19th Conf. on Weather Analysis and Forecasting
San Antonio, TX, 12–16 August 2002

P1.14 A GLOBAL 500 HPA CUTOFF CYCLONE CLIMATOLOGY: 1953–1999

*Brandon A. Smith, Lance F. Bosart, Daniel Keyser
University at Albany, State University of New York, Albany, New York

Dan St. Jean
National Weather Service Forecast Office, Burlington, Vermont

1. INTRODUCTION

Cutoff cyclones are associated with many significant forecasting problems in the northeastern United States (US). Given the complex terrain in the Northeast, forecasting the precipitation distribution associated with slow-moving cutoff cyclones is often a challenge. As an initial step toward addressing this challenge, we present the results of a 47-year (1953–1999) climatology of 500 hPa cutoff cyclones in order to map the spatial and temporal distributions of these events. This task is accomplished by using twice daily (0000 and 1200 UTC) 500 hPa gridded geopotential height analyses from the National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) reanalysis dataset (Kalnay et al. 1996; Kistler et al. 2001).

2. METHODOLOGY

The algorithm used to identify and count cutoff cyclones is fundamentally similar to that used in Bell and Bosart (1989). The validity of the cutoff cyclone counts and frequency was established by comparing our results with those of Bell and Bosart (1989) and Parker et al. (1989). The algorithm detects cutoff cyclones by reading in the gridded 500 hPa height data for a specified geographical area. Once all the grid points are read, the algorithm evaluates each grid point, and determines whether the grid point is a height minimum. A grid point is considered a height minimum if it has the lowest height of the eight surrounding grid points. Once the height minima are located, a test is performed to verify if an individual minimum is a cutoff cyclone. For the purposes of this research, a cutoff cyclone is a low height center with at least a 30 m height rise in all directions. To perform this test, the algorithm extends radial arms from the height minimum every 20° (for a total of 18 arms). Heights are interpolated every 76 km along each radial arm, and if a 30 m height rise is detected in every direction before a height fall, then the height minimum is considered a cutoff cyclone.

A comparison of the objectively derived cutoff cyclones with manually analyzed cutoff cyclones shown on NWS DIFAX 500 hPa charts and the Daily Weather Map Series determined that using this height rise criterion along all 18 radial arms was too restrictive, resulting in "missing" cutoff cyclones. By reducing the radial arm threshold to 16 of 18 arms, acceptable results were achieved. The cutoff cyclones were catalogued using the General Meteorological Package (GEMPAK). Maps of cutoff cyclone frequency and cutoff cyclone 12 h periods were produced. Initially, maps were produced for the Northern Hemisphere for the time period specified in Bell and Bosart (1989) in order to confirm that we could reproduce their results. Subsequently, a new climatology was produced for the entire 47-year period for the Northern and Southern Hemisphere and then for the CSTAR domain over eastern North America.

3. RESULTS

A grand total of 897,472 cutoff cyclones were identified globally during the 1953–1999 period, prompting future visions of a "1,000,000 Cutoff Cyclone" celebration. The distribution of Northern Hemisphere cutoff cyclones in winter (defined as December, January, and February) is mapped in Fig. 1a. Cutoff cyclone frequency is maximized across the northwestern Pacific Ocean, with the highest frequencies over the Sea of Okhotsk. This favored area extends eastward across the North Pacific and the Aleutian Islands. Cutoff cyclone frequency is also maximized over the southwestern US, in the vicinity of Hudson Bay, over extreme eastern Canada, near the southern tip of Greenland, and in a band stretching from northern Africa eastward to the Turkish Plateau. The lowest cutoff cyclone frequency is found over the northern Rockies.

Figure 1b shows a more detailed view of cutoff cyclone frequency over Eastern North America for the same time period Inspection of this figure reveals some of the smaller scale features not as well resolved on the hemispheric view. Of interest are the maxima located over Hudson Bay and extreme eastern Canada. The Hudson Bay maximum is likely associated with centers of 1000–500 hPa thickness minima over the Northern Hemisphere during winter. The maximum over eastern Canada likely reflects cutoff cyclone development in response to cyclogenesis over the Great Lakes and southeast US. Storms originating over the Great Lakes and the southeast US often become associated with cutoff cyclones at 500 hPa as they deepen and track east-northeast and northeast, respectively. The lobes of higher frequency values

---

**Corresponding author address*: Brandon Smith, Dept. of Earth and Atmospheric Sciences, University at Albany, SUNY, 1400 Washington Ave., Albany, NY 12222. email: bsmith@atmos.albany.edu

extending along the US east coast and across the Great Lakes, with a relative minimum in cutoff cyclone frequency extending northeastward from the Tennessee Valley through northern Quebec support this idea. Cutoff cyclones occurring over the southwest US often originate as fractures from the equatorward ends of mobile troughs (Lefevre and Nielsen-Gammon 1995; Dean and Bosart 1996). It is likely that remnants of these systems track east-northeast and then northeast toward the Great Lakes as indicated by the apparent "cutoff freeway" linking the areas of favored occurrence previously discussed.

The frequency maximum near the southeast tip of Greenland east to just west of Iceland seen in Fig. 1b likely arises because of a combination of regional orographic influences on cyclogenesis and because that area is a graveyard for mature transient cyclones that deepen, occlude and die out in the North Atlantic (see, e.g., Doyle and Shapiro 1999). Distinct minima occur over Greenland and more prominently over the Canadian and northern US Rocky mountains. These minima are due more to the elevation of those areas than any synoptic feature.

Selected monthly plots of cutoff cyclone frequency for eastern North America are shown in Figs. 2a–d. In October (Fig. 2a), the frequency maximum off the southern tip of Greenland seen in the previous figures is present. The Hudson Bay frequency maximum is mostly absent and is displaced poleward in response to the lack of cold air seen in the winter months when the water is frozen. A prominent frequency maximum appears in the southwest US, with a possible connection across the central Plains to another relative frequency maximum over the Great Lakes. A distinct frequency minimum occurs over the Canadian Rockies, as seen in the hemispheric and regional plots in Fig. 1. The persistence of this feature suggests the likely orographic link discussed earlier. By December (Fig. 2b) the frequency maximum over Hudson Bay intensifies and moves equatorward as cold air accumulates over the now-frozen water surface. The cutoff frequency maximum over the southwest US has shifted eastward across New Mexico. This maximum appears to connect with a weak relative maximum over the Great Lakes. The frequency minimum over the Rockies has increased in size and may represent some of the aforementioned weakening as cold stable air invades the northern US more frequently. The development of a cutoff cyclone frequency maximum over eastern Canada is likely a reflection of the more active US east coast and Great Lakes storm tracks.

In February (Fig. 2c), the overall pattern of large-scale cutoff cyclone frequency maxima remains intact over Hudson Bay, extreme eastern Canada and off the southern tip of Greenland, as does the frequency minimum over the northwest US. There is a weakening trend in the frequency maximum over the southwest US, together with a near-disappearance of the frequency maximum over the Great Lakes. Far more noticeable changes take place as spring approaches. In April (Fig. 2d), the "cutoff freeway" clearly reappears. This cutoff cyclone frequency axis stretches from a frequency maximum over the Southwest desert region east-northeast across the central Plains to the Great Lakes. Cutoff cyclones continue to cluster near the US eastern seaboard and Canadian Maritimes, indicative of the more robust cyclogenesis common in spring in this region. Compared to February, the frequency maximum over Hudson Bay has retreated well poleward by April.

4. SUMMARY

The results of a 47-year (1953–1999) climatology of 500 hPa cold season cutoff cyclones are presented for the Northern Hemisphere and eastern North America. The results of this climatology show that the distribution of cutoff cyclones appears to be both orographically and synoptically dependent. Areas favored for cold season cutoffs include the northern Pacific ocean, the southwestern US, north-central and extreme eastern Canada, the North Atlantic off of Greenland, and along an east–west oriented belt stretching from the Strait of Gibraltar across northern Africa and the Mediterranean into the Turkish Plateau. The frequency of occurrence generally increases and shifts equatorward with the onset of winter, and the strongest signals occur with the approach of spring.

5. ACKNOWLEDGMENTS

Anantha Aiyyer from the University at Albany was essential in developing the algorithms used to construct this climatology. This work was supported by NOAA Grant 1007941–1–012365, 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.

6. 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.

Daily Weather Map Series, October 1 – April 30, 1969 – 1973, and 1984–1989, National Oceanic and Atmospheric Administration.

Dean, D. B., and L. F. Bosart, 1996: Northern Hemisphere 500 hPa trough merger and fracture: A climatology and case study. *Mon. Wea. Rev.*, **124**, 2644–2671.

Doyle J. D., and M. A. Shapiro, 1999: Flow response to large scale topography: The Greenland tip jet. *Tellus*, **51A**, 728–748.

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.

Lefevere, R. J., and J. W. Nielsen-Gammon, 1995: An objective climatology of mobile troughs in the Northern Hemisphere. *Tellus*, **47A**, 638–655.

Parker, S. S., J. T. Hawes, S. Colucci, and B. Hayden, 1989: Climatology of 500 mb cyclones and anticyclones, 1950–1985. *Mon. Wea. Rev.*, **117,** 558–570.

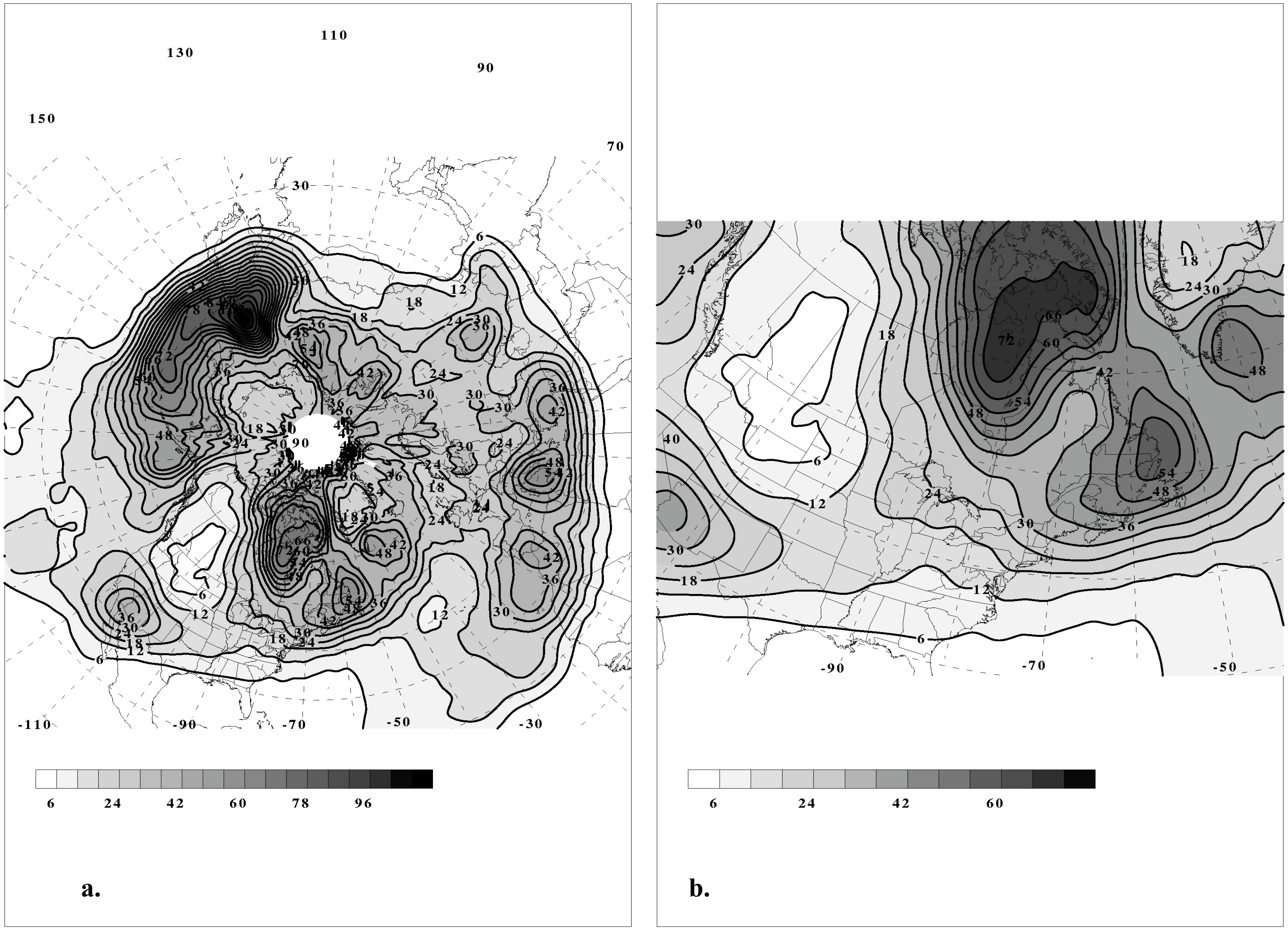

Fig. 1. Number of December, January, and February cutoff cyclones, 1953–1999, contoured and shaded every 6, for (a) the Northern Hemisphere and (b) eastern North America.

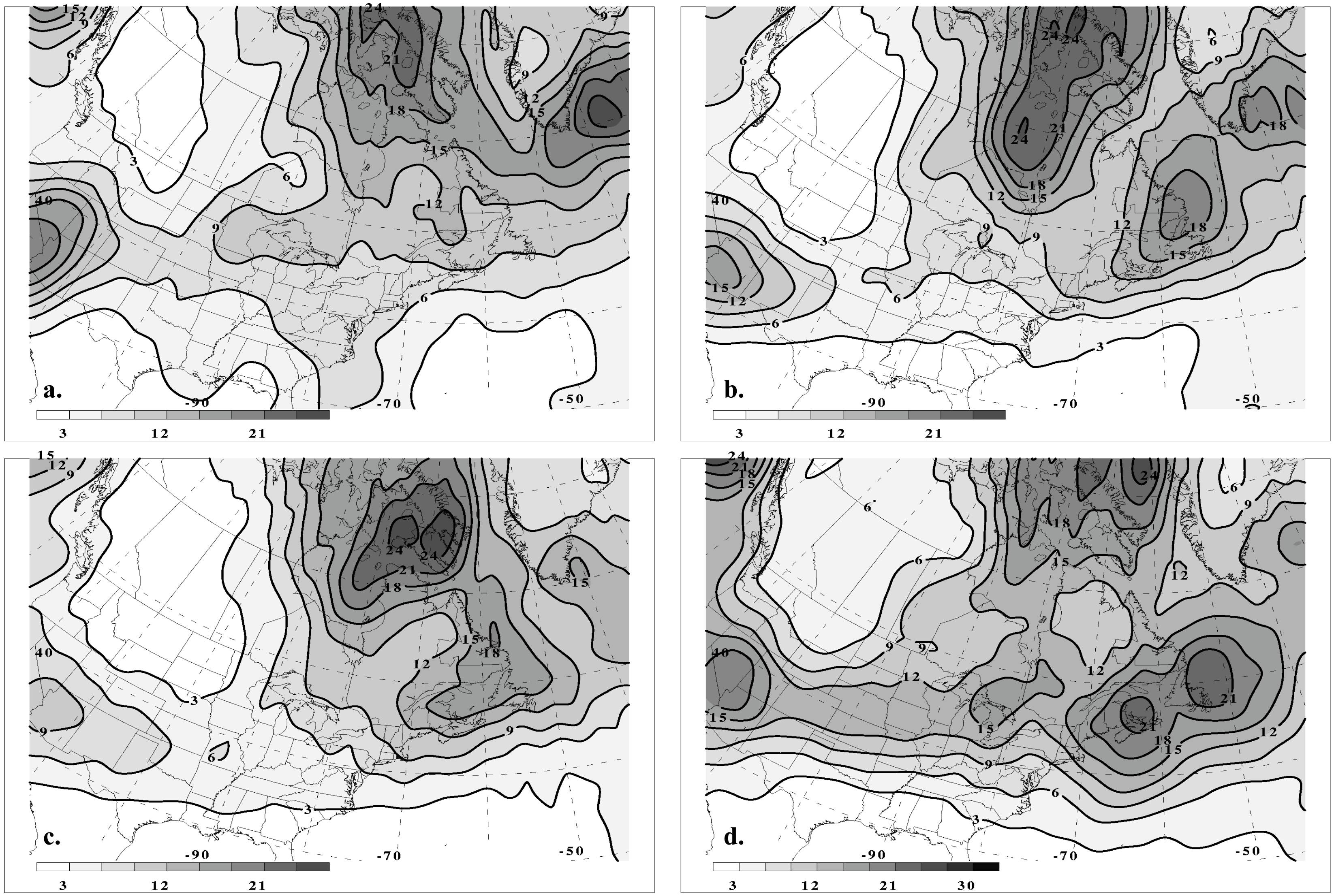

Fig. 2. Number of cutoff cyclones, contoured and shaded every 3, for (a) October, (b) December, (c) February, (d) April, 1953–1999.