SWS Miscellaneous Publication 148

USER GUIDE
MIDWESTERN AGRICULTURAL CLIMATE ATLAS
Version 1.0

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MIDWESTERN CLIMATE CENTER

May 1993

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May 1993

2nd Printing October 1993

RATIONALE FOR AN AGRICULTURAL CLIMATE ATLAS

In an average year, the United States produces approximately seven billion bushels of corn, and 1.8 billion bushels of soybeans. Direct cash receipts from this production exceed $20 billion. Most of this production occurs in the central part of the U.S. Climate fluctuations have caused large year-to-year variability in production. Drought, one of the biggest climatic threats to production, in 1988 reduced corn yields by more than 40%, compared to the previous year. Other recent severe droughts affected production in 1980, 1983, and 1991. Additional climate conditions influencing yields include wet springs that delay planting, heat stress during critical growth stages, and early freezes that kill crops prior to maturity.

There are a variety of management decisions that can be enhanced by appropriate climatic information. For example, hybrid/variety selection can be influenced by the length of the growing season and drought probabilities. Decisions on date of planting can be influenced by knowledge of the probabilities for last spring freezes. Disease and pest development can be affected by temperature, humidity and wind conditions. Likewise, resource allocation for spraying to control diseases and pests can be planned by monitoring plant and insect growth stages with growing degree day accumulations.

The rapid advance of computer technology and the widespread use of computers in agricultural production management have made it possible to provide climatic information in a digital format for use in agricultural decision making. A major advantage of the computerized Midwestern Agricultural Climate Atlas compared to a more traditional published atlas is that many more products can be made available, the database can be easily updated, and the products can be tailored to a user-specific location and question. This greater flexibility results in a more effective product. We welcome any comments regarding the atlas' capabilities and ways to improve it

This atlas was developed by the staff of the Midwestern Climate Center, one of six regional climate centers around the United States. The regional climate centers, jointly funded by federal and state sources, have as one of their objectives the provision of climatic information to all potential users. This atlas is an outgrowth of the Midwestern Climate Information System (MICIS), which is an on-line computerized information system providing up-to-date climate data and information. The atlas provides a subset of products available on MICIS, and does not require dialing into an on-line system.

Acknowledgements. Funding for development of the Midwestern Agricultural Climate Atlas was provided by the National Oceanic and Atmospheric Administration through the Regional Climate Center Program with Kenneth Kunkel as Principal Investigator. The concept for the agricultural climate atlas was developed by Steven Hollinger with assistance from Beth Reinke. Leadership in determining the contents and characteristics of the atlas was provided by Kenneth Kunkel and Steven Hollinger. Beth Reinke wrote most of the software and coordinated the writing of software routines contributed by Carl Lonnquist and Julia Chen. Analysis of the raw climate data used to compute the climate statistics contained in the atlas was lead by James Angel with contributions from Robert Scott and Mary Schoen Petersen. Jean Dennison assembled and typed the manuscript and Dave Cox provided the drafting. The comments of those who reviewed the earlier versions of the software are much appreciated. A special thanks goes to the volunteers of the NWS Cooperative Network for providing the basic climate information that made this atlas possible.

TABLE OF CONTENTS

Introduction

The Midwestern Agricultural Climate Atlas contains climate statistics for a large number of locations in the Midwest with long-term daily climate records. The daily data themselves are not included in the atlas, but only the statistics of these data. The atlas covers a nine-state region in the central U.S., including the states of Illinois, Indiana, Iowa, Kentucky, Michigan, Minnesota, Missouri, Ohio, and Wisconsin. The statistics included in the atlas are means, extremes, and probabilities of occurrence for various time durations from one week to one year. Primary climatic elements included are air temperature, precipitation, and snowfall. From these primary elements, a number of other variables are derived, including growing degree days, and growing season length.

Data from the atlas are presented in report, graph, or map formats. Report products give a tabular summary of single station climate statistics for several different time periods. Graph products show the temporal distribution of a single element for a single station. The map products show the spatial patterns of a single element over a single state or over the entire region for a given time period.

Getting Started

Hardware Requirements

The atlas requires the following computer configuration:

- An IBM PC or 100% compatible microcomputer running DOS version 3.3 or later.
- An 80286 or higher processor (80386 processor recommended).
- A color monitor with an EGA or VGA graphics adapter (VGA recommended).
- 640 kilobytes of available memory.
- One hard-disk drive with at least 4 megabytes of free space.
- One 1.2 megabyte 5.25" floppy disk drive or one 1.44 megabyte 3.5" floppy disk drive.
- An HP Laserjet or Epson dot matrix printer if a hardcopy of atlas products is needed. Other printers may work, but cannot be guaranteed.

The atlas program will run on an 80286 system with an EGA graphics adapter, however, response time and graphics quality are greatly improved with a faster computer and a VGA graphics adapter.

Installation

- As noted above, make sure you have at least 4 megabytes of free space on your hard disk before attempting to install the atlas software.

1) Create an atlas subdirectory on the hard disk to hold all atlas files. We suggest "atlas" as the subdirectory; however, you may select your own subdirectory name.
C:\>**mkdir atlas**

2) Make the newly created atlas subdirectory the current working directory:
C:\>**cd atlas**

3) Insert disk #1 in a: and start the install program:
C:\ATLAS> **a:install**

4) Follow the install instructions, inserting new disks when prompted to do so.

5) To run the atlas program, type agat
C:\ATLAS> **agat**

After installation, the following files will be on your hard disk in the atlas subdirectory you created:

Program Files:	agatexe
Data Files:	agdat.bin
	mwlwt.bin
	menu.def
	settings. def
	labels.bin
	helvb.fon
	outlines.def
Help Files:	agat.hlp
	graph.hlp
	general. hlp
	map.hlp
	report.hlp

NOTE: The main atlas data file (agdat.bin) was too large to fit on one floppy diskette. Therefore, it was split into two parts and compressed for distribution (the files are named parti.z and part2.z). The install program uncompresses and rejoins these files to produce the main 2.6 megabyte atlas data file. The compression program (GZIP) is licensed by Free Software Foundation, Inc. Documentation for use and copying this program as well as an executable version of the program are in the GZIP subdirectory on distribution diskette 1. A complete machine-readable copy of the corresponding source code can be provided for a small fee upon request.

Quick Reference

Menus: The atlas' main menu is a sliding bar with selections displayed horizontally across the bar. Each selection has an associated pop-down menu. Menu items can be selected by either

1) moving the highlighted (GREEN) box over the menu item with the arrow keys (← or → for the main menu, and ↑ or ↓ for pop-down menus) and pressing the <ENTER> key, or
2) pressing the highlighted (RED) hot-key.

Pop-down menus can be exited by either

1) highlighting the "Exit submenu...." option and pressing the <ENTER> key,
2) pressing the "Exit submenu...." hot key, <X>, or
.3) pressing the <ESC> key.

To exit the atlas program, exit to the main horizontal menu bar, select "Quit" or press <ESC> and press the 'Y' key in response to the question: "Are you sure you want to exit?"

User-Entry Screens: User-entry screens are windows that pop-up at the end of most menus, asking for user input. An 'X' marks the position of the current selection in each user-entry screen. To select an item, position the 'X' at the desired selection by using the arrow keys (←,→,↑,↓), the <HOME> key and the <END> key, and then press <ENTER>. Only one item can be selected from each user-entry screen. To move back to the previous user-entry screen or menu, press the <ESC> key.

Function Keys: The following function keys are defined for use within the atlas program when the status bar (message area on bottom of screen) indicates they are available:

<F1> Provides context-sensitive help for menus, user-entry screens, and report reviewing.
<F2> Prints the report, graph, or map displayed on the screen.
<F3> Saves a report file displayed on the screen to disk.

Help: Help is available via three ways:

1) By consulting the status bar, the message area on the bottom line of the screen. The status bar indicates which keystrokes are valid and also contains system messages at certain points in the program.
2) By pressing <F1>, which provides context-sensitive help for menus, user-entry screens, and report viewing;

3) By reading the on-line system help files found under "System Help" on the main menu. On-line system help topics are
   a) General Info
   b) Generating Reports
   c) Generating Graphs
   d) Generating Maps

Printing: Printer support is provided for Hewlett-Packard LaserJet printers and Epson dot matrix printers connected to parallel port LPT1. Other printers may work, but cannot be guaranteed. Before printing, the user should make certain that he/she has selected the appropriate printer type (HP or Epson) for his/her computer set-up. The printer selection can be changed from the "Select Printer" option in the "System Help" menu. Printer selection will be preserved between executions of the atlas program. After a report, graph, or map has been generated and is displayed on the screen, it can be printed by pressing the <F2> key. The user should expect a delay of 30 seconds to over a minute (depending upon computer processing speed) for printing of graphs and maps to complete. The screen background will change to Black while printing is in progress and return to the normal color display background once printing is complete.

Program Description

Stations and Data

Two major categories of climate stations are included in this atlas. The first category includes the first-order stations located at the National Weather Service (NWS) offices which are the backbone of the NWS station network. The first-order stations record hourly measurements of a wide range of variables including air temperature, humidity, wind, visibility, precipitation, and cloud cover. This very detailed set of observations is available for 4 to 5 locations per state. The other major category of climate stations is the NWS Cooperative Observer Network. This network is made up primarily of individual and institutional volunteers who record measurements on a daily basis and provide them to the NWS. Primary observations include daily maximum and minimum temperature, daily precipitation, daily snowfall, snowdepth, and in some cases soil temperature and pan evaporation. Although these observations are not as detailed (comprising daily observations rather than hourly observations), the network is much denser than the NWS first-order stations. There are approximately 1,500 cooperative observers within the 9-state region covered by this atlas.

For the purposes of this atlas, we have included only stations with long-term, nearly complete data. In particular, stations were included only if missing data comprised less than 10% of the total number of observations for the period 1949-1990. In essence, stations with more than 4 years of missing data were not included. This criterion resulted in 645 stations available for temperature and precipitation statistics in the atlas.

Statistics

Statistical quantities in this report include mean, extremes, and frequencies of occurrence. Brief definitions of these statistics are as follows:

Mean - arithmetic average of all observations in the 1961-1990 record.
Extremes - the maximum and minimum values of all observations in the 1949-1990 record.
Frequencies of occurrence - the frequency (in percent) with which a particular event occurs in all observations in the 1949-1990 record. For example, one may be interested in the frequency of days with maximum temperatures greater than 90°F in July. A 30 percent frequency indicates that one would expect to find temperatures greater than 90°F in 3 out of every 10 days, weeks, months, seasons, or years.

Most of the statistics are computed for weeks and months. Seasonal and annual values are then determined from the monthly values. To more closely match the actual growing season, the weekly statistics are computed for the climatological year, which begins on March 1. The four traditional seasons are winter (December-February), spring (March-May), summer (June-August), and fall (September-November). Information on frost and growing season length use the actual dates rather than the nearest week or month. The products containing 30- and 90-day probabilities have their own starting times as noted in the atlas.

Derived Variables

Several derived variables were calculated from the directly observed elements. The descriptions and definitions of these follow.

- **Growing season length** - this is defined as the period between the last spring freeze and the first fall freeze. A freeze is defined as a day on which the temperature falls to or below some threshold that might cause damage to plants. The threshold is not necessarily 32°F, since perennial plants must be hardy enough to withstand temperatures below freezing. For this atlas, we have chosen 5 thresholds of significance. These are 32°F, 28°F, 24°F, 20°F, and 16°F. Statistics related to the growing season are the number of days between the last spring and first fall freezes, the date of the last spring freeze, and the date of the first fall freeze. Products may be generated for any of the above temperature thresholds at probability levels of 10, 30, 50, 70, and 90 percent.

- **Growing degree days** - the growing degree day (GDD) is a concept used to estimate plant/insect growth and development The basic concept is that plant/insect growth and development will occur only when the temperature exceeds some minimum developmental threshold. Above that threshold, the rate of plant/insect growth will increase linearly as the temperature increases. It has been found for plants/insects that accumulated GDD can be associated with certain stages of development. For example, the alfalfa weevil requires 300 base 48°F GDDs from January 1 for eggs to hatch and an additional 300 to grow from newly hatched larvae to pupa (Higley, 1987).

For plants, GDDs are calculated as follows. First, the average temperature T_a for a day is calculated. This is given by

$$T_a = (T_{max} + T_{min})/2$$

where T_{max} is the maximum daily temperature and T_{min} is the minimum daily temperature. The number of GDD for a single day is then given as follows

$$GDD = T_a - T_{base} \quad \text{if } T_a \text{ is greater than } T_{base}$$
$$GDD = 0 \quad \text{if } T_a \text{ is less than or equal to } T_{base}$$

where T_{base} is the base or minimum developmental threshold temperature. For corn and other warm-season crops, the above method is modified slightly as follows. For the purpose of calculating the daily average temperature, if the daily maximum temperature exceeds 86°F, it is set equal to 86°F, and if the minimum temperature is below 50°F, it is set equal to 50°F. Table 1 lists some of the crops that develop according to the base temperatures used in this atlas.

For insects, GDDs are calculated using a modified sine wave method (Allen, 1976), which assumes that the temperature cycle is not linear but instead is approximated by a sine wave. The method allows for an upper and lower developmental threshold. Different equations are used, depending on the relationships between T_{max}, T_{min}, and the upper and lower thresholds. Table 2 lists some of the insects that develop according to the base temperatures used in this atlas.

Table 1. Reported base temperatures for GDD computations for different crops. From Aceves-Navarro (1987).

Base Temperature	Crops
40°F	Wheat, barley, rye, oats, flaxseed, lettuce, asparagus
45°F	Sunflower, potato
50°F	Sweet corn, corn, sorghum, pearl millet, proso millet, rice, soybeans, dry beans, cantaloupe, lima beans, snap beans, tomato, sugarbeet, pumpkin

Table 2. Reported base temperatures for GDD computations for different insects. From Higley (1987) and Steffy (1993).

Base Temperature	Insects
44°F	Com Rootworm
48°F	Alfalfa Weevil
50°F	Black cutworm, European Corn Borer
52°F	Green Cloverworm

To accumulate degree days appropriate for crop development, the daily GDD values are accumulated from the date of planting. For insects, GDD are often accumulated from January 1 or some known insect event such as the date of the first intense flight.

- **Accumulated degree days to first frost** - this statistic is of use for hybrid/variety selection when wet weather delays spring planting past the average dates of planting. Under such conditions, it may be necessary to choose a shorter season hybrid/variety. These statistics may also be applicable to second crop planting of soybeans after wheat harvest in southern portions of the Midwestern region. This product provides statistics on accumulated degree days from selected planting dates to the date of the first frost. The user may select the frost temperature threshold.

A final application occurs during growing seasons of significantly below normal temperatures. In these types of years, the development of crops may be behind schedule. This product provides an estimate of the likely number of degree days to be accumulated from any day during the growing season up to the first frost. It thus can provide information on the probability that a crop will reach maturity before the first frost.

• **Heating/Cooling Degree Days -** Heating and cooling degree days are a concept similar to growing degree days but applied to energy usage. Heating degree days are used to estimate the amount of energy required for residential space heating during the cool season. Likewise, cooling degree days are used to estimate air conditioning energy usage during the warm season. In general, the amount of energy required for heating and cooling are approximately proportional to the number of accumulated heating and cooling degree days. Cooling degree days (CDD) are calculated in similar fashion to growing degree days as follows:

$CDD = T_a - T_{base}$ if T_a is greater than T_{base}
$CDD = 0$ if T_a is less than or equal to T_{base}

For cooling degree days the usual T_{base} is 65°F. Heating degree days (HDD) are calculated as follows:

$HDD = T_{base} - T,$ if T_a is less than T_{base}
$HDD = 0$ if T_a is greater than or equal to T_{base}

As with cooling degree days, T_{base} for heating degree days is usually taken as 65°F. The number of heating/cooling degree days does not directly provide information on the cost of heating/cooling. However, the relative amount of energy required for heating/cooling can be compared across the region by comparing the number of heating/cooling degree days.

• **Temperature probabilities** - temperature probabilities for selected 30- and 90-day periods are expressed using an approach familiar to climatologists (see Table 3). These probabilities, or percentiles, are used as a way of assigning numbers to such general terms as "normal" or "below normal." For example, from Table 3 we see that the meaning of the "much above normal" category is 12½ percent. This means that for the given time period, we would expect temperatures to exceed this value only 12½ percent of the time. From this example, one can see that the categories "much above normal" and "much below normal" are very rare indeed. The 30- and 90-day periods are selected to match the 30- and 90-day forecasts issued by the Climate Analysis Center (CAC) of the NWS. Therefore, this product allows you to assign specific numbers to the long-range forecasts. These probabilities were obtained by ranking the temperature data (1961-1990) and calculating the percentiles. This process assumes that the data are normally distributed.

• **Precipitation probabilities** - precipitation probabilities for selected 30- and 90-day periods are calculated differently than the temperature probabilities. Because precipitation exhibits a non-normal distribution, the ranking approach described for temperature probabilities is less satisfactory for precipitation. To minimize this problem, the observed data are used to estimate the parameters of a mathematical function known as the gamma distribution. This function provides an approximate but smoothed fit to the measured precipitation data. The threshold values are then calculated from the smoothed mathematical form rather than from the actual data (Haan, 1971). Refer to Table 3 to interpret the precipitation probabilities.

Table 3. Categories Used in the 30- and 90-Day Temperature and Precipitation Probabilities and Their Meaning.	
Category	Meaning
much below normal*	12½% of the values are **below** this number OR 87½% of the values are **above** this number
below normal	30% of the values are **below** this number OR 70% of the values are **above** this number
normal	values between 30% and 70%
above normal	70% of the values are **below** this number OR 30% of the values are above this number
much above normal*	87½% of the values are **below** this number OR 12½% of the values are **above** this number
*These terms are currently not used in the NWS 30- and 90-day outlooks, however, they are included here as additional information. The percentages associated with these terms are based on Wagner (1989).	

Product Summary

A complete list of the available products follows:

- Precipitation - All of the following are available for weekly, monthly, seasonal, and annual time periods:
  - Average Precipitation
  - Average Snowfall
  - Number of days with precipitation greater than 0.00"
  - Number of days with precipitation greater than or equal to 0.10"

- Precipitation probabilities. The threshold values for much below normal, below normal, above normal, and much above normal are provided for the following time periods.
  - 30-day periods beginning on the 1st of the month and on the 16th of the month.
  - 90-day periods beginning on the 1st of the month

- Temperature. The following elements are available for weekly, monthly, seasonal, and annual time periods:
  - Average maximum temperature
  - Average minimum temperature
  - Extreme daily maximum temperature
  - Extreme daily minimum temperature

- Temperature probabilities. Threshold values are provided for the categories for much below normal, below normal, above normal, and much above normal for the following time periods:
  - 30-day periods beginning on the 1st of the month and on the 16th of the month.
  - 90-day periods beginning on the 1st of the month.

- Temperature threshold exceedence. The probability of the daily maximum temperature exceeding the following thresholds are given: 32°F, 40°F, 50°F, 60°F, 65°F, 75°F, 80°F, 86^{d}F, 90°F, 95°F, and 100°F. The probabilities of the minimum temperature falling below the following thresholds are given: -20°F, -15°F, 0° F, 20° F, 28° F, 32° F, 40° F, 50° F, 55° F, 60° F, 65° F, and 70° F. These probabilities are available for weekly, monthly, seasonal, and annual time periods.

- Crop degree days. Mean crop degree days are provided for weekly and monthly time periods for the following bases: 40°F, 45°F, and 50°F.

- Insect degree days. Mean insect degree days are provided for weekly and monthly time periods for the following bases: 44°F, 48°F, 50°F, and 52°F.

- Heating/cooling degree days. Mean heating and cooling degree days are provided for weekly and monthly time periods for base 65°F.

- Growing season/frost information. Various statistics on the first fall frost and the last spring frost are provided. These include probabilities of exceedence for the following probabilities: 90%, 70%, 50%, 30%, and 10%; for freezing temperature thresholds of 32°F, 28°F, 24°F, 20°F, and 16°F. Statistics are provided for the following elements:
  - The date of the last spring frost
  - The date of the first fall frost
  - The growing season length (in days).

- Crop degree days to first frost. The mean accumulated crop GDDs from various dates to the first fall frost are computed. This product uses the mean last spring frost (various bases) and growing season climatological weeks as the starting dates and the 10%, 50%, and 90% first fall frosts as the ending dates.

Examples

In these examples, the phrases "select" or "choose" mean to pick your menu choice on the screen using the appropriate key strokes. If you are unfamiliar with how to select menu items, press F1 to get the context-sensitive help screens or consult the quick reference guide in the manual.

1. Question: What are the expected dates for the last spring frost in Indianapolis, Indiana?

   Answer: There are two ways to find this answer with the atlas. If there is a climate station nearby (refer to the list of stations in the manual), you can generate a frost report for that station. If there isn't a nearby station, you can create a map of expected frost dates for your state or for the Midwest.

   First, let's look at the report for a particular station. From the main menu, choose **"Reports".** A list of reports will appear. Choose "**Frost/Freeze/Growing Season**". Now begin the search for Indianapolis. First, choose **Indiana** in the state selection. Now you are prompted for the climate division. Climate divisions are regions with similar climate with most states having six to nine such divisions. You can refer to the climate division map in Appendix A and the station listing in Appendix B to help find the appropriate climate division and station. In this case, Indianapolis is in the **Central** division (#5). Next, the atlas asks for a particular station. Choose **Indianapolis_WSFO_AP** (WSFO stands for Weather Service Forecast Office and AP stands for Airport).

   After a short delay (depending upon computer speed), the table for spring and fall frost dates and length of growing season appears (Table 4). The first table shows the probability of last spring frost. Using a base temperature of 32°F, we see that there is a 50% chance (one year in two) that the last spring frost is April 20th, but there is a 10% chance (one year in 10) that it will be as late as May 8th. We can also get this kind of information from the atlas contour maps. Exit from the report display by pressing the <ESC> key, and then out to the main menu by pressing <ESC> again. Choose "Maps", **"Frost/Freeze/Growing Season**", and then **"Last Spring** Freeze". For the map area, choose **Indiana.** For the probability of last spring frost, choose 50% (the most likely date). Now choose a temperature of **32°F**. After a short delay, a map showing the dates of the last spring frost will be displayed (Figure 1). As you would expect, the dates are earlier in the south. You will also notice that the dates from the report do not exactly match the map. This is because the map contouring routine takes into account the stations surrounding Indianapolis when drawing the contours. In the case of Indianapolis (an urban site), there may be some local effects, such as nearby buildings and parking lots, which cause local warming. The data for urban areas is not representative of all locations within that area.

   From this example, you will probably notice that the advantage of the report is that it can give you several pieces of information, but for only one station. On the other hand, the map can give you an idea about how one climate variable changes across a region. Use the <ESC> key to get back to the main menu.

Table 4.

Freezing Information for Growing Season
Station: Indianapolis_WSFO_AP, Indiana (124259)
Based on 1961-1990 Data

Probabilities That The Last Spring Occurrence of Several Freezing Temperature Thresholds Will Be After The Date Shown

Base Temp	90 %	70 %	50 %	30 %	10 %
32	4/07	4/11	4/20	4/26	5/08
28	3/23	4/05	4/09	4/13	4/22
24	3/16	3/20	3/26	4/03	4/10
20	3/02	3/10	3/16	3/21	4/01
16	2/09	2/19	3/06	3/13	3/20

Probabilities That The First Fall Occurrence of Several Freezing Temperature Thresholds Will Be Before The Date Shown

Base Temp	10 %	30 %	50 %	70 %	90 %
32	10/04	10/10	10/17	10/26	11/03
28	10/12	10/21	10/28	11/04	11/11
24	10/21	11/02	11/07	11/14	11/21
20	11/01	11/15	11/25	12/01	12/07
16	11/16	11/26	12/05	12/09	12/16

Probabilities That The Length of The Growing Season Will Not Exceed The Day Totals Shown

Base Temp	10 %	30 %	50 %	70 %	90 %
32	154	173	183	189	199
28	182	194	203	209	226
24	207	216	222	234	247
20	227	242	253	260	271
16	252	266	276	282	302

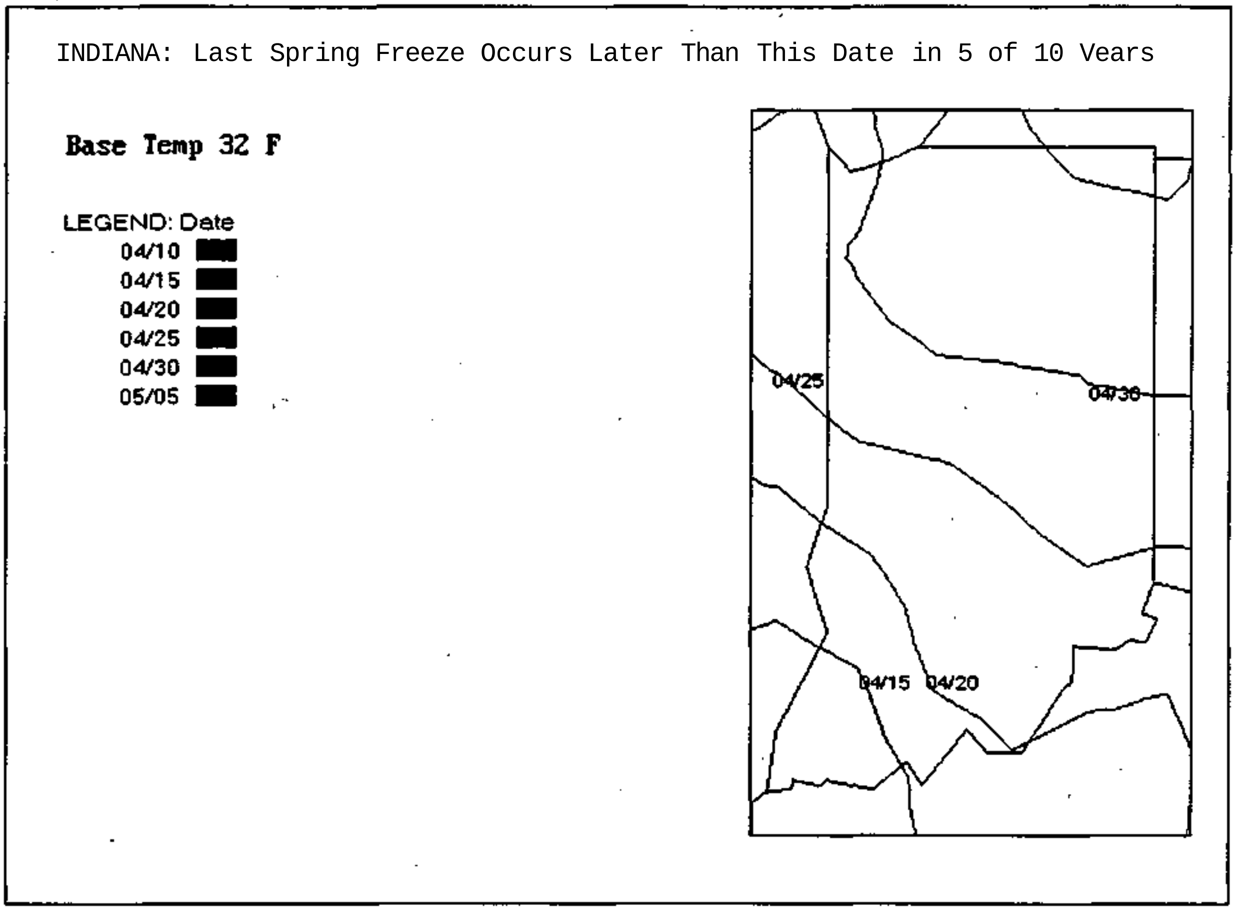

Figure 1. Mean date (50% level) of last spring freeze (32°F) for Indiana.

2. Question: What are the average or normal temperatures and precipitation amounts for Bowling Green, Kentucky?

   Answer: The best way to answer this is to look at a report. From the main menu, choose **"Reports",** then choose **"Precipitation and Temperature".** As before, you will be asked for a state **(Kentucky),** a climate division **(Central),** and a station **(Bowling Green** FAA **AP).** Now you have the choice of monthly or weekly data. Choose "Weekly Data". The weekly choice gives you a week-by-week breakdown of the climatological year (Table 5). Please note that the climate week year starts on March 1st to correspond with most agricultural activities. This report shows you the weekly average total precipitation and the number of days with precipitation above the noted amount. It also shows the weekly average high and low temperatures and their extremes. The same kind of information can be found in the monthly report.

Table 5.

Precipitation and Temperature Summary for Bowling_Green_FAA_AP, Kentucky (1509 09)

Week Beginning	<-- Precipitation --> Avg Total	# Days > 0.00	# Days >=0.10	<---------- Temperature ---------> Avg MAX	Avg MIN	Extreme MAX	Extreme HXN
1 Mar 1	1.4	3.7	2.8	54.0	33.7	82	-6
2 Mar 8	1.0	3.6	2.6	57.0	35.9	84	5
3 Mar 15	1.1	4.3	2.7	58.4	35.8	85	17
4 Mar 22	0.9	3.7	2.4	59.6	36.7	82	14
5 Mar 29	1.7	4.2	2.9	64.0	41.8	85	21
6 Apr 5	0.8	3.5	2.5	63.6	40.7	89	23
7 Apr 12	0.9	3.4	2.3	68.5	44.6	90	22
8 Apr 19	1.0	3.7	2.5	71.6	48.6	90	27
9 Apr 26	1.1	3.8	2.7	72.2	48.9	90	30
10 May 3	1.1	2.9	2.2	73.8	49.9	94	32
11 May 10	1.2	3.8	2.7	76.1	53.2	92	33
12 May 17	1.1	3.4	2.4	78.8	55.8	94	38
13 May 24	1.0	3.7	2.5	79.8	57.4	93	35
14 May 31	0.9	3.2	2.3	81.8	59.8	98	40
15 Jun 7	1.1	3.3	2.2	85.1	61.8	99	43
16 Jun 14	0.9	3.4	2.4	84.9	62.6	99	48
17 Jun 21	1.0	2.6	2.0	86.7	63.5	102	46
18 Jun 28	1.3	3.3	2.4	87.2	65.4	105	48
19 Jul 5	1.2	3.1	2.0	88.1	66.3	103	49
20 Jul 12	0.6	2.9	2.0	88.4	66.5	107	50
21 Jul 19	0.9	3.0	2.0	89.4	67.8	104	55
22 Jul 26	1.0	3.1	2.2	87.5	66.6	106	51
23 Aug 2	0.8	2.5	1.6	87.4	65.9	102	52
24 Aug 9	0.7	2.7	1.9	86.4	64.3	101	50
25 Aug 16	0.7	2.8	2.0	87.5	65.7	102	49
26 Aug 23	0.8	2.8	1.8	86.3	64.1	103	43
27 Aug 30	0.9	2.6	1.8	84.9	63.1	104	45
28 Sep 6	0.5	2.2	1.5	83.7	60.8	104	42
29 Sep 13	1.0	2.8	1.8	80.4	57.7	99	40
30 Sep 20	1.0	2.7	1.8	77.3	54.7	97	33
31 Sep 27	0.9	2.3	1.7	74.7	51.0	98	31
32 Oct 4	0.6	2.3	1.5	72.3	46.8	93	30
33 Oct 11	0.8	2.2	1.3	72.0	47.0	90	29
34 Oct 18	0.8	2.8	1.7	67.0	43.0	88	23
35 Oct 25	0.6	2.6	1.6	65.9	41.2	86	24
36 Nov 1	0.9	2.8	2.0	62.2	40.5	83	13
37 Nov 8	0.8	2.4	1.6	58.2	36.8	80	15
38 Nov 15	1.1	3.5	2.6	56.3	36.6	80	12
39 Nov 22	1.4	4.0	3.1	54.5	35.1	78	-7
40 Nov 29	1.0	2.9	1.8	50.7	31.3	78	9
41 Dec 6	1.3	4.0	2.5	48.3	29.4	74	-5
42 Dec 13	0.8	2.8	1.7	45.7	26.4	73	-8
43 Dec 20	1.4	3.5	2.4	43.8	26.2	73	-14
44 Dec 27	1.2	4.1	2.7	43.8	26.3	76	0
45 Jan 3	1.0	3.5	2.5	40.7	23.3	68	-7
46 Jan 10	0.8	3.2	2.0	39.7	21.1	72	-9
47 Jan 17	0.9	4.2	2.4	42.6	25.1	71	-21
48 Jan 24	0.8	3.5	2.3	43.8	24.5	76	-21
49 Jan 31	1.1	4.3	2.9	44.1	24.3	72	-20
50 Feb 7	1.0	3.3	1.9	43.2	23.9	82	-6
51 Feb 14	1.0	3.7	2.5	48.2	28.0	73	-9
52 Feb 21	1.2	4.4	2.8	50.0	29.3	79	0

Averages based on 1961-1990 data, Extremes based on 1949-1990 data

3. Question: The latest 30-day forecast from the Climate Analysis Center of the NWS calls for above normal temperatures and below normal precipitation. What does that mean in terms of actual temperatures and precipitation for Des Moines, Iowa?

Answer: The information needed to answer this can be found in either Reports or in Maps. In this case, we will look at the reports. Select **"Reports",** then select **"30-Day Precip. Probabilities".** Now select the state **(Iowa),** the climate division **(Central),** and the city (Des **Moines** WSFO AP), just like we did in the first example. The 30-day forecast is updated every 15 days, so there is one at the beginning of the month and one at the middle of the month. In the report now on your screen (Table 6), you will see the time periods that the 30-day forecast covers in the left-hand column. Let's say that the latest 30-day forecast is for mid-January to mid-February. Normal precipitation ranges from 0.54" to 1.19" for Des Moines. Below normal precipitation is considered anything less than 0.54". Now exit the report by pressing <ESC> and you will return to the **Report** menu. Choose **"30-day Temp. Probabilities",** then the state, climate division, and city just as before. Now you have the 30-day temperature probability report (Table 7). You can see that above normal temperatures for Des Moines for mid-January to mid-February correspond to a mean temperature above 25.3°F.

Table 6.

30-Day Precipitation (To be used in conjunction with the 30-Day
Forecast by the Climate Analysis Center)
Station: Dea_Moines_WSFO_AP, Iowa (132203) Based on 1961-1990 Data

30-Day Period	Much Below Normal (Less Than)	Below Normal	Normal	Above Normal (Greater Than)	Much Above Normal
January	0.21	0.48	0.48 - 1.15	1.15	1.91
mid-Jan to mid-Peb	0.27	0.54	0.54 - 1.19	1.19	1.89
February	0.39	0.74	0.74 - 1.53	1.53	2.35
mid-Feb to mid-Mar	0.39	0.89	0.89-2.16	2.16	3.61
March	0.68	1.30	1.30 - 2.71	2.71	4.18
mid-Mar to mid-Apr	0.71	1.37	1.37 - 2.86	2.86	4.43
April	1.21	2.12	2.12 - 4.05	4.05	6.00
mid-Apr to mid-May	1.05	2.09	2.09 - 4.50	4.50	7.06
May	1.87	2.70	2.70 - 4.21	4.21	5.60
mid-May to mid-Jun	1.69	2.83	2.83-5.15	5.15	7.43
June	1.94	3.07	3.07 - 5.31	5.31	7.45
mid-Jun to mid-Jul	1.57	2.69	2.69-5.00	5.00	7.30
July	1.00	2.05	2.05 - 4.56	4.56	7.26
mid-Jul to mid-Aug	1.03	1.98	1.98-4.12	4.12	6.37
August	1.11	2.24	2.24 - 4.88	4.88	7.71
mid-Aug to mid-Sep	1.12	2.32	2.32 - 5.20	5.20	8.31
September	1.12	2.10	2.10 - 4.28	4.28	6.56
mid-Sep to mid-Oct	0.49	1.26	1.26 - 3.41	3.41	5.95
October	0.59	1.27	1.27 - 2.93	2.93	4.76
mid-Oct to mid-Nov	0.77	1.43	1.43 - 2.91	2.91	4.43
November	0.33	0.82	0.82 - 2.18	2.18	3.77
mid-Nov to mid-Dec	0.34	0.75	0.75 - 1.75	1.75	2.85
December	0.40	0.76	0.76 - 1.56	1.56	2.38
mid-Dec to mid-Jan	0.27	0.58	0.58 - 1.37	1.37	2.24

Table 7.

30-Day Temperature (To be used in conjunction with the 30-Day Forecast by the Climate Analysis Center)
Station: Des_Moines_WSFO_AP, Iowa (132203) Based on 1961-1990 Data

30-Day Period	Much Below Normal (Less Than)	Below Normal	Normal	Above Normal	Much Above Normal (Greater Than)
January	9.40	15.40	15.40 - 23.20	23.20	27.70
mid-Jan to mid-Feb	10.70	16.00	16.00 - 25.30	25.30	29.70
February	15.30	21.90	21.90 - 28.50	28.50	34.20
mid-Feb to mid-Mar	21.80	27.10	27.10 - 34.70	34.70	39.60
March	28.90	33.80	33.80 - 40.40	40.40	42.90
mid-Mar to mid-Apr	35.60	40.80	40.80 - 46.50	46.50	50.10
April	46.70	49.10	49.10 - 52.40	52.40	55.50
mid-Apr to mid-May	51.70	56.20	56.20 - 58.80	58.80	63.40
May	57.70	59.70	59.70 - 64.90	64.90	67.10
mid-May to mid-Jun	64.40	65.90	65.90 - 69.10	69.10	70.60
June	68.10	70.40	70.40 - 73.20	73.20	74.90
mid-Jun to mid-Jul	71.60	74.10	74.10 - 76.40	76.40	78.20
July	73.30	75.60	75.60 - 77.60	77.60	80.70
mid-Jul to mid-Aug	72.40	74.10	74.10 - 76.30	76.30	79.90
August	70.70	72.40	72.40 - 74.60	74.60	77.80
mid-Aug to mid-Sep	67.20	69.40	69.40 - 72.20	72.20	75.50
September	61.70	63.50	63.50 - 66.50	66.50	68.10
mid-Sep to mid-Oct	56.00	58.00	58.00 - 59.80	59.80	62.80
October	48.30	51.90	51.90 - 54.80	54.80	58.80
mid-Oct to mid-Nov	42.00	44.50	44.50 - 48.50	48.50	52.00
November	33.20	38.40	38.40 - 41.00	41.00	43.40
mid-Nov to mid-Dec	22.50	29.50	29.50 - 34.10	34.10	36.00
December	14.10	23.20	23.20 - 28.80	28.80	31.20
mid-Dec to mid-Jan	12.00	17.00	17.00 - 22.80	22.80	29.00

4. Question: What is the annual temperature variation (highs, lows, and extremes) near my farm in Aledo, IL?

   Answer: The best way to answer this is to look at a graph. From the main menu, choose "Graphs", and then choose "Max/Min Temperature", and then "Max, Min, and Extreme Temperatures". As before, you will be asked for a state (Illinois), a climate division (Northwest), and a station (Aledo). Now you have a choice of weekly or monthly data. Choose "Weekly Data" (for more detail). The resulting graph (Fig. 2) gives the average weekly high and low temperatures as well as the extreme temperatures during the period 1949-1990. As you would expect, all four curves show warming to the middle of July, followed by cooling to the middle of January.

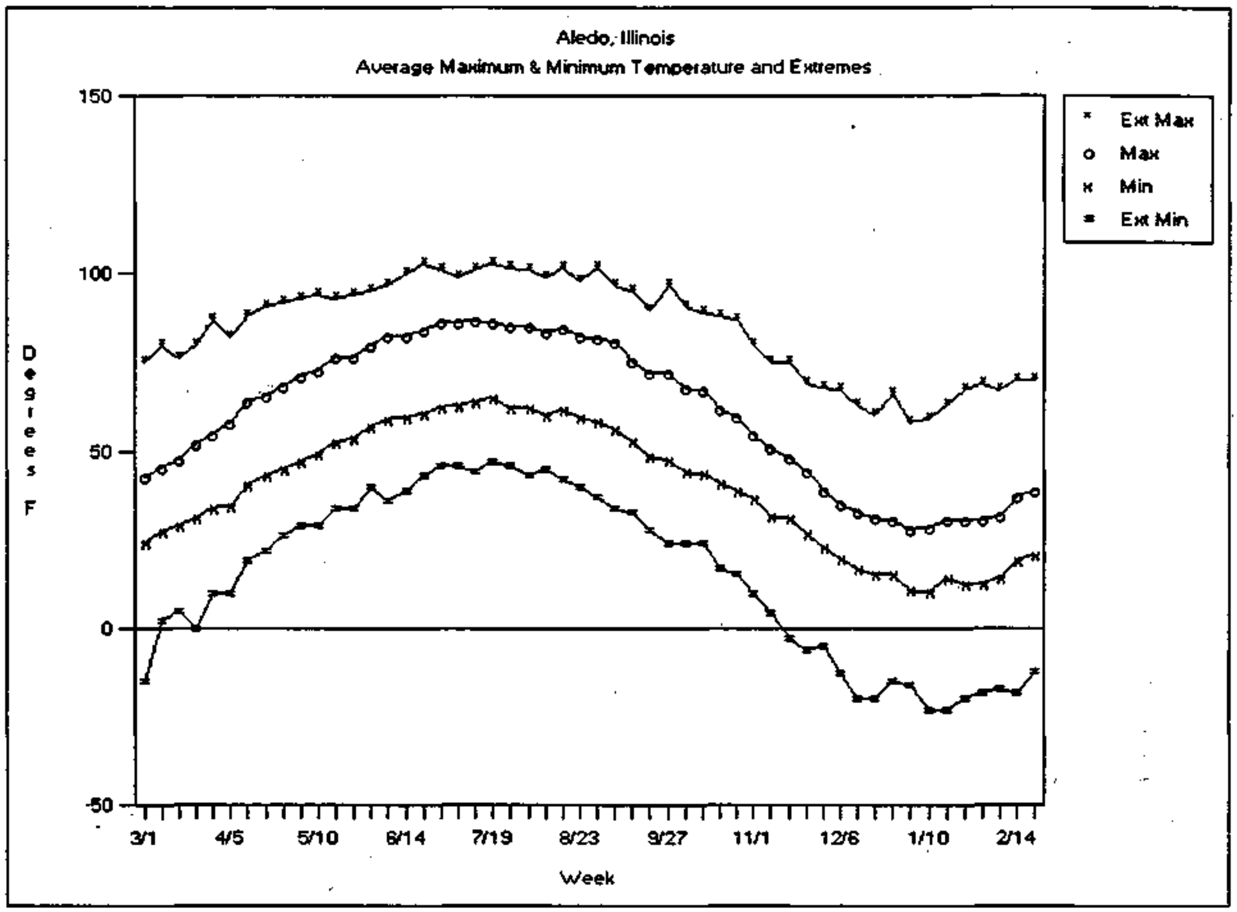

Figure 2. Average weekly maximum, minimum, extreme maximum, and extreme minimum temperatures at Aledo, IL.

5. Question: The com hybrid I plan to plant requires 2700 Base 50°F growing degree days (GDD) from planting to reach maturity. How late can I plant and still expect to accumulate 2700 GDDs before the first fall frost?

   Answer: To answer this question, you can generate a table listing accumulated degree days from various dates to the first fall frost. From the main menu, select **"Reports",** then **"Degree Days",** and then **"Crop to First Frost".** Next, choose the crop degree day base (choose **"Base 50 F"** for com) and first fall frost temperature threshold (in this case, 32 F). As before, you will be asked to select a state **(Ohio),** a climate division (Central), and a station **(Marion_2_N).** The resulting report (Table 8) lists accumulated Base 50 Crop degree days from various beginning dates to the first fall frost in 1 of 10, 5 of 10, and 9 of 10 years. In this discussion, a first fall frost date in 1 of 10 years means that you expect the first fall frost to occur on or before this date in 1 out of 10 years on average. A first frost date in 9 of 10 years means the first fall frost occurs 9 out of 10 years before this date. A 5 in 10 year date would be the most likely (that is, you would expect this date 50% of the time). The beginning dates are the typical (5 of 10 year) last spring frost at 5 temperature thresholds and each climatological week throughout the growing season. From Table 8 you can see that in order to reach 2700 degree days by the typical first fall frost (October. 7), you must plant by May 10. If the fall frost is early (September 23, 1 in 10 years), you must plant by roughly April 23. If the fall frost is late (October 20, 9 in 10 years), you can plant as late as May 18 and still expect to accumulate 2700 degree days.

Table 8.

Accumulated Degree Days From Various Dates to the First Fall Frost
For Base 50 Crop Degree Days and a 32F Fall Frost
Station: Marion_2_N, Ohio (334942) Based on 1961-1990 data

	First Fall Frost Occurs Before Given Date in		
	1 of 10 yrs	5 of 10 yrs	9 of 10 yrs
Beginning Day	Sep 23	Oct 7	Oct 20
Mar 15 (last 16 F freeze)	2867	3022	3128
Mar 22	2855	3009	3116
Mar 26 (last 20 F freeze)	2844	2999	3105
Mar 29	2836	2991	3097
Apr 5	2808	2962	3069
Apr 9 (last 24 F freeze)	2792	2947	3053
Apr 12	2781	2935	3042
Apr 19	2734	2889	2995
Apr 20 (last 28 F freeze)	2726	2881	2987
Apr 26	2679	2833	2940
May 3 (last 32 F freeze)	2617	2771	2878
May 10	2549	2703	2810
May 17	2468	2623	2729
May 24	2373	2527	2634
May 31	2273	2427	2534
Jun 7	2156	2310	2417
Jun 14	2023	2177	2284
Jun 21	1888	2043	2149
Jun 28	1751	1905	2012
Jul 5	1603	1757	1864
Jul 12	1451	1605	1712
Jul 19	1295	1449	1556
Jul 26	1134	1288	1395
Aug 2	983	1138	1244
Aug 9	833	988	1094
Aug 16	691	845	952
Aug 23	549	704	810
Aug 30	412	567	673
Sep 6	281	436	542
Sep 13	160	314	421
Sep 20	53	208	314
Sep 27	-	114	221
Oct 4	-	36	142
Oct 11	-	-	80
Oct 18	-	-	19

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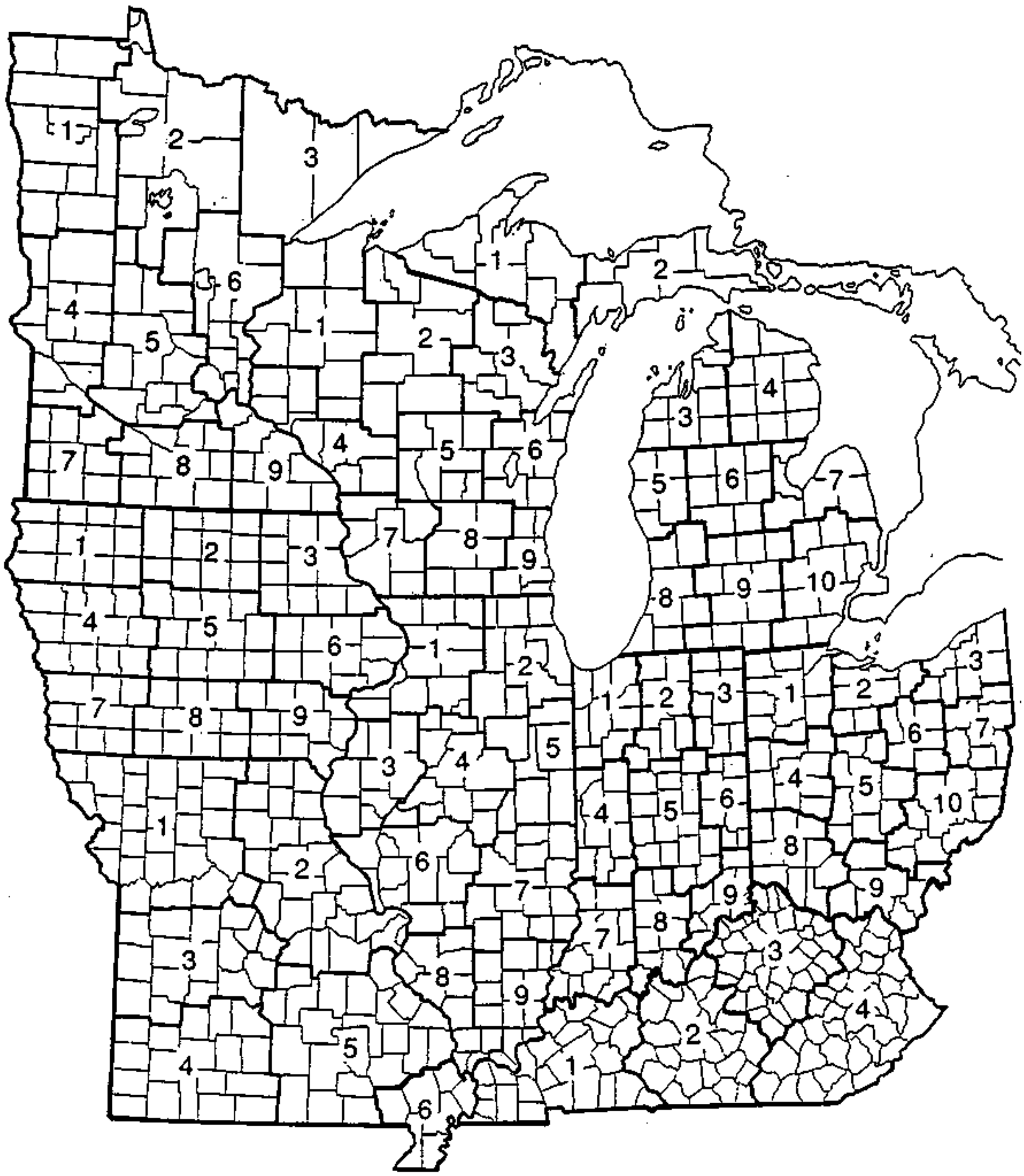
Appendix A.

Regional Climate Division map



Appendix B. Station Listing

Illinois

CD	Name	Lat		Long	
1	Aledo	41	13	90	43
1	Dixon_l_NW	41	49	89	31
1	Fulton_L&d_#_13	41	54	90	9
1	Galva	41	9	90	2
1	Kewanee_l_E	41	15	89	54
1	Moline_WSO_AP	41	28	90	30
1	Morrison	41	49	89	58
1	Mount_Carroll.	42	4	89	58
1	Rockford_WSO_AP	42	12	89	5
1	Stockton_l_N	42	20	90	0
1	Walnut	41	32	89	35
2	Antioch	42	30	88	7
2	Aurora.	41	45	88	20
2	Chicago_Midway	41	46	87	45
2	Chicago_University	41	46	87	35
2	Marengo	42	15	88	35
2	Ottawa_4_SW	41	19	88	55
2	Park_Forest	41	30	87	40
2	Waukegan	42	20	87	52
2	Wheaton_3_SE	41	49	88	4
3	Galesburg	40	56	90	22
3	La_Harpe	40	34	90	58
3	Monmouth	40	55	90	37
3	Quincy_FAA_Airport	39	55	91	11
3	Rushville	40	6	90	34
4	Chenoa	40	43	88	43
4	Decatur	39	49	89	0
4	Lincoln	40	8	89	22
4	Minonk	40	53	89	2
4	Peoria_WSO_AP	40	40	89	40
5	Danville	40	7	87	39
5	Hoopeston	40	27	87	39
5	Pontiac	40	52	88	37
5	Rantoul	40	19	88	10
5	Urbana	40	4	88	12
5	Watseka	40	46	87	45
6	Alton_Dam_26	38	52	90	10
6	Carlinville	39	16	89	52
6	Griggsville	39	42	90	43
6	Hillsboro	39	9	89	28
6	Jacksonville	39	43	90	11
6	Jerseyville_2_SW	39	5	90	20
6	Pana	39	22	89	4
6	Springfield_WSO_AP	39	50	89	40
6	Virden	39	30	89	45
6	White_Hall_l_E	39	25	90	22
7	Charleston	39	28	88	10
7	Effingham	39	7	88	20
7	Flora	38	40	88	33
7	Mattoon	39	28	88	19
7	Newton	38	54	88	6
7	Olney	38	42	88	10
7	Palestine	39	0	87	36
7	Paris_Waterworks	39	37	87	41
7	Tuscola	39	47	88	16
7	Windsor	39	25	88	35
8	Anna_l_E	37	28	89	13
8	Belleville	38	30	89	50
8	Cairo_WSO	37	0	89	10
8	Carbondale	37	43	89	11
8	Du_Quoin_4_SE	38	0	89	15
8	Sparta	38	7	89	43
9	Albion	38	22	88	2
9	Fairfield	38	22	88	18
9	Harrisburg	37	45	88	33
9	Mc_Leansboro	38	5	88	32
9	Mt_Vernon	38	20	88	51

Indiana

CD	Name	Lat		Long	
1	Hobart	41	31	87	15
1	Kentland	40	45	87	26
1	La_Porte	41	35	86	42
1	Valparaiso	41	30	87	1
1	Wheatfield_2_NNW	41	13	87	4
2	Delphi_3_NNE	40	37	86	40
2	Goshen_College	41	34	85	49
2	Plymouth	41	19	86	18
2	Rochester	41	3	86	12
2	South_Bend_WSO_AP	41	42	86	19
2	Wabash	40	46	85	48
3	Angola	41	37	84	58
3	Berne	40	39	84	56
3	Fort_Wayne_WSO_AP	41	0	85	11
4	Greencastle	39	38	86	50
4	Rockville	39	46	87	13
4	Spencer	39	16	86	45
5	Anderson_Sewage_Plant	40	5	85	43
5	Columbus	39	11	85	54
5	Elwood	40	15	85	50
5	Frankfort	40	18	86	30
5	Greenfield	39	46	85	45
5	Greensburg	39	19	85	26
5	Indianapolis_SE	39	45	86	6
5	Indianapolis_WSFO_AP	39	43	86	-16
5	Marion	40'	3 3	'85	-39
5	Martinsville_2_SW	39	24	86	2 6
5	Oaklandon_Geist_Resvr	39	54	85	58
5	Rushville	39	35	85	26
5	Shelbyville_Sewage_Pl	39	31	85	46
5	Whitestown	40	0	86	19
6	Cambridge_City	39	48	86	9
6	New_Castle	39	55	85	22
7	Crane_Naval_Depot	38	52	86	49
7	Evansville	37	58	87	33
7	Evansville_WSO_AP	38	2	87	31
7	Mount_Vernon	37	56	87	52
7	Princeton	38	20	87	34
7	Shoals	38	39	86	47
7	Washington	38	39	87	10
8	Bedford	38	52	86	32
8	Bloomington	39	9	86	3 0
8	Paoli	38	32	86	28
8	Salem	38	37	86	4
8	Seymour	38	58	85	53
8	Tell_City	37	56	86	45
9	Brookville	39	24	85	0
9	Madison	38	43	85	23
9	North_Vernon_2_SW	39	0	85	39
9	Scottsburg	38	42	85	46
9	Vevay	38	45	85	4

Iowa

CD	Name	Lat		Long	
1	Cherokee	42	45	95	31
1	Emmetsburg	43	5	94	40
1	Estherville	43	24	94	49
1	Hawarden	43	0	96	28
1	Lake_Park	43	26	95	18
1	Le_Mars	42	47	96	10
1	Milford_4_NW	43	22	95	10
1	Pocahontas	42	41	94	39
1	Primghar	43	4	95	37
1	Rock_Rapids	43	25	96	9
1	Sanborn	43	10	95	40
1	Sheldon	43	10	95	50
1	Sibley	43	26	95	42
1	Sioux_Rapids_4E	42	52	95	9
1	Spencer_l_N	43	10	95	9
1	Storm_Lake	42	37	95	10
2	Algona	43	3	94	17
2	Allison	42	45	92	46
2	Britt	43	4	93	48
2	Charles_City	43	2	92	39
2	Clarion	42	43	93	43
2	Forest_City_2NNE	43	16	93	37
2	Hampton	42	45	93	11
2	Mason_City	43	9	93	11
2	Mason_City_FAA_AP	43	10	93	19
2	Northwood	43	27	93	13
2	Osage	43	16	92	47
3	Cascade	42	17	91	1
3	Cresco	43	22	92	5
3	Decorah	43	17	91	47
3	Dubuque_L_&_D_ll	42	31	90	39
3	Dubuque_WSO_AP	42	24	90	41
3	Elkader_5_SSW	42	49	91	25
3	Fayette	42	49	91	47
3	Guttenberg_L_And_D_10	42	46	91	5
3	New_Hampton	43	2	92	18
3	Oelwein	42	38	91	54
3	Tripoli	42	48	92	15
3	Waterloo_WSO_AP	42	32	92	24
3	Waukon	43	15	91	28
4	Audubon	41	43	94	55
4	Carroll	42	3	94	50
4	Castana	42	3	95	48
4	Denison	42	1	95	19
4	Guthrie_Center	41	40	94	31
4	Harlan	41	39	95	19
4	Ida_Grove	42	20	95	28
4	Jefferson	42	1	94	22
4	Logan	41	37	95	49
4	Mapleton_No.2	42	10	95	46
4	Onawa	42	1	96	5
4	Rockwell_City	42	24	94	37
4	Sac_City	42	25	95	0
4	Sioux_City_WSO_AP	42	24	96	22
5	Ankeny_3_S	41	40	93	35
5	Boone	42	2	93	52
5	Des_Moines_WSFO_AP	41	31	93	39
5	Fort_Dodge	42	30	94	11
5	Grinnell	41	42	92	43
5	Grundy_Center	42	22	92	46
5	Iowa_Falls	42	31	93	15
5	Marshalltown	42		92	55
5	Newton	41	41	93	2
5	Perry	41	49	94	6
5	Toledo	41	58	92	34
5	Webster_City	42	28	93	48
6	Anamosa	42	6	91	17
6	Belle_Plaine	41	54	92	16
6	Bellevue_L_And_D_12	42	16	90	25
6	Cedar_Rapids_No_l	42	1	91	34
6	Clinton_No_l	41	47	90	16
6	Iowa_City	41	38	91	31
6	Le_Claire_L_And_D_14	41	34	90	25
6	Maquoketa_2_W	42	4	90	41
6	Muscatine	41	24	91	4
6	Tipton	41	46	91	6
6	Vinton	42	9	92	0
6	Williamsburg	41	40	92	1
7	Atlantic	41	24	95	0
7	Bedford	40	40	94	43
7	Clarinda	40	43	95	1
7	Corning	41	0	94	45
7	Glenwood_3sw	41	0	95	46
7	Greenfield	41	17	94	28
7	0akland_2_E	41	19	95	22
7	Red_Oak	41	0	95	13
7	Sidney	40	45	95	39
8	Albia	41	3	92	46
8	Centerville	40	43	92	51
8	Chariton	41	0	93	18
8	Creston	41	1	94	23
8	Indianola	41	22	93	33
8	Knoxville	41	19	93	7
8	Mount_Ayr	40	38	94	17
8	Osceola	41	0	93	48
8	Winterset	41	19	94	0
9	Bloomfield	40	45	92	25
9	Columbus_Junct_2_SSW	41	15	91	22
9	Fairfield	41	1	91	56
9	Keokuk_Lock_Dam_19	40	24	91	22
9	Keosauqua	40	43	91	58
9	Mount_Pleasant	40	56	91	32
9	Oskaloosa	41	18	92	38
9	Ottumwa_Airport	41	5	92	26
9	Sigourney	41	19	92	11
9	Washington	41	16	91	40

Kentucky

CD	Name	Lat		Long	
1	Beaver_Dam	37	25	86	52
1	Henderson	37	45	87	37
1	Hopkinsville	36	49	87	30
1	Lovelaceville	36	58	88	49
1	Madisonville	37	20	87	30
1	Murray	36	37	88	41
1	Owensboro_3_W	37	46	87	9
1	Paducah_WSO	37	4	88	46
2	Bowling_Green_FAA_AP	36	58	86	25
2	Campbellsville	37	13	85	20
2	Greensburg	37	15	85	30
2	Leitchfield	37	30	86	17
2	Louisville_WSFO_AP	38	10	85	43
2	Mammoth_Cave	37	10	86	4
2	Scottsville	36	43	86	12
2	Summer_Shade	36	52	85	43
3	Berea_College	37	33	84	17
3	Carrollton_Lock_l	38	39	85	9
3	Covington_WSO_AP	39	4	84	40
3	Danville	37	39	84	46

3	Farmers_2S(Cave_Runl)	38	7	83	33
3	Frankfort_Lock_4	38	13	84	52
3	Lexington_WSO_AP	38	1	84	35
3	Maysville	38	40	83	46
3	Shelbyville	38	11	85	11
3	Williamstown_3_NW	38	39	84	37
4	Ashland	38	27	82	37
4	Barbourville	36	51	83	52
4	Baxter	36	50	83	19
4	Heidelberg	37	32	83	45
4	Manchester_4_SE	37	5	83	43
4	Middlesboro	36	35	83	43
4	Somerset	37	6	84	36
4	West_Liberty	37	55	83	16

Michigan

CD	Name	Lat		Long	
1	Beechwood_7_WNW	46	10	88	52
1	Bergland_Dam	46	34	89	33
1	Champion_Van_Riper_Pk	46	31	87	58
1	Houghton_FAA_Airport	47	10	88	30
1	Iron_Mtn.-Kingsford_Wwtp	45	46	88	4
1	Ironwood	46	27	90	10
1	Ishpeming	46	28	87	39
1	Lapeer	43	2	83	19
1	Marquette	46	32	87	22
1	Mt_Clemens	42	35	82	49
1	Port_Huron	42	58	82	25
1	Stambaugh	46	3	88	37
1	Stephenson	45	26	87	45
2	Chatham	46	20	86	55
2	Dunbar_Forest_Exp_Sta	46	19	84	13
2	Fayette_4_SW	45	40	86	43
2	Grand_Marais_2_E	46	40	85	58
2	Manistique	45	57	86	15
2	Newberry_State_Hosp	46	19	85	30
2	Sault_Ste_Marie_WSO	46	28	84	22
3	Cadillac	44	16	85	24
3	East_Jordan	45	9	85	7
3	Houghton_Lake_6_WSW	44	19	84	52
3	Lake_City	44	18	85	11
3	Manistee	44	13	86	16
3	Pellston_FAA_Airport	45	34	84	46
4	Alpena_WSO_AP	45	4	83	34
4	Alpena_Wastewater_Pl	45	4	83	25
4	Cheboygan	45	39	84	28
4	Gaylord_2_W	45	1	84	43
4	Grayling	44	39	84	41
4	Hale_Loud_Dam	44	28	83	43
4	Lupton_l_S	44	25	84	1
4	Mio_Hydro_Plant	44	40	84	7
4	Onaway_State_Park	45	25	84	13
5	Baldwin	43	53	85	50
5	Hart	43	41	86	21
5	Hesperia	43	34	86	5
5	Ludington_4_SE	43	54	86	24
5	Montague_4_NW	43	28	86	25
5	Muskegon_WSO_AP	43	10	86	13
6	Alma	43	22	84	39
6	Big_Rapids_Waterworks	43	42	85	28
6	Evart	43	54	85	16
6	Gladwin	43	58	84	30
6	Greenville_2_NNE	43	12	85	15
6	Mt_Pleasant_Univ	43	34	84	46
7	Bad_Axe	43	48	83	0
7	Caro_State_Hospital	43	27	83	24
7	Harbor_Beach_l_SSE	43	49	82	37
7	Saginaw_FAA_Airport	43	31	84	4
7	Sandusky	43	24	82	49
7	Standish	44	0	83	57
8	Allegan	42	30	85	49
8	Benton_Harbor_Airport	42	7	86	25
8	Bloomingdale	42	22	85	58
8	Eau_Claire_4_NE	42	1	86	15
8	Grand_Haven_Fire_Dept.	43	4	86	13
8	Gull_Lake	42	23	85	23
8	Holland	42	47	86	6
8	Kalamazoo	42	16	85	35
8	South_Haven	42	24	86	16
9	Battle_Creek	42	19	85	10
9	Charlotte	42	32	84	49
9	Coldwater	41	56	85	0
9	Hastings	42	38	85	17
9	Hillsdale	41	55	84	37
9	Ionia	42	58	85	3
9	Jackson_FAA_AP	42	15	84	26
9	Owosso	42	57	84	11
9	Saint_Johns	43	1	84	33
9	Three_Rivers	41	55	85	37
10	Adrian_2_NNE	41	55	84	1
10	Ann_Arbor_U_Of_Mich	42	17	83	43
10	Flint_WSO_AP	42	58	83	45
10	Grosse_Pointe_Farms	42	22	82	54
10	Milford	42	34	83	41
10	Monroe	41	55	83	24
10	Pontiac_State_Hosp	42	39	83	18

Minnesota

CD	Name	Lat		Long	
1	Ada	47	17	96	31
1	Argyle	48	19	96	43
1	Crookston_NW_Exp_Sta	47	47	96	37
1	Detroit_Lakes	46	48	95	41
1	Fosston	47	34	95	43
1	Hallock	48	46	96	56
1	Itasca_Univ_Of_Minn	47	13	95	11
1	Red_Lake_Falls	47	52	96	16
1	Warroad	48	55	95	19
2	Baudette	48	43	94	37
2	Bemidji	47	30	94	55
2	Big_Falls	48	12	93	48
2	Cass_Lake	47	22	94	37
2	Grand_Rapids	47	13	93	30
2	Gull_Lake_Dam	46	25	94	20
2	Int_Falls_WSO_AP	48	34	93	22
2	Leech_Lake_Dam	47	15	94	13
2	Park_Rapids	46	55	95	4
2	Pokegama_Dam	47	15	93	34
2	Red_Lake_Indian_Agcy	47	52	95	1
2	Walker_Ah_Gwah_Ching	47	4	94	34
2	Winnibigoshish_Dam	47	25	94	3
3	Duluth_WSO_AP	46	49	92	10
3	Grand_Marias	47	43	90	20
3	Two_Harbors	47	1	91	40
4	Alexandria_FAA_AP	45	52	95	22
4	Artichoke_Lake	45	22	96	7
4	Benson	45	18	95	35
4	Canby	44	43	96	16
4	Fergus_Falls	46	16	96	4
4	Glenwood_2_WNW	45	40	95	25
4	Madison_Sewage_Plant	45	0	96	10
4	Milan_l_NW	45	0	95	55
4	Montevideo	44	55	95	45
4	Morris	45	34	95	52

4	Wheaton	45	47	96	28
5	Chaska	44	47	93	34
5	Collegeville_St_John	45	34	94	24
5	Jordan_l_S	44	39	93	37
5	Litchfield	45	6	94	31
5	Little_Falls_l_N	45	58	94	20
5	Long_Prairie	45	58	94	50
5	St_Cloud_WSO_AP	45	32	94	4
5	Wadena	46	23	95	8
5	Willmar_State_Hospital	45	7	95	1
6	Cambridge_State_Hospital	45	34	93	13
6	Cloquet	46	42	92	31
6	Hinckley	46	0	92	55
6	Milaca_l_ENE	45	47	93	40
6	Minneapolis_RFC	44	52	93	13
6	Moose_Lake_l_SSE	46	27	92	45
6	Mora	45	52	93	18
6	Pine_River_Dam	46	40	94	7
6	Sandy_Lake_Dam_Libby	46	47	93	19
7	Marshall	44	26	95	47
7	Pipestone	44	1	96	19
7	Redwood_Falls_FAA_AP	44	32	95	4
7	Tracy	44	13	95	37
7	Windom	43	52	95	5
8	Albert_Lea	43	36	93	24
8	Fairmont	43	37	94	28
8	Faribault	44	17	93	15
8	New_Ulm	44	17	94	26
8	Springfield_l_NW	44	15	94	58
8	St_Peter_2_SW	44	17	93	58
8	Waseca	44	3	93	30
8	Winnebago	43	46	94	10
9	Austin_3_S	43	37	93	0
9	Farmington_3_NW	44	40	93	10
9	Grand_Meadow	43	42	92	34
9	Rochester_WSO_AP	43	55	92	30
9	Rosemount_Agr_Exp_Sta	44	43	93	5
9	Winona	44	2	91	37
9	Zumbrota	44	17	92	39

Missouri

CD	Name	Lat		Long	
1	Bethany	40	15	94	2
1	Brookfield	39	47	93	4
1	Brunswick	39	25	93	7
1	Carrollton	39	22	93	30
1	Conception	40	15	94	40
1	Grant_City	40	28	94	24
1	Lexington	39	12	93	52
1	Maryville_2_E	40	20	94	49
1	Salisbury	39	25	92	49
1	Sweet_Springs	38	57	93	24
1	Unionville	40	28	93	0
2	Canton_L_And_D_20	40	9	91	31
2	Elsberry_l_S	39	9	90	46
2	Fulton	38	50	91	56
2	Hannibal	39	42	91	21
2	Kirksville_Radio_KIRX	40	13	92	34
2	Mexico	39	10	91	54
2	Moberly	39	23	92	25
2	Saverton_L_And_D_22	39	37	91	15
2	Shelbina	39	40	92	2
2	St_Charles	38	46	90	30
2	St_Louis_WSCMO_AP	38	36	90	10
2	Steffenville	39	57	91	52
2	Union	38	26	91	0
3	Appleton_City	38	11	94	1
3	Boonville	38	57	92	45
3	Butler	38	15	94	18
3	Camdenton	38	0	92	45
3	Clinton	38	23	93	45
3	Eldon	38	20	92	34
3	Jefferson_City	38	34	92	8
3	Lakeside	38	12	92	37
3	Nevada	37	50	94	23
3	Sedalia	38	39	93	12
3	Versailles	38	25	92	50
3	Warrensburg	38	43	93	42
4	Anderson	36	39	94	25
4	Bolivar	37	35	93	24
4	Carthage	37	10	94	19
4	Joplin_FAA_Airport	37	10	94	30
4	Lamar	37	30	94	15
4	Lebanon_2_W	37	40	92	39
4	Lockwood	37	22	93	56
4	Marshfield	37	19	92	53
4	Mountain_Grove	37	8	92	15
4	Neosho	36	51	94	21
4	Ozark_Beach	36	39	93	6
4	Springfield_WSO_AP	37	13	93	22
5	Arcadia	37	34	90	37
5	Clearwater_Dam	37	7	90	46
5	Doniphan	36	34	90	48
5	Farmington	37	41	90	22
5	Greenville_6_N	37	12	90	26
5	Jackson	37	22	89	40
5	Licking	37	32	91	53
5	Marble_Hill	37	17	89	58
5	Salem	37	37	91	31
5	Waynesville	37	48	92	13
5	West_Plains	36	43	91	50
5	Willow_Spgs_Rdo_KUKU	36	58	91	58
6	Advance_l_S	37	5	89	54
6	Caruthersville	36	11	89	39
6	Poplar_Bluff	36	45	90	24
6	Wappapello_Dam	36	55	90	16

Ohio

CD	Name	Lat		Long	
1	Bowling_Green_Sewage	41	22	83	37
1	Defiance	41	16	84	22
1	Findlay_FAA_AP	41	1	83	40
1	Findlay_Wpcc	41	2	83	40
1	Hoytville_2_NE	41	13	83	46
1	Lima_Wwtp	40	43	84	7
1	Montpelier_lWSW	41	34	84	35
1	Pandora	40	57	83	58
1	Paulding	41	7	84	35
1	Toledo_Blade	41	39	83	31
1	Van_Wert	40	49	84	34
1	Wauseon_Water_Plant	41	31	84	9
2	Bucyrus	40	49	82	58
2	Elyria_3_E	41	22	82	3
2	Fremont	41	19	83	7
2	Norwalk_Wwtp	41	16	82	37
2	Oberlin	41	16	82	13
2	Sandusky	41	27	82	43
2	Tiffin	41	7	83	10
2	Upper_Sandusky	40	49	83	16
3	Akron_Canton_WSO_AP	40	55	81	25
3	Ashtabula	41	50	80	48
3	Chardon	41	34	81	10
3	Chippewa_Lake	41	4	81	54
3	Cleveland_WSFO_AP	41	25	81	52
3	Hiram	41	17	81	9

3	Mineral_Ridge_Water_Works	41	9	80	46
3	Painesville_4_NW	41	45	81	18
3	Warren_3_S	41	12	80	49
3	Youngstown_WSO_AP	41	15	80	40
4	Bellefontaine	40	20	83	46
4	Greenville_Water_Plant	40	5	84	39
4	Kenton	40	39	83	35
4	Urbana_Wwtp	40	5	83	46
5	Circleville	39	37	82	56
5	Columbus_Vly_Crossing	39	54	82	55
5	Columbus_WSO_AP	40	0	82	52
5	Delaware	40	16	83	4
5	Irwin	40	7	83	28
5	London_Water_Works	39	52	83	26
5	Marion_2_N	40	37	83	7
5	Marysville	40	13	83	22
5	Newark_Water_Wks	40	4	82	25
5	Washington_Court_House	39	31	83	25
6	Ashland_2_SW	40	49	82	20
6	Charles_Mill_Lake	40	43	82	22
6	Coshocton_3_SSW	40	15	81	52
6	Fredericktown_4_S	40	25	82	31
6	Mansfield_5_W	40	46	82	37
6	Mansfield_WSO_AP	40	49	82	31
6	Wooster_Exp_Station	40	46	81	55
7	Cadiz	40	16	81	0
7	Canfield_l_S	41	1	80	46
7	Millport_2_NW	40	43	80	54
7	Steubenville	40	22	80	37
8	Chilo_Meldahl_Locks_&_Dam	38	47	84	10
8	Dayton-mcd	39	46	84	10
8	Dayton_WSO_AP	39	54	84	11
8	Hillsboro	39	12	83	37
8	Wilmington_3_N	39	28	83	50
8	Xenia_5_SSE	39	37	83	54
9	Gallipolis	38	49	82	10
9	Jackson_2_NW	39	4	82	39
9	Portsmouth	38	45	82	52
9	Waverly	39	7	82	58
10	Barnesville	39	58	81	9
10	Mc_Connellsville_Lk_7	39	39	81	50
10	New_Lexington_2_NW	39	43	82	13
10	Philo_3_SW	39	49	81	55
10	Senecaville_Lake	39	55	81	25
10	Zanesville_FAA_AP	39	57	81	54

Wisconsin

CD	Name	Lat		Long	
1	Amery	45	17	92	22
1	Ashland	46	33	90	57
1	Bayfield	46	52	90	48
1	Bloomer	45	5	91	28
1	Cumberland	45	31	92	1
1	Danbury	46	0	92	21
1	Grantsburg	45	46	92	41
1	Holcombe	45	13	91	7
1	Rice_Lake	45	30	91	43
1	Solon_Springs	46	20	91	48
1	Spooner_Exp_Farm	45	49	91	52
1	St_Croix_Falls	45	25	92	39
1	Stanley	44	58	90	55
1	Superior	46	42	92	1
1	Weyerhauser_2_SSE	45	25	91	22
2	Long_Lake_Dam	45	54	89	7
2	Madeline_Island	46	49	90	39
2	Medford	45	7	90	20
2	Mellen_4_NE	46	25	90	37
2	Merrill	45	10	89	40
2	Minocqua_Dam	45	52	89	43
2	Neillsville	44	31	90	37
2	North_Pelican	45	37	89	15
2	Owen	44	56	90	31
2	Park_Falls	45	55	90	26
2	Prentice_No._2	45	31	90	16
2	Rainbow_Reservoir	45	49	89	33
2	Rest_Lake	46	7	89	52
2	Rhinelander	45	37	89	25
2	Rosholt	44	45	89	15
2	Wausau_FAA_Airport	44	55	89	37
3	Antigo	45	7	89	8
3	Brule_Island	45	57	88	13
3	Crivitz	45	16	88	11
3	Laona_6_SW	45	31	88	45
3	Marinette	45	5	87	37
3	Oconto_4_W	44	54	87	56
3	Shawano_2_SSW	44	46	88	37
4	Alma_Dam_4	44	19	91	55
4	Blair	44	17	91	13
4	Eau_Claire_FAA_AP	44	52	91	28
4	Ellsworth_l_E	44	43	92	28
4	Hatfield_Hydro_Plant	44	24	90	43
4	La_Crosse_FFA_AP	43	52	91	15
4	Mather_3_NW	44	10	90	22
4	Mondovi	44	34	91	40
4	River_Falls	44	52	92	37
4	Sparta	43	55	90	49
4	Trempealeau_Dam_6	44	0	91	25
5	Clintonville	44	37	88	45
5	Dalton	43	39	89	11
5	Hancock	44	6	89	31
5	Marshfield_Exp_Farm	44	39	90	7
5	New_London	44	22	88	43
5	Stevens_Point	44	30	89	34
5	Waupaca	44	20	89	3
5	Wisconsin_Rapids	44	22	89	48
6	Appleton	44	15	88	22
6	Chilton	44	1	88	8
6	Fond_Du_Lac	43	47	88	26
6	Green_Bay_WSO_AP	44	28	88	7
6	Kewaunee	44	25	87	31
6	Manitowoc	44	5	87	40
6	Oshkosh	44	1	88	32
6	Plymouth	43	45	87	58
6	Sheboygan	43	45	87	43
6	Sturgeon_Bay	44	51	87	19
6	Two_Rivers	44	9	87	34
6	Washington_Is	45	22	86	55
7	Baraboo	43	28	89	43
7	Darlington	42	40	90	6
7	Dodgeville	42	57	90	6
7	Genoa_Dam_8	43	34	91	13
7	Lancaster	42	49	90	46
7	Lynxville_Dam_9	43	13	91	5
7	Platteville	42	45	90	28
7	Prairie_Du_Chien	43	1	91	8
7	Prairie_Du_Sac_2_N	43	19	89	43
7	Reedsburg	43	31	90	1
7	Richland_Center	43	19	90	22
7	Virogua	43	33	90	53
8	Beloit	42	30	89	1
8	Brodhead	42	36	89	22
8	Fort_Atkinson	42	52	88	49
8	Lake_Mills	43	4	88	55
8	Madison_WSO_AP	43	7	89	19
8	Portage	43	31	89	25
8	Stoughton	42	55	89	13

8	Watertown	43	10	88	43
9	Burlington	42	40	88	16
9	Germantown	43	13	88	7
9	Kenosha	42	32	87	49
9	Lake_Geneva	42	35	88	25
9	Milwaukee_Mt_Mary_Col	43	4	88	1
9	Milwaukee_WSFO_AP	42	57	87	54
9	Oconomowoc	43	5	88	30
9	Racine	42	42	87	46
9	Waukesha	43	1	88	13
9	West_Bend	43	24	88	10