Seasonal cycle of methane on Mars could be produced by variations of the Hadley cell and differential hemispheric releases

Jorge Pla-García\textsuperscript{1,2}, Scot C.R. Rafkin\textsuperscript{3}, C.R. Webster\textsuperscript{4}, P.R. Mahaffy\textsuperscript{5}, O. Karatekin\textsuperscript{6}, E. Gloesener\textsuperscript{6} and J.E. Moores\textsuperscript{7}

\textsuperscript{1}Centro de Astrobiología; \textsuperscript{2}Space Science Institute; \textsuperscript{3}Southwest Research Institute; \textsuperscript{4}Jet Propulsion Laboratory; \textsuperscript{5}NASA Goddard Space Flight Center; \textsuperscript{6}Royal Observatory of Belgium, \textsuperscript{7}Centre for Research in Earth and Space Science

jpla@cab.inta-csic.es
Background levels of methane in Mars’ atmosphere show strong seasonal variations. 

Webster et al. 2018
Mars Global circulation studies using (18) passive tracers in MRAMS atmospheric transport experiments

T1-T6: 0-10 km above ground level
T7-T12: 10-30 km above ground level
T13-T18: 30-50 km above ground level

Global slice of the martian topography along 0° E longitude (MGS)
Equinox (southern fall)

Sols:ce (southern summer)

Release time

Modeling results

Air masses confined close to equator at equinoxes
Seasonal variations of the Hadley cell impacts transport of trace gases to Gale
(based on MRAMS global tracers experiments, Pla-García et al. 2020, tbs)

Equinoxes ($L_s$ 0° & $L_s$ 180°)

**Dual** Hadley cells with air rising near the equator being fed by surface flow from both hemispheres helps to confine air masses close to Gale crater.

$L_s$ 90° solstice

$L_s$ 270° solstice

**Global** Hadley Cell drives air coming in straight from high latitudes of the winter hemisphere almost undiluted replacing Gale air masses.
Seasonal variations of the Mars Hadley cell and CH$_4$ release may drive the seasonal CH$_4$ cycle at Gale Crater

CH$_4$ rich (warmer seasons at Gale) internal crater air is being rapidly replaced with a wholesale inundation of *putative*- CH$_4$ poor external crater air from the NORTHERN winter hemisphere.

Equinoxes: internal crater air is mixed with external crater air from more tropical regions. AIR MASSES ARE BEING CONFINED CLOSE TO EQUATOR.

CH$_4$ poor (cooler seasons at Gale) internal crater air is mixed with *-putative*- CH$_4$ poor (cooler seasons close to Gale) external crater air from the SOUTHERN winter hemisphere.
Conclusions

• Strong correlation between atmospheric CH₄ values and ground temperature at Gale during most of the year except during Ls216-298.

• If methane release is related to ground temperature, then we can assume that the cold polar regions have lower emissions and will tend to be methane poor.

• Placement of latitudinally initialized tracers to test the hemispheric transport hypothesis.

• The circulation during Ls216-298 transports cold, north polar air into Gale. This should result in methane concentrations that are lower than what would be expected based on the local ground temperature.

• At equinoxes, the source of air in Gale is more tropical, and thus the methane concentrations should roughly track the local ground temperature.

• The seasonal change in the global circulation (winds) combined with seasonal changes in the hemispheric release of CH₄ (temperature dependent subsurface emissions) could produce a seasonal CH₄ signal at Gale.