9.3 **Development of Regional Snowfall Indices**

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1. Introduction

This paper describes a collaborative effort between NOAA's National Climatic Data Center (NCDC) and Rutgers University to develop regional snowfall indices that attempt to gauge the societal impact of snowstorms. Population information derived from the 2000 Census is used with conventional meteorological data to help quantify societal effects. It is reasonable to assume that a given amount of snowfall in a populated region will have a larger societal impact than the same amount of snowfall in a less populated area. In a similar vein, Schneider et. al. (2009) has examined the impact of severe weather events on society by using population density information. Kocin and Uccellini (2004) developed the Northeast Snowfall Impact Scale (NESIS) to characterize snowstorms in the Northeast. The index is based on the spatial extent of the storm, the amount of snowfall, and the juxtaposition of population and snowfall. Including population information ties the index to societal impacts. In 2005, NCDC began calculating NESIS scores operationally for large snowstorms affecting the Northeast (Squires and Lawrimore, 2006).

The goal of the current project is to develop NESIS-like indices for all regions of the country. The indices are calculated in a similar fashion to NESIS, but our experience has led us to propose a change in the methodology. The new indices require region-specific parameters and thresholds for the calculations. This paper discusses the process of developing new regional snowfall impact scales.

2. Data and Storm Selection

Gridded snowfall information was generated at the Rutgers University Global Snow Lab using the Integrated Near Real-Time (INRT) station data from NCDC and the Spheremap spatial interpolation program, developed at the Center for Climatic Research, University of Delaware. The data were first examined using various quality control criteria set forth by Robinson (1989). Once the quality control and Spheremap interpolation were complete, final 1° x 1° grids were prepared using software developed by T. Mote and J. Dyer at the Department of Geography, University of Georgia (Dyer and Mote 2006).

Average snowfall for each grid cell was multiplied by cell population using 2000 U.S. census data, and then summed within each region to obtain daily regional population-weighted snow values. Running four-day totals of the daily snow values were calculated, with the largest totals used to identify high-impact snow events in each region. Storm event dates were determined by evaluating a combination of the daily population-weighted snow values, daily weather maps (source: http://docs.lib.noaa.gov/rescue/dwm/data_rescue_daily_weather_maps.html), and daily GIS snowfall maps. Once storm event dates were identified, population-weighted snow totals for each event were computed by summing the daily values for the dates within each event period. The fifty largest event totals within each of the of the six eastern NCDC Climate Regions were used to select the candidate storms for which detailed quality control was performed and snow impact scale indices were calculated. Figure 1 is a map of the NCDC Regions.

3. Regional Snowfall Impact Scale

Local versus Regional Effects NCDC has been calculating NESIS values since the 2004-2005 winter season. Since then there has been a call to compute regional indices for other areas of the country. There have also been many questions about what is meant by regional effects. It is important to differentiate between *regional* effects and *local* effects. Local effects can usually be related to the timing of a storm within a city or county. For example, a storm that reaches maximum intensity during rush hour will

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have a much greater impact than a storm that occurs during the middle of the night on a weekend. See Call (2005) for a description and explanation of local effects. By contrast, regional effects include the impacts that affect areas large enough to include several states. The time scale for regional effects is normally on the order of days. The impacts are typically related to the disruption of commerce and transportation across a multi-state area. It is impossible to quantify all the local effects associated with a storm and aggregate them across a region, so an alternative is to develop an index that makes use of snowfall and population data and combine them in a manner which puts the storms and their societal impacts into historical perspective.

ReSIS Algorithm The general equation used to calculate the Regional Snowfall Impact Scale (ReSIS) is given by:

$$ReSIS = \sum_{T=T_1}^{T_4} \left[\left(\frac{A_T}{\bar{A}_T} + \frac{P_T}{\bar{P}_T} \right) \right] \qquad (1)$$

where:
T = regional specific snowfall thresholds
A_T = area affected by snowfall greater than threshold T
$\bar{A}_T$ = mean area affected by snowfall greater than threshold T
P_T = population affected by snowfall greater than threshold T
$\bar{P}_T$ = mean population affected by snowfall greater than threshold T

The regions referred to above are the nine NCDC Climate Regions. The regional specific snowfall thresholds, *T*, serve to calibrate ReSIS to each region. For example, the regional snowfall thresholds for the Southern Plains are 2", 5", 10", and 15" while thresholds for the East North Central region are 3", 7", 14", and 21". Thus, a ReSIS value is calculated from a linear combination of four terms, with each term representing the sum of normalized snowfall area and population information. The area and population values are normalized because in a typical storm the area (in square miles) is about two orders of magnitude less than the population. Normalizing the area and population for a particular storm by their mean values transforms these terms into a "percent of normal" expression. The mean values of snowfall area and population above these four thresholds are calculated using the fifty snowstorms analyzed for each region. Using the mean area and population to normalize each term for each threshold also helps to ensure the final distributions for all the regions are similar, despite large differences in regional snowfall climatologies, region population, and region area. This is a desirable attribute because it allows comparisons of snowstorms across regions. For example, a snowstorm in the Southeast may receive less snow than the Northeast for the same storm, but the societal impacts may be similar. This is because the Northeast is more resilient to snowstorms; more snow removal equipment, people have more experience driving in snowstorms, … Having similar values across regions also makes it easier for the public to understand the index.

Region Specific Thresholds Obviously, the amount of snowfall in the Northeast region is very different from the Southeast. The original NESIS algorithm uses snowfall thresholds of 4", 10", 20", and 30". These values were chosen by Kocin and Uccellini based on their expert knowledge of Northeast snowstorms. However, an objective method was needed to identify these thresholds for the other snowfall regions. It was decided to use return period statistics as a means of providing an objective basis for determining these thresholds.

First, the average 2-day 10-year return period and the average 2-day 25-year return period for snowfall was computed for each region. This was done by simply averaging all the stations within a region. Next a relationship was found between these values and the existing Northeast thresholds. The first threshold (4") is approximately one-quarter of the average 2-day 10-year return period for the Northeast. The second threshold (10") is approximately one-half of the average 2-day 25-year return period for the Northeast. The third and fourth thresholds (20" and 30") are just multiples of the second threshold. This relationship was applied to all the regions' average return period statistics to create regional snowfall thresholds. Table 1 lists the regional snowfall thresholds for all the regions.

ReSIS Calculation The 5km population density grid used in the ReSIS calculations is shown in Figure 2. The grid is in an Albers equal area projection to facilitate area calculations in a Geographical Information System (GIS). The map clearly shows the very populated areas of the Northeast, east coast, Gulf coast, Florida, and various metropolitan areas in the Midwest and Great Plains. Most of the snow-prone areas of the West are sparsely populated except the larger urban areas like Denver and Salt Lake City.

The process for calculating a ReSIS value for the March 12-14, 1993 super storm is shown in Figure 3. The population density and snowfall grids are both 5km resolution and the individual grid cells align with each other. The area of snowfall and population associated with each threshold are calculated within the GIS and written to a table which provides all the required inputs to the ReSIS algorithm. The final ReSIS value for this storm is 19.648.

Table 2 shows the relative contribution of each of the four terms to the final ReSIS score for a selection of the top 50 Southeast storms. Using this method, indices for storms with larger index values are dominated by the third and fourth terms, which are associated with higher snowfall amounts. Indices for storms with lower index values are dominated by the first and second thresholds, which are associated with lower snowfall amounts. In the middle of the rankings, there is a transition from the upper thresholds to the lower thresholds. In the March 1993 storm, 41% of the final value came from the fourth term which is associated with snowfall greater than 15". The contributions from the first two terms, which correspond to snowfall amounts greater than 2" and 5" respectively, have much lower contributions. By contrast, the February 1910 storm which had a low ReSIS value of 2.04, is driven primarily by the first term. This term contributed 63% to the final value and is associated with snowfall totals greater than 2". This pattern of how the individual terms contribute to the index values is a desirable attribute to this method. All of the regions behaved this way.

The ReSIS values have no physical meaning; their purpose is to rank snowstorms in terms of societal impacts and place them into historical perspective. It is reasonable to ask what a particular ReSIS value looks like in terms of a traditional snowfall map. The top 20 Southeastern snowstorms are listed in Figure 4 along with snowfall maps of the top and 20th ranked storms. Metropolitan areas with populations over half a million people are indicated by stars on the maps. This comparison gives a sense how different ReSIS values relate to spatial distributions of snowfall and population. It is possible for two storms with two similar ReSIS values to have maps that look somewhat different from each other. A particular ReSIS value is a function of the spatial juxtaposition of snowfall and population.

Regional ReSIS Distributions Figure 5 shows a series of boxplots illustrating the regional distributions of ReSIS values for the five NCDC Regions that have been completed. The boxes encapsulate the central 50% of the distribution; the whiskers define the central 90% of the distribution. The median is represented by the solid horizontal line and the mean is depicted by the dashed horizontal line. The points outside the whiskers represent outliers above and below the 95th and 5th percentiles. The boxplots clearly indicate that all of the regional distributions are positively skewed. Although there are some differences between individual regions, the distributions of all the regional snowfall indices are quite similar.

The Wilcoxon-Mann-Whitney rank sum test was applied to the regional ReSIS distributions to formally test their "similarity". This is a nonparametric procedure to test for differences in *location* between two data samples (Wilks, 2006). This nonparametric test was chosen because of the non-Gaussian nature of the regional distributions. The null hypothesis is that both batches of data are from the same distribution. The tests were constructed in such a way that each regional distribution was compared to the pooled distributions of the other four regions (five tests). Or put another way, the assumption is that each of the regional distributions come from one larger pooled distribution. The results for all five tests were insignificant. Thus, there is not enough evidence to reject the null hypothesis that the individual regional ReSIS distributions are part of the larger pooled distribution of all ReSIS values.

Categorization of Raw ReSIS Scores The raw ReSIS scores offer good resolution between storms of similar societal impact. However, one must keep in mind that there is some amount of uncertainty in these values. This uncertainty arises from the snowfall grid generated from daily observations (mostly COOP), conversion of polygon based census data to gridded population density information, and the whole concept of using population and snowfall to estimate societal impacts. Additionally, the raw scores would be confusing to the general public. Therefore, it is advantageous to convert the continuous raw index values to five categories. Since all the regional ReSIS distributions are similar, it is possible to apply the same categorization scheme across all regions. The relationship between raw ReSIS scores and categories is shown in Table 3. Category 5 snowstorms, the top category, have raw ReSIS values larger than 18 and comprise approximately the top five percent of all the storms studied. Category 4 snowstorms have raw ReSIS values larger than 10 and comprise about 12% of the 250 storms analyzed. Category 3, Category 2, and Category 1 snowstorms have raw ReSIS values larger than 6, 4, and 2 respectively. The ReSIS category boundaries get closer together for the lower categories due to the positively skewed distribution of the raw index values (see Figure 5). The regional ReSIS values and their ranks within their respective regions are presented in Table 4. Keep in mind that only the largest snowstorms affecting populated areas are included in this analysis. There are many other snowstorms that have not been included either because not enough people were affected, there was not enough snowfall, or the amount of snow was not large enough.

4. Summary and Conclusion

This paper has summarized the ongoing development of regional snowfall impact scale indices. The new indices are an evolution of the Northeast Snowfall Impact Scale (NESIS). Development so far has concentrated on areas east of the Rocky Mountains. The new indices are calculated in a manner similar to NESIS, but there are some important differences. The biggest difference is that only snowfall and population information within a region's boundaries are used to calculate that region's index. This is in sharp contrast to NESIS which uses all snowfall and population information from a storm, no matter how far removed from the 13 state Northeast region. Our decision was based on the fact that many storms that have low to moderate impact in the Southeast would be ranked as significant because snowfall over the densely populated Northeast corridor from the same storm would artificially inflate the index. Other differences between NESIS and the new regional indices include how the population and snowfall terms are normalized and how each of the terms is weighted.

Also, new snowfall thresholds within those regions were defined. These regions and thresholds were chosen with the help of 10 and 25 year-return period statistics to help ensure objective and consistent choices across regions.

5. References

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REGION	Area (mi^2)	Population	T1	T2	T3	T4
Central	310,367	46,987,525	3	6	12	18
East North Central	254,766	23,147,922	3	7	14	21
Northeast	178,509	60,246,523	4	10	20	30
Northwest	247,707	10,609,473	3	8	16	24
South	563,004	36,977,926	2	5	10	15
Southeast	285,895	47,755,771	2	5	10	15
Southwest	424,443	13,484,108	3	8	16	24
West	268,446	35,869,905	4	10	20	30
West North Central	470,385	4,504,284	3	7	14	21

Table 1. Area and population for the NCDC Climate Regions shown in Figure 1. T1-T4 are the region specific snowfall thresholds used in the ReSIS algorithm.

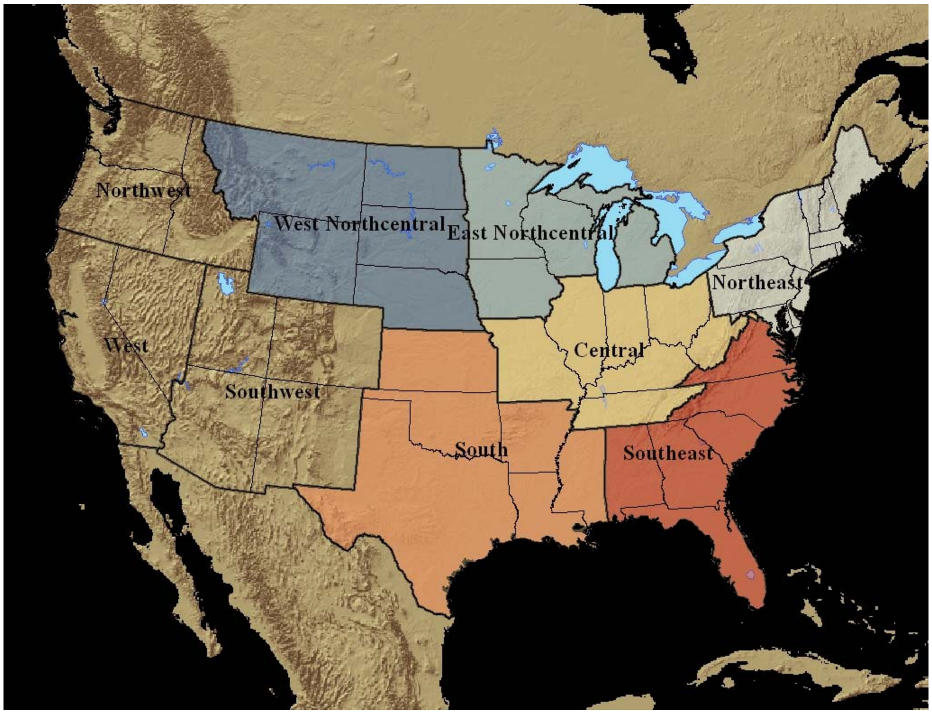

Figure 1. NCDC Climate Regions. The eastern six regions are highlighted because they are the emphasis of the current study.

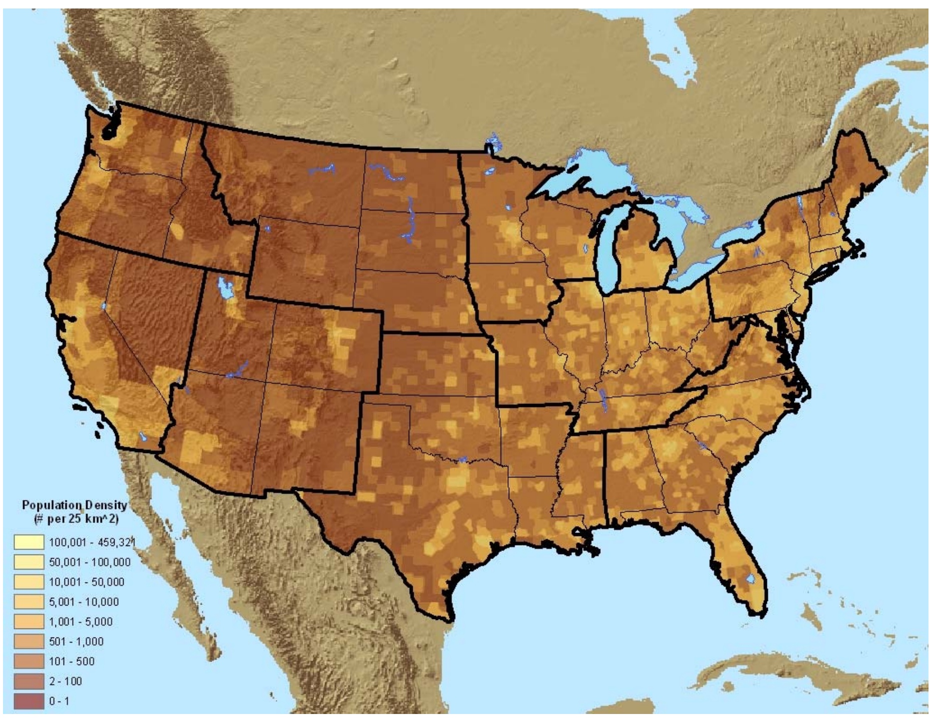

Figure 2. Population density derived from the 2000 Census.

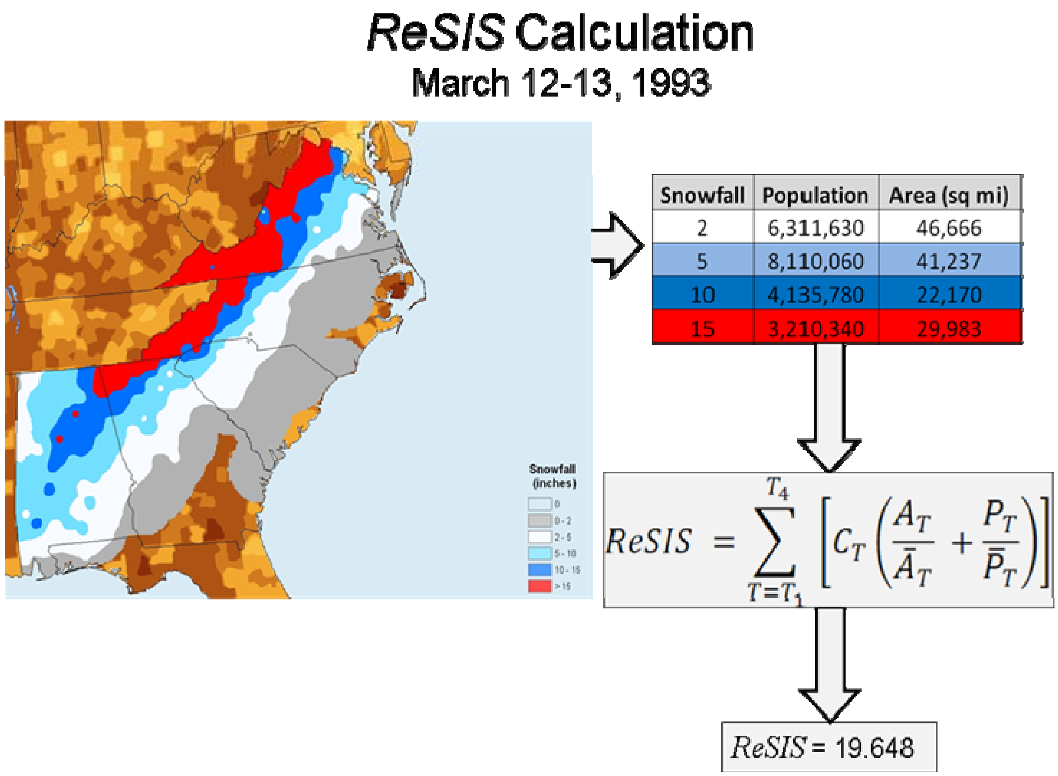

Figure 3. ReSIS calculation for the March 1993 Super Storm in a GIS environment

	Storm Date	Index	> 2"	> 5"	> 10"	> 15"
Top of distribution	1993-Mar-12-14	***19.65***	15%	17%	27%	41%
	1996-Jan-06-09	***19.51***	10%	12%	26%	53%
	1927-Mar-01-03	***16.29***	12%	15%	29%	44%
	1940-Jan-23-24	***16.12***	20%	27%	29%	25%
	1922-Jan-26-29	***14.98***	11%	13%	26%	49%
Middle of distribution	1942-Mar-02-03	***7.34***	21%	25%	30%	24%
	1966-Jan-29-31	***7.33***	30%	30%	27%	13%
	1960-Feb-13-15	***6.91***	29%	32%	32%	7%
	1958-Feb-14-17	***6.63***	32%	32%	22%	14%
	1930-Jan-29-31	***6.47***	40%	40%	19%	1%
Bottom of distribution	1900-Mar-15-16	***3.14***	29%	27%	40%	4%
	1962-Jan-09-11	***2.93***	84%	16%	0%	0%
	1926-Jan-07-10	***2.65***	68%	28%	4%	0%
	1968-Jan-12-15	***2.50***	41%	26%	29%	5%
	1910-Feb-11-13	***2.04***	63%	33%	4%	0%

Table 2. Relative contribution of each of the four terms in the ReSIS algorithm to the final index.

Top 20 Southeast Snowstorms

Storm Date	Area (sq mi)	Population	Index
1993-Mar-12-14	140,056	21,767,810	*19.648*
1996-Jan-06-09	82,232	14,973,350	*19.505*
1927-Mar-01-03	93,361	14,246,920	*16.293*
1940-Jan-23-24	148,685	24,698,910	*16.125*
1922-Jan-26-29	71,959	13,324,460	*14.982*
1979-Feb-18-19	145,034	24,713,830	*13.465*
1980-Mar-01-03	124,958	21,601,770	*13.018*
1930-Dec-17-18	92,438	17,777,300	*11.460*
1983-Feb-10-12	46,397	7,502,419	*11.285*
1936-Feb-06-07	108,419	18,714,421	*10.500*
1987-Jan-21-23	92,044	18,104,674	*10.374*
1973-Feb-09-11	116,780	12,435,609	*10.246*
1962-Mar-05-07	52,134	8,923,510	*9.215*
1902-Feb-14-17	99,665	16,393,906	*8.933*
1988-Jan-06-08	138,258	24,221,031	*8.556*
1960-Mar-01-04	102,288	18,043,010	*7.955*
1966-Jan-25-27	99,953	17,297,296	*7.854*
1914-Feb-25-26	160,198	22,346,073	*7.706*
1942-Mar-02-03	64,108	12,649,065	*7.345*

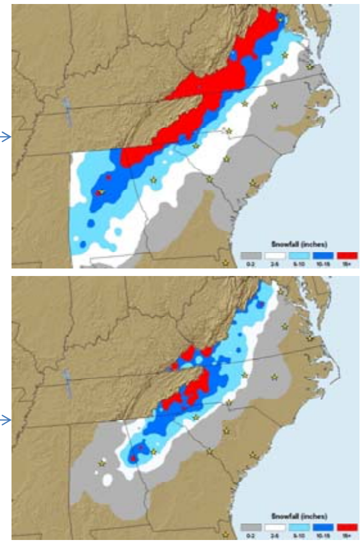

Figure 4. Top twenty Southeast storms and their total area, population, and ReSIS score. Maps for the top and twentieth ranked storms are shown.

Distribution of Regional Indices

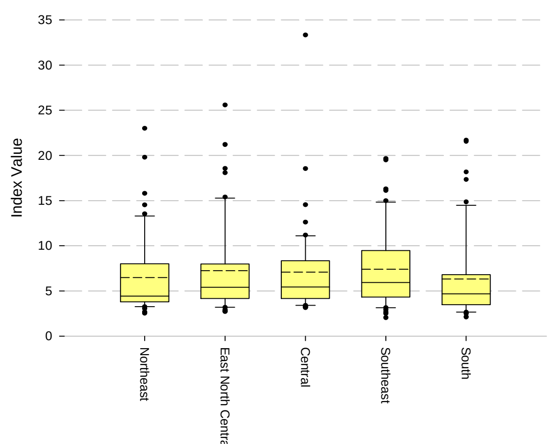

Figure 5. Regional distributions of ReSIS scores. See text for details

ReSIS Category Definitions		
Category	***ReSIS Raw Score***	***Approximate Percent Of Storms***
5	>18	5%
4	>10	12%
3	>6	23%
2	>4	33%
1	>2	27%

Table 3. ReSIS categories.

	Northeast			Southeast			Central		
Rank	**Storm Date**	**Index**	**Category**	**Storm Date**	**Index**	**Category**	**Storm Date**	**Index**	**Category**
1	1996-Jan-07-09	*23.00*	5	1993-Mar-12-14	*19.65*	5	1950-Nov-22-29	*33.33*	5
2	1993-Mar-13-15	*19.80*	5	1996-Jan-06-09	*19.51*	5	1979-Jan-12-14	*18.55*	5
3	1978-Feb-06-08	*15.80*	4	1927-Mar-01-03	*16.29*	4	1967-Jan-26-28	*14.54*	4
4	2003-Feb-15-19	*14.53*	4	1940-Jan-23-24	*16.12*	4	1999-Jan-01-04	*12.62*	4
5	1947-Mar-01-05	*13.53*	4	1922-Jan-26-29	*14.98*	4	1910-Feb-16-18	*11.19*	4
6	1966-Jan-29-01	*11.11*	4	1979-Feb-18-19	*13.47*	4	1900-Feb-26-01	*10.31*	4
7	1969-Dec-25-29	*10.55*	4	1980-Mar-01-03	*13.02*	4	2004-Dec-22-24	*9.89*	3
8	1914-Feb-13-15	*9.99*	3	1930-Dec-17-18	*11.46*	4	1968-Jan-12-16	*9.21*	3
9	2003-Dec-05-08	*9.70*	3	1983-Feb-10-12	*11.29*	4	1978-Dec-28-02	*8.93*	3
10	1961-Feb-03-05	*9.44*	3	1936-Feb-06-07	*10.50*	4	1984-Feb-26-01	*8.77*	3
11	1947-Dec-26-28	*8.87*	3	1987-Jan-21-23	*10.37*	4	1944-Dec-09-12	*8.71*	3
12	1983-Feb-11-12	*8.12*	3	1973-Feb-09-11	*10.25*	4	1973-Dec-18-22	*8.44*	3
13	1958-Feb-15-17	*7.97*	3	1962-Mar-05-07	*9.21*	3	1931-Mar-05-11	*8.30*	3
14	1958-Mar-18-23	*7.76*	3	1902-Feb-14-17	*8.93*	3	1974-Nov-29-03	*8.28*	3
15	1960-Mar-03-05	*6.78*	3	1988-Jan-06-08	*8.56*	3	1912-Feb-20-22	*8.20*	3
16	1915-Dec-12-15	*6.64*	3	1960-Mar-01-04	*7.95*	3	1978-Jan-25-27	*8.08*	3
17	1978-Jan-19-22	*6.20*	3	1966-Jan-25-27	*7.85*	3	1985-Feb-10-15	*8.04*	3
18	1964-Jan-12-14	*5.99*	2	1914-Feb-25-26	*7.71*	3	1994-Jan-16-18	*8.01*	3
19	1920-Feb-04-07	*5.59*	2	1942-Mar-02-03	*7.34*	3	1917-Dec-07-09	*7.33*	3
20	1972-Feb-18-20	*5.37*	2	1966-Jan-29-31	*7.33*	3	1978-Jan-16-18	*6.88*	3
21	1935-Jan-22-25	*5.22*	2	1960-Feb-13-15	*6.91*	3	1960-Mar-01-05	*6.64*	3
22	1926-Feb-03-05	*5.02*	2	1958-Feb-14-17	*6.63*	3	1964-Jan-11-14	*6.39*	3
23	1987-Jan-22-24	*4.94*	2	1930-Jan-29-31	*6.47*	3	1918-Jan-10-13	*5.83*	2
24	1936-Jan-18-20	*4.84*	2	1960-Mar-09-10	*6.24*	3	1914-Feb-12-14	*5.80*	2
25	1947-Feb-20-22	*4.51*	2	1935-Dec-28-30	*6.14*	3	1909-Jan-10-14	*5.49*	2
26	1917-Dec-13-15	*4.36*	2	1908-Dec-22-23	*5.73*	2	1951-Nov-05-08	*5.38*	2
27	1960-Dec-11-13	*4.35*	2	1965-Jan-15-17	*5.66*	2	1909-Dec-24-26	*5.31*	2
28	1941-Mar-07-10	*4.34*	2	1982-Jan-12-15	*5.61*	2	1908-Feb-18-20	*5.29*	2
29	1995-Feb-04-06	*4.28*	2	1948-Jan-31-01	*5.55*	2	1929-Dec-17-20	*5.19*	2
30	1940-Feb-13-15	*4.15*	2	1936-Jan-29-31	*5.36*	2	1903-Feb-14-17	*5.17*	2
31	1903-Feb-15-17	*4.13*	2	1969-Feb-28-02	*5.33*	2	1993-Feb-15-18	*5.02*	2
32	1961-Jan-19-21	*4.12*	2	1904-Jan-28-30	*5.29*	2	1934-Feb-24-27	*5.01*	2
33	1921-Feb-20-21	*4.08*	2	1917-Dec-11-13	*5.13*	2	1918-Jan-05-08	*4.95*	2
34	1917-Mar-01-06	*4.08*	2	1932-Dec-16-18	*4.95*	2	1927-Jan-12-15	*4.81*	2
35	1907-Feb-04-06	*3.95*	1	1969-Dec-25-27	*4.75*	2	1965-Feb-23-26	*4.71*	2
36	1966-Jan-22-25	*3.90*	1	1947-Feb-19-21	*4.65*	2	1951-Jan-31-02	*4.70*	2
37	1946-Feb-19-21	*3.80*	1	1901-Feb-22-24	*4.50*	2	1993-Feb-24-27	*4.40*	2
38	1909-Dec-25-26	*3.79*	1	1996-Feb-02-04	*4.40*	2	1906-Mar-18-20	*4.24*	2
39	1966-Feb-24-26	*3.77*	1	1963-Dec-31-02	*4.10*	2	1926-Mar-29-01	*3.90*	1
40	1927-Feb-18-21	*3.77*	1	1921-Jan-25-28	*3.96*	1	1977-Jan-09-11	*3.86*	1
41	1910-Jan-13-15	*3.72*	1	1979-Feb-06-08	*3.86*	1	1951-Mar-10-15	*3.76*	1
42	1967-Feb-06-08	*3.69*	1	1987-Apr-02-06	*3.74*	1	1988-Feb-10-13	*3.71*	1
43	1966-Dec-24-26	*3.68*	1	1914-Feb-13-15	*3.42*	1	1997-Jan-08-11	*3.56*	1
44	1938-Nov-23-25	*3.38*	1	1948-Jan-23-25	*3.39*	1	1987-Dec-13-17	*3.50*	1
45	1995-Dec-19-22	*3.28*	1	1929-Dec-21-23	*3.16*	1	1987-Jan-09-12	*3.49*	1
46	1910-Feb-11-13	*3.26*	1	1900-Mar-15-16	*3.14*	1	1974-Jan-08-12	*3.39*	1
47	1964-Feb-18-20	*3.04*	1	1962-Jan-09-11	*2.93*	1	1915-Jan-21-23	*3.32*	1
48	1943-Jan-26-29	*2.68*	1	1926-Jan-07-10	*2.65*	1	1901-Feb-01-04	*3.25*	1
49	1902-Mar-04-06	*2.61*	1	1968-Jan-12-15	*2.50*	1	1965-Mar-03-06	*3.19*	1
50	1934-Feb-25-27	*2.54*	1	1910-Feb-11-13	*2.04*	1	1981-Feb-09-12	*3.15*	1

Table 4a. ReSIS ranks and values for the Northeast, Southeast, and Central regions.

East North Central			Southern Plains			West North Central		
Storm Date	***Index***	**Category**	**Storm Date**	**Index**	**Category**	**Storm Date**	**Index**	**Category**
1985-Nov-29-02	*25.58*	5	1921-Feb-18-20	*21.68*	5	1919-Apr-06-10	*25.023*	5
1978-Jan-25-27	*21.20*	5	1988-Jan-05-08	*21.56*	5	1927-Apr-11-16	*20.891*	5
1999-Jan-01-04	*18.56*	5	1929-Dec-20-22	*18.16*	5	1957-Apr-01-05	*18.198*	5
1985-Feb-09-15	*18.09*	5	1971-Feb-21-23	*17.34*	4	1967-Apr-28-01	*17.792*	4
1985-Mar-02-06	*15.40*	4	1987-Dec-13-15	*14.85*	4	1984-Apr-25-28	*14.964*	4
1967-Jan-26-28	*14.19*	4	1980-Feb-07-10	*11.05*	4	1997-Apr-04-07	*13.994*	4
1951-Mar-10-15	*12.91*	4	1918-Dec-22-25	*10.67*	4	1923-Dec-28-31	*12.640*	4
1947-Jan-28-31	*11.79*	4	1956-Jan-31-06	*10.35*	4	1931-Dec-27-01	*11.503*	4
1950-Dec-04-09	*10.23*	4	1987-Jan-16-19	*8.38*	3	1955-Dec-01-04	*9.977*	3
1929-Dec-16-20	*9.68*	3	2000-Jan-26-29	*7.25*	3	1959-Dec-31-02	*9.441*	3
1979-Jan-11-14	*8.41*	3	1930-Jan-07-10	*7.14*	3	1968-Dec-20-23	*8.175*	3
1940-Mar-11-14	*7.99*	3	1985-Jan-11-14	*6.92*	3	1907-Feb-01-05	*7.803*	3
1965-Mar-16-19	*7.98*	3	1918-Jan-09-12	*6.76*	3	1975-Dec-30-02	*7.773*	3
1951-Dec-19-22	*7.96*	3	1946-Dec-30-03	*6.66*	3	1972-Dec-28-31	*7.746*	3
1969-Dec-05-10	*7.92*	3	1940-Jan-21-24	*6.45*	3	1936-Feb-10-13	*7.687*	3
1997-Jan-09-12	*7.15*	3	1963-Dec-20-23	*6.43*	3	1938-Feb-14-17	*7.029*	3
1971-Jan-02-05	*7.04*	3	1949-Jan-29-31	*6.34*	3	1953-Feb-27-03	*6.831*	3
1994-Jan-05-08	*6.78*	3	1926-Mar-29-31	*6.03*	3	1966-Feb-28-05	*6.641*	3
1917-Jan-20-22	*6.76*	3	1906-Nov-18-21	*5.92*	2	1978-Feb-10-14	*6.601*	3
1977-Dec-07-10	*5.94*	2	1985-Jan-30-02	*5.73*	2	1984-Feb-17-19	*5.830*	2
1989-Mar-02-05	*5.69*	2	1944-Jan-07-09	*5.44*	2	1987-Feb-23-01	*5.534*	2
1970-Dec-10-14	*5.62*	2	1961-Feb-04-08	*5.16*	2	1993-Feb-18-22	*5.478*	2
1900-Mar-03-06	*5.55*	2	1940-Jan-05-07	*4.79*	2	1915-Jan-30-02	*5.435*	2
2004-Jan-25-28	*5.52*	2	1929-Feb-06-09	*4.73*	2	1936-Jan-14-18	*5.397*	2
2005-Jan-21-23	*5.50*	2	1924-Mar-12-14	*4.68*	2	1949-Jan-01-05	*5.384*	2
1968-Dec-21-23	*5.30*	2	1960-Feb-12-14	*4.67*	2	1954-Jan-14-20	*5.175*	2
1908-Jan-30-02	*5.19*	2	1917-Jan-14-16	*4.55*	2	1982-Jan-20-23	*5.083*	2
1993-Feb-20-24	*5.10*	2	1978-Feb-17-18	*4.41*	2	2004-Jan-24-27	*4.986*	2
2000-Dec-10-12	*5.06*	2	1924-Mar-18-20	*4.21*	2	1912-Mar-18-21	*4.947*	2
1952-Feb-17-21	*4.91*	2	1926-Jan-23-25	*4.21*	2	1929-Mar-11-15	*4.814*	2
1909-Jan-28-31	*4.90*	2	1924-Feb-24-26	*4.08*	2	1915-Mar-02-07	*4.783*	2
1983-Nov-26-30	*4.89*	2	1903-Feb-14-17	*4.04*	2	1940-Mar-10-13	*4.747*	2
1993-Jan-11-14	*4.84*	2	1932-Dec-14-17	*3.90*	1	1943-Mar-13-17	*4.730*	2
1909-Feb-08-11	*4.68*	2	1949-Jan-23-28	*3.86*	1	1975-Mar-25-29	*4.564*	2
1909-Dec-10-14	*4.64*	2	1964-Jan-15-17	*3.62*	1	1983-Mar-24-27	*4.527*	2
1952-Mar-21-24	*4.59*	2	1923-Feb-03-06	*3.51*	1	1985-Mar-01-05	*4.464*	2
1990-Feb-14-17	*4.33*	2	1951-Feb-13-16	*3.50*	1	1989-Mar-01-04	*4.240*	2
1915-Mar-03-07	*4.16*	2	1966-Feb-21-24	*3.50*	1	1996-Mar-22-25	*4.071*	2
1999-Mar-08-10	*4.16*	2	1905-Feb-17-19	*3.40*	1	1905-Nov-25-29	*4.066*	2
2002-Jan-28-01	*4.12*	2	1960-Feb-22-25	*3.30*	1	1919-Nov-25-29	*4.038*	2
1988-Jan-22-26	*3.60*	1	1951-Jan-29-01	*3.15*	1	1921-Nov-19-22	*3.534*	1
2005-Jan-04-07	*3.52*	1	1939-Dec-25-27	*3.01*	1	1958-Nov-13-18	*3.446*	1
1908-Dec-16-18	*3.51*	1	1910-Feb-16-18	*2.97*	1	1978-Nov-30-03	*3.440*	1
1950-Feb-12-16	*3.50*	1	1944-Jan-12-15	*2.95*	1	1983-Nov-24-30	*3.436*	1
1977-Dec-31-02	*3.22*	1	1976-Nov-12-14	*2.78*	1	1986-Nov-06-09	*3.163*	1
1936-Feb-02-05	*3.18*	1	1921-Jan-11-14	*2.64*	1	1993-Nov-21-28	*3.120*	1
1943-Jan-02-05	*2.91*	1	1909-Dec-17-20	*2.53*	1	1973-Oct-31-04	*2.860*	1
1965-Feb-23-26	*2.81*	1	1918-Jan-20-22	*2.49*	1			
1921-Nov-07-09	*2.74*	1	1973-Jan-09-12	*2.14*	1			
1962-Feb-20-22	*2.73*	1	1915-Mar-08-10	*2.10*	1			

Table 4b. ReSIS ranks and results for the East North Central, Southern Plains, and West North Central regions.