Process-Based Flood Frequency Analysis (FFA) using Stochastic Storm Transposition and WRF-Hydro

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Summary

- We present a flood frequency analysis framework that couples Stochastic Storm Transposition (SST) with high-resolution radar rainfall data and the WRF-Hydro distributed hydrologic model
- SST generates a large number of realistic extreme rainfall scenarios by temporal resampling and spatial transposition of observed storms
- The framework allows the exploration of interactions between spatial and temporal rainfall structure with watershed properties, and translation into flood frequency estimates across the entire river network
- The process-based FFA approach holds potential for understanding flood frequency in nonstationary conditions and across scales

Process-Based FFA Framework:

RainyDay (Stochastic Storm Transposition) + WRF-Hydro

Preprocessing
Set up WRF-Hydro based on NWM configuration

WRF-Hydro MODELING SYSTEM

RAINY DAY

Model Calibration
- Water balance
- Peak flow
- Soil moisture

Long-term simulation
Provides antecedent conditions for event-based simulation ("Hot Start")

Rainfall scenarios
- Realistic rainfall scenarios
- Spatially and temporally varied rainfall structure

CENTER FOR HIGH THROUGHPUT COMPUTING

The CHTC at UW-Madison supports computing resources for this project.

Event-based simulation
- Massive-scale grid computing
- "Server-side" postprocessing

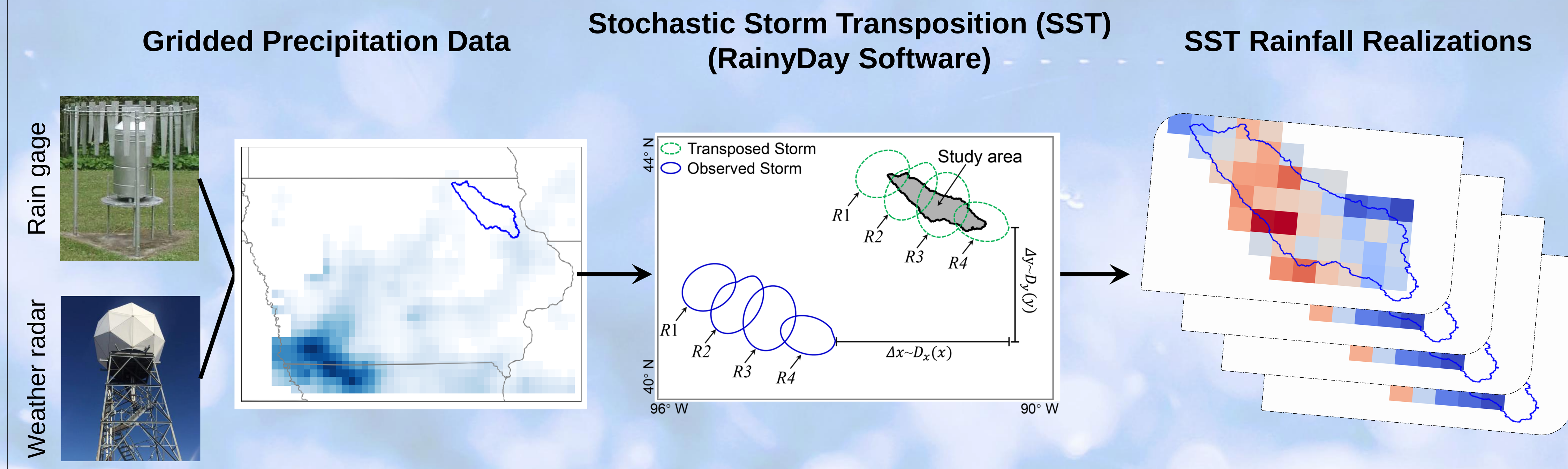
High Throughput Computing (HTC), breaks up a large computational task into many smaller tasks. Ideal for Monte Carlo problems.

Flood Frequency Analysis
- Results across entire river network
- Flood volume analysis
- Analyze the impacts of rainfall, soil moisture, etc. on flood frequency

Step 1: Long-term continuous rainfall-runoff simulation.
Step 2: Deriving SST based realistic rainfall scenarios.
Step 3: Event-based peak flood simulation.

Scan QR code to visit RainyDay website !

Key Result 1: Generating extreme precipitation scenarios

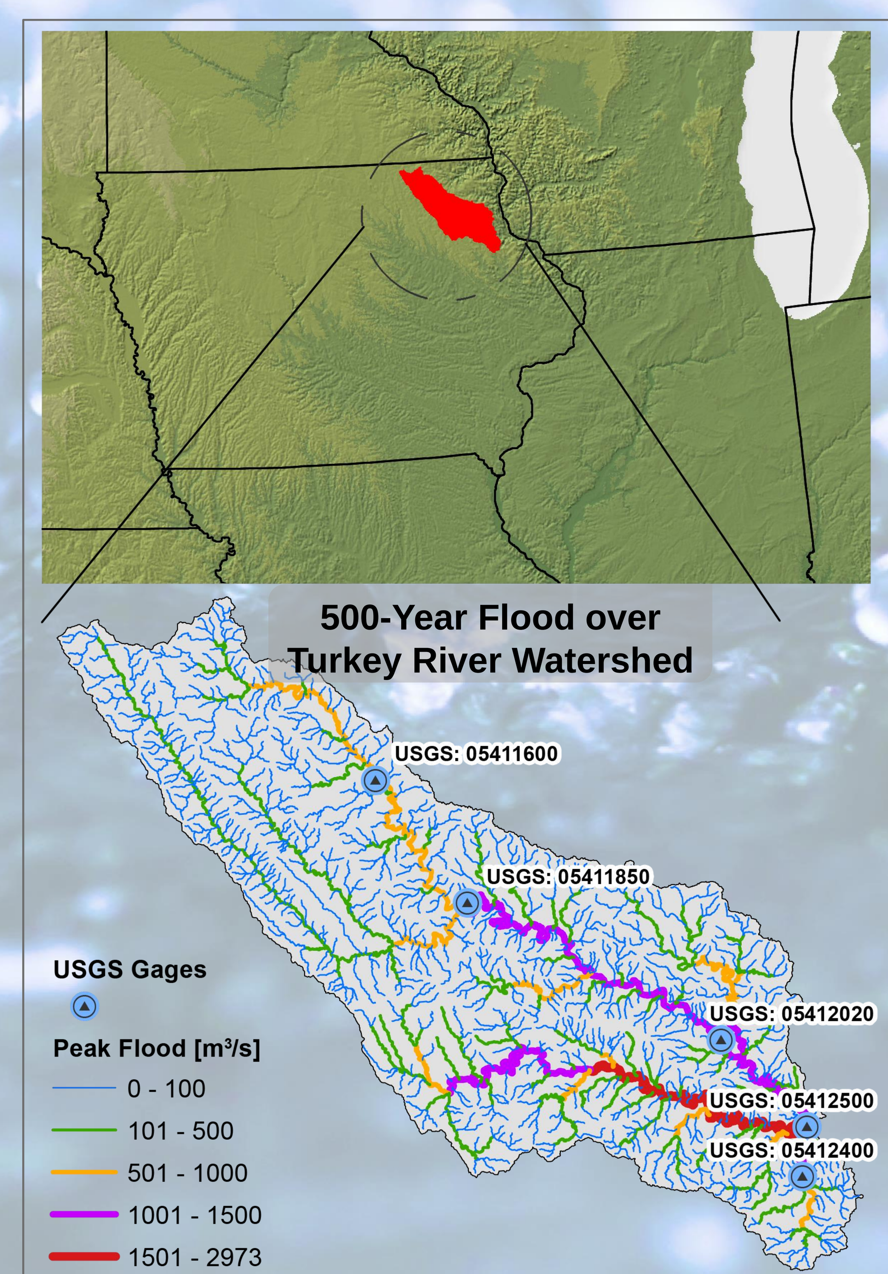


Key feature: SST rainfall realizations do not require any assumptions regarding the spatial and temporal structure of rainfall.

Findings:
Resampling and transposing of observed rainstorms from the surrounding region makes it feasible to generate extreme precipitation scenarios using relatively short rainfall records.

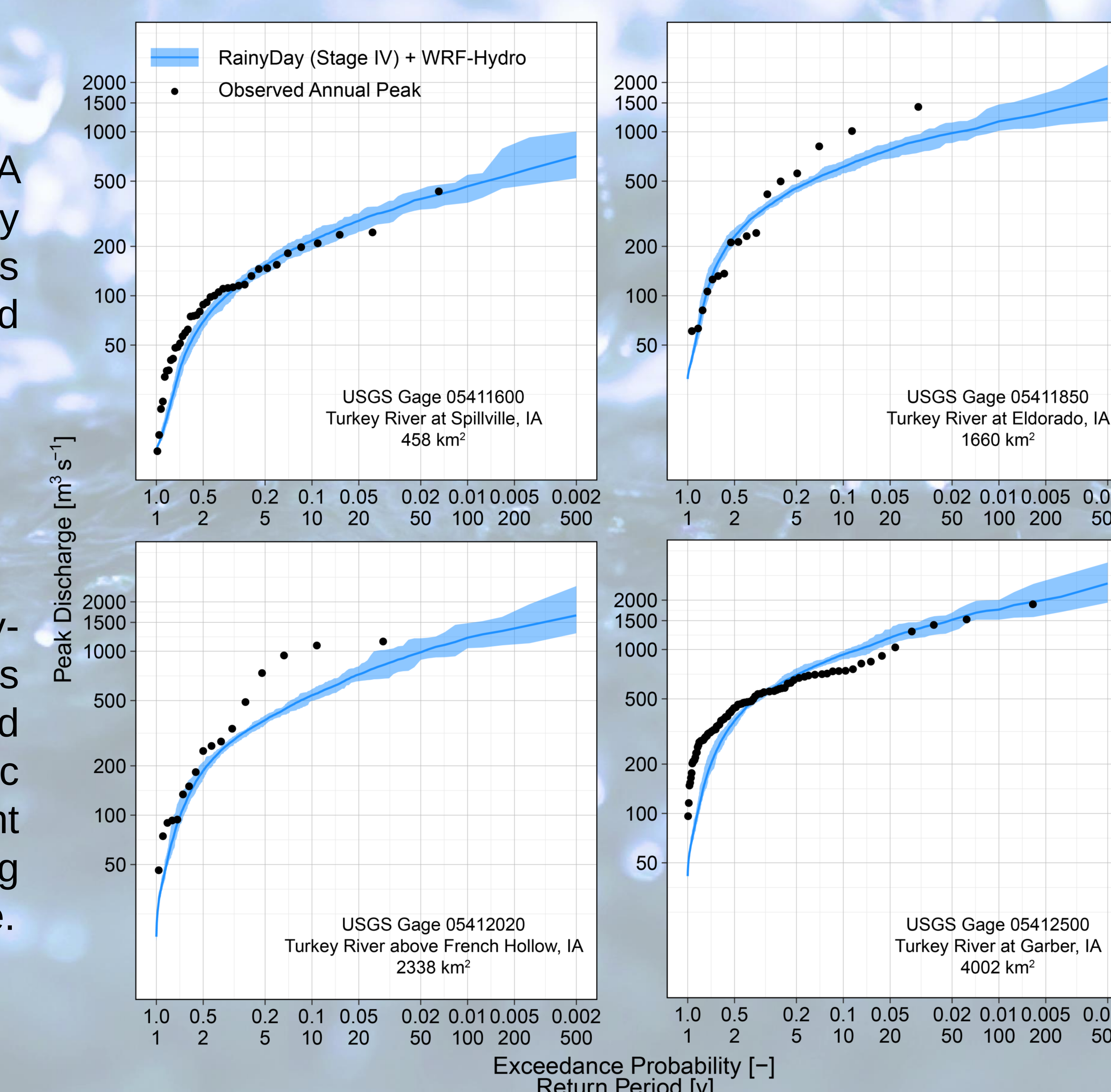
SST: It is a bootstrap method that aims to effectively "lengthen" the rainfall records by performing "space-for-time substitution" within a rigorous probabilistic framework.

Key Result 2: Estimating flood frequency over the entire watershed



Turkey River, Iowa:
The "process-based" FFA approach is applied in Turkey River in Iowa, a watershed that is undergoing climatic and hydrologic change.

Findings:
WRF-Hydro "fills in" poorly-observed geospatial variables (such as soil moisture) and enables more realistic representation of important characteristics like changing land use and rainfall structure.



Next Steps:

- Expand process-based approach to improve understanding of flood generation drivers: Initial soil moisture, rainfall structure, watershed morphology, seasonality, etc.
- Expand SST methodology for examining spatial scaling properties in rainfall and flood response.

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Related Publications:

- Yu, G., Wright, D. B., Zhu, Z., Smith, C., and Holman, K. D.: Process-Based Flood Frequency Analysis in an Agricultural Watershed Exhibiting Nonstationary Flood Seasonality, *HESS*, in review, 2018.
- Zhu, Z., Wright, D. B., Yu, G.: The impact of rainfall space-time structure in flood frequency analysis. *WRR*, 2018