Winter Storm

A winter storm event occurs resulting in direct economic losses of $1 billion or greater.[1]

Data Summary

Category	Description	Metric	Low	Best	High
Health and Safety	Fatalities	Number of Fatalities	0[2]	50[3]	270[4]
	Injuries and Illnesses	Number of Injuries or Illnesses[5]	0	1,700	14,000
Economic	Direct Economic Loss	U.S. Dollars (2011)[6]	$1 Billion	$3.1 Billion	$9 Billion
	Indirect Economic Loss	U.S. Dollars (2011)	N/A		
Social	Social Displacement	People Displaced from Home ≥ 2 Days	N/A		
Psychological	Psychological Distress	Qualitative Bins	N/A		
Environmental	Environmental Impact	Qualitative Bins	N/A		
LIKELIHOOD	Frequency of Events	Number of Events per Year	0.125	0.56	2

Event Background[7]

The SNRA Winter Storm national-level event was originally developed by the DHS Office of Policy for the 2012–13 Homeland Security National Risk Characterization (HSNRC) project.[8] The original HSNRC data and analysis were expanded and revised for the 2015 SNRA by project staff from Argonne National Laboratory and FEMA.

The 2015 SNRA considered winter storms, including blizzards, snow storms, and ice storms, together with freezes and other periods of unusual and extremely cold temperatures hazardous to life and agriculture, within the scope of this event.[9]

[1] For the purposes of the SNRA, the Winter Storm event includes snow storms, ice storms, freezes and other periods of extremely and exceptionally cold temperatures, and heavy snowfalls, but excludes snowmelt induced flooding which is counted in the SNRA Flood event.
[2] Minimum fatalities of the 19 billion dollar winter storm events in Table 2.
[3] Average number of fatalities in the 19 winter storm events in Table 2.
[4] Highest number of fatalities in the 19 winter storm events in Table 2.
[5] Estimated from NCDC Billion Dollar Disaster List, which does not report injuries or illnesses, by applying injury/fatality ratios from NCDC StormData events corresponding to the winter storm events of the primary data set. See Injuries for details.
[6] Low, average, and high reported direct economic loss of the 19 winter storm events in Table 2, converted from reported (2014) dollars to 2011 dollars.
[7] This section is substantially adapted from National Weather Service (2008, June), *Winter storms: the deceptive killers,* at http://www.nws.noaa.gov/om/winter/resources/Winter_Storms2008.pdf; National Weather Service (2003), *All about winter storms*; at https://web.archive.org/web/20040214012848/http://www.nws.noaa.gov/om/brochures/wintstm.htm (retrieved January 2014); Chapter 7, Federal Emergency Management Agency (1997), Multi-Hazard Identification and Risk Assessment (MHIRA): A Cornerstone of the National Mitigation Strategy: FEMA Mitigation Directorate, at https://www.fema.gov/media-library/assets/documents/7251?id=2214 (retrieved April 2013); and Federal Emergency Management Agency (2013, April 26). Emergency preparedness: secondary hazards associated with severe winter weather. Trend analysis, Lessons Learned Information Sharing (LLIS), at https://www.llis.dhs.gov/content/emergency-preparedness-secondary-hazards-associated-severe-winter-weather (retrieved January 2014).
[8] The HSNRC was a collaborative effort of the DHS analytic enterprise to expand the 2011 SNRA risk knowledge base to additional threats and hazards, and to adapt the SNRA to the information needs of DHS strategic planning. The HSNRC title for this event is Extreme Cold/Winter Weather.
[9] Snowmelt-induced flooding is treated within the scope of the SNRA Flood event.

Extreme cold and winter weather events produce extremely high winds that can create blizzard conditions with wind driven snow, drifting, and dangerous wind chills. Heavy snow accumulations can immobilize a region and paralyze a city, strand motorists, stop the flow of supplies, and disrupt emergency services. Heavy snows can also create the opportunity for avalanches in mountainous regions. Heavy ice accumulations can bring down trees, utility poles and lines and communication towers. Extreme cold temperatures can cause potentially life-threatening conditions such as hypothermia and frostbite. These below-freezing temperatures can damage vegetation and crops and cause water pipes to burst. The melting of significant snow accumulations and ice flow can produce major widespread flooding of rivers and low areas, resulting in potential environmental impacts and substantial damage to property, businesses, transportation infrastructure, and farmland.

Winter storms can be snowstorms and other types of weather associated with winter storms that can be extremely hazardous. These include storms with strong winds, ice storms, extremely cold temperatures, and heavy snow.

- **Storms with strong winds:** Winter storms can be accompanied by strong winds creating blizzard conditions with blinding wind-driven snow, severe drifting, and dangerous wind chill. Strong winds with these intense storms and cold fronts can knock down trees, utility poles, and power lines. Storms near the coast can cause coastal flooding and beach erosion as well as sink ships at sea.
- **Ice storms:** Heavy accumulations of ice can bring down trees and topple utility poles and communication towers. Ice can disrupt communications and power for days while utility companies repair extensive damage. Even small accumulations of ice can be extremely dangerous to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces.
- **Extreme cold:** Exposure to cold can cause frostbite or hypothermia and become life-threatening. Infants and elderly people are most susceptible. What constitutes extreme cold varies in different parts of the country.
    - In the South, near freezing temperatures are considered extreme cold. Freezing temperatures can cause severe damage to citrus fruit crops and other vegetation. Pipes may freeze and burst in homes that are poorly insulated or without heat.
    - In the North, below zero temperatures may be considered as "extreme cold." Long cold spells can cause rivers to freeze, disrupting shipping. Ice jams may form and lead to flooding.
- **Heavy snow storms:** Heavy snow can immobilize a region and paralyze a city, stranding commuters, closing airports, stopping the flow of supplies, and disrupting emergency and medical services. Accumulations of snow can cause roofs to collapse and knock down trees and power lines. Homes and farms may be isolated for days and unprotected livestock may be lost. In the mountains, heavy snow can lead to avalanches. The cost of snow removal, repairing damages, and the loss of business can have severe economic impacts on cities and towns.[10]

[10] Adapted from National Weather Service (2008, June). *Winter storms: the deceptive killers*, at http://www.nws.noaa.gov/om/winter/resources/Winter_Storms2008.pdf; and National Weather Service (2003) All about winter storms; at https://web.archive.org/web/20040214012848/http://www.nws.noaa.gov/om/brochures/wintstm.htm (retrieved January 2014).

Winter storms are known to spawn other natural hazards, such as severe thunderstorms, tornadoes, and extreme winds. These effects disrupt commerce and transportation and often result in loss of life due to accidents or hypothermia. Vulnerable populations such as the elderly and homeless may have adverse health effects if exposed to the elements for extended periods of time. In addition to the impacts on transportation, power transmission, communications, agriculture, and people, severe winter storms can cause extensive coastal flooding, erosion, and property loss.

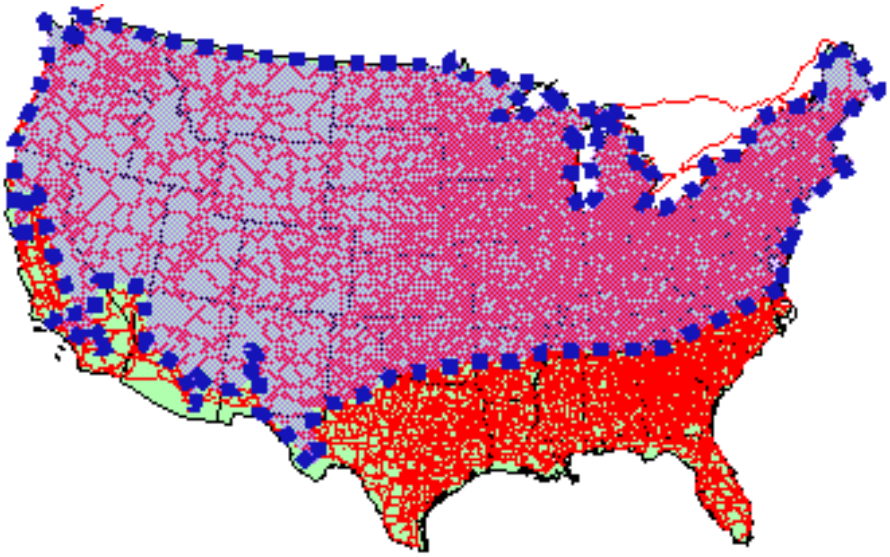
Winter storms and blizzards originate as mid-latitude depressions or cyclonic weather systems, sometimes following the meandering path of the jet stream.[11] A blizzard combines heavy snowfall, high winds, extreme cold, and ice storms. The origins of the weather patterns that cause severe winter storms, such as snowstorms, blizzards, and ice storms are primarily from four sources in the continental U.S.

- In the northwestern states, cyclonic weather systems from the North Pacific Ocean or the Aleutian Island region sweep in as massive low-pressure systems with heavy snow and blizzards.
- In the Midwestern and Upper Plains states, Canadian and Arctic cold fronts push ice and snow deep into the interior region and, in some instances, all the way down to Florida.
- In the Northeast, lake-effect snowstorms develop from the passage of cold air over the relatively warm surfaces of the Great Lakes, causing heavy snowfall and blizzard conditions.
- The eastern and northeastern states are affected by extra-tropical cyclonic weather systems in the Atlantic Ocean and Gulf of Mexico that produce snow, ice storms, and occasional blizzards.

Nearly the entire United States, except the extreme southern states, Hawaii, Puerto Rico, the U.S. Virgin Islands, and the U.S. Pacific territories is considered at risk for severe winter storms. The degree of exposure depends on the normal severity of local winter weather. In particular, Alaska, the Northeast, and the upper Midwest tend to be more susceptible than others to severe winter storms. Generally, these regions are more prepared for severe winter weather. Areas where such weather is rare, such as the extreme South, are disrupted more severely than are regions that experience severe weather more frequently.

[11] Bryant, Edward (1991), Natural Disasters: Cambridge University Press, New York; as cited by FEMA (1996).

Figure 1: Extent of the Continental U.S. Receiving 5 or More Inches Annual Snowfall[12]



However, experience has shown that no area can fully prepare for severe winter storms. The past two decades have seen many severe winter events forecast days in advance and for which individuals and communities made substantial preparation, but which nonetheless paralyzed multi-state regions for a week or more.

Heavily populated areas are particularly impacted when severe winter storms disrupt communication and power due to downed distribution lines. Snow and ice removal from roads and highways is difficult when accumulations build faster than equipment can clear. Debris associated with heavy icing may impact utility systems and transportation routes.

Secondary and cascading hazards from severe winter storms may include:

- **Power outages:** Power outages can negatively impact response operations by forcing emergency operations centers to operate on standby power and generators. Power outages can also hinder distribution of food, water, and fuel supplies, cause chaos in transportation and response coordination facilities such as airports and train stations, and lead to loss of lives in hospitals and nursing homes.
- **Downed trees and power transmission lines:** In addition to being a hazard in themselves, downed trees and power lines are underlying causes of other secondary hazards such as power outages, road closures, debris removal issues, and restoration challenges.
- **Responder communications issues:** Winter storm emergencies can increase response operations' need for key communication systems such as landlines and battery powered radios at the same time as burdening and disrupting them.
- **Phone service outages:** These include landline outages due to downed telephone wires and drained batteries for wireless personal communication devices due to extended power outages.

[12] U.S Department of Transportation Federal Highway Administration (FHWA) (2013, July 2). *Snow and Ice* [electronic resource]. FHWA Road Weather Management Program Office of Operations: at http://ops.fhwa.dot.gov/weather/weather_events/snow_ice.htm (retrieved January 2014).

- **Road closure:** In most cases, road closure is due to snow and ice built up on primary and secondary roads, but roads may also be closed due to downed trees or tree branches, utility poles, and electrical lines. Over 70 percent of U.S. roads are located in snowy regions that annually receive more than 5 inches average snowfall. Further, approximately 70 percent of the U.S. population lives in these regions. Each year, state and local agencies spend more than $2.3 billion on snow and ice control operations. In addition to their direct effects on the local population and economy, road closures can hinder response operations.[13]
- **Public transportation closure:** Snow clearing operations, downed trees and wires, landslides, and overall dangerous conditions can impede public transit.
- Need for **public shelters and warming centers:** Demand for shelters usually increases significantly during larger-scale, prolonged events. Shelters provide cots, food, water, and sometimes shower facilities, and serve as places to gather information, charge electronics, and pick up supplies. Local communities frequently rely on non-governmental organizations to establish and manage shelters. However, communities may not always have a sufficient number of pre-identified sheltering locations, and temporary ad-hoc shelters established as a result often lack emergency power and trained personnel.
- Extensive power outages combined with extreme cold temperatures can also necessitate the opening of designated warming stations. Warming stations provide temporary relief from the cold and can be used to distribute hot meals, provide information, and stage transportation to overnight shelters. Schools, churches, libraries, and public and private community centers can serve as warming stations. Warming station management can include challenges such as ensuring sufficient staffing, understanding roles and responsibilities, having safe transportation to and from the stations, having emergency power, and coordinating delivery of supplies.
- **School, government, and public services closure:** Dangerous weather conditions, snow accumulation, and loss of power are the most frequent reasons determining school closure. However, schools may also be closed in order to be used as emergency shelters. Snow and ice storms affecting the National Capital Region can force closure of Federal Government offices in the Washington, DC area, affecting the entire country.
- **Water distribution issues:** Power loss and burst pipes can cause issues with water distribution and force families to seek alternative shelter to flooded homes or homes without water. Other challenges include providing water to shelters, distribution points, and livestock. Public education on water safety and maintaining or restoring water systems is especially important for winter storms, as power outages can prevent customers from following boil-water and other safety notices. In the aftermath of especially widespread or destructive storms, the state National Guard may be called on to provide water buffaloes for portable water distribution points, in addition to distributing other essential items and assisting in emergency operations and critical infrastructure restoration.

The primary data source for the SNRA Winter Storm event is the Billion-Dollar Disaster List of the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center

[13] DOT FHWA (2013), *Snow and Ice*, as cited in FEMA (2013). Snow, sleet, and ice cause 580,000 crashes, 180,000 injuries, and 2,200 deaths on U.S. roadways each year. DoT FHWA (2013), *Snow and Ice*, and DoT FHWA (2013, July 2), *How do weather events impact roads?* [electronic resource], FHWA Road Weather Management Program Office of Operations, http://www.ops.fhwa.dot.gov/weather/q1_roadimpact.htm (retrieved January 2014) (cited figures include snow, sleet, slush, and ice -related accidents only).

(NCDC).[14] Between the years of 1980 and 2013, there were 19 winter storm, ice storm, freeze, and cold wave incidents identified by NOAA as meeting the billion-dollar threshold of the SNRA event (Table 2).[15] There were 945 fatalities and $58 billion dollars' damage ($2011) as a result of these extreme events.

Snow flooding incidents were not included within the SNRA Winter Storm data set to avoid double counting with the SNRA Flood event which includes these incidents within its scope.[16] In addition, flood caused fatalities and economic impacts were subtracted from the reported total fatalities and economic impacts of the January 1996 Blizzard/Flood incident prior to calculations.[17]

Assumptions

The threshold for this event was set at $1 billion of direct economic loss. This difference from the $100 million direct economic loss per occurrence threshold used for other SNRA natural hazards was intentional. While the majority of other SNRA natural hazard incidents are exceptional events by their inherent nature, the regular recurrence of winter storms and freezes as a normal feature of the national risk background required a higher threshold than other hazards in order to capture only those incidents which are exceptions to the norm.

- The Billion-Dollar Disaster List of the NOAA NCDC was used for the identification of extreme cold, freeze, and winter storm events from 1980 to 2013.

Frequency

Low, best, and high estimates of annual frequency represent the inverse of the longest time between incidents in the data set (1/8 years), the average frequency (19 incidents in 34 years, 01/01/1980–12/31/2013), and the maximum number of incidents in 1 year (2).

Fatalities

Low, best, and high estimates of fatalities per occurrence are the minimum (0), average, and maximum fatalities reported by the Billion-Dollar Disaster List (BDL).

Injuries

The BDL[18] does not report injury estimates. Proxy estimates of persons injured were constructed from raw data reported to the NCDC StormData database for winter storm/ice storm/freeze incidents[19] corresponding in temporal and spatial scope to those reported by BDL from 1993 onward.[20] Where both sources reported non-zero fatalities, the totals from StormData records were substantially lower than those of BDL, indicating underreporting or a distinction between

[14] National Climatic Data Center (2015). Billion-dollar U.S. weather/climate disasters 1980-2013: http://www.ncdc.noaa.gov/billions/overview.
[15] An additional incident from 2014 is reported, but final cost estimates in the primary source were not yet available for 2014 incidents at the conclusion of the SNRA 2015 analysis (April 2015). For this reason, the observation period used as the basis for the frequency estimates of the SNRA Winter Storm event is limited to 1980–2013.
[16] Snowmelt induced floods can have catastrophic impacts of their own: the SNRA project team identified nine such incidents among the incidents reported on the Billion -Dollar Disaster List.
[17] See footnotes to this incident, Table 2.
[18] Note that this is a convenience abbreviation used here: it is not a term used outside of the context of the SNRA.
[19] Blizzard, Extreme Cold/Wind Chill, Frost/Freeze, Heavy Snow, Ice Storm, Lake-Effect Snow, Winter Storm, Winter Weather, Winter Weather/Mix.
[20] Incidents having beginning dates between the dates specified by BDL. Spatial scope of selection is indicated in the above table. StormData reports for the specified hazards begin 1/1/1993.

direct and indirect fatalities.[21,22] The SNRA project team made the assumption that winter storm, ice storm, and cold wave injuries would generally scale to fatalities (both direct and indirect), while fatalities and injuries from a freeze event would, unless reported otherwise, generally be zero as freeze events primarily damage crops.

- Where StormData reported injuries and both sources reported fatalities, the BDL/StormData fatality ratio for each incident was applied to the StormData reported injuries to estimate total injuries.
- Where StormData reported injuries but BDL did not report fatalities, the average BDL/StormData fatality ratio (6.46) was applied to the StormData reported injuries to estimate total injuries.
- Where StormData did not report injuries but BDL reported fatalities, the average StormData injury/fatality ratio (26.5) was applied to the BDL fatality estimates to estimate total injuries. These incidents included all incidents prior to 1993.[23]

Table 1: Injury Estimates Construction

Begin Date	Type	Storm Data Fatal	BDL Fatal	Under-count ratio	Storm Data Injured	Injured (adjusted)	Included/Excluded
3/11/1993	Blizzard	36	270	7.5	428	3,200	All but TX
1/17/1994	Cold Wave	0	70		0	1,850[24]	All
2/8/1994	Ice Storm	1	9	9	1600	14,400	Listed states
1/1/1996	Blizzard	33	154	4.7	186	870	All
1/5/1998	Ice Storm	2	16	8	2	16	Listed states
12/20/1998	Freeze	2	0		0	0	CA only
1/1/1999	Winter Storm	15	25	1.7	91	150	All
1/13/1999	Winter Storm	0	0		75	480[25]	Listed states + DC
1/11/2007	Freeze	0	1		0	0	CA only
4/4/2007	Freeze	0	0		0	0	Listed states
2/1/2011	Blizzard	1	36	36	0	950[26]	All
	Total	90			2,382		
			Average	**6.46**			

[21] Although both are NCDC products, BDL uses StormData reporting as one of many inputs. Smith et al (2013, June), U.S. billion-dollar weather and climate disasters: Data sources, trends, accuracy and biases; *Natural Hazards* 67(2) 387–410: at http://www.ncdc.noaa.gov/billions/docs/smith-and-katz-2013.pdf (retrieved 18 January 2014).

[22] StormData preparers report both direct and indirect fatalities and injuries, but only direct fatalities and injuries are represented in the numerical fields. A direct fatality or injury is defined as a fatality or injury directly attributable to the hydro-meteorological event itself, or impact by airborne/falling/moving debris—the weather event or its debris are the active agent of harm. Indirect fatalities injuries occur in the vicinity or aftermath of a weather event, but are not directly caused by the event. Examples of direct fatalities and injuries include exposure, hypothermia, and injuries from collapsed roofs under heavy snow. Examples of indirect injuries and fatalities include heart attacks from overexertion, vehicle accidents, and carbon monoxide poisoning caused by improvised or improperly vented heating devices. Pp. 9–10, and sections on hazard classes listed in footnote 19: National Weather Service (2007, August 17), Storm Data Preparation (Instruction 10-1605), National Oceanic and Atmospheric Administration; at http://www.nws.noaa.gov/directives/sym/pd01016005curr.pdf (retrieved 5 March 2014). Indirect fatalities and injuries usually make up the largest proportion of fatalities and injuries from winter storm, cold weather, and ice storm events. FEMA (2013); Iqbal et al (2012, September), National carbon monoxide poisoning surveillance framework and recent estimates, *Public Health Reports* 127(5) 486–96; at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3407848/pdf/phr127000486.pdf (retrieved 7 October 2014); Hamilton, Janice (1998, February 24), Quebec's Ice Storm '98: "all cards wild, all rules broken" in Quebec's shell-shocked hospitals, *Canadian Medical Association Journal [CMAJ/JAMC]* 158(4) 522–524.

[23] A ratio of 40 persons ill per fatality from expert estimation/rule of thumb alternatively could be applied. Changnon, Stanley A. (1999, February). January 1999 Blizzard: Impacts of the New Year's 1999 Blizzard in the Midwest. National Climatic Data Center, NOAA at http://www.ncdc.noaa.gov/oa/climate/extremes/1999/january/blizzard99.html (retrieved 13 April 2014).

[24] Applying average StormData ratio 26.5 injuries/fatality to BDL fatalities to estimate total injuries (StormData reported 0 injured).

[25] Applying average fatality undercount ratio of 6.46 (90 reported StormData fatalities/581 reported BDL fatalities) to reported StormData injuries.

[26] Applying average StormData ratio 26.5 injuries/fatality to BDL fatalities to estimate total injuries (StormData reported 0 injured).

Economic Impacts

Direct Economic Impacts

Direct economic impacts as defined in the SNRA include decontamination, disposal, and physical destruction costs including property (structure, contents, physical infrastructure and other physical property) and crop damage; one year's lost spending due to fatalities; medical costs; and business interruption directly resulting from the impacts of an event. The direct economic loss estimates of the BDL were used for the 2015 SNRA without modification because of the close similarity of its direct economic loss estimation methodology with that of the SNRA.[27]

In performing these disaster cost assessments, the NCDC gathers the statistics from a wide variety of sources.[28] The total estimated costs of these events are the costs in terms of dollars that would not have been incurred had the event not taken place. Insured and uninsured losses are included in damage estimates. Sources include the National Weather Service, FEMA, U.S. Department of Agriculture, other U.S. Government agencies, individual state emergency management agencies, state and regional climate centers, media reports, and insurance industry estimates.[29] Given the threshold of $1 billon events, the best estimate was $3 billion with low and high estimates at $1 billion and $9 billion dollars, respectively.

Indirect Economic Impacts[30]

Direct economic losses alone do not represent the full picture of the economic impacts to the Nation from a disaster or attack. Indirect and induced economic losses can be substantially larger than the direct economic losses that occur in the aftermath of an event.

- Indirect economic impacts include costs incurred by the suppliers and vendors in the associated expenditure sectors for the industries impacted by the direct costs. Indirect impacts also include positive offsets due to increased spending within sectors impacted by the direct costs.[31]
- Induced economic impacts include those incurred due to reduced spending by households with members employed in any of the directly or indirectly affected industries. Induced impacts can also include substitution effects or likely transfers of economic activity from one set of sectors to another set, such as avoidance of air or other travel or altered transportation mode preferences to other sectors following an attack on the commercial air transport sector.

Highly mature economic models exist for calculating estimates of indirect and induced economic losses for natural disasters, human and animal pandemics, technological accidents, terrorist attacks, and cyber events. At present, there is no generally agreed upon or practical method for

[27] Smith et al (2013, June). U.S. billion-dollar weather and climate disasters: Data sources, trends, accuracy and biases. *Natural Hazards* 67(2) 387–410. At http://www.ncdc.noaa.gov/billions/docs/smith-and-katz-2013.pdf (retrieved 18 January 2014).
[28] In 2012, NCDC reviewed its methodology how it develops Billion-dollar Disasters and examined possible inaccuracy and biases in the data sources and methodology used in developing the loss assessments. As a result, NCDC temporarily rounded their loss estimates to the nearest billion dollars while implementing the newest research to define uncertainty and confidence intervals surrounding these loss estimates. The current methodology for the production of this loss data set is described in Smith et al (2013). This document highlights its strengths and limitations including sources of uncertainty and bias. The Insurance Services Office/Property Claims Service, FEMA's National Flood Insurance Program and the U.S. Department of Agriculture's crop insurance program are key sources of quantified disaster loss data, among others. The methodology uses a factor approach to convert from insured losses to total direct losses, one potential limitation.
[29] National Climatic Data Center; http://www.ncdc.noaa.gov/billions/overview.
[30] The SNRA's taxonomy of indirect and induced economic impacts comes from the DHS Terrorism Risk Assessments and so is retained here for consistency across DHS assessments. However, both combined will be referred to as 'indirect economic impacts' where it is not expected to impede clarity.
[31] These may include the waste management, environmental consulting, mortuary services, and medical industries, among others.

translating estimates produced by these disparate models into a single measure which can be meaningfully compared across all of the threats and hazards of the SNRA in a defensible fashion. Because such a measure would yield data of great value for multiple purposes beyond the context of the SNRA and similar assessments, it has been among the highest risk research priorities for the U.S. Department of Homeland Security (DHS) and its academic Centers of Excellence for over a decade. Should these efforts prove successful in coming years, the next iteration of the SNRA will include comparisons of total economic loss to the Nation across all of its threats and hazards.

Social Displacement

The impacts of extreme cold/winter weather in North American climate regions are comparatively minor, in the sense of permanent disruption to life for most individuals and communities. Impacts generally include closed business and schools along with decreased travel. With the exception of homes destroyed by collapsed roofs or storm-induced flooding, long-term social displacement resulting from this threat is rare.

The SNRA project team was not able to find defensible estimates for persons displaced from home for two or more days corresponding to the historical data set of winter storm events used for the other impact estimates. Determining such estimates is a priority for the next update of the SNRA.

Psychological Impacts

The SNRA metric of psychological distress uses the fatality, injury/illness, and social displacement estimates as inputs (Appendix G). As social displacement estimates could not be determined for the Extreme Cold/Winter Weather event, the psychological distress impact measure could not be calculated.

Environmental Impact

The environmental impact estimate, which was assessed for the 23 original national-level events of the 2011 SNRA by subject matter experts from the U.S. Environmental Protection Agency (EPA), could not be assessed for the winter weather event which was added to the SNRA in calendar year 2015. A future iteration of the SNRA will assess the environmental impacts of this event.

Potential Mitigating Factors

Mitigation efforts to reduce the frequency severity of extreme cold/winter weather are related to a reduction in the burning of hydrocarbons through a decreased global dependence on fossil fuels. These mitigation efforts are focused on reduced occurrence and decreased severity rather than individual measures that can be taken to reduce extreme cold/winter weather mortality (e.g., limiting exposure to the elements, using safer heating devices). At present, emergency planning efforts to ensure vulnerable populations are cared for during extreme cold/winter weather events will limit health-related illnesses and fatalities from exposure.

Table 2: Winter Storm Events[i]

Begin Date[ii]	End Date	Fatal	Injured[iii]	DE $B[iv] (2014)	Description
01/08/82	01/16/82	85	2,250	2	Midwest/Southeast/Northeast Winter Storm/Coldwave—January 1982: Winter storm and coldwave affect numerous states (AL, AR, CT, DE, FL, GA, IA, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, MS, NC, ND, NH, NJ, NY, OH, OK, PA, RI, SC, TN, TX, VA, VT, WI, WV) across the Midwest, Southeast, and Northeast.
12/24/83	12/25/83	0	0	5	Florida Freeze—December 1983: Severe freeze central/northern Florida.
01/19/85	01/22/85	150	4,000	2	Winter Damage, Cold Wave—January 1985: Extreme cold and winter storms in the Southeast, South, Southwest, Northeast, Midwest, and North.
01/20/85	01/22/85	0	0	3	Florida Freeze—January 1985: Severe freeze central/northern Florida.
12/21/89	12/26/89	100	2,700	1	Winter Damage, Cold Wave, Frost—December 1989: Northeast, Southeast hit by winter storms.
12/23/89	12/25/89	10	270	4	Florida Freeze—December 1989: Severe freeze damages citrus crops across central/northern Florida.
12/18/90	12/25/90	0	0	6	California Freeze—December 1990: Severe freeze in the Central and Southern San Joaquin Valley caused the loss of citrus, avocado trees, and other crops in many areas. Several days of subfreezing temperatures occurred, with some valley locations in the teens.
12/10/92	12/13/92	19	500	4	Nor'easter—December 1992: Slow-moving storm batters northeast U.S. coast, New England hardest hit.
03/11/93	03/14/93	270	3,200	9	Storm/Blizzard—March 1993: Storm of the Century hits entire eastern seaboard with tornadoes (FL), high winds, and heavy snows (2–4 feet).
01/17/94	01/20/94	70	1,859	2	Winter Damage, Cold Wave—January 1994: Winter storm affects Southeast and Northeast.
02/08/94	02/13/94	9	14,400	5	Southeast Ice Storm—February 1994: Intense ice storm with extensive damage in portions of TX, OK, AR, LA, MS, AL, TN, GA, SC, NC, and VA.
01/01/96	01/31/96	154[v]	870	4[vi]	Blizzard [Blizzard/Flood]—January 1996: Very heavy snowstorm (1–4 feet) over Appalachians, Mid-Atlantic, and Northeast [followed by severe flooding in parts of same area due to rain and snowmelt].
01/05/98	01/09/98	16	16	2	Northeast Ice Storm—January 1998: Intense ice storm hits Maine, New Hampshire, Vermont, and New York, with extensive forestry losses.
12/20/98	12/28/98	0	0	4	California Freeze—December 1998: A severe freeze damaged fruit and vegetable crops in the Central and Southern San Joaquin Valley. Extended intervals of sub 27°F temperatures occurred over an 8-day period.
01/01/99	01/04/99	25	150	1	Winter Storm—January 1999: South, Southeast, Midwest, Northeast affected by damaging winter storm.
01/13/99	01/16/99	0	480	1	Central and Eastern Winter Storm—mid-January 1999: Winter storm affecting the Central and Eastern states including IL, IN, OH, MI, WV, VA, MD, PA, NJ, NY, MA, CT, VT, NH and ME.
01/11/07	01/17/07	1	0	2	California Freeze—January 2007: Widespread agricultural freeze— for nearly 2 weeks in January, overnight temperatures over a good portion of California dipped into the 20s, destroying numerous agricultural crops; with citrus, berry, and vegetable crops most affected.
04/04/07	04/10/07	0	0	2	Spring Freeze—April 2007: Widespread severe freeze over much of the east and Midwest (AL, AR, GA, IL, IN, IA, KS, KY, MS, MO, NE, NC, OH, OK, SC, TN, VA, WV), causing significant losses in fruit crops, field crops (especially wheat), and the ornamental industry. Temperatures in the teens/20s accompanied by rather high winds nullified typical crop-protection systems.
02/01/11	02/03/11	36	950	2	Groundhog Day Blizzard—February 1–3, 2011: A large winter storm impacted many central, eastern and northeastern states. The city of Chicago was brought to a virtual standstill as between 1 and 2 feet of snow fell over the area.

[i] Winter Storm and Freeze events as reported by the Billion Dollar Disaster List of NOAA's National Climatic Data Center (NCDC). NCDC (2015). Billion-dollar U.S. weather/climate disasters 1980–2013: at http://www.ncdc.noaa.gov/billions/events [dynamic resource: table represents data current as of 3 April 2015]. This table reflects the 2014 dollars reported by the NOAA source. The final SNRA estimates in the Data Table summary are converted to 2011 dollars for comparison with existing SNRA events (CPI 2014–2011, 0.950).

[ii] Dates as reported by Web version (4/3/2015) of Billion Dollar Disaster List (static pdf version, http://www.ncdc.noaa.gov/billions/events.pdf [retrieved 3 April 2015] does not list exact dates for all incidents).

[iii] Proxy estimates constructed from corresponding incidents 1993–2011 in the StormData database and ratios between BDL and StormData reported fatalities to account for underreporting and differing reporting of direct/indirect fatalities and injuries.

[iv] Direct economic loss. Costs adjusted to 2014 dollars: Cost estimates are rounded to nearest billion-dollars. Ongoing research is seeking to define uncertainty and confidence intervals around the cost of each event.

[v] Flood fatalities are backed out to avoid double counting with the SNRA Flood event. Of the 187 total fatalities reported by NCDC, 154 were reported as due to blizzard and winter conditions, and 33 as due to flooding. Lott et al (1996, April). The winter of '95–96: a season of extremes. Pp. 3–4. National Oceanic and Atmospheric Administration, National Climatic Data Center, technical report 96-02: at http://www1.ncdc.noaa.gov/pub/data/techrpts/tr9602/tr9602.pdf (retrieved 13 April 2014).

[vi] Lott et al (1996) do not split out flood economic damages. The direct economic losses reported from the corresponding incident in the SNRA flood data set (see Flood risk summary sheet), snowmelt flood VA-NY start date 1/18/1996: USD2011 $475,800,500 inflated to 2014 dollars [$500, 843,000] rounded to nearest billion to maintain one significant figure of primary NCDC source used for this summary sheet) were subtracted from the NCDC reported $5 billion total damage to avoid double counting with the SNRA flood event.