THE 1993 SUPERSTORM: 15-YEAR RETROSPECTIVE

RMS Special Report

INTRODUCTION

From March 12–14, 1993, a powerful extra-tropical storm descended upon the eastern half of the United States, causing widespread damage from the Gulf Coast to Maine. Spawning tornadoes in Florida and causing record snowfalls across the Appalachian Mountains and Mid-Atlantic states, the storm produced hurricane-force winds and extremely low temperatures throughout the region. Due to the intensity and size of the storm, as well as its far-reaching impacts, it is widely acknowledged in the United States as the "1993 Superstorm" or "Storm of the Century."

During the storm's formation, the National Weather Service (NWS) issued storm and blizzard warnings two days in advance, allowing the 100 million individuals who were potentially in the storm's path to prepare. This was the first time the NWS had ever forecast a storm of this magnitude. Yet in spite of the forecasting efforts, about 100 deaths were directly attributed to the storm (NWS, 1994). The storm also caused considerable damage and disruption across the impacted region, leading to the closure of every major airport in the eastern U.S. at one time or another during its duration. Heavy snowfall caused roofs to collapse in Georgia, and the storm left many individuals in the Appalachian Mountains stranded without power. Many others in urban centers were subject to record low temperatures, including -11°F (-24°C) in Syracuse, New York. Overall, economic losses due to wind, ice, snow, freezing temperatures, and tornado damage totaled between $5-6 billion at the time of the event (Lott et al., 2007) with insured losses of close to $2 billion.

Fifteen years after the event, this report chronicles the meteorological features of the storm and the potential impact of the event should it occur in 2008. The new 2008 RMS® U.S. Winterstorm Model is utilized to highlight the range of insured losses from the perils of snow, ice, wind, and freezing temperatures.

Figure 1: Record snowfalls blanketed the eastern U.S. states during the 1993 Superstorm, including over two feet (0.6 meters) of snow in parts of North Carolina

THE 1993 SUPERSTORM

Synopsis of the Storm[1]

On Friday, March 12, 1993, an extra-tropical cyclone developed in the western Gulf of Mexico near Brownsville, Texas, at the border between the United States and Mexico. At 12:00 UTC on Friday, March 12, the storm's central pressure measured 1000 millibars (mb) and the low-pressure system moved rapidly in a northeasterly direction across the Gulf of Mexico toward the Florida panhandle. As it moved to a point just south of New Orleans, the storm's pressure dropped approximately 16 mb in 12 hours to reach 984 mb at 0:00 UTC on Saturday, March 13.

The storm's center made landfall just west of Tallahassee at approximately 06:00 UTC on Saturday, March 13, with a central pressure of 975 mb. Florida's coastline was flooded and the worst of the storm surge occurred between Tallahassee and Tampa Bay, although flooding occurred across western Florida and the northern coast of Cuba. A 12-foot (3.7-meter) storm surge occurred in Taylor County, Florida and hurricane-force winds were also felt as far south as Havana, Cuba.

As the storm moved across Florida, a squall line emerged, spawning many thunderstorms and at least 11 tornadoes. To the south, the squall line was the most damaging one ever recorded in Cuba, causing 10 casualties and over $1 billion in economic losses (Alfonso and Naranjo, 1996). By 12:00 UTC on Saturday, March 13, the storm was located over southeastern Georgia with a central pressure of 971 mb and the rain associated with the storm turned to snow to the north and west with severe convective storms to the south and east. Heavy snow and high winds were felt in regions across the southeastern U.S., including Alabama and Georgia. A reported 6 inches (15 cm) of snow fell in the Florida panhandle and 13 inches (33 cm) of snow in Birmingham, Alabama. Hurricane-force winds were also felt along the southeastern coastline, with recorded wind speeds of 83 mph (134 km/hr) in Vero Beach, Florida and 90 mph (145 km/hr) in Myrtle Beach, South Carolina. The dynamics of the extra-tropical storm system reached an incredible extent, covering the entire eastern U.S. through the Caribbean Sea, as illustrated in Figure 2.

[1] This synopsis of the storm is taken primarily from Kocin et al., 1994 and Kocin and Uccellini, 2004.

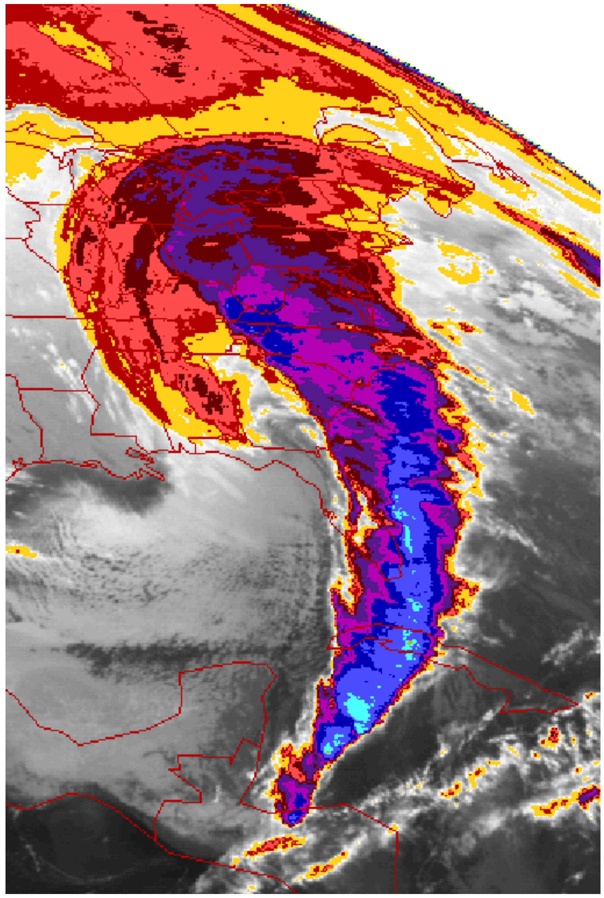

Figure 2: Satellite image of the 1993 Superstorm on March 13, 1993 at 10:01 UTC (Source: National Aeronautics and Space Administration)

Late in the day on March 13 through the early hours of Sunday, March 14, the storm produced heavy amounts of snow from the Mid-Atlantic states up to Pennsylvania, as well as westward into eastern Kentucky, Tennessee, and Ohio. Record snowfall totals were recorded across the Appalachian states, including 50 inches (127 cm) of snow in Mount Mitchell, North Carolina, and 56 inches (142 cm) in Mount Le Conte, Tennessee (Figure 3). Mount Le Conte additionally had a record low temperature of -10°F (-23°C). Recorded wind gusts in the Appalachian Mountains hit hurricane-force, such as a measured 101 mph (163 km/hr) on Flattop Mountain in North Carolina.

At 0:00 UTC on March 14, the lowest central pressure of the storm was measured at 960 mb over the Chesapeake Bay as the storm continued to move northeastward along the Atlantic coast. The storm tracked west of the northeastern urban corridor with the heaviest snowfall to the west of the storm and snow turning to ice and rain to the east. For example, Syracuse, New York was under blizzard conditions, receiving 43 inches (109 cm) of snow, whereas the cities of Philadelphia, New York, and Boston averaged less than 12 inches (30 cm) of snow before ice pellets began to fall. However, the changeover from snow to ice and rain with the falling temperatures (e.g., 11°F or -12°C in Philadelphia) left a layer of ice on top of snow that was dangerous for driving conditions and difficult to shovel.

Throughout Sunday, March 14, record low temperatures were measured in 68 cities across 18 states. As the storm's center continued to move northward, it diminished in intensity to reach 965 mb by 12:00 UTC to the east of Portland, Maine, reaching Canada by 18:00 UTC. Snowfalls tapered off across the northeastern U.S. late on March 14 but the freezing temperatures remained.

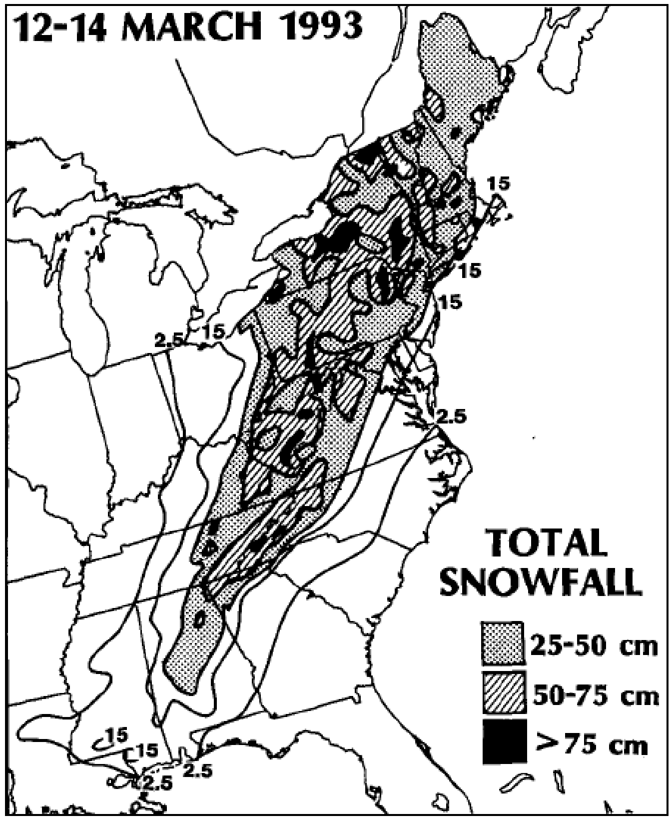

Figure 3: Snowfall accumulation due to the 1993 Superstorm (Source: Kocin et al., 1994)

Forecasting the Storm

One of the interesting features of the 1993 Superstorm was the forecasting of the event. Scientists in the Meteorological Operations Division (MOD) of the National Meteorological Center (NMC), which was the forecast center of the National Weather Service (NWS) at the time, predicted the size of the storm five days in advance and the amount of snowfall two days in advance (Uccellini et al., 1994). The NWS forecasters used information from three different global models and three regional-scale numerical models to continually construct both medium-term (i.e., 3 to 5 days) and short-term (i.e., 12 hours to 2 days) forecasts for the days leading up to March 14, 1993. For example, medium-range forecasts predicted a potential major storm as early as March 10 and the local NWS office in Raleigh, North Carolina issued the first winter storm watch at 21:00 UTC on March 11. The lead times for winter storm watches and winter storm warnings have been described as "unprecedented" by the National Weather Service (See Figure 4).

Of course, considering the model differences and the use of expert opinion in estimating each model's accuracy, the forecasts were not without their problems. In particular, in Uccellini et al. (1994), it is noted that the rapid development of the storm over the Gulf of Mexico between 12:00 UTC on March 12 and 0:00 UTC on March 13 was underestimated, as was the snowfall in eastern Kentucky and southeastern Ohio. Nevertheless, the forecasts issued to the public and media outlets from the local NWS offices were instrumental in reducing the impact from the storm. Blizzard warnings were issued 10 to 24 hours in advance of the first snowfall, which allowed, for example, emergency management personnel in western Pennsylvania to prepare by declaring a state of emergency, closing the interstate, and activating the National Guard. In New York, the emergency broadcast system was activated to issue a blizzard warning.

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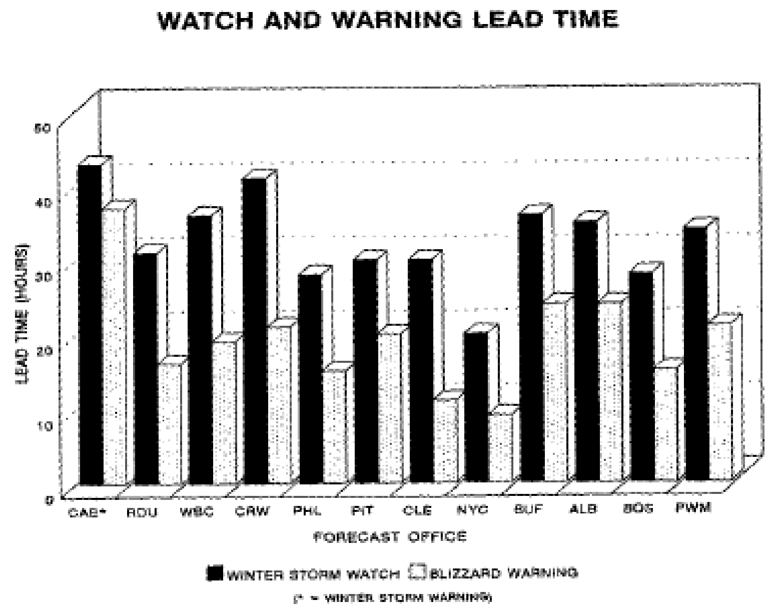

Figure 4: Lead times for winter storm watches and blizzard warnings. CAE=Columbia, South Carolina; RDU=Raleigh-Durham, North Carolina; WBC=Sterling, Virginia; CRW=Charleston, West Virginia; PHL=Philadelphia, Pennsylvania; PIT=Pittsburgh, Pennsylvania; CLE=Cleveland, Ohio; NYC=New York, New York; BUF=Buffalo, New York; ALB=Albany, New York; BOS=Boston, Massachusetts; PWM=Portland, Maine (Source: Uccellini et al., 1994)

Comparison to Past Historical Storms

Although the 1993 Superstorm is argued to be the strongest extra-tropical cyclone to impact the U.S. in the last century, several other winter storms are comparable to the meteorological parameters of the storm. In 1962, a powerful extra-tropical cyclone impacted the Pacific Northwest with hurricane-force wind speeds. The 1962 event developed from the remains of a decaying tropical storm off the northern California coastline and then headed toward the Pacific Northwest coastline. A large swath of the western half of Washington and Oregon experienced wind gusts in excess of 80 mph (129 km/hr) with locations along the coastline experiencing gusts greater than 135 mph (217 km/hr), including Camp Blanco and Newport, Oregon. High wind gusts also extended inland, with 80 mph (129 km/hr) winds impacting a larger region than those observed during the 1993 Superstorm.

The impact of the 1993 storm can also be compared to two historical storms in the eastern U.S. In Lott (1994), comparisons to the Great Blizzard of 1888 are highlighted, which impacted the northeastern U.S. and occurred from March 11–14, 1888. A total of 48 inches (122 cm) of snow fell in Albany, New York and wind gusts of 80 mph (129 km/hr) were reported in other areas of the state. Snow drifts reportedly covered three-story houses around New England. In addition, people were isolated for days, as telegraph lines and railway systems were shut down across the region. The Great Blizzard of 1899 caused record low temperatures across the eastern U.S. in February of that year, including -15°F (-26°C) in Washington, D.C. and -2°F (-19°C) in Tallahassee, Florida. Snow fell across the west coast of Florida and the port of New Orleans was frozen. Further north, Cape May, New Jersey sustained 34 inches (86 cm) of snow in one day.

The Storm's Impact

While the 1993 storm created hurricane-force winds as far south as Cuba and as far north as Nova Scotia, Canada, the primary impact of the storm was on the United States. According to a national disaster survey report on the storm by the National Weather Service (NWS, 1994), 100 million people in 26 states were impacted by the snow, ice, rain, and wind conditions (Figure 5). At the height of the storm, over 3 million individuals were without power due to downed power lines. Travel across the U.S. was impeded as interstates and airports across the eastern U.S. were impacted by the weather conditions. Moreover, the high winds and heavy snow caused the cancellation of approximately 25% of the country's flights over the weekend as all major airports along the eastern seaboard closed at some point during the storm.

The Department of Commerce measured an economic downturn in the nation's economy due to the heavy snowfall of the 1993 storm. According to testimony by Dr. Uccellini before the U.S. Senate in 2006, econometric studies have suggested that a major snowstorm in heavily populated areas negatively impacts both the regional and national economies, as millions of individuals are temporarily out of work, retail sales decline, and housing activity stagnates (Uccellini, 2006).

Figure 5: Snowfall in western Pennsylvania during the 1993 Superstorm

According to the Property Claim Services (PCS) unit of the Insurance Services Office (ISO), in October 1993, close to 900,000 claims were filed in twenty-four states for a total insured loss of $1.75 billion due to wind, hail, tornado, flooding, snow, ice, and freezing perils. Losses included damage to the residential, commercial, auto, and inland marine lines of business. Additionally, the National Flood Insurance Program (NFIP) had over 11,000 claims for $186 million in flood-related damage. In 2008, the 1993 Superstorm still ranks in the top twenty insured losses according to PCS.

Approximately 25% of the storm's loss was sustained by the state of Florida, which was still recovering from the impacts of Hurricane Andrew in August 1992. Severe winds, coastal flooding, and tornadoes caused $500 million in property damage and the deaths of 26 individuals (Glantz et al., 2004). In northern Georgia, the heavy snow caused industrial roofs to collapse, in particular some structures containing carpet manufacturers. Interestingly, it was reported in several sources that homes "fell into the sea" on Long Island and severe damage to homes along the Outer Banks of North Carolina caused them to become uninhabitable.

THE STORM IN PERSPECTIVE

The 1993 Superstorm in 2008

For this report, RMS evaluated the potential impact of a winter storm of similar magnitude striking the region in 2008. Loss estimates for a repeat of the event were obtained by analyzing property at risk (e.g., commercial, personal, auto lines of business) utilizing the 2008 RMS® Industry Exposure Database and the 2008 RMS® U.S. Winterstorm Model, which allows a user to run simulations of historical and stochastic winter storms against property at risk to the perils of snow, ice, freezing temperatures, and wind. The model calculates a range of possible losses that reflects the uncertainty in both the winter storm perils and the vulnerability of property within the footprint. RMS developed individual vulnerability damage functions capturing the unique impacts from snow, ice, wind, and freezing temperatures on structures, their contents, and time element coverages. The model produces an expected (or mean) loss representing the best estimate of the most likely outcome within that range.

Analysis Procedures

RMS reconstructed the 1993 Superstorm footprints for each of the winter storm perils of snow, ice, freezing temperatures, and wind from the available meteorological data collected at observation weather stations across the U.S. To account for the degree of uncertainty in the meteorological values at reporting stations, as well as the interpolation between reporting stations, RMS created an ensemble of footprints. For each peril, a set of footprints was generated and compared to the observed insured loss in each state; the footprint that produced the best fit to the observed data was selected as the historical footprint available in the 2008 RMS® U.S. Winterstorm Model. The four hazard footprints selected to represent the 1993 Superstorm—for the wind, snow, ice, and freezing temperature perils—are shown in Figure 6(a) through Figure 6(d).

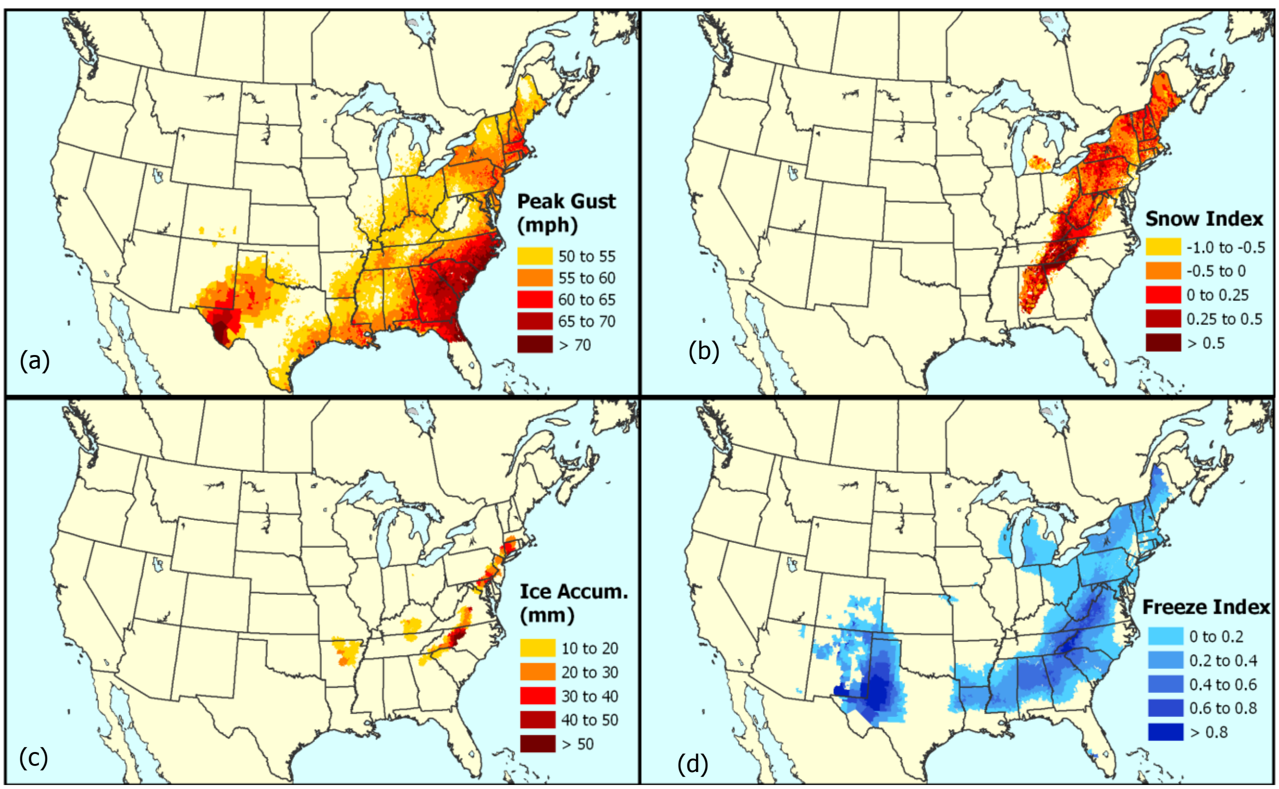

Figure 6: Hazard reconstruction footprints for the 1993 Superstorm as modeled by the RMS® U.S. Winterstorm Model: (a) 3-second peak gust windspeed in mph; (b) snowfall as an index of its deviation from climatological conditions; (c) ice thickness in millimeters; and (d) index of temperature deviation from climatological conditions

Results

RMS estimates that should this storm recur in 2008, the winter storm perils of snow, ice, wind, and freezing temperatures would result in a total insured loss between $3.0 and $6.0 billion across the U.S., with a mean loss of $5.1 billion. Moreover, based on the 2008 RMS® U.S. Severe Convective Storm Model, an additional $1.2 to $1.7 billion of insured loss would occur due to tornado damage in Florida, resulting in a total storm loss between $4.2 and $7.7 billion, with a mean loss of $6.5 billion (see Table 1). While the majority of the loss would result from damage due to high winds and heavy snow, tornado damage in Florida would comprise approximately 25% of the total insured loss. In addition, the combination of perils causes a larger overall insured loss estimate than if each peril was analyzed separately. Losses at some individual locations would not exceed the deductible for one peril but will cause losses to the insurer for a mixture of perils (i.e., as perils are covered under the same policy).

Table 1. Range of insured losses from a repeat of the 1993 Superstorm in 2008 to all lines of business

Peril	Mean Insured Loss (in millions)	Range of Insured Loss (in millions)
Wind	$1,700	$1,000 - $2,000
Snow	$2,400	$1,400 - $2,800
Freezing Temperature	$300	$200 - $400
Ice	$700	$400 - $800
Tornado	$1,400	$1,200 - $1,700
TOTAL	**$6,500**	**$4,200 - $7,700**

Return Period of the Event

In order to fully assess the risk from the 1993 Superstorm, it is necessary to compare this event to an extensive set of stochastic events that assign probabilities of occurrence to different winter storm scenarios. By comparing the losses generated by the 1993 Superstorm with those generated by other stochastic events similar in nature, the return period of loss can be assessed. This is accomplished using the RMS probabilistic winter storm catastrophe model, which was developed using a new and innovative hybrid modeling approach. This modeling approach combines the latest technologies and strengths of numerical weather prediction (NWP) models and statistical techniques to create a fully representative stochastic event set based on 30,000 years of winter storm activity.

The high wind speeds, along with meteorological records for snowfall and temperatures at several locations, caused some to consider the 1993 Superstorm to be a 100-year return period event, hence the nickname "Storm of the Century." Although the storm's return period exceeded 100 years in some locations, the majority of the major cities in the Northeast corridor were spared from the intense snowfall accumulations that had occurred further inland. Cities such as Washington, D.C., Baltimore, Philadelphia, New York, and Boston reported snowfalls around 12 inches (30 cm) or less. There are other past and possible future events whose effects could be even more devastating because they may contain different combinations and intensities of the winter storm perils or impact more populous cities.

Comparing the winter storm peril losses generated by the 1993 Superstorm (snow, ice, wind, and freezing temperatures) with those generated from other possible future events in the RMS® U.S. Winterstorm Model, it is clear that an expected loss of $5.1 billion in the U.S. is not that unusual, with a return period of approximately 30 years.

Implications of the 1993 Superstorm on Modeling

In 2008, the 1993 Superstorm still ranks in the top twenty loss events for the U.S. insurance industry. Moreover, it ranks as the highest insured loss from a winter storm event ever recorded by PCS. The severity of the event served as a reminder to the insurance industry that losses from a winter storm can greatly impact their portfolio. However, since the mid 1990s, there has not been a major winter storm impacting the U.S. This lack of severe winter storm events, combined with the very active U.S. hurricane seasons in 2004 and 2005, have left some insurers managing their portfolios to the dominant hurricane peril rather than to the complete range of natural catastrophe perils to which their exposure is at risk.

RMS, through its expanded suite of natural catastrophe probabilistic modeling for winter storm and severe convective storm perils, allows insurers to better manage their U.S. and Canadian portfolios at risk. With the explicit capturing of the modes of damage (snow, wind, ice, and freezing temperatures) in the U.S. and Canada Winterstorm models, the modeling of straight-line winds, tornadoes, and hail in the U.S. and Canada Severe Convective Storm models, and the modeling of wind and storm surge damage in the U.S. Hurricane Model, RMS models provide a comprehensive view of weather risk across North America.

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