Lateral momentum transport by equatorial waves in vertical shear in the Venus atmosphere

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The meridional transport of zonal momentum by equatorial waves in a vertical shear of the zonal wind is studied theoretically and applied to the Venusian atmosphere. Andrews and McIntyre (1976) has suggested the occurrence of non-zero meridional momentum fluxes for Kelvin wave and mixed Rossby-gravity wave using an asymptotic linear theory, but its physical meaning has not been discussed. An explanation can be given as follows. The latitudinal widths (deformation radius) of equatorial waves should change with height if the waves retain their identity while propagating upward, and associated with such focusing or defocusing of wave activity density, there must be non-zero meridional EP fluxes. If so, similar processes are expected to occur also for other equatorial waves.

Such a process might play important roles in the easterly shear region of the retrograde-superrotating atmosphere below the cloud top of Venus. Let the direction of zonal coordinate be westward (direction of planetary rotation). In the easterly shear, focusing (defocusing) occurs for westward (eastward) waves while propagating upward. Since westward (eastward) waves have negative (positive) wave activity, poleward EP flux should occur for both westward and eastward waves. In other words, zonal momentum is transported equatorward for any equatorial waves, although the sign of vertical momentum flux depends on the sign of horizontal phase velocity.

In the presence of the Hadley circulation, such an equatorward momentum transport will accumulate angular momentum in the equatorial upper atmosphere and maintain the superrotation. The behavior of equatorial waves predicted above was examined using a nonlinear numerical model on the equatorial beta-plane.