ArcGIS Python-based Hybrid Hydrologic Model (Distributed-Clark) for Spatially Distributed Rainfall-Runoff Generation and Routing

Younghyun Cho[1, 2] and Bernard A. Engel[2] | Email: yhcho@kwater.or.kr
[1]Hydrometeorological Cooperation Center, K-water (Korea Water Resources Corporation), Gwacheon, Korea, The Republic of
[2]Department of Agricultural and Biological Engineering, Purdue University, West Lafayette, IN 47907

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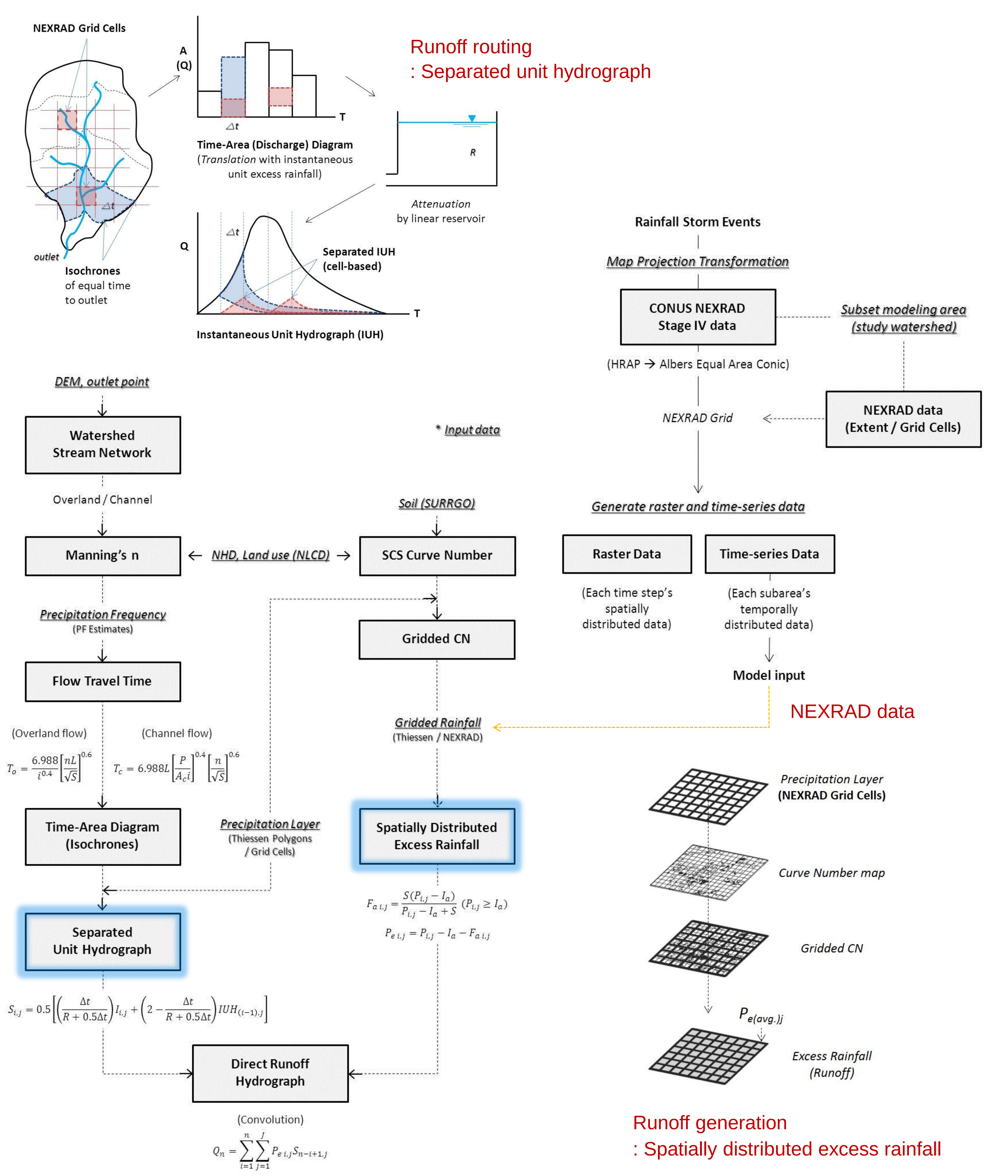
Introduction

- A GIS-based **hybrid hydrologic model** (conceptually lumped and distributed feature model), **Distributed-Clark**, was developed for spatially distributed rainfall-runoff flow prediction (Cho, 2016). In this model, the SCS curve number estimated spatially distributed excess rainfall and GIS-derived time-area diagram (isochrones) based on a set of separated unit hydrographs are utilized to calculate a direct runoff hydrograph.
- Development of the Distributed-Clark model includes four main steps: **watershed pre-processing**, **spatially distributed excess rainfall estimation**, which includes NEXRAD precipitation data processing (Cho and Engel, 2017), **spatially distributed unit hydrograph derivation**, and **direct runoff hydrograph convolution**.
- For this implementation, ArcGIS 10.1 was used as the GIS platform to build and execute the **Python script tools (DistributedClark_10.1; Python Toolbox, storm event ver.)** for each step.

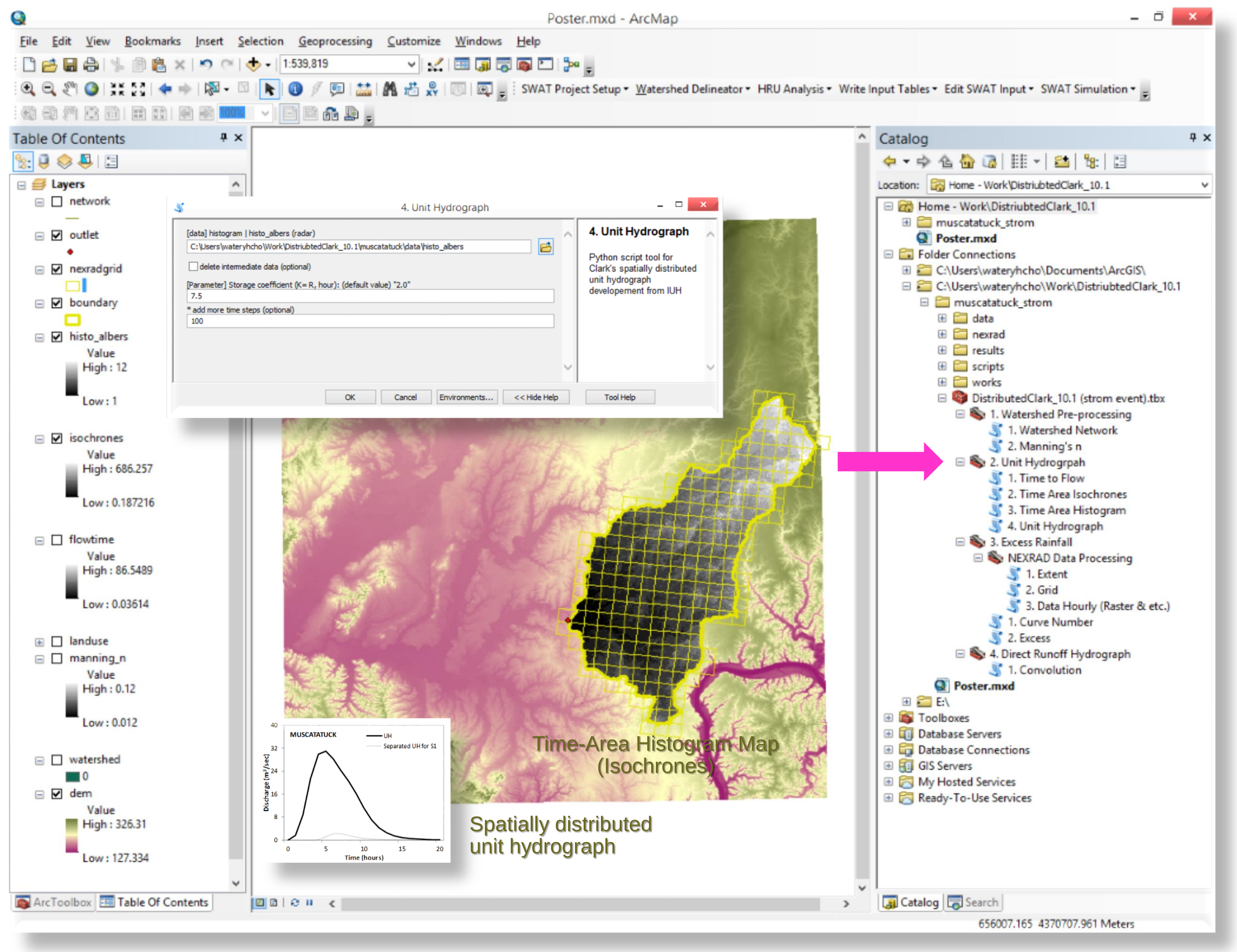
Model Description

- Procedures: Distributed-Clark development & NEXRAD data processing

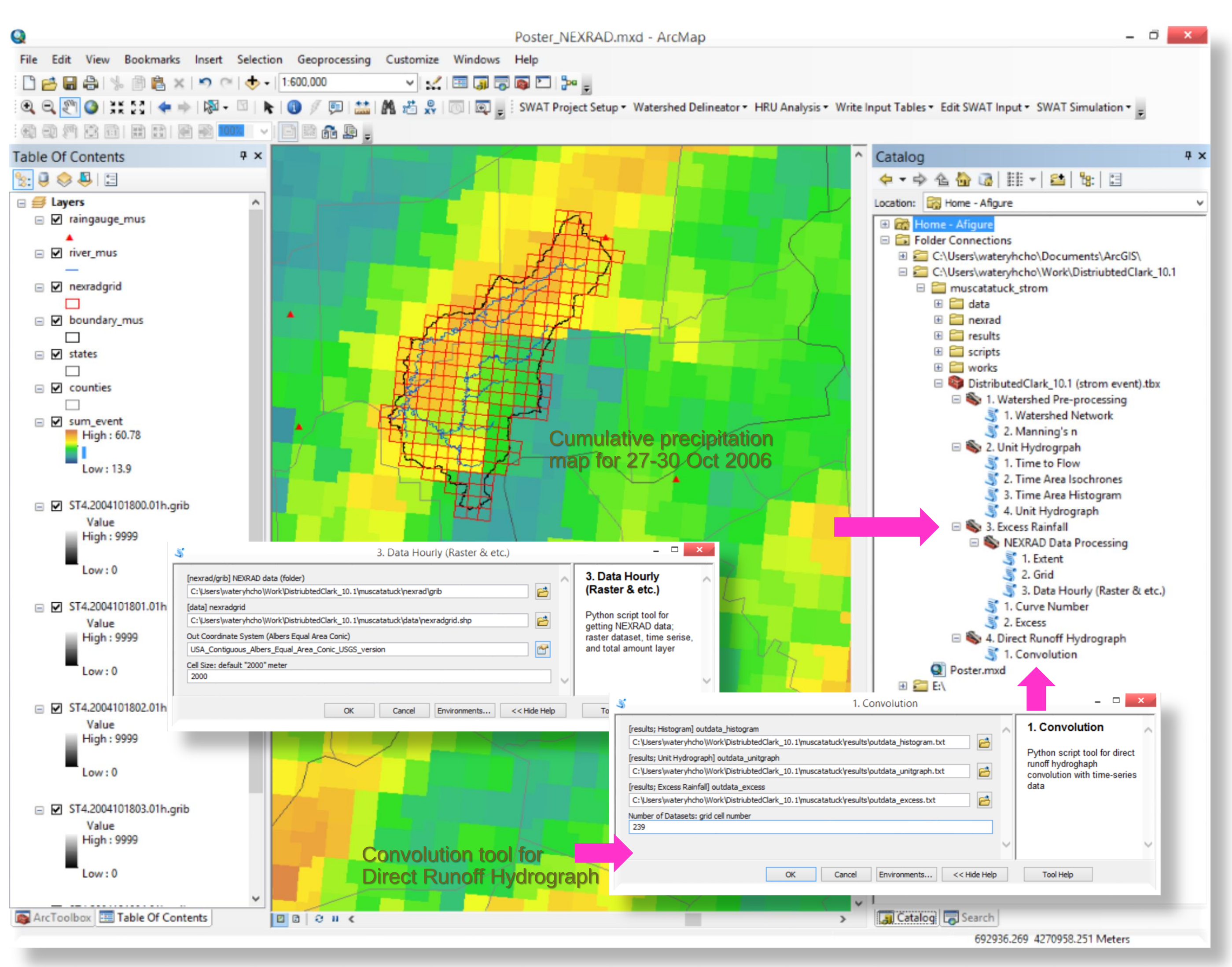


Implementation

- DistributedClark_10.1 (storm event version)
  - Deriving time-area histogram and unit hydrograph using Watershed Pre-processing and Unit Hydrograph Toolbox (Python Script Tools)
  - input data: DEM, outlet point, NLCD land use, and NEXRAD grid

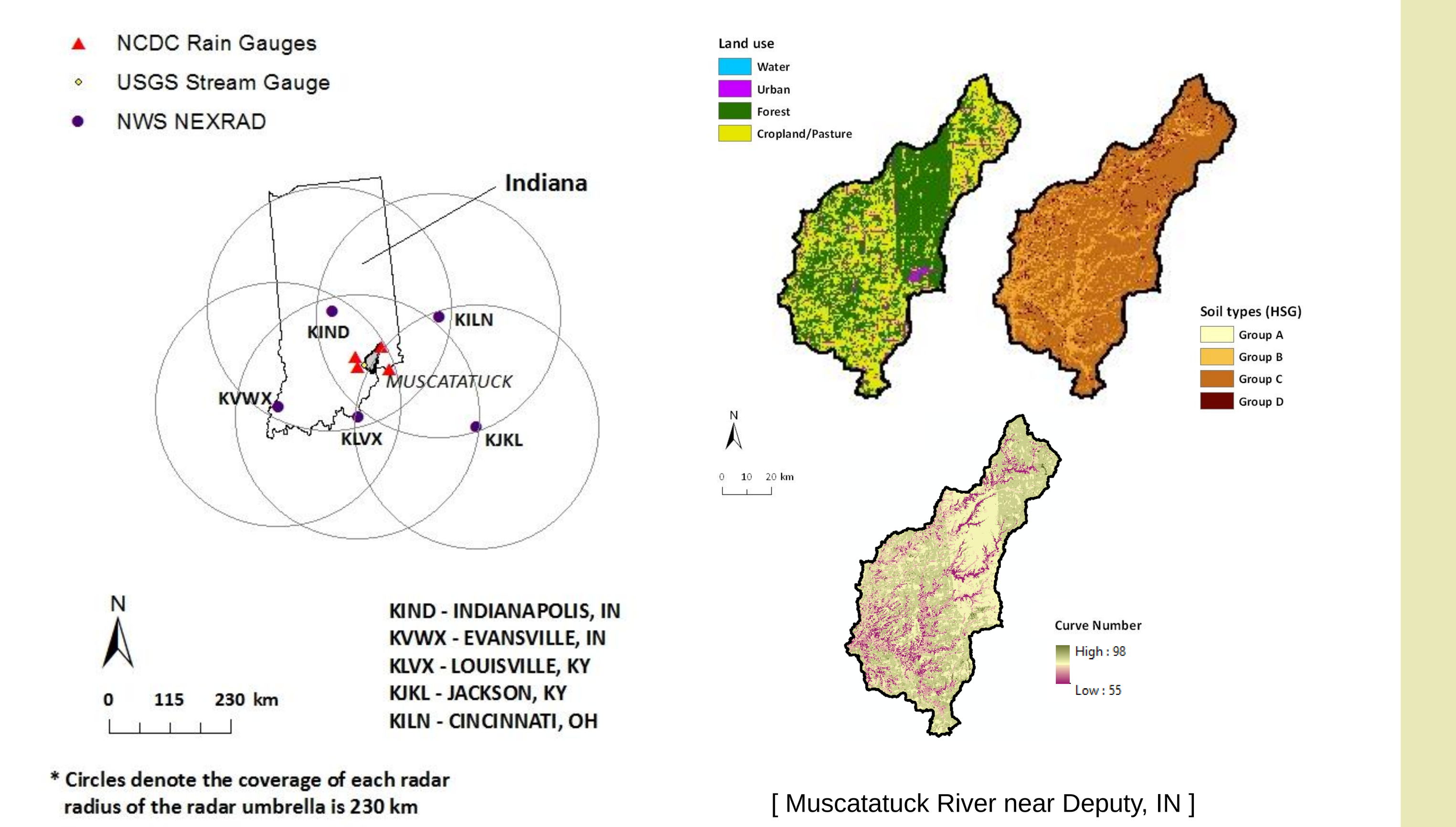


  - NEXRAD precipitation data processing for spatiotemporally varied rainfall inputs; Runoff can be obtained using Excess Rainfall Toolbox
  - input data: NEXRAD NCEP Stage IV product and soil map for CN

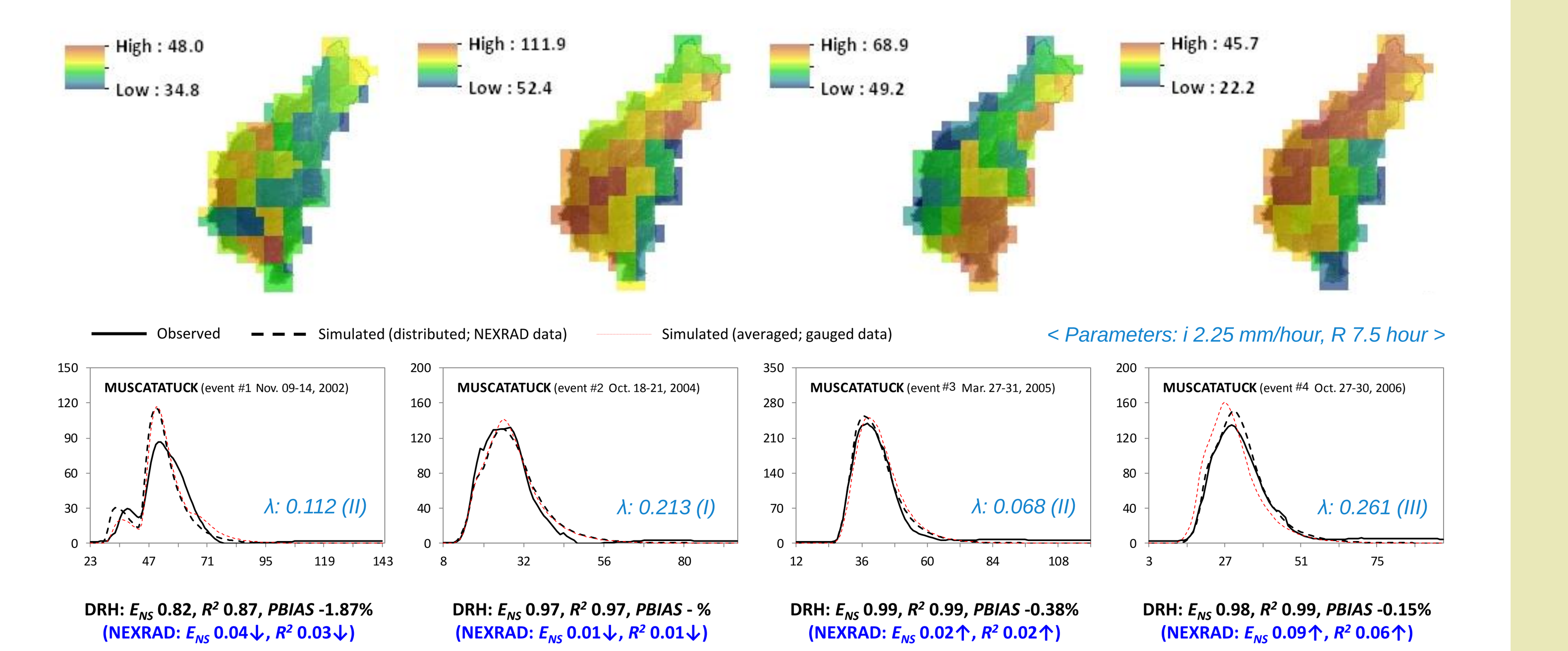


Application

- Watershed, Gauge, Radar Locations, Land use, Soil, and CN map



- Storm event (4 cases, 2002 to 2006) simulation results



Results

- A model case study of single storm event application for a river basin was conducted; the Mucatatuck River near Deputy, IN using NEXRAD precipitation product demonstrated relatively good fit (direct runoff E_{NS} 0.94, R^2 0.96, and *PBIAS* -0.60%) against observed streamflow as well as a slightly better fit (direct runoff; E_{NS} of 0.2% and R^2 1.0%) in comparison with the outputs of spatially averaged rainfall data simulations.

References

- Cho, Y., 2016: Development and evaluation of a watershed-scale hybrid hydrologic model. Ph.D. dissertation, Dept. of Agricultural and Biological Eng., Purdue University, 211 pp.
- Cho, Y. and B. A. Engel, 2017: NEXRAD Quantitative Precipitation Estimations for Hydrologic Simulation Using a Hybrid Hydrologic Model. *J. Hydrometeor.*, 18, 25-47.