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AN EVALUATION OF THE PRECIPITATION DISTRIBUTION IN LANDFALLING TROPICAL CYCLONES

by

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1. INTRODUCTION:

Several recent storms have highlighted the importance of understanding the effect of the interaction of landfalling tropical systems with mid-latitude features such as cold upper-level troughs and baroclinic zones. Floyd (1999) proved to be a particularly difficult forecast challenge as most of the hazardous weather warnings as the storm approached the coast focused on the potential for wind damage. However, flooding proved to be by far the most significant threat to life and property in association with Floyd as more than 50 cm of rain fell over sections of North Carolina with widespread amounts exceeding 20 cm stretching from the Piedmont region of North Carolina into southeastern New York (Lawrence et al. 2000).

Atallah and Bosart (2003) provide a detailed case study of Floyd and indicate that the precipitation distribution and intensity associated with Floyd resulted from its interaction with a potent mid-latitude trough and subsequent extratropical transition. This paper will attempt to generalize the results of Atallah and Bosart (2003) and will focus on the dynamical basis for understanding the expected distribution, aerial extent, location, and intensity of precipitation relative to the track of the tropical cyclone prior to and subsequent to landfall for numerous cyclones.

2. DATA AND METHODOLOGY:

All gridded fields for use in the composites are taken form the National Centers for Environmental Prediction (NCEP)/National Center for Atmospheric Research's (NCAR) Reanalysis taken from 00 and 12 UTC (Kalnay et al. 1996). The first time period, or t=0, for each of the composites, is defined as the first time that the storm exhibits a left of track, right of track, or along track precipitation distribution. The storm is then composited relative to a reference storm track. The evolution in each of the composites is then taken as the 24 h period following the time listed in the table. In order to be included in any of the composites, each storm had to meet the following criteria: 1) the storm had to make landfall along either the Gulf or Atlantic coasts of the United States, 2) the storm had to display a poleward component in its track, 3) the storm had to pass far enough inland that precipitation measurements could be made in all quadrants of the storm.

3. RESULTS:

Figure 1 shows the 1000-500 hPa thickness, the 1000 hPa heights, and the 850-200 hPa wind shear for the left of center (loc) and right of center (roc) storms. At time t=0, storms exhibiting an loc precipitation distribution are characterized by a relatively strong cold-core mid-latitude trough located to the northwest of the composite storm situated off the South Carolina coast (Fig. 1a). Moderate warm-air advection (waa) is implied over the Middle Atlantic States as the circulation of the storm interacts with the baroclinic zone in this area. Furthermore, the loc storm is in close proximity of the equatorward jet-entrance region as indicated by the large values of shear (40 m s^{-1}) just downstream of the trough axis. In contrast, storms exhibiting an roc precipitation distribution are characterized at time t=0 by a relatively zonal baroclinic zone located well to the north of the composite storm situated over eastern Texas (Fig. 1b). The displacement of the baroclinic zone relative to the cyclone in this situation precludes any significant temperature advections.

Twelve hours later, the loc storm has moved northward in closer proximity to the mid-latitude trough (Fig. 1c). The region of waa has moved northward along the East Coast while a region of cold-air advection (caa) is now evident stretching from the Ohio Valley into the Southeast. As the cyclone interacts with the trough, the orientation of the trough begins to change as ridging is enhanced in the Northeast. The thickness values now start to take on the characteristic "S" shape associated with potent extratropical storms. The cyclone has also moved toward higher shear values and now appears coupled to the equatorward jet-entrance region. At the same time, the roc storm has remained somewhat isolated from any deep baroclinic zones (Fig 1 d). However, a weak trough in the thickness field to the north-northwest of the composite cyclone in conjunction with the expanding area of moderate shear perhaps suggests the beginning of a weak interaction.

By time t-24, the structure of the loc composite is characteristic of a storm having completed extratropical transition (Fig 1e). The thickness contours having taken on a negative tilt, indicating a more dynamically active trough realized through an increase in vorticity advection. In the roc composite, the trough in the thickness field becomes slightly more pronounced, with the trough axis centered over the northern Plains (Fig. 1f). However, although the storm has moved towards colder thickness values, it still appears to be south of the main baroclinic zone and somewhat tropical in structure.

4. ACKNOWLEDGEMENT:

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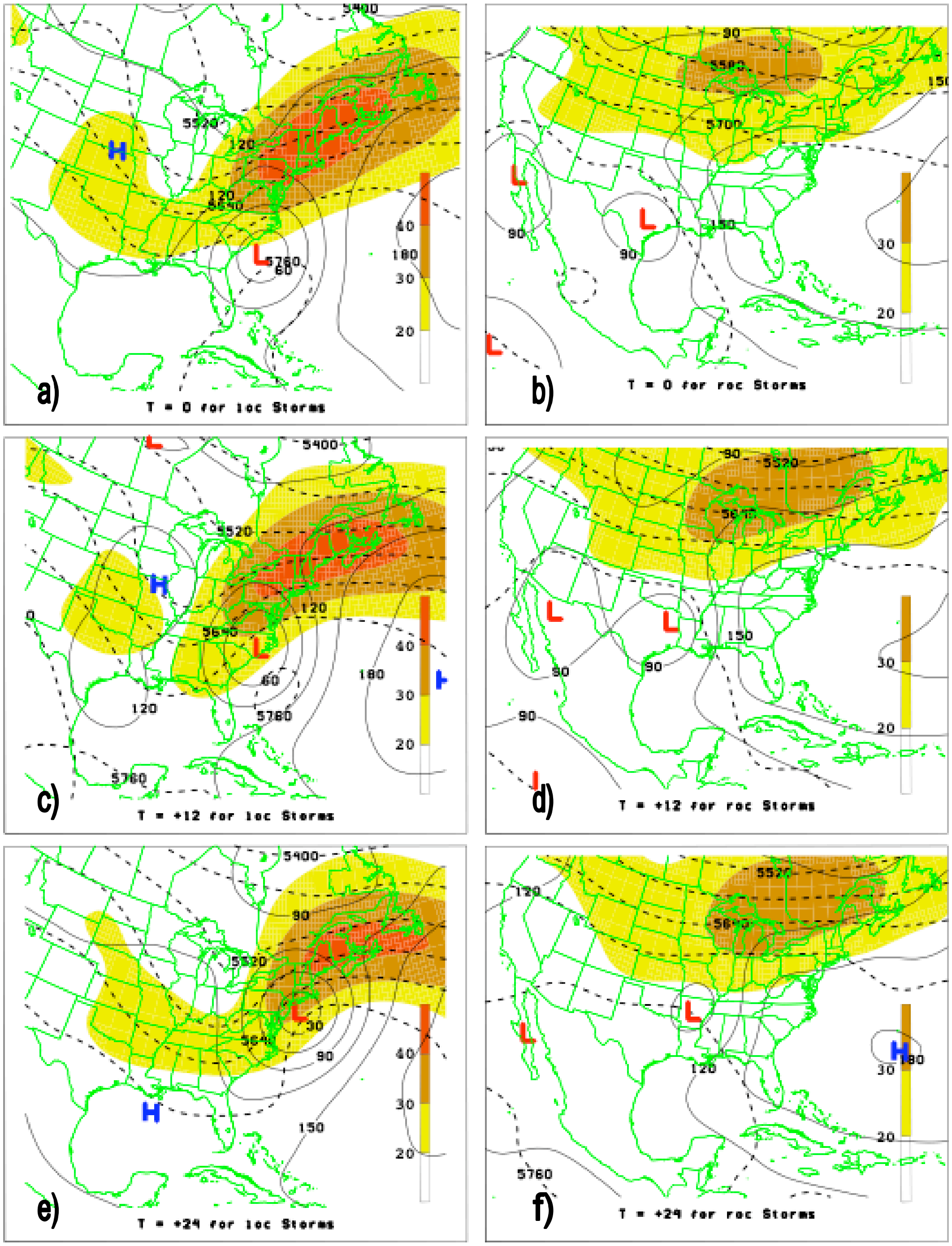

Figure 1. 1000-500 hPa thickness (dashed lines, contoured every 60 m), 1000 hPa geopotential height (solid lines, contoured every 30 m) and 850-200 hPa shear (shaded, every 20 m s^{-1}) for a) t=0 loc composite, b) t=0 roc, c) t=12 loc, d) t=12 roc, e) t=24 loc, and f) t=24 roc.