SEASONAL VARIATION OF MARTIAN POLAR CAPS: 1999 AND 2001 MOC DATA. P.B. James[1], J.L. Benson[1], and B.A. Cantor[2], [1]Affiliation (Department of Physics and Astronomy, University of Toledo, Toledo, OH 43606 (pbj@physics.utoledo.edu;jbenson@physics.utoledo.edu), [2]Malin Space Science Systems, Box 910148, San Diego, CA 92191 (cantor@msss.com).

Introduction: The seasonal Martian polar caps wax and wane in response to condensation and sublimation of carbon dioxide resulting from seasonal insolation changes on Mars. Numerous data exist on observations of the recession or sublimation phases in the visible portion of the spectrum for the last two centuries. William Herschel published the first quantitative observations of the seasonal recession of the Martian polar caps in 1784 [1]. During the next 180 years, ground based observers used a variety of techniques to observe recessions; Slipher summarized these observations in 1962, on the eve of the first space exploration of Mars [2]. Portions of the seasonal cycles of the surface caps that were observed by Mariners 7 and 9 and by Viking as well as ground based studies from 1971-1988 by the International Planetary Patrol were summarized in a review article following the Fourth International Conference on Mars in 1989 [3]. Hubble Space Telescope observed points in the seasonal recessions of the south [4] and north [5] caps during the 1990's. Differences between different Martian regressions have been reported in the past; but, because many of the relevant data sets are localized in longitude, at least some of these results could be an artifact introduced by the considerable longitudinal asymmetry that is observed during recessions.

Mars Global Surveyor went into orbit around Mars in September 1997. The wide-angle cameras (WA) of the Mars Orbiter Camera (MOC) experiment acquire images of the entire planet every day at a resolution of ~ 7 km/pixel in both red (575 nm – 625 nm) and blue (400 nm-450 nm) wavelengths. Some polar cap observations were acquired during the aerobraking (AB) and science phasing (SPO) of MGS before systematic mapping commenced in April, 1999 at L_S = 118°. More than two complete Martian years have now been monitored. The spring recession of the seasonal south polar cap was monitored during the aerobraking phase of the MGS mission [6], and data pertaining to the spring / summer recessions of the south [7] and north [8] caps during the first year of mapping have been reported previously. The spring – summer recession of the south polar cap in 1999 was characterized by its strong resemblance to the recession that was monitored by Viking in 1977. The north polar recession in 2000 was also very similar to previously observed recessions. The MOC observations confirmed an almost linear cap regression from L_S = 330° until L_S = 60° without the somewhat controversial "plateau" that has sometimes been reported in early spring.

We have studied the subsequent spring recessions of both polar caps during the second year of MGS mapping. This comparison of the two years is especially interesting because an extensive planet encircling dust storm occurred in early southern spring of the second Martian year while there was no such large storm in the first year. So it may be possible to determine the effects of dust on the condensation and sublimation of the carbon dioxide in the cap.

Seasonal South Cap: The planet-encircling dust storm was first observed at about the spring equinox in the south, when the boundaries of the CO_2 cap were extended to nearly the latitude of the southern parts of Hellas and exposed to the effects of atmospheric dust (Figure 1).

Figure 1: South cap in early stages of 2001 storm.

Although small local differences are seen, there is no significant difference between the regressions expressed in terms of the average cap radius (Figure 2).

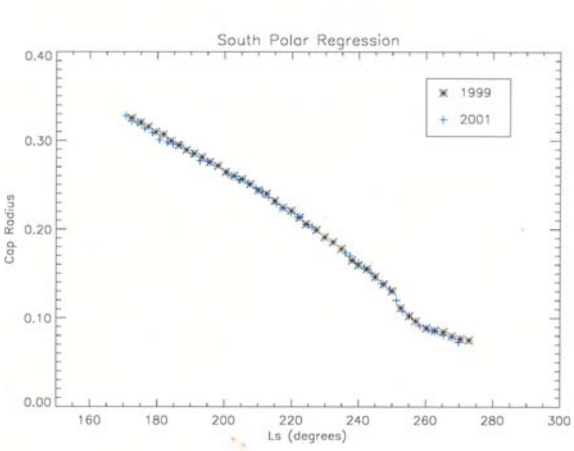

Figure 2: Regression of the south polar cap in 1999 (*) and 2001 (+). The dimensionless average cap radius on a sterographic projection is ploted versus areocentric solar longitude. Recessions are nearly identical apart from minor effects of the dust storm in very early spring.

The most interesting differences between the two recessions that we observed was the more rapid disappearance of regions in the cap that are characterized by higher than average albedo; the Mountains of Mitchel, for example, disappears roughly 5° of L_S earlier in the second year [9]. Infrared observations by TES confirmed this result and also indicated the darker than average cryptic regions sublimed later in the second year [10]. The similarity between the two regression curves indicates that regions in the cap of average albedo behave similarly. This has been explained by detailed simulations of the effects of dust on the total energy absorbed by these various regions in the visible and infrared; these calculations are the subject of a separate paper at this meeting.

Residual South Cap: The recession of the south polar cap terminates at about $L_S = 300°$ in its " residual cap" configuration, and only minor changes in the cap then occur during the rest of the summer. Viking IRTM observations of this residual south cap showed that it was composed at least partially of carbon dioxide ice, stabilized against the high insolation of southern summer by its high albedo [11]. In the case of the residual cap we have four relatively high-resolution observations from 1971 (Mariner 9), 1977 (Viking), and 2000 and 2002 (MGS). The residual caps in 2000 and 1977 were essentially identical [7]. However, the residual cap in 1971 was significantly different; the residual configuration was smaller, and the interior of the cap appeared to include significant patches of unfrosted ground [12]. Both observations suggest additional sublimation in 1971 relative to 1977.

The recent MGS observations of the residual south cap in 2002 show it to be identical to the residual cap in 2000 aside from a few very small effects near the edge (Figure 3).

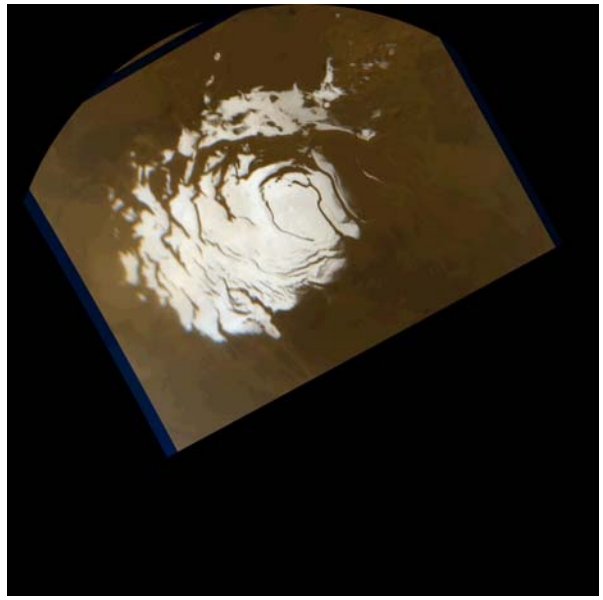

Figure 3a: Residual south polar cap on February 22, 2002 (L_S =306º).

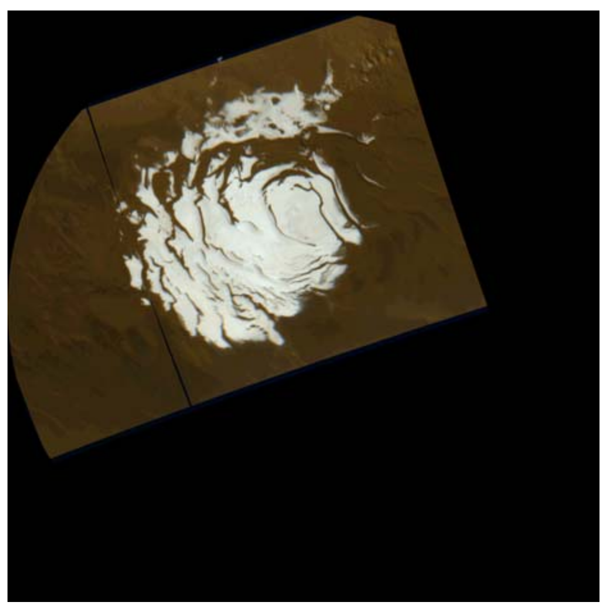

Figure 3b: Residual south polar cap on January 9, 2002 (L_S = 306º).

Evidently, the major dust storms in 2001 had little effect on the central portions of the cap despite their high albedo. This may be due to the fact that dust storm did not seem to penetrate extensively into the center of the cap, perhaps due to the net outflow due to sublimation in the outer regions. In addition, the insolation on the residual cap during the storm was small due to the large incidence angles.

Seasonal North Cap: The late winter and early spring portions of the north cap recession have been phases for which the largest interannual variability has been reported. The locations of the surface cap boundary in late winter has been controversial, and a possible "standstill" in the regression at approximately 65º latitude reported in early spring in some years. A global dust storm during the condensations phase of the north cap is one mechanism suggested to be responsible for this variability. On the other hand, observations are especially complicated in the north by confinement of data points to limited longitude regions; even Viking data are subject to this experimental limitation.

We have determined the regression curves for the 2000-2001 and 2002-2003 recessions of the north polar cap; a planet encircling dust storm occurred in early fall in the second year. As in the case of the south polar cap, the regression curves from the two years are almost indistinguishable, and there is no sign of a standstill in either year.

Residual North Cap:

Mars Global Surveyor mapping commenced at L_S = 118º in 1999. By the time of this conference we will have seen the third summer season in the northern hemisphere. Detailed comparisons of the caps in different years is complicated by frequent dust storms that may obscure the surface cap as in Figure 4; fallout from these storms on the surface cap may also affect the apparent albedo for longer periods.

In the accompanying graph, the Lambert albedo of the center (geographic pole) of the RNPC is plotted against L_S for 1999 (◊) and 2001 (+). The 2001 data have been corrected for a change in sensitivity of the MOC WA Red Camera during the fall of 2001 by applying a correction determined using a high albedo region in Isidis. The general behaviors of the albedo in this central region of the cap seem to be similar in the two years (Figure 5). The main exceptions are two data points from 1999 near L_S = 135°. The albedo at this time could be reduced if dust from an unusually large dust storm that was observed near the edge of the cap at this time [13] extended over the center of the RNPC. There is a gap in the MOC WA red mapping subsequent to these events due to the Geodesy Campaign; so the question of the duration of this suppression is not answered by the red images alone, and additional investigation using the blue filter mapping images, which continued through the period, will be needed. The abrupt decrease at $L_S > 150°$ is probably due to the fact that the Lambert approximation fails at the large incidence angles in late summer.

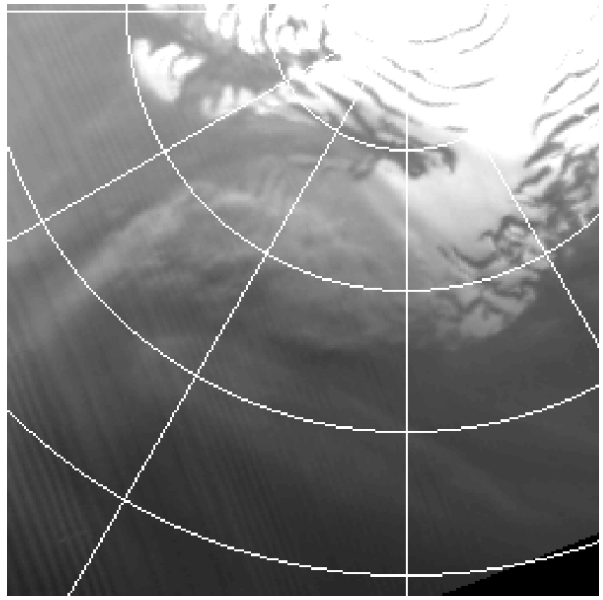

Figure 4: Example of a local dust storm event that almost completely hides the normally bright arm of the north residual cap that lies to the east of Chasma Borealis.

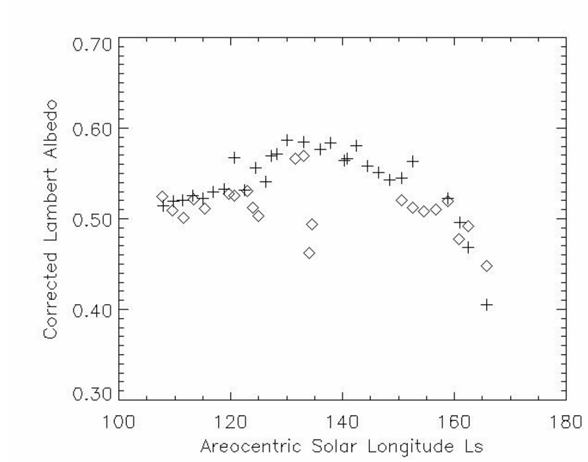

Figure 5: Lambert albedo of the region around the geographic north pole as a function of L_S for 1999 (◊) and for 2001 (+).

Acknowledgements: The authors gratefully acknowledge support of this work by a Mars Data Analysis Grant (NAG5-12186) and by an MGS Team Data Analysis Grant from JPL.

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