The University of Georgia

Assessment of Indirect Fatalities from Winter Precipitation

Alan W. Black
Department of Geography, University of Georgia, Athens, GA

Introduction

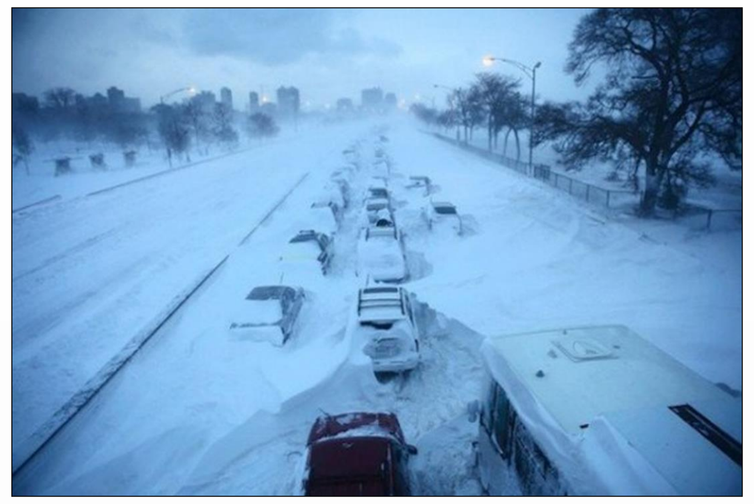

Figure 1. Vehicles stranded along Lake Shore Drive in Chicago, IL during the 1-2 February 2011 event called "Snowpocalypse." Chicago O'Hare International Airport received over 20 inches of snow during the event.

Winter precipitation such as snow, sleet, and freezing rain is a hazard that can have a disruptive effect on human lives. One of the greatest impacts of winter precipitation is on travel. Poor road conditions and reduced visibility during winter precipitation can lead to automobile accidents, while reduced visibility or flight through winter precipitation can lead to aircraft crashes.

Previous research has estimated that 30-40 (Changnon 2007) or as many as 70 (Borden and Cutter 2008) fatalities a year can be attributed to winter storms. However, these studies have only considered what are termed as "direct" fatalities, where the storm is a direct agent in the death (NOAA 2007). However, a much larger number of winter precipitation fatalities are "indirect," where the weather created a situation that led to the death (NOAA 2007).

This distinction is important as *Storm Data*, the publication of the National Weather Service (NWS) that records weather injuries and fatalities, only includes direct fatalities (NOAA 2007). This study seeks to paint a more complete picture of winter weather hazards by addressing indirect fatalities due to winter precipitation related transportation accidents and comparing these accidents to mortality information from *Storm Data*.

Methodology

Information on fatal vehicle accidents in the conterminous U.S. was gathered from the National Highway Traffic Safety Administration's (NHTSA) Fatality Analysis Reporting System (FARS) for the years 1975-2011. To isolate the fatalities which were related to winter precipitation, each annual FARS file was searched for coded weather variables that indicate the weather at the time of the crash. Fatalities and accidents due to winter precipitation were extracted from the FARS data for further analysis.

Data on fatal aircraft accidents in the conterminous U.S. was gathered from the National Transportation Safety Board's (NTSB) Aviation Accident Database for the years 1975-2011. The NTSB database contains information about aviation accidents from 1962 to present and lists the circumstances and cause of the each accident. For each event, the accompanying narrative was read to determine if winter precipitation was involved in the accident. If winter weather was involved, the accident was included in subsequent analysis.

Fatalities for both automobile and aviation events were aggregated by counties due to a lack of more precise location data within the automobile accident data. A geographic information system (GIS) was used to reveal the spatial patterns of these events and fatalities. Mortality rates were calculated to explore the effect of population on the spatial pattern of fatalities and to compare the number of expected deaths due to winter precipitation to the actual number of deaths were observed. Age-adjusted death rates were calculated using direct standardization techniques based on winter precipitation related automobile fatalities and the population by age group within each state. An empirical Bayes transformation was used to address the "small number problem" – variation in rates attributable to the small population of some counties (Lawson 2001). The standardized mortality ratio (SMR) was then calculated for each county by dividing the observed number of fatalities by the expected number of fatalities. SMR values greater than one indicate that the death rate in a particular area was higher than that of the standard population (Wilson and Buescher 2002). Finally, contiguous areas of elevated mortality were identified using the local Moran's I statistic (Borden and Cutter 2008; Anselin 1995).

Results

Spatial and Temporal Analysis of Fatalities

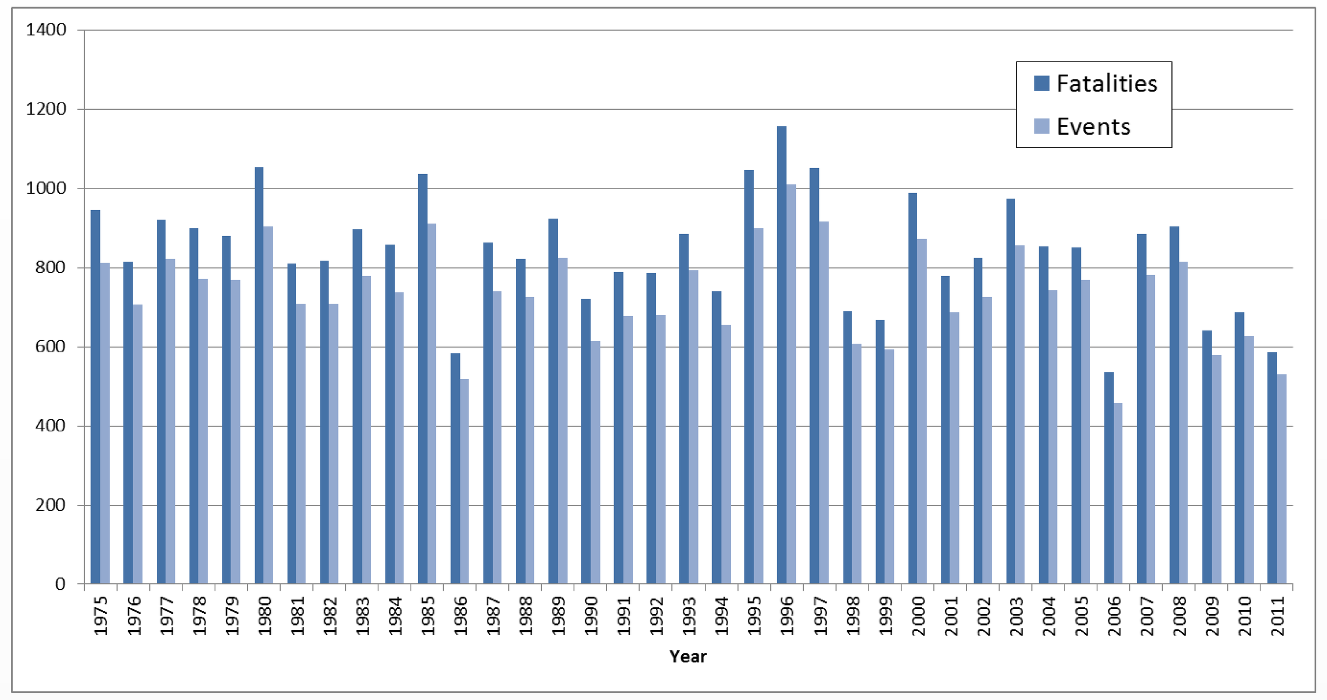

Figure 2. Number of winter precipitation related automobile fatalities (dark blue) and fatal vehicle accidents (light blue) by year, 1975-2011.

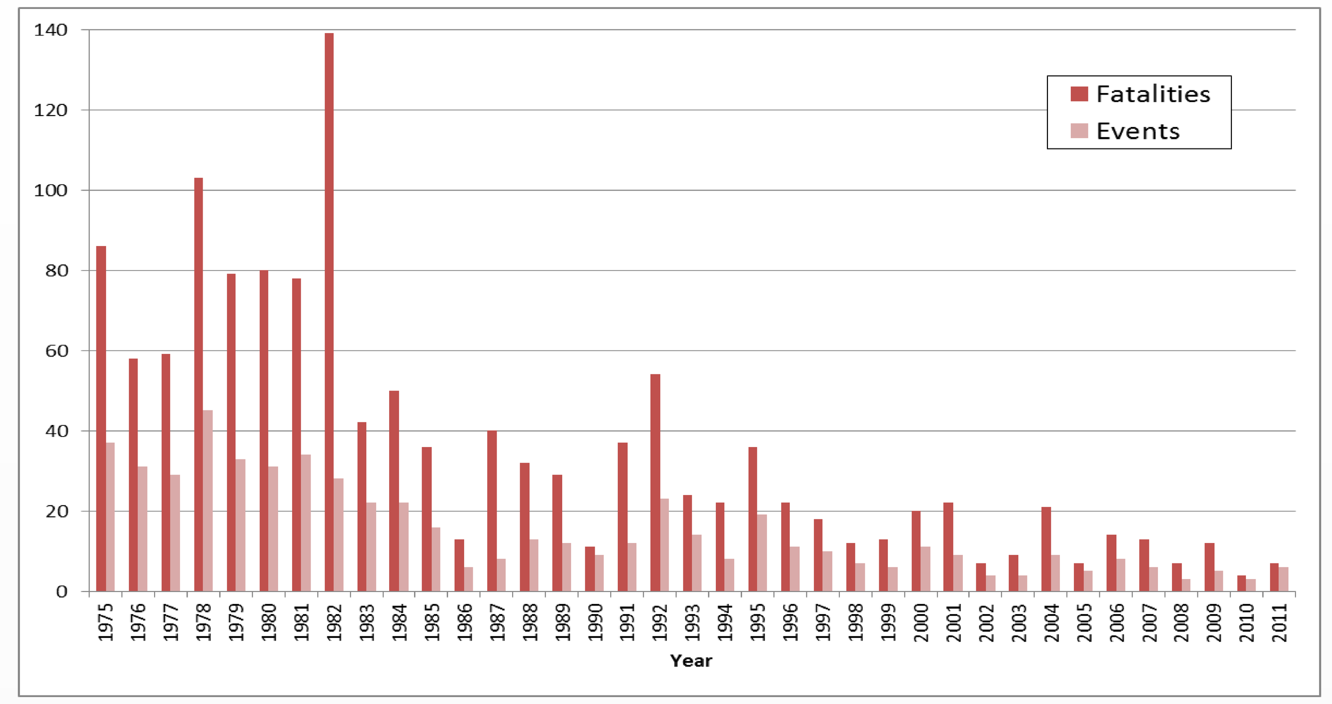

Figure 3. Number of winter precipitation related aircraft fatalities (dark red) and fatal aviation accidents (light red) by year, 1975-2011.

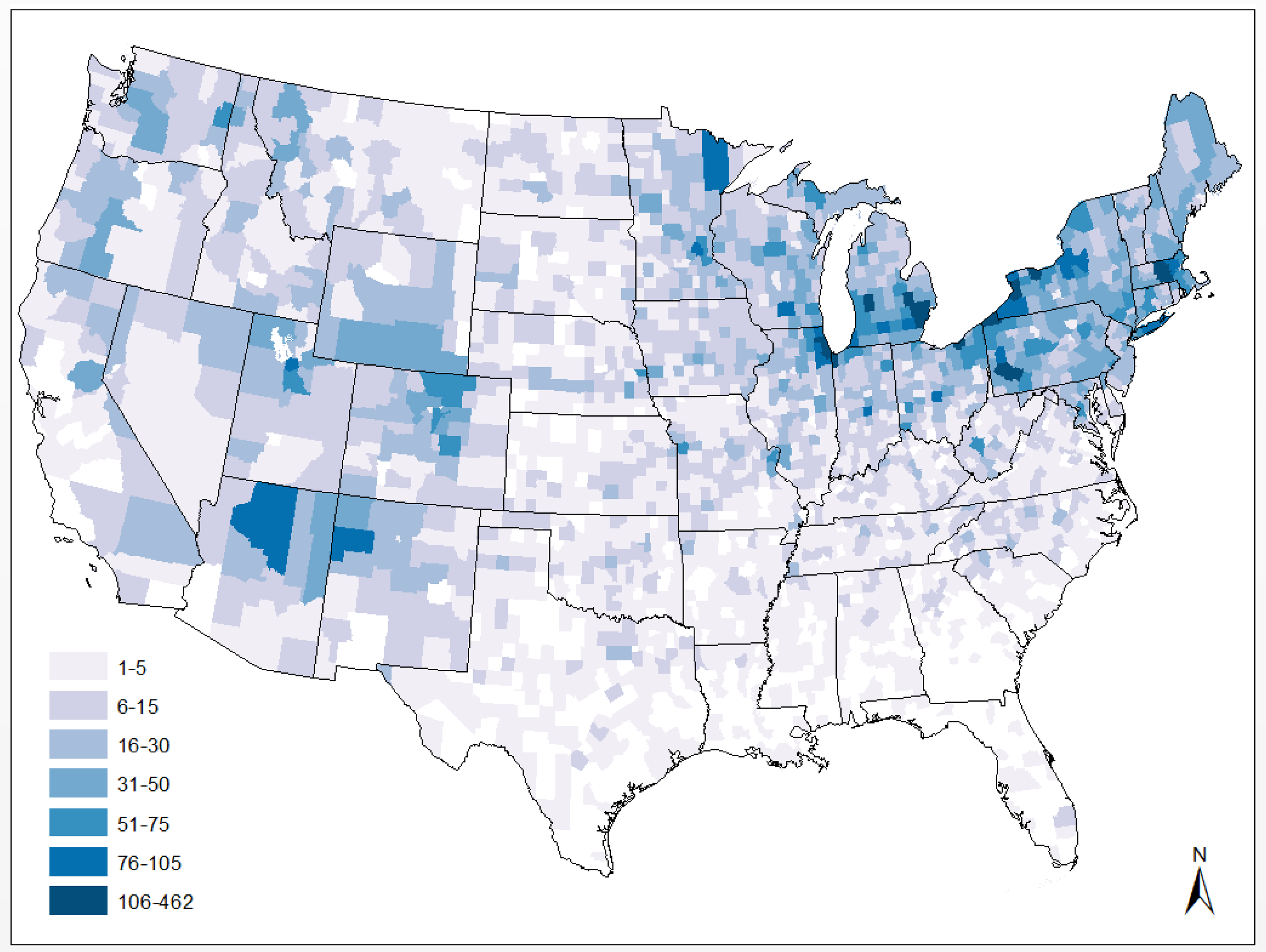

Figure 4. Number of winter precipitation related automobile fatalities by county, 1975-2011.

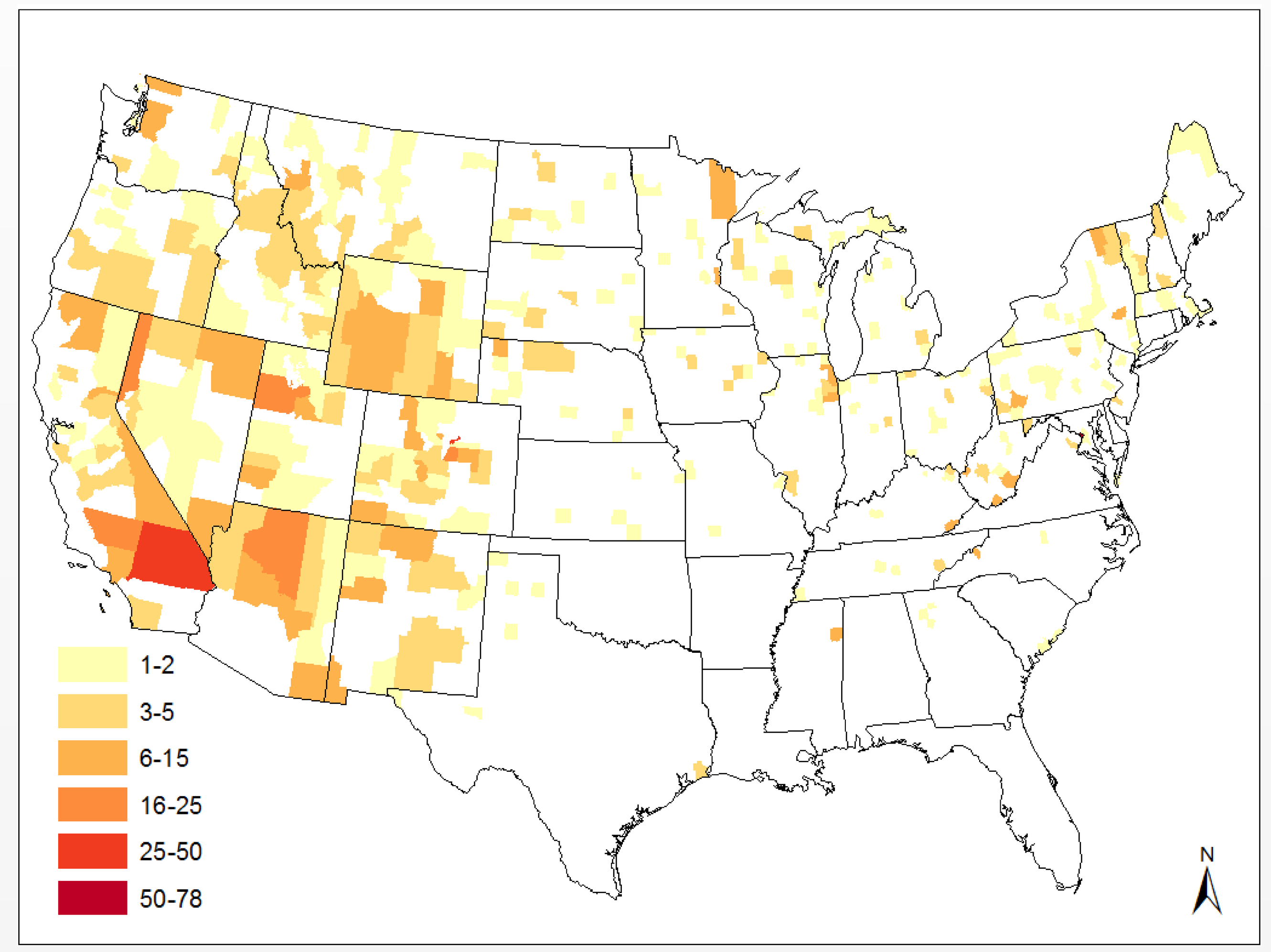

Figure 5. The number of winter related aviation fatalities by county, 1975-2011.

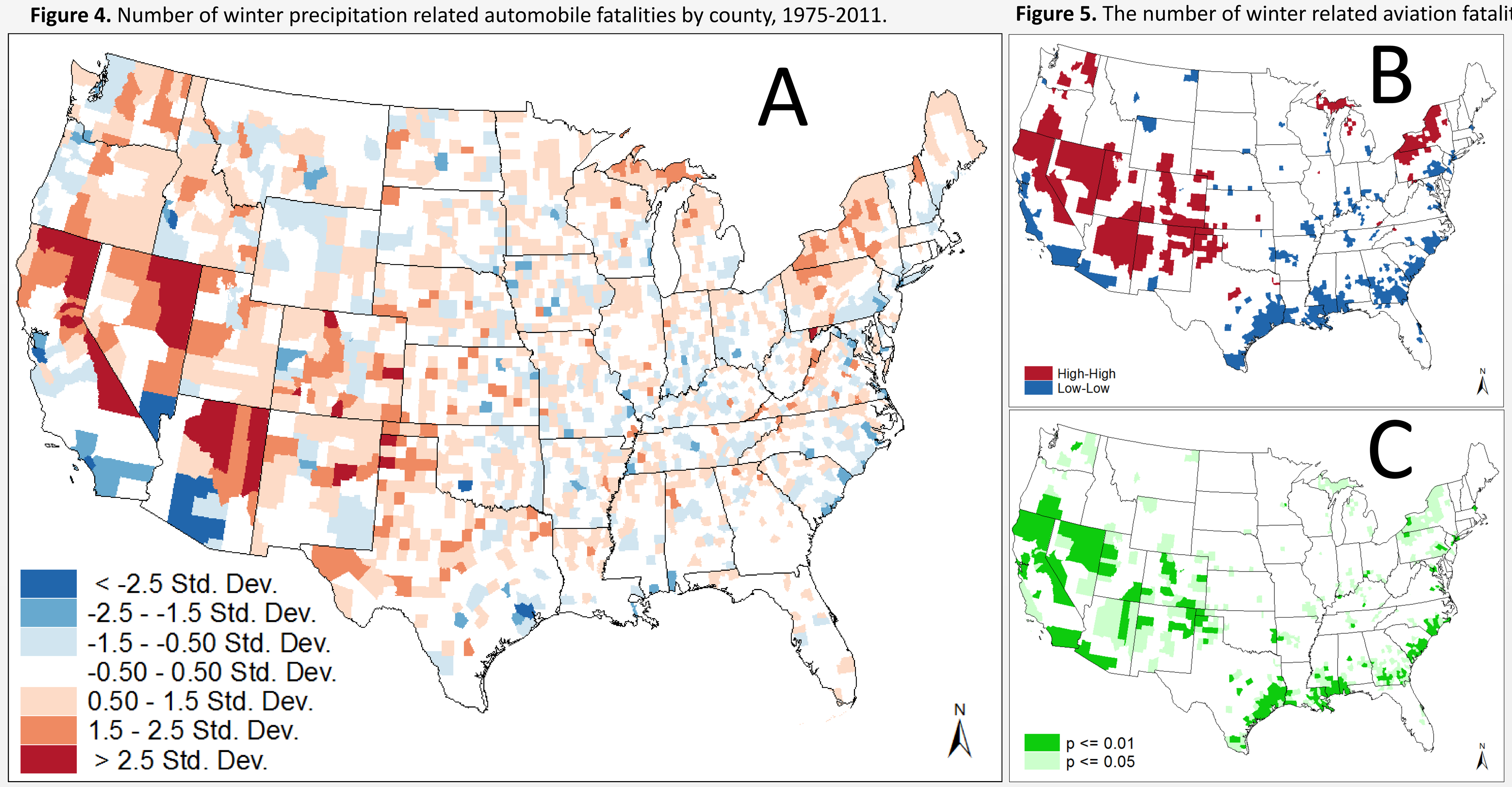

Figure 6. A) County-level Standardized Mortality Ratio (SMR) for winter precipitation related automobile fatalities. SMR calculated using age-adjusted mortality ratios using empirical Bayes procedure and log transformed. Positive (negative) values indicate areas where the SMR was higher (lower) than the mean and that saw higher (lower) than expected mortality.

B) County-level SMR clusters of winter precipitation related automobile fatalities, 1975-2011 identified using the local Moran's I statistic. High-High indicates areas where high SMR values are near other high SMR values. Low-Low indicates areas of low SMR near other low SMR values.

C) Significance levels of SMR clusters from winter precipitation related automobile fatalities, 1975-2011.

Results

Comparison with *Storm Data*

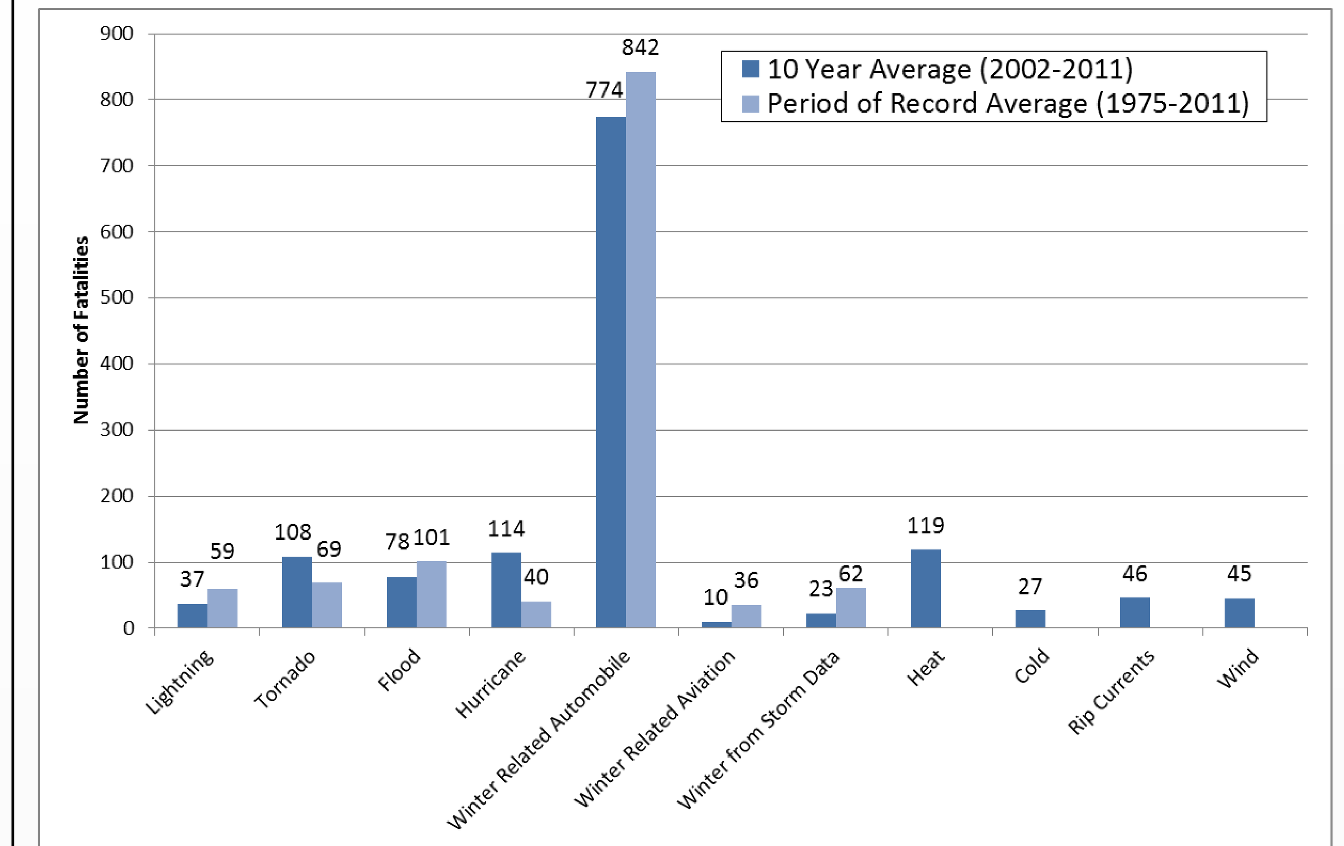

Figure 7. The number of fatalities from various meteorological hazards for the ten year period 2002-2011 (dark blue) and for the period 1975-2011 (light blue). Fatality totals for all hazards except winter related automobile and winter related aviation are derived from *Storm Data*. While Storm Data is intended to capture direct fatalities due to weather and fatalities from automobile and aviation accidents are classified as indirect, it is important to compare these datasets to better understand the limitations of using Storm Data (or any dataset) when examining hazard losses.

Conclusions

- Between 1975-2011, winter precipitation caused nearly 28,000 aviation and automobile accidents and over 32,000 fatalities.
- There was little discernable annual trend in winter precipitation related automobile fatalities. In contrast to automobile fatalities, aviation fatalities did follow a declining trend during the 1975-2011 period.
- Fatal automobile accidents are most commonly found in the Northeast, Great Lakes, and western U.S. where snowfall and/or freezing rain is most common and large numbers of motorists are exposed to winter precipitation.
- Age-adjusted standardized mortality ratios reveal significant clusters of increased mortality in the western U.S. and areas of New York and Pennsylvania.
- Most fatal winter precipitation related aircraft accidents occur in the western U.S.
- While this study found over 32,000 fatalities due to winter precipitation during the period, *Storm Data* only contained 2,200 winter fatalities due to the exclusion of vehicle fatalities which are considered to be indirect.
- Users of *Storm Data* must understand that omitting indirect fatalities results in an underestimation of the number of deaths caused by winter weather. Reduction of mortality due to winter precipitation (or any hazard) requires an understanding of all fatalities, both direct and indirect. The author echoes the call of Gall et al. (2009) for an open, comprehensive dataset of hazard losses which focuses on accurate counts of losses, both direct and indirect, from all hazards.

References

Anselin, L., 1995: Local Indicators of Spatial Association – LISA. *Geogr. Anal.*, **27**, 93-115.
Borden, K., and S. Cutter, 2008: Spatial patterns of natural hazards mortality in the United States. *Int. J. Health Geog.*, **7**.
Changnon, S.A., 2007: Catastrophic winter storms: An escalating problem. *Clim. Change*, **84**, 131-139.
Gall, M., K.A. Borden, and S.L. Cutter, 2009: When do Losses Count? Six Fallacies of Natural Hazard Loss Data. *Bull. Amer. Meteor. Soc.*, **90**, 799-809.
Lawson, A.B., 2001: Tutorial in Biostatistics: Disease map reconstruction. *Stat. Med.*, **20**, 2183-2204.
National Oceanic and Atmospheric Administration, 2007: National Weather Service Instruction 10-1605, Storm Data Preparation. [Available online at http://www.weather.gov/directives/sym/pd01016005curr.pdf.]
Wilson, J.L., and P.A. Buescher, 2002: Mapping Mortality and Morbidity Rates. In Statistical Primer No 15 Volume 2008. Raleigh, NC: North Carolina Department of Health and Human Services.

Contact Information

Alan W. Black, Department of Geography, University of Georgia, 210 Field St., Athens, GA 30602.
E-mail: awblack@uga.edu