Effect of Spatial Distribution of Precipitation Data on Temporal and Spatial Uncertainty of Swat Output

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Introduction & Objectives

Accurate modeling of water quality, water availability, and transport of pollutants at the watershed scale requires an accurate representation of the precipitation data. For this reason, the ability of hydrologic models to predict accurate outputs depends to a great extent on how well the rainfall data is distributed.

In general, rainfall intensities can vary in space and time, particularly in convective events. A number of schemes are available to account for temporal and spatial uncertainties of precipitation data. The simplest method is the arithmetic mean, which assumes the rainfall is uniformly distributed over the watershed. The Thiessen polygon method is an improvement over the arithmetic approach, by assigning the record from the closest rain gauge to the unstamped location. The Centroid method is another popular method. The centroid method uses the rain gauge nearest to the centroid of each subbasin.

The objectives of this project are (1) to assess the impacts of using different interpolation schemes for incorporating spatially variable precipitation data into the Soil and Water Assessment Tool (SWAT) and (2) assess the impacts of using three levels of subbasin delineation on the streamflow.

Study Area

Twelve-Mile Creek Basin is located in Pickens County, South Carolina. The drainage area of the Twelve-Mile Creek is approximately 106 square-mile. The basin slopes from the northeast to the southwest, with elevations ranging from 503–4591 ft. above sea level (Figure 1).

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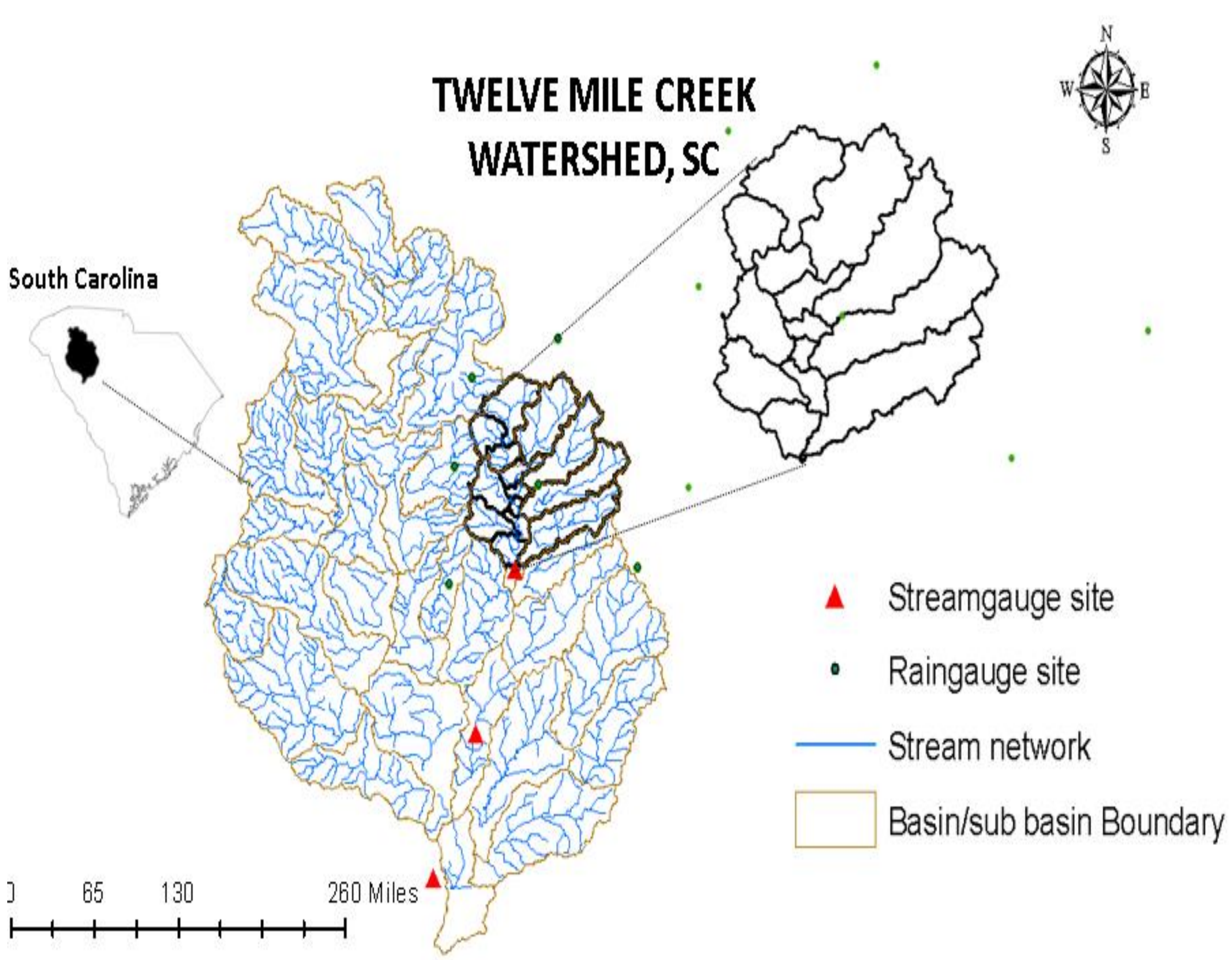

Figure 1: Location of the Twelve-Mile Creek watershed and the spatial distribution of rain gauge stations.

Materials and Methods

The model chosen for this project is the SWAT model, which is a semi distributed, hydrologic model that operates in a daily and monthly time-step. SWAT was applied to assess the impact of using different interpolation schemes on the streamflow. Figure 2 provides an overview of five different interpolation methods and the steps used for model calibration and ensemble based processing.

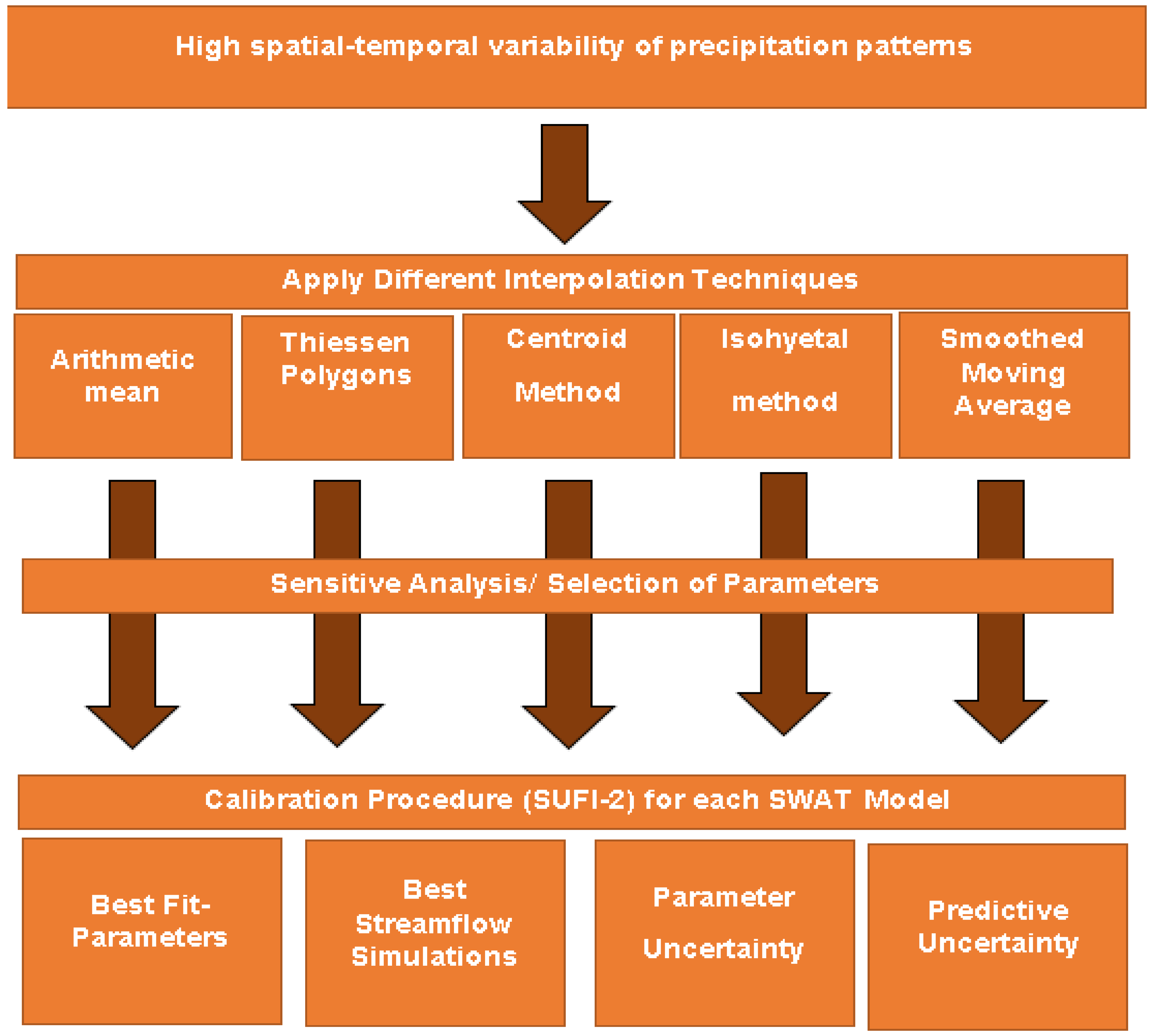

Figure 2: Methodology Flowchart

Model Performance

Simulated data from the SWAT model can be compared to observed data to evaluate SWAT's capability in predicating streamflow. In this project, the correlation coefficient (R2) and Nash-Sutcliffe model efficiency coefficient (NSE) were used as a statistical method to evaluate and analyze the daily streamflow data.

$$E = 1 - \frac{\sum_{t=1}^{T}\left(Q_o^t - Q_m^t\right)^2}{\sum_{t=1}^{T}\left(Q_o^t - \overline{Q_o}\right)^2}$$

Results

The precipitation distribution by centroid method, which is currently used by the SWAT model, and the arithmetic mean method for the entire watershed (average method) were not sensitive to subwatershed delineation (Figure 4). The impacts of delineation on streamflow were also less with these two methods (Figure 5). The Thiessen polygon for each subwatershed showed that the streamflow increased as subwatershed delineation level decreased from high-density to low-density (Figure 5).

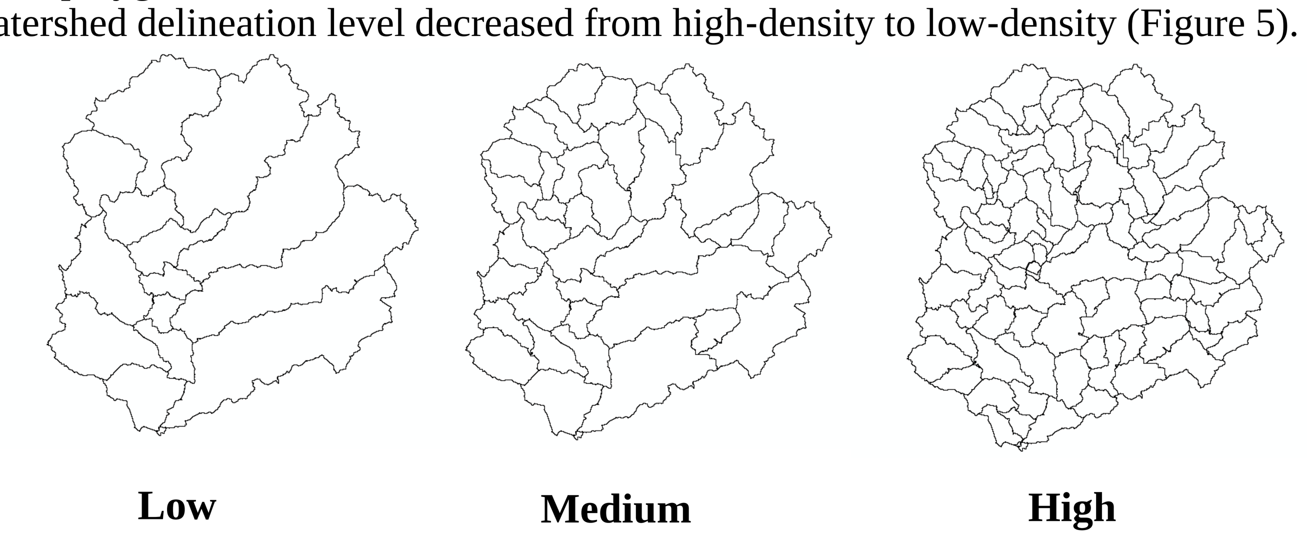

Figure 3: Subwatershed configurations (high, medium, and low density)

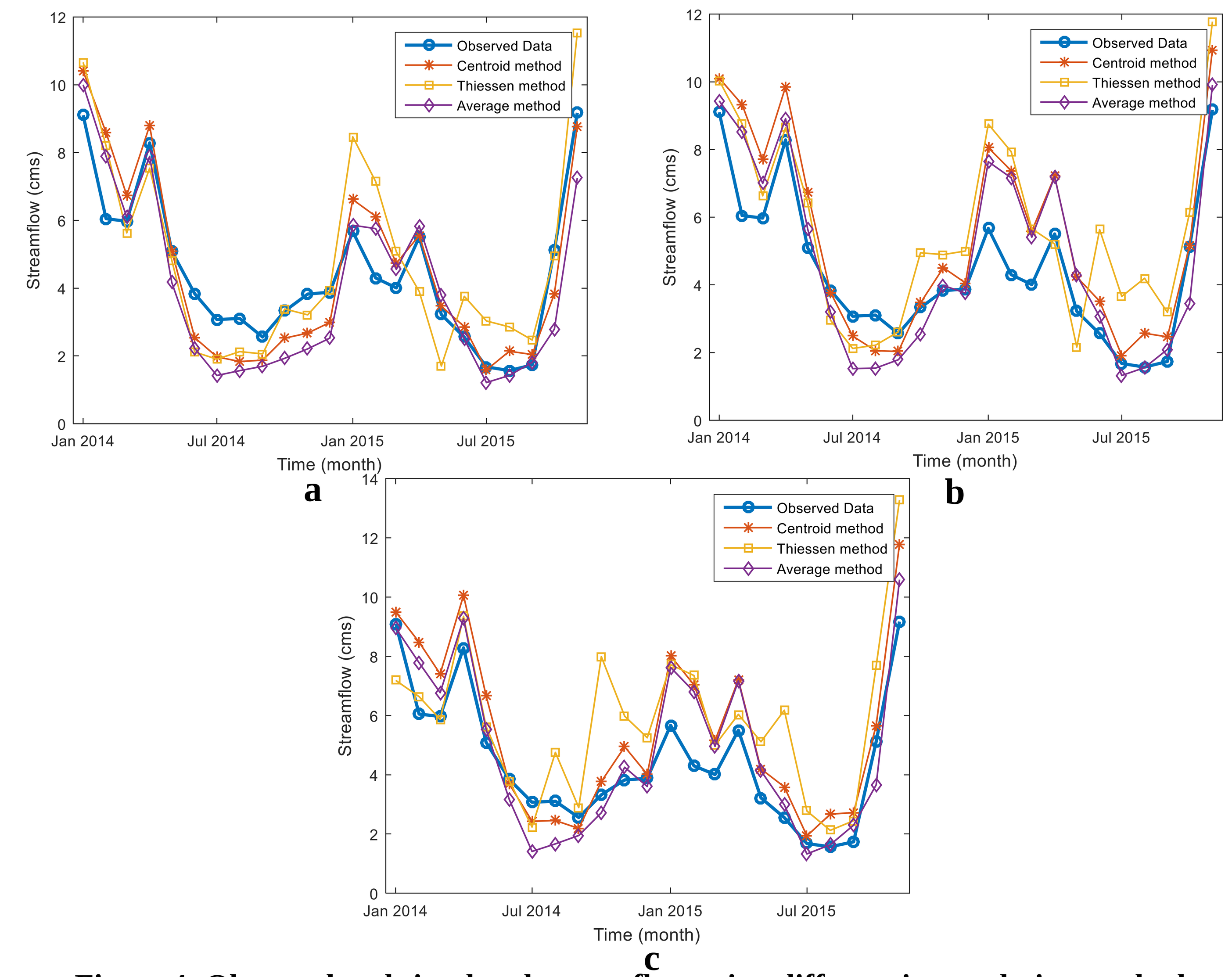

Figure 4: Observed and simulated streamflow using different interpolation methods and subwatershed configurations : (a) low density, (b) medium density, and (c) high density for 2014 and 2015

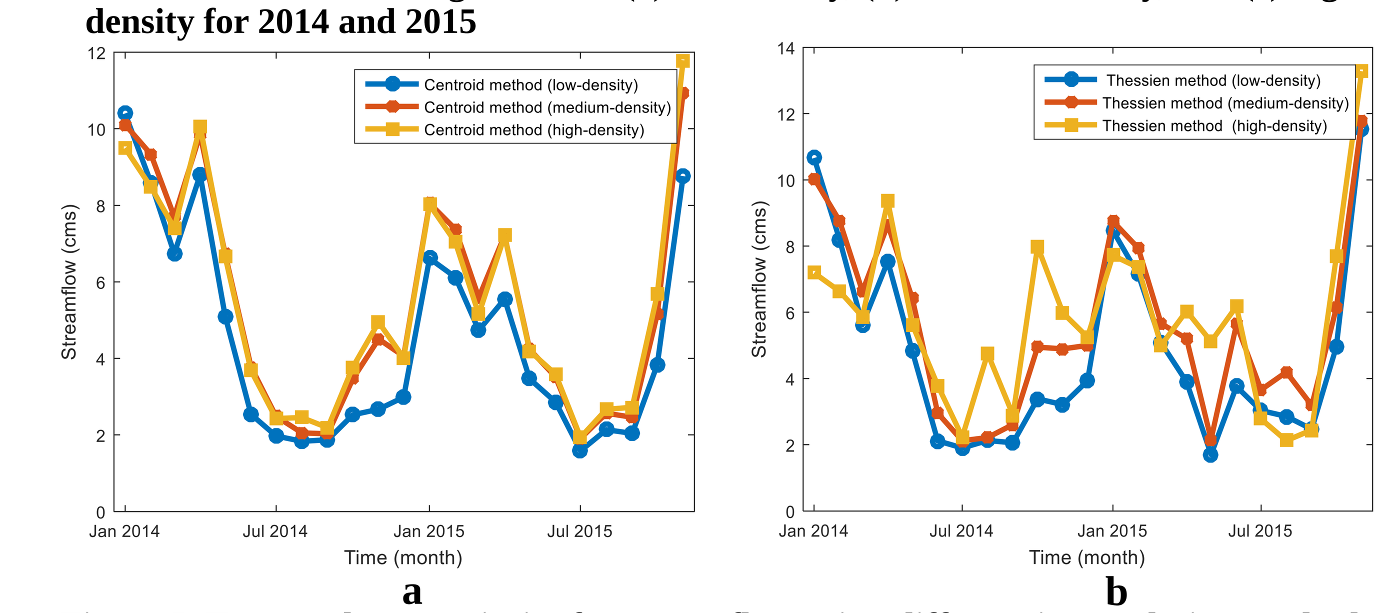

Figure 5. Temporal uncertainties for streamflow using different interpolation methods and subwatershed configurations: (a) Centroid method and (b) Thiessen method.