MAPPING THE METHANE ON MARS: SEASONAL COMPARISON.

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Introduction:

Methane has recently been detected in the Martian atmosphere at abundances of 10 parts per billion (ppb) or greater [1, 2, 3], and because of the short photochemical lifetime (~300 Earth years) [3, 5] these detections suggest recent geological or biological activity. Not only has methane been detected on a planet where its existence is unexpected, these observations suggest a spatially and temporally variable methane abundance with a lifetime (~0.6 Earth years) much shorter than expected from photochemical destruction. These observations provide a limited amount of data, and none occur during the same season, so there are few constraints on the spatial and temporal evolution of Martian methane. In order to understand the sources and sinks of the gas, we need a broader dataset with more spatial and temporal coverage.

Tools have been developed to utilize an already existing dataset to fill in this gap. I will use a statistical clustering technique developed by Marzo et al. [2006] to investigate the available Mars Global Surveyor Thermal Emission Spectrometer data to derive methane abundances at seasons analogous to the Mumma et al. [2009] observations.

Tools:

Marzo et al. [2006] have developed a statistical clustering technique which works by comparing thousands of spectra and grouping spectra together based on similar characteristics. The usefulness of this technique has been demonstrated through analysis of a large number of Mars Global Surveyor Thermal Emission Spectrometer (TES) spectra and successfully reproduced results of surface mineralogy mapping, and identified CO_2 and H_2O aerosol and water ice content in the Martian atmosphere [6, 7]. The clustering method provides a time efficient manner to process a large number of spectra without a need for reduction of individual spectra or preprocessing.

Application to Methane:

This clustering technique has been applied by Fonti and Marzo [2010] to derive putative methane abundances using TES spectra at 7.8 microns. The spectral resolution (6.25 or 12.5 cm^{-1}) of an individual spectrum from the TES instrument should not be sufficient to detect the narrow methane band feature at 1306 cm^{-1}, but by averaging together a few thousand spectra (minimum of 3000 spectra for 6.25 cm^{-1}, 11000 spectra for 12.5 cm^{-1}) the methane feature is detectable [4]. Results for the cardinal seasons (L_s 0º, 90º, 180º, 270º) of 3 Martian years (MY 24/25, 25/26, 26/27) have been derived to demonstrate the usefulness of this technique. These data can be used to study the spatial and temporal distribution of methane because they are globally extensive and cover a wide seasonal range.

An example of the results of Marzo et al. [2010], maps from Mars year 24/25 are shown in Figure 1.

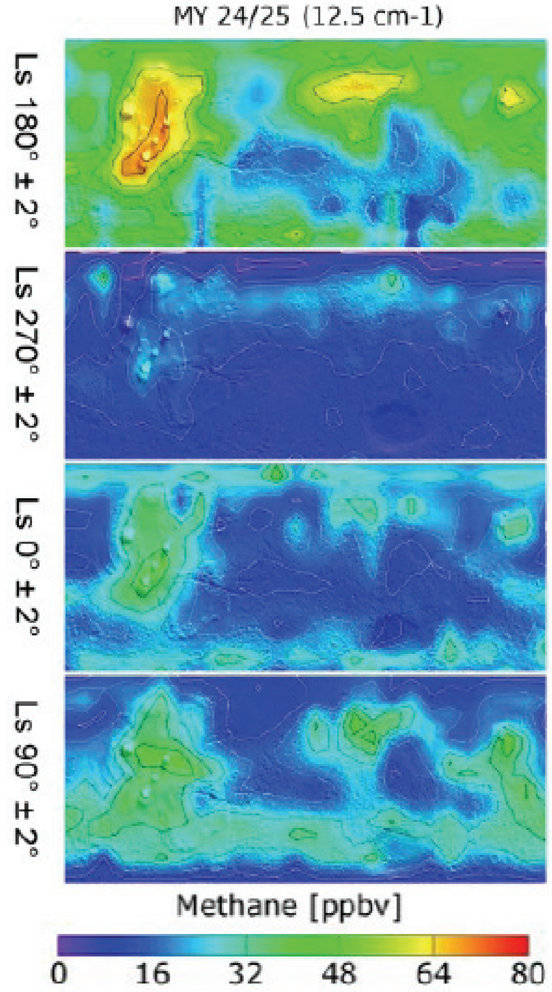

Figure 1: Map of Martian methane distribution at cardinal seasons for one Martian year. A topographical map is included.

There are three methane sources identified from these maps, Arabia Terra (source identified by Mumma et al. [2009]), and Elysium and Tharsis volcanic provinces. These sources appear to be most active during late Northern Summer, and least active in late Northern Autumn. The selected spectra are from the warmest part of the day, in nadir configuration in order to take advantage of the high radiance and spatial resolution and cover latitudes between 60º S and 60º N. Peak methane abundances of ~70 ppb in Figure 1 are comparable to those derived by Mumma et al. [2009], shown in Figure 2 (~45 ppb).

Seasonal Comparison:

I will utilize the clustering technique of Fonti and Marzo [2010] with available TES spectra to investigate the methane distribution at the seasons observed by Mumma et al. [2009] (L_s 17º, 121º, 155º). I will derive methane abundance maps like those of Fonti and Marzo [2010] at the observed seasons of Mumma et al. [2009], and I will compare the latitudinal abundance distributions from these maps with abundance distributions shown in Figure 2 (from Mumma et al. [2009], Figure 2c) at the longitude ranges observed by Mumma et al. [2009].). I expect to find abundances similar to Figure 2 from the TES derivations in the longitude ranges observed by Mumma et al. [2009].

This will be the first comparison of two different sets of detections of Martian methane at the same seasonal dates. These detections are also made in two different methane bands (TES at 7.8 microns, Mumma et al. [2009] at 3.3 microns).

References: [1] Mumma, M. J. et al. (2009), *Science,* 323, 1041-1045. [2] Formisano, V. et al. (2004), *Science*, 306, 1758-1761. [3] Krasnopolsky, V. et al., (2004) *Icarus*, 172, 537-547. [4] Fonti, S. and Marzo, *Astronomy & Astrophysics,* 512, A51, [5] Lefevre, F. and Forget, F. (2009), *Nature*, 460, 720-723 [6] Marzo, G. A., et al. (2006), *J. Geophys. Res.*, 111, 3002, [7] Marzo, G. A. et al. (2008), *J. Geophys. Res. (Planets)*, 113, 12009

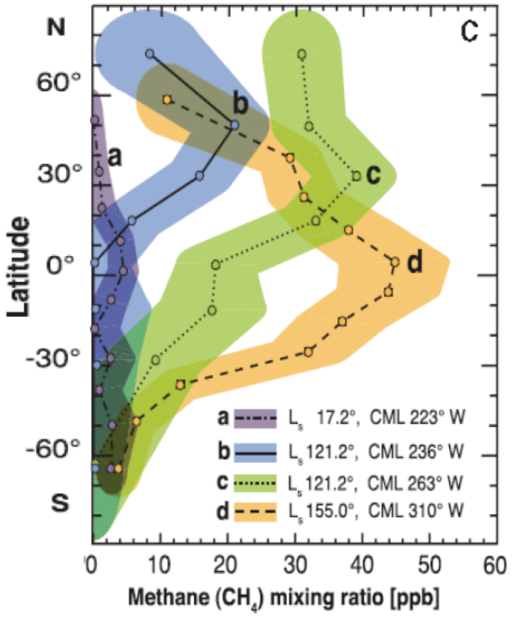

Figure 2: Longitudinal abundance distribution of methane from the observations of Mumma et al. [2009] at 4 different seasonal dates. Observations cover a longitude range of ~40° about the center meridian longitude (CML).