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THE BEHAVIOR OF WATER ON MARS

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Our recent focus in Mars research has been in the area of the seasonal behavior of water in the atmosphere, surface, and polar caps, and exchange of water between these reservoirs. Below, we summarize some of our recent results.

We have analyzed the behavior of water in the atmosphere and on the surface in the vicinity of the Viking-2 lander on Mars, with an emphasis on understanding the stability of H_2O and CO_2 frosts. The analysis consisted of examining surface and atmospheric temperatures measured by the Viking Infrared Thermal Mapping experiment in order to constrain the physical properties and processes in the vicinity of the lander site, followed by modeling of the sublimation rates of CO_2 and H_2O frosts based on these properties. We show via an equilibrium surface energy balance calculation that CO_2 frost is not stable when frost is observed on the surface. We estimate the stability of H_2O frost based on sublimation rates controlled by the surface temperature; water frost was stable during the period when frost was actually observed, but was not stable after the frost actually disappeared. Results on these calculations, estimates of the amount of water actually involved in exchange with the surface, and discussion of the implications for the seasonal cycle of water in the atmosphere are contained in a paper by Hart and Jakosky (1986).

The relationship between atmospheric water and ozone is an especially interesting one. Both species can play a role in impacting the seasonal weather patterns and current-epoch climate. Therefore, computer simulations of the behavior of ozone have been conducted. Photochemistry in the winter polar atmosphere of Mars has been examined for several latitudes, cloud types, and dust abundances. Computer simulation reproduces the ozone abundances observed by the Mariner 9 ultraviolet spectrometer experiment. Clouds change ozone abundances by only a few percent; however, typical dust abundances induce 10 to 30% increases in ozone abundances, primarily because photodissociation rates are drastically reduced by dust absorption. Furthermore, annual, latitudinal, and seasonal variations in dust opacity cause variations of 30% or greater in the ozone abundance. Results of these calculations have been reported in a paper submitted for publication by Lindner (1987).

Interactions between subsurface and atmospheric water play a major role in controlling the seasonal water cycle. Observations of the subsurface water abundance can constrain both the interactions between the surface and the atmosphere and the physical state of any near-surface water. The gamma-ray spectrometer on the upcoming Mars Observer spacecraft will contain a neutron spectrometer mode which will allow estimates of subsurface hydrogen to be made. We have done a preliminary study of the efficacy with which subsurface water can be measured by such an investigation. Results of these calculations have been reported in a paper submitted for publication by Drake et al. (1987).

Our ongoing research is currently centered on two specific areas. First, a re-analysis of the radiance data obtained by the Viking atmospheric water detection experiment will provide updated information on the atmospheric water abundance. Second, physical modeling of the sublimation and transport of water from the summer residual north polar cap will constrain the physical processes which control the seasonal water cycle.

The radiance data consist of measurements of the solar flux reflected from the martian surface in five channels, two of which are in continuum regions and three of which are in water vapor absorption bands. We are pursuing the goal of using the three band absorption measurements to derive simultaneously the column water vapor abundance as well as the effective temperature and pressure of line formation. Error analyses provide us with the information that we need in order to properly choose the data which can be averaged together to improve the signal-to-noise ratio enough to allow successful inversion. Additionally, the role of dust scattering and absorption must be taken into account at the level of accuracy desired. Finally, we are correcting problems in the earlier inversions of the MAWD data in terms of failing to correct properly for the variations of the solar flux with wavelength. The end result will be a better estimate of the abundance of water vapor in the martian atmosphere, an estimate of the vertical distribution of the water, and, perhaps most importantly, a better estimate of the uncertainties in the data inversion and analysis. Preliminary results have been reported by Hart and Jakosky (1987).

Physical modeling of the sublimation and transport of water from the vicinity of the north polar cap during northern hemisphere summer season on Mars is important in order to understand the processes which control the current seasonal cycles on Mars. Previous analysis suggests that water appears in the atmosphere over the north polar cap as the cap heats up during summer and is transported equatorward by the circulation of the atmosphere. We have used Viking IRTM measurements of the temperature of the cap to calculate the amount of water sublimed into the atmosphere, using previously described models of the sublimation process. For realistic estimates of the boundary layer properties, it is possible to sublime sufficient water to explain the global increase in atmospheric water content. Interestingly, if the dark lanes or the circumpolar debris deposits contain water which is capable of subliming into the atmosphere, this source of water could dominate the polar behavior of water. Calculations of the transport equatorward of this polar water, using the two-dimensional, axisymmetric model developed by

R. Haberle, cannot explain the apparent migration of water, however. This results due to the sluggish circulation in the polar region; once water can be moved to the region near 60° latitude, the cross-equatorial Hadley cell can move the water efficiently. Aspects of the seasonal cycle of water can be reproduced if the atmosphere contains a non-axisymmetric source of mixing; the only currently known mechanism for such eddy mixing is the near-polar cyclonic motions suggested by spiral wave clouds seen at these seasons. Preliminary results of these investigations have been presented by Jakosky (1987) and Haberle and Jakosky (1987).

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