7. Conclusions and suggestions for future work

7.1 Conclusions

The primary objectives of this thesis were to: 1) document the distinct synoptic-scale configurations favorable for the development of PREs, and 2) examine the dynamical mechanisms associated with PREs. To accomplish these objectives, PREs occurring in the U.S. ahead of North Atlantic basin TCs during 1988–2008 were stratified based upon the upper-tropospheric flow configuration within which the PRE and TC were embedded. This stratification procedure revealed three PRE categories: JR, SJ, and DC, each category linked to a distinct synoptic-scale flow configuration. Following this stratification procedure, a climatology for 1988–2008 was conducted in order to document the temporal and geographical distributions and the statistical properties of PREs. PRE-relative composites were prepared for each of the three PRE categories in order to elucidate the key synoptic-scale features and dynamical mechanisms associated with PRE development. The PREs associated with TC Rita (2005; JR category), TC Wilma (2005; SJ category), and TC Ernesto (2006; DC category) were selected for individual case studies.

The results of the composites and the case studies provide insight into the key environmental properties and dynamical mechanisms associated with PREs. These results also indicate that the influence of the TC on the development of the PRE varies among the three categories. For the JR category, a TC is typically embedded within an environment resembling the Maddox et al. (1979) "frontal" pattern for flash-flood-producing MCSs, acting as a source of moisture to a region already favorable for heavy rainfall. The SJ category is typified by the direct dynamical interaction between a TC

and an approaching midlatitude baroclinic system, often closely resembling the early stages of ET (e.g., Klein et al. 2000). During this TC–midlatitude interaction, the low-level cyclonic circulation and the upper-level diabatically driven outflow associated with the TC contribute to dynamical forcing for PRE development in the presence of deep moisture emanating from the TC. For the DC category, the role of the TC can vary among individual PRE cases. For many DC category PREs, the direct dynamical interaction between the TC and a weak midlatitude baroclinic zone contributes to the development of a PRE, whereas for others [e.g., the PRE ahead of TC Ernesto (2006)], the TC primarily acts as a source of moisture to a region already favorable for heavy rainfall and has no direct dynamical influence on the development of the PRE.

C07 asserted that a TC can contribute to the development of a PRE by: (1) transporting deep moisture poleward to a region of ascent, and (2) amplifying an upper-level ridge downstream of the TC through diabatic heating and enhancing the horizontal divergence within the equatorward entrance region of an intensifying upper-level jet streak. The results of the current study support this assertion and, moreover, suggest a third possible contribution of a TC: poleward low-level flow on the eastern flank of the cyclonic circulation of a TC can aid in establishing focused warm-air advection and frontogenesis along a low-level baroclinic zone.

7.2 Suggestions for future work

While this thesis provides insight into the favorable synoptic-scale environments and dynamical mechanisms associated with PREs, opportunities remain for future work on PREs. There is a continued need for detailed case studies in order to improve

understanding of the various dynamical processes associated with PREs. Unresolved issues related to operational forecasting that should be the subject of future case studies are: 1) the processes associated with the generation of multiple concurrent or consecutive PREs ahead of a single TC, and 2) the processes that govern the so-called "unclassifiable" (UC) PREs. UC PREs pose a considerable forecasting challenge because they typically occur in association with subtle mesoscale boundaries or with topographic features in environments of weak dynamical forcing. In conjunction with continued case studies, a comprehensive assessment of the performance of medium- and extended-range operational models for individual PRE cases is necessary in order to provide operational forecasters with useful information on how to use model guidance to forecast the location, intensity, and longevity of PREs.

The results of the composites and case studies presented in this thesis suggest that the presence of a stream of deep moisture emanating from a TC can significantly enhance rainfall totals associated with a PRE. Of interest from both an operational and a research perspective would be a quantitative assessment of the relative impact of TC-related moisture on rainfall totals in individual PRE cases using numerical model simulations. For these model simulations, the high moisture values associated with the TC could be reduced in the initial conditions to values representative of the ambient environment. The model could then be run through the lifespan of the PRE, and the resultant precipitation distribution could be compared with that of a control simulation or perhaps with actual precipitation observations.

Numerical model simulations could also be employed to assess the dynamical influence of a TC on PRE development. For assessing the role of the cyclonic circulation

of the TC, a similar methodology to the one used by McTaggart-Cowan et al. (2001) could be employed. Specifically, the PV anomaly associated with the TC circulation could be removed from the initial conditions of a numerical model simulation. Upon removal of this PV anomaly, a piecewise PV inversion (e.g., Davis 1992) could then be performed on the resultant PV field in order to obtain the balanced fields with which to initialize the model. The results of the model simulation could then be compared with the results of a control simulation that includes the PV anomaly associated with the TC in order to quantify the influence of the TC circulation on the development of the PRE. To assess the impacts of the diabatically driven outflow associated with the PRE and the TC, numerical model simulations could be run with the effects of latent heating removed and compared with a control simulation that includes the effects of latent heating.