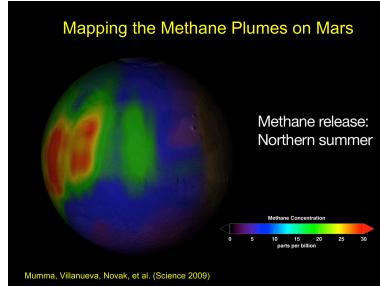
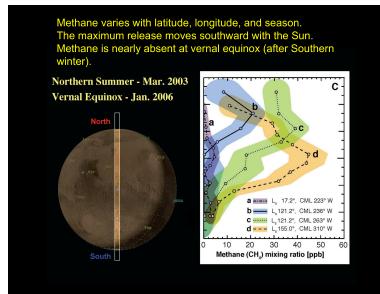
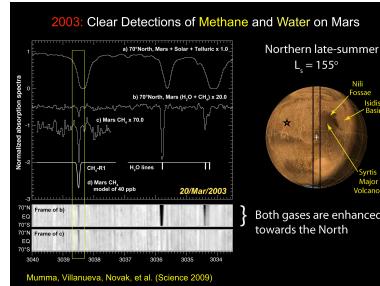
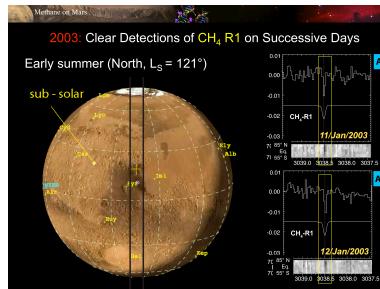




Methane and Related Trace Gases on Mars during 2003-2015, and planned extensions through 2016.

Methane & Water Detections – Jan & March 2003



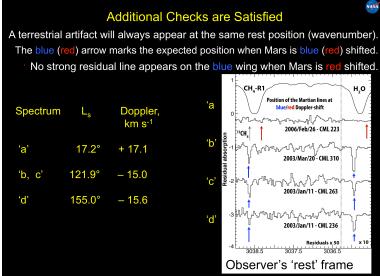
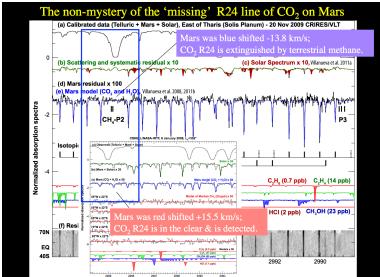
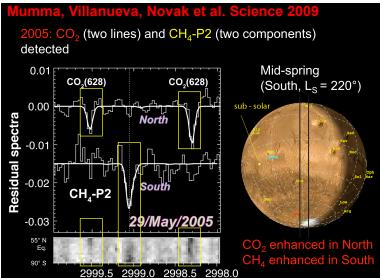
"Mars – The Cutting Edge Today"

Trace Gases: CH₄, CO, O₂, O₃, H₂O, HDO, H₂O₂, etc.
3-D spatial: longitude, latitude, & vertical
1-D temporal: (diurnal, seasonal, & inter-annual)
High resolution (spectral & spatial)

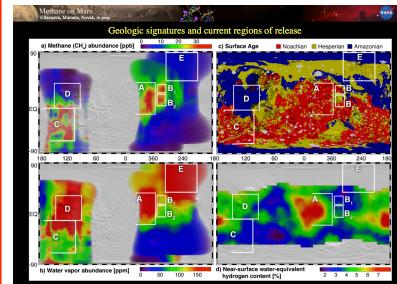
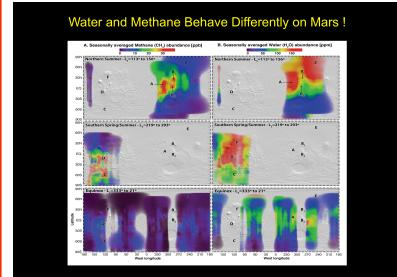
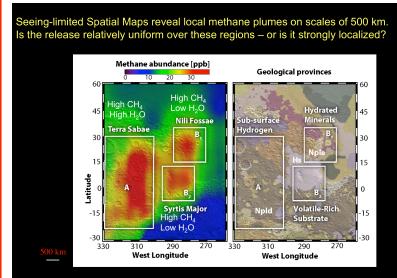
Orbiters & Rovers
MGS, MRO, Mars Express, MAVEN, ExoMars 2016
Curiosity, ExoMars 2018, Mars 2020

Ground-based
Keck, NASA-IRTF, VLT
ALMA
SOFIA

Methane & CO₂ Detections – May 2005



Methane & Water – Geological Context



Methane & Trace Gases: Telescopic Studies 2006 - 2010

Table 2
Abundance limits (3- σ) of trace species on Mars in parts-per-billion (ppb, 10⁻⁹)

Villanueva, Mumma, Novak et al. Icarus 2013

Molecule	Previous (3- σ , ppb)	06 January 2006 L _S 352° MY29	19 August 2009 L _S 324° MY27	20 November 2009 L _S 12° MY30	28 April 2010 L _S 83° MY30
Methane (CH ₄)	3-50°	<7.8	<6.6	<6.6	<7.2
Ethane (C ₂ H ₆)	<0.2-0.6°	<0.7	<0.6	<0.2	<0.2
Methanol (CH ₃ OH)	-	<19	<21	<6.9	-
Formamide (H ₂ CO)	<4.5°	<3.9	-	-	<3.9
Acetyl (CH ₃ C)	<5°	<6	<6	-	<4.2
Bilobane (C ₆ H ₁₂)	<70°	<1.2	<9	<4.1	-
Nitrous oxide (N ₂ O)	100°	<87	-	-	<65
Ammonia (NH ₃)	<8°	<57	-	-	<45
Hydrogen cyanide (HCN)	-	<4.5	-	-	<2.1
Methyl chloride (CH ₃ Cl)	-	<14.3	-	-	-
Hydrogen chloride (HCl)	<0.3°	<2.1	<1.5	<0.6	-
Hydroperoxy radical (HO ₂)	-	<198	-	-	<255

^a Mumma et al. (2009), Krasnopolsky et al. (2004), and Formisano et al. (2005).

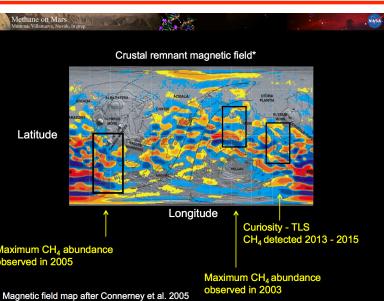
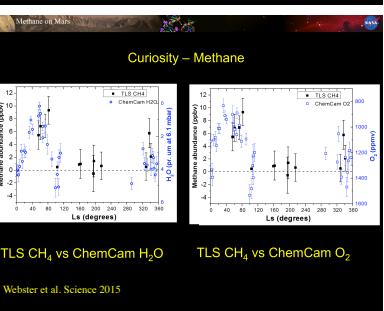
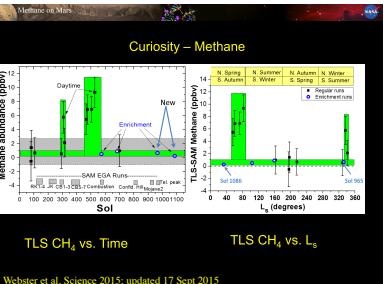
^b Villanueva et al. (2011) and Krasnopolsky (2012).

^c Krasnopolsky et al. (1997).

^d Maguire (1977).

^e Hartogh et al. (2010).

Methane, O₂ & Water – Curiosity 2013 - 2015



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