ABSTRACT

High winds, defined as gradient- or thunderstorm-driven winds greater than or equal to 25 m s^{-1} or damaging winds of any speed, can be challenging for National Weather Service (NWS) forecasters in the Northeast (NE). In the cool season, the NE experiences approximately 22 high-wind events per cool season, defined as October through April. The main goals of this thesis are to: 1) diagnose the climatological frequency of high winds in the NE and adjacent regions; 2) construct composite charts that represent the synoptic environments and mechanisms that lead to the production of high winds in the NE; 3) examine specific high-wind events that illustrate important atmospheric processes associated with the occurrence of high winds; and 4) increase situational awareness of the mechanisms that can lead to the production of severe high winds.

High-wind reports in the NE from 15 October 1993 through 31 December 2008 were extracted from the National Climatic Data Center (NCDC) storm report database and stratified into events. An event was defined as any series of greater than or equal to two storm reports separated by less than or equal to 12 h. A total of 335 high-wind events were identified. These events were then categorized based upon the type of reports that constitute the series. If an event consisted of only gradient or thunderstorm wind reports, the event was considered a pure gradient event or a pure convective event, respectively. If an event consisted of both thunderstorm and gradient wind reports, the event was considered a hybrid event.

A climatology of high-wind events that impacted the NE from 15 October 1993 through 31 December 2008 was developed in order to document the spatial and temporal frequencies of high-wind events. The pure gradient and hybrid events were subjectively divided into four subcategories (northeast, northwest, southwest, and southeast) based upon where the initial NE report occurred relative to the center of the surface cyclone for each event. The pure convective events were subjectively divided into two subcategories based upon whether a 300-hPa trough or ridge was present in the vicinity of the initial NE report. For each of the resulting 10 subcategories, report-relative composites were constructed to elucidate the synoptic structures and dynamical mechanisms associated with high winds that occur in each quadrant of a surface cyclone for pure gradient and hybrid events, and in the vicinity of an upper-level trough or ridge for pure convective events. Results reveal that hybrid events tend to accumulate the largest number of high-wind reports, which suggests hybrid events have the greatest societal impact. Also, the initial NE report for hybrid and pure gradient events occurs most frequently in the southeast and southwest quadrants, respectively. The initial NE report for pure convective events occurs most frequently in the vicinity of upper-level troughs.

Two high-impact hybrid high-wind events (17 February 2006; 15–16 April 2007) were analyzed to identify mechanisms responsible for the production of high winds during each event. Results from the composite and case study analyses provided insight into mechanisms that were responsible for the production of strong surface winds. The southwest quadrant of a cyclone was characterized by near dry-adiabatic planetary boundary layer (PBL) lapse rates and strong PBL wind speeds, which is favorable for turbulent transport of high momentum air to the surface. In both of the case studies,

ascent, likely associated with frontogenesis, was occurring in the presence of potentially unstable layers, which developed as a result of upward-decreasing equivalent potential temperature advection and a dry-air intrusion. Other important features evident in the composite analysis and the case studies were strong mean sea level pressure gradients and strong isallobaric gradients. Based upon the results of the composite analysis and the case studies, conceptual models are presented in order to highlight the important features associated with each event.