References: [1] Rubincam D. P. (1992) *JGR, 97*, 2629–2632. [2] Haberle R. M. et al. (1992a) *LPI Tech. Rpt. 92-08, Part 1*, 10–11. [3] Haberle R. M. et al. (1992b) *Bull. A.A.S., 24*, 1015–1016. [4] Ward W. R. (1973) *Science, 181*, 260–262. [5] Ward W. R. (1974) *JGR, 79*, 3375–3386. [6] Ward W. R. (1979) *JGR, 84*, 237–241. [7] Murray B. C. et al. (1973) *Science, 180*, 638–640. [8] Ward W. R. et al. (1979) *JGR, 84*, 243–259. [9] Rubincam D. P. (1990) *Science, 248*, 720–721. [10] Chao B. F. and Rubincam D. P. (1990) *JGR, 95*, 14755–14760. [11] Bills B. G. (1990) *JGR, 95*, 14137–14153. [12] Ward W. R. and Ruby D. J. (1991) *Icarus, 94*, 160–164. [13] Touma J. and Wisdom J. (1993) *Science, 259*, 1294–1297. [14] Laskar J. and Robutel P. (1993) *Nature, 361*, 608–612. [15] Sagan C. et al. (1973) *Science, 181*, 1045–1049. [16] Ward W. R. (1974) *JGR, 79*, 3387–3395. [17] Toon O. B. et al. (1980) *Icarus, 44*, 552–607. [18] Fanale F. P. et al. (1982) *Icarus, 50*, 381–407. [19] Pollack J. B. and Toon O. B. (1982) *Icarus, 50*, 259–287. [20] Francois L. M. et al. (1990) *JGR, 95*, 14761–14778. [21] Leighton R. B. and Murray B. C. (1966) *Science, 153*, 136–144. [22] James P. B. and North G. R. (1982) *JGR, 87*, 10271–10283. [23] Lindner B. L. (1990) *JGR, 95*, 1367–1379. [24] Lindner B. L. (1992) *GRL, 19*, 1675–1678. [25] Lindner B. L. (1993) *JGR, 98*, 3339–3344. [26] Wood S. E. and Paige D. A. (1992) *Icarus, 99*, 1–14. [27] Lindner B. L. and Jakosky B. M. (1985) *JGR, 90*, 3435–3440.

427034

N94-33214

524-91 ABS ONLY

ESCAPE OF MARS ATMOSPHERIC CARBON THROUGH TIME BY PHOTOCHEMICAL MEANS. J. G. Luhmann[1], J. Kim[2], and A. F. Nagy[3], [1]Institute of Geophysics and Planetary Physics, University of California, Los Angeles CA 90024-1567, USA, [2]KARI, Seoul, Korea, [3]Space Research Laboratory, University of Michigan, Ann Arbor MI 48109, USA.

Luhmann et al. [1] recently suggested that sputtering of the martian atmosphere by reentering O^+ pickup ions could have provided a significant route of escape for CO_2 and its products throughout Mars' history. They estimated that the equivalent of C in a ~140-mbar CO_2 atmosphere should have been lost this way if the Sun and solar wind evolved according to available models. Another source of escaping C (and O) that is potentially important is the dissociative recombination of ionospheric CO^+ near the exobase [2]. We have evaluated the loss rates due to this process for "ancient" solar EUV radiation fluxes of 1, 3, and 6× the present flux in order to calculate the possible cumulative loss over the last 3.5 Gyr. (Earlier estimates of loss by McElroy [2] used the present-day rates and thus represent underestimates.) The inputs and assumptions for this calculation are the same as used by Zhang et al. [3] for an evaluation of historical O escape by dissociative recombination of ionospheric O_2^+. We find loss rates of C that are at least comparable to the sputtering loss rates, thereby potentially accounting for another 100 mbar or more of Mars' original atmosphere.

References: [1] Luhmann J. G. et al. (1992) *GRL, 19*, 2151–2154. [2] McElroy M. B. (1972) *Science, 443*. [3] Zhang M. H. G. et al. (1993) *JGR, 98*, 10915–10923.

N94-33215

525-91 ABS ONLY

p. 2

MIGHT IT BE POSSIBLE TO PREDICT THE ONSET OF MAJOR MARTIAN DUST STORMS? L. J. Martin[1], P. B. James[2], and R. W. Zurek[3], [1]Lowell Observatory, Flagstaff AZ 86001, USA, [2]University of Toledo, Toledo OH 43606, USA, [3]Jet Propulsion Laboratory and California Institute of Technology, Pasadena CA 91109, USA.

This was done very successfully by the late "Chick" Capen in 1971, but we now believe that the chance of having a planet-encircling storm in any given Mars year is less than 50% [1]. Capen suggested that these storms begin around the time of perihelion. More recent storms have extended this season to nearly one-third of a martian year, during the same interval that the south polar cap is receding [2]. There is no observational evidence that storms of this size have occurred outside of that period, although smaller dust storms have been observed throughout most of the martian year. The circumstances that allow a limited storm to become a runaway or encircling storm are not well understood. Seasonal effects are apparently just one aspect of these circumstances, but apparently a critical one. Dust activity seen by Viking near the edges of the receding cap and data showing that the cap may be receding at a faster rate prior to these storms suggest that the seasonal south cap may be influencing dust activity.

We have also determined that the north polar hood recedes during major dust storms, but it is not clear whether impending storms might have an effect upon this atmospheric phenomenon. Viking images do show local storm clouds near the hood prior to the first 1977 planet-encircling dust storm, but the hood is such a dynamic feature that minor changes may not be meaningful. We are, however, continuing to analyze these data.

Several datasets indicate that Mars' atmosphere was less clear before the first 1977 encircling storm, although we cannot discount the possibility that this was merely a seasonal change. Data from other Mars years are less detailed and comprehensive, but the 1977 Viking data from both imaging [3] and infrared [4] suggest that dust in the atmosphere was increasing prior to the storm. Peter Boyce found that, prior to the 1971 planet-encircling storm, there was "violet haze" present on Mars. He attributed this to the impending storm, which may have been correct, but this condition, which could be due in part to atmospheric dust on Mars, is not uncommon at times when no storm is on the way. This may also be true for other indicators of increasing atmospheric dust mentioned above.

Capen also believed that smaller, precursor storms occurred before a planet-encircling storm. This generally seems to be the case, although the data are not conclusive. These earlier storms certainly provide a good vehicle for raising dust into the the atmosphere and regional dust storms may be a sign of an impending larger storm. However, many of these storms occur without any subsequent dust activity, even during the dust storm "season."

Investigations of dust-storm observations show that that the Hellas Basin is the most active area on Mars for all sizes of storms [2]. This area is probably their primary dust source.

Earth-based observations suggest that, during the expansion phase of planet-encircling storms, diurnal cycles often begin at Hellas, presumably with a new load of dust, as mountain climbers return to a base camp for more supplies to be cached along their route. Each day the storms carry an increasing supply of dust farther to the west, until Hellas is reached from the east, completing the circuit of the globe. This scenario probably requires that the dust supply in Hellas was adequate to provide for a large daily removal during the two-week period that it takes for these storms to encircle Mars. It may be that storms that died out earlier did so because there was not enough dust in Hellas at that time.

Hellas is a traditional name for a bright albedo feature now known as Hellas Planitia. Not everyone is aware, however, that this area is not always bright, and sometimes is not even lighter than its surroundings. Hellas was bright during the Viking and Mariner 9 missions, which, of course, took place during dust-storm years. During Mariner 9 and after the global storm, the basin floor was covered with so much dust that almost no detail showed. In recent years, during which no encircling storms have been observed, Hellas has become less prominent and smaller as an albedo feature. We assume that this means that it contained less dust and possibly not enough to support a runaway dust storm. The albedo of this basin should be closely monitored, especially during the season of the south polar cap's recession.

Predicting major dust storms seemed easier when we knew less about them. We can probably expect this trend to continue. The possible indicators of impending storms discussed above may be helpful, however, and perhaps should be taken seriously in the event that all signs are positive at once.

Martin's research is primarily supported by NASA grants NAGW-2257 and NAGW-3311. HST observations are supported by Space Telescope Institute grant 2379 to the University of Toledo, with subcontracts that include the Lowell Observatory. James is the Principal Investigator for the HST General Observer Team for Mars imaging and a collaborator for the above NASA grants.

References: [1] Zurek R. W. and Martin L. J. (1993) *JGR, 98,* 3247–3259. [2] Martin L. J. and Zurek R. W. (1993) *JGR, 98,* 3221–3246. [3] Martin L. J. and Richardson M. I. (1993) *JGR, 98,* 10941–10949. [4] Martin L. J. et al. (1992) *LPI Tech. Rpt. 92-02,* 99–100.

N94-33216

S26-91 ABS. ONLY

STUDIES OF ATMOSPHERIC DUST FROM VIKING IR THERMAL MAPPER DATA.

T. Z. Martin, Jet Propulsion Laboratory, California Institute of Technology, Pasadena CA 91109, USA.

Following earlier work to map the dust opacity of the Mars atmosphere [1], a number of separate studies have been performed employing the radiometric measurements of the Viking IR Thermal Mappers: (1) extension of global opacity mapping to the entire Viking mission period; L_s 84° in 1976 until L_s 210° in 1979—a span of 1.36 Mars years—with 5° L_s resolution [2]; (2) isolation of opacity behavior at the inception of the two major storms 1977a and 1977b [2]; (3) determination of the effects of topography on the opacities [3]; (4) computation of the mass of dust raised by both local and global dust events [4,5]; and (5) mapping of local dust storm opacity using individual IRTM sequences to provide "snapshots" [5].

These efforts have resulted in a new perspective on the atmospheric dust distribution during the Viking mission, as well as quantitative measures useful in the modeling of likely behavior at other times, and improved boundary conditions for circulation models of Mars. Among the significant findings are these: (1) Confirmation of the persistent dust present in Hellas, as seen frequently in Earthbased observations. A new storm was detected there prior to the 1977a event; however, Hellas seemed less obscured during the 1977a storm than its surroundings. (2) Opacity mapping confirms other evidence that the 1977a and 1977b storms commenced in southern midlatitudes and grew laterally. (3) Minimal opacity increases at the southernmost latitudes provide evidence against significant poleward dust transport during the major 1977 storms. (4) Continued high opacity in equatorial latitudes during later stages of the 1977b storm, consistent with findings from Mariner 9, supports the hypothesis that dust is lofted by diurnal tides [6]. (5) Dust raising appears to be ubiquitous in high northern latitudes during northern spring and summer. This is evidence for significant surface wind stress. (6) Considerable differences in opacity exist between the first and second Mars years observed by Viking, with clearer conditions in the latter. (7) As expected, topography influences observed opacities during relatively clear periods, but the correlation disappears during major storms. (8) Approximately 10^{12} kg of dust were raised at the peak of the 1977b storm, corresponding to 800 kg/km^2. The variation of atmospheric dust loading can be portrayed by computing total dust mass as a function of time from the set of 5° L_s opacity maps (see Fig. 1). (9) The well-known L_s 226° (1977) local dust storm raised about 1.6×10^8 kg of dust.

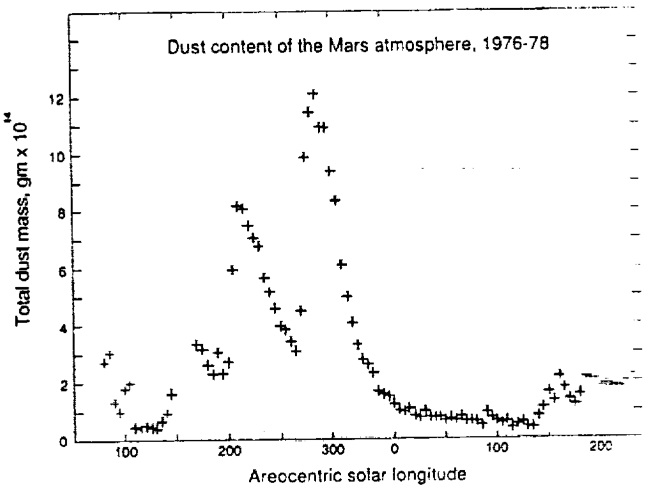

Fig. 1.

While the temporal and spatial coverage of the mapping was not ideal for tracking the development of dust storms, the opacities derived from IRTM data offer good characterization of the general character of martian atmospheric changes. The value of doing both synoptic "snapshots" and systematic coverage is demonstrated.

The research described in this paper was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

References: [1] Martin T. Z. (1986) *Icarus, 66,* 2. [2] Martin T. Z. and Lachin A. (1992) *Bull. AAS, 24,* 1009. [3] Martin T. Z. and Richardson M. I. (1993) *JGR, 98,* 10941. [4] Martin T. Z. (1993) *LPI Tech. Rpt. 93-05,* in press. [5] Martin T. Z. and Lachin A. (1993) *Bull. AAS,* in press. [6] Anderson E. and Leovy C. (1978) *J. Atmos. Sci., 35,* 723.