Icarus
Volume 30, Issue 4 , April 1977, Pages 626-649

The low-latitude circulation of Mars[*1]

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Received 3 April 1976; revised 27 October 1976

Abstract

A simple linear, baroclinic and primitive equation model which includes both parameterized dissipation and a fairly realistic basic state is used to study the seasonal response of the Martian atmosphere to the steady-state influence of the orography of Mars. It is argued that the orography possesses a thermal and mechanical influence upon the state of the atmosphere. The thermal influence, which has a maximum at low latitudes, is a result of the temperature anomaly introduced into the atmosphere throughout the troposphere by the orographic feature. The resultant heat sources are shown to possess time scales which are much longer than diurnal, thus allowing a steady-state background circulation to develop. Using thermal and mechanical forcing derived from simple laws, the model is solved numerically to provide seasonal distributions of the steady-state circulation.

The steady-state solutions are dominated by the thermal forcing of the Tharsis Ridge region and to a lesser degree, by that of the Olympus Mons region. Mechanical orographic forcing appears to possess an insignificant role in determining the low-latitude circulation. The states of the winter midlatitudes and tropics and the summer midlatitudes are very different, with the former region the most energetic. In the winter midlatitudes the kinetic energy is seen to increase with height with the excitation of large-scale and geostrophic near-barotropic eddies. In the tropics, the kinetic energy decreases with height and the response is nearly completely confined to the longitude-height plane. The transition between these two states occurs abruptly in the subtropics.

Some of these features are similar to the planetary scale and long-period circulation of the low latitudes of the terrestrial atmosphere. Other features require consideration of properties inherent in the Martian atmosphere. To study these a simple, continuous analytic model is introduced which contains strong dissipation of time scales characteristic of Mars. It is shown that one solution, the equatorial Kelvin wave, is modified considerable by the strong damping and that it dominates the low-latitude circulation. Besides decaying rapidly with height, the vertical wave scale is stretched considerably with height by the dissipative processes. Such a stretching is shown to be scale selective and the longest horizontal modes are stretched the most in the vertical. Besides allowing an explanation of some features of the Martian atmosphere, the

predominant vertical scale of the equatorial Kelvin wave allows some confidence in the choice of a two-layer model for the numerical study.

*1 Contribution Number 386, Department of Atmospheric Sciences, University of Washington.