INTERANNUAL VARIABILITY IN MARS' ATMOSPHERE.

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Summary:

Ten-year simulations of Mars' atmosphere with the NASA Ames Research Center Mars General Circulation Model (MGCM) (1) reveal considerable interannual (IA) variability in both surface statistics and within the atmosphere itself. These simulations involve identical forcing each year, including an imposed dust cycle which is identical each year.

IA variability is largest in the *storm zones* of the northern hemisphere (2), and maximizes during the northern winter season. These findings are a reflection of the non-deterministic nature of the climate: although baroclinic storms *will* form each year (and are much more pronounced in the northern hemisphere), they will not necessarily form having the same lifecycle and intensity, nor will they form in the same precise geographic location. Possible consequences of this variability are further discussed.

Experiments and Surface Results:

We have conducted two simulations so far, one with fixed dust all year (visible opacity τ=0.5), the second with time-varying dust opacities obtained from the Viking year-one data. In both cases, the dust is specified as spatially uniform referenced to the 6.1 mbar level. Results are largely independent of dust loading, indicating that the IA variability is likely a fundamental feature of the dynamical system.

Initially we have focused attention on surface data, since any long-term *in-situ* atmospheric observations have been/almost certainly will be surface-based.

Figure 1 shows the 10-year record of surface pressure at the model's two Viking grid points (VL2 blue, VL1 green).

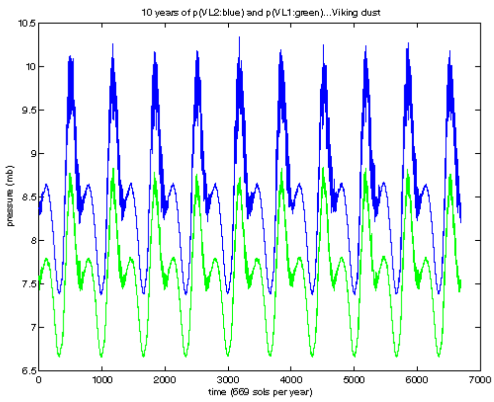

Figure 1. Surface pressure record at VL2 (blue) and VL1 (green) for the 10-year simulation with Viking dust.

Although the trace is highly repeatable from year-to-year, closer examination reveals large IA variations. Figure 2 shows the deviations of surface pressure (in mbar) at VL2 from the 10-year mean.

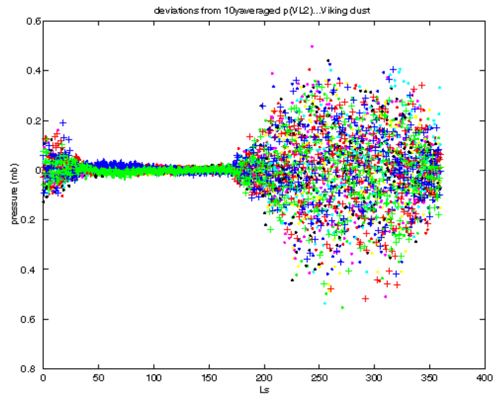

Figure 2. Daily deviations of surface pressure (mb) from the 10-year mean (Viking dust experiment). Each symbol/color represents a different year.

During the northern winter season, deviations from the 10-year average on any given Martian day (i.e., sol) may be as large as several tenths of a millibar. Also noteworthy is the very high degree of repeatability during the northern summer season (L_s 90°). The corresponding plot for the 10-year simulation with visible opacity fixed at τ=0.5 is essentially the same.

This calculation can be repeated for all model grid points, generating a field of surface pressure variances from the 10-year mean (Figure 3).

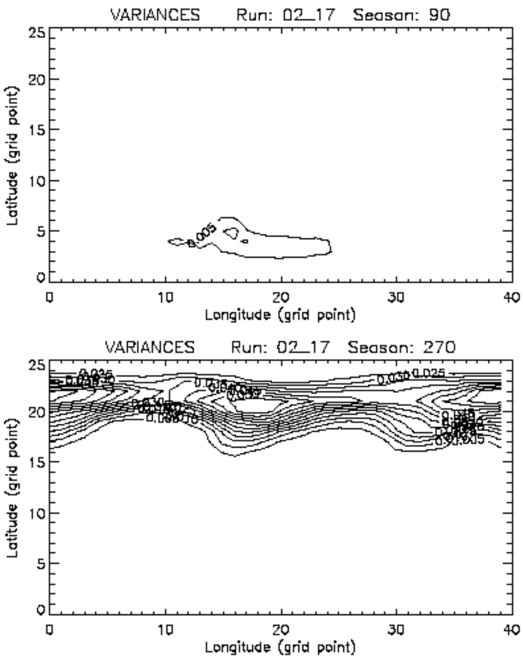

Figure 3. Contour plots of 10 sol-averaged variance in surface pressure in the two winter seasons (Viking dust experiment).

Values are highest in the northern hemisphere storm zones (2) during the northern winter season. Conversely, they are low in the southern hemisphere, even in southern midwinter. This suggests that the baroclinic waves are responsible for the IA variability noted (as opposed to tides, the zonally-symmetric circulation etc.) Previous modeling work (2,3,4) has indicated that baroclinic wave activity is much weaker in the southern hemisphere during southern winter than in the northern hemisphere during northern winter. In this regard, when Figs. 2 and 3 are reconstructed from data averaged over several sols, variability is significantly reduced.

Having implicated baroclinic waves, we have examined temperatures and meridional winds, since both of these are strongly modulated by these eddies. Figure 4 shows IA variations in the surface temperature field (i.e., at the model's lowest level of ~ 5m above ground level (AGL)). Variations as large as O(20) K are noted in this experiment (O(10) K in the τ=0.5 experiment). Again, the L_s 90° season is very "quiet". A similar picture emerges from examining surface meridional winds.

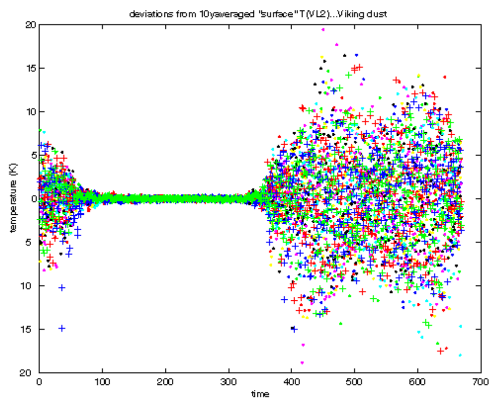

Figure 4. Daily deviations of surface temperature (K) at VL2 from the 10-year mean (Viking dust experiment). Each symbol/color represents a different year.

Further Results and Implications: We have also examined temperatures, meridional winds, and their associated heat fluxes in the atmosphere away from the surface. At 3 mbar, for example, we find year-to-year variations in poleward eddy heat fluxes. Variations in heat fluxes into the polar cap might result in changes in ice cap extent and/or ice volume. On the other hand, they may be balanced by changes in heat transport associated with the zonally-averaged overturning circulation. These issues are under examination, and will be discussed at the workshop.

References:

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(2) "Orographic control of storm zones on Mars", J.L. Hollingsworth, R.M. Haberle, J.R. Barnes, A.F.C. Bridger, J.B. Pollack, H. Lee & J. Schaeffer. *Nature*, **380**, pp 413-416, 1996.

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(4) "Southern hemisphere storm zones on Mars: Implications of MOLA topography", J.L. Hollingsworth, R.M. Haberle & J.Schaeffer. *5th Intl. Conf. On Mars*, Pasadena CA, p.6222, 1999.