Inclusion of evaporation physics in the modeling of water availability in the Savannah River basin.

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Introduction

Current models used in determining water availability within the Savannah River basin rely on historical pan evaporation data combined with Hamon PET estimates to determine evaporative loss. The primary source of current and historical pan data is obtained on shore, likely to result in values different from actual lake evaporation.

Values of evaporation obtained via a parameterization that uses inputs believed to be valid for the actual lakes are likely to be better estimates than evaporation measurements obtained on shore. Using local lake climate conditions, a comparison of empirical and more physics based (TBL -Turbulent Boundary Layer) parameterizations to estimate lake evaporation will be determined. Applying the aforementioned evaporation parameterization to the current water availability model will yield the overall sensitivity in the model. However, these models require adequate climate data and lake surface temperature.

Savannah River Basin

Basin Description:

The majority of available water in the Savannah River basin is located within lakes and reservoirs. The river basin has a total drainage area of approximately 10,577 square miles, of which 4,581 square miles are in South Carolina, 5,821 square miles are in Georgia, and 175 square miles are in North Carolina.

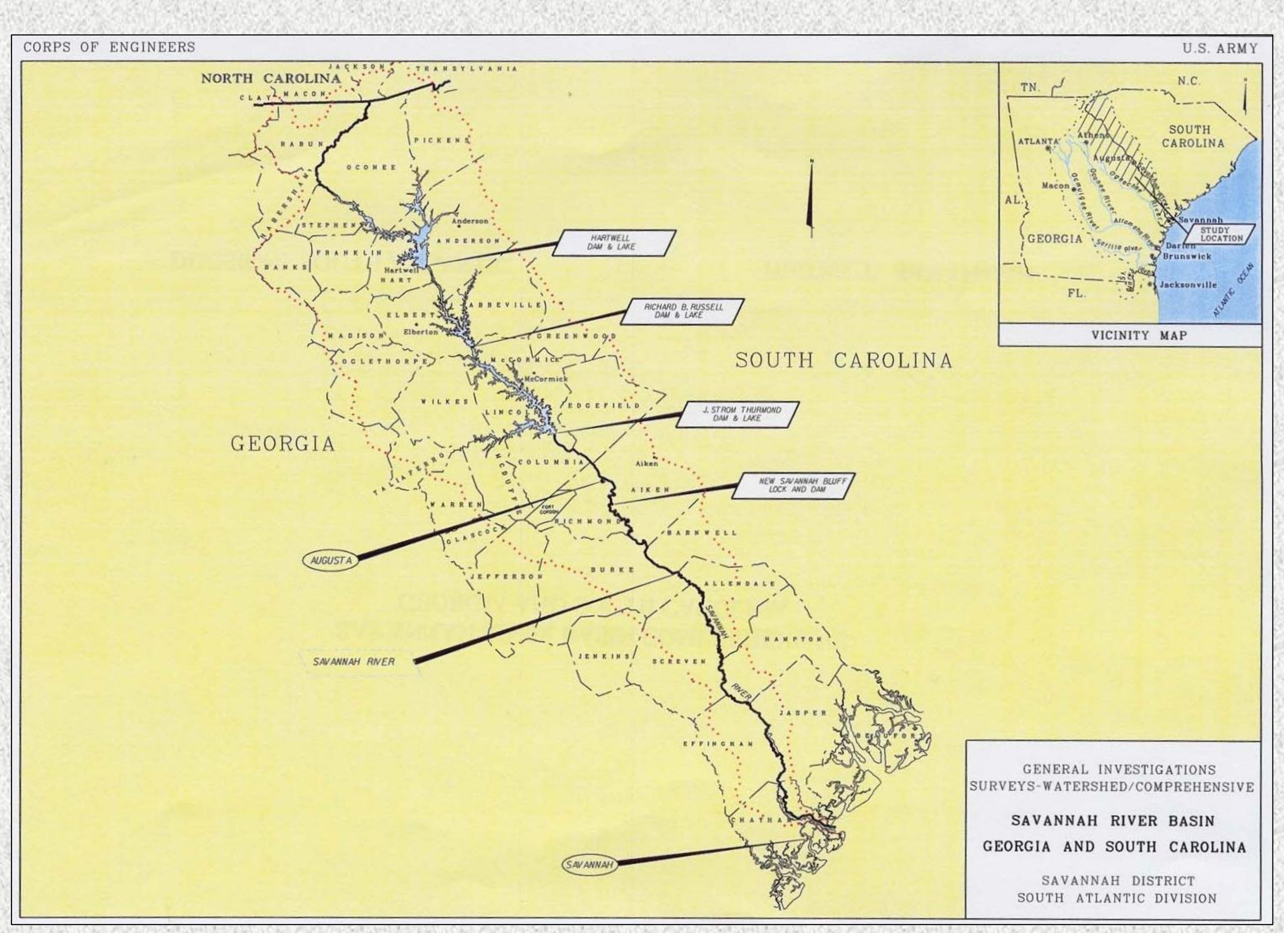

Figure 1 – Hydrological and county map of the Savannah River Basin (USACE).

Major Lakes/Reservoirs, Surface Area and Storage Volume:

- Lake Jocassee = 7,318 acres and 29.2 million gallons
- Lake Keowee = 18,373 acres and 27.0 million gallons
- Lake Hartwell = 55,900 acres and 69.2 billion gallons
- Lake Russell = 26,000 acres and 3.4 billon gallons
- Lake Strom Thurmond = 78,500 acres and 68.2 billion gallons

Surface Water Consumptive Water Uses:

- Municipal (M) and Industrial (I)
- Thermal Power (T)
- Agricultural Irrigation (A)

Methods

- Input variables needed for the evaporation models are: 1) Relative Humidity; 2) Air Temperature; 3) Wind Speed; and 4) Surface "Skin" Water Temperature.
- Determined accurate and available climate/meteorological data sources surrounding the Savannah River basin.
- Raw hourly air temperature, relative humidity and wind speed data were collected from weather stations aggregated by NOAA, NCDC and SERFC (Figure 2).
- Surface temperature measurements have been obtained from the Moderate Resolution Imaging Spectrometer (MODIS) sensor aboard the TERRA and AQUA satellites.
- Spatial resolution of the satellite imagery limits the number of available study points throughout the basin. GIS software was utilized to develop a shoreline mask (overlay high resolution Landsat 4-7 TM+ to determine land-free pixels/point locations of MODIS imagery.

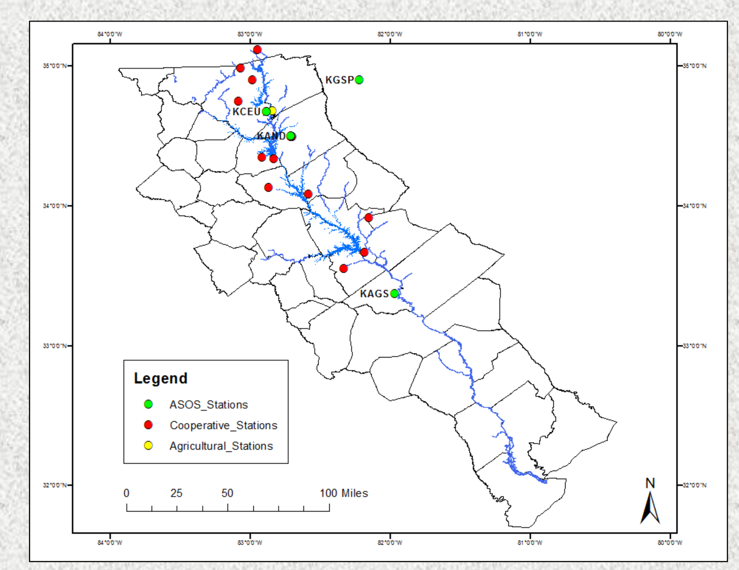

Figure 2 – Weather station map.

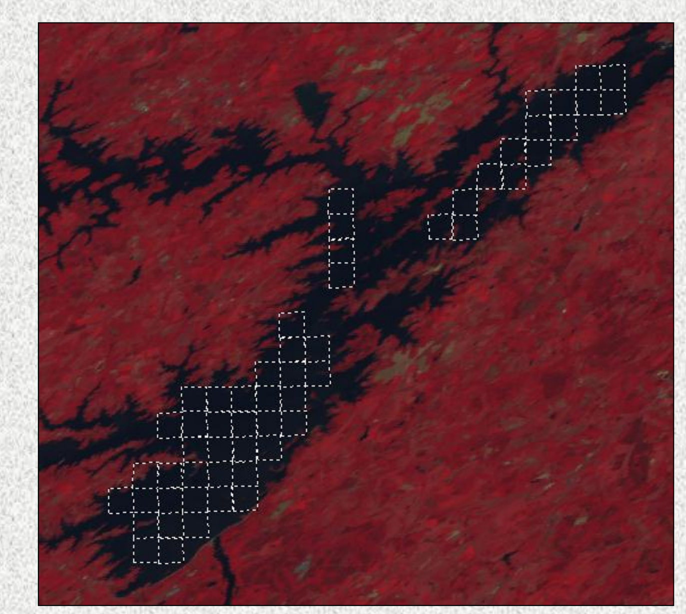

Figure 3 – Lake Hartwell MODIS pixel locations (1km²).

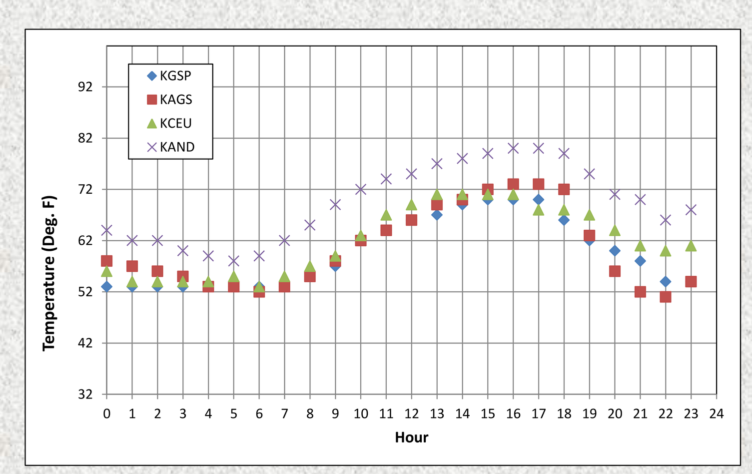

Figure 4 – Available May 6, 2005 hourly air temperature data.

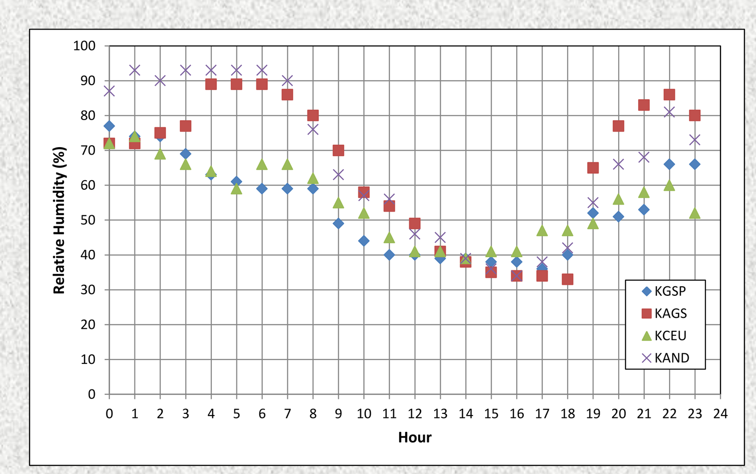

Figure 5 – Available May 6, 2005 hourly relative humidity data.

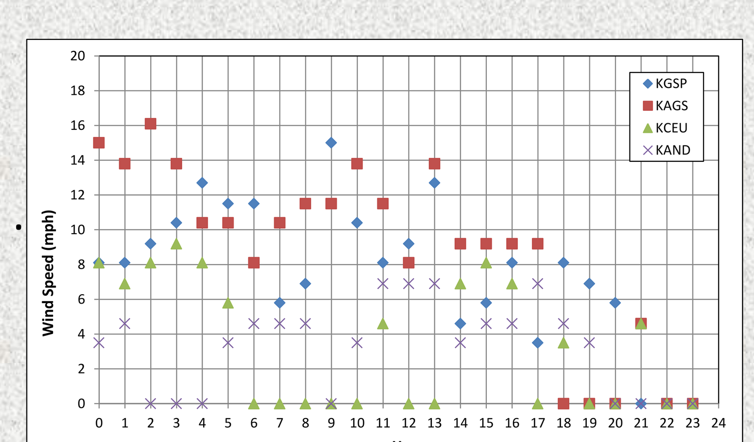

Figure 6 – Available May 6, 2005 hourly wind speed data.

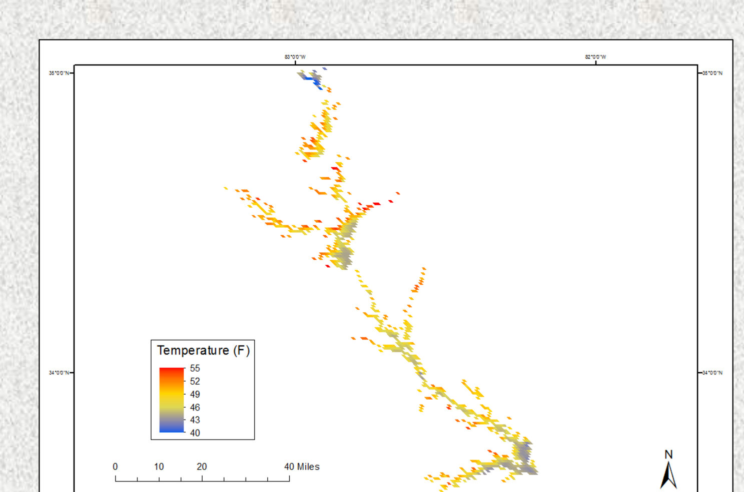

Figure 7 – Lake surface temperature via MODIS sensor aboard Aqua (1:30 pm).

Evaporation Test Runs

- Preliminary test runs to determine governing factors (diurnal and seasonal variability).
- Test run model comparisons using a Hamon method (E_H), normalized to pan data, Mass-Transfer method (E_M), and NOAA pan evaporation map data.

$$E_H = 0.55D^2 \frac{4.95e^{(0.062Ta)}}{100} \qquad E_M = 0.622\frac{\rho_a C_E}{\rho_w P}(e_s - e_a)u_z$$

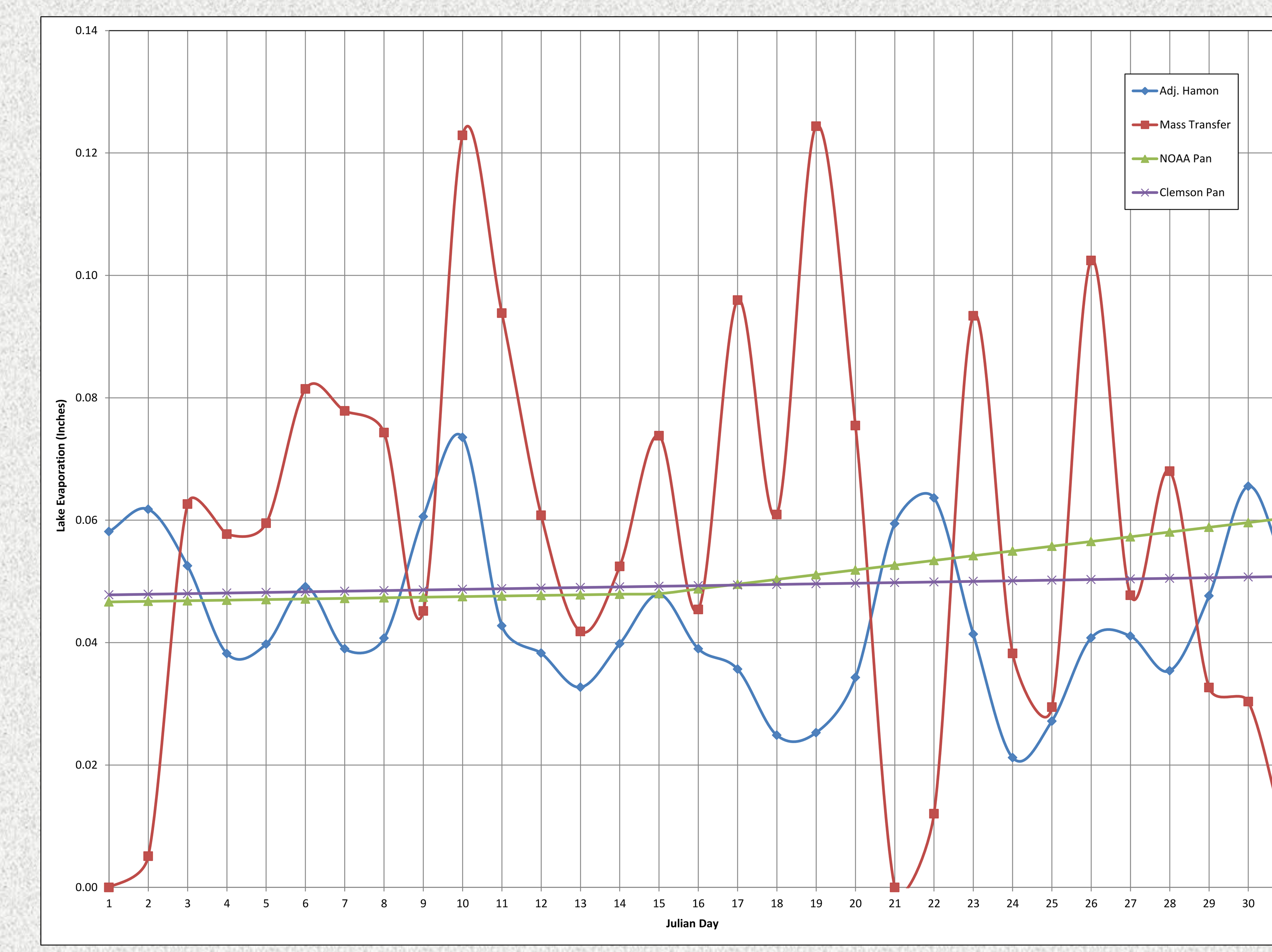

Figure 8 – Lake Hartwell evaporation in January of 2003. Mass transfer method computed using daily average KCEU weather station data. Pan data was obtained via NOAA evaporation atlas maps.

Future Work

- Analyze spatial and diurnal variability among available weather station data to determine correct interpolation methods used in estimating local lake conditions.
- Comparison and analysis of empirical and turbulent boundary layer evaporation models.
- Comparison and analysis of daily evaporation computed from averaged hourly evaporation rates and daily averaged climate data.
- Sensitivity analysis of Savannah River basin water availability model with respect to evaporation models, consumptive water use demand, and changing climate conditions.

Acknowledgements

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