storms have been observed. Variable recession rates for the polar caps were suspected from Earth-based data and proven by Mariner 9 and Viking observations. The cycles for water, CO_2, and dust are thought to vary with the cap recessions, although the nature of the variations is not yet known. The possible relationship between variable recession rates and dust storm activity has been investigated by James et al. [6]. Iwasaki et al. [7] proposed a correlation between retarded cap recessions and the occurrence of major storms that seems plausible, although more data are needed. Certainly, the polar cap recession rates are at least one phenomenon that needs to be monitored in conjunction with dust storm activity. Since there is evidence that cap recessions may accelerate prior to the onset of encircling storms [5], this monitoring might even lead to predicting these storms. The possible advent of a planet-encircling storm during the Mars Observer (MO) Mission will provide a detailed correlation with a cap recession for that one martian year. We will then need to compare that cap recession with other storm and nonstorm years observed by other spacecraft and from Earth. MO data will also provide a stronger link between cap recessions and the water and CO_2 cycles. Cap recession variability might also be used to determine the variability of these cycles.

Observations—Present, Past, and Future: After nearly a century of valiant attempts at measuring polar cap recessions [8], including using Mariner 9 and Viking data [9–11], MO will provide the first comprehensive dataset. In contrast to MO, the older data are much less detailed and precise and could easily be forgotten, except that it will still be the only information on interannual variability. Since the MO mission will map just one martian year, it will provide a singular set of seasonal data. Standing alone it will not be possible to be certain which MO data are "seasonal" or whether an "average" or "abnormal" year is portrayed. Of course, even if MO could continue its work indefinitely, it might take a very long time to accumulate enough data to have a representative sample of Mars years. Therefore, we are obliged to retain and refer back to the still-viable historical records, including spacecraft data. These records will be easier to interpret and evaluate based upon new insights from MO data: By obtaining simultaneous Earth-based observations (including those from Hubble Space Telescope) during the MO mission, we will be able to make direct comparisons between the datasets. This will be very helpful in interpreting and measuring the Earth-based data taken during other periods. Continued Earth-based observations will be needed after MO to monitor the martian climate and extend the time line of the data. Improved techniques will allow us to monitor longer seasonal segments of martian years and to better interpret and measure the data. Eventually we may be able to establish limits on the degrees of variability of the polar cap recessions and, consequently, variations in the H_2O, CO_2, and dust cycles. Many of the questions presented by MO data and its upgraded portrayal of Mars can be addressed to longer-term, albeit cruder, Earth-based observations.

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DUST TRANSPORT INTO MARTIAN POLAR LATITUDES. J. R. Murphy[1,2] and J. B. Pollack[2], [1]National Research Council Associate, [2]NASA Ames Research Center, Moffett Field CA 94035.

The presence of suspended dust in the martian atmosphere, and its ultimate return to the planet's surface, is implicated in the formation of the polar layered terrain and the dichotomy in perennial CO_2 polar cap retention in the two hemispheres. We have been employing a three-dimensional numerical model to study martian global dust storms. The model accounts for the interactive feedbacks between the atmospheric thermal and dynamical states and an evolving radiatively active suspended dust load. Results from dust storm experiments, as well as from simulations in which we are interested in identifying the conditions under which surface dust lifting occurs at various locations and times, indicate that dust transport due to atmospheric eddy motions is likely to be important in the arrival of suspended dust at polar latitudes.

The layered terrain in both the northern and southern polar regions of Mars is interpreted as the manifestation of cyclical episodes of volatile (CO_2, H_2O) and dust deposition. The cyclical nature of this deposition is assumed to be driven by long-period variations that arise from orbital and axial tilt variations and influence the climatic conditions. The dust is assumed to be provided primarily by the occurrence of global-scale dust storms that fill the atmosphere with large quantities of suspended dust, some of which settles back to the surface in the polar regions. The dust settles onto the cap either independently due to gravitational sedimentation or incorporated into CO_2 snow [1], possibly serving as condensation nuclei for such a process. The dust storms develop at southern subtropical latitudes, and barring any other sources (which is probably a poor assumption), the dust that appears in suspension at polar latitudes is transported over long distances. It has been a common belief that an intensified Hadley-type circulation is responsible for transporting the dust to high northern latitudes. However, two-dimensional zonally symmetric numerical modeling of dust storms [2,3] has suggested that this mechanism is ineffective at transporting significant quantities of dust beyond middle latitudes. Recent three-dimensional numerical simulations conducted by us [4], in which the full spectrum of atmospheric eddy motions are present and capable of transporting dust, have shown that the amount of dust transported into polar regions from a southern subtropical source is greatly increased. The eddy transport mechanisms suggested in previous works [5,6] appear to be operating in these simulations.

The apparent preference for dust storm development during northern autumn and winter, when the north seasonal cap is growing, is interpreted as one reason for the retention of a perennial CO_2 residual cap in the south, while in the north all the CO_2 laid down during the winter season sublimes away in the spring. In the north, due to the dust incorporated into the cap during its growth, albedos during springtime are lower than the albedo of the south cap during its spring retreat, which develops during a typically less dusty time of the martian year [7,8]. The less "contaminated" south cap reflects more solar insulation, maintains a lower temperature during spring and summer, and thus is able to retain a cover of CO_2 ice throughout summer. In the north the lower cap albedo results in a larger net radiative flux at the cap surface and the CO_2 cap is unable to survive the summer.

We wish to point out that it is not necessarily the seasonal preference for dust storm development alone that conspires to affect the residual cap and layered terrain variations that are presently seen. Under present orbital characteristics, southern summer solstice occurs close in time to orbital perihelion, producing short "hot" summers and long cold winters in the south. This long cold winter results in a more extensive seasonal CO_2 cap in the south than in the north. The size of the cap can have implications for suspended dust reaching the pole, even in the absence of a global dust storm. Baroclinic waves, which develop due to the large horizontal temperature gradients at middle to high latitudes of the autumn, winter, and spring hemispheres, are probably capable of lifting dust from the surface. This lifted dust can then be carried poleward by these same waves. As the seasonal cap grows, the distance between the location of dust lifting and the pole increases, and thus the dust must be transported a greater distance if it is to become incorporated into the developing cap at polar latitudes, if in fact it can reach those latitudes [5]. Since the southern cap is, at its maximum extent, larger than the northern seasonal cap, the north cap (at polar latitudes) might be more susceptible to dust contamination than the south cap, even without dust storms. In fact, numerical simulations [9] suggest that the magnitude of baroclinic waves is larger in the north than in the south, further increasing the northern hemisphere preference for cap contamination by dust.

We will present model results detailing the mechanisms by which suspended dust is transported into polar latitudes and quantify polar dust deposition magnitudes as a function of various model assumptions.

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NUMERICAL SIMULATIONS OF DRAINAGE FLOWS ON MARS. Thomas R. Parish[1] and Alan D. Howard[2], [1]Department of Atmospheric Science, University of Wyoming, Laramie WY 82071, USA, [2]Department of Environmental Sciences, University of Virginia, Charlottesville VA 22903, USA.

Introduction: Data collected by the Viking Landers (VL-1, 23°N; VL-2, 48 °N) have shown that the meteorology of the near-surface martian environment is analogous to desertlike terrestrial conditions [1]. Geological evidence such as dunes and frost streaks indicate that the surface wind is a potentially important factor in scouring of the martian landscape [2]. In particular, the north polar basin shows erosional features that suggest katabatic wind convergence into broad valleys near the margin of the polar cap. The pattern of katabatic wind drainage off the north polar cap is similar to that observed on Earth over Antarctica [3] or Greenland.

In this paper we will explore the sensitivity of martian drainage flows to variations in terrain slope and diurnal heating using a numerical modeling approach. The model used in this study is a two-dimensional sigma-coordinate primitive equation system [4] that has previously been used for simulations of Antarctic drainage flows. Prognostic equations include the flux forms of the horizontal scalar momentum equations, temperature, and continuity. Explicit parameterization of both longwave (terrestrial) and shortwave (solar) radiation is included [5]. Turbulent transfer of heat and momentum in the martian atmosphere remains uncertain since relevant measurements are essentially nonexistent. Standard terrestrial treatment of the boundary layer fluxes is employed [6–8].

Model Results: *Katabatic wind simulations.* A series of numerical experiments has been conducted that focuses on the relationship between katabatic wind intensity and terrain slope. The model runs are valid for high-latitude (75°), nocturnal conditions similar to midwinter on the north polar cap in which no solar radiation reaches the ground. A horizontal grid consisting of 20 points with a grid spacing of 20 km was used; 15 levels were used in the vertical with higher resolution in the lower atmosphere. The results of five uniform slope runs are presented here. Each model simulation covered