HISTORICAL DROUGHTS IN GEORGIA AND DROUGHT ASSESSMENT AND MANAGEMENT

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Abstract. The understanding and use of past climate information is key to proper drought mitigation and water management planning. Since 1960, Georgia's population has increased from near 4 million inhabitants to over 8 million while the water resources have remained constant. Until the 1998-2002 drought, most Georgians had not experienced a major Georgia drought. However, 13 long-term, severe droughts have impacted the state over the past 325 years. The Policy Statement on Climate Variability and Change by the American Association of State Climatologists gives guidance on using climate information in decision making processes.

INTRODUCTION

The purpose of this paper is to show the relevance of using past climate information in drought mitigation and water management planning. This paper also cautions against the use of particular climate model outputs in drought mitigation and water management planning.

Drought is a *normal* component of the Southeastern US climate system. Many of Georgia's native ecosystems depend on drought for health and survival. While drought is a natural component of the climate system, its negative impacts on the state's environmental, economic, and social systems can be major. The droughts of the 1920s accelerated the mass migration of poor farmers from rural Georgia. Many rural counties reached their peak population in 1920 and have remained below the 1920 level since then.

The period from the middle 1950s through the middle 1990s was relatively benign in climate history. During this period droughts were relatively infrequent and of short duration. However, the 1998-2002 drought was more in line with past Georgia climate patterns. Since the 1998-2002 drought is more indicative of the climate record than the 1956-1997 period, planners need to use long-term records for proper planning.

The American Association of State Climatologists (AASC) have issued a Policy Statement on Climate Variability and Change. The policy statement gives guidance for using climate information in planning. The statement also warns against relying on climate models in developing policy.

PAST CLIMATE IS A USEFUL GUIDE TO FUTURE

Using tree ring analysis, Cook, Meko, et al. (1999) show that prolonged droughts have impacted Georgia several times since 1680 (Fig. 1). They used the Palmer Drought Severity Index (PDSI) to categorize the severity of a drought. With the PDSI, values less than -0.99 indicate drought. In the recent past, the period after 1956 stands out for its lack of drought. However, many major long-term (3 years or more) droughts are evident earlier

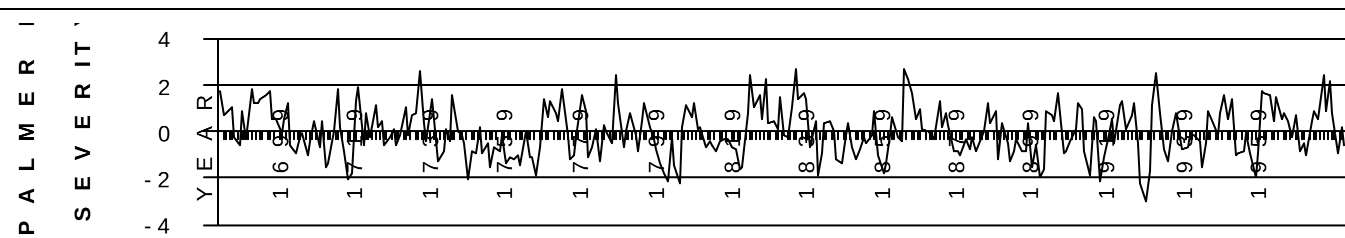

Figure 1. Palmer Drought Severity Index by Year for Central Georgia based on tree analysis (Cook, Mach, et al., 1999)

in the record. Long-term Georgia droughts occurred in the following years:

1756-1760	1762-1764	1797-1802
1855-1857	1896-1899	1925-1927
1954-1956	1998-2002 (not shown in Fig. 1)	

Thus Georgia has experienced a major prolonged drought of three years or more eight times since 1680. This means that on average, Georgia experiences a drought lasting three or more years about once every 40 years.

If the definition of a long-term drought is changed from three to two consecutive years, then we will need to add the following to the list of long-term droughts impacting Georgia:

1708-1709	1714-1715	1839-1840
1844-1845	1914-1915	

Based on the climatological record, Georgia can expect a drought of two or more years on average about once in 25 years. This analysis does not include short-term or agricultural droughts that are not well represented in the tree ring record.

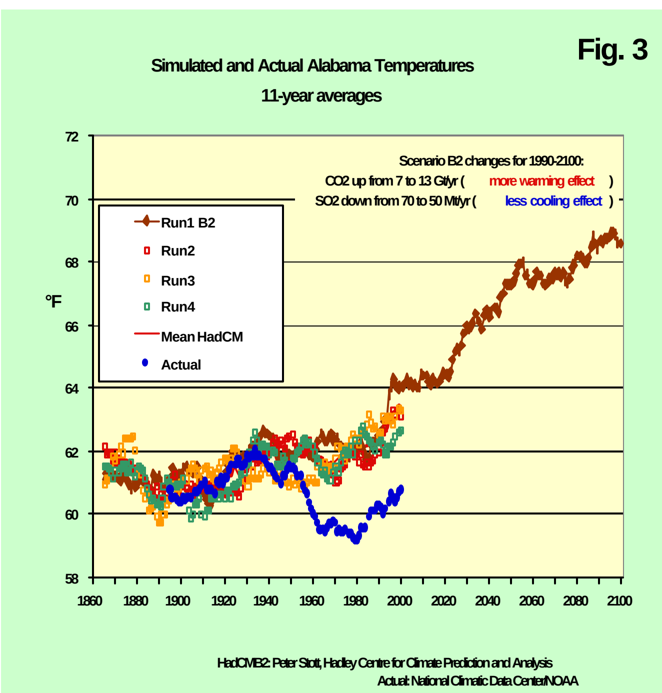

Figure 2. HadAM simulation of SE (roughly Alabama) temperature since 1860 (Christy, 2003 personal comm.).

CLIMATE PREDICTION IS COMPLEX WITH MANY UNCERTAINTIES

Predicting future climate is complex and involves many processes that are either not well understood and/or not easily quantified. The climate model predictions are impossible to verify in the time scale needed for planning.

Attempts to verify climate models starting with earlier conditions and predicting the recent known climate has not been promising. John Christy, professor of atmospheric sciences at the University of Alabama - Huntsville, has analyzed the Hadley Climate Model output for 1860-2100 versus actual temperatures for Alabama (Fig. 2). Not only did the model fail to accurately predict the actual temperature, it was not even able to get the trend sign correct.

The Canadian Climate Model output for the Southeast appears to be even worse. The fundamental physics handling the energy budget seems to be wrong with excessive summer warming predicted. The Canadian model predicts an increase of 25 °F in the heat index across the Southeast during the summer (National Assessment Synthesis Team, 2001). Since the greenhouse gases have their major impacts on the nighttime, winter temperatures in the high latitudes, predicting major increases in daytime summer temperatures does not agree with the known physics of greenhouse warming. The summer maximum temperatures in the Southeast are mainly controlled by the amount of incoming solar radiation which is not impacted by greenhouse gases.

The Canadian Climate Model seems unable to handle evaporation correctly and/or cloud formation and convective temperatures. To increase the heat index while keeping July humidity the same, Atlanta would have to increase the maximum temperature more than 10 °F. An increase of 10 °F would lead to more convective activity and thus afternoon and evening thundershowers. This increase in thundershowers would act as a lid on afternoon heating and thus prevent the 10 °F increase in July temperatures. Another way to get the 25 °F increase in heat index is to lower the afternoon relative humidity for Atlanta to 40% and to raise the afternoon maximum temperature to 105 °F. Unless the Atlantic Ocean and Gulf of Mexico disappear, this does not seem likely to occur. Because of the problems with the Canadian Climate Model, policy makers in Georgia should be very leery of using its outputs for drought mitigation and water management planning.

There are many reasons that the models have a difficult time in accurately predicting the present climate correctly. First and foremost, the climate system is complex and does not behave linearly. The climate system includes not only the atmosphere, but land surfaces of different vegetative cover and thus different energy budgets, ice surfaces, the oceans, and clouds. Many of processes involved with the various climate components are not well understood. Climatologists are not even sure how the energy budget changes with changes in many of the components.

While climate models are wonderful research tools that have proven invaluable in helping climatologists to better understand the climate system, they are not to the point that they serve as useful tools for drought mitigation and water management planning.

POLICY RESPONSES TO CLIMATE VARIABILITY & CHANGE

Since climate models are not very helpful in policy development, what should policy makers do? The AASC recommends that climate-related policies should be sensible and flexible and should not be based on particular predictions.

For Georgians this means that water management and drought mitigation plans should at least take into account known natural variability in the climate system. Policy makers should expect a drought of two years or more at least once every 25 years. This is regardless of any other pressures put on the water supply due to population growth.

MODERNIZING AND MAINTAINING HIGH QUALITY LONG-TERM CLIMATE DATA

Long-term, high quality climate records are needed to accurately assess changes in the state's climate. Modernization of the national climate observing network should be of high priority. With the modern communications near-realtime monitoring can now be performed so that decision makers can take steps to mitigate the impacts of natural climate variations.

RECOMMENDATIONS FOR POLICY MAKERS

1. Use the long-term climate record to formulate policies that take into account the known natural variability in Georgia's climate system.

2. Policies should be based on various temporal (weeks to decades) and natural spatial scales (e.g., watersheds, physiographic provinces).

3. Policies should not be made on a particular prediction such as output from a climate model.

4. Georgia's climate should be monitored in near-real time so that decision makers can quickly respond to and mitigate the impacts of natural climate variability.

5. The human element is key to any successful planning. Changes in population, water needs and use, and perceptions must be taken into account in policy formulation.

REFERENCES

Cook, E.R., Meko, D.M., Stahle, D.W. and Cleaveland, M.K. 1999. Drought reconstructions for the continental United States. Journal of Climate, 12:1145-1162.

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Policy Statement on Climate Variability and Change by the American Association of State Climatologists (AASC)[*]

This statement provides the perspective of the AASC on issues of climate variability and change. Since the AASC members work directly with users of climate information at the local, state and regional levels, it is uniquely able to put global climate issues into the local perspective needed by the users of climate information. Our conclusions are as follows:

1. Past climate is a useful guide to the future – Assessing past climate conditions provides a very effective analysis tool to assess societal and environmental vulnerability to future climate, regardless of the extent the future climate is altered by human activity. Our current and future vulnerability, however, will be

different than in the past, even if climate were not to change, because society and the environment change as well. Decision makers need assessments of how climate vulnerability has changed.

2. Climate prediction is complex with many uncertainties – The AASC recognizes climate prediction is an extremely difficult undertaking. For time scales of a decade or more, understanding the empirical accuracy of such predictions – called "verification" – is simply impossible, since we have to wait a decade or longer to assess the accuracy of the forecasts.

Climate prediction is difficult because it involves complex, nonlinear interactions among all components of the earth's environmental system. These components include the oceans, land, lakes, and continental ice sheets, and involve physical, biological, and chemical processes. The complicated feedbacks and forcings within the climate system are the reasons for the difficulty in accurately predicting the future climate. The AASC recognizes that human activities have an influence on the climate system. Such activities, however, are not limited to greenhouse gas forcing and include changing land use and sulfate emissions, which further complicates the issue of climate prediction. Furthermore, climate predictions have not demonstrated skill in projecting future variability and changes in such important climate conditions as growing season, drought, flood-producing rainfall, heat waves, tropical cyclones and winter storms. These are the type of events that have a more significant impact on society than annual average global temperature trends.

3. Policy responses to climate variability and change should be flexible and sensible – The difficulty of prediction and the impossibility of verification of predictions decades into the future are important factors that allow for competing views of the long-term climate future. Therefore, the AASC recommends that policies related to long-term climate not be based on particular predictions, but instead should focus on policy alternatives that make sense for a wide range of plausible climatic conditions regardless of future climate. Climate is always changing on a variety of time scales and being prepared for the consequences of this variability is a wise policy.

4. In their interactions with users of climate information, AASC members recognize that the nation's climate policies must involve much more than discussions of alternative energy policies – Climate has a profound effect on sectors such as energy supply and demand, agriculture, insurance, water supply and quality, ecosystem management and the impacts of natural disasters. Whatever policies are promulgated with respect to energy, it is imperative that policy makers recognize that climate – its variability and change – has a broad impact on society. The policy responses too should also be broad.

Thus, to address the issues of climate variability and change, modernizing and maintaining high quality long-term climate data must be a high priority in order to permit careful monitoring. With the rapid dissemination of these data, State Climate Offices, as well as the Regional Climate Center Offices, and the National Climatic Data Center can better monitor emerging climate threats to critical national resources, such as our water supply, agriculture, and energy needs. The climate data must include all-important components of the climate system (e.g., temperature, precipitation, humidity, vegetation health and soil moisture). We also recommend that the nation strengthen its local, state, and regional climate services infrastructure in order to develop greater support capabilities for those decision makers who have to respond to climate variability and change.

Finally, ongoing political debate about global energy policy should not stand in the way of common sense action to reduce societal and environmental vulnerabilities to climate variability and change. Considerable potential exists to improve policies related to climate; the AASC is working to turn that potential into reality.

Approved by AASC in November, 2001

[*] The American Association of State Climatologists (AASC) is the professional organization of State Climatologists of the United States. Each State Climatologist is appointed in his/her respective state to provide expertise on issues associated with climate. The State Climatologists collaborate with the six Regional Climate Centers and the Department of Commerce's National Climatic Data Center (NCDC) located in Asheville, North Carolina.