

SPATIAL DISTRIBUTION AND TEMPORAL EVOLUTION OF METHANE IN THE MARTIAN ATMOSPHERE

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Previous measurements

Maguire, Icarus, 1977

IRIS (v_4) < 20 ppbv

Krasnopolsky, JGR, 1997

Ground (v_3) < 15 ppbv

Mumma, Bull. AAS, 2003

Ground (v_3) ---

Formisano, Science, 2004

PFS (v_3) 10 ± 5 (0 to 35)

Mumma, Bull. AAS, 2004 – 2008

Ground (v_3) ---

Krasnopolsky, Icarus, 2004, 2007

Ground (v_3) 10 ± 3 ppbv

Geminale & Formisano, PSS, 2008

PFS (v_3) 14 ± 5 (0 to 60)

Mumma, Science, 2009

Ground (v_3) 0 to 50 ppbv

Fonti & Marzo, submitted

TES (v_4)

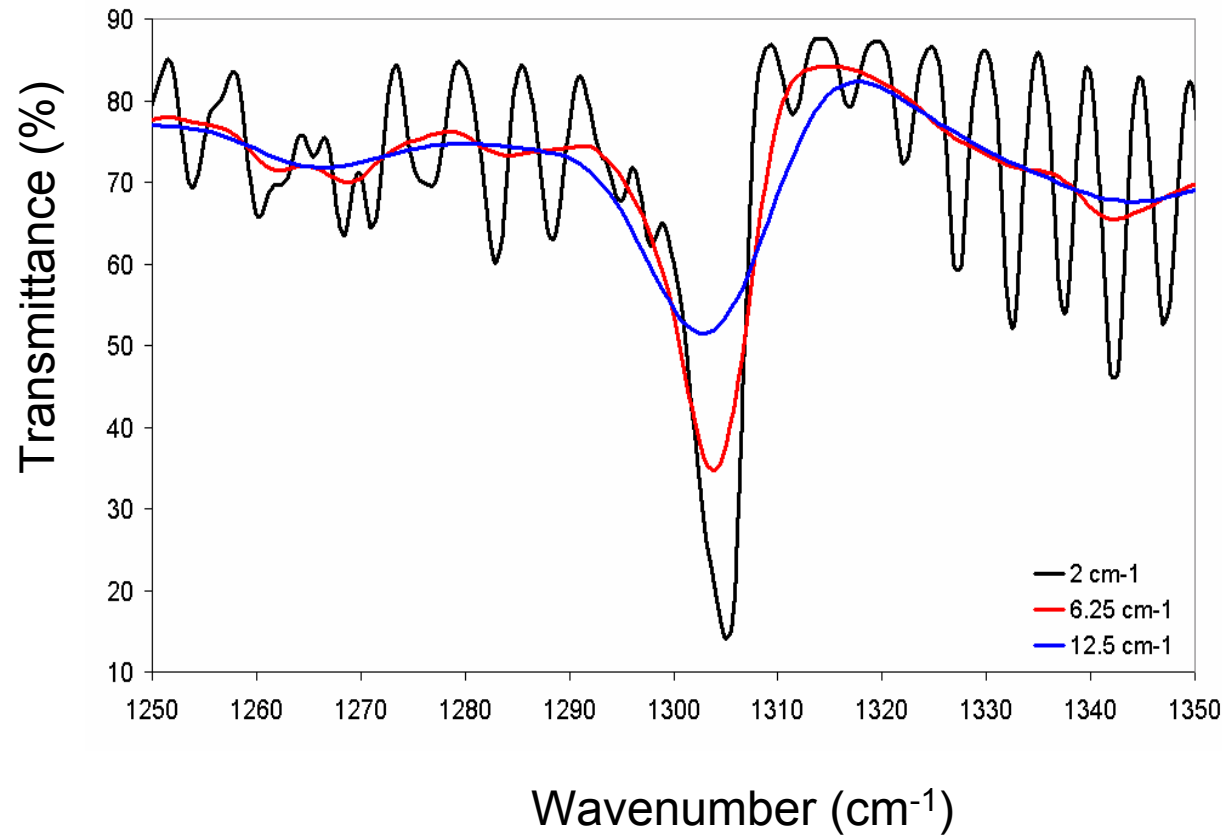
Planet coverage virtually complete

- Possibility to compare different regions and/or different time

Huge amount of data readily usable

- Meaningful averages in most places and at most times

Excellent S/N (~ 300) between 1250 – 1350 cm^{-1}



Acceptable
spectral
resolution

TES

Selection criteria

TES spectra have been selected in geography ($\pm 60^\circ$ in **latitude**), geometry and time of observation (**nadir; 11-15 h**) and Solar longitude ($\pm 2^\circ$ around each **equinox/solstice**)

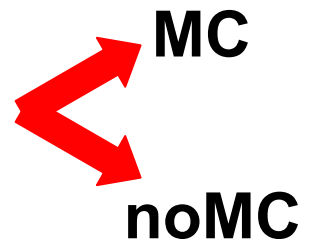
About 3,000,000 spectra

between Autumn of MY24 and Summer of MY27

Cluster Analysis

Clustering criterion: spectral differences around 1306 cm^{-1}

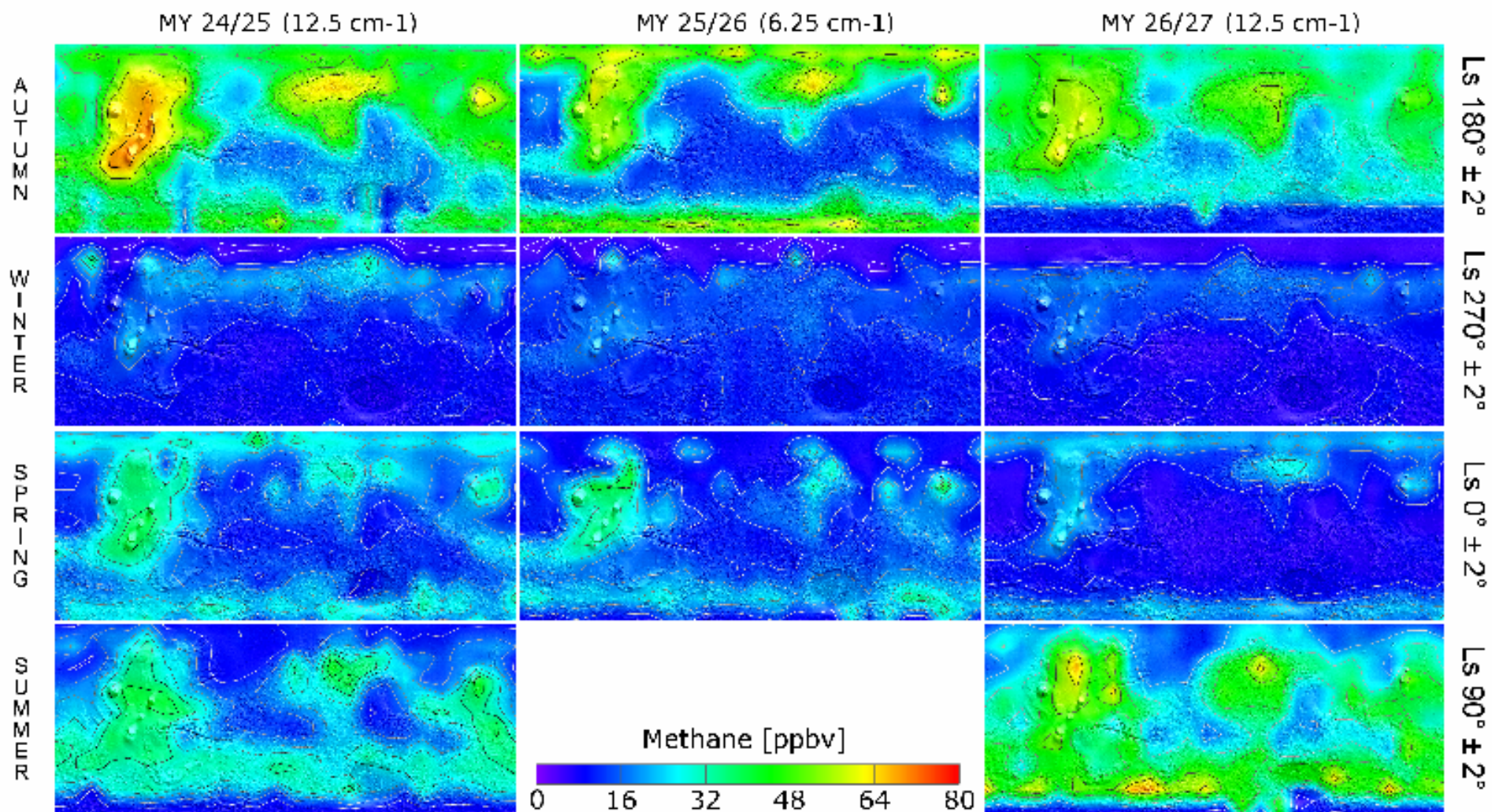
Results: two groups of spectra (plus spurious clusters)



RESULTS

Observation period	Resolution	Number of spectra		Methane (ppbv)
		Total	MC	
MY24 Ls 180	(12.5 cm ⁻¹)	516,701	213,522 (41%)	33 ± 9
MY24 Ls 270	(12.5 cm ⁻¹)	159,201	28,428 (18%)	6 ± 2
MY25 Ls 0	(12.5 cm ⁻¹)	359,717	144,898 (40%)	17 ± 5
MY25 Ls 90	(12.5 cm ⁻¹)	442,296	136,775 (30%)	14 ± 4
MY25 Ls 180	(6.25 cm ⁻¹)	68,901	18,495 (27%)	18 ± 7
MY25 Ls 270	(6.25 cm ⁻¹)	143,840	43,438 (30%)	5 ± 2
MY26 Ls 0	(6.25 cm ⁻¹)	69,349	14,003 (20%)	10 ± 4
MY26 Ls 90	(6.25 cm ⁻¹)	----	----	----
MY26 Ls 180	(12.5 cm ⁻¹)	507,365	200,508 (40%)	30 ± 8
MY26 Ls 270	(12.5 cm ⁻¹)	320,180	45,961 (14%)	5 ± 1
MY27 Ls 0	(12.5 cm ⁻¹)	197,327	42,677 (22%)	9 ± 3
MY27 Ls 90	(12.5 cm ⁻¹)	115,194	38,041 (33%)	28 ± 8

First spatial-temporal map of Martian methane



Questions

How the amount of methane was derived ?

Is it really methane ?

Is the result consistent with previous findings ?

How the reported amounts of methane have been derived ?

The methane abundance should be evaluated, taking into account both the **relative number of spectra** associated to the Methane Cluster and the **methane band depth** in the corresponding average spectrum

The chosen **Methane Index** has been the **band depth** in the ratio **(MC + noMC) / noMC** properly scaled, in order to take into account the different resolution

Locally the quantity of methane has been derived **scaling the number of spectra** present in **each cell** ($10^\circ \times 10^\circ$) to that of the corresponding **temporal slice**

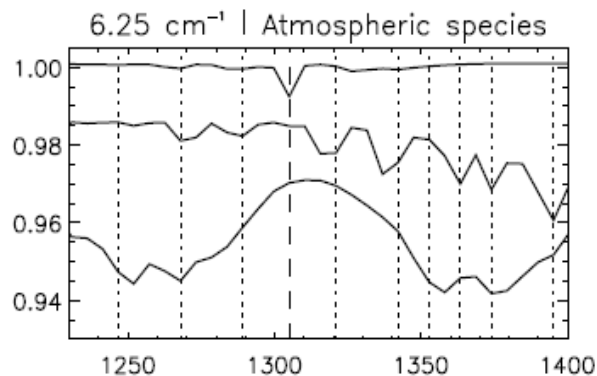
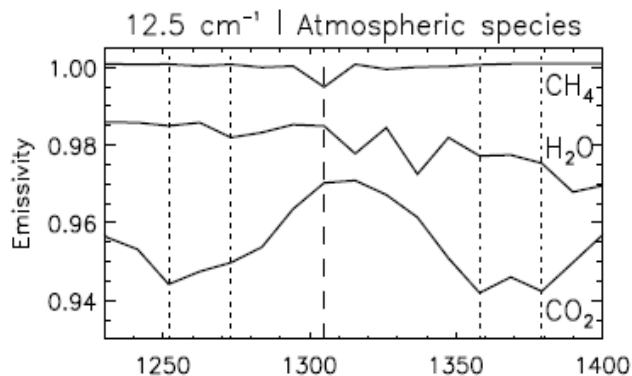
We have only the relative abundance

We have scaled the estimated detection limit given by Maguire

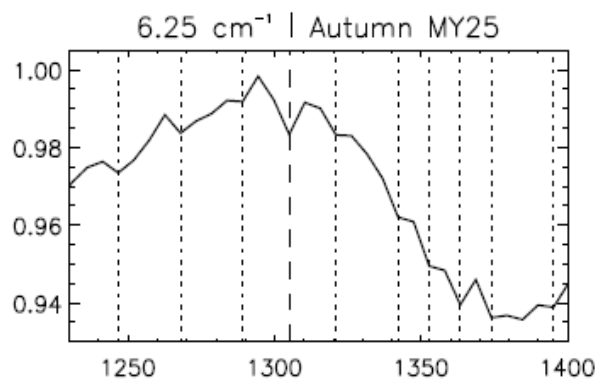
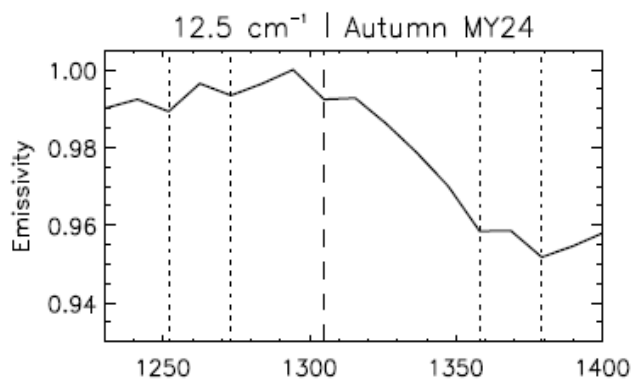
	IRIS	TES
Spectral resolution	2.4 cm ⁻¹	6.25 or 12.5 cm ⁻¹
NESR	5.0 10 ⁻⁸ W ⁻¹ cm ⁻² str ⁻¹ cm ⁻¹	1.2 10 ⁻⁸ W ⁻¹ cm ⁻² str ⁻¹ cm ⁻¹
Number of spectra	1,747	from 14,003 to 213,522
Derived detection limit	20 ppbv	from 2 to 6 ppbv

The normalization has been done assuming that methane was at its detection limit (5 ppbv) in Winter of MY26

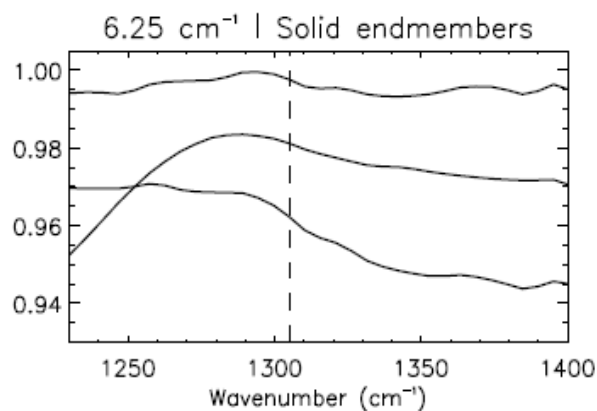
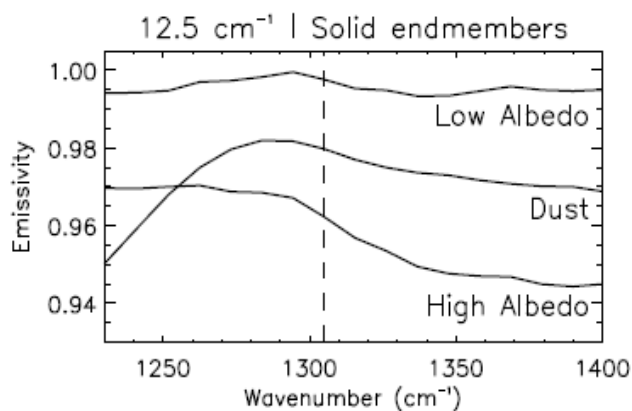
Is it really methane?



Comparison with
O₂ and CO₂
synthetic spectra



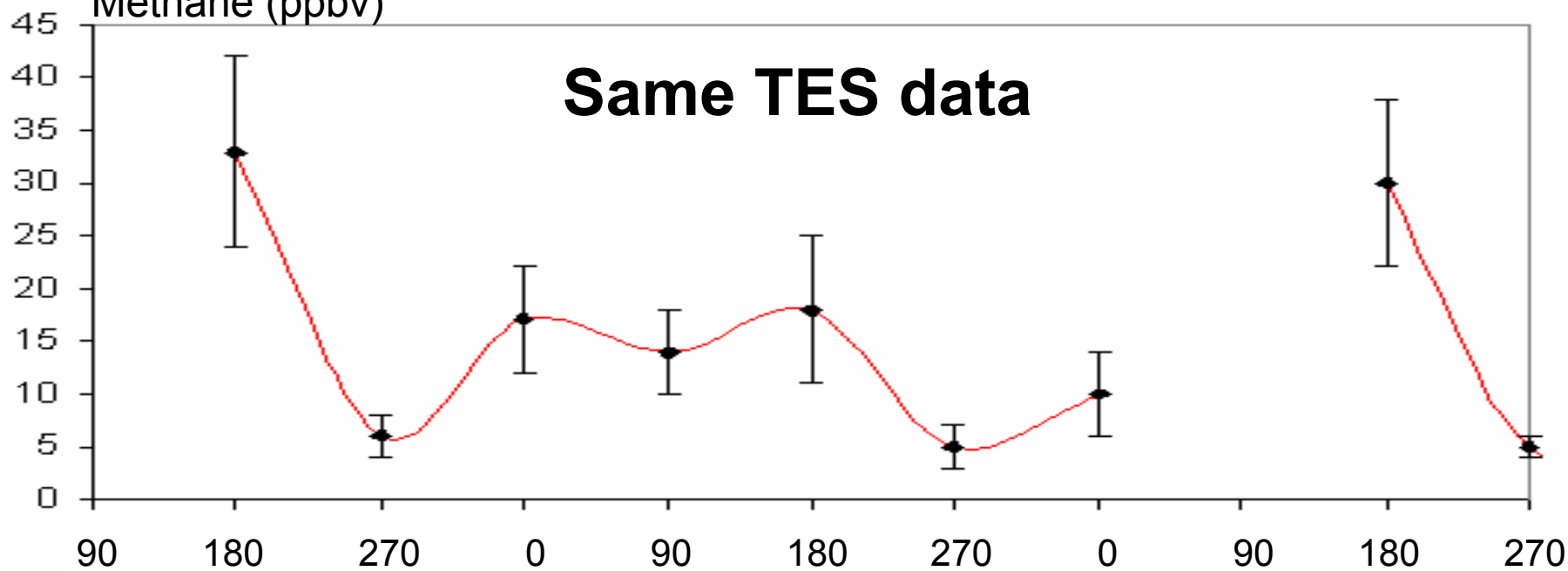
Measured spectra
(averages of two
Methane Clusters)



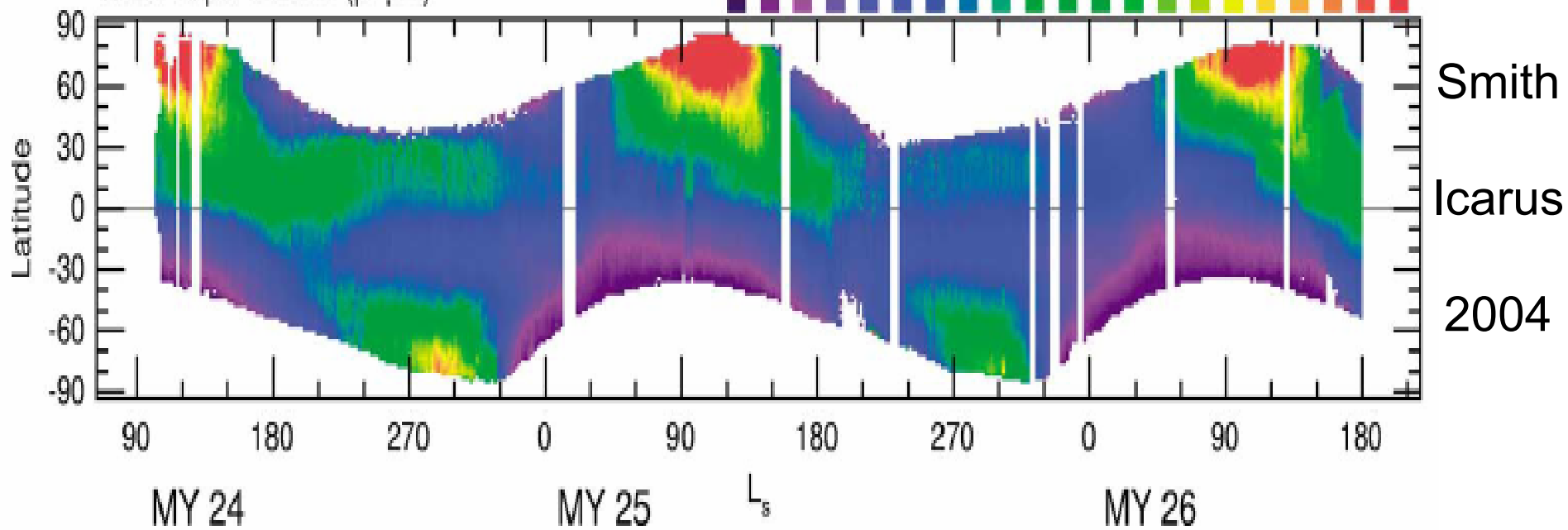
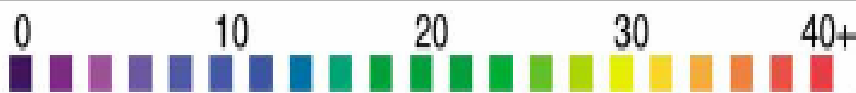
Solid component
(from Bandfield
and Smith)

Methane (ppbv)

Same TES data



Water Vapor Column (pr- μm)



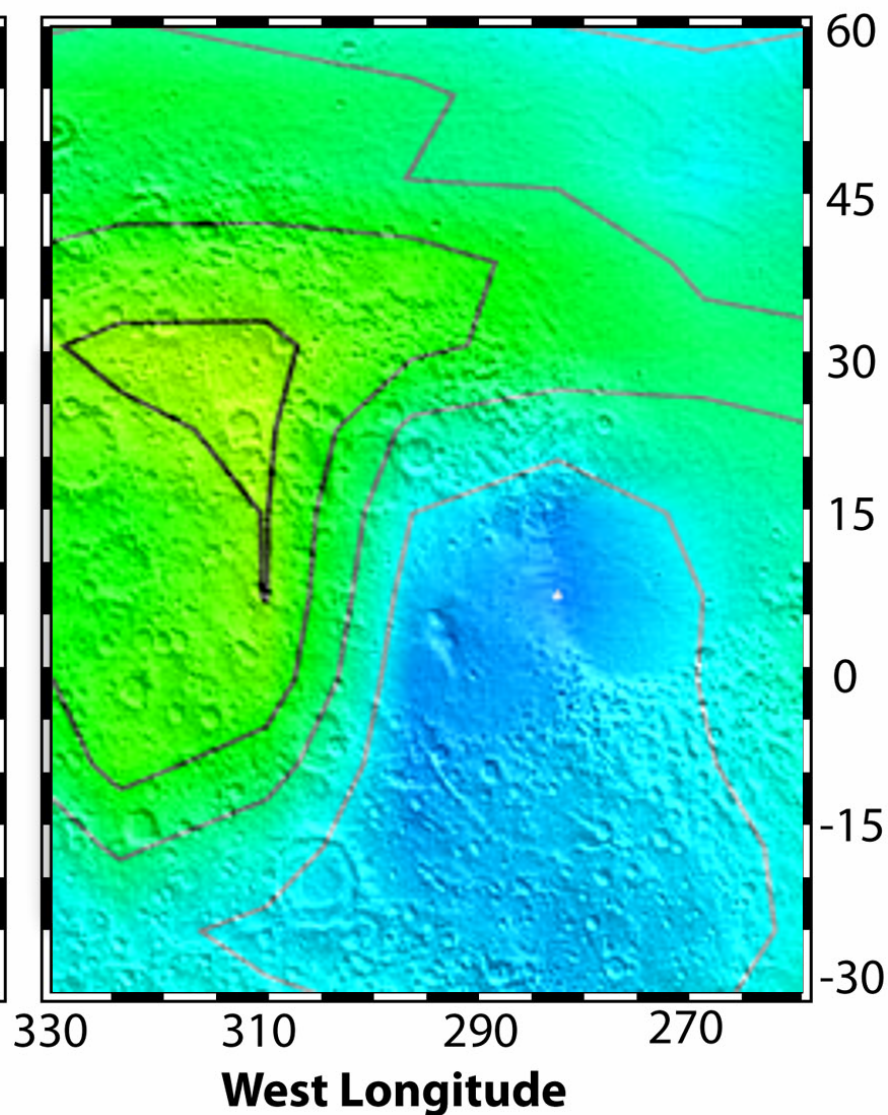
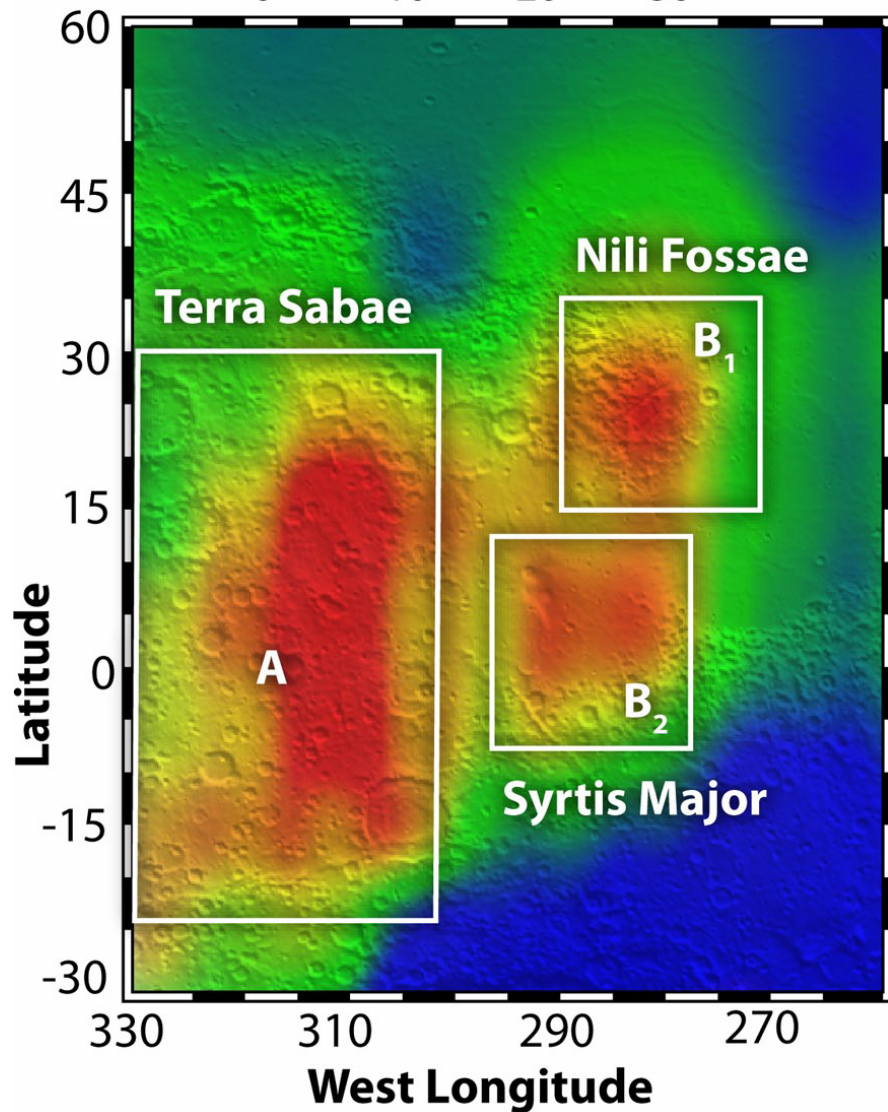
Are they consistent with previous findings ?

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Fonti & Marzo, submitted	TES (v_4)	16 ± 5 (0 to 70)

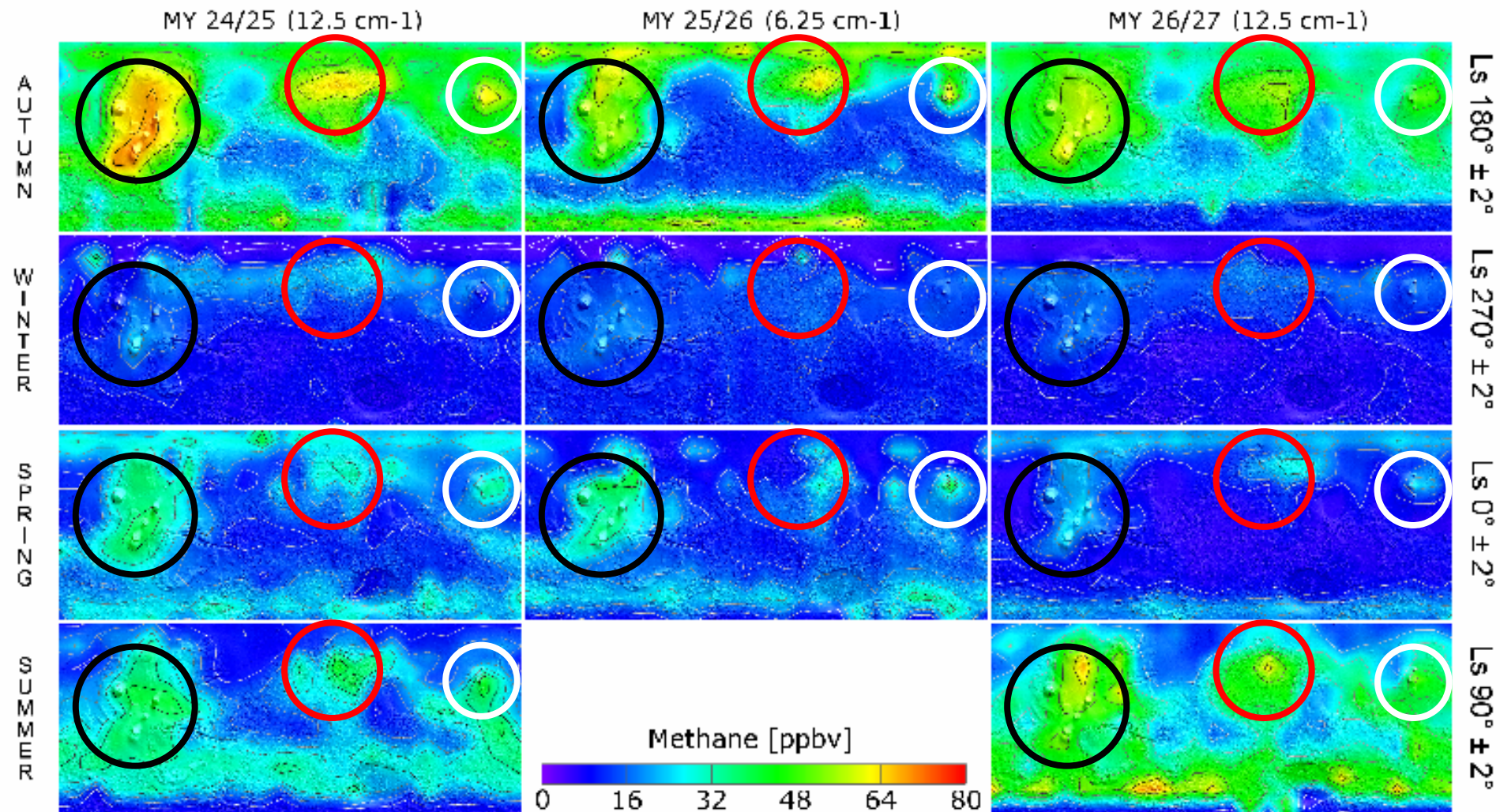
March 2003

May 2003

Methane abundance [ppb]



Discussion



Tharsis

Arabia Terra

Elysium

Methane Sources

Tharsis

Elysium



Dohm et al. (PSS, 56, 2008) reported multiple evidence for recent geological/hydrological activity in the Tharsis/Elysium corridor

Arabia Terrae

Associated with an extensive subsurface deposit of permafrost (Boynton et al., JGR, 112, 2007) and the presence of ancient springs (Allen and Oehler, Astrobiology, 8, 2008),

Hydration is a required condition for both the hydrogeochemical and biogenic hypotheses

Where is the methane coming from?

Most fascinating hypothesis: biology

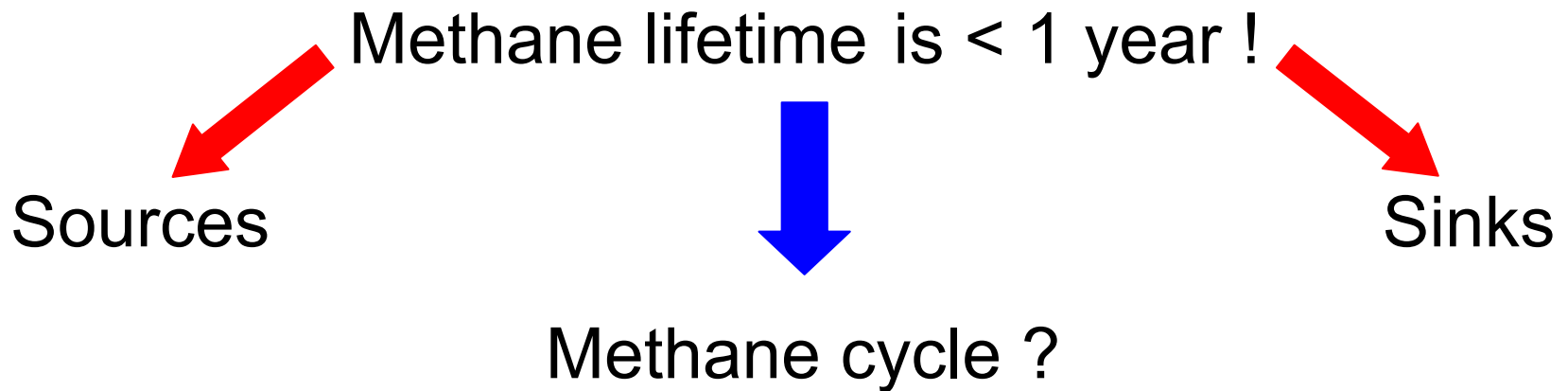
Possible

Other fascinating hypothesis: geology

Probable

Least fascinating hypothesis: external

Ruled out



Where (and how) is the methane going?