# Meteorological and Associated Data Collected Over Agricultural Fields in Pinal County, Arizona, 1989 and 1990

By SANDRA J. OWEN-JOYCE and PAUL W. BROWN

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## CONVERSION FACTORS AND VERTICAL DATUM

| Multiply | By | To obtain |
|---|---|---|
| *Area* | | |
| square meter ($m^2$) | 10.76 | square foot ($ft^2$) |
| square kilometer ($km^2$) | 0.3861 | square mile ($mi^2$) |
| hectare (ha) | 2.471 | acre |
| *Density* | | |
| grams per cubic centimeter ($g/cm^3$) | 62.428 | pounds per cubic foot ($lb/ft^3$) |
| *Energy* | | |
| joule (J) | $9.4787 \times 10^{-5}$ | British thermal unit (Btu) |
| joule (J) | 0.2388 | calorie (cal) |
| *Length* | | |
| kilometer (km) | 0.621 | mile (mi) |
| meter (m) | 3.281 | foot (ft) |
| centimeter (cm) | 0.3937 | inch (in.) |
| *Mass* | | |
| gram (g) | $2.205 \times 10^{-3}$ | pound (lb) |
| *Power* | | |
| kilowatt (kW) | $10^{-3}$ | watt (W) |
| watt (W) | 3.412 | British thermal units per hour (Btu/hr) |
| watt (W) | 0.2388 | calories per second (cal/s) |

## CONVERSION FACTORS AND VERTICAL DATUM—Continued

| Multiply | By | To obtain |
|---|---|---|
| *Pressure* | | |
| kilopascal (kPa) | 0.2953 | inches of mercury (in. Hg) |
| kilopascal (kPa) | 0.1450 | pound per square inch ($lb/in^2$) |
| kilopascal (kPa) | 10 | millibar (mbar) |
| millibar (mbar) | $0.9869 \times 10^{-3}$ | atmosphere (atm) |
| *Temperature* | | |
| degree Celsius (°C) | 1.8°C+32 | degree Fahrenheit (°F) |
| Kelvin (K) | (K-273.15)1.8+32 | degree Fahrenheit (°F) |
| *Velocity or Rate* | | |
| meter per second (m/s) | 2.237 | mile per hour (mi/hr) |

*Sea level*: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929—A geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called "Sea Level Datum of 1929."

## SYMBOLS USED IN TEXT

| | |
|---|---|
| ET | Evapotranspiration |
| $e_a$ | Atmospheric vapor pressure |
| $e_s$ | Saturation vapor pressure |
| *RH* | Relative humidity |
| $R_N$ | Net radiation |
| *SR* | Solar radiation |
| *G* | Soil heat flux density |
| $T_a$ | Air temperature |
| $T_c$ | Surface or canopy temperature |
| $T_s$ | Soil temperature |
| *U* | Wind speed |
| *VPD* | Vapor pressure deficit |
| $\Theta g$ | Gravimetric soil-water content |
| $\Theta v$ | Surface-layer volumetric water content |
| $\rho_b$ | Soil bulk density |

# Meteorological and Associated Data Collected Over Agricultural Fields in Pinal County, Arizona, 1989 and 1990

*By* Sandra J. Owen-Joyce *and* Paul W. Brown[1]

## Abstract

Data were collected at temporary meteorological stations installed in agricultural fields in Pinal County, Arizona, to evaluate the spatial and temporal variability of point data and to examine how station location affects ground-based meteorological data and the resulting values of evapotranspiration calculated using remotely sensed multispectral data from satellites. Time-specific data were collected to correspond with satellite overpasses from April to October 1989 and June 27–28, 1990.

Meteorological data consisting of air temperature, relative humidity, wind speed, solar radiation, and net radiation were collected at each station during all periods of the project. Supplementary measurements of soil temperature, soil heat flux density, and surface or canopy temperature were obtained at some locations during certain periods of the project. Additional data include information on data-collection periods, station positions, instrumentation, sensor heights, and field dimensions. Other data, which correspond to the extensive field measurements made in conjunction with satellite overpasses, include crop type, canopy cover, canopy height, irrigation, cultivation, and orientation of rows. Field boundaries and crop types were mapped in a 2- to 3-square-kilometer area surrounding each meteorological station. Field data are presented in tabular and graphic form. Meteorological and supplementary data are available, upon request, in digital form.

## INTRODUCTION

Current methods to estimate evapotranspiration (ET) of crops and natural vegetation in arid and semiarid areas use a simple model that includes standard empirical or semiempirical equations that require some form of ground-based meteorological data. Meteorological stations collect data at various points in agricultural areas. Most commonly used ET models are not highly accurate, particularly when used to estimate ET for regional use.

The acquisition of remotely sensed emitted and reflected electromagnetic radiation (multispectral) data from satellites provides a means of obtaining regional coverage. A method that uses remotely sensed multispectral data has been suggested as a means of improving regional ET estimation. Techniques have been developed to estimate ET by using remotely sensed multispectral data and ground-based meteorological data as a result of cooperative research among the U.S. Department of Agriculture, Agricultural Research Service, the University of Arizona, and the U.S. Geological Survey. Remotely sensed multispectral data, combined with ground-based meteorological data, can provide accurate estimates of ET under clear sky conditions and over uniformly cropped fields (Hatfield and others, 1983; Jackson and others, 1983, 1987; Reginato and others, 1985). For regional use, a major limitation to the accuracy of the ET estimates from the method that combines remotely sensed and ground-based data is thought to be the areal limitation over which the ground-based meteorological data can be extrapolated

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(Jackson and others, 1987; Reginato and others, 1985). The quality and acquisition interval of ground-based meteorological data and the condition of underlying and surrounding surfaces also can limit the accuracy of the ET estimates; successful extrapolation of ground-based meteorological data across a region probably will depend on whether surface characteristics at the station are representative of regional surface conditions (Brown and Owen-Joyce, 1991).

## Background

Annual cooperative research field experiments, organized by the U.S. Department of Agriculture, Agricultural Research Service, Water Conservation Laboratory, were conducted at the University of Arizona Maricopa Agricultural Center (MAC) south of Phoenix (fig. 1) from 1985 to 1990 and included the study of ET at point scale and the relation of point ET to the spatial distribution of vegetation. These five MAC experiments, known as MACI to MACV, varied in length and included participation by scientists of the U.S. Geological Survey and other agencies who work independently but cooperatively share the data collected (Moran, 1986a, b). The similarly designed Remote Sensing Technology Transfer experiment, coordinated by the University of Arizona, was conducted between MACIV and MACV.

The MACIV experiment was held April 8–10, 1989, to correspond with the overpasses of the Systeme Probatoire pour l'Observation de la Terre (SPOT) satellite on April 9 and 10. The experiment investigated water use by crops and plant response with special emphasis on the comparison of ground-based measurements of ET with estimates based on remotely sensed data coupled with ground-based temperature and vapor-pressure data. Major objectives were to measure photosynthesis, water use, and components of the energy balance of large wheat and alfalfa fields using a variety of instruments and techniques, and to characterize the spatial variation in plant distribution using aircraft and SPOT satellite sensors.

The Remote Sensing Technology Transfer experiment, which has become known among the participants as MacSPOT, began in April during MACIV and continued through October to demonstrate the feasibility of remote-sensing techniques as an agricultural-management tool. The experiment investigated the potential commercial applications of this technology to agriculture with a long-term goal of providing the farmer with a "real time" management tool for (1) detection and early warning indicators of pest, water, and nutrient stress problems; (2) yield forecasting; and (3) efficient application of water, nutrients, and biologic pest-control substances.

The MACV experiment was held June 26–28, 1990, to correspond with the overpasses of the Landsat and SPOT satellites on June 27 and 28. The experiment continued the investigation of water use by crops and plant response. Major objectives were to measure water use and components of the energy balance of alfalfa and cotton fields using a variety of instruments and techniques and to characterize the spatial variation in plant distribution using aircraft and satellite sensors.

## Purpose of the Investigation

This research project was one of many individual efforts to collect the data necessary to estimate ET and to explore the relation between ET and the variables required to estimate ET in coordination with the MACIV, MacSPOT, and MACV experiments during 1989 and 1990. This independent project was designed to evaluate the spatial and temporal variability of point data collected at meteorological stations and to examine how station location affects ground-based meteorological data and the resulting values of ET calculated using remotely sensed multispectral data from satellites and aircraft—the remote model of Jackson and others (1985). Research was conducted by the U.S. Geological Survey and University of Arizona, in cooperation with the Bureau of Reclamation. The meteorological data were collected under contract by the University of Arizona.

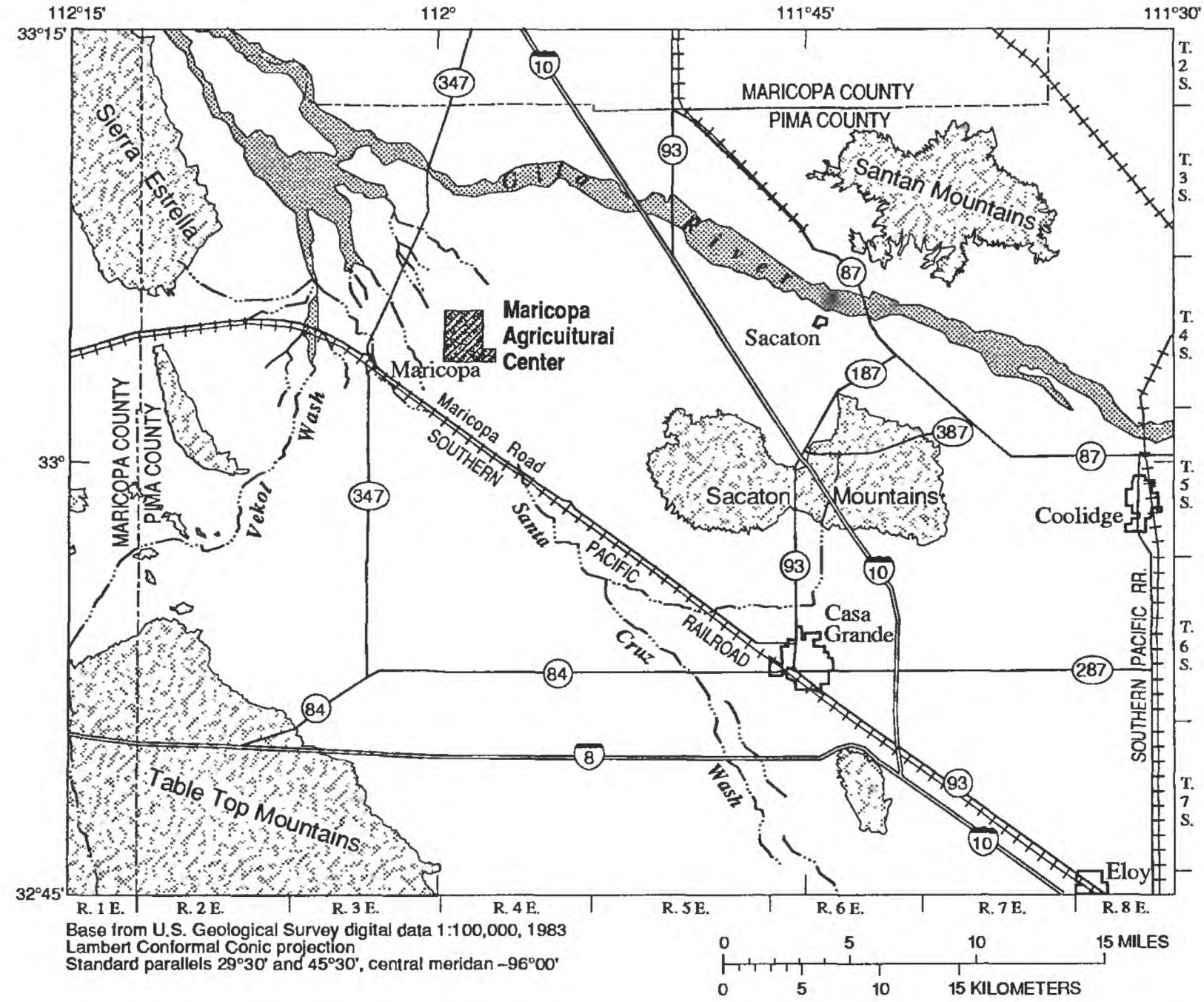


**Figure 1.** Location of the Maricopa Agricuiturai Center, Pinal County, Arizona.

## Scope of Report

In order to share the data collected among the participating scientists, this report presents (1) a description of the meteorological data collected during each part of this project, which was subdivided to correspond with the different groups of participating scientists; (2) documentation of the supplementary data associated with the meteorological data; (3) some sample data plots from the MACIV and MACV experiments; and (4) information on the data-file format and how to obtain the computer files of the data sets. Supplementary data include information on station position, instrumentation, sensor heights, field dimensions, crop type, and data-collection periods. Additional data correspond to the extensive field measurements made in conjunction with satellite overpasses and include changes in canopy cover and canopy height.

## Algorithms

In addition to the meteorological parameters measured in the field, some other parameters were calculated. Saturation vapor pressure, atmospheric vapor pressure, and vapor pressure deficit were calculated and added to the data base for each station during MACIV. Saturation vapor pressure was calculated from air temperature using the formula of Tetens (1930)

$$e_s = 6.108 \times \exp[(17.27 \times T_a)/(T_a + 237.3)], \quad (1)$$

where

$e_s$ = saturation vapor pressure, in mbar, and

$T_a$ = air (dry bulb) temperature, in degrees Celsius.

Atmospheric vapor pressure was obtained as

$$e_a = (RH/100) \times e_s, \quad (2)$$

where

$e_a$ = atmospheric vapor pressure, in mbar, and

$RH$ = relative humidity, in percent.

Vapor pressure deficit ($VPD$) was determined as

$$VPD = e_s - e_a. \quad (3)$$

Soil samples were delivered to the lab where the gravimetric water content was obtained by first obtaining the mass of the "wet" sample, oven-drying the soil, and reweighing the sample to obtain a dry mass. Most of the soil samples were collected about solar noon (12:30 m.s.t.); therefore, the soil-moisture values should be fairly representative of the daily average (Jackson and others, 1976). Gravimetric soil-water content was determined as

$$\Theta g = \frac{(\text{wet soil weight}) - (\text{oven-dry soil weight})}{(\text{oven-dry soil weight})}, \quad (4)$$

where

$\Theta g$ = gravimetric soil-water content, in g/g.

Soil bulk-density measurements were obtained in the surface layer and surface-layer volumetric water content was determined as

$$\Theta v = \rho_b \times \Theta g, \quad (5)$$

where

$\Theta v$ = surface-layer volumetric water content, in g/cm$^3$, and

$\rho_b$ = soil bulk density, in g/cm$^3$.

## Acknowledgments

The authors wish to acknowledge the cooperation of the personnel at the Maricopa Agricultural Center, Ak Chin Farm, and Casa Grande Farm. Special thanks to Mr. A. Pat Murphree, Mr. John Smith, Mr. Oliver Anderson, Mr. Jim Hennis, and Mr. Jack Hennis for allowing us to set up equipment in their agricultural fields.

## DATA COLLECTION

Groups of temporary meteorological stations were installed over a variety of surfaces in agricultural fields ranging from bare, fallow ground to full-cover crops of cotton, alfalfa, and wheat (table 1). Ground-based meteorological data were acquired during five separate data-collection periods (table 2) and named in accordance with the experiment in progress (MACIV, MacSPOT, and MACV), whether all the stations were located in fields at the Maricopa Agricultural Center (On Farm) or in fields on several farms (Off Farm), and the type of surface over which the sensors were mounted (mixed crops, cotton, or alfalfa). In general, a standard base set of meteorological data consisting of air temperature ($T_a$), relative humidity ($RH$), wind speed ($U$), solar radiation ($SR$), and net radiation ($R_N$) was acquired by each station during all periods of the project. Supplementary measurements of soil temperature ($T_s$), soil heat flux density ($G$), and surface or canopy temperature ($T_c$) were obtained at some locations during certain periods of the project.

The On-Farm and Off-Farm groups each had two distinct data-collection periods. Stations set up during the On-Farm groups were positioned within about 3 km of each other and during the Off-Farm groups were within about 13 km. During the first period of the On-Farm group, four meteorological stations were installed over a mixture of crop types; during the second period, the stations were installed over similar surfaces (cotton). During the first period of the Off-Farm group, four ground-based meteorological stations were positioned over cotton fields on and to the south of MAC. These stations were subsequently moved into nearby alfalfa fields during the second data-collection period. Distances between stations were increased for an Off-Farm group during MACV; stations were positioned in cotton fields over a maximum distance of about 40 km.

During each data-collection period, ground-based meteorological stations were installed in fields and positioned to provide a fetch-to-instrument-height ratio of at least 100:1 and to maximize the fetch length in the direction of the prevailing winds. Each station consisted of a standard tripod tower, an auxiliary sensor support mast, a datalogger, attendant sensors, and equipment necessary to store incoming data on magnetic tape (cassettes). Sensors used to measure $T_a$, $RH$, and $U$ were installed 1.5 m above the top of the canopy in the cropped fields and 1.5 m above the soil surface in the fallow field. Net radiometers were installed 1.0 m above the canopy or soil surface, and pyranometers were installed between 0.75 and 1.5 m above the canopy or soil surface. An infrared thermometer (IRT, 15° field of view) was installed at some stations during MACIV and during the Off-Farm data-collection periods to provide $T_c$. The IRT's, calibrated at the U.S. Water Conservation Laboratory in Phoenix, were mounted 1.3 m above the canopy and oriented to provide a nadir view of the canopy. Output from each sensor was sampled once each minute by automatic dataloggers except during periods when the sampling interval was decreased to average values (2 minute or 15 minute) so that data-storage capacity would not be exceeded before retrieval. Data are stored by Julian day (day) of the year; therefore, Julian days are used in this report to maintain consistency but month and day designations are included for the reader's convenience.

The field boundaries and crop types at and surrounding each meteorological station were mapped by the U.S. Geological Survey. Crop mapping covered a minimum radius of at least 1 km around each station to provide surface data over all possible upwind fetch directions. Although the crop data were mapped at a scale of 1:24,000 for the area surrounding all the stations in 1989, the area was subdivided for presentation in this report to cover 2- to 3-square-kilometer areas surrounding each station. Maps were prepared using the ARC/INFO geographic information software. The software translates mapped data—field boundaries, crop types, and station locations—into digital form and stores the data as coverages. Transfer of coverages between participating scientists proved easy and useful in preventing duplication of work. Field boundaries at MAC were surveyed by the University of Arizona (Regan and others, 1989) and an ARC cover was created. Points surveyed were tied to the section and half-section corners on the farm for which Universal Transverse Mercator (UTM) coordinates were known. All point data were reported in UTM meters. A copy of the ARC

**Table 1.** Meteorological stations at which data were collected at or near the Maricopa Agricultural Center in Pinal County, Arizona, during April–November 1989 and June–July 1990

[Station name: MAC, Maricopa Agricultural Center; AZMET, Arizona Meteorological Network]

| Station Identifier[1] | Station name | Surface | Elevation[2], in meters | Location | Latitude, °N | Longitude, °W |
|---|---|---|---|---|---|---|
| | | | ***MACIV/MacSPOT—On Farm—Mixed Crops*** | | | |
| A | MAC Field 2 | Alfalfa | 362.7 | T.4S., R.4E. sec. 20 | 33°03′39″ | 111°58′37″ |
| B | MAC Field 11 | Alfalfa | 359.7 | T.4S., R.4E. sec. 17 | 33°04′43″ | 111°58′18″ |
| C | MAC Field 30 | Fallow | 360.3 | T.4S., R.4E. sec. 19 | 33°04′01″ | 111°59′25″ |
| D | MAC Field 31 | Cotton | 360.0 | T.4S., R.4E. sec. 19 | 33°04′09″ | 111°59′24″ |
| E | MAC Field 3201 | Wheat | 360.0 | T.4S., R.4E. sec. 19 | 33°04′17″ | 111°59′25″ |
| | | | ***MacSPOT—On Farm—Cotton*** | | | |
| F | MAC Field 18 | Cotton | 358.7 | T.4S., R.4E. sec. 18 | 33°04′35″ | 111°59′09″ |
| G | MAC Field 20 | Cotton | 358.4 | T.4S., R.4E. sec. 17 | 33°05′01″ | 111°58′23″ |
| H | MAC Field 27 | Cotton | 362.1 | T.4S., R.4E. sec. 19 | 33°03′36″ | 111°59′10″ |
| I | MAC Field 30 | Fallow | 360.3 | T.4S., R.4E. sec. 19 | 33°04′00″ | 111°59′14″ |
| J | MAC Field 31 | Cotton | 359.7 | T.4S., R.4E. sec. 19 | 33°04′09″ | 111°59′15″ |
| | | | ***MacSPOT—Off Farm—Cotton*** | | | |
| K | MAC Field 20 | Cotton | 358.4 | T.4S., R.4E. sec. 17 | 33°05′04″ | 111°58′23″ |
| L | Murphree | Cotton | 367.3 | T.4S., R.4E. sec. 31 | 33°01′57″ | 111°59′19″ |
| M | Smith | Cotton | 371.2 | T.5S., R.3E. sec. 12 | 33°00′02″ | 111°59′54″ |
| N | Ak Chin | Cotton | 377.6 | T.5S., R.4E. sec. 19 | 32°58′12″ | 111°59′09″ |
| | | | ***MacSPOT—Off Farm—Alfalfa*** | | | |
| O | MAC Field 11 | Alfalfa | 359.7 | T.4S., R.4E. sec. 17 | 33°04′43″ | 111°58′18″ |
| P | Anderson | Alfalfa | 369.1 | T.4S., R.4E. sec. 28 | 33°02′58″ | 111°56′47″ |
| Q | Murphree | Alfalfa | 365.2 | T.4S., R.4E. sec. 30 | 33°02′47″ | 111°59′06″ |
| R | Ak Chin | Alfalfa | 378.9 | T.5S., R.4E. sec. 19 | 32°58′15″ | 111°58′40″ |
| S | Ak Chin[3] | Alfalfa | 378.3 | T.5S., R.4E. sec. 19 | 32°58′15″ | 111°58′49″ |
| | | | ***MACV—Off Farm—Cotton*** | | | |
| T | MAC Field 37 | Cotton | 357.2 | T.4S., R.4E. sec. 18 | 33°04′55″ | 111°59′25″ |
| U | Casa Grande | Cotton | 424.3 | T.6S., R.6E. sec. 16 | 32°54′22″ | 111°44′15″ |
| V | Hennis | Cotton | 436.2 | T.6S., R.7E. sec. 20 | 32°53′19″ | 111°38′20″ |
| | | | ***AZMET Stations*** | | | |
| W | Maricopa AZMET | Turf | 361.5 | T.4S., R.4E. sec. 20 | 33°04′01″ | 111°58′17″ |
| X | Coolidge AZMET | Turf | 422.1 | T.5S., R.7E. sec. 23 | 32°58′48″ | 111°36′19″ |
| Y | Eloy AZMET | Turf | 461.5 | T.7S., R.8E. sec. 18 | 32°48′27″ | 113°33′20″ |

[1]Corresponds to stations plotted on figures 2, 8–11, and 15–19.
[2]Estimated from U.S. Geological Survey 7.5–minute topographic quadrangle maps.
[3]Temporary position while the alfalfa field to the east was mowed.

**Table 2.** Meteorological data collected at or near the Maricopa Agricultural Center in Pinal County, Arizona, during April–November 1989 and June–July 1990

[Site name: FAL, fallow; PCA, partial-cover alfalfa; FCA, full-cover alfalfa; FUR, furrowed; WHT, wheat; MAC, Maricopa Agricultural Center; MUR, Murphree Farm; AK, Ak Chin Farm; SMI, Smith Farm; AND, Anderson Farm; HEN, Hennis Farm; CG, Casa Grande Farm. IRT Data collection: IRT, infrared thermometer. Dashes indicate no data collected]

| Site name[1] | Field number[2] | Surface | Data collection | | | | IRT Data collection | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Begin | | End | | Begin | | End | |
| | | | Data | Day[3] | Date | Day[3] | Date | Day[3] | Date | Day[3] |
| **1989** | | | | | | | | | | |
| ***MACIV/MacSPOT—On Farm—Mixed Crops*** | | | | | | | | | | |
| FAL | 30 | Fallow | Apr. 7 | 97 | May 12 | 132 | Apr. 7 | 97 | Apr. 10 | 100 |
| PCA | 11 | Alfalfa | Apr. 8 | 98 | Apr. 29 | 119 | Apr. 8 | 98 | Apr. 10 | 100 |
| FCA | 2 | Alfalfa | Apr. 6 | 96 | May 12 | 132 | --- | --- | --- | --- |
| FUR | 31 | Fallow[4] | Apr. 8 | 98 | Apr. 10 | 100 | --- | --- | --- | --- |
| WHT | 32 | Wheat | Apr. 7 | 97 | May 25 | 145 | Apr. 7 | 97 | Apr. 10 | 100 |
| ***MacSPOT—On Farm—Cotton*** | | | | | | | | | | |
| 1 | 30 | Fallow | June 14 | 165 | July 18 | 199 | --- | --- | --- | --- |
| 2 | 31 | Cotton | June 14 | 165 | July 18 | 199 | --- | --- | --- | --- |
| 3 | 18 | Cotton | June 15 | 166 | July 18 | 199 | --- | --- | --- | --- |
| 4 | 20 | Cotton | June 15 | 166 | July 18 | 199 | --- | --- | --- | --- |
| 5 | 27 | Cotton | June 15 | 166 | July 18 | 199 | --- | --- | --- | --- |
| ***MacSPOT—Off Farm—Cotton*** | | | | | | | | | | |
| FAL | 30 | Fallow | July 19 | 200 | Sept. 20 | 263 | --- | --- | --- | --- |
| MAC | 20 | Cotton | Aug. 3 | 215 | Sept. 20 | 263 | --- | --- | --- | --- |
| MUR | --- | Cotton | Aug. 4 | 216 | Sept. 27 | 270 | Aug. 23 | 235 | Sept. 27 | 270 |
| AK | --- | Cotton | Aug. 15 | 227 | Sept. 23 | 266 | --- | --- | --- | --- |
| SMI | --- | Cotton | Aug. 15 | 227 | Sept. 20 | 263 | Sept. 12 | 255 | Sept. 12 | 255 |
| ***MacSPOT—Off Farm—Alfalfa*** | | | | | | | | | | |
| FAL | 30 | Fallow | Sept. 21 | 264 | Nov. 1 | 305 | --- | --- | --- | --- |
| MAC | 11 | Alfalfa | Sept. 20 | 263 | Nov. 2 | 306 | --- | --- | --- | --- |
| MUR | --- | Alfalfa | Sept. 27 | 270 | Nov. 1 | 305 | Sept. 27 | 270 | Nov. 1 | 305 |
| AK[5] | --- | Alfalfa | Sept. 20 | 263 | Nov. 1 | 305 | Sept. 20 | 263 | Nov. 1 | 305 |
| AND | --- | Alfalfa | Sept. 21 | 264 | Nov. 2 | 306 | Sept. 28 | 271 | Sept. 28 | 271 |
| Do. | --- | Do. | --- | --- | --- | --- | Oct. 13 | 286 | Oct. 13 | 286 |
| **1990** | | | | | | | | | | |
| ***MACV—Off Farm—Cotton*** | | | | | | | | | | |
| MAC | 37 | Cotton | June 26 | 177 | July 2 | 183 | --- | --- | --- | --- |
| HEN | --- | Cotton | June 26 | 177 | July 2 | 183 | --- | --- | --- | --- |
| CG | --- | Cotton | June 26 | 177 | July 2 | 183 | --- | --- | --- | --- |

[1]Corresponds to site file names at the University of Arizona.
[2]Field numbers at the Maricopa Agricultural Center; other farms do not assign field numbers.
[3]Julian day of year.
[4]No emergence of seeded cotton on north-south rows raised about 13 centimeters above adjacent furrows.
[5]Field was mowed on day 275 (Oct. 2); station moved temporarily to an adjacent field with a full-cover canopy. Station was returned to original location on day 279 (Oct. 6).

cover with the surveyed field boundaries was obtained (John J. Regan, Computer Applications Specialist, University of Arizona, written commun., 1988) and incorporated into the larger study-area field-boundary map generated for this study. The following sections detail the locations of each temporary meteorological station, site conditions, the sensors used at each station, sensor exposure, and crop maps for each period of the project.

## MACIV/MacSPOT—On Farm—Mixed Crops

The MACIV/MacSPOT period of the project encompassed the intense 3-day measurement period of MACIV from April 8–10 (day 98–100) immediately followed by the period of MacSPOT. Meteorological stations were installed in fields 2, 11, 30, 31, and 32 at MAC (fig. 2). During MACIV, $T_a$, $RH$, $U$, $R_N$, $SR$, $T_s$, and $G$ were measured at each station and $T_c$ was measured in fields 11, 30, and 32; $e_s$ (eq. 1), $e_a$ (eq. 2), and $VPD$ (eq. 3) were calculated. The instruments used to measure $T_a$, $RH$, $U$, $R_N$, $SR$, and $T_c$ were mounted on the instrument towers at a height of 1.5 m above the crop and (or) soil surface. The vegetation, surface characteristics, and field dimensions differed significantly among the five fields (table 3). Fields 2 and 11 contained stands of alfalfa (*Medicago sativa*) at differing stages of canopy development. Field 2 (fig. 2, station A; fig. 3) supported a well-developed, full-cover alfalfa canopy and field 11 (fig. 2, station B; fig. 4) had recently been mowed and offered a short, partially developed alfalfa canopy. Much of the canopy in field 11 was old stem stubble from the recent cutting, although new shoot growth was evident on 80 percent of the crowns at the start of the study. The alfalfa in both fields was watered as needed using flood irrigation. Field 32 (fig. 2, station E; fig. 5) supported a uniform, full-cover canopy of spring wheat (*Triticum aestivum*) that was heading at the time of the study. Flood irrigation was used to provide water to the wheat. Fields 30 and 31 were devoid of green vegetation. In field 30 (fig. 2, station C; fig. 6), a cover crop of small grain had been turned under with a chisel plow approximately 1 month before the study, which left the soil surface covered with dry clods ranging from 1 to 20 cm in diameter. Field 31 (fig. 2, station D; fig. 7) had been seeded to cotton (*Gossypium hirsutum*) just prior to the study, but no cotton had emerged at the time of MACIV. Individual rows of cotton were located on soil beds raised approximately 13 cm above the adjacent furrow bottoms. The beds were oriented north-south and were spaced 1.0 m apart. Notice the variations among the plots of $T_a$, $RH$, $U$, and $T_c$ over the different surfaces, especially cropped versus fallow (figs. 3–7; missing data are shown for

**Table 3.** Site information for meteorological stations that collected data over mixed surfaces at the Maricopa Agricultural Center, Pinal County, Arizona, April 8–10, 1989

[Site name: FCA, full-cover alfalfa; PCA, partial-cover alfalfa; FAL, fallow; FUR, furrowed; WHT, wheat]

| Station identifier[1] | Site name[2] | Field number | Field dimensions, in meters | | Surface | Canopy cover, in percent | Canopy height, in centimeters |
|---|---|---|---|---|---|---|---|
| | | | North–South | East–West | | | |
| A | FCA | 2 | 100 | 30 | Alfalfa | 96 | 58±10 |
| B | PCA | 11 | 750 | 250 | Alfalfa | 70 | 15±3 |
| C | FAL | 30 | 300 | 1,500 | Fallow | 0 | ([3]) |
| D | FUR | 31 | 300 | 1,500 | Cotton | 0 | ([4]) |
| E | WHT | 32 | 300 | 1,500 | Wheat | 100 | 100 |

[1]Corresponds to stations plotted on figure 2.

[2]Corresponds to site file names at the University of Arizona.

[3]Cover crop of small grain had been tumed under with a chisel plow about 1 month before, which left the soil surface covered with dry clods ranging from 1–20 centimeters in diameter.

[4]No emergence of seeded cotton on north-south rows raised about 13 centimeters above adjacent furrows.

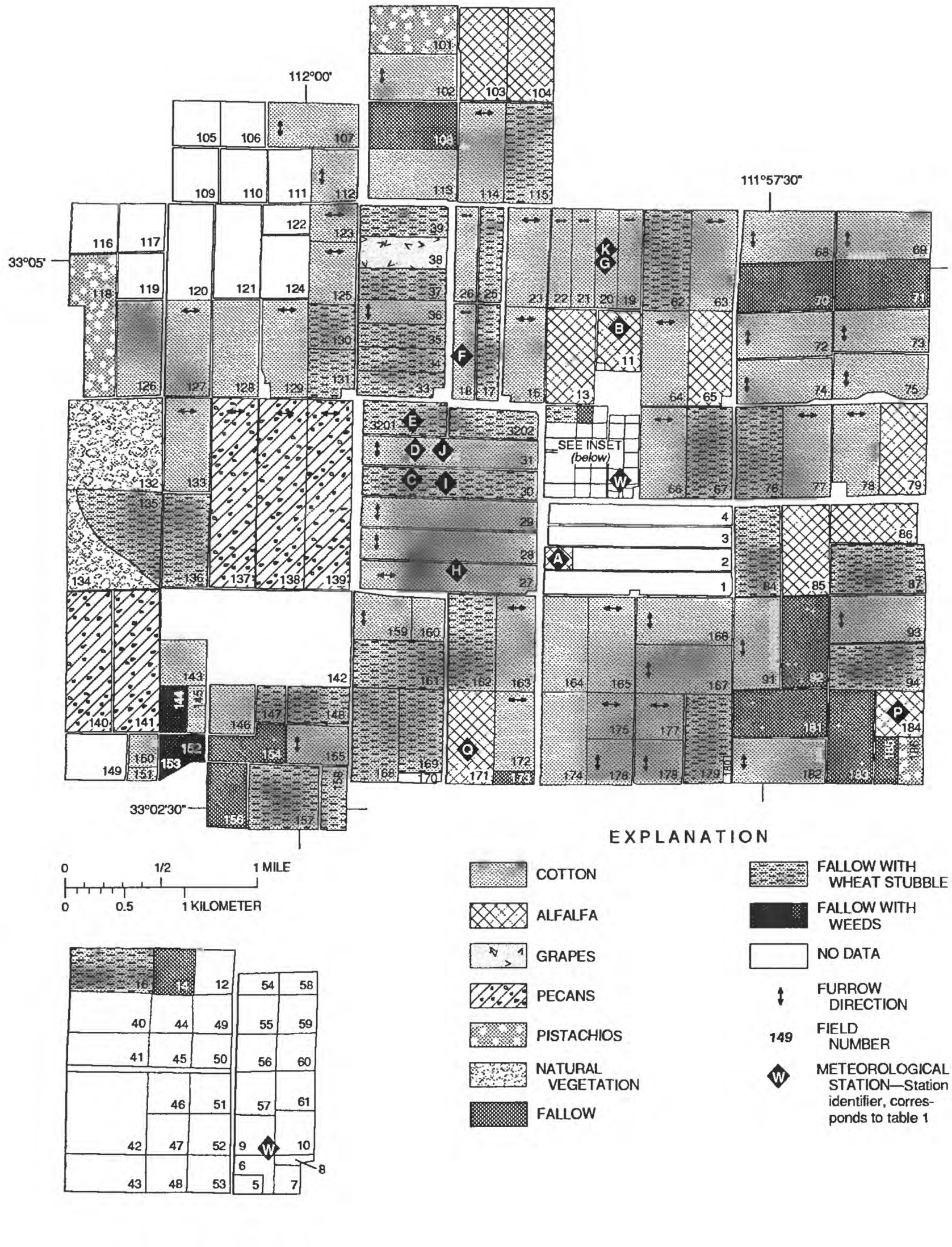


**Figure 2.** Crop types in fields surrounding the meteorological stations at and south of the Maricopa Agricultural Center, Pinal County, Arizona, April to September 1989.

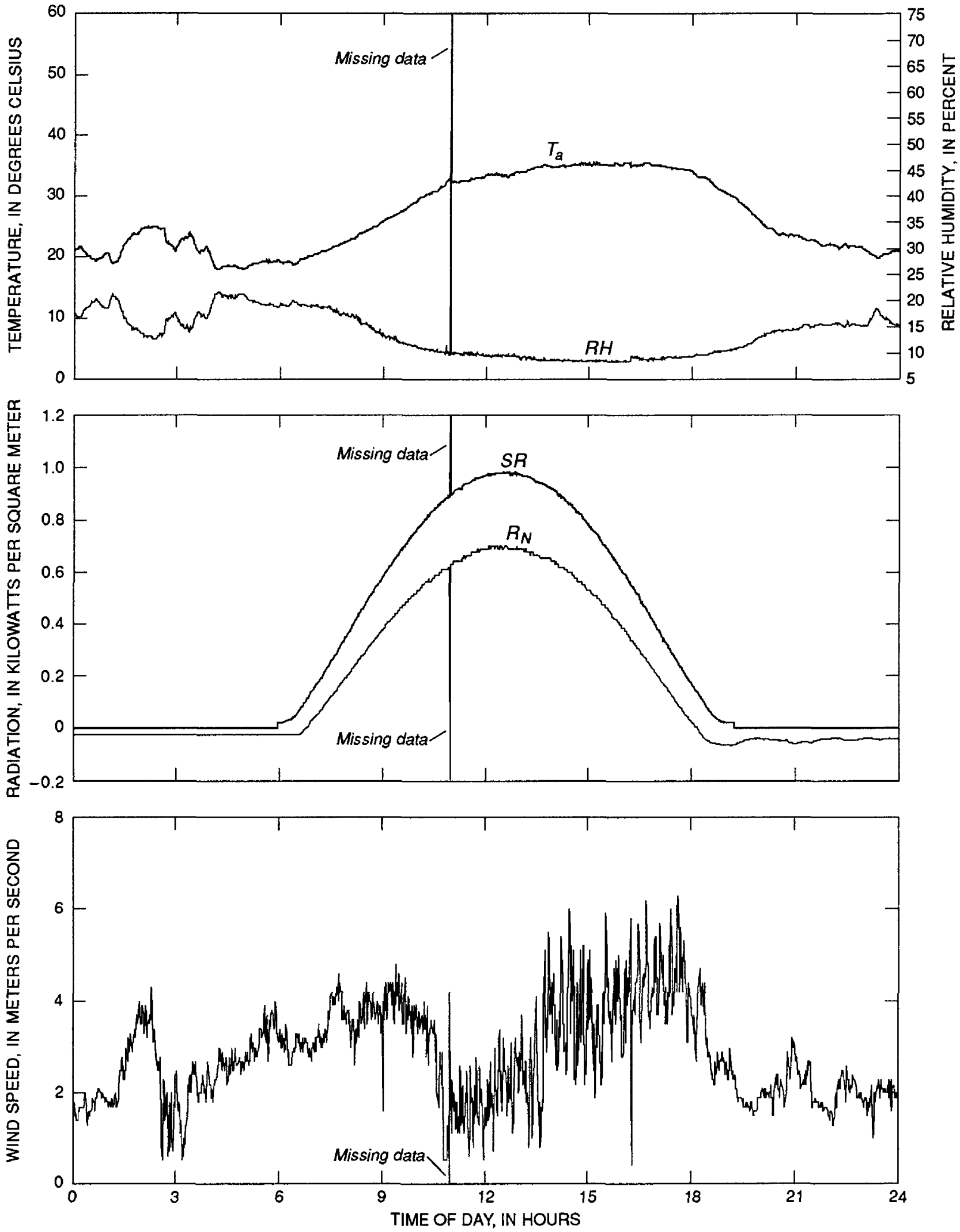


**Figure 3.** Air temperature *($T_a$)*, relative humidity *(RH)*, solar radiation *(SR)*, net radiation *($R_N$)*, and wind speed collected at one-minute intervals over full-cover alfalfa in field 2 at the Maricopa Agricultural Center during the MACIV experiment April 9, 1989 (day 99).

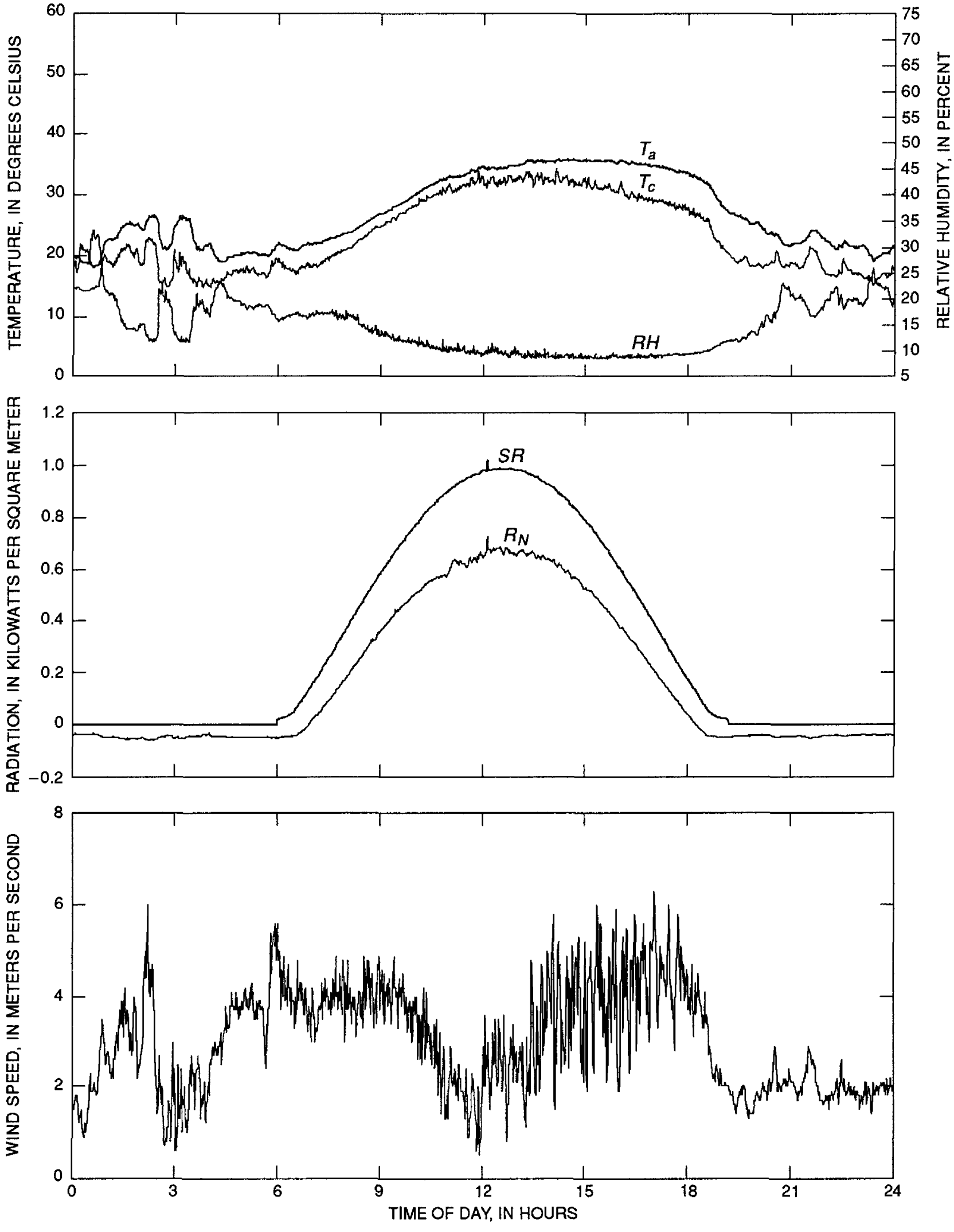


**Figure 4.** Air temperature *($T_a$)*, canopy or surface temperature *($T_c$)*, relative humidity *(RH)*, solar radiation *(SR)*, net radiation *($R_N$)*, and wind speed collected at one-minute intervals over partial-cover alfalfa in field 11 at the Maricopa Agricultural Center during the MACIV experiment April 9, 1989 (day 99).

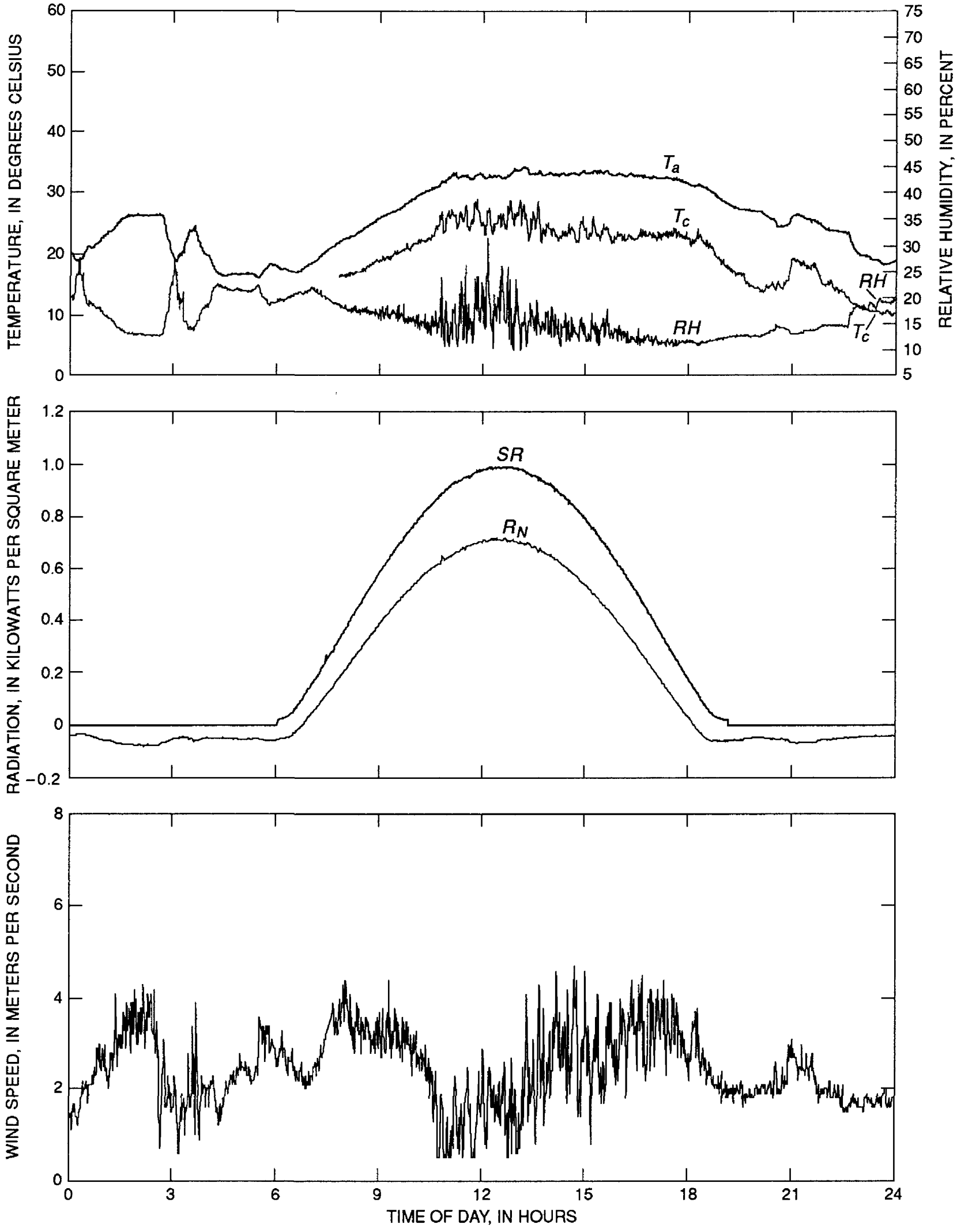


**Figure 5.** Air temperature *($T_a$)*, canopy or surface temperature *($T_c$)*, relative humidity *(RH)*, solar radiation *(SR)*, net radiation *($R_N$)*, and wind speed collected at one-minute intervals over full-cover wheat in field 32 at the Maricopa Agricultural Center during the MACIV experiment April 9, 1989 (day 99).

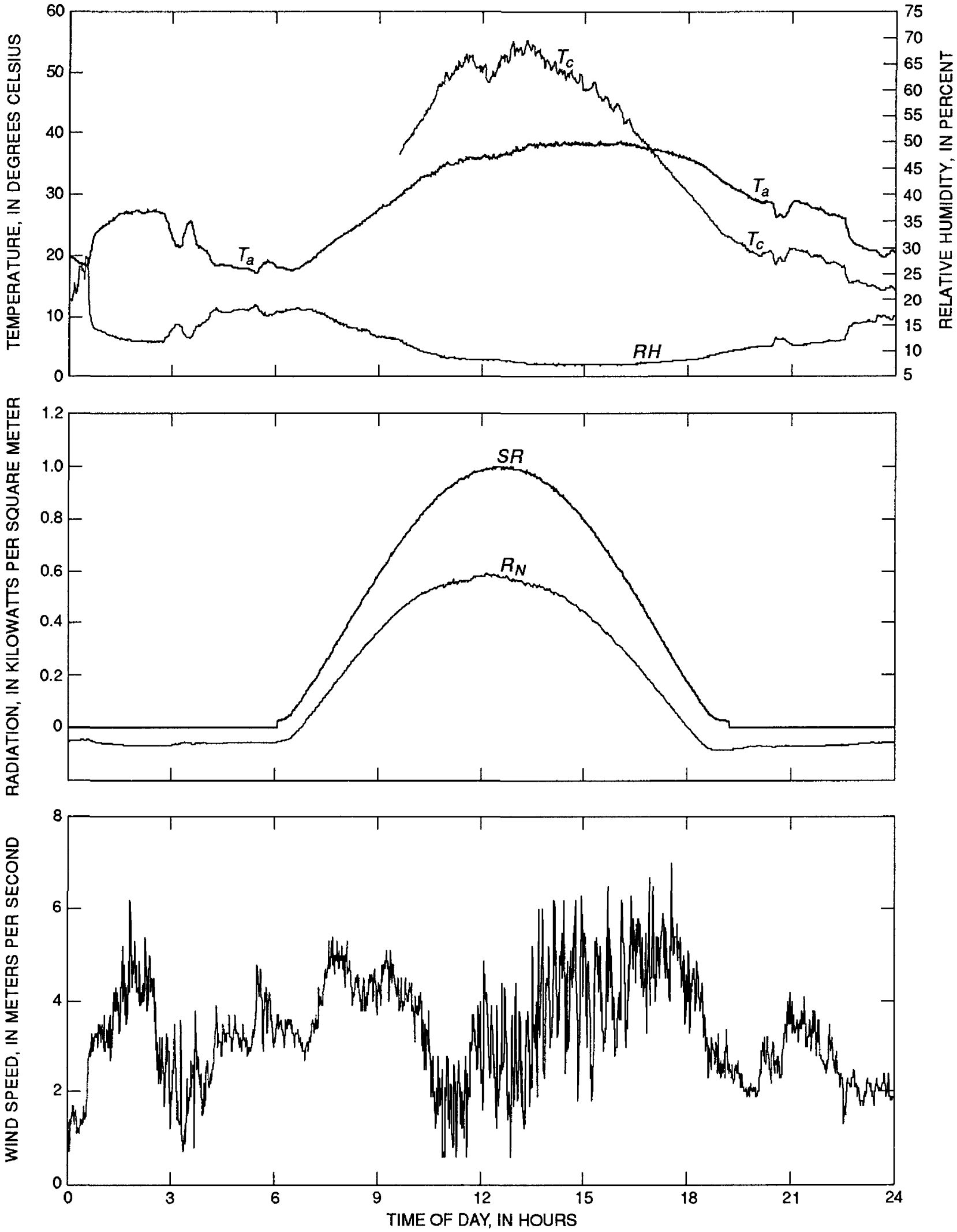


**Figure 6.** Air temperature *($T_a$)*, canopy or surface temperature *($T_c$)*, relative humidity *(RH)*, solar radiation *(SR)*, net radiation *($R_N$)*, and wind speed collected at one-minute intervals over a fallow surface in field 30 at the Maricopa Agricultural Center during the MACIV experiment April 9, 1989 (day 99).

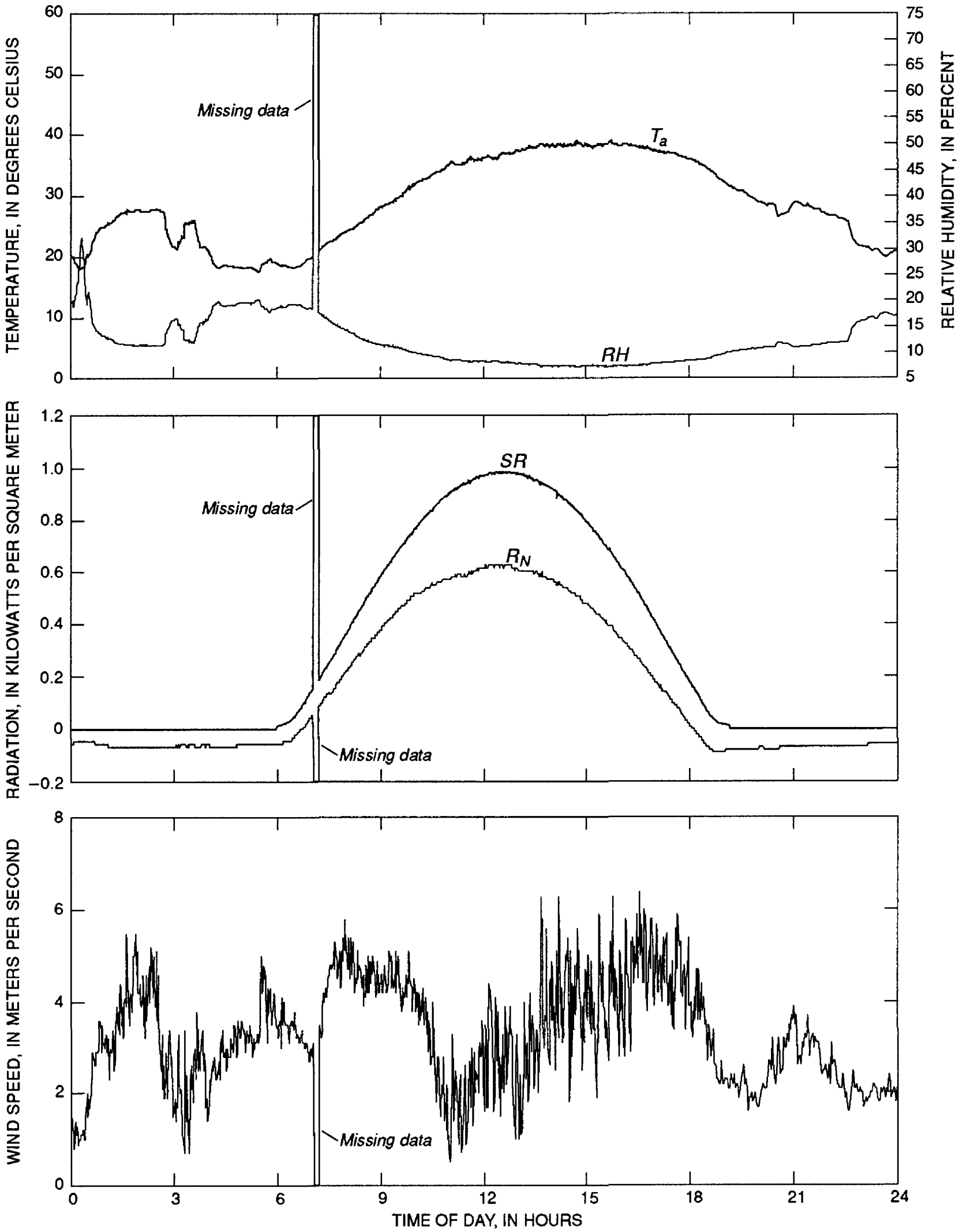


**Figure 7.** Air temperature *($T_a$)*, relative humidity *(RH)*, solar radiation *(SR)*, net radiation *($R_N$)*, and wind speed collected at one-minute intervals over a furrowed fallow surface in field 31 at the Maricopa Agricultural Center during the MACIV experiment April 9, 1989 (day 99).

illustrative purposes, see section of report entitled "Computer Data Files").

Heat flux plates (transducers) were buried 5 cm below the soil surface to measure $G$. Thermocouples were installed midway between the surface and the flux plate to provide $T_s$, which is necessary for calculating heat storage in the near-surface soil layer. Two to five sets of heat flux plates and thermocouples were buried in each field to sample the variation in surface conditions and estimate the mean surface heat flux. The furrowed surface of field 31 required five sets of flux plates and thermocouples. The sensors were installed as follows: one each in the tops of two adjacent raised beds, one each on the east- and west-facing slopes of the adjacent beds, and one in the furrow bottom between the adjacent beds.

The dataloggers were programmed to record sensor output once each minute during the daylight hours. The data-acquisition interval was lengthened to 2 minutes during the evening hours at some stations to ensure that data-storage tapes would last through the night. Specific details on the sensors and dataloggers used at each station are presented in table 4.

The mean surface soil-moisture content (0–5 cm layer) was measured at all five sites by taking several soil samples at each site. Most of the soil samples were collected about solar noon (12:30 m.s.t.) to provide daily average soil-moisture values (Jackson and others, 1976). Soil bulk-density measurements were obtained in the surface layer at each site on day 99; gravimetric soil-water content (eq. 4) and surface-layer volumetric water content (eq. 5) were calculated (table 5).

Field conditions were documented to provide ground-truth data during the SPOT satellite overpass on April 9, 1989. Crop types were mapped and photographed for each demonstration farm field at MAC. Information on irrigation, cultivation, and orientation of rows are described by Owen-Joyce (1989a).

Data collection during MacSPOT commenced on day 101 (Apr. 11) and was a continuation of the MACIV data collection. Three of the five monitoring stations utilized during MACIV were

**Table 4.** Manufacturer and model number of instrumentation used at each of five field-monitoring stations at the Maricopa Agricultural Center during April 6–10, 1989

[MFG, Manufacturer: CSI, Campbell Scientific, Inc.; EV, Everest Interscience, Inc.; MO, Met-One, Inc.; MMI, Micromet Instruments, Inc.; LC, Li Cor, Inc.; WT, Weathertronics; REBS, Radiation and Energy Balance Systems, Inc.; RMY, R.M. Young, Inc.; WCL, U.S. Water Conservation Laboratory; HW, Made by Hal Weaver (1985); N/A, Not applicable (homemade). Dashes indicate no instrument installed]

| Instrument or sensor | Field 2 | | Field 11 | | Field 30 | | Field 31 | | Field 32 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | MFG | Model | MFG | Model | MFG | Model | MFG | Model | MFG | Model |
| Air temperature | CSI | [1]201 | CSI | 207 | CSI | 207 | CSI | 201 | CSI | 207 |
| Relative humidity | CSI | [1]201 | CSI | 207 | CSI | 207 | CSI | 201 | CSI | 207 |
| Anemometer | MO | 024 | WT | 2032 | RMY | 03001–5 | MO | 024 | RMY | 03001–5 |
| Pyranometer | LC | 200SZC | LC | 200SZC | LC | 200SZC | LC | 200SZC | LC | 200SZC |
| Soil heat flux | REBS | HFT–3 | REBS | HFT–3 | HW | N/A | REBS | HFT–3 | REBS | HFT–3 |
| Soil temperature | WCL | N/A | WCL | N/A | WCL | N/A | WCL | N/A | WCL | N/A |
| Net radiation | REBS | Q*4 | MMI | 1–Dome | REBS | Q*4 | REBS | Q*4 | REBS | Q*4 |
| Surface temperature | ------ | ------- | EV | 4009 | EV | 4009 | ------ | ------- | EV | 4009 |
| Datalogger | CSI | [1]CR21 | CSI | 21X | CSI | 21X | CSI | CR21 | CSI | 21X |

[1]Switched datalogger to CR10 and air-temperature and humidity sensor to model 207 on April 9, 1989.

**Table 5.** Gravimetric soil water content, soil bulk density, and surface-layer volumetric soil water content for the five fields at the Maricopa Agricultural Center monitored April 8–10, 1989

[Characteristic: Θg, gravimetric soil water content; $\rho_b$, soil bulk density; Θv, surface-layer volumetric soil water content]

| Characteristic | Day | Maricopa Agricultural Center Field Number | | | | |
|---|---|---|---|---|---|---|
| | | 2 | 11 | 30 | 31 | 32 |
| Θg, g/g | 99 | 0.11 | 0.03 | 0.05 | 0.06 | 0.25 |
| | 100 | 0.11 | 0.03 | 0.04 | 0.04 | 0.23 |
| $\rho_b$, g/cm$^3$ | ---- | 1.36 | 1.57 | 1.36 | 1.51 | 1.36 |
| Θv, g/cm$^3$ | [1]98 | 0.15 | 0.04 | 0.06 | 0.12 | 0.41 |
| | 99 | 0.15 | 0.04 | 0.06 | 0.09 | 0.38 |
| | 100 | 0.15 | 0.04 | 0.05 | 0.06 | 0.34 |

[1]Values of Θv for day 98 (Apr. 8) were estimated by linear interpolation using the rate of change of soil moisture between days 99 and 100 (Apr. 9 and 10).

left in their respective fields for periods ranging from 19 to 45 days (table 2). The station in field 11 (fig. 2, station B) was left in place through day 119 (Apr. 29) to monitor meteorological conditions over alfalfa during the entire regrowth period; the station was removed just prior to the next cutting. The station in field 32 (fig. 2, station E) was left in place through day 145 (May 25) to monitor the meteorological conditions over wheat as the crop progressed from heading to senescence. Finally, the station located over fallow ground in field 30 (fig. 2, station C) was left in place until day 132 (May 12) to monitor conditions there. No adjustments were made in station design or sensor exposure during this data-collection period (table 3). Sensors remained at the same heights (relative to ground level) as indicated during MACIV. Soil-moisture measurements were not obtained during the three satellite-overpass dates and therefore are not available for adjusting values of G (obtained from heat flux plates) for surface soil heat storage.

The canopy height of the two cropped surfaces did change during the first data-collection period. Canopy height in the wheat increased to 1.1 m on day 103 (Apr. 13) and then stabilized for the duration of the period. The alfalfa canopy continued to grow vigorously throughout the remainder of its regrowth period. Measurements of canopy height taken prior to the overpass on day 103 revealed canopy height to be variable, ranging from 15 to 30 cm. New vegetation covered approximately 80 percent of the soil surface.

## MacSPOT—On Farm—Cotton

The next period of data collection, MacSPOT—On Farm in cotton fields, began on day 165 (June 14) and continued through day 199 (July 18) (table 2). Four meteorological stations were installed in cotton fields (MAC fields 18, 20, 27, and 31) and the fifth station was installed in a fallow field (MAC field 30; fig. 2, station I). The vegetation, surface characteristics, and field dimensions differed among the five fields (table 6). The meteorological stations in fields 18, 20, and 31 (fig. 2, stations F, G, and J, respectively) were centrally located to maximize fetch in all directions. The station in field 27 (fig. 2, station H) was more or less centrally located in the east-west direction but located only 65 m from the north edge of the field to maximize fetch in the southerly direction (direction of prevailing wind). Fields 18, 20, and 31 were furrow irrigated and field 27 was irrigated using a trickle system.

The meteorological stations used during the data-collection period over cotton collected regular measurements of $T_a$, $RH$, $U$, $R_N$, and $SR$; no measurements of $G$, $T_s$, or $T_c$ were obtained.

**Table 6.** Site information for meteorological stations that collected data over cotton at the Maricopa Agricultural Center, Pinal County, Arizona, June 16–July 18, 1989

| Station identifier[1] | Site name[2] | Field number | Field dimensions, in meters | | Surface | Date | Day[3] | Canopy cover, in peroent | Canopy height, in meters |
|---|---|---|---|---|---|---|---|---|---|
| | | | North–South | East–West | | | | | |
| F | 1 | 30 | 300 | 1,500 | Fallow | June 16 | 167 | 0 | ([4]) |
| G | 2 | 31 | 300 | 1,500 | Cotton | June 16 | 167 | 47 | 0.44 |
| | | | | | | June 26 | 177 | 55 | 0.62 |
| | | | | | | June 29 | 180 | 58 | 0.65 |
| | | | | | | July 7 | 188 | 70 | 0.75 |
| | | | | | | July 18 | 199 | 80 | 0.85 |
| H | 3 | 18 | 820 | 125 | Cotton | June 16 | 167 | 53 | 0.48 |
| | | | | | | June 26 | 177 | 65 | 0.68 |
| | | | | | | June 29 | 180 | 73 | 0.68 |
| | | | | | | July 7 | 188 | 88 | 0.80 |
| | | | | | | July 18 | 199 | 90 | 0.85 |
| I | 4 | 20 | 820 | 125 | Cotton | June 16 | 167 | 42 | 0.35 |
| | | | | | | June 26 | 177 | 52 | 0.45 |
| | | | | | | June 29 | 180 | 62 | 0.55 |
| | | | | | | July 7 | 188 | 75 | 0.82 |
| | | | | | | July 18 | 199 | 85 | 1.02 |
| J | 5 | 27 | 300 | 1,500 | Cotton | June 16 | 167 | 50 | 0.40 |
| | | | | | | June 26 | 177 | 60 | 0.57 |
| | | | | | | June 29 | 180 | 65 | 0.65 |
| | | | | | | July 7 | 188 | 80 | 0.80 |
| | | | | | | July 18 | 199 | 90 | 1.00 |

[1]Corresponds to stations plotted on figure 2.
[2]Corresponds to site file names at the University of Arizona.
[3]Julian day of the year.
[4]Station reinstalled about 280 meters east of the MACIV position. Soil surface was covered with dry clods ranging from 0.5–10 centimeters in diameter.

Sensors measuring $T_a$, $RH$, $R_N$, and $U$ were initially installed at 1.5 m above the canopy and (or) soil surface. The $SR$ sensor was installed above the canopy at a height convenient for routine maintenance. The height of the $T_a$, $U$, and $RH$ sensors located in cotton fields were adjusted upward four times during this data-collection period to reestablish a 1.5 m distance between the canopy and the sensors. Data on canopy height and percentage of canopy cover were obtained on days when sensor heights were adjusted (table 6). Sensor output was monitored by dataloggers and stored on magnetic tape as either 1-minute samples or 15-minute average values. Specific details on the sensors and dataloggers used at each station are presented in table 7.

Field conditions were documented to provide ground-truth data during the Landsat and SPOT satellite overpasses on June 16, 1989. Crop types were mapped and photographed for each demonstration farm field at MAC. Information on irrigation, cultivation, and orientation of rows are described by Owen-Joyce (1989b).

**Table 7.** Manufacturer and model number of instrumentation used at each field-monitoring site at the Maricopa Agricultural Center during June 16–July 18, 1989

[MFG, Manufacturer: CSI, Campbell Scientific, Inc.; RMY, R.M. Young, Inc.; MO, Met-One, Inc.; WT, Weathertronics; LC, Li Cor, Inc.; MMI, Micromet Instruments, Inc.]

| Instrument or sensor | Field 30 | | Field 31 | | Field 18 | | Field 20 | | Field 27 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | MFG | Model | MFG | Model | MFG | Model | MFG | Model | MFG | Model |
| Air temperature | CSI | 207 | CSI | 207 | CSI | 207 | CSI | 207 | CSI | 207 |
| Relative humidity | CSI | 207 | CSI | 207 | CSI | 207 | CSI | 207 | CSI | 207 |
| Anemometer | RMY | 03001–5 | RMY | 03001–5 | MO | 024 | MO | 024 | WT | [1]2032 |
| Pyranometer | LC | 200SZC | LC | 200SZC | LC | 200SZC | LC | 200SZC | LC | 200SZC |
| Net radiation | MMI | 1–Dome | MMI | 1–Dome | MMI | 1–Dome | MMI | 1–Dome | MMI | 1–Dome |
| Datalogger | CSI | CR10 | CSI | CR10 | CSI | 21X | CSI | 21X | CSI | 21X |

[1]Replaced with RMY model 03001–5 on day 188 (July 7).

## MacSPOT—Off Farm—Cotton

The MacSPOT—Off Farm data collection began over cotton and was initiated on day 215 (Aug. 3) and continued until day 270 (Sept. 27) (table 2). One meteorological station was installed in MAC field 20 (fig. 2, station K) less than 100 m from the location previously monitored during MacSPOT—On Farm—Cotton. Three additional stations were installed in cotton fields farmed by A. Pat Murphree (MUR) (fig. 8, station L), John Smith (SMI) (fig. 8 and 9, station M), and Ak Chin Farm (AK) (fig. 9, station N). The fifth station continued monitoring over fallow ground at MAC in field 30 (fig. 2, station I; table 1).

The standard instrument tower and sensor package described in previous sections were installed at each location. An attempt was made to locate each station either in the center of the field or in a manner that would maximize fetch in the upwind direction. All stations monitored $T_a$, $RH$, $U$, $R_N$, and $SR$. An IRT was installed at station MUR on day 235 (Aug. 23) to provide regular $T_c$ measurements (table 2). The IRT was mounted at a height of 1.3 m above the canopy and oriented to provide a nadir view of the surface. A hand-held IRT was used to measure midday (10:44–11:44 m.s.t.) values of $T_c$ on day 255 (Sept. 12) at station SMI. The IRT was held 1.25 m above the canopy and oriented to provide a nadir view of the surface. The $T_a$, $RH$, and $U$ sensors were initially installed at a height of 1.5 m above the canopy. The $R_N$ sensor was installed approximately 1.0 m above the surface and the SR sensor installed above the canopy at a height convenient for routine maintenance. Sensor output was monitored by dataloggers and stored on magnetic tape as either 1-minute samples or 15-minute average values. Specific details on the sensors and dataloggers used at each station are presented in table 8.

The cotton canopy at stations MUR, AK, and SMI was green and healthy at the time of station installation with no significant vertical growth during data collection. Canopy height remained at 1.15 m, 0.95 m, and 1.0 m at stations MUR, AK, and SMI, respectively, for the duration of the data-collection period (table 9). The cotton at station MAC continued to increase in height until day 235 (Aug. 23), resulting in adjustments of sensor ($T_a$, $RH$, and $U$) height on days 227 (Aug. 15) and 235 (Aug. 23).

## MacSPOT—Off Farm—Alfalfa

The four meteorological stations previously used over cotton were moved to alfalfa fields during the continuation of the MacSPOT—Off Farm data collection from day 263 (Sept. 20) to day 306 (Nov. 2) (table 2); the station in MAC field 30 (fig. 2, station I) remained operational during this period and collected data over fallow ground. One station was installed over alfalfa in field 11 (fig. 2, station O) at MAC and the remaining three stations

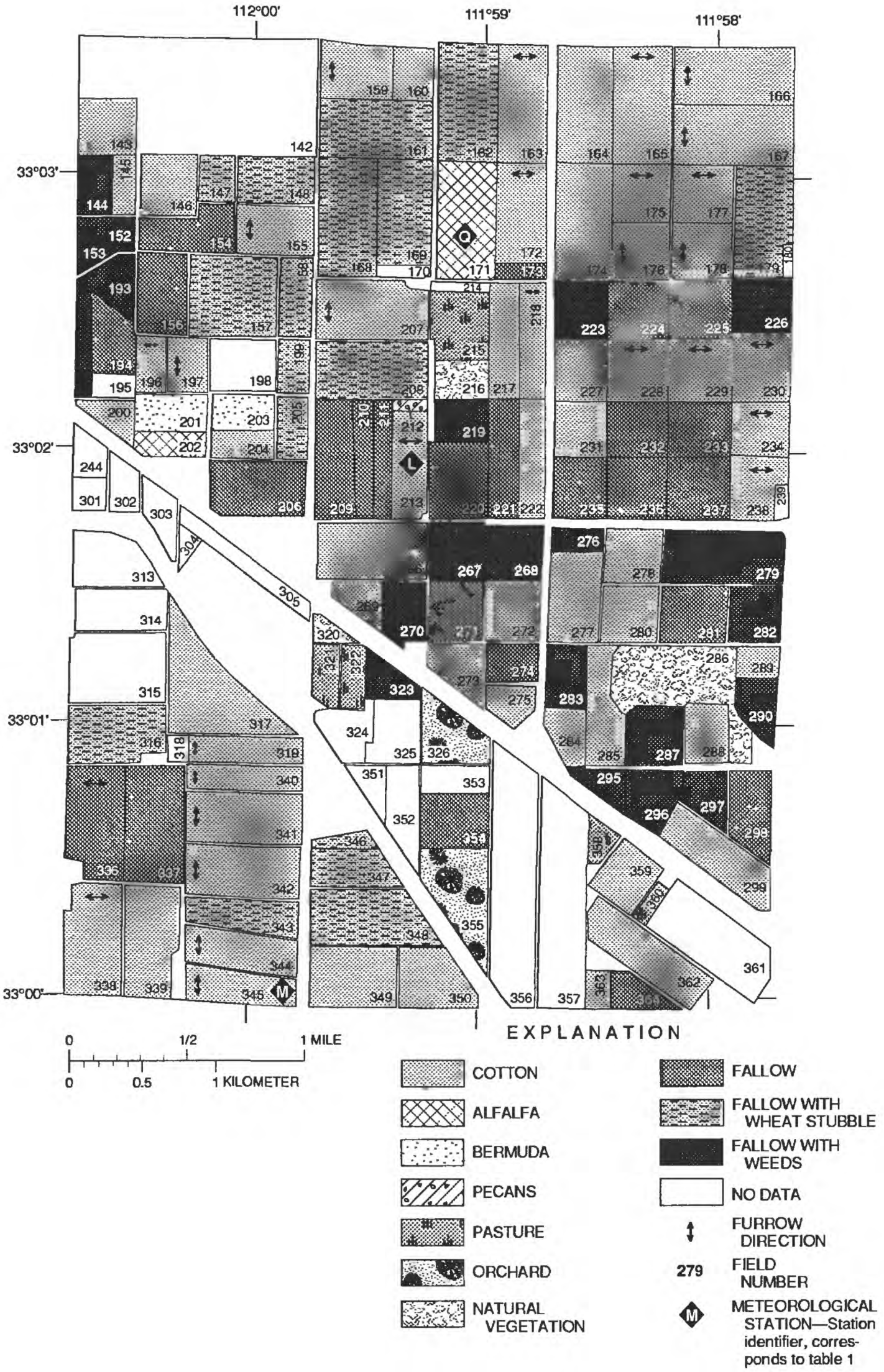


**Figure 8.** Crop types in fields surrounding the meteorological stations at Murphree and Smith Farms south of the Maricopa Agricultural Center, Pinal County, Arizona, August to September 1989.

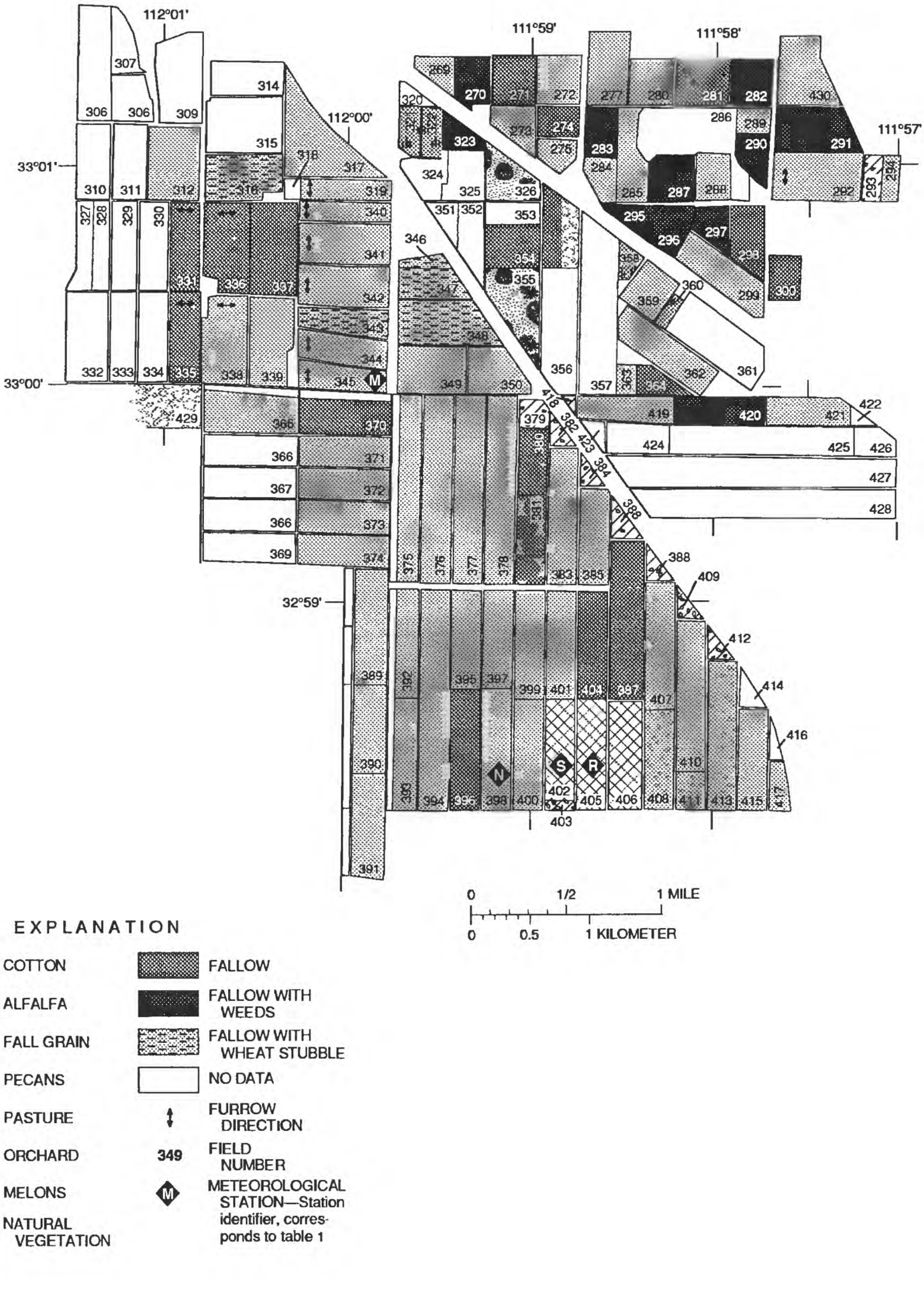


**Figure 9.** Crop types in fields surrounding the meterorological stations at Smith and Ak Chin Farms south of the Maricopa Agricultural Center, Pinal County, Arizona, August to September 1989.

**Table 8.** Manufacturer and model number of instrumentation used at each field-monitoring site at and south of the Maricopa Agricultural Center during August and September 1989

[MFG, Manufacturer: CSI, Campbell Scientific, Inc.; RMY, R.M. Young, Inc.; MO, Met-One, Inc.; LC, Li Cor, Inc.; MMI, Micromet Instruments, Inc.; EV, Everest Interscience, Inc. Dashes indicate no instrument installed]

| Instrument or seneor | MAC 30 | | MAC20 | | Murphree | | Ak Chin | | Smith | |
|---|---|---|---|---|---|---|---|---|---|---|
| | MFG | Model | MFG | Model | MFG | Model | MFG | Model | MFG | Model |
| Air temperature | CSI | 207 | CSI | 207 | CSI | 207 | CSI | 201 | CSI | 207 |
| Relative humidity | CSI | 207 | CSI | 207 | CSI | 207 | CSI | 201 | CSI | 207 |
| Anemometer | RMY | 03001–5 | RMY | 03001–5 | MO | 024 | MO | 024 | RMY | 03001–5 |
| Pyranometer | LC | 200SZC | LC | 200SZC | LC | 200SZC | LC | 200SZC | LC | 200SZC |
| Net radiation | MMI | 1–Dome | MMI | 1–Dome | MMI | 1–Dome | MMI | 1–Dome | MMI | 1–Dome |
| Surface temperature | ----- | -------- | ----- | ------- | EV | 4002 | ------ | -------- | EV | [1]110 |
| Datalogger | CSI | CR10 | CSI | CR10 | CSI | 21X | CSI | 21X | CSI | 21X |

[1]Manual measurement made between 10:44 and 11:44 m.s.t. on day 240 (Aug. 28) only.

**Table 9.** Site information for meteorological stations that collected data over cotton at and south of the Maricopa Agricultural Center, Pinal County, Arizona, August 3–September 27, 1989

[Farm and field number: MAC, Maricopa Agricultural Center; MUR, Murphree Farm; AK, Ak Chin Farm; SMI, Smith Farm]

| Station identifier[1] | Farm and field number | Field dimensions, in meters | | Surface | Date | Day[2] | Canopy cover, in percent | Canopy height, in meters | Furrow height, in meters |
|---|---|---|---|---|---|---|---|---|---|
| | | North–South | East–West | | | | | | |
| I | MAC 30 | 300 | 1,500 | Fallow | Aug. 3 | 215 | 0 | ([3]) | 0 |
| K | MAC 20 | 820 | 125 | Cotton | Aug. 3 | 215 | 100 | 0.9 | 0.17 |
| | | | | | Aug. 15 | 227 | 100 | 1.2 | 0.17 |
| | | | | | Aug. 23 | 235 | 100 | 1.35 | 0.17 |
| L | MUR | 720 | 230 | Cotton | Aug. 4 | 216 | 100 | 1.15 | 0.15 |
| | | | | | Aug. 23 | 235 | 100 | 1.1 | 0.15 |
| M | SMI | 200 | 730 | Cotton | Aug. 15 | 227 | 90 | 1.0 | 0.20 |
| N | AK | 1,020 | 250 | Cotton | Aug. 15 | 227 | 75 | 0.95 | 0.20 |

[1]Corresponds to stations plotted on fignres 2, 8, and 9.
[2]Julian day of the year.
[3]Soil surface was covered with dry clods ranging from 0.5–10 centimeters in diameter.

were installed in alfalfa fields owned by A. Pat Murphree (MUR; fig. 8, station Q), Ak Chin Farm (AK; fig. 9, station R), and Oliver Anderson (AND; fig. 10 and table 1, station P).

The stations were positioned in the same manner with $T_a$, $T_c$, $RH$, $U$, $R_N$, and $SR$ sensors installed 1.5 m above the canopy surface. Continuous measurements of $T_c$ were obtained at stations MUR and AK using IRT's. The IRT's were mounted to provide a nadir view of the canopy surface. A hand-held IRT was used to measure midday values of $T_c$ on days 271 (Sept. 28) and 286 (Oct. 13) at station AND. The IRT was held approximately 1.5 m above the canopy and oriented

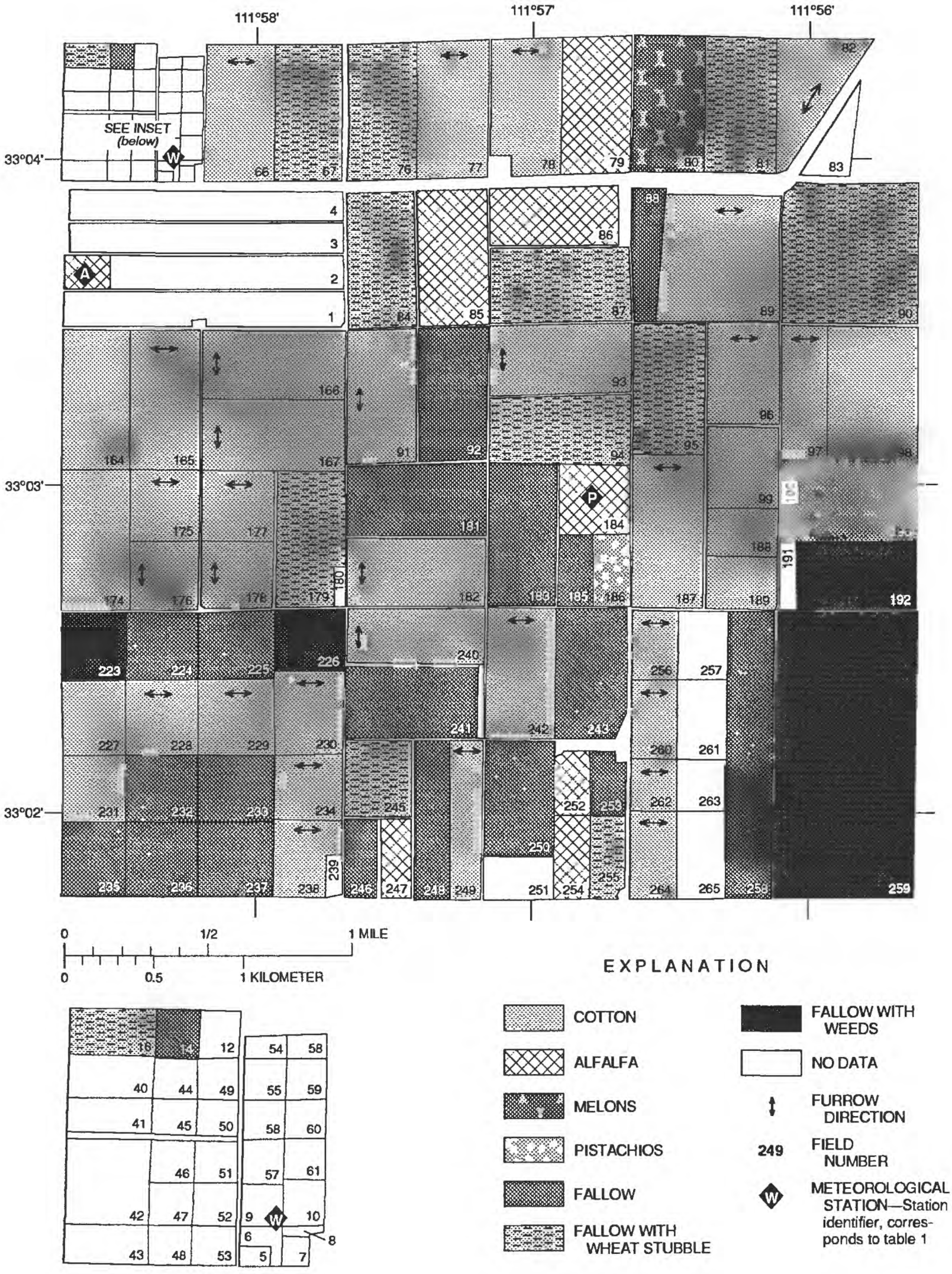


**Figure 10.** Crop types in fields surrounding the meteorological station at Anderson Farm southeast of the Maricopa Agricultural Center, Pinal County, Arizona, from September to November 1989.

to provide a nadir view of the surface. Sensor output was monitored by dataloggers and stored on magnetic tape as 1-minute samples or as 15-minute average values. Specific details on the sensors and dataloggers used at each station are presented in table 10.

Canopy height varied considerably across the four alfalfa fields at the onset of the data-collection period. Station MAC (fig. 2, station O) was installed over a nearly full-cover (90 percent) canopy that was 40 cm in height, which was subsequently cut on day 272 (Sept. 29), eliminating much of the cover and lowering canopy height to 4 cm. No further cutting or field operations were performed near station MAC after day 276 (Oct. 3). Station MUR (fig. 8, station Q) was installed over a freshly cut alfalfa field. Canopy height averaged 4 cm with little vegetation beyond stubble. No additional field cutting or field operations were performed near station MUR following installation. Station AK (fig. 9, station R) was installed over a full-cover canopy that averaged 55 cm in height. This field was subsequently cut on day 275 (Oct. 2), which forced the station to be moved temporarily to an adjacent field with a full-cover canopy (fig. 9 and table 1, station S). The station was returned to its original location on day 279 (Oct. 6) and no further field operations were performed near station AK for the duration of the data-collection period. Station AND (fig. 10, station P) was installed over a canopy that averaged 20 cm in height and 80 percent cover. No cutting or field operations were conducted near station AND during the remainder of the data-collection period. Periodic adjustments in sensor height were made to account for changes in canopy height. Specific information on changes in canopy height and canopy cover are provided in table 11.

Field conditions were documented to provide ground-truth data during the Landsat and SPOT satellite overpasses on September 28, 1989. Crop types were mapped and photographed for each demonstration farm field at MAC. Information on irrigation, cultivation, and orientation of rows are described by Owen-Joyce (1989c). Crop types mapped June 16, September 20, and September 28, 1989 (figs. 2 and 8–10), and descriptions of the fields, including information on irrigation, cultivation, and orientation of rows, are presented for fields surrounding all the meteorological stations (table 12).

## MACV—Off Farm—Cotton

The MACV—Off Farm data collection over cotton began in 1990 on day 177 (June 26) and continued to day 183 (July 2) (table 2). One

**Table 10.** Manufacturer and model number of instrumentation used at each field-monitoring site at and south of the Maricopa Agricultural Center during September and October 1989

[MFG, Manufacturer: CSI, Campbell Scientific, Inc.; RMY, R.M. Young, Inc.; MO, Met-One, Inc.; LC, Li Cor, Inc.; MMI, Micromet Instruments, Inc.; EV, Everest Interscience, Inc. Dashes indicate no instrument installed]

| Instrument or sensor | MAC 30 | | MAC 11 | | Murphree | | Ak Chin | | Anderson | |
|---|---|---|---|---|---|---|---|---|---|---|
| | MFG | Model | MFG | Model | MFG | Model | MFG | Model | MFG | Model |
| Air temperature | CSI | 207 | CSI | 207 | CSI | 207 | CSI | 207 | CSI | 207 |
| Relative humidity | CSI | 207 | CSI | 207 | CSI | 207 | CSI | 207 | CSI | 207 |
| Anemometer | RMY | 03001–5 | RMY | 03001–5 | MO | 024 | MO | 024 | RMY | 03001–5 |
| Pyranometer | LC | 200SZC | LC | 200SZC | LC | 200SZC | LC | 200SZC | LC | 200SZC |
| Net radiation | MMI | 1–Dome | MMI | 1–Dome | MMI | 1–Dome | MMI | 1–Dome | MMI | 1–Dome |
| Surface temperature | ----- | -------- | ----- | -------- | EV | 4002 | EV | 4002 | EV | [1]110 |
| Datalogger | CSI | CR10 | CSI | CR10 | CSI | 21X | CSI | 21X | CSI | 21X |

[1]Manual measurement made between 10:05 and 12:10 m.s.t. on day 271 (Sept. 28) and between 11:10 and 12:05 m.s.t. on day 286 (Oct. 13) only.

**Table 11.** Site information for meteorological stations that collected data over alfalfa at and south of the Maricopa Agricultural Center, Pinal County, Arizona, September 20–November 2, 1989

[Site name: FAL, fallow; MAC, Maricopa Agricultural Center; AND, Anderson Farm; MUR, Murphree Farm; AK, Ak Chin Farm. Field number: dashes indicate no field number assigned]

| Station Identifier[1] | Site name | Field number | Field dimensions, in meters | | Surface | Date | Day[2] | Canopy cover, in percent | Canopy height, in meters |
|---|---|---|---|---|---|---|---|---|---|
| | | | North–South | East–West | | | | | |
| I | FAL | 30 | 240 | 1,400 | Fallow | Sept. 20 | 263 | 0 | ([3]) |
| O | MAC | 11 | 500 | 360 | Alfalfa | Sept. 20 | 263 | 90 | 0.40 |
| | | | | | | Sept. 29 | 272 | ([4]) | 0.04 |
| | | | | | | Oct. 6 | 279 | 60 | 0.20 |
| | | | | | | Oct. 13 | 286 | 85 | 0.40 |
| | | | | | | Oct. 24 | 297 | 80 | 0.40 |
| P | AND | --- | 380 | 400 | Alfalfa | Sept. 21 | 264 | 80 | 0.20 |
| | | | | | | Oct. 6 | 279 | 100 | 0.50 |
| | | | | | | Oct. 13 | 286 | 95 | 0.55 |
| | | | | | | Oct. 24 | 297 | 95 | 0.45 |
| Q | MUR | --- | 810 | 380 | Alfalfa | Sept. 27 | 270 | ([4]) | 0.04 |
| | | | | | | Oct. 6 | 279 | 50 | 0.12 |
| | | | | | | Oct. 13 | 286 | 65 | 0.23 |
| | | | | | | Oct. 24 | 297 | 75 | 0.45 |
| R | AK | --- | 930 | 250 | Alfalfa | Sept. 23 | 266 | 100 | 0.55 |
| | | | | | | Sept. 29 | 272 | ([4]) | 0.05 |
| | | | | | | Oct. 6 | 279 | 10 | 0.20 |
| | | | | | | Oct. 13 | 286 | 80 | 0.40 |
| | | | | | | Oct. 24 | 297 | 80 | 0.45 |

[1]Corresponds to stations plotted on figures 2 and 8–10.
[2]Julian day of the year.
[3]Soil surface was covered with dry clods ranging from 0.5–10 centimeters in diameter.
[4]Canopy dominated by old stem stubble.

meteorological station was installed in MAC field 37 (fig. 11, station T; fig. 12). Two additional stations were installed in cotton fields farmed by Jim Hennis (HEN) (fig. 11, station V; fig. 13) and Casa Grande Farm (CG) (fig. 11 and table 1, station U; fig. 14), which increased the distances between stations compared with those in 1989. Data collection during MACV was just before the start of the monsoon season and was characterized by clouds (compare *SR* in figs. 3–7 to *SR* in figs. 12–14 for time of day 6–9 hours).

The stations were positioned in the same manner with $T_a$, $RH$, $U$, $R_N$, and $SR$ sensors installed 1.5 m above the canopy surface; $e_s$ (eq. 1), $e_a$ (eq. 2), and $VPD$ (eq. 3) were calculated. The cotton canopy at stations MAC, CG, and HEN was green and healthy at the time of station installation. Canopy height increased at the three cotton stations during the data-collection period (table 13). Sensor output was monitored by dataloggers and stored on magnetic tape as 1-minute samples. Specific details on the sensors and dataloggers used at each station are presented in table 14.

Field conditions were documented at MAC and nearby Arizona Meteorological Network (AZMET) stations to provide ground-truth data during the Landsat and SPOT satellite overpasses on June 27 and 28, 1990. Ground-based meteorological data are available in southern Arizona because of the presence of the automated AZMET weather-station

**Table 12.** Ground-truth data for fields surrounding the meteorological stations at and surrounding the Maricopa Agricultural Center, Pinal County, Arizona, June to September 1989

[Crop: ND, No data]

| Field number[1] | Crop | Description |
|---|---|---|
| 1 | ND | |
| 2 | Alfalfa | 250 m east-west at west end of field. No data rest of field. |
| 3-8 | ND | |
| 9 | ------- | Building with gravel lot, site of Maricopa AZMET station in southeast corner. |
| 10 | Wheat/Fallow | Full-cover wheat 4/8/89. Fallow with wheat stubble 6/16/89. Fallow 9/28/89. |
| 11 | Alfalfa | Recently mowed 4/9/89. Soil wet and northwest corner bare 6/16/89. Soil damp 9/28/89. |
| 12 | ND | |
| 13 | Alfalfa | Recently mowed, small plot of unmowed alfalfa in northwest corner 4/9/89; bales picked up 4/8/89. Standing water in north half and dry in south half 6/16/89. Soil damp 9/28/89. |
| 14 | Fallow | Furrowed 4/8/89. Plowed 6/16/89. |
| 15 | Fallow/Cotton | East-west rows. Fallow, cultivated, dry 4/9/89. Cotton, cultivated, middle of field contains open areas, dry except for about 45 m at south end, which was wet 6/16/89. Dry 9/28/89. |
| 16 | Fallow | Wheat stubble. |
| 17 | Wheat/Fallow | Full-cover wheat 4/8/89. Fallow; north half plowed, clods, yellow stubble, dry; south half smooth, dry and being laser leveled 6/16/89. Dry 9/28/89. |
| 18 | Fallow/Cotton | East-west rows. Fallow, cultivated, dry 4/9/89. Cotton, cultivated, dry 6/16/89. Dry 9/28/89. |
| 19 | Fallow/Cotton | East-west rows. Fallow, cultivated, dry 4/9/89. Cotton, not cultivated, dry except limited irrigation in north 15 rows, some rows wet, standing water between rows 7 and 8 from the north end 6/16/89. Dry 9/28/89. |
| 20 | Fallow/Cotton | East-west rows. Fallow, cultivated, dry; north end of field has plot of weeds; south end is plowed, clods, dry 4/9/89. Cotton, not cultivated, dry, north end of field has about 45 m of sparse weeds 6/16/89. Dry 9/28/89. |
| 21 | Fallow/Cotton | East-west rows. Fallow, cultivated, dry, scattered weeds 4/9/89. Cotton, soil wet except about 90 m at south end, which was dry, scattered weeds 6/16/89. Dry 9/28/89. |
| 22 | Fallow/Cotton | East-west rows. Fallow, cultivated, dry 4/9/89. Cotton, cultivated, dry in about 210 m at north end, standing water in about 120 m north central part of field, dry in south 490 m 6/16/89. Dry 9/28/89. |
| 23 | Fallow/Cotton | East-west rows. Fallow, cultivated, dry 4/9/89. Cotton, cultivated, dry 6/16/89. Dry 9/28/89. |
| 25 | Wheat/Fallow | Full-cover wheat, sparse at north end with water ponded along the east-west bench mounds 4/9/89. Plowed, clods, yellow stubble, dry 6/16/89. Dry 9/28/89. |
| 26 | Fallow/Cotton | East-west rows. Fallow, cultivated, dry 4/9/89. Cotton, north 45 m fallow, clods, lumpy, and smooth where water evaporated. Cultivated south half, not cultivated north half, dry 6/16/89. Dry 9/28/89. |
| 27 | Fallow/Cotton | East-west rows. Fallow, cultivated, dry, some clods at west end 4/9/89. Cotton, east end has carbon dioxide rings set up, drip irrigated field. Cultivated, dry at surface, sparse at south end in west half 6/16/89. Dry 9/28/89. |

**Table 12.** Ground-truth data for fields surrounding the meteorological stations at and surrounding the Maricopa Agricultural Center, Pinal County, Arizona, June to September 1989—Continued

| Field number[1] | Crop | Description |
|---|---|---|
| 28 | Fallow/Cotton | North-south rows. Fallow, cultivated, dry, clods 4/9/89. Cotton, dry, tractor cultivating from east to west 6/16/89. Dry 9/28/89. |
| 29 | Fallow/Cotton | North-south rows. Fallow, cultivated, dry; west half has flat-topped rows and cotton plants about 15 mm high grading to 30 mm high at east end 4/9/89. Cotton; west quarter of field soil wet with standing water at east end and active irrigation at west end, middle two quarters of field soil wet, east quarter not cultivated and dry at surface 6/16/89. Dry 9/28/89. |
| 30 | Fallow | Plowed with yellow stubble in east half; west half plowed with clods; dividing line runs diagonally to northeast from half way point on south field border 4/9/89. Plowed with yellow stubble, dry 6/16/89. Plowed, clods, dry 9/28/89. |
| 31 | Fallow/Cotton | North-south rows. Fallow, cultivated, dry 4/9/89. Cotton, west 910 m cultivated and dry, east 335 m not cultivated and dry at surface, middle 210 m standing water and active irrigation with water across field at east side of irrigation and a quarter to half way across field on west side of irrigation 6/16/89. Dry 9/28/89. |
| 3201 | Wheat/Fallow | Wheat, east half wheat/barley mix test plot for early removal that gives a non-uniform surface, west half same as field 3202 4/9/89. Fallow, plowed, clods, yellow stubble, dry 6/16/89. Plowed, rounded clods, some stubble, dry 9/28/89. |
| 3202 | Wheat/Fallow | Wheat, west half of field irrigated prior to experiment, along north boundary canal some standing water and mud, east half dry 4/9/89. Fallow, same as field 3201 6/16/89 and 9/28/89. |
| 33 | Fallow | Plowed, some yellow stubble, some clods, some weeds, dry 4/9/89 and 6/16/89. Plowed, some stubble, clods, dry 9/28/89. |
| 34 | Fallow | Plowed, some clods, some yellow stubble, dry 4/9/89 and 6/16/89. Plowed, clods, some stubble, dry 9/28/89. |
| 35 | Fallow | Plowed with green stubble and clods, dry but soil appears darker than in fields with yellow stubble 4/9/89. Plowed, clods, some yellow stubble, dry 6/16/89. Plowed, clods, some stubble, dry 9/28/89. |
| 36 | Fallow/Cotton | North-south rows. Fallow, cultivated, dry 4/9/89. Cotton, not cultivated, dry, sparse at east end 6/16/89. Dry 9/28/89. |
| 37 | Fallow | Same as field 35 on 4/9/89. Plowed, clods, some yellow stubble, some weeds, dry 6/16/89. Plowed, clods, some stubble, dry 9/28/89. |
| 38 | Grapes | North-south rows. Recently plowed between the frames and around edges of field, dry 4/9/89. Not cultivated, dry, plants in east center rows are smaller than rest of field 6/16/89. Not cultivated, dry, many weeds around plants and between rows, any grapes on vines are dried 9/28/89. |
| 39 | Fallow | Same as field 35 on 4/9/89. Plowed, clods, yellow stubble, dry 6/16/89. Plowed, clods, some stubble, dry 9/28/89. |

**Table 12.** Ground-truth data for fields surrounding the meteorological stations at and surrounding the Maricopa Agricultural Center, Pinal County, Arizona, June to September 1989—Continued

| Field number[1] | Crop | Description |
|---|---|---|
| 40-61 | ND | |
| 62 | Fallow | Wheat stubble. |
| 63 | Cotton | East-west rows. |
| 64 | Cotton | East-west rows. |
| 65 | Alfalfa | |
| 66 | Cotton | East-west rows. |
| 67 | Fallow | Wheat stubble, plowed. |
| 68 | Cotton | North-south rows. |
| 69 | Cotton | North-south rows. |
| 70 | Fallow | |
| 71 | Fallow | |
| 72 | Cotton | North-south rows. |
| 73 | Cotton | North-south rows. |
| 74 | Cotton | North-south rows. Small garden at east end of field with melons, corn, and squash. |
| 75 | Cotton | North-south rows. |
| 76 | Fallow | Wheat stubble. |
| 77 | Cotton | East-west rows. |
| 78 | Cotton | East-west rows. |
| 79 | Alfalfa | |
| 80 | Melons | |
| 81 | Fallow | Wheat stubble, plowed smooth. |
| 82 | Cotton | Northeast-southwest rows, irrigated 6/16/89. |
| 83 | ND | |
| 84 | Fallow | Wheat stubble. |
| 85 | Alfalfa | Irrigated at north end 9/20/89. |
| 86 | Alfalfa | |
| 87 | Fallow | Wheat stubble, plowed 6/16/89. |
| 88 | Fallow | |
| 89 | Cotton | East-west rows. |
| 90 | Fallow | Wheat stubble. |
| 91 | Cotton | North-south rows. |
| 92 | Fallow | |
| 93 | Cotton | North-south rows. |
| 94 | Fallow | Wheat stubble. |
| 95 | Fallow | Wheat stubble, plowed 6/16/89. |
| 96 | Cotton | East-west rows. |
| 97 | Cotton | East-west rows. |
| 98 | Cotton | |
| 99 | Cotton | |
| 100 | -------- | Buildings. |
| 101 | Pistachios | |
| 102 | Cotton | North-south rows. |
| 103 | Alfalfa | |
| 104 | Alfalfa | |
| 105 | ND | |
| 106 | ND | |
| 107 | Cotton | North-south rows. |
| 108 | Fallow | |
| 109 | ND | |
| 110 | ND | |
| 111 | ND | |
| 112 | Cotton | North-south rows. |
| 113 | Cotton | |
| 114 | Cotton | East-west rows. |
| 115 | Fallow | |
| 116 | ND | |
| 117 | ND | |
| 118 | Pistachios | |
| 119 | ND | |
| 120 | ND | |
| 121 | ND | |
| 122 | ND | |
| 123 | Cotton | East-west rows. |
| 124 | ND | |
| 125 | Cotton | East-west rows. |
| 126 | Cotton | |
| 127 | Cotton | East-west rows. |
| 128 | Cotton | |
| 129 | Cotton | East-west rows. |
| 130 | Fallow | Wheat stubble. |
| 131 | Fallow | Wheat stubble. |
| 132 | Natural | |
| 133 | Cotton | East-west rows. |
| 134 | Natural | |
| 135 | Fallow | Wheat stubble. |
| 136 | Fallow | Wheat stubble. |
| 137 | Pecans | East-west rows. |
| 138 | Pecans | East-west rows. Irrigated 9/20/89. |
| 139 | Pecans | East-west rows. Irrigated 9/20/89. |
| 140 | Pecans | |
| 141 | Pecans | |
| 142 | ------- | Houses. |
| 143 | Cotton | |
| 144 | Fallow | Weeds. |
| 145 | Cotton | |

**Table 12.** Ground-truth data for fields surrounding the meteorological stations at and surrounding the Maricopa Agricultural Center, Pinal County, Arizona, June to September 1989—Continued

| Field number[1] | Crop | Description |
|---|---|---|
| 146 | Cotton | |
| 147 | Fallow | Wheat stubble. |
| 148 | Fallow | Wheat stubble. |
| 149 | ND | Weeds. |
| 150 | Cotton | |
| 151 | ------- | Buildings. |
| 152 | Fallow | Weeds. |
| 153 | Fallow | Weeds. |
| 154 | Fallow | |
| 155 | Cotton | North-south rows. |
| 156 | Fallow | |
| 157 | Fallow | Wheat stubble. |
| 158 | Fallow | Wheat stubble, being plowed 9/28/89. |
| 159 | Cotton | North-south rows. |
| 160 | Cotton | North-south rows. |
| 161 | Fallow | Wheat stubble. |
| 162 | Fallow | Wheat stubble. |
| 163 | Cotton | East-west rows. |
| 164 | Cotton | |
| 165 | Cotton | East-west rows. |
| 166 | Cotton | North-south rows. |
| 167 | Cotton | North-south rows. |
| 168 | Fallow | Wheat stubble. |
| 169 | Fallow | Wheat stubble. |
| 170 | ND | |
| 171 | Alfalfa | Site of meteorological station. |
| 172 | Cotton | East-west rows. |
| 173 | Fallow | |
| 174 | Cotton | |
| 175 | Cotton | East-west rows. |
| 176 | Cotton | North-south rows. |
| 177 | Cotton | East-west rows. |
| 178 | Cotton | North-south rows. |
| 179 | Fallow | Smooth, old wheat stubble at north end. |
| 180 | ------- | Buildings. |
| 181 | Fallow | |
| 182 | Cotton | North-south rows. |
| 183 | Fallow | |
| 184 | Alfalfa | Site of meteorological station. |
| 185 | Fallow | |
| 186 | Pistachios | |
| 187 | Cotton | East-west rows. |
| 188 | Cotton | |
| 189 | Cotton | |
| 190 | Fallow | |
| 191 | ------- | Buildings. |
| 192 | Fallow | Weeds. |
| 193 | Fallow | Weeds. |
| 194 | Fallow | |
| 195 | ------- | Buildings. |
| 196 | Cotton | East-west rows. |
| 197 | Cotton | North-south rows. |
| 198 | ------- | Buildings, weeds to north. |
| 199 | Fallow | Weeds. |
| 200 | Cotton | |
| 201 | Bermuda | North third of field wet; middle third being irrigated with sprinklers; south third dry 9/28/89. |
| 202 | Alfalfa | |
| 203 | Bermuda | Open area of dirt in middle of field; plowed. |
| 204 | Cotton | |
| 205 | Fallow | Wheat stubble. |
| 206 | Fallow | |
| 207 | Cotton | North-south rows. |
| 208 | Fallow | Wheat stubble. |
| 209 | Fallow | |
| 210 | Fallow | |
| 211 | Fallow | |
| 212 | Pecans | |
| 213 | Cotton | East-west rows, site of meteorological station. |
| 214 | ND | |
| 215 | Pasture | Horses 9/20/89. |
| 216 | Natural | |
| 217 | Cotton | |
| 218 | Cotton | |
| 219 | Fallow | Weeds. |
| 220 | Fallow | |
| 221 | Fallow | |
| 222 | Cotton | |
| 223 | Fallow | Weeds. |
| 224 | Fallow | |
| 225 | Fallow | |
| 226 | Fallow | Weeds. |
| 227 | Cotton | |
| 228 | Cotton | East-west rows. |
| 229 | Cotton | East-west rows. |
| 230 | Cotton | East-west rows. |
| 231 | Cotton | |

**Table 12.** Ground-truth data for fields surrounding the meteorological stations at and surrounding the Maricopa Agricultural Center, Pinal County, Arizona, June to September 1989—Continued

| Field number[1] | Crop | Description |
|---|---|---|
| 232 | Fallow | |
| 233 | Fallow | |
| 234 | Cotton | East-west rows. |
| 235 | Fallow | |
| 236 | Fallow | |
| 237 | Fallow | |
| 238 | Cotton | East-west rows. |
| 239 | ------- | Buildings. |
| 240 | Cotton | North-south rows. |
| 241 | Fallow | |
| 242 | Cotton | East-west rows. |
| 243 | Fallow | |
| 244 | ND | |
| 245 | Fallow | Wheat stubble. |
| 246 | Fallow | |
| 247 | Alfalfa | |
| 248 | Fallow | |
| 249 | Cotton | East-west rows. |
| 250 | Fallow | |
| 251 | ------- | Buildings. |
| 252 | Alfalfa | |
| 253 | Fallow | |
| 254 | Alfalfa | |
| 255 | Fallow | Wheat stubble. |
| 256 | Cotton | East-west rows. |
| 257 | ND | |
| 258 | Fallow | Weeds. |
| 259 | Fallow | Weeds. |
| 260 | Cotton | East-west rows. |
| 261 | ND | |
| 262 | Cotton | East-west rows. |
| 263 | ND | |
| 264 | Cotton | East-west rows. |
| 265 | ND | |
| 266 | Cotton | |
| 267 | Fallow | Weeds. |
| 268 | Fallow | Weeds. |
| 269 | Cotton | |
| 270 | Fallow | Weeds. |
| 271 | Fallow | |
| 272 | Cotton | |
| 273 | Cotton | |
| 274 | Fallow | |
| 275 | Cotton | |
| 276 | Fallow | |
| 277 | Cotton | |
| 278 | Cotton | |
| 279 | Fallow | Weeds. |
| 280 | Cotton | |
| 281 | Fallow | |
| 282 | Fallow | Weeds. |
| 283 | Fallow | Sparse weeds. |
| 284 | Cotton | |
| 285 | Cotton | |
| 286 | Natural | |
| 287 | Fallow | Sparse weeds. |
| 288 | Cotton | |
| 289 | Cotton | |
| 290 | Fallow | Weeds. |
| 291 | Fallow | Weeds. |
| 292 | Cotton | North-south rows. |
| 293 | Pecans | |
| 294 | Cotton | |
| 295 | Fallow | Sparse weeds. |
| 296 | Fallow | Weeds. |
| 297 | Fallow | Weeds. |
| 298 | Fallow | |
| 299 | Cotton | |
| 300 | Fallow | |
| 301-311 | ND | |
| 312 | Cotton | |
| 313-315 | ND | |
| 316 | Fallow | Wheat stubble. |
| 317 | Cotton | |
| 318 | ------- | Houses. |
| 319 | Cotton | |
| 320 | Natural | |
| 321 | Pasture | |
| 322 | Pasture | |
| 323 | Fallow | Weeds. |
| 324 | ND | |
| 325 | ------- | Stock yards. |
| 326 | Orchard | Type unknown. |
| 327-330 | ND | |
| 331 | Fallow | East-west furrows. |
| 332-334 | ND | |
| 335 | Fallow | East-west furrows. |
| 336 | Fallow | East-west furrows. |
| 337 | Fallow | Smooth. |
| 338 | Cotton | East-west rows. |
| 339 | Cotton | |
| 340 | Cotton | North-south rows. |

**Table 12.** Ground-truth data for fields surrounding the meteorological stations at and surrounding the Maricopa Agricultural Center, Pinal County, Arizona, June to September 1989—Continued

| Field number[1] | Crop | Description |
|---|---|---|
| 341 | Cotton | North-south rows. |
| 342 | Cotton | North-south rows. |
| 343 | Fallow | Wheat stubble. |
| 344 | Cotton | North-south rows. |
| 345 | Cotton | North-south rows. |
| 346 | Fallow | Wheat stubble. |
| 347 | Fallow | Wheat stubble. |
| 348 | Fallow | Wheat stubble. |
| 349 | Cotton | |
| 350 | Cotton | |
| 351 | ------- | Bale storage. |
| 352 | ------- | Bale storage. |
| 353 | ND | |
| 354 | Fallow | |
| 355 | Orchard | Type unknown. |
| 356 | ------- | North part—east half natural vegetation, west half fallow. South part—bale storage. |
| 357 | ------- | Stock yard. |
| 358 | Pasture | |
| 359 | Cotton | |
| 360 | Pasture | Dried. |
| 361 | ------- | Stock yard. |
| 362 | Cotton | |
| 363 | Cotton | |
| 364 | Fallow | |
| 365 | Cotton | |
| 366-369 | ND | |
| 370 | Fallow | |
| 371 | Cotton | |
| 372 | Cotton | |
| 373 | Cotton | |
| 374 | Cotton | |
| 375 | Cotton | |
| 376 | Cotton | |
| 377 | Cotton | |
| 378 | Cotton | |
| 379 | Pecans | Small trees. |
| 380 | Fallow | Weeds in south part. |
| 381 | Melons | Irrigated 9/20/89. |
| 382 | Pecans | Small trees. |
| 383 | Cotton | |
| 384 | Pecans | Small trees. |
| 385 | Cotton | |
| 386 | Pecans | Small trees. |
| 387 | Fallow | |
| 388 | Pecans | Small trees. |
| 389 | Cotton | |
| 390 | Cotton | |
| 391 | Cotton | |
| 392 | Cotton | |
| 393 | Cotton | |
| 394 | Cotton | |
| 395 | Cotton | |
| 396 | Fallow | |
| 397 | Cotton | |
| 398 | Cotton | Site of meteorological station. |
| 399 | Cotton | |
| 400 | Cotton | |
| 401 | Cotton | |
| 402 | Alfalfa | Temporary site of meteorological station while field 405 was mowed. |
| 403 | Pecans | Small trees. |
| 404 | Fallow | |
| 405 | Alfalfa | Site of meteorological station. |
| 406 | Alfalfa | |
| 407 | Cotton | |
| 408 | Grain | |
| 409 | Pecans | Small trees. |
| 410 | Cotton | |
| 411 | Grain | |
| 412 | Pecans | Small trees. |
| 413 | Cotton | |
| 414 | ND | |
| 415 | Cotton | |
| 416 | ND | |
| 417 | Cotton | |
| 418 | Pecans | Small trees. |
| 419 | Cotton | |
| 420 | Fallow | Weeds with salt on land surface. |
| 421 | Cotton | |
| 422-428 | ND | |

[1]Corresponds to field numbers on figures 2 and 8–10.

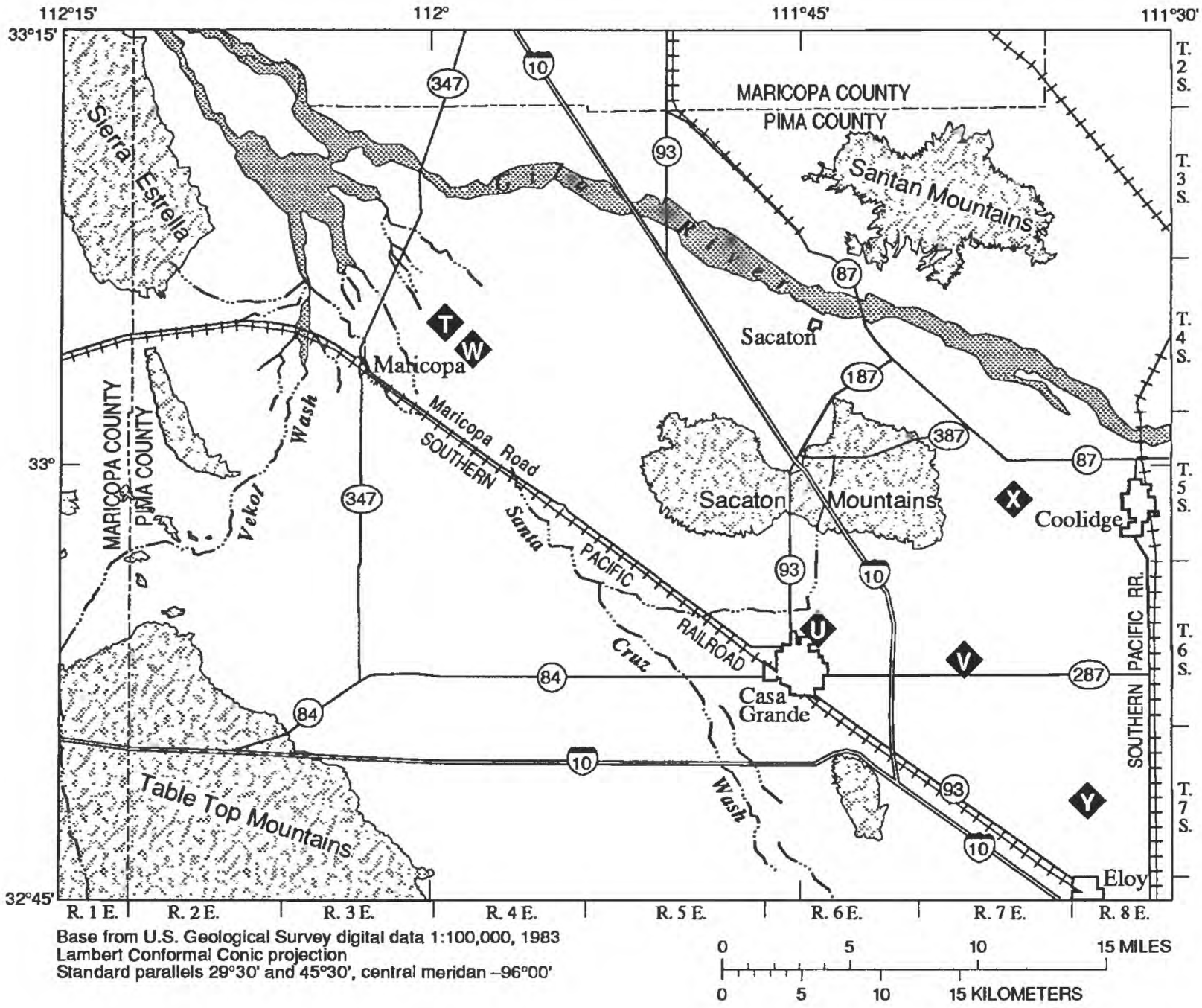


**Figure 11.** Meteorological stations at and southeast of the Maricopa Agricultural Center, Pinal County, Arizona, from June 26–July 2, 1990.

**Table 13.** Site information for meteorological stations that collected data over cotton at and east of the Maricopa Agricultural Center, Pinal County, Arizona, June 26–July 2, 1990

[Field number: dashes indicate no field number assigned]

| Station identifier[1] | Site name | Field number | Field dimension, in meters | | Surface | Canopy cover, in percent[2] | Canopy height, in centimeters |
|---|---|---|---|---|---|---|---|
| | | | North–South | East–West | | | |
| T | MAC | 37 | 260 | 740 | Cotton | 37–45 | 40–47 |
| U | CG[3] | --- | 460 | 540 | Cotton | 40–46 | 50–68 |
| V | HEN | --- | 270 | 430 | Cotton | 80–90 | 75–86 |

[1]Corresponds to stations plotted on figures 11 and 15–17.
[2]Range indicates values at the start and end of data collection.
[3]Field is "L" shaped; station position yields maximum north-south and east-west dimensions.

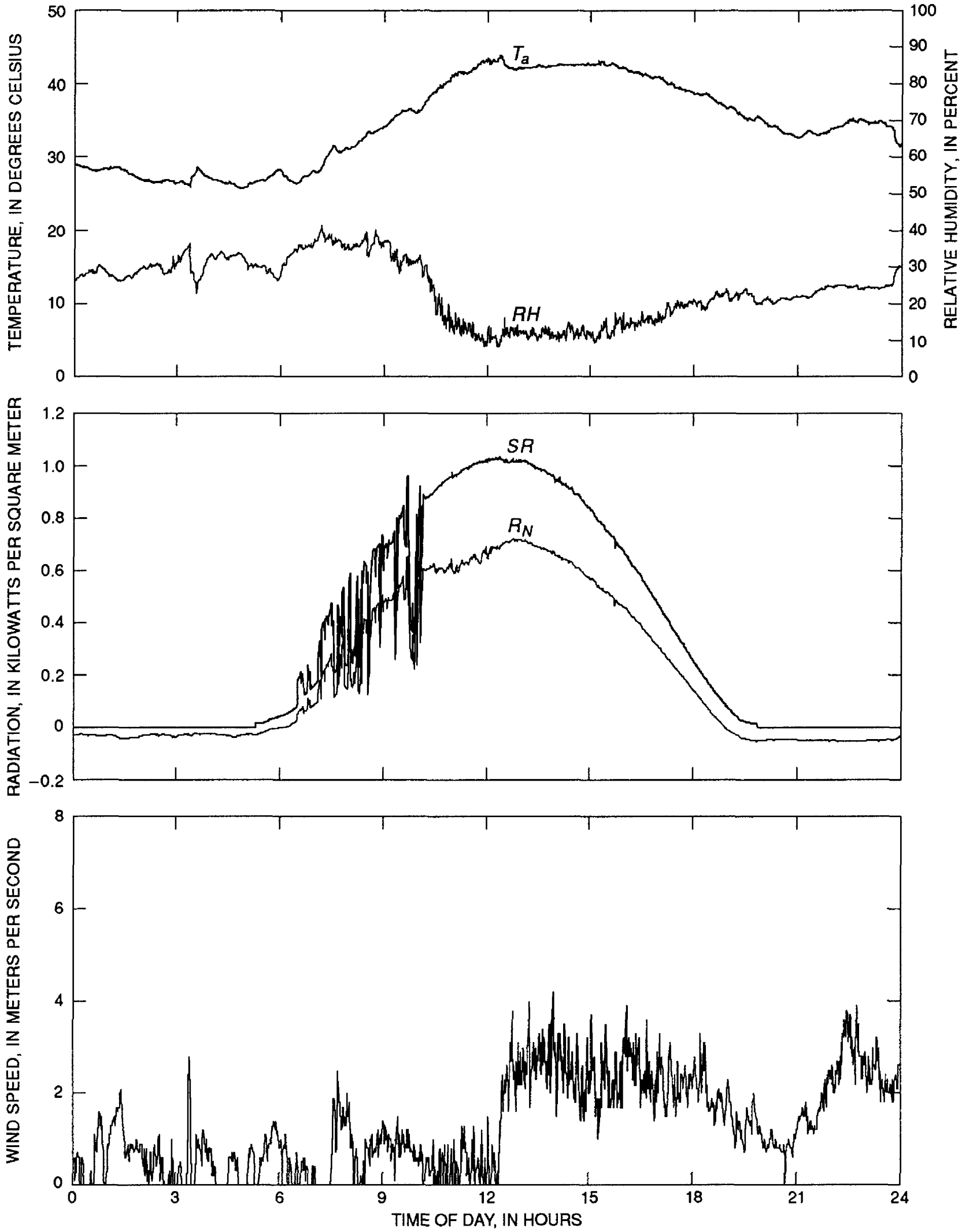


**Figure 12.** Minute data values of air temperature *($T_a$)*, relative humidity *(RH)*, solar radiation *(SR)*, net radiation *($R_N$)*, and wind speed collected over cotton in field 37 at the Maricopa Agricultural Center during the MACV experiment June 28, 1990 (day 179).

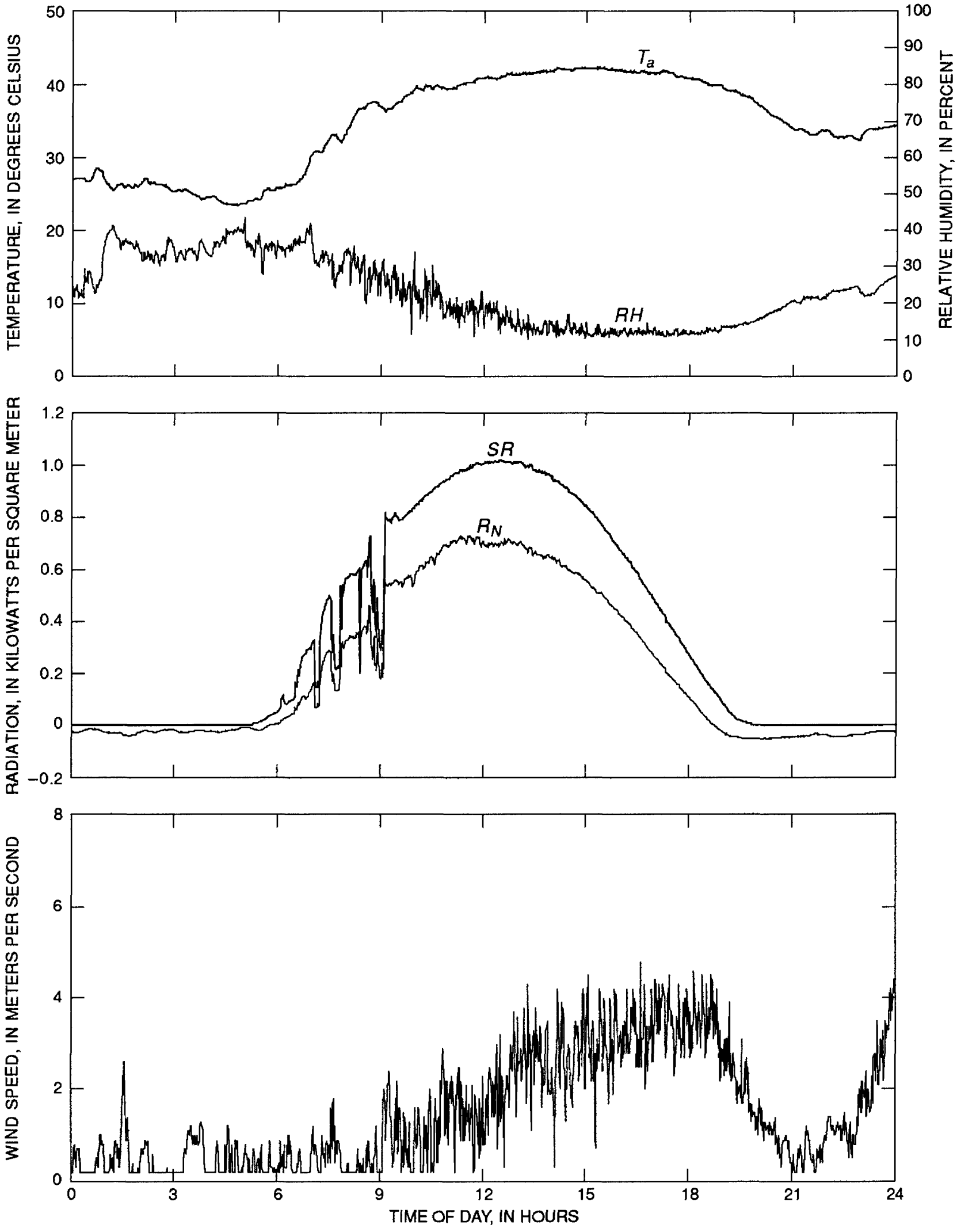


**Figure 13.** Minute data values of air temperature *($T_a$)*, relative humidity *(RH)*, solar radiation *(SR)*, net radiation *($R_N$)*, and wind speed collected over cotton in a field at Casa Grande Farm during the MACV experiment June 28, 1990 (day 179).

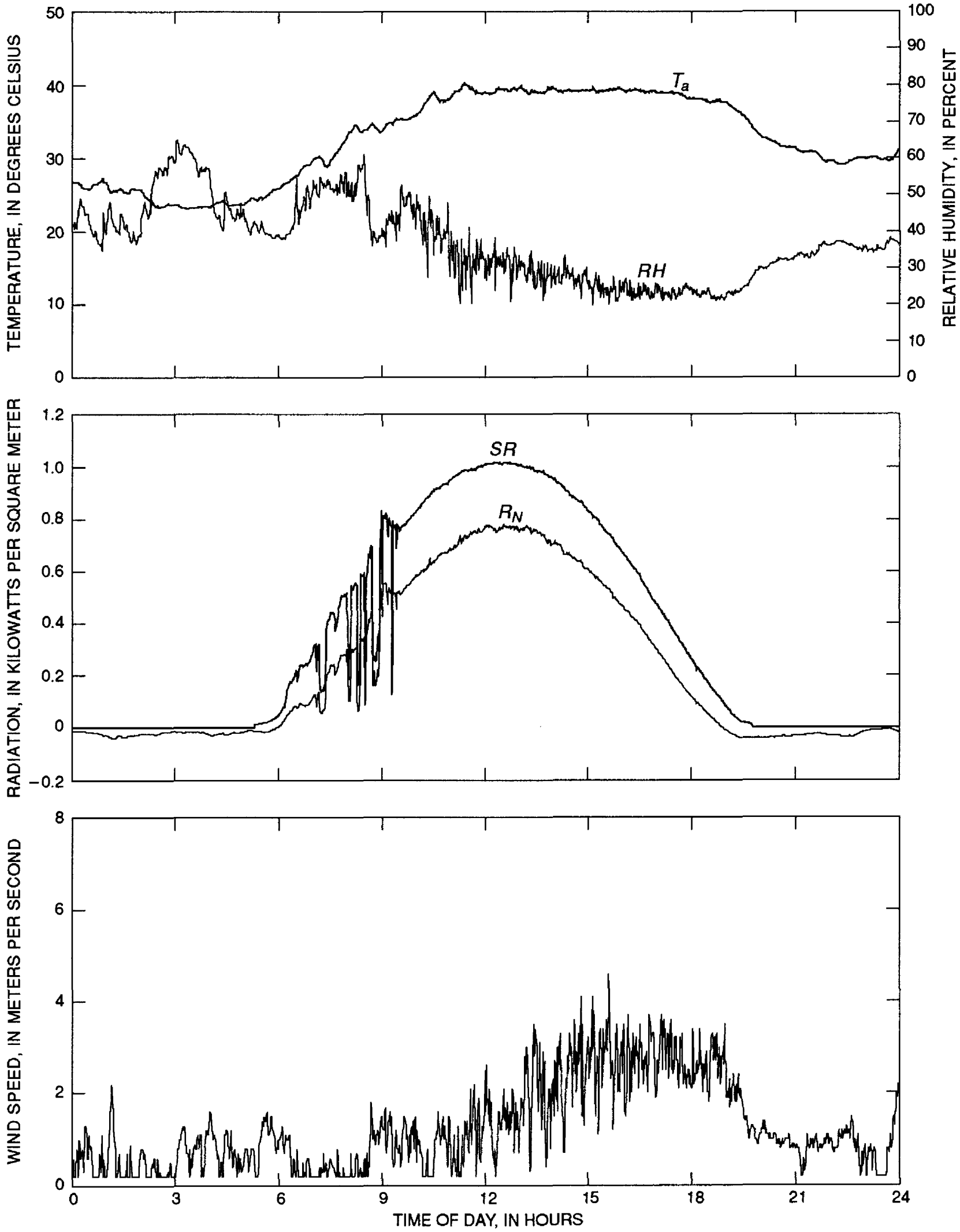


**Figure 14.** Minute data values of air temperature *($T_a$)*, relative humidity *(RH)*, solar radiation *(SR)*, net radiation *($R_N$)*, and wind speed collected over cotton in a field at Hennis Farm during the MACV experiment June 28, 1990 (day 179).

**Table 14.** Manufacturer and model number of instrumentation used at each field monitoring site during June 26–July 2, 1990

[MFG, Manufacturer: CSI, Campbell Scientific, Inc.; RMY, R.M. Young, Inc.; LC, Li Cor, Inc.; MMI, Micromet Instruments, Inc.; EV, Everest Interscience, Inc.]

| Inatrument or sensor | MAC 37 | | Casa Grande | | Hennis | |
|---|---|---|---|---|---|---|
| | MFG | Model | MFG | Model | MFG | Model |
| Air temperature | CSI | 201 | CSI | 201 | CSI | 201 |
| Relative humidity | CSI | 201 | CSI | 201 | CSI | 201 |
| Anemometer | RMY | 03301–5 | RMY | 03301–5 | RMY | 03301–5 |
| Pyranometer | LC | 200 | LC | 200 | LC | 200 |
| Net radiation | MMI | 1–Dome | MMI | 1–Dome | MMI | 1–Dome |
| Datalogger | CSI | 21X | CSI | 21X | CSI | 21X |

network (Brown, 1987; 1989), which provides weather-based information to agricultural clients. Nearly all agricultural weather networks collect and disseminate data on solar radiation, temperature, wind, and humidity—parameters currently used to estimate ET. Crop types were mapped and photographed for each demonstration farm field. Information on irrigation, cultivation, and orientation of rows are described by Owen-Joyce (1991). In addition, field boundaries and crop types were mapped June 26–28, 1990, in a 2- to 3-square-kilometer area around each of the temporary stations at MAC (fig. 15, station T), CG (fig. 16, station U), and HEN (fig. 17, station V) and the AZMET stations at Maricopa (fig. 15, station W), Coolidge (fig. 18, station X), and Eloy (fig. 19, station Y). Surface conditions surrounding the different sites were variable. Crop types and descriptions of the fields, including information on irrigation, cultivation, and orientation of rows are presented for MAC and Maricopa (table 15), CG (table 16), HEN (table 17), Coolidge (table 18), and Eloy (table 19). Photographs of each site are documented by Owen-Joyce (1991).

## COMPUTER DATA FILES

All acquired digital data were transferred from storage tapes to the fixed disk of a personal computer at the University of Arizona and inserted into data-base files using the commercial data-base management software DBASE III+ (Ashton Tate Inc., Torrence, California). The data were checked for errors using a combination of manual and computer-based error-checking routines prior to a final adjustment using appropriate calibration equations.

The entire ground-based meteorological data set acquired during the project is subdivided into individual station-day data files that are available on disk from the University of Arizona. Each station-day file is available in ASCII text file format and provides all data collected from a given meteorological station on a particular satellite overpass day. Similar units are utilized throughout the entire data set.

| Parametera | Unita of measure |
|---|---|
| $T_a$, $T_s$, $T_c$ | Degrees Celsius |
| $RH$ | Percent |
| $SR$, $R_N$, $G$ | Kilowatts per square meter |
| $U$ | Meters per second |
| $e_a$, $e_s$, $VPD$ | Millibars |

Within a given station-day file, all data collected at a particular time (defined as a record) are stored on one line of the text file with individual data points separated by commas (comma delimited). Time of day is presented as mountain standard time (m.s.t.) and is expressed as hours and minutes with no colon between the numbers representing the hour and minute values. For data sets containing time-averaged 15-minute data, the values presented are averaged for the 15-minute period ending at the time of day presented in the file. Each record (or

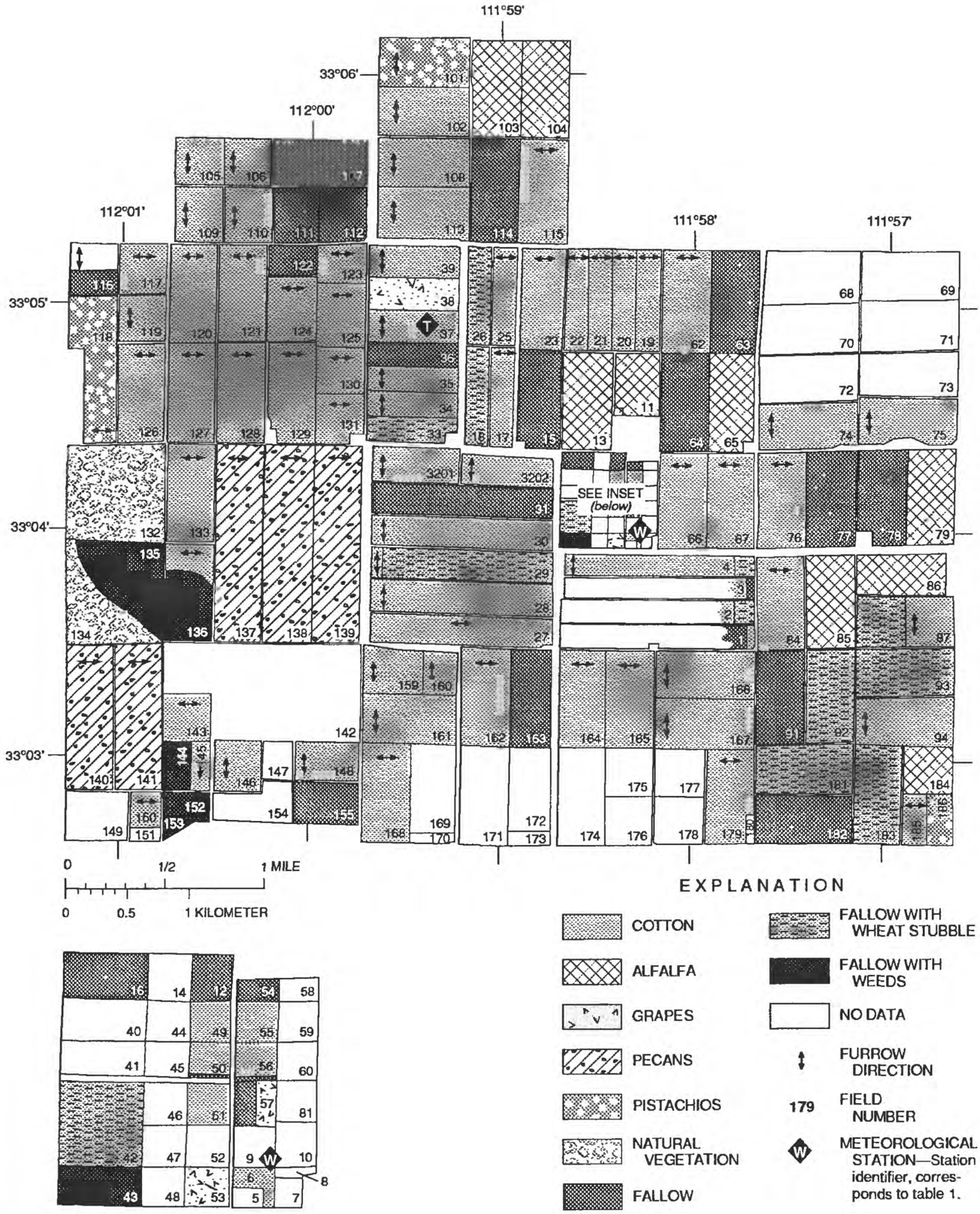


**Figure 15.** Crop types in fields surrounding the meteorological station in a cotton field at the Maricopa Agricultural Center and of the Arizona Meteological Network station east of Maricopa, Arizona, June 28–29, 1990.

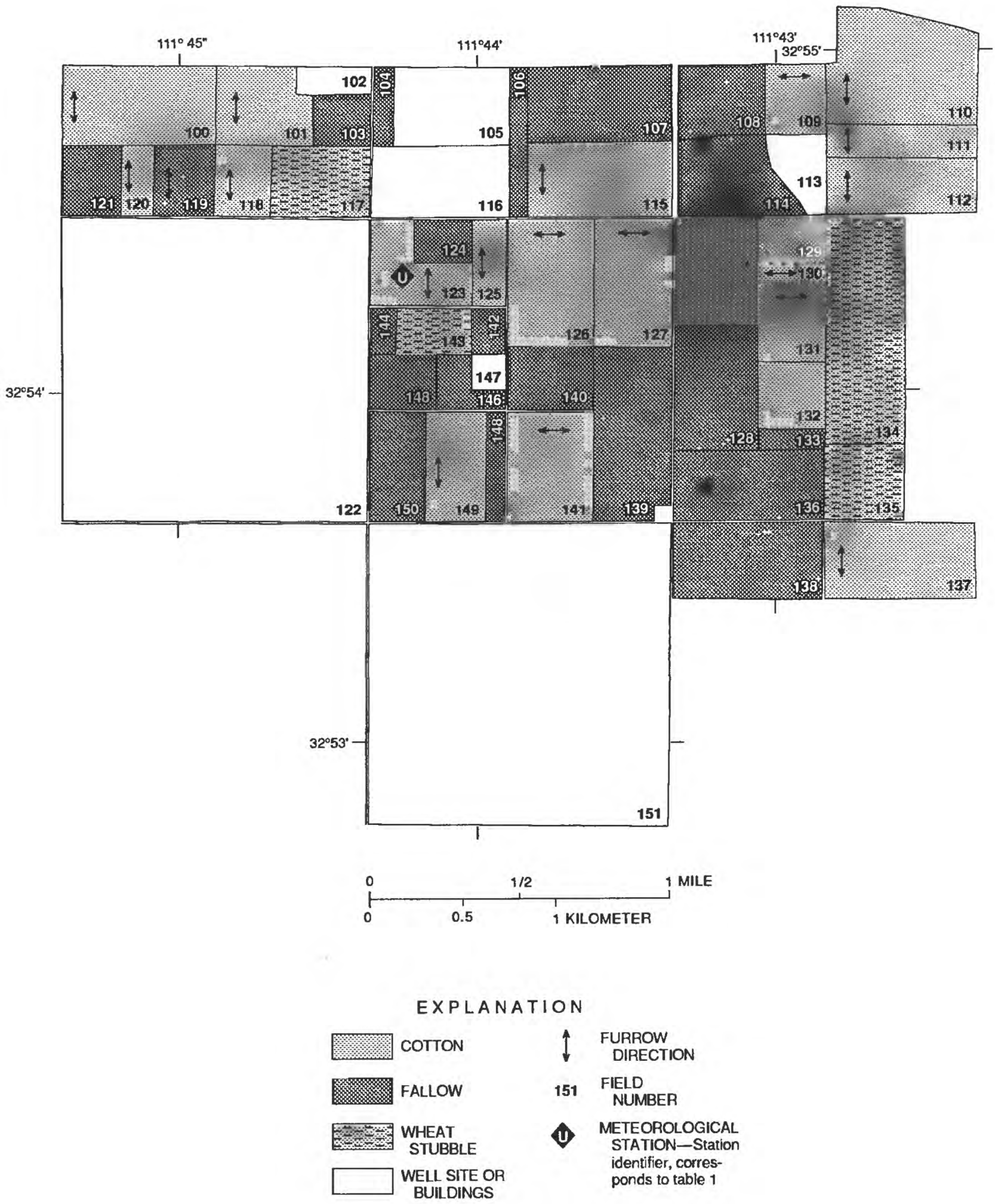


**Figure 16.** Crop types in fields surrounding the meteorological station in a cotton field at Casa Grande Farm north of Casa Grande, Arizona, June 28, 1990.

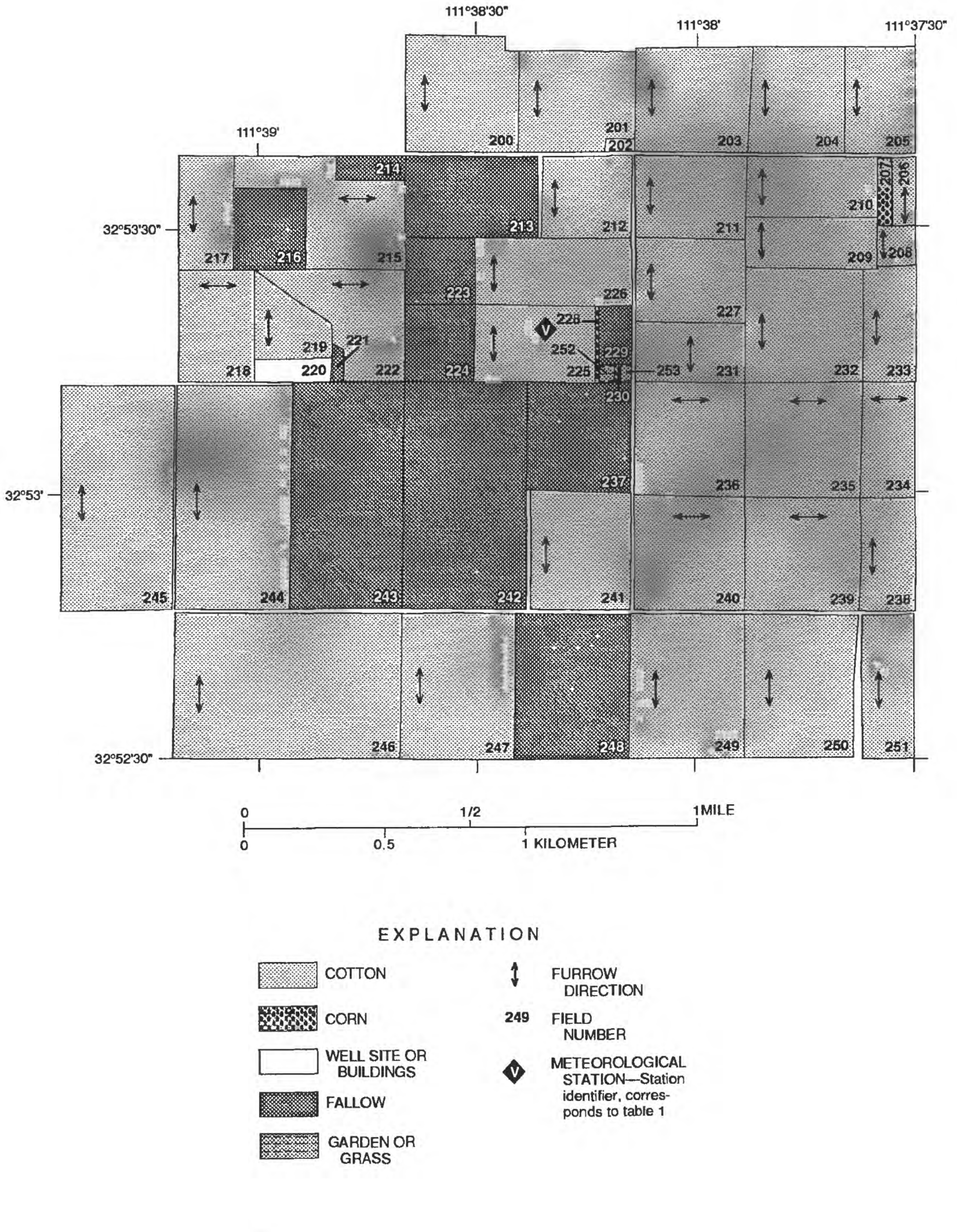


**Figure 17.** Crop types in fields surrounding the meteorological station in a cotton field at the Hennis Farm east of Casa Grande, Arizona, June 28, 1990.

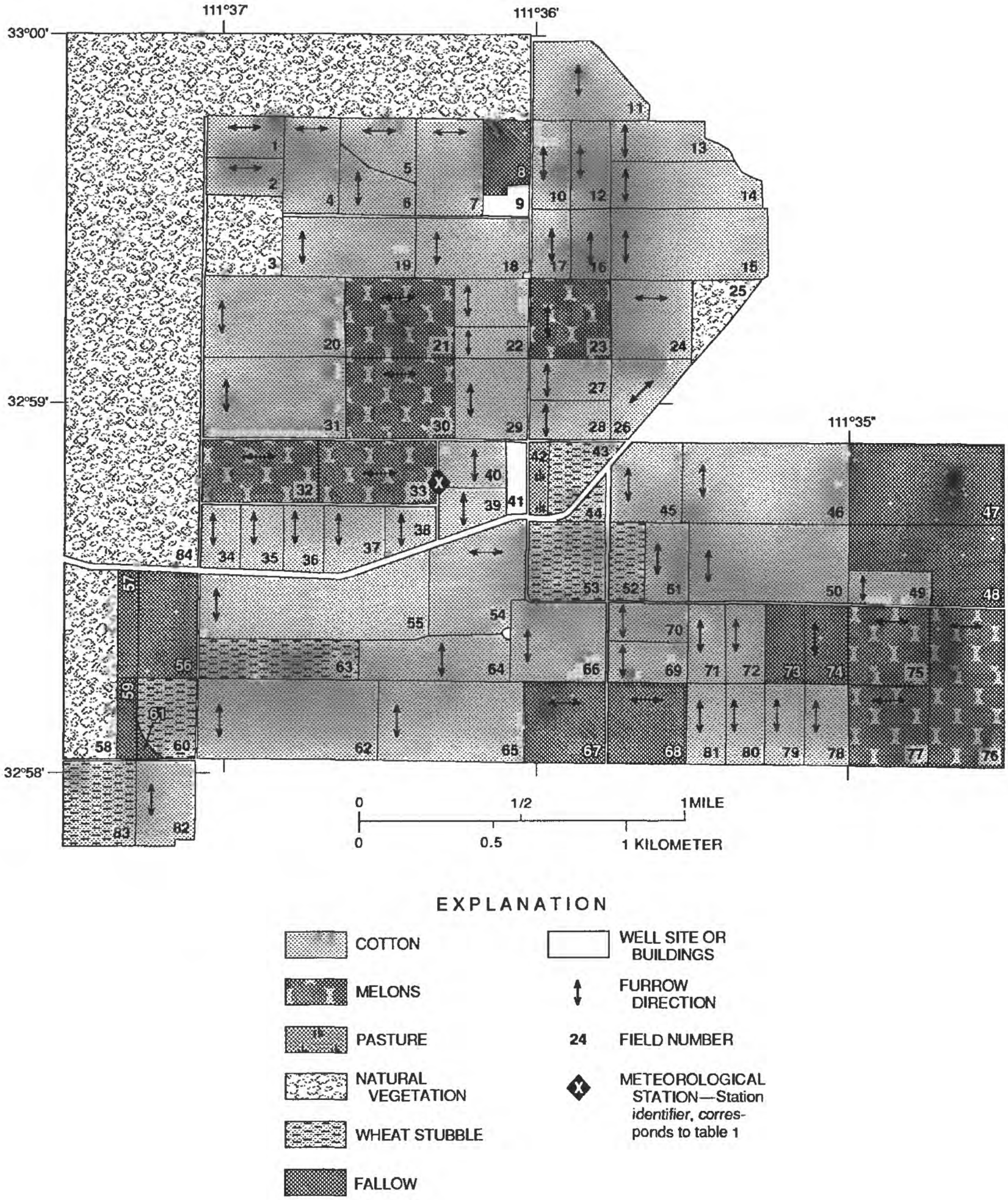


**Figure 18.** Crop types in fields surrounding the Arizona Meteological Network station west of Coolidge, Arizona, June 29, 1990.

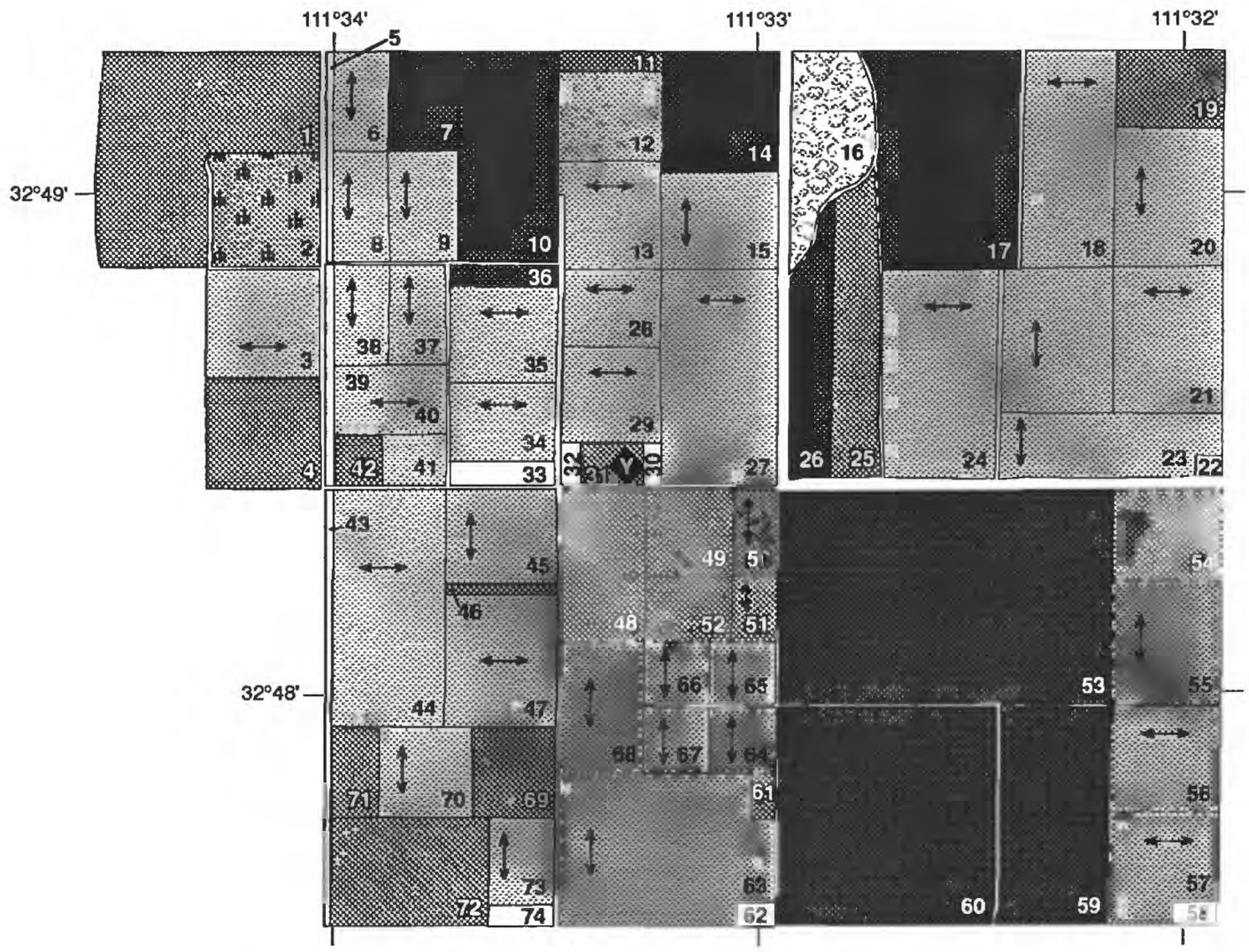


**Figure 19.** Crop types in fields surrounding the Arizona Meteological Network station north of Eloy, Arizona, June 29, 1990.

**Table 15.** Ground-truth data for fields surrounding the meteorological stations at and surrounding the Maricopa Agricultural Center, Pinal County, Arizona, June 26–28, 1990

[Crop: ND, No data]

| Field number[1] | Crop | Description |
|---|---|---|
| 101 | Pistachios | |
| 102 | Cotton | North-south rows, water at west end 6/28/90. |
| 103 | Alfalfa | Flowers. |
| 104 | Alfalfa | Short. |
| 105 | Cotton | North-south rows, dry 6/28/90. |
| 106 | Cotton | North-south rows, dry 6/28/90. |
| 107 | Fallow | Clods. |
| 108 | Cotton | North-south rows, white flowers. |
| 109 | Cotton | North-south rows, dry 6/28/90, cultivated. |
| 110 | Cotton | North-south rows, dry 6/28/90, cultivated. |
| 111 | Fallow | Clods. |
| 112 | Fallow | Clods. |
| 113 | Cotton | North-south rows. |
| 114 | Fallow | Clods. |
| 115 | Cotton | East-west rows, every 5th row blank. Water at south end 6/28/90. |
| 116 | Cotton/Fallow | North half cotton, north-south rows, yellow flowers, wilted 6/28/90. South half fallow, smooth. |
| 117 | Cotton | East-west rows, yellow flowers. |
| 118 | Pistachios | East-west rows. |
| 119 | Cotton | North-south rows. |
| 120 | Cotton | East-west rows, dry 6/28/90, not cultivated. |
| 121 | Cotton | East-west rows, dry 6/28/90, not cultivated. |
| 122 | Fallow | Smooth. |
| 123 | Cotton | East-west rows, cultivated 6/26/90, wilted 6/28/90. |
| 124 | Cotton | East-west rows. |
| 125 | Cotton | East-west rows, cultivated 6/26/90 |
| 126 | Cotton | East-west rows, cultivated 6/26/90 |
| 127 | Cotton | East-west rows. |
| 128 | Cotton | East-west rows. |
| 129 | Cotton | East-west rows. |
| 130 | Cotton | East-west rows, cultivated 6/26/90. |
| 131 | Cotton | East-west rows, yellow flowers, cultivated with irrigation 6/26/90. |
| 132 | Natural | |
| 133 | Cotton | East-west rows, dry 6/26/90. |
| 134 | Natural | |
| 135 | Fallow | Weeds. |
| 136 | Cotton/Fallow | North third cotton, east-west rows, dry 6/26/90. South two-thirds fallow, weeds. |
| 137 | Pecans | East-west rows. |
| 138 | Pecans | East-west rows. |
| 139 | Pecans | East-west rows, dry 6/26/90. |
| 140 | Pecans | East-west rows. |
| 141 | Pecans | East-west rows, irrigated 6/26/90. |
| 142 | Natural | Houses. |
| 143 | Cotton | East-west rows, yellow flowers, not cultivated, dry 6/26/90. |
| 144 | Fallow | Weeds. |
| 145 | Cotton | North-south rows, not cultivated, water in northeast, dry in northwest 6/26/90. |
| 146 | Cotton | North-south rows. |
| 147 | ND | |
| 148 | Cotton | North-south rows. |
| 149 | ND | |
| 150 | Cotton | East-west rows, not cultivated, dry 6/26/90. |
| 151 | ------- | Buildings. |
| 152 | Fallow | Weeds. |
| 153 | Fallow | Weeds. |
| 154 | ND | |
| 155 | Fallow | Clods. |
| 156 | ND | |
| 157 | ND | |
| 158 | Cotton | |
| 159 | Cotton | North-south rows, not cultivated 6/26/90. |
| 160 | Cotton | North-south rows. |
| 161 | Cotton | North-south rows. |

**Table 15.** Ground-truth data for fields surrounding the meteorological stations at and surrounding the Maricopa Agricultural Center, Pinal County, Arizona, June 26–28, 1990—Continued

| Field number[1] | Crop | Description |
|---|---|---|
| 162 | Cotton | East-west rows. |
| 163 | Fallow | Clods. |
| 164 | Cotton | East-west rows. |
| 165 | Cotton | East-west rows. |
| 166 | Cotton | North-south rows, dry 6/26/90. |
| 167 | Cotton | North-south rows, dry 6/26/90. |
| 168 | Cotton | East-west rows. |
| 169-178 | ND | |
| 179 | Cotton | East-west rows, dry 6/26/90 and 2/28/90. |
| 180 | ------- | Buildings. |

[1]Corresponds to field numbers on figure 15.

**Table 16.** Ground-truth data for fields surrounding the meteorological station in a cotton field at Casa Grande Farm, north of Casa Grande, Pinal County, Arizona, June 28, 1990

| Field number[1] | Crop | Description |
|---|---|---|
| 100 | Cotton | North-south rows. |
| 101 | Cotton | North-south rows, water on west side. |
| 102 | ------- | Rancho Del Sol Mobile Park. |
| 103 | Fallow | Old stubble. |
| 104 | Fallow | Weeds. |
| 105 | ------- | Casita Verde Trailer Park. |
| 106 | Fallow | Plowed. |
| 107 | Fallow | Plowed with clods. |
| 108 | Fallow | Plowed with clods. |
| 109 | Cotton | East-west rows, every other row with water. |
| 110 | Cotton | North-south rows, yellow flowers, wet. |
| 111 | Cotton | North-south rows, dry. |
| 112 | Cotton | North-south rows, dry. |
| 113 | ------- | Buildings and dead grass. |
| 114 | Fallow | Plowed with clods, weeds. |
| 115 | Cotton | North-south rows. |
| 116 | ------- | Apartments. |
| 117 | Fallow | Wheat stubble. |
| 118 | Cotton | North-south rows, dry, cultivated. |
| 119 | Fallow | North-south furrows. |
| 120 | Cotton | North-south rows. |
| 121 | Fallow | Weeds, old stubble, buildings along south side. |
| 122 | ------- | Buildings. |
| 123 | Cotton | North-south rows. |
| 124 | Fallow | Weeds. |
| 125 | Cotton | North-south rows. |
| 126 | Cotton | East-west rows. |
| 127 | Cotton | East-west rows. |
| 128 | Fallow | Clods. |
| 129 | Fallow | Clods. |
| 130 | Cotton | East-west rows, new planting, wet. |
| 131 | Cotton | East-west rows, dry. |
| 132 | Cotton | East-west rows, dry. |
| 133 | Fallow | Clods. |
| 134 | Wheat | Stubble. |
| 135 | Wheat | Stubble. |
| 136 | Fallow | Smooth surface, weeds, some wheat regrowth. |
| 137 | Cotton | North-south rows. |
| 138 | Fallow | Smooth surface, weeds, some wheat regrowth. |
| 139 | Wheat | Stubble, plowed. |
| 140 | Fallow | Clods and wheat stubble. |
| 141 | Cotton | East-west rows, white flowers, wet at north, dry at south. |
| 142 | Fallow | Weeds. |
| 143 | Fallow | Wheat stubble. |
| 144 | Fallow | Clods. |
| 145 | Fallow | Smooth surface, wheat stubble. |
| 146 | Fallow | Smooth surface, wheat stubble. |
| 147 | ------- | Buildings. |
| 148 | Fallow | Smooth surface. |
| 149 | Cotton | North-south rows. |
| 150 | Fallow | Smooth surface. |
| 151 | ------- | Cleared land with buildings. |

[1]Corresponds to field numbers on figure 16.

**Table 17.** Ground-truth data for fields surrounding the meteorological station in a cotton field at the Hennis Farm, east of Casa Grande, Pinal County, Arizona, June 28, 1990

| Field number[1] | Crop | Description |
|---|---|---|
| 200 | Cotton | North-south rows. |
| 201 | Cotton | North-south rows. |
| 202 | ------- | Well site. |
| 203 | Cotton | North-south rows. |
| 204 | Cotton | North-south rows. |
| 205 | Cotton | North-south rows. |
| 206 | Cotton | North-south rows. |
| 207 | Corn | |
| 208 | Cotton | North-south rows. |
| 209 | Cotton | North-south rows. |
| 210 | Cotton | North-south rows. |
| 211 | Cotton | North-south rows, yellow flowers. |
| 212 | Cotton | North-south rows. |
| 213 | Fallow | Smooth surface, stubble, irregular cover of grasses at west end. |
| 214 | Fallow | Smooth surface. |
| 215 | Cotton | East-west rows. |
| 216 | Fallow | Smooth surface. |
| 217 | Cotton | North-south rows. |
| 218 | Cotton | East-west rows, wet on north side. |
| 219 | Cotton | North-south rows. |
| 220 | ------- | Well site and buildings. |
| 221 | Fallow | |
| 222 | Cotton | East-west rows. |
| 223 | Fallow | Smooth surface, stubble. |
| 224 | Fallow | Smooth surface. |
| 225 | Cotton | North-south rows, yellow flowers, wet. |
| 226 | Cotton | North-south rows, yellow flowers. |
| 227 | Cotton | North-south rows, yellow flowers. |
| 228 | Corn | |
| 229 | Fallow | Smooth surface, garden at south end on both sides of corn. |
| 230 | Corn | |
| 231 | Cotton | North-south rows. |
| 232 | Cotton | North-south rows. |
| 233 | Cotton | North-south rows. |
| 234 | Cotton | East-west rows. |
| 235 | Cotton | East-west rows. |
| 236 | Cotton | East-west rows. |
| 237 | Fallow | Plowed wheat stubble. |
| 238 | Cotton | North-south rows. |
| 239 | Cotton | East-west rows. |
| 240 | Cotton | East-west rows. |
| 241 | Cotton | North-south rows. |
| 242 | Fallow | Clods. |
| 243 | Fallow | Clods. |
| 244 | Cotton | North-south rows. |
| 245 | Cotton | North-south rows. |
| 246 | Cotton | North-south rows. |
| 247 | Cotton | North-south rows. |
| 248 | Fallow | Clods. |
| 249 | Cotton | North-south rows. |
| 250 | Cotton | North-south rows. |
| 251 | Cotton | North-south rows. |

[1]Corresponds to field numbers on figure 17.

**Table 18.** Ground-truth data for fields surrounding the Arizona Meteorological Network Coolidge station, Pinal County, Arizona, June 29, 1990

| Field number[1] | Crop | Description |
|---|---|---|
| 1 | Cotton | East-west rows. |
| 2 | Cotton | East-west rows. |
| 3 | Natural | |
| 4 | Cotton | East-west rows, yellow flowers. |
| 5 | Cotton | East-west rows. |
| 6 | Cotton | East-west rows, yellow flowers. |
| 7 | Cotton | East-west rows. |
| 8 | Fallow | Smooth surface, weeds at north end. |
| 9 | ------- | Yard with buildings. |
| 10 | Cotton | North-south rows. |
| 11 | Cotton | North-south rows. |
| 12 | Cotton | North-south rows. |
| 13 | Cotton | North-south rows, yellow flowers. |
| 14 | Cotton | North-south rows, yellow flowers. |

**Table 18.** Ground-truth data for fields surrounding the Arizona Meteorological Network Coolidge station, Pinal County, Arizona, June 29, 1990—Continued

| Field number[1] | Crop | Description |
|---|---|---|
| 15 | Cotton | North-south rows. |
| 16 | Cotton | North-south rows. |
| 17 | Cotton | North-south rows. |
| 18 | Cotton | North-south rows. |
| 19 | Cotton | North-south rows, yellow flowers. |
| 20 | Cotton | North-south rows. |
| 21 | Melons | East-west rows, drip irrigated, wheat stubble. (See Owen-Joyce, 1991, table 2, slide 7–6). |
| 22 | Cotton | North-south rows, yellow flowers. |
| 23 | Melons | North-south rows, wheat stubble. |
| 24 | Cotton | East-west rows, white flowers. |
| 25 | Natural | Desert area used as a dump. |
| 26 | Cotton | Northeast-southwest rows. |
| 27 | Cotton | North-south rows, wheat stubble. |
| 28 | Cotton | North-south rows, wheat stubble. |
| 29 | Cotton | North-south rows. |
| 30 | Melons | East-west rows, drip irrigated. |
| 31 | Cotton | North-south rows, yellow flowers. |
| 32 | Melons | East-west rows, wheat stubble, plants about 25 mm high. |
| 33 | Melons | East-west rows, wheat stubble. |
| 34 | Cotton | North-south rows. |
| 35 | Cotton | North-south rows. |
| 36 | Cotton | North-south rows. |
| 37 | Cotton | North-south rows. |
| 38 | Cotton | North-south rows. |
| 39 | Cotton | North-south rows. |
| 40 | Cotton | North-south rows. |
| 41 | ------- | Sundance Farm buildings. |
| 42 | Pasture | |
| 43 | Wheat | Stubble. |
| 44 | Wheat | Stubble, cut. |
| 45 | Cotton | North-south rows. |
| 46 | Cotton | North-south rows. |
| 47 | Fallow | Wheat stubble, regrowth at west side and tumbleweeds. |
| 48 | Fallow | Wheat stubble and weeds, regrowth at west side and tumbleweeds. |
| 49 | Cotton | North-south rows. |
| 50 | Cotton | North-south rows. |
| 51 | Cotton | North-south rows. |
| 52 | Wheat | Stubble, bailed. |
| 53 | Wheat | Stubble, bailed. |
| 54 | Cotton | East-west rows. |
| 55 | Cotton | North-south rows. |
| 56 | Fallow | Plowed clods. |
| 57 | Fallow | Weeds. |
| 58 | Natural | |
| 59 | Fallow | Weeds. |
| 60 | Wheat | Stubble. |
| 61 | Fallow | |
| 62 | Cotton | North-south rows. |
| 63 | Wheat | Stubble. |
| 64 | Cotton | North-south rows. |
| 65 | Cotton | North-south rows. |
| 66 | Cotton | North-south rows. |
| 67 | Fallow | Furrowed east-west, wheat stubble. |
| 68 | Fallow | Furrowed east-west, wheat stubble. |
| 69 | Cotton | North-south rows. |
| 70 | Cotton | North-south rows. |
| 71 | Cotton | North-south rows. |
| 72 | Cotton | North-south rows. |
| 73 | Fallow | Furrowed, wheat stubble. |
| 74 | Fallow | Furrowed north-south, wheat stubble. |
| 75 | Melons | East-west rows, drip irrigated, wheat stubble. |
| 76 | Melons | East-west rows, drip irrigated, wheat stubble. |
| 77 | Melons | East-west rows, drip irrigated, wheat stubble. |
| 78 | Cotton | North-south rows. |
| 79 | Cotton | North-south rows. |
| 80 | Cotton | North-south rows. |
| 81 | Cotton | North-south rows. |
| 82 | Cotton | North-south rows. |
| 83 | Wheat | Stubble. |
| 84 | Natural | |
| 85 | ------- | Outside mapped area. |
| 86 | Cotton | North-south rows, yellow flowers. |

[1]Corresponds to field numbers on figure 18.

**Table 19.** Ground-truth data for fields surrounding the Arizona Meteorological Network Eloy station, Pinal County, Arizona, June 29, 1990

| Field number[1] | Crop | Description |
|---|---|---|
| 1 | Fallow | Plowed with clods. |
| 2 | Pasture | |
| 3 | Cotton | East-west rows. |
| 4 | Fallow | Plowed. |
| 5 | Fallow | Power-line access. |
| 6 | Cotton | North-south rows. |
| 7 | Fallow | Abandoned fields with weeds. |
| 8 | Cotton | North-south rows. |
| 9 | Cotton | North-south rows. |
| 10 | Fallow | Abandoned field with dead weeds. |
| 11 | Fallow | Smooth surface with weeds. |
| 12 | Grain | |
| 13 | Cotton | East-west rows. |
| 14 | Fallow | Abandoned field, smooth surface with weeds. |
| 15 | Cotton | North-south rows. |
| 16 | Natural | Desert vegetation, mixed species. |
| 17 | Fallow | Abandoned field, flat surface with weeds. |
| 18 | Cotton | East-west fields. |
| 19 | Fallow | Plowed with clods and weeds. |
| 20 | Cotton | North-south rows. |
| 21 | Cotton | East-west rows. |
| 22 | ------- | Well site. |
| 23 | Cotton | North-south rows. Yellow flowers. |
| 24 | Cotton | East-west rows. |
| 25 | Fallow | Plowed with clods. |
| 26 | Fallow | Abandoned field, flat surface with weeds. |
| 27 | Cotton | East-west rows. |
| 28 | Cotton | East-west rows. |
| 29 | Cotton | East-west rows. |
| 30 | ------- | House and yard. |
| 31 | Fallow | Smooth surface, small area of turf around meteorological station, some weeds around station. |
| 32 | ------- | Buildings. |
| 33 | ------- | Buildings. |
| 34 | Cotton | East-west rows. |
| 35 | Cotton | East-west rows. |
| 36 | Fallow | Abandoned field with dead weeds. |
| 37 | Cotton | North-south rows. |
| 38 | Cotton | North-south rows. |
| 39 | Fallow | Power-line access. |
| 40 | Cotton | East-west rows, wheat stubble. |
| 41 | Cotton | |
| 42 | Fallow | |
| 43 | Fallow | Power-line access. |
| 44 | Cotton | East-west rows. |
| 45 | Cotton | North-south rows. |
| 46 | Fallow | |
| 47 | Cotton | East-west rows. |
| 48 | Fallow | Plowed with clods. |
| 49 | Fallow | Plowed with clods. |
| 50 | Fallow | Plowed with clods and north-south furrows. |
| 51 | Fallow | Plowed with clods and north-south furrows. |
| 52 | Fallow | Plowed with clods. |
| 53 | Fallow | Abandoned field, flat surface with weeds. |
| 54 | Fallow | Flat surface with weeds. |
| 55 | Cotton | North-south rows. |
| 56 | Cotton | East-west rows. |
| 57 | Cotton | East-west rows, yellow flowers. |
| 58 | ------- | Well site. |
| 59 | Fallow | Abandoned field, flat surface with weeds. |
| 60 | Fallow | Abandoned field, flat surface with weeds. |
| 61 | Fallow | |
| 62 | ------- | Well site. |
| 63 | Cotton | North-south rows. |
| 64 | Cotton | North-south rows. |
| 65 | Cotton | North-south rows. |
| 66 | Cotton | North-south rows, yellow flowers. |
| 67 | Cotton | North-south rows, yellow flowers. |
| 68 | Cotton | North-south rows, yellow flowers. |
| 69 | Fallow | Plowed with clods. |
| 70 | Cotton | North-south rows, yellow flowers. |
| 71 | Fallow | Plowed with clods, wheat stubble. |
| 72 | Fallow | Plowed with clods, wheat stubble. |
| 73 | Cotton | North-south rows. |
| 74 | ------- | Well site. |
| 75 | ------- | Outside mapped area. |
| 76 | Cotton | North-south rows. |

[1]Corresponds to field numbers on figure 19.

line) ends with a carriage-return line-feed character sequence. Each station collected a slightly different data set; therefore, the format of the data files differs among stations. Formatting information for the data files is given in table 20.

Erroneous data were obtained on occasion from individual sensors during the project. Such data have been identified and converted to a standard numerical code consisting only of nines (9), a decimal point, and a negative sign (where necessary). The specific error codes were established to provide an unrealistic value for any of the measured or calculated parameters and therefore should stand out when the data are viewed manually or plotted graphically (see figs. 3 and 7). The data codes for erroneous or missing values for each parameter are

| Parameters | Missing or erroneous value code |
|---|---|
| $T_a$, $T_s$, $T_c$ | 99.9 |
| $R_N$, $G$ | –.999 |
| $SR$ | 9.999 |
| $RH$ | 999.9 |
| $e_a$, $e_s$, $VPD$ | –99.9 |
| $U$ | –9.9 |

In some cases, an entire line of data associated with an individual time unit or multiple lines of data are missing; these larger blocks of missing data are itemized in table 21.

Three satellite-overpass dates were selected by experiment participants for intense study during the MACIV/MacSPOT—On Farm—Mixed Crops data-collection period: day 103 (Apr. 13), day 120 (Apr. 30), and day 130 (May 10). Fifteen-minute-average values of all ground-based meteorological parameters were obtained from all working stations during these three overpass dates. Data were not obtained from field 11 on days 120 and 130 because the station had been decommissioned on day 119. Data were not obtained from field 32 on day 120 because of a battery failure in the station datalogger.

Eight satellite-overpass dates were selected for intense study during the MacSPOT—Off Farm—Cotton data-collection period: day 215 (Aug. 3), day 223 (Aug. 11), day 231 (Aug. 19), day 234 (Aug. 22), day 239 (Aug. 27), day 247 (Sept. 4), day 255 (Sept. 12), and day 256 (Sept. 13). Ground-based meteorological data obtained on these 8 days were extracted from the overall data set, edited, and adjusted for calibration as necessary.

During the MacSPOT—Off Farm—Alfalfa data-collection period, four satellite overpass dates were selected for intense study: day 271 (Sept. 28), day 286 (Oct. 13), day 295 (Oct. 22), and day 296 (Oct. 23). Ground-based meteorological data obtained on these 4 days were extracted from the overall data set, edited, and adjusted for calibration as necessary.

Ground-based meteorological data obtained at each station also are available as station data files that are available on disk from the U.S. Geological Survey and the University of Arizona. These data sets correspond to the stations and data-collection periods itemized in table 21. Each station file is available in ASCII text file format. Within a given station file, all data collected at a particular time are stored on one line of the text file with individual data points separated by commas or spaces in the same format described previously for the station-day files.

## SUMMARY

Meteorological data consisting of air temperature, relative humidity, wind speed, solar radiation, and net radiation were collected at temporary meteorological stations installed in agricultural fields in Pinal County, Arizona. Supplementary measurements of soil temperature, soil heat flux density, and surface or canopy temperature were obtained at some locations. Additional data include information on data-collection periods, station positions, instrumentation, sensor heights, and field dimensions. Other time-specific data were collected to correspond with satellite overpasses from April to October 1989 and June 27–28, 1990, that include crop type, canopy cover, canopy height, irrigation, cultivation, and orientation of rows. Meteorological and supplementary data are available, upon request, in digital form.

**Table 20.** Format of each line (record) in meteorological data files

[Station: MAC, Maricopa Agricultural Center and field numbers; MUR, Murphree Farm; SMI, Smith Farm; AK, Ak Chin Farm; AND, Anderson Farm; CG, Casa Grande Farm; HEN, Hennis Farm; FCA, Full-cover alfalfa; PCA, Partial-cover alfalfa; FAL, Fallow; FUR, Furrowed fallow prior to emergence of cotton; WHT, Wheat; COT, Cotton; ALF, Alfalfa. Data File Sequence Number: DOY, Day of Year; TI, Time of Day; AT, Air Temperature; WS, Wind Speed; RN, Net Radiation; G[1], Soil Heat Flux; ST[1], Soil Temperature; CT, Canopy or Surface Temperature; RH, Relative Humidity; SR, Solar Radiation; ES, Saturation Vapor Pressure; EA, Actual Vapor Pressure; VPD, Vapor Pressure Deficit; YR, Year]

| Station | Data File Sequence Number[2] | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| | | | | | | | | | | *1989* | | | | | | | | | | | |
| | | | | | | | | | | *MACIV[3]—On Farm—Mixed Crops* | | | | | | | | | | | |
| MAC02FCA | DOY | TI | AT | WS | RN | G1 | G2 | G3 | ST1 | ST2 | ST3 | RH | SR | ES | EA | VPD | | | | | |
| MAC11PCA | DOY | TI | AT | WS | RN | G1 | G2 | G3 | G4 | ST1 | ST2 | ST3 | ST4 | CT | RH | SR | ES | EA | VPD | | |
| MAC30FAL | DOY | TI | AT | WS | RN | G1 | G2 | G3 | G4 | G5 | ST1 | ST2 | ST3 | ST4 | ST5 | CT | RH | SR | ES | EA | VPD |
| MAC31FUR | DOY | TI | AT | WS | RN | G1 | G2 | G3 | G4 | G5 | ST1 | ST2 | ST3 | ST4 | ST5 | RH | SR | ES | EA | VPD | |
| MAC32WHT | DOY | TI | AT | WS | RN | G1 | G2 | ST1 | ST2 | CT | RH | SR | ES | EA | VPD | | | | | | |
| | | | | | | | | | | *MacSPOT—On Farm—Cotton* | | | | | | | | | | | |
| MAC18COT | DOY | TI | AT | RH | SR | RN | WS | | | | | | | | | | | | | | |
| MAC20COT | DOY | TI | AT | RH | SR | RN | WS | | | | | | | | | | | | | | |
| MAC27COT | DOY | TI | AT | RH | SR | RN | WS | | | | | | | | | | | | | | |
| MAC30COT | DOY | TI | AT | RH | SR | RN | WS | | | | | | | | | | | | | | |
| MAC31FAL | DOY | TI | AT | RH | SR | RN | WS | | | | | | | | | | | | | | |
| | | | | | | | | | | *MacSPOT—Off Farm—Cotton* | | | | | | | | | | | |
| MAC20COT | DOY | TI | AT | RH | SR | RN | WS | | | | | | | | | | | | | | |
| MAC30FAL | DOY | TI | AT | RH | SR | RN | WS | | | | | | | | | | | | | | |
| MURCOT | DOY | TI | AT | RH | SR | RN | WS | [4]CT | | | | | | | | | | | | | |
| SMICOT | DOY | TI | AT | RH | SR | RN | WS | [5]CT | | | | | | | | | | | | | |
| AKCOT | DOY | TI | AT | RH | SR | RN | WS | | | | | | | | | | | | | | |

**Table 20.** Format of each line (record) in meteorological data files

| Station | Data File Sequence Number[2] | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| ***1989*** | | | | | | | | | | | | | | | | | | | | | |
| ***MacSPOT—Off Farm—Alfalfa*** | | | | | | | | | | | | | | | | | | | | | |
| MAC11ALF | DOY | TI | AT | RH | SR | RN | WS | | | | | | | | | | | | | | |
| MAC30FAL | DOY | TI | AT | RH | SR | RN | WS | | | | | | | | | | | | | | |
| ANDALF | DOY | TI | AT | RH | SR | RN | WS | [6]CT | | | | | | | | | | | | | |
| MURALF | DOY | TI | AT | RH | SR | RN | WS | CT | | | | | | | | | | | | | |
| AKALF | DOY | TI | AT | RH | SR | RN | WS | CT | | | | | | | | | | | | | |
| ***1990*** | | | | | | | | | | | | | | | | | | | | | |
| ***MACV—Off Farm—Cotton*** | | | | | | | | | | | | | | | | | | | | | |
| MAC37COT | YR | DOY | TI | AT | RH | SR | RN | WS | ES | EA | VPD | | | | | | | | | | |
| CGCOT | YR | DOY | TI | AT | RH | SR | RN | WS | ES | EA | VPD | | | | | | | | | | |
| HENCOT | YR | DOY | TI | AT | RH | SR | RN | WS | ES | EA | VPD | | | | | | | | | | |

[1]G1, G2, G3, G4, and G5 were obtained from top of west soil bed, west-facing slope of bed, furrow bottom, east-facing slope and top of east soil bed, respectively. G and ST values ending with the same number were obtained at the same location. Users should note that the values for G have not been corrected for changes in surface-soil heat storage.

[2]Numbers correspond to sequence of data points within a given line (record) of a data file.

[3]Data files for days 97–100 (Apr. 7–10).

[4]Continuous measurement of canopy temperature was initiated on day 235 (Aug. 23).

[5]Canopy temperature only available for station-day data file for day 255 (Sept. 12).

[6]Canopy temperature only available for station-day data file for days 271 (Sept. 28) and 286 (Oct. 13).

**Table 21.** Itemized data-collection periods at meteorological stations installed over agricultural fields, Pinal County, Arizona, April–November 1989 and June–July 1990

[Farm: MAC, Maricopa Agricultural Center; MUR, Murphree Farm; SMI, Smith Farm; AK, Ak Chin Farm; AND, Anderson Farm; CASA, Casa Grande Farm; HEN, Hennis Farm]

| Station identifier[1] | Farm and field number[2] | Sampling interval, in minutes | Data collection | | | | Missing periods | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Begin | | End | | Begin | | End | |
| | | | Day[3] | Time | Day[3] | Time | Day[3] | Time | Day[3] | Time |
| **1989** | | | | | | | | | | |
| ***MacSPOT—Fallow*** | | | | | | | | | | |
| I | MAC30 | 1 | 165 | 1910 | 166 | 1948 | 166 | 1949 | 166 | 2006 |
| | | 1 | 166 | 2007 | 167 | 1256 | 167 | 1257 | 170 | 0330 |
| | | 1 | 170 | 0331 | 170 | 1316 | 170 | 1317 | 170 | 1329 |
| | | 15 | 170 | 1330 | 177 | 1000 | 177 | 1001 | 177 | 1005 |
| | | 1 | 177 | 1006 | 186 | 2338 | 186 | 2339 | 188 | 0649 |
| | | 1 | 188 | 0650 | 188 | 1643 | 188 | 1644 | 188 | 1644 |
| | | 1 | 188 | 1645 | 199 | 1720 | 199 | 1721 | 199 | 1729 |
| | | 15 | 199 | 1730 | 221 | 0100 | 221 | 0101 | 221 | 1614 |
| | | 15 | 221 | 1615 | 227 | 1845 | 227 | 1846 | 227 | 1851 |
| | | 1 | 227 | 1852 | 227 | 1855 | 227 | 1856 | 235 | 1141 |
| | | 1 | 235 | 1142 | 240 | 0944 | 240 | 0945 | 240 | 0945 |
| | | 1 | 240 | 0946 | 265 | 2117 | 265 | 2118 | 265 | 2323 |
| | | 1 | 265 | 2324 | 266 | 0911 | 266 | 0912 | 266 | 0912 |
| | | 1 | 266 | 0913 | 266 | 0916 | 266 | 0917 | 266 | 0929 |
| | | 15 | 266 | 0930 | 269 | 2230 | 269 | 2231 | 270 | 1053 |
| | | 1 | 270 | 1054 | 272 | 1746 | 272 | 1747 | 272 | 1759 |
| | | 15 | 272 | 1800 | 277 | 1115 | ----- | ------ | ----- | ------ |
| | | [4]15 | 272 | 1130 | 272 | 2015 | ----- | ------ | ----- | ------ |
| | | 15 | 272 | 2030 | 286 | 0900 | 286 | 0901 | 286 | 0903 |
| | | 1 | 286 | 0904 | 297 | 1440 | 297 | 1441 | 297 | 1441 |
| | | 1 | 297 | 1442 | 305 | 1735 | ----- | ------ | ----- | ------ |
| ***MacSPOT—On Farm—Cotton*** | | | | | | | | | | |
| F | MAC18 | [4]1 | 166 | 1122 | 170 | 1516 | 170 | 1517 | 170 | 1529 |
| | | [4]15 | 170 | 1530 | 177 | 1130 | 177 | 1131 | 180 | 0753 |
| | | 1 | 180 | 0754 | 187 | 1018 | 187 | 1019 | 188 | 1441 |
| | | 1 | 188 | 0817 | 199 | 1317 | ----- | ------ | ----- | ------ |
| G | MAC20 | [4]1 | 166 | 2310 | 167 | 0935 | 167 | 0936 | 167 | 1036 |
| | | [4]1 | 167 | 1036 | 170 | 1523 | 170 | 1524 | 170 | 1614 |
| | | [4]15 | 170 | 1615 | 177 | 1300 | 177 | 1301 | 177 | 1307 |
| | | 1 | 177 | 1308 | 187 | 1156 | 187 | 1157 | 187 | 1604 |
| | | 1 | 187 | 1605 | 194 | 0401 | 194 | 0402 | 194 | 0808 |
| | | 1 | 194 | 0809 | 199 | 1114 | ----- | ------ | ----- | ------ |
| H | MAC27 | 1 | 166 | 1934 | 170 | 1220 | 170 | 1221 | 170 | 1229 |
| | | 15 | 170 | 1230 | 177 | 0915 | 177 | 0916 | 177 | 0933 |
| | | 1 | 177 | 0934 | 180 | 0258 | 180 | 0259 | 180 | 0706 |

**Table 21.** Itemized data-collection periods at meteorological stations installed over agricultural fields, Pinal County, Arizona, April–November 1989 and June–July 1990—Continued

| Station identifier[1] | Farm and field number[2] | Sampling interval, in minutes | Data collection | | | | Missing periods | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Begin | | End | | Begin | | End | |
| | | | Day[3] | Time | Day[3] | Time | Day[3] | Time | Day[3] | Time |
| | | | ***MacSPOT—On Farm—Cotton—Continued*** | | | | | | | |
| H | MAC27 | 1 | 180 | 0707 | 185 | 1558 | 185 | 1559 | 185 | 1745 |
| | | 1 | 185 | 1746 | 186 | 2056 | 186 | 2057 | 187 | 0410 |
| | | 1 | 187 | 0411 | 188 | 1553 | 188 | 1554 | 188 | 1615 |
| | | 1 | 188 | 1616 | 193 | 1614 | 193 | 1615 | 197 | 2217 |
| | | 1 | 197 | 2218 | 199 | 0916 | ----- | -------- | ----- | ------ |
| J | MAC31 | 1 | 165 | 2115 | 170 | 1404 | 170 | 1405 | 170 | 1429 |
| | | 15 | 170 | 1430 | 177 | 0245 | 177 | 0246 | 177 | 1032 |
| | | 1 | 177 | 1033 | 188 | 1706 | 188 | 1707 | 188 | 1707 |
| | | 1 | 188 | 1708 | 193 | 0900 | 193 | 0901 | 197 | 0840 |
| | | 1 | 197 | 0841 | 199 | 1603 | ----- | ------ | ----- | ------ |
| | | | ***MACV—Off Farm—Cotton*** | | | | | | | |
| K | MAC20 | 15 | 215 | 1515 | 216 | 0515 | 216 | 0516 | 221 | 1414 |
| | | 15 | 221 | 1415 | 227 | 1745 | 227 | 1746 | 227 | 1827 |
| | | 1 | 227 | 1828 | 240 | 0922 | 240 | 0923 | 240 | 0923 |
| | | 1 | 240 | 0924 | 279 | 1114 | ----- | ------ | ----- | ------ |
| | | [4]1 | 279 | 1115 | 286 | 0839 | ----- | ------ | ----- | ------ |
| | | 1 | 286 | 0840 | 263 | 1416 | ----- | ------ | ----- | ------ |
| L | MUR | 15 | 216 | 1315 | 219 | 1245 | 219 | 1246 | 222 | 0059 |
| | | 15 | 222 | 0100 | 227 | 1915 | 227 | 1916 | 227 | 1920 |
| | | 1 | 227 | 1921 | 233 | 0233 | 233 | 0234 | 233 | 0234 |
| | | 1 | 233 | 0235 | 235 | 1607 | 235 | 1608 | 235 | 1613 |
| | | 1 | 235 | 1614 | 235 | 1616 | 235 | 1617 | 235 | 1622 |
| | | [5]1 | 235 | 1623 | 238 | 0720 | 238 | 0721 | 238 | 0721 |
| | | [5]1 | 238 | 0722 | 252 | 1651 | 252 | 1652 | 262 | 1652 |
| | | [5]1 | 252 | 1653 | 252 | 1655 | ----- | ------ | ----- | ------ |
| | | [5]1 | 252 | 1656 | 261 | 2135 | 261 | 2136 | 261 | 2136 |
| | | [5]1 | 261 | 2137 | 261 | 2137 | ----- | ------ | ----- | ------ |
| M | SMI | 1 | 227 | 1701 | 231 | 0056 | 231 | 0057 | 231 | 0057 |
| | | 1 | 231 | 0058 | 237 | 0201 | 237 | 0202 | 237 | 0202 |
| | | 1 | 237 | 0203 | 252 | 1723 | 252 | 1724 | 252 | 1726 |
| | | 1 | 252 | 1727 | 264 | 1100 | ----- | ------ | ----- | ------ |
| N | AK | 1 | 227 | 1300 | 241 | 1934 | 241 | 1935 | 242 | 2052 |
| | | 1 | 242 | 2053 | 243 | 0841 | 243 | 0842 | 243 | 0842 |
| | | 1 | 243 | 0843 | 243 | 1126 | 243 | 1127 | 243 | 1127 |
| | | 1 | 243 | 1128 | 243 | 1343 | 243 | 1344 | 243 | 2135 |
| | | 1 | 243 | 2136 | 244 | 0454 | 244 | 0455 | 244 | 0455 |
| | | 1 | 244 | 0456 | 244 | 0512 | 244 | 0513 | 244 | 0513 |
| | | 1 | 244 | 0514 | 244 | 1241 | 244 | 1242 | 244 | 1242 |
| | | 1 | 244 | 1243 | 246 | 1225 | 246 | 1226 | 246 | 1226 |

**Table 21.** Itemized data-collection periods at meteorological stations installed over agricultural fields, Pinal County, Arizona, April–November 1989 and June–July 1990—Continued

| Station identifier[1] | Farm and field number[2] | Sampling interval, in minutes | Data collection | | | | Missing periods | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Begin | | End | | Begin | | End | |
| | | | Day[3] | Time | Day[3] | Time | Day[3] | Time | Day[3] | Time |
| | | | ***MACV—Off Farm—Cotton—Continued*** | | | | | | | |
| N | AK | 1 | 246 | 1227 | 249 | 1636 | 249 | 1637 | 250 | 0940 |
| | | 1 | 250 | 0941 | 263 | 1837 | ----- | ------ | ----- | ------ |
| O | MAC11 | 15 | 264 | 1900 | 270 | 0700 | 270 | 0701 | 270 | 1018 |
| | | 1 | 270 | 1019 | 272 | 1619 | 272 | 1620 | 272 | 1744 |
| | | 15 | 272 | 1745 | 286 | 0745 | 286 | 0746 | 286 | 0821 |
| | | [4]1 | 286 | 0822 | 297 | 1418 | 297 | 1419 | 297 | 1419 |
| | | 1 | 297 | 1420 | 306 | 1318 | ----- | ------ | ----- | ------ |
| | | | ***MacSPOT—On Farm—Alfalfa*** | | | | | | | |
| P | AND | 15 | 264 | 1615 | 270 | 0000 | 270 | 0001 | 270 | 0938 |
| | | 1 | 270 | 0939 | 272 | 1831 | 272 | 1832 | 272 | 1859 |
| | | 15 | 272 | 1900 | 279 | 1515 | 279 | 1516 | 279 | 1559 |
| | | [4]15 | 279 | 1600 | 286 | 1100 | 286 | 1101 | 286 | 1106 |
| | | 1 | 286 | 1107 | 286 | 1215 | 286 | 1216 | 286 | 1216 |
| | | 1 | 286 | 1217 | 288 | 0420 | 288 | 0421 | 288 | 0421 |
| | | 1 | 288 | 0422 | 301 | 0817 | ----- | ------ | ----- | ------ |
| | | [4]1 | 301 | 1818 | 306 | 1125 | ----- | ------ | ----- | ------ |
| Q | MUR | [5]1 | 270 | 1908 | 272 | 1824 | 272 | 1825 | 272 | 1829 |
| | | [5]15 | 272 | 1830 | 286 | 1015 | 286 | 1016 | 286 | 1024 |
| | | [5]1 | 286 | 1025 | 296 | 1444 | 296 | 1445 | 297 | 0542 |
| | | [5]1 | 297 | 0543 | 297 | 1318 | 297 | 1319 | 297 | 1319 |
| | | [5]1 | 297 | 1320 | 305 | 1625 | ----- | ------ | ----- | ------ |
| R | AK | 15 | 266 | 1730 | 270 | 0130 | 270 | 0131 | 270 | 1159 |
| | | 1 | 270 | 1200 | 270 | 1934 | 270 | 1935 | 270 | 2028 |
| | | [5]1 | 270 | 2029 | 272 | 1115 | 272 | 1116 | 272 | 1344 |
| | | [5]15 | 272 | 1345 | 275 | 1430 | 275 | 1431 | 279 | 1359 |
| | | [4,5]15 | 279 | 1400 | 286 | 0930 | 286 | 0931 | 286 | 0942 |
| | | [5]1 | 286 | 0943 | 286 | 0944 | 286 | 0945 | 286 | 0945 |
| | | [5]1 | 286 | 0946 | 305 | 1445 | ----- | ------ | ----- | ------ |
| | | | **1990** | | | | | | | |
| | | | ***MACV—Off Farm—Cotton*** | | | | | | | |
| T | MAC37 | 1 | 177 | 1722 | 180 | 1808 | 180 | 1809 | 181 | 2052 |
| | | 1 | 181 | 2053 | 183 | 1303 | ----- | ------ | ----- | ------ |
| U | CASA | 1 | 177 | 1310 | 183 | 1500 | ----- | ------ | ----- | ------ |
| V | HEN | 1 | 177 | 2039 | 183 | 1035 | ----- | ------ | ----- | ------ |

[1]Corresponds to stations plotted on figures 2, 8–10, and 15–19.
[2]Field number included with farm name when available.
[3]Julian day.
[4]No net radiation data.
[5]Surface- or canopy-temperature data available.

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