CLIMATE VARIABILITY AND CHANGE ASSESSMENTS FOR THE ACF AND ACT RIVER BASINS

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Abstract. Climate variability and potential change have important implications for the management of the ACF and ACT river basins. This article discusses these implications using a decision support system developed by the Georgia Water Resources Institute at Georgia Tech. These assessments are made for historical as well as for potential climates generated by General Circulation Models (GCMs). The most important conclusion is that water resources planning and management decisions, including the water compacts being negotiated, should explicitly recognize and address climate variability and uncertainty by being flexible and adaptive.

CLIMATE VARIABILITY

River basin planning and management traditionally focuses on *seasonal* climate variability. However, climate and hydrologic processes vary not only by season but also by year, decade, and often longer time scales. Figure 1 illustrates the inter-annual variability of the Upper Coosa River at Resaca and Rome, Georgia. In this figure, the historically observed streamflows are averaged over a moving four-year window and plotted from 1905 to 1993. The average four-year streamflow mean is approximately 2850 cubic feet per second (cfs). However, the figure shows that the actual four-year mean flow varies from 50% to 140% of the long term mean value, providing an example of marked *inter-annual* climate variability.

Furthermore, comparing the plot for the first and second halves of the 20th century, a case can be made that the range of the successive highs and lows of the climate cycles is increasing. This sort of climate variability over 30-year and longer time scales would fall under the category of *climate change*, be it human-induced or natural.

The thesis of this short article is that climate variability may have important implications for river basin planning and management over *all* above-mentioned time scales.

INTER-ANNUAL CLIMATE VARIABILITY AND RIVER BASIN PLANNING AND MANAGEMENT

Figure 2 is a schematic of the Apalachicola-Chattahoochee-Flint (ACF) and the Alabama-Coosa-Tallapoosa (ACT) river basins in the Southeastern US. The ACF and ACT basins cover areas of 50,000 and 58,000 square kilometers respectively within the states of Georgia, Alabama, and Florida. Their water uses include water supply (for domestic, industrial, and agricultural sites), hydropower, lake recreation, navigation, and environmental and ecosystem protection. The figure also includes detailed schematic diagrams of the basin storage and hydropower facilities that show the complexity of the river network, including an ACT-ACF water transfer. All three states have vital interests in the ACF and ACT water resources and have been negotiating water sharing compacts for several years. (The above-mentioned locations of Resaca and Rome are at the ACT headwaters on the Coosawattee and Etowah rivers respectively.)

Expected to be applicable for several decades, water sharing compacts are good examples of water resources planning decisions that should consider the implications of climate variability. The ACF and ACT compacts attempt to define agreed upon future water withdrawals and streamflow levels. For example, Georgia expects that water demands in the upper Coosa basin will increase 2.5 times by the year 2030, from their present level of 174 cfs annual daily average to 433 cfs. Alabama, on the other hand, is interested in the flow that enters the Coosa River being maintained above 1,800 cfs. While the anticipated demands are relatively small compared to mean streamflow conditions, water resources stresses and shortages may significantly magnify during severe and persistent droughts.

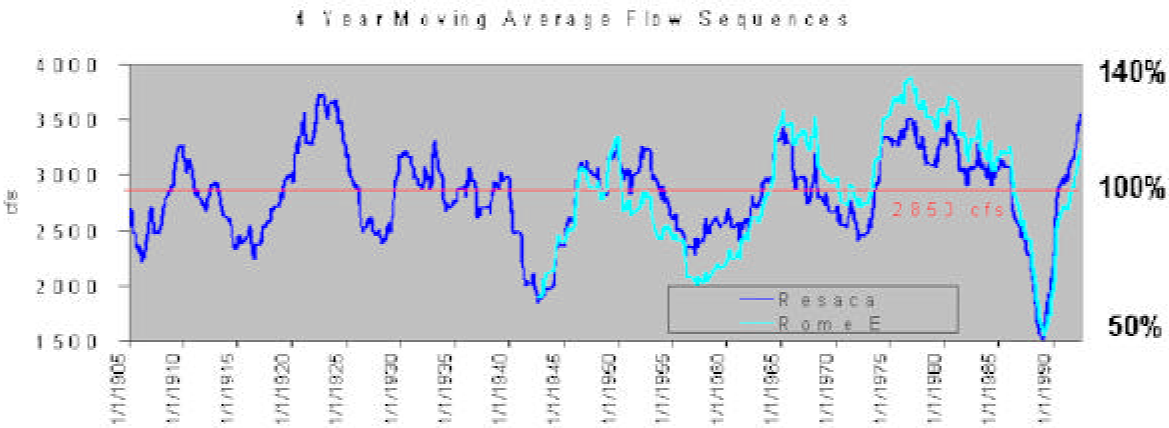

Figure 1. Four-Year Moving Average Flow Sequences at Resaca and Rome, Upper Coosa River, Georgia.

A decision support system (DSS) for ACT and ACF was developed to help assess the implications of the various proposed compacts. The Georgia Tech DSS (GT-DSS) includes all ACT and ACF tributaries, withdrawal locations, storage impoundments, and hydropower facilities. GT-DSS consists of integrated models for streamflow forecasting, river and reservoir simulation (weekly time step), system-wide reservoir release and hydropower optimization, and scenario assessment (*Georgakakos and Yao*, 1999).

Figure 3 shows the level sequences of Carters and Allatoona (the two reservoirs on the Upper Coosa River Basin) for the historical streamflow sequence (1939 to 1993) and terms similar to one of the early compact proposals. In addition to the 2030 demands and the 1800 cfs minimum flow requirement, the assessment assumes that the reservoirs are managed to maintain the current in-stream flow requirement (minimum 7 day average flow with a 10 year frequency of occurrence, 7Q10) throughout the Upper Coosa system. The figure shows that reservoir levels are expected to experience severe drawdowns during dry climate cycles such as those of the 50s and the 80s. In particular, during the 80s, both reservoirs are empty for several weeks. During such times, in-stream flows drop below 7Q10 (indicating potential environmental and ecosystem degradation), and water withdrawals are markedly curtailed. The reservoir response is drastically different from historical reservoir levels that are usually near the top of the conservation pools.

With respect to hydropower, Carters and Allatoona presently generate an average of 380 GWH per year (not considering the pump-back operation at Carters). Under the 2030 demand conditions, the joint energy output of the two reservoirs during the 80s would approximately decrease to 300 GWH per year, a 21% reduction. Moreover, for approximately a whole year during this period, the hydropower capacity of these reservoirs would not be dependable.

The important point to be made is that water resources planning decisions are critically important and are especially tested during dry (or wet) climate cycles, not during average climatic conditions. As in the case of the ACT system, a four to five year drought is sufficient to bring about depletion of reservoir storage, serious water supply shortages, and environmental degradation. In view of such risks, system performance during average climatic conditions is irrelevant. We note that system response would be drastically different had climate departures away from the mean (Figure 1) been less pronounced and less persistent. For the Upper ACT basin, the conclusion is that the combination of future demands and climate variability are such that the existing reservoir storage is no longer sufficient to maintain historical performance standards. Options being considered are the creation of additional storage, restrictions on future water supply permits, and the development of a comprehensive drought management plan.

Climate variability also impacts water resources demand. Water demand investigations in Georgia have shown that Atlanta water demand may increase by as much as 20% during drought years. What is more, agricultural demand may increase two to three times that of an average water year. Finally, power demand is also expected to increase in drier and warmer climatic periods. Thus, by reducing supply and increasing demand climate variability poses a dual challenge for water resources planning and management. Policy decisions should be based on

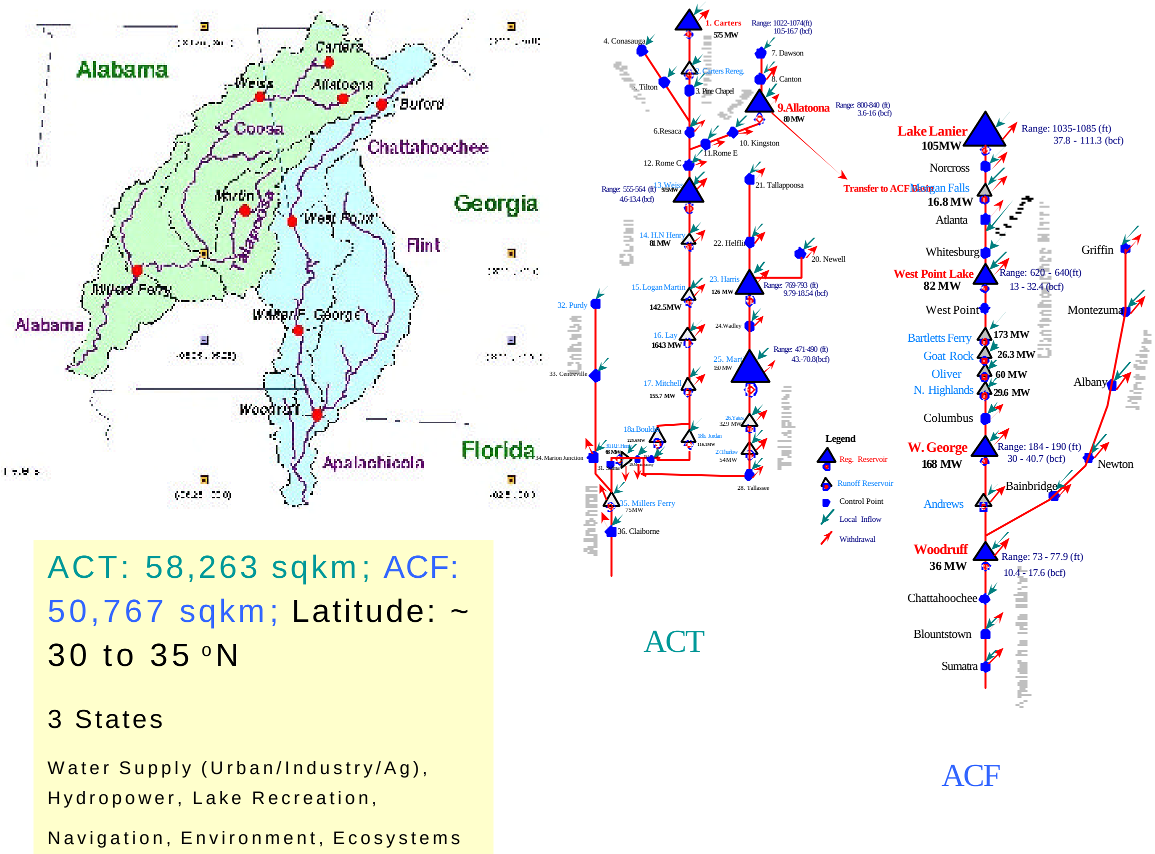

Figure 2. The ACF and ACT River Basins in the Southeastern US.

water resources assessments that consider both climate and demand variability in a fully integrated manner.

CLIMATE CHANGE AND RIVER BASIN PLANNING AND MANAGEMENT

Figure 4 shows the ACF reservoir response for two different potential future climate scenarios, one generated by the Global Circulation Model of the Canadian Center for Climate Analysis (CGCM1), and a second from the British Hadley Center for Climate Prediction (HADCM2). Both climate scenarios assume an annual atmospheric CO_2 increase of 1%. The response of the ACF system is simulated by the GT-DSS for the 1994-2093 time frame using the climate scenarios, the water demands projected for 2050, and low flow requirements similar to those being negotiated under the ACF compact. The plots shown pertain to the federal ACF reservoirs: Lake Lanier, Lake West Point, Lake George, and Lake Woodruff.

The two assessment runs paint a very different picture of the basin future. Under HADCM2, future streamflows are similar to those of the historical past, and the compact requirements are met with relative ease. By contrast, CGCM1 predicts a much warmer and drier climate with devastating water resources consequences. Under this scenario, ACF would experience a perpetual drought and would frequently fail to meet the projected water, power, and environmental demands.

Though the two previous scenarios may be viewed as two extreme cases, the point to be made is that there is considerable uncertainty regarding the future climate. Water resources planning decisions based on the assumption that historical conditions are indicative of future climates may seriously increase water resources vulnerability and may risk catastrophic failures. At the very least, water resources planning and management decisions should recognize the uncertainty of future climate by being flexible and by allowing for effective adaptation options should adverse climate changes do occur.

ADAPTIVE RIVER BASIN MANAGEMENT

In recent years, climate science has made great strides, and the ability to predict future climates over seasonal, inter-annual, and decadal time scales has improved

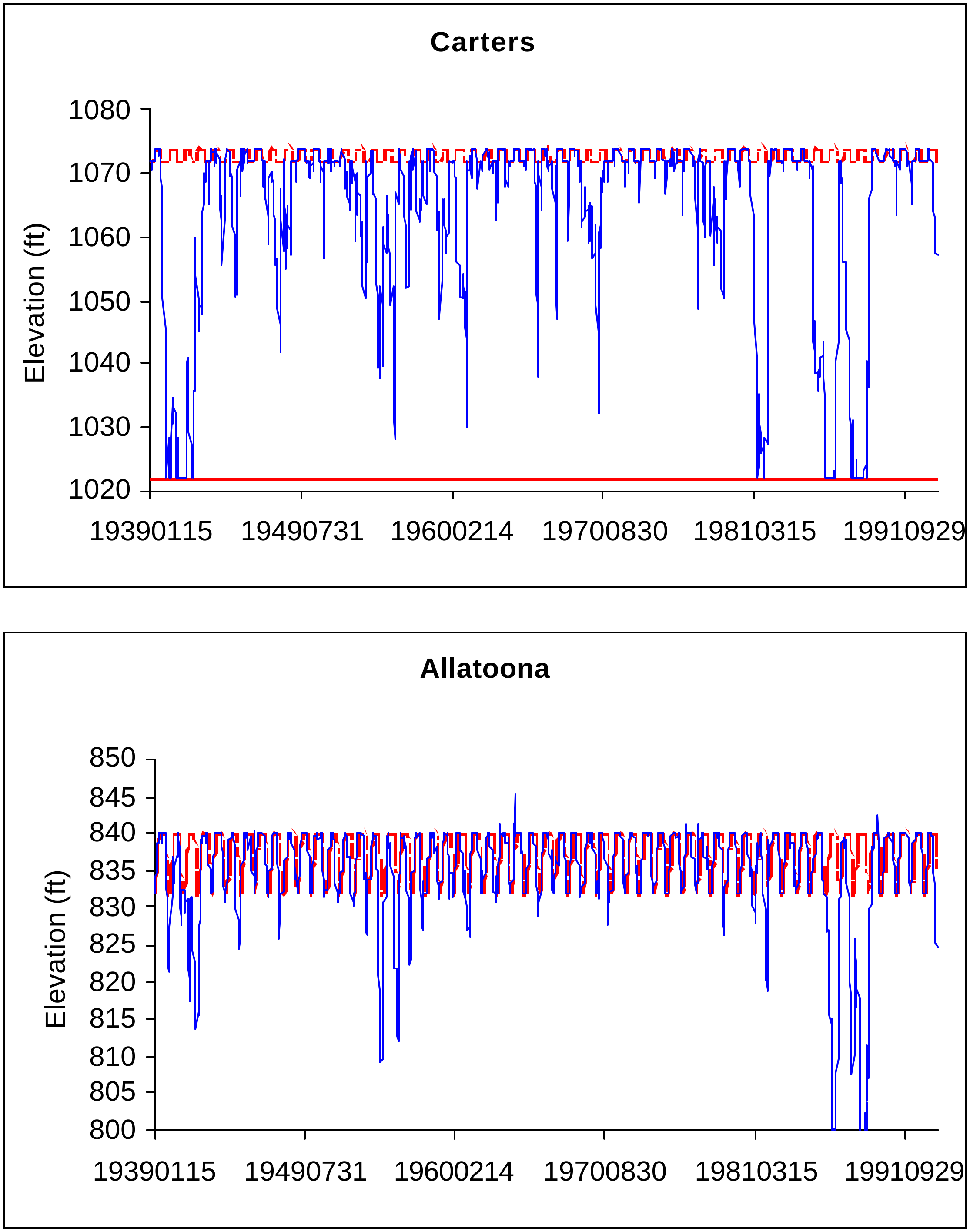

Figure 3. Reservoir Response under the Proposed ACT Compact Terms.

considerably. There is little doubt that the quality of climate forecasts will continue to improve, creating an opportunity for more effective river basin management. However, traditional reservoir management methods are not prepared to fully utilize climate forecast information (*Yao and Georgakakos, 2001*). Climate forecasts can best be utilized through integrated and adaptive forecast-decision processes (*Georgakakos et al., 2000*). Such approaches link climate, hydrology, and water resources in a seamless information and decision framework, allowing for the development of fully adaptive management policies. *Georgakakos et* *al., 2000*, make a strong case that reliable characterization of future climate uncertainty is critical for water resources planning and management.

It would thus appear timely for water resources agencies to re-evaluate their planning and management practices and establish information and decision systems that fully utilize current scientific advances and mitigate the adverse effects of climate variability.

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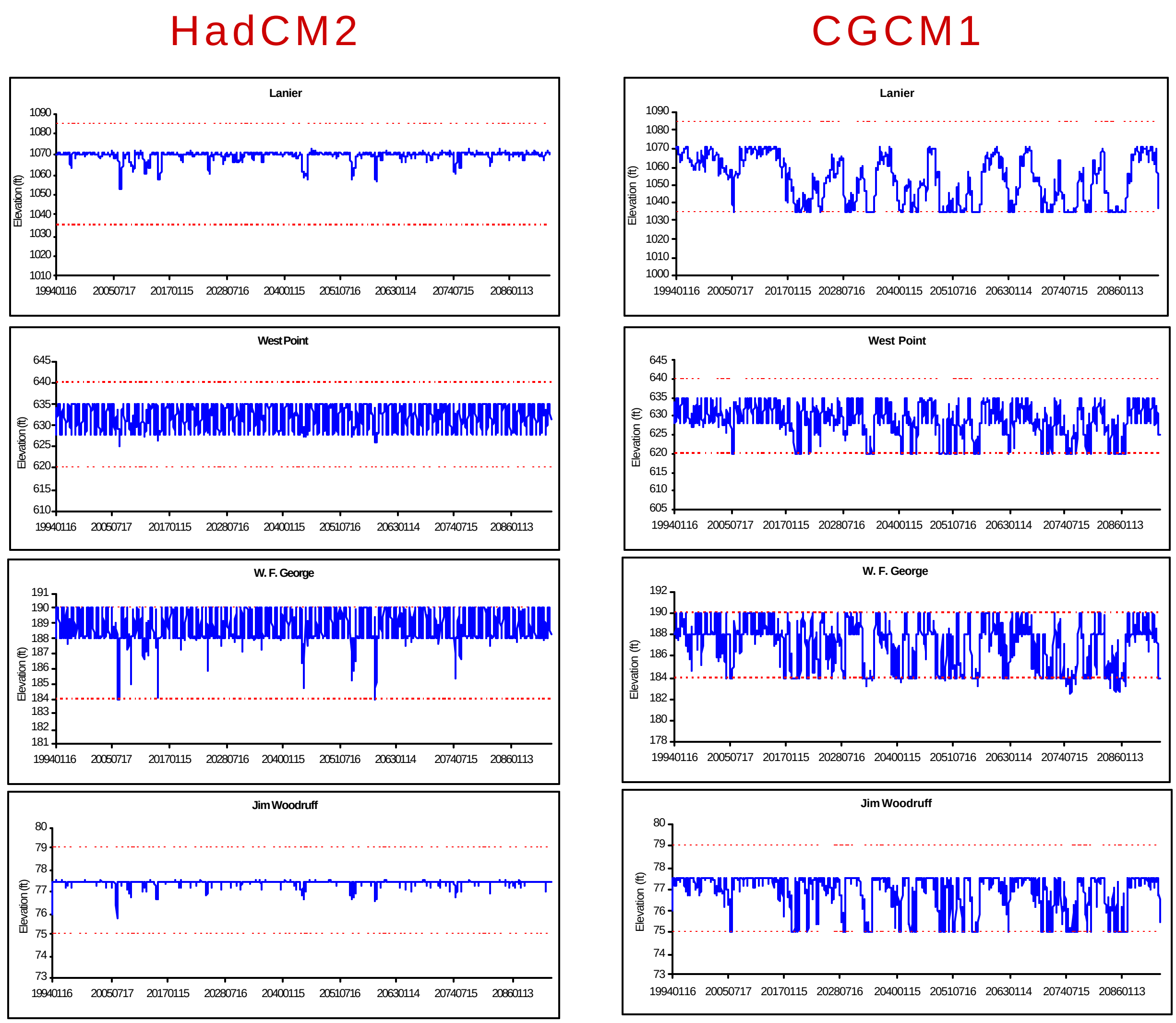

Figure 4. ACF Assessment under Future Climate Scenarios.