**SURFACE DUST REDISTRIBUTION ON MARS AS OBSERVED BY THE MARS GLOBAL SURVEYOR.** M. A. Szwast[1], M. I. Richardson[2], and A. R. Vasavada[3], [1]Caltech, 150-21, 1200 E. California Blvd., Pasadena, CA 91125. szwast@caltech.edu, [2]Caltech, 150-21, 1200 E. California Blvd., Pasadena, CA 91125. mir@gps.caltech.edu, [3]JPL/Caltech, 183-501, 4800 Oak Grove Drive, Pasadena, CA 91109. Ashwin.R.Vasavada@jpl.nasa.gov.

**Introduction:** The global redistribution of dust by the atmosphere is geologically and climatologically important. Dust deposition and removal at the surface represents ongoing sedimentary geology: a vestige of aeolian processes responsible for the concentration of vast dustsheets and potentially for ancient layered units at various locations on Mars. The varying amount of dust on the surface has also long been hypothesized as a factor in determining whether regional or global dust storms occur in a given year. Indeed, the atmosphere has a very short, sub-seasonal time-scale (or memory) and as such, any inter-annual variability in the climate system that is not simply ascribable to stochastic processes, must involve changing conditions on the surface.

An excellent, multi-year dataset is provided by the Mars Global Surveyor (MGS) Thermal Emission Spectrometer (TES) and the Mars Orbiter Camera Wide Angle imager (MOC-WA). This dataset allows investigation into the degree to which surface dust deposits on Mars really change: over decadal time scales, over the course of the annual cycle, and as a result of global and regional dust storms. The MGS mapping orbit data set extends over almost 3 Martian years at the time of writing. These data sets include one global dust storm and smaller regional storms (one in the first TES mapping year and two in the third).

**Data and Methods:** This study makes extensive use of data collected by the MGS TES. In addition, some imaging data from MGS are also used. In all cases, the data have been taken from the PDS archives. The albedo is not corrected for atmospheric scattering, thus it is a measure of the net reflectivity of surface plus atmosphere, rather than a pure measure of the surface. Because of this, the low atmospheric dust opacity periods of northern spring and summer were used for interannual comparisons. The albedo provides information to the depth of penetration of visible photons – typically a few microns.

An alternate means of mapping fine-grained silicates (taken to be dust) was developed by Ruff and Christensen [1]. The “Dust Cover Index” (DCI) is defined as the average emissivity between 1350-1400 $cm^{-1}$. The DCI effectively integrates information over a depth of a few 10’s of microns, rather than the few microns for albedo. However, for dust deposits of several particle thickness or greater, DCI and albedo should agree if both are good gauges of the true dust coverage.

Imaging data from the MGS Mars Orbiter Camera provides an alternate, albeit non quantitative, means of measuring the albedo of the surface [2, 3]. We use MOC Wide Angle (WA) red-channel images to provide independent confirmation of albedo changes measured by TES. The MOC WA data are taken from the PDS and processed using the USGS ISIS package.

**Results and Discussion:** The first topic addressed was the comparison of albedo and DCI. Detailed comparison of the maps demonstrate that there are no discernable regions of high or low albedo that are not simultaneously regions of low or high DCI (low DCI corresponds to high dust cover), suggesting that both are providing a direct measure of the surface dust coverage. Due to the much greater volume of the albedo data (after appropriate data quality control for both), we chose to use the albedo data to study the temporal and spatial variability of dust cover in this study.

The 2001 global dust storm (GDS) originated in the Hellas basin, and spread to the north and east. After about 20 days, a secondary source arose around the Daedalia region. This storm caused widespread surface dust redistribution. In Figure 1a we show the albedo during the northern spring ($L_s$=0°-90°, used to minimize the effect of atmospheric dust) of the third mapping year (the spring following the 2001 storm) and in Figure 1b the difference between the albedo in year 2 and year 3 (both $L_s$=0°-90°). While some data noise is apparent, especially in the northern high latitudes (associated with the seasonal ice cap and hood), significant and spatially coherent regions of change in the albedo can easily be identified. The numbered areas in Figure 1a are the ten chosen regions of interest. Figure 1b shows the changes caused by the global dust storm. Red regions experienced an increase in albedo, indicating increased surface dust. Blue regions experienced a decrease in albedo, indicating a loss of surface dust.

Figure 1c shows the changes in albedo for the year after the GDS. In general, the areas that experienced a large increase in albedo from the GDS experienced a significant decrease in albedo in the following year. This suggests that the dust that was deposited at the end of the GDS was largely removed. However, the areas that were darkened by the GDS show a much smaller recovery back to pre-storm conditions in the time since the storm.

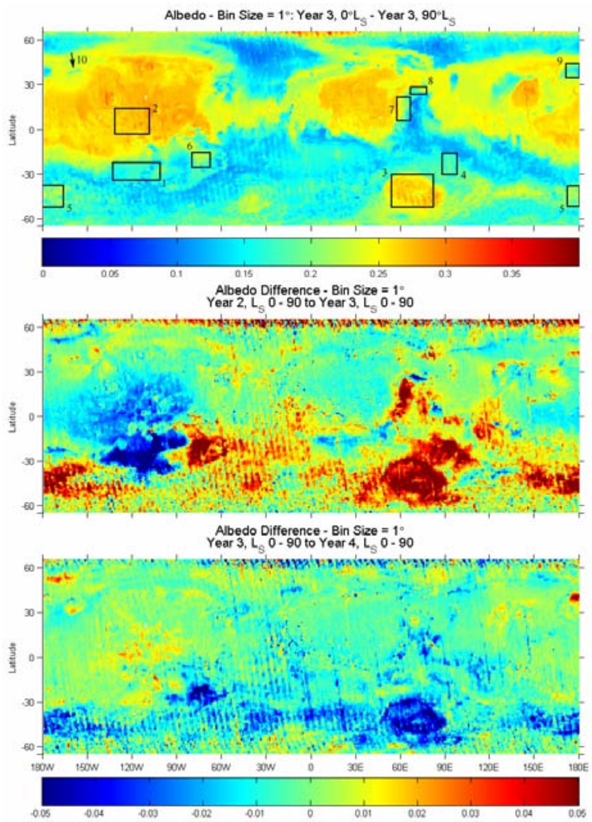


**Figure 1:** Martian albedo maps. (a) Year 3, $L_s$=0°-90°. (b) Change from Year 2 to Year 3 ($L_s$=0°-90°). (c) Change from Year 3 to Year 4 ($L_s$=0°-90°).

One example of a region darkened by the 2001 GDS is Daedalia (region #1), whose albedo and atmospheric dust opacity are shown in Figure 2. The albedo for the first complete year (from $L_s$=110° in year 1 to this same seasonal date in year 2) has a mean value of about 0.225. The largest signal in the multi-year Daedalia albedo data not caused by atmospheric dust opacity (which is the case for the peak during the GDS) is a roughly 0.06 drop in albedo across the 2001 global dust storm. Following the storm, after roughly $L_s$=240° in the second mapping year, the albedo remains near a new mean value of roughly 0.17. Examining the period between $L_s$=330° and $L_s$=90° for the final two years of observations, it is possible to argue that a year after the global storm, the Daedalia albedo has increased by maybe 0.005-0.01.

In contrast to Daedalia, Solis (region #6) experiences a rise in albedo from the GDS. Figure 3 shows the region's albedo and dust opacity. There is a large jump in albedo following the storm that does not decay as the dust opacity decays. The albedo remains high during the third mapping year, with some indication of a steady decrease in albedo if one attempts to subtract-out the high frequency opacity interference.

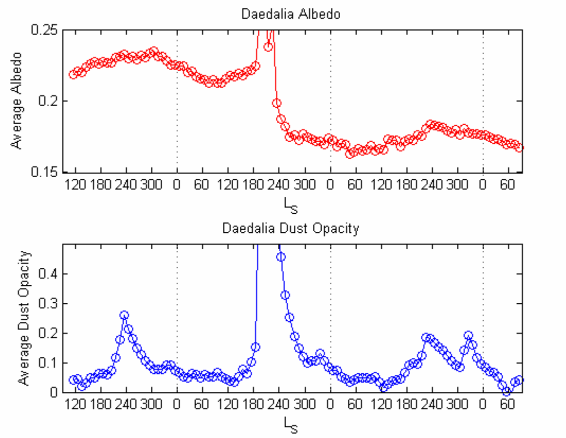


**Figure 2:** Albedo and dust opacity of Daedalia

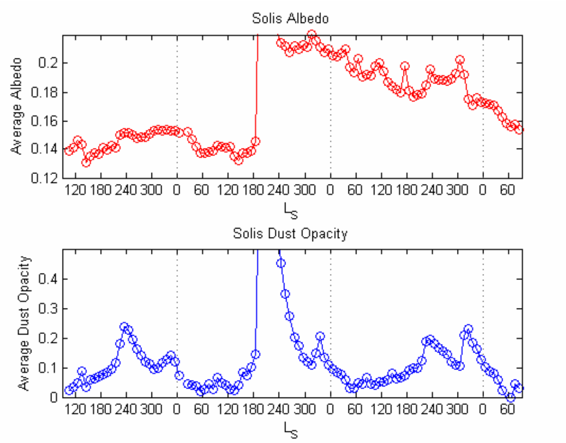


**Figure 3:** Albedo and dust opacity of Solis

**Conclusions:** The MGS albedo data provide the ability to trace dust cover changes to specific atmospheric phenomena at a detailed level. These data show that the 2001 global dust storm caused widespread dust cover changes. Long-term responses to the 2001 storm varied. Areas that were darkened by the 2001 storm tend to show little or no recovery since, while areas that were brightened by the 2001 storm tend to recover over several years. This implies that dust redistribution may be cyclical, but with a multi-year time scale

**References:**

[1] Ruff S. W. and Christensen P. R. (2002) *JGR, 107,* 5127. [2] Malin M. C. and Edgett K. S. (2001) *JGR, 106,* 23429-23570. [3] Coplinger M. A. and Malin M. C. (2001) *JGR, 106,* 23595-23606.