Distributed Flood Frequency Analysis Using Stochastic Storm Transposition and 2D HEC-HMS

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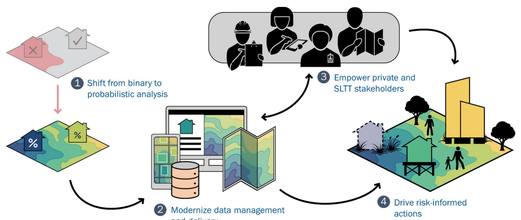
Motivation

FEMA's Future of Flood Risk Data initiative emphasizes a shift from binary to graduated risk analysis, analyzing hazards at any location in a watershed where development has or will occur.

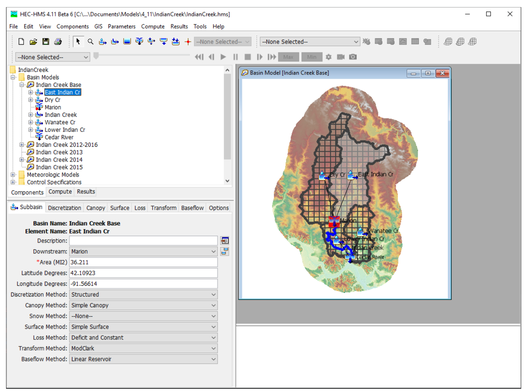
Poster SY45C-0653 Thursday, 15 December 2022 14:45 - 18:15



The four major elements of the FEMA Future of Flood Risk Data initiative. FFRD is an agile series of exploratory projects designed to help define the future direction of the mapping program.

HEC-HMS

The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) is a flexible and scalable hydrologic modeling platform that allows a modeler to choose the most appropriate hydrologic and meteorologic methods for simulating watershed processes.



The HEC-HMS user interface is used to build and modify hydrologic models, complete simulations, and visualize results. It includes integrated geographic information systems capabilities including watershed delineation and parameter estimation.

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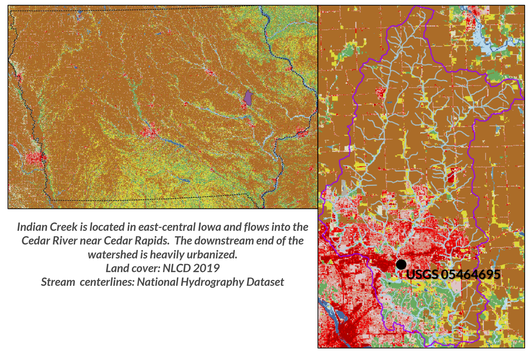
Study Area

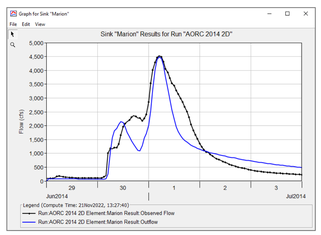
Indian Creek is a 93 mi^2 tributary to the Cedar River in Linn County, IA. It is a mixed agricultural-urban watershed in east-central Iowa with a USGS streamgage in the city of Marion.



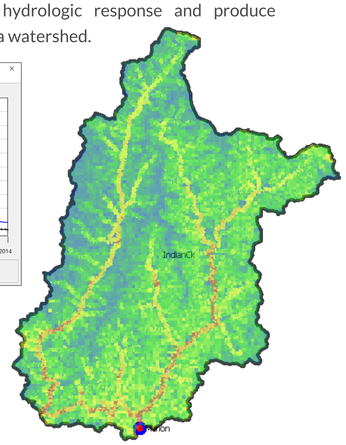
Indian Creek is located in east-central Iowa and flows into the Cedar River near Cedar Rapids. The downstream end of the watershed is heavily urbanized.
Land cover: NLCD 2019
Stream centerlines: National Hydrography Dataset

2D Diffusion Wave Transform

HEC-HMS uses the 2-dimensional diffusion wave transform engine from HEC-RAS to route excess precipitation. This allows HMS to capture the nonlinearity in hydrologic response and produce inundation results throughout a watershed.



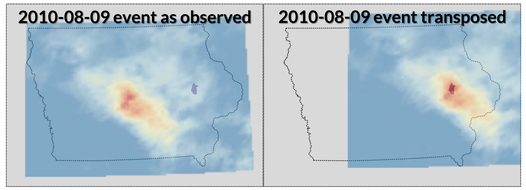
Flow hydrograph and maximum hydraulic depth for the 2014-06-30 flood event in Indian Creek.



Stochastic Storm Transposition

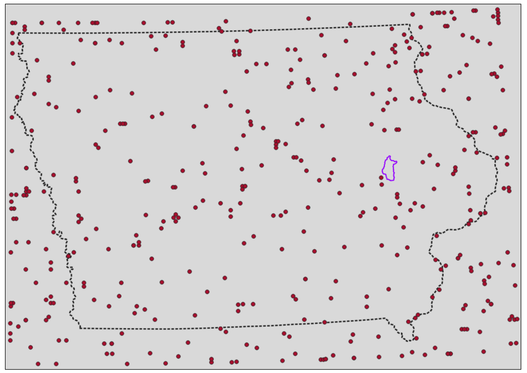
Stochastic Storm Transposition (SST; Foufoula-Georgiou 1989) is a method for non-parametric space-for-time substitution for watershed precipitation-frequency analysis. Modern SST utilizes catalogs of multi-sensor precipitation observations for storms in a homogeneous transposition domain to develop watershed-averaged precipitation-frequency relationships. SST requires fewer assumptions than traditional design storm modeling for flood frequency analysis.

HEC-HMS implements SST using its Uncertainty Analysis feature, randomly varying storm events and the location of their transposition within a domain.



Storm Catalog

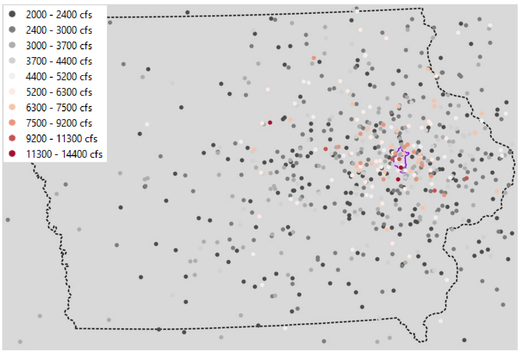
A storm catalog was developed from the AORC 4 km precipitation dataset (Kitzmiller, et al. 2018) from the 10 largest 100 mi^2 72-hour storms from each year of the period of record (1979-2022.)



Storm centers for the 10 largest 72-hour 100 mi^2 accumulations based on point maximum rainfall.

SST Simulation

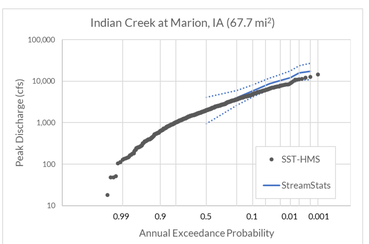
10,000 randomly-sampled storm events were transposed with a uniform distribution in x and y coordinate across the domain. Initial soil moisture was sampled from an exponential distribution.



Heatmap for 699 transpositions resulting in greater than the 2-year flow (1,960 cfs) at Marion

Flow Frequency Results

The simulation results below are based 10,000 transpositions (10/year) using a calibrated model based on a conventional Clark synthetic unit hydrograph and random initial conditions. The results demonstrate need for application of 2D diffusion wave or variable Clark UH to capture nonlinearity in runoff response. The agreement between StreamStats and the simulated results is in the range of the flow magnitudes where the model was calibrated.



Annual maximum flow frequency curve for the Marion, IA USGS gage compared to flow frequency estimates from USGS StreamStats.

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