SWAT Calibration in Data Scarce Area through Remote Sensing Data

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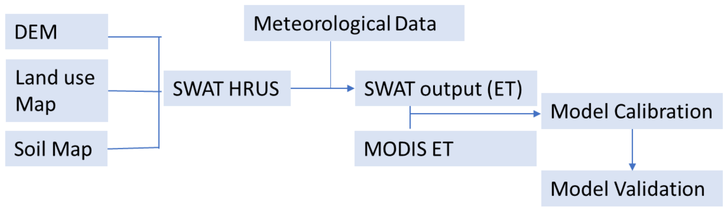
Abstract

Microcystins (MCs) is pervasive during cyanobacterial blooms in freshwater systems. MCs detection/prediction can be achieved by analyzing nitrogen and phosphorous loadings from watershed. Soil and water assessment tool (SWAT) can provide the dynamics of pollutants in watershed caused by agricultural use, especially nonpoint sources pollution. In previous research, discharge data is widely used in SWAT model calibration and validation. However, streamflow data is not recorded in every basin. Evapotranspiration (ET) data derived from satellite is applied in SWAT model calibration or evaluation in data scarce area. The study will focus on evaluate the spatial distribution of the MODIS-based ET performance in SWAT calibration.

Method



Data

Physiographical Maps:

1. DEM:

Seamless 1 arc-second DEM (30 m × 30 m resolution) derived from the Shuttle Radar Topography Mission (SRTM) was used to delineate basins and calculate watershed configuration and topographic information such as the slope and stream network.

2. Cropland

The Cropland Data Layer (CDL) 2010 obtained from the United States Department of Agriculture (USDA) is used as the land use map with 30 meters' spatial resolution.

3. Soil

The State Soil Geographic (STATSGO) database 1:250,000 scale soil map

Meteorological Data:

Gridded Parameter–Elevation Regressions on Independent Slopes Model (PRISM), as a High-resolution weather dataset

ET:

MOD16A2 Version 6 Evapotranspiration/Latent Heat Flux product is pre-processed through Google Earth Engine

Study Area

Cheney Reservoir, situated in south-central Kansas, is one of the major drinking-water sources for Wichita. The North Fork Ninnescah Watershed above Cheney Reservoir (Fig. 1) was defined by a USGS stream gauging station (07144780) that encompasses an area of 2,400.2 km^2 (926.7 mi2). In this study, the watershed is delineated into 23 sub-watersheds through ArcMap. The main type of crops in the watershed contains Winter Wheat (23.95%), Corn (11.8%), Soybeans (6.06%), Sorghum (4.44%) obtained from the United States Department of Agriculture (USDA). Agricultural activities within the North Fork Ninnescah Watershed may have direct impact on the health or water quality of the Cheney Reservoir via the North Fork Ninnescah River.

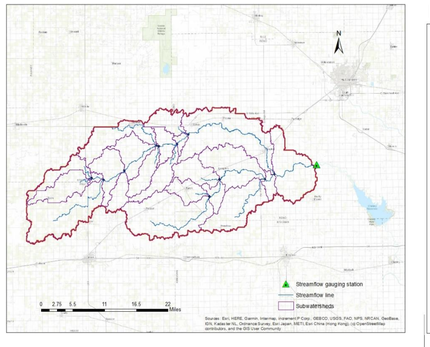


Fig.1 Research Area

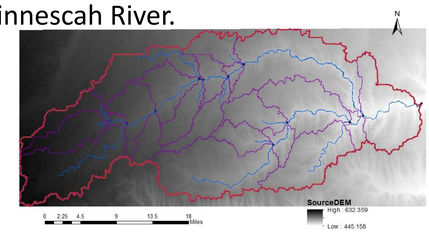


Fig.2 DEM in Research Area

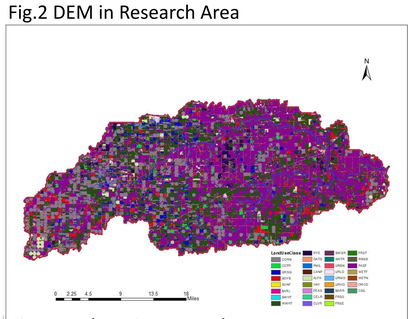


Fig.3 Land use in Research Area

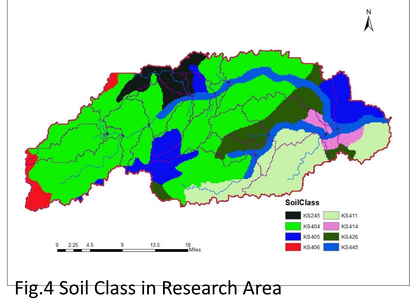


Fig.4 Soil Class in Research Area

Calibration and Validation

$$NSE = 1 - \frac{\sum_{i=1}^{n}(O_i - P_i)^2}{\sum_{i=1}^{n}(O_i - \overline{O})^2}$$

$$R^2 = \left(\frac{\sum_{i=1}^{n}(O_i - \overline{O})(P_i - \overline{P})}{\sqrt{\sum_{i=1}^{n}(O_i - \overline{O})^2}\sqrt{\sum_{i=1}^{n}(P_i - \overline{P})^2}} \right)^2$$

where O_i are observed data, P_i are predicted data, $\overline{O}$ and $\overline{P}$ are observed and predicted mean values, respectively, and n is the number of observations.

When compared to the default ET modeled by SWAT, it shows that the ET calibration performed was able to improve the simulation of ET values. Approximately 80% of subbasin showed a good model performance in both calibration period (2010-2012) and validation period (2013-2015) with satisfactory statistical criteria values. The R2 reached to 0.69 and the average NSE increased to 0.55 during calibration period. The average NSE among entire subbasin boosted to 0.67 in validation period.

NSE R^2

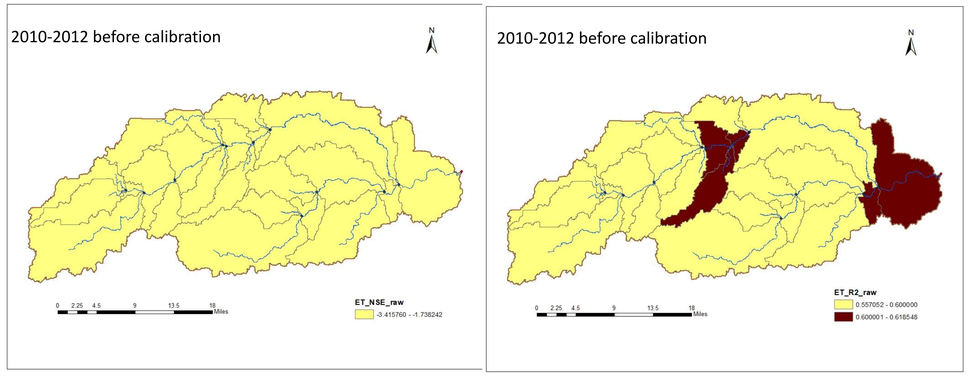


Fig.5 Performance metrics of simulated ET before calibration during 2010-2012

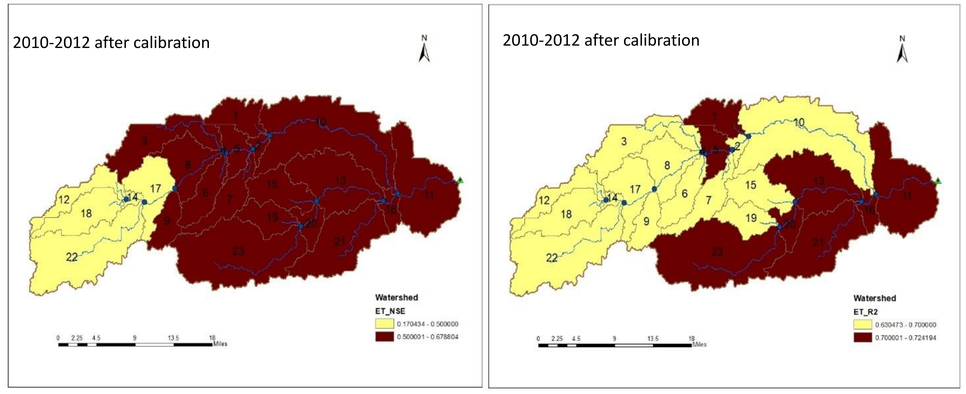


Fig.6 Performance metrics of simulated ET after calibration during 2010-2012

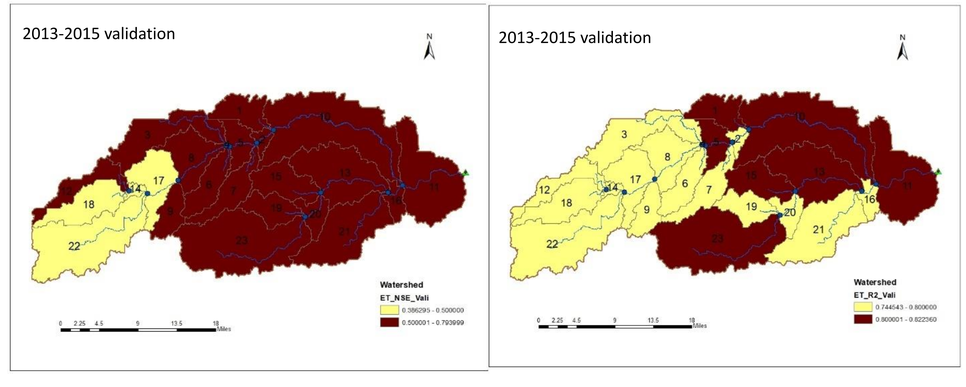


Fig.7 Performance metrics of simulated ET in validation during 2013-2015

Conclusion

Other remote sensing ET products may also need to be involved in the study to prevent the prejudice from one dataset. As the limitation of temporal resolution of MOD16A2 ET product, calculating daily model cannot be accomplished. It may decrease the accuracy of the output predicted by the model because less reliable calibrated parameter values produced. MOD16A2 ET product derived from GEE is an 8-day composite product; therefore, the monthly ET only covers 25 or 26 days depends on the month. It may distort the calibration.