STABILITY OF MARTIAN SURFICIAL BRINES DURING RECENT ORBITAL CYCLES. A. Soto[1], E. G. Rivera-Valentín[2], and V. Chevrier[3]; [1]Sothwest Research Institute, Boulder, CO, USA; [2]Lunar and Planetary Institute (USRA), Houston, TX; [3]University of Arkansas, Fayetteville, AR.

Introduction: Although meta-stable brines can form and persist on the surface and in the shallow subsurface of Mars for up to six consecutive hours for a few percent of the Martian year, the maximum temperature at which such brines are stable is 225 K, which is far too low to sustain life [1][2]. However, brine formation, persistence, and habitability may be different over the last few million years, given that Mars has undergone significant orbital cycles during that time. Variations in obliquity and eccentricity change the distribution of ice at the surface and in the subsurface, which affects the brine (meta)stability [3]. Therefore we are investigating how the Martian climate response to varying orbital configurations may have affected the distribution and habitability of brines in Mars' modern history.

To investigate the possible liquid brine and habitability conditions during recent geologic history, we have applied the analyses of [1] and [3] to climate model simulations for obliquity and eccentricity that sample the range of values experienced by Mars in the last 10 million years. Here we discuss the preliminary results from this work and how this history of liquid brine distribution informs the history of recent habitability on Mars.

Selecting Recent Martian Climates to Simulate: Over the past 10 million years, Mars has experienced obliquity oscillations with a period of about 120,000 years and eccentricity oscillations with a period of 95,000 to 99,000 years [4][5]. Thus, the Martian obliquity ranged from ~15° to ~35° while the eccentricity varied from just below 0.03 to as high as 0.11, dring the last 10 million years [4][5]. Obliquity variations change the surface brines distribution by changing the annual average distribution of insolation. At lower obliquities (less than 20°), less insolation reaches the polar regions, therefore the bulk of radiative energy is delivered to the tropics and extratropics. At higher obliquities (greater than 40°), the annual peak insolation occurs in the polar region and the equatorial region becomes the preferred residence of water and carbon dioxide ice.

Since simulating every obliquity cycle over the last 10 million years is computationally unfeasible, we used the annually and globally averaged insolation history as a guide in selecting orbital conditions that sampled the range of possible recent Martian climates [5]. Figure 1 shows the orbital configurations chosen, and Figure 2 shows the latitudinally-distributed insolation as a function of time of year (i.e., solar longitude) for each of the orbital configurations. First, we selected the orbital configuration for the maximum and minimum annually averaged insolation received by Mars. The next set of simulations were for the maximum and minimum possible obliquities and eccentricities, individually. These simulations allow us to understand how both orbital properties separately affect brine distribution. Since the maximum insolation occurs when the eccentricity is at a maximum, the maximum insolation and maximum eccentricity configurations are the same. Although in Figure 1 the minimum eccentricity configuration looks the same as the minimum insolation, the two configurations have different arguments of perihelion, which leads to a difference in the insolation distribution, particularly in the polar region, which can be seen in Figure 2.

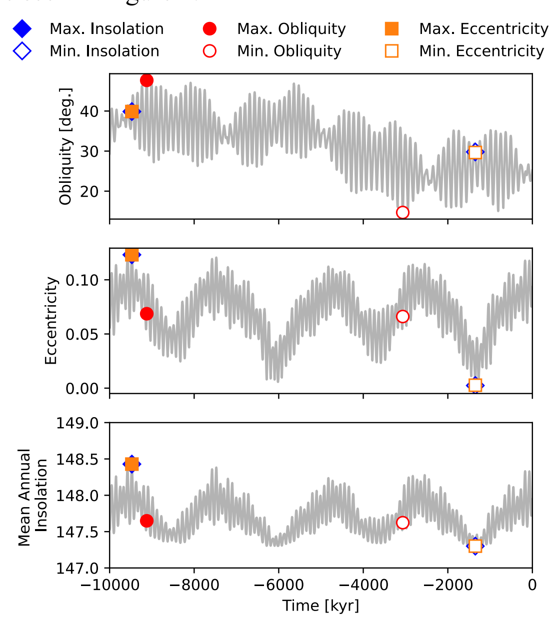

Figure 1. The periodicities seen in the insolation history are due to a climatic precession with a period of about 51,000 yr, an obliquity oscillation with a period of about 120,000 yr, and a 95,000 to 99,000yr oscillation in eccentricity [6]. This data also shows a modulation with a period 2.4 Myr that is due to secular resonances [6]. For our climate simulations, we sampled a few extreme points in this history (see legend for marker explanation). This figure was created using data from [5].

We focused on obliquity and eccentricity since these two orbital parameters are known to strongly control the forcing of the climate in terrestrial atmospheres. As the obliquity increases, the annually averaged coldest region on the planet moves from the poles, to the equatorial regions, while the poles receive much more insolation compared to the current insolation. When the obliquity is greater that roughly 40°, much of the polar ice moves to mainly the equatorial mountains. This shift in ice distribution undoubtedly affects the distribution of potential brines. Additionally, increasing the obliquity increases the polar insolation leading to increased sublimation of water from the surface, which may generate annually averaged higher atmospheric water content near the surface. This higher water content may allow the near surface atmosphere to reach nearly 100% RH at higher temperatures, within the stability field of liquid brines.

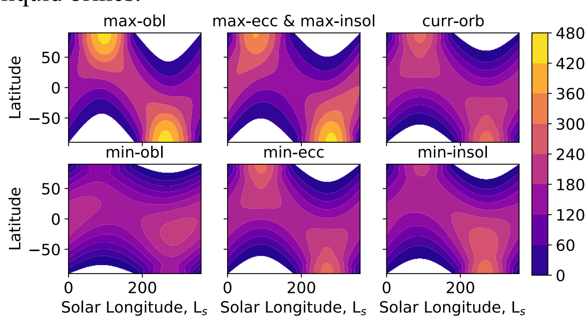

Figure 2. The latitude and solar longitude dependent insolation at the top of the Martian atmosphere for each of the simulated scenarios. The polar regions received much more insolation during periods of maximum obliquity (max-obl), maximum eccentricity (max-ecc), and when the annual mean insolation is at a maximum (max-insol). Additionally, there is a strong north-south asymmetry in the distribution of insolation.

The eccentricity affects the asymmetry in the length of the seasons, and the combination of the changing longitude of perihelion with the eccentricity determines when the longest season occurs. Over orbital change time scales, the shifts in the accumulated insolation per season may affect the duration of brine formation events. The higher eccentricities may increase the atmospheric water content, thereby contributing to the formation of stable liquid brines.

Anticipated results: We will show how liquid brine stability and durations are affected by the various orbital conditions. Our analysis is similar to [1] and [3]. In Figure 3, which shows an example of the expected results, we see the percent of the year that each region on Mars sustains liquid brine for the minimum insolation simulation (min-insol) as well as the maximum number of hours, for any given sol, for which the brines are in a liquid state. Similar plots for the minimum obliquity case (min-obl), are shown in Figure 4. The difference in the results is drastic. Although the minimum obliquity case has a higher annual average insolation, the climate generates less liquid brine because of the increased insolation in the extratropics and polar regions. This is just one example of the results that we will present.

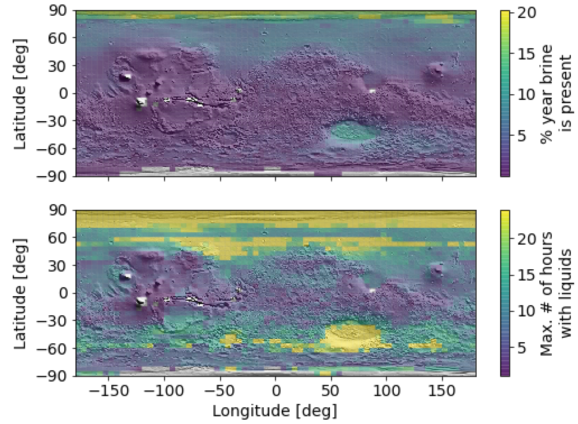

Figure 3. (top) Percent of the year when the brine is in solution for the minimum insolation simulation (min-insol). (bottom) The maximum number of hours in a sol during which there is liquid brine. MOLA shaded relief plotted below the data in each plot.

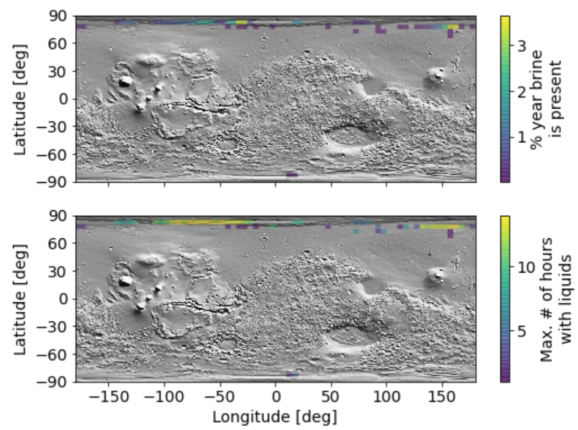

Figure 4. (top) Percent of the year when the brine is in solution for the minimum obliquity simulation (min-obl). (bottom) The maximum number of hours in a sol during which there is liquid brine. MOLA shaded relief plotted below the data in each plot.

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