Mechanisms for Predecessor Rain Events in Advance of Tropical Cyclones

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Predecessor rain events (PREs) are distinct mesoscale regions of heavy rainfall that develop approximately 1000 km poleward and in advance of landfalling tropical cyclones (TCs), and approximately 24–36 h before the passage of the main rain shield associated with the TC. PREs develop as a continuous poleward-moving stream of deep tropical moisture emanating from the TC encounters a region of atmospheric lifting 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). The objectives of this presentation are to: (1) document key synoptic-scale features in the environments of PREs in order to establish distinctive scenarios favorable for PRE development, and (2) examine, through a case study of a PRE associated with TC Ernesto (2006), mechanisms for PRE development and maintenance.

While most PREs exhibit similar synoptic-scale characteristics (e.g., anomalously high precipitable water values, formation in an equatorward jet entrance region), they can vary considerably with respect to their location relative to the parent TC. Additionally, there is considerable variability in the structure, intensity, and longevity of PREs. In order to account for this variability and to investigate their preferred synoptic-scale environments, PREs occurring during 1988–2008 are stratified into three distinct categories: “jet in ridge,” “southwesterly jet,” and “downstream confluence,” based upon the configuration of the upper-tropospheric flow within which the TC is embedded. PRE-relative composites are presented to elucidate key dynamical and physical processes in each category. While the composites indicate the importance of an upper-level jet, thermal advection, and low-/mid-level frontogenesis, the location, orientation, and magnitude of these key features differ markedly among the three PRE categories. Our results therefore are suggestive of three distinct flow configurations favoring PRE development.

Dynamical and physical mechanisms associated with PREs are further illustrated through a case study of a high-impact “downstream confluence” category PRE (event rainfall totals >100 mm), which occurred during 30–31 August 2006 in advance of TC Ernesto. This PRE was characterized by a region of stratiform and convective rain (embedded radar echoes ~50–60 dBZ) that developed in central and eastern North Carolina and Virginia as a poleward stream of deep tropical moisture (precipitable water values ~50 mm) interacted with a stalled cold front and a region of cold-air damming beneath the equatorward entrance region of a 200 hPa jet streak. Subsequently, significant flooding occurred as Ernesto (and its associated rain shield),

aided by weak southwesterly steering flow, moved poleward over the region that had been affected by the PRE ~24 h earlier.