ANALYSIS OF PHOTOMETRY OF THE MARTIAN SKY AND GROUND TO DETERMINE THE COUPLING BETWEEN DERIVED VALUES OF THE OPTICAL CONSTANTS OF THE MARTIAN AEROSOLS AND THE SURFACE REFLECTIVITY. E. Wegryn, M. G. Tomasko, and L. R. Doose.

The Imager for Mars Pathfinder (IMP) measured the brightness of the sky of Mars during the morning and evening over a time period covering 52 Martian Sols. The evening observations for one sol have been analyzed and published in JGR 104, 1999. Recently, our analysis has been extended to cover the entire timespan of observations with the goal of understanding any variations in the optical properties of the aerosol particles during the roughly two months of operation on the Martian surface.

This investigation to explore the variation in aerosol properties over the course of the Pathfinder mission revealed some interesting photometric effects. Firstly, the preliminary analyses of Martian surface photometry (Johnson, et al., JGR 104, 1999) did not include the influence of changing illumination of the surface due to diffuse sky illumination during the observations. When the sun is reasonably low in the sky (elevation around 20°) as it was for the conditions when the sky observations were made to derive aerosol properties, the downward diffuse flux from sky is roughly equal to the downward flux from the directly transmitted solar beam. Thus, values for the asymmetry of the reflectivity of the Martian surface determined by Johnson, et al., which do not include the effects of the dilution by the diffuse sky underestimate the value of the asymmetry parameter of the surface by about a factor of two.

Secondly, attempts to use constant values for the Hapke parameters for the ground reflectivity in the analysis of the sky observations covering the two months of measurements lead to apparent variations in the imaginary refractive index of the Martian aerosols by more than a factor of two over this time span. However, these variations are strongly correlated with the solar elevation angle at which sky observations were made. When constant Hapke reflectivity parameters are used in the analysis, observations at lower solar elevation angles yield smaller values of the imaginary refractive index of the aerosols, and observations at higher solar elevation angles give larger values. This means that before any meaningful results for the variations in the optical constants of the aerosols with time can be determined, the surface reflectivity must be more accurately characterized. Such a more accurate determination requires a fully coupled model of sky and ground brightness constrained by both the observations of the brightness of the ground and the brightness of the sky.

We have undertaken such a coupled study. We find that for each solar elevation angle at which data were taken, the sky observations alone can be fitted with a family of solutions for the value of the ground reflectivity and the imaginary refractive index of the aerosols. If the model ground is made brighter, the aerosols must be made darker (have larger imaginary refractive indices) to compensate and match the observations. Thus, one way for the models to give the same optical constants for the aerosols is for the ground to be brighter than the standard Johnson model at low solar elevation angles compared to larger solar elevation angles. This behavior must extend across the range from about 7° elevation angle to some 25° elevation angle.

In addition small sample of sky observations exists when the sun is high in the sky. For these data, the derived value of the imaginary refractive index is significantly smaller than any of the values derived with the sun at low elevation angles. This means that while the Martian surface must be brighter than the standard model (reflect more flux up into the sky) at very low solar elevation angles than at 25°, it must also be brighter than the standard model at very large elevation angles (near 80°).

We have begun the study models of the Martian surface reflectivity constrained by Pathfinder observations and by observations made near the same time by the Hubble Space Telescope (HST). Models of the surface include standard Hapke-type surfaces as well as modifications to estimate the effect of a distribution of large rocks on the surface. The fraction of the surface covered by rocks is a variable, as is the reflectivity of the rock and soil material. When the sun is high, the reflectivity is simply the area average of the reflectivity of the soil and the rocks. When the sun is lower, the rocks shadow the soil, decreasing its contribution to the average, and as the sun sets the rocks continue to be illuminated from the side, leading to a finite reflectivity even for the sun at the horizon.

The ability of a range of surface reflectivity models to fit observations of the brightness of the sky and ground measured by Pathfinder and the HST will be discussed, as will the resulting changes (if any) in the optical constants of the aerosols during the Pathfinder Mission.