NIGHT AND DAY: THE OPACITY OF CLOUDS MEASURED BY THE MARS ORBITER LASER ALTIMETER (MOLA).

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Introduction: The Mars Orbiter Laser Altimeter (MOLA) [1] on the Mars Global Surveyor spacecraft ranged to clouds over the course of nearly two Mars years [2] using an active laser ranging system. While ranging to the surface, the instrument was also able to measure the product of the surface reflectivity with the two-way atmospheric transmission at 1064 nm. Furthermore, the reflectivity has now been mapped over seasonal cycles using the passive radiometric capability built into MOLA [3]. Combining these measurements, the column opacity may be inferred. MOLA uniquely provides these measurements both night and day. This study examines the pronounced nighttime opacity of the aphelion season tropical water ice clouds, and the indiscernibly low opacity of the southern polar winter clouds. The water ice clouds (Figure 1) do not themselves trigger the altimeter but have measured opacities $\tau > 1.5$ and are temporally and spatially correlated with temperature anomalies predicted by a Mars Global Circulation Model (MGCM) that incorporates cloud radiative effects [4]. The south polar CO_2 ice clouds trigger the altimeter with a very high backscatter cross-section over a thickness of 3-9 m and are vertically dispersed over several km, but their total column opacities lie well below the MOLA measurement limit of $\tau \approx 0.7$. These clouds correspond to regions of supercooled atmosphere that may form either very large specularly reflecting particles [2] or very compact, dense concentrations ($>5\times10^6$ m^{-3}) of 100-μ particles [5]. Detailed modeling of cloud opacity addresses these enigmatic clouds.

High-opacity Water-ice Clouds: We examine the ratio between active bidirectional reflectance ($r\tau^2$) and passive radiometry r for nighttime and daytime tracks at L_s =90° of L_s during the second year of MOLA operations (450°-480°). Complete extinction frequently occurred at night, particularly over the western flanks of Elysium, Syrtis Major, and the Tharsis volcanoes, while moderate attenuation of pulses over a more limited region occurs during daytime. Their location and opacity is consistent with the MGCM and with thermal measurements [6]. High extinction also occurs during northern spring over the the seasonal polar cap, implying values of $\tau > 2$.

High-backscatter CO_2-ice Clouds: The southern winter polar CO_2 ice clouds occurred only at night, comprised up to 1/3 of the MOLA returns on a given profile, and were astonishingly bright. However, the remaining 2/3 of the MOLA returns from the ground were invariably saturated, i.e. above the highest digital recording level, indicating that nowhere did these polar clouds block the majority of the laser pulses in both directions. Either these cloud fronts are much smaller than the ~70-m-diameter MOLA footprint and do not cover the ground, or they have an unusually bright specular return without significant opacity.

References:[1] Smith, D.E. et al. (2001) *JGR, 106,* 23,689-23,722. [2] Neumann, G.A. et al. (2003) *JGR, 108(E4),* 5023. [3] Sun, X. et al., (2006) *Applied Optics,* in press. [4] Hinson, D.P. and R.J. Wilson (2004) *JGR 109*, E0100265. [5] Colaprete, A. et al. (2003) *JGR, 108(E4), 5081.* [6] Wilson, R. J. et al. (2005) *LPSC XXXVI,* Abstract #1947.

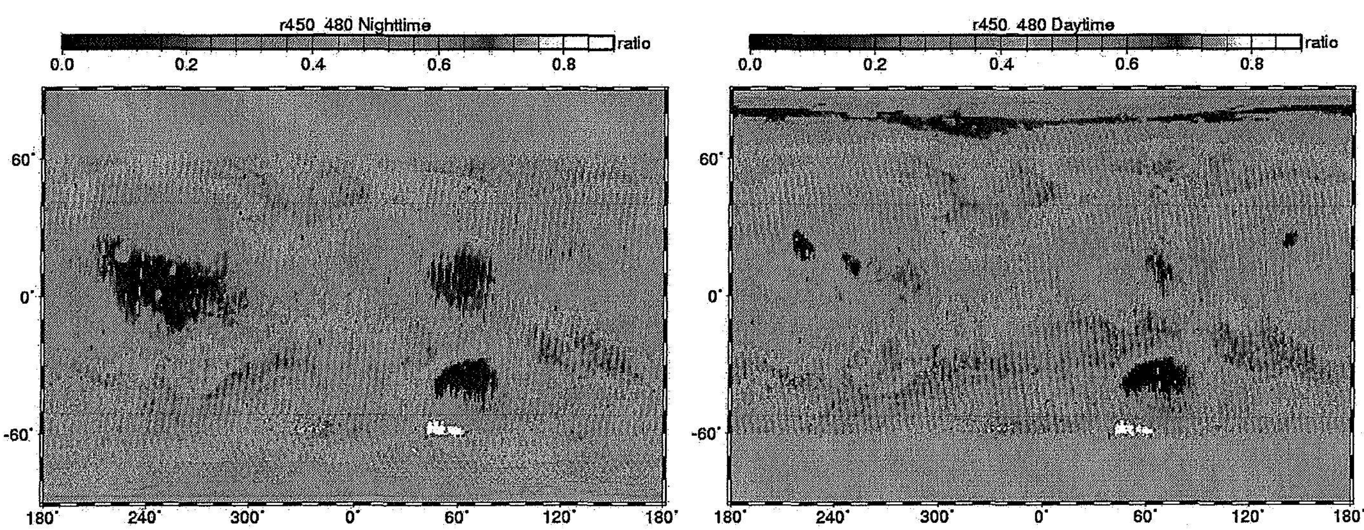

Figure 1. Ratio of active to passive radiometry measured by MOLA on nightside and dayside orbital passes.