THE GEORGIA AUTOMATED ENVIRONMENTAL MONITORING NETWORK

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ABSTRACT

In 1991 the College of Agricultural and Environmental Sciences of the University of Georgia established the Georgia Automated Environmental Monitoring Network. The objective of this network is to collect reliable weather and other environmental variables for agriculture, environmental research and other related applications. Weather stations have been installed on research stations and farms of the Agricultural Experiment Stations, and currently sixteen weather stations are in operation. Each station measures air temperature, relative humidity, rainfall, solar radiation, wind speed, wind direction, and soil temperature at 5, 10, and 20 cm depths. The sensors are scanned at one-minute intervals and data are permanently stored as either hourly averages or totals. In addition daily summaries are calculated at midnight. A micro-computer at the Georgia Experiment Station in Griffin generates telephone calls to all weather stations at midnight and downloads the data collected during the previous day. Tabular reports are generated daily and data are graphically printed weekly. The weather data are made available upon request for research and other related projects. In addition support has been given to local industries, federal and state agencies, the 1996 Atlanta Committee for the Olympic Games and others.

INTRODUCTION

Weather traditionally has been of interest to many people and seems to be one of the leading topics in many conversations. Recently environmental and climatological issues have received more attention in the news media, especially the problems related to water resources availability and quality, environmental pollution, and global climate change.

The National Weather Service (NWS) operates a network of weather stations located at major airports throughout Georgia. These sites, which include the Hartsfield International Airport in Atlanta, record hourly weather variables such as temperature and precipitation. In addition the NWS operates a network of cooperative weather stations, which currently includes 152 sites. At these sites maximum and minimum temperature and daily total precipitation are recorded manually by volunteer observers. Some stations also record soil temperature, wind run and daily evapotranspiration.

Several of these cooperative weather stations are located on research stations of the Georgia Agricultural Experiment Stations of the University of Georgia (UGA). Weather is an important environmental variable which affects both crop growth, development, and yield. For agrometeorology research, it has become important to monitor weather variables at a greater frequency than is currently reported by the NWS. In addition other weather variables such as wind speed and direction, relative humidity, and solar radiation are required. Reliable weather information is also needed to help farmers with their farm management practices, such as irrigation and pesticide applications.

An interdisciplinary committee, existing of representatives of the UGA Agricultural Experiment Stations, the Agricultural Extension Service, USDA-Agricultural Research Service, and the NWS was formed in 1987 to study the need for an automated weather station network in Georgia. This committee concluded that continuous long-term weather records are needed for many areas of the state and also that real time weather data are needed for applications in

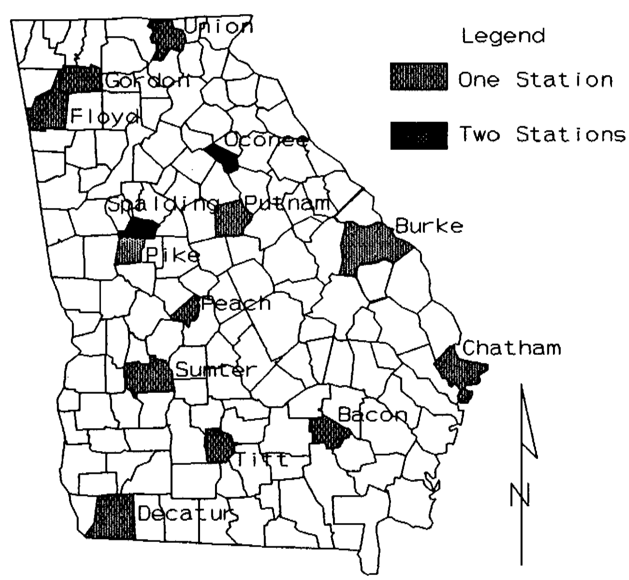

Figure 1. Coverage of the Automated Environmental Monitoring Network for Georgia.

agriculture and research management (Westbrook et al., 1988). In 1990, the participants at a workshop organized by the UGA Department of Agricultural Engineering recommended establishing a pilot automated weather station network (Threadgill, 1990). The College of Agricultural and Environmental Sciences would assume leadership in this pilot network. It was also proposed to change the name to Georgia Automated Environmental Monitoring Network (AEMN) to more accurately represent the information which potentially can be monitored by this system.

Successful automated weather data networks currently exist in Florida (Chang et al., 1983), Illinois (Hollinger and Reitz, 1990), Nebraska (Hubbard et al., 1983), Ohio (Curry et al., 1988), Oklahoma (Elliott et al., 1992), Washington State (Ley and Muzzy, 1992) and several other states (Meyer and Hubbard, 1992; Tanner, 1990). A precedent has therefore been set that Agricultural Experiment Stations of land-grant universities can, and should, develop successful weather station networks.

METHODS

Hoogenboom et al. (1991) presented the initial development of the Georgia AEMN. The first three weather stations were purchased in 1990, followed by nine in 1991 and one in 1992, supported by the Georgia Agricultural Experiment Station. Four stations were purchased in 1992 through a grant from the Office of Energy Resources. The stations have been mainly installed on agricultural research stations and farms. An overview of the coverage of the stations for Georgia is presented in Figure 1. The actual sites and locations of the weather stations and dates of installation are presented in Table 1.

The basic control unit of each weather station is a Campbell Scientific CR10. The CR10 is a fully programmable datalogger/controller with 64K of random access memory, which can store 29,900 data values. The wiring panel has six differential analog inputs or twelve single-ended measurement inputs, two pulse inputs and three excitation outputs. In the current configuration 12 Volt DC rechargeable sealed batteries are used, which are recharged during the daytime by a 12 Volt solar panel and a regulator. A modem with a dedicated phone line is connected to the serial I/O port for communications.

The CR10 can be programmed manually through a keyboard attached to the I/O port of the wiring panel or through uploading a program. The current program scans all sensors at one-minute intervals and these observations are stored in a temporary storage location. At hourly intervals average, cumulative, and other values are calculated and stored in permanent memory. At midnight the system also calculates a daily summary, including maximum, minimum, average and total values.

The variables which are recorded by the Georgia AEMN are considered to be the most important one's for agriculture and other environmental applications and are common among automated weather data networks (Meyer and Hubbard, 1992). These variables include air temperature, relative humidity (air), soil temperature at 5, 10, and 20 cm depths, wind speed, wind direction, solar radiation, and precipitation. In addition some sites measure photosynthetically active radiation (PAR), and open pan evaporation. The parameters, units, observation heights, and accuracy are presented in Table 2.

A micro-computer in the Department of Biological and Agricultural Engineering at the Georgia Experiment Station in Griffin has been dedicated for data processing. The

Table 1. Sites of the Georgia Automated Environmental Monitoring Network.

City	County	Location	Installed
Alma	Bacon	FAA Airport	03/93
Attapulgus	Decatur	Extension Research Center	07/92
Blairsville	Union	Georgia Mountain Experiment Station	01/92
Calhoun	Floyd	Northwest Georgia Experiment Station - Battey Research Farm	07/92
Calhoun	Gordon	Northwest Georgia Experiment Station	02/92
Eatonton	Putnam	Central Georgia Experiment Station	03/92
Fort Valley	Peach	Fort Valley State College	02/93
Griffin	Spalding	Georgia Experiment Station	05/91
Griffin	Spalding	Georgia Experiment Station - Dempsey Research Farm	05/92
Midville	Burke	Southeast Georgia Experiment Station	10/91
Plains	Sumter	Southwest Georgia Experiment Station	01/92
Savannah	Chatham	Coastal Area Extension and Research Center	12/92
Tifton	Tift	Coastal Plain Experiment Station	05/91
Watkinsville	Oconee	Plant Sciences Research Farm	07/92
Watkinsville	Oconee	USDA-ARS Southern Piedmont Conservation Laboratory	09/91
Williamson	Pike	Georgia Experiment Station - Bledsoe Research Farm	01/93

system is programmed to initiate telephone calls to each weather station at midnight and to download the data recorded during the previous day. These data are then transferred to various sections of the computer for further processing and permanent storage. All hourly variables are printed in tabular format, which currently is the main format for quality control. At weekly intervals all data are plotted for additional error checking. Procedures will be developed to further improve the quality control features of the system in order to provide reliable data.

RESULTS

Since most of the stations were installed during 1992, it is not possible at this stage to present annual summaries for each site. Instead a typical week during the 1992 summer (August 21 - 28) has been selected for the Georgia Experiment Station in Griffin to depict the hourly information collected by a typical weather station. This is the same week during which hurricane Andrew struck both Florida and Louisiana. On August 24 (Day 234) a total rainfall of 34 mm was recorded during a one-hour period (Figure 2). Temperature was relatively low and humidity was high during the same period; in most cases relative humidity was inversely related to air temperature (Figure 3). Soil temperature at the three depths slightly decreased during the first day of that week (Figure 4). Average wind speed and wind direction are presented in Figure 5. Radiation was very low during the first of this week due to heavy precipitation (Figure 6). Both solar and photosynthetically active radiation measures are very closely related, especially for clear sky conditions.

Table 2. Weather Variables, Observation Height, Accuracy, and Recording Units of the Georgia Automated Environmental Monitoring Network.

Variable	*Height*	*Unit*	*Accuracy*
	m		
Standard Sensors :			
Air temperature	2.0	°C	±0.5 °C
Relative Humidity	2.0	%	±2 %
Wind Speed	3.5	m/s	±1.5 %
Wind Direction	3.5	Degree	±5 D
Solar Radiation	3.0	W/m^2	±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 :			
Photos. Active Radiation	3.0	$\mu E/m^2/s$	±5 %
Open Pan Evaporation	0.20	mm	±0.381 mm
Soil Temperature	0.025	°C	±0.4 °C

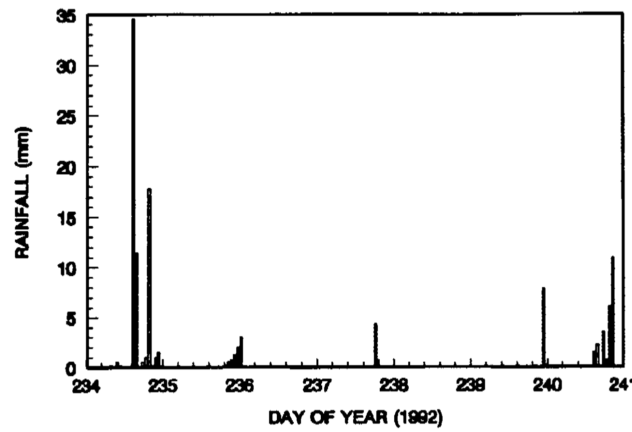

Figure 2. Hourly Total Precipitation Observed in Griffin.

APPLICATIONS

Currently no procedures have been developed for distribution of the weather data collected by the Georgia AEMN. Data are made available upon request to researchers affiliated with the University of Georgia. In addition, requests are received for specific information, such as rainfall and temperature extremes. Currently information from Griffin is used to estimate cooling requirements for a local factory and daily gas delivery for a utility company. Data are also being made available to the NWS service in Atlanta. It is expected that the range of applications of the weather

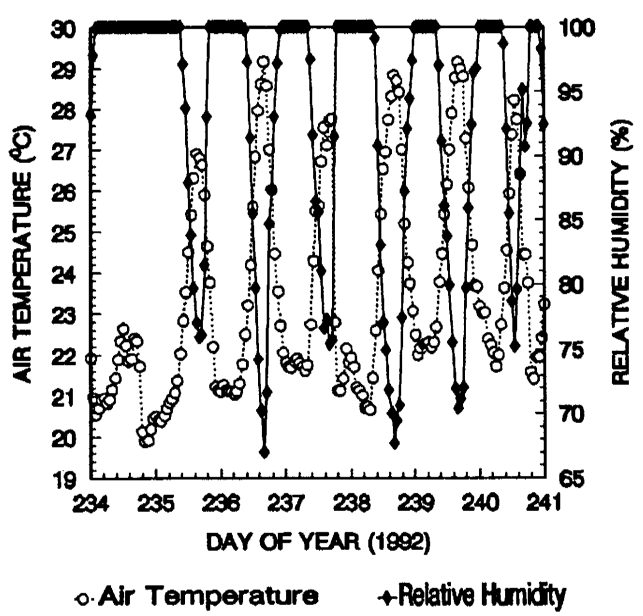

Figure 3. Hourly Average Air Temperature and Relative Humidity Observed in Griffin.

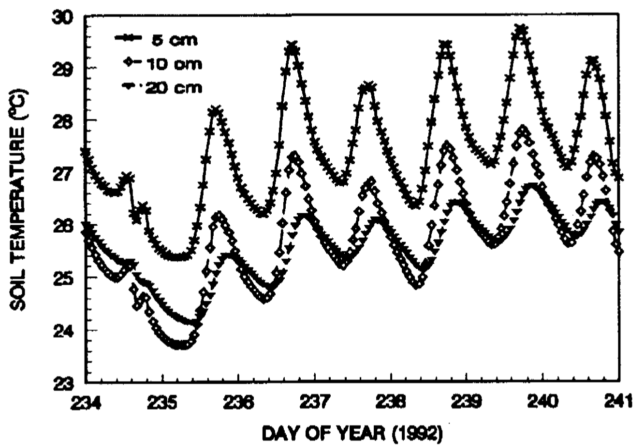

Figure 4. Hourly Average Soil Temperatures Observed at Three Different Depths in Griffin.

data is unlimited and will gradually expand, as people realize the existence of the Georgia AEMN and the availability of these data.

ACKNOWLEDGMENTS

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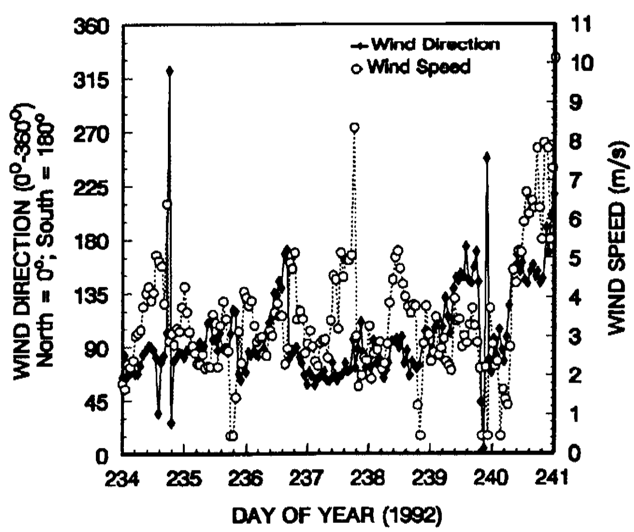

Figure 5. Hourly Average Wind Speed and Wind Direction Observed in Griffin.

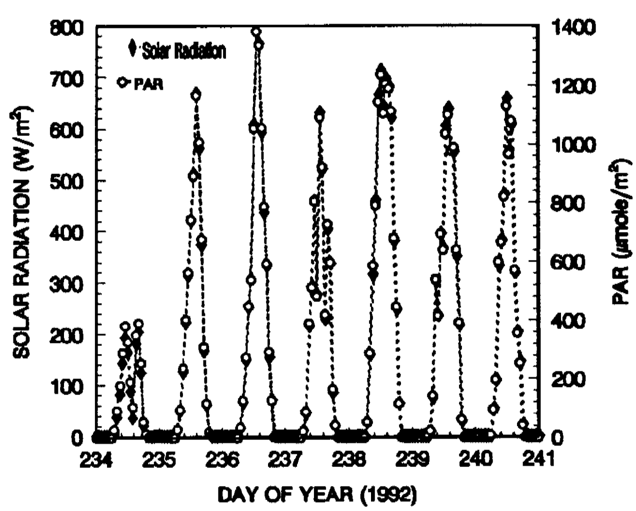

Figure 6. Hourly Average Solar and Photosynthetically Active Radiation Observed in Griffin.

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