Characteristics of Temperature Depressions Associated with Snow Cover across the Northeast United States

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ABSTRACT

Daily snow cover and temperature data are collected for a network of 91 stations covering the northeast United States and the association between the two is explored. Observations are examined for the six-month winter season, November–April, for the period 1948/49–1987/88. Daily maximum and minimum temperatures are stratified by 15-day periods and further by the presence or absence of a snow cover. It is found that for snow covers of 2.5 cm or greater, depressions of daily maximum and minimum temperature average approximately 6° and 5°C, respectively. Relatively large variations in the temperature depressions are observed across space, whereas smaller variability is found across the snow cover season.

Temporally, maximum temperature depressions are greater during the early and later portions of the snow cover season and somewhat smaller during the midwinter months. The magnitude of minimum temperature depressions are larger during the midwinter months but decrease in size early and especially late in the snow cover season. The presence of a snow cover decreases the daily temperature range in November, March, and April and has little effect during the intervening months.

Spatially, the magnitude of both maximum and minimum temperature depressions increases away from coastal areas. In the case of maximum temperature depressions, there is also a consistent increase toward the southern portion of the region. For minimum temperature depressions, no large-scale geographic control, except for coastal proximity, dominates the spatial distribution of the depression magnitudes.

Potential geographic "forcing" mechanisms are evaluated. The results indicate that large sensible and, in some cases, latent heat fluxes from the lower atmosphere to the snowpack account for much of the observed temperature depressions.

1. Introduction

The interaction between snow cover and boundary layer climate variables has attracted the attention of atmospheric scientists for several decades. This interest is spurred by the fact that the presence or absence of snow cover constitutes the largest naturally occurring change to the earth's surface on timescales of days to months (Walsh et al. 1982). The association between snow cover and the earth's atmosphere has been investigated from a variety of viewpoints and across the full spectrum of spatial and temporal scales. As an element in the diagnosis of climate, the role of snow cover has been investigated in connection with local temperature anomalies (Dewey 1977; Baker et al. 1992; Wojcik and Wilks 1992), and temperature anomalies on continental scales (Walsh et al. 1982; Heim and Dewey 1984; Namias 1985; Robinson and Leathers 1993; Leathers and Robinson 1993; Karl et al. 1993; Groisman et al. 1994). Moreover, snow cover has been suggested as an important component of the dynamics of the climate system for the entire Northern Hemisphere (Foster et al. 1983; Ross and Walsh 1986; Walsh and Ross 1988; Robinson and Dewey 1990). As a modifier of atmospheric circulation, snow cover has been studied with reference to large-scale circulation anomalies (Namias 1978; Walsh et al. 1982; Heim and Dewey 1984; Gutzler and Rosen 1992) and changes in synoptic-scale cyclone frequency and intensities (Ross and Walsh 1986; Dewey 1987). Even submesoscale events, such as the occurrence of tornadic storms, have been suggested as being modulated by snow cover extent (Dewey 1987).

Daily data have been used in some studies in an effort to quantify the effect of snow cover on the overlying temperature and moisture characteristics of the planetary boundary layer (Dewey 1977; Kukla 1981; Baker et al. 1992; Wojcik and Wilks 1992). However, these studies have been limited by the availability of a dataset possessing a dense network of stations with

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quality-controlled values of snow cover and surface air temperatures. Thus, previous studies have been limited to investigating the effects of snow cover at a single (Dewey 1977; Baker et al. 1992) or at a few (Kukla 1981; Wojcik and Wilks 1992) stations at a time. Therefore, the spatial variability of the snow cover influence has in the past been largely neglected. The studies previously conducted (i.e., Kukla 1981; Baker et al. 1992) have suggested that the major effect of a snow cover on the surface energy balance is to greatly reduce the magnitude of the absorbed shortwave radiation. Using long-term radiation measurements, Baker et al. (1992) found that the primary forcing function of snow cover–induced temperature depressions is related to the reduction of absorbed shortwave radiation and not to changes in longwave fluxes or net radiation. This result was obtained for a single, open site in Minnesota.

It is the purpose of the present study to examine the effects of snow cover on surface air temperature variables across a large region with heterogeneous surface properties. To this end, the northeastern portion of the United States has been chosen as the study region for three reasons. First, the area from Maine south through West Virginia encompasses a latitudinal extent of approximately 10° latitude and exhibits very different snow cover climatologies from north to south. Second, the region is overlain with very different surface characteristics including some of the country's largest urban areas, extensive agricultural lands, and densely forested regions. Finally, although the longitudinal extent is not large, the area is affected by maritime influences, elevation differences, and Great Lake-induced climate modifications. We believe that the diversity of the region and a relatively dense station distribution will improve the current understanding of potential geographic controls on snow cover–atmosphere interactions. Moreover, this study will extend the analysis of snow cover–induced temperature depressions over a previously unstudied region with very different surface characteristics from those that have previously been investigated (Kukla 1981; Baker et al. 1992).

2. Data and methodology

The recent development of the Historical Daily Climate Dataset (HDCD; Robinson 1988, 1993) has made available lengthy records of daily snowfall, snow depth, precipitation, and temperature for approximately 1500 stations across the coterminous United States. These data have been extensively quality controlled (Robinson 1988) and in many cases extend back to the turn of the century. For this study, a network of 91 stations is chosen, with stations distributed relatively homogeneously across the northeastern United States from Maine through West Virginia (Fig. 1). All stations selected for this study have 40-yr records for the snow cover season (November–April) for the years 1948/49–1987/88. Although the data completeness varies from station to station, in general less than 10% of the daily data are missing. The temperature data are gathered at standard temperature shelters with sensors positioned approximately 1.5 m above the snow-free surface. The three temperature variables considered in this study (daily maximum temperature, daily minimum temperature, and daily temperature range) are stratified by 15-day periods (November–April) and further separated according to the presence or absence of snow cover of a certain depth. The magnitude of the temperature variables are calculated during days within a 15-day period with snow cover greater than 2.5 cm present and days with no snow cover.

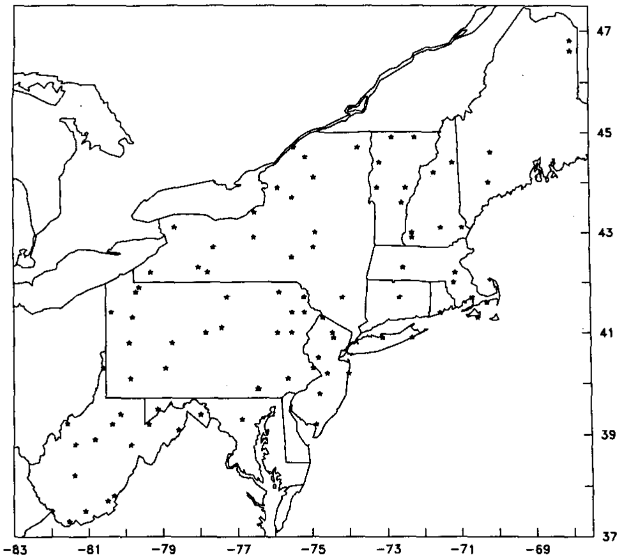


FIG. 1. Distribution of study stations possessing daily snow cover and temperature data for the snow cover seasons 1948/49–1987/88.

For the results for an individual station to be considered in the subsequent analyses, each category (snow covered and noncovered) must contain at least 10 days of data. This criterion allows for the maximum inclusion of stations, while limiting any anomalous depression values that arise because of small sample sizes. Graphs showing the spatially aggregated results are presented in Fig. 2, and maps depicting the spatial distribution of the temperature depressions associated with snow cover are presented in Figs. 3 and 4. For the maps, the station data are gridded using an inverse-distance-squared nearest-neighbor routine (Surfer 1991). These grids are subsequently smoothed, after which a contouring algorithm is applied.

3. Aggregated results

a. Maximum temperature depressions

To understand the effect of snow cover on temperature across the Northeast in an aggregate sense, the

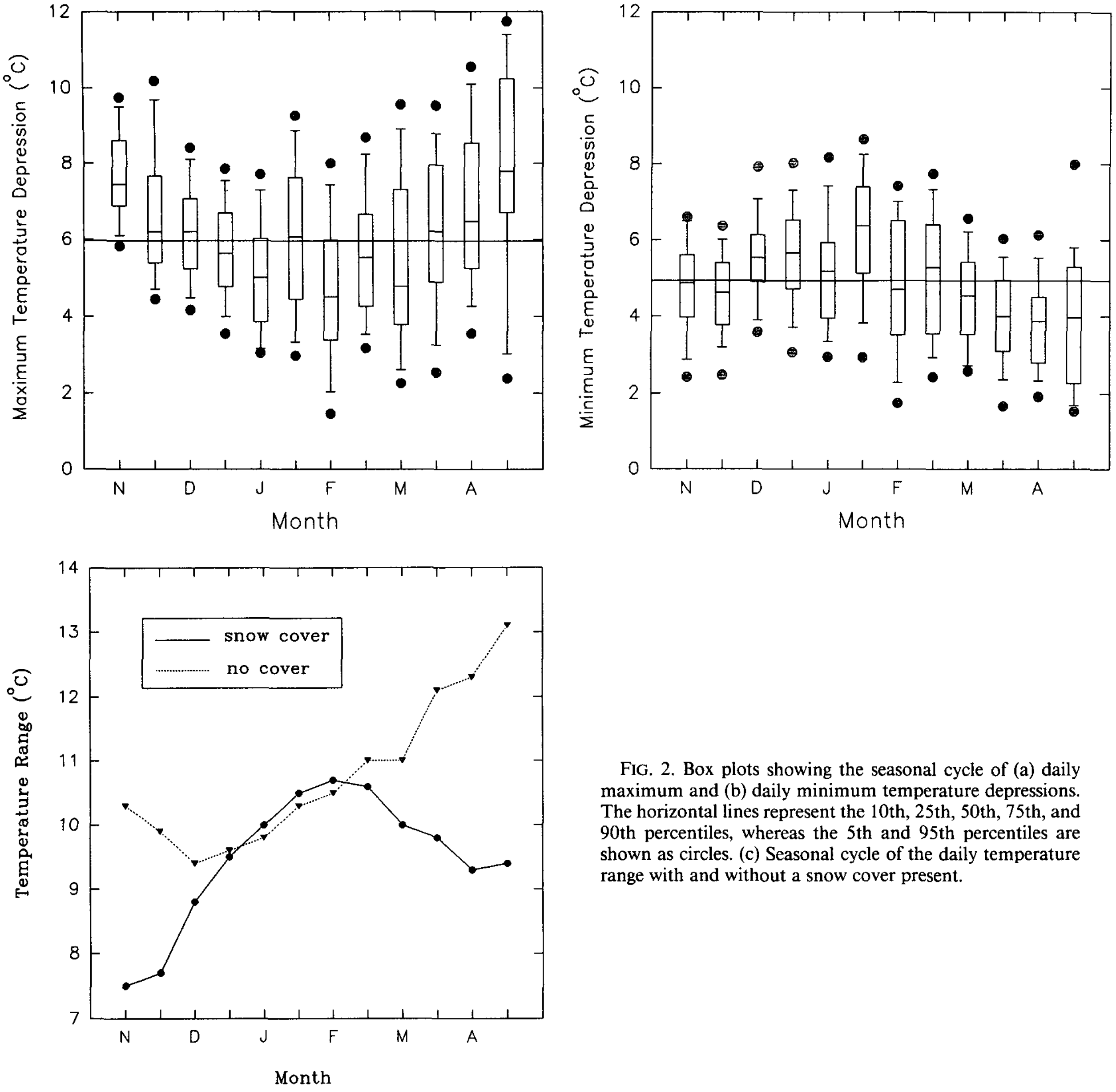


FIG. 2. Box plots showing the seasonal cycle of (a) daily maximum and (b) daily minimum temperature depressions. The horizontal lines represent the 10th, 25th, 50th, 75th, and 90th percentiles, whereas the 5th and 95th percentiles are shown as circles. (c) Seasonal cycle of the daily temperature range with and without a snow cover present.

mean temperature and the distribution of values is calculated for all stations for each 15-day period and each snow cover category. Table 1a shows the 15-day stratifications for maximum temperature and minimum temperature for days with snow cover of 2.5 cm or greater and days with no snow cover. The number of stations used in the calculation of the spatially averaged values for each category, the standard deviations of the temperature values, the mean number of days that occur in each category, and the magnitude of the temperature depressions are also presented. Table 1b indicates the magnitude of the daily temperature range for each 15-day stratification with and without a snow cover present.

Differences in maximum temperature between snow-covered and noncovered days range from 7.9°C during the second half of April to a low of 4.6°C during the first 15 days of February. The depressions of maximum temperature are somewhat larger at the beginning and end of the snow cover season, and slightly smaller during the midwinter months (Fig. 2a, Table 1a). The box plots of Fig. 2a show some indication of an annual cycle in the magnitude of the maximum temperature depressions. However, during all 15-day periods except for the first period in November and the last period in April, the seasonal mean falls within the range of the middle 50% of each distribution.

TABLE 1a. Fifteen-day stratification of daily maximum temperature and daily minimum temperature for days with snow cover greater than 2.5 cm and days with no snow cover. The number of stations used in the calculation of the spatially averaged values for each category, the standard deviations of the temperature values, the mean number of days that occur in each category, and the magnitude of the temperature depressions are also presented.

Month	T (without)	No. of days (without)	Standard deviation (without)	T (with)	No. of days (with)	Standard deviation (with)	Depression (°C)	No. of stations
N1	10.8	513	5.2	3.3	36	3.2	7.6	54
N2	8.6	458	5.3	1.9	83	3.7	6.7	76
D1	6.3	351	5.4	0.2	163	4.3	6.2	87
D2	5.0	284	5.6	−0.7	251	4.6	5.7	90
J1	3.8	205	5.7	−1.3	291	5.0	5.1	90
J2	4.8	209	5.9	−1.2	322	5.4	6.1	84
F1	4.4	198	5.4	−0.2	301	5.0	4.6	81
F2	7.3	216	5.4	1.7	232	4.8	5.6	83
M1	7.8	293	5.4	2.3	215	4.5	5.4	87
M2	10.4	395	6.1	4.1	154	4.4	6.3	86
A1	12.2	473	5.5	5.4	74	4.1	6.8	62
A2	14.9	522	5.9	7.1	32	4.0	7.9	23
N1	0.5	513	4.9	−4.2	36	3.2	4.8	54
N2	−1.3	458	4.8	−5.8	83	4.1	4.6	76
D1	−3.1	351	5.2	−8.6	163	5.4	5.6	87
D2	−4.6	284	5.6	−10.2	251	5.7	5.6	90
J1	−6.0	205	5.8	−11.1	291	6.2	5.2	90
J2	−5.5	209	5.8	−11.7	322	6.6	6.2	84
F1	−6.1	198	5.6	−10.9	301	6.1	4.8	81
F2	−3.7	216	5.3	−8.9	232	5.9	5.2	83
M1	−3.2	291	4.9	−7.7	218	5.5	4.5	87
M2	−1.7	395	4.9	−5.7	154	4.6	3.9	86
A1	−0.1	473	4.3	−3.9	74	3.6	3.9	62
A2	1.8	522	4.4	−2.3	32	2.4	4.1	23

Early and late in the season (November, March, and April) snow cover is often associated with outbreaks of cold air from central Canada. In fact, a snowfall is unlikely without the presence of an anomalously cold air mass. While these cold air masses are in residence, they are likely to augment the depression of maximum temperatures associated with the coincident snow covers. Moreover, during these months, the advection of warm air masses into the region during days with no snow cover can lead to high maximum temperature values. These separate effects taken together are likely to be the primary reason for the larger temperature depressions during the early and late portions of the snow cover season.

A physical mechanism related to the snow cover involves the partitioning of energy received at the surface. Maximum temperatures may be more greatly affected by snow cover during the early and late season when average maximum temperatures are above the freezing point across the majority of the region. During these periods, much of the available energy would be used in raising the temperature of the snowpack and in melting snow instead of sensible heat production, greatly decreasing the daily maximum air temperature. During the midwinter period, less energy is available from the overlying air mass and because the maximum temperatures are below the freezing point, little energy is utilized for snowmelt.

b. Minimum temperature depressions

Minimum temperature depressions are relatively consistent throughout the annual cycle (Fig. 2b, Table 1a) with slightly larger temperature depressions occurring during the midwinter months and smaller depressions occurring at the beginning and the end of the snow cover season. The larger values during the midwinter months (December and January) may be

TABLE 1b. Fifteen-day stratification of daily temperature range for days with and without a snow cover present. Temperature data are reported in degrees Celsius.

Month	Range (without) (°C)	Range (with) (°C)
N1	10.3	7.5
N2	9.9	7.7
D1	9.4	8.8
D2	9.6	9.5
J1	9.8	10.0
J2	10.3	10.5
F1	10.5	10.7
F2	11.0	10.6
M1	11.0	10.0
M2	12.1	9.8
A1	12.3	9.3
A2	13.1	9.4

a result of longer nighttime hours, enhancing the radiative effects of the snow cover (Wagner 1973). Also, these midwinter months are associated with more spatially complete and deeper snow covers, which leads to a further decrease in the flux of heat from the soil to the near-surface atmosphere. At the beginning and end of the season (November, March, and April), an increase in the average vapor pressure across the region may lead to a decrease in the effect of the snow cover on the minimum temperatures. In addition, shorter nighttime hours and less complete snow covers may be associated with the smaller minimum temperature depressions in March and April.

Averaged across space and time (November–April), the depression of maximum temperature associated with the presence of snow cover of 2.5 cm or greater is approximately 6.0°C, while the depression of minimum temperature is somewhat smaller (approximately 5°C). These values are similar, but slightly smaller than those attained by Baker et al. (1992) for a single, open, rural site near St. Paul, Minnesota, under conditions of snow depths greater than 0 and less than 10 cm. In addition, they are in the range of snow cover temperature depressions suggested by several other studies (Dewey 1977; Walsh and Ross 1988; Leathers and Robinson 1993).

In a spatially aggregated sense, the daily temperature range is decreased by the presence of snow cover during the early and later portions of the snow cover season (December, March, April) and is affected little by the presence of snow cover during the midwinter months (Table 1b; Fig. 2c). The magnitude of the change in the daily range is quite large in November and April (Fig. 2c). This large decrease in the daily range early and late in the season is a result of the large depression in maximum temperature that occurs at this time of the year when a snow cover is present.

4. Spatial results

To better understand potential geographic controls on the snow cover–atmosphere interactions, the temperature depressions associated with snow covers of greater than 2.5 cm are mapped. The depression of maximum temperature for selected 15-day periods during the snow cover season is presented in Fig. 3, whereas Fig. 4 presents the same information for minimum temperature depressions. The locations of the stations that are used in the analysis for a specific 15-day period are identified by asterisks on each map.

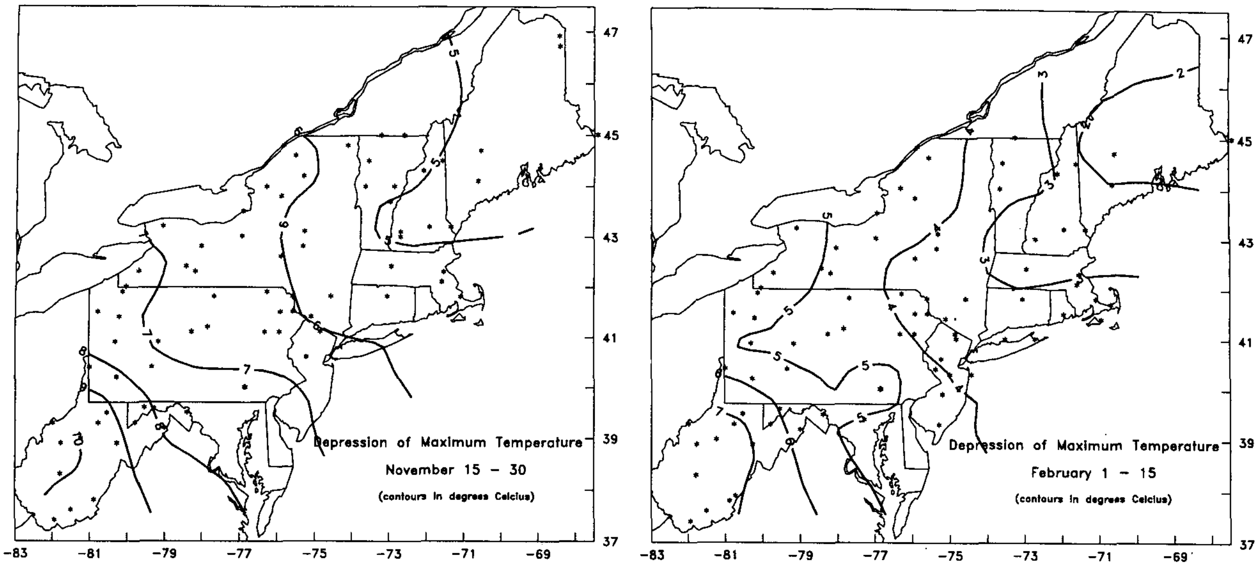
To investigate the geographic controls on temperature depressions related to snow cover, multiple linear regression techniques are employed. Specifically, maximum and minimum temperature depressions at each station are regressed against longitude, latitude, elevation, and the temperature without a snow cover present for each 15-day period. In addition, the number of days falling into each stratification is entered into the regression as independent variables to test the sensitivity of the magnitude of the depressions to the number of observations at each station (Table 2). A stepwise screening procedure was utilized within the multiple regression analysis to aid in the elimination of predictors that added redundant information to the equation (Davis 1986).

a. Maximum temperature depressions

In general, depressions of maximum temperature increase from the northeast to the southwest in every month (Fig. 3). The spatial distribution of the magnitude of the temperature depressions and the regression analysis (Table 2) suggests a potential role of two major forcings. First, the latitudinal gradient of the depression values and the importance of latitude or longitude in the regression equation indicates a likelihood that the amount of absorbed solar radiation may be a forcing mechanism. It is important to note that in the northeast United States the longitude and latitude of the stations are themselves highly correlated ($R = -0.67$ for the 91 stations) because of the northeast to southwest orientation of the region. Thus, latitude and longitude add significant redundant information to the regression equation and the inclusion of one implicitly indicates the potential importance of the other.

Second, the pattern of maximum temperature depressions closely matches the spatial orientation of the maximum temperatures themselves when no snow cover is present (Fig. 5a). Moreover, the temperature at each station with no cover present is significantly related to the magnitude of the depressions for each stratification category (Table 2). Thus, airmass temperature characteristics may play a role in the magnitude of the depressions. Unfortunately, the maximum temperatures without snow cover are highly correlated with latitude and longitude making a clear identification of the dominant forcing difficult.

To diagnose the relative importance of the two potential forcings, mean monthly incident solar radiation data were collected for 15 stations across the region. Similar information for 15-day periods was unavailable. These data represent mean observed values for varying periods of record, and include the effects of clouds. The data are interpolated to the same grid as the temperature depression values and a linear regression analysis is performed regressing the gridded temperature depression values against the gridded solar radiation observations. The results indicate that the amount of incident solar radiation is not strongly associated with the magnitude of the maximum temperature depressions during any month. Correlation coefficients range from a low of −0.19 during March to a maximum of −0.51 in February (Table 3). The reason for the small correlation values is clear with inspection of Figs. 3b and 5b. Figure 5b shows the mean daily



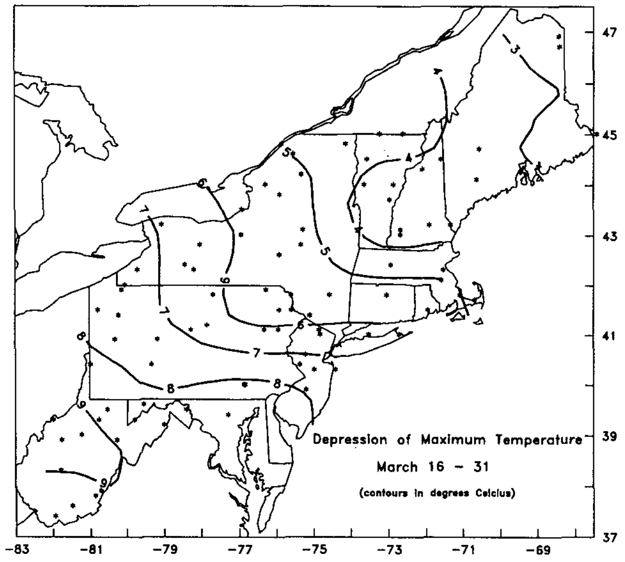


FIG. 3. Spatial distribution of daily maximum temperature depressions associated with snow covers of greater than 2.5 cm for (a) 15–30 November, (b) 1–15 February, and (c) 16–31 March. Depressions are given in degrees Celsius and station locations are marked with an asterisk.

incident solar radiation for the month of February. When compared to the magnitude of the temperature depressions (Fig. 3b), very little spatial correspondence is noted. It is also interesting to note that the general relationship between the magnitude of the depression values and the incident solar radiation is such that larger incident solar radiation values are associated with smaller temperature depressions.

The temperature on days without snow cover is gridded in a similar manner and regressed against the magnitude of the temperature depressions for each month (Table 3). The temperature on days without snow cover is strongly related to the magnitude of temperature depression values. Correlation coefficients range from 0.49 in December to 0.88 in April. Figures 3b and 5a show the spatial correspondence between the temperature depression values and the temperature on days without snow cover for the first 15-day period of February. Thus, this analysis suggests that the air-mass temperature is of primary importance in the explanation of the spatial distribution of the maximum temperature depressions.

b. Minimum temperature depressions

In general, depressions of minimum temperature increase from coastal areas toward the west (Fig. 4). The multiple regression analysis indicates that the spatial distribution of the minimum temperature depressions is not as dependent on large-scale controls as the maximum temperatures. Multiple *R* values are not as large, and there is no clear ordering of importance in

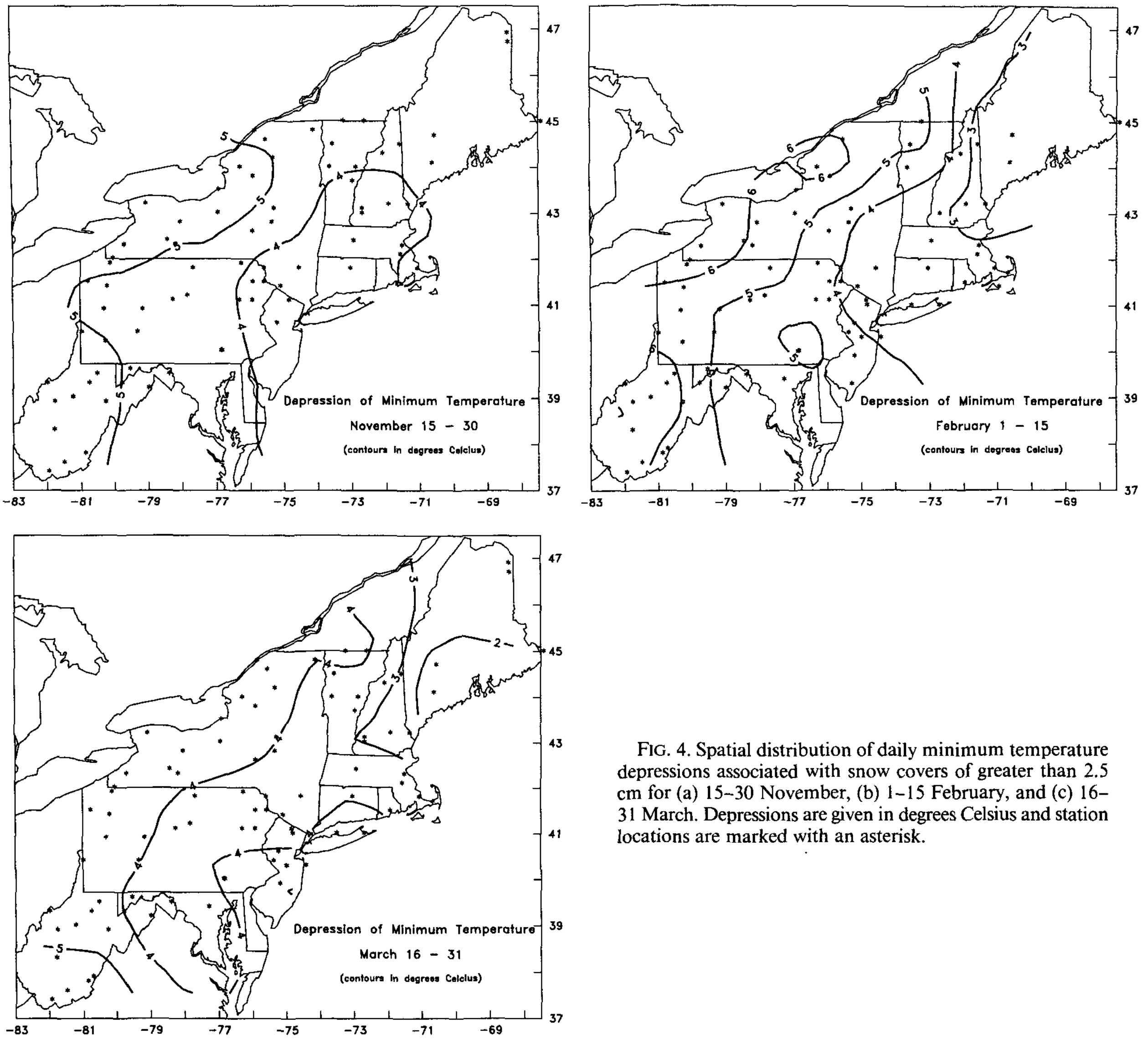


FIG. 4. Spatial distribution of daily minimum temperature depressions associated with snow covers of greater than 2.5 cm for (a) 15–30 November, (b) 1–15 February, and (c) 16–31 March. Depressions are given in degrees Celsius and station locations are marked with an asterisk.

the variables that are included in the regression equation (Table 2).

The spatial orientation of the minimum temperature depressions suggests a role for oceanic influences in their magnitude. To evaluate this role, gridded minimum temperature depression values are regressed against the gridded mean monthly dewpoint temperature values for each month. Results (not shown) indicate a weak relationship throughout the snow cover season. We hypothesize that the effect of the oceans is multifaceted, with the oceans responsible for increased cloudiness and higher vapor pressures in the near-coastal region. This would be especially true on days with easterly flow. On such days the radiative effects of a snow cover may be preferentially diminished in coastal areas because of increased cloudiness and vapor pressures (Wagner 1973).

5. Summary and discussion

This study has explored the relationships between snow cover and the maximum and minimum temperature of the overlying atmosphere at a height of approximately 1.5 m. Results from this study can be summarized with the following general points.

1) For a snow cover of 2.5 cm or greater, depressions of daily maximum and minimum temperature, aggregated temporally and spatially, average approximately 6° and 5°C, respectively. Moreover, there is relatively large variation in the temperature depressions across space and a smaller variation throughout the snow cover season.

2) Temporally, maximum temperature depressions are greater during the early and later portions of the

TABLE 2. Results of a multiple regression with the temperature depression (maximum or minimum) as the dependent variable and longitude (long), latitude (lat), elevation (ele), temperature on days without snow cover present (T_{wo}), number of observations with snow cover, and number of observations without snow cover as independent variables. The ordering of the variables indicate their importance in the multiple regression equation.

Period	Adjusted R^2	Variables in equation
	Maximum temperature	
N1	0.66	T_{wo}, long, ele
N2	0.76	T_{wo}, long, ele
D1	0.71	lat, T_{wo}, long
D2	0.63	lat, T_{wo}, long, ele
J1	0.57	lat, T_{wo}, long
J2	0.81	lat, T_{wo}, long
F1	0.79	lat, T_{wo}, long
F2	0.69	lat, T_{wo}, long
M1	0.86	long, T_{wo}
M2	0.81	long, T_{wo}
A1	0.74	long, T_{wo}
A2	0.78	long, T_{wo}
	Minimum temperature	
N1	0.42	long, lat
N2	0.26	T_{wo}, ele
D1	0.18	lat, T_{wo}
D2	0.35	lat, long, T_{wo}, ele
J1	0.21	lat, long, T_{wo}
J2	0.44	lat, long, T_{wo}
F1	0.56	lat, long, T_{wo}
F2	0.48	lat, T_{wo}, long, ele
M1	0.31	long
M2	0.32	lat, T_{wo}, long
A1	0.53	lat, T_{wo}, long
A2	0.79	T_{wo}

snow cover season and somewhat smaller during the midwinter months. The magnitude of minimum temperature depressions are larger during the midwinter months but decrease in size early and especially late in the snow cover season. The presence of a snow cover decreases the daily temperature range in November, March, and April and has little effect during the intervening months.

3) Spatially, the magnitude of both maximum and minimum temperature depressions increase away from coastal areas. Near the coast, the radiative effects of snow cover are likely to be diminished because of the more frequent presence of clouds and large atmospheric water vapor contents (Wagner 1973). For maximum temperature depressions, there is also a consistent increase toward the southern portion of the region. This increase is most likely due to the advection of warm air masses from the south that lead to increased energy transfer to the snow cover from the atmosphere. In the case of minimum temperature depressions, no large-scale geographic control, except for coastal proximity, dominates the spatial distribution of the depression magnitudes.

The results presented here differ from those obtained for open sites across the plains region of North America (Dewey 1977; Kukla 1981; Baker et al. 1992). Across the open plains, the major effect of a snow cover has been shown to be related to smaller values of absorbed solar radiation at the earth's surface due to greatly increased albedo values (Dewey 1977; Baker et al. 1992). Across the plains, regional albedo following a snowfall of several centimeters can exceed 80% (Kung et al. 1964; Baker et al. 1991; Baker et al. 1992). Thus the surface radiation balance is greatly affected, reducing the net radiation significantly and decreasing the surface air temperature.

In the forested Northeast, the presence of a snow cover increases the surface albedo to a lesser degree. Kung et al. (1964) estimates surface albedos in the range of 25%–50% across the Northeast for midwinter snow cover conditions. Therefore, in the Northeast the net radiation is not as greatly reduced by a snow cover. Instead, the relatively large latitudinal extent of the region leads to very different airmass frequencies and airmass characteristics from north to south. During the snow cover season, the southern portion of the region is more frequently under the influence of relatively mild air masses with mean temperatures above 0°C (Kalkstein et al. 1995). With the presence of a snow cover, a large near-surface temperature inversion is established due to the transfer of heat from the bottom atmospheric layer to the snowpack. The sensible heat flux is dependent on the sign and magnitude of the near-surface temperature gradient. The strong inversion leads to a strong downward flux of sensible heat from the lower atmosphere to the snowpack. Moreover, after the snowpack has warmed to 0°C, additional energy is transferred from the atmosphere to the snowpack to facilitate melting. The total transfer of energy from the atmosphere to the pack, both sensible and latent heat, greatly lowers the near-surface atmospheric temperature resulting in large temperature depressions. In the northern portion of the region, airmass frequencies and characteristics are very different. Here, airmass temperatures at or below 0°C set up a weak inversion or very often a lapse temperature profile. Thus less sensible heat is transferred from the atmosphere to the snowpack. In addition, with snowpack and atmospheric temperatures below the freezing point, little additional energy is utilized for melting. Thus atmospheric temperatures are not as greatly reduced in the northern portion of the region.

It is clear from this study that the relationship between snow cover and surface air temperatures is highly dependent on the geographic position and typical airmass characteristics (temperature and vapor pressure) of a given individual station. Moreover, the influence of snow cover on maximum and minimum temperature is somewhat dependent upon the timing within the annual cycle. Thus, to truly understand the role of snow cover in the modification of surface air temper-

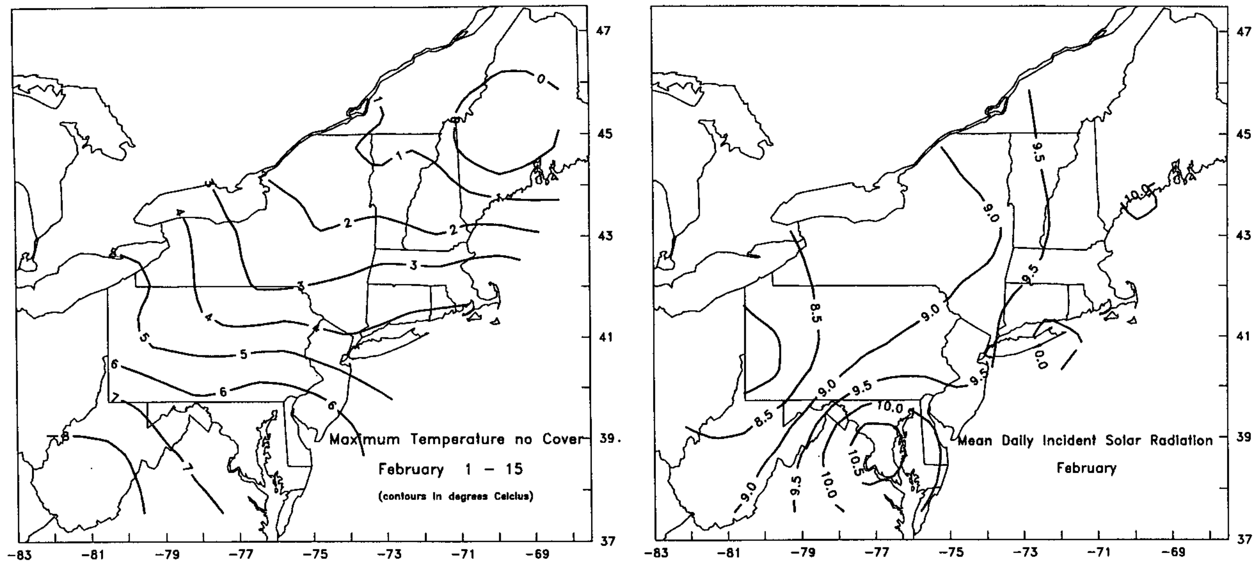


FIG. 5. Maps showing (a) the maximum temperature on days with no snow cover for 1–15 February and (b) the mean daily incident solar radiation (MJ m^{-2} day^{-1}) for the month of February.

atures, detailed studies must be undertaken in diverse locations across the Northern Hemisphere.

This study represents a needed first step toward a more complete understanding of the role of snow cover in the dynamics of regional climate. A second step is to study the role of snow cover under differing airmass types and synoptic situations. Also, an analysis of the role of snow depth on the magnitude of the temperature depressions is needed to better understand how changing snowfall regimes may effect atmospheric temperatures (Leathers et al. 1993). The authors are currently completing analyses on both of these topics and are beginning work on snow cover modeling experiments to support the empirical inferences made in this paper.

The magnitude of the temperature depressions associated with snow cover speak to its importance in climate diagnostics and climate change studies. For example, a dramatic change in the snow cover climatology of an area from one of consistent winter snow cover to one with sparse, erratic covers may lead to a major temperature response. Thus, a thorough knowledge of the dynamics of snow cover–atmosphere interactions is needed if an understanding of present climate variations and long-term climate change is desired.

TABLE 3. Results of a bivariate regression between daily maximum temperature depressions, stratified by month, and the mean monthly incident solar radiation and the mean monthly temperature without a snow cover present.

Period	$R_{\text{solar radiation}}$	$R_{\text{temp. without cover}}$
November	0.05	0.87
December	−0.50	0.49
January	−0.43	0.83
February	−0.51	0.69
March	−0.19	0.87
April	−0.23	0.88

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