

# **Impact of future hydrologic extremes on water supply and irrigation water demand under changing climate in Texas**

2016-17 TWRI Mills Scholarship Application

## **Contact Information**

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## **Proposed Use of Funds**

The proposed research is a continuation of the ongoing research “Future climate change impacts on agroclimate and surface hydrology: case studies in Baja California (MEXICO) and Texas (USA)” funded by the TAMU-CONACYT Collaborative Research Grant Program (PI: Huilin Gao). The study will extend the research scope from surface hydrology to agricultural impacts—especially irrigation water availability and crop yields under a changing climate.

## **Abstract**

With the ongoing and increasing pressures brought on by climate change, hydrologic extreme events—such as heat waves and droughts—are becoming more frequent and intensified. These changes will affect Texas water availability and agricultural production significantly. The objective of this study is to investigate how future extreme events will impact irrigation water availability and crop yields under different future emission scenarios in Texas. The VIC-CropSyst model will be used to simulate changes in water demand and availability (simultaneously) over agricultural regions in selected Texas river basins. First, the VIC model will be forced by statistically downscaled Global Circulation Model (GCM) outputs under different emission scenarios. Results will be analyzed to identify the frequency, severity, and the extent of extreme events over three 30-year periods (1970-1999, 2020-2049 and 2070-2099). Second, a groundwater pumping scheme will be implemented into the VIC-CropSyst model, such that irrigation water can be withdrawn from both groundwater and surface water sources. Third, changes in crop yield and irrigation water demand due to climate change will be investigated using the simulated ensemble outputs. The results are expected to contribute to future agricultural production management and planning in Texas.

## **Research Proposal**

The population in the State of Texas has doubled from 1978 to 2014, and it is expected to reach 54.4 million by 2050. Under this pressure, fresh water availability and agricultural production are key factors for sustaining the ongoing social-economic development in Texas. However, Texas is a water deficient state that is highly vulnerable to droughts. Drought events occur every few years, with the worst annual drought on record occurring in 2011. The 2011

drought dried up many lakes and rivers, and it cost the state \$5.2 billion in the agricultural sector alone. Texas water shortages are further worsened by climate change, which has led to more frequent and severe extreme events, such as heat waves and droughts. Such extreme events directly affect agricultural production and food supplies.

This study will be a continuation of the ongoing collaborative project between TAMU and CONACYT (Mexico) led by Dr. Gao, which focuses on evaluating future climate effects on surface hydrology in Texas and Baja California (Mexico). Based on Global Circulation Model (GCM) predictions, it has been found that, in the foreseeable future, total precipitation will decrease while mean temperature will increase. In eastern Texas, precipitation and runoff will significantly decrease. Results suggest that both the frequency and extent of future droughts and heat waves will increase, with a significant increase in the number of extreme events projected to occur between 2020 and 2049 in Texas (Gao et al., 2015). The available results also suggest that the future drought occurrence trend will vary by season. For instance, there will be less drought events in summer and more drought events in spring (Lee et al., 2015).

The objective of this study is to investigate how future extreme events will impact irrigation water availability and crop yields under different future emission scenarios in Texas. The proposed plan will extend the results from hydrological modelling to agricultural simulations. The downscaled climate forcing ensembles from twelve Coupled Model Intercomparison Project Phase 5 (CMIP5) models will be divided into three periods: a historical baseline period (1970-1999), and two future periods (2020-2049 and 2070-2079). Future projections are available under the Representative Concentration Pathway (RCP) +2.6w/m<sup>2</sup>, +4.5w/m<sup>2</sup>, +6.0w/m<sup>2</sup>, and +8.5w/m<sup>2</sup> scenarios. The VIC-CropSyst model—which integrates a cropping simulation model (CropSyst) into a hydrologic model (the Variable Infiltration Capacity model, VIC)—will be used to simulate changes in water demand and availability simultaneously over agricultural regions in selected Texas river basins. The advantage of using this grid-based hydrologic model is its ability to calculate the spatial distribution of each crop growth area and the irrigation water demand. Particularly, a groundwater pumping scheme will be implemented into the VIC-CropSyst model. Then, the model will be calibrated and validated using observation based historical data. Agricultural productivity from the top five Texas cash crops (cotton, hay, sorghum, corn, and wheat) will be simulated under different future emission scenarios. Since future climate change involves many uncertainties, water management planning without considering these uncertainties will only result in biased and flawed decisions. Therefore, we will use the integrated model to simulate various future scenarios with the uncertainties associated with the key outputs quantified.

### **Timeline**

Jan~Mar 2016: VIC-Cropsyst model set up and collection of crop information

Apr~Jun 2016: Run the model and investigate the relationship between groundwater and surface water.

Jul~Sep 2016: Analyze the results at the basin scale for each crop (with regard to production and irrigation water demand).

Oct~Dec 2016: Write the final report, and propose future agricultural management and planning strategies for Texas

## **References**

Huilin Gao, Francisco Bautista, Manuel E. Mendoza, Carmen Delgado, Kyungtae Lee, Teodoro Carlón Allende, Gabriela Garcia, (2015). “Future climate change impacts on agroclimate and surface hydrology: case studies in Baja California (MEXICO) and Texas (USA)” 2015 TAMU-CONACYT Research Symposium, Texas, USA.

Kyungtae Lee, Huilin Gao, Maoyi Huang, Justin Sheffield, (2015). “The Future Climate Change and its Impacts on Heatwave and Drought in Texas using the Downscaled CMIP5 Climate Projections”, *in preparation*, Advances in Meteorology.

## **Intended Career Path**

During my Ph.D. program, I plan to extend the knowledge about how climate change impacts future surface hydrology (evapotranspiration, runoff and soil moisture), agricultural production (crop yield), and extreme drought events in Texas river basins. After graduation, I want to work for the climate and water research group at the Pacific Northwest National Laboratory, where I had an internship in the summer of 2014. I want to continue using my knowledge to help resolve water resources-related issues.