NIGHTTIME OPTICAL DEPTH PATTERNS FROM THE MARS EXPLORATION ROVERS. K. M. Bean and M. T. Lemmon, Texas A&M University, 3150 TAMU, College Station, TX, kbean1988@neo.tamu.edu

Introduction: Using images from the Mars Exploration Rovers, the nocturnal optical depth variations can be better characterized. Objects such as Mars' moons Phobos and Deimos provide bright sources from which we can determine optical depth. Statistically significant trends are searched for, including but not limited to an increase in optical depth due to water ice cloud formation or a decrease in optical depth due to large particle settling in a calmer boundary layer.

Discussion: Optical depth is the measurement of the amount of radiation that is scattered or absorbed through the atmosphere. [1] It is very sensitive to particle size and concentration. Optical depth can also vary over the electromagnetic spectrum.

The Martian diurnal optical depth cycle is well constrained due to several Mars mission. However, little is known about the nocturnal patterns due to difficulty in obtaining the images and irregularity in observations.

Mars Exploration Rovers Spirit and Opportunity have accumulated hundreds of images of bright nighttime objects such as Phobos, Deimos, and Earth. Using these images, we can calculate the optical depth over the course of several nights.

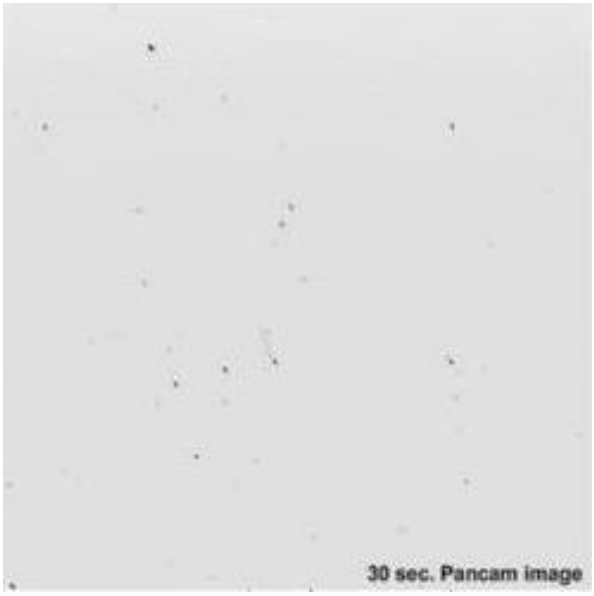

Figure 1: A 30 second exposure of the constellation Orion from MER-A, Spirit. This was taken on sol 632 at approximately 12:45am LTST. Image credit: NASA/JPL Caltech/Cornell/Texas A&M/Space Science Institute

To determine the optical depth in the nighttime images, we compare the absolute magnitude of the objects from above the atmosphere to the observed magnitude from the rover image. Using this difference, we can determine the amount of radiation getting through the atmosphere.

Object	**Sols Observed (through 1978)**
Venus	1978
Earth	1978
Phobos	104, 403, 404, 406, 497, 585, 590, 594, 595, 602, 607, 611, 612, 616, 617, 639, 675, 682, 687, 691, 693, 765, 1077, 1083
Deimos	68, 79, 420, 585, 590, 594, 595, 602, 607, 611, 612, 616, 617, 639, 687, 692, 696
Star fields	611†, 612†, 632†, 643†, 647†, 652†, 654*, 659†, 661*, 664†, 666-669†, 694, 1941-1943, 1949, 1977, 1978

Table 1: Objects observed by MER-A, Spirit, through sol 1978. * indicate joint optical observations with Mars Odyssey. † indicates star field also used for meteor searching.

The Mars Pathfinder mission observed higher optical depth at night, and this is suspected to be due to water ice crystals forming in the atmosphere. [2] More recently, the Phoenix Mars Lander mission observed clouds and precipitation using the LIDAR instrument. [3] To determine if water ice clouds form in the equatorial regions over the rovers, we would suspect an increase in the optical depth, especially in the blue filter, during the later hours.

The second pattern is to look for is the settling of dust particles over time. If the boundary layer remains relatively calm that night, we expect particles, especially the larger dust particles, to settle out of the atmosphere and the optical depth to decrease. If the optical depth remains relatively constant during that night, then we can determine that mixing in the boundary layer is rather constant and does not allow for dust settling. We can compare this to daytime optical depth values to determine the amount of dust settling and to help understand the daily dust cycle.

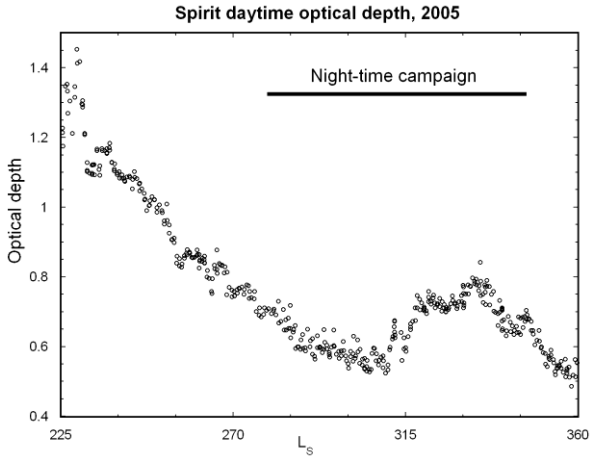

Figure 2: Daytime optical depth values from MER-A, Spirit during L_s=225-360. The first major nighttime campaign occurred during the time indicated.

References: [1] R. A. Kahn, T. Z. Martin, R. W. Zurek, S. W. Lee. (1992) *The Martian Dust Cycle*, "Mars", 1017-1053. [2] P. H. Smith, J. F. Bell III, N. T. Bridges, D. T. Britt, L. Gaddis, F. Gliem, R. Greeley, H. U. Keller, K. E. Herkenhoff, S. Hviid, R. Jaumann, J. R. Johnson, R. L. Kirk, M. Lemmon, J. N. Maki, M. C. Malin, S. L. Murchie, J. Oberst, T. J. Parker, R. J. Reid, P. Rueffer, R. Sablotny, L. A. Soderblom, C. Stoker, R. Sullivan, N. Thomas, M. G. Tomasko, W. Ward, E. Wegryn. (1997). "Results from the Mars Pathfinder Camera." *Science*, *278*, no. 5344, 1758-1765. [3] J. A. Whiteway, L. Komguem, C. Dickinson, C. Cook, M. Illnicki, J. Seabrook, V. Popovici, T. J. Duck, R. Davy, P. A. Taylor, J. Pathak, D. Fisher, A. I. Carswell, M. , V. Hipkin,A. P. Zent, M. H. Hecht, S. E. Wood, L. K. Tamppari, N. Renno, J. E. Moores, M. T. Lemmon, F. Daerden, P. H. Smith. (2009). "Mars Water-Ice Clouds and Precipitation." *Science*, *325*, no. 5936, 68-70.