WEATHER DATA COLLECTION FOR IRRIGATION MANAGEMENT

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Abstract
Advances in information technology have provided managers with alternate options for irrigation management. With water becoming a limiting resource, managers depend on these new technologies to determine optimal irrigation management schemes. Weather variables play a key role in these decisions. The College of Agricultural and Environmental Sciences of the University of Georgia has developed a network of automated weather stations that has grown from three stations in 1991 to 45 stations in 2001. It is expected that more than 50 stations will be operational by the end of 2002. These stations have mainly been installed in unique ecological regions where agriculture is important. Weather variables that are observed include air temperature, relative humidity, wind speed and direction, solar radiation, precipitation, soil temperature at different depths and soil moisture. These variables are summarized every 15 minutes and at midnight daily summaries and extremes are determined. Using dedicated telephone lines and modems, the data are transmitted to a central location in Griffin. After processing, the data are made available via the web site www.Georgiaweather.net. Besides obtaining the summarized data, users have also access to calculators that determine potential evapotranspiration and rainfall. This information can then be used as a guideline for irrigation management. It is expected that more advanced irrigation schedulers will be added to the system in the near future.

Introduction
The existence of irrigation companies is largely due to the variability of our weather and climate, especially rainfall. If rainfall amounts and events were evenly spread across the year, there would be no need for farmers, growers, homeowners and others to irrigate. Fortunately or unfortunately, depending on your business perspective, weather is variable and possibly unreliable. There is therefore a need to supplement the natural precipitation with supplemental irrigation to maintain healthy crops, gardens and lawns. Although in the past water was an unlimited resource, recently it has become more restricted. For instance in the greater Atlanta metropolitan areas, outdoor watering is now limited due to lack of sufficient water for irrigation. The recent drought in the southeast that started in 1998 and has continued through 2002, has been the major cause for this restriction. With limited or restricted water resources, there is a need to schedule irrigation based on the actual needs of a crop or a plant. Weather plays a critical role in irrigation scheduling and to be able to schedule irrigation, accurate weather information is required.

Figure 1. Traditional rain gauge operated by the National Weather Service (left).

Background
Traditionally the National Weather Service (NWS) has been responsible for weather observations. Most of the weather observations are made at major airports, due to the need to forecast local weather conditions for

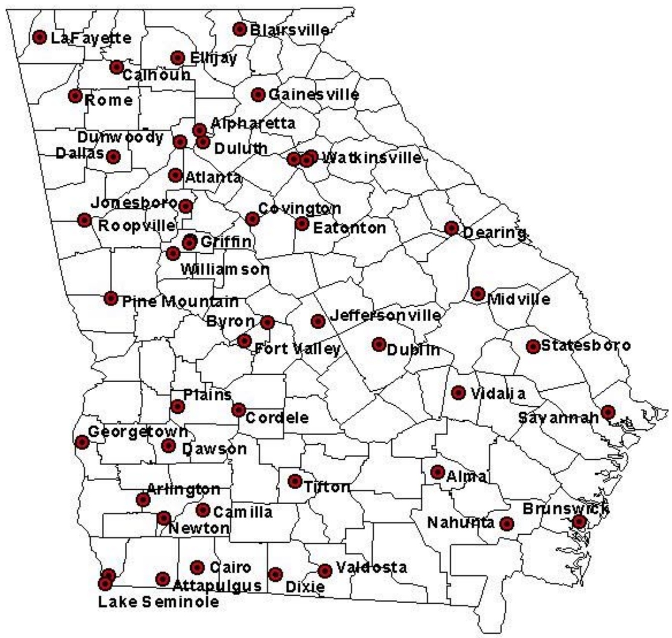


Figure 2. Locations of the weather stations of the Georgia Automated Environmental Monitoring Network.

aviation. The NWS also operates a Cooperative Observer Network, in which volunteers record local weather conditions. These observations are normally made once a day at 8.00 am and include maximum and minimum temperature and rainfall (Figure 1). However, this information is inadequate for irrigation scheduling as the variables that are being collected are limited, the access to the data is difficult and the availability of data is not timely. Therefore several Land-grant universities have developed automated weather station networks to collect weather data in a timely manner and make the data available to the general public. One of the larger networks is the Mesonet in Oklahoma, where at least one weather station is operational in each county. Large networks also exist in California, Washington, Arizona, Nebraska, North Dakota, Texas, Florida and several other states.

The Georgia Automated Environmental Monitoring Network (AEMN) was developed by the College of Agricultural and Environmental Sciences of the University of Georgia. The first weather station was installed in 1991 and currently 49 weather stations are in operation. Most of these weather stations have been installed at sites that relate to agriculture. Examples include experimental research stations in Blairsville, Plains, Midville, Tifton, Griffin and Watkinsville; USDA research laboratories in Plains, Byron and Watkinsville; nurseries in Dearing and Cairo, row crop farms in Georgetown, Cordele, Arlington, and Vidalia; fruit orchards in Ellijay, Alma, Cleveland and Nahunta; educational facilities in Covington, Fort Valley, Dallas, and Jeffersonville, and golf courses in Duluth, Dunwoody, Alpharetta, and Pinemountain. The stations are located across the state and are representative for regional weather conditions. The current locations of the weather stations can be found in Figure 2.

Figure 3. Tipping bucket rain gauge.

Operation

The automated weather stations of the AEMN are based on Campbell Scientific units. The control and monitoring unit is based on a Campbell Scientific CR10 and CR10X data logger, which has 128K memory and can store up to 62,000 data points. The data logger has 12 single-ended or six differential analog inputs, two pulse counters, three switched excitation channels and eight digital I/O ports. A basic configured station records precipitation, air temperature and relative humidity, wind speed and wind direction, solar radiation, soil temperature at three different depths, barometric pressure and soil moisture. The sensors that are currently being used are listed in Table 1. Rainfall is measured with a tipping bucket rain gauge as shown in Figure 3. Each “bucket” holds 0.01 inch of rain; once the

Figure 4. Weather station at the Atlanta Athletic Golf Club in Duluth, Georgia.

bucket is full it tips and a pulse signal is sent to the data logger. The data logger then converts the number of pulses to total rainfall by the data logger. Each data logger is programmed to scan all sensors at a one-second frequency and data are summarized every 15 minutes. At midnight daily extremes and daily totals are calculated. The system is battery operated, which is recharged with a solar panel during daytime hours. Communications are handled through a modem and a dedicated telephone line to each station or a cellular phone system. An example of a complete operational weather station is shown in Figure 4 for the Atlanta Athletic Golf Club.

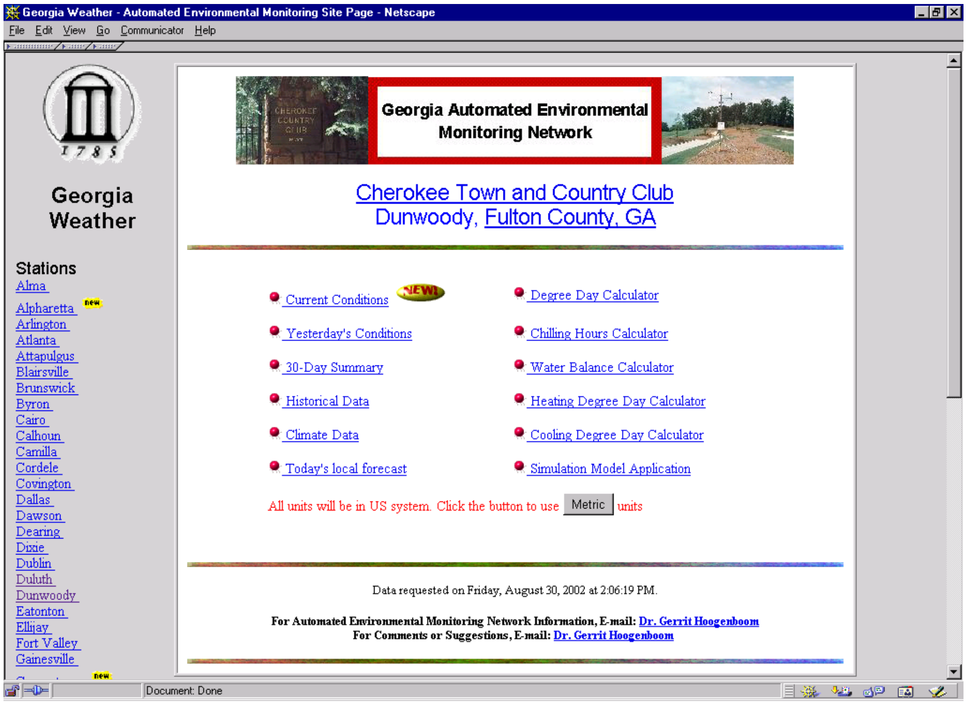
Data are downloaded to a centrally located computer at the College of Agricultural and Environmental Sciences Campus in Griffin. Data are downloaded every 12 hours for all stations. In addition, the detailed data from the stations located in the greater Atlanta area are downloaded every 15 minutes as soon as the data loggers have been updated. Several stations are called at least hourly to download the most recent weather data. Once the data have been downloaded from the web, they are processed and pushed to data and web servers.

Data Dissemination

A special web page has been developed for distribution of the weather data collected by all stations and dissemination of weather-based information for application in agriculture, engineering and other disciplines, including irrigation management. The web page is located at www.Georgiaweather.net. The main page displays a map similar to the one shown in Figure 2. Each point is clickable and once a site has been selected, the user is presented with 12 different options as shown in Figure 5. Data that can be retrieved include current conditions for some of the sites as discussed previously, yesterday's data, data for the last 30 days, historical data recorded by the station, long-term climate data and a link to the local weather forecast page provided by the NWS. The AEMN is not a position to provide forecasts for local weather data, as this is the main responsibility of NWS.

Table 1. Weather variables and sensors of the Georgia Automated Environmental Monitoring Network.

Variable	Sensor
Air temperature	HMP-45C Vaisala Temperature and RH Probe
Relative humidity	HMP-45C Vaisala Temperature and Relative Humidity Probe
Precipitation	TE525 Texas Electronics Tipping Bucket Rain Gage
Wind Speed	034A Met One Wind Set
Wind Direction	034A Met One Wind Set
Solar Radiation	LI200X Li-Cor Silicon Pyranometer
Soil Temperature @ 2, 4 and 8 inches	CS-107 Water/Soil Temperature Probe
Barometric Pressure	CS-105 Vaisala PTB101B Barometric Pressure Sensor
Soil Moisture	CS-615 Water Content Reflectometer



Weather Data Applications

A second set of information is based on applications of the weather data. This includes the calculation of chilling hours and degree-days for agricultural crops, vegetables, fruits and ornamentals. Plant growth and development is a function of temperature and with these calculators users can obtain an indication about rates of growth and development for various plants as a function of local conditions. A similar set of calculators include the cooling degree-day and heating degree-day calculators, which are used extensively by the heating and air conditioning industry as well as agricultural industries associated with confined spaces such as greenhouses.

Figure 5. Main menu for weather data retrieval and applications. Example shown is for the Cherokee Town and Country Club in Dunwoody, Georgia.

The water balance calculator is most directly associated with irrigation. It provides the user with an indication of cumulative rainfall for a defined period, as well as potential water loss. Cumulative rainfall is based on local rainfall observed by the weather station, while cumulative water loss is calculated using a potential evapotranspiration equation that has local temperature and solar radiation as input. The difference between these two calculations, i.e. cumulative rainfall and evapotranspiration, provides the user with an indication of local water needs and supplemental irrigation. In figure 6 an example is shown for Callaway Gardens in Pine Mountain. Cumulative rainfall for this year is 26.9 inches, while cumulative evapotranspiration is 33.8 inches. There is a deficit of 6.9 inches. Note that the cumulative normal rainfall is 38.8 inches. Current rainfall is therefore 11.9 inches below normal.

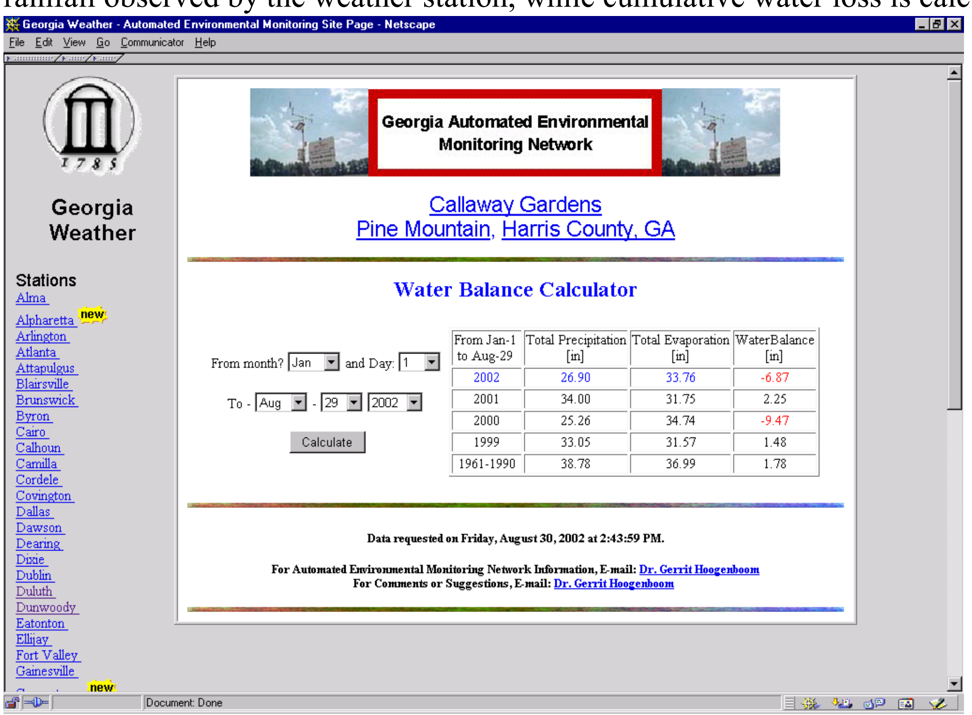


Figure 6. Water balance for Callaway Gardens, Pine Mountain, Georgia for January 1 through August 29, 2002.

Future

The water balance calculator shown in Figure 6 is rather simple. More advanced decision support systems and computer tools are needed to help users decide when to irrigate and how much water to apply. Factors that should be taken into consideration include effective rainfall, water holding capacity of the soil, date of last irrigation or rainfall, type and stage of the crop, and the local weather forecasts. With this type of information users can apply water more selectively, while maintaining optimum growing conditions. At the same time water use will be reduced. A prototype of this type of irrigation scheduling system has been designed for peaches. Hopefully it can be expanded to include other crops to benefit all irrigation applicators.