ANALYSIS OF MARTIAN PRESSURE DATA TO INVESTIGATE POTENTIAL CO_2 ADSORPTION.

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Introduction: When considering the atmospheric CO_2 cycle on Mars, little research has been done regarding the possibility of the contribution of adsorption in and out of the regolith. The driving force behind the seasonal CO_2 cycle is the sublimation and deposition of CO_2 ice in and out of the polar caps [1,2]. Other processes at various timescales also play a role, including but not limited to atmospheric tides, dust storms, and transient eddies [3,4,5]. With all of these components comprising such a complex system, it can be difficult, but also important, to understand and account for each of the processes that make up the overall CO_2 cycle. It has been suggested that the Martian regolith has high internal surface area and therefore a relatively high capacity for storing adsorbed gas [6]. This leaves open the possibility of significant levels of CO_2 adsorption into the Martian regolith [7]. Adsorption into the regolith has been previously proposed to explain the observed cycles in the methane [8,9] or water [6,7] mixing ratios. Determining if CO_2 adsorption is occurring, and to what extent, is important to having a complete picture of the processes that control the CO_2 cycle on Mars and strengthening our understanding of the Martian atmosphere and climate.

Methods: The objective of this work is to produce power spectra of both in-situ and modelled Martian pressure data. In both cases, the peaks of the power spectra are analyzed to identify various individual contributors in the overall Martian CO_2 cycle. Since the models account only for known cycles, peaks or cycles that appear in the in-situ power spectra but not the modelled power spectra may provide evidence for the adsorption of CO_2 in and out of the regolith. To get the power spectra, we used the OriginPro data analysis software. First, we extracted Viking Lander 1 and 2 pressure data from the NASA Planetary Data System (PDS) [10] into OriginPro. We then selected a portion of the data that was approximately 1 Martian year (Viking 1, mission year 1, solar longitude (Ls) ~97-360), performed a linear interpolation to evenly space the data, and then performed a fast Fourier transform (FFT) to obtain the power spectrum. For modelled data we used the Mars Climate Database (MCD) version 6.1, which is publicly available at http://www-mars.lmd.jussieu.fr/mcd_python/ [11,12]. To align with the in-situ data that we used, we set the variable to pressure and the spatial coordinates to the Viking 1 landing site. Since each MCD run only produces 25 data points, we used two methods to increase the resolution of the model. First, instead of modelling one Martian year by doing one run from Ls 0-360, we broke it up into chunks of 15 Ls at a time, and combined the data later on. Second, we ran the model at 12 different local times (every 2 Martian hours from 0 to 24) for each Ls range. Since Ls and local time are two separate variables in the MCD, one must be set as constant while the other is modelled over a range. Because of this, we had to manually convert our local times, in Martian hours, to Ls and shift them accordingly to achieve an accurate timescale of the data as you move across the graph in Ls. Once this was complete, we had 1 Martian year of modelled data with just under 7,000 data points, compared to just over 40,000 data points from the in-situ Viking 1 data that we used. Just like with the in-situ data, we imported our modelled data over the same Ls range (~97-360) into OriginPro and performed the linear interpolation and FFT to obtain the power spectrum. We then analyzed and compared the peaks of the in-situ and modelled power spectra both by hand and by using peak analysis tools available in OriginPro. The entire process was repeated using in-situ data from the Mars Science Laboratory (MSL) Curiosity Rover [13,14], over a time range of just above 3 years (Ls ~155-1301).

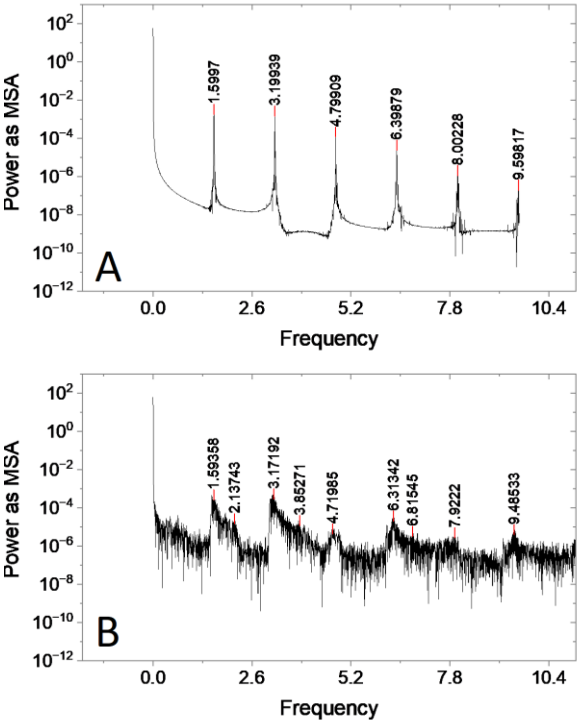

Figure 1: Power spectrum with labeled peaks for the MCD (A) and in-situ (B) Viking data.

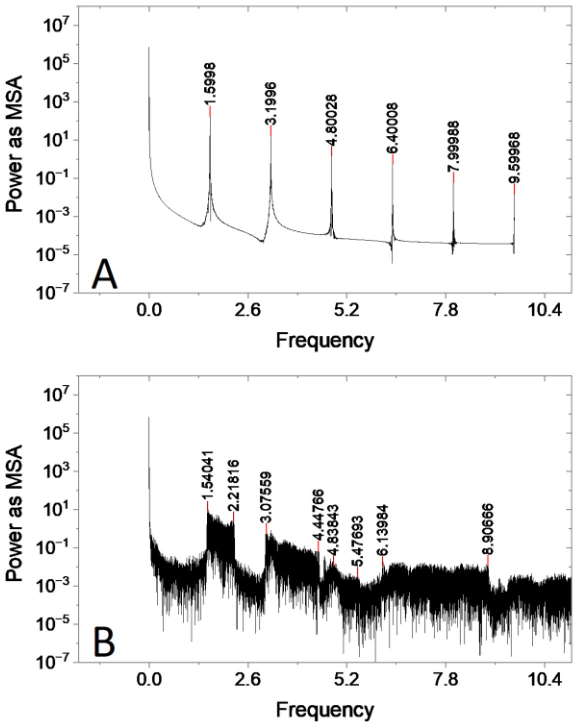

Figure 2: Power spectrum with labeled peaks for the MCD (A) and in-situ (B) MSL data.

Results and Discussion: Peak analysis for the MCD Viking data power spectrum was straightforward, with six clear peaks and little noise. The in-situ Viking data spectrum provided more challenge to analyze, with a much higher noise level and less obvious peaks. There are a few clear peaks, as well as several more that appear to be smaller but distinguishable from the noise (Fig. 1). The MCD MSL power spectrum was extremely similar to the MCD Viking spectrum, again with six prominent peaks and very little noise. The in-situ MSL spectrum was similar to the in-situ Viking spectrum in that there were some more obvious peaks as well as some smaller ones, and the total number was higher than in the corresponding modelled spectrum (Fig. 2). The entire spectra are shown for the MCD data, but we chose to cut off the graph at just above 11 on the x-axis for the in-situ Viking and MSL data to match the scales for both graphs. We can afford to make this cutoff because no peaks were observed in the data beyond that point. The frequency values of each identified peak, and their corresponding cycle timescales, are given in Table 1. The six peaks that are seen in the MCD Viking power spectrum are closely matched in the in-situ Viking data, showing good agreement between the two. These peaks also seem to appear in the in-situ MSL spectrum, but we see only 5 of the 6, and they don’t match quite as closely. We also see some smaller peaks in the in-situ spectra for both missions that do not appear in the respective MCD spectra. The frequency values, in Ls^{-1}, of these peaks for Viking are 2.137, 3.853, and 6.815. For MSL, the peak values are 2.218, 4.838, and 5.477. The corresponding time durations, in sols, are 0.869, 0.482, and 0.273 for Viking and 0.837, 0.384, and 0.339 for MSL.

Conclusions: While not direct evidence for the adsorption of CO_2, the apparent presence of more peaks in the in-situ data power spectra than in the corresponding power spectra of modelled data for both Viking and MSL is an encouraging indicator that additional processes may be occurring. More in-depth analysis will be required to increase confidence, but these initial results are still a sign that we cannot rule out the possibility of CO_2 adsorption taking place on Mars and playing a significant role in the overall atmospheric CO_2 cycle.

Power Spectra Peaks							
Viking				MSL			
MCD		In-situ		MCD		In-situ	
Freq. (Ls^{-1})	Cycle (sol)	Freq. (Ls^{-1})	Cycle (sol)	Freq. (Ls^{-1})	Cycle (sol)	Freq. (Ls^{-1})	Cycle (sol)
1.600	1.161	1.594	1.165	1.600	1.161	1.540	1.206
		2.137	0.869			2.218	0.837
3.199	0.580	3.172	0.586	3.200	0.580	3.076	0.604
		3.853	0.482				
4.799	0.387	4.720	0.393	4.800	0.387	4.448	0.418
						4.838	0.384
						5.477	0.339
6.399	0.290	6.313	0.294	6.400	0.290	6.140	0.302
		6.815	0.273				
8.002	0.232	7.922	0.234	8.000	0.232		
9.598	0.194	9.485	0.196	9.600	0.193	8.907	0.209

Table 1: List of all identified peaks, broken down by mission and then model vs in-situ, given in frequency and then converted to time units in sols. Common peaks across the various spectra are grouped by row.

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