The role of advective and non-advective fluxes of isobaric vorticity substance in tropical cyclogenesis

Timothy J. Dunkerton
NorthWest Research Associates, Redmond, WA

16th Cyclone Workshop

22-27 September 2013
Sainte-Adele, Quebec, Canada

Tropical cyclogenesis can be viewed, among other ways, as the aggregation and concentration of vorticity substance within isobaric layers in the free troposphere. As shown by Haynes and McIntyre 25 years ago, potential vorticity substance cannot be created or destroyed within isentropic layers that do not intersect the surface. A similar principle applies to isobaric vorticity substance, as suggested originally to those authors by Jim Holton. As argued recently by Kevin Tory and colleagues, this principle (in isobaric or isentropic form) provides an intuitively simpler view of tropical cyclone formation and intensification than the traditional (non-flux) form of the vorticity equation. Indeed, any process leading to isobaric or isentropic mass exchange, including penetrative deep convection crossing stratification iso-surfaces of the stable environment, is governed by substance conservation, no matter how complex the diabatic and turbulent sub-grid processes involved. From this point of view I consider various scenarios of tropical cyclone formation observed in the atmosphere, four of which have been documented in recent literature in the Atlantic sector: (i) penetration of a tropical wave critical layer to the boundary layer, (ii) alignment of an elevated cyclonic critical layer with distinct pieces of low-level vorticity advected into favorable alignment with the parent wave, (iii) near-surface concentration of vorticity substance owing the diabatic convection in the favorable environment of the parent wave's cyclonic gyre-pouch, and (iv) diabatic merger of unrelated vortical elements in a region of confluence in the lower troposphere. Case studies illustrating these scenarios will be presented, based on ERA-Interim re-analyses, PREDICT and HS3 dropsondes, and geostationary satellite imagery.