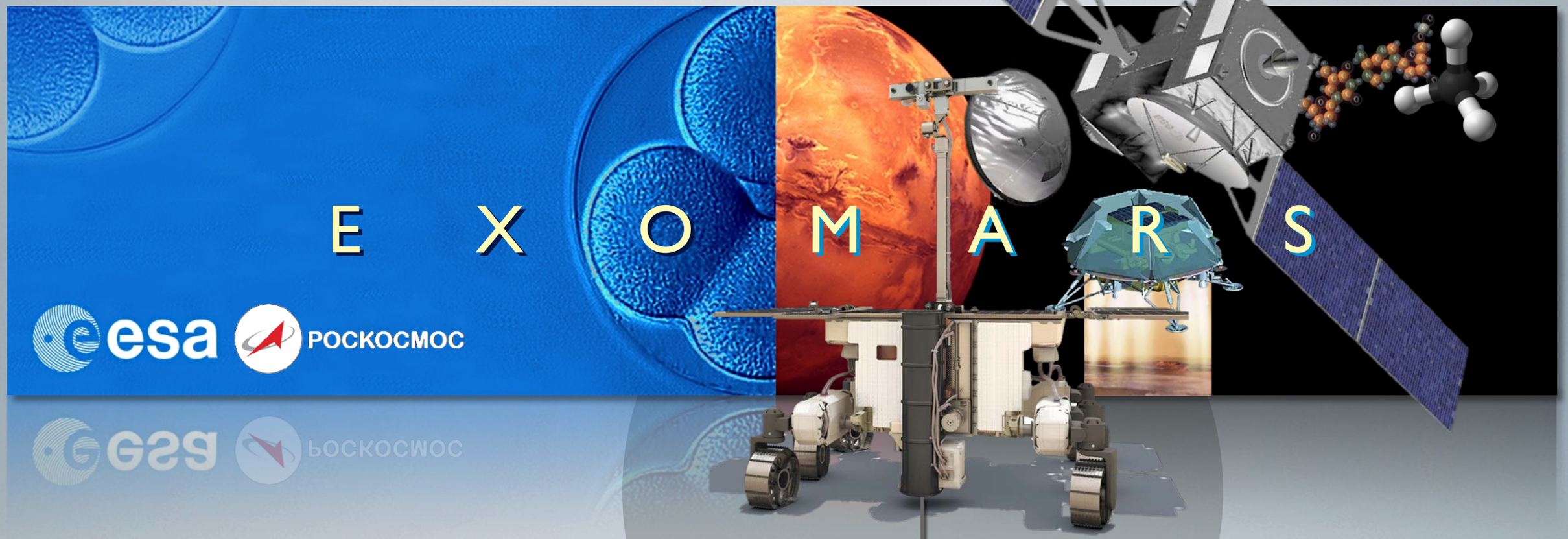


Methane on Mars:

… What's the Deal ?

J. L. Vago, O. Witasse

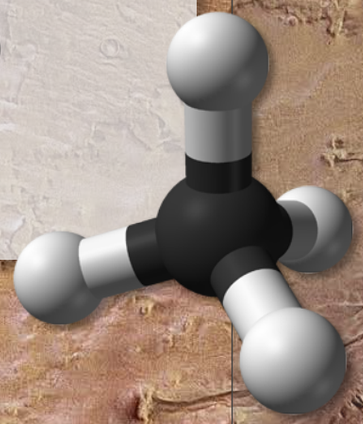
6th Interdisciplinary Science Workshop (IDSW #6)
19 November 2013, Aranjuez (E)

So, Why Do We Care ?

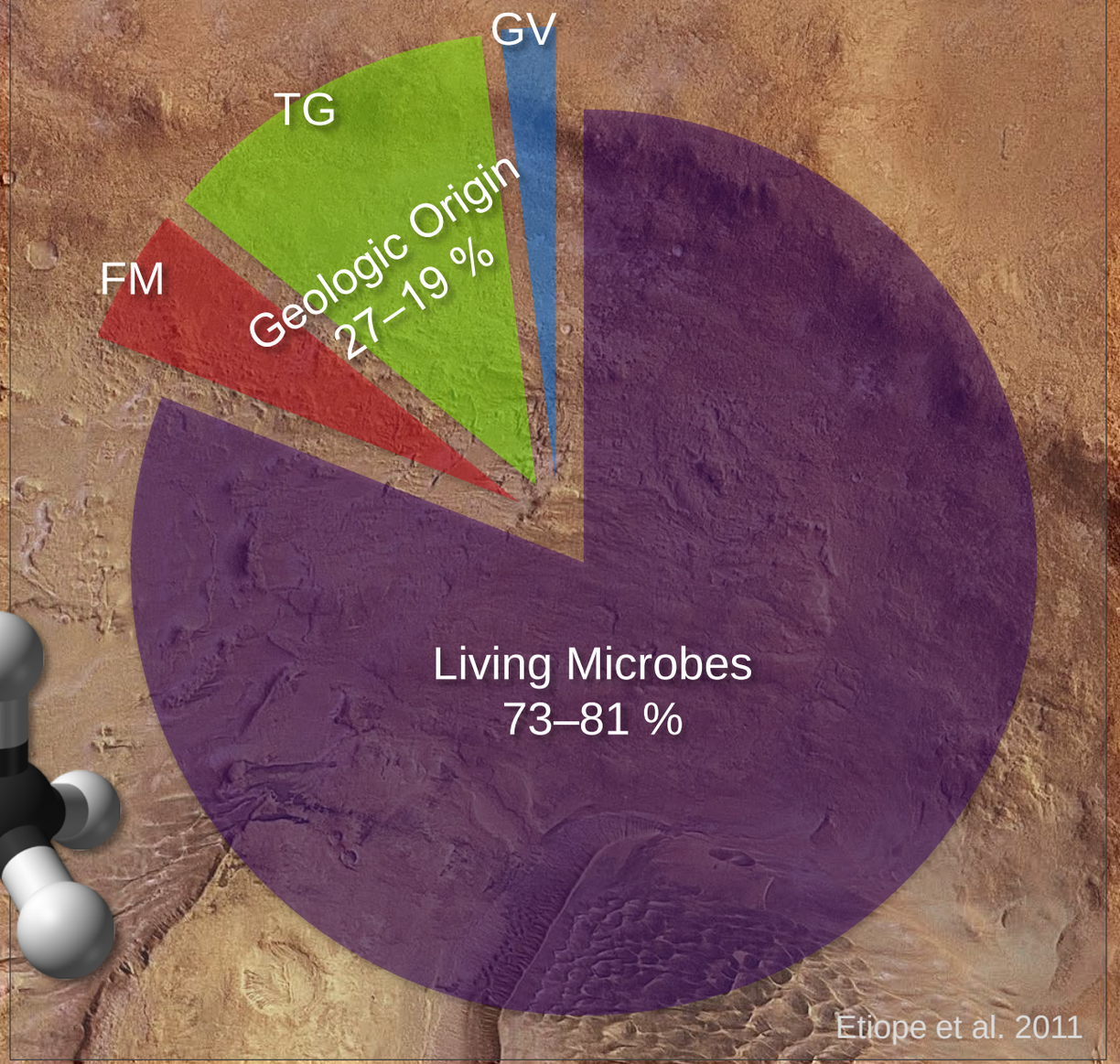
Origin of Methane on Earth:

Origin: How it was made
Source: How it is delivered

- Biotic
  - Biogenic or Microbial
    - Living Microbes
    - Fossil Microbes
  - Thermogenic (TG) (from kerogen maturation)
- Abiotic
  - Geologic reactions (e.g. rock-water)
  - Hydrothermal or Volcanic



Relative natural emissions of CH_4 on Earth



Etiope et al. 2011

Credit: Argyre Planitia, MEX/HRSC

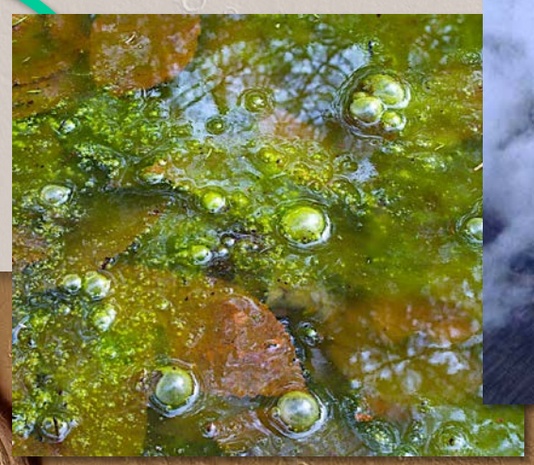
Sources on Earth

Geologic emissions:

- In petroliferous sedimentary areas
  - On-shore mud volcanoes
  - Gas seeps (macro seeps)
  - On-shore microseepage
  - Submarine seepage
- In geothermal and volcanic areas
  - Geothermal, hydrothermal
  - Volcanic

Biological emissions:

- Living microbes
  - Wetlands
  - Oceans and lakes
- UV irradiation of organic matter



Credit: Reul vallis, MEX/HRSC

Methane on Mars

Adapted from
Atreya et al. 2007

Space

Atmosphere

Surface

Subsurface

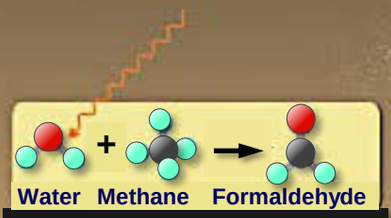
Aquifer

Deep crust and mantle

METHANE DESTRUCTION

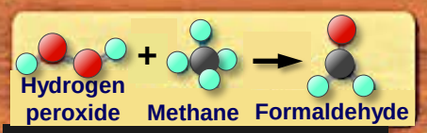
Ultraviolet photon

Photochemistry
Mainly ≥ 60-km altitude



Oxidation
In lower atmosphere

Dust devil



Electrochemistry
Driven by dust winds

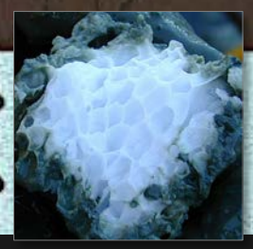
METHANE SOURCES

Meteoritic dust
Negligible amounts

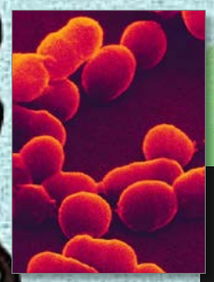
Mixing

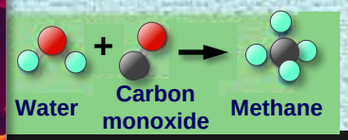
Comet impacts
Negligible amounts

Volcanoes
Could contribute if they were active

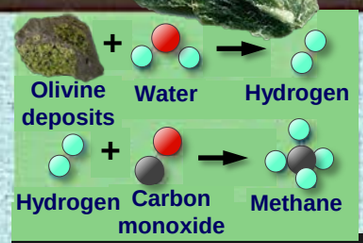


Methane clathrates
Could store methane and release it slowly





Microbes
Methanogens could be active in the subsurface



Serpentinisation
Water-rock processes

Methane on Mars

- **If it is there…**

  Its origin has to be biological or geological. All other sources have been ruled out (negligible contributors).

  For either origin, biotic or abiotic, liquid water is essential.

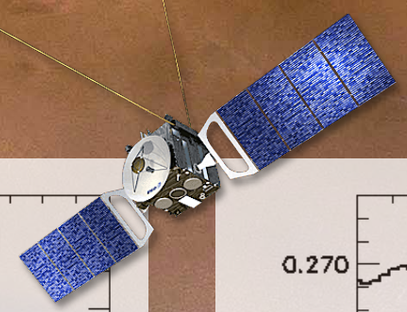
  Several potential sources:

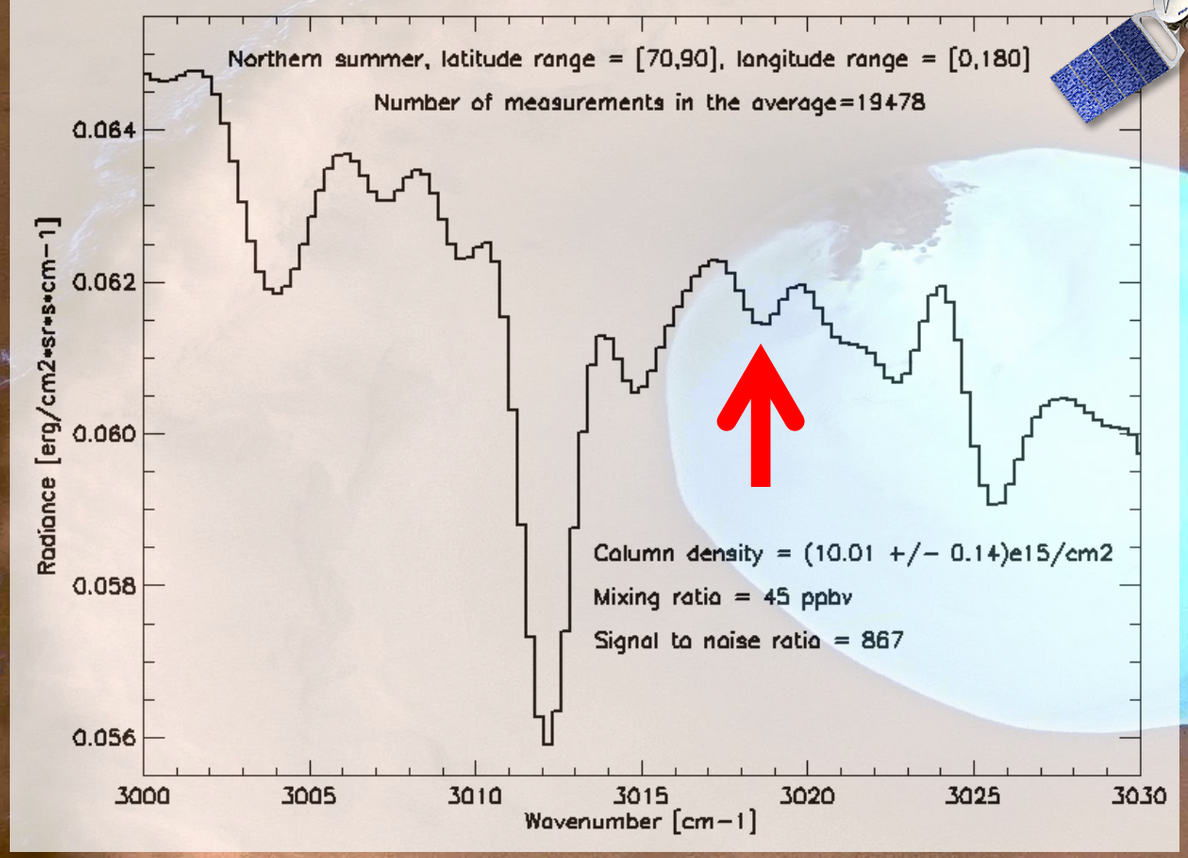
  1. On-going serpentinisation or Fisher-Tropsch type reactions fuelled by hydrothermalism;
  2. Exhalation by present-day subsurface methanogens;
  3. Seasonal release of ancient methane, e.g. stored in clathrates (ice boxes), or thermogenesis.

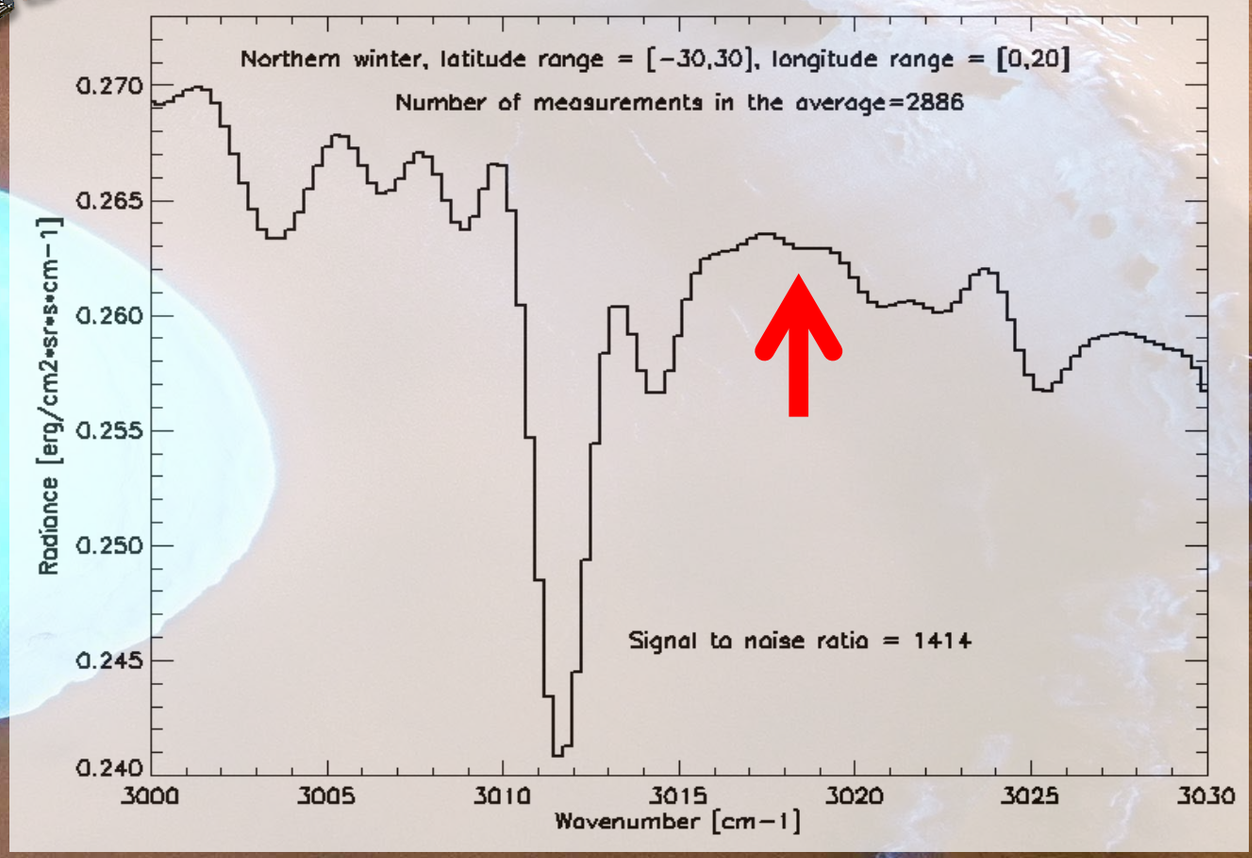
Credit: Meridiani Planum, Odyssey/ASU

Mars Express

EXOMARS







Positive detection

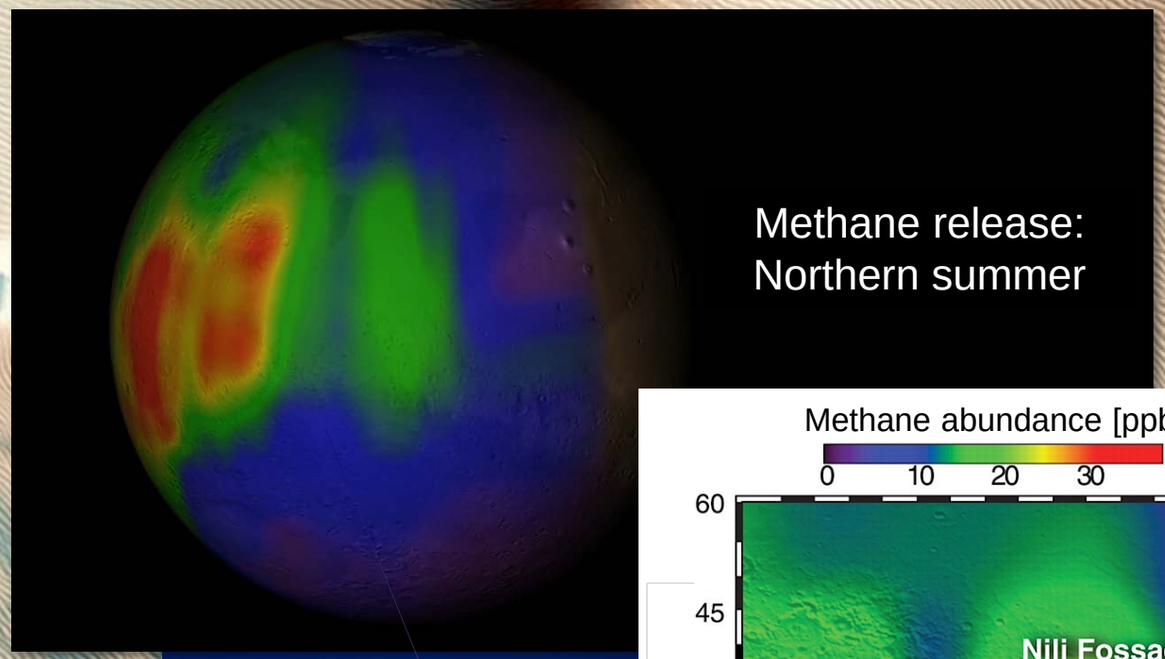
Negative detection

A. Geminale, Methane Workshop, Frascati (ITA), 2009

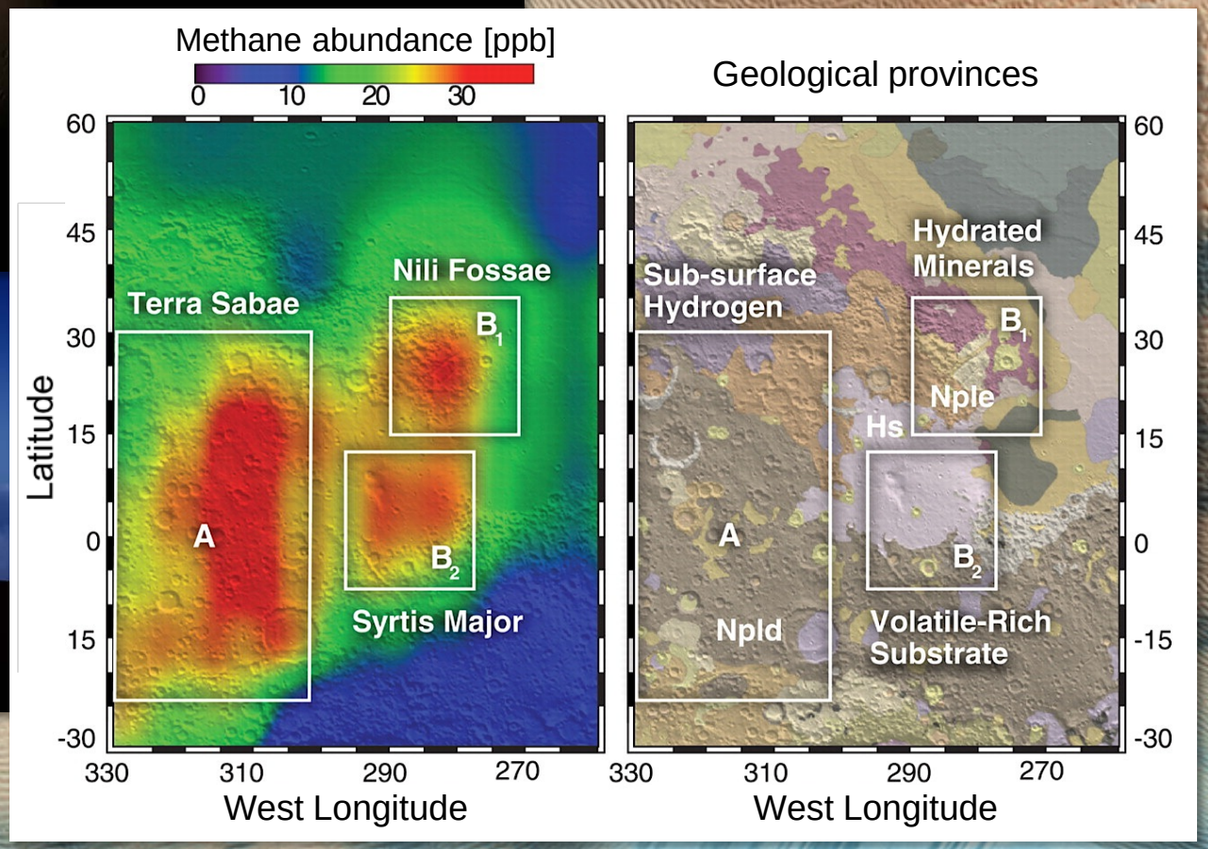
- Methane detection by PFS remains controversial: Close to the sensitivity level of the instrument.
- Nevertheless, PFS-derived maps of methane distribution have been produced. They show an enhancement during spring/summer at high latitudes—related to sublimation of polar ices ?

Credit: Crater with ice, MEX/HRSC

Measurements from Earth



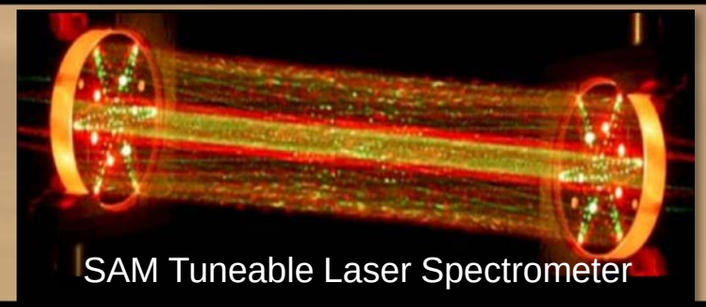
Methane release:
Northern summer



- Mumma et al. 2009 used IR spectrometers attached to powerful ground-based telescopes.
- Integrated four years' worth of data, matching four spectral lines in their spectra to methane.
- Observations indicate methane is localised in discrete, short-lived hot spots, peaking at 60 ppb.

Credit: Dust devil tracks, MRO/HiRISE

Mars Science Laboratory



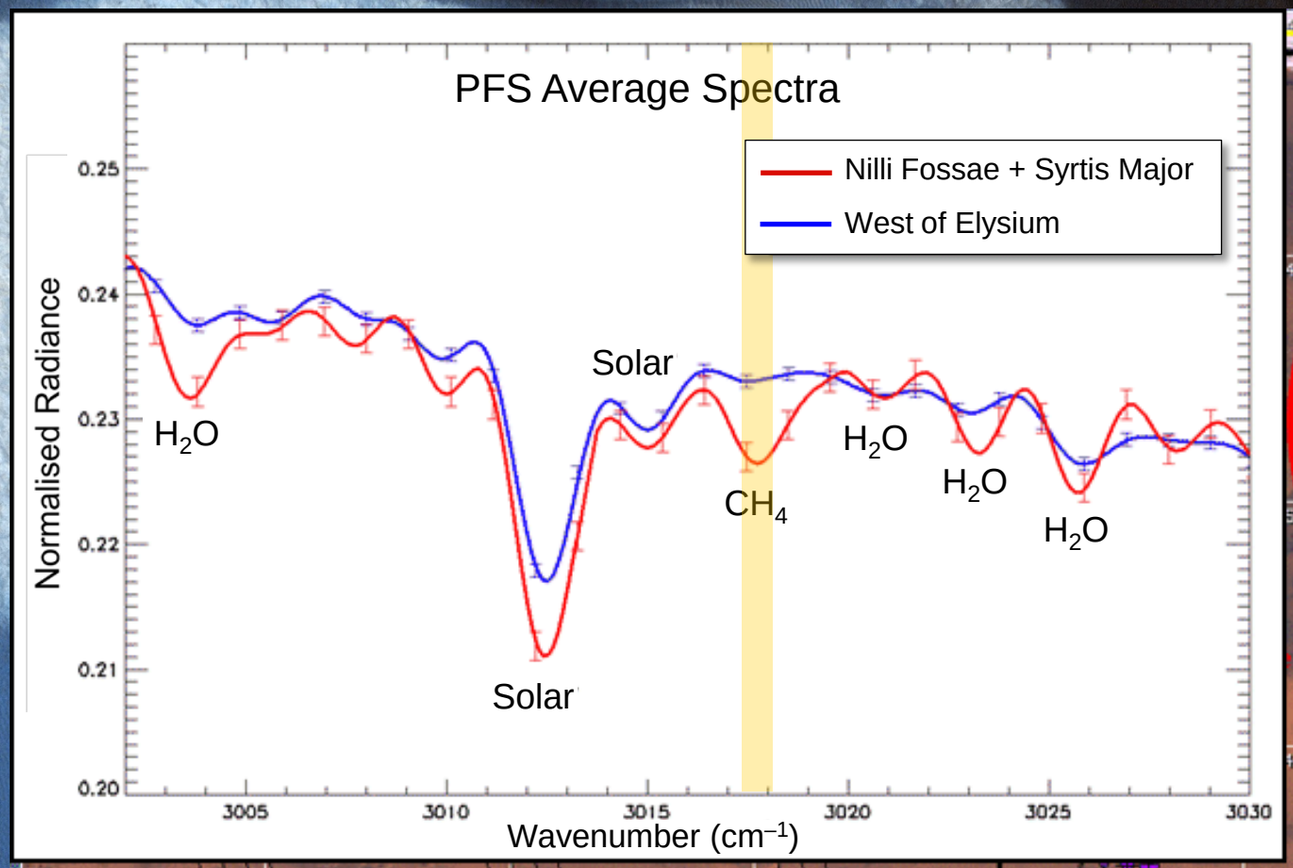
Webster et al. 2013

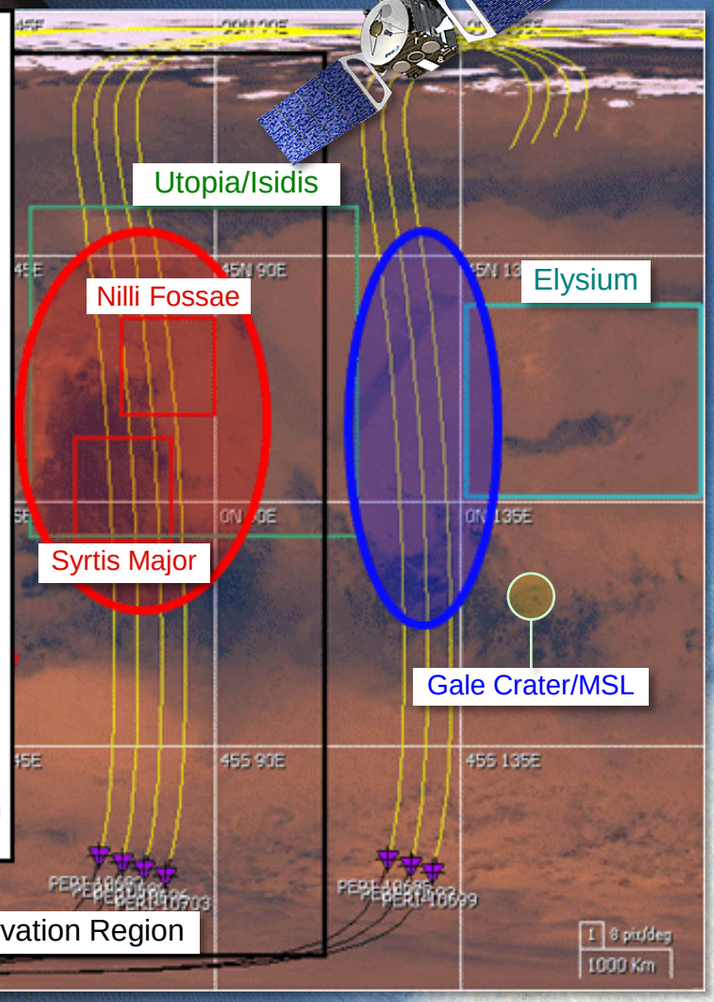
- Six high-sensitivity measurements were conducted between Oct 2012 and Jun 2013 (three in southern spring and three during summer—all at night).
- No methane detected at Gale Crater within an abundance floor of 1.3 ppbv.

Credit: MSL

More Mars Express

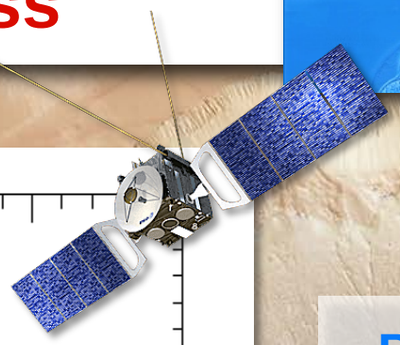
Source: M. Giuranna, Unpublished Material, 2013

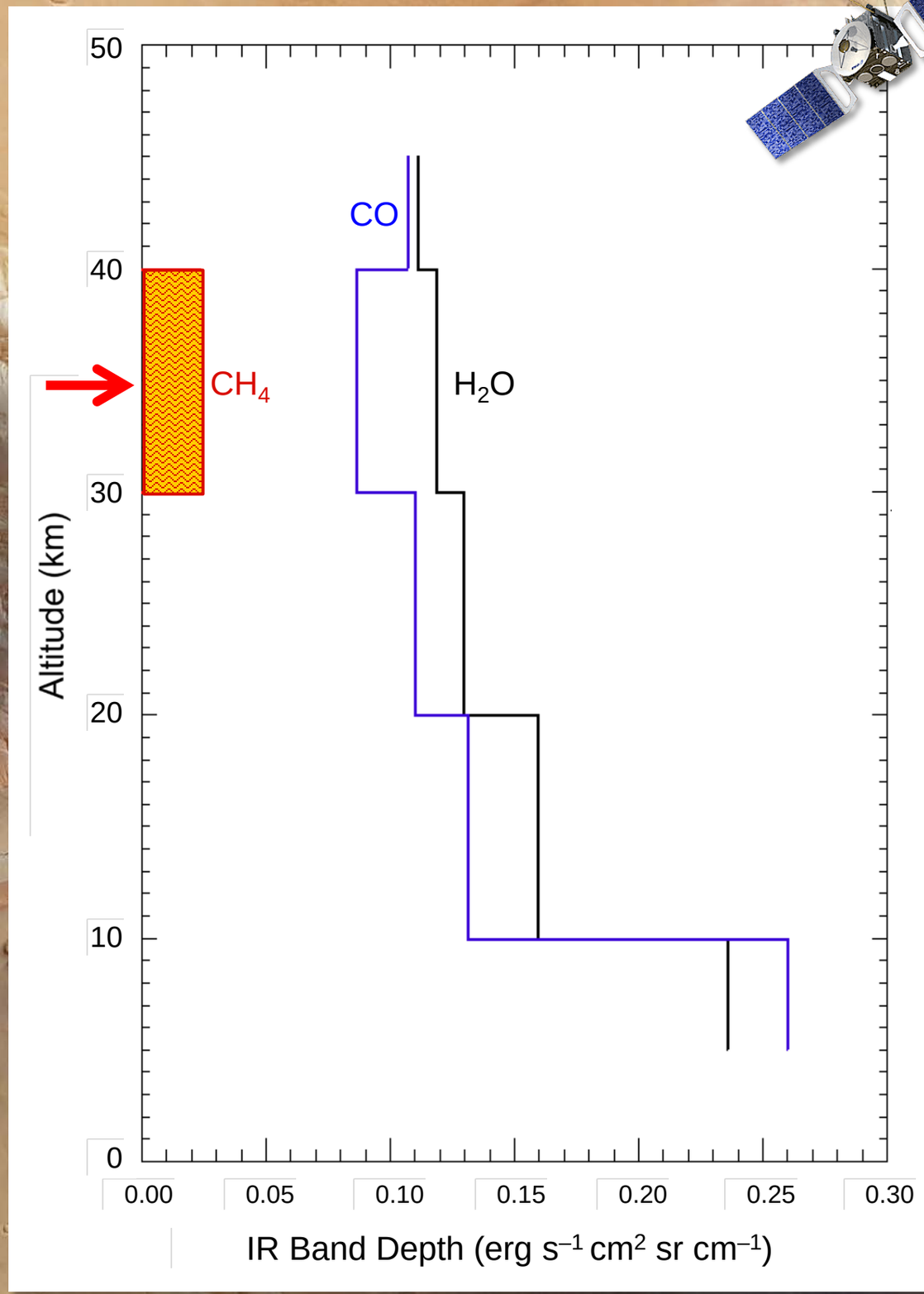




Credit: Sand dunes near north pole, MRO/HiRiSE

Still More Mars Express





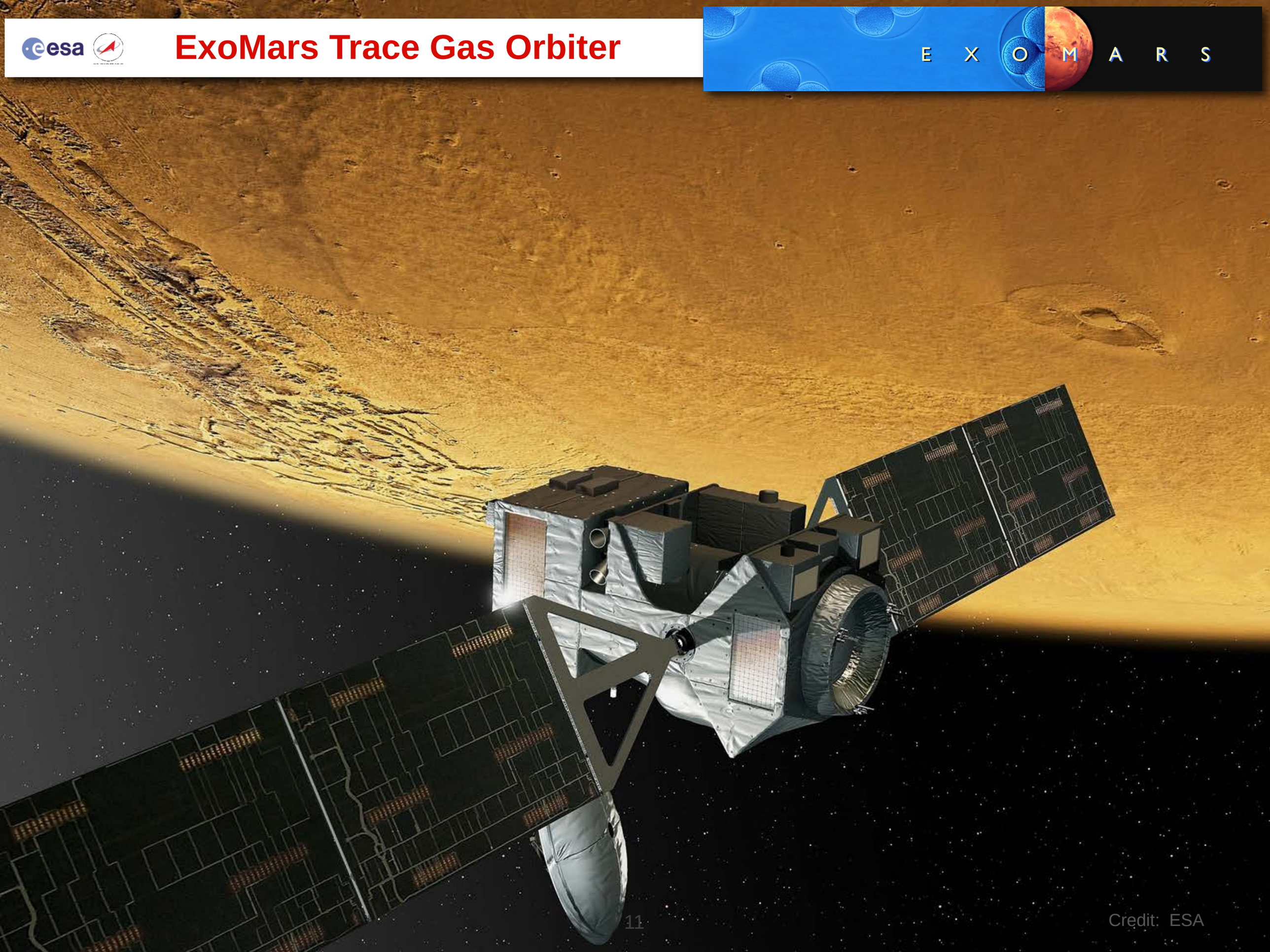
PFS Atmospheric Limb Scans as a Function of Height during Spring

- PFS has a large FOV so the data analysis is complicated. These results were never published.
- Data suggest that during spring the methane is located at 30–40 km altitude.

V. Formisano, Methane Workshop, Frascati (ITA), 2009

Credit: Hebes Chasma, MEX/HRSC

ExoMars Trace Gas Orbiter



Credit: ESA

TGO Payload

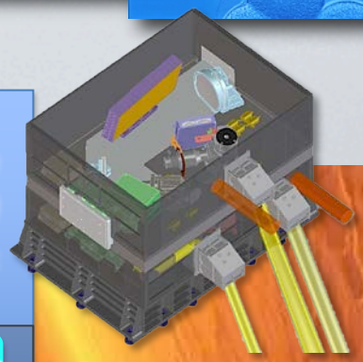
E X O M A R S

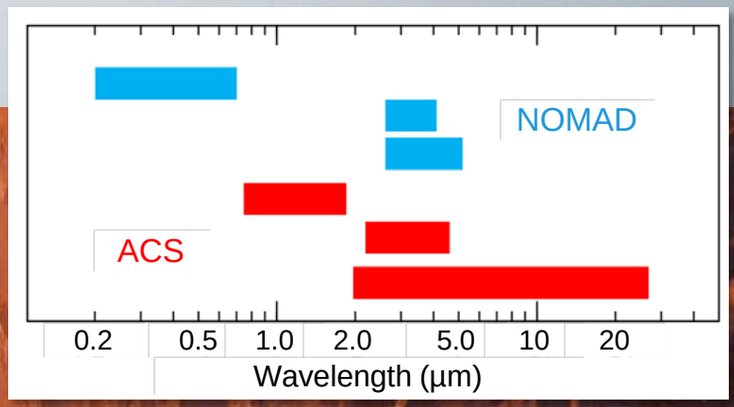
NOMAD

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		

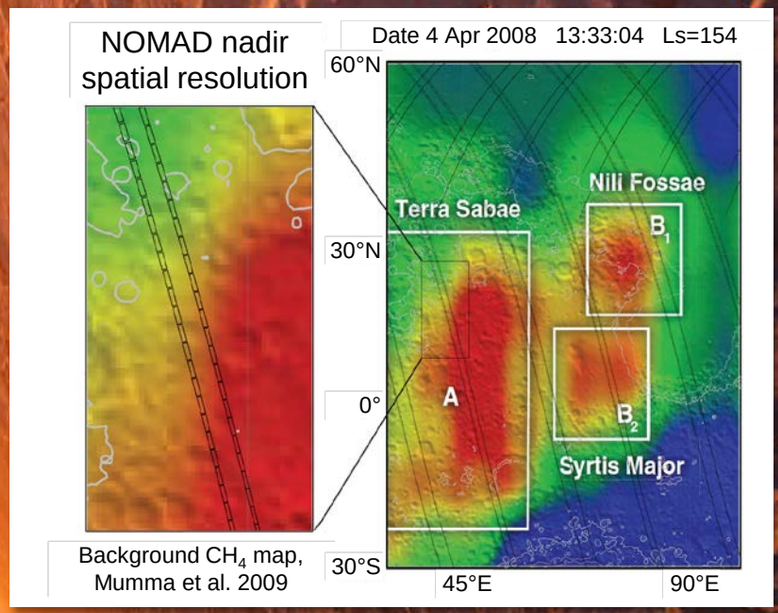




CaSSIS

High-resolution, stereo camera

Mapping of sources Landing site selection

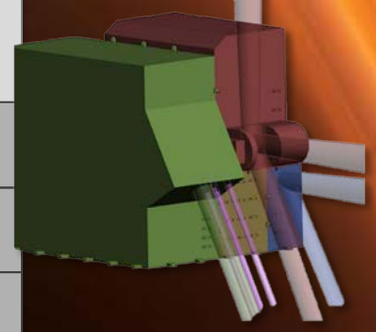


ACS

Suite of 3 high-resolution spectrometers

Atmospheric chemistry, aerosols, surface T, structure

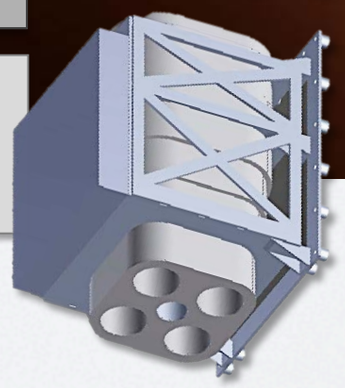
Near IR (0.7 – 1.7 μm) λ/Δλ ~20,000	SO	Limb	Nadir
IR (Fourier, 2 – 25 μm) λ/Δλ ~4000 (SO)/500 (N)	SO		Nadir
Mid IR (2.2 – 4.3 μm) λ/Δλ ~50,000	SO		



FREND

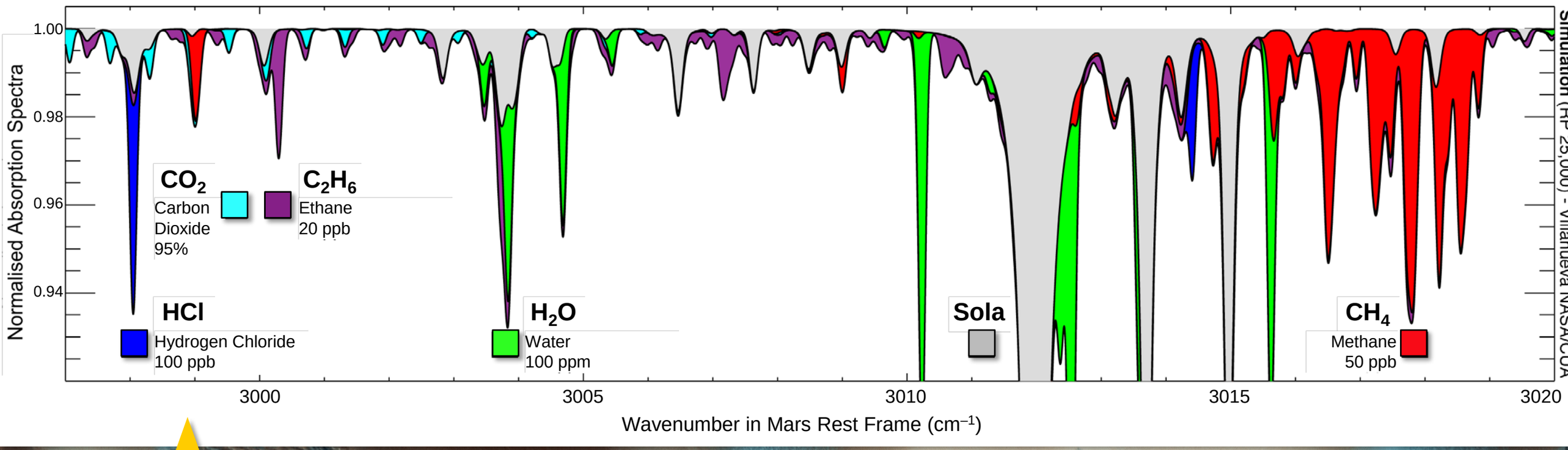
Collimated neutron detector

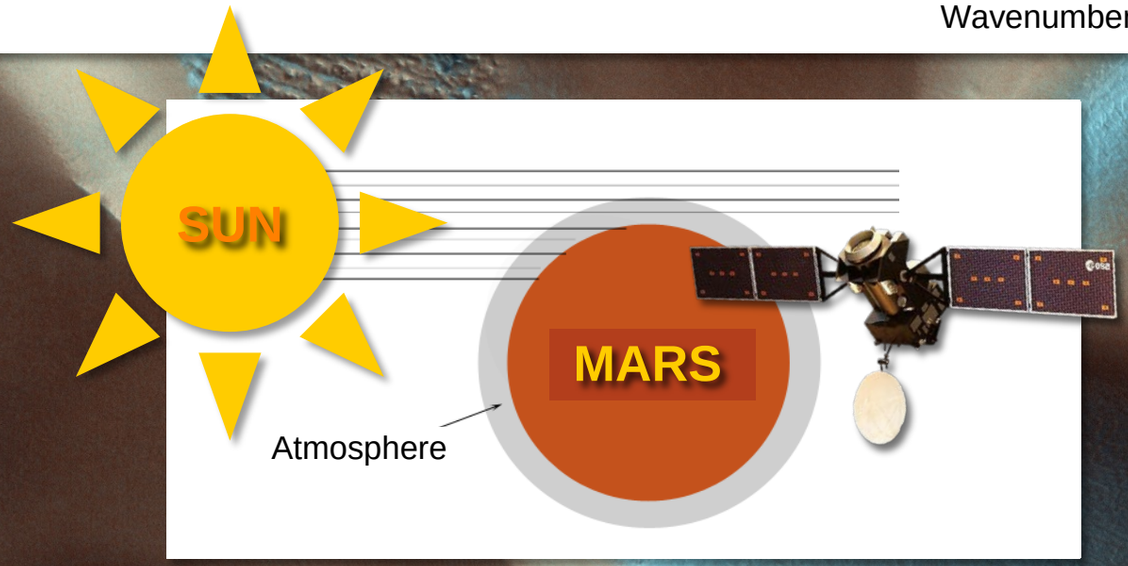
Mapping of subsurface water and hydrated minerals



Credit: Kees Veenenbos

Trace Species Visible in IR





- Methane detection can be confirmed (if present) by many absorption bands.
- TGO sensitivity is 100 ppt (~1000 times better than Mars Express).
- The ability to also measure other hydrocarbons will help establish its origin.

Credit: Frost covered dunes, MRO/HiRISE

Conclusions

You want to know what is kicking in Mars' atmosphere?

… ExoMars TGO will tell you.