AUTOMATED WEATHER STATION NETWORK

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Abstract. An automated weather station network has been developed by the College of Agricultural and Environmental Sciences of the University of Georgia. Since 1991 more than 30 weather stations have been installed in mainly remote locations of the state of Georgia. A climatic data base is being developed that includes detailed rainfall, temperature, wind, solar radiation, and other variables. This information can be used as an environmental resource by managers and other decision makers.

INTRODUCTION

In 1988 an ad-hoc working group of the Coastal Plain Experiment Station at the University of Georgia established the need for an automated weather station network for Georgia that would mainly be dedicated to agricultural research. This was followed in 1990 by a two-day workshop sponsored by the Georgia Agricultural Experiment Stations, the Cooperative Extension Service, and the United States Department of Agriculture (USDA). Participants from various state and federal agencies and representatives from industry participated in this workshop. One of the recommendations of this workshop was to establish a pilot weather network. Due to restrictions in funding, no further action was taken (Hoogenboom, 1993).

The continued need for detailed weather data lead to acquisition of the first units and sensors in 1991. Stations were installed at the Coastal Plain Experiment Station in Tifton, the Georgia Station in Griffin, the USDA-ARS Southern Piedmont Conservation Center in Watkinsville, and the Southeast Georgia Branch Station in Midville. In 1991 a special grant was received from the Director of the Georgia Agricultural Experiment Station to purchase nine weather stations. In 1992 four weather stations were purchased through a grant from the Georgia Office of Energy Resources. In 1994 eight weather stations were purchased to support the 1996 Olympic Games through a grant from the University of Georgia Research Corporation. In summary four weather stations were installed in 1991, nine in 1992, three in 1993, five in 1994, eight in 1995, and two in 1996. A table with the installation dates can be found in Hoogenboom (1996).

During the 1996 Centennial Olympic Games, weather data support was provided to the National Weather Service. Local computers in the Peachtree City National Weather Service Forecast Office accessed all weather stations at 15-minute intervals to retrieve the weather information for the previous 15 minutes. The weather data was then processed, analyzed and converted into data files for local weather forecast models. The forecast models were run continuously and they provided venue and sport specific weather forecasts (Garza and Hoogenboom, 1996, 1997; Hoogenboom and Garza, 1997).

After the Olympic Games five of the weather stations were removed; four of these stations had been installed at Olympic Venues, including Conyers, Savannah and at the Ocoee River. The stations will be relocated to regions were currently no weather stations have been installed. New sites include Ellijay, Arlington, Dublin, and Camilla. A map with the location of the current sites is shown in Figure 1.

EQUIPMENT

The central component of the weather stations is the Campbell Scientific CR10 measurement and control unit (Tanner, 1990). The system operates like a computer and has 64 K of random access memory, which is the equivalent of 29,900 data points storage capacity. The wiring panel has six analog inputs in differential mode or twelve single ended inputs. It has two pulse counter inputs and three switched excitation outputs. The CR10 uses 12 V DC power, supplied by a 12 Volt battery. The battery is recharged every day through a solar panel and voltage regulator. Each unit has a modem and a dedicated telephone for communication and data transfer.

A set of standard sensors for all units has been defined. These standard sensors measure air temperature, relative humidity, wind speed and wind direction, solar radiation,precipitation, and soil temperature at 5, 10, and 20 cm. Additional sensors measure open pan evaporation, photosynthetic active radiation, soil temperature at 2.5 cm, water temperature of the pan, leaf wetness and barometric pressure. A list of these variables is summarized in Table 1.

DATA COLLECTION

Currently the weather stations are programmed to scan all

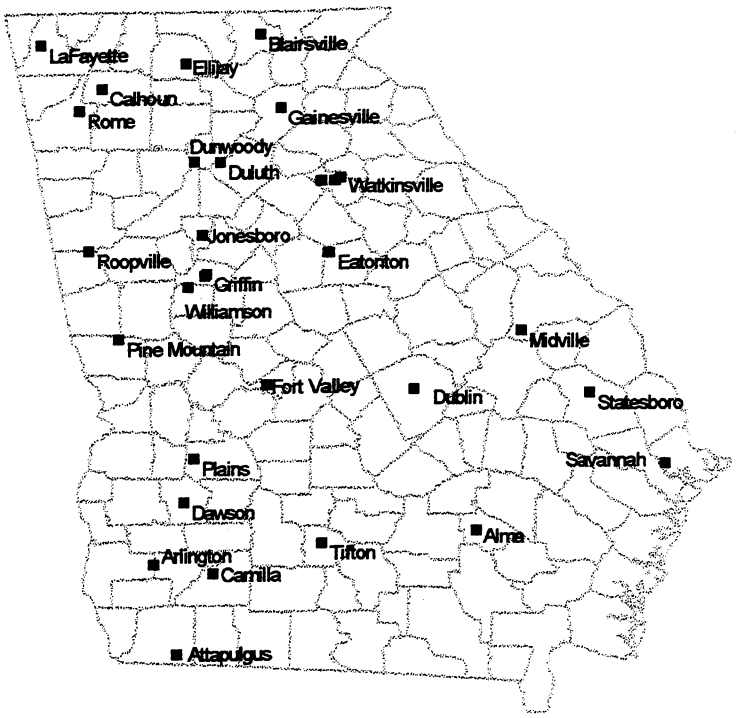

Figure 1. Location of the stations of the Georgia Automated Environmental Monitoring Network.

sensors at one-second intervals. This information is stored in temporary memory. Every 15 minutes the processor calculates 15-minute averages and totals, depending on the variable, from the previous 15-minute period. For wind speed and rainfall the program also stores the maximum values of these two parameters and the time that this extreme event occurred. At midnight further processing takes place to determine the daily extremes, averages, and totals for the previous day.

A personal computer in the agrometeorology laboratory in Griffin runs continuously 24 hours a day. At midnight a program is started to call each weather station individually. During this phone call, the data collected during the previous day by the weather station are downloaded to the personal computer. An average call takes less than 60 seconds. The local weather stations are normally called more frequently. A special software program developed by Campbell Scientific controls this process so that only the most recent weather data are downloaded to a personal computer.

DATA PROCESSING

After the data for all weather stations have been transferred to this personal computer, the data files are copied to backup directories. The data are also added to a raw data file that is maintained for each site. At the beginning of each year a new file is opened. This raw data file contains both the hourly and daily data collected by a particular weather station since January 1 until present for the current year. This gives us access to near real-time weather data. The raw data files are further processed and split into two files, one for the 15-minute data and one for the daily data. The format of these files is identical for all weather stations; missing variables are designated with a "-99". After all processing has been completed, the data on the personal computer are backed up to a SUN workstation.

Each morning several site specific files are generated. These files are automatically FAXed to various customers who have expressed an interest in receiving weather data for a particular site. These customers include television stations in Albany, Griffin, and Cordele; newspapers in Calhoun, Griffin, and Dawson; propane gas delivery companies; agricultural supply companies; and some local industries. In addition automatic e-mail reports are generated and distributed to county specialists and directors.

WEATHER DATA REPORTS

The system currently generates several reports. Each morning the hourly data for all stations are automatically printed. The main purpose of this information is for sensor operation and quality control. An annual file with monthly summary information is updated daily. This report is normally printed at the beginning of each month. So far most of the

Table 2. Weather Variables Monitored by the Georgia Automated Environmental Monitoring Network

Variable	Height	Unit	Accuracy
Standard Sensors			
Air Temperature	2.0	°C	±0.5°C
Relative Humidity	2.0	%	±2%
Wind Speed	3.5	m/s	±1.5°C
Wind Direction	3.5	Degree	±5D
Solar Radiation	3.0	W/m²	±5%
Precipitation	0.6	mm	±1.0%
Soil Temperature	0.05	°C	±0.4°C
Soil Temperature	0.10	°C	±0.4°C
Soil Temperature	0.20	°C	±0.4°C
Additional Sensors			
Soil Temperature	0.025	°C	±0.5°C
Photos. Active Rad.	3.0	μE/m²/s	±5%
Open Pan Evaporation	0.20	mm	±0.381mm
Leaf Wetness	0.50	kohm	----
Barometric Pressure	2.0	millibar	±0.5mbar
Water Temperature	0.20	°C	±0.5°C

interest in weather data has been for the monthly weather data reports that contain the daily summaries for all variables. These include the daily minimum, maximum and average air temperature, relative humidity, soil temperatures, wind speed and direction, and daily total rainfall and solar radiation. Most of these reports are distributed through regular mail or Fax. Users include researchers, extension agents, farmers, private industry, and news media.

Climate Summary.

A summary of the annual daily data is presented in Table 2 for the sites that have been operational since 1991 and 1992. Annual temperature is remarkably constant for each location; most of the variation is found in annual precipitation.

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Table 2. Annual Weather Data Summary for the Main Stations of the Georgia Automated Environmental Monitoring Network

Site	Year	Maximum Air Temp. °C	Minimum Air Temp. °C	Avereage Air Temp. °C	Total Solar Rad. MJ	Total Rainfall mm
ATTAPULGUS	93	25.27	12.77	18.65	6221.26	1200.91
	94	25.71	12.66	19.01	5555.12	1927.39
	95	26.41	9.32	18.55	5961.82	1234.18
	96	25.61	10.39	17.92	6132.85	1234.75
BLAIRSVILLE	92	20.08	7.09	13.41	5140.68	1353.31
	93	19.42	5.53	12.42	5576.01	1099.82
	94	19.45	6.05	12.62	5370.82	1405.62
	95	19.46	5.80	12.48	5405.12	1313.39
	96	19.24	5.00	12.07	5489.00	1454.43
CALHOUN	93	22.10	9.30	15.51	5382.06	970.00
	94	21.88	9.75	15.55	5227.43	1561.40
	95	21.94	9.21	15.41	5395.68	1411.24
	96	21.49	8.33	14.75	5355.69	1254.85
GRIFFIN	92	21.61	10.51	15.88	5541.51	1468.65
	93	22.25	10.51	16.28	5944.64	1033.51
	94	22.03	10.74	16.28	5667.33	1670.80
	95	22.58	10.24	16.26	5883.30	1192.98
	96	22.33	9.40	15.73	5778.39	1145.03
MIDVILLE	92	23.31	11.64	17.22	5511.59	1143.23
	93	24.23	11.62	17.71	5782.21	873.52
	94	24.07	12.10	17.75	5737.47	1302.77
	95	24.26	11.89	17.81	5952.09	1143.01
	96	24.11	11.08	17.28	6093.38	976.40
PLAINS	92	24.19	12.07	17.80	5584.45	1194.84
	93	24.31	11.61	17.65	5887.27	1068.31
	94	23.88	12.04	17.56	5657.77	1892.29
	95	24.06	11.37	17.39	5774.80	992.18
	96	23.92	10.28	16.81	5920.14	1113.79
TIFTON	92	23.80	12.84	18.56	5960.47	1119.12
	93	24.22	12.92	18.57	5515.28	1192.53
	94	24.63	13.69	19.02	5710.67	1479.80
	95	25.12	13.16	19.14	5823.23	857.25
	96	24.80	12.79	18.79	6112.10	1001.52
WATKINSVILLE	92	21.80	10.17	15.73	5397.44	1503.70
	93	21.89	9.61	15.54	5673.16	998.47
	94	21.76	9.49	15.35	5490.93	1510.22
	95	22.21	9.19	15.51	5590.40	1164.87
	96	23.80	8.75	15.36	5756.38	1090.92

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