6A.7 REGIONAL SNOWFALL IMPACT SCALE

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1. INTRODUCTION

This paper describes a new regional snowfall impact index that is being produced operationally on an experimental basis by NOAA's National Climatic Data Center. The Regional Snowfall Impact Scale (ReSIS) is based on the spatial extent of the storm, the amount of snowfall, and the juxtaposition of these elements with population. Including population information ties the index to societal impacts. ReSIS is an evolution of the Northeast Snowfall Impact Scale (NESIS) which NCDC began producing operationally in 2005. While NESIS was developed for storms that had a major impact in the Northeast (Kocin and Uccellini, 2004), it includes the impact of snow on other regions as well. It can be thought of as a quasi-national index that is calibrated to Northeast snowstorms. By contrast, ReSIS is a regional index; a separate index is produced for each of the six NCDC climate regions in the eastern two-thirds of the nation. 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. The methodology for computing ReSIS, using these region-specific parameters and thresholds, is explained. The new index has been calculated for 471 snowstorms that occurred between 1900 and 2010, including the 50 largest snowstorms in each of the six eastern climate regions. This allows ReSIS to put snowstorms into a century-scale historical perspective. Several seasons will be examined in detail to show the operational impact of calculating the index in near-real time and the seasonal variability of snowstorms.

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2. DATA and STORM SELECTION

While daily snowfall value are available for many locations, there is not a comprehensive list of starting and ending dates for snowstorms going back to 1900. A process was developed to identify the beginning and ending dates of large snowstorms dating back to 1900. 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 (Figure 1) were used to select the candidate storms for which detailed quality control was performed and snow impact scale indices were calculated.

As mentioned before, there is not a comprehensive list of snowstorm dates back to 1900; however there are sources for more recent time periods. The Cooperative Institute for Precipitation Systems at St Louis University has developed a comprehensive list of snowstorms for the 1980-2009 period (Gravelle, et al. 2009). We used this list to identify snowstorms that were not large enough to be in the top 50 storms for each region. Since ReSIS will be produced as an experimental product starting this year (2010-2011 snow season), NCDC needs to know approximately how many snowstorms occur each year so the correct amount of resources can be allocated.

Once these beginning and ending dates were identified, snowfall data was extracted from NCDC's Global Historical Climatological Network – Daily (GHCN-D). GHCN-D was chosen as a data source for two reasons; it has undergone significant and consistent automated quality control (QC) for the entire period of record and it will eventually be the official data source for daily data from NOAA. Since the GSDB contains storms dating back to 1900, it is important that a consistent QC process be applied to the entire dataset. Durre et al. (2008) describes the strategies for constructing the QC algorithms used in GHCN-D. The automated QC procedures used to produce GHCN-D do not change values, rather elements that fail any checks are flagged. The data used in the current snowstorm study only uses snowfall values that are not flagged. However, upon manual inspection of mapped snowfall values, some of the snowstorm totals appear to be in error. These errors at individual stations could adversely affect spatial analysis techniques and the subsequent development of regional and national snowstorm indices. Therefore, storm total snowfall at individual stations is subject to a manual QC process before being used in any analysis. In order to ensure consistent manual QC for all snowstorms, the assumption is made that all the GHCND snowfall values are correct unless there is sufficient evidence to imply otherwise. If a snowfall total is significantly different from its neighbors, the analyst evaluates the data for topographic or other issues that would account for the discontinuity. If no explanation is found, the station is removed from the analysis. This protocol is enforced to minimize type I errors (false positives) and ensue consistent manual QC between different analysts. In a typical snowstorm comprised of 1,000 to 2,500 stations, about 1% of the stations will be eliminated because the validity of the total snowfall value at these stations is deemed suspect.

Besides the top 50 storms from each of the six eastern NCDC regions, all the snowstorms from the 1999-2000 and 2009-2010 seasons were extracted from GHCND and ReSIS values calculated. Also, a number of snowstorms from the Northwest and Southwest NCDC regions were identified and ReSIS values calculated. Of course, most storms spanned several regions. Eliminating duplicate starting/ending dates resulted in 471 net individual snowstorms.

3. REGIONAL SNOWFALL IMPACT SCALE

3.1 Local versus Regional Effects

NCDC has been calculating NESIS values since the 2004-2005 winter season. There has been a call to compute regional indices for other areas of the country. Despite its name, NESIS is a quasi-national index since it uses snowfall and population information for the entire country. There have also been many questions about what is meant by regional effects. It is important to differentiate between *regiona*l 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 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. Therefore local affects occur on the time scales of about a day and spatial scales of about 10^3 square miles. In contrast, regional effects affect areas large enough to include several states (10^5 square miles). The time scale for regional effects is normally on the order of several 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.

3.2 ReSIS Algorithm

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

— — (1)

where:
T = regional specific snowfall thresholds
A_T = area affected by snowfall greater than threshold T
= mean area affected by snowfall greater than threshold T
P_T = population affected by snowfall greater than threshold T
= mean population affected by snowfall greater than threshold T

The regions referred to above are the nine NCDC Climate Regions (Fig. 1). 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". Table 1 lists the thresholds for all the regions. 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 "percent of normal" expressions. 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. See Table 1, Fig. 1, and Fig.2. 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.

3.3 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.

3.4 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 appropriate attribution of the individual terms to the final index values is a desirable characteristic of 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.

3.5 Regional ReSIS Distributions

Figure 5 shows a series of boxplots illustrating the regional distributions of ReSIS values for the six NCDC Regions. The boxes encapsulate the central 50% of the distribution; the whiskers define the central 90% of the distribution. The points outside the whiskers represent outliers above and below the 95th and 5th percentiles. The median is represented by the solid horizontal line and the mean is depicted by the dashed horizontal line. 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.

3.6 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 two percent of all the storms studied. Category 4 snowstorms have raw ReSIS values larger than 10 and comprise about 5% of the 471 storms analyzed. Category 3, Category 2, and Category 1 snowstorms have raw ReSIS values larger than 6, 3, and 1 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. Snowstorms that have a raw index value of less than 1.000 are defined as Category 0 storms. These storms cover smaller areas and affect less people.

4. SELECTED YEARLY RESULTS

ReSIS values for the 1999-2000 and 2009-2010 are shown in Tables 5a and 5b. The 1999-2000 season (Table 5a.) was chosen because it represented a “typical” year in terms of the number of snowstorms. As Table 3 indicates, most storms are Category 1 or less. Typically, one snowstorm will affect several regions with a different ReSIS value for each. This shows the ability of ReSIS to discriminate societal impacts between regions. The maximum ReSIS value for each storm is given in the last column. The highest ReSIS value for the 1999-2000 season was Category 3. If this is indeed a typical year, it implies that NCDC would be analyzing about 1-2 storms per week.

The ReSIS values for the 2009-2010 winter season is shown in Table 5b. This year was chosen because of the relatively large number of significant storms that occurred that season. There was a Category 5 storm in the Southeast during December and several Category 3 and 4 storms during February. This table also shows how some of the larger storms occurred in the same period.

5. 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 for the Southeast. 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.

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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.

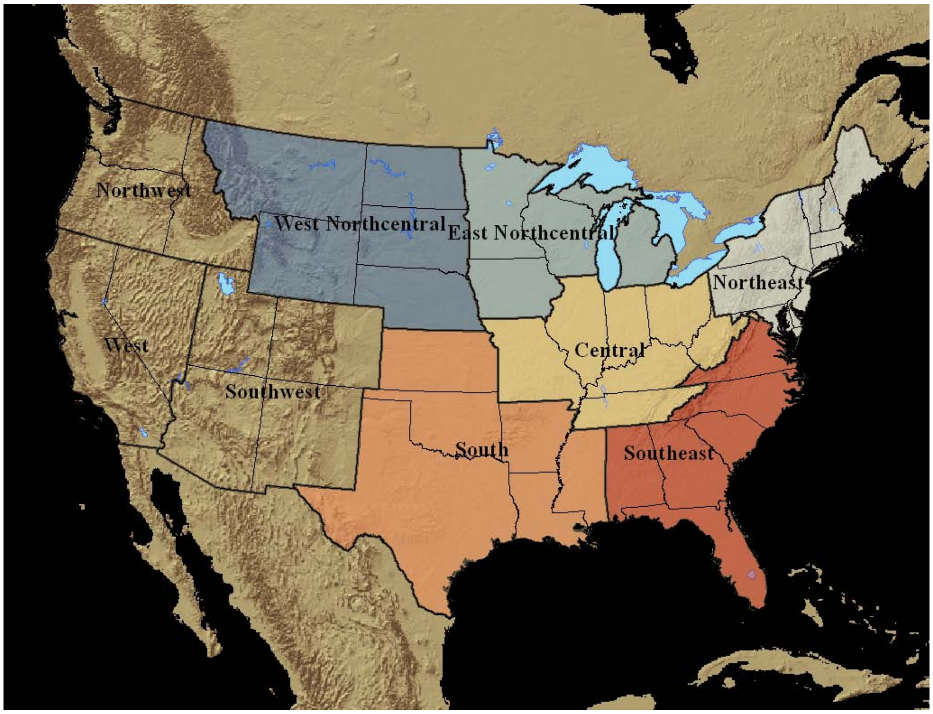

Figure 1. NCDC Climate Regions. The eastern six regions are highlighted because they are the emphasis of the current study.

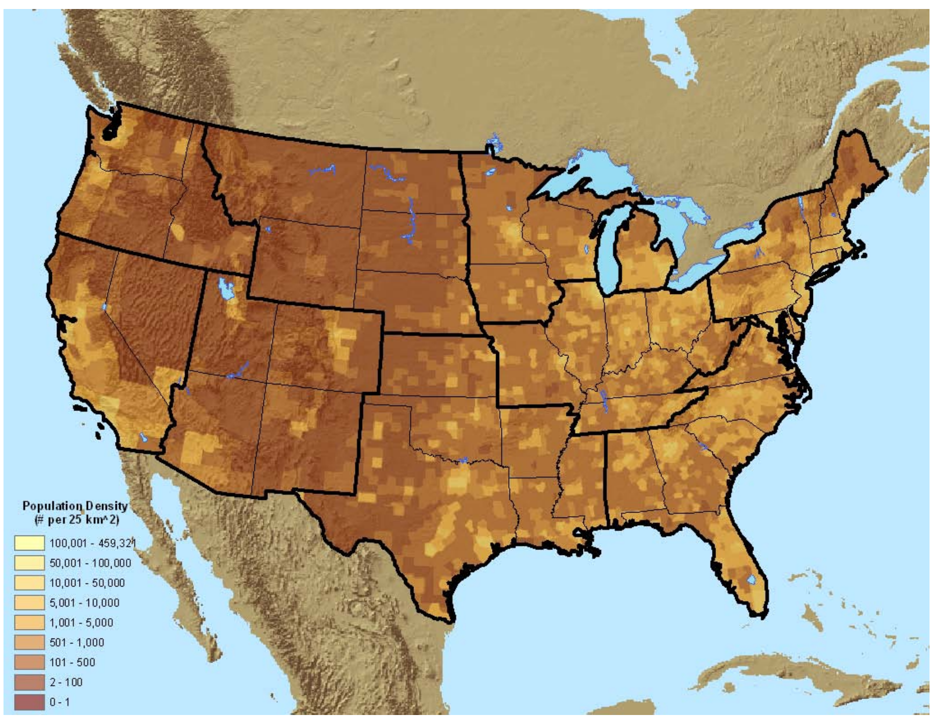

Figure 2. Population density derived from the 2000 Census.

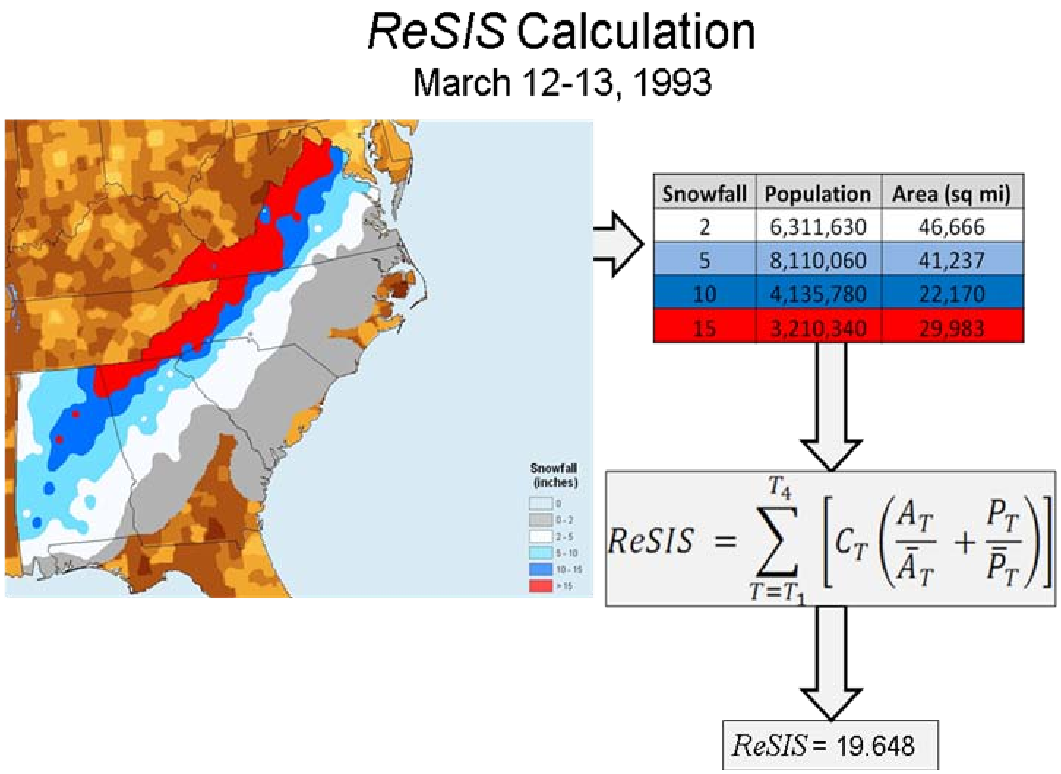

Figure 3. ReSIS calculation for the March 1993 Super Storm in a GIS environment

	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*

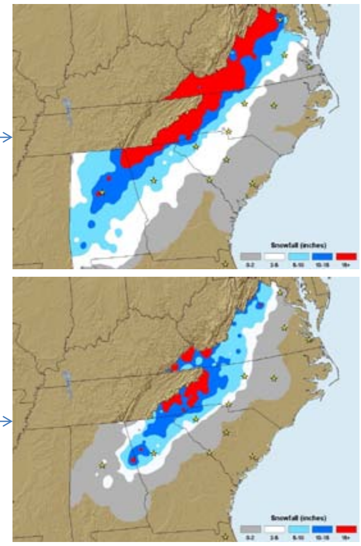

Figure 4. Top twenty Southeast storms and their total area, population, and ReSIS score. Maps for the top and twentieth ranked storms are shown.

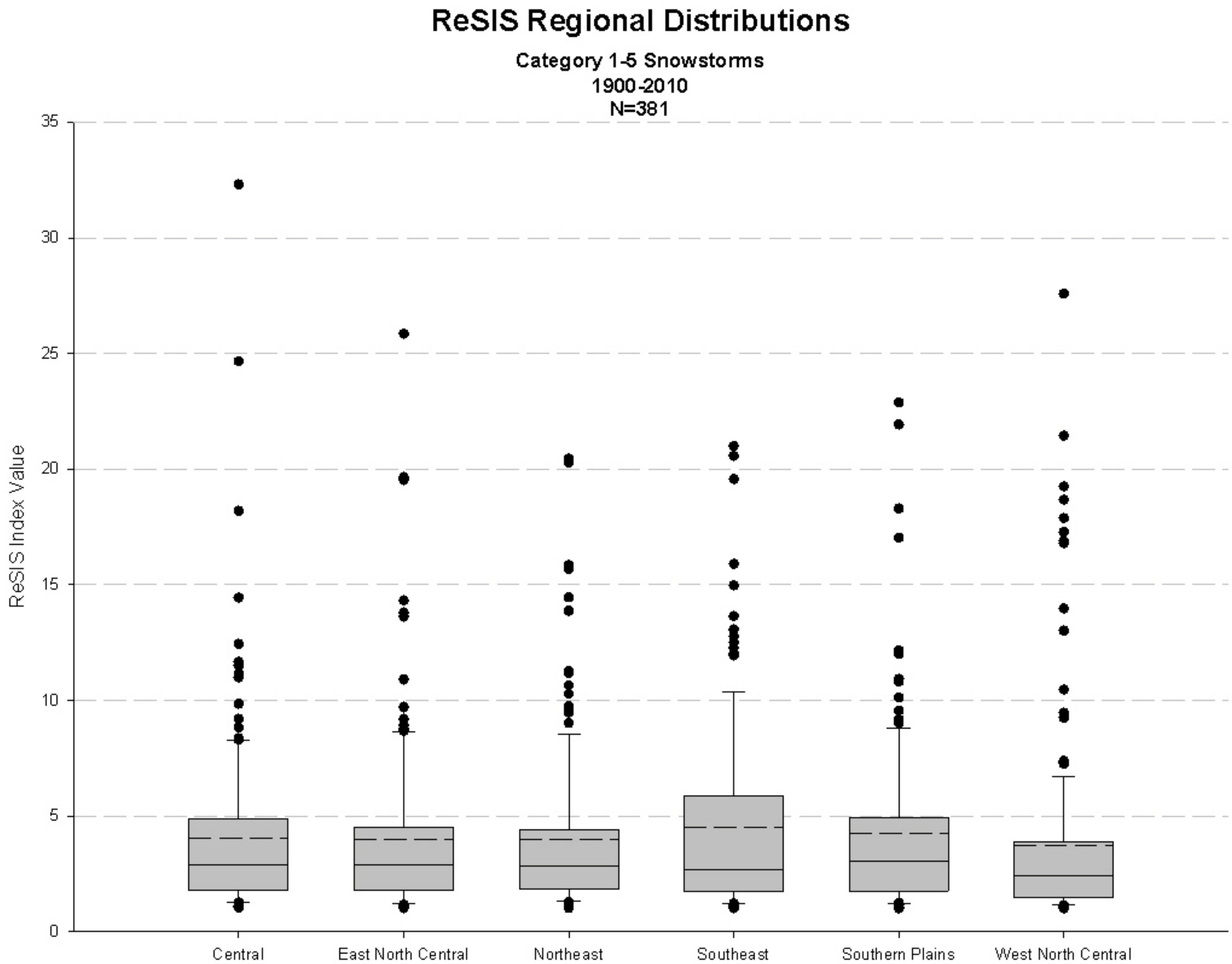

Figure 5. Regional distributions of ReSIS scores. See text for details

ReSIS Category Definitions		
Category	***ReSIS Raw Score***	***Approximate Percent Of Storms***
5	>18	2%
4	10- 18	5%
3	6 - 10	11%
2	3 - 6	29%
1	1 - 3	54%

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	2002-01-28-02	*2.826*	1
1921-Nov-07-09	*2.74*	1	1973-Jan-09-12	*2.14*	1	1912-03-19-22	*2.814*	1
1962-Feb-20-22	*2.73*	1	1915-Mar-08-10	*2.10*	1	1962-03-08-14	*2.787*	1

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

1999-2000							
STORM DATE	**Central**	**East North Central**	**Northeast**	**Southeast**	**Southern Plains**	**West North Central**	**MAX**
1999/10/01-1999/10/02		0				0	0
1999/10/04-1999/10/05			0				0
1999/11/14-1999/11/17			0				0
1999/11/17-1999/11/19						0	0
1999/11/21-1999/11/24		0			0	0	0
1999/12/03-1999/12/06	0	0			1	0	1
1999/12/08-1999/12/09					0		0
1999/12/09-1999/12/12		0	0				0
1999/12/13-1999/12/16		0			0	0	0
1999/12/18-1999/12/20	0	0			0	0	0
1999/12/22-1999/12/25	0	0		0			0
1999/12/27-1999/12/29	0	0	0	0			0
1999/12/28-1999/12/30	0	0	0	0			0
2000/01/01-2000/01/03	0	0			0	0	0
2000/01/02-2000/01/04	0	0			0	0	0
2000/01/04-2000/01/06		0				0	0
2000/01/09-2000/01/12		0	0	0		0	0
2000/01/10-2000/01/14	0	1	0	0		1	1
2000/01/15-2000/01/17			0				0
2000/01/17-2000/01/18	0			0			0
2000/01/18-2000/01/22	1	1	0	1		0	1
2000/01/21-2000/01/23	0			0		0	0
2000/01/24-2000/01/27	0	0	1	3			3
2000/01/24-2000/02/01	1	0	1	1	3	1	3
2000/02/09-2000/02/12		0	0			0	0
2000/02/10-2000/02/15	0	0	0		0	0	0
2000/02/14-2000/02/17		0	0			1	1
2000/02/16-2000/02/20	1	1	1	0	0	1	1
2000/02/24-2000/02/26					0	1	1
2000/03/01-2000/03/04	0				0	0	0
2000/03/07-2000/03/10		0				1	1
2000/03/09-2000/03/12	1		0		0	0	1
2000/03/13-2000/03/15		0				0	0
2000/03/15-2000/03/17		0	0		0	0	0
2000/03/19-2000/03/21						0	0
2000/03/20-2000/03/22	0		0	0			0
2000/03/27-2000/03/28		0					0
2000/04/06-2000/04/10	0	0	0	0		0	0
2000/04/10-2000/04/12		0	0			0	0
2000/04/13-2000/04/16		0				1	1
2000/04/18-2000/04/20		0				1	1

Table 5a. ReSIS regional values for the 1999-2000 snow season.

2009-2010							
STORM_DATE	Central	East North Central	Northeast	Southeast	Southern Plains	West North Central	MAX
2009/10/03-2009/10/06						1	1
2009/10/21-2009/10/24		0			0	0	0
2009/10/27-2009/10/30		0			0	2	2
2009/11/12-2009/11/17	0	0			0	1	1
2009/11/27-2009/11/29	0	0	0	0			0
2009/12/05-2009/12/06	0		0	0	0		0
2009/12/07-2009/12/11	0	3	1	0	1	2	3
2009/12/12-2009/12/16		0	0			0	0
2009/12/18-2009/12/21	3		1	4			4
2009/12/22-2009/12/29	1	3	0	0	2	5	5
2009/12/28-2010/01/04	1	1	2	0	0	0	2
2010/01/04-2010/01/09	2	1	0	0	0	2	2
2010/01/18-2010/01/21		0	0				0
2010/01/20-2010/01/27	0	0	0	0	0	1	1
2010/01/27-2010/01/31	1		0	2	2		2
2010/01/30-2010/02/03	0	0	0			0	0
2010/02/02-2010/02/03	0		0	0			0
2010/02/03-2010/02/07	2	0	3	3	1	1	3
2010/02/05-2010/02/11	2	2	2	1	1	0	2
2010/02/08-2010/02/13	0			1	4		4
2010/02/12-2010/02/19	2	0	1	1		1	2
2010/02/16-2010/02/21	0	0			0	0	0
2010/02/19-2010/02/24					0	0	0
2010/02/21-2010/03/01	3	1	4	1	0	0	4
2010/02/27-2010/03/04	0			0	0		0
2010/03/03-2010/03/07						0	0
2010/03/07-2010/03/15	0		0	0	0	0	0
2010/03/11-2010/03/15						0	0
2010/03/18-2010/03/24	0	0	0	0	2	0	2
2010/03/22-2010/03/25					0	0	0
2010/03/30-2010/04/03						1	1
2010/04/04-2010/04/07					0	0	0
2010/04/20-2010/04/29			0			0	0
2010/04/27-2010/04/30						0	0

Table 5b. ReSIS regional values for the 2009-2010 snow season.