

Constructing river stage-discharge rating curves using remotely sensed river cross-sectional inundation areas and river bathymetry

*Feifei Pan¹

1. University of North Texas

Remote sensing from satellites and airborne platforms provides valuable data for monitoring and gauging river discharge. One effective approach first estimates river stage from satellite-measured inundation area based on the inundation area-river stage relationship (IARSR), and then the estimated river stage is used to compute river discharge based on the stage-discharge rating (SDR) curve. However, this approach is difficult to implement because of a lack of data for constructing the SDR curves. This study proposes a new method to construct the SDR curves using remotely sensed river cross-sectional inundation areas and river bathymetry. The proposed method was tested over a river reach between two USGS gauging stations, i.e., Kingston Mines (KM) and Copperas Creek (CC) along the Illinois River. First a polygon over each of two cross sections was defined. A complete IARSR curve was constructed inside each polygon using digital elevation model (DEM) and river bathymetric data. The constructed IARSR curves were then used to estimate 47 river water surface elevations at each cross section based on 47 river inundation areas estimated from Landsat TM images collected during 1994-2002. The estimated water surface elevations were substituted into an objective function formed by the Bernoulli equation of gradually varied open channel flow. A nonlinear global optimization scheme was applied to solve the Manning' s coefficient through minimizing the objective function value. Finally the SDR curve was constructed at the KM site using the solved Manning' s coefficient, channel cross sectional geometry and the Manning' s equation, and employed to estimate river discharges. The root mean square error (RMSE) in the estimated river discharges against the USGS measured river discharges is $112.4 \text{ m}^3/\text{s}$. To consider the variation of the Manning' s coefficient in the vertical direction, this study also suggested a power-law function to describe the vertical decline of the Manning' s coefficient with the water level from the channel bed lowest elevation to the bank-full level. The constructed SDR curve with the vertical variation of the Manning' s coefficient reduced the RMSE in the estimated river discharges to $83.9 \text{ m}^3/\text{s}$. These results indicate that the method developed and tested in this study is effective and robust, and has the potential for improving our ability of remote sensing of river discharge and providing data for water resources management, global water cycle study, and flood forecasting and prevention.

Keywords: Landsat TM imagery, digital elevation model, river bathymetry, Manning's equation, river stage and discharge, Bernoulli equation