

ABSTRACT

Predecessor rain events (PREs) are distinct mesoscale regions of heavy rainfall that develop ahead of landfalling tropical cyclones (TCs) as a continuous poleward-moving stream of deep tropical moisture emanating from the TC encounters a region of ascent to produce heavy, prolonged rainfall. PREs present a forecast challenge because they have the potential to cause significant inland flooding, given that they are typically characterized by large rainfall totals (>100 mm in 24 h). An increased risk of flooding is posed if the TC rain shield subsequently passes over the region affected by the PRE. The primary objectives of this thesis are to: 1) document the distinct synoptic-scale configurations favorable for the development of PREs, and 2) examine the dynamical mechanisms associated with PREs. Accomplishing these objectives will ultimately lead to the development of a set of operational forecasting tools and techniques not only to diagnose the potential for PRE development but also to predict how a PRE may evolve in time and space.

A climatology of PREs occurring in the U.S. ahead of North Atlantic basin TCs during 1988–2008 is presented in order to document the temporal and geographical distributions and the statistical properties of PREs. In conjunction with this climatology, PREs are stratified into three distinct categories: “jet in ridge” (JR), “southwesterly jet” (SJ), and “downstream confluence” (DC), based upon the configuration of the upper-tropospheric flow within which the PRE and TC are embedded. PRE-relative composites are presented in order to elucidate the key synoptic-scale features and dynamical mechanisms associated with each PRE category. While the PRE-relative composites for

each category indicate that PREs tend to develop as a stream of moisture from a TC encounters a region of ascent situated along a low-level baroclinic zone and beneath the equatorward entrance region of an upper-level jet streak, the lower- and upper-level synoptic-scale flow configurations associated with each category differ markedly. Moreover, the role of the TC in establishing favorable conditions for PRE development varies among the three categories.

Detailed case studies of the PREs that occurred ahead of TC Rita (2005; JR category), TC Wilma (2005; SJ category), and TC Ernesto (2006; DC category) are performed in order to investigate the dynamical mechanisms associated with each PRE category. The findings for these three case studies bolster the findings for the PRE-relative composites by providing considerable insight into the diverse synoptic and mesoscale mechanisms that can be associated with PRE development. Based upon the results of these case studies and of the PRE-relative composites, conceptual models are presented in order to illustrate the salient features and processes associated with each PRE category.