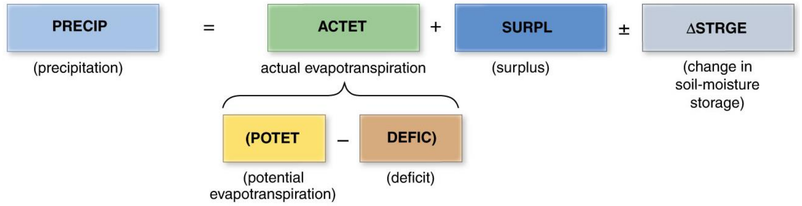
Modeling Climate Change Impacts on the Water Balance of a Medium-Scale Mixed-Forest Watershed, SE USA

C. Andrew Day, University of Louisville, Dept. of Geography and Geosciences; a.day@louisville.edu
David Howarth, University of Louisville, Dept. Of Geography and Geosciences; david.howarth@louisville.edu

Introduction:

Much of the current research on the impacts of climate change on US water resources has focused on larger watersheds (>1000km^2) across the drier western US, with reduced coverage for smaller and/or eastern watersheds.

Furthermore, much of this research does not account for the full water balance (in particular soil moisture) which is crucial in determining water resource availability at present and in the future in response to projected climate change.



A typical water balance.

Objective:

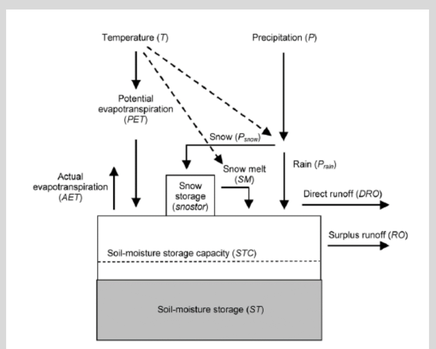
We investigated the impacts of projected longer-term changes in monthly air temperature and precipitation on the full water balance of a medium-scale watershed within the SE US region, the Red River of Kentucky. In particular, we were interested in examining the potential future influence of air temperature and precipitation on ET, soil moisture availability and resulting runoff to assess possible impacts on water resource availability for a mixed-forest watershed.

Data:

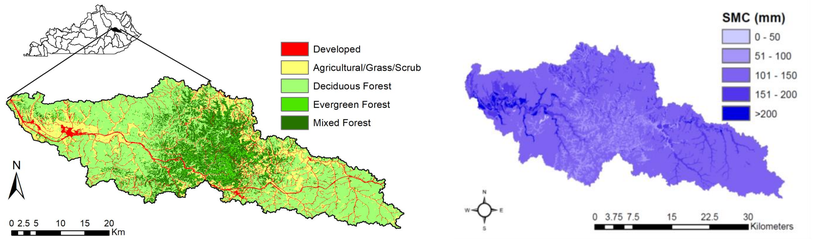
-Gridded Normal (1981-2010) monthly temperature and precipitation (PRISM)
-Normal monthly runoff (US Geological Survey)
-Gridded Soil Moisture Storage Capacity (NRCS SSURGO)
-Gridded Projected (2040-2069) monthly temperature and precipitation for 3 IPCC scenarios (Nature Conservancy/Climate Wizard)

Methods:

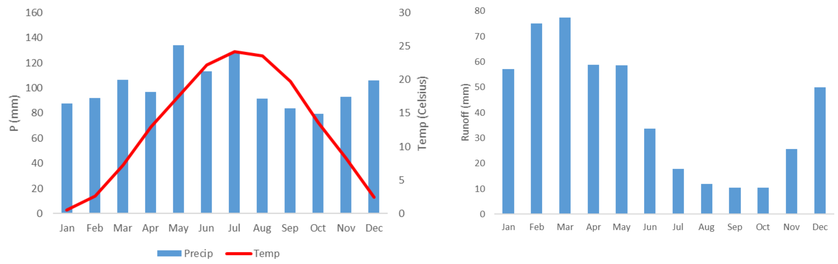
We applied the USGS Water Balance Model (WBM), using the normal monthly conditions for calibration, before running the model using the climate projections to 2040-2069.



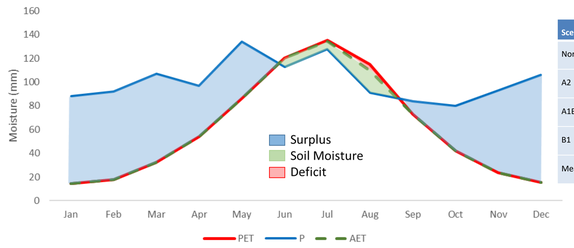
The WBM schematic.



Red River Basin land cover and soil moisture capacity (SMC).

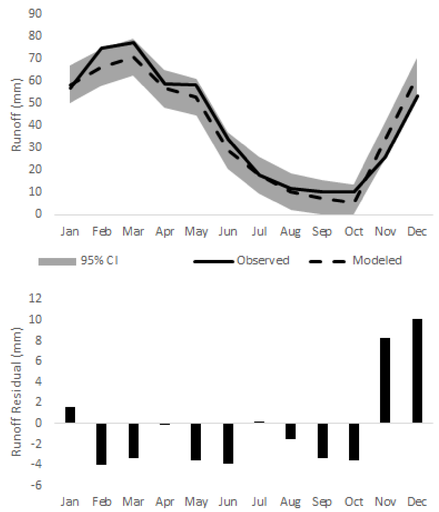


Red River Basin normal monthly climate and runoff.



Scenario	Surplus	SM Utilization	Deficit
Normal (1981-2010)	521.2	32	6.6
A2	527.7	76.6	36.1
A1B	518.1	77.6	37.4
B1	505.9	62.1	24.1
Mean Projections	517.2	72.1	32.5

Red River Basin normal monthly soil water balance. Soil moisture projections included in table (all values in mm).



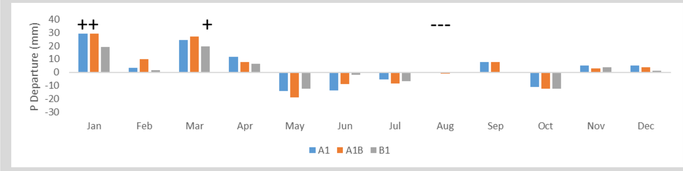
Statistic	Value
Nash-Sutcliffe	0.93
Vol. Diff	3.03%
RMSE	7.13mm
MAE	5.76mm

WBM calibration statistics based on normal runoff conditions.

Projected Findings:

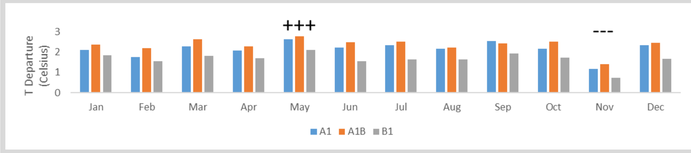
Precipitation

-max increases in late winter/early spring, with general decreases from May onwards



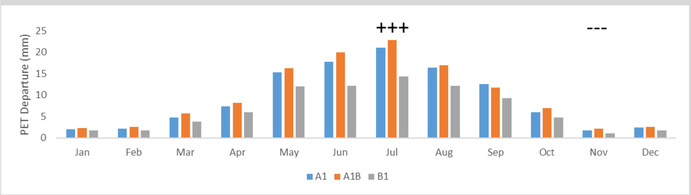
Air Temperature

-increases across all months across all scenarios, max in May, min in Nov
-Increases in spring offsets precipitation departures



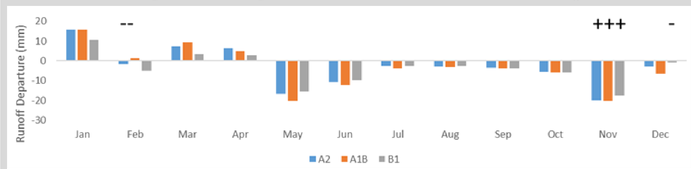
Potential Evapotranspiration

-increases across all scenarios and months, max in Jul, min in Nov



Runoff

-largest reductions in runoff occur in Nov due to both reductions in Oct precip and prolonged prior air temp and PET increases
-min runoff phase expands from Jul-Oct to May-Nov



Soil Moisture

-small surplus increase for A2 scenario due to increase in precipitation during Mar-April.
-deficits and SM utilization increase across all scenarios
-deficit/SM utilization season expands from Jun-Aug to May-Sep
-increased temperatures will eventually offset any increases in precipitation throughout the year