1C.7 Tropical Transition: Tropical Cyclone Formation from Extratropical Disturbances

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Tropical transition (TT) refers to the dynamic and thermodynamic transformation of disturbances of sub-tropical or extratropical origin into tropical cyclones. This is often synonymous with a transition from a cold-core disturbance to a warm-core disturbance. In this paper, we discuss two pathways of TT, one involving initially strong extratropical precursors (often baroclinic cyclones) and the other involving perturbations that mainly organize convection but do not grow from baroclinic energy conversion. The two classes of precursors are referred to as strong and weak extratropical (SE and WE), respectively.

The synoptic-scale composite structure for four SE cases (Florence, Michael, Erin and Karen, Fig. 1a) shows a pronounced, localized trough in the upper troposphere to the west of the surface low just prior to TT. The lower-tropospheric temperature pattern exhibits a locally enhanced equatorward temperature gradient in the vicinity of the surface low, with drastically reduced equatorward gradients further north (Fig. 1b). This mini-composite strongly resembles the 24-case composite shown by Bracken and Bosart (2000), although it is larger in amplitude. It also strongly resembles the anticyclonic wave breaking scenario (LC1) presented in Thorncroft et al. (1993).

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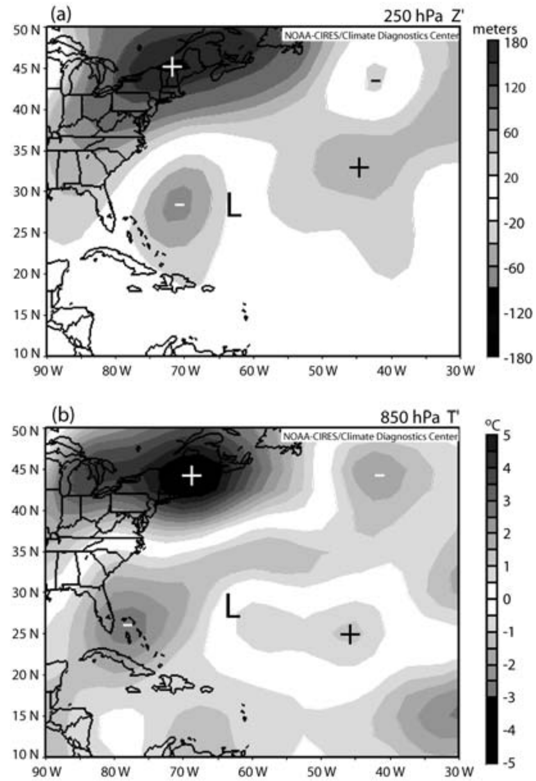

Figure 1. (a) 250 hPa height anomaly and (b) 850 hPa temperature anomaly for 4-case composite prior to tropical cyclogeneis. The position of the composite surface low center is indicated with an 'L'. Composite maps were constructed using software from the Climate Diagnostics Center of the National Oceanic and Atmospheric Administration.

In SE cases, a low-latitude frontal cyclone develops to an intensity sufficient to trigger wind-induced surface heat exchange (WISHE) (Emanuel 1987). Davis and Bosart (2003) showed how initially large vertical wind shear over the storm center prior to Hurricane Michael (2000) was reduced rapidly through diabatic redistribution and advection of potential vorticity (PV). This process left an equilibrated, or occluded cyclone over warm water and created a sub-synoptic “cocoon” of weak shear within which TT occurred. In contrast to the classical extratropical cyclone occlusion, the process here was diabatically driven.

In WE cases, precursor disturbances can be weak baroclinic waves, such as in the cases of Diana (1984) (Bosart and Bartlo 1991) and Humberto (2001) (Fig. 2b) or mid-tropospheric vortices as in Danny (Molinari et al. 2003) and Gabrielle (2001) (Fig. 2a). The weak baroclinic systems in this category simply have insufficient amplitude to create a surface cyclone capable of amplifying by WISHE without invoking an intermediate process to enhance mesoscale vorticity.

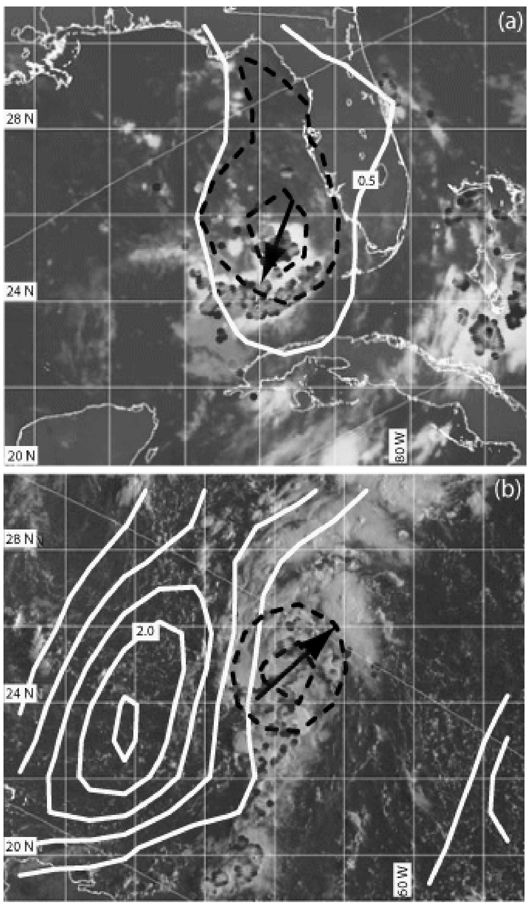

Figure 2. (a) PV on the 310 K isentropic surface (white, contour interval 0.5 PVU) and 900 hPa relative vorticity (black dashed, 0.5 and 1.0 X 10^{-4} s^{-1} contoured) for 1200 UTC 11 September, 2001; (b) as in (a) but for 340 K PV and at 1200 UTC 21 September, 2001. Black arrow indicates shear vector orientation over low-level vorticity center. Fields are superposed on SSM/I 85 GHz PCT and IR (top) and visible (bottom) satellite images courtesy of the Naval Research Laboratory.

The mechanism responsible for the warm-core transition in WE cases is unclear. The production of cyclonic vorticity centers on scales of 10-20 km, so-called rotating hot towers (Hendricks et al. 2004), may be the preferred means by which the convective scale influences the development of the primary, larger-scale vortex. Detailed, cloud-system resolving simulations of Humberto are being conducted at present to elucidate the mechanism of vorticity growth. Results from these simulations will be shown at the conference.

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