WEATHER MONITORING FOR MANAGEMENT OF WATER RESOURCES

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Abstract. The College of Agricultural and Environmental Sciences of the University of Georgia has developed an automated weather station network that has grown from four stations in 1991 to more than 45 stations in 2001. The stations are strategically located across the state of Georgia; they mainly have been installed at agricultural and other representative sites. During the droughts of 1998, 1999, and 2000, the network was able to depict specific regions in the state that were exposed to extremely dry conditions. Weather, climate and related information are delivered via the Internet at www.Georgiaweather.net in a near real-time mode.

INTRODUCTION

Weather has continued to be an important issue in the state of Georgia during the last few years. Especially the lack of sufficient rainfall has caused a continuous drought since May 1998. This has affected the availability of water across the entire state for the major metropolitan areas, such as Atlanta, as well as small rural communities where water is being pumped from wells. It also has impacted major industries that rely on water as a resource, such as mills, and animal and crop production.

Especially the availability of water for irrigated agriculture has become limiting. This has resulted in the implementation of the Flint River Drought Protection Act on March 2001, as the Georgia Environmental Protection Division expects a fourth consecutive drought this year. As part of the drought protection act, farmers can participate in a voluntary auction to provide bids on acreage that they are willing to remove from irrigation.

A drought cannot be avoided, as it is completely controlled by various weather and other atmospheric phenomena. However, it is important to have access to detailed monitoring of weather observations to be able to collect scientifically valid data that can be used for policy decisions, such as the Flint River Drought Protection Act. In the state of Georgia, the National Weather Service (NWS) is the main provider for short-term weather forecasts. The NWS operates automated stations at major airports, such as the Hartsfield International Airport in Atlanta and regional 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 also manages a Cooperative Weather Observer network. This network is operated by volunteers, who manually read a set of instruments once a day. Timely access to the data collected by this network is rather difficult, which is critical for decision making in agriculture, hydrology and other environmental disciplines. The installation and operation of automated weather station networks by universities and other state agencies has 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). The objective of this paper is to present an overview of a network that provides timely access to

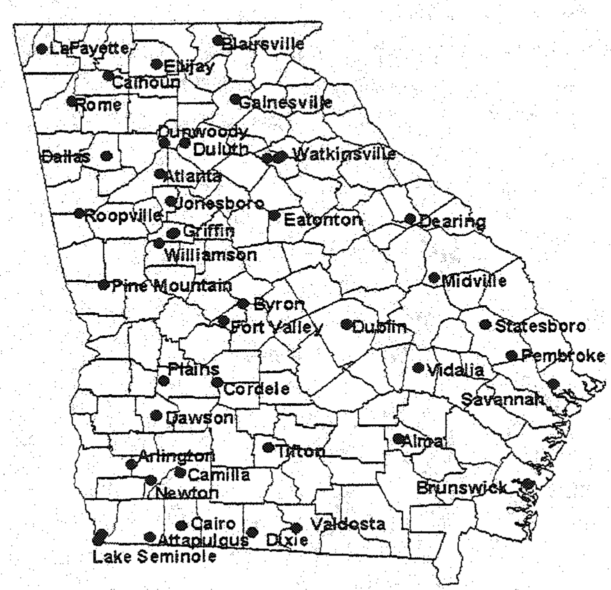

Figure 1. Location of automated weather stations across the state of Georgia.

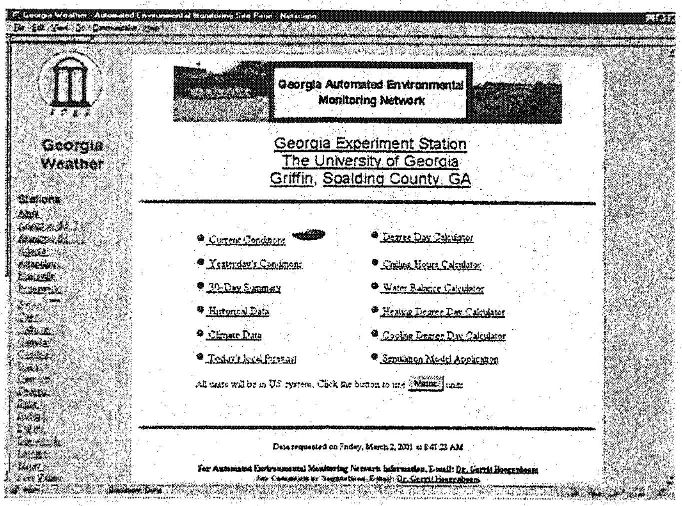

Figure 2. Weather data and products that can be obtained from the AEMN web site at www.Georgiaweather.net.

a range of weather variables, collected at remote locations across the state of Georgia.

PROCEDURE

The College of Agricultural and Environmental Sciences of the University of Georgia initiated the development of an automated weather station network in the early 90's (Hoogenboom, 1993; Hoogenboom et al., 1991). The main objective of this network was to collect detailed weather variables at remote locations across the state that are representative of the local weather and climate conditions. Easy access to the data was also one of the main objectives. The first automated weather stations were installed at agricultural experiment stations in 1991. In 2001, 45 stations are operational and the installation of at least three more stations is being planned. The location of the current sites is shown in figure 1. The network played a key role during the 1996 Centennial Olympic Games to provide weather data for "now" casting of weather conditions at the venues by the NWS (Garza and Hoogenboom, 1997). A close collaboration has also been established with the Georgia Forestry Commission for fire weather prediction and the US Geological Survey for hydrological studies.

Variables

Each weather station monitors air temperature, relative humidity, precipitation, wind speed, wind direction, solar radiation, and soil temperature at 2, 4 and 8 inches. Some sites monitor open pan evaporation, water temperature, leaf wetness, and soil surface temperature. All stations are also being instrumented with a barometric pressure and a soil moisture probe. Each sensor is scanned at a one second frequency and the data are summarized at 15 minute intervals to calculate either an average or a total value, depending on the parameter that is being collected. At midnight, daily summaries are calculated in the form of daily extremes, averages, and totals.

Communications

Each station is a stand alone unit, that is powered by digital current through a battery and solar panel. Communications are handled via a dedicated telephone line and a modem. Recently, several stations have been installed that use a cellular phone device, rather than a land line. Cellular phones might be more cost effective, although their high power consumption is a concern. The data communications are controlled by a dedicated computer, located in the Department of Biological and Agricultural Engineering at the College of Agricultural and Environmental Sciences Campus in Griffin, Georgia. This computer operates continuously and all communications and processing are done automatically. For ten stations located in the greater Atlanta area, the weather data are downloaded every 15 minutes. For 15 stations located across the state, the data are downloaded every 60 minutes and for the remaining 20 stations the data are downloaded daily at midnight.

Data processing

As soon as the data have been downloaded, they are processed. 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,

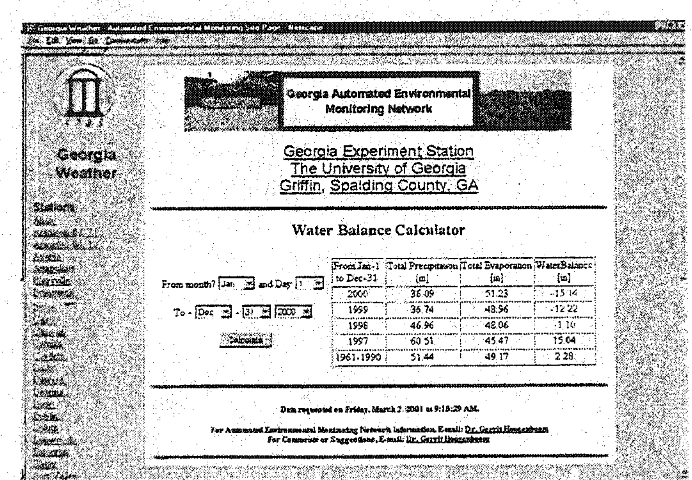

Figure 3. Water balance calculator for the period January 1 through December 31, for the years 1997, 1998, 1999 and 2000 for Griffin, Georgia.

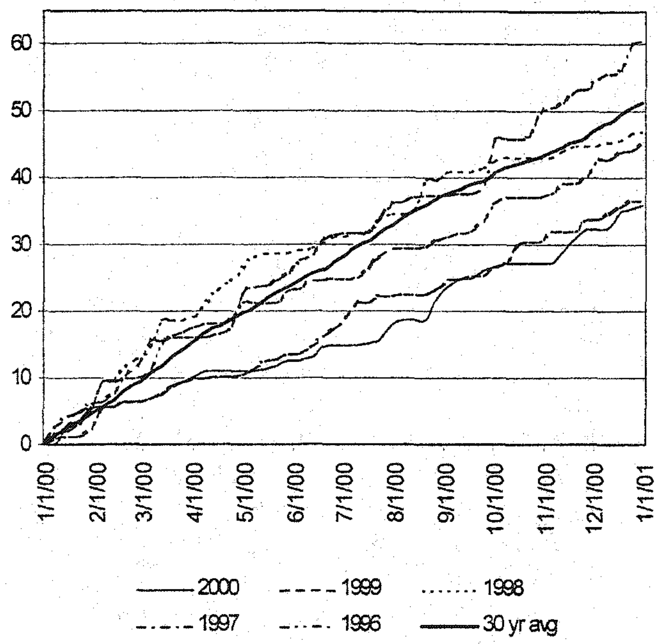

Figure 4. Cumulative weekly precipitation for Griffin, Georgia for 1996 through 2000.

based on the data that are downloaded from 25 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 options that are currently available for each individual station at the web site www.Georgiaweather.net are shown in figure 2.

Data products

In addition to retrieving weather data, a user can also determine several weather data-based products. 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 being 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 3). 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 Griffin, Georgia shown in figure 3, demonstrate that there has been a significant drought during the last three years. Annual rainfall for 1999 and 2000 was 36.7 and 36.1 inches, respectively, about 15 inches below the normal of 51.4 inches/year. In contrast, annual total rainfall for 1997 was about 19 inches above normal. Based on the last four years, there has been a total deficit of 25.5 inches for Griffin.

In table 1, an overview is presented for the water balance for 1996 through 2000 for most of the weather stations of the network. Normal annual total rainfall varies between 45 inches in Central Georgia (Cordele) to 57 inches in the Georgia mountains (Blairsville). All sites show a significant drought during both 1999 and 2000. However, total precipitation for 1998 shows a strong variation across the state, ranging from 20 inches below normal to six inches above normal. An analysis for earlier data collected by the network can be found in Hoogenboom and Gresham (1997).

Total annual precipitation does not really present a complete picture with respect to the water balance for hydrology. It is well known that there is also a significant seasonal variation. Therefore, the number of rainy days as well as individual rainfall amounts should also be analyzed. An example for Griffin is shown in Figure 4. For instance, the winter of 1998 was one of the wettest periods for the years analyzed, but starting in early fall, it really started to dry out, causing an annual total rainfall that was below normal. Cumulative precipitation patterns for 1999 and 2000 seem very similar, being below normal for most of the year. Only 1997 shows a consistent rainfall accumulation above normal for the entire year.

Based on the extensive use of the data and the popularity of the web site (www.Georgiaweather.net), it can be concluded that the Automated Environmental Monitoring Network (AEMN) has been a great resource for the management of the natural resources in Georgia.

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Table 1. Annual total precipitation in Georgia for 1996 through 2000 as compared to normal (1961-1990).

Total Precipitation (inches)						
Site	1996	1997	1998	1999	2000	Normal
Alma	40.94	51.77	47.61	33.16	41.69	48.27
Arlington	n/a	n/a	56.53	38.50	35.59	52.71
Attapulgus	48.63	61.75	50.02	28.92	35.19	52.46
Atlanta	52.06	49.63	43.59	33.76	37.71	50.81
Blairsville	57.28	50.23	54.75	41.30	41.22	57.07
Calhoun	49.41	42.36	47.61	42.04	41.46	55.39
Camilla	n/a	n/a	46.87	33.17	43.21	52.55
Cordele	n/a	n/a	45.60	34.15	22.56	45.12
Dawson	45.64	55.11	57.86	38.02	33.66	51.22
Eatonton	39.84	46.57	42.05	31.59	32.41	48.11
Ft. Valley	41.15	56.22	27.60	31.67	30.72	47.82
Griffin	45.11	60.51	46.96	36.74	36.09	51.44
Midville	38.46	51.26	45.72	33.44	34.37	45.98
Plains	43.88	61.32	53.79	32.47	38.43	48.54
Rome	58.49	59.01	49.59	37.01	37.08	55.30
Savannah	40.70	54.83	51.65	46.62	36.44	48.72
Statesboro	33.11	53.84	55.93	23.46	35.33	46.65
Tifton	39.46	43.00	44.07	31.70	36.23	47.80
Watkinsville	29.79	60.89	45.61	37.65	33.81	51.31

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