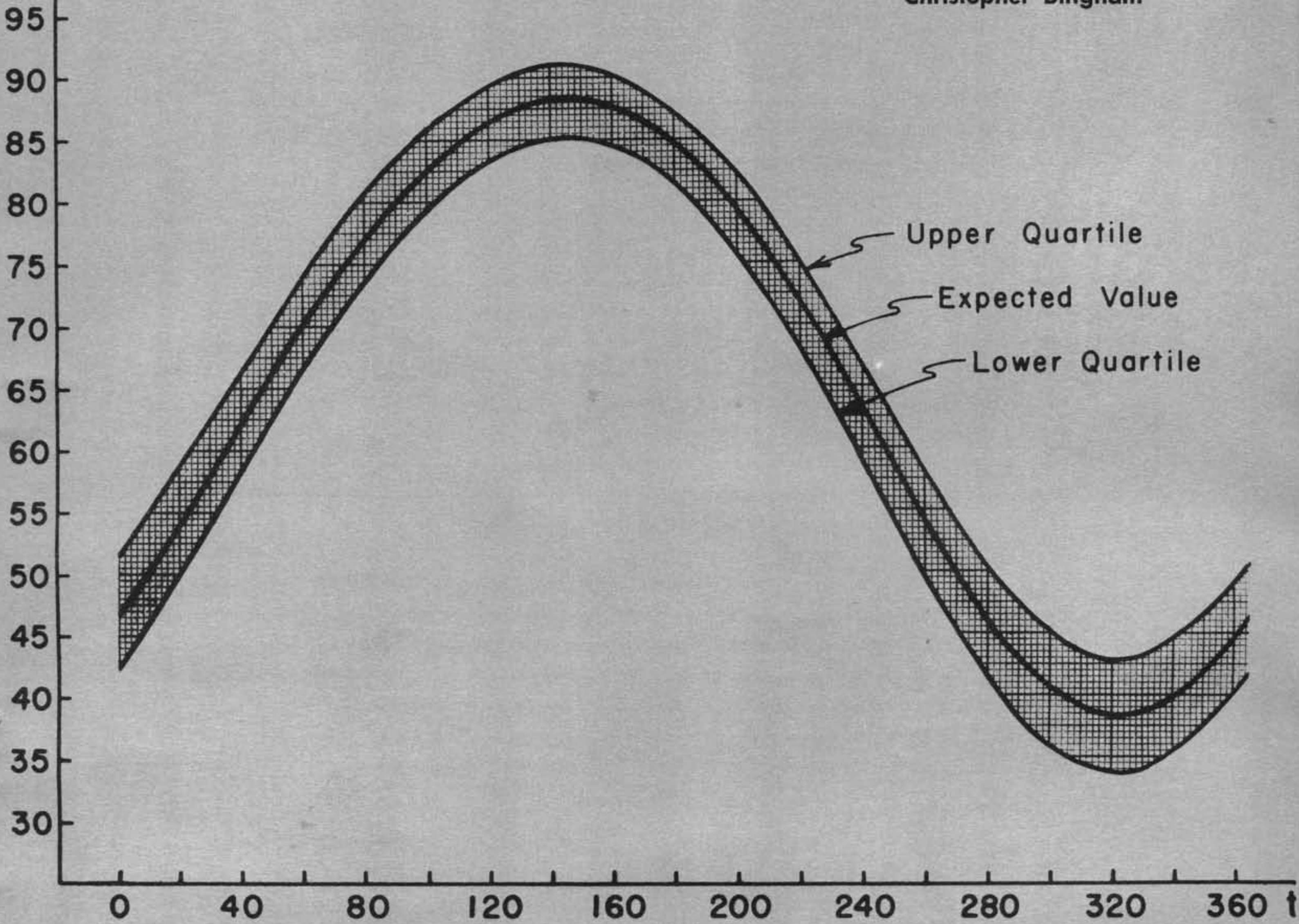
NORTHEAST REGIONAL RESEARCH PUBLICATION

# THE CLIMATE OF THE NORTHEAST

# Probabilities of Weekly Averages of the Daily Temperature Maximum, Minimum, and Range

**Christopher Bingham**

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**THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION, NEW HAVEN**

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## INTRODUCTION

A complete description of the climatology of a region requires not only the average values or normals of climatological variates, but also information about their probability distributions. This bulletin provides in a compact form the information necessary to compute all probability levels of certain temperature variates at all points in the Northeastern region of the United States: New England, New York, Pennsylvania, New Jersey, Delaware, Maryland, and West Virginia. These temperature variates are the following:

1. The average of any 7 consecutive values of the diurnal maximum temperature;
2. The average of any 7 consecutive values of the diurnal minimum temperature;
3. The average of any 7 consecutive values of the diurnal temperature range.

When we refer to the maximum temperature, the minimum temperature, or the diurnal temperature range, we will always mean these 7-day averages.

## THEORY

It has been shown elsewhere (Bingham 1961) that the probability distributions of these three variates are not in general normal. That is, they do not have the bell-shaped frequency curve given by $\frac{1}{\sqrt{2\pi}\,\sigma} \exp\left(-\frac{[x-\mu]^2}{2\sigma^2}\right)$. However, for most practical applications, it was shown that the normal distribution is an adequate approximation. This assumption underlies all that follows. Because of the non-normality, the method given herein is not recommended for estimating probabilities very far in the tails of a distribution, say beyond the 5% or 95% points. For probabilities in this region it should be preferable to use some form of extreme value analysis on the original data.

Given that a distribution is normal, we can easily see that it will be completely specified by its expected or average value $\mu$, which determines the center of the bell-shaped curve, and by its standard deviation $\sigma$, which indicates the "spread" of the distribution. The parameters are illustrated in Figure 1. It was also shown (Bingham 1961), using methods developed by Bliss (1958), that the values of these parameters for every week of the year for the maximum and minimum temperatures and the diurnal temperature range can be specified very concisely using Fourier or harmonic analysis as described below.

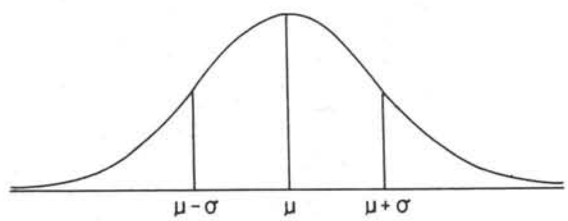


*Figure 1.* The frequency curve $\frac{1}{\sqrt{2\pi}\,\sigma} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)$ of the normal distribution with expected value $\mu$ and standard deviation $\sigma$. This approximates the distributions of the maximum and minimum temperatures and the diurnal temperature range.

In the following formulae and throughout this bulletin, t is the number of days after March 1, the start of the climatological year. The correspondence between the ordinary calendar and t is given in Table 1. For instance, $t=131$ refers to the week for which July 10 is the midpoint, i.e., the week of July 7 through 14. Thus $\mu(t)$ and $\sigma(t)$ are the expected value and standard deviation of a variate for the week whose midpoint comes t days after March 1. Clearly $t=0$ on March 1, that is, for the week of February 26 through March 3.

The expected value $\mu(t)$ and the common logarithm of the standard deviation $\sigma(t)$ for the maximum, minimum, or range can be expressed with notable accuracy by an equation of the form

$$y(t) = a_0 + A_1 \cos(t-\phi_1) + A_2 \cos 2(t-\phi_2) + A_3 \cos 3(t-\phi_3) \qquad (1)$$

where $y(t)$ can represent either $\mu(t)$ or $\log \sigma(t)$. Here t, $\phi_1$, $\phi_2$, and $\phi_3$ are measured in days after March 1,*

* For computational convenience, the notation here differs slightly from Bingham (1961). $\phi_2$ and $\phi_3$ in this bulletin are equal respectively to 1/2 $\phi_2$ and 1/3 $\phi_3$ in the previous paper.

TABLE 1

| Date | | t | Date | | t |
|---|---|---|---|---|---|
| March | 1 | 0 | Sept. | 1 | 184 |
| | 10 | 9 | | 10 | 193 |
| | 20 | 19 | | 20 | 203 |
| | 30 | 29 | | 30 | 213 |
| April | 1 | 31 | Oct. | 1 | 214 |
| | 10 | 40 | | 10 | 223 |
| | 20 | 50 | | 20 | 233 |
| | 30 | 60 | | 30 | 243 |
| May | 1 | 61 | Nov. | 1 | 245 |
| | 10 | 70 | | 10 | 254 |
| | 20 | 80 | | 20 | 264 |
| | 30 | 90 | | 30 | 274 |
| June | 1 | 92 | Dec. | 1 | 275 |
| | 10 | 101 | | 10 | 284 |
| | 20 | 111 | | 20 | 294 |
| | 30 | 121 | | 30 | 304 |
| July | 1 | 122 | Jan. | 1 | 306 |
| | 10 | 131 | | 10 | 315 |
| | 20 | 141 | | 20 | 325 |
| | 30 | 151 | | 30 | 335 |
| August | 1 | 153 | Feb. | 1 | 337 |
| | 10 | 162 | | 10 | 346 |
| | 20 | 172 | | 20 | 356 |
| | 30 | 182 | | 28 | 364 |

*Table 1.* t = number of days after March 1 of calendar dates.

while $a_0$, $A_1$, $A_2$, and $A_3$ are either in °F or log °F. Strictly speaking, we should transform the units of days to units of angular measure such as radians or degrees. However, since a table of cos t in units of days is included in the bulletin (Table 2) no confusion should arise.

Formula (1) expresses y(t) as the sum of a yearly average and three cosine terms, as is displayed in Figure 2. The average over the whole year is $a_0$. The first cosine term, $A_1 \cos (t-\phi_1)$, has a single maximum at day $\phi_1$. Its semi-amplitude, $A_1$, is the height of this maximum above $a_0$. The second cosine term, $A_2 \cos 2(t-\phi_2)$, has two maxima during the year at days $\phi_2$ and $(\phi_2 + 182\frac{1}{2})$. Its semi-amplitude, $A_2$, measures its maximum effect. The third term, $A_3 \cos 3(t-\phi_3)$, has three maxima at days $\phi_3$, $(\phi_3 + 121\frac{2}{3})$, and $(\phi_3 + 243\frac{1}{3})$, with $A_3$ having a similar significance as $A_1$ and $A_2$. The meaning of all seven parameters is made clear in Figure 2 where they are displayed separately in the decomposition of the curve y(t) at the top of the figure. At any time t, y(t) is found by adding to $a_0$ the values of the three cosine curves at that time t. Once the coefficients $a_0$, $A_1$, $A_2$, $A_3$, $\phi_1$, $\phi_2$, and $\phi_3$ for a curve of the form (1) have been given, the value of y(t) can be easily computed using Table 2.

Both the mean, $\mu$ (t), and the log standard deviation, log $\sigma$ (t), for the maximum and minimum temperature and the diurnal temperature range can be approximated over the entire year by curves of the form (1). Hence no more than 14 parameters — 7 for $\mu$ (t) and 7 for log $\sigma$ (t) — are needed to compute probabilities for any week of the year for any one of these variates. In fact, fewer are required, since the second and third terms do not always add to the accuracy of the curve. For example, the log standard deviation of both the maximum and minimum temperatures can be specified sufficiently accurately by $\log \sigma(t) = a_0 + A_1 \cos (t-\phi_1)$ which requires only three parameters. Similarly, log $\sigma$(t) for the range needs only five parameters, as does $\mu$ (t) for the maximum temperature.

A further simplification is possible. Since the diurnal temperature range is equal to (diurnal maximum temperature)−(diurnal minimum temperature), one can compute the curve for $\mu$ (t) for the range from the difference of the curves for the maximum and minimum. Hence separate parameters are not needed for $\mu$ (t) for the range. Thus a large amount of reduction is possible. With no more than 23 parameters for any single location (8 for $\mu$ (t) and log $\sigma$ (t) of the maximum, 10 for $\mu$ (t) and log $\sigma$ (t) of the minimum, and 5 for log $\sigma$ (t) of the range), probabilities for any 7-day period in the year can be computed for all three variates.

One final and very important step can now be taken. Since the parameters $a_0$, $A_j$, and $\phi_{j3}$ for both $\mu$ (t) and log $\sigma$ (t), vary regularly with location, isolines can be drawn on maps so that parameter values for any location in the Northeast can be determined. This has been done in the present bulletin. Since $\phi_2$ for log $\sigma$ (t) is effectively constant over the region, 22 maps, one for each parameter, replace a voluminous set of tables of different probability levels for a dense net of locations. The price paid is some easy calculations. These are simplified by the use of Tables 1, 2, and 3, and Workforms A, B, and C. Detailed instructions for these are given below, although the reader may find the workforms self-explanatory.

## DATA

The maps were constructed from calculations which were performed using data on summary cards from the 149 stations in the Northeast listed in Table 4. This was part of the program of the Regional Technical Committee on Agricultural Climatology (NE 35). This program is described more fully by Havens and McGuire (1961). All stations with a summarized record of 20 to 30 years were used. Most have 30 years of record. These stations are listed in Table 4 together with their station numbers. Their locations may be determined from Map 1 on which the station numbers are plotted. The summary cards, 52 for each station, from week 1 (March 1-7) to week 52 (February 21-27), contained the (usually) 30-year averages and the estimated variances of the weekly averages of diurnal maximum and minimum temperatures. In addition, the average and the estimated variance of the weekly "mean" temperature, (1/2

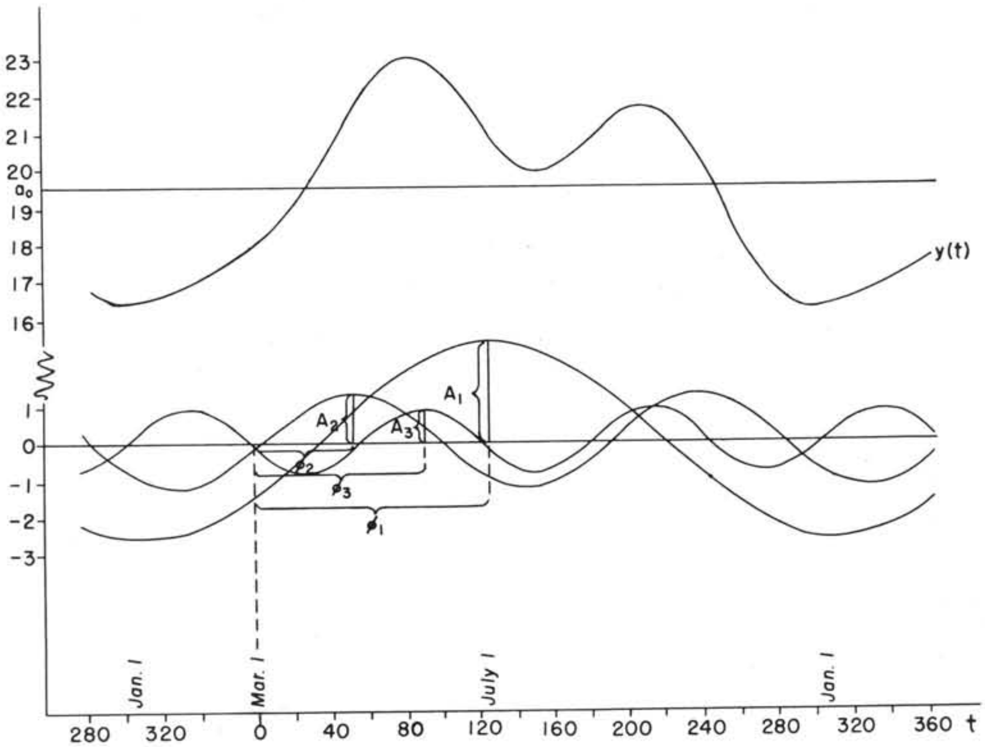


*Figure 2.* The decomposition of the curve y(t) into the sum of a mean $a_0$ and three cosine terms.

(maximum + minimum)), were available on the cards. From these data, an IBM 650 program computed the average diurnal temperature range and its variance and then calculated the best fitting curve of type (1) to the variates and their log standard deviations. (The analysis was carried out on the "mean" temperature as well as on the other three variates. The "mean" was not included in this bulletin, since it has little intrinsic interest. Moreover, since it is derived by an even weighting of the maximum and minimum temperatures, it is not a fully accurate measure of the true mean temperature. This last is defined as an average over the entire course of temperature in a day, not just over the extreme values.) The maps in this bulletin were then compiled from the results of these calculations.

It will be noticed that the maps of $a_0$ for both the maximum and the minimum temperatures include exact calculated values for each station, while all other maps show only isolines. The relatively steep gradient of $a_0$ over the area, and the relatively greater influence of local topography upon $a_0$ make it impossible to get satisfactorily accurate values from an isoline map of the scale included. The exact values should enable fairly accurate interpolation on the map for any location not listed explicitly. However, $a_0$ is the long-term yearly average of each variate. Hence, whenever such an average is available for any location it can be used in place of $a_0$ from the maps.

## FINDING TEMPERATURE PROBABILITIES FROM MAPS

Three elements go into computing probabilities for normally distributed temperatures — an expected value $\mu$, a standard deviation $\sigma$, and probabilities of the normal distribution. Corresponding to these, three workforms are used. Workform A is used to compute the expected value $\mu$ for one or several weeks during the year. Workform B is used to compute the common logarithm of the standard deviation $\sigma$ for these same weeks. Workform C presents a straightforward means of computing the 5, 10, 20, 25, 50, 75, 80, 90, and 95 percentiles for each of these same weeks.

Detailed instructions for these workforms are presented below. The workforms are compiled and their use described in greatest generality. That is, provision has been made for using all terms up to those in cos $3(t\text{-}\phi_3)$ for $\mu$ and up to cos $2(t\text{-}\phi_2)$ for log $\sigma$. However, since the effect of including the second or third terms is never greater than their semi-amplitudes $A_2$ and $A_3$, where these are small they contribute very little and hence should not be included. Thus, because $A_3$ for the maximum temperature is less than 0.5°F over practically the whole Northeast, no maps of $A_3$ (or $\phi_3$) are included. Similarly, along the Atlantic coast and Lake Ontario, $A_2$ for the maximum temperature is less than 0.5°F and hence the term in cos $2(t\text{-}\phi_2)$ would generally not be included in this region. In cases in which a coefficient is

TABLE 2

| t | | | cos t | t | | |
|---|---|---|---|---|---|---|
| 0 | 365 | 730 | 1.000 | 1095 | 730 | 365 |
| 5 | 370 | 735 | 0.996 | 1090 | 725 | 360 |
| 10 | 375 | 740 | 0.985 | 1085 | 720 | 355 |
| 15 | 380 | 745 | 0.967 | 1080 | 715 | 350 |
| 20 | 385 | 750 | 0.941 | 1075 | 710 | 345 |
| 25 | 390 | 755 | 0.909 | 1070 | 705 | 340 |
| 30 | 395 | 760 | 0.870 | 1065 | 700 | 335 |
| 35 | 400 | 765 | 0.824 | 1060 | 695 | 330 |
| 40 | 405 | 770 | 0.772 | 1055 | 690 | 325 |
| 45 | 410 | 775 | 0.715 | 1050 | 685 | 320 |
| 50 | 415 | 780 | 0.652 | 1045 | 680 | 315 |
| 55 | 420 | 785 | 0.584 | 1040 | 675 | 310 |
| 60 | 425 | 790 | 0.512 | 1035 | 670 | 305 |
| 65 | 430 | 795 | 0.438 | 1030 | 665 | 300 |
| 70 | 435 | 800 | 0.358 | 1025 | 660 | 295 |
| 75 | 440 | 805 | 0.276 | 1020 | 655 | 290 |
| 80 | 445 | 810 | 0.192 | 1015 | 650 | 285 |
| 85 | 450 | 815 | 0.107 | 1010 | 645 | 280 |
| 90 | 455 | 820 | 0.022 | 1005 | 640 | 275 |
| 95 | 460 | 825 | −0.065 | 1000 | 635 | 270 |
| 100 | 465 | 830 | −0.150 | 995 | 630 | 265 |
| 105 | 470 | 835 | −0.234 | 990 | 625 | 260 |
| 110 | 475 | 840 | −0.317 | 985 | 620 | 255 |
| 115 | 480 | 845 | −0.398 | 980 | 615 | 250 |
| 120 | 485 | 850 | −0.475 | 975 | 610 | 245 |
| 125 | 490 | 855 | −0.549 | 970 | 605 | 240 |
| 130 | 495 | 860 | −0.619 | 965 | 600 | 235 |
| 135 | 500 | 865 | −0.684 | 960 | 595 | 230 |
| 140 | 505 | 870 | −0.744 | 955 | 590 | 225 |
| 145 | 510 | 875 | −0.799 | 950 | 585 | 220 |
| 150 | 515 | 880 | −0.848 | 945 | 580 | 215 |
| 155 | 520 | 885 | −0.890 | 940 | 575 | 210 |
| 160 | 525 | 890 | −0.926 | 935 | 570 | 205 |
| 165 | 530 | 895 | −0.955 | 930 | 565 | 200 |
| 170 | 535 | 900 | −0.977 | 925 | 560 | 195 |
| 175 | 540 | 905 | −0.992 | 920 | 555 | 190 |
| 180 | 545 | 910 | −0.999 | 915 | 550 | 185 |
| 182.5 | 547.5 | 912.5 | −1.000 | 912.5 | 547.5 | 182.5 |

*Table 2.* cos t , t given in days, cos (−t) = cos t.

either omitted from the bulletin by the author or is considered by the user to be too small to be important, the lines in Workforms A and B corresponding to it can be skipped. The use of a short table for cos t (Table 2) is made possible by the equality cos (-t) = cos t. Hence in using Table 2 the sign of t is ignored, although the sign of cos t is always retained. Thus cos (−150) = cos 150 = −0.848.

In the following outline, Workforms A, B, and C will be referred to simply as A, B, and C respectively.

I. Parameters: $\mu$ and log $\sigma$

1. Maximum temperature

a. Expected value $\mu$.

*i.* Obtain $\phi_1$, $\phi_2$, $A_1$, $A_2$, and $a_0$ for maximum temperature from Maps 2, 3, 4, 5, and 6, respectively and enter them in the appropriate lines on the left side of A.

*ii.* Using Table 1, find the number of days, t, after March 1 of the midpoints of the weeks for which probabilities are sought and enter these values in row 1 of A, B, and C. (e.g., for the week of September 11 through 17 with midpoint September 14, t = 197).

*iii.* Fill in rows 1, 2, 3, 4, 5, 6, 10, 11, and 13 of A, using Table 2 to find cos $t_1'$ and cos $t_2'$.

*iv.* Enter row 13 of A into row 2 of C.

b. Log standard deviation, log $\sigma$.

*i.* Obtain $\phi_1$, $A_1$, and $a_0$ for log standard deviation of maximum temperature from Maps 7, 8, and 9 respectively and enter them on the left side of B.

*ii.* Fill in rows 2, 3, 7, and 9 of B (row 1 should already be completed from a. *ii.* above), using Table 2 to find cos $t_1'$.

*iii.* Enter row 9 of B into row 3 of C.

c. See II below.

2. Minimum temperature

a. Expected value $\mu$.

*i.* Obtain $\phi_1$, $\phi_2$, $\phi_3$, $A_1$, $A_2$, $A_3$, and $a_0$ from Maps 10, 11, 12, 13, 14, 15, and 16 respectively, and enter them in the appropriate lines on the left side of A.

*ii.* Same as a.*ii.* for maximum temperature.

*iii.* Fill in all rows of A, using Table 2 to find cos $t_1'$, cos $t_2'$, and cos $t_3'$.

*iv.* Enter row 13 of A into row 2 of C.

b. Log standard deviation, log $\sigma$.

*i.* Obtain $\phi_1$, $A_1$, and $a_0$ for the log standard deviation of the minimum temperature from Maps 17, 18, and 19 respectively and enter them on the left side of B.

*ii.* Same as b.*ii.* for maximum temperature.

*iii.* Enter row 9 of B into row 3 of C.

c. See II below.

3. Diurnal temperature range

a. Expected value $\mu$.

*i.* Carry out a.*i.*, a.*ii.*, and a.*iii.* for both the maximum and minimum temperatures, using two separate workforms A, entering t in one copy each of B and C.

*ii.* Compute the difference, (row 13 of $A_{max}$) − (row 13 of $A_{min}$), and enter it into row 2 of C.

b. Log standard deviation, log $\sigma$.

*i.* Obtain $\phi_1$, $A_1$, $A_2$, and $a_0$ for the log standard deviation of the range from Maps 20, 21, 22, and 23 respectively, and enter them on the left side of B. Insert $\phi_2 = 41$ on left of B.

*ii.* Fill in all rows of B (row 1 should already be completed from a.*i.*), using Table 2 to find cos $t_1'$ and cos $t_2'$.

*iii.* Enter row 9 of B into row 3 of C.

c. See II below.

II. Probability estimation

1. Check to see that rows 1, 2, and 3 of C are filled in as they should be if I has been completed.

2. From Table 3, interpolate the anti-logarithm of the value in row 3 of C and enter it in row 4 of C. The expected values $\mu$ (t) and the standard deviations $\sigma$ (t) of the

TABLE 3

| Log $\sigma$ | $\sigma$ |
|---|---|
| 0.45 | 2.82 |
| 0.50 | 3.16 |
| 0.55 | 3.55 |
| 0.60 | 3.98 |
| 0.65 | 4.47 |
| 0.70 | 5.01 |
| 0.75 | 5.62 |
| 0.80 | 6.31 |
| 0.85 | 7.08 |
| 0.90 | 7.94 |
| 0.95 | 8.91 |
| 1.00 | 10.00 |
| 1.05 | 11.22 |

*Table 3.* Values of $\sigma$ corresponding to values of log $\sigma$ obtained from row 3 of Workform C.

distributions for the weeks considered are now in rows 2 and 4 respectively.

3. a. Rows 5 through 16 can be filled in to provide estimates of the probability levels indicated on the left. Row 2 is, of course, the median or 50% level.

b. Alternatively, one may use $\mu$ and $\sigma$ in rows 2 and 4 of C, together with a table of the normal distribution to compute other percentiles or to find the probability that a given level will be exceeded.

## APPLICATIONS

*Example 1:* What are the 5 and 95 percentiles of the distribution of the diurnal maximum temperature for the week of August 1 through 7 at Washington, D. C.? The midpoint of this week is August 4 which corresponds to $t = 156$ (Table 1). In Table 5 are replicas of Workforms A, B, and C, the numbering of the rows being the same as in the workforms. The values of the parameters from Maps 2 through 9 have been entered in the appropriate places in Table 5. $\mu$ (t) and log $\sigma$ (t) for $t = 156$ are then computed as described above and the results entered on rows 2 and 3 of C. The percentiles are then computed in Workform C. Thus 1 year out of 20, the average maximum temperature in Washington should be above 93.8°F the first week in August, and 1 year out of 20 below 80.4°F.

*Example 2:* What is the probability that the average maximum temperature at Washington, D. C., exceeds 90°F for the week of August 1 through 7? We can use the expected value and standard deviation already computed in example 1 on rows 2 and 4 of Table 5C. Entering a table of the normal probability distribution (e.g., Fisher and Yates (1957), Table $II_1$) with standardized argument $(90.0 - 87.1) / 4.1 = 0.71$, we find this probability to be 0.24. That is, 24 years out of 100 the average maximum temperature will exceed 90°F.

*Example 3:* What are the 20 and 80 percentiles of the distribution of the minimum temperature at Bangor, Maine, for the week of January 1 through 7? For this week $t = 309$. Filling in the relevant lines of Workforms A, B, and C as shown in Table 6, we find that one year in five the minimum temperature will be less than 6.5°F and one year in five will be above 18.1°F.

*Example 4:* What is the probability that the average minimum temperature in Bangor falls below 5°F for the week of January 7? Using the values 12.3°F and 6.9°F for the mean and standard deviation which are already computed on rows 2 and 4 of Table 6C, we enter a table of the normal distribution with the standardized argument $(5.0 - 12.3)/6.9 = -1.06$. The corresponding probability is 0.14.

*Example 5:* Since the diurnal temperature range appears to be of considerable importance as an element determining the suitability of the climate of a given location for growth of various species of plants (Brooks 1959 p. 174 ff.; Hocker 1956), the probability distribution of this variate is of interest. Although studies of the relationship of the range and ecological and phenological phenomena have used only the average range, its specification is incomplete without its probability distribution. To illustrate the determination of this distribution by maps we wish to find the 5, 10, 20, 25, 50, 75, 80, 90, and 95 percentiles of the distribution of the average of the diurnal range at Utica, New York, for the week of April 10 through 16. From Table 1 this week corresponds to $t = 43$. We computed the expected value $\mu$ for the maximum and minimum temperatures for this week on two separate Workforms A and calculate the expected value of the range from the difference. The log standard deviation is computed on Workform B using Maps 20 through 23 while the percentiles are computed in Workform C. In Table 7 the parameters and filled-in rows of these workforms are given. Row 2 and rows 9 through 16 of Table 7C contain the desired percentiles. The value of $\mu$ in row 2 of Table 7C is the difference (row 13 of Table $7A_{max}$) − (row 13 of Table $7A_{min}$). The cumulative probability distribution interpolated from these percentiles is graphed in Figure 3. It can be seen that, although the average range for this April week is 19.3°F, it exceeds 22°F about one year in four.

*Example 6:* One useful and intuitively appealing way of graphically depicting the statistical behavior of a climatological variate such as the maximum or minimum temperature, or diurnal temperature range is the following: The curve for the expected value $\mu$ (t) is plotted for the entire year. Then, above and below this curve and roughly parallel to it, curves are drawn corresponding to the upper and lower quartiles of the distribution for each week. One can then state that for any particular week the average value of the variate will fall between these upper and lower lines 5 years out of 10. Of course other percentiles could be used

*Table 4.* List of stations for which harmonic regression parameters were computed.

| *Station Name* | *Number* | *Elevation* |
|---|---|---|
| CONNECTICUT | | |
| Cream Hill | 1715 | 1300 |
| Hartford, Brainard Field | 3451 | 15 |
| Norwalk | 5892 | 120 |
| Storrs | 8138 | 600 |
| Waterbury | 8911 | 288 |
| DELAWARE | | |
| Bridgeville 1NW | 1330 | 50 |
| Dover | 2730 | 34 |
| Milford | 5915 | 10 |
| MAINE | | |
| Eastport | 2426 | 100 |
| Farmington | 2765 | 390 |
| Houlton 1NE | 3897 | 410 |
| Lewiston | 4566 | 182 |
| Old Town | 6420 | 108 |
| Portland, airport | 6905 | 61 |
| Presque Isle | 6937 | 606 |
| Rockland | 7250 | 40 |
| Rumford 1SSE | 7330 | 505 |
| MARYLAND | | |
| Chewsville-Bridgeport | 1790 | 560 |
| Crisfield | 2205 | 5 |
| Easton | 2695 | 28 |
| Elkton | 2860 | 28 |
| Frederick, police barrack | 3348 | 380 |
| Frostburg | 3410 | 2035 |
| Keedysville | 4780 | 420 |
| Oakland 1SE | 6620 | 2420 |
| Owings Ferry Landing | 6770 | 120 |
| Princess Anne 1E | 7330 | 17 |
| Salisbury | 8000 | 10 |
| Westminster | 9435 | 770 |
| Woodstock | 9750 | 415 |
| MASSACHUSETTS | | |
| Adams | 0049 | 750 |
| Amherst | 0120 | 210 |
| East Wareham | 2451 | 20 |
| Hyannis 2NNE | 3821 | 35 |
| Lawrence | 4105 | 57 |
| Springfield | 8046 | 190 |
| Weston | 9360 | 224 |
| Worcester | 9928 | 628 |
| NEW HAMPSHIRE | | |
| Berlin | 0690 | 1110 |
| Durham | 2174 | 73 |
| Hanover | 3850 | 603 |
| Keene | 4399 | 490 |
| NEW JERSEY | | |
| Belvidere | 0729 | 289 |
| Boonton | 0907 | 280 |
| NEW JERSEY Continued | | |
| Charlotteburg | 1582 | 760 |
| Flemington 1NE | 3029 | 134 |
| Indian Mills | 4229 | 100 |
| Layton | 4735 | 480 |
| Long Branch | 4987 | 34 |
| Moorestown | 5728 | 55 |
| New Brunswick | 6062 | 80 |
| Pleasantville | 7131 | 8 |
| NEW YORK | | |
| Albany | 0047 | 19 |
| Alfred | 0085 | 1760 |
| Angelica | 0183 | 1420 |
| Auburn, water works | 0321 | 715 |
| Binghamton | 0691 | 858 |
| Bridgehampton | 0889 | 60 |
| Buffalo, airport | 1012 | 693 |
| Canton | 1185 | 406 |
| Carmel 1SW | 1207 | 500 |
| Dannemora | 1966 | 1338 |
| Delhi | 2036 | 1460 |
| Elmira | 2610 | 863 |
| Fredonia | 3033 | 750 |
| Geneva, Expt. Sta. | 3177 | 615 |
| Hemlock | 3773 | 920 |
| Ithaca, Cornell Univ. | 4174 | 950 |
| Jamestown | 4206 | 1390 |
| Little Falls, city res. | 4791 | 890 |
| Lockport | 4844 | 520 |
| Lowville | 4912 | 860 |
| Morrisville | 5512 | 1325 |
| New York, Central Park | 5801 | 132 |
| Norwich 1WNW | 6085 | 1070 |
| Ogdensburg 3NE | 6164 | 258 |
| Oswego | 6314 | 292 |
| Port Jervis | 6774 | 470 |
| Poughkeepsie | 6817 | 103 |
| Rochester, airport | 7167 | 543 |
| Roxbury | 7317 | 1494 |
| Salisbury | 7413 | 1300 |
| Setauket | 7633 | 40 |
| Syracuse | 8383 | 419 |
| Walden 2NE | 8902 | 400 |
| Wanakena | 8944 | 1510 |
| Watertown | 9000 | 497 |
| PENNSYLVANIA | | |
| Altoona | 0134 | 1500 |
| Bethlehem | 0634 | 436 |
| Brookville | 1002 | 1417 |
| Butler | 1130 | 1100 |
| Carlisle | 1234 | 460 |
| Claysville | 1512 | 1150 |
| Corry | 1790 | 1427 |
| Donora | 2190 | 814 |
| Ebensburg | 2466 | 2090 |
| Emporium 1E | 2633 | 1160 |
| Franklin | 3028 | 987 |
| PENNSYLVANIA Continued | | |
| Freeland | 3056 | 1900 |
| George School | 3200 | 135 |
| Gettysburg | 3218 | 540 |
| Greenville | 3526 | 1026 |
| Huntingdon | 4159 | 700 |
| Johnstown | 4385 | 1214 |
| Lancaster 2NE | 4758 | 255 |
| Lawrenceville 2S | 4873 | 1000 |
| Lock Haven | 5104 | 570 |
| Montrose | 5915 | 1630 |
| Mount Pocono | 6055 | 1915 |
| New Castle 1N | 6233 | 825 |
| Newell | 6246 | 805 |
| Palmerton | 6689 | 435 |
| Philadelphia-Shawmont | 6904 | 38 |
| Ridgway | 7477 | 1371 |
| Selinsgrove | 7931 | 437 |
| Somerset | 8249 | 2150 |
| State College | 8449 | 1175 |
| Stroudsburg | 8596 | 440 |
| Towanda | 8905 | 760 |
| Uniontown | 9050 | 1040 |
| Warren | 9298 | 1280 |
| Wellsboro | 9408 | 1920 |
| York 3SSW | 9933 | 390 |
| RHODE ISLAND | | |
| Kingston | 4266 | 100 |
| VERMONT | | |
| Burlington | 1081 | 331 |
| Cornwall | 1580 | 500 |
| Newport | 5542 | 766 |
| Northfield | 5733 | 840 |
| St. Johnsbury | 7054 | 699 |
| WEST VIRGINIA | | |
| Bayard | 0527 | 2375 |
| Charleston | 1575 | 600 |
| Clarksburg | 1677 | 977 |
| Elkins | 2718 | 1970 |
| Fairmont | 2920 | 1298 |
| Flat Top | 3072 | 3225 |
| Gary | 3353 | 1426 |
| Glenville | 3544 | 740 |
| Huntington | 4378 | 675 |
| Mannington 1N | 5621 | 974 |
| Martinsburg | 5707 | 537 |
| Parkersburg | 6859 | 615 |
| Piedmont | 7004 | 1053 |
| Point Pleasant | 7105 | 569 |
| Rainelle-McRoss | 7306 | 2424 |
| Spencer | 8384 | 789 |
| Wardensville | 9281 | 1200 |
| Wheeling, Warwood Dam | 9492 | 659 |
| White Sulphur Springs | 9522 | 1914 |
| Williamson | 9605 | 673 |

TABLE 5

| A | | | B | | | C | | |
|---|---|---|---|---|---|---|---|---|
| | Row | | | Row | | | Row | |
| | 1 | 156 | | 1 | 156 | | 1 | 156 |
| $\phi_1$=142 | 2 | 14 | $\phi_1$=329 | 2 | −173 | 50% | 2 | 87.1 |
| | 3 | 0.971 | | 3 | −0.986 | | 3 | 0.61 |
| $\phi_2$= 31 | 4 | 125 | $\phi_2$= | 4 | | | 4 | 4.1 |
| | 5 | 250 | | 5 | | | 5 | 6.7 |
| | 6 | −0.398 | | 6 | | | 6 | |
| $\phi_3$= | 7 | | $A_1$= 0.13 | 7 | −0.13 | | 7 | |
| | 8 | | $A_2$= | 8 | | | 8 | |
| | 9 | | $a_0$= 0.74 | 9 | 0.61 | 5% | 9 | 80.4 |
| $A_1$= 21.5 | 10 | 20.9 | | | | 10% | 10 | |
| $A_2$= 1.4 | 11 | −0.6 | | | | 20% | 11 | |
| $A_3$= | 12 | | | | | 25% | 12 | |
| $a_0$= 66.8 | 13 | 87.1 | | | | 75% | 13 | |
| | | | | | | 80% | 14 | |
| | | | | | | 90% | 15 | |
| | | | | | | 95% | 16 | 93.8 |

*Table 5.* Replicas of Workforms A, B, and C showing calculation of the 5 and 95 percentiles of the distribution of the average diurnal maximum temperature at Washington, D. C., for the week of August 1 through 7 (Example 1).

TABLE 6

| A | | | B | | | C | | |
|---|---|---|---|---|---|---|---|---|
| | Row | | | Row | | | Row | |
| | 1 | 309 | | 1 | 309 | | 1 | 309 |
| $\phi_1$=147 | 2 | 162 | $\phi_1$=309 | 2 | 0 | 50% | 2 | 12.3 |
| | 3 | −0.938 | | 3 | 1.000 | | 3 | 0.84 |
| $\phi_2$= 45 | 4 | 264 | $\phi_2$= | 4 | | | 4 | 6.9 |
| | 5 | 528 | | 5 | | | 5 | |
| | 6 | −0.943 | | 6 | | | 6 | |
| $\phi_3$= 23 | 7 | 286 | $A_1$= 0.17 | 7 | 0.17 | | 7 | 5.8 |
| | 8 | 858 | $A_2$= | 8 | | | 8 | |
| | 9 | −0.591 | $a_0$= 0.67 | 9 | 0.84 | 5% | 9 | |
| $A_1$= 22.8 | 10 | −21.4 | | | | 10% | 10 | |
| $A_2$= 1.0 | 11 | − 0.9 | | | | 20% | 11 | 6.5 |
| $A_3$= 1.5 | 12 | − 0.9 | | | | 25% | 12 | |
| $a_0$= 35.5 | 13 | 12.3 | | | | 75% | 13 | |
| | | | | | | 80% | 14 | 18.1 |
| | | | | | | 90% | 15 | |
| | | | | | | 95% | 16 | |

*Table 6.* Replicas of Workforms A, B, and C showing calculation of the 20 and 80 percentiles of the distribution of the average diurnal minimum temperature at Bangor, Maine, for the week of January 1 through 7 (Example 3).

instead of the 25 and 75 percentiles. Such a graph can easily be constructed using the methods of this bulletin. It is sufficient to compute expected values and log standard deviations for only 12 equally spaced times using Workforms A, B, and C and employing graphical interpolation for the intervening times. The expected value is given by row 2 of C while the quartiles are obtained from rows 12 and 13 of C. Such a graph for the maximum temperature at Harrisburg, Pennsylvania, is shown in Figure 4.

*Example 7:* Another use for the maps in this bulletin is the determination of "homoclimes" for crops. Since the coefficients of the curves for expected values and log standard deviations characterize an important aspect of the temperature climate, they can be used to compare different locations in respect to suitability for crops. If a given plant is known to thrive at one location, the parameters for a proposed location can be compared with those at the established location. If they are similar, this indicates that the temperature climates are also similar. This was proposed by J. A. Prescott (1943) using a curve fit to mean temperatures. Clearly, however, information about the variance should increase the value of this method for it indicates how variable the climate is.

TABLE 7

| $A_{max}$ | | | $A_{min}$ | | | B | | | C | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Row | | | Row | | | Row | | | Row | |
| | 1 | 43 | | 1 | 43 | | 1 | 43 | | 1 | 43 |
| $\phi_1$=144 | 2 | −101 | $\phi_1$=146 | 2 | −103 | $\phi_1$= 0 | 2 | 43 | 50% | 2 | 19.3 |
| | 3 | −0.167 | | 3 | −0.200 | | 3 | 0.738 | | 3 | 0.62 |
| $\phi_2$= 46 | 4 | −3 | $\phi_2$= 63 | 4 | −20 | $\phi_2$=41 | 4 | 2 | | 4 | 4.2 |
| | 5 | −6 | | 5 | −40 | | 5 | 4 | | 5 | 6.9 |
| | 6 | 0.994 | | 6 | 0.772 | | 6 | 0.997 | | 6 | 5.4 |
| $\phi_3$= | 7 | | $\phi_3$= 30 | 7 | 13 | $A_1$= 0.03 | 7 | 0.02 | | 7 | 3.5 |
| | 8 | | | 8 | 39 | $A_2$= 0.05 | 8 | 0.05 | | 8 | 2.8 |
| | 9 | | | 9 | 0.782 | $a_0$= 0.55 | 9 | 0.62 | 5% | 9 | 12.4 |
| $A_1$= 26.8 | 10 | −4.5 | $A_1$= 23.1 | 10 | −4.6 | | | | 10% | 10 | 13.9 |
| $A_2$= 1.1 | 11 | 1.1 | $A_2$= 1.0 | 11 | 0.8 | | | | 20% | 11 | 15.8 |
| $A_3$= | 12 | | $A_3$= 1.0 | 12 | 0.8 | | | | 25% | 12 | 16.5 |
| $a_0$= 55.5 | 13 | 52.1 | $a_0$= 35.8 | 13 | 32.8 | | | | 75% | 13 | 22.1 |
| | | | | | | | | | 80% | 14 | 22.8 |
| | | | | | | | | | 90% | 15 | 24.7 |
| | | | | | | | | | 95% | 16 | 26.2 |

*Table 7.* Two replicas of Workform A and replicas of Workforms B and C showing calculation of 5, 10, 20, 25, 50, 75, 80, 90, and 95 percentiles of the average diurnal temperature range at Utica, New York, for the week of April 10 through 16.

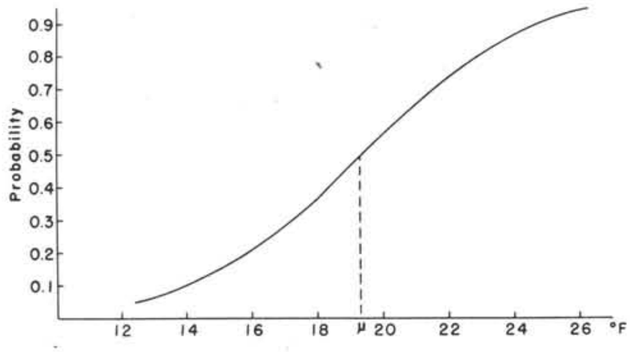


*Figure 3.* The cumulative probability distribution of the average diurnal range at Utica, New York, for the week of April 10 through 16.


## ACKNOWLEDGEMENTS

This bulletin would not have been possible without the full cooperation of the members of the NE 35 Technical Committee on Agricultural Climatology. I am especially grateful to those of the Committee who skillfully and efficiently handled the machine computations on which this bulletin is based. Finally, my thanks are due to Jane Belcher for her long hours spent to make the maps and figures as nearly perfect as possible.


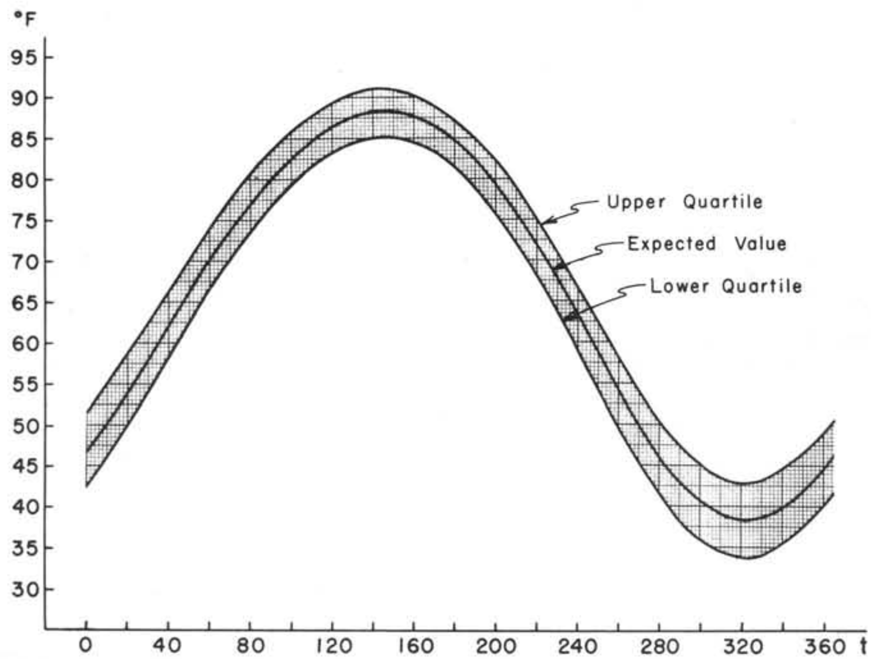


*Figure 4.* The expected value and upper and lower quartiles of the average maximum temperature at Harrisburg, Pennsylvania, through the year.

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WORKFORM A: Expected value

| | | | | |
|---|---|---|---|---|
| | 1 | t | | |
| $\phi_1=$ .......... | 2 | $t_1'=t-\phi_1$ | | |
| | 3 | cos $t_1'$ | | |
| $\phi_2=$ .......... | 4 | $t-\phi_2$ | | |
| | 5 | $t_2'=2(t-\phi_2)$ | | |
| | 6 | cos $t_2'$ | | |
| $\phi_3=$ .......... | 7 | $t-\phi_3$ | | |
| | 8 | $t_3'=3(t-\phi_3)$ | | |
| | 9 | cos $t_3'$ | | |
| $A_1=$ .......... | 10 | $A_1$ cos $t_1'$ | | |
| $A_2=$ .......... | 11 | $A_2$ cos $t_2'$ | | |
| $A_3=$ .......... | 12 | $A_3$ cos $t_3'$ | | |
| $a_0=$ .......... | 13 | $a_0+10+11+12$ | | |

WORKFORM A: Expected value

| | | | | |
|---|---|---|---|---|
| | 1 | t | | |
| $\phi_1=$ .......... | 2 | $t_1'=t-\phi_1$ | | |
| | 3 | cos $t_1'$ | | |
| $\phi_2=$ .......... | 4 | $t-\phi_2$ | | |
| | 5 | $t_2'=2(t-\phi_2)$ | | |
| | 6 | cos $t_2'$ | | |
| $\phi_3=$ .......... | 7 | $t-\phi_3$ | | |
| | 8 | $t_3'=3(t-\phi_3)$ | | |
| | 9 | cos $t_3'$ | | |
| $A_1=$ .......... | 10 | $A_1$ cos $t_1'$ | | |
| $A_2=$ .......... | 11 | $A_2$ cos $t_2'$ | | |
| $A_3=$ .......... | 12 | $A_3$ cos $t_3'$ | | |
| $a_0=$ .......... | 13 | $a_0+10+11+12$ | | |

WORKFORM B: Log standard deviation

| | | | | |
|---|---|---|---|---|
| | 1 | t | | |
| $\phi_1=$ .......... | 2 | $t_1'=t-\phi_1$ | | |
| | 3 | cos $t_1'$ | | |
| $\phi_2=$ .......... | 4 | $t-\phi_2$ | | |
| | 5 | $t_2'=2(t-\phi_2)$ | | |
| | 6 | cos $t_2'$ | | |
| $A_1=$ .......... | 7 | $A_1$ cos $t_1'$ | | |
| $A_2=$ .......... | 8 | $A_2$ cos $t_2'$ | | |
| $a_0=$ .......... | 9 | $a_0+7+8$ | | |

WORKFORM B: Log standard deviation

| | | | | |
|---|---|---|---|---|
| | 1 | t | | |
| $\phi_1=$ .......... | 2 | $t_1'=t-\phi_1$ | | |
| | 3 | cos $t_1'$ | | |
| $\phi_2=$ .......... | 4 | $t-\phi_2$ | | |
| | 5 | $t_2'=2(t-\phi_2)$ | | |
| | 6 | cos $t_2'$ | | |
| $A_1=$ .......... | 7 | $A_1$ cos $t_1'$ | | |
| $A_2=$ .......... | 8 | $A_2$ cos $t_2'$ | | |
| $a_0=$ .......... | 9 | $a_0+7+8$ | | |

WORKFORM C: Probability levels

| | | | | |
|---|---|---|---|---|
| | 1 | t | | |
| 50% | 2 | $\mu=$ mean value | | |
| | 3 | log $\sigma$ | | |
| | 4 | $\sigma=$ stand. dev. | | |
| | 5 | 1.64 $\sigma$ | | |
| | 6 | 1.28 $\sigma$ | | |
| | 7 | 0.84 $\sigma$ | | |
| | 8 | 0.67 $\sigma$ | | |
| 5% | 9 | (2) – (5) | | |
| 10% | 10 | (2) – (6) | | |
| 20% | 11 | (2) – (7) | | |
| 25% | 12 | (2) – (8) | | |
| 75% | 13 | (2) + (8) | | |
| 80% | 14 | (2) + (7) | | |
| 90% | 15 | (2) + (6) | | |
| 95% | 16 | (2) + (5) | | |

WORKFORM C: Probability levels

| | | | | |
|---|---|---|---|---|
| | 1 | t | | |
| 50% | 2 | $\mu=$ mean value | | |
| | 3 | log $\sigma$ | | |
| | 4 | $\sigma=$ stand. dev. | | |
| | 5 | 1.64 $\sigma$ | | |
| | 6 | 1.28 $\sigma$ | | |
| | 7 | 0.84 $\sigma$ | | |
| | 8 | 0.67 $\sigma$ | | |
| 5% | 9 | (2) – (5) | | |
| 10% | 10 | (2) – (6) | | |
| 20% | 11 | (2) – (7) | | |
| 25% | 12 | (2) – (8) | | |
| 75% | 13 | (2) + (8) | | |
| 80% | 14 | (2) + (7) | | |
| 90% | 15 | (2) + (6) | | |
| 95% | 16 | (2) + (5) | | |

WORKFORM A: Expected value

| | | | | |
|---|---|---|---|---|
| | 1 | t | | |
| $\phi_1=$ .......... | 2 | $t_1'=t-\phi_1$ | | |
| | 3 | $\cos t_1'$ | | |
| $\phi_2=$ .......... | 4 | $t-\phi_2$ | | |
| | 5 | $t_2'=2(t-\phi_2)$ | | |
| | 6 | $\cos t_2'$ | | |
| $\phi_3=$ .......... | 7 | $t-\phi_3$ | | |
| | 8 | $t_3'=3(t-\phi_3)$ | | |
| | 9 | $\cos t_3'$ | | |
| $A_1=$ .......... | 10 | $A_1 \cos t_1'$ | | |
| $A_2=$ .......... | 11 | $A_2 \cos t_2'$ | | |
| $A_3=$ .......... | 12 | $A_3 \cos t_3'$ | | |
| $a_0=$ .......... | 13 | $a_0+10+11+12$ | | |

WORKFORM A: Expected value

| | | | | |
|---|---|---|---|---|
| | 1 | t | | |
| $\phi_1=$ .......... | 2 | $t_1'=t-\phi_1$ | | |
| | 3 | $\cos t_1'$ | | |
| $\phi_2=$ .......... | 4 | $t-\phi_2$ | | |
| | 5 | $t_2'=2(t-\phi_2)$ | | |
| | 6 | $\cos t_2'$ | | |
| $\phi_3=$ .......... | 7 | $t-\phi_3$ | | |
| | 8 | $t_3'=3(t-\phi_3)$ | | |
| | 9 | $\cos t_3'$ | | |
| $A_1=$ .......... | 10 | $A_1 \cos t_1'$ | | |
| $A_2=$ .......... | 11 | $A_2 \cos t_2'$ | | |
| $A_3=$ .......... | 12 | $A_3 \cos t_3'$ | | |
| $a_0=$ .......... | 13 | $a_0+10+11+12$ | | |

WORKFORM B: Log standard deviation

| | | | | |
|---|---|---|---|---|
| | 1 | t | | |
| $\phi_1=$ .......... | 2 | $t_1'=t-\phi_1$ | | |
| | 3 | $\cos t_1'$ | | |
| $\phi_2=$ .......... | 4 | $t-\phi_2$ | | |
| | 5 | $t_2'=2(t-\phi_2)$ | | |
| | 6 | $\cos t_2'$ | | |
| $A_1=$ .......... | 7 | $A_1 \cos t_1'$ | | |
| $A_2=$ .......... | 8 | $A_2 \cos t_2'$ | | |
| $a_0=$ .......... | 9 | $a_0+7+8$ | | |

WORKFORM B: Log standard deviation

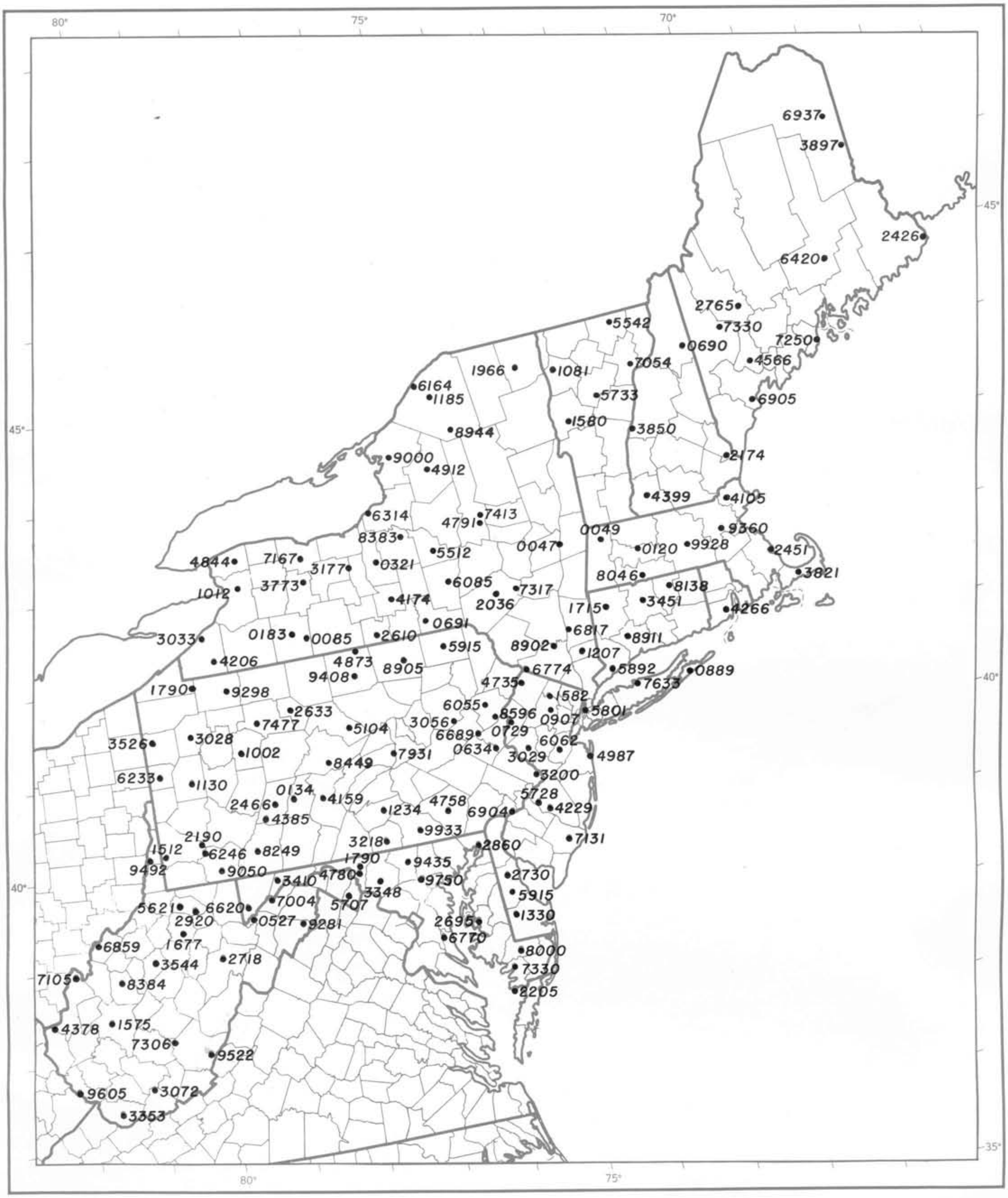
| | | | | |
|---|---|---|---|---|
| | 1 | t | | |
| $\phi_1=$ .......... | 2 | $t_1'=t-\phi_1$ | | |
| | 3 | $\cos t_1'$ | | |
| $\phi_2=$ .......... | 4 | $t-\phi_2$ | | |
| | 5 | $t_2'=2(t-\phi_2)$ | | |
| | 6 | $\cos t_2'$ | | |
| $A_1=$ .......... | 7 | $A_1 \cos t_1'$ | | |
| $A_2=$ .......... | 8 | $A_2 \cos t_2'$ | | |
| $a_0=$ .......... | 9 | $a_0+7+8$ | | |

WORKFORM C: Probability levels

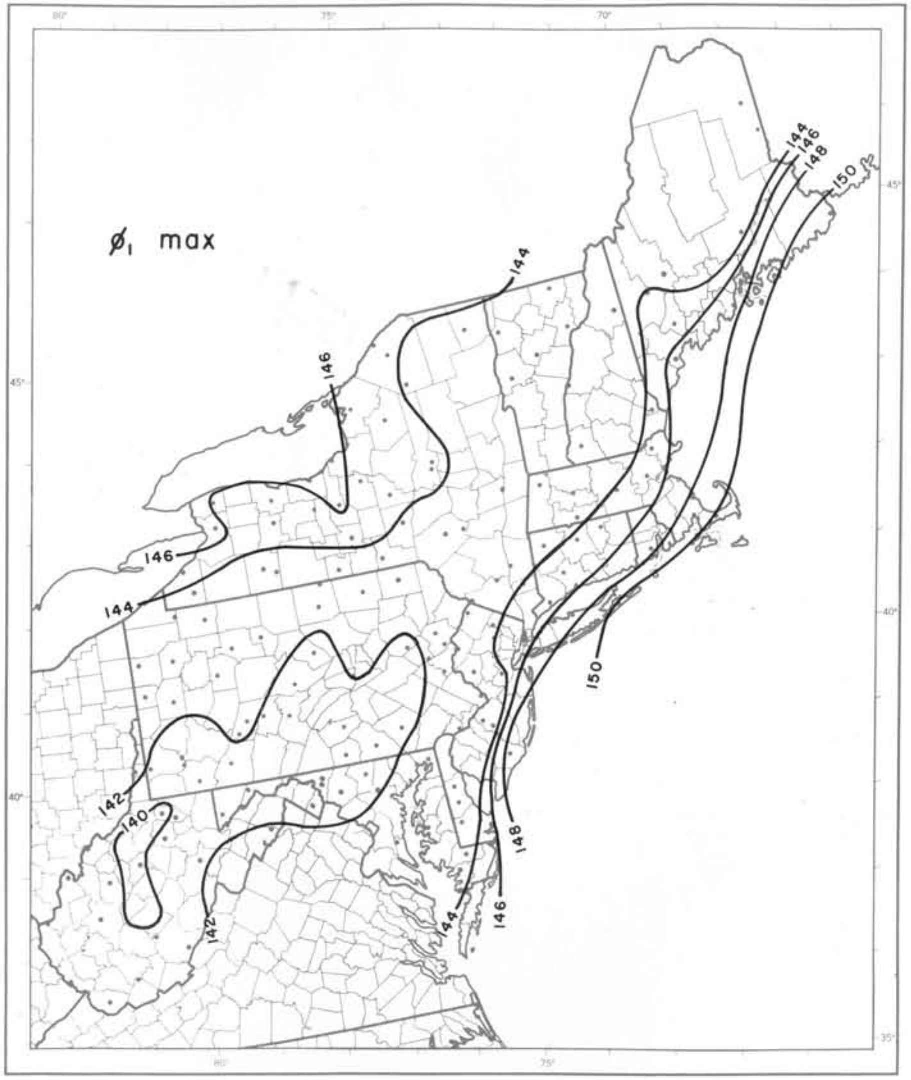
| | | | | |
|---|---|---|---|---|
| | 1 | t | | |
| 50% | 2 | $\mu=$ mean value | | |
| | 3 | $\log \sigma$ | | |
| | 4 | $\sigma=$ stand. dev. | | |
| | 5 | $1.64\ \sigma$ | | |
| | 6 | $1.28\ \sigma$ | | |
| | 7 | $0.84\ \sigma$ | | |
| | 8 | $0.67\ \sigma$ | | |
| 5% | 9 | (2) – (5) | | |
| 10% | 10 | (2) – (6) | | |
| 20% | 11 | (2) – (7) | | |
| 25% | 12 | (2) – (8) | | |
| 75% | 13 | (2) + (8) | | |
| 80% | 14 | (2) + (7) | | |
| 90% | 15 | (2) + (6) | | |
| 95% | 16 | (2) + (5) | | |

WORKFORM C: Probability levels

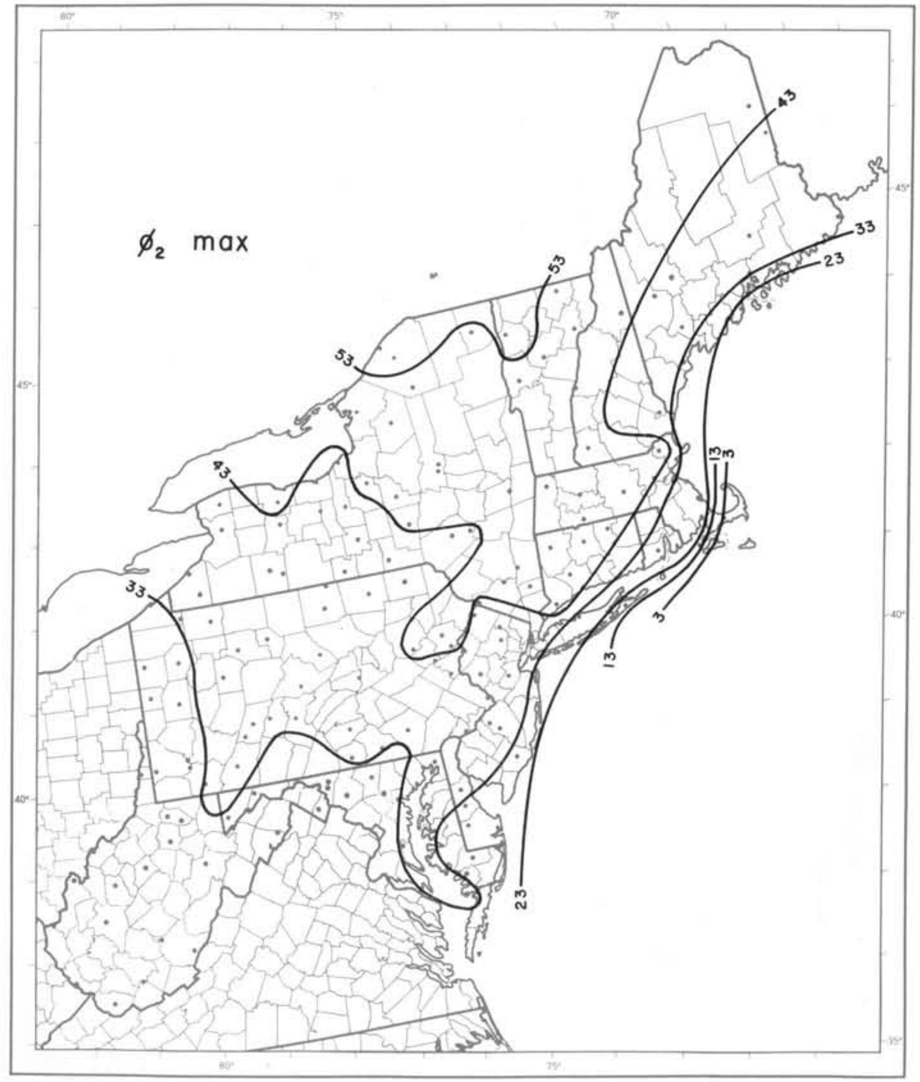
| | | | | |
|---|---|---|---|---|
| | 1 | t | | |
| 50% | 2 | $\mu=$ mean value | | |
| | 3 | $\log \sigma$ | | |
| | 4 | $\sigma=$ stand. dev. | | |
| | 5 | $1.64\ \sigma$ | | |
| | 6 | $1.28\ \sigma$ | | |
| | 7 | $0.84\ \sigma$ | | |
| | 8 | $0.67\ \sigma$ | | |
| 5% | 9 | (2) – (5) | | |
| 10% | 10 | (2) – (6) | | |
| 20% | 11 | (2) – (7) | | |
| 25% | 12 | (2) – (8) | | |
| 75% | 13 | (2) + (8) | | |
| 80% | 14 | (2) + (7) | | |
| 90% | 15 | (2) + (6) | | |
| 95% | 16 | (2) + (5) | | |



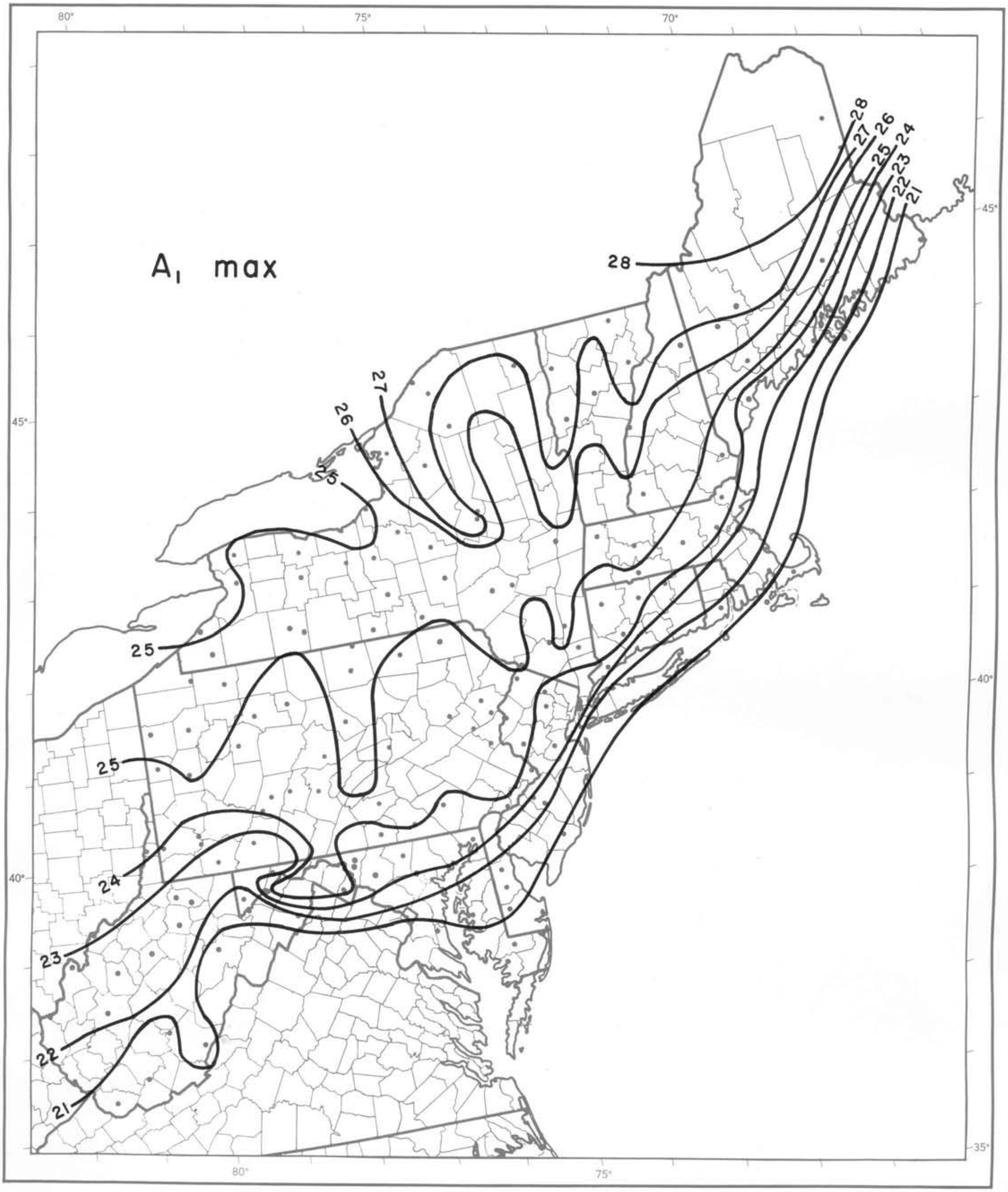

*Map 1.* Station locator map.



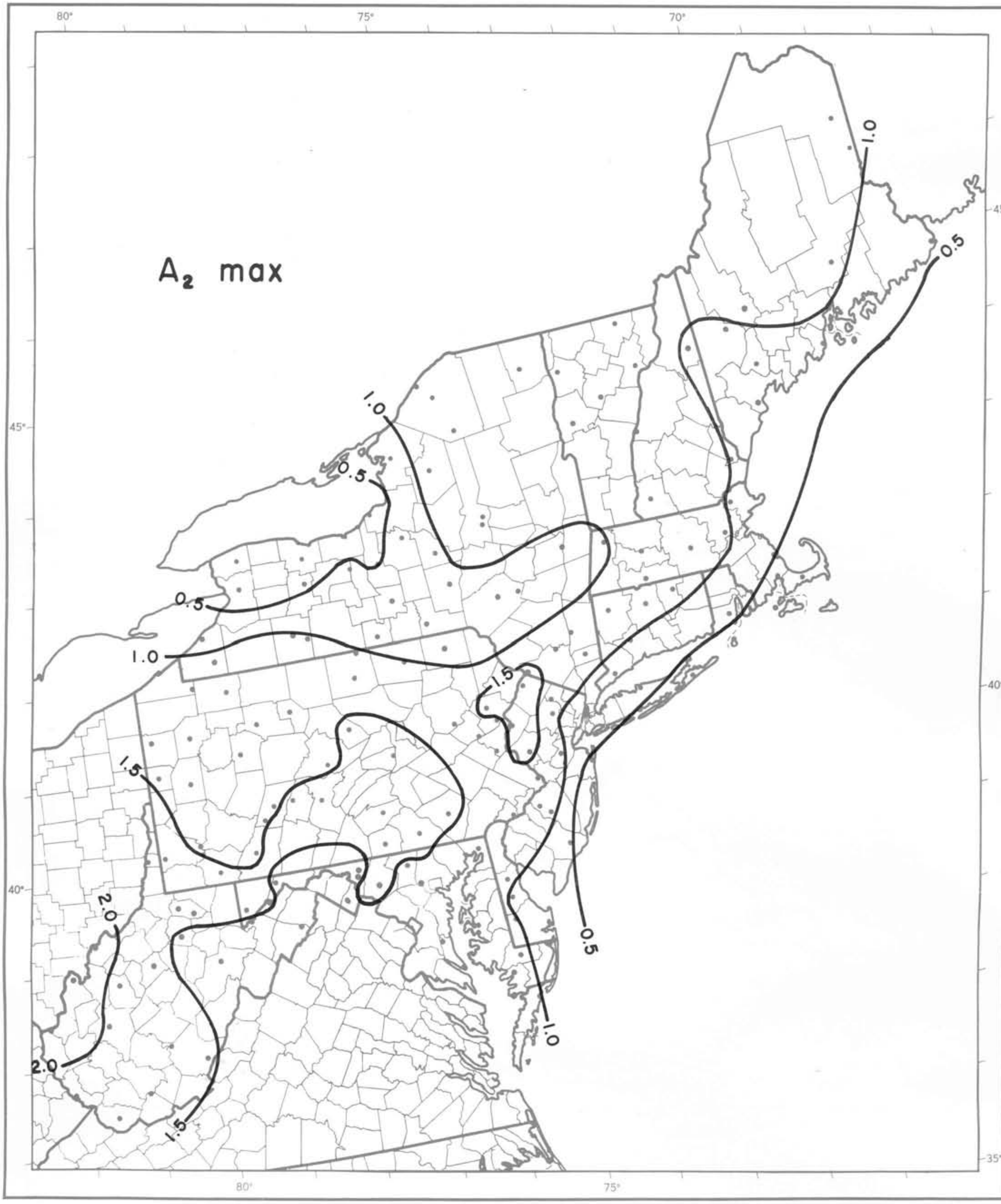

*Map 2.* $\phi_1$ for the diurnal maximum temperature. In days after March 1.



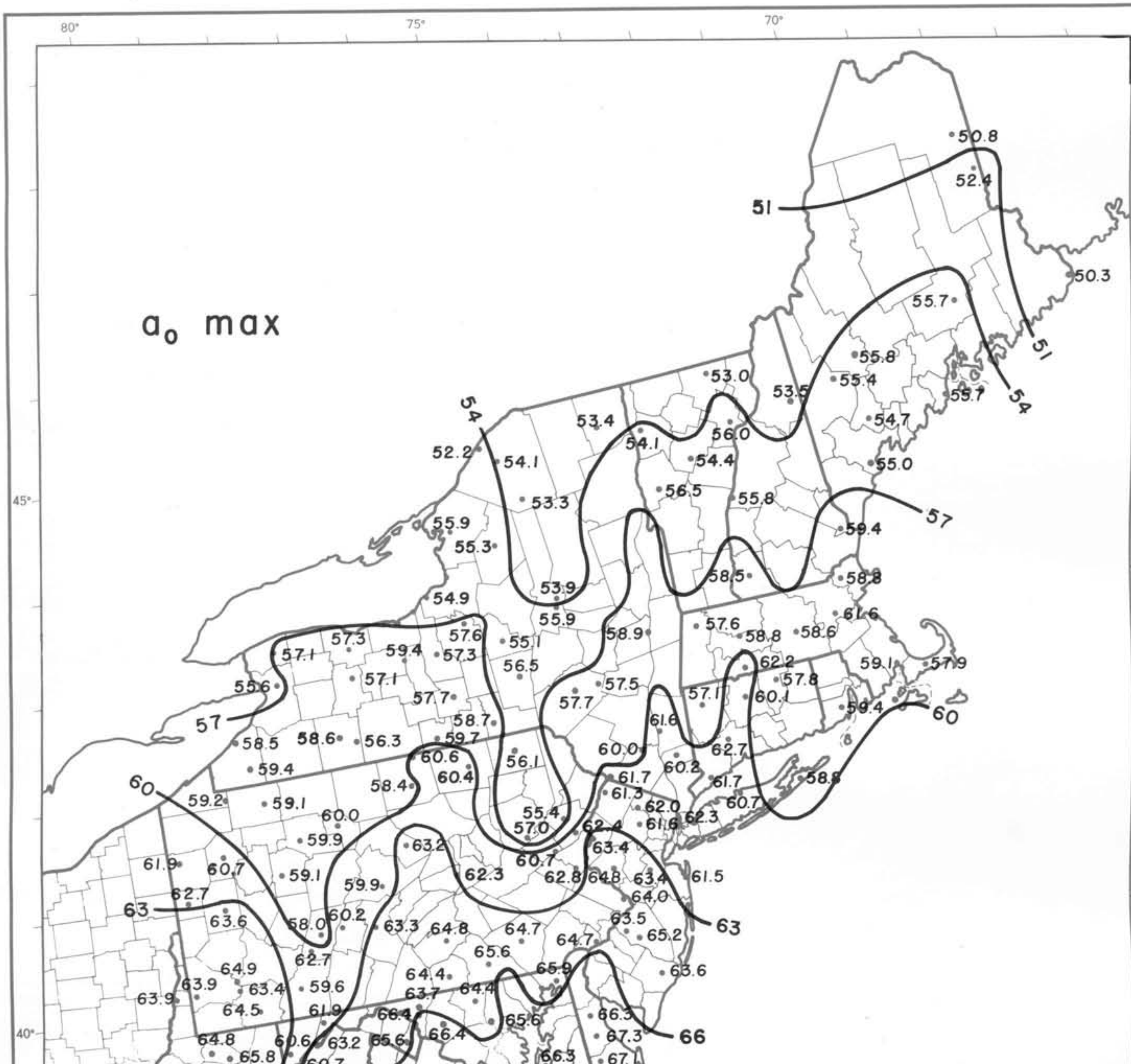

*Map 3.* $\phi_2$ for the diurnal maximum temperature. In days after March 1.



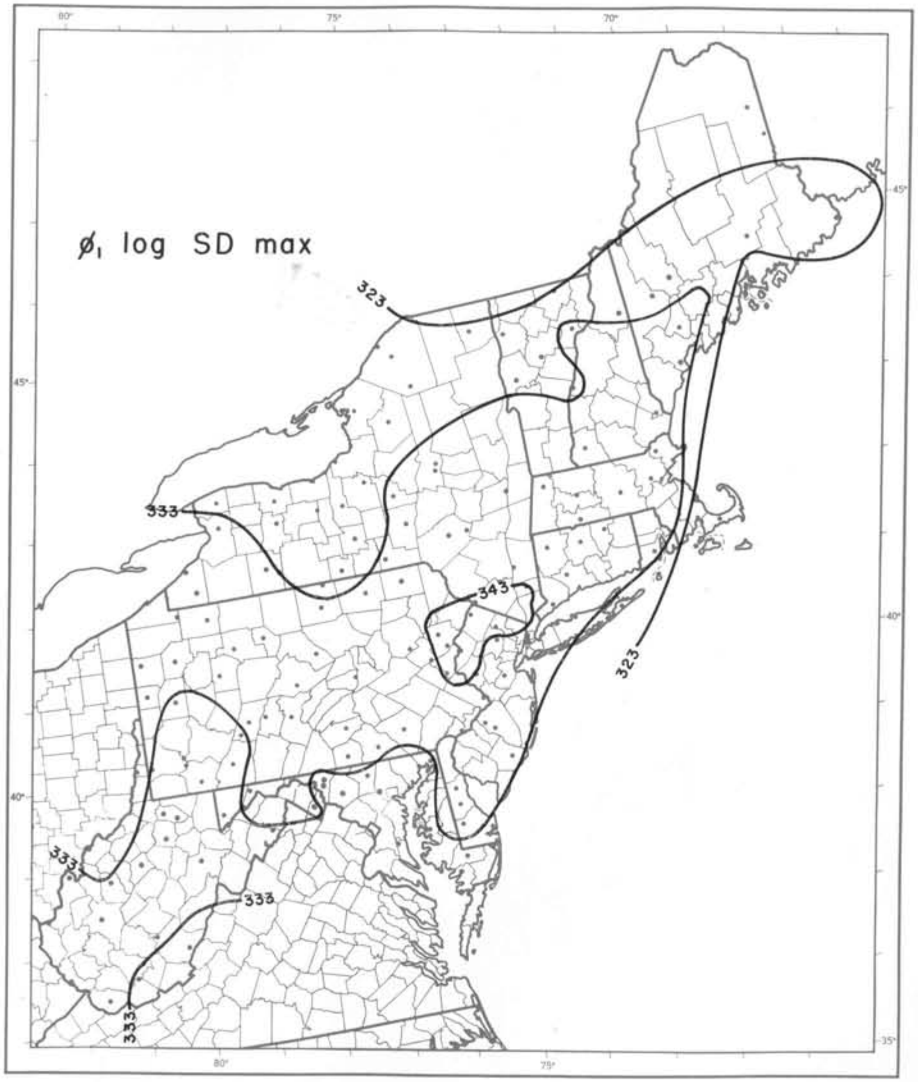

*Map 4.* $A_1$ for the diurnal maximum temperature, in °F.



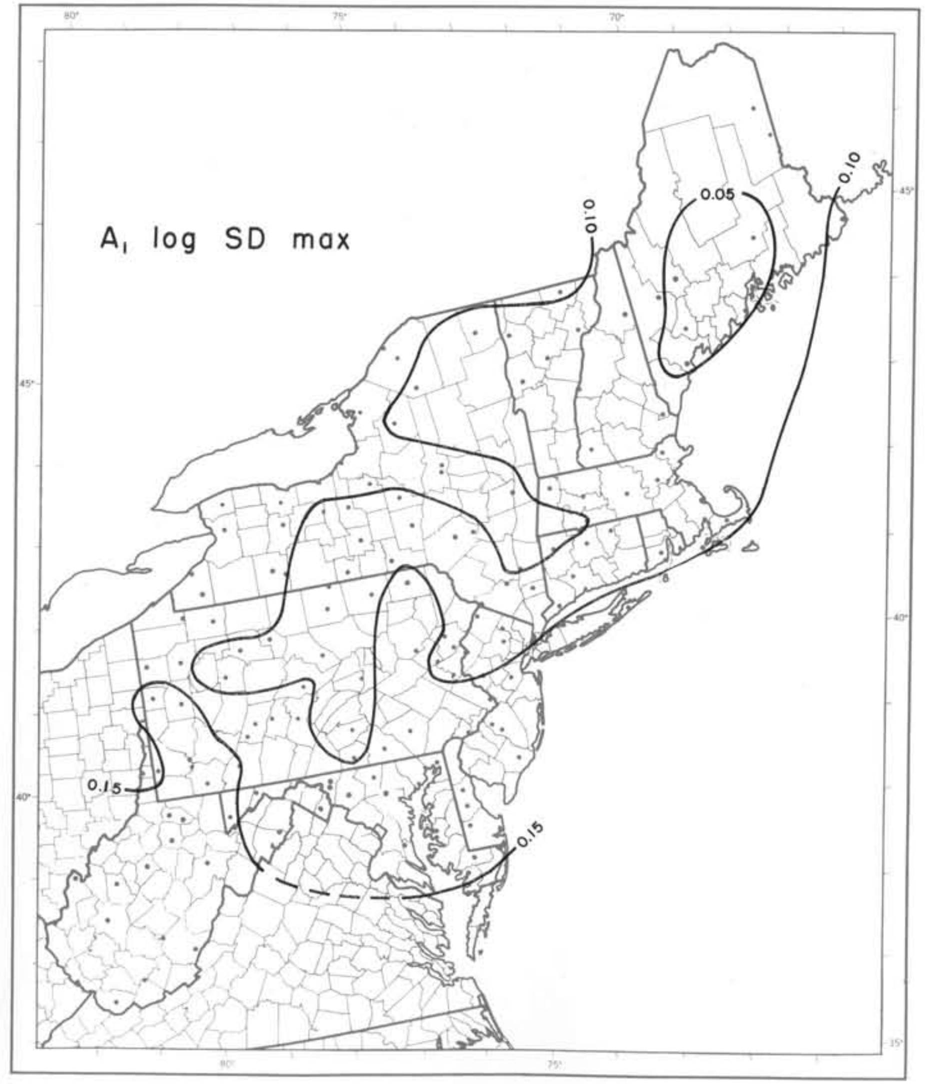

*Map 5.* A₂ for the diurnal maximum temperature, in °F.



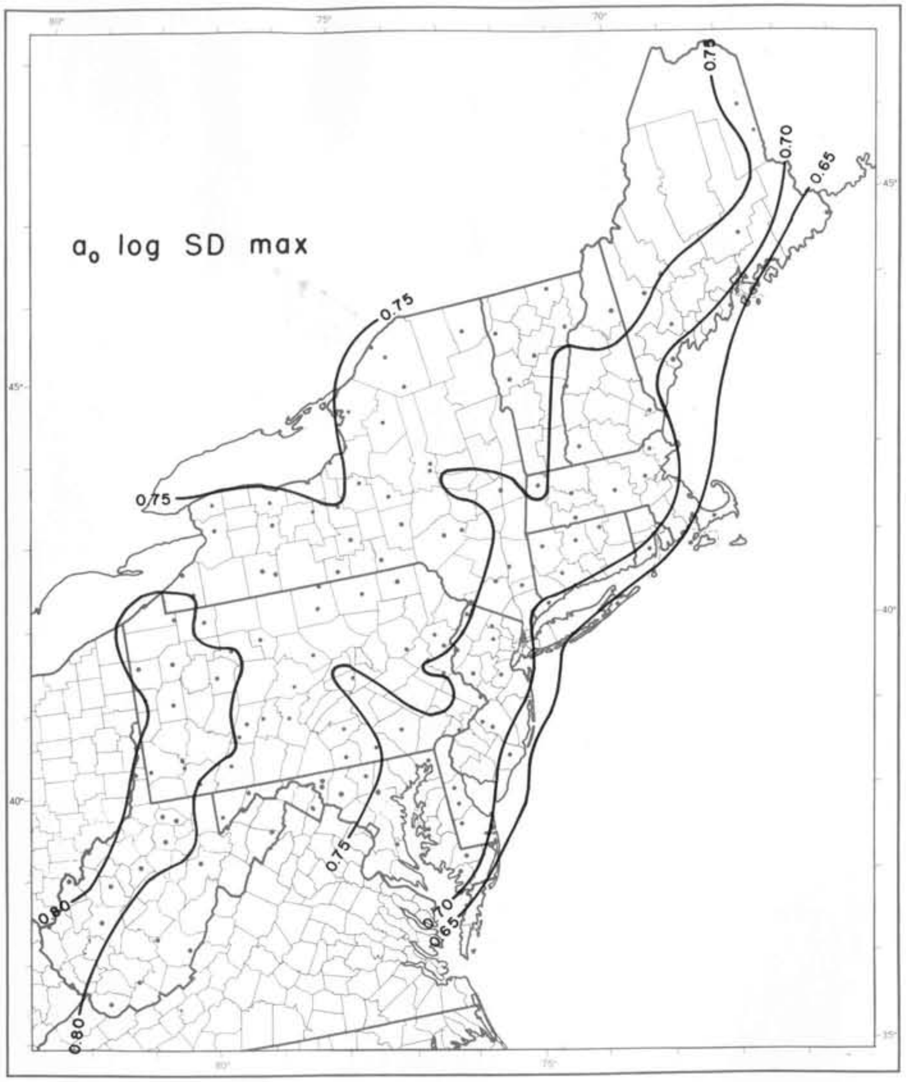

*Map 6.* $a_0$ for the diurnal maximum temperature, in °F.



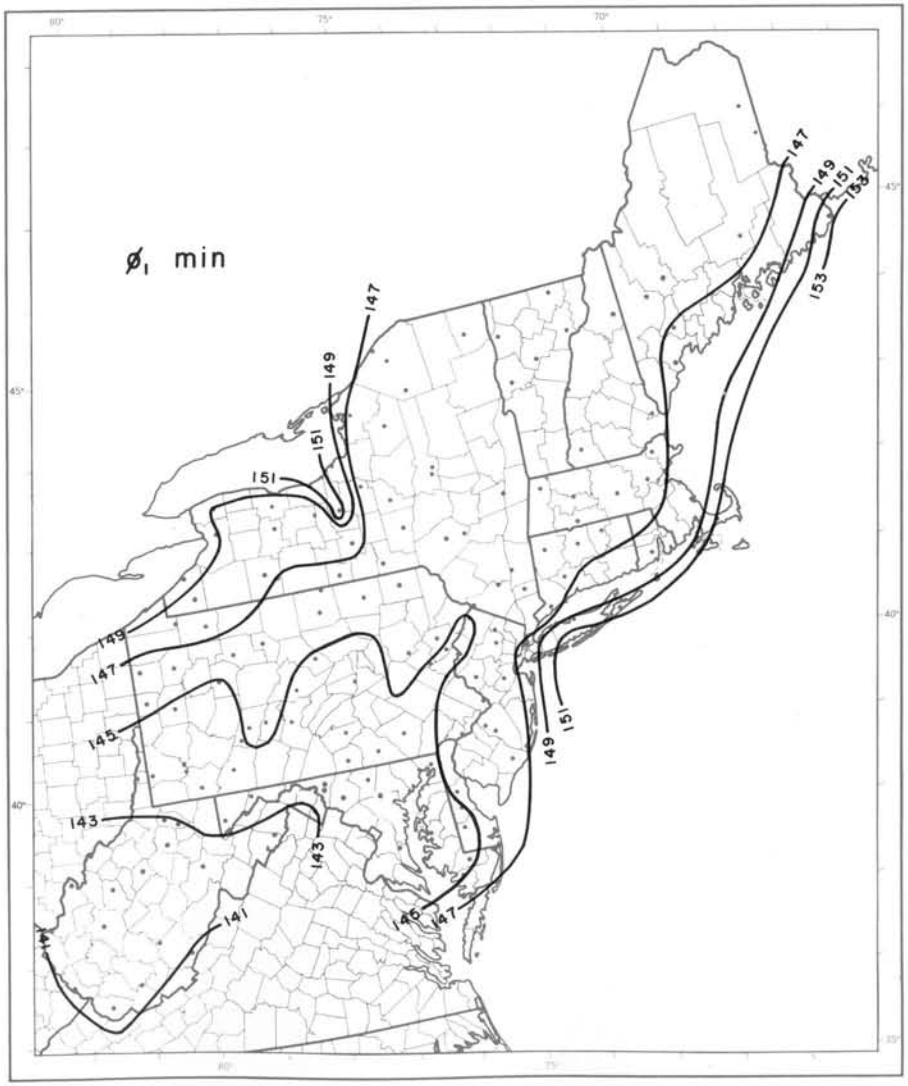

*Map 7.* $\phi_1$ for the log standard deviation of diurnal maximum temperature. In days after March 1.



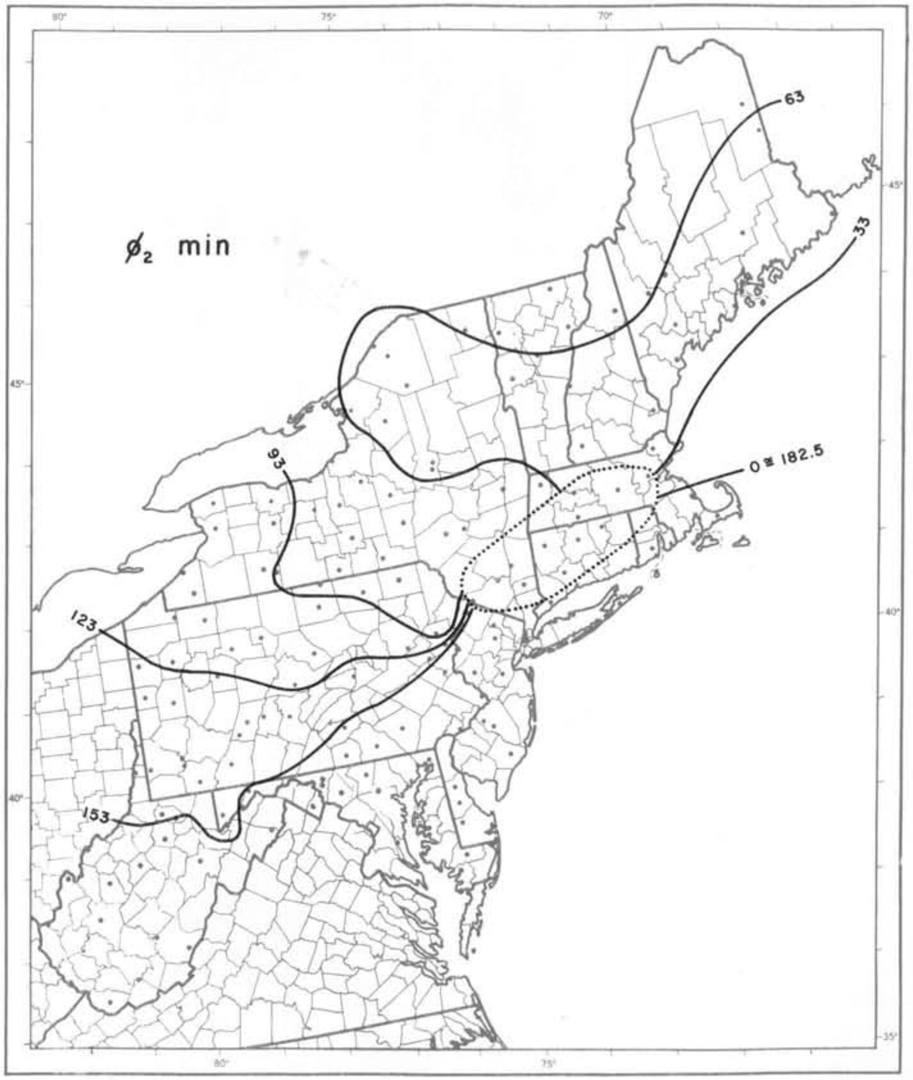

*Map 8.* $A_1$ for the log standard deviation of diurnal maximum temperature, in log (°F).



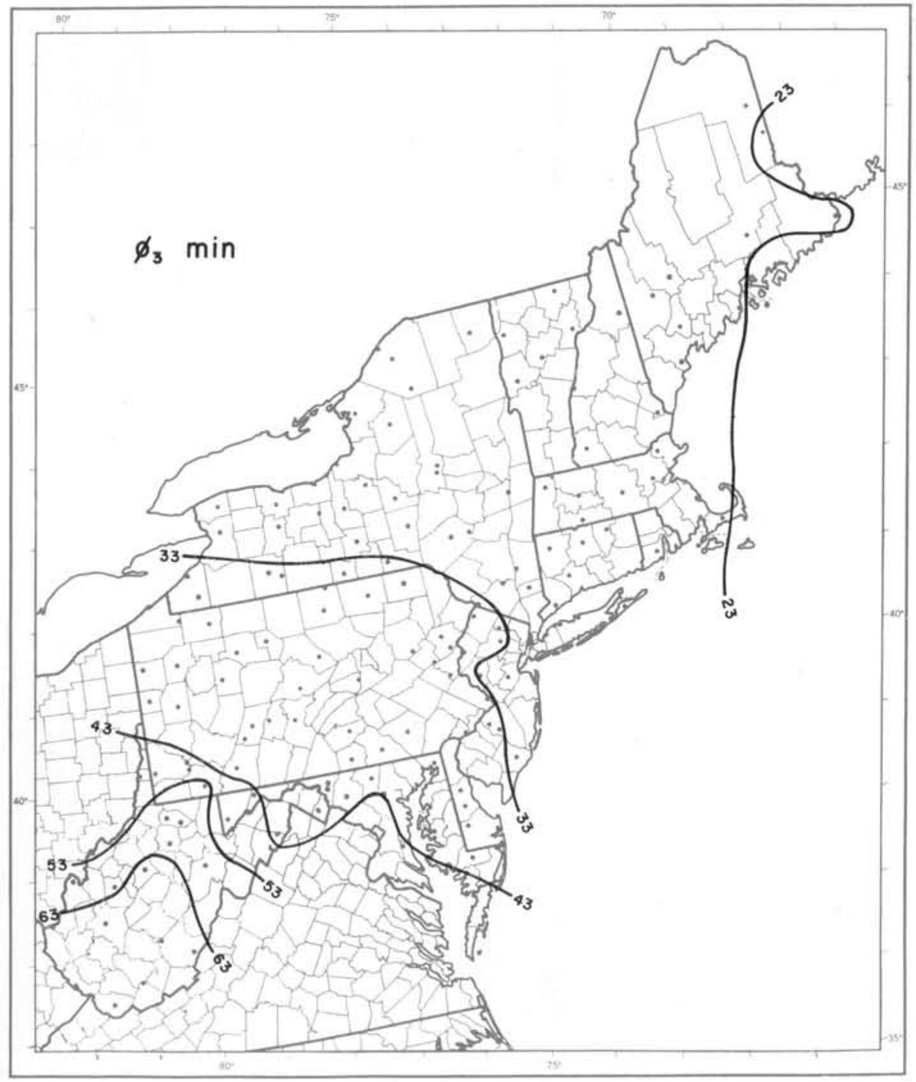

*Map 9.* $a_0$ for the log standard deviation of diurnal maximum temperature, in log (°F).



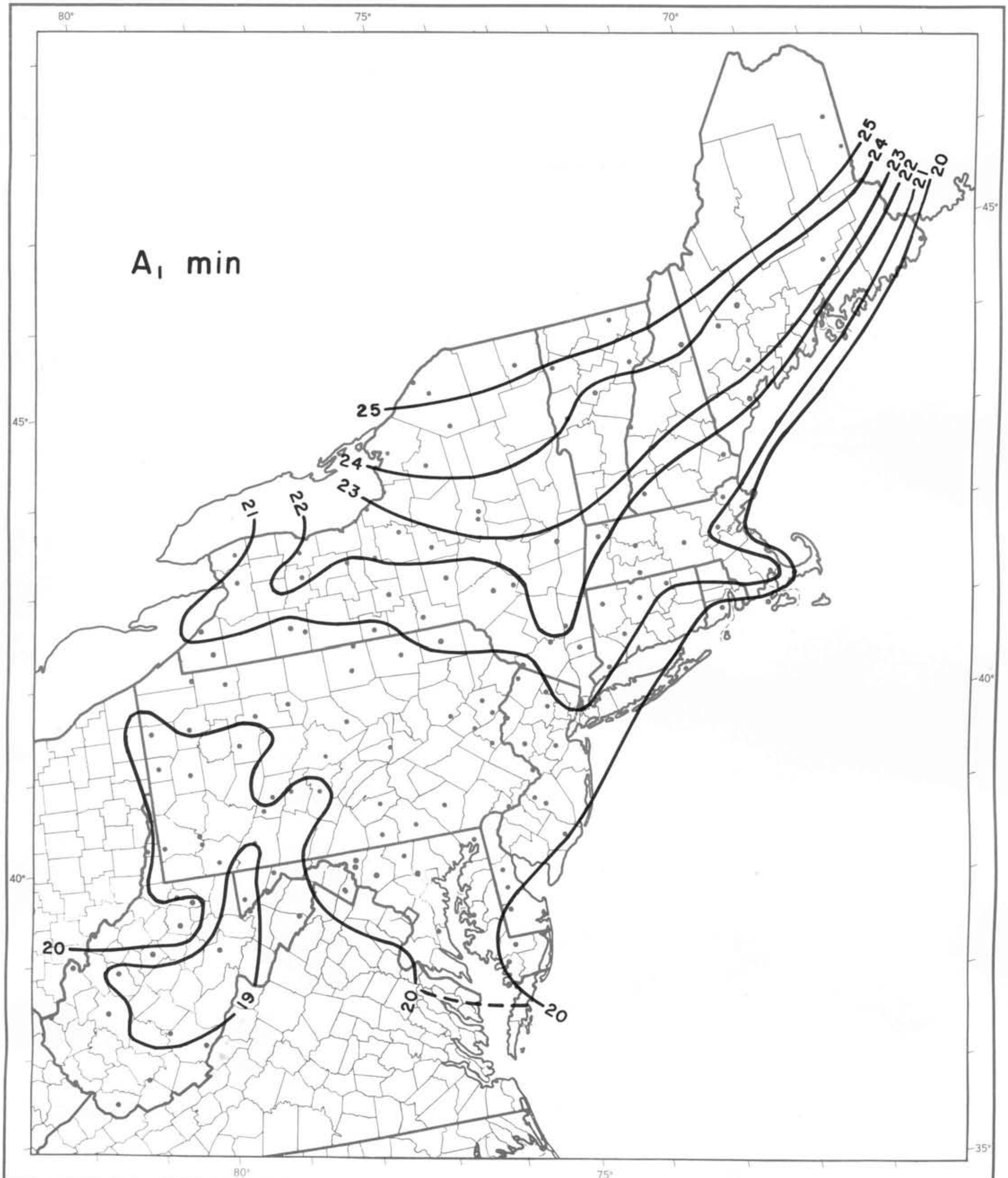

*Map 10.* $\phi_1$ for the diurnal minimum temperature. In days after March 1.



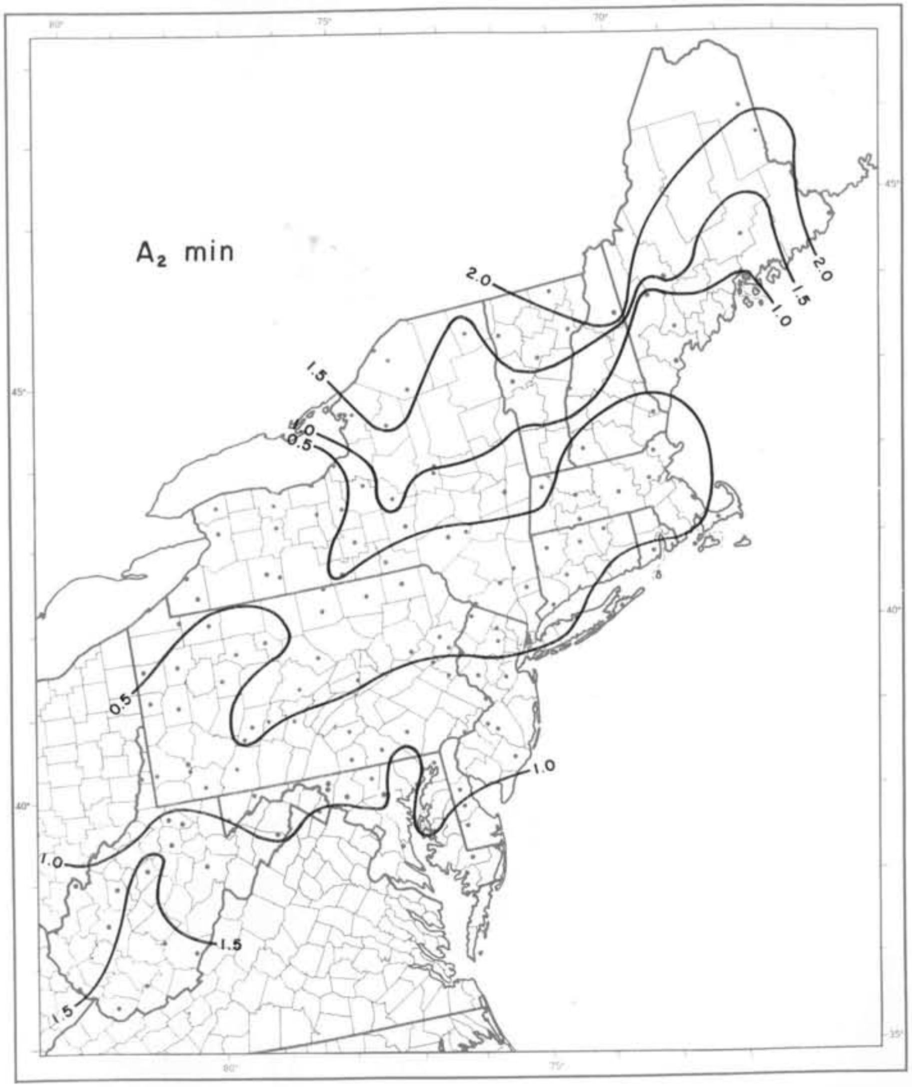

*Map 11.* $\phi_2$ for the diurnal minimum temperature. In days after March 1.



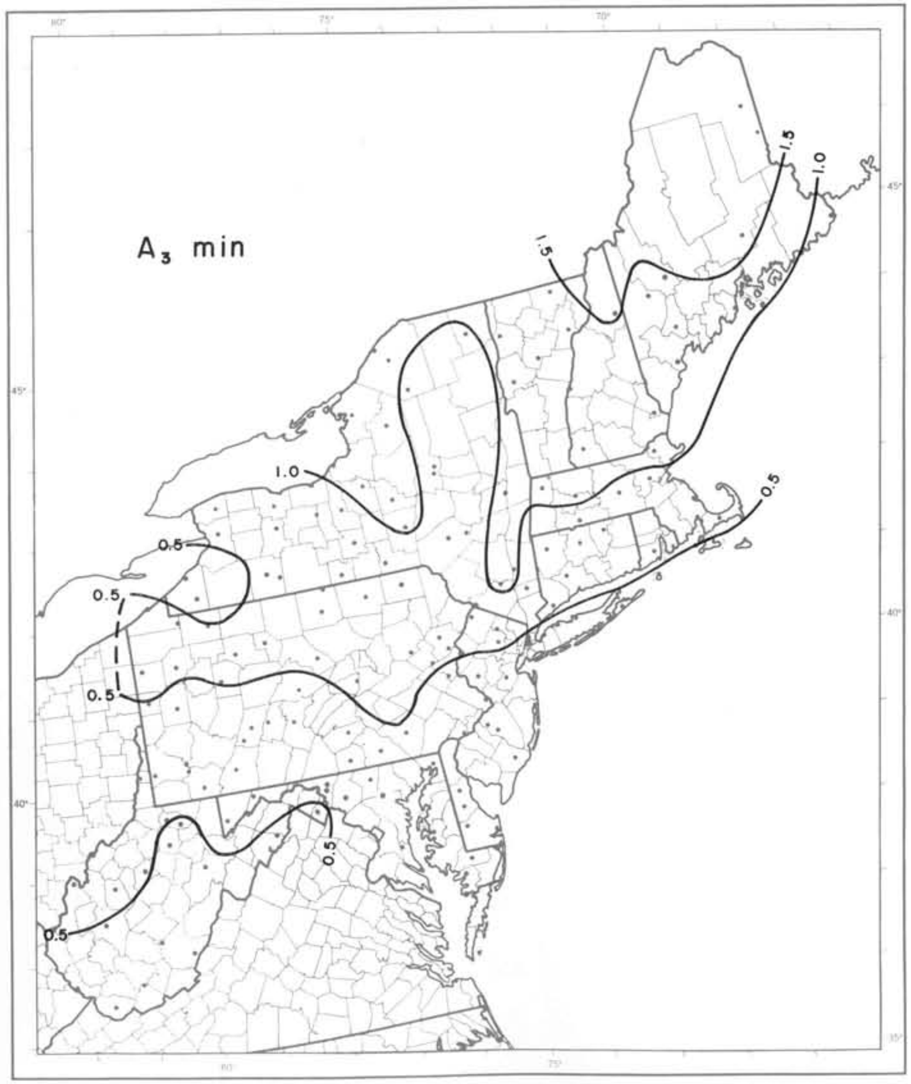

*Map 12.* $\phi_3$ for the diurnal minimum temperature. In days after March 1.



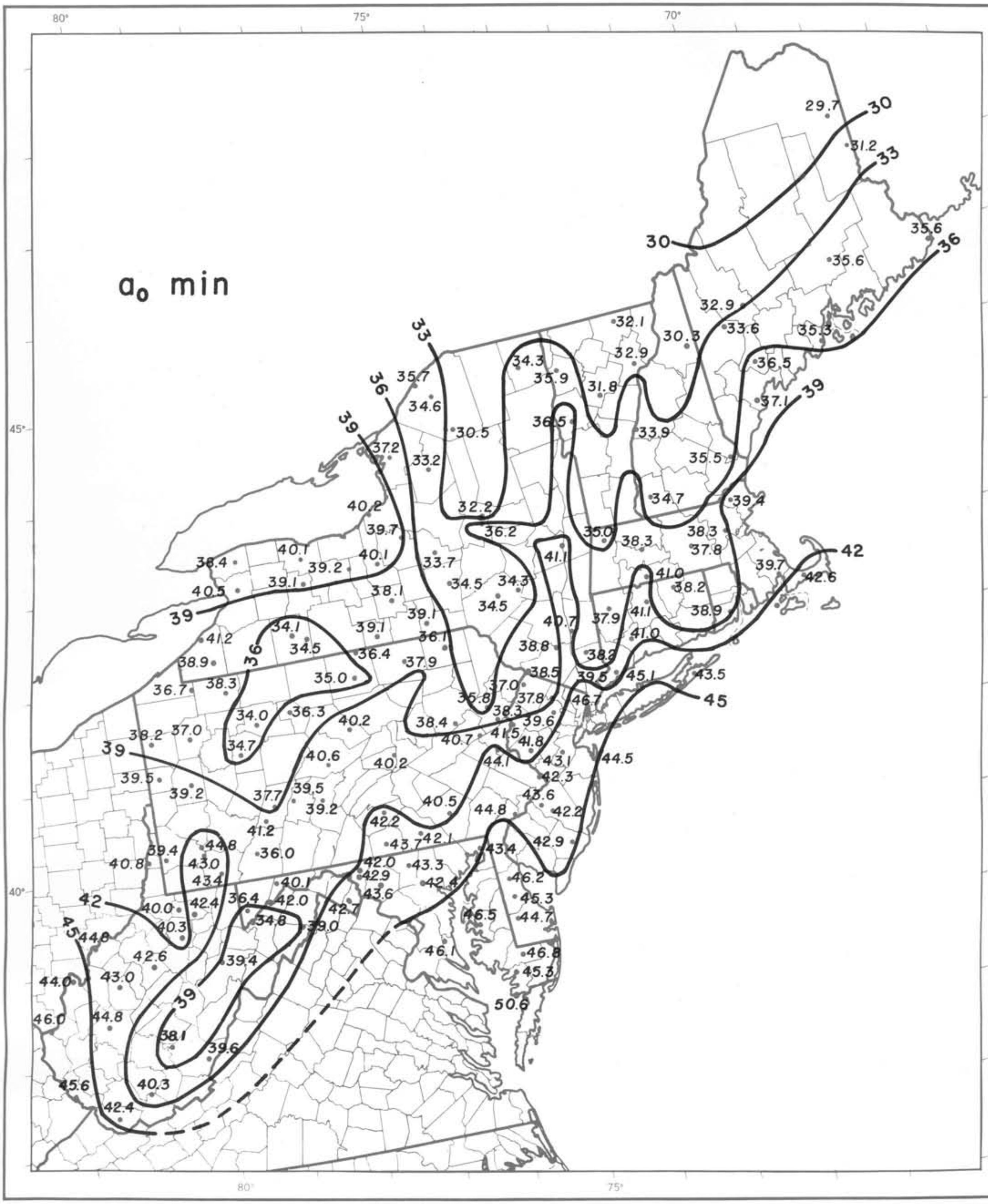

*Map 13.* $A_1$ for the diurnal minimum temperature, in °F.



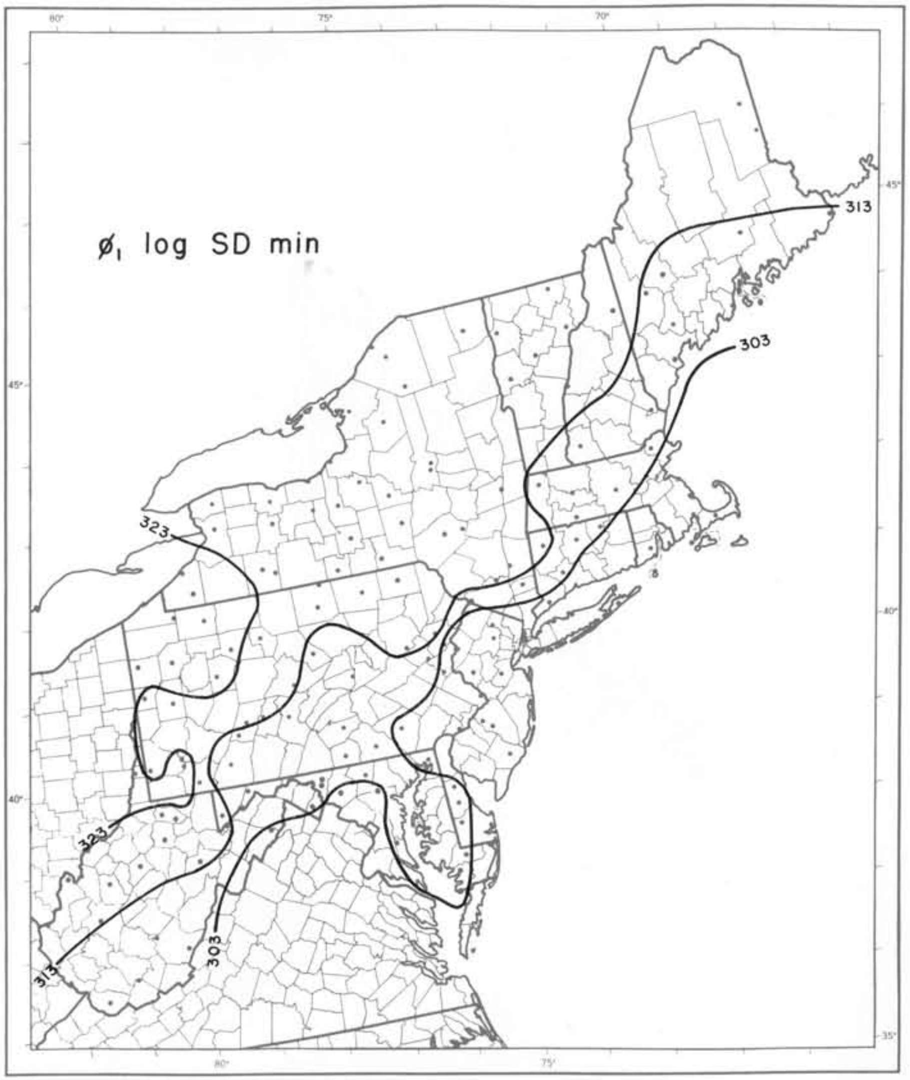

*Map 14.* $A_2$ for the diurnal minimum temperature, in °F.



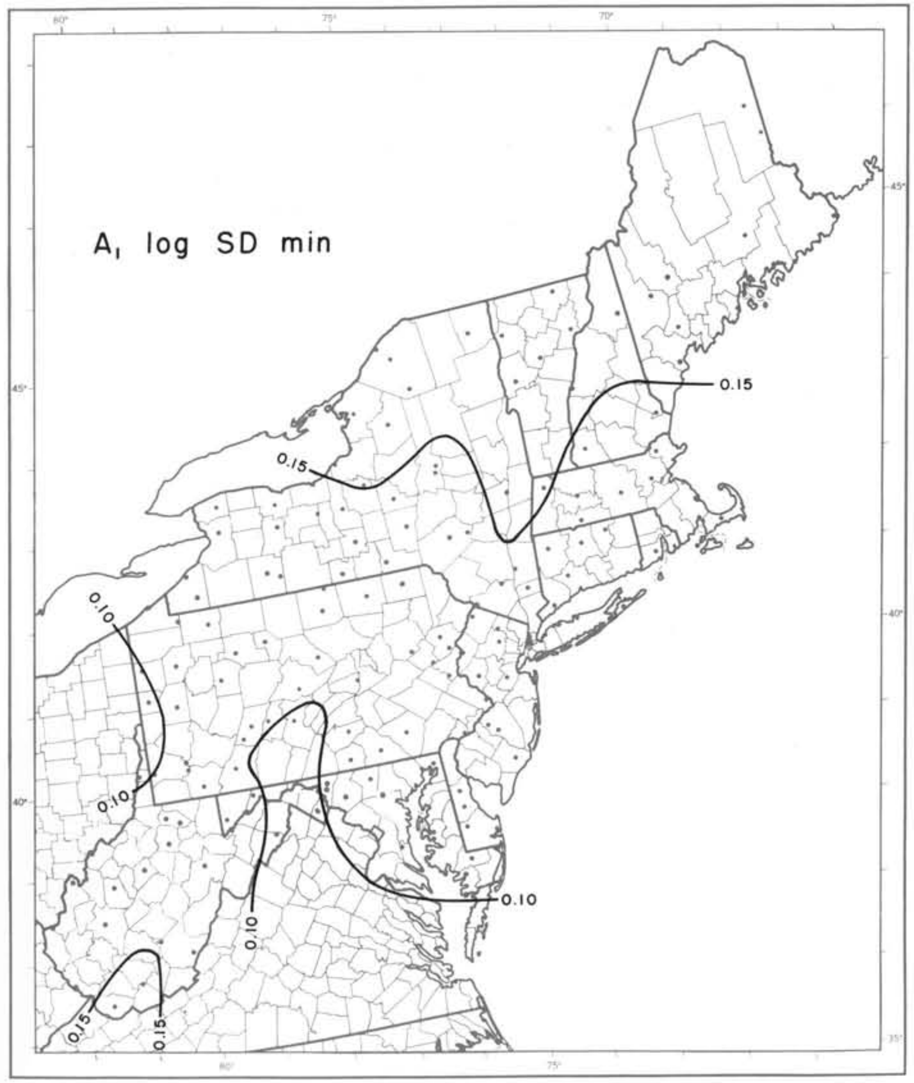

*Map 15.* $A_3$ for the diurnal minimum temperature, in °F.



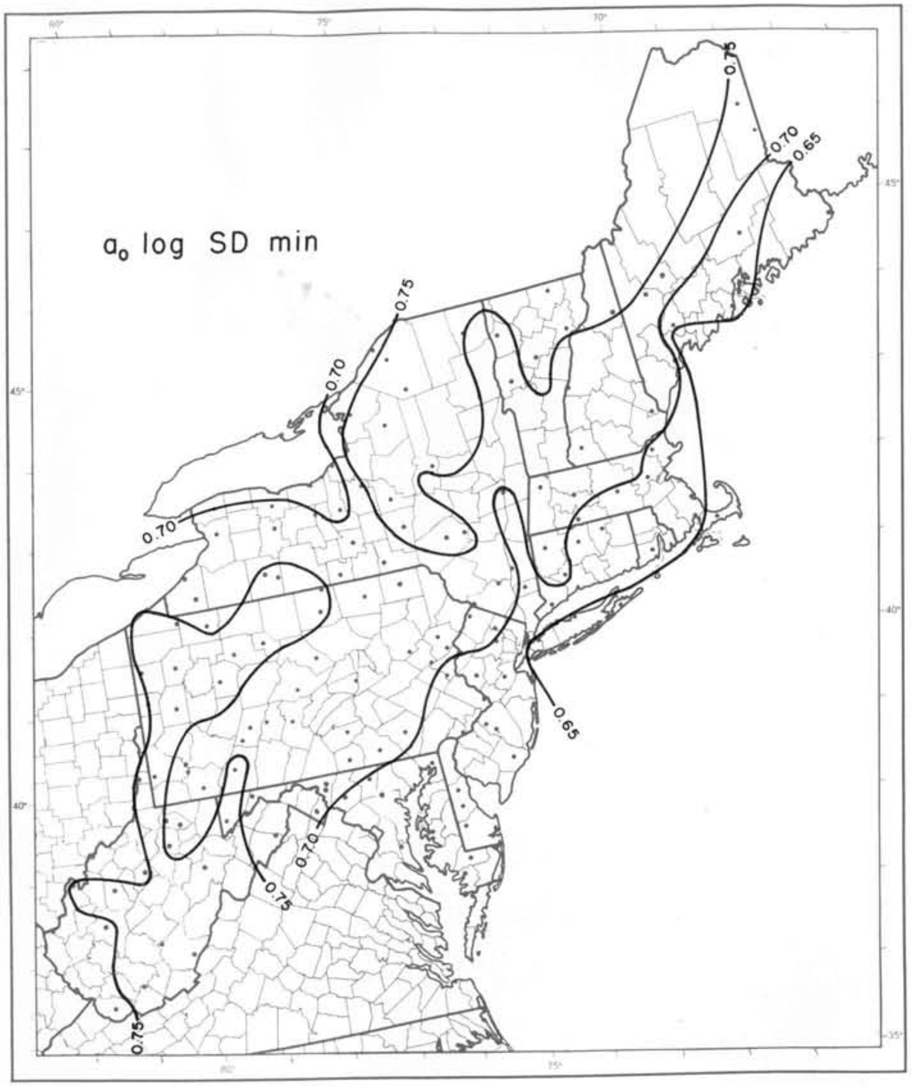

*Map 16.* $a_0$ for the diurnal minimum temperature, in °F.



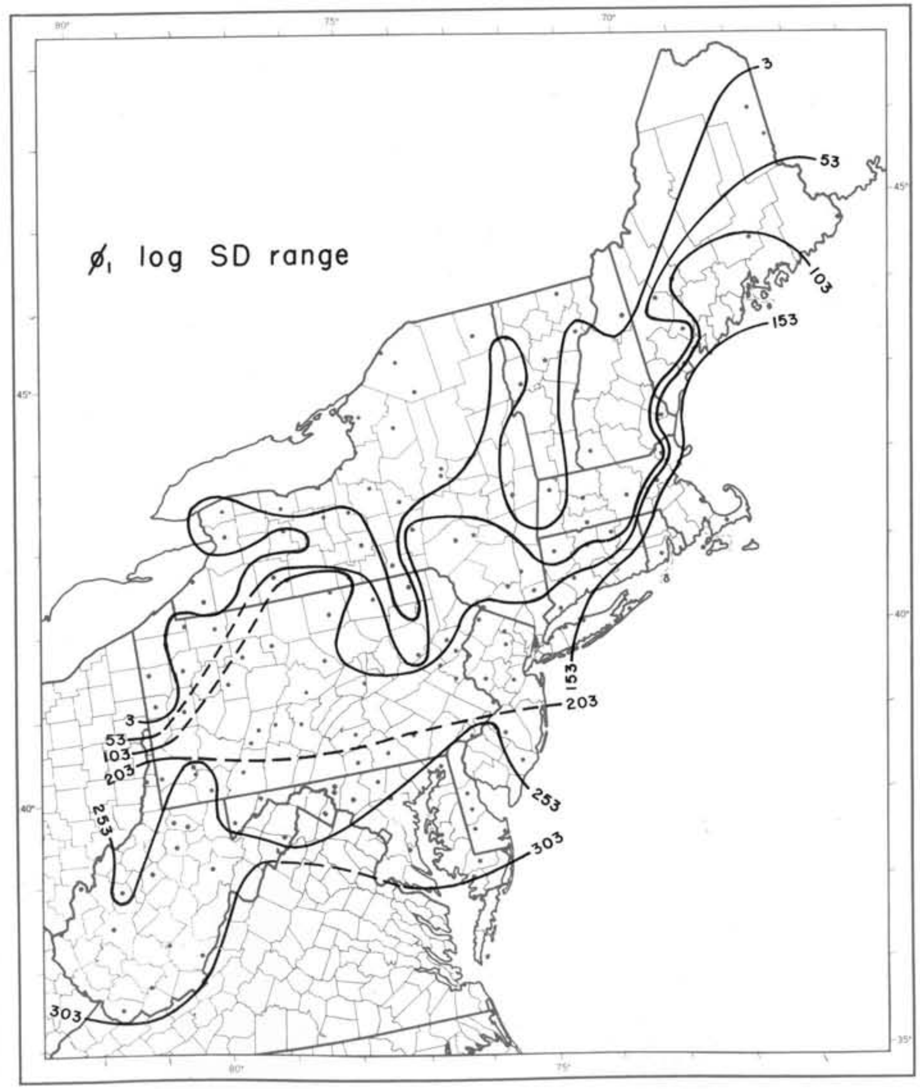

*Map 17.* $\phi_1$ for the log standard deviation of diurnal minimum temperature. In days after March 1.



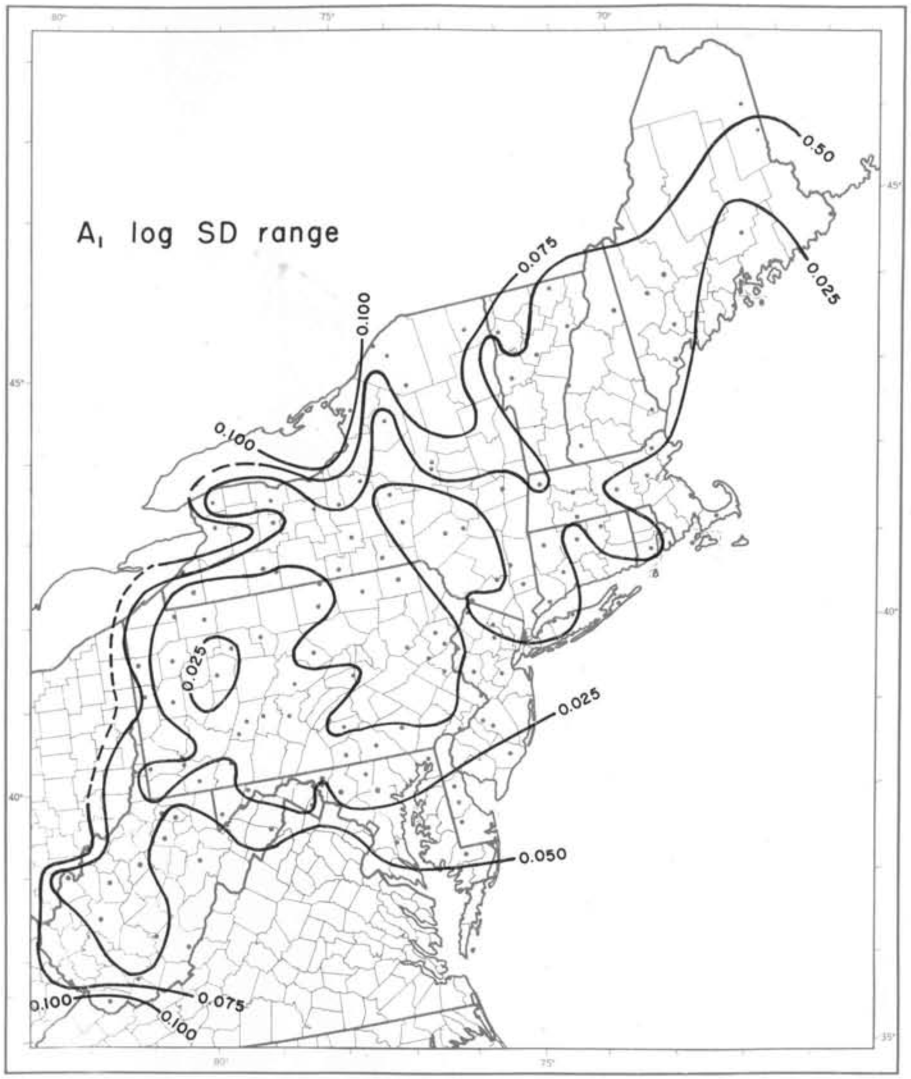

*Map 18.* $A_1$ for the log standard deviation of diurnal minimum temperature, in log (°F).



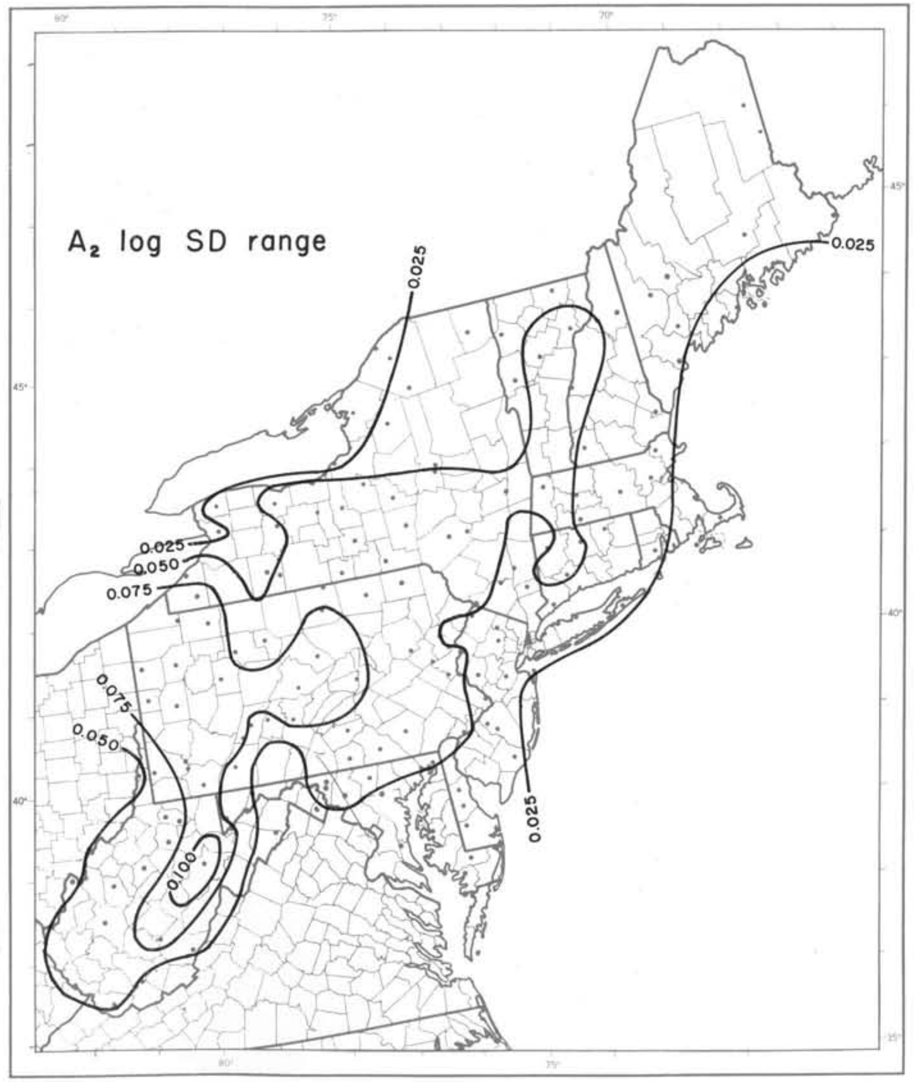

*Map 19.* $a_0$ for the log standard deviation of diurnal minimum temperature, in log (°F).



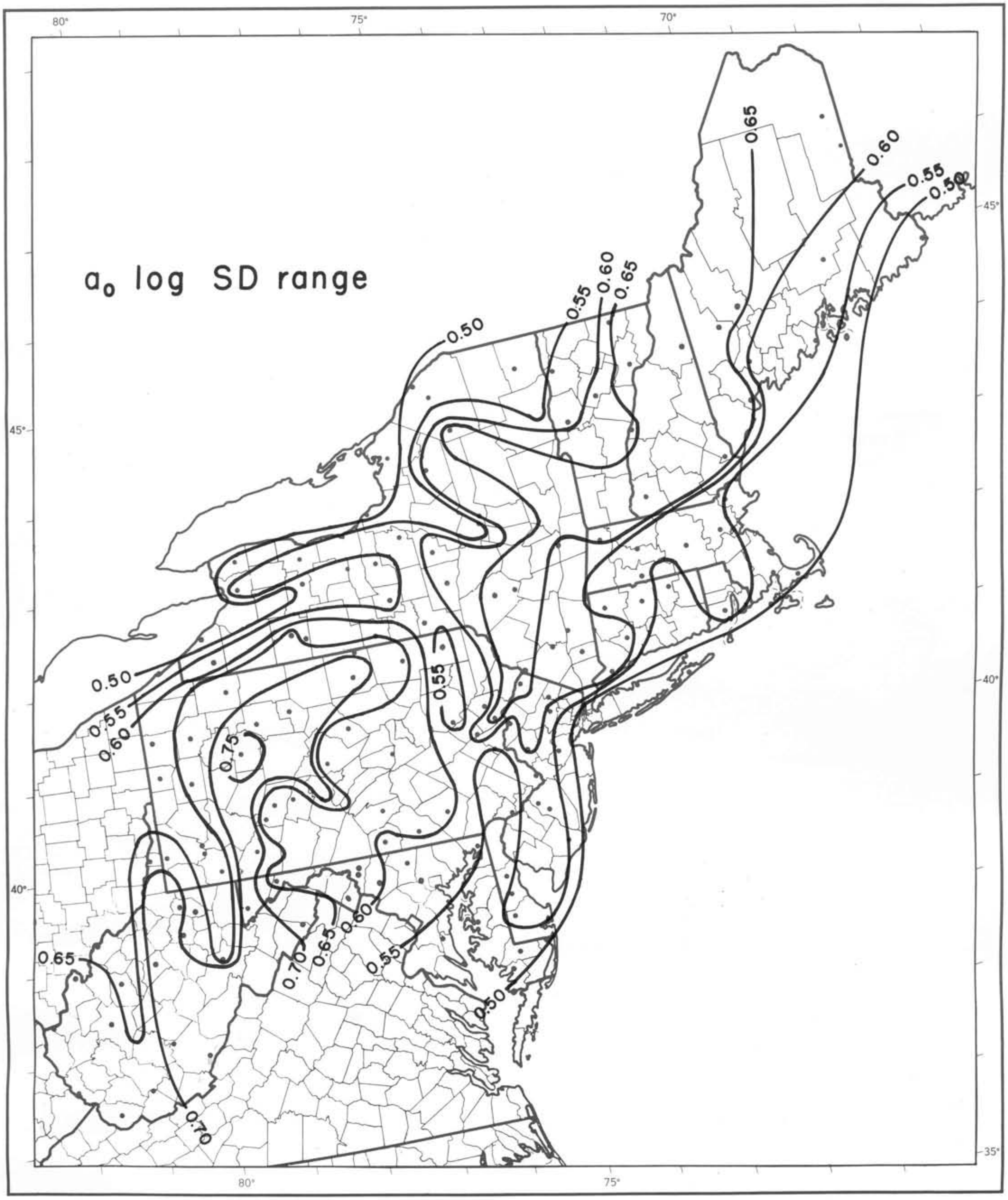

*Map 20.* $\phi_1$ for the log standard deviation of diurnal temperature range. In days after March 1.




*Map 21.* $A_1$ for the log standard deviation of diurnal temperature range, in log (°F).




*Map 22.* $A_2$ for the log standard deviation of diurnal temperature range, in log (°F).




*Map 23.* $a_0$ for the log standard deviation of diurnal temperature range, in log (°F).

## THE NE 35 TECHNICAL COMMITTEE

Members of the committee and the participating state and federal agencies that they represented follow:

| | |
|---|---|
| P. E. Waggoner | The Connecticut Agricultural Experiment Station, New Haven |
| B. E. Janes | Agricultural Experiment Station, University of Connecticut, Storrs |
| D. J. Fieldhouse | Agricultural Experiment Station, University of Delaware, Newark |
| G. R. Cooper | Agricultural Experiment Station, University of Maine, Orono |
| O. E. Street | Agricultural Experiment Station, University of Maryland, College Park |
| H. Joa | Agricultural Experiment Station, University of Massachusetts, Amherst |
| S. J. Dunn[1] | Agricultural Experiment Station, University of New Hampshire, Durham |
| A. V. Havens | Agricultural Experiment Station, Rutgers—The State University, New Brunswick |
| N. C. Brady | Agricultural Experiment Station, Cornell University, Ithaca |
| M. T. Vittum | New York Agricultural Experiment Station, Geneva |
| L. D. Tukey | Agricultural Experiment Station, Pennsylvania State University, University Park |
| R. J. Hopp[2] | Agricultural Experiment Station, University of Vermont, Burlington |
| W. H. Dickerson, Jr. | Agricultural Experiment Station, West Virginia University, Morgantown |
| O. Starnes[3] (Administrative Advisor) | Agricultural Experiment Station, Rutgers—The State University, New Brunswick |
| E. R. Lemon | U. S. Department of Agriculture, Agricultural Research Service, Soil and Water Conservation Branch |
| A. J. Loustalot | U. S. Department of Agriculture, Agricultural Research Service, State Experiment Stations Division |
| J. K. McGuire | U. S. Department of Commerce, Weather Bureau, Office of Climatology |

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[1] Succeeded J. J. Kolega
[2] Succeeded C. H. Blasberg
[3] Succeeded A. A. Spielman