H35V-1284 - Using Remote Sensing and Machine Learning to Estimate Groundwater Use in the Mississippi Alluvial Plain

Wednesday, 15 December 2021

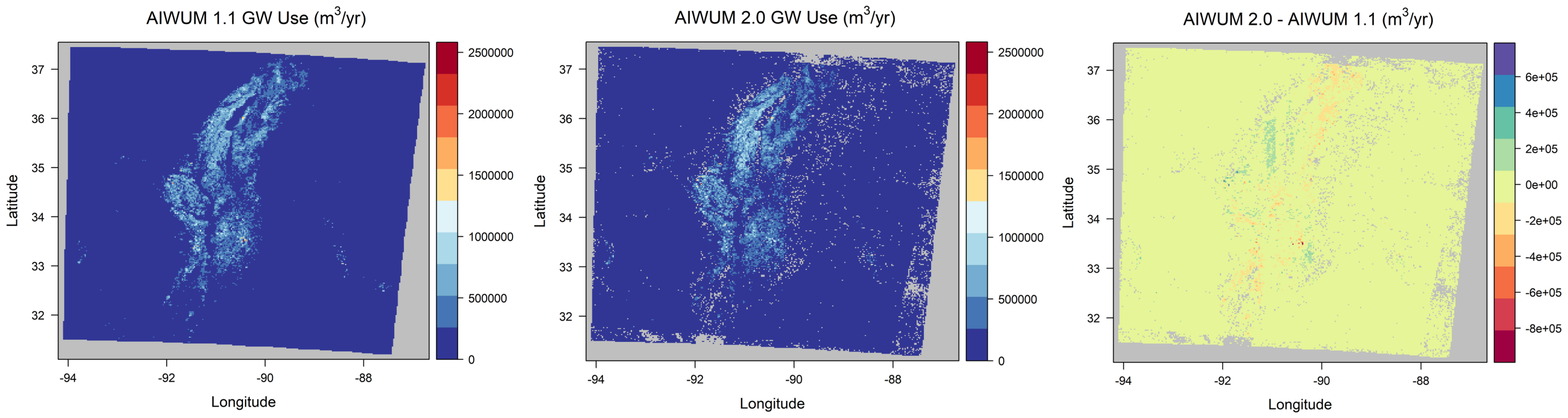
16:00 - 18:00

Convention Center - Poster Hall, D-F

Abstract

In this study, we improve estimates of groundwater usage across the Mississippi Alluvial Plain (MAP) in support of an ongoing USGS effort to model the groundwater resources of the region. Previously, the USGS developed a lookup table based on flowmeter data that estimates water use based on average water use for each crop type, for specific regions and precipitation amounts. The latest iteration of this model is known as Aquaculture and Irrigation Water-Use Model (AIWUM) 1.1 and we refer to our method as AIWUM 2.0. Here, we apply gradient boosted trees (GBT) to predict groundwater use across the MAP from 2014-2019. The predictor variables include well locations (latitude and longitude), crop type, precipitation, maximum temperature (the average daily maximum from April - September), total evapotranspiration estimated with MOD16, and surface run-off (TerraClimate).

The existing flowmeter data over the Mississippi Delta were randomly split into training (80%) and validation (20%) data. The following parameters in the GBT algorithm were tuned: the number of estimators, learning rate, maximum tree depth, the objective function, and the percentage of training data that are randomly sampled in the training process. We observe very low model overfitting where the training error metrics are R^2 = 0.58, mean absolute error (MAE) = 0.30 ft, and root mean square error (RMSE) = 0.51 ft, respectively, and the corresponding test metrics are R^2 = 0.49, MAE = 0.32 ft, and RMSE = 0.51 ft. This is an improvement over AIWUM 1.1, where the corresponding R^2, MAE, and RMSE were 0.27, 0.40 ft, and 0.67 ft. These water use estimates will result in an improved ability to accurately model groundwater flow in this aquifer, which accounts for roughly 20% of the total groundwater pumping in the United States.



The AIWUM 1.1 and AIWUM 2.0 mean volumetric predictions at 1 sq mile from 2014-2019 are shown, along with the difference raster (AIWUM 2.0 - AIWUM 1.1). The greyed-out pixels within the AIWUM 2.0 and difference rasters indicate unknown water use in areas other than Corn, Cotton, Rice, Soybeans, and Catfish ponds. Since the AIWUM 2.0 training data consist of only these five crop types, we did not predict water use for other crops.

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The goal of this study was to improve on that method by using additional data that is likely related to water use, such as remotely sensed evapotranspiration, model-based estimates of soil moisture, and temperature. These and other variables are likely related to water use, but quantifying this relationship, which is often complex and non-linear, with traditional models is a challenge. Machine learning provides robust tools for ingesting large numbers of predictor variables and quantifying how they are related to a prediction of interest. In this study, we implement a machine learning-based approach (gradient boosted trees) to estimate groundwater pumping throughout the Mississippi Alluvial Plain (MAP) at an annual time-step (2014-2019), using data from existing flowmeters in Mississippi. The predictor variables include well locations (latitude and longitude), crop type, precipitation, maximum temperature (the average daily maximum from April - September), total evapotranspiration estimated with MOD16, and surface run-off (TerraClimate). We find that this approach improves upon the previous USGS lookup table-based model for the MAP region.

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