20th Conf. on Weather Analysis and Forecasting
Seattle, WA, 11-15 January 2004

P1.44 Cold Season 500 hPa Cutoff Cyclone Precipitation Distribution and a Case Study

Anthony Fracasso*, Lance F. Bosart, Daniel Keyser
University at Albany/SUNY, Albany, NY

and

Michael Evans
Binghamton National Weather Service Forecast Office, Binghamton, NY

1. INTRODUCTION

Cutoff cyclones are a forecasting challenge, especially in the northeastern United States. Because their movement is often slow and their horizontal and vertical structure can often change dramatically from day to day, precipitation associated with these cutoffs can vary significantly in location, duration, and amount.

The purpose of this paper is to present results of a 51-year (1948–1998) climatology of cool season (1 October–31 May) precipitation distribution in association with 500 hPa cutoff cyclones that affect the northeastern United States. It builds upon a recent cool-season global and North American climatology of cutoff cyclones was prepared by Smith (2003). A presentation of a case study of a late cool-season cutoff during May 2003 will illustrate the characteristic structural changes of a particular cutoff cyclone.

2. METHODOLOGY

A closed low tracking program, developed in-house, was employed in order to find and record all cutoffs that affected the Northeast (New England, New York, New Jersey, and Pennsylvania). The tracking domain is bounded by latitudes 34ºN and 53ºN and longitudes 60ºW and 91ºW. It was within this area that cutoffs were deemed close enough to produce precipitation in the Northeast. The analysis was performed using the four-times daily National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) gridded reanalysis dataset, available on a 2.5º by 2.5º grid (Kalnay et al. 1996; Kistler et al. 2001). Following Bell and Bosart (1989), a cutoff is defined as a geopotential height minimum surrounded by at least one closed contour based on a 30 m height rise in all directions. The algorithm performs a series of tests, details of which can be found in Smith (2003).

* *Corresponding author address:* Anthony Fracasso, Dept. of Earth and Atmospheric Sciences, ES 337, University at Albany/SUNY, 1400 Washington Ave., Albany, NY 12222; e-mail:fracasso@atmos.albany.edu.

Based on the list of cutoffs derived from the objective tracking program, composite precipitation maps were produced using the NCEP Unified Precipitation Dataset (UPD), a once-daily (1200–1200 UTC) gridded precipitation dataset available on a 0.25º grid. Days in which a cutoff was present within the domain, as well as days in which precipitation was observed in a grid box, were catalogued and then used as input to average the precipitation that fell over the Northeast.

3. RESULTS

Daily average precipitation maps were produced for all cutoffs observed in a month (October–May) over the 51-year period (Fig. 1, November, January, March, and May shown). Note that all tracks of cutoffs are included in this climatology, yet there is some information evident in these maps. The area of greatest average daily precipitation is consistently in coastal areas, decreasing to the north and west. The maximum precipitation occurs in downeast Maine in all four months, but decreases in magnitude with time, especially from November to January. By May, a slight inland shift in the area of maximum precipitation is evident. Note that precipitation contoured over the water is a by-product of the contouring program and does not reflect the contribution of observed data. An orographic signal is observed, especially away from the immediate coast, for all months shown, with higher (lower) average precipitation amounts occurring over higher (lower) elevations. Prominent features are clearly seen in November. Local minima are noted in the Hudson and Connecticut River valleys, while local maxima are noted in the Worcester hills, Adirondacks, Catskills, Poconos, Berkshires, and Green and White mountain areas. This signal is dampened in later months, but may be masked by an overall decrease in average precipitation for the entire Northeast.

4. CASE STUDY: 24–29 MAY 2003

Based on Smith (2003), a composite mean cutoff cyclone path was referenced in order to choose case studies representative of each of the tracks. A late cool season cutoff occurred during May 2003, tracking from Wisconsin towards southeastern Ontario, then slowly looping to just west of New York State, and finally accelerating to the northeast across northern New England (Fig. 2). While the cutoff is meandering over Ontario, the precipitation associated with it ceases. Subsequent rainfall in the Northeast is then caused, in part, by other vorticity maxima rotating around the main cutoff. It is noted that the vorticity maximum associated with the cutoff is collocated with the height minimum until the cutoff increases its forward speed. At this point the vorticity maximum shifts off-center, and is cyclonically advected ahead of the cutoff over New England, which aides in producing a more uniform precipitation distribution (not shown) on either side of the cutoff track. Precipitation over the six-day period ranges from less than 1 cm over northwestern Pennsylvania to as much as 10 cm over Long Island. The distribution of precipitation is comparatively similar to the composite mean for May (Fig. 1d), with the maximum located inland over Connecticut and eastern Massachusetts as opposed to Maine (in the mean).

5. SUMMARY

A 51-year climatology of cool season precipitation distribution in association with 500 hPa cutoff cyclones was presented. Monthly variations show an areal decrease in average daily precipitation from November to May, and a slight inland shift in maximum precipitation as well. An orographic signal is evident throughout the cool season, but is more clearly shown in November than during latter months.

A case study was presented of a slow-moving cutoff in late May 2003 that underwent a decided change in characteristic structure over the six-day period. The vorticity maximum associated with the cutoff was initially collocated with the height minimum, but as the cutoff increased its forward speed the vorticity maximum became displaced from the height minimum. These changes affected the precipitation distribution around the cutoff and were crucial to forecasts.

6. ACKNOWLEDGMENTS

Anantha Aiyyer from the University at Albany/SUNY provided critical help in running the various algorithms to produce the climatology. This work was supported by NOAA Grant NA07WA0458, awarded to the University at Albany/SUNY as part of the CSTAR program. Additional information concerning the University at Albany CSTAR project may be found at http://cstar.cestm.albany.edu/.

7. REFERENCES

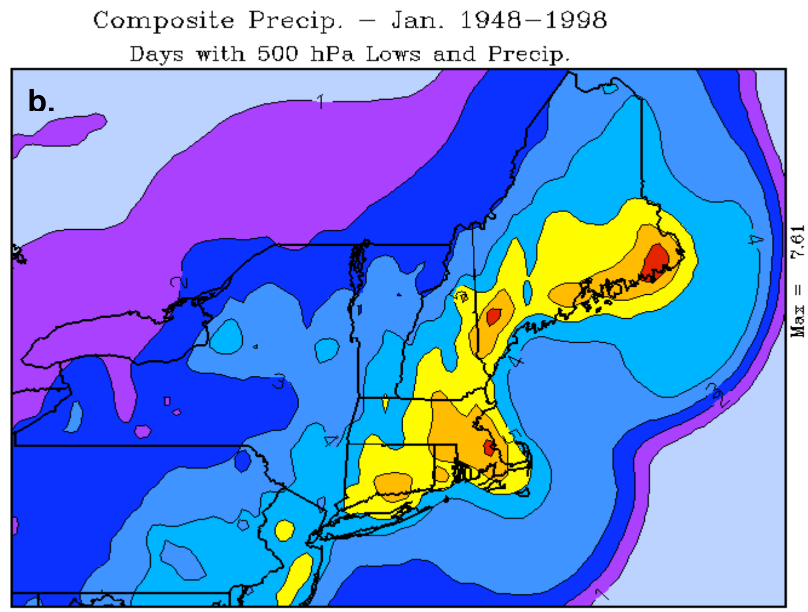
Bell, G. D., and L .F. Bosart, 1989: Climatology of Northern Hemisphere 500 mb closed cyclone and anticyclone centers. *Mon. Wea. Rev.*, **117**, 2142–2163.

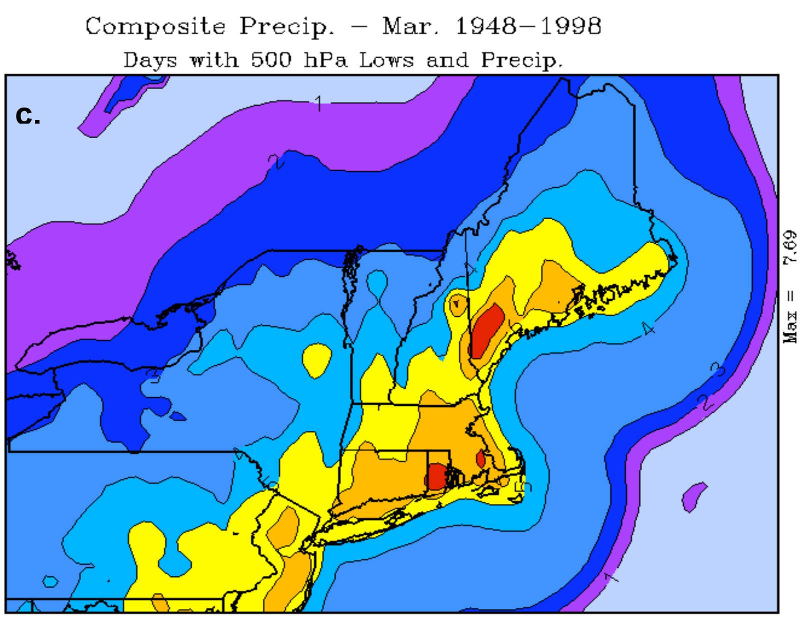
Kalnay, E., M. Kanamitsu, R. Kistler, W. Collins, D. Deaven, L. Gandin, M. Iredell, S. Saha, G. White, J. Woollen, Y. Zhu, A. Leetmaa, B. Reynolds, M. Chelliah, W. Ebisuzaki, W. Higgins, J. Janowiak, K. C. Mo, C. Ropelewski, J. Wang, R. Jenne, and D. Joseph, 1996: The NCEP/NCAR 40-year reanalysis project. *Bull. Amer. Meteor. Soc.*, **77**, 437–471.

Kistler, R., E. Kalnay, W. Collins, S. Saha, G. White, J. Woolen, M. Chelliah, W. Ebisuzaki, M. Kanamitsu, V. Kousky, H. Van den Dool, R. Jenne, and M. Fiorino, 2001: The NCEP–NCAR 50-year reanalysis: Monthly means CD-ROM and documentation. *Bull. Amer. Meteor. Soc.*, **82**, 247–267.

Smith, B. A., 2003: Cutoff Cyclones: A Global and Regional Climatology and Two Case Studies. Master of Science Thesis, Department of Earth and Atmospheric Sciences, University at Albany/SUNY, Albany, NY, 165 pp.

a.





d.

Fig. 1. Daily average precipitation for all cutoffs observed in a month over the 1948–1998 period [color bar: in/day (top) and mm/day (bottom)]: (a) November, (b) January, (c) March, and (d) May.

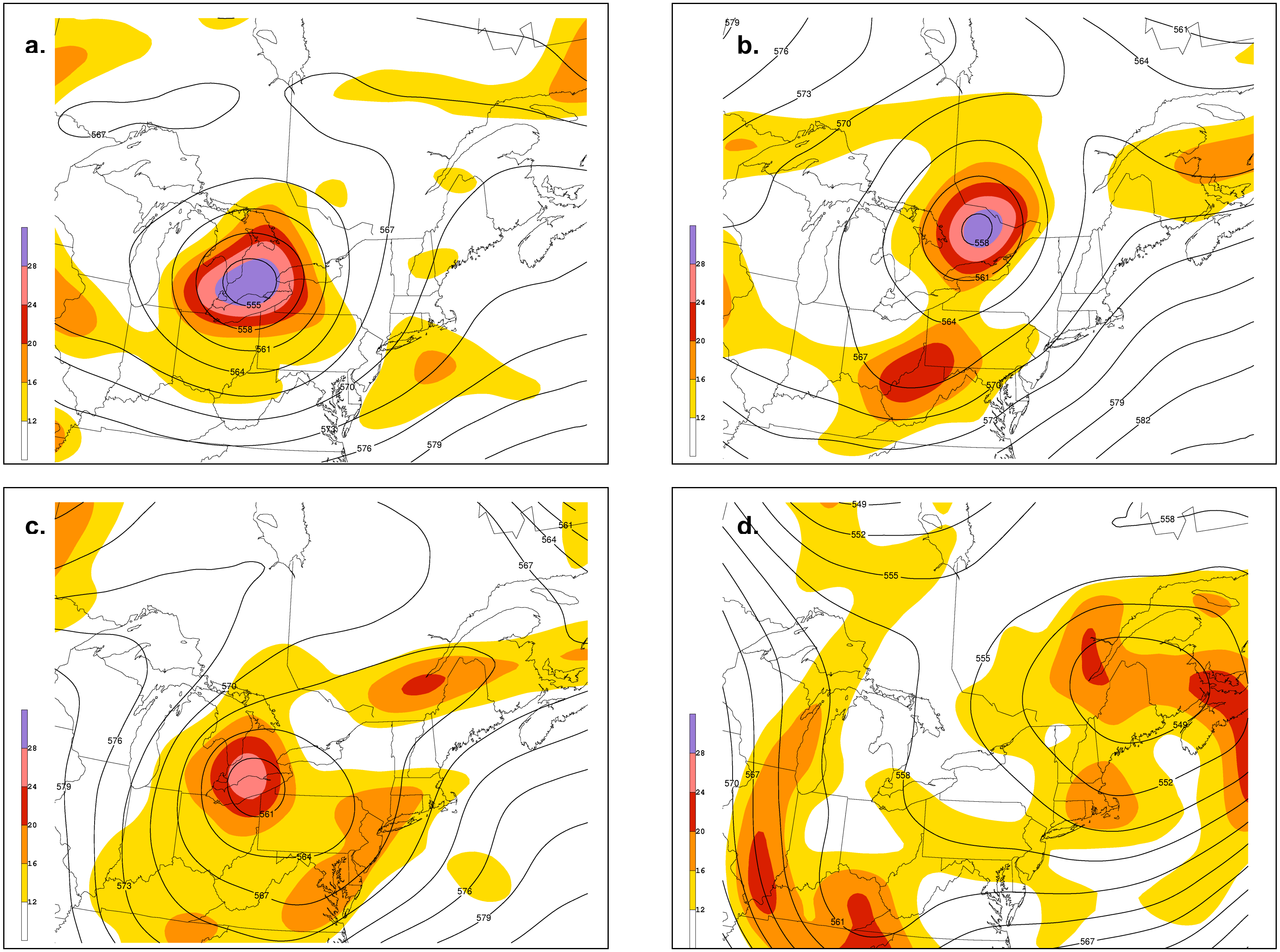


Fig. 2. 500 hPa heights (dam, solid contours) and absolute vorticity (10^{-5} s^{-1}, shaded) at 36 h intervals for (a) 0000 UTC 25 May, (b) 1200 UTC 26 May, (c) 0000 UTC 28 May, and (d) 1200 UTC 29 May 2003.