GCM SIMULATIONS OF MARTIAN METHANE.
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Introduction: The spectroscopic detection of methane in the atmosphere of Mars is the first observation of an organic compound on that planet [1-3]. CH_4 has a lifetime of a few centuries, which suggests a young or current source. On the other hand, this lifetime is long enough for the atmospheric circulation to yield a uniform distribution of CH_4 across the planet, which is not what is observed. Indeed an intriguing aspect of Martian methane is that it appears to vary with time and location. Earth-based and satellite observations report the presence of strong local enhancements, as well as a substantial seasonal evolution [4-6]. To understand better how such variations can occur and what are the implications on the nature of the source, we performed multiple general circulation model simulations including various scenarios of emission.

Method: We used the LMD general circulation model which has been shown to represent the details of Martian climate [7], tracer transport [8] and photochemistry [9] with good accuracy. The methane chemistry has been implemented in our photochemical module. Loss of methane occurs by photolysis above 80 km, and by oxidation by OH and $O(^1D)$ at lower altitudes. These constituents are produced respectively by the photolysis of H_2O and O_3. The fact that the LMD GCM reproduces well their observed climatology, subject to large seasonal and geographical variations, is an important advantage for a precise estimate of the fate of methane in the Martian atmosphere.

Results: we first considered a simulation which does not include any active source of methane. Thus, the experiment reproduces a scenario which assumes that methane was released sometime in the Martian past, and is currently only subject to atmospheric transport and photochemical loss. The model is initialized with a uniform methane mixing ratio of 14 ppbv, corresponding to the yearly-averaged value measured by the Planetary Fourier Spectrometer (PFS) on board Mars-Express [6]. Figure 1 displays the results obtained at vernal equinox after a quasi-stationary state is reached. It can be seen that methane remains almost uniformly mixed up to about 70 km at low to mid latitudes. Above that altitude, its mixing ratio decreases rapidly as a consequence of fast loss by photolysis, whereas the meridional circulation brings low values down towards the poles. Results obtained at other seasons, as well as the enrichment/depletion of methane caused by CO_2 condensation/sublimation [10], will be presented in the workshop.

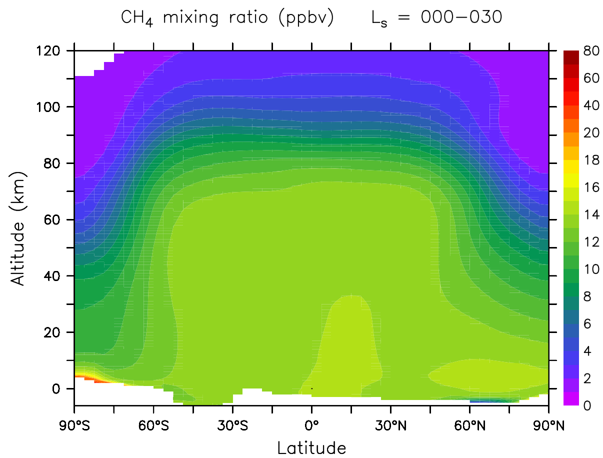

Figure 1. Zonal mean mixing ratio of methane computed at L_s = 0-30°. The simulation is initialized with a uniform value of 14 ppbv.

We then examined methane variations created by an active source at the surface. Based on the conventional chemistry and a long-term simulation of the GCM, we have derived the CH_4 atmospheric lifetime, from which the rate of methane emission required to maintain global equilibrium can be calculated. The possibility that a local or transient source could create local enhancements in these conditions has been investigated with detailed GCM experiments. Finally, we used idealized tracers to derive what should be the lifetime of a gas showing variations similar to those observed for methane on Mars.

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