Martian methane: Fluxes, Lifetimes etc

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Deriving the CH_4 flux : conventional chemistry

- vmr_{CH4} : CH_4 equilibrium mixing ratio

PFS :	vmr_{CH4} = 10 ppbv	(Formisano et al., 2004)
TLS :	vmr_{CH4} = 0.7 ppbv	(Webster et al., 2015)

- M_{CH4} : total mass of CH_4 in the atmosphere (kg)

$$M_{CH4} = \Sigma\Sigma\Sigma\ mmr_{CH4} / g\ \Delta p\ \Delta x\ \Delta y$$

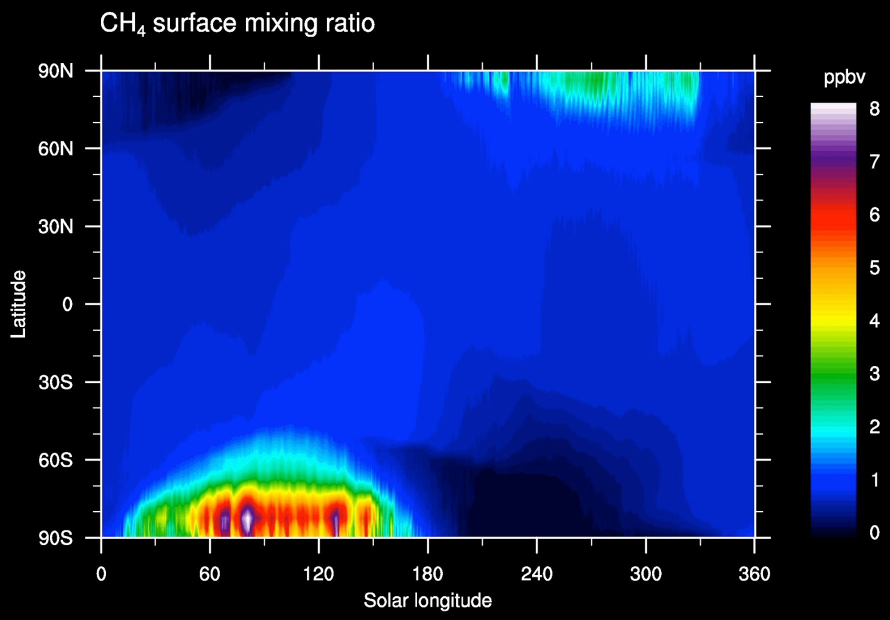
- F_{CH4} : CH_4 flux (kg/s)

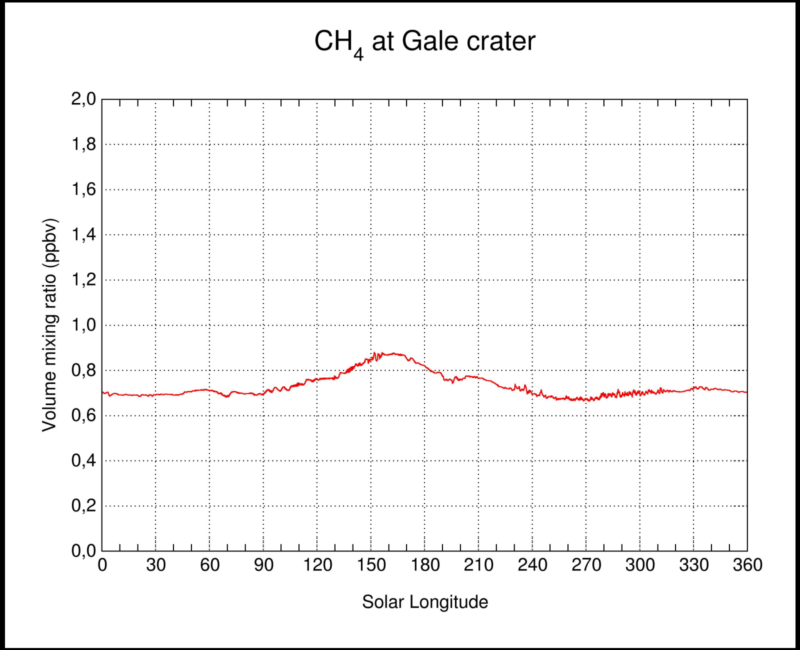
$$F_{CH4} = M_{CH4}/\text{lifetime}$$

for a lifetime of 300 years :

PFS :	$F_{CH4} = 260\ t\ yr^{-1}$	(2000 cows)
TLS :	$F_{CH4} = 20\ t\ yr^{-1}$	(250 cows)
Earth :	$F_{CH4} = 580 \times 10^6$ t yr-1	(total)
	$60 \times 10^6\ t\ yr^{-1}$	(abiotic)

CH_4 seasonal evolution (300 year lifetime)



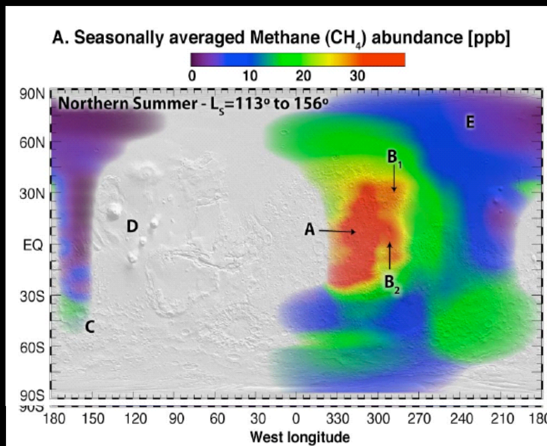


CH_4 seasonal evolution

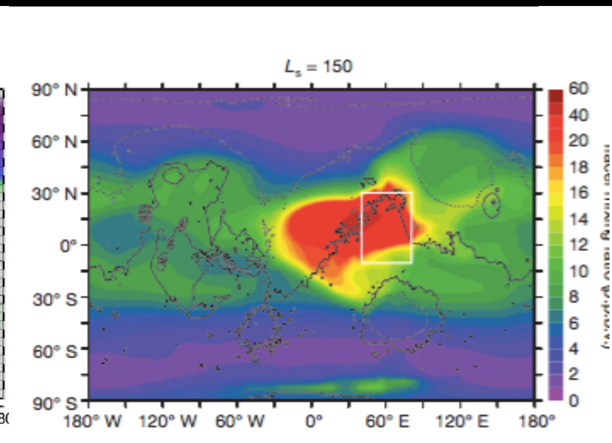
CH_4 at Gale Crater

- ➢ CH_4 spike ? → a stronger source is needed → shorter lifetime

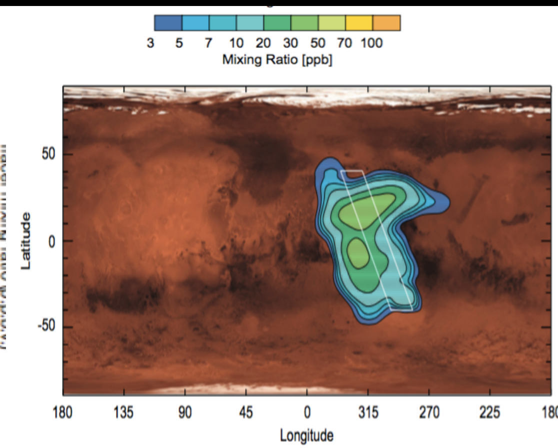
The CSHELL/NIRSPEC case



Mumma et al., 2009



Lefèvre and Forget, 2009

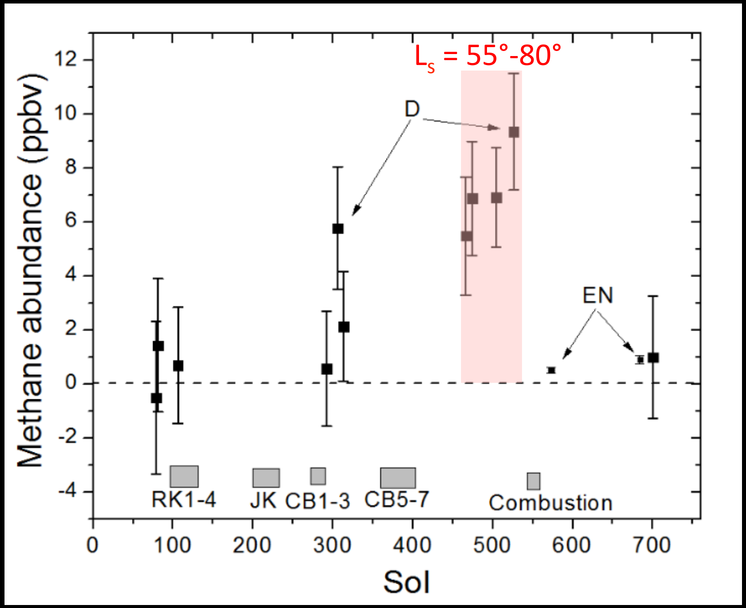


Mischna et al., 2011

	Mumma et al. (2009)	Lefèvre and Forget (2009)	Mischna et al. (2011)
Lifetime, seasonal event	400 days	200 days	
Lifetime, single event	4 years	2 years	2.7 years
Flux, seasonal event	20 000 t yr^{-1}	150 000 t yr-1	
Flux, single event		80 000 t yr-1	19 000 t yr^{-1}

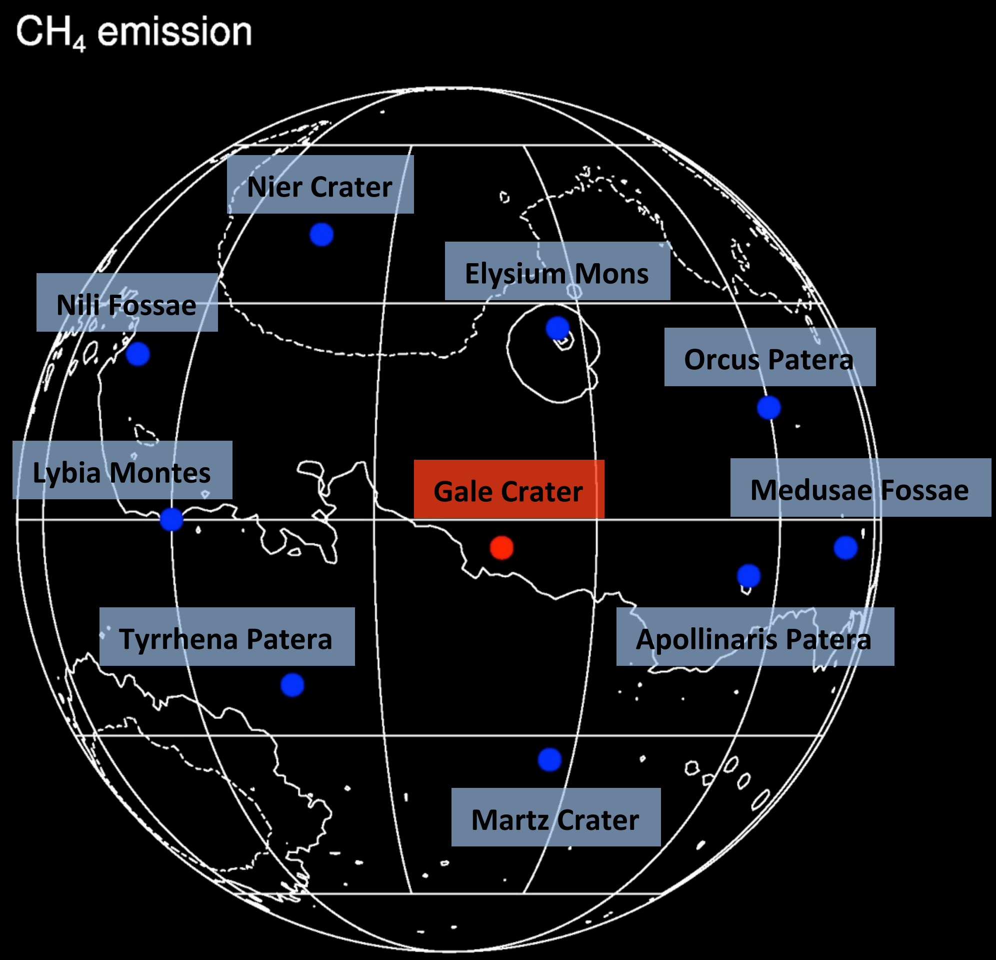
The TSL-SAM case

- TSL scenario
  - CH_4 background level : 0.7 ppbv
  - CH_4 spike of 7 ppbv between L_s = 55°-80°
  - Permanent release

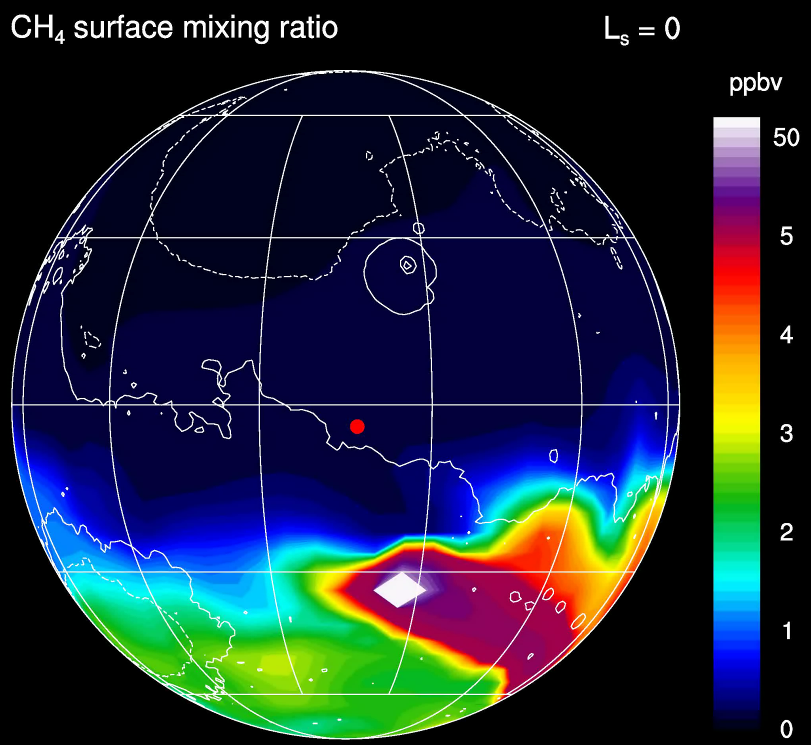


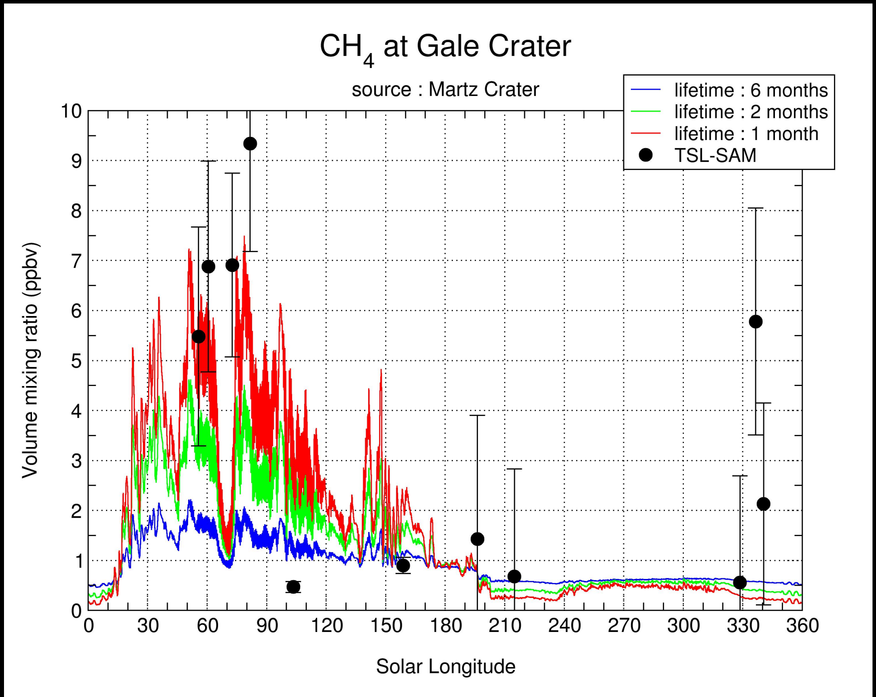
Webster et al., 2015

CH_4 plume at Gale ?



Source: Martz Crater





CH_4 lifetime : 1 month (75 000 t yr^{-1})

Summary

Observations	hypothesis	CH_4 lifetime	CH_4 Flux (t yr-1)
Mumma et al. (2009)	single event	2-4 years	20 000 – 80 000
Mumma et al. (2009)	seasonal release	200-400 days	20 000 – 150 000
Webster et al. (2015)	permanent release	1 month	75 000
Webster et al. (2015)	no spike, 0.7 ppbv	300 years	20
Etiope (2015)	Earth, total geologic	10 years	60 000 000

- **Caveats**
  - Difficulty to reconcile Earth-based, PFS, and MSL observations
  - Lack of observations to constrain GCMs
  - CH_4 surface loss requires even faster destruction mechanism
  - No viable explanation to date for a CH_4 lifetime << 300 years