SUMMER SEASON VARIABILITY OF THE NORTH RESIDUAL CAP OF MARS FROM MGS-TES.

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INTRODUCTION: There is a long history of telescopic and spacecraft observations of the polar regions of Mars. The finely laminated ice deposits and surrounding layered terrains are commonly thought to contain a record of past climate conditions and change. Understanding the basic nature of the deposits and their mineral and ice constituents is a continued focus of current and future orbited missions. Recent work using Mars Global Surveyor (MGS) data sets have described evolution of the seasonal CO_2 frost deposits [1-5]. In addition, the north polar residual ice cap exhibits albedo variations between Mars years and within the summer season [4-6]. The Thermal Emission Spectrometer (TES) data set can augment these observations providing calibrated albedo over the course of the summer season and additional constraints such as temperature evolution and spectral properties associated with ice and rocky materials.

PREVIOUS OBSERVATIONS: Earlier workers noted the change in albedo in a number of north pole bright outliers and in the overall coverage by bright ice deposits both between Viking summers and between Viking and Mariner 9 [6-8]. This was possibly attributed to the affects of global dust storms [8]; however Bass et al. [6] showed that significant within season variation occurred among Viking imagery. Cantor et al. [5] also explored this variation in MOC images and noted brightening at the edges within a given Mars summer season and changes in the cap appearance at the same L_s between MGS years (1 and 2 as defined in the table above). The early season appearance was possibly attributed to the occurrence of a large dust storm the previous year, and it was noted that late season ice extent recovers to Viking levels but exhibits small-scale inter-year variations that may not be related to globally repeated weather events [5].

MGS-TES DATA SET: Mars Global Surveyor began systematic mapping of the planet in March of 1999. The Mars season was early northern summer, L_s=104. To date MGS has collected data for three northern summer seasons allowing us to examine both summer season changes and repeatability of phenomena between Mars years. Table 1 shows the time of acquisition of MGS data between Ls 65 and 165 (roughly bounding the spring disappearance and fall onset of deposition of the seasonal CO_2 frost.)

For this analysis we have used the visual bolometer data calibrated to albedo by the TES standard data processing pipeline. The data have been binned into 5 degrees of Ls and spatial averages of 1/4 degree in latitude and longitude in order to improve signal to noise. This spatial and seasonal averaging allows a synoptic view of frost migration and mobility within the northern summer season as well as examination of interannual variation of specific terrains. Coverage in the first year is somewhat sparse but still allows comparison with later Mars years.

Northern Summer	L_s 65	L_s 165	Mission Phase
1-partial	4-Dec-98 (pre-mapping)	5-Jul-99	Map
2-full	20-Oct-00	22-May-01	Map/Ext
3-full	8-Sept-02	9-Apr-03	Ext-Ext

OBSERVED VARIATIONS:

Large scale brightness variations are observed in four general areas (see Figure 1):

(1) The patchy outlying frost deposits (dubbed here Mrs. Chippy's Ring, from 90 to 270 east, 75 to 80 north).
(2) The large "tail" below the Chasma Boreal and its associated plateau (see Zuber et al. [9] for topography) from 315 to 45 east, 80 to 85 north, called here the "Boreale Tongue". This also includes variations on the end of "tongue" (Hyperboreae Undae) noted by Malin and Edgett [10, Figure 76].
(3) The troughed terrain in the region from 0 to 120 east longitude (lower right on a polar stereographic projection) "Shackleton's Grooves".
(4) The unit mapped as residual ice in Olympia Planitia (see e.g. [11]).

We also note two areas which seem to persist as cool and bright throughout the summer and between Mars years. One is at the "source" of Chasma Boreal (~15E, 85N) dubbed here "McMurdo", and the "Cool and Bright Anomaly (CABA)" noted by Kieffer and Titus [2] at ~330E, 87N called here "Vostok".

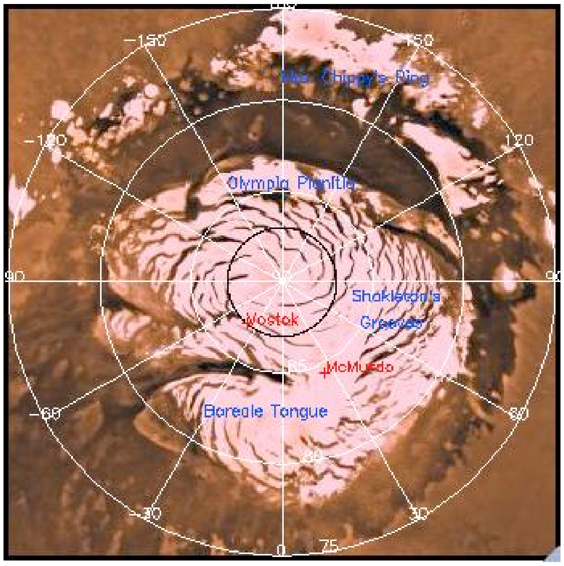

Figure 1: North residual cap as observed by Viking. Black ring denotes area within which TES does not acquire data. Place names denote areas where frost mobility and variation are observed.

Figure 2 shows TES albedos for various seasons. The Boreal Tongue and Shackleton's Grooves begin with a high albedo that lowers until approximately Ls 110 when brightening begins again. At the end of the season the albedos of the Boreal Tongue are substantially lower than at the beginning of the summer (Figure 3). The residual ice unit of Olympia Planitia begins very bright, appears defrosted (in MOC images) by Ls ~95 and remains defrosted for the remainder of the summer. The bright spots McMurdo and Vostok are larger or smaller during the summer but have a consistent end of summer high albedo in all 3 martian years. There is a good deal of seasonal variation in Mrs. Chippy's ring making generalizations difficult.

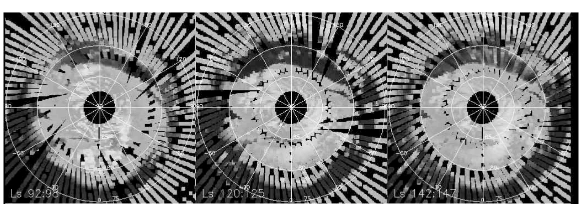

Figure 2: TES albedo is shown for various seasons. Frost variation is seen in Mrs. Chippy's ring, the Boreale tongue and Shackleton's Grooves (see Fig. 1 and text for names). The residual bright anomalies McMurdo and Vostok are also evident. {Note: Frost variation is clearer in a color version of this figure available from the author – this had to be converted to b/w due to abstract file size limits.}

The conversion from albedo to "frosted or defrosted" includes many parameters. In general lower albedo can imply loss of water ice frost, increase in dust levels or evolution of frost grain size to larger values. Future work will attempt to quantify these parameters in relation to the albedo variations observed.

References: [1]Kieffer et al, *JGR*, **105**(E4), 9653, 2000. [2]Kieffer and Titus, *Icarus*, **154**, 162, 2001. [3]Titus et al. *JGR*, **106**(E10), 23181, 2001. [4]James and Cantor, *Icarus*, **154**, 131, 2001. [5]Cantor et al. *JGR*, **107**(E3), 2002. [6] Bass et al. *Icarus*, **144**, 382, 2000. [7] Kieffer, *JGR*, **96**, 1481, 1990, [8] Paige et al. *JGR*, **99**, 25959,1994. [9] Zuber et al. *Science*, **282**, 2053, 1998. [10] Malin and Edgett, *JGR*, **106**(E10), 23429, 2001. [11]Fishbaugh and Head *JGR* **105**(E9), 22455, 2000.

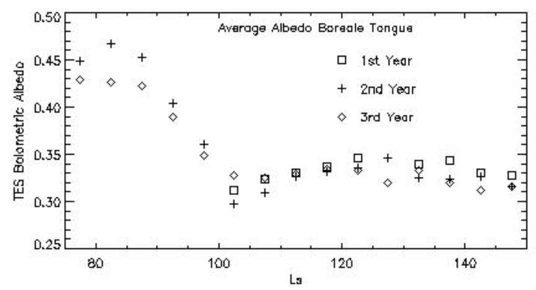

Figure 3: Albedo over the Boreal Tongue for 3 years as a function of Ls.