RAINFALL TRENDS IN THE GEORGIA COASTAL PLAIN

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INTRODUCTION

Interest in projected global climatic change resulting from the greenhouse effect and concern over recent droughts have focused attention on climate and climatic change. Climate models indicate that global average temperatures will increase by about 3°C ± 1.5° due to increasing CO_2 and other greenhouse gases. In addition to projected increases in global temperatures, components of the hydrologic cycle (particularly precipitation and evapotranspiration) are expected to change as a result of altered wind and weather patterns.

Agriculture is the sector of our economy most directly affected by climatic change or perturbation. Adaptation of agriculture and other sectors to climatic change must take place on a regional scale, in response to regionally varying weather patterns which do not necessarily follow mean global trends. Before accurate regional projections of future climatic scenarios can be developed, current climatic trends and weather patterns must be examined on a regional basis.

This paper examines available historical rainfall data for several locations in the Coastal Plain of Georgia to determine current trends in annual and seasonal rainfall, and to explore the potential impact of these trends on agriculture, the primary economic activity of the region.

LITERATURE REVIEW

A recent evaluation of climatic records for use in long-term model simulations showed statistically significant trends in both annual and seasonal rainfall at a Georgia Coastal Plain location (Knisel and Leonard, 1989). Analyses of a 50-year period (1936-85) at the Coastal Plain Experiment Station at Tifton, GA showed: (1) an increasing trend in annual rainfall, (2) a downward trend in the 5-month growing season (April-August) rainfall, and (3) an increasing trend in the remaining 7-month dormant season rainfall.

Plummer, et al. (1981), in an analysis of climatic trends at Augusta, GA, reported a decreasing trend in annual rainfall equivalent to 7.9 cm/century, which was attributed in part to changing land-use patterns and the resultant albedo/thermal convection alterations in the region.

For comparison, an evaluation of precipitation fluctuations over continental land areas of the Northern Hemisphere reported significant increases in mid-latitude precipitation over the last 30 to 40 years (Bradley, et al., 1987). Precipitation in the United States increased markedly for about the last 30 years, attributed principally to increases in autumn thru spring precipitation. Globally, Europe and the USSR showed similar trends of increasing rainfall since the mid-1900's, resulting primarily from increased non-summer rainfall.

Current climate models generally predict dryer conditions during crop production seasons at the mid-latitutes, with resultant decreases in soil moisture (Dudek, 1987).

DATA AND PROCEDURES

Locations selected for evaluation were Tifton, Americus, Augusta, and Savannah in the Coastal Plain region, and Athens in the Piedmont region of Georgia. Athens was included in the analyses for purposes of comparison. Mean annual rainfall and record periods used for the respective locations are summarized in Table 1.

TABLE 1. Locations, mean annual rainfall, and record periods.

Location	Mean Annual Rainfall	Record Period
Tifton	120.8 cm (S.D. - 21.4)	1922-1988
Americus	124.7 cm (S.D. - 22.7)	1914-1988
Augusta	109.6 cm (S.D. - 20.2)	1900-1988
Savannah	125.6 cm (S.D. - 26.0)	1900-1988
Athens	125.3 cm (S.D. - 24.0)	1900-1988

Annual rainfall is similar for each of the locations, with only Augusta being out of the 121-126 cm/year range. As Plummer, et al. (1981) noted, Augusta is in the lowest annual rainfall area of the state, with approximately 110 cm/year. Record periods utilized for these analyses were the longest continuous available record at each location since 1900, with total records ranging from 67 to 89 years.

Visual comparisons of average monthly rainfall graphs for the three inland Coastal Plain locations (Tifton, Americus, and Augusta) show similar annual rainfall distributions. The coastal location, Savannah, has a markedly different distribution with a more pronounced rainy period of June thru September. Athens, the Piedmont location, has more evenly distributed rainfall throughout the year than the Coastal Plain locations.

Annual and seasonal precipitation data from the selected locations were examined for evidence of trends, periodicities, and other climatic characteristics that might be of interest to the agricultural community. Analyses were performed on raw data as well as on smoothed (multiple-year moving averages) data for both an annual and seasonal basis. Climatic time-series data were examined graphically and by regression analyses for trends as evidenced by testing for regression slopes significantly different from zero. Results of statistical tests are presented in brief summary form only.

RESULTS

ANNUAL RAINFALL

Regressions fitted to time-series rainfall data for the study locations showed mixed results. Slopes of regressions fitted to the 5-year moving average rainfall and probabilities of slopes of resulting regressions being different from zero slope (i.e. no statistically significant trend) were similar for both the annual calendar-year rainfall and for the annual water-year (October 1 - September 31) rainfall. Therefore, only results of the annual water-year rainfall analyses are presented.

Tifton, Augusta, and Athens showed no significant annual rainfall trends, with slopes of regressions fitted to annual rainfall data not significantly different from zero at the 0.95 level (Table 2). Augusta showed a decreasing trend of ≈0.04 cm/yr, confirming the findings of Plummer, et al (1981), but the slope of the regression was not significantly different from zero. Annual rainfall at Americus, however, showed a significant decreasing trend, while

TABLE 2. Annual (Water-year) Rainfall Trends.

Location	Statistical Significance	Trend	Slope (cm/yr)
Tifton	Not significant	-	-
Americus	Significant	decreasing	-0.09
Augusta	Not significant	-	-
Savannah	Significant	increasing	+0.21
Athens	Not significant	-	-

Savannah showed a statistically significant increasing trend in total annual rainfall.

The lack of a significant trend for annual rainfall at Tifton differs from the results obtained by Knisel and Leonard (1989) for a shorter record period at that location. This difference, in fact, vividly demonstrates the primary point of the Knisel and Leonard paper regarding the difficulty in selecting representative climatic periods. Annual rainfall time series data for Tifton, along with smoothed, 5-year moving average rainfall, and the fitted trend lines are shown in Figure 1. Mean rainfall and trend lines are indistinguishable for the Tifton location.

Since 1900, relatively dry periods occurred in the 1930's and 1950's and wetter than average periods occurred in the 1920's and late 1940's. Annual rainfall at Tifton since the drought of the 1950's has generally shown less variability in total amounts with fewer annual extremes.

Some periodic patterns in annual rainfall data were noted for Tifton, but this topic will not be treated extensively in this paper. Notable wet years occurred in 1928, 1947, 1964, and 1984 at intervals of 17 to 20 years (mean - 18.7 years). Dry years of note occurred more frequently at 4 to 13 year intervals (mean - 7.4 years.

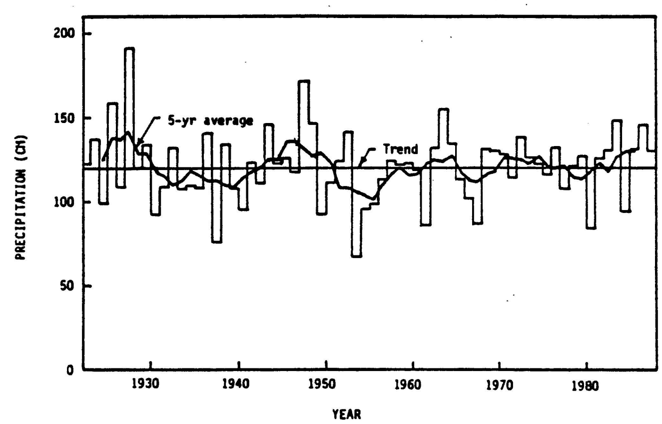

Figure 1. Annual Rainfall, 5-Year Moving Average, and Trend Line for Tifton, GA.

SEASONAL RAINFALL

To evaluate rainfall trends for shorter than annual periods, the agricultural season definition used by Knisel and Leonard (1989) was retained. Although this season-cropping definition is not universally suited to all segments of agriculture, it is a useable definition for most of the major agricultural crops produced in the Coastal Plain of Georgia. Regression analyses were used to determine statistically significant trends on 5-year moving average rainfall totals for the 5-month growing season

(April-August) and for the remainder of the year, which is considered to be the dormant season.

Seasonal rainfall trend comparisons across the Coastal Plain were mixed (Table 3). Tifton showed the strongest trends, highly significant for both dormant and growing season rainfall (Figure 2). Seasonal trends corresponded to those previously reported by Knisel and Leonard (1989) for the shorter record period. Since about the mid-1970's, a rather dramatic decrease in the relative portion of the annual rainfall occurring in the growing season has been observed at Tifton.

TABLE 3. Agricultural Season Rainfall Trends.

Location	Season	Statistical Significance	Trend slope (cm/yr)
Tifton	Growing	Significant	-0.16
	Dormant	Significant	+0.16
Americus	Growing	Significant	-0.13
	Dormant	Not significant	-
Augusta	Growing	Not significant	-
	Dormant	Significant	+0.09
Savannah	Growing	Significant	+0.10
	Dormant	Significant	+0.12
Athens	Growing	Not significant	-
	Dormant	Not significant	-

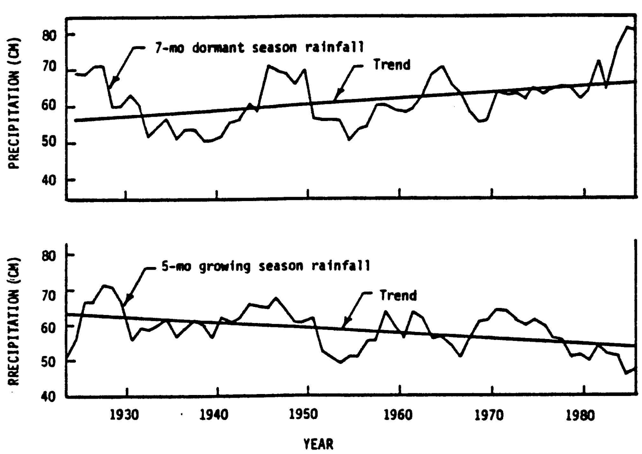

Figure 2. Moving Average Seasonal Rainfall and Trend Lines for Tifton, GA.

Americus showed a similar statistically significant decreasing trend in growing season rainfall, but no significant trend was observed for dormant season rainfall. Augusta also showed a decreasing trend in growing season rainfall, but the trend was not significant at the 0.95 level. Dormant season rainfall at Augusta showed a highly significant increasing trend.

Savannah showed significant increasing trends for both the 5-month growing season and for the 7-month dormant season. These trends are consistent with the overall increased annual rainfall trend for that location. Seasonal rainfall at Athens showed no statistically significant trend for either of the agriculturally-defined seasons.

Overall, Augusta's rainfall trends were most similar to those of Tifton, with both locations having non-significant trends in annual rainfall and significant increasing trends in dormant season rainfall.

DISCUSSION

Analyses of agricultural seasonal rainfall trends generally show a tendency toward seasonally-diverging rainfall amounts for the inland Coastal Plain locations. Recent trends are toward wetter dormant seasons, with drier conditions during the typical growing season. This trend currently is resulting in greater rainfall amounts (probably frontal storms of lower intensities) occurring in the winter-early spring months. This portion of the year has been demonstrated by previous research at the Southeast Watershed Research Laboratory of the USDA-ARS to be the primary period with saturated conditions required for drainage of gravitational water, and for recharge of groundwater aquifers in those areas of the Coastal Plain where subsurface geology permits. The current trends are also resulting in diminished rainfall for replenishing moisture in surface soils during the growing season. These trends, if continued, would lead to some adaptation of cropping practices within the region, with the most likely result being increased irrigation from available ground water to make up for growing season soil moisture deficits. Under this scenario, the Coastal Plain could possibly be in the fortunate position of having increased rates of groundwater recharge during the dormant season, which could offset to some degree increased groundwater usage during the cropping season. The effects of increased CO_2 levels on decreasing transpiration from crops, and the subsequent decrease in the rate of soil moisture depletion would also be a factor to consider.

Understanding of current regional climatic trends, particularly changes in rainfall and the subsequent effects on streamflow, soil moisture, and groundwater recharge/withdrawal, is necessary for projecting regional change and adaptation of agriculture to future climatic change. Such capabilities are essential for developing alternative agricultural production and management practices for the region, as well as for developing strategies for dealing with future climatic variability, which is perhaps of equal or even greater concern as gradual climatic change.

CONCLUSIONS

Based on analyses of annual and seasonal rainfall at selected locations in the Coastal Plain and Piedmont regions of Georgia, the following was concluded:

(1) No consistent trend for annual rainfall currently exists for locations in the Georgia Coastal Plain. Tifton and Augusta showed no statistically significant trends in annual rainfall, while Americus showed a significant decreasing trend and Savannah a significant increasing trend. Annual rainfall at Athens showed no significant trend.

(2) Somewhat more consistent trends for seasonal rainfall were observed in the Coastal Plain. Tifton and Americus exhibited significant decreasing trends in 5-month growing season (April-August) rainfall, while Augusta showed a decreasing, non-significant trend for that same period. Augusta and Tifton showed significant increasing trends in the 7-month dormant season rainfall. Savannah, the coastal location with the strongest oceanic influence, showed significant increasing trends for both dormant and growing season rainfall. Athens showed no statistically significant trends for either season. Tifton exhibited a rather dramatic decrease in the percentage of annual rainfall occurring within the growing season over the past 15-20 years.

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WATER USE AND POWER GENERATION IN GEORGIA

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The Georgia Water-Use Program has been effective in collecting, compiling and dissem-inating water-use data for the principal water users in the State. This poster session will present information from the Georgia Water Use Data System (GWUDS) to illustrate how water is used in Georgia by Physiographic Province, with emphasis on power generation.

The Physiographic Provinces play an important role in the distribution of water use throughout Georgia. With an annual average of 50 inches of precipitation statewide, there is an abundant supply of water to replenish the lakes and streams and ground-water table. In the Valley and Ridge province, which includes the Appalachian Ridge, water is obtained from both ground-water and surface-water sources. Most of the water in the Piedmont and Blue Ridge provinces, is primarily supplied by surface water. In the Coastal Plain, the ground-water aquifers are the principal sources of water.

In 1985, an estimated 5.4 billion gallons of freshwater was withdrawn each day in Georgia. Although water withdrawals vary with user, the largest amounts were for power generation. Withdrawals of surface water totaled 4.4 billions gallons per day of which 75 percent was used for cooling purposes at thermoelectric plants. An additional 40 billion gallons per day was used in-stream to generate hydroelectric power.

There has been a steady increase in hydroelectric and thermoelectric power generation since 1950. However, in recent years hydroelectric power generation has been curtailed because of drought conditions and below-normal reservoir levels. Withdrawals for thermoelectric power in Georgia declined by about 25% from 1980 to 1985 or nearly 1.1 billion gallons per day.

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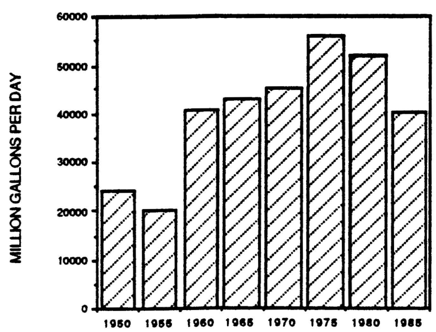
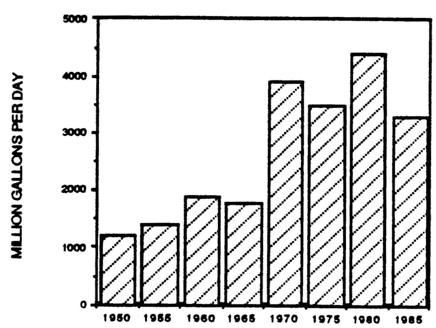


Surface water use for hydroelectric power generation in Georgia, 1950-85



Surface water withdrawals for thermoelectric power generation in Georgia, 1950-85