NEW OBSERVATIONS OF THE MARTIAN NORTHERN SEASONAL CAP RECESSION WITH MARCI. E. M. Dixon[1], W. M. Calvin[1], P. B. James[2], and B. A. Cantor[3], [1]Geological Sciences & Engineering, MS 172, University of Nevada, Reno, NV 89557 (emdixon88@gmail.com), [2]Space Science Institute, 4750 Walnut Street, #205, Boulder, CO 80301, [3]Malin Space Science Systems, P.O. Box 910148, San Diego, CA 92191.

Introduction: A large fraction of the martian atmosphere is cycled onto and off of the surface during the advance and retreat of seasonal frost deposits. This cycle of condensation and ablation of a large portion of the atmosphere is the driver behind the climate cycle of Mars. Spacecraft observations of seasonal cap recession curves from Mars Global Surveyor (MGS) (MOC and TES instruments), Mars Express (OMEGA), and Mars Reconnaissance Orbiter (MARCI) allow comparison of global properties and variation over multiple Mars years.

Background: The first step in studying recession is to collect data on the rate of recession. James and Cantor have recorded and graphed the north polar cap recession of 2000 (MY25) using images from the Mars Orbiter Camera (MOC) [1]. Benson and James extended these observations to MY26 [2]. Kieffer and Titus mapped retreating seasonal frost based on temperature data from TES [3]. Appéré et al. show seasonal recession data from OMEGA for MY28 [4]. Cantor et al. present MY28 and 29 data from MOC and MARCI [5]. Although there are broad similarities between the recession curves in each of these years, there are regional and local variations as well as systematic changes between instruments. Most observers note the difficulty in identifying the cap edge, which is often diffuse or obscured by atmospheric dust, aerosols or clouds, so this study seeks to both determine recession rates for new observations as well as understand any potential observer bias in defining the retreating cap edge.

We made new measurements for the 2008 (MY29) recession using a different method than that of Cantor et al. [5]. We will also calculate the recession curves for MY30 and 31 (occurring now). The data for 2008 was collected from images taken by the Mars Color Imager (MARCI). MARCI is used to gain information about global atmospheric processes of Mars, interaction between the atmosphere and the surface, and climate evolution [6]. This project compares the recession of the north polar cap for 2000, as determined by James and Cantor [1] with our own methods for 2008.

Data Sets: In mapping orbit MARCI acquires roughly 10 images a day, the vast majority covering the polar regions allowing for high time fidelity synoptic coverage of the varying albedo deposits. These images are mosaicked into daily global maps at Malin Space Science Systems (MSSS) using automated routines that create standard Mercator projection jpg images. These daily maps are reprojected into polar sterographic coordinates. Many gaps or "gores" exist in these polar projections due to the spacecraft viewing targeted locations off-nadir. We compile the "gore-free" images into time evolution daily still frames to observe seasonal changes. We have compiled images for MY29 (calendar 2008) and MY30 (calendar 2010), MY31 began in September 2011 and daily images covering the cap retreat are currently being acquired.

Methods: The daily polar mosaics were viewed in image processing software that allows definition of a “region of interest” (ROI) as a collection of points that mark the boundary between the high albedo, seasonally frosted surface and the lower albedo unfrosted surface. The images were time-stamped in Earth days, which were converted to L_S values using the Mars 24 software from the Goddard Institute for Space Studies [7]. The ROIs were selected by outlining the high albedo area around the pole. ROIs were traced on images that had the least amount of dust or clouds in the atmosphere that block the view of the ground. This was done approximately every L_S 5 starting at L_S 340 and ending at L_S 80. The larger ROIs, L_S 340 to L_S 30, contain around 1500 points and the smaller ROIs, L_S 30 to L_S 80, contain closer to 1000 points. The regions were saved as text files listing the pixel location of points of the selected region (Figure 1). The distance of the pixel points, (x,y), was found from the center of the image, which represents 90°N. The polar projection extent was set to 50°N, so that the image horizontal or vertical size is 40 degrees. The distance in pixel number can thus be converted into latitude of the boundary location. The latitudes were averaged for each L_S and plotted. This ROI approach also allows us to quantify the variability of the cap edge by exploring the deviation from the average value at a particular L_S. The average data are compared to data collected in 2000.

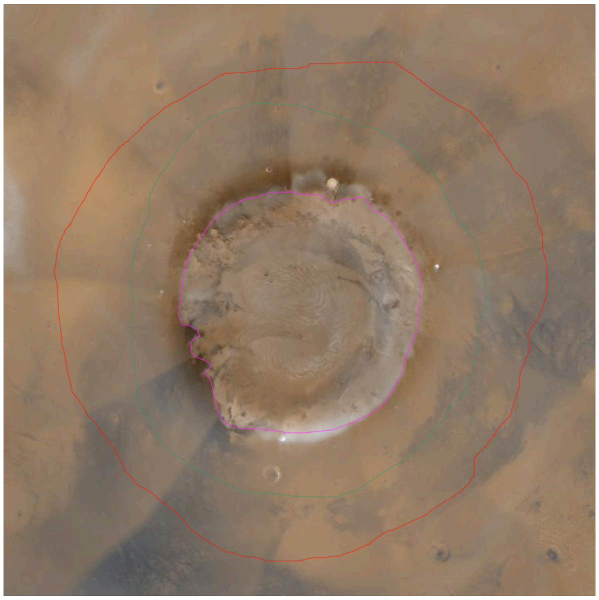

Figure 1: ROIs of L_S 340 (red), L_S 20 (green), L_S 60 (purple) on the reprojected MARCI image of the north pole at L_S 60. The polar projection goes from 90° N (center) to 50° N (edge).

Results: The retreats for 2000 (MY26) and 2008 (MY29) were plotted on the same graph for comparison (Figure 2). The MY29 seasonal polar retreat has the same negative slope as the MY26 seasonal polar retreat with a slight hump between L_S 20 and L_S 70 that rises over the best-fit line. Both data sets also dip significantly below the best-fit line after L_S 70. The equation for the best-fit line of the MY26 data is $58.6 + 0.218L_S$ and the equation for the MY29 data is $60.6 + 0.224L_S$. The best fit curve for MY26 is different than that cited in James and Cantor [1], but it is unclear if the fit in Figure 5 of that paper is to all the data, which includes HST, Viking and MOC. Our best fit for MY29 is systematically higher than that determined by Cantor et al. [5] and provides evidence that these best fit curves may include observer bias, or at least dependence on method, when determining an "edge" for the diffuse boundary. Earlier methods select points on the boundary and calculate a best fit circle, whereas our method determines thousands of points and finds an average. The systematics of these approaches may lead to the differences in slope and offset of the best fit curves. However, both this study and Cantor et al. [5] note that the MY29 recession was more advanced than in previous years.

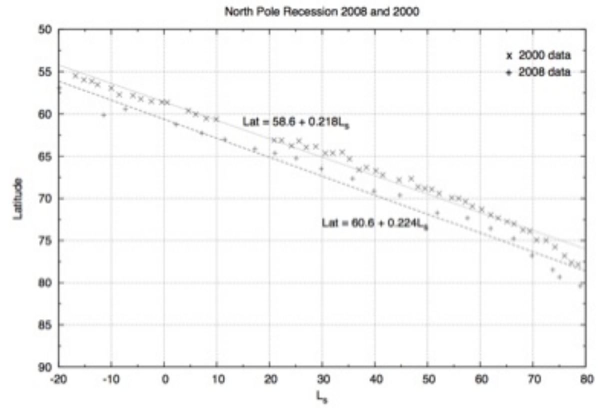

Figure 2: North pole recession for 2000 and 2008 with lines of best fit for each year from L_S 340 (-20 on the graph) to L_S 80.

Summary/Conclusions: While the overall trend of recession is similar between the two years, there is a significant difference between them. The 2008 recession was at higher latitude than the 2000 recession. The 2008 recession is earlier, demonstrated in Fig 1 as the 2008 data are consistently at higher latitudes for each L_S value. The rate of retreat (slope) is similar for the two years. The mechanism during the retreat in these two years is the same. Something triggered a later retreat in 2000 or an earlier retreat in 2008. There was a global dust storm in the summer of 2007 [2].

Next steps: Future work for this project includes processing data collected in 2010 and exploring the variability of the cap edge with season. The more data available for analysis will provide a better understanding of polar retreat for different martian years. This will highlight outliers that can be used to ascertain what impact changes in climate have on global cap recession curves. Another goal for this project is to determine whether the pole is experiencing a net erosional phase or a net accumulation phase. More data over a long period will show long-term trends on Mars.

References: [1] James P. B. and Cantor B. A. (2001) *Icarus, 154,* 131-144. [2] Benson J. L. and P. B. James (2005) Icarus, 174, 513-523. [3] Kieffer, H. H. and T. N. Titus (2001) Icarus, 154, p. 162. [4] Appéré et al. JGR 116, doi:10.1029/2010JE003762, 2011. [5] Cantor, B. A. et al. Icarus (2010) 208 (1), pp. 61-81. [6] Bell III J. F. et al. (2009) *JGR, 114,* 1-41. [7] Allison M. "Mars24 Sunclock – Time on Mars." 2008. *National Aeronautics and Space Administration, Goddard Institute for Space Studies*. <http://www.giss.nasa.gov/tools/mars24/>.