SNOWSTORMS ALONG THE NORTHEASTERN COAST OF THE UNITED STATES: 1955 TO 1985



Paul J. Kocin and Louis W. Uccellini

American Meteorological Society

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SNOWSTORMS ALONG THE NORTHEASTERN COAST OF THE UNITED STATES: 1955 to 1985

PAUL J. KOCIN AND LOUIS W. UCCELLINI

Goddard Laboratory for Atmospheres
NASA/Goddard Space Flight Center
Greenbelt, Maryland

American Meteorological Society

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Dedication

Paul J. Kocin dedicates this monograph to his wife Marla, his sons Matthew and Joshua, his parents, Eugene and Irene Kocin, and to his sister, Barbara Wallace.

Louis W. Uccellini dedicates this monograph to his parents Louis and Margaret Uccellini, his wife Susan, his children Anthony, Francesca and Dominic and his friend Frank DeLaurentis who shared many a snowstorm on Long Island and is a retired snowplow operator living near Troy, NY

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Prologue

Saturday, 8 February 1969, was not the bitterly cold day that often serves as a harbinger of a severe winter snowstorm on New York's Long Island. Instead, it was generally sunny and cool, about 40°F (5°C). The weather forecast that morning, though, provided a little bit of encouragement to a 13-year-old snow fanatic: "Tomorrow will be cloudy with rain OR SNOW likely."

I[1] knew from experience that the probability of a big snowstorm on Long Island was not very great because of its close proximity to the relatively warm Atlantic Ocean. I had already felt the crushing disappointment when potentially major snowstorms became rainstorms, and sure days off from school became days like all the rest. My pessimism was reinforced by the local weather reports on Saturday evening, indicating southeasterly winds, a bad sign for impending snowstorms. As I went to bed that night, I prepared myself for the usual disappointment, since outdoor temperatures held well above freezing and the wind continued to blow from the ocean.

When I awakened the following morning, a strong wind was whistling through the air-conditioning unit that extended outside my room. This sound was not enough to arouse me until I suddenly realized that the glow emanating from the translucent shutters covering my window was unusually bright for early morning. I shot out of bed and flung open the shutters to discover that the world outside was white. There wasn't very much accumulation on the ground yet, maybe an inch, but the snow was falling fast and flying horizontally from the northeast. A busy day lay ahead of me!

While my family still slept, I ran from window to window to see how the storm was changing the environment outside. I turned the radio on, only to become annoyed at the weather forecasters' insistences that the snow would soon end. After a while, confidence in the original forecasts eroded as the storm grew more and more intense.

By late morning, my family awoke in astonishment as they gazed out the window, wondering what to do now that they knew the day would be spent inside. The snow had picked up in intensity, falling at perhaps 1 or 2 inches (2.5 to 5 cm) per hour. Savoring every moment, I felt victorious when the weather forecasters finally succumbed to the storm and admitted that they didn't know how much more would fall or when the storm would end. Then, the inevitable comparisons with earlier blizzards began to pour forth from the radio and TV.

The day wore on and snow continued to fall heavily. The wind increased, making it difficult to determine how much of the swirling snow outside was due to falling snow versus snow blowing off the roof or from the ground. Drifting snow eventually began to cover several windows, making it more difficult to observe what was obviously a great storm. As the drifts grew, it became impossible to open the front door, and by evening, the cars parked on the street appeared as white swells in the sea of snow that

[1] Paul J. Kocin

covered the street. Tremendous gusts of wind whistled through the house and actually seemed to shake the foundation.

The snow finally ended in the middle of the night. About 18 hours had passed since the time the early forecasts indicated that the storm would cease. By morning, the only sound heard was that of an overworked snowplow. Radio reports now documented the extent of the storm. The entire New York City metropolitan area was paralyzed. As several hundred cars became stranded, scores of motorists spent a harrowing night on the Tappan Zee Bridge north of New York City. Many other motorists met similar fates on the myriad of roadways throughout the metropolitan area that were littered with stranded cars. Thousands more were stranded at airports that remained closed anywhere from 1 to 2 days following the storm. Food was airlifted by helicopter to Kennedy Airport to feed the weary travelers. Schools closed on Monday and many didn't reopen until Thursday, Friday, or even the following Monday. Snow-clearing equipment was slow to be deployed in parts of the New York City area and couldn't keep up with the storm. Some city streets remained unplowed many days after the storm, creating a public furor. Dozens of deaths and several hundred injuries were attributed to the storm while millions of dollars were lost due to delayed or lost business.

This particular snowstorm, and other similar storms during the late 1950s and 1960s, provided the motivation for the monograph that follows. Questions concerning how these storms develop, what weather patterns provide clues that foretell such events, and what factors delineate snow/no snow situations, have challenged forecasters and researchers alike. This study is our attempt at describing a phenomenon that has stirred our curiosity, and provided countless hours of speculation, entertainment, and, for those numerous false alarms, profound disappointment. The disappointments (i.e., those storms that changed to rain or veered harmlessly out to sea) will not be highlighted here. The greatest snowstorms to affect the northeastern coast of the United States during the 1950s, 1960s, 1970s, and 1980s will be explored in the following chapters.

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CHAPTER 1

Introduction

The aesthetic appeal of snowstorms is shared by many, who, overlooking the discomforts and hardships such storms may yield, find the transformation of familiar surroundings into spectacular landscapes of white and gray an exhilarating experience. The strong emotions brought forth by these great storms of snow and wind are revealed in the following excerpts:

> There is nothing quite like the promise and anticipation of a good snowstorm. It makes Christmas pale, birthdays insignificant, and is rivalled only by Election Day for the joy of anxious hope.[1]

> The sun that brief December day
> Rose cheerless over hills of gray,
> And, darkly circled, gave at noon
> A sadder light than waning moon.
> Slow tracing down the thickening sky
> Its mute and ominous prophecy,
> A portent seeming less than threat,
> It sank from sight before it set.
> A chill no coat, however stout,
> Of homespun stuff could quite shut out,
> A hard, dull bitterness of cold,
> That checked, mid-vein, the circling race
> Of life-blood in the sharpened face,
> The coming of the snow-storm told.
> The wind blew east; we heard the roar
> Of Ocean on his wintry shore,
> And felt the strong pulse throbbing there
> Beat with low rhythm our inland air.
>
> Meanwhile we did our nightly chores,
> Brought in the wood from out of doors,
> Littered the stalls, and from the mows
> Raked down the herd's-grass for the cows:
> Heard the horse whinnying for his corn;
> And, sharply clashing horn on horn,
> Impatient down the stanchion rows
> The cattle shake their walnut bows;
> While, peering from his early perch
> Upon the scaffold's pile of birch,

[1] From an article entitled "Meteorological Ambitions" from *News from Bennett Noble.* Source unknown.

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The cock his crested helmet bent
And down his querulous challenge sent.

Unwarmed by any sunset light
The gray day darkened into night,
A night made hoary with the swarm
And whirl-dance of the blinding storm,
As zigzag, wavering to and fro,
Crossed and recrossed the winged snow;
And ere the early bedtime came
The white draft piled the window-frame,
And through the glass the clothes-line posts
Looked in like tall and sheeted ghosts.

So all night long the storm roared on:
The morning broke without a sun;
In tiny spherule traced with lines
Of Nature's geometric signs,
In starry flake, and pellicle
All day the hoary meteor fell;
And, when the second morning shone,
We looked upon a world unknown,
On nothing we could call our own.
Around the glistening wonder bent
The blue walls of the firmament,
No cloud above, no earth below,—
A universe of sky and snow!
The old familiar sights of ours
Took marvellous shapes; strange domes and towers
Rose up where sty or corn-crib stood,
Or garden-wall, or belt of wood;
A smooth white mound the brush-pile showed,
A fenceless drift what once was road.[2]

Episodes of heavy snowfall, however, are also cause for concerns that are larger in scope than the mere discomfort and inconvenience of shoveling the driveway or walks. The combined effects of heavy snow, high winds, and cold temperatures can be particularly debilitating, especially in a heavily populated and highly industrialized environment. Such is the case along the Northeast coast of the United States, a region which will be defined in this monograph as extending from Virginia to Maine and includes the densely populated metropolitan centers of Washington, D.C., Baltimore, Maryland, Philadelphia, Pennsylvania, New York, New York, Boston, Massachusetts, and dozens of smaller urban areas. Here, heavy snowfall associated with storms known as "Nor'easters" may maroon millions of people at home, work, or in transit, severely disrupt human services and commerce, and endanger the lives of those who venture outdoors.

Snowstorms along the northeastern coast of the United States result from a complex interaction of physical mechanisms that acts to organize a widespread region of ascent, entrain large amounts of water vapor necessary to produce heavy amounts of

[2] From "Snowbound" by John Greenleaf Whittier, *The Family Book of Verse*, Louis Gannett, Ed., Harper and Row, New York, 1961, pp. 302–303.

precipitation, and supply a source of cold air that enables precipitation to reach the ground as snow. These physical mechanisms are associated with cyclonic and anticyclonic weather systems that traverse the middle latitudes and interact with the unique topography of the eastern United States.

Topographical factors that contribute to these weather systems include land–ocean temperature and frictional contrasts, the influences of the Atlantic Ocean, Gulf of Mexico, and Great Lakes on air mass modification, the position of the Gulf Stream, and the effects of the Appalachian Mountains on the low-level temperature and wind fields. This combination of factors favors the northeastern United States and its offshore waters as an important site for cyclogenesis (Petterssen 1956; Klein and Winston 1958; Reitan 1974; Colucci 1976; Sanders and Gyakum 1980; Hayden 1981; Roebber 1984) that can occasionally result in heavy snowfall.

The ability of weather forecasters to recognize and account for the many elements that influence the development and evolution of major snowstorms is crucial for the accurate prediction of heavy snowfall in the northeastern United States. Before the advent of numerical weather modeling techniques, attempts to forecast such storms had yielded mixed results, at best. Some of the worst snowstorms in New York City's history, most notably the March 1888 "Blizzard of '88" (Kocin 1983), the city's record snow of December 1947[3], and the "Lindsay Storm" of February 1969,[4] described in the Prologue, were severely underforecast. Thus, the public's continuing lack of confidence in forecasters' abilities to predict such storms is, to some degree, justified by past experience.

The increasing use and sophistication of numerical weather prediction models has improved the forecasts of the timing and location of cyclogenesis, precipitation amounts, and the location of the rain–snow line, all important considerations in potential heavy snow situations. Operational and research numerical weather forecasts have performed well in many recent heavy snow situations, as demonstrated by simulations of the intense New England snowstorm of February 1978 (Brown and Olson 1978), the spring blizzard of April 1982 (Kaplan et al. 1982), and a convective snow event in March 1984 (Kocin et al. 1985). The models have failed on other occasions, however, most notably the February 1979 "Presidents' Day Storm" (Bosart 1981; Uccellini et al. 1984, 1985, 1987; Atlas 1987). An example of a numerical weather forecast that can be described as both a success *and* a failure is the operational numerical model forecast of the urban snowstorm of 11–12 February 1983. A major snowfall was predicted for the Middle Atlantic states (a success), but a small error in the model forecast of the northward extent of heaviest precipitation amounts likely resulted in the underprediction of excessive snowfall in New York City and southern New England (a failure). Therefore, even a relatively good numerical model forecast may contain small errors that can have a profound impact on the accuracy of weather forecasts that are released to the general population.

The inconsistent quality of the forecasts of these storms suggests that certain physical features and dynamical processes, whose influences vary widely from case to case, are better understood or more accurately simulated than others. In view of the

[3,4] Forecasts for these storms were examined from local newspaper reports.

obvious need for an improved understanding of these storm systems, this monograph provides an analysis of the horizontal and vertical structures and evolution of 20 of the most crippling snowstorms to affect the heavily populated Northeast region over a 30-year period from 1955 through 1985. These events are examined from historical, climatological, and dynamical perspectives.

It is not the intent of this monograph to introduce detailed dynamical interpretations of cyclone events, as can be found in specialized diagnostic and modeling studies of individual cases. The Genesis of Atlantic Lows Experiment [GALE (Dirks et al. 1988)] and the Canadian Atlantic Storms Program [CASP (Stewart et al. 1987)], conducted in January through March 1986, and the Experiment on Rapidly Intensifying Cyclones over the Atlantic [ERICA (Hadlock and Kreitzberg 1988)], conducted during the winter of 1988/1989, should serve as excellent sources of specialized studies of cyclogenetic episodes that attempt to address the relative importance of the various processes that influence cyclone development along the East Coast of the United States.

Brandes and Spar (1971) attempted to define the necessary conditions for heavy snowfall along the East Coast using a composite approach. They found that compositing failed to resolve antecedent patterns 12–24 hours prior to heavy snowfalls. Apparently, the synoptic- and mesoscale features in the geopotential height and wind fields that are important factors in the evolution of snowstorms were eliminated by combining many storm systems characterized by significant case-to-case variability. Therefore, the approach used in this monograph is based on sequences of conventional weather charts and detailed descriptions of each individual storm. This method enables us to identify patterns in the surface, lower-tropospheric, and upper-tropospheric fields that precede and accompany the development of heavy snowfall and to document the case-to-case variability that frustrates efforts to specify required conditions or standard scenarios that are applicable to all storms.

The interactions of the varied mechanisms and processes that produce these storms span the spectrum of time and length scales from the nucleation of cloud particles to planetary wave dynamics. The temporal and spatial resolution of the operational weather analyses from which this study is derived limit us to describing only those features which operate over periods of several hours to several days and lengths of 10^2 to 10^4 km [the meso-, synoptic, and planetary scales; see Orlanski (1975)]. Details on the physical principles in snow formation can be found in Byers (1965) and other texts on cloud physics, and will not be addressed here.

We hope that this work will provide a foundation for researchers and students interested in investigating the processes that interact to produce major winter storms and serve as an easily referenced guide for forecasters concerned with predicting heavy snowfalls along the northeastern coast of the United States. In the following pages, historical and climatological overviews of heavy snow events in the Northeast will be discussed in Chapters 2 and 3. A description of the meteorological characteristics of 20 major storms will follow, derived from conventional analyses of sea-level pressure, geopotential height, wind, temperature, and other parameters, in Chapters 4 and 5. The patterns presented by these fields reveal many of the dynamical and physical processes that contribute to the storms, which shall also be discussed. Chapter 6 provides a brief summary of observations and an overview of the physical processes that contribute to these storms, as well as a discussion of remaining issues. Schematic diagrams

illustrating key dynamical patterns and physical processes are included in Chapters 4, 5, and 6, adding a visual perspective to the written descriptions of how the atmosphere evolves prior to and during periods of heavy snow in the northeastern urban corridor. Finally, a series of weather map analyses for each of the 20 storms is presented in Chapter 7, concluding in Chapter 8 with analyses of three storms which occurred during the 1986/1987 winter season.

CHAPTER 2

Historical Overview: A Brief Review of Major Snowstorms of the Eighteenth, Nineteenth, and Twentieth Centuries

Through the centuries, severe winter storms have become part of the historical folklore of many regions. A comprehensive accounting of major winter storms in the Northeast over the past three centuries has been assembled by David Ludlum (1966, 1968, 1976, 1982, 1983).[5] His unique studies document the distribution, depth, and duration of great snowfalls, along with their wind velocity, degree of cold, and effects on the general population. Nearly 300 years of such information provides important historical and climatological insight into the limits of severity these storms are capable of attaining. A sampling of the region's legendary storms is briefly described below.

2.1 EIGHTEENTH CENTURY

27 February–7 March 1717. "The Great Snow of 1717." A series of four snowstorms, two relatively minor and two major, left depths in excess of 90 to 120 cm across most of southern New England, with drifts exceeding 750 cm. The effects of these storms were so impressive that local historical accounts still singled out this storm period as "The Great Snow" more than 100 years following the event.

24 March 1765. This storm affected the area from Pennsylvania to Massachusetts. From Philadelphia came this report: "On Sunday night last there came on here a very severe snowstorm, the wind blowing very high, which continued all the next day, when it is believed there fell the greatest quantity of snow that has been known for many

[5] Historical discussions of storms also appear in selected issues of *Weatherwise* magazine, 1948 to the present.

years past; it being generally held to be two feet [(60 cm)], or two feet and a half [(75 cm)], on the level, and in some places deeper."[6]

27–28 January 1772. "The Washington and Jefferson Snowstorm." George Washington in Mount Vernon and Thomas Jefferson in Monticello were marooned by this storm. Snowfall was estimated at 90 cm on a level across Virginia and Maryland. Washington wrote, ". . . the deepest snow which I suppose the oldest living ever remembers to have seen in this country."[7]

26 December 1778. "The Hessian Storm" was a severe blizzard accompanied by heavy snows, high winds, and bitter cold from Pennsylvania to New England, with drifts reported to 500 cm in Rhode Island. The storm was named for troops occupying Rhode Island during the Revolutionary War.

28 December 1779–7 January 1780. Three storms during one of the coldest winters of the past three centuries produced deep snows in much of New England. The first storm produced rain from New York City southward, but snow occurred in New England with 45 cm at New Haven, Connecticut. The second system was a violent snowstorm with extremely high tides from the Carolinas northward. The third storm was confined primarily to eastern New England. Snow depths in the wake of the three storms ranged between 60 and 120 cm from Pennsylvania to New England.

4–10 December 1786. This period featured another succession of three crippling snowstorms. Estimates in the local press placed snow depths from Pennsylvania to New England at 60 to 120 cm. In describing the third storm, a Boston newspaper notes, "a snowstorm equally severe and violent with that we experienced on Monday and Tuesday preceding. The quantity of snow is supposed to be greater, now, than has been seen in this country at any time since that which fell seventy years ago, commonly termed 'The Great Snow.' "[8]

19–21 November 1798. "The Long Storm" is described by Ludlum as the heaviest November snowstorm in the history of the coastal northeast from Maryland to Maine. Forty-five cm of snow reportedly fell in New York City.

2.2 NINETEENTH CENTURY

26–28 January 1805. This cyclone brought a very heavy snowstorm to New York City and New England. Snow fell continuously for 48 hours in New York City, where 60 cm reportedly accumulated.

23–24 December 1811. Temperatures fell from well above freezing on 23 December to −15°C on 24 December, while a storm intensified explosively off Long Island, New York. Snowfall in New York City, Long Island, and southern New England averaged 30 cm, as severe blizzard conditions prevailed. Strong winds and high tides caused extensive damage to shipping.

[6] Ludlum, D., 1966, p. 62.
[7] Ludlum, D., 1966, p. 145.
[8] Ludlum, D., 1966, p. 71.

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