VALIDATING MARS GCMs USING HIGH RESOLUTION GROUND-BASED OBSERVATIONS. M. C. Parks [1,2], C. A. Nixon [1], G. L. Villanueva [1], M. D. Smith [1], A. S. J. Khayat [1,7,] M. A. Cordiner [1,3], S. B. Charnley [1], V. A. Allen [1,4], E. Villard [5], J. A. Holmes [6], A. E. Thelen [1,3], [1]NASA Goddard Space Flight Center, [2]University of Maryland, Baltimore County, [3]Catholic University of America, [4]Universities Space Research Association, [5]ESO/Joint ALMA Observatory, [6]The Open University, [7]University of Maryland, College Park,

Introduction: Martian climate data is primarily provided by spacecraft, with data from landers providing data when possible. These missions have provided a wealth of information on the Martian atmosphere, but have their blind spots[1]. A submillimeter observatory on Earth might supplement the data provided by spacecraft, filling in certain areas underrepresented in the data (e.g. 40+ km in altitude) where spacecraft are less sensitive. However, historical submillimeter observatories have been constrained by their spatial resolution,[2] limiting their contributions to Global Climate Modeling.

This research uses spectra from the Atacama Large Millimeter/submillimeter Array (ALMA) to investigate the possibility of validating Mars GCMs using ground based observations. Specifically, we focus on observing absorption and emission features of carbon monoxide. Martian Carbon Monoxide has a lifetime of 3-6 years is noncondensable. This leads to a relatively even distribution around the planet, with an increased mixing ratio near the winter pole. The chemical stability and known distribution of CO in the Martian atmosphere allows us to characterize temperature profiles in the atmospheric column.

Methods: We utilized an ALMA archival dataset that had the necessary spectral and spatial resolution. The observation was made on March 13, 2016, and was of Mars' eastern hemisphere in northern summer (L_s = 121.8°). Our beam width was 0.73", or about 500km/beam across the surface of Mars. After running a Moment-0 map of the 337GHz line for the C17O 3-2 transition, we can see the spatial distribution of CO emission at the edge of the Martian disk. [Figure 1]

After calibrating the data, we acquired data from the Mars Climate Database (MCD) corresponding to the date and time of the observation. MCD is a global circulation model covering the bottom 200+ km of the Martian atmosphere, developed by the Laboratoire de Météorologie Dynamique[1].

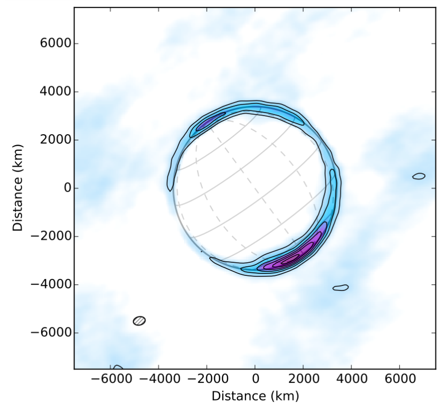

Figure 1: Moment-0 map of 337 GHz line for $C^{17}O$ J=3-2 transition

Spectra were analyzed with the NEMESIS radiative transfer retrieval code[3], which we have previously applied to analysis of Titan submillimeter spectra from ALMA[4]. The modeling approach follows that discussed in detail in Teanby et al. (2013)[5]. Once modelled against the Mars Climate Database predictions, we can determine where our observations of Mars align with the predicted emission features, and where prediction disagrees with observation. Figure 2 shows an example of such a comparison.

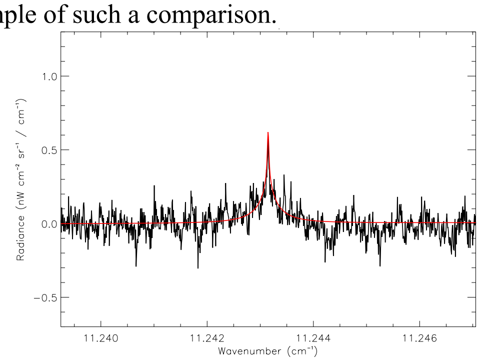

Figure 2: Sample Continuum Subtracted Line with NEMESIS. Black is data, red is model.

Results: As a proof of concept, we have focused on two longitudinal swaths across Mars; one at 90°E and one at 180°E. These swaths can be seen in Figure 3. Checking the predicted spectral emission features against the observation gives us an indication of whether or not the model and observation are in agreement. The results of this preliminary investigation for the 90°E can be seen in Figure 4, and the 180°E can be seen in Figure 5.

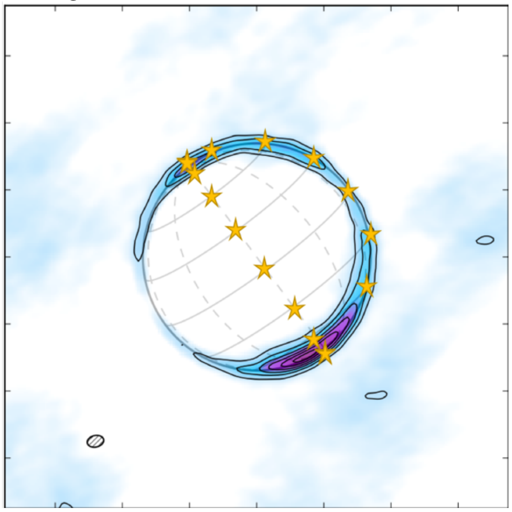

Figure 3: Longitudinal swaths, with stars at sampling locations

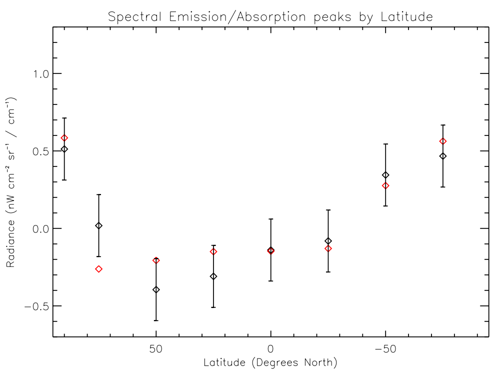

Figure 4: Observed Emission Features at 90°E (Black), compared to modelled emission features (Red)

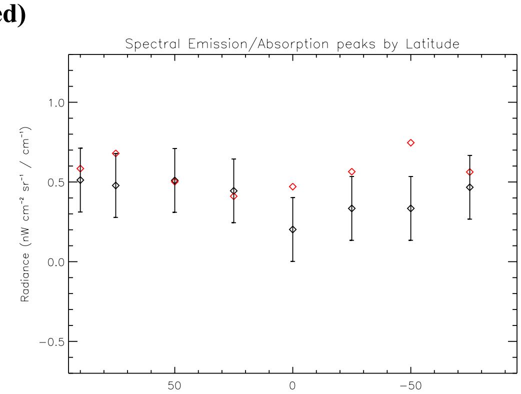

Figure 5: Observed Emission Features at 180°E (Black), compared to modelled emission features (Red)

Discussion: With the surface temperature generally higher than the atmospheric column temperature, we expect mostly absorption in the disk, with brightened emission on the limb. Across the disk, the data was almost entirely within the uncertainty. One area of interest was the 75°N feature, where the model came in much lower than the observation. Across the east limb, there exists a significant discrepancy in the southern hemisphere. This offset merits further examination.

Once we have confirmed that the signals we are seeing are real, and indicative of the state of the Martian atmosphere, we will use NEMESIS to conduct retrievals on these spectra. Retrieving atmospheric temperature profiles will give us possible atmospheric states to feed back into our GCMs.

Conclusion: Having demonstrated that we can use Martian CO to assess the atmospheric state on the Red Planet, and that ALMA has the spatial and spectral resolution to provide meaningful data for Martian GCMs, we now need to apply these methods over the entire planet comprehensively, and to a multitude of data sets. Additionally, we also will conduct retrievals to determine what adjustments to atmospheric state would be necessary to get the model and data to agree. This research hopefully paves the way for ground-based observatories to supplement the existing data collection pipelines for the Martian atmosphere, and add another tool to the toolbelt of Mars climate modelers.

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