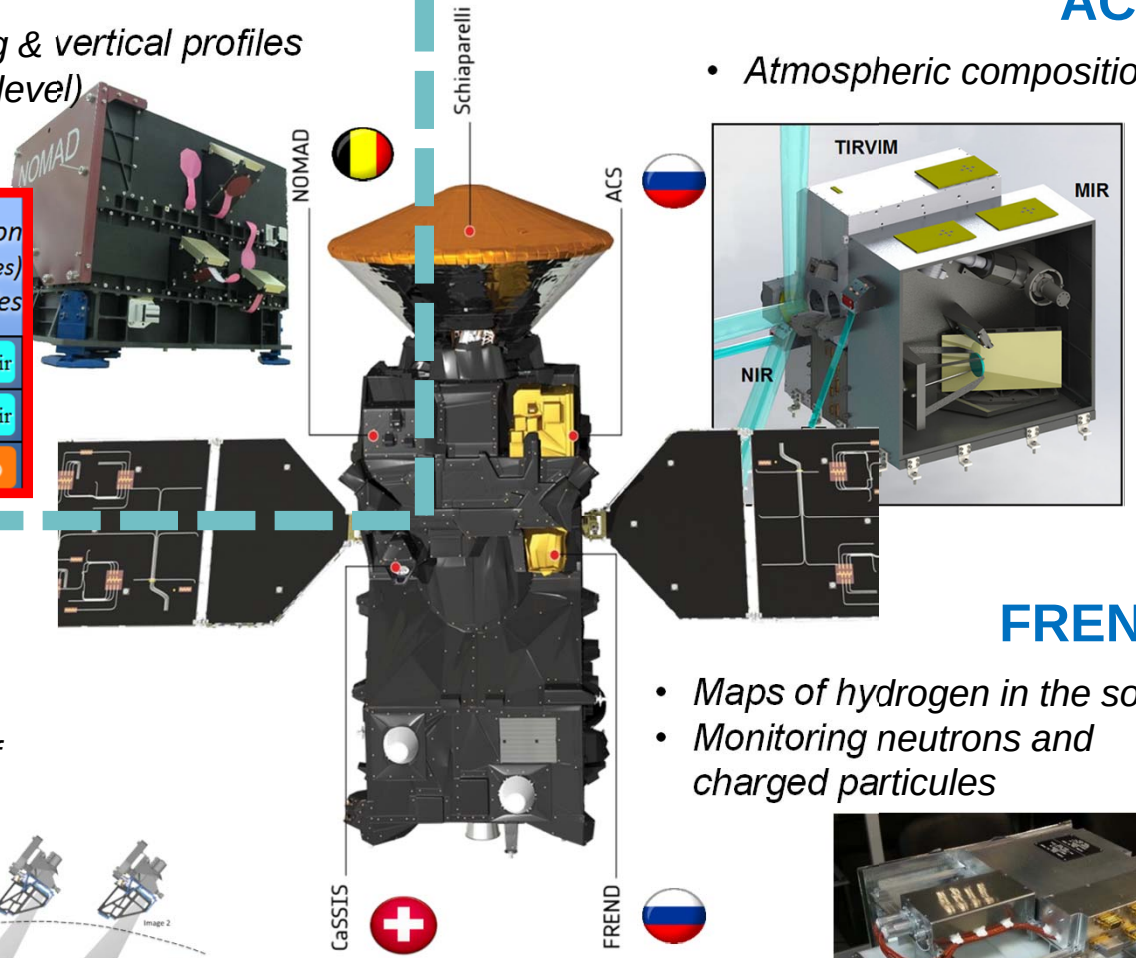
UPWARDS
UNDERSTANDING PLANET MARS

ExoMars 2016: Trace Gas Orbiter

NOMAD

- *Atmospheric composition: mapping & vertical profiles*
- *Improve climatologies (ozone, UV level)*

NOMAD High resolution occultation and nadir spectrometers	*Atmospheric composition (CH_4, O_3, trace species, isotopes) dust, clouds, P&T profiles*	
UVIS (0.20 – 0.65 µm) λ/Δλ ~ 250	SO, Limb, Nadir	
IR (2.3 – 3.8 µm) λ/Δλ ~ 10,000	SO, Limb, Nadir	
IR (2.3 – 4.3 µm) λ/Δλ ~ 20,000	SO	

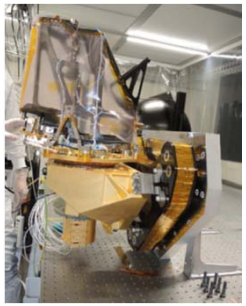


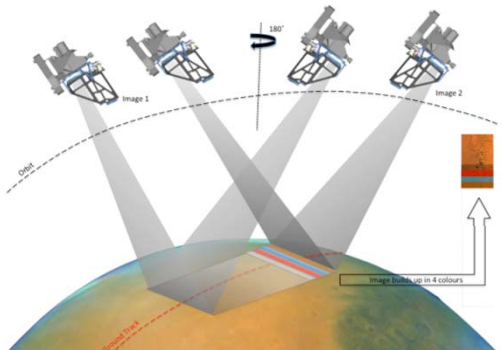
ACS

- *Atmospheric composition*

CaSSIS

- *Images of surface features*
- *Map regions of potential sources of trace gases*



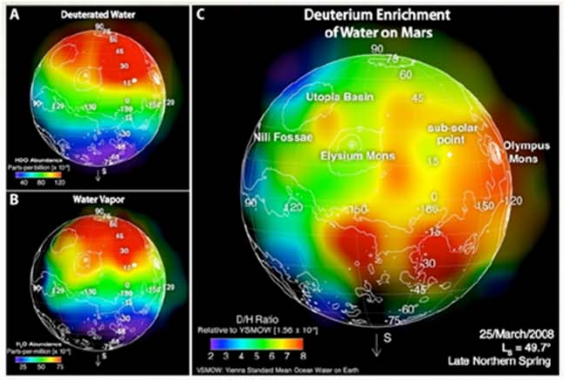


FREND

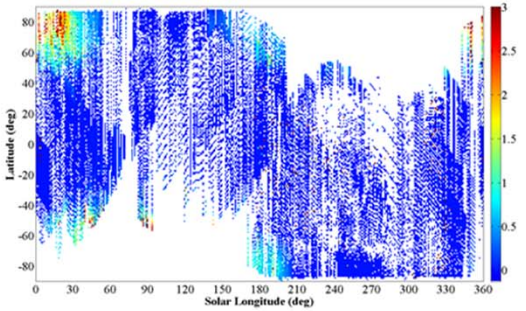
- *Maps of hydrogen in the soil*
- *Monitoring neutrons and charged particules*

NOMAD : Science Objectives

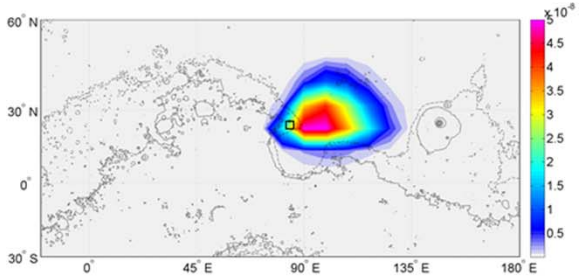
- Chemical composition
  - Detection of a broad suite of trace gases and key isotopes
    - CO_2, CO, O_3
    - CH_4 related : CH_4, $^{13}CH_4$, CH_3D, C_2H_2, C_2H_4, C_2H_6, H_2CO
    - Escape processes : H_2O, HDO -> D/H
    - Volcanism related : SO_2, H_2S, HCl
- Mars Climatology & Seasonal cycles
  - 3D spatial & temporal variability of trace gases and aerosols
  - Climatology of O_3 and UV radiation levels
- Sources & Sinks
  - Analyse correlation trace gases – dust – clouds – T&P
  - Use GCM for interpretation



Villanueva et al., 2008

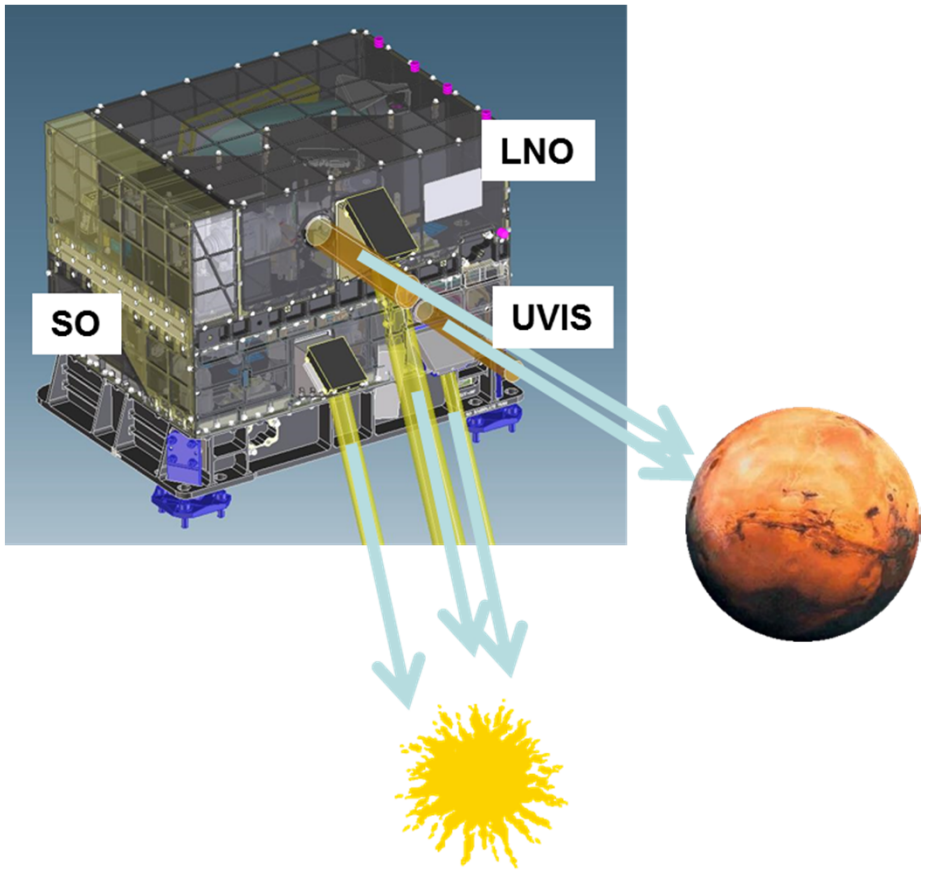


O_3- SPICAM-UV/Mars Express (Y. Willame)



GCM simulation (F. Daerden)

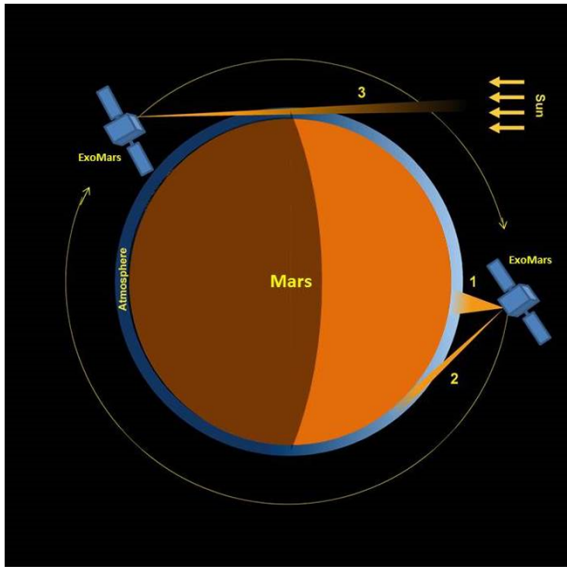
NOMAD : 3 channels

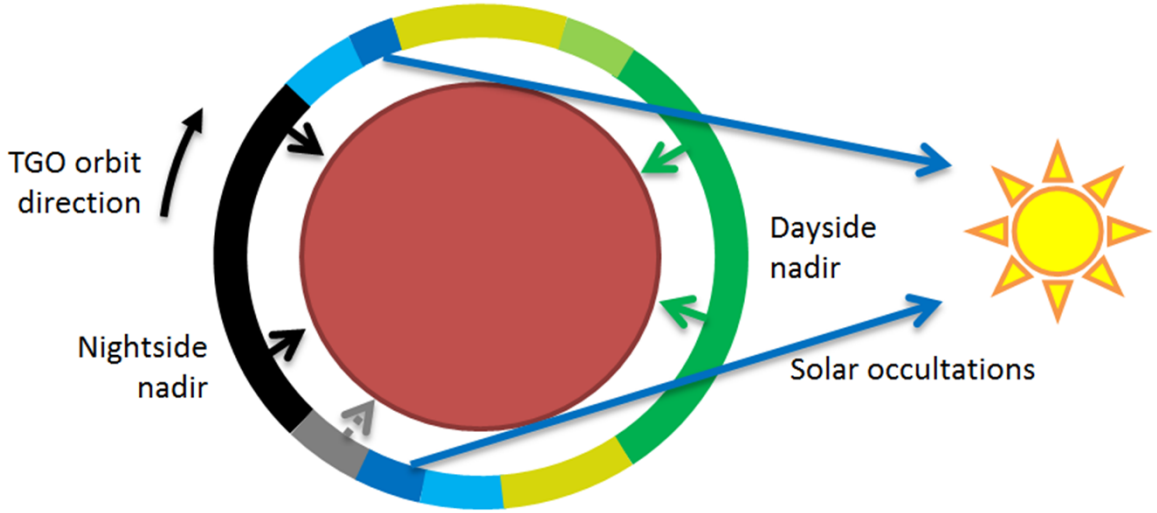


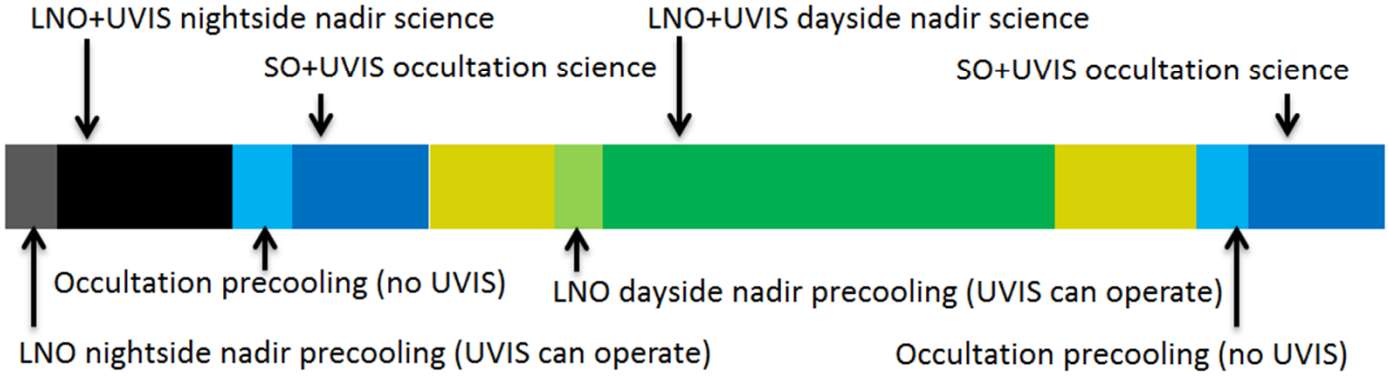
- SO **SOIR/ Venus Express**
  - Solar Occultation
  - IR : 2.2-4.3 μm
  - Resolution ~ 0.15 cm^{-1}
  - Resolving power = 22000
- LNO
  - Nadir, Limb, Solar Occultation
  - IR : 2.2-3.8 μm
  - Resolution ~ 0.3 cm^{-1}
  - Resolving power = 11000
- UVIS **Humbolt/ExoMars**
  - Nadir, Limb, Solar Occultation
  - UV-vis : 200-650 nm
  - Resolution ~ 1 - 2 nm

Final science orbit: typical observations

- Near-circular @ ~400 km; 74° incl.; 2h period (24 solocc/sol)

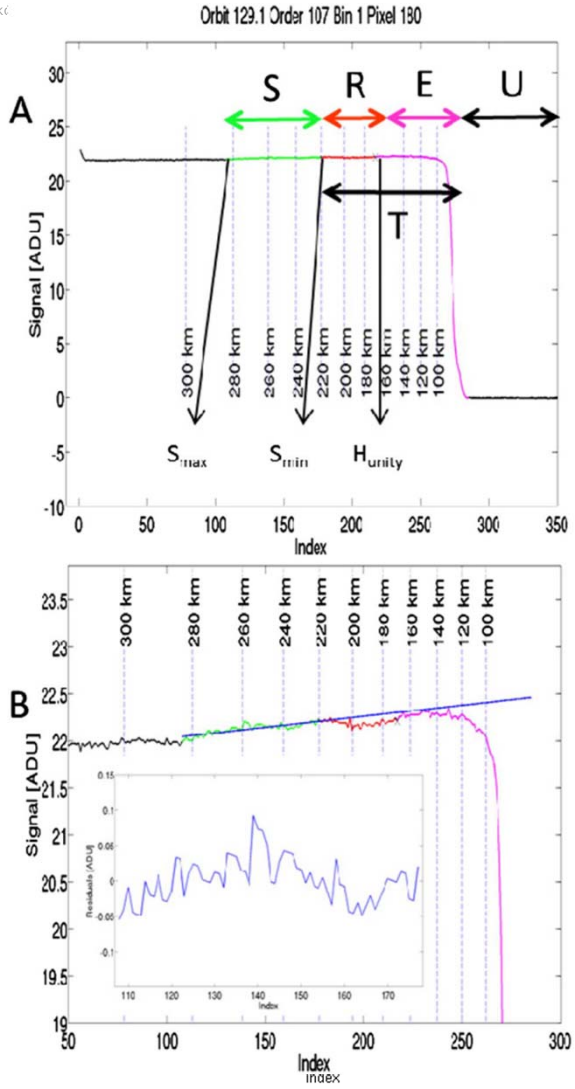




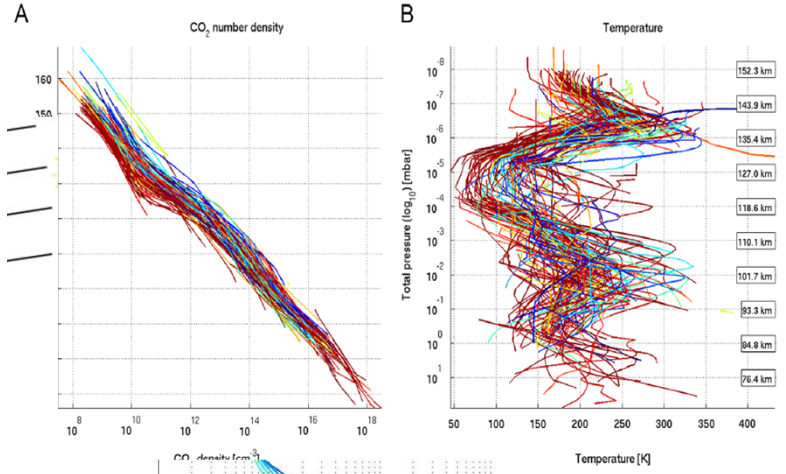


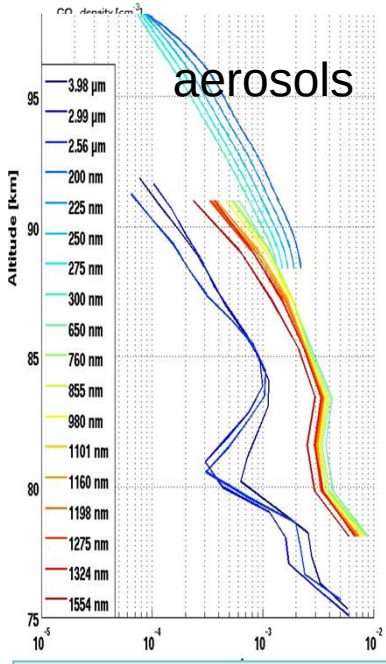
Gold = Poor nadir surface illumination angles. Potential off periods to cool instrument

Solar occultation in the IR – SOIR/VEx



Trompet et al. , AO 55, p9275 (2016)

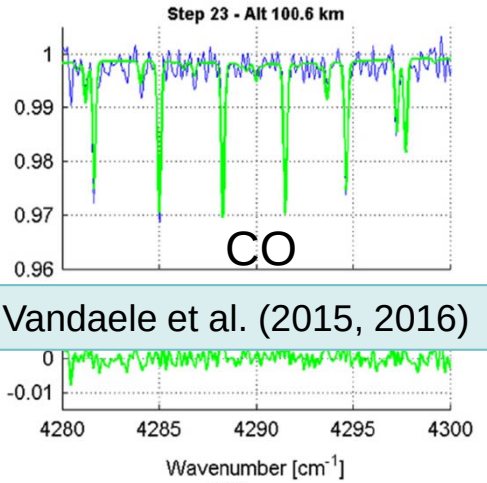




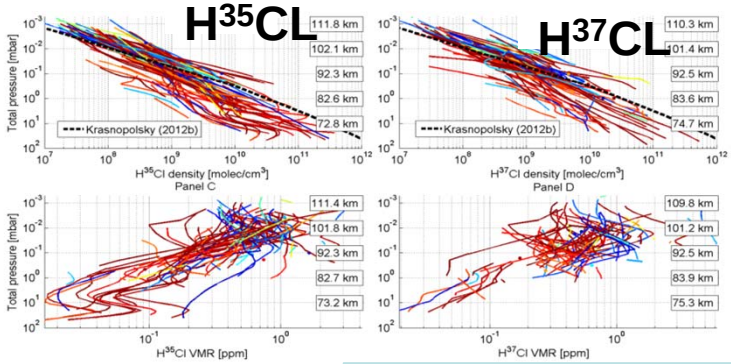
Wilquet et al. (2009, 2012)

CO_2 & Temperature

Mahieux et al. (2010, 2012, 2015)

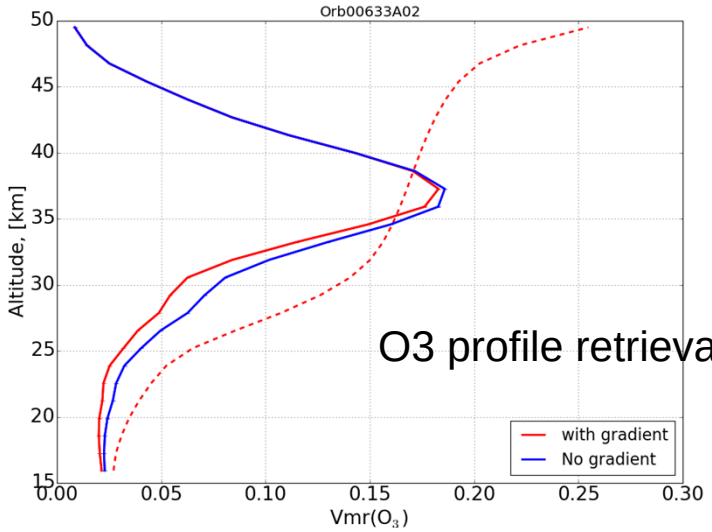


Vandaele et al. (2015, 2016)



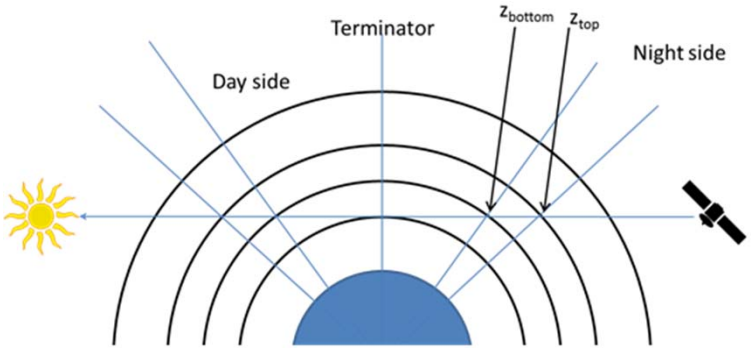
Mahieux et al. (2015)

Solar occultation in the UV: SPICAM UV/MEx



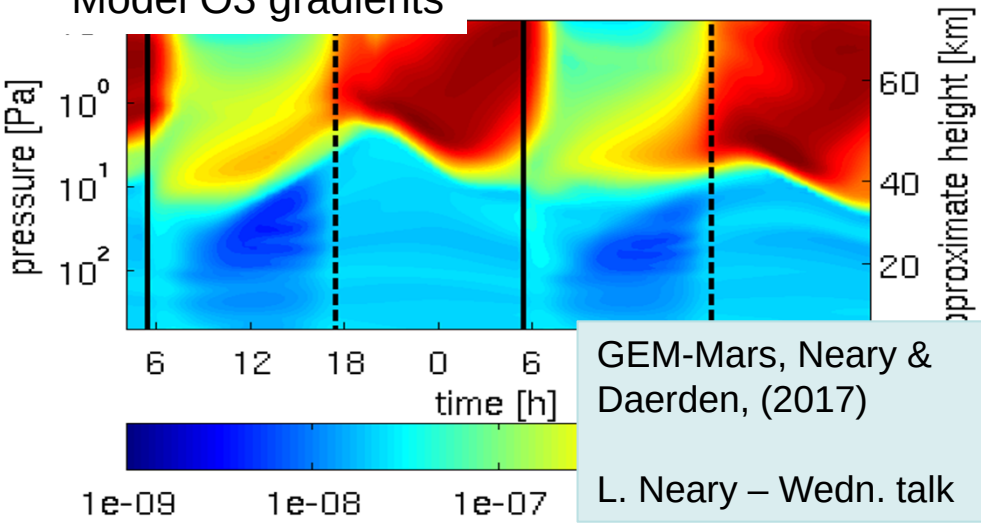
O3 profile retrieval

Considering Gradients @ terminator and along LOS



UPWARDS

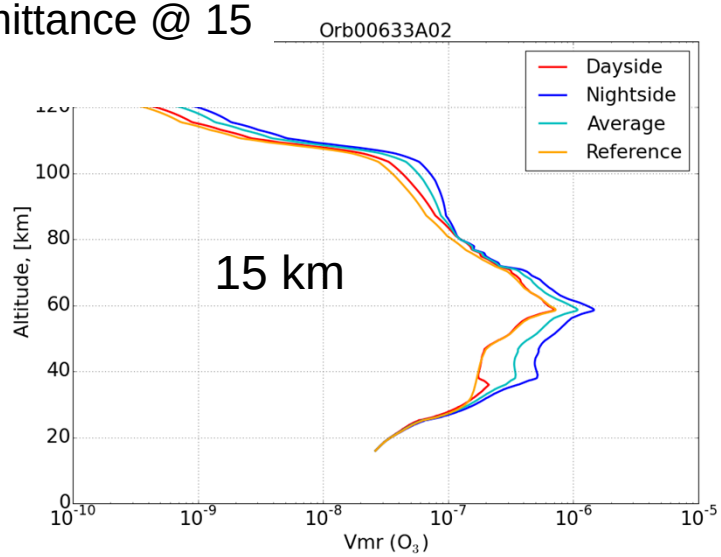
Model O3 gradients



GEM-Mars, Neary & Daerden, (2017)

L. Neary – Wedn. talk

O3 gradients for calculating transmittance @ 15 km

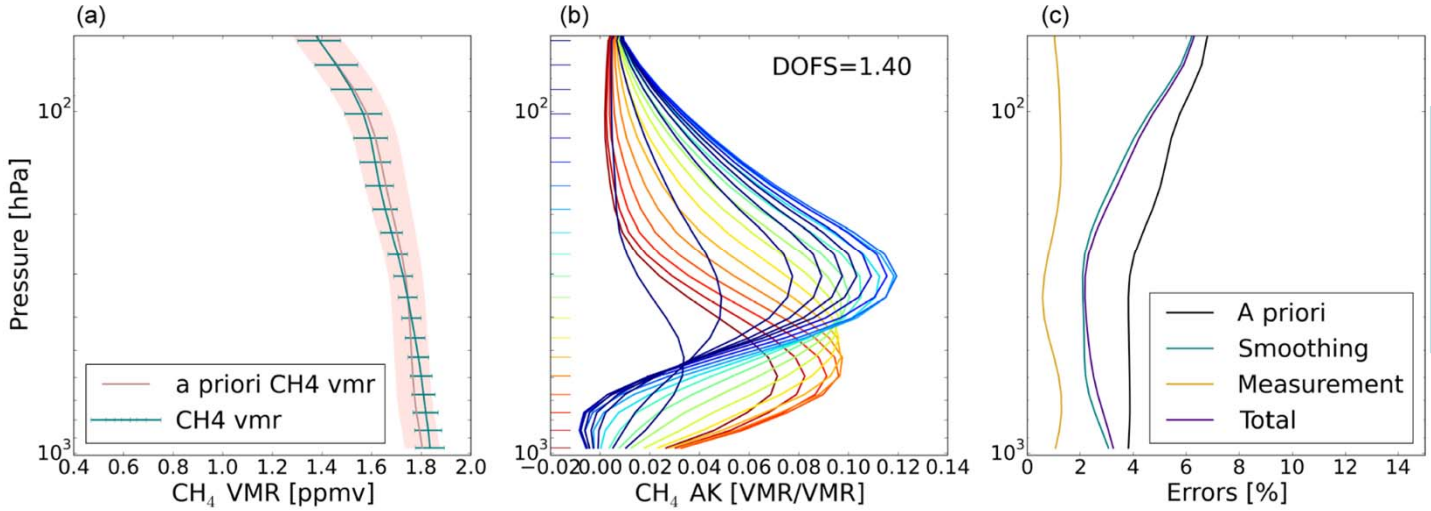


A. Piccialli et al., New retrievals of ozone at the terminator on Mars (manuscript in preparation)

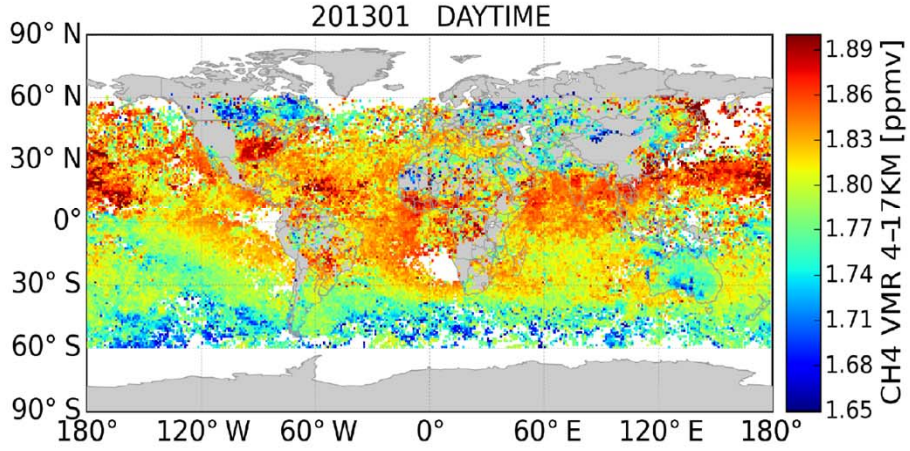
A. Piccialli – Tuesday talk

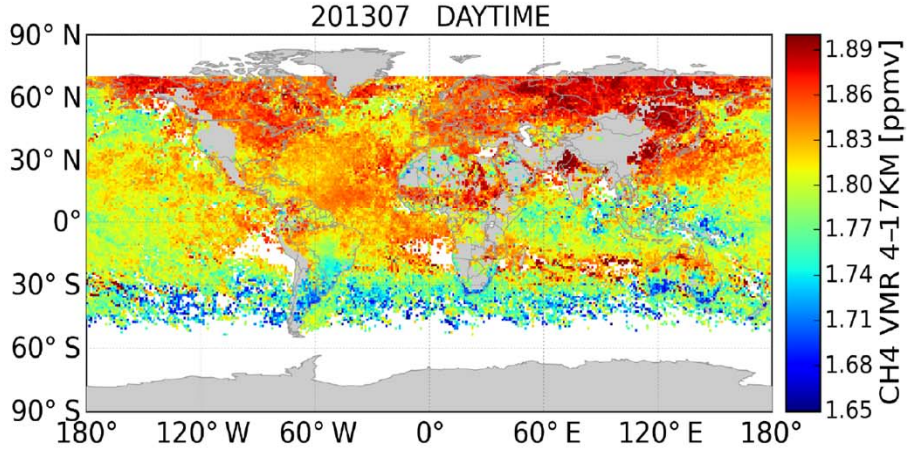
Trace gases mapping : IASI (Earth) – CH_4

- Retrieval of CH_4 on 2011-2014 Eumetsat PCC L1C data – 1200-1290 cm^{-1} (ν_4)

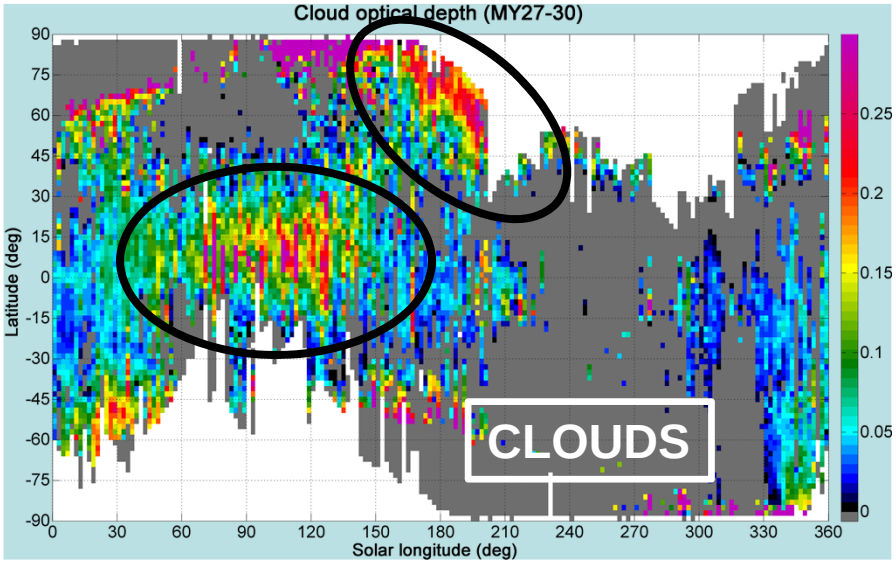


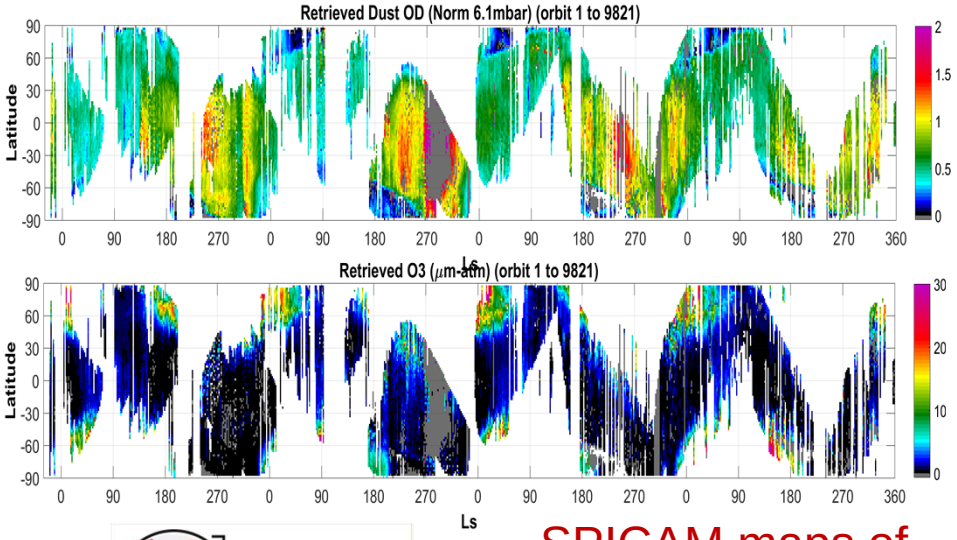
Retrieval and validation of MeTop/IASI methane, De Wachter E. et al., Atmos. Meas. Tech., 10, 4623–4638, 2017





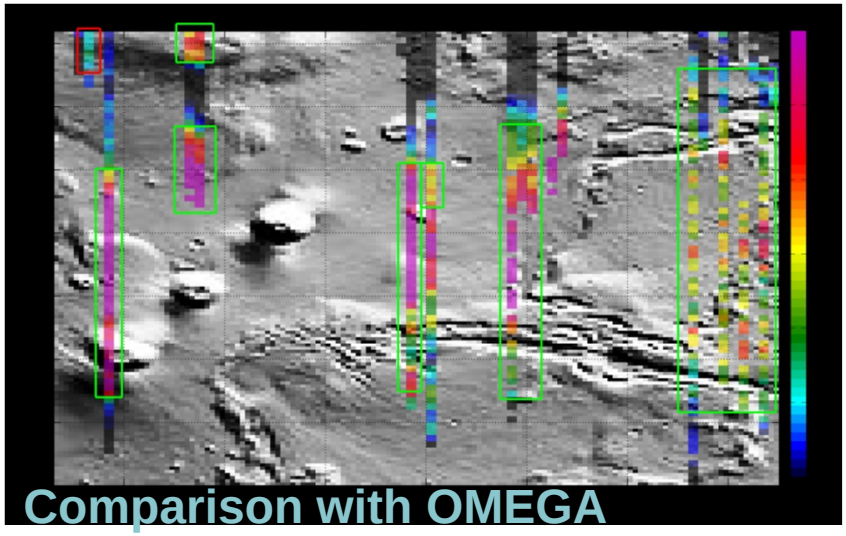
Trace gases, dust/clouds mapping-SPICAM/MEx





UPWARDS
UNDERSTANDING PLANET MARS

SPICAM maps of dust and ozone

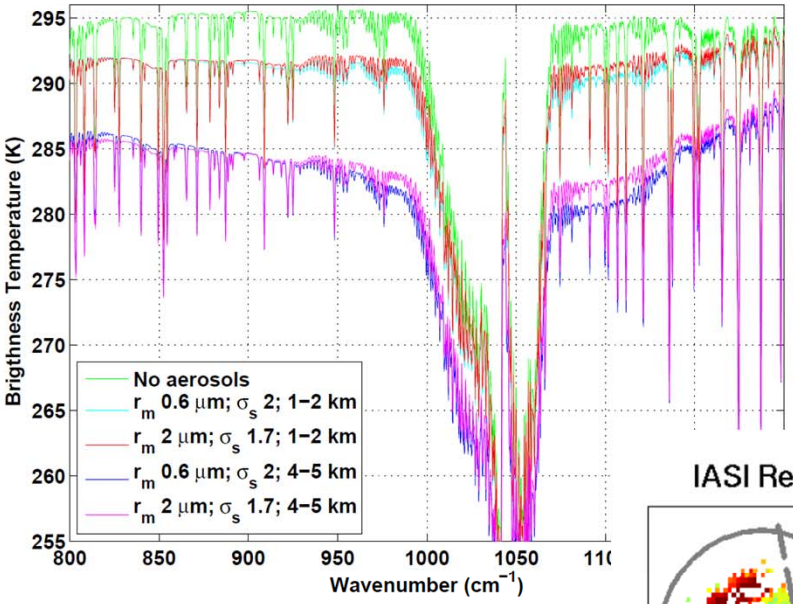


Retrieving cloud, dust and ozone abundances in the Martian atmosphere using SPICAM/UV nadir spectra
Y. Willame et al., PSS 142 (2017) 9-25

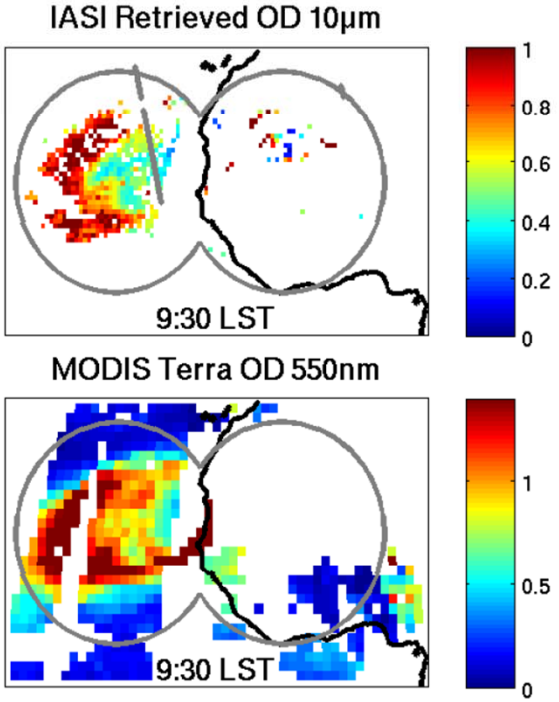
Ice cloud retrieval in the Martian atmosphere using SPICAM/UV nadir spectra
Y. Willame et al. (in preparation)

Y. Willame – Wedn. Talk

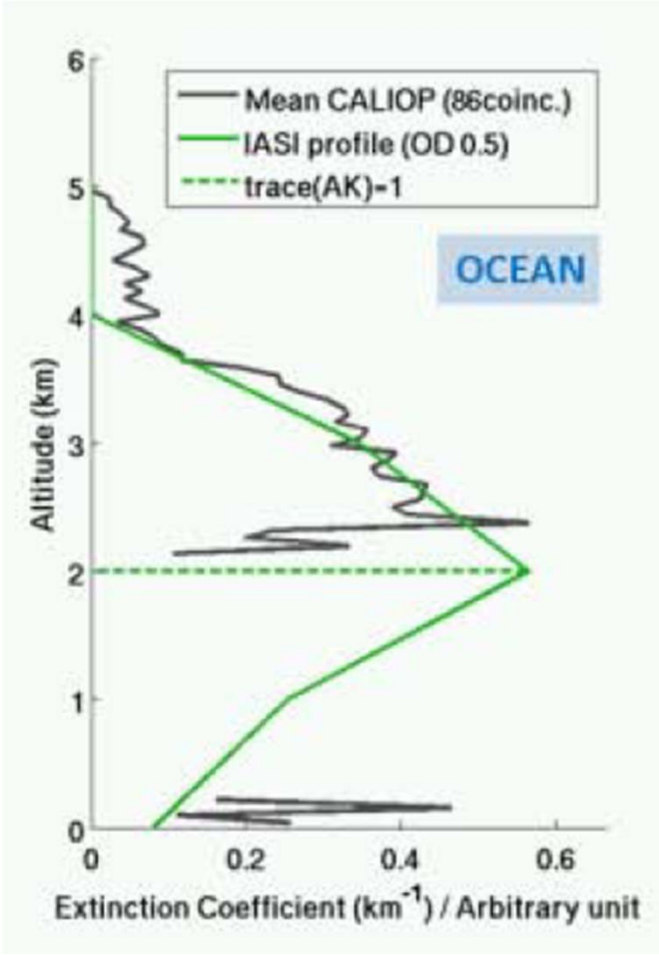
Aerosol/dust/clouds mapping: IASI (Earth)



IASI TIR nadir measurements

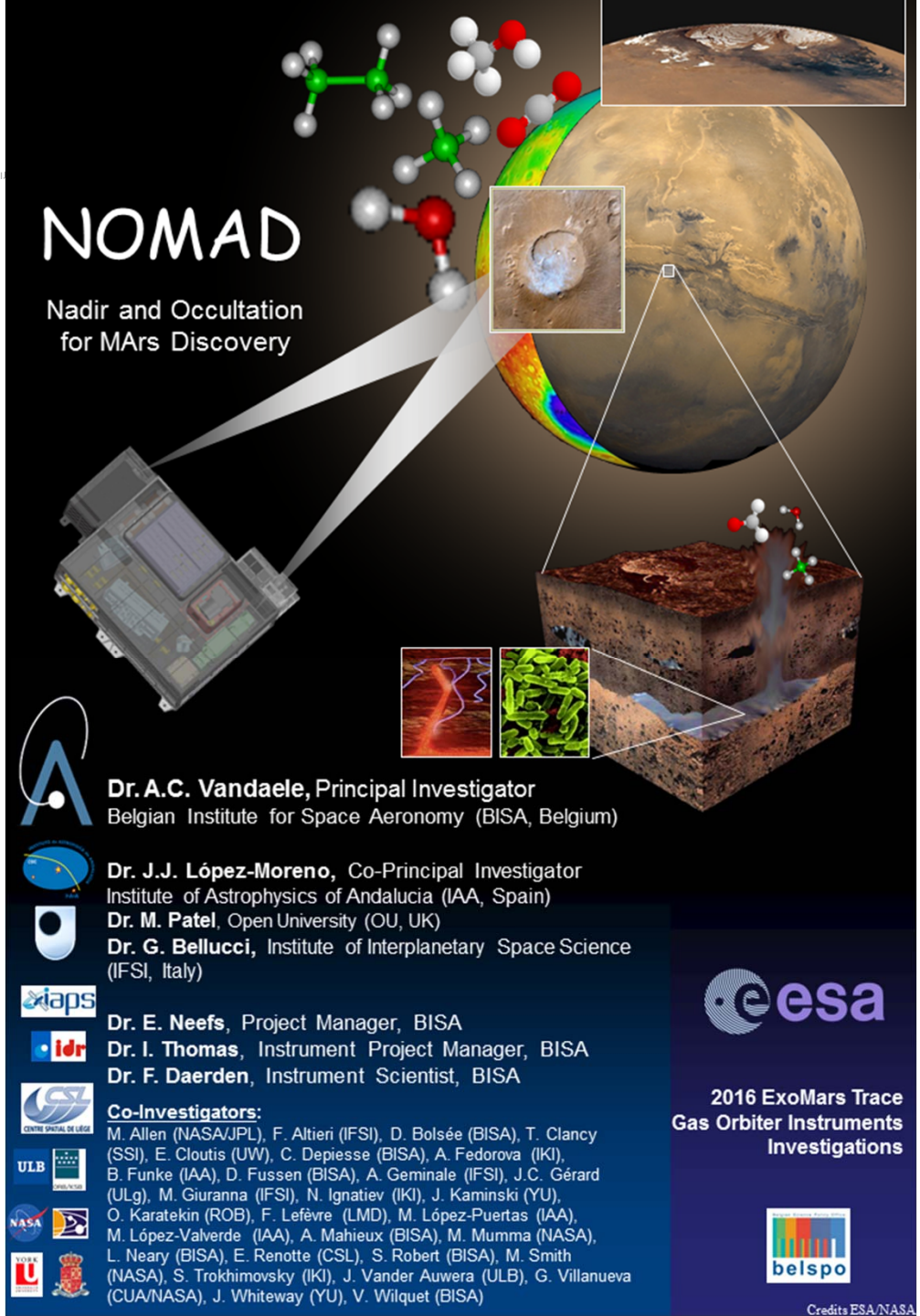


Vandenbusssche et al. (2012, 2013)



Conclusions

- We are ready !
- We just need data now !



The NOMAD Science Team

Vandaele, Ann Carine; Lopez Moreno, Jose Juan; Bellucci, Giancarlo; Patel, Manish; Allen, Mark; Alonso-Rodrigo, Gustavo; Altieri, Francesca; Aoki, Shohei; Bolsée, David; Clancy, Todd; Cloutis, Edward; Daerden, Frank; D'Aversa, Emiliano; Depiesse, Cédric; Erwin, Justin; Fedorova, Anna; Formisano, Vittorio; Funke, Bernd; Fussen, Didier; Garcia-Comas, Maia; Geminale, Anna; Gérard, Jean-Claude; Gillotay, Didier; Giuranna, Marco; Gonzalez-Galindo, Francisco; Hewson, Will; Homes, James; Ignatiev, Nicolai; Kaminski, Jacek; Karatekin, Ozgur; Kasaba, Yasumasa; Lanciano, Orietta; Lefèvre, Franck; Lewis, Stephen; López-Puertas, Manuel; López-Valverde, Miguel; Mahieux, Arnaud; Mason, Jon; Mc Connell, Jack; Mumma, Mike; Neary, Lori; Neefs, Eddy; Novak, R.; Oliva, Fabrizio; Piccialli, Arianna; Renotte, Etienne; Robert, Severine; Sindoni, Giuseppe; Smith, Mike; Stiepen, Arnaud; Thomas, Ian; Trokhimovskiy, Alexander; Vander Auwera, Jean; Villanueva, Geronimo; Viscardy, Sébastien; Whiteway, Jim; Willame, Yannick; Wilquet, Valérie; Wolff, Michael

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