Forecasting Heavy Precipitation Associated with Cool-Season 500-hPa Cutoff Cyclones in the Northeast

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Forecasting precipitation distributions associated with cool-season 500-hPa cutoff cyclones can be a challenge in the Northeast, given that cutoff cyclones are generally slow moving and can have varying precipitation distributions throughout their lifetimes. Current numerical weather prediction models often have trouble forecasting heavy precipitation associated with cutoff cyclones because of difficulties in predicting their track, intensity, and location. The goal of this presentation is to investigate the typical synoptic-scale environments of neutrally tilted cutoff cyclones that are associated with heavy precipitation (≥25 mm over a 24-h period) in the Northeast. This goal will be accomplished by conducting a composite analysis of this category of cutoff cyclones and a representative case study of a recent event that produced widespread flooding in the Northeast on 12–16 March 2010.

Cutoffs cyclones were identified using four-times daily 1.0° GFS analyses for the five cool seasons (1 October–30 April) from 2004/05 through 2008/09. A cutoff cyclone was defined as a 30-m geopotential height rise in all directions at 500 hPa for at least three consecutive analyses (i.e., over a 12-h period). Each cutoff cyclone day was categorized by the tilt (negative, neutral, or positive) and structure (purely cut off from the background flow or closed low embedded within a large-scale trough) of the cyclone as manifested in the 500-hPa geopotential height field. For the purpose of this presentation, only neutrally tilted cutoff cyclones associated with heavy precipitation are examined, of which 14 occurred during the five winter period studied. Cyclone-relative composites were created from 2.5° NCEP/NCAR reanalysis data. The composite analyses indicate that neutrally tilted cutoff cyclones associated with heavy precipitation are typically located to the south and east of the Northeast region. The composites suggest that the presence of southeasterly low-level flow contributes to the heavy precipitation by advecting Atlantic moisture into the region northeast of the cutoff cyclone. In addition, the positioning of the upper-level jet and cyclonic absolute vorticity advection ahead of the cutoff cyclone provide favorable forcing for ascent over the region of heaviest precipitation.

The 12–16 March 2010 cutoff cyclone was a long-duration event associated with widespread flooding across southern New England. Locations in eastern Massachusetts and coastal New Hampshire received 125–150 mm of precipitation on 13–16 March. Throughout the event, a strong (>60 kt) southeasterly low-level jet acted to enhance precipitation by advecting anomalous warm, moist air into the region from the east, resulting in precipitable water values on the order of +2 to +3 standard deviations above normal along the coast. Forcing for ascent was favored within the entrance and exit regions of an easterly upper-level jet poleward of the cutoff cyclone and ahead of a lobe of cyclonic absolute vorticity moving westward across southern New England into New York and Pennsylvania. Further contributing to the heavy precipitation was a quasi-stationary region of low-level frontogenesis that developed along coastal New England.