MARS POLAR CAP EDGES TRACKED OVER 3 FULL MARS YEARS. T. N. Titus[1], [1]U.S. Geological Survey, Flagstaff, AZ 86001 (ttitus@usgs.gov).

Introduction: The polar caps of Mars have been observed since 1666 [1]. The advance and retreat of the polar caps were one of the first observations that indicated Mars had seasons. In more recent history, the polar caps have gained significance in that they are one of the driving forces of martian climate, with approximately 25% of the atmosphere being cycled through the polar caps annually [2]. Understanding the nature of the seasonal polar caps is imperative if we are to understand the current martian climate.

The retreat of the martian seasonal caps has been monitored by both satellite and telescopic observations, over a period of several years. Most of these studies utilized visible imaging to determine the albedo contrast between the edge of the seasonal cap and the volatile free soil [3,4]. The use of visible imaging, while widely used, has some limitations. Cap edge detection depends on albedo contrast between the polar cap and the soil. This contrast is below reliable detection methods where the CO_2 cap is dark, as in the south polar cryptic region [5], or during the advance of the seasonal cap [6]. The visible method also fails to distinguish between CO_2 and H_2O ices. Kieffer and Titus [7], using the Mars Global Surveyor (MGS) Thermal Emission Spectrometer (TES), observed a warm and bright annulus around the retreating northern seasonal CO_2 polar cap. They concluded that this annulus was most likely water ice.

In this study, we extend the analysis of the cap edge by using the techniques of Kieffer et al. [5] and Kieffer and Titus [7] using 3 Mars years of MGS TES data. We characterize the seasonal cap edges as a function of season and longitude, which aid in the detection of inter-annual changes, longitudinal asymmetries in both the seasonal caps advance and retreat, and detection of a seasonal water-ice rim following the retreating seasonal CO_2 cap.

Data Processing: The first step in monitoring the seasonal cap edge is the construction of a data hypercube, with 2 spatial dimensions (polar stereographic projection at approximately 60km resolution), 2 temporal dimensions (700 seasons and 2 local times of day), and 1 parameter dimension (albedo and 30 μm brightness temperature). Data extracted from the TES database are averaged and binned into the hypercube per every 12 orbits (approximately 23.55 hours), separated into ascending and descending data, which roughly defines day and night side data. This creates a hypercube of dimensions 90 x 90 x 700 x 2 x 2. Five of these hypercubes were constructed: 3 complete mapping years in the north and 2 complete mapping years in the south. The hypercubes were constructed so that the seasons start and end in the summer in order to capture the advance and then the retreat of the seasonal cap.

IR Cap Detection Technique: For this study, we applied the cap edge detection techniques used by Kieffer et al. [5] and Kieffer and Titus [7]. They made use of the rapid rise in surface temperature that occurs when CO_2 ice is removed. For this study, we defined the advancing cap edge, or frost date, to be when the 30 μm brightness temperature drops below 155 K. We define the retreating cap edge, or crocus date, as the date when the 30 μm brightness temperature rises above 165 K. The springtime threshold temperature is set slightly higher due to effects from atmospheric dust that are common during the cap retreat. The fitting of frost and crocus dates are illustrated in Figure 1.

Once the frost and crocus dates have been determined for each 60km x 60km cell, we fit the latitude of the cap edge to a series of sine and cosines which are functions of season and longitude. The sine and cosine fit is effectively a low-pass filter that removes the high frequency artifacts caused by the data being collected only at 12 longitudes per day.

VIS Cap Edge Detection Technique: MGS TES also has a solar bolometer that can be used to detect the cap edge. We fit an arc tangent curve to the albedo as a function of season, and define the cap edge as the inflection point (See Figure 2). Because of a lack of albedo contrast between the soil and CO_2 in the early spring and a lack of contrast between the water ice northern residual cap and the seasonal CO_2 cap, this analysis is restricted to the latitude range of ±60° to ±80°.

Once the VIS cap crocus dates have been determined, we fit the latitudes of retreat to a quadratic (to account for the mean zonal retreat) and a series of sine and cosines (to account for asymmetries in the cap retreat).

Results: While the results discussed in this abstract will be restricted to the northern seasonal cap for TES Mapping Years 2 and 3, complete results for both seasonal caps for all 3 years are presented at LPSC.

North polar seasonal CO_2 cap: Inter-annual comparisons between TES mapping years 2 and 3 show very little variation. Small asymmetries, on the order of a few degrees of latitude, are apparent in both the advance and recession of the seasonal cap. Figure 3 shows a comparison at 2 different longitudes.

North polar water ice annulus: Comparisons of the visibly and thermally determined cap edges between latitudes of 60°N and 80°N reveal a visible seasonal cap that is always larger than the thermal infrared cap (See Figure 4). This warm and bright annulus that surrounds the retreating CO_2 cap was first observed by Kieffer and Titus [7]. They suggested that the warm and bright annulus that circumscribes the IR cap is mostly a mix of exposed H_2O and CO_2 ices, and perhaps clathrates. The length of time that this warm bright annulus persists, and given that its temperatures remain at or below 205 K, is suggestive that the primary constituent is H_2O ice.

By comparing the length of time between the IR crocus date and the VIS crocus date, we can determine the lifetime of the water-ice annulus. Figure 5 shows the mean lifespan for the water-ice annulus as a function of latitude. Local regions have water ice present for as long as 45 Julian days.

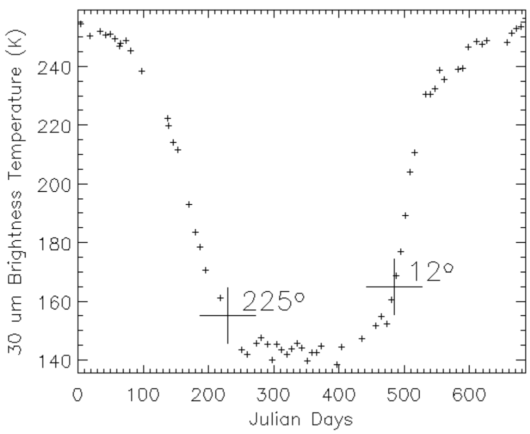

Figure 1: Temperature trends at 215°E, 64°N. The large plus signs indicate the frost and crocus dates at Ls 225° and 12°, respectively.

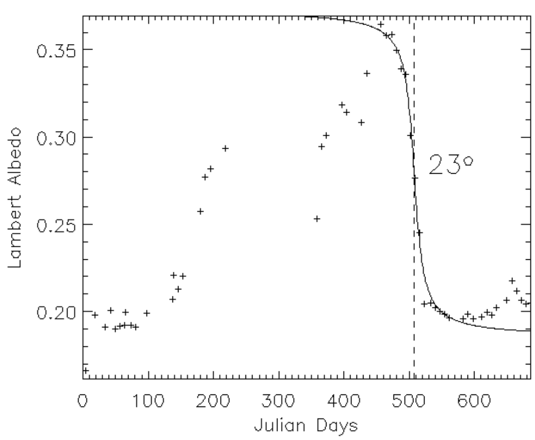

Figure 2: Albedo trends at same location as Figure 1. The dashed line indicates the VIS crocus date.

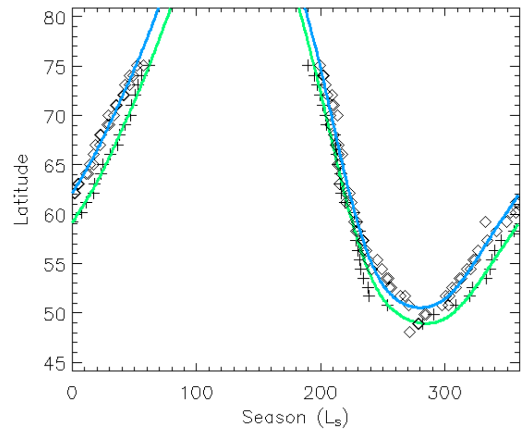

Figure 3: Cap Edge Latitude vs. Season. The plus signs and green line are the derived cap edge and best-fit for Longitude 0°, respectively. The diamonds and blue line are the derived cap edge and best-fit for longitude 180°, respectively.

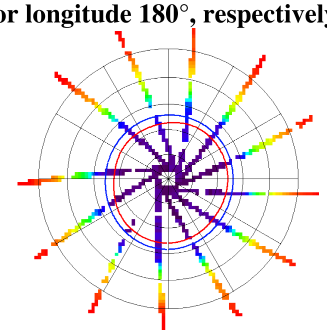

Figure 4: Best-fit cap edge for Ls 23°. The red contour is the IR cap edge. The blue line is the VIS cap edge. The underlying data is TES brightness temperature.

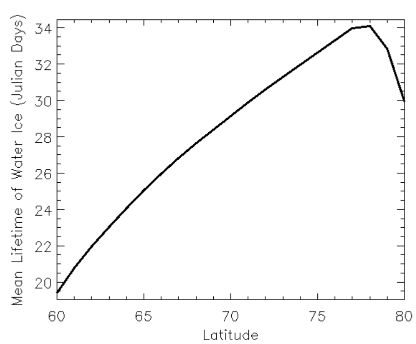

Figure 5: Zonal Mean Water-Ice Annulus Lifetime.

References: [1] Kieffer H. H. et al. (1992) in *Mars*, 1-33. [2] Tillman *et al*. (1993) *JGR*, 98, 10963–10971 [3] James P. and Cantor B. (1997) *JGR, 90,* 1151–1154. [4] James, P. B. et al. (1996) *Icarus,* 123, 87 [5] Kieffer H. et al. (2000) *JGR*, 105, 9653–9699. [6] Titus et al. (2001) *JGR*, 106, 23181–23196. [7] Kieffer H. and Titus T. (2001) *Icarus*, 154, 162-180.