GC23G-1310: Investigation Into the Effects of Climate Variability and Land Cover Change on the Hydrologic System of the Lower Mekong Basin

Kel N. Markert[1*], Robert Griffin[2], Ashutosh S. Limaye[3], Richard T. McNider[2], Eric R. Anderson[1]

[1]Earth System Science Center, University of Alabama in Huntsville, [2]Atmospheric Science Department, University of Alabama in Huntsville, [3]NASA Marshall Space Flight Center

Abstract

The Lower Mekong Basin (LMB) is an economically and ecologically important region that experiences hydrologic hazards such as floods and droughts, which can directly affect human well-being and limit economic growth and development. To effectively develop long-term plans for addressing hydrologic hazards, the regional hydrological response to climate variability and land cover change needs to be evaluated. This research aims to investigate how climate variability, specifically variations in the precipitation regime, and land cover change will affect hydrologic parameters both spatially and temporally within the LMB. The research goal is achieved by (1) modeling land cover change for a baseline land cover change scenario as well as changes in land cover with increases in forest or agriculture and (2) using projected climate variables and modeled land cover data as inputs into the Variable Infiltration Capacity (VIC) hydrologic model to simulate the changes to the hydrologic system. The VIC model outputs were analyzed against historic values to understand the relative contribution of climate variability and land cover to change, where these changes occur, and to what degree these changes affect the hydrology. This study found that the LMB hydrologic system is more sensitive to climate variability than land cover change. On average, climate variability was found to increase discharge and evapotranspiration (ET) while decreasing water storage. The change in land cover show that increasing forest area will slightly decrease discharge and increase ET while increasing agriculture area increases discharge and decreases ET. These findings will help the LMB by supporting individual country policy to plan for future hydrologic changes as well as policy for the basin as a whole.

Objectives

How will climate variability and land cover change affect the *spatial and temporal characteristics* of the hydrologic system within the LMB?

- Develop, calibrate and validate a land cover change model for the LMB
- Setup, calibrate, and validate a hydrologic model for the LMB
- Simulate land cover change for different user-defined land cover change scenarios with variable increases in forested, agricultural, and urban areas for the region
- Develop a climatology dataset for hydrologic variables by simulating the hydrology for observed climate from 1980-2010
- Simulate hydrologic flow for a projected climate scenario and different land cover change scenarios
- Compare simulated projected hydrologic variables with climatology to understand changes in the system.

Study Area

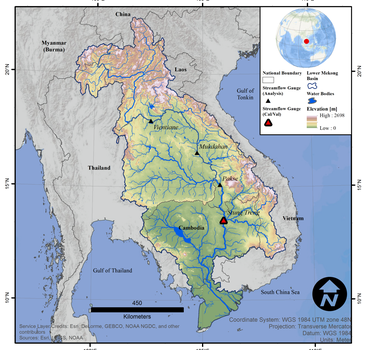

Fig. 1 Study area map showing the LMB and gauging stations used in analysis.

Methodology

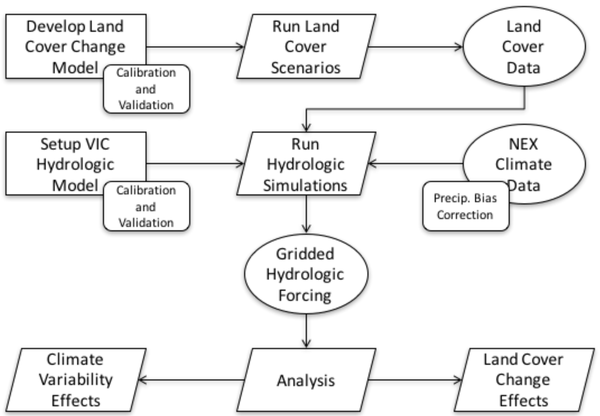

Fig. 2 Flow chart of methodology used for study.

Results

Climate variability had the largest effects by altering the annual discharge amount and seasonality as well as altering the storage, runoff/precipitation (RP) ratio, and ET for the entire basin. The changes in hydrology due to land cover found that increases in forest decreased annual streamflow, increased ET, and increased storage. Increases in agricultural land had the opposite effect where discharge increased and there were decreasing trends in ET and storage. The scenarios with 10% increase for forest and agriculture were found to have the most amplified effects on the system.

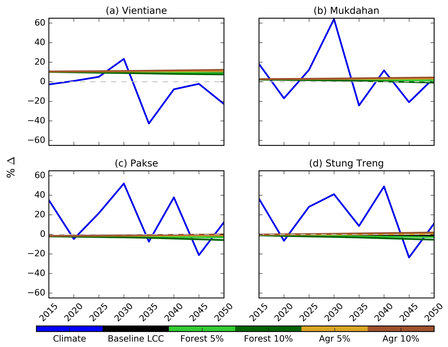

Fig. 3 Percent changes in mean annual discharge from climate scenario and land cover change scenarios through time.

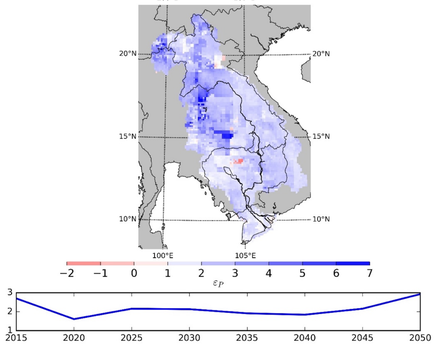

Fig. 4 Spatial and temporal representation of runoff elasticity for the LMB.

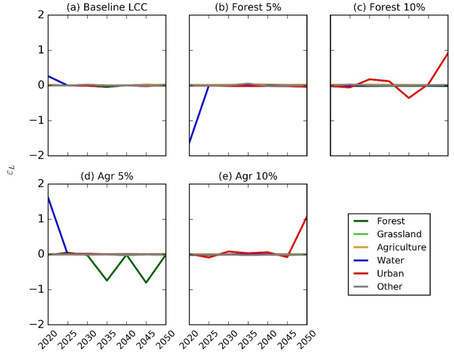

Fig. 5 Runoff elasticity values for each land cover class for each land cover scenario.

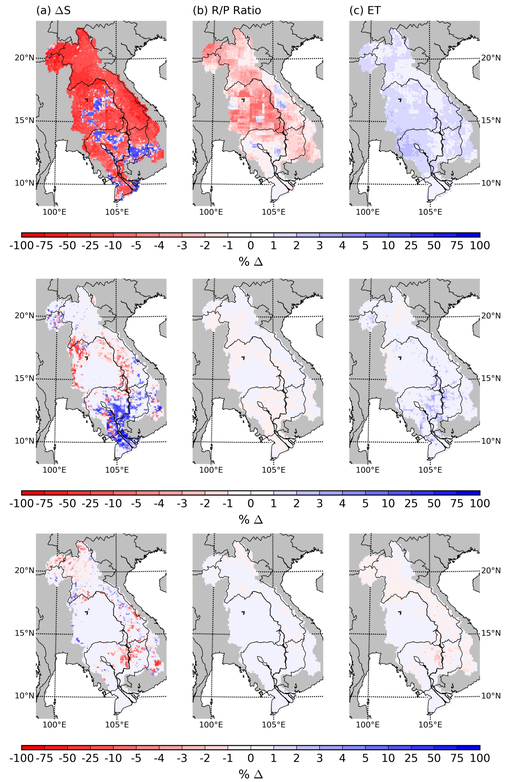

Fig. 6 Spatial trends of hydrologic variables for climate variability (top), and land cover change scenarios (middle/bottom)

Conclusions

Overall

- The LMB hydrologic system is more sensitive to climate variability than land cover change

Climate Effects

- Climate variability will result in variable river discharge with different onset and durations of the wet season
- Almost surface runoff sensitivity doubling of surface runoff with increases in precipitation
- Decreasing trend in water storage, increasing trend in ET

Land Cover Effects

- Land cover was found to have minimal impacts on the discharge for the entire basin
- Increases in forest area resulted in a decrease in discharge whereas increases in agriculture areas increased discharge
- Negligible sensitivity of surface runoff to land cover change
- Increasing trend in storage and ET with increase in forested area and a decreasing trend in storage and ET with increases in agricultural area.

Future Work

- Update land cover model to incorporate spatial disaggregation of land cover demand for more accurate allocations of land cover change
- Make land cover model dynamic to use in other regions
- Use high and low climate projections to provide a range of hydrologic response for the basin
- Add effects of dams into hydrologic response framework for a more comprehensive analysis

Acknowledgements

This work was funded through the NASA-SERVIR program part of the Capacity Building program of NASA Applied Sciences as part of Markert's graduate work. The observed discharge data used in this study was provided by the Mekong River Commission. We are grateful to Dan Irwin, Africa Flores, Lee Ellenburg, Larry Carey, Maury Estes, and others for their support and comments.

*Contact: Kel N. Markert, kel.markert@nasa.gov
servirglobal.net