Geophysical Research Abstracts
Vol. 13, EGU2011-1481, 2011
EGU General Assembly 2011
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Transition to Superrotation in Terrestrial Atmospheres

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We investigate the underlying dynamical mechanisms that give rise to superrotation in terrestrial planetary atmospheres. In particular, we show that by changing a single non-dimensional number, the thermal Rossby number, global atmospheric simulations with only axisymmetric forcing pass from an Earth-like atmosphere to a superrotating atmosphere that more resembles the atmospheres of Venus or Titan. The mechanism for this transition will be discussed. Superrotation occurs under conditions in which equatorward-propagating Rossby waves generated by baroclinic instability at intermediate and high latitudes are suppressed, which will occur when the deformation radius exceeds the planetary radius. At large thermal Rossby numbers following an initial, nearly axisymmetric phase, a global baroclinic wave of zonal wavenumber one generated by mixed barotropic-baroclinic instability dominates the eddy flux of zonal momentum. The global wave converges eastward zonal momentum to the equator and deposits westward momentum at intermediate latitudes during spinup and before superrotation emerges, and the baroclinic instability ceases once superrotation is established. The generality and relevance of the mechanism to planetary atmospheres in the solar system and beyond will be discussed.