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THE DOUBLE TRANSITION OF HURRICANE MICHAEL (2000): BAROCLINIC TO TROPICAL TO BAROCLINIC

by

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1. INTRODUCTION:

We describe the evolution of Hurricane Michael (October 2000) from its origin as a baroclinic system, its transformation to a minimal hurricane, and its subsequent extratropical transition (ET). Evans et al. 2002 and Davis and Bosart 2002a discuss other aspects of Michael. Observational and numerical studies of the development of Hurricane Diana (1984) from a baroclinic initial disturbance can be found in Bosart and Bartlo (1991) and Davis and Bosart (2001, 2002b), respectively. The importance of baroclinic processes in tropical cyclogenesis is documented in Bracken and Bosart (2000).

2. DATA AND METHODOLOGY:

NCEP AVN model grids (1.0 x 1.0 deg) were used in all computations. A potential vorticity (PV), dynamical tropopause (DT) perspective is adopted to facilitate the analysis. See Morgan and Nielsen-Gammon (1998) and Nielsen-Gammon (2001) for a PV/DT perspective. Here we define the DT by the 1.5 PV-unit (PVU) surface in accord with earlier studies. Special satellite datasets from CIMSS were used in the analysis.

3. RESULTS:

Wave development began along an old cold front/inverted surface trough northeast of Cuba after 00Z/12. Over the next 48-72 h period the cyclone slowly strengthened, gradually taking on tropical characteristics, and achieved minimal hurricane status southeast of Bermuda by 00Z/16. Michael was most intense between 18-19 Oct (a maximum of 85 kt in the NHC best track data). Subsequently, Michael accelerated northeastward, underwent ET, and became an intense (960 hPa) cyclone as it crossed the coast of southern Newfoundland near 00Z/20.

Figure 1 shows potential temperature/winds on the DT (left panels) and 900 hPa relative vorticity, 1000-500 hPa thickness, and equivalent potential temperature (shaded) for 00Z/13,15,17,19. Initial development occurred ahead of a small-scale trough (cool potential temperatures on the DT) east of Florida at 00Z/13. By 00Z/15 this trough had cutoff just west of the strengthening surface system as higher θ_e air enveloped the storm. By 00Z/17 now-Hurricane Michael was sandwiched in a weaker shear region between stronger westerlies to the north and a weakening DT disturbance to the southwest. Michael was undergoing ET process at 00Z/19 in response to a new deepening trough that was dropping southeastward across the northeastern US (this disturbance was apparent over the western Great Lakes at 00Z/17).

Figure 2 shows a time series of 900-200 hPa shear, pressure on the DT, central pressure, and 900 hPa relative vorticity, all centered on Michael, for 11-21 October. The pressure on the DT increases from 160 to 225 hPa in the 96 h ending 00Z/15 as baroclinic cyclogenesis proceeds amidst relatively high shear. Subsequently, the shear weakens and is followed by a decrease in DT pressure as Michael becomes a hurricane. After 00Z/19 a rapid increase of pressure on the DT and a corresponding increase in shear marks the onset of the explosive ET phase. Model-derived storm central pressures (NHC best track after 00Z/16) are underestimated compared to the 900 hPa relative vorticity before 00Z/18.

4. ACKNOWLEDGEMENT:

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5. REFERENCES:

Bosart, L. F., and J. A. Bartlo, 1991: Tropical storm formation in a baroclinic environment. *Mon. Wea. Rev.*, **119**, 1979-2013.
Bracken, W. E., and L. F. Bosart, 2000: The role of synoptic-scale flow during tropical cyclogenesis over the North Atlantic Ocean. *Mon. Wea. Rev.,* **128**, 353-376.
Davis, C., and L. F. Bosart, 2001: Numerical simulations of the genesis of Hurricane Diana (1984) Part I: Control Simulation. *Mon. Wea. Rev.,* **129**, 1859-1881.
Davis, C. A., and L. F. Bosart 2002a: Baroclinic tropical cyclogenesis: Developing and nondeveloping cases. Preprints of 25th Conference on Hurricanes and Tropical Meteorology, American Meteorological Society, San Diego, CA, 29 April – 3 May 2002.
Davis, C., and L. F. Bosart, 2002: Numerical simulations of the genesis of Hurricane Diana (1984), Part II: Sensitivity of track and intensity prediction (in press).
Evans, J. L., C. Velden, L. F. Bosart, J. Molinari, and P. Black, 2002: Hurricane Michael: The "Two-Way TC". Preprints of 25th Conference on Hurricanes and Tropical Meteorology, American Meteorological Society, San Diego, CA, 29 April – 3 May 2002.
Morgan, M. C., and J. W. Nielsen-Gammon, 1998: Using tropopause maps to diagnose midlatitude weather systems. *Mon. Wea. Rev.* **126**, 2555–2579.
Nielsen-Gammon, J. W., 2001: A visualization of the global dynamic tropopause. *Bull. Amer. Meteor. Soc.*, **82,** 1151-1167.

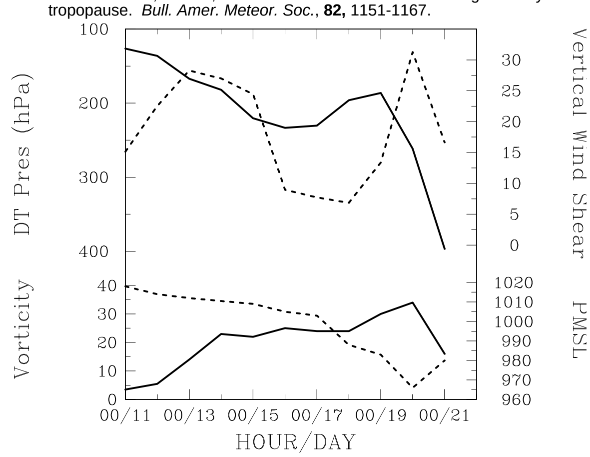

Fig. 2: Time series of 900-200 hPa vertical shear (dashed, m s^{-1}), pressure on the DT (solid, hPa), 900 hPa relative vorticity (solid, x 10^{-5} s^{-1}), and sea-level central pressure (dashed, hPa) for 11-21 October 2000.

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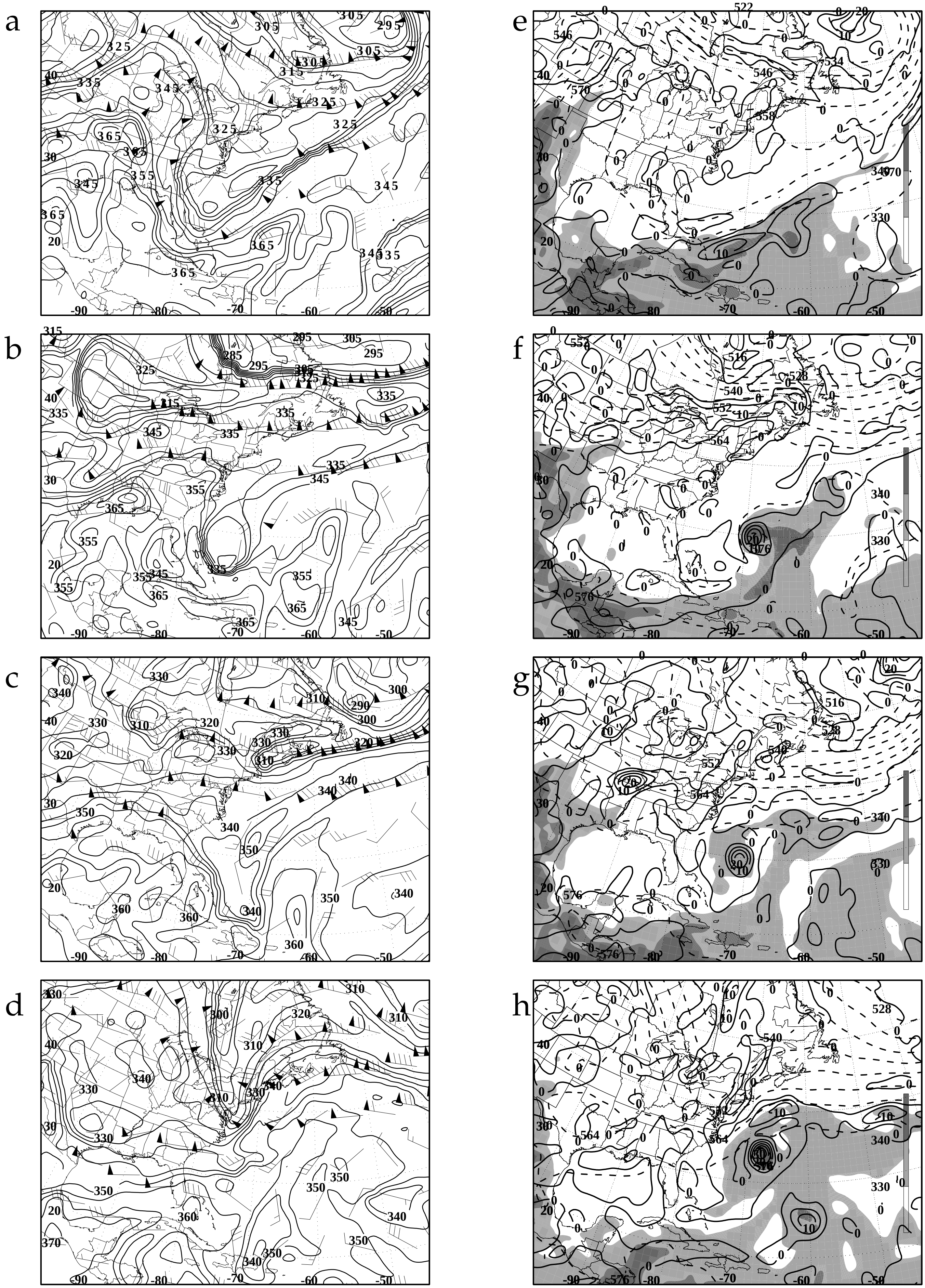

Fig. 1: Left: Theta (K)/winds (kt) on the dynamic tropopause, DT, (1.5 PVU surface) for 00Z/13,15,17, 19 Oct'00. Right: As in left except for 900 hPa relative vorticity (solid), 1000-500 hPa thickness (dashed, every 6 dam) and 850 hPa equivalent potential temperature (shaded, every 10 K starting at 330 K)