MGS-MOC OBSERVATIONS OF MARTIAN DUST STORM ACTIVITY. B. A. Cantor[1], [1]Malin Space Science, San Diego, CA.,USA (cantor@msss.com).

Introduction: The Mars Observer Camera (MOC) completed its second consecutive Martian year of monitoring on December 12, 2002, since entering its mapping orbit on March 9, 1999. During this time the narrow-angle (NA) camera has been taking snapshots of the surface at a resolution of 3-40 m/pixel, while the two wide-angle (WA) cameras, which cover two wavelength bands spanning from the blue (400-450 nm) to the red (575-625 nm), have been continuously mapping the dayside of Mars at a constant resolution of 7.5 km/pixel. Because the WA cameras have a 140° FOV, which allows for limb-to-limb views of the planet, the local time across these low-resolution images ranges from 12:17 to 15:43 at the equator. Some overlap exists between images taken on consecutive orbits, allowing for complete global coverage of the planet to be obtained in two colors in only 12 to 13 orbital passes or about once per a sol.

The MGS-MOC experiment has provided an unique opportunity to study Martian weather phenomena, ranging from dust devils and dust storms to condensate clouds to the seasonal behavior of the Martian polar caps, all on time scales ranging from semi-diurnally to interannually. We present here a brief description of the dust activity observed by MOC during the past 2 Mars years in terms of the interannual invariability/variability of these events.

MOC has observed dust events across much of the planet from the depths of Hellas basin to the summit of Arsia Mons. These events range in size from dust devils to planet encircling dust veils.

Dust Devils: Martian dust devils range in size from a few to 10s of meters across to 100s of meters across and over 6 km high. Though dust devils occur throughout most of the Martian year, each hemisphere has a "dust devil season" that generally follows the subsolar latitude and appears to be repeatable from year-to-year. An exception is NW Amazonis, which has frequent, large dust devils throughout northern spring and summer.

MOC observations show no evidence that dust devils cause or lead to dust storms, however, observations do suggest that dust storms can initiate dust devil activity (i.e., Dust devils sometimes do occur near small, localized storms). One specific relation occurred during the onset of the planet encircling dust event of 2001, when slightly elevated levels of atmospheric dust, associated with the developing planet encircling dust veil, triggered a very short period of dust devil activity in NW Amazonis in early northern autumn. The redistribution of dust by the initial onset of the 2001 planet-encircling dust activity may have also affected subsequent spring and summer dust devil activity in Hellas, where considerably fewer dust devils occurred in 2001-2002 than 1999-2000. In SW Syria, frequent, large dust devils occurred after the 2001 global activity and persisted through southern summer. While dust devils have no specific relation to dust storms, they might play a role in maintaining the low background dust opacity of the Martian atmosphere, as well as, the seasonal "wave of darkening" at middle and high latitudes by removing or disrupting thin veneers of dust.

Dust devils are also important in terms of the shadows they cast, which can provide a snapshot view of the afternoon vertical structure of the lower several kilometers. A northern Amazonis, summertime dust devil, shown in Figure 1, has a distinct shadow that shows the fine vertical structure of the vortex and plume. The bending of the vortex by 45° to the northwest is indicative of a wind-shear layer about 0.6 km high, which extend from 0.64 km to 1.24 km above the surface. The direction of the prevailing winds in this layer are to the northwest. The point where the vortex and plume interface, defines another boundary layer, which occurs at an altitude of 1.68 km above the surface.

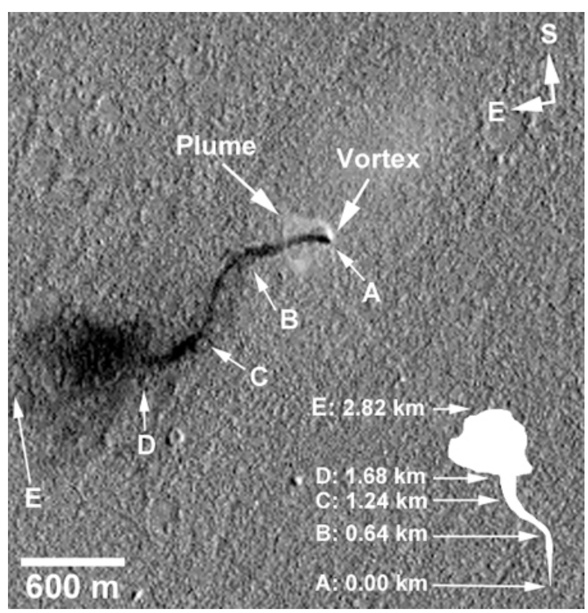

Figure 1. MOC-NA image of an Amazonis dust devil.

Dust Storms: Global maps are important for monitoring all but the smallest scale dust activity on Mars. MGS global observations have shown that storms occur almost daily with few exceptions, with thousands occurring each year in the present Martian environment, dispelling the notion of a "Classical Dust Storm Season". However, there does appear to be an annual dust storm cycle, with storms developing in specific locations during certain seasons; see Figure 2. MOC observations taken during the past 2 Martian years, suggest that this dust cycle was in general, repeatable from year-to-year. The majority of storms develop near the receding seasonal polar cap edge or along the corresponding polar hood boundaries in there respective hemispheres, suggesting that large thermal gradients and the surface winds they generate are the triggering mechanism for some of the dust activity. Because of MGS's polar orbit, some of these high-latitude local dust storms have been monitored with sufficient temporal sampling density (every 2 hours) to observe their semi-diurnal evolution; see Figure 3. These observations showed that most high-latitude storms formed in the early to late morning hours when boundary layer instabilities would be greatest and would expand rapidly, covering a large area in a matter of just 4-6 hours.

In the northern plains, spiral dust events tend to be seen in the spring and summer seasons and resemble terrestrial polar lows "cold fronts". Those seen during late northern summer tend to resemble terrestrial baroclinic fronts and are accompanied by condensate clouds, traveling eastward at about 12-15 m/s for several days before dissipating. Still other storms develop in the low laying regions where atmospheric conditions are optimized for dust lifting (e.g., plains on the windward side of Olympus and Elysium Mons and Alba Patera, in Hellas and Argyre Basins, in Chryse Planitia, ect…).

Dust storms such as the cross-equatorial events that form in Acidalia/Chryse and travel southward following the low-lying topography into Valles Marineris, also tend to follow a seasonal trend occurring in two periods from about L_s = 208°-224° and L_s = 315°-333°; see Figure 4. They appear to be associated with the strengthening of the Hadley circulation during the southern spring and summer seasons. These storms are part of a class of large dust events referred to in the scientific literature as "Regional" dust storms because of their great extent and duration (> 3 sols). Though limited in number with a few 10s of regional storms occurring per Martian year, their size, duration, and unrestricted seasonality make them ideal tracers of atmospheric circulation for global mapping investigations. MOC has used this capability to observe for the first time the north-to-south cross-equatorial circulation associated with the lower-branch Hadley circulation in the Chryse/Valles Marineris region (as noted above), as well as, the general circulation at high latitudes in both hemispheres. At present our understanding of regional storms is fairly limited. Analysis of the historical records suggested that regional dust storms occur in all seasons, but are absent during two periods of the year L_s = 130°-160° and L_s = 330°-20°. Recent MOC observations suggest that this later time period may be even shorter (L_s = 0°-20°). As for why some local storms become regional is unclear, but WA images suggest that about half of the larger regional storms may form from the merge of two or more active local storms.

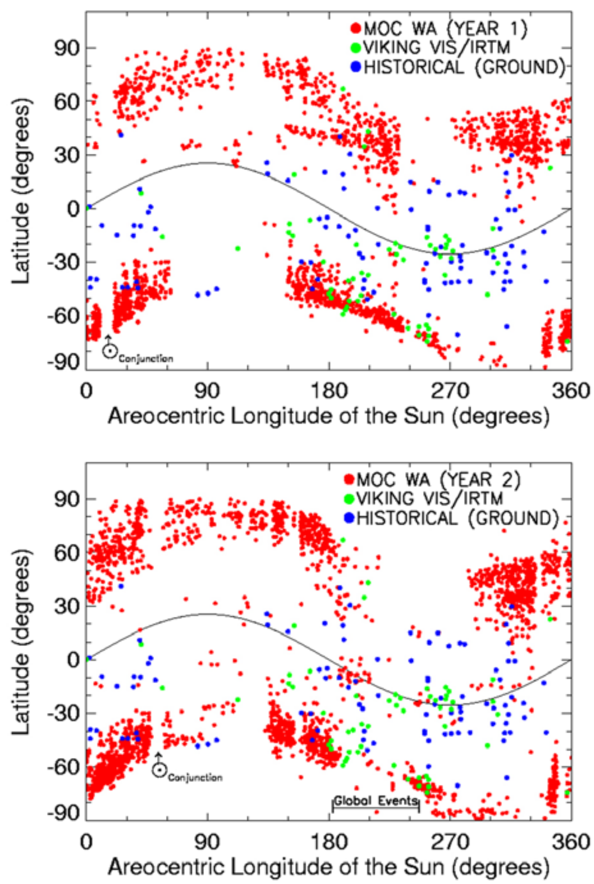

Figure 2. Latitudinal distribution of dust storms as a function of L_s. Comparison of the MOC wide-angle red filter observations taken during the first Mars year (top) [1] and the second Mars year (bottom) with Viking Orbiters' infrared and visible observations [2, 3] and historical ground-based observations [4]. Solid line corresponds to the subsolar latitude.

Figure 3. Semi-diurnal evolution of summertime, local dust events in the southern hemisphere.

Figure 4. Cross-equatorial dust storm observed during northern winter.

The largest and rarest of dust phenomena on Mars are referred to as the "Great Storms" or "Global Storms". These dust events can encircle the planet in specific latitude bands, such as the southern subtropics ("planet encircling" storm) or on occasion have been observed to enshroud the planet ("global" storm). These dust events are quite rare, with only 6 confirmed events on record, 4 planet-encircling and 2 global [5]. The MGS MOC global imaging investigation has provided the first comprehensive planet-wide views of almost the entire development of the 2001 global "planet enshrouding" dust event. Such global mapping has led to new insights into the initiation and evolution of these global atmospheric phenomena, as well as place constraints on model predictions. With MOC we have observed that global dust events are not individual storms but are composed of a number of local and regional storms (sources). The storms that created the planet-encircling dust veil lasted from a few days to a few months, as in the case of the Syria-Claritas regional storm, which lasted for over 3 months in the same location. It was the dust raised into the upper atmosphere by the larger, longer-lasting storms that appears to have stimulated further storm activity across the planet, possibly due of diabatic heating of atmospheric dust, and are also responsible for the planet-encircling dust veil. MOC also observed that the storms responsible for the initiation of the start of the "planet-encircling dust activity" did not form in the southern subtropics, but developed in the mid-latitudes adjacent to the receding south polar cap. These storms then traveled northward into the subtropics, which is consistent with the class of global storm generating mechanism models that emphasize enhancement of the planetary scale circulation [6]. The effects of the planet-encircling dust activity on the Martian climate are at best minimal, in fact, dust storm and condensate cloud activity returned to their normal predictable seasonal behavior within a few months of the ending of the planet-encircling event.

Though dust storms occur throughout the Martian year and across most of the planet, there are regions and times where dust activity was at a minimum or non-existent; see Figure 2. One region where MOC has observed no dust activity over the past 3 Martian years is Arabia Terra. In the Northern Hemisphere, the period of minimum dust activity occurs during northern fall between about L_s = 235°-270°. In the southern hemisphere, there appears to be three periods of minimum dust activity, the most significant occurs while the seasonal south polar cap is forming between about L_s = 65°-130°. The other two occur during southern summer between about L_s = 275°-290° and L_s = 313°-340°. Because of the lingering effects of the planet-encircling dust veil of 2001, MOC was not able to confirm whether the period of minimum dust activity in the Northern Hemisphere was repeatable from year-to-year. The periods of minimum dust activity in the Southern Hemisphere have been fairly repeatable, with the exception that the southern fall/winter minimum was of shorter duration (by about two months) in 2002. Possibly the result of the redistribution of surface dust caused by the long-lived (90-sol duration) dust storm in the Syria-Claritas region, part of the planet-encircling dust activity of 2001.

In summary, MOC has observed that dust events follow general seasonal cycles that are reproducible from one year to the next and that global dust events do not signify climatic changes, but are only short-term perturbations to the interannual repeatable dust and condensate cloud cycles of Mars.

References: [1] Cantor, B. A. et al. (2001) *JGR, 106,* 23653–23687. [2] Peterfruend A. R. (1985) *Ph.D. thesis*, Ariz. *State Univ.*, 246. [3] Briggs, B. A. et al. (1979) *JGR, 84,* 2795-2820. [4] Wells, R. A. (1979) *Geophysics of Mars*, *Elsevier Sci.*, 678. [5] Zurek, R. W. and Martin, L. J. (1993) *JGR, 98,* 3247–3259. [6] Leovy, C. B. et al. (1973) *J. Atmos. Sci.*, *30*, 749-762.