APPLICATION OF WEATHER DATA TO HELP IMPROVE COTTON PRODUCTION

Gerrit Hoogenboom and Joel O. Paz
Biological and Agricultural Engineering, University of Georgia, Griffin Campus

Introduction

The year 2008 was again a very dry year, especially for North and Central Georgia, while Southwest Georgia was very wet and Southeast Georgia was very dry. When one analyzes the annual precipitation map that compares the 2008 rainfall with normal rainfall for the period 1971-2000, the spatial variability across Georgia is striking (Figure 1). The region around Attapulgus showed 15 inches above normal, while North Georgia showed between 10 and 17 inches below normal.

Most of the weather stations of the Georgia Automated Environmental Monitoring Network (www.Georgiaweather.net) showed a negative water balance for the cotton growing season, except for Attapulgus and Cairo, demonstrating the need for supplemental irrigation. The same observations were also made for previous years. These droughts are one of the main reasons that the availability of water for irrigation has become limited for Georgia producers. The future does not look very bright, especially for producers located in the Flint River basin. In 2000, the Georgia legislature approved the Flint River Drought Protection act. This act was implemented during both the 2001 and 2002 spring seasons. Farmers were asked to bid for acreage that they were willing to remove from irrigation. Fortunately, the drought mitigation act has not been implemented since 2003, as the weather outlook provided for a wetter growing season compared to the previous years. However, both 2007 and 2008 turned out to be one of the driest years on record. As a result, there serious water use restrictions across the state of Georgia. In addition, the discussions among the states of Georgia, Alabama, and Florida also intensified, especially due to the very limited availability of water for the greater Atlanta area.

The availability of near real-time weather data is critical for cotton production. This weather information can be used in various computer programs to help producers with their daily management decisions. There is a need to develop and implement computer-based information technologies for decision-making, using local weather data from Georgia and other input conditions such as soil and crop management. Although weather and decision support systems have not been listed as one of the research needs for the Georgia cotton industry, it directly or indirectly affects many issues and decisions that are made on a daily basis by producers. These decisions relate to planting date selection, deficit irrigation management, when to start and stop irrigation, replanting in case of establishment failure, irrigation timing and crop water use, and pesticide and herbicide applications. The strategic plan of the Georgia Cooperative Extension Service has identified Information Technology as one of the critical issues for the near future for dissemination of knowledge and information to farmers, producers, growers, consultants, and other stakeholders.

Materials and Methods

The College of Agricultural and Environmental Sciences of the University of Georgia has established an extensive network of automated weather stations that are located across the state of Georgia. There are currently 77 stations in operation in Albany, Arlington, Calhoun, Camilla, Cordele, Dublin, Newton, Statesboro, Vidalia, and many other locations (Figure 2). Several of these weather stations have been installed in farmers' fields, such as in Georgetown and Cordele. In 2008, two new weather stations were installed on the John A. Flowers Blueberry Farm in Odum, Wayne County, and on the Whitewater Creek Ranch in Howard, Taylor County. We expect the network to slowly expand in the coming years, with most of the new stations to be installed in areas where there is currently no or a poor coverage.

The weather variables that are collected include rainfall, air temperature, soil temperature, relative humidity, wind speed and direction, solar radiation, soil moisture, and barometric pressure. The data logger is the central core for the operation of the weather station and storage of the data and it automatically records the weather data. Each weather sensor is scanned at a one-second frequency and every 15 minutes summaries are calculated for the previous period. At midnight, daily extremes, daily totals, and other summaries are determined.

Each weather station is a stand-alone unit, powered by a battery, which is recharged by a solar panel. Communications are handled through a dedicated telephone line or cell phone, which is connected to the modem of each weather station. Recently, some new communication technologies have been added, including WiFi and a combination of local radio telemetry and the internet. A computer located at the Griffin Campus of the University of Georgia calls each station at 30-minute intervals or more frequently and downloads the data. After processing, error checking, and other procedures, all data are pushed to a web server. Users can retrieve various types of weather and climate data from www.Georgiaweather.net, including yesterday's conditions, weather conditions for the last 31 days, as well as historical data for temperature and rainfall. Weather data are also distributed to local news media, including television stations and newspapers, and to farmers and agribusinesses via electronic mail. Current weather conditions are now updated at least every 30 minutes for all sites and more frequently for some of the sites.

A key component for decision making by growers and producers is the suite of application programs that have been implemented on the web site (www.Georgiaweather.net). Users can calculate degree-days for any period of time until present. As part of the degree-day calculator, users can define the base temperature as well as a maximum temperature, above which no degree-days are calculated. During the winter months, users can also calculate chilling hour. A third calculator is the water balance calculator, which provides total precipitation received for any period of time, as well as potential evapotranspiration. Potential evapotranspiration is the potential amount of water that can be lost by a crop that is grown under well-watered conditions. The difference between total precipitation and total potential evapotranspiration reflects the need for irrigation to avoid water stress. Recent additions include simple calculators to provide the first and last frost dates. The newest tool has the capability to graph daily weather data, as shown for maximum and minimum temperature and daily total rainfall for Moultrie in Figure 3 and Figure 4, and local temperature predictions up to 12 hours ahead. Other new additions included a first and last frost date for each location where a weather station has been installed.

Results

For this study, we compared the cumulative number of degrees days, using a base temperature of 60 degrees Fahrenheit. We did not use a maximum temperature cutoff in our calculators. The results for 2008 were compared with the previous growing seasons from 2003 through 2007. Please note that the automated weather station network is continuously being expanded. As a result, we do not have complete weather records for all sites. Recent installations include Moultrie, Unadilla, Vienna, and Woodbine in 2005; Ty Ty, Tennille, and Blue Ridge in 2006, Baxley and Danielsville in 2007, and Howard and Odum in 2008. We defined the start of the growing season as May 1 and the end of the growing season as October 31. In reality, this can vary from location to location. Cumulative degrees days for the 2003 through 2008 growing seasons are shown in Table 1. The maximum number of degree-days for 2008 was found in Albany at 3267, Valdosta at 3243, Savannah at 3072, Cairo at 3060, and Vidalia at 3059. The minimum number of degrees in 2008 was found in Rome at 2357, Watkinsville at 2469 and Griffin at 2474. For all sites, the cumulative total number of degree-days was significantly lower for 2008 than for 2007. For the six-year period from 2003 through 2008, 2003 had the lowest number of degree days for about 70% of the sites, while 2008 had the lowest number of degree days for the remaining sites. 2004, 2005, and 2006 were very similar, while 2007 had the highest number of degree days.

Cumulative precipitation for May 1 until October 31 is shown in Table 2. Similar to the previous years, rainfall varied significantly across the state and among weather stations for this period. Cordele and Watkinsville were the driest locations, with respectively 15.5 and 16.8 inches. Attapulgus, Cairo, and Camilla had the highest amount of precipitation, with respectively 40.3 and 37.7, and 31.1 inches of rain. When comparing the period 2003 through 2008, the growing season of 2008 was wet for some sites, with the highest amount of rainfall received during the last six years. However, note that, for instance for Attapulgus, 16 inches of rain was recorded from August 20 through August 25. This shows that total amount of rain during the growing season is not always a good indicator for dry or wet conditions.

The water balance for the same period is presented in Table 3. The water balance represents the difference between incoming water through rainfall and outgoing water lost through potential evapotranspiration for a well-watered crop. All sites except for Attapulgus, Cairo, and Camilla had a negative water balance that ranged from -1.6 inches for Dixie to -17.7 for Cordele. During the period from 2003 through 2008, two sites had a negative water balance for all six years. These include Dearing, and Fort Valley, while eleven sites had a negative balance during five of the six years, e.g., Arlington, Attapulgus, Cairo, Camilla, Cordele, Dublin, Elberton, Jeffersonville, Plains, Rome, and Valdosta. This is somewhat of concern and could mean that for these sites an investment in supplemental irrigation should be recommended. Unfortunately, the water balance does not provide much information with respect to both the rainfall distribution and intensity, and only provides a seasonal summary. For instance, recent reports show that late rains really help boost cotton yields compared to the early estimates based on drought and heat stress.

Summary and Conclusions

Temperature and rainfall display a very strong annual variability, as well as among sites. Although this is not a new observation, it shows that the availability of local weather information is critical for day-to-day decision making by farmers. This weather information can be integrated in management and decision support tools, such as models, to provide alternate management options and solutions for farmers. Especially schedulers for irrigation management are needed if water for agricultural use will become restricted.

The automated weather station network will continue to collect local weather data as long as financial support will be provided by industry, government, and others interested in weather data to support their operation and management decisions. Weather information can be retrieved at no-cost via the world wide web at www.Georgiaweather.net and specific web pages have been developed for cotton producers to be able to quickly retrieve degree days (www.griffin.uga.edu/aemn/degreedays.htm) and cumulative rainfall (www.griffin.uga.edu/aemn/rainNOV.htm) for the main cotton producing areas in Georgia. The degree-day and water balance calculators can also be run interactively on the web, using local weather data as input. We feel that the combination of near real-time weather data and decision support systems is critical to maintain an economically sustainable farming operation.

Acknowledgments

This work was sponsored in part by a grant from the Georgia Cotton Commission, a partnership with the United States Department of Agriculture - Risk Management Agency, local sponsors such as AgAmerica Empowerment Agency, Inc., and Federal

and State Funds allocated to the University of Georgia - College of Agricultural and Environmental Sciences.

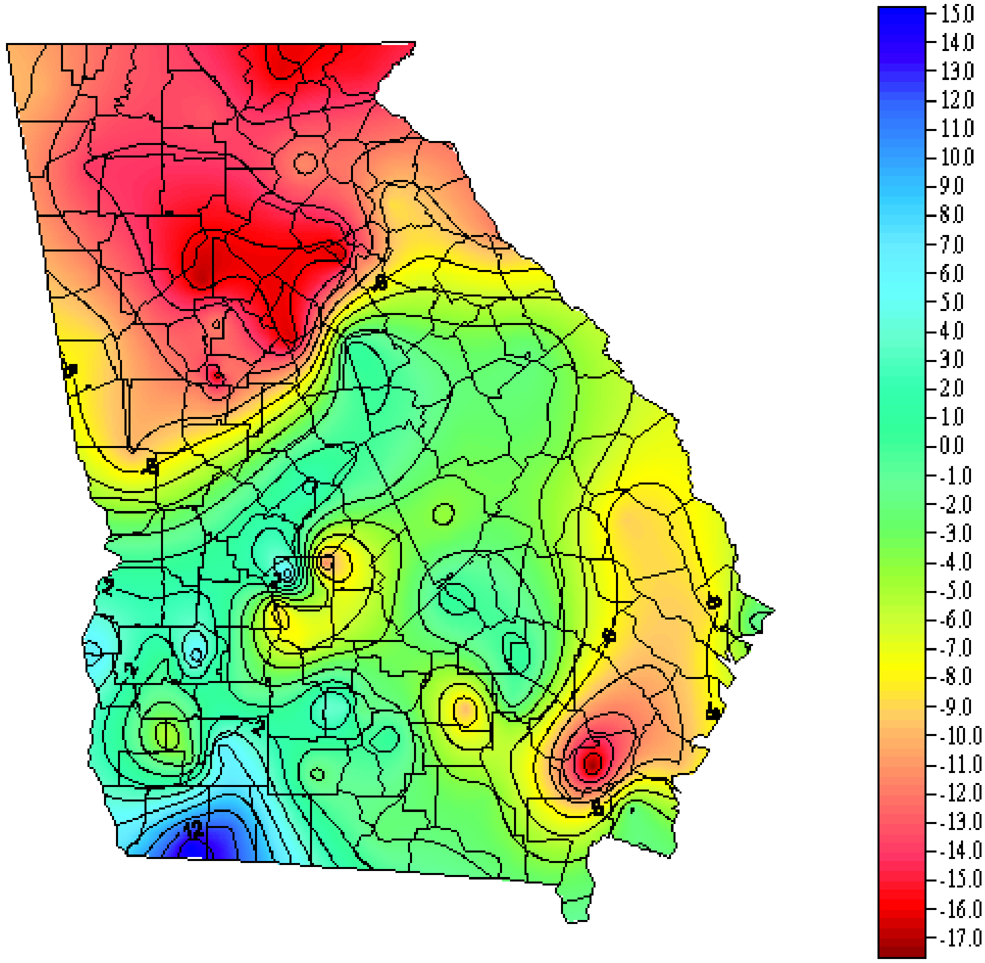

Figure 1. Deviation from normal (1971-2000) precipitation (inches) for January 1 - December 31, 2008

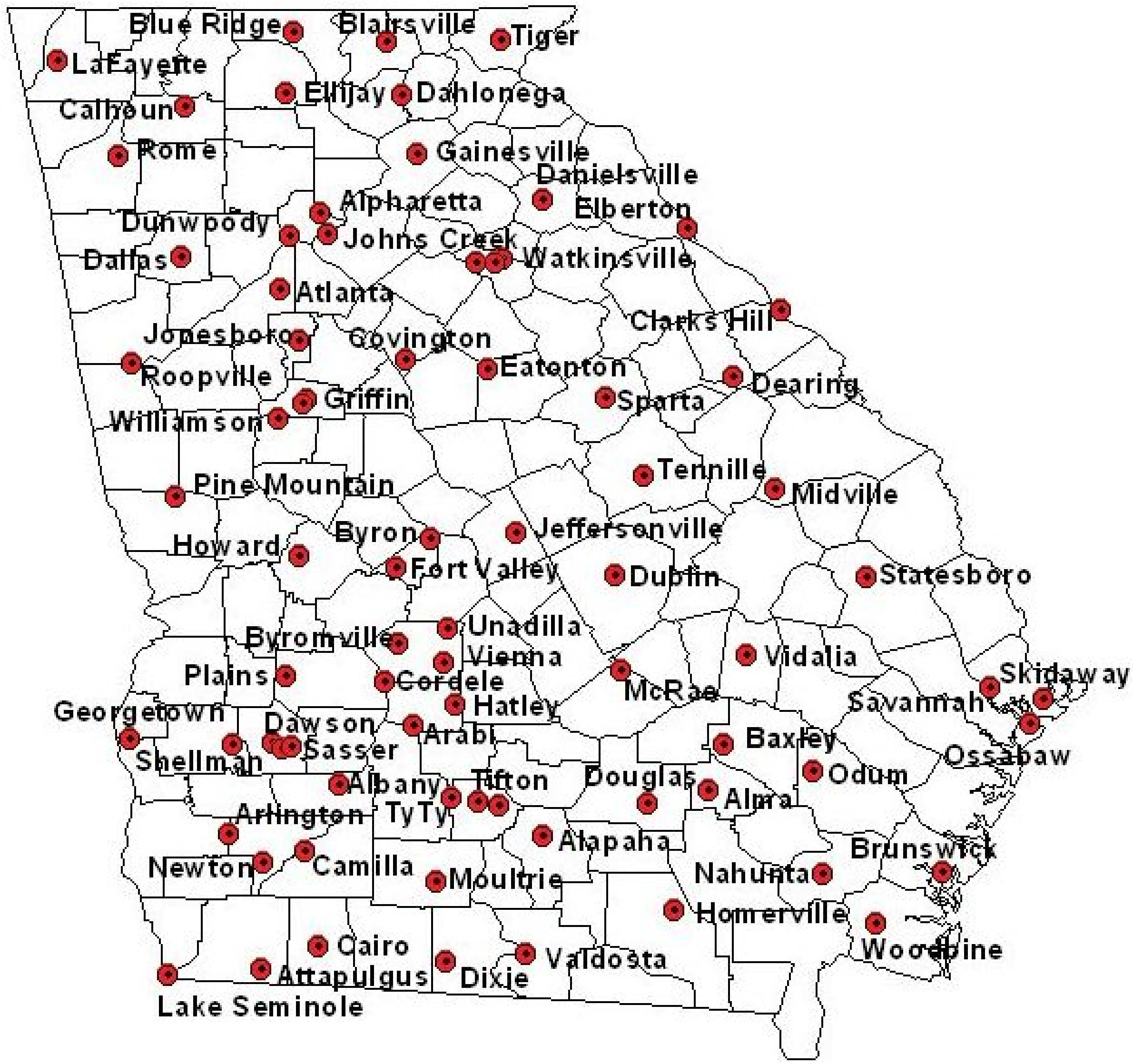

Figure 2. Location of the weather stations of the Georgia Automated Environmental Monitoring Network.

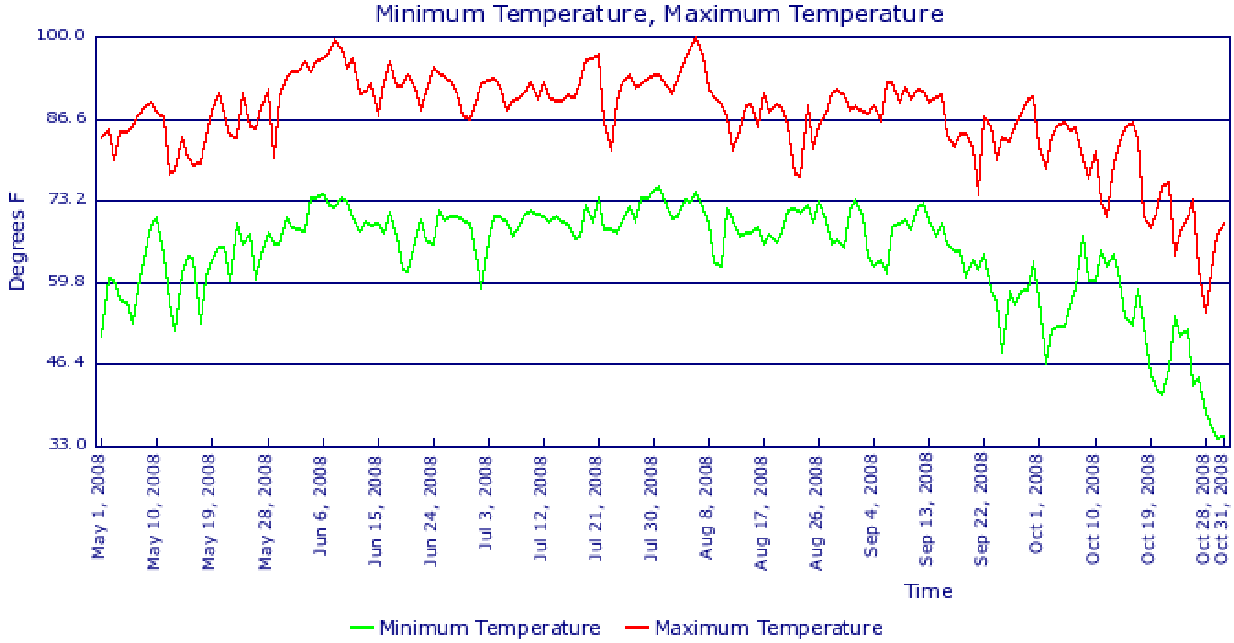

Figure 3. Daily maximum and minimum temperature for May 1 through October 31, 2008 for Cordele, Georgia.

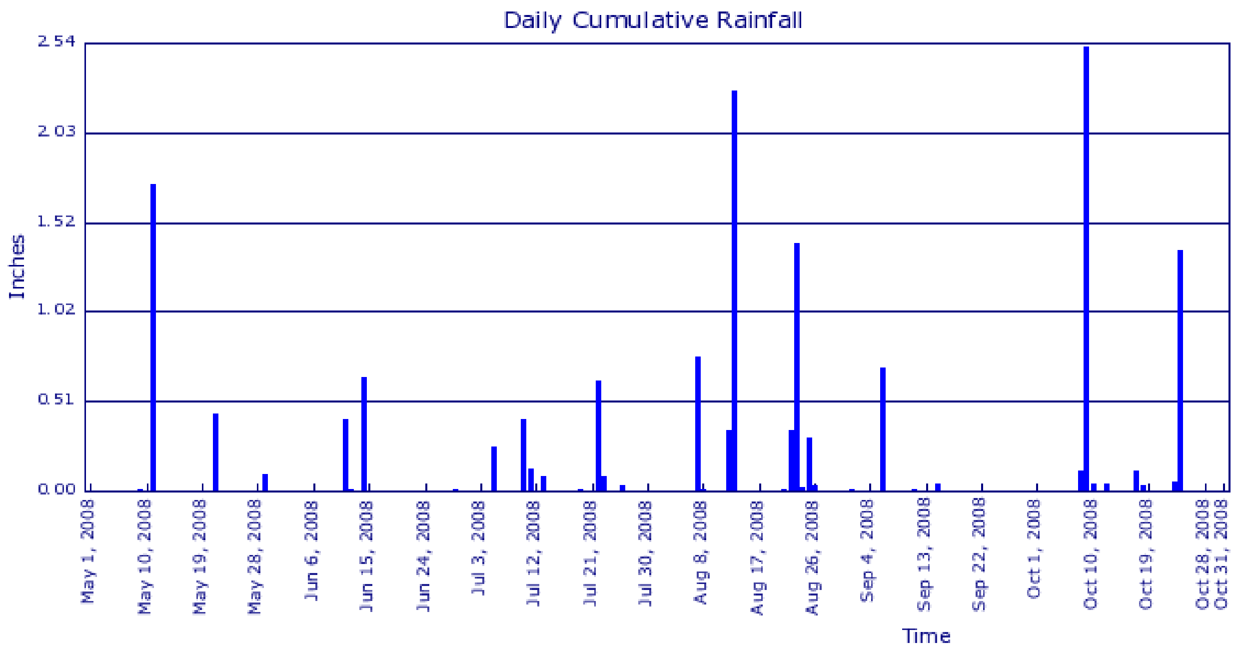

Figure 4. Daily total precipitation for May 1 through October 31, 2008 for Cordele, Georgia.

Table 1. Degree-days from May 1 until October 31 with a base of 60 °F.

Site	2008	2007	2006	2005	2004	2003
Alapaha	2850	3038	2600	3025	3052	2941
Albany	3267	3421	3253	3250	3279	N/A
Alma	3035	3216	3056	3162	3182	3030
Arlington	2941	3189	2985	3086	3067	2923
Attapulgus	2945	3209	3046	2850	3096	3023
Cairo	3060	3335	3120	3185	3275	3043
Camilla	2882	3275	3096	3133	3225	3026
Cordele	2920	3144	3020	3102	3124	2946
Dearing	2861	3050	2837	2898	2984	2676
Dixie	2814	3263	3009	3208	3242	3067
Dublin	2980	3047	2993	3048	3077	2818
Elberton	2700	2950	2612	2720	2749	N/A
Ft. Valley	2805	3031	2910	2895	2889	2610
Georgetown	2888	3100	2926	2892	2936	2822
Griffin	2474	2709	2540	2495	2515	2269
Homerville	2920	3115	2983	3137	3125	2966
Jeffersonville	2738	2882	2779	2780	2845	2597
McRae	2875	2929	2798	2916	2934	N/A
Midville	2955	3081	2904	3019	3010	2758
Moultrie	3041	3302	3136	3105	N/A	N/A
Plains	2712	3015	2947	2924	2938	2741
Rome	2357	2684	2444	2475	2430	2182
Savannah	3072	3142	3001	3251	2983	2936
Statesboro	2821	3040	2689	2724	3029	2818
Tifton	2935	3161	3025	3080	3196	2950
Valdosta	3243	3452	3384	3456	3467	3224
Vidalia	3059	3169	3082	3147	3219	2935
Watkinsville	2469	2761	2487	2497	2548	2294

Table 2. Total precipitation (inches) from May 1 until October 31.

Site	2008	2007	2006	2005	2004	2003
Alapaha	21.76	22.74	20.74	18.93	35.70	40.79
Albany	29.50	20.10	25.78	30.15	33.34	N/A
Alma	27.69	27.83	19.46	23.39	33.45	35.23
Arlington	23.68	18.16	28.62	28.11	32.61	23.49
Attapulgus	40.29	18.22	27.79	28.13	28.83	25.39
Cairo	37.74	25.13	19.76	27.51	28.10	27.29
Camilla	31.13	21.15	25.65	24.24	23.77	25.71
Cordele	15.49	18.91	17.16	19.77	34.72	27.71
Dearing	20.38	10.18	21.20	28.31	28.32	22.22
Dixie	30.20	28.93	20.27	32.97	35.63	27.84
Dublin	19.29	20.53	17.06	17.93	31.73	32.42
Elberton	18.88	9.56	19.39	25.60	23.40	N/A
Ft. Valley	23.16	21.09	12.20	23.94	20.56	17.04
Georgetown	27.50	19.13	17.90	25.63	25.52	33.29
Griffin	20.10	15.50	16.52	31.71	35.52	32.80
Homerville	25.58	25.28	16.72	28.89	40.88	32.63
Jeffersonville	18.18	17.81	16.85	22.52	29.00	28.80
McRae	23.54	21.81	19.62	17.30	35.79	N/A
Midville	17.65	17.89	14.37	28.71	30.45	35.20
Moultrie	21.60	28.95	12.63	28.20	N/A	N/A
Plains	24.78	18.13	27.07	29.11	32.07	26.00
Rome	18.27	13.41	19.61	15.30	24.12	31.85
Savannah	27.81	32.86	18.48	31.00	37.85	24.52
Statesboro	17.98	25.55	19.28	28.86	24.37	36.34
Tifton	26.31	22.22	15.78	18.84	33.62	31.78
Valdosta	27.72	25.30	22.93	31.12	31.96	25.97
Vidalia	27.51	29.15	13.03	15.75	35.86	40.37
Watkinsville	16.76	12.21	17.70	29.02	30.36	34.27

Table 3. Water balance (inches) from May 1 until October 31. (The calculation of the water balance is based on [total seasonal rainfall - total seasonal evapotranspiration]).

Site	2008	2007	2006	2005	2004	2003
Alapaha	-9.00	-9.39	-6.13	-6.60	9.69	14.35
Albany	-4.64	-12.98	-7.74	-0.91	1.38	N/A
Alma	-4.57	-4.63	-14.13	-7.83	2.50	5.82
Arlington	-9.09	-14.40	-3.80	-1.27	2.62	-5.22
Attapulgus	10.89	-13.77	-5.18	-2.48	-2.08	-2.92
Cairo	5.80	-7.00	-12.85	-1.80	-2.17	-1.16
Camilla	1.13	-10.69	-7.76	-7.20	-8.08	-4.04
Cordele	-17.73	-14.68	-16.82	-14.21	1.21	-3.64
Dearing	-11.84	-21.58	-10.45	-0.89	-2.10	-5.67
Dixie	-1.57	-4.15	-11.60	3.15	4.49	-1.96
Dublin	-11.45	-11.06	-14.51	-12.72	-0.51	3.04
Elberton	-15.83	-25.27	-10.41	-4.27	-5.05	N/A
Ft. Valley	-8.20	-11.99	-20.15	-0.18	-3.90	-6.92
Georgetown	-2.11	-11.78	-13.28	0.88	-0.77	6.92
Griffin	-10.23	-16.06	-15.21	3.51	7.18	5.27
Homerville	-4.57	-5.08	-14.56	0.97	12.15	5.07
Jeffersonville	-13.75	-14.07	-15.61	-8.10	-1.11	2.21
McRae	-7.31	-11.46	-11.84	-12.28	5.44	N/A
Midville	-15.30	-15.48	-18.93	1.22	3.59	7.25
Moultrie	-10.83	-3.99	-21.43	-3.12	N/A	N/A
Plains	-4.83	-15.77	-6.96	-1.27	2.87	-1.04
Rome	-9.27	-15.05	-9.07	-11.21	-1.41	7.19
Savannah	-2.46	2.18	-13.34	1.82	9.02	-4.06
Statesboro	-15.12	-6.27	-12.29	0.35	-5.31	8.59
Tifton	-6.67	-10.47	-17.61	-12.02	2.70	0.90
Valdosta	-4.81	-6.71	-10.32	-0.75	0.06	-2.85
Vidalia	-4.35	-7.95	-25.64	-15.40	2.47	11.35
Watkinsville	-13.69	-18.68	-11.44	1.02	1.24	7.47