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Wave-Mean flow interactions in the atmosphere of Mars

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Atmospheric circulations of both Mars and Earth deviate from zonally axisymmetric. Observations reveal a broad range of zonally asymmetric disturbances in the Martian atmosphere: solar tides, (quasi)-stationary planetary waves, travelling (baroclinic) planetary waves and smaller-scale internal gravity waves. When allowed by background conditions to propagate vertically, these eddies grow up in amplitude due to the density stratification. At some heights, the growth is ultimately limited by wave breaking and/or dissipation. The momentum and heat carried by the eddies is then deposited to the mean flow thus providing an impact on the zonal mean circulation.

Certain features of the Martian circulation are the result of a strong wave influence on the mean flow. The meridional pole-to-pole transport from the summer hemisphere to the winter one is primarily caused not by a differential heating but is driven by the "extra-tropical pump" created by breaking and dissipating eddies. Similarities and differences with the stratospheric transport on the Earth will be discussed.

Another prominent feature of the Martian circulation, the temperature inversion and the corresponding winter polar warming, can be explained by the effects of eddies propagating pole ward from mid latitudes. They also control the strength and the shape of the winter polar vortex.

Martian atmosphere is mostly convectively stable. From general fluid dynamic principles, this implies that strong gravity wave activity must exist. Some measurements indicate gravity wave signatures in the atmosphere of Mars, and probably more definitive data will be obtained in the future. Numerical experiments with the General Circulation Model of the Martian Atmosphere (MAOAM) show that breaking gravity waves can provide closure of both westward and eastward zonal winds, as is in the mesosphere on the Earth.

Keywords: Mars; general circulation model; atmospheric dynamics; MAOAM; solar tides; traveling (baroclinic) planetary waves; (quasi)-stationary planetary waves; internal gravity waves; winter polar vortex; eddies; Earth mesosphere