THE OBSERVED DAY-TO-DAY VARIABILITY OF MARS WATER VAPOR.

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Introduction. Analyses of observations of water vapor in the Mars atmosphere have centered on the gross spatial and seasonal variation (e.g.,1,2). Although variations on timescales short compared to the martian seasons have been observed (3,4), there has been no systematic analysis of such variability. We have examined the variations of water vapor which occur from day to day within a given season using Viking Mars Atmospheric Water Detector (MAWD) data. This will allow us to understand short-term variations and observational effects which may play an important role in our understanding of the seasonal cycle of water.

Both real variations in water vapor and observational effects may result in an observed day-to-day variation of water vapor. Real effects include atmospheric transport of water vapor and ice or possible surface sources or sinks of water vapor active on short timescales. Observational effects that would produce an apparent day-to-day variability include variations of cloud or dust opacity, variable viewing geometry with some aerosol present, or variations in the vertical distribution of water vapor within the atmosphere (due to the uniform vertical profile assumed in the data inversions).

Data Analysis. Three distinct stages were involved in the data analysis. Initially, the entire MAWD database was re-inverted under a constant set of assumptions. Each raster, consisting of five radiance measurements which are the average of fifteen individual field-of-view measurements, was inverted to obtain the column water vapor abundance, assuming a constant effective temperature and an effective pressure of half of the (seasonally and spatially varying) surface pressure. All further analysis was done using this reduced data set. This approach is distinct from that used earlier (1,2,3), where values were averaged over 10° of latitude and longitude and 15° of L_s; our approach is more appropriate for examining day-to-day variations in column water abundance.

In the second step, daily averages of water vapor were obtained by averaging over 10° of latitude and longitude. These averages were used to construct maps of the day-to-day variability over 15° of L_s; the variability was calculated as the standard deviation of the daily averages, normalized to the average water value within this bin. Finally, these maps were examined, and selected locations (in space and season) were chosen for further study. This final stage took the form of constructing plots of the raster-level data (such as water vapor versus local time of day or observed brightness) in order to constrain those processes which might be producing the observed variability of water.

Results. Figure 1 shows a zonally-averaged plot of the water vapor variability as a function of latitude and season for the bulk of the Viking mission. Systematic trends in the variability are, in fact, seen. Increased variability is seen at the start of the two 1977 global dust storms (at L_s 205° and 275°); this variability is due to the effects of obscuration of the water vapor by airborne dust. High variability is seen along the edge of the retreating north polar seasonal cap during the northern spring season (L_s 0-60°); clouds were observed here at these seasons (5,6), and the MAWD data indicate that the variability is an observational effect due to their presence. Finally, high variability is seen in the northern spring season in the Tharsis and Lunae Planum regions. The water vapor data here indicates a large apparent dependence on local time of day and a correlation with the observed brightness that suggests that morning and afternoon clouds combined with the day-to-day variations of the observing geometry are responsible.

There is a remarkable correlation of the seasonal and spatial trends of the water vapor variability with the occurrence of moderate and thick diffuse hazes in the atmosphere as mapped by Kahn (6). Much of this observed variability is probably an artifact of the variable viewing geometry. Due to the nature of the Viking orbit, which was most often asynchronous, a location on the surface that is observable for many consecutive days will be seen first near one limb, then near the center of the disk, then near the other limb. Scattering by aerosol will reduce the apparent column water vapor abundance, producing an apparent time-of-day or day-to-day variability of water (3,7). Superimposed on this apparent variation with time of day is an additional time-of-day dependence due to the diurnal variations of atmospheric temperature and the tendency for clouds to form preferentially near dawn and dusk.

Conclusions. Analysis of the day-to-day variability of water vapor in the martian atmosphere suggests that the observations are, at certain locations and seasons, significantly affected by the presence of water-ice hazes. Because such effects are generally limited to specific locations, such as Tharsis, Lunae Planum, and the polar cap edge during the spring, the seasonal and latitudinal trends in water vapor that have been previously reported are not significantly affected.

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Figure 1: Zonally-averaged normalized day-to-day water vapor variability in the martian atmosphere.