SOUTH SEASONAL CAP RETREAT MY 28-31 USING MARCI: DEVELOPMENT AND EVOLUTION OF THE CRYPTIC REGION AND OTHER INTERESTING FEATURES. W. M. Calvin[1], P. B. James[2] and B. A. Cantor[3], [1]University of Nevada Reno, Dept. Geological Sciences & Engineering, 1664 N. Virginia, Reno, NV 89557, email: wcalvin@unr.edu, [2]Space Science Institute, Boulder, CO, 80301, [3]Malin Space Science Systems, San Diego, CA 92191

Introduction: Spacecraft observations of the southern seasonal cap recession have been made using MOC, TES, OMEGA and CRISM [1-4]. The asymmetric retreat of the seasonal cap has been known from many previous observations, and the southern seasonal cap recession is fundamentally different than the north. Seasonal frost remains long past the summer solstice and removal of CO_2 ice is not complete until Ls 320 or 330. Kieffer et al. [2] coined the term "cryptic region" for an area within the retreating seasonal cap that develops a very low albedo, but retains the cold temperature of CO_2 ice in equilibrium with the atmosphere. This dark region is also clearly seen in MOC mosaics [1]. This area is associated with dust deposition and jetting of material from underneath translucent slab ice to darken the seasonal cap and mask the signature of CO_2 ice features [5,6].

As shown in Table 1, MRO has observed the southern seasonal retreat in MY 28-31, but the late summer season was not monitored in MY29 due to spacecraft recovery from several safe-mode events. We here compare various features of the south seasonal cap retreat as observed by MARCI.

Table 1: MRO Observations of South Retreat

Mars Year Earth Date of Ls=0	South Recession Ls 175 to 325	South Summer Ls 325 to 360
MY 28 1/21/2006	2/07 -9/07 Planet wide dust event	10/07 – 12/07
MY 29 12/9/2007	12/08 to 8/08	Not observed after Ls 328
MY 30 10/26/2009	11/10 – 7/11	7/11 – 9/11
MY 31 9/13/2011	9/12 – 5/13	5/13 – 7/13

Development and Evolution of the Cryptic Region: The "cryptic" region is identified with an array of jetting and venting events from underneath the transparent CO_2 slab ice and development of an array of unusual landforms [5,7]. Kieffer et al. [2] noted the development of the cryptic area between Ls 196 and 217, in MOC [1] dark patches appear by Ls 198 and the large dark region is fully developed by Ls 210. Both MOC and TES observations noted that this region is offset from the pole and largely covers the SPLD. In OMEGA observations of MY 27 [3] the development was not discussed, but the area is clearly well developed by Ls 221 (their Figure 13a). Figure 1 shows the development of the cryptic terrain in MY 31. Jetting and dust deposition begins in small localized regions around Ls 192 and the dark deposits continue to expand until reaching a maximum areal extent at Ls 210. The configuration is largely stable throughout the remainder of the cap retreat, with small areas changing from dark to light as the edge of the retreating cap encroaches on the dark ice deposits. Analysis of MARCI movies of the cap recession show the development of this dark area within the seasonal ice occurs at similar Ls in each year and that the maximum extent is also similar in all years (Figure 2). However there are subtle differences between the development and locations of small high albedo patches within the dark region as spring progresses.

Draping MARCI imagery over topography (Figure 2, 3) illustrates that the cryptic region covers a wide range of surface elevations and slopes, suggesting venting is a ubiquitous process. The relative absence of winds is implicated in areas that develop a dark dust veneer, as well as the thickness of the seasonal ice.

Asymmetric Retreat / Mountains of Mitchel: The visual appearance of retreating seasonal frost is largely symmetric around the pole until ~ Ls 220 when the edge of the bright seasonal frost encroaches on the cryptic region and retreat appears to become asymmetric and more centralized on the south residual polar ice dome. Kieffer et al. [2] note that the optical and thermal "crocus maps" (edge of last CO_2 frost as determined by visual appearance or temperature) are dissimilar between Ls 225 and 245. The "anti-cryptic" region (Figure 3) is an area of high albedo that remains bright throughout seasonal cap recession and disappears only very late, slowly from Ls 255 to 300 or 310, and the Ls of the retreat to the water ice outlier (see below) varies in each year observed.

Late summer / Water ice outlier: A water ice outlier occurring adjacent to the residual ice has been noted in THEMIS and OMEGA data [8,9] and is associated with the persistence of seasonal frost (Fig. 3). This outlier is observed to retain seasonal frost very late and the spatial coverage and timing of changes varies among the four MY observed. In MY 30 bright CO_2 frost never disappears, where in MY28 the area reaches the albedo of the surrounding dirt and in MY 31 it reaches an intermediate albedo that is brighter than the dirt, but not as bright as the residual CO_2 cap.

References: [1]James et al., JGR, 106, 3635, 2001 [2]Kieffer et al. JGR, 105, 9653, 2000 [3]Langevin et al. JGR, 112, E08S12, 2007 [4]Brown et al. JGR, 115, 2010 [5] Kieffer et al. Nature, 442, 793, 2006 [6] Langevin et al. Nature, 442, 831, 2006 [7]Hansen et al. Icarus, 205, 283, 2010 [8]Piqueux et al., JGR, 113, E08014, 2008 [9]Doute et al. PSS, 55, 113, 2007.

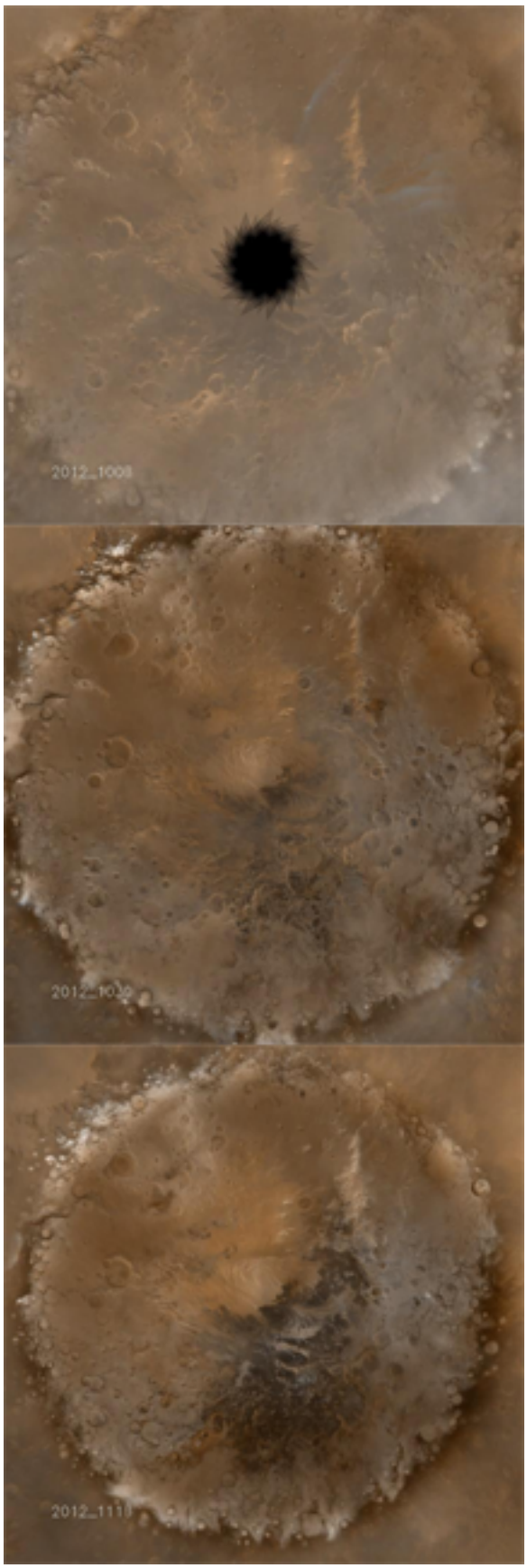

Figure 1 (left): Shows development of the cryptic region in MY 31. Each frame is an average of 5 individual images spanning about 3° of Ls. The upper frame is Ls 183 and the central gore is due to restricted coverage. The middle frame is Ls 198 when low albedo regions are just emerging. The bottom frame is Ls 210 when the extent of the cryptic region has reached a maximum and stable configuration. Dark edges adjacent to the cap edge are a processing artifact.

Figure 2: 3D surface projection of the Ls 210 image from Figure 1 placed over MOLA topography and showing a wide range of slopes and elevations are associated with cryptic terrain.

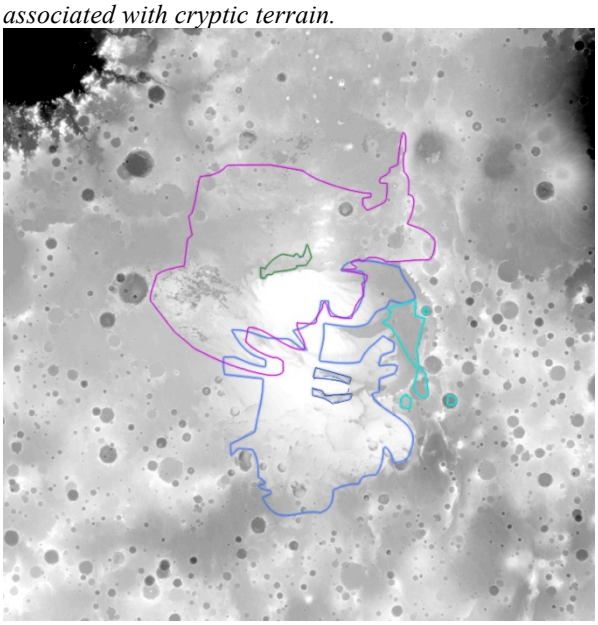

Figure 3: An approximate outline of the cryptic region (blue), anti-cryptic high albedo deposits (magenta) and the water ice outlier (green) over MOLA topography. Comparing these outlines with images in various years shows these locations are largely repeatable, however larger dark areas are noted in MY29 (aqua).