An Updated U.S. Blizzard Climatology: 1959-2014

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ABSTRACT

The National Weather Service (NWS) defines blizzards as areas of considerable falling and/or blowing snow with sustained wind speeds of 35 miles per hour or greater for an extended period of time (3 hours or greater) in which visibility is frequently reduced to less than a quarter of a mile. Using this operational definition, blizzard occurrence by county was collected from *Storm Data* for the 1959/60 through 2013/14 winter seasons (n = 55). The primary objectives of this study were to: 1) update the blizzard climatology for the conterminous United States; and 2) examine the recent spatiotemporal variability in blizzard occurrence. The conterminous U.S. recorded 713 blizzards, averaging 13 blizzards per season for the entire record; however, the overall trend in blizzard activity has increased. In comparison with the 1960-1994 period, mean annual blizzard frequency in the past two decades has more than doubled (mean = 19) with more blizzards occurring outside the traditional October to March season. Blizzards have occurred somewhere in the contiguous U.S. in all months except July, August and September. By decade, blizzard activity is most widespread in the 1970s and 1990s; the 2010s are also trending toward a wider geographic distribution. The other decades show blizzards generally confined to the blizzard zone of the northern Great Plains. Overall, the average blizzard area impacted decreases over time, partially due to improved technology and reporting methods. Federal disaster declarations and monetary impacts from blizzard events have substantially increased in the 21st century.

Keywords: blizzard, snowstorm, Storm Data, Great Plains

INTRODUCTION

Atmospheric hazards cause significant disruption and damage to various socioeconomic sectors with annual $US losses in the billions (NCEI 2015a; 2015b); winter storm losses in the United States average $1.2 billion per year (Munich RE 2015). Eastern U.S. winter storm events that include heavy snow, ice storms, frigid temperatures and blizzards have received widespread media attention in recent years with dubious monikers such as “Snowmageddon”, “Snowzilla” and “Polar Vortex” (e.g., Rice and Stanglin, 2016; Samenow, 2016; LeComte, 2011). The heightened media interest coupled with above average winter storm events and associated losses has spurred investigation into whether or not this apparent increase in severe winter weather is part of an overall upward trend and/or a changing climate (e.g., Burnett *et al.,* 2003; Kunkel *et al*., 2009; Edwards *et al.,* 2014; Lawrimore *et al.,* 2014).

With the exception of Schwartz and Schmidlin (2002) (henceforth SS2002), few modern studies have focused exclusively on blizzards and are usually incorporated into an overall discussion on winter storms in the United States or specific regions and case studies (e.g., Zielinksi, 2002; Changnon and Changnon, 2005; Changnon *et. al.,* 2006; Thomas and Martin, 2007). The purpose

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of this research is to update the blizzard climatology of the conterminous United States from SS2002 and Schwartz (2001), extending the analysis period from 1959/60 through the 2013/14 winter season. Data are examined for decadal, annual, and monthly spatiotemporal patterns and trends; the additional 21st century data may reveal features not readily apparent during the shorter record period and largely pre-NWS modernization era.

DATA AND METHODS

Blizzard records for the conterminous U.S. were compiled from *Storm Data* (SD), a monthly publication of the National Centers for Environmental Information (NCEI) (formerly the National Climatic Data Center (NCDC)) available in digital form at their website (2015b). SD chronicles severe weather events and unusual meteorological phenomena by state, detailing the time period, counties and/or forecast zones impacted, storm event type, general storm paths, and total monetary, human life, and agricultural loss. Since SD relies on submissions from a NWS Warning Coordination Meteorologist (WCM), storm specifics may vary depending on the report preparation and event investigation of the WCM (or designated Focal Point) and their local NWS office.

For September 1959 through August 2015, blizzard events from SD were identified using the procedure outlined in SS2002 and Schwartz (2001) and briefly described here. All monthly publications and digital entries (including any later corrections) were reviewed for storm features referencing blizzards. Only events characterized specifically as blizzards in the event type column and/or text description were used; thus, "near-blizzard conditions" and other similar phrasing for blizzard-like situations were not included. Blizzards that occurred over several states yet caused by the same synoptic-scale disturbance were considered a single blizzard event (after a similar methodology in Branick 1997). The annual blizzard season was defined as September through August with January used to define the blizzard year (e.g., the 1960 season refers to all blizzards occurring between September 1959 and August 1960). The annual number of blizzards and annual area affected by blizzards were analyzed for temporal trends using linear regression and a spectral analysis to detect any blizzard cycles.

Annual, decadal and monthly blizzard frequencies were mapped by county for the conterminous United States for a visual examination of the spatiotemporal changes in blizzard events. In order to account for large variations in county size, the blizzard count data were normalized by area using the following procedure for each county: 1) averaged the number of blizzards occurring within a 28.196 km radius of the county center. The radius was based on the average size of a contiguous US county area (2497.59 km^2); 2) divided the resulting blizzard average by the mean contiguous US county area; and 3) multiplied the result by 1000 km^2. In other words, the resultant maps show an average number of blizzards per 1000 km^2 that a specific county would have if every county in the continental US had the exact same area.

RESULTS

Annual blizzard frequency and trends

Based on SD reports, the conterminous U.S. recorded 713 blizzards of various size, intensity, and duration between 1959/60 and 2013/14. The average number of blizzards per season (September through August) is 13.0 with a standard deviation of 7.0, indicating the relatively high interannual variability in blizzard frequency (Fig. 1). Seasonal blizzard frequency ranged from one blizzard in the 1980/81 season to 32 blizzards in the 2007/08 season. Based on three-month intervals, blizzard frequencies as expected are highest during the boreal winter peak (December through February) at 8.3. Late season blizzards (March through May) occurred twice as often as early season blizzards (September through November), averaging 3.1 per season compared with 1.5. Summer blizzards were only reported once, occurring in June 2002.

Seasonal blizzard frequencies displayed a distinct upward trend with a more substantial rise over the past two decades. A linear regression analysis revealed a statistically significant positive trend in blizzards over time ($\beta = 0.29$, $p << 0.000$) with a standard error of the estimate of 5.3. The occurrence year explained almost half of the variability in seasonal blizzard frequency ($R^2 = 0.438$, $p<<0.000$). The modeled increase in blizzard activity showed a nearly four-fold upsurge from between the start and end of the study period at 5.9 and 21.6 blizzards, respectively. Based on current model trends, the expected blizzard total for a season is 32 blizzards by 2050; however, uncertainty exists on whether or not the linear trend will continue or stabilize in the near future.

Figure 1 also displayed a noticeable cycle in blizzard frequency with a peak every 11-14 years. A spectral analysis was conducted on the blizzard time series from the detrended dataset using standardized residuals from the linear regression analysis. Although blizzard frequency peaks coincide with a 13 or 14-year cycle with a secondary peak at 4 years, the peaks could not be separated from independent errors (or 'white noise') and were found statistically insignificant based on the Fisher's Test for periodicity (Bloomfield 2000).

In addition to an increased frequency over time, blizzard occurrence (shown as the average number of blizzards per 1000 km^2) between 1959/60 and 2013/14 seasons showed a wider geographic distribution (Fig. 2). Only six states in the conterminous U.S. (Alabama, Florida, Louisiana, Mississippi, South Carolina, and Tennessee) do not have any officially reported blizzards for their counties in the SD publication database; however, meteorological data and the spatial pattern of snowfall distribution from the March 1993 "Storm of the Century" (Lott 1993) suggested blizzard conditions may have occurred in eastern Tennessee, western South Carolina, and northeastern Alabama.

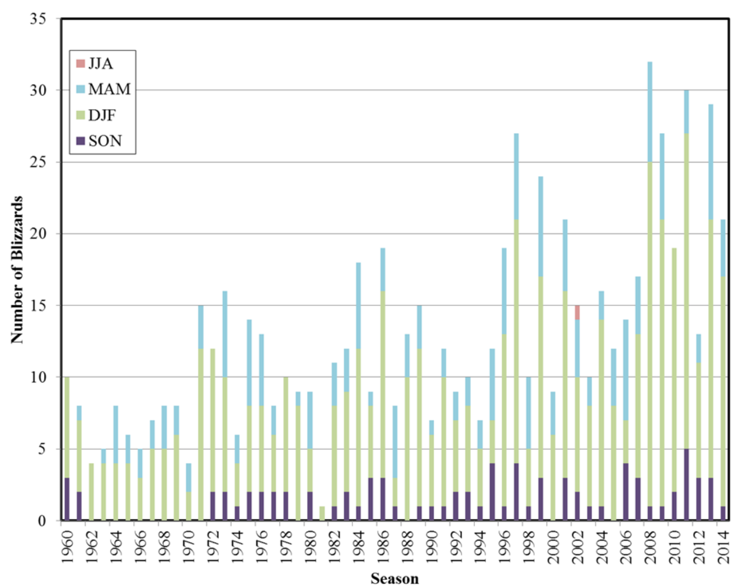

Figure 1. Annual blizzard frequency for the 1959/60 through 2013/14 seasons subdivided in three-month intervals.

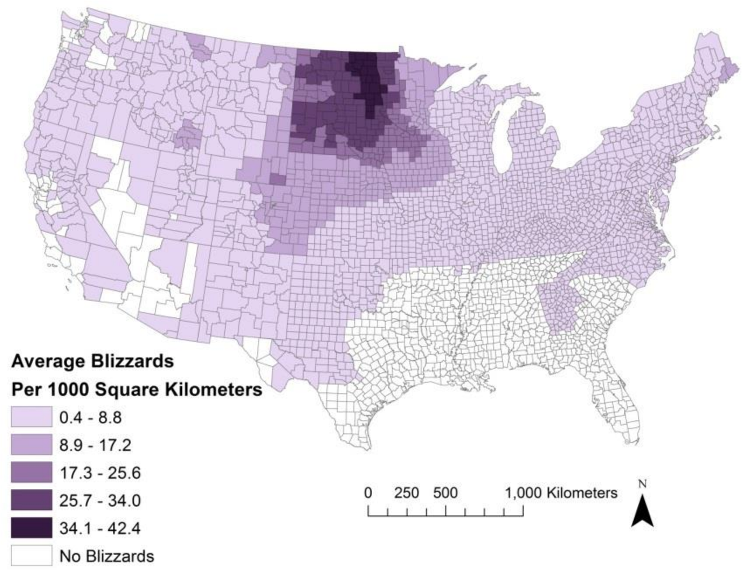

Figure 2. Average number blizzards per 1000 km^2 for the 1959/60 through 2013/14 seasons. Average blizzard number is determined as the average number of blizzards in all counties within a 28.196 km radius divided by 2497.59 km^2 (or an average contiguous U.S. county) and then multiplied by 1,000 km^2.

Decadal variability in blizzard frequency

The geographic distribution of blizzards by decade displayed distinct periods of concentrated blizzard events contrasted with phases of more widespread activity (Fig. 3). Spatially, blizzards in the 1960s (Figure 3a) and 1980s (Figure 3b) were more focused in the northern Great Plains blizzard zone with secondary activity around the extreme Northeast coast. Although the blizzard activity was also more concentrated in the 2000s (Fig. 3e), blizzard reports shifted westward from the Dakotas centered blizzard zone to the mountainous regions of the West (Rockies, Cascades, and Sierra Nevada) with a secondary geographic blizzard peak limited to southeastern Maine. In comparison, blizzard reports from the 1970s (Fig. 3b) were prevalent throughout the North and were shifted south of their mean position to include states such as New Mexico, Oklahoma and North Carolina where severe winter weather events were rare. The 1990s (Fig. 3d) also has widespread blizzard activity that also included much of the West as well as the entire Northeast corridor. Based on the 2010 through 2014 seasons, blizzard activity trends for the 2010s (Fig. 3f) demonstrated a trend toward more geographically extensive blizzards reports with current activity highly spread throughout the central United States and Rockies; however, the blizzard zone of the northern Great Plains remains the most active blizzard area.

Monthly blizzard frequency

Blizzards have been reported in all months except July, August and September. Monthly blizzard occurrence highlighted a more active blizzard season (December, January, February, and March; Fig. 4) and a less active blizzard period during the transitional seasons (October, November, April, and May; Fig. 5). Blizzard values were highest in January, ranging from average of 9.3 to 13.6 per 1000 km^2 throughout the blizzard zone and extending into northern Iowa. While actual blizzard totals were highest in December (n = 168), the highest December average blizzard values were around 7 blizzards per 1000 km^2 and confined to extreme eastern North Dakota. February and March have similar average blizzard values (ranging from 0.4 to about 6.5 per 1000 km^2); though, March has higher blizzard activity throughout the blizzard zone and central Great Plains. In the transitional seasons, November (n =65) and April (n = 56) were three to four times more likely to have a blizzard than in October (n = 17) or May (n =7). Blizzard averages in November and April were comparable (0.4 to around 4 per 1000 km^2) yet contrast geographically (Fig. 5). June (not shown) had only one reported blizzard, occurring in 2002 over a small mountainous region of Montana; this is the latest season blizzard reported in SD.

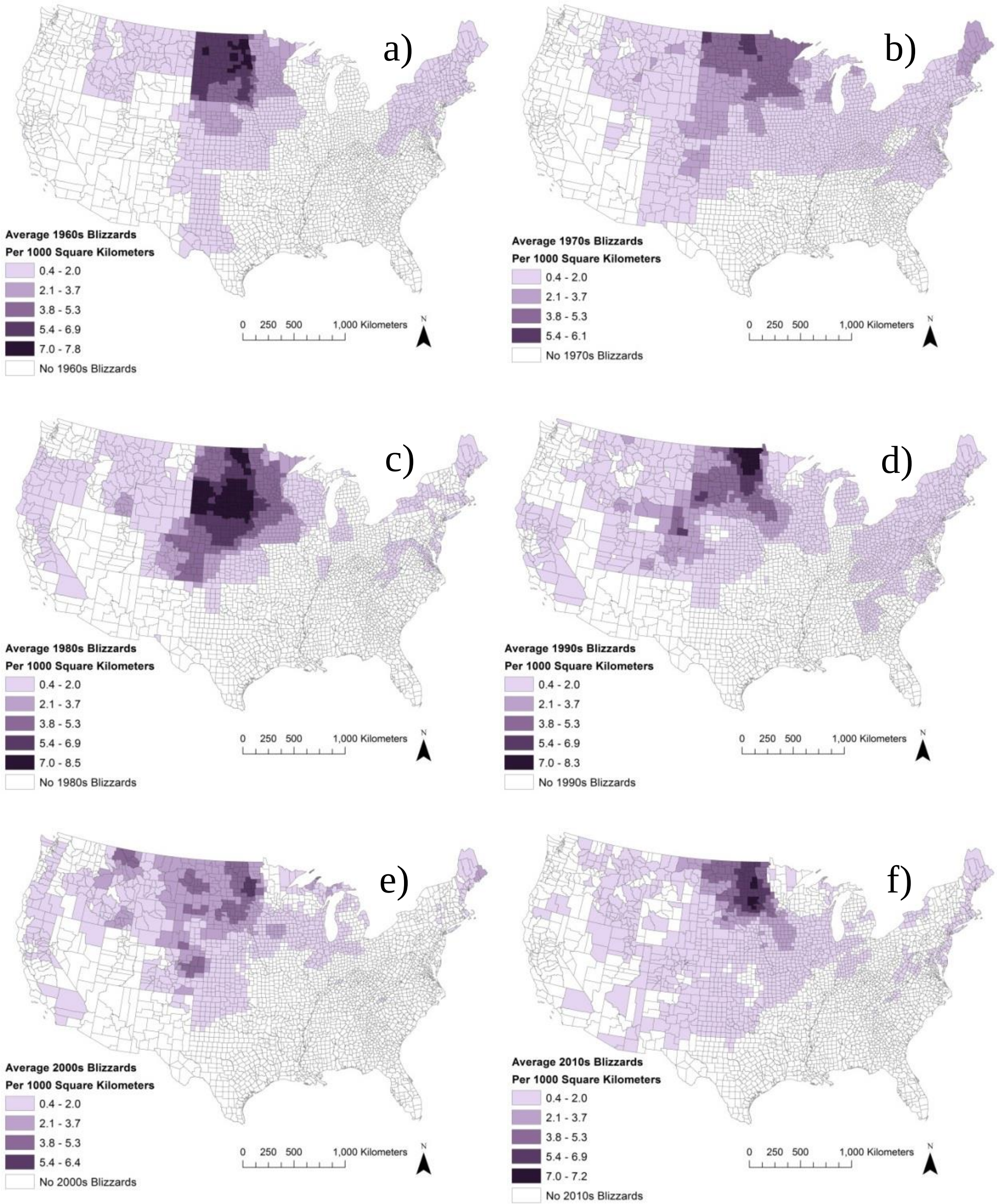

Figure 3. Average number of blizzards per 1000 sq. km2 (similar as Figure 2) for the 1959/60 through 2013/2014 seasons subdivided by decade: a) 1960s; b) 1970s; c) 1980s; d) 1990s; e) 2000s; f) 2010s. Note: the 2010s comprise the years 2010 through 2014.

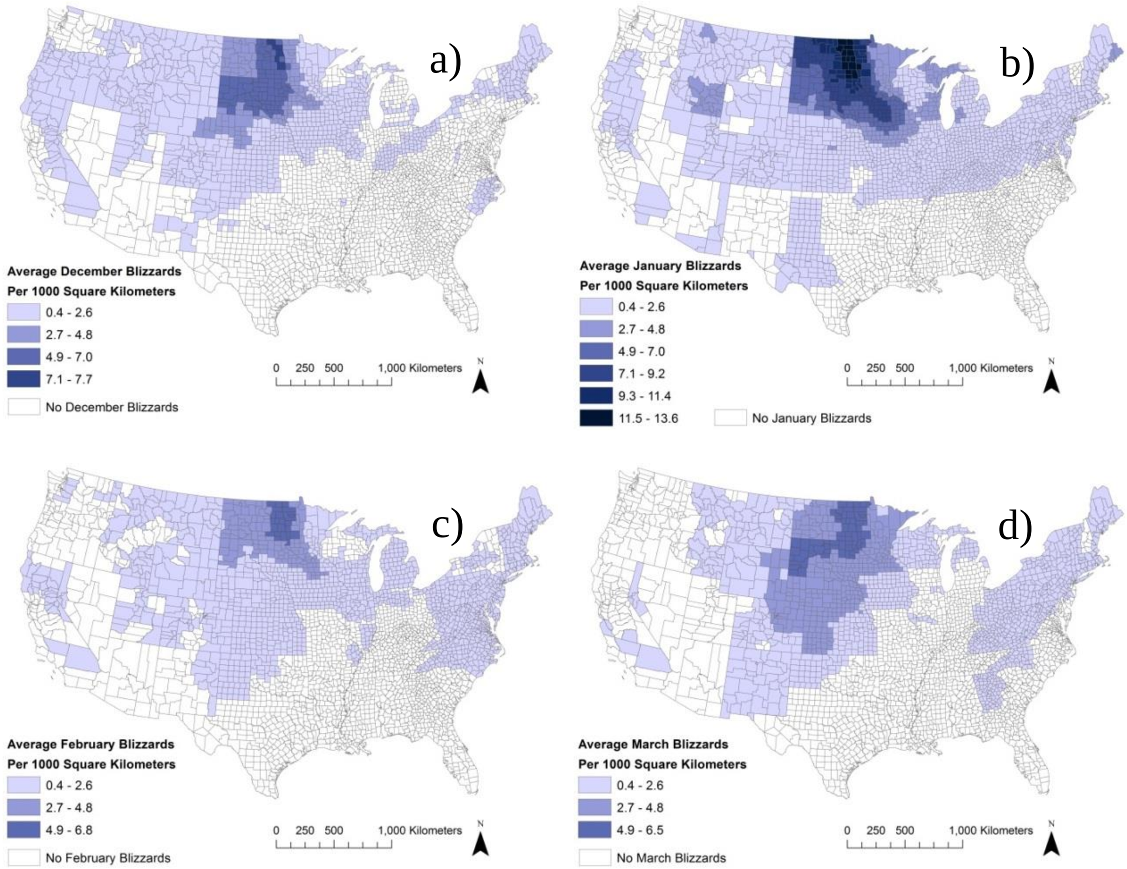

Figure 4: Average number of blizzards per 1000 sq. km^2 (similar as Figure 2) for the 1959/60 through 2013/14 seasons for the more active blizzard months a) December; b) January; c) February; and d) March.

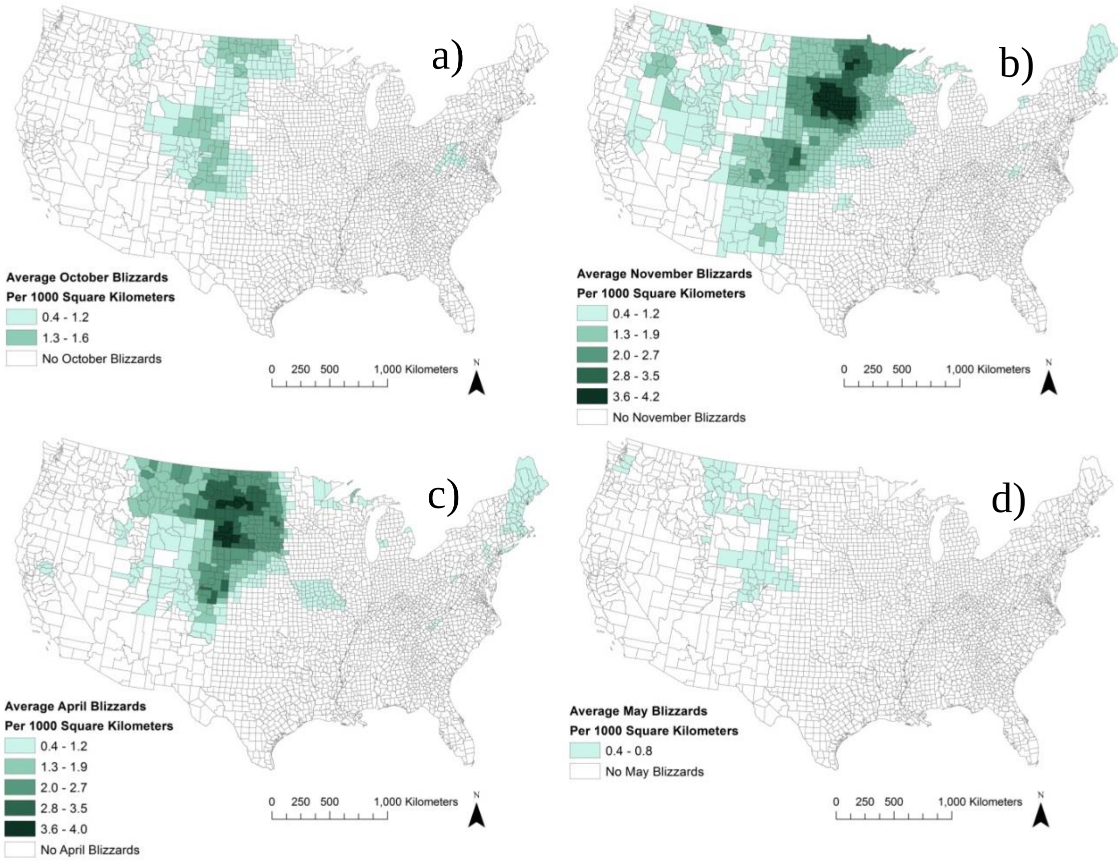

Figure 5. Average number blizzards per 1000 km^2 for the 1959/60 through 2013/14 seasons for the less active blizzard months: a) October; b) November; c) April; and d) May.

DISCUSSION AND CONCLUSIONS

A blizzard climatology for the conterminous United States was developed by updating and expanding upon the initial methodology outlined in SS2002. Using the SD and the NCEI Storm Event database for the 1959/60 to 2013/14 winter seasons (n = 55), blizzard events totaled 713 and annually averaged 13. Observations indicated a strong positive trend in annual blizzard frequency, especially in the 2000s as highlighted by the 2007/2008 season that recorded 32 blizzards. A potential explanation for the generally larger annual blizzard counts since the 1990s may be an artifact of greater consistency in common blizzard terminology and reporting parameters; NWS modernization and blizzard detection capabilities; and increased spatial precision from smaller forecast zones and/or geographically specific narratives. Investigations into the physical mechanisms of these patterns, including any climate change implications, are needed.

The revised dataset highlighted a discernable cycle in annual blizzard frequency, peaking approximately every 11-14 years with a secondary peak every 4 years. A spectral analysis revealed the peaks not to be statistically significant; the result is not unexpected given the relatively short data record. The noticeable blizzard cycles may also just be an artifact of the data and methodology employed. Additional analysis (e.g., storm track variability, 11- year sunspot cycles) is needed to understand the apparent blizzard periodicity that occurs independently of the positive trend in blizzard counts.

While annual blizzard counts have increased substantially in the past two decades, the average area covered by blizzard events displayed a marked decrease; however, a regression analysis showed the trend to be insignificant. The average size of a blizzard event across the entire study period was 83,474 km^2 or approximately the size of South Carolina, a nearly 50% reduction in the average blizzard size of 150,492 km^2 reported in SS2002 for the 1959/60 to 2000/01 period. Between the 1990/91 and 2013/14 winter seasons, blizzard events averaged only 61,088 km^2 while pre-modern era (1959/1960 to 1989/90) blizzard events averaged 79,811 km^2. Yet, a two-tailed t-test between the pre-modern era (n = 30) and post-modern era (n =25) was not statistically significant (α = 0.05).

Future research will focus on examining the physical mechanisms for the trends and large interannual variability in blizzard events. The synoptic circulation characteristics associated with the geographic distribution and frequency of blizzards will be investigated, particularly the prevailing storm track position in relation to changing blizzard activity. Teleconnection patterns (e.g., the Pacific-North American pattern, North Atlantic Oscillation, Arctic Oscillation) and other sources of climate variability will also be examined for potential linkages.

ACKNOWLEDGMENTS

The authors would like to thank Candace Boren and Nicholas Eckstein at Ball State University for assistance with the GIS data compilation.

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