CROP WATER USE AS A FUNCTION OF CLIMATE VARIABILITY IN GEORGIA

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Abstract. Climate variability in Georgia during the 20th century was investigated in this project. Crop water use of important agricultural crops, including maize, soybean and peanut, was assessed with crop simulation models of the decision support system for agrotechnology transfer (DSSAT). Spatial distributions of irrigation requirements during the growing season are presented. It was found the requirements for supplemental irrigation have a high negative correlation with precipitation received during the growing season.

INTRODUCTION

In recent years the problem of climate variation, caused by natural processes as well as anthropogenetic changes in the atmosphere, has reached world-wide attention by scientists. Any modifications of weather due to the impact of climate variability directly affect crop water use and agricultural production (Hansen et al., 1998; Jinghua and Erda, 1996; Riha et al., 1996; Semenov and Porter, 1995; Wilks and Riha, 1996). The objective of this study was to investigate climate variability in Georgia, to determine the temporal and spatial variability of crop water use and to relate irrigation requirements to climate variability.

EXPERIMENTAL DESIGN AND METHODS

Daily weather data for different time periods during the 20th century were gathered for several climatic zones in Georgia (Figure 1). Maximum and minimum air temperature and precipitation data were obtained from EarthInfo Inc. (1997). Missing values were interpolated using available weather information from nearest neighbor stations. Solar radiation was generated using the weather data utility program WeatherMan, distributed with the DSSAT v.3.5 (Pickering et al., 1994; Tsuji et al., 1994). DSSAT integrates soil, weather and crop data bases with dynamic crop simulation models. Strategy evaluations related to crop water use are among the useful applications of crop models. The generic grain cereal and grain legume models of DSSAT v3.5 were used to determine irrigation requirements during the crop-growing season of the above-mentioned crops. The automatic irrigation option of the crop models was selected for irrigation applications to determine irrigation amounts that would prevent yield reducing water stress.

Soil profiles for each location were extracted from the state soil survey geographic data base (STATSGO, 1994). Planting dates and crop management conditions were based on the information provided in the variety trial reports of the Georgia Agricultural Experiment Stations (Coy et al., 1997; Raymer et al., 1997). A maize hybrid, i.e., "medium growing season", soybean cultivar, i.e., "Leflore", and peanut, i.e., "Florunner", were selected as representative cultivars for Georgia.

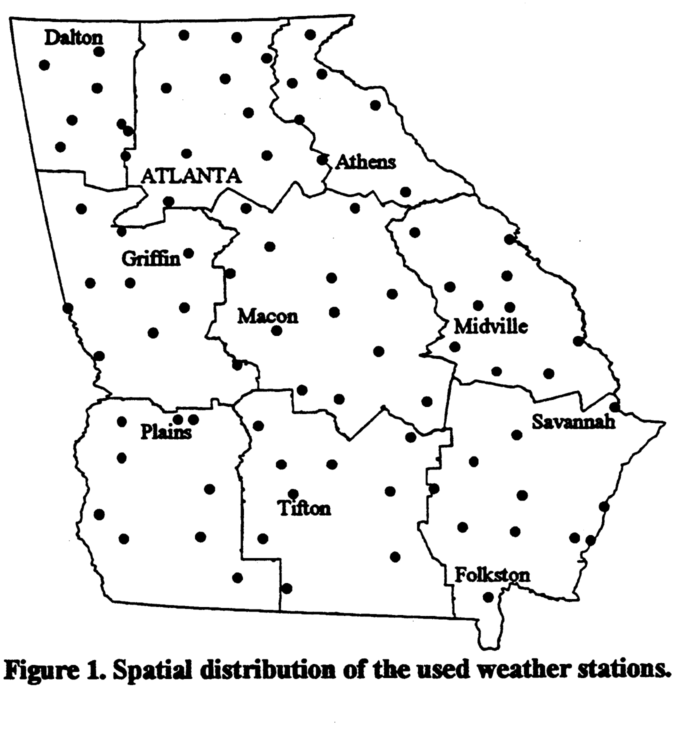

Figure 1. Spatial distribution of the used weather stations.

RESULTS AND CONCLUSIONS

Climate Variability

Annual average air temperature in Georgia was higher during the first half of the century, relative to the current climatic conditions. The current climatic conditions are based on the period 1961-1990 according to the World Meteorological Organization (WMO). Air temperatures were lower in 1996 and 1997. Crop water use is considered to be a major function of the variability of precipitation. Annual precipitation varied considerably from year to year during the study period. Georgia has experienced several drought episodes during the 20th century, most notably in the 1930s, 1950s and 1980s (Figure 2). The filtered curve in Figure 3a suggests that there was a decreasing trend in precipitation during the major crop-growing season (April-September) from the end of 1970s. Precipitation was below the 30-year (1961-1990) average for 13 of the last 21 years of investigation (Figure 3).

Temporal Variability of Irrigation

In Figures 4-5 variations of simulated irrigation and observed precipitation and air temperature at two locations are presented.

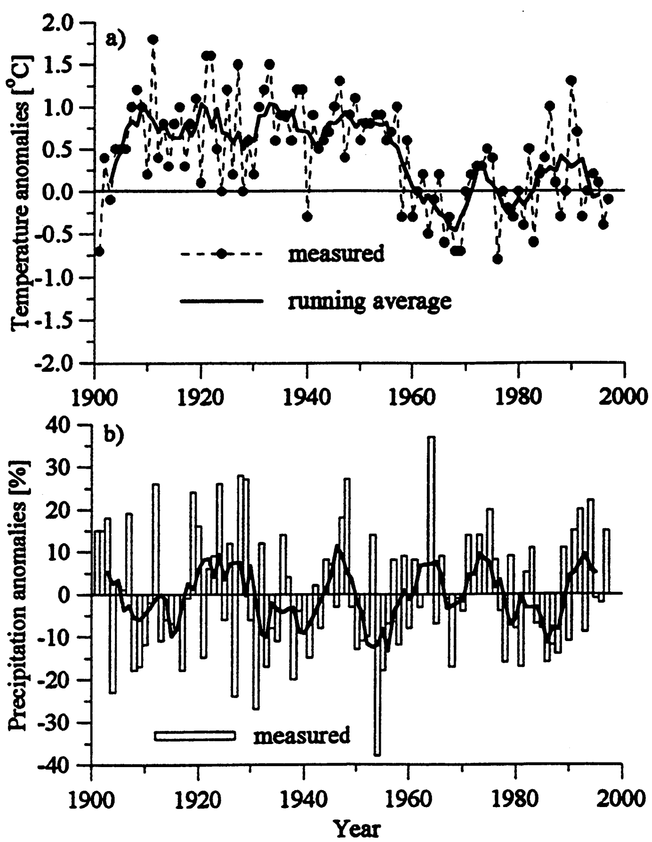

Figure 2. Anomalies of annual mean air temperature (a) and precipitation (b) in Georgia, relative to the period 1961-1990.

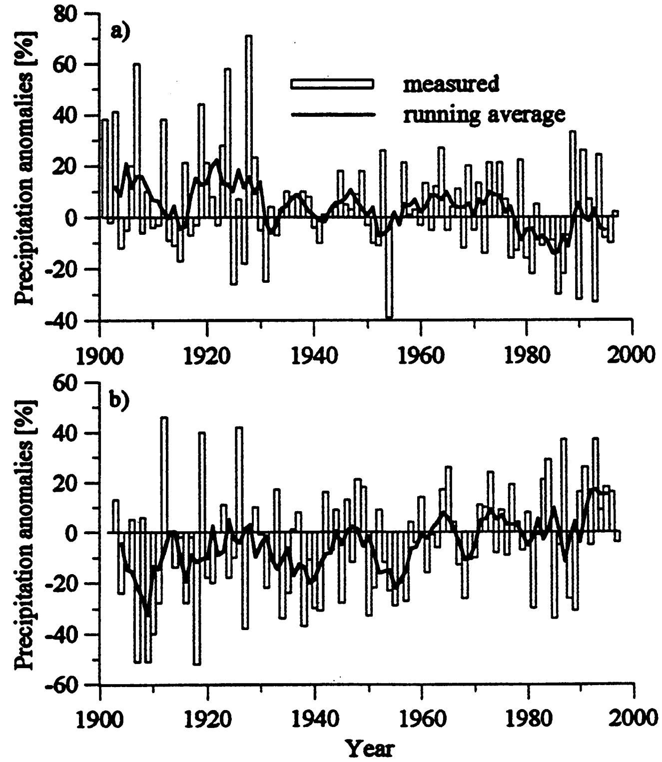

Figure 3. Anomalies of precipitation in Georgia during the warm (a: April-September) and cold (b: October-March) half of the year, relative to the period 1961-1990.

There was an increasing trend of irrigation requirements for maize, grown in Tifton from the end of 1970s. The precipitation trend during the growing season of maize was opposite. The correlation coefficient (r) between irrigation and precipitation amounts was -0.81 (Figure 4). A similar relation was found for peanut growth in Midville. The relationship between irrigation applied and total evapotranspiration was also high ($r = 0.77$) (Figure 5). In some years, the demand for supplemental irrigation increased significantly under both drought conditions and higher air temperatures. This situation occurred during maize growth in 1954, 1986 and 1990 in Tifton (Figure 4) and peanut growth in 1977 and 1993 in Midvile (Figure 5).

Spatial Distribution of Irrigation

Irrigation requirements for maize and soybean cultivation in Georgia were plotted using averaged simulated results (Figure 6). The central region of the state requires more water for irrigation. The irrigation requirements are less in the most northern and southern regions of the state, where precipitation is higher due to the influence of mountains and the Atlantic Ocean and the Gulf of Mexico, respectively.

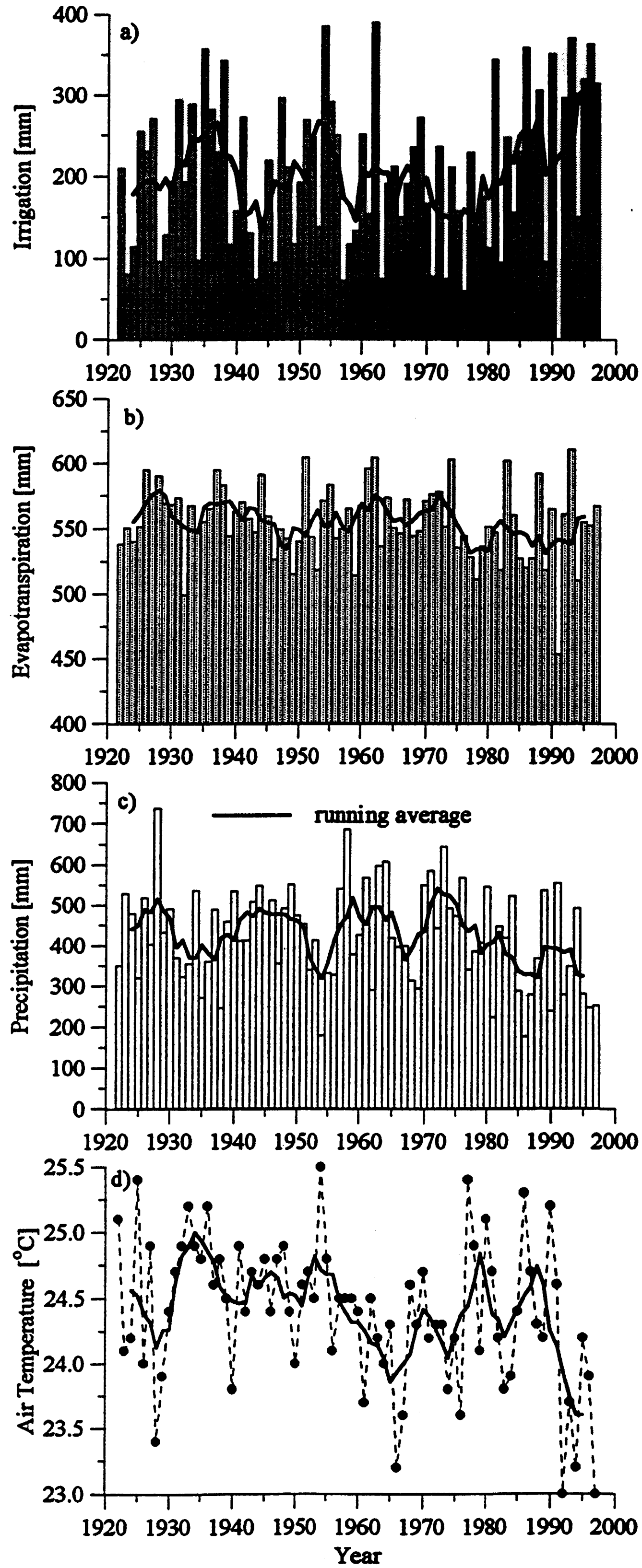

Figure 4. Variations of irrigation, evapotranspiration and precipitation during the simulated crop-growing season of maize and mean air temperature (April-September) in Tifton.

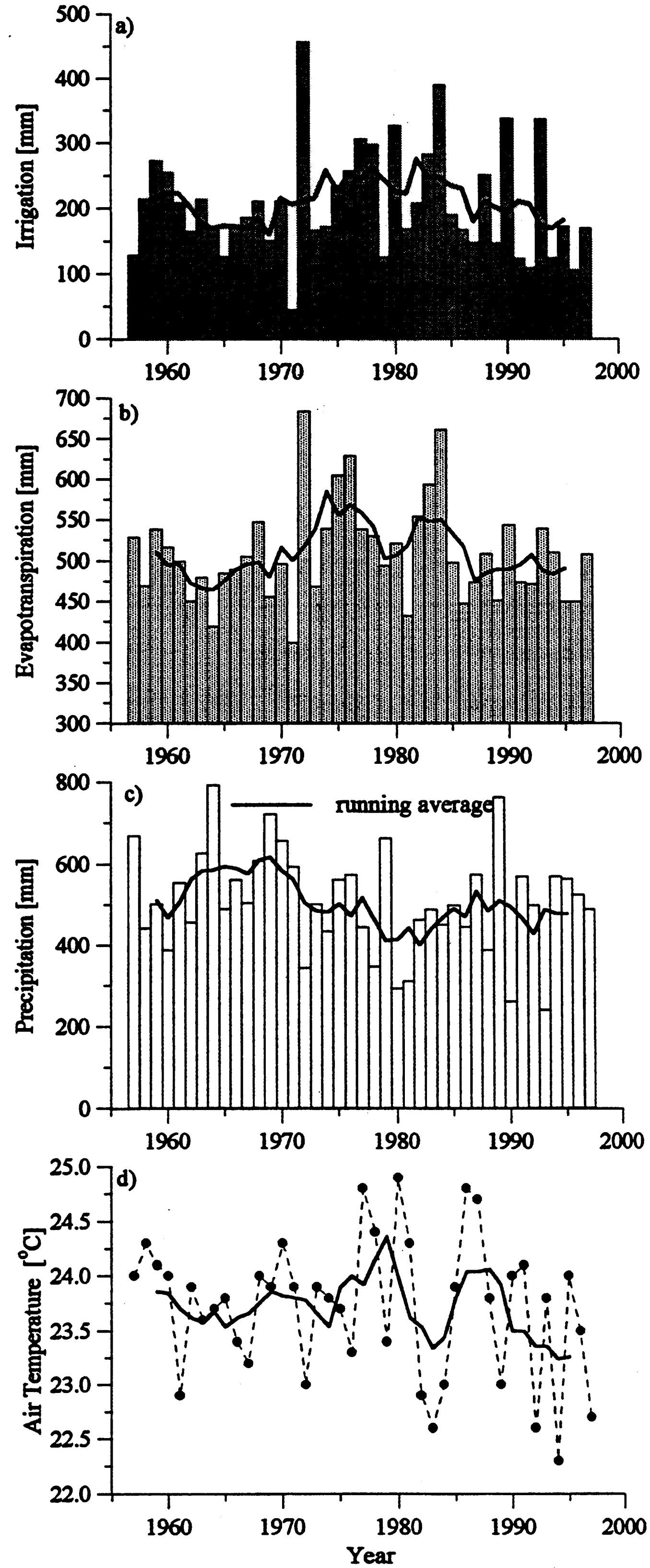

Figure 5. Variations of irrigation, evapotranspiration and precipitation during the simulated crop-growing season of peanut and mean air temperature (April-September) in Midville.

Figure 6. Spatial distribution of irrigation requirements (in mm) for maize and soybean growth, development and yield formation, averaged for the period 1961-1990.

RECOMMENDATIONS

The obtained averages and trends of climate variability can be used by researchers to assess current climatic fluctuations and variability and the expected climate change for the next century.

The simulated by DSSAT v.3.5 temporal and spatial variability of crop water use and the maps presenting the spatial distribution of averaged crop irrigation requirements can be used by individual farmers, state or private organizations when irrigation strategies for particular soil or climatic condition are needed. The outputs of the DSSAT strategy evaluation can be an useful tool for helping decision-makers to "pre-screen" a wide variety of irrigation options and identifying those options or treatments that merit further investigation.

ACKNOWLEDGMENTS

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