A Twenty Year Recollection of the Superstorm of March 1993 in the Western Carolinas and Extreme Northeast Georgia

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1. Introduction

Much has been written about the eastern United States extratropical cyclone of March 1993 that often is referred to as "The Storm of the Century" or the "Superstorm" (Fig. 1). Interested readers can refer to a number of technical and non-technical papers describing various aspects of the event. The storm had profound effects across a considerable portion of the eastern United States, including heavy snow, damaging winds, blizzard conditions, severe convective storms, coastal erosion, and coastal flooding. Unfortunately, fatalities occurred, and there were crippling impacts on the economy and infrastructure. The information below provides an overview of significant occurrences and impacts in the County Warning Area (CWA) of the Greenville-Spartanburg (GSP) National Weather Service (NWS) Forecast Office[1]. Kocin et al. (1995) and Kocin and Uccellini (2004a,b) provided excellent reviews of the storm's development and its impacts. Much of the information that follows was extracted from their work.

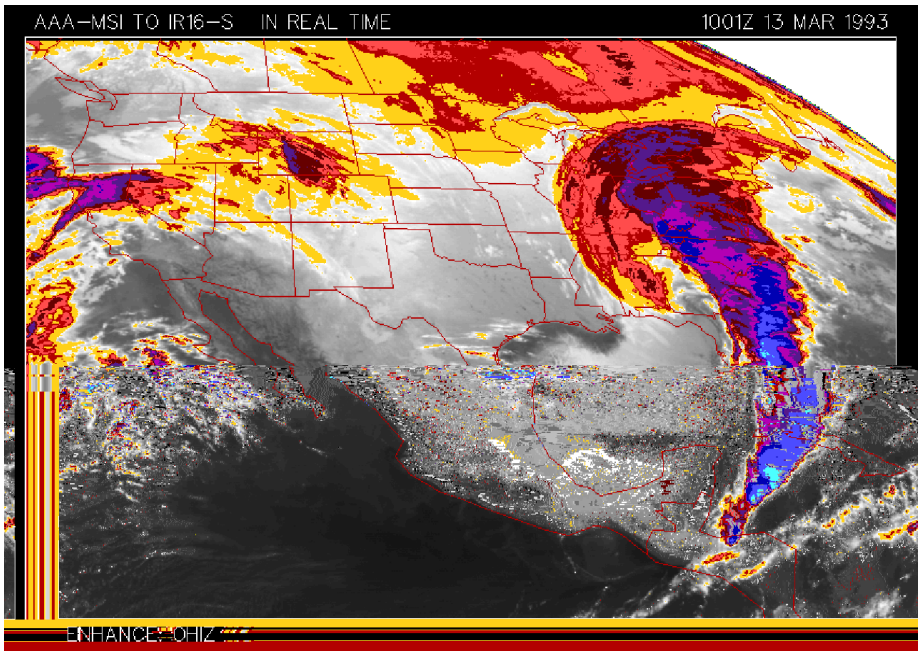


Fig. 1. Infrared satellite image at 1001 UTC on 13 March 1993. Source: National Climatic Data Center

[1] The County Warning Area for the Greenville-Spartanburg NWS office was created subsequent to March 1993.

2. Synoptic Overview

At 0000 UTC on 12 March 1993, a weak area of low pressure was in the western Gulf of Mexico just southeast of Texas. High pressure centered over the northern Great Plains extended eastward and covered most of the central and eastern states (Fig. 2). A broad cyclonic flow aloft existed over much of the country, but a developing trough was over the southwestern United States. Two short wave troughs over the western states moved toward the Gulf region and subsequently merged. The merger contributed to the development of a highly amplified trough-ridge system across the country by 0000 UTC on 13 March. The deepening and sharpening upper-level trough over the Gulf of Mexico promoted rapid organization and strengthening of the surface low pressure system. For details, refer to Kocin and Uccellini (2004a,b).

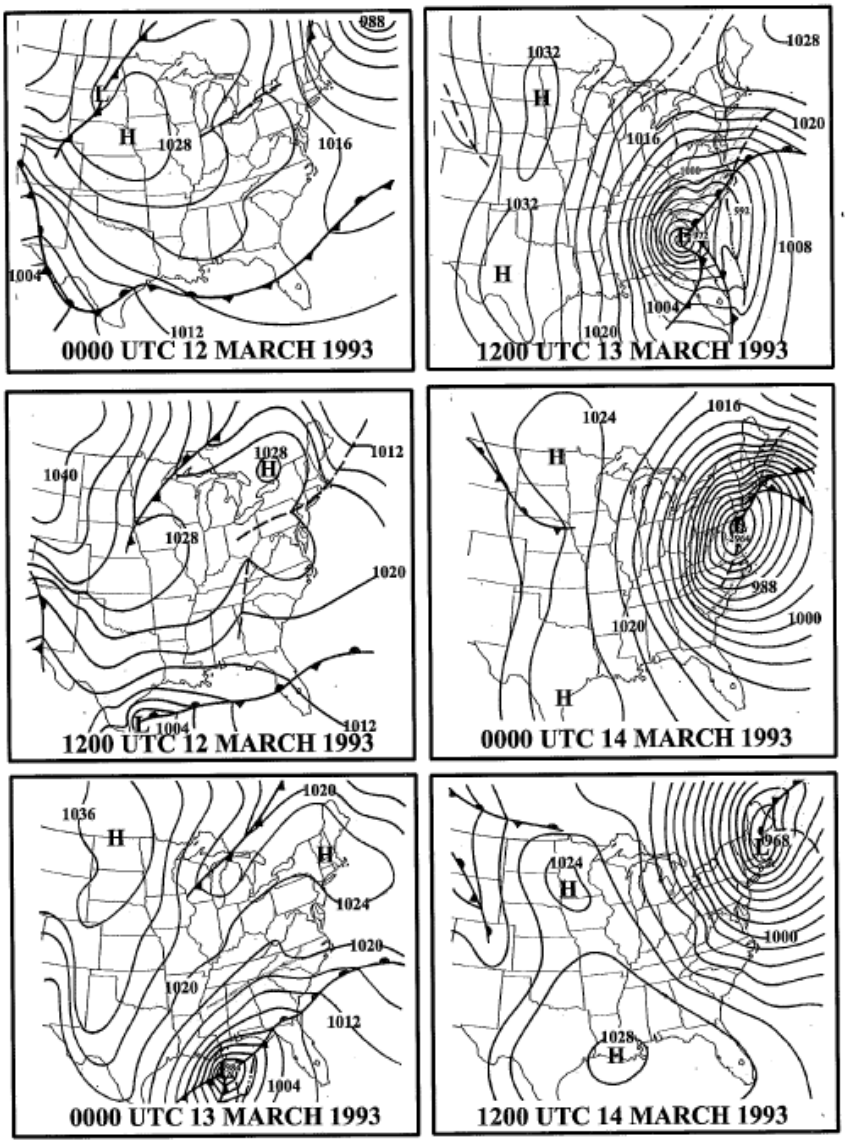


Fig. 2. Surface analyses at times indicated from 12 to 14 March 1993 (Kocin and Uccellini, 2004)

The surface low pressure system moved to a position just south of Louisiana at 0000 UTC on 13 March then it curved toward the northeast to east-central Georgia by 1200 UTC on 13 March (Fig. 3). Rapid deepening of the surface low under the influence of a strongly divergent, negatively tilted upper-level trough (Fig. 4) caused precipitation to spread northward and surface wind speeds to increase. Rain and snow moved from Alabama and Georgia into the western Carolinas during 12 March and became mostly snow across the region during the overnight and early morning hours of 13 March.

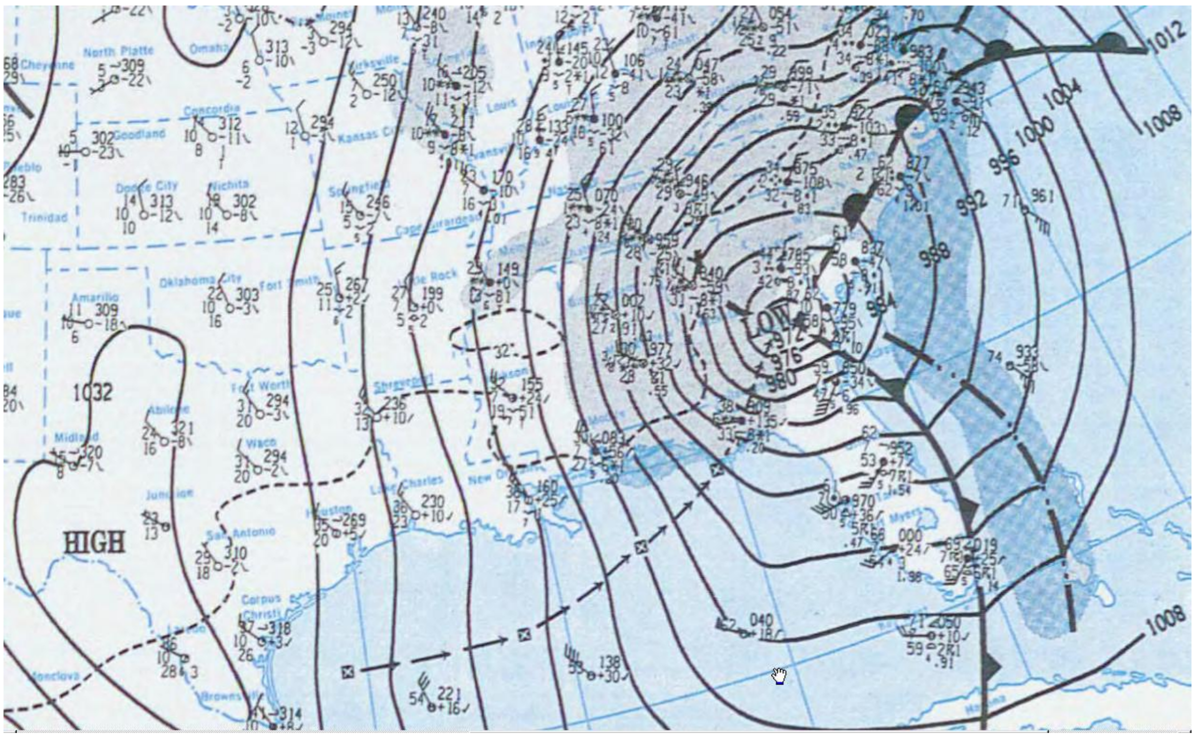


Fig. 3. NWS National Meteorological Center Surface analysis at 1200 UTC on 13 March 1993.

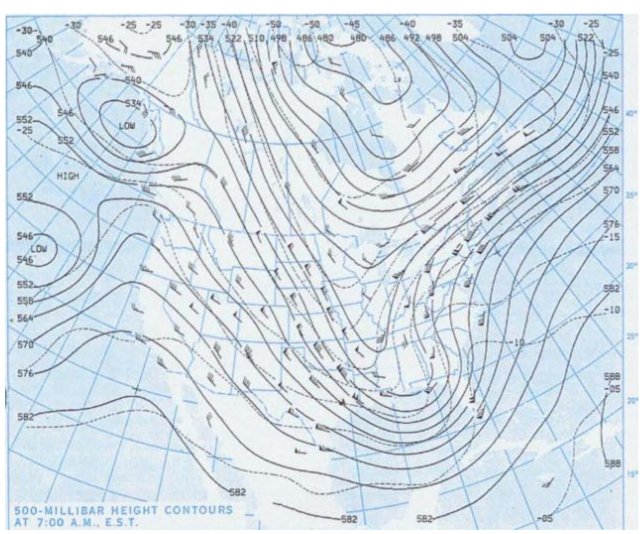


Fig. 4. NWS National Meteorological Center 500 mb analysis at 1200 UTC on 13 March 1993.

The deep low pressure center moved across the central Carolinas during 13 March and reached the vicinity of New Jersey by 0000 UTC on 14 March (Fig. 5). Even as the storm moved away from the western Carolinas and extreme northeast Georgia, strong winds and northwest flow snow continued (Fig. 6). The combined circulation around the deep low pressure and the high pressure in the central United States fed record cold air across the region on the heels of winds strong enough to cause damage and considerable drifting snow in some areas.

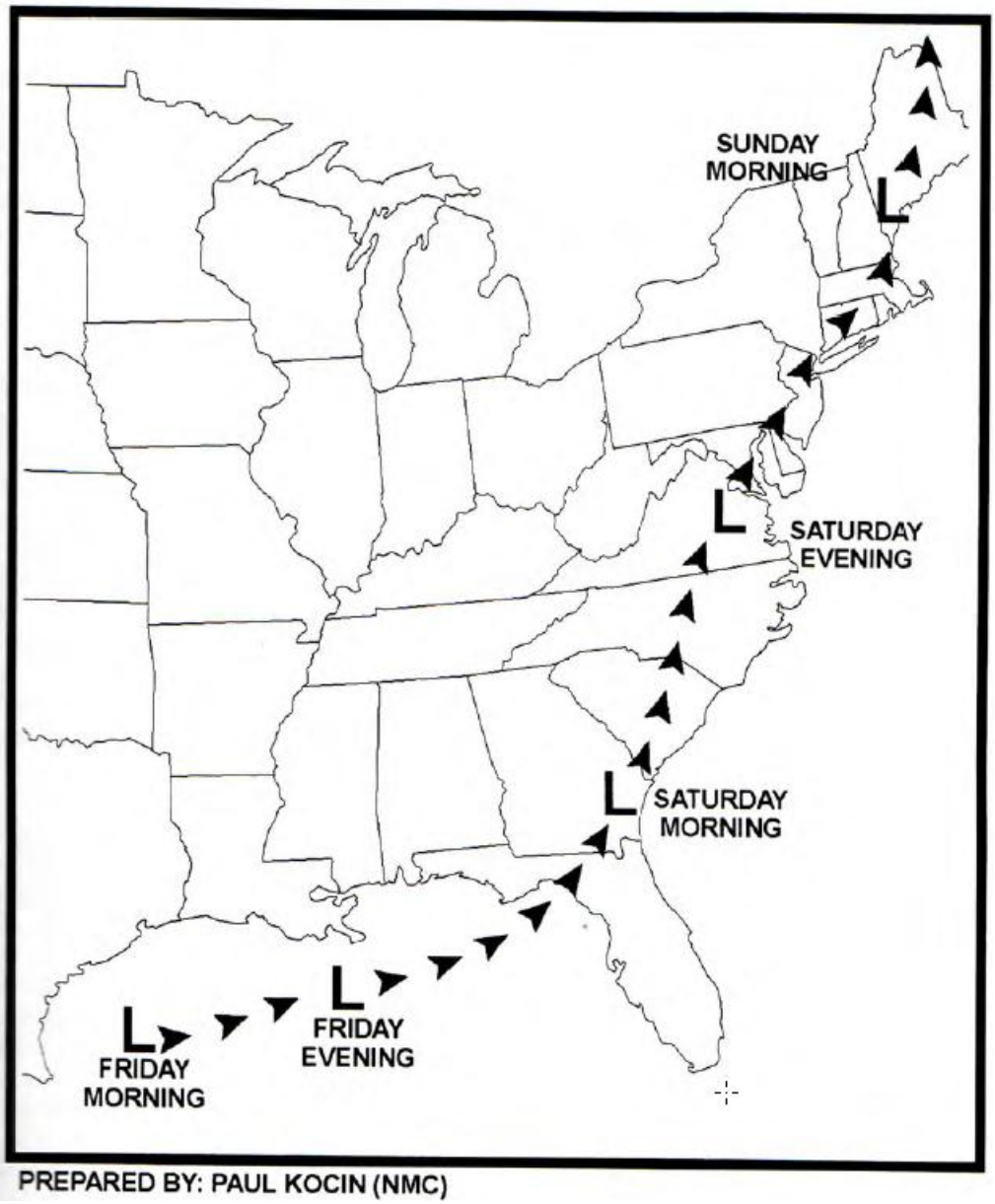


Fig. 5. Track of the March 1993 Superstorm. Source: DOC/NOAA Natural Disaster Survey Report: Superstorm of March 1993

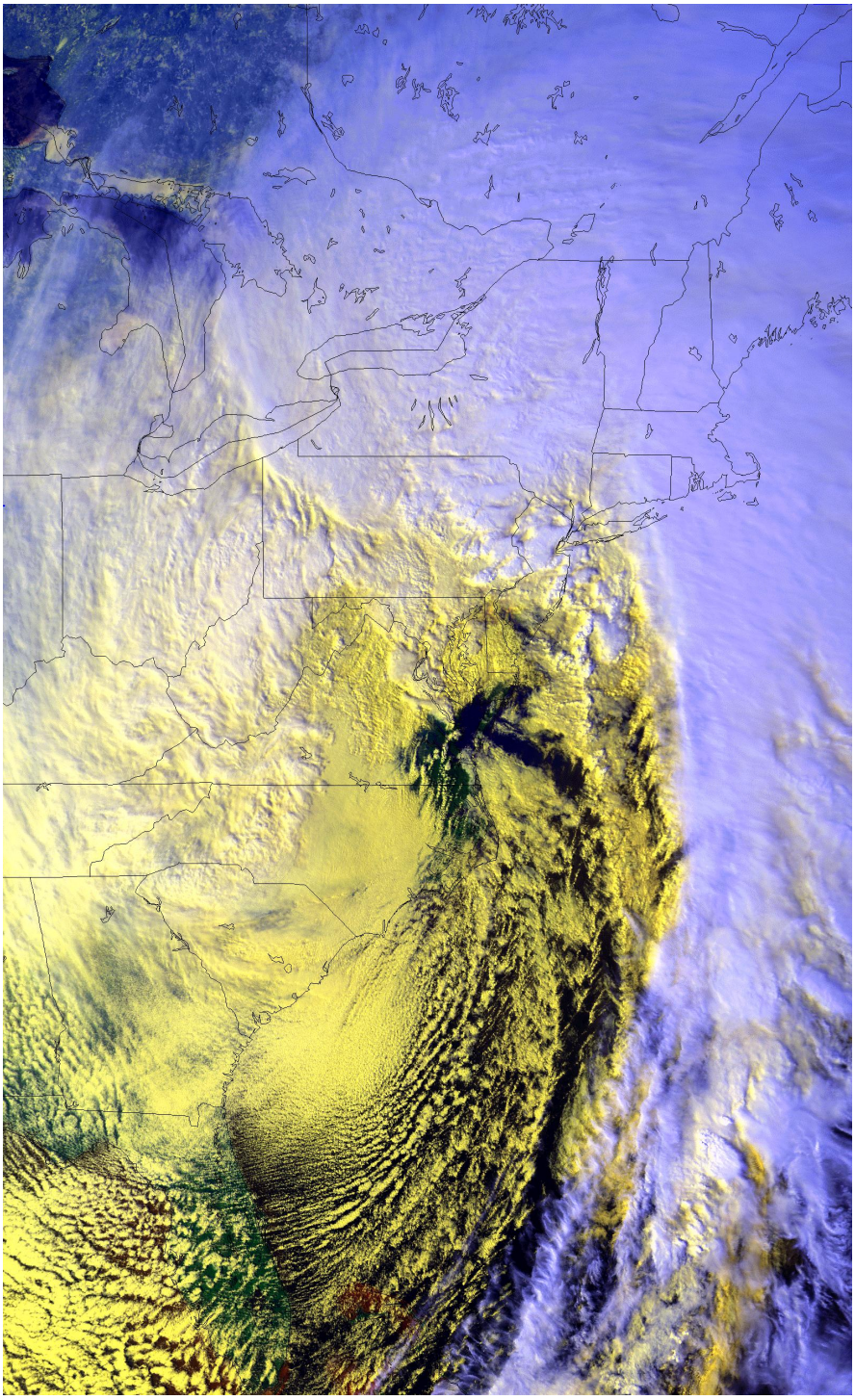


Fig. 6. Multi-Channel POES satellite image on 13 March 1993. The low pressure center was over the mid-Atlantic coast. Cold air, strong winds, and northwest flow snow were spreading over the southern Appalachians. Source: National Climatic Data Center

3. Impacts

a. Georgia

The following narrative was extracted from the March 1993 issue of *Storm Data* (DOC/NOAA/NESDIS/NCDC 1993d).

> *An intense late winter storm moving northeast from the Gulf of Mexico began producing light snow around 2200 EST [12 March; 0300 UTC 13 March] over the extreme north Georgia mountains. By 0200 EST [13 March; 0700 UTC], the snow was falling at a rate of 1 inch per hour…*
>
> *Most secondary roads had become impassable across north Georgia by sunrise while primary roads were limited primarily to emergency travel.*
>
> *The heavy snow warning for extreme north Georgia was upgraded to a blizzard warning by 0500 EST [13 March; 1000 UTC] Sustained winds of 40 to 50 mph with gusts as high as 65 mph combined with heavy snow to produce deadly white-out conditions. Visibilities were reduced to zero as snow continued to fall at a rate of 1 to 2 inches per hour.*
>
> *Temperatures throughout the early morning continued to fall into the 20s and combined with storm force winds to produce dangerous wind chills approaching 20 below zero. Roads across the north Georgia mountains became impassable by mid morning due to heavy snow, fallen trees, downed powerlines, and white-out conditions.*
>
> *Accumulations of snow by late evening had averaged 18 to 24 inches from near Rome to Clayton…*
>
> *Snow drifts ranged from 8 to 10 feet high.*

b. South Carolina

The following narrative was extracted from the March 1993 issue of *Storm Data* (DOC/NOAA/NESDIS/NCDC 1993d).

The wind became very high early Saturday [13 March] morning with gusts reaching an estimated 65 mph in the foothills. This area, extending from near Table Rock in Pickens County to north of Gaffney in Cherokee County, received the most upstate wind damage from the storm. Winds remained near this level through most of the day. The S.C. Forestry Commission estimated that high winds damaged 28,385 acres of forests within the four counties of Greenville, Pickens, Oconee, and Spartanburg with a loss exceeding three million dollars. In Greenville County alone, 26,000 acres were damaged. Effects of the winds were no doubt greater because of snow loading and soggy ground conditions. There was some structural damage to buildings in the area of highest winds and numerous cases of trees falling on structures. Winds reached advisory level (peak gusts to near 50 mph across much of the remainder of the foothills and the Piedmont counties. The storm began with a cold rain mixed with sleet. The water equivalent was 1.5 to 2 inches across the area and then changed to snow with an additional half inch or so water equivalent. In the mountains, however, precipitation was mostly snow throughout the event. Snow depths ranged from 2 to 5 inches in the Piedmont, 3 to 10 inches in the foothills, and up to 18 inches in the mountains. One of the larger amounts reported was 18 inches at Camp Greenville near Caesar's Head. Actual snowfall was considerably higher at many locations than the maximum reported snow depth due to melting. It is likely that blizzard conditions existed in the mountain counties. One of the larger evacuations was the evacuation by air of about 100 teenagers from Camp Greenville. One of the hardest hit towns was Landrum. Electrical power there, and at other places, was out for nearly a week following the storm.

Thunderstorms were associated with the highest amounts of snowfall. They were embedded in the stratiform precipitation from about 0800 EST to about 1400 EST [1300 UTC to 1900 UTC]. Lightning struck the Union County Communications Center knocking plaster from the wall and disrupting communications. Record cold weather followed the storm. The 11 degrees at the Greenville-Spartanburg Airport on the 15th tied the coldest temperature recorded in March and was the coldest so late in the season. The cold rain and wind contributed to one death on the 13th and the record cold to another death on the 15th.

The March 1993 *Storm Data* also contained the following information that pertained to York and Chester counties.

> *Snowfall varied from 3 to 5 inches, disrupting traffic. High winds damaged several thousand acres of forests. Numerous power outages [were caused] from trees across power lines.*

c. North Carolina

Record low sea level pressure occurred at Charlotte (28.68 in) and Asheville (28.89 in). The 18.2 inch (4.0 inches on the 12th, 14.0 inches on the 13th, and 0.2 inch on the 14th) snowfall at the Asheville Regional Airport was a record total for March.

The following narrative was extracted from the March 1993 *Storm Data* (DOC/NOAA/NESDIS/NCDC 1993d).

> *Blizzard conditions prevailed in the western half of the state. Snowfall totals ranged from 2 to 13 inches in the western Piedmont, 15 to 19 inches in the foothills, and from 18 to 24 inches in the valleys to as much as 50 inches atop Mount Mitchell in the mountains. Mountain winds reached 101 mph at Flat Top Mountain east of Asheville. Snow drifts of 8 to 21 feet were reported. At Asheville Airport, winds peaked from the northwest at 48 mph with gusts to 64 mph at 12 noon [1700 UTC] on the 13th.*
>
> *The major impacts to the western part of the state was from heavy snow accumulation resulting in extensive road blockages, stranded motorists, and in the mountains lost hikers and campers. Strong winds and heavy snow brought down trees, limbs, and power lines leaving many without heat or electricity or telephone service. At one point, Polk County reported 99% of its electrical customers without power. …over 160 thousand people were reported to be snowbound by the storm.*

The backlash of the storm brought extremely cold air into North Carolina late on the 13th and lasting through daybreak on the 15th. Wind chill values colder than minus 20 degrees were felt in western North Carolina on the 13th and 14th. Early on the 15th, the temperature bottomed at record setting levels for March with 2 degrees at Asheville … and minus 4 degrees at Waynesville.

Loss of home heating and the extreme cold resulted in seven deaths[1] and one injury from exposure. Elements of the storm contributed to the deaths of seven others with medical problems. These included snow-shoveling heart attack victims. Freezing temperatures caused water pipes to burst and resulted in death of livestock. The heavy wet snow caved in the roofs of several chicken houses killing the chickens.

4. Snowfall Impacts Beyond the Southern Appalachians

The winter precipitation produced by the storm extended from the Gulf Coast region all the way to New England (Fig. 7). The Northeast Snowfall Impact Scale (NESIS) developed by Kocin and Uccellini (2004) categorized this storm as number one on the list. NESIS measures impact as a function of snowfall distribution, snowfall amounts, and population density across the Northeast urban corridor.

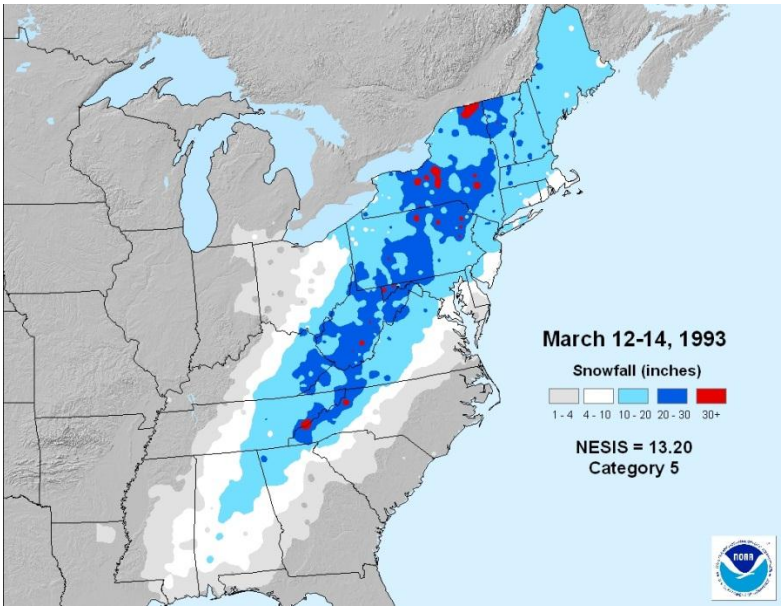


Fig. 7. Snowfall distribution across the eastern United States during 12-14 March 1993. Details regarding NESIS can be found in Kocin and Uccellini (2004c).

5. Summary

The Superstorm of 12-14 March 1993 was one of them most severe winter storms to affect the East Coast during the twentieth century. The low pressure system that developed in the northern Gulf of Mexico and subsequently tracked all the way to New England left in its wake widespread damage, destruction, and misery. Details regarding the meteorological and societal aspects of the event were documented in a number of publications (e.g., DOC/NOAA/NWS, 1994; Kocin et al., 1995; Uccellini et al., 1995; Kocin and Uccellini, 2004a,b).

Primary storm effects in the current NWS Greenville-Spartanburg CWA consisted of heavy snow and strong winds that produced blizzard conditions, wind damage to structures and trees, life-threatening low temperatures and wind chill, and considerable disruption to normal business and commerce. Several fatalities were directly and indirectly attributed to the storm and damage was in the millions of dollars.

An overview of sea level pressure, snowfall, wind, and temperature reports and monetary damage estimates can be found in Fig. 8 and Tables 1 through 5. Appendix I contains a portion of the Swannanoa 2 SSE (Flat Top Mountain, North Carolina; 4,320 ft MSL) March 1993 NWS cooperative observer record. Appendix II displays a map of selected NWS cooperative observer snowfall totals in the current NWS Greenville-Spartanburg County Warning Area.

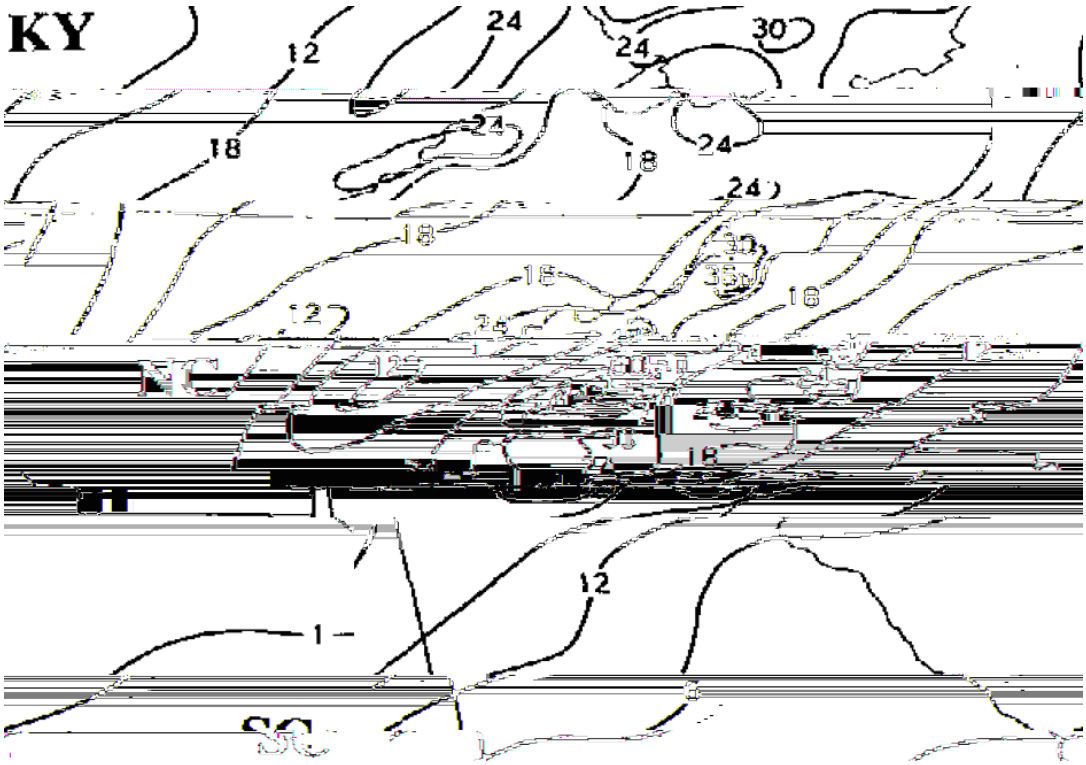


Fig. 8. Storm Total Snowfall (inches) during 12-14 March 1993 (DOC/NOAA/NESDIS/NCDC 1993c).

Table 1. Record Low Sea Level Pressure on 13 March 1993

Record Low Sea Level Pressure	inches
Asheville	28.89
Greenville-Spartanburg (Greer)	28.74

Table 2. Highest Wind Gust on 13 March 1993

Location	Highest Wind Gust (mph)	Direction
Asheville NCDC	70 (estimated)	Northwest
Asheville Airport	64	Northwest
Swannanoa 2 SSE (Flat Top Mtn.)	101	Northwest
Greenville-Spartanburg (Greer)	46*	Northeast
Charlotte	44	Southwest
*A gust to 48 mph was reported at GSP on both 8 and 10 March 1993		

Table 3. List of Deaths, Injuries, and Damage Estimates by State (DOC/NOAA/NWS 1994)

Deaths, Injuries, and Damage Estimates				
State (Entire)	Deaths		Injuries	Damage Estimate (Millions)
	Direct	Indirect		
Georgia	15		420	$355
South Carolina	2	2	4	$22.2
North Carolina	2	7	13	$13.5

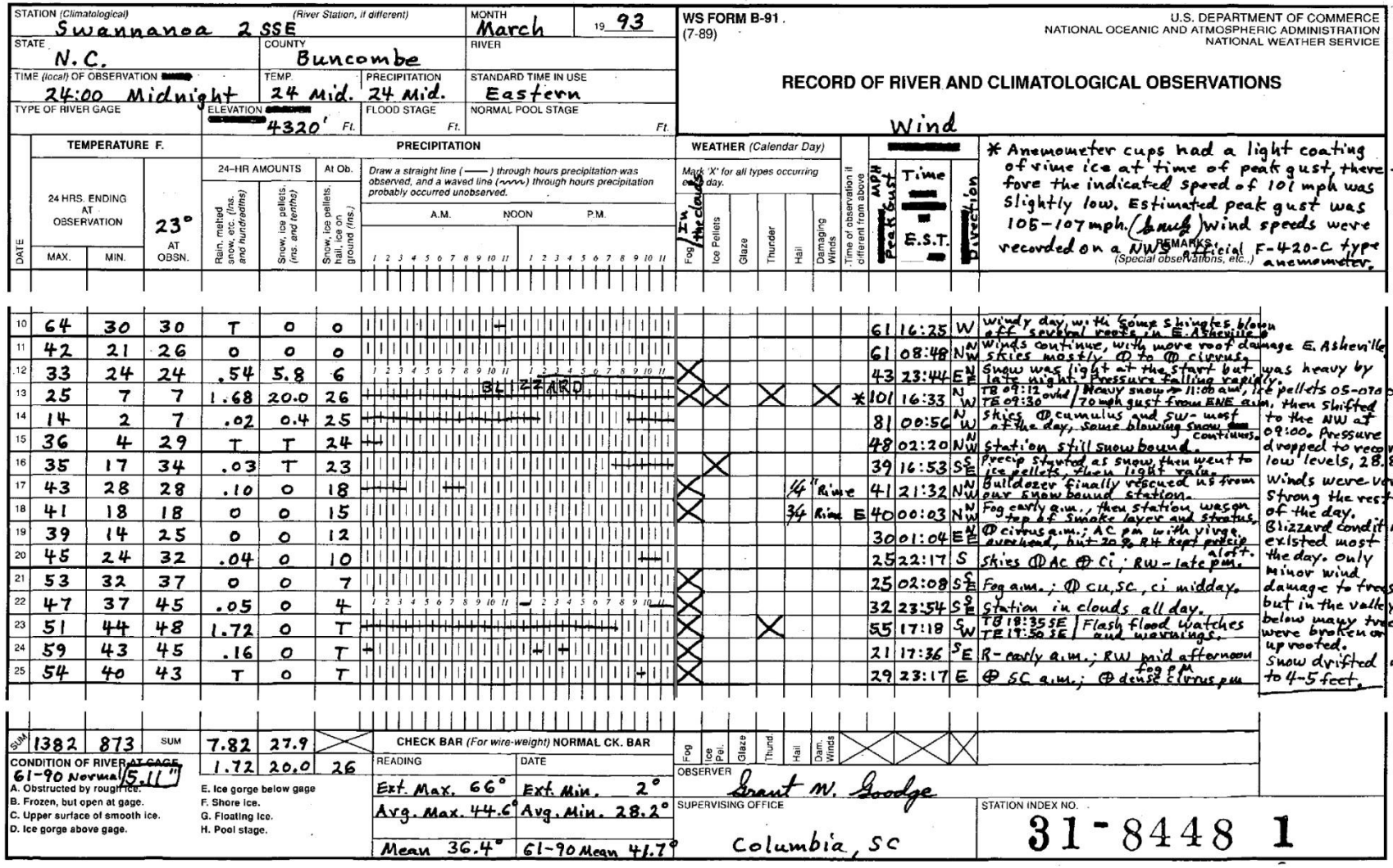
Table 4. Snowfall During 12-14 March 1993

Storm Total Snowfall			
North Carolina			
Station	**Snow (inches)**	**Station**	**Snow (inches)**
Asheville Airport	18.2*	Lenoir	13.0
Asheville NCDC	20.3	Lincolnton 4 W	9.2
Bent Creek, NC	18.0	Marion	18.0
Black Mountain 2 W	18.0	Marshall	22.0
Cataloochee	22.0	Monroe 4 SE	2.3
Celo 2 S	24.0	Morganton	11.3
Charlotte	1.6	Mount Mitchell	50.0
Concord	5.0	Pisgah Forest 1 N	11.5
Coweeta Exp. Stn.	26.5	Salisbury	4.0
Cullowhee	19.0	Salisbury 9 WNW	3.0
Fletcher 2 NE	16.0	Shelby 2 NNE	5.8
Fletcher 3 W	18.0	Statesville 2 NNE	6.0
Forest City 6 SW	9.0	Swannanoa 2 SSE	26.2
Hendersonville 1 NE	18.0	Tryon	9.5
Hickory	10.0	Waterville 2	26.0
Highlands	16.5	Waynesville 1 E	18.0
Hot Springs	26.0		
*Monthly Record			
South Carolina			
Station	**Snow (inches)**	**Station**	**Snow (inches)**
Caesars Head	17.0	Ninety Nine Islands	2.0
Calhoun Falls	3.0	Salem 2 NNW	1.0
Chesnee 7 WSW	6.0	Santuck	3.1
Chester 1 NW	4.0	Spartanburg 3 SSE	4.0
Clemson University	5.0	Union 8 SW	4.0
Greenville-Spartanburg (Greer)	9.8*	Walhalla	3.0
Greenwood 3 SW	4.0	West Pelzer	5.0
Laurens	3.0	Winthrop College	3.0
Longcreek	7.0		
*March Monthly Record			
Georgia			
Station	**Snow (inches)**	**Station**	**Snow (inches)**
Clarksville	3.7	Clayton 1 SSW	7.0

Table 5. Minimum Temperatures Associated with the 12-14 March 1993 Superstorm

Minimum Temperatures					
North Carolina					
Station	**Temperature (°F)**	**Date**	**Station**	**Temperature (°F)**	**Date**
Asheville Airport	2*	15	Hickory	10	15
Asheville NCDC	10	15	Highlands	5	15
Banner Elk	-9	15	Lenoir	6	15
Bent Creek	-1	15	Lincolnton 4 W	6	15
Black Mountain 2 W	11	13	Marion	7	15
Canton 1 SW	-4	15, 16	Marshall	-3	15, 16
Cataloochee	0	15	Monroe 4 SE	13	15
Celo 2 S	10	14	Morganton	5	15
Charlotte	16	15	Oconaluftee	-3	15
Concord	15	15	Pisgah Forest 1 N	-2	15, 16
Coweeta Exp. Stn.	-1	15	Salisbury	12	15
Cullowhee	-1	15	Salisbury 9 NNW	8	15
Fletcher 2 NE	-4	15, 16	Shelby 2 NNE	6	15
Fletcher 3 W	-1	15	Statesville 2 NNE	10	15
Forest City 6 SW	7	15, 16	Swannanoa 2 SSE	2	14
Franklin	-5	15	Tapoco	-1	15
Gastonia	14	15	Tryon	18	15
Grandfather Mtn.	-3	14	Waterville 2	6	15
Hendersonville 1 NE	-2	15	Waynesville 1 E	-8	15
*March Record Low					
South Carolina					
Station	**Temperature (°F)**	**Date**	**Station**	**Temperature (°F)**	**Date**
Anderson	13	15	Laurens	13	15
Anderson Airport	14	15	Longcreek	6	15
Caesars Head	10	15	Ninety Nine Islands	11	15
Calhoun Falls	19	15	Salem 2 NNW	12	15, 16
Chesnee	9	15	Santuck	13	15
Chester 1 NW	11	15, 16	Spartanburg 3 SSE	12	15
Clemson University	18	15	Union 8 SW	12	15
Greenville Downtown Airport	15	15	Walhalla	11	15
Greenville-Spartanburg (Greer)	11*	15	West Pelzer	12	15
Greenwood 3 SW	16	15	Winthrop College	17	15
March Record Low					
Georgia					
Station	**Temperature (°F)**	**Date**	**Station**	**Temperature (°F)**	**Date**
Clarksville	8	15, 16	Elberton 2 N	13	15
Clayton 1 SSW	6	15	Hartwell	18	15
Cornelia	14	15	Toccoa	16	15, 16

Edited March 1993 Record of River and Climatological Observations (Form B-91) at Swannanoa 2 SSE (Flat Top Mountain, North Carolina)



STATION (Climatological): Swannanoa 2 SSE | (River Station, if different) | MONTH: March | 19 93
STATE: N.C. | COUNTY: Buncombe | RIVER
TIME (local) OF OBSERVATION: 24:00 Midnight | TEMP.: 24 Mid. | PRECIPITATION: 24 Mid. | STANDARD TIME IN USE: Eastern
TYPE OF RIVER GAGE | ELEVATION: 4320' Ft. | FLOOD STAGE: Ft. | NORMAL POOL STAGE: Ft.

WS FORM B-91 (7-89)
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE

RECORD OF RIVER AND CLIMATOLOGICAL OBSERVATIONS

Wind

* Anemometer cups had a light coating of rime ice at time of peak gust, therefore the indicated speed of 101 mph was slightly low. Estimated peak gust was 105–107 mph. (hourly) wind speeds were recorded on a NWS official F-420-C type anemometer.

REMARKS (Special observations, etc.)

DATE	TEMPERATURE F. 24 HRS. ENDING AT OBSERVATION MAX.	MIN.	23° AT OBSN.	PRECIPITATION 24-HR AMOUNTS Rain, melted snow, etc. (Ins. and hundredths)	Snow, ice pellets (Ins. and tenths)	At Ob. Snow, ice pellets, hail, ice on ground (Ins.)	Draw a straight line (——) through hours precipitation was observed, and a waved line (~~~) through hours precipitation probably occurred unobserved. A.M. NOON P.M. 1 2 3 4 5 6 7 8 9 10 11 1 2 3 4 5 6 7 8 9 10 11	WEATHER (Calendar Day) Mark 'X' for all types occurring each day. In the clouds	Fog	Ice Pellets	Glaze	Thunder	Hail	Damaging Winds	Time of observation if different from above	Peak Gust MPH	Time E.S.T.	Direction	
10	64	30	30	T	0	0									61	16:25	W	windy day, with some shingles blown off several roofs in E. Asheville.
11	42	21	26	0	0	0									61	08:48	NW	Winds continue, with more roof damage E. Asheville. skies mostly ⊘ to ◑ cirrus.
12	33	24	24	.54	5.8	6		X							43	23:44	ENE	Snow was light at the start but was heavy by late night. Pressure falling rapidly.
13	25	7	7	1.68	20.0	26	BLIZZARD	X			X		X		*101	16:33	NW	TS 09:12 ovhd / Heavy snow on 11:00 a.m., ice pellets 05-070; TS 09:30 ovhd / 70 mph gust from ENE a.m., then shifted to the NW at 09:00. Pressure dropped to record low levels, 28.89 (sea level)
14	14	2	7	.02	0.4	25		X							81	00:56	NW	skies ◑ cumulus and SW- most of the day, some blowing snow continues.
15	36	4	29	T	T	24									48	02:20	NW	Station still snowbound.
16	35	17	34	.03	T	23		X							39	16:53	SE	Precip started as snow then went to ice pellets, then light rain.
17	43	28	28	.10	0	18		X			1/4" Rime				41	21:32	NW	Bulldozer finally rescued us from our snow bound station.
18	41	18	18	0	0	15		X			3/4 Rime E				40	00:03	NW	Fog early a.m., then station was on top of smoke layer and stratus.
19	39	14	25	0	0	12									30	01:04	ENE	◑ cirrus a.m.; AC pm with virga overhead, but 20% RH kept precip aloft.
20	45	24	32	.04	0	10									25	22:17	S	skies ◑ AC ◑ Ci; RW - late pm.
21	53	32	37	0	0	7		X							25	02:08	SSE	Fog a.m.; ◑ CU, SC, ci midday.
22	47	37	45	.05	0	4		X							32	23:54	SSE	Station in clouds all day.
23	51	44	48	1.72	0	T		X					X		55	17:18	SW	TS 19:35 SE / TS 19:50 SE / Flash flood watches and warnings.
24	59	43	45	.16	0	T		X							21	17:36	SE	R - early a.m.; RW mid afternoon fog PM
25	54	40	43	T	0	T		X							29	23:17	E	◑ SC a.m.; ◑ dense cirrus pm
SUM	1382	873	SUM	7.82	27.9													
				1.72	20.0	26												

Snow drifted up to 4-5 feet.

CONDITION OF RIVER AT GAGE
61-90 Normal 5.11"
A. Obstructed by rough ice.
B. Frozen, but open at gage.
C. Upper surface of smooth ice.
D. Ice gorge above gage.
E. Ice gorge below gage
F. Shore ice.
G. Floating ice.
H. Pool stage.

CHECK BAR (For wire-weight) NORMAL CK. BAR

READING	DATE
Ext. Max. 66°	Ext. Min. 2°
Avg. Max. 44.6°	Avg. Min. 28.2°
Mean 36.4°	61-90 Mean 41.7°

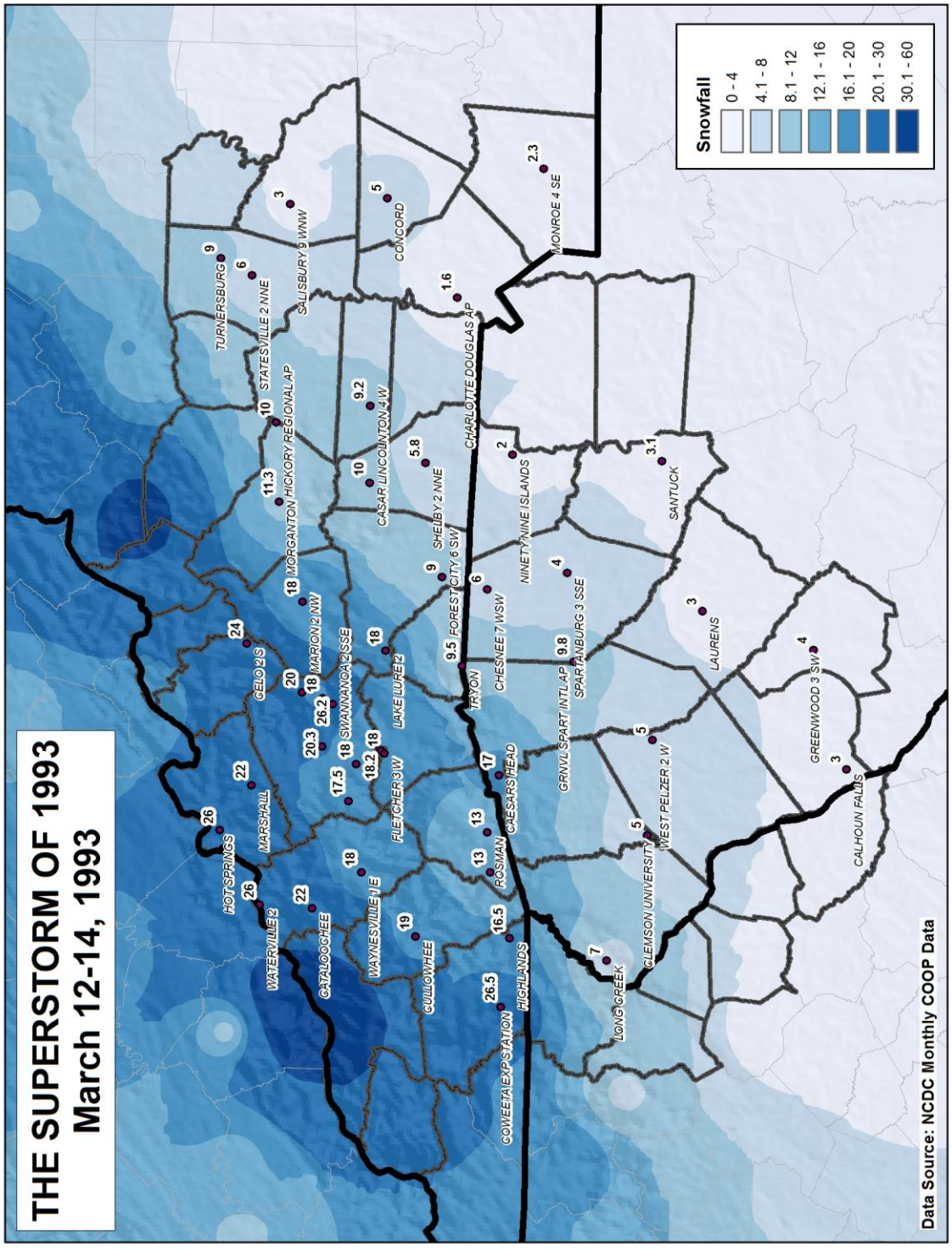
Fog | Ice Pel. | Glaze | Thund | Hail | Dam. Winds

OBSERVER: Grant W. Goodge

SUPERVISING OFFICE: Columbia, SC

STATION INDEX NO.: 31-8448 1

Selected Snowfall Totals from NWS Cooperative Observers during the Superstorm of March 1993. Source: Greg Dobson,National Environmental Modeling and Analysis Center, University of North Carolina - Asheville



Acknowledgments. National Weather Service cooperative observers took excellent daily temperature and precipitation observations in harsh conditions that have allowed a number of studies and reviews to be performed during the past 20 years on the Superstorm of March 1993. Grant W. Goodge recorded the weather conditions at Swannanoa 2 SSE (Flat Top Mountain, North Carolina) with detail, neatness, precision, and accuracy that shed light on aspects of the storm that might otherwise not be known. The National Meteorological Center (now the NCEP/Weather Prediction Center) surface and 500 mb analyses were obtained online from the NOAA Central Library U.S. Daily Weather Maps Project. The map of NWS cooperative observer snowfall totals was provided by Greg Dobson of the National Environmental Modeling and Analysis Center at the University of North Carolina-Asheville.

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