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

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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 $E_{DRH}$ 0.94, $R^2$ 0.96, and PBIAS -0.60%) against observed streamflow as well as a slightly better fit (direct runoff; $E_{DRH}$ of 0.2% and $R^2$ 1.0%) in comparison with the outputs of spatially averaged rainfall data simulations.

References