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Development of Equatorial Superrotation in a Titan Global Climate Model

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Abstract

A global climate model of Titan's atmosphere (Friedson et al. 2009, Pl. Sp. Sci. 57, 1931) is used to investigate the processes controlling development of atmospheric superrotation at low latitudes during the initial spin-up phase. Superrotation at low latitudes is first established in a shallow layer situated at the top of the planetary boundary layer. Over time the superrotating layer is seen to thicken as progressively higher altitudes are accelerated. The development of the superrotation is accompanied by the appearance of a global scale, wavenumber-1 wave which transports zonal angular momentum toward the equator in each hemisphere. The equatorward eddy flux of angular momentum peaks at mid-latitudes near the 500 mbar level in the model, just above the boundary layer, and this level remains stationary as the layer thickens. It thus appears that the thickening of the layer is primarily caused by vertical advection of zonal angular momentum by the low-latitude Hadley circulation, rather than by any significant change in the altitude of maximum eddy transport of angular momentum. The meridional structure and symmetry of the eddy velocity fields associated with the global wave have the character of a westward propagating Rossby-Haurwitz rotational mode of meridional index 2, but the zonal mean potential vorticity gradient that acts as a restoring force for the wave is more likely associated with the latitudinal structure of the zonal mean wind than with the planetary vorticity. The dispersion properties of the wave and their relationship to the background potential vorticity structure will be discussed at the meeting. This research is supported by a grant from the NASA Planetary Atmospheres Program.

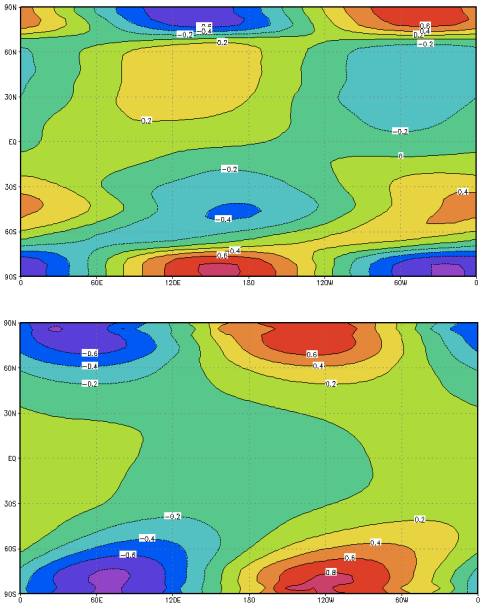

Figure 1: Structure of the global wave. Contours of the 500-hPa perturbation zonal velocity (upper panel) and meridional velocity (lower panel) are plotted on a cylindrical latitude-longitude map. The dominant wavenumber-1 component is easily seen. The eddy zonal velocity field (and geopotential height, not shown) is antisymmetric and the meridional velocity field is symmetric with respect to the equator. This symmetry and the position of the meridional nodal points is similar to that of a westward propagating Rossby-Haurwitz rotational mode of meridional index 2.

1. Figures