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Geography of Blizzards in the Continental United States, 1978–1999

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ABSTRACT

Many individuals think of tornadoes and hurricanes when considering weather-related storms. However, in both 1996 and 1997, winter weather was the second most fatal category behind floods in the United States. Winter storms have potential impacts on millions of people and effects on the social landscape, such as fatalities, injuries, and economic consequences. This study examined the climatology of blizzards in the continental United States from 1978 to 1999, utilizing data from *Storm Data* to identify the areal extent and temporal trends. Additionally, effects of blizzards on the social landscape were analyzed to ascertain the affected population, population centers, transportation networks, and disaster areas. Maps were produced utilizing a Geographic Information System (GIS) to summarize regional differences and temporal trends. Finally, a perception study from respondents in various United States regions was conducted utilizing a survey to determine whether there are different definitions of a blizzard as compared to the official definition from the National Weather Service (NWS).

Key words: blizzards, climatology, hazards geography

INTRODUCTION

When most individuals think of severe weather-related storms, the majority have visions of thunderstorms, tornadoes, and hurricanes. Some of the weather-related phenomena that affect society are floods, hurricanes, extreme temperatures, thunderstorm-related events, droughts, and winter storms (Kunkel et al. 1999). This study concentrated on blizzards, the most extreme form of winter storms.

Research objectives

The wide and severe economic and societal impacts associated with blizzards demonstrate the four main objectives addressed by this research. The first objective was to establish a 40-year climatology of blizzards to identify any patterns from both spatial and temporal perspectives. A second goal was to verify whether there is a correlation of the number of blizzards associated with a teleconnection as the El Niño phase. The third objective was to examine the segments of the

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social landscape that are affected by blizzards and the impacts on infrastructure such as interstate highways, airports, population in affected counties, number of fatalities, number of injuries, economic damages, and number of federally declared disaster areas. The final objective was a perception study to determine whether people know what constitutes a blizzard and whether people in different states have definitions that vary from the official definition established by the National Weather Service.

Subject relevancy

The National Weather Service summarizes deaths, injuries, and damage costs attributed to various weather events. Based on NWS statistics from 1988 through 1995, it may appear that winter storms have less societal impact than convective storms, tropical cyclones, heat waves, floods, drought, and cold waves. This period recorded total damage estimates of $114 billion with slightly over $3 billion, or less than 3% of the total, from winter storms. Two events in that time period, Hurricane Andrew in 1992 and the flooding of the Mississippi River in 1993, accounted for about half of the total damage. Winter storm fatalities were about 9% of the total and injuries accounted for around 20% of the total during the same time period (Kocin 1997). However, winter weather was the second most fatal category behind floods in both 1996 and 1997 (NWS 1996, 1997). There are potential impacts on millions of people and significant economic costs associated with these storms as evidenced by the March 1993 Superstorm and the January 1996 blizzard (Kocin 1997). These two events affected the daily routine for nearly 100 million people over the time period of several days to more than a week. The 1993 Superstorm damage estimates range from a conservative $1 billion to $6 billion according to newspaper reports. According to the NWS report (NWS 1994), there was over $2 billion in damages associated with the 1993 Superstorm while the 1996 blizzard caused insured losses of over $500 million. These costs are primarily from wind and water damage and do not include costs such as the economic impact of lost revenues and public cleanup (Kocin 1997). *Weatherwise* (Henson et al. 1999) recently rated the 20th century's top ten United States weather and climate events with one winter storm in the top ten and four winter storm events listed in the seven honorable mentions.

Winter weather can spread hazardous conditions as it moves from county to county or one state to another. Whether the storm hits the Pacific Northwest, Rocky Mountains, Great Plains, Midwest, or the Northeast, winter storms can create dangerous situations for large numbers of the American population. Blizzards are considered the most dangerous of winter storms, as they combine very cold temperatures with strong winds and blowing snow (NWS 1999a,b).

Blizzards

Blizzards are the most extreme form of winter storms and thus pose the greatest hazard to society from this type of phenomena. Blizzards are defined as large amounts of falling or blowing snow with winds in excess of 35 mi h^{-1} (15 m s^{-1}), visibility of less than 1/4 mi (0.4 km), for a minimum of three hours (American Red Cross 1999; Branick 1997, 1999; NSIDC 1999; NWS 1999b,c,d). However, a previous definition from the U.S. Weather Bureau (now the NWS) stated

that winds were greater than 28 knots, temperatures less than or equal to 20°F, and visibility not greater than 500 ft (Black 1971, United States Air Force 1978).

Blizzards are often accompanied by low temperatures (usually below 20°F) and are severe when temperatures are around or below 10°F, winds more than 45 mph, and visibility is near zero (Weather Channel 2000). The previous description of a severe blizzard included temperatures no greater than 10°F, winds greater than 39 knots, and visibility 100 ft or less due to falling snow and/or either blowing or drifting snow (Black 1971, United States Air Force 1978).

One of the first individuals to use the term "blizzard" was mariner Henry Ellis who wintered over on Hudson Bay in 1746. He described a storm with strong northwest winds and intense cold that was filled with fine, hard particles of snow (Black 1971).

In the 13-year period from 1982 to 1994, there were 1661 winter weather events in the contiguous United States. Of these 1661 events, 167 were blizzards, comprising about 10% of the total events and giving an annual mean of 13 blizzards (Branick 1997).

METHODOLOGY

Blizzard climatology

There were several attempts to locate an archive of blizzard warnings to study warnings issued in the United States. Sources attempted to find this database included contacts at NOAA, forecasters with the NWS, Storm Prediction Center, National Climatic Data Center, Midwest Climate Center, U.S. Army Topographic Engineering Center, and the author of the "Snow Booklet" (Doesken and Judson 1996). It was determined there was no database of blizzard warnings issued in the United States.

In the absence of data on blizzard warnings, the occurrence of blizzards during 1959–1999 will be assembled using the monthly publication *Storm Data (SD)* from the National Climatic Data Center (NCDC). While not a perfectly reliable dataset, *SD* is the best source of blizzard data since no database exists exclusively for this type of meteorological event. Branick (1997, 1999) reported that "*SD* is perhaps the only unified source of data on *all* types of hazardous winter weather events."

Monthly *SD* publications from 1959 to 1999 were reviewed for "character of storm" titles referencing blizzards. Issues from 1959 to 1999 are available in hard copy while 1994–1999 issues are accessible on the Internet from NCDC's web site (NCDC 1999). It is estimated that about 500 blizzards will be analyzed in the study. A study has been completed for 1978–1999. Spot checking to verify accuracy of Internet data was completed and found no discrepancies from the paper copies.

After compilation of the blizzard events by date, state, and county, the data will be entered on tables. This will enable analysis to show the spatial extent of each blizzard in a table or map format for the county level and state level. Additionally, these data will assist with the compilation of spatial and descriptive statistics to analyze the climatology of blizzards in the study period. Frequency by county and state will also be determined and summarized by tables or maps. The date of occurrence within the winter season will be determined and summarized for the United States and regions to provide seasonal and regional variability in blizzard occurrences. Finally, a time series analysis will be conducted to examine any changes in blizzard frequency or extent over the 40-year period. Maps and tables will be generated for each individual blizzard event. A summary will be made for each year, decade, and the entire study period.

Teleconnections

To study teleconnections, the ENSO index will be utilized from the Climate Prediction Center (CPC 1999) to compare the number and location of blizzards associated with different El Niño/La Niña events. This method utilizes a classified ENSO intensity category along with neutral periods. The dates of blizzards will be compared with the type of ENSO classification to see if there are any correlations using a regression equation for statistical analysis.

Effects of blizzards on the social landscape

Population

The population in counties affected by each blizzard during 1959–99 will be extracted from United States Census data. Population data will use 1960 data for events in the 1960s, 1970 data for 1970s events, 1980 for 1980s events, and 1990 data for events in the 1990s. These will be totaled to identify the total population affected by each blizzard and compilations will be illustrated on tables or maps. Summarization will display regional differences and temporal trends of the population affected by the blizzards. This will be analyzed to show population affected by blizzards by month and region over the 40-year time series with maps and tables for annual, decade, and total study temporal periods.

Transportation infrastructure

Transportation networks such as commercial airports and interstate highways will also be variables on the tables. The total miles of interstate highways in each county will be tallied in each blizzard area and analyzed by month, region, and across time to assess impacts on highway travel. In the case of interstates added during the study period, primary Federal highways will be utilized. Additionally, commercial airports in each county will be summarized in the same blizzard areas. Commercial airports are defined as airports with passenger enplanement data or cargo activity listed by the Federal Aviation Authority (FAA) statistics for calendar year 1998. This will help illustrate the extent of blizzard impacts by showing airports and interstates affected by blizzard events.

Social and economic impacts

SD lists fatalities, injuries, property damage, and crop damage for all storms. These data will be analyzed and summarized for regional and temporal patterns for each county in the blizzard areas. Dollar damage will be described in standardized dollars adjusted by the Consumer Price Index from the Department of Labor.

Declared disaster areas data will be obtained from FEMA to be associated with the blizzard event. The list of declared disaster or emergency areas will be summarized for comparison to the blizzards. These areas will also be displayed on tables or maps. Damage amounts available from FEMA will be compared to damage statistics from *SD*.

Comparative perception of the definition of a blizzard

The main questions of this portion of the study are 1) Do people really know what components constitute a blizzard?; 2) Do people in different states have different perceptions of the definition?; and 3) How do these definitions vary from the official definition established by the National Weather Service? This was accomplished by a self-administered closed-ended survey.

PRELIMINARY RESULTS

Since this is ongoing research, only a portion of the results are available at this time. This consists of a pilot survey and the climatology from 1978 to 1999.

Pilot survey study

Two survey instruments were developed utilizing the open-ended and close-ended technique for a pilot study administered to the author's "Introduction to Geography" students in a classroom exercise. Questions included perceptions of other hazzards such as tornadoes, hurricanes, floods, and drought in comparison to blizzards. Eighty-two respondents answered the questionnaire with 41 receiving an open-ended survey and 41 students receiving the close-ended survey. After examining the surveys, it was determined that the close-ended instrument would be most effective to answer the questions. Survey results were entered into SPSS for descriptive statistics used in analysis. Future survey results will also include appropriate statistical testing.

It is acknowledged that utilizing students as respondents has limitations, but this method will be the most efficient way to obtain a broad, geographic sample. Other methods were considered but because of financial and locational restraints, they were eliminated. There is a presumption of self-selection using students, but they are also individuals that may influence policy in the future.

Survey results indicate accuracy of blizzard definition perceptions and the regional variability of that perception. It also examined other variables such as preparedness, perceptions of other hazards, and demographic information such as home state, age, education, and previous experiences with blizzards.

Most respondents knew that a blizzard has snow and wind components but results were mixed in the actual characteristics. Of the open-ended survey respondents, 95.1% indicated a snowfall component but none mentioned a rate compared to the close-ended survey where 17.1% indicated 1/2"/hour, 73.2% 1"/hour, and 9.8% checked any type of snowfall.

Of the open-ended responses, 43.9% mentioned a temperature component in comparison to 65.9% of close-ended responses. The temporal component was not mentioned by 87.8% from the open-ended group while only 41.5% selected that option from the close-ended cohort. Visibility was not mentioned by 63.4% from the open-ended responses in comparison to only 9.8% of the close-ended responses. Finally, only 14.6% of the close-ended group thought there was no wind component while 43.9% of the open-ended respondents did not mention wind.

Climatology

Between 1978 and 1999, 265 blizzards occurred. The least amount was three blizzards in 1981 and the largest number was 28 events in 1996. This amounted to a mean of 12.05 blizzards per year and a median number of 11.50 blizzards per year. Figure 1 displays the number of blizzards per calendar year.

Figure 1. Number of blizzards, 1978–1999.

During the 22-year period, South Dakota had the majority of blizzards with 62, followed by North Dakota (52), Minnesota (49), Nebraska (46), and Wyoming (38) to round out the top five states. However, South Dakota led the nation during the 1980s, but Minnesota had the majority of events during the 1990s.

During the 1980s, South Dakota had 34, while Nebraska followed with 31, North Dakota with 21, Minnesota with 17, and Colorado with 13 (Fig. 2). In contrast during the 1990s, Minnesota had 32 blizzards, North Dakota (27), South Dakota (26), Wyoming (26), and Montana had 19 (Fig. 3). Two major events, the 1993 “Storm of the Century” and the 1996 blizzard in January, constituted most of the events for other states (Kocin 1997; NCDC 1999; NOAA 1993, 1996; Rosenfeld 1999).

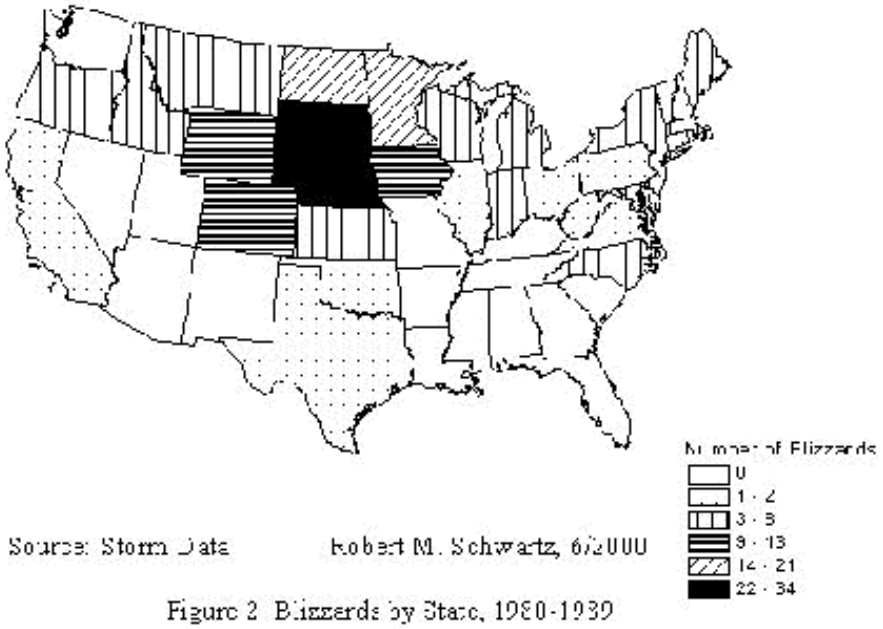

Figure 2 Blizzards by State, 1980-1989

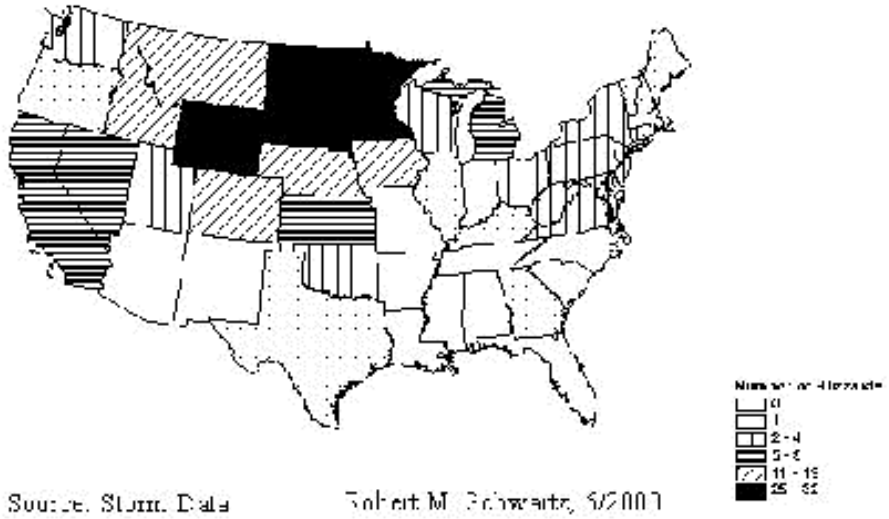

Figure 3. Blizzards by State, 1990-1999

SUMMARY

This research is expected to add to the knowledge and literature regarding blizzards. A pioneering 40-year climatology of blizzards will identify any patterns from spatial and temporal perspectives on this important natural hazard. The database will prove helpful to future research regarding blizzards. The maps and tables generated will illustrate the counties and states where blizzards occurred. Summaries will be made for each year, decade, and the entire study period, and a time series analysis will place these results in the context of climate change by examining trends.

The teleconnection of ENSO to blizzards will be compared to blizzards on an annual, decade, and 40-year basis. This can also be related to the general context of climate change by observing relationships between ENSO and blizzards for trends as other research has examined the number of winter cyclones or hurricanes compared to ENSO.

Effects of blizzards on the social landscape will analyze and summarize impacts on people and the selected infrastructure to determine the extent of social impacts from blizzards. It is necessary to establish the climatology in order to measure these impacts.

The perception study will determine regional differences in perceptions of blizzards, their impacts, and their definitions. This can potentially help the NWS in describing the potential dangers to the public when a blizzard warning is issued.

This study is an integrated approach that takes into account the physical (climatology and teleconnections) and social (impacts on humans) aspects of a natural hazard—the blizzard.

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