Abstract

Water resources are important to both natural ecosystems and human societies. Surface water is the most readily accessible water resource and provides an array of ecosystem services. Water stress, the ratio of water demand to supply, is a global concern as water resources are stressed by changes in climate, land cover, and population size. Understanding current and projected spatial and temporal factors of surface water dynamics is key to better managing our water resources and limiting the effects of water stress. However, few studies estimating changes in surface water account for climate and human drivers synergistically. Therefore, we compared three sets of statistical models using climate only, anthropogenic only, and the combination of climate and anthropogenic explanatory variables to assess the influence of each set of drivers on estimating surface water. We then used the most accurate model, the combination of climate and anthropogenic drivers (-0.17% average watershed mean percent error), with climate and land use projection data to project surface water areas under different climate and land use scenarios. For climate drivers, we used precipitation and temperature data from ensembles of the Inter-Comparison of Coupled Models-Phase 5 (CMIP5) Global Climate Models under three Representative Concentration Pathways (RCPs)—RCP4.5, RCP6.0, and RCP8.5. For anthropogenic drivers, we used three land use/land cover change projections from the U.S. Geological Survey’s FOR-SCE model corresponding to Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES) that have RCP counterparts. Our models suggest an uneven distribution of projected change in surface water area, where watersheds with more natural land cover will experience less change (positive or negative) and watersheds with less natural land cover will experience more change. We also expect to find that, under the business-as-usual scenario, watersheds with greater urbanization will see a reduction in surface water area by 2100. These results highlight our ability to mitigate water stress with land use management and also emphasize the need to account for both climate and anthropogenic drivers when estimating and predicting surface water area.
Why the Southeastern U.S.?

- Most land cover and land use change of any region in the U.S.
- Highest population growth rate in the U.S. leading to increased water demand
- Sprawling urban growth pattern increases impervious surface area
- Variable precipitation patterns that are projected to become more seasonal

Main findings

- The Mixed Effect Random Forest (MERF) model with a combination of climate and human drivers was the best model for estimating percent surface water area
- The MERF model had the smallest absolute average watershed-MPE (~0.7%) while the random forest model with only climate data had the highest absolute average watershed-MPE (~ -27%)
- The MERF model is able to predict future percent surface water area (using simulated climate and land cover data)
- Simulated predictions show a consistently higher percent surface water area at the seasonal, watershed scale

Objectives

- Determine what drivers - human, climate, or both - have the greatest impact on estimating surface water area based on satellite observation and train a machine learning model using these drivers.
- Use the machine learning model to predict surface water area through 2100 based on different climate and land cover/land use projections

Methods

- Aggregated Landsat-derived Dynamic Surface Water Extent product to seasonal surface water area per 8-digit HUC
- Aggregated climate and land cover data: maximum temperature and precipitation, and natural, intensive, and agricultural
- Train and test three data-driven statistical models with three different sets of explanatory variables
- Generated future climate and land cover data from annual trends
- Run the most accurate statistical model with simulated future explanatory variables
- Run the trained MERF model on land use/land cover data projected under SSP2-RCP4.5 and climate data projected under RCP4.5
- Run the trained MERF model on land use/land cover data projected under SSP5-RCP8.5 and climate data projected under RCP8.5
- Compare MERF projections to the Water Supply Stress Index surface water supply

Acknowledgement