APPLICATION OF WEATHER DATA TO HELP IMPROVE COTTON PRODUCTION

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Introduction

The year 2007 was one of the driest years on record, especially for North and Central Georgia. 2007 was also a very dry year when compared to 2005 and especially 2003 and 2004. Most of the weather stations of the Georgia Automated Environmental Monitoring Network (www.Georgiaweather.net) showed a negative water balance, demonstrating the need for supplemental irrigation. These continuing droughts are one of the main reasons that the availability of water for irrigation has become limited for Georgia farmers. The future does not look very bright, especially for farmers located in the Flint River basin. In 2000, the Georgia legislature approved the Flint River Drought Protection act. This act was implemented during the springs of both 2001 and 2002, when 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, 2007 turned out to be one of the driest years on record and has resulted in serious water use restrictions. 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. It is still unclear how the Georgia Comprehensive State-wide Water Management Plan, ratified by Georgia's General Assembly on January 18, 2008, will affect agriculture and access to water for irrigation.

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 system 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 applications of pesticides and herbicides. 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 74 stations in operation in Albany, Arlington, Calhoun, Camilla, Cordele, Dublin, Newton, Statesboro, Vidalia, and many other locations (Figure 1). Several of these weather stations have been installed in farmers' fields, such as at Georgetown and Cordele. In 2007, three new weather stations were installed at the Madison County Emergency Services in Danielsville, at the Miles Berry Farm in Baxley, Appling County, and on Ossabaw Island in Chatham County. 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 calculated.

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. A computer located at the Griffin Campus of the University of Georgia calls each station at hourly or more frequent intervals and downloads the data. After processing, error checking, and other procedures, all data are published 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 at Moultrie in Figure 2 and Figure 3, and local temperature predictions up to 12 hours ahead.

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 2007 were compared with the previous growing seasons for 2002 through 2006. Please note that the automated weather station network is continuously being expanded and that we, therefore, do not have complete weather records for all sites. Recent installations include Albany, Tiger, and Clarks Hill, South Carolina in 2004; Moultrie, Unadilla, Vienna, and Woodbine in 2005; Ty Ty, Tennille, and Blue Ridge in 2006, and Baxley, and Danielsville in 2007. 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 2002 through 2007 growing seasons are shown in Table 1. The maximum number of degree-days for 2007 was found in Valdosta at 3464, Albany at 3431, and Cairo at 3345. The minimum number of degrees in 2006 was found in Rome at 2685, Eatonton at 2686, and Griffin at 2712. For all sites, the cumulative total number of degree-days was significantly higher for 2007 than for 2006. For the six-year period from 2002 through 2007, 2003 had the lowest number of degree days, except for a few 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. Dearing and Watkinsville were the driest locations, with 10.8 and 12.2 inches respectively. Savannah, Vidalia, and Moultrie had the highest amount of precipitation, with 32.9, 29.2, and 28.9 inches of rain respectively. When comparing the period 2002 through 2007, the growing season of 2007 was dry and for some sites the driest for the past six years.

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. In 2007, all sites except Savannah had a negative water balance that ranged from -4.1 inches for Moultrie to -21.7 for Dearing. During the period from 2002 through 2007, five sites had a negative water balance for all six years. These include Attapulgus, Cairo, Camilla, Dearing, and Fort Valley, while seven sites had a negative balance during five of the six years, e.g., Arlington, Cordele, Dublin, Eatonton, 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 either the rainfall distribution or 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 exhibit high variability among years and locations. 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. For example, schedulers for irrigation management will be needed if water for agricultural use becomes 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

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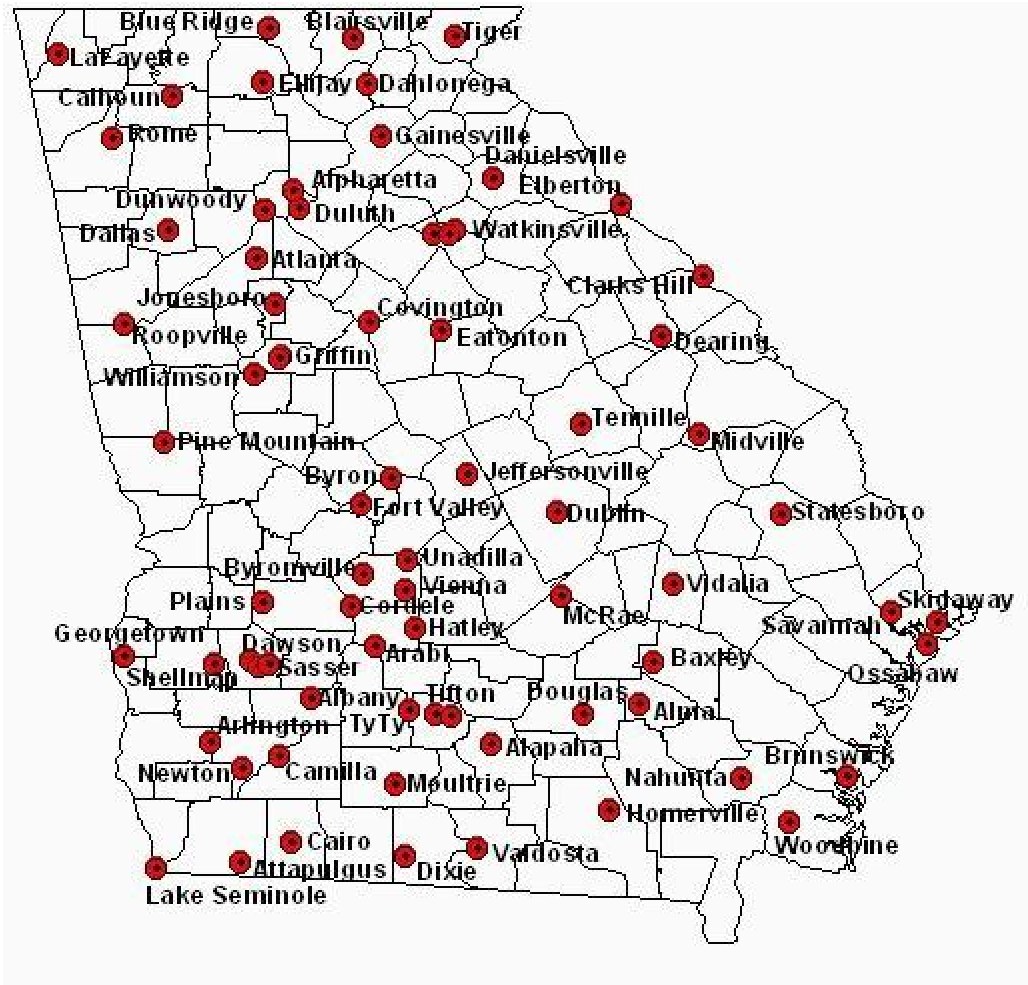

Figure 1. Location of the weather stations of the Georgia Automated Environmental Monitoring Network.

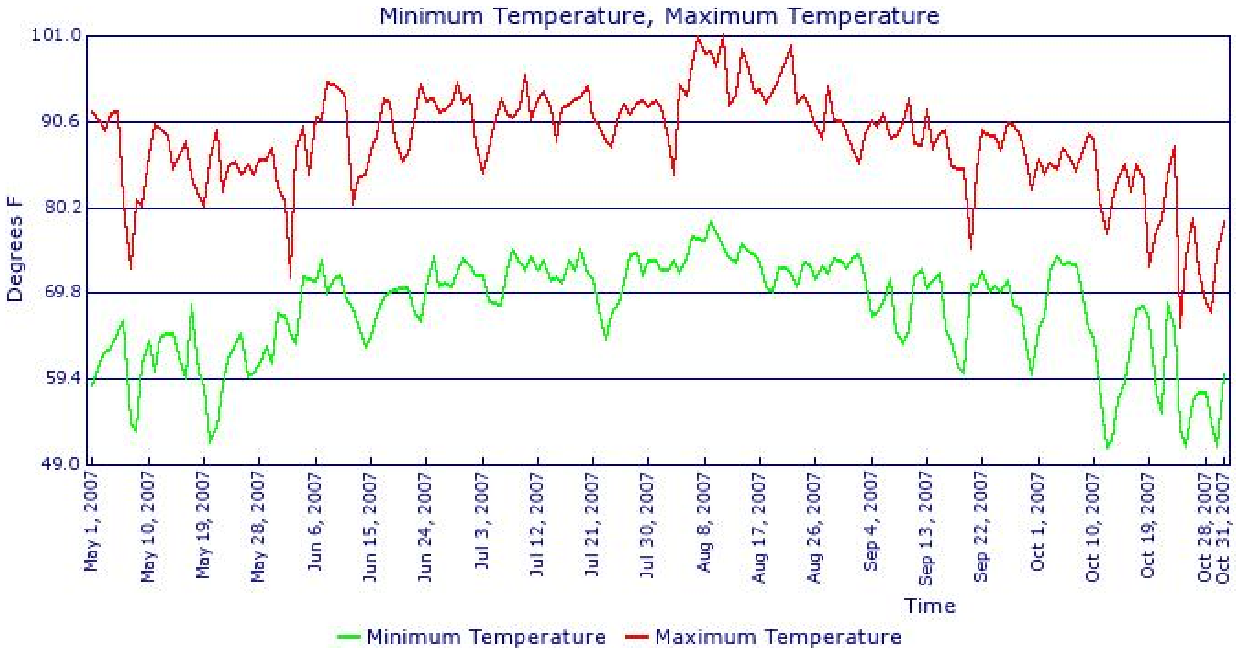

Figure 2. Daily maximum and minimum temperature for May 1 through October 31, 2007 at Moultrie, Georgia.

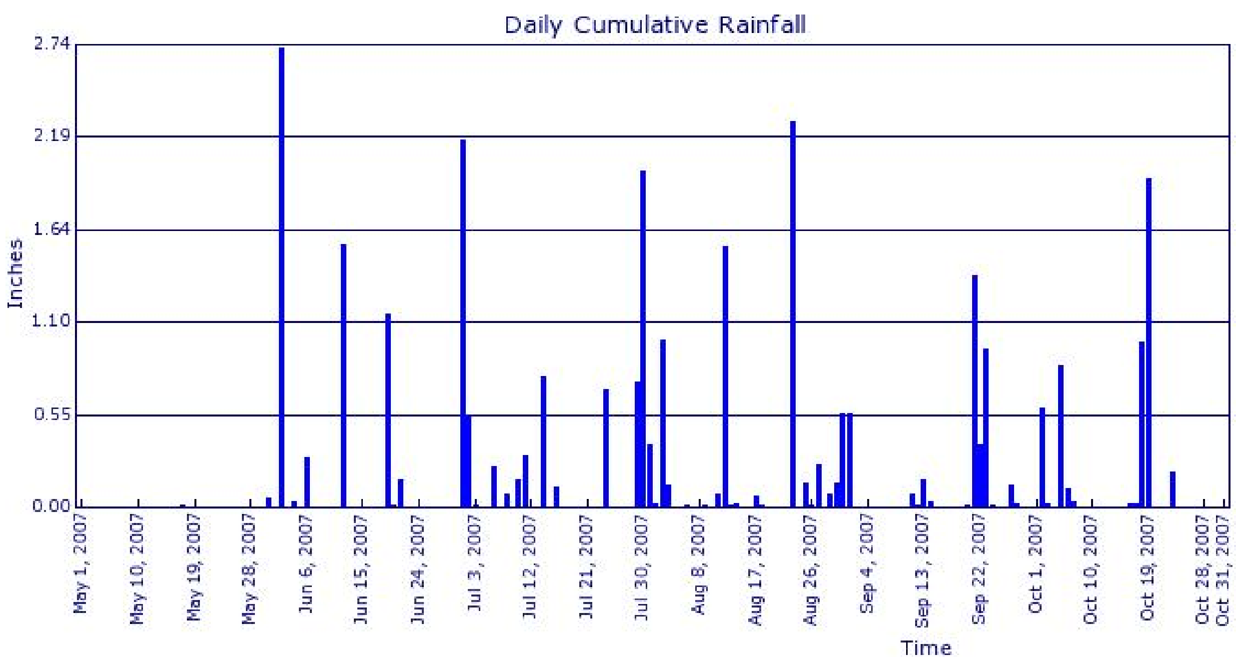

Figure 3. Daily total precipitation for May 1 through October 31, 2007 at Moultrie, Georgia.

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

Site	2002	2003	2004	2005	2006	2007
Alapaha	N/A	2950	3065	3030	2605	3049
Albany	N/A	N/A	3293	3256	3259	3431
Alma	3297	3038	3196	3168	3064	3227
Arlington	3207	2932	3080	3092	2990	3197
Attapulgus	3297	3034	3109	2855	3053	3219
Cairo	3327	3053	3289	3192	3127	3345
Camilla	3354	3035	3238	3139	3101	3285
Cordele	3210	2954	3137	3108	3024	3151
Dearing	2983	2682	2995	2902	2842	3057
Dublin	3127	2825	3089	3054	2998	3056
Eatonton	2601	2282	2549	2509	2555	2686
Ft. Valley	2893	2619	2899	2901	2914	3038
Griffin	2571	2275	2526	2499	2542	2712
Jeffersonville	N/A	2605	2855	2785	2783	2888
McRae	N/A	N/A	2946	2922	2802	2936
Midville	3097	2764	3020	3025	2909	3090
Moultrie	N/A	N/A	N/A	3112	3144	3313
Pine Mountain	2615	2388	2545	2534	2494	2730
Plains	3016	2749	2949	2931	2951	3022
Rome	2610	2186	2441	2475	2446	2685
Savannah	3114	2944	2991	3257	3010	3155
Statesboro	3106	2825	3041	2728	2696	3049
Tifton	3252	2959	3210	3086	3031	3170
Valdosta	3438	3236	3482	3467	3393	3464
Vidalia	3147	2943	3143	3155	3090	3178
Watkinsville	2594	2300	2557	2498	2489	2764

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

Site	2002	2003	2004	2005	2006	2007
Alapaha	N/A	40.79	35.70	18.98	20.74	22.74
Albany	N/A	N/A	33.40	30.68	25.78	20.10
Alma	26.17	35.23	33.45	23.39	19.46	27.83
Arlington	28.36	23.49	32.61	28.56	28.62	18.16
Attapulgus	27.82	25.39	28.83	28.28	27.79	18.22
Cairo	19.99	27.29	28.11	27.85	19.76	25.13
Camilla	25.70	25.71	23.77	24.71	25.65	21.15
Cordele	19.40	27.71	34.72	19.81	17.16	18.91
Dearing	23.02	22.22	28.32	28.31	21.20	10.81
Dublin	22.95	32.42	31.73	17.93	17.06	20.53
Eatonton	17.48	25.11	32.95	23.33	15.96	17.71
Ft. Valley	24.40	17.04	20.56	23.94	12.20	21.09
Griffin	21.75	32.80	35.52	31.71	16.52	15.50
Jeffersonville	N/A	28.80	29.00	22.52	16.85	17.81
McRae	N/A	N/A	35.79	17.30	19.62	21.81
Midville	18.52	35.20	30.45	28.71	14.37	17.89
Moultrie	N/A	N/A	N/A	28.37	12.63	28.95
Pine Mountain	18.67	34.56	38.87	24.11	17.32	19.31
Plains	19.50	26.00	32.07	29.53	27.07	18.13
Rome	26.23	31.85	24.12	15.30	19.71	13.41
Savannah	38.28	24.52	37.85	31.00	18.48	32.86
Statesboro	25.67	36.34	24.37	28.86	19.28	25.55
Tifton	17.21	31.78	33.62	18.97	15.78	22.22
Valdosta	24.93	25.97	31.96	31.12	22.93	25.30
Vidalia	28.06	40.37	35.87	15.75	13.03	29.15
Watkinsville	19.48	34.27	30.36	29.02	17.70	12.21

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

Site	2002	2003	2004	2005	2006	2007
Alapaha	N/A	14.26	9.61	-6.60	-6.23	-9.49
Albany	N/A	N/A	1.35	-0.89	-7.84	-13.09
Alma	-3.38	5.72	2.40	-7.83	-14.22	-4.72
Arlington	-2.77	-5.32	2.52	-1.27	-3.89	-14.49
Attapulgus	-2.62	-3.03	-2.17	-1.80	-5.27	-13.87
Cairo	-9.79	-1.26	-2.26	-1.80	-12.95	-7.10
Camilla	-7.30	-4.13	-8.18	-7.20	-7.85	-10.79
Cordele	-14.36	-3.74	1.10	-14.21	-16.91	-14.77
Dearing	-6.85	-5.76	-2.18	-0.89	-10.53	-21.67
Dublin	-8.91	2.94	-0.60	-12.72	-14.59	-11.15
Eatonton	-12.05	-1.24	3.87	-3.42	-15.05	-13.33
Ft. Valley	-4.35	-7.00	-3.97	-0.18	-20.24	-12.07
Griffin	-7.37	5.18	7.10	3.51	-15.29	-16.13
Jeffersonville	N/A	2.12	-1.20	-8.10	-15.69	-14.16
McRae	N/A	N/A	5.35	-12.28	-11.92	-11.56
Midville	-11.90	7.17	3.52	1.22	-19.02	-15.58
Moultrie	N/A	N/A	N/A	-3.12	-21.51	-4.10
Pine Mountain	-8.64	9.17	13.37	-1.29	-8.99	-5.35
Plains	-9.77	-1.13	2.79	-1.27	-7.04	-15.86
Rome	-0.97	7.12	-1.47	-11.21	-9.03	-15.13
Savannah	6.98	-4.16	8.94	1.82	-13.43	2.09
Statesboro	-2.78	8.50	-5.40	0.35	-12.37	-6.37
Tifton	-15.52	0.80	2.61	-12.02	-17.71	-10.58
Valdosta	-5.48	-2.96	0.04	-0.75	-10.42	-6.81
Vidalia	-2.49	11.26	2.38	-15.40	-25.74	-8.05
Watkinsville	-9.78	7.39	1.17	1.02	-11.51	-18.76