OBSERVATIONS OF THE SEASONAL POLAR ICECAPS OF MARS AT 1064 nm.
Maria T. Zuber[1] and David E. Smith[2], [1]Dept of Earth Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, 77 Massachusetts Ave. 54-918, Cambridge, MA 02139-4307, e-mail: zuber@mit.edu, [2]Laboratory for Terrestrial Physics, NASA Goddard Space Flight Center, Greenbelt, MD 20771, e-mail: David.E.Smith@nasa.gov.

Introduction. The Mars Orbiter Laser Altimeter (MOLA) [1, 2] is routinely making radiometric observations of Mars at a wavelength of 1064 nm. Although the altimeter function is no longer operational, the MOLA detector [3] continues to measure the reflectivity of the surface. Observations have been obtained almost continuously since the beginning of the Mars Global Surveyor (MGS) [4] mapping mission in February 1999, and are providing measurements relevant to understanding the seasonal cycling of CO_2 surface frost.

Radiometer Data. The field of view of the MOLA detector is approximately 800 μrad and from an altitude of 400 km receives reflected solar radiation from a roughly circular spot ~300 m in diameter. The data are acquired at a rate of 8 Hz and with a ground track velocity of the spacecraft of about 3 km s^{-1} the along-track resolution is slightly less than 400 m, thus providing an almost continuous profiling measurement of Martian surface brightness.

To determine reflectivity, the received optical power can be estimated by a mathematical model that utilizes the MOLA threshold setting and noise counts [5, 6]. Utilizing the link equation [7], observations are normalized to a constant mean solar flux assuming Lambertian scattering to yield a spectral radiance *(I/F).*

For the purposes of this analysis the data were binned in 1 second time intervals representing a pixel size of 300 m x 3 km. The detector operates at 1064 ± 1 nm and measures the reflected signal strength to about 1%, and the receiver performance closely matches pre-launch testing. For the seasonal variations of interest in the present analysis the stability of the measurement is more important than the absolute calibration.

In this passive mode the radiometry is only obtainable when the surface of Mars is illuminated by sunlight. Further, since the orbit of the spacecraft is approximately sun-synchronous with a 2:00 PM local time the data are generally acquired under similar lighting conditions.

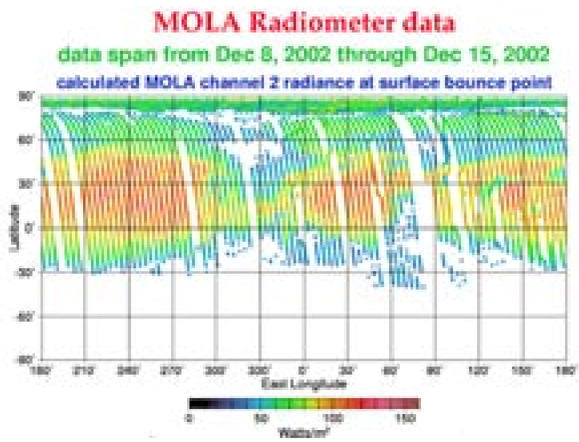

Fig. 1. *Uncalibrated passive radiometry observations acquired by MOLA between Dec 8 and 15, 2002. During the observation period the season was northern summer, with the sun illuminating the northern hemisphere of the planet. An example of the spacecraft being pointed off-nadir is evident in the figure at lat 25º N, 55 º E. The spacecraft was traveling from south to north.*

However, the spacecraft instrument deck is not always pointed toward nadir and for much of the last year has been tilted off-nadir by approximately 16^o in order to save on propellant used for attitude control. Further, the spacecraft is frequently rolled and pitched toward a particular target for camera observations, and the MOLA detector field of view follows the same path (Fig.1).

Seasonal Changes. The radiometry data show clear seasonal brightness changes in the polar regions that are a result of the deposition and sublimation of CO_2 on the surface at the onset of fall and in early spring. Fig. 2 shows the reflectivity at 1064 nm at the beginning of spring and early summer in the 2 hemispheres. Generally, the frost deposition in the north is distributed uniformly in longitude except on the polar cap itself, where the deposition and the sublimation appear to be related to the topography of the cap. In general areas that are less bright are lower in elevation and receive less solar illumination.

In the south the frost covering varies significantly with latitude and longitude (Fig. 2) and some regions appear even in early spring to have lost all their seasonal covering of CO_2. In contrast to the north polar region, the brightest regions do not correspond to those of highest elevation. The residual cap remains bright throughout the year and is probably a result of the exposure of water ice under the seasonal frost.

Seasonal frost on the southern polar residual cap is brighter than in the north and lasts longer in the spring. Both seasonal caps brighten as winter proceeds, and the brightness of both caps oscillates just before the frost sublimates back to the atmosphere, most markedly in the north. This phenomenon is observed in consecutive Martian years.

Observations of the process of frost deposition are more difficult to obtain due to most of the frost at high latitudes being deposited when the region is in darkness. However, the radiometry data do suggest that frost at the higher latitudes actually starts to form on the surface before the end of summer when the sun is approaching the equator but the pole is still illuminated. For the high northern latitudes this appears to begin around L_s= 150^o. The frost covering at both poles appears to have been similar, but not identical, in the two successive Mars years so far studied.

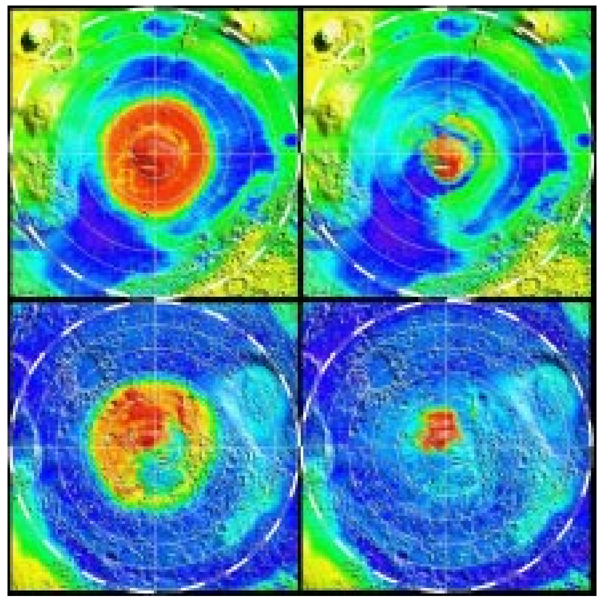

Fig. 2. *Seasonal images of the 1064-nm reflectance in the polar regions in early spring and early summer. The top 2 images are of the northern hemisphere (30^{o}N to pole) for L_s= 32^o (left) and L_s= 12^o (right). Bottom 2 images are of the southern hemisphere (30^o S to pole) for L_s= 212^o (left) and L_s= 272^o (right).*

References. [1] Zuber M.T. et al. (1992) *JGR, 97,* 7781-7797. [2] Smith D.E. et al. (2001) *JGR, 106,* 23,689-13,722. [3] Abshire J.B. et al. (2000) *Appl. Opt., 39, 90,* 2440-2460. [4] Albee A. et al. (2001) *JGR, 106,* 23,291-23,316. [5] Sun, X., et al. (1992) *IEEE Trans. Aero. Elec. Syst.,28,* 268-274. [6] Sun X. et al., (2001) *EOS Trans. Am. Geophys. Un.* [7] Gardner C.S. (1992) *IEEE Trans. on Geosci. Rem. Sens., 30,* 1061-1072.