THE GEORGIA AUTOMATED ENVIRONMENTAL MONITORING NETWORK: TEN YEARS OF WEATHER INFORMATION FOR WATER RESOURCES MANAGEMENT

Gerrit Hoogenboom, D.D. Coker, J.M. Edenfield, D.M. Evans and C. Fang

AUTHORS: Department of Biological & Agricultural Engineering, the University of Georgia, Griffin, Georgia, 30223-1797.
REFERENCE: Proceedings of the 2003 Georgia Water Resources Conference, held April 23-24, 2003, at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, The University of Georgia, Athens, Georgia 30602-2202.

Abstract. With the continuing drought that started in 1998, access to accurate rainfall information for remote locations in Georgia remains very important. One of the main goals of the Automated Environmental Monitoring Network (AMEN) is the collection of weather data across the state of Georgia. The AEMN was established in 1991 with the installation of four automated weather stations in Griffin, Tifton, Watkinsville and Midville. A major milestone was reached at the end of 2001 with the completion of 10 years of continuous records for these first stations. A second milestone was reached in September 2002 with the installation of the 50th weather station in Homerville in south Georgia. The weather data are disseminated in near real-time mode via the world wide web (www.Georgiaweather.net). The main goal of this paper is to present an overview of the network and examples of the application of this information for water resources management.

INTRODUCTION

Weather has continued to be an important issue in the state of Georgia during the last few years, especially as it relates to water resources management. The last major drought started in May 1998. Only recently the state of Georgia and neighboring states seem to have recovered from this drought with ample rainfall received during the first three months of 2003. However, the issue of appropriate allocation of water between the various sectors and distribution between the major metropolitan areas and rural communities has not been resolved.

Agriculture has mainly been affected through the availability of water for irrigation. Both in 2001 and 2002 the Georgia Environmental Protection Division implemented the Flint River Drought Protection Act. Based on long-term climate forecasts for 2003 as well as the rainfall received during the winter of 2003, the Flint River Drought Protection Act was not implemented in March 2003. The main goal of this act is to remove water from irrigation through a voluntary auction by farmers located in the Flint river basin.

National Weather Service

Both droughts and floods are natural phenomena that cannot be avoided and they are part of the weather extremes that people experience on a daily basis. However, for appropriate policy decisions as well as management decisions, it is important to have access to accurate weather information. In the state of Georgia, the National Weather Service (NWS) is the main provider for short-term weather forecasts. The NWS also operates automated stations at major airports, such as the Hartsfield International Airport in Atlanta and regional

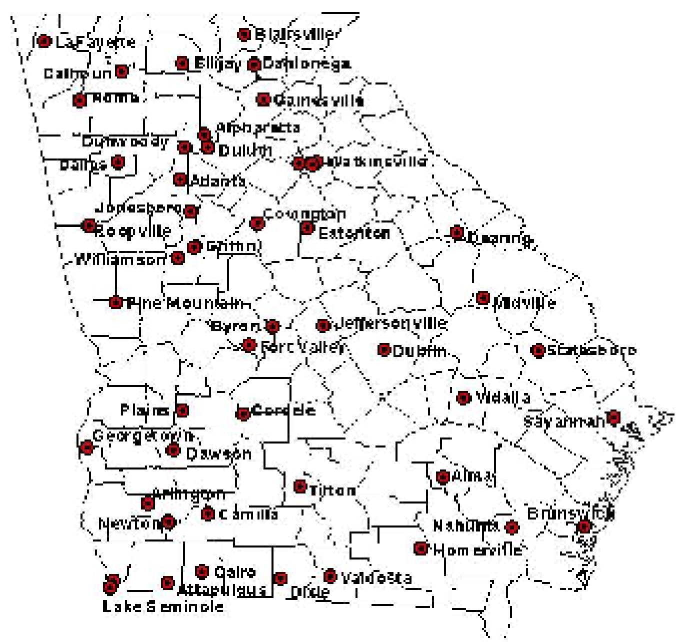

Figure 1. Locations of automated weather stations across the state of Georgia.

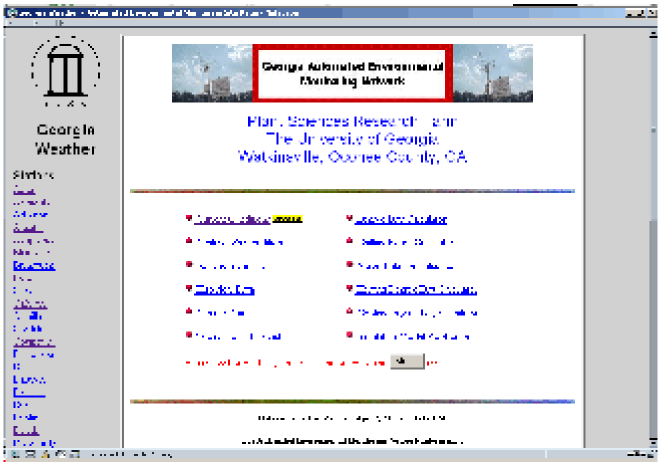

Figure 2. Weather data and products that can be obtained from the AEMN web site at www.Georgiaweather.net.

airports in Albany, Savannah, Augusta, Macon, and other locations. Unfortunately, the number of observation stations in the Flint river basin and other major watersheds is rather limited. In addition to the automated weather stations, the NWS manages a Cooperative Weather Observer network. This network is operated by volunteers, who manually read a set of instruments once a day. This network has been in existence for many years, with some stations having records that are more than 100 years old. However, to obtain the data collected by this network is rather difficult. For decision making in agriculture, forestry, hydrology, pollution prevention, and other environmental disciplines, access to timely weather information is critical.

Automated Weather Stations

The installation and operation of automated weather station networks by universities and other state agencies have solved some of the issues related to weather data access, as well as monitoring of variables that are important for agricultural, environmental and hydrological applications (Tanner, 1990). Especially during the last decade several networks have been developed under the auspices of universities (Meyer and Hubbard, 1992). In the southeast, there are now networks in Florida, Alabama and North Carolina, in addition to Georgia. The objective of this paper is to present an overview of the Georgia Automated Environmental Monitoring Network (AEMN), which collects a range of weather variables at remote locations across the state of Georgia.

PROCEDURE

General

The College of Agricultural and Environmental Sciences of the University of Georgia initiated the development of an automated weather station network in the early 1990's (Hoogenboom, 1993; Hoogenboom et al., 1991). The main objective of this network was to collect detailed weather information at agricultural experiment stations that are located across the state of Georgia. These experiment stations represent the unique climate and soil conditions of the state; examples include Blairsville, Plains, Eatonton, Attapulgus and others (Figure 1).

Milestones

The first automated weather stations were installed in 1991 in Watkinsville, close to the main campus in Athens, Griffin, Tifton and Midville. At the end of 2001 we reached a major milestone with 10 years of continuous records for these stations. In 2002, the 50th station was installed in Homerville. This represented a second milestone. The locations of the current weather station sites are shown in figure 1. The network also played a key role during the 1996 Centennial Olympic Games to provide near real-time weather data for "now" casting of weather conditions by the NWS (Garza and Hoogenboom, 1997).

Environmental Variables

All weather stations monitor air temperature, relative humidity, vapor pressure deficit, precipitation, wind speed and direction, solar radiation, and soil temperature at 2, 4 and 8 inches. Some sites also monitor open pan evaporation, water temperature, leaf wetness, and soil surface temperature. Many stations are also being instrumented with a barometric pressure sensor and a soil moisture probe. Each sensor is scanned at a one second frequency and the data are summarized at 15-minute intervals as well as at midnight.

Communications

Each station is a stand-alone unit that is powered by a battery, which is recharged during the daylight hours with a solar panel. Each weather station also has a modem and either a dedicated land line or a cell phone. A computer at the College of Agricultural and Environmental Sciences Campus in Griffin connects to each station on an hourly basis and downloads the most recently collected weather

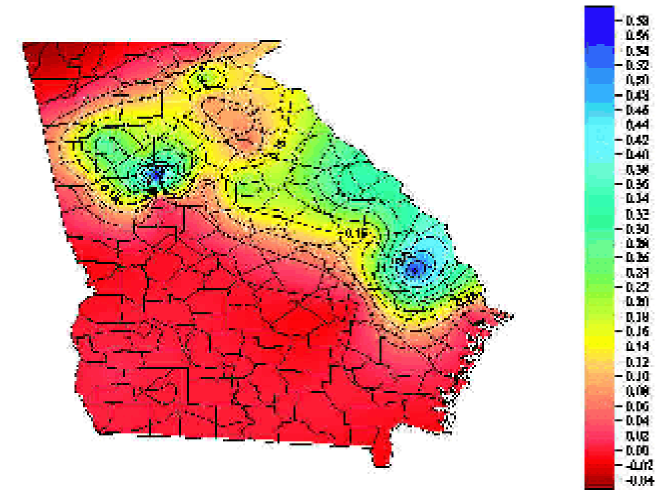

Figure 3. Spatial rainfall distribution for April 6, 2003.

data. For the 13 stations that are located in the greater Atlanta area, the weather data are downloaded every 15 minutes.

Data processing

As soon as the data have been downloaded, they are processed by another dedicated computer. The raw data are converted into two data sets that include the detailed data, collected every 15 minutes, and the daily data. Several data products are created, most of them for delivery via the Internet (Hoogenboom et al., 2000). These include current weather conditions, based on the data that are downloaded from all 50 sites, daily weather summaries, 30-day summaries, and a historical data base that provides users with the option to download historical temperature and rainfall data. The access options that are currently available for each individual station from the web site www.Georgiaweather.net are shown in figure 2.

Data products

In addition to single station data, the weather data are also interpolated across space to develop daily weather maps, such as the rainfall map for April 6, 2003 shown in figure 3. Some data are integrated over time and interpolated across space to develop annual maps, such as for average temperature, cumulative rainfall and drought.

Another application of the weather data includes weather-based calculators and models. These include a degree day calculator, a chilling hour calculator, and a heating and cooling degree day calculator. The first two options are important for agricultural applications, while the latter two applications are used extensively by the heating and air-conditioning industry.

For water resources management, the water balance calculator is an important application. For any site shown in figure 1, a user can select a starting and ending date (figure 4). The program will then determine cumulative precipitation received during that period not only for the current year, but also the preceding years. A comparison is provided to the normal data, based on the climate records collected from 1961 until 1990. In addition to cumulative precipitation, the program also calculates cumulative potential evapotranspiration. In this case, the Priestley-Taylor equation, based on solar radiation and temperature as input, is used (Priestley and Taylor, 1972).

RESULTS AND DISCUSSION

The water balance calculations for Watkinsville shown in figure 4, demonstrate that there has been a significant drought during the last three out of four years, while even in 2002 rainfall was below normal.

In table 1, an overview is presented for the water balance for 1998 through 2002 for most of the weather stations of the network. Normal annual rainfall varies between 45 inches in central Georgia (Cordele) to 57 inches in the Georgia mountains (Blairsville). All sites show a significant drought during 1999, 2000 and 2001. An analysis for earlier data collected by the network can be found in Hoogenboom and Gresham (1997) and Hoogenboom (2001).

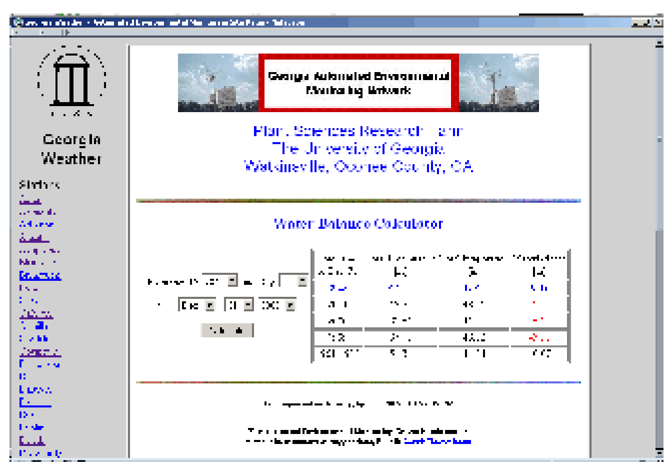

Figure 4. Water balance calculator for the period January 1 through December 31, for the years 1999, 2000, 2001 and 2002 for Watkinsville, Georgia.

Table 1. Annual total precipitation in Georgia for 1998 through 2002 as compared to normal (1961-1990)

Total Precipitation (inches)						
Site	1998	1999	2000	2001	2002	Normal
Alma	47.61	33.16	41.69	30.52	44.63	48.27
Arlington	56.53	38.50	35.59	34.20	54.06	52.71
Attapulgus	50.02	28.92	35.19	44.81	54.00	52.46
Atlanta	43.59	33.76	37.71	37.48	52.09	50.81
Blairsville	54.75	41.30	41.22	49.46	48.19	57.07
Calhoun	47.61	42.04	41.46	45.06	41.71	55.39
Camilla	46.87	33.17	43.21	40.36	56.44	52.55
Cordele	45.60	34.15	22.56	35.01	40.41	45.12
Dawson	57.86	38.02	33.66	37.00	43.78	51.22
Eatonton	42.05	31.59	32.41	37.61	41.88	48.11
Ft. Valley	27.60	31.67	30.72	28.38	41.72	47.82
Griffin	46.96	36.74	36.09	34.78	45.54	51.44
Midville	45.72	33.44	34.37	27.98	40.33	45.98
Plains	53.79	32.47	38.43	44.33	40.17	48.54
Rome	49.59	37.01	37.08	39.80	54.60	55.30
Savannah	51.65	46.62	36.44	33.09	57.07	48.72
Statesboro	55.93	23.46	35.33	26.16	43.46	46.65
Tifton	44.07	31.70	36.23	35.06	38.44	47.80
Watkinsville	45.61	37.65	33.81	42.39	47.91	51.31

So far the web site www.Georgiaweather.net has shown an increase in use by many different people. We expect that the network can also be a great resource to deal with water related issues across the state of Georgia.

REFERENCES

Garza, C., and G. Hoogenboom. 1997. The use of diverse surface weather data collection systems in support of the 1996 Olympic Games. p. 288-290. *In* : [K. J. Hatcher, editor] *Proceedings of the 1997 Georgia Water Resources Conference*. The University of Georgia, Athens, Georgia.

Hoogenboom, G., G.A. Georgiev, and D.D. Gresham. 2000. Development of weather-based products for agricultural and environmental applications. p. 66-67. *In*: Preprints 24rd Conference on Agricultural and Forest Meteorology. American Meteorological Society, Boston, Massachusetts.

Hoogenboom, G., and D. D. Gresham. 1997. Automated Weather Station Network. p. 483-486. *In* : [K. J. Hatcher, editor] *Proceedings of the 1997 Georgia Water Resources Conference*. The University of Georgia, Athens, Georgia.

Hoogenboom, G. 1993. The Georgia Automated Environmental Monitoring Network. p. 398-402. *In* : [K. J. Hatcher, editor] *Proceedings of the 1993 Georgia Water Resources Conference*. The University of Georgia, Athens, Georgia.

Hoogenboom, G. 2001. Weather monitoring for management of water resources. p. 778-781. *In* : [K. J. Hatcher, editor] *Proceedings of the 2001 Georgia Water Resources Conference*. The University of Georgia, Athens, Georgia.

Hoogenboom, G., B. P. Verma, and E. D. Threadgill. 1991. The development of the Georgia Automated Environmental Monitoring Network. p. 285-287. *In* : [K. J. Hatcher, editor] *Proceedings of the 1991 Georgia Water Resources Conference*. The University of Georgia, Athens, Georgia.

Meyer,S.J., andK.G.Hubbard. 1992. Nonfederal Automated Weather Station and Networks in the United States and Canada: A Preliminary Survey. *Bull. Amer. Meteorol. Soc*. 73:449-457.

Priestley, C.H.B, and R.J. Taylor. 1972. On the assessment of surface heat flux and evaporation on large-scale parameters. Monthly Weather Review 100:81-92.

Tanner, B.D. 1990. Automated weather stations. Remote Sensing Reviews 5(1):73-98.