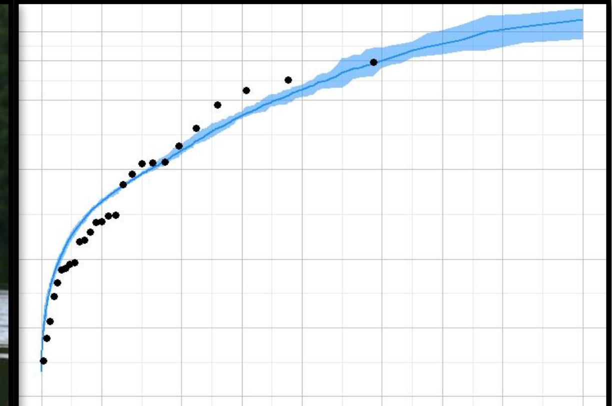
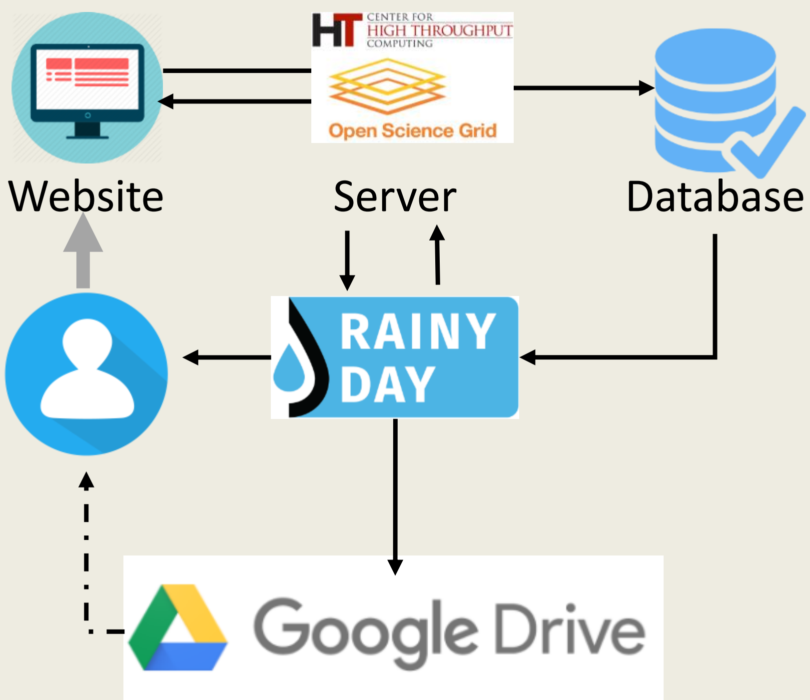


Application of Stochastic Storm Transposition and Hydrologic Modelling to Flood Frequency Analysis:

A Case Study for Turkey River, Iowa



Guo Yu

Civil & Environmental Engineering

University of Wisconsin-Madison

RESEARCH QUESTION

- Can we develop a new framework which can be used to derive robust flood frequency analysis ?

- Tring to understand the role of rainfall and antecedent conditions in deriving flood frequency analysis.

OUTLINE

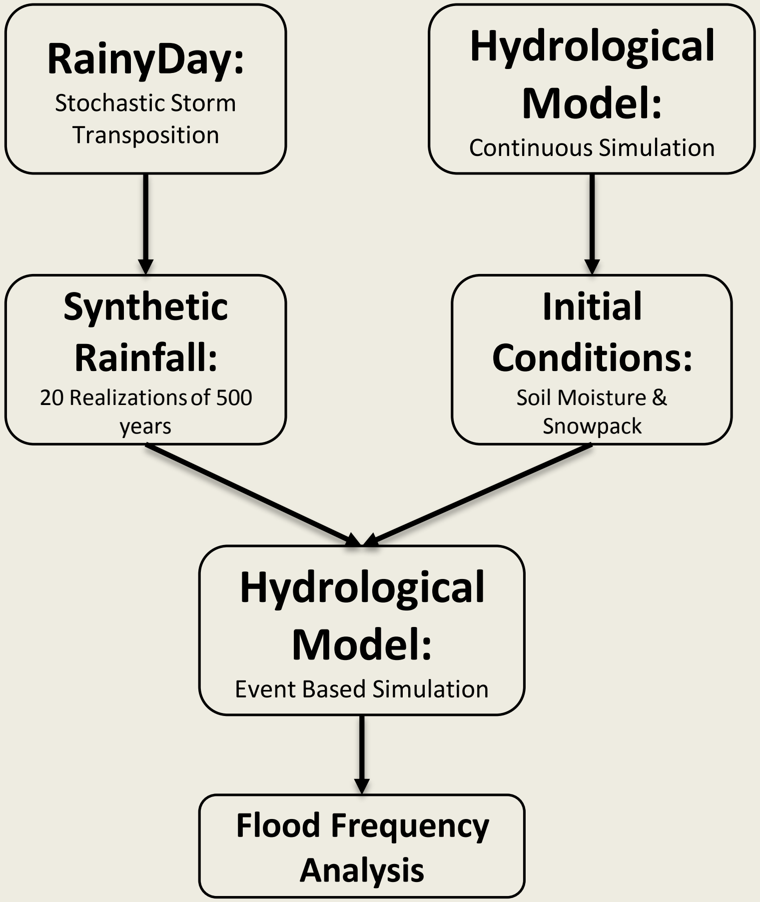
I. Conventional Methods:
   - Limitations

II. RainyDay:
   - Stochastic Storm Transposition

III. Hydrological Modelling:
   - Coupled with RainyDay

IV. Case Study:
   - Hydroclimatology of Turkey River Basin
   - Derived Flood Frequency Analysis

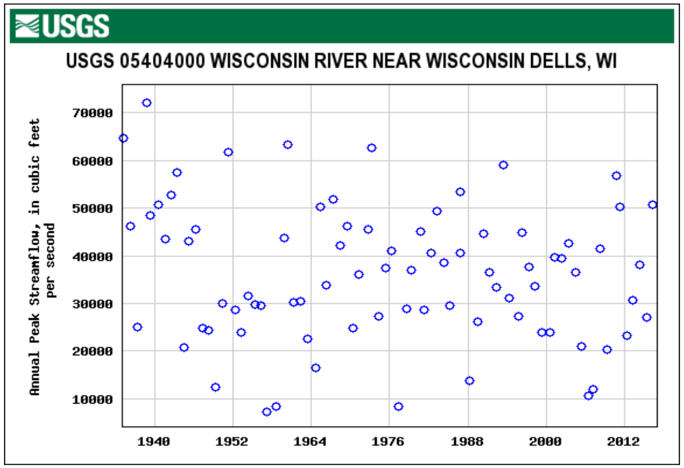
A New Framework

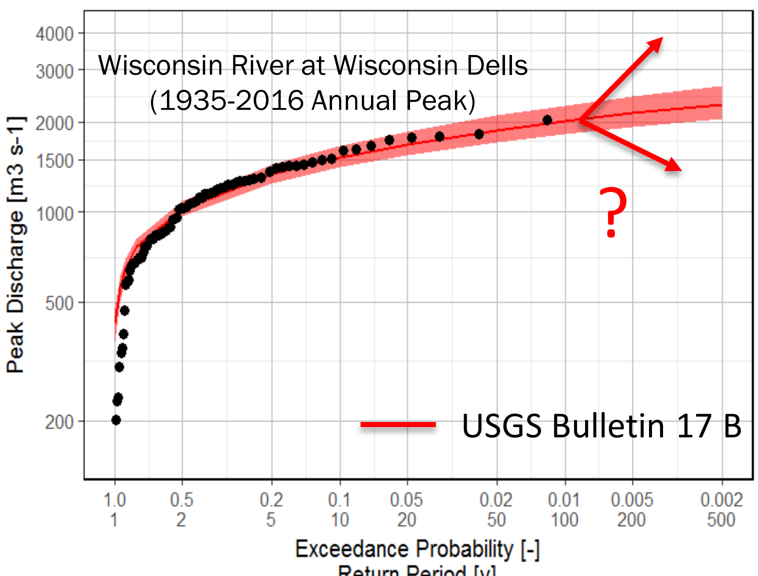


Existing methods of flood frequency analyses

- Statistical Modelling Approach
  - Annual Peak flows
  - Peak over threshold
  - Regional Analysis
- Hydrological Modelling Approach
  - Design Storm Approach
  - Continuous Simulation
  - Joint Probability Approach

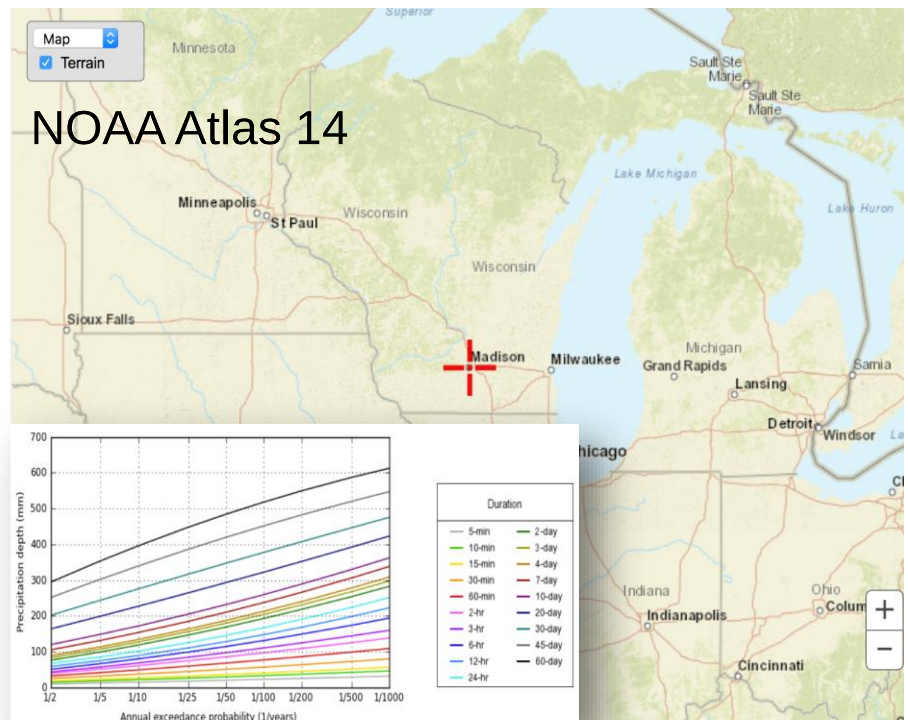
Statistical





Hydrological

Select probability of occurrence → Determine rainfall duration and intensity → Assume spatially uniform rainfall → Apply hydrologic model



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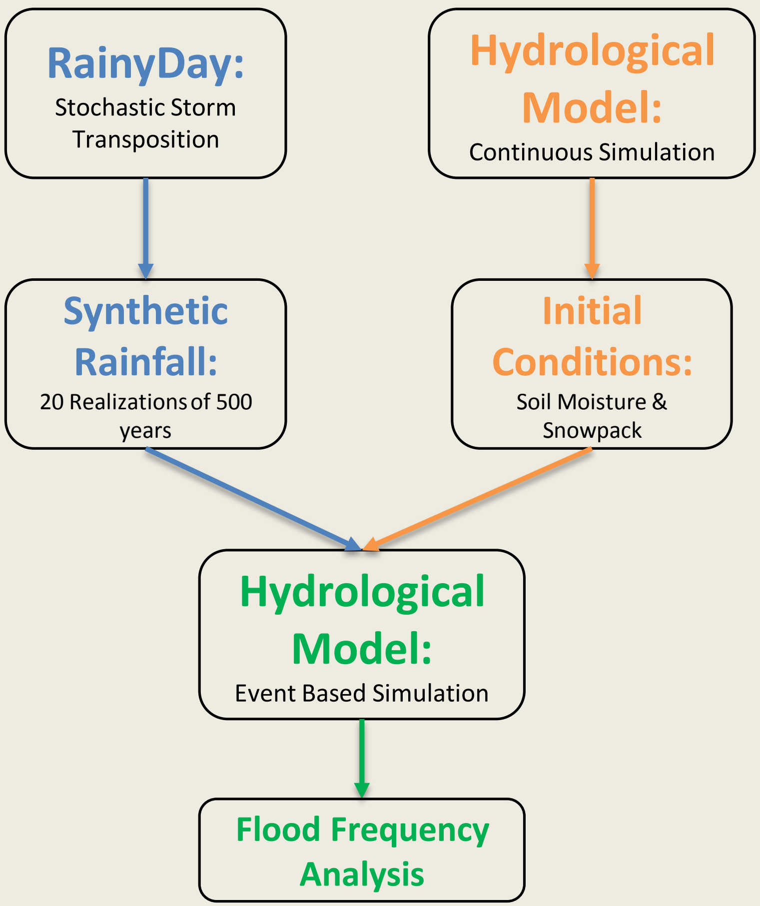
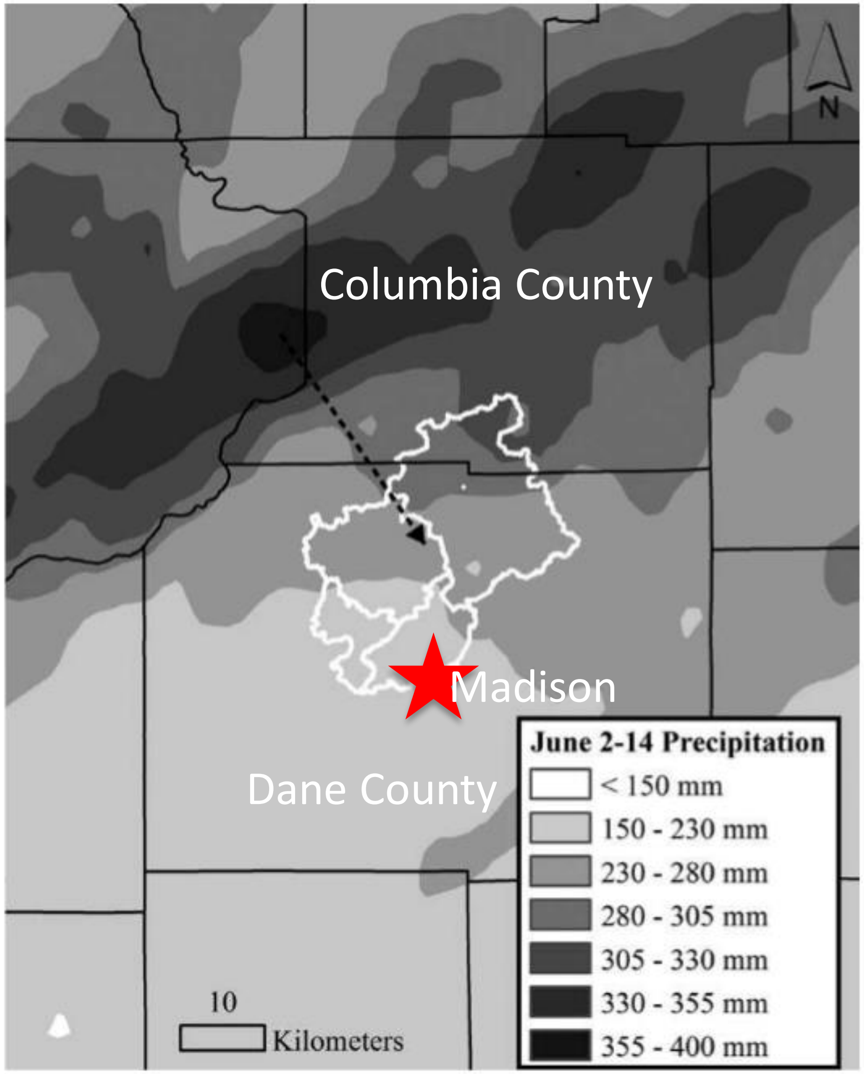


Stochastic Storm Transposition (SST)

Storm Transposition + dynamical flood simulations

Gives "worst case scenarios," but not the likelihood that they happen…



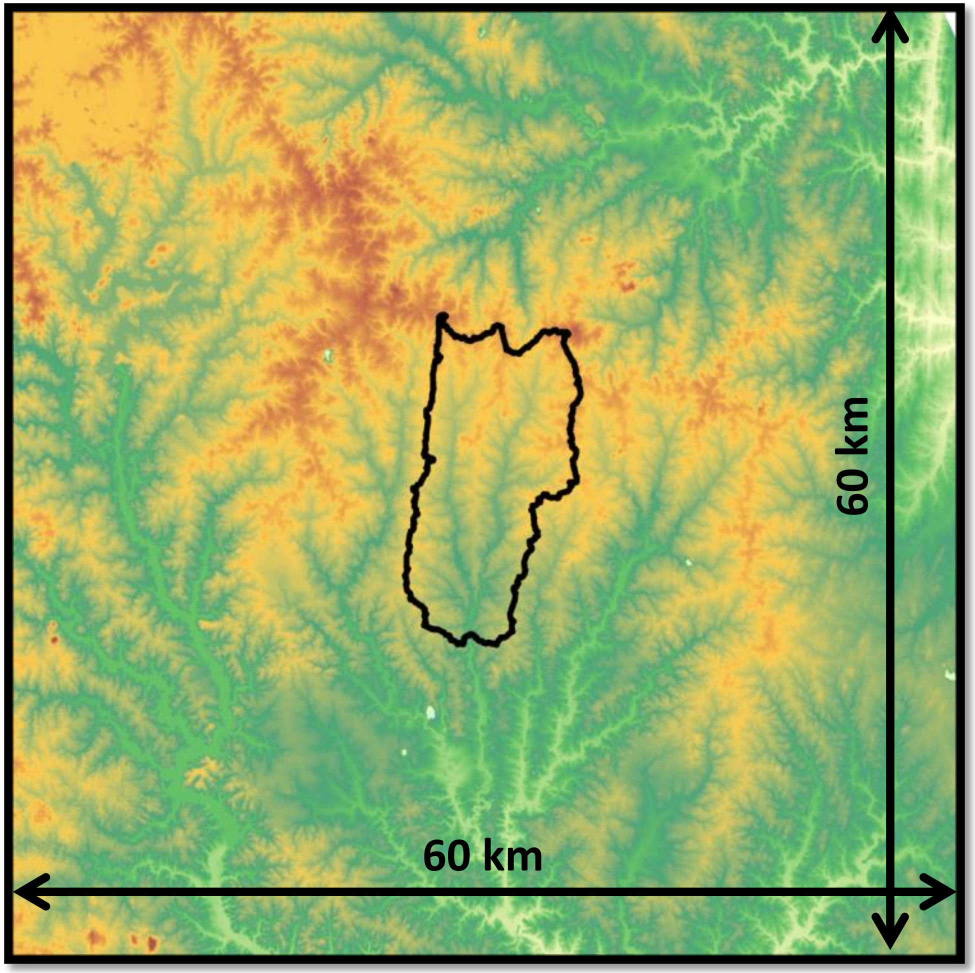
Hayden, N. G., K. W. Potter, and D. S. Liebl (2016). Evaluating Infiltration Requirements for New Development Using Extreme Storm Transposition: A Case Study from Dane County, WI. *JAWRA*

Stochastic Storm Transposition (SST)

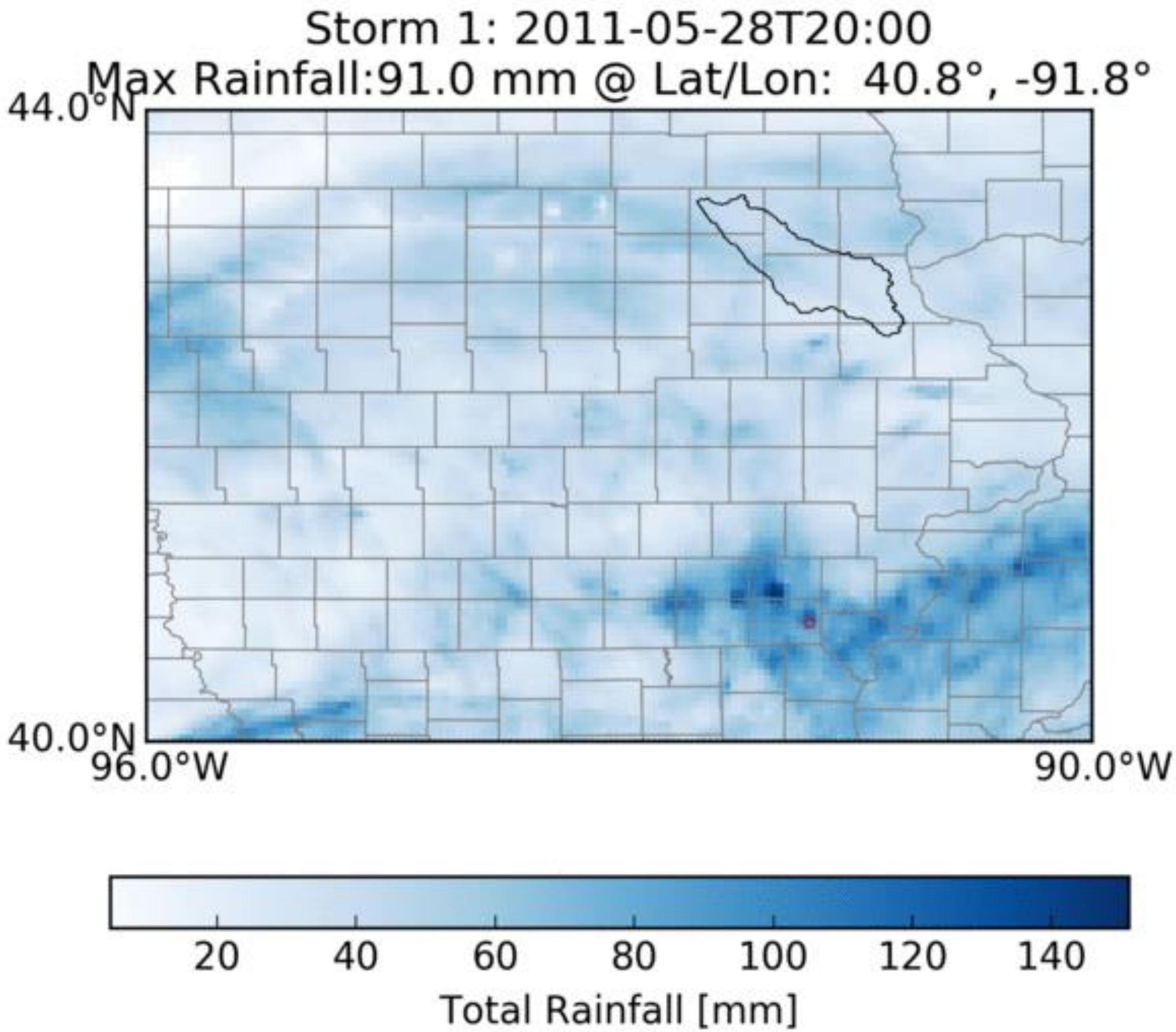
Identify storms:

1. Define a larger "domain" that contains watershed

2. Identify largest X rain events from the N-year remote sensing record → **"Storm Catalog"**



RainyDay Application: Turkey River Basin



Stochastic Storm Transposition (SST)

Transpose storms:

3. Randomly select a storm from catalog and randomly move its starting location

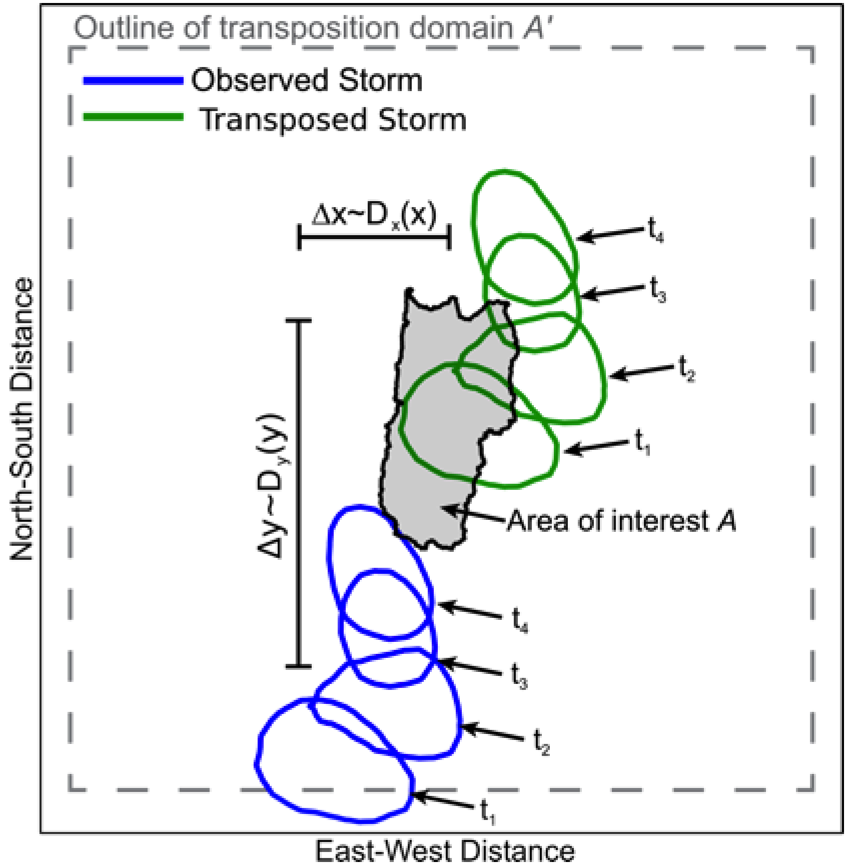
4. Calculate the resulting rainfall over the watershed

Repeat:

5. Repeat steps 3-4 *k* times, where:

   k ~ Poisson(λ=X/N storms/year)

6. Repeat step 5 to generate thousands of synthetic rainfall scenarios

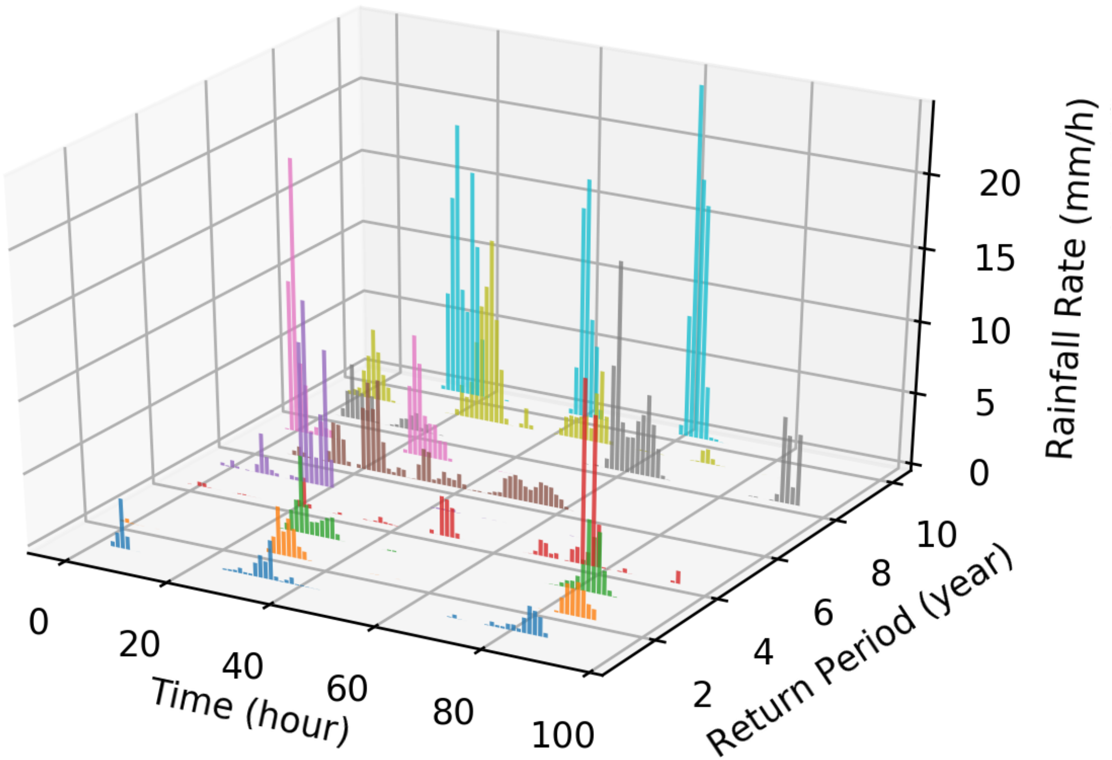


RainyDay Application: Turkey River Basin

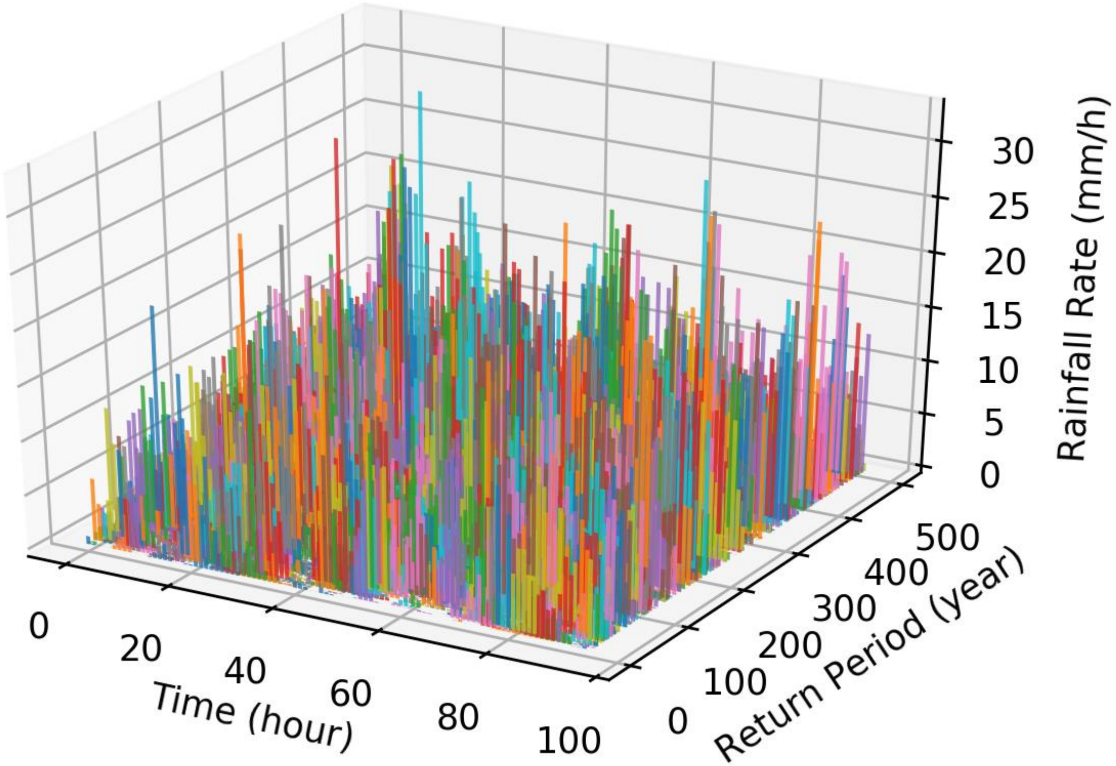
A synthetic year:

- *k* events/year
- *k* ~ *Poisson*
- The largest of these k events is analogous to an annual rainfall maximum

Synthetic annual rainfall maximum



RainyDay Application: Turkey River Basin

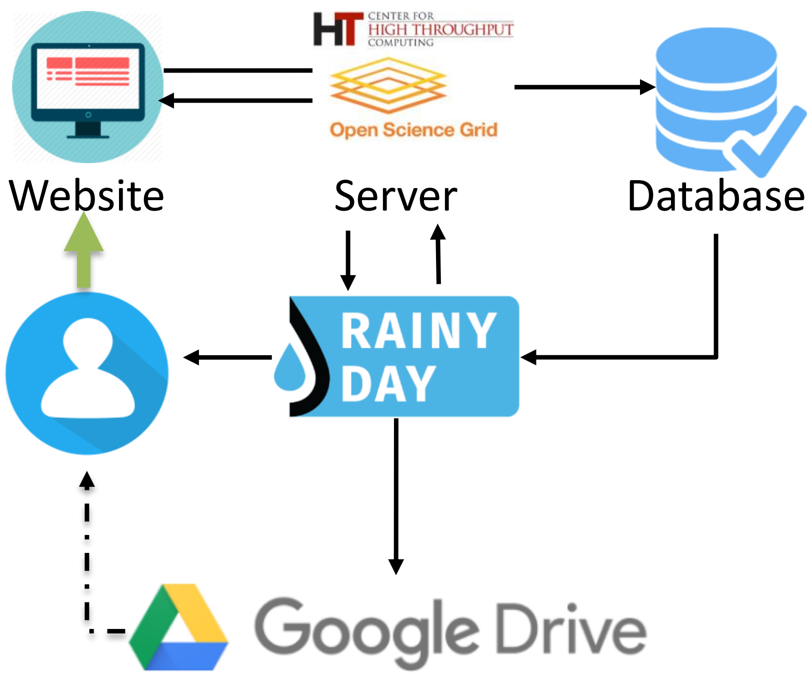


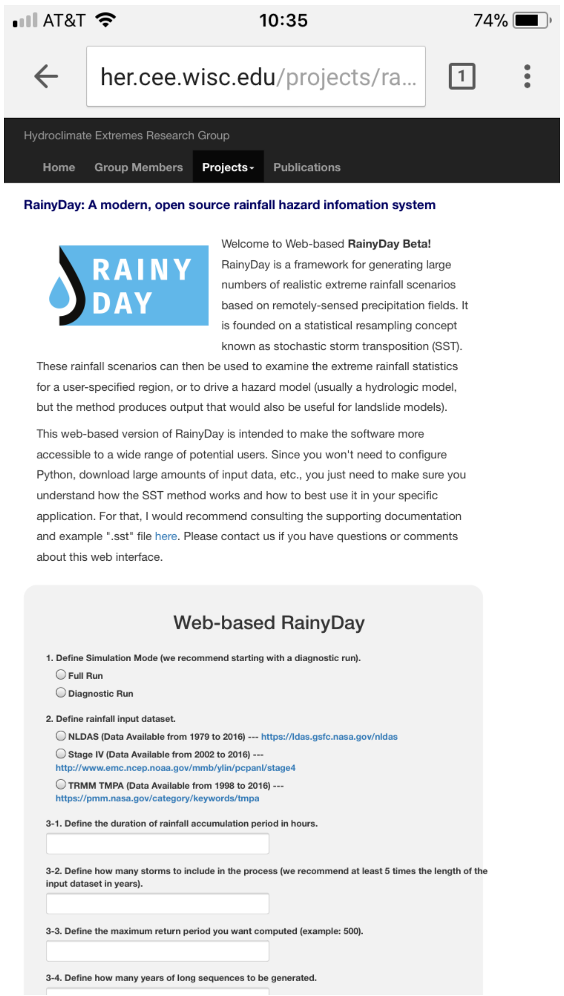
Output Format

- Basin Averaged Rainfall Time Series (.txt, .csv, etc.)
- Realistic, Spatially Distributed Rainfall (netcdf)

Web RainyDay: Accessible to Everyone

her.cee.wisc.edu/projects/rainyday





Project funded by US Bureau of Reclamation

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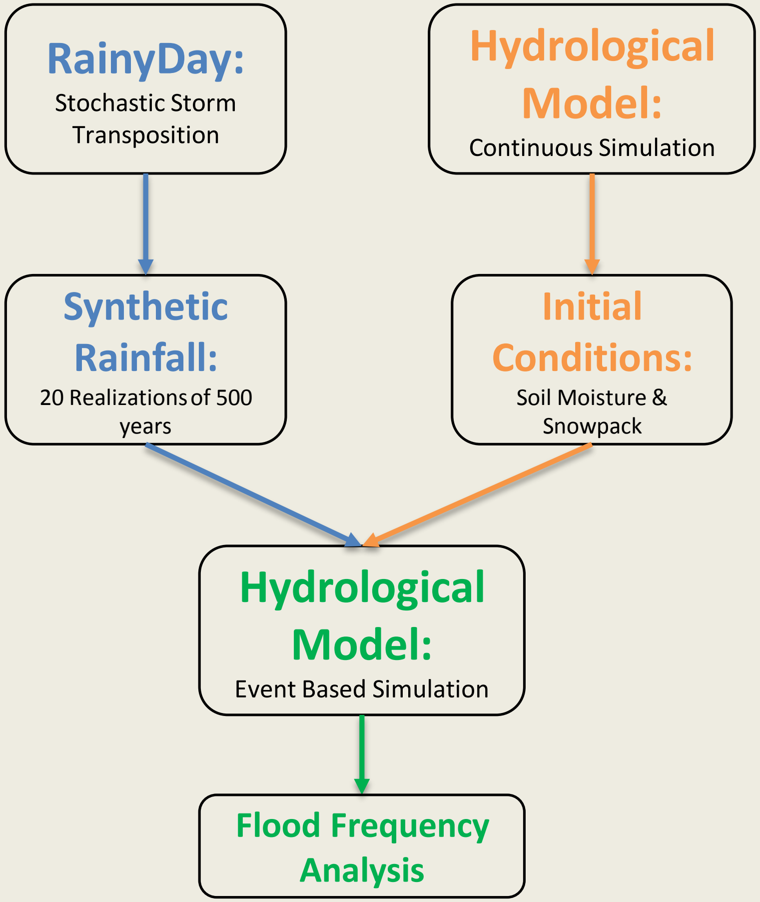
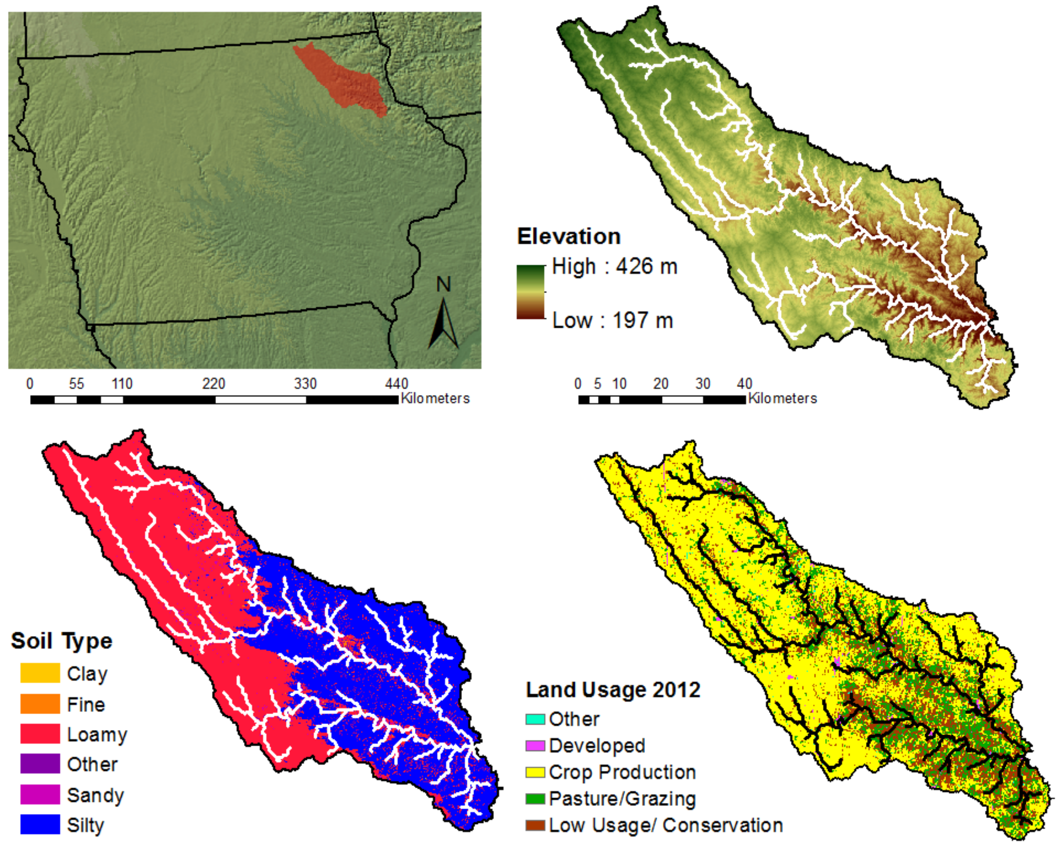


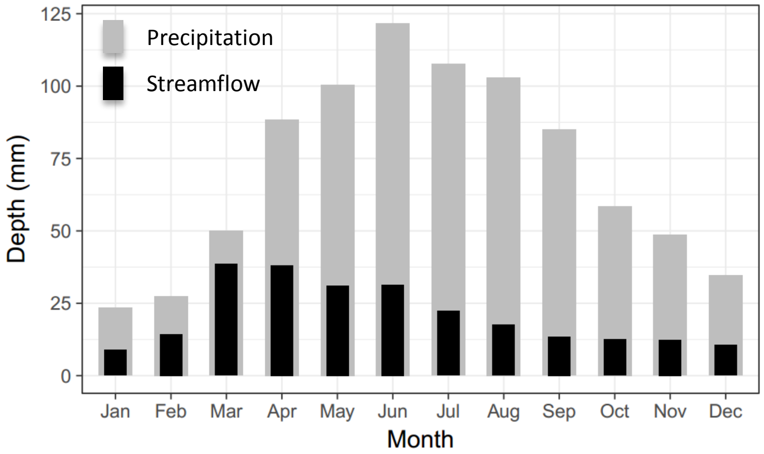
A Case Study for Turkey River, Iowa

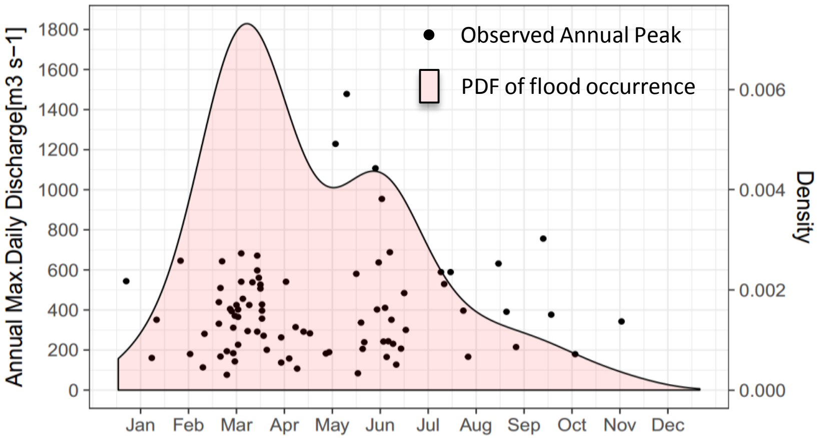
- Located in the northeastern corner of Iowa
- 1545 square miles
- 76% of the land is used for crops and grazing



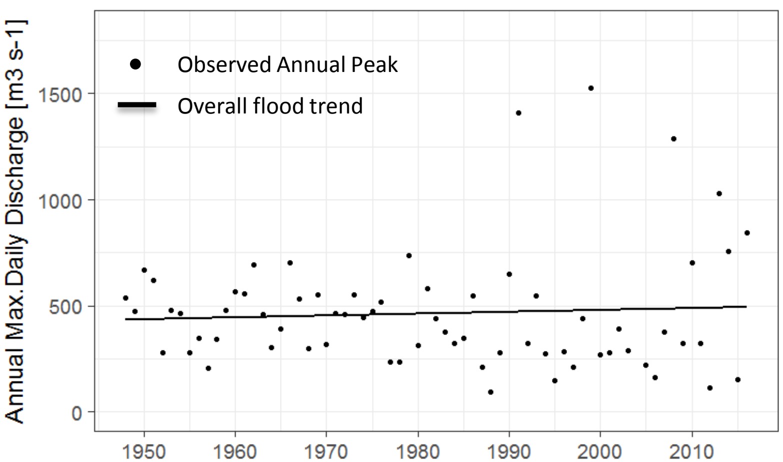
Hydroclimatology of Turkey River Basin

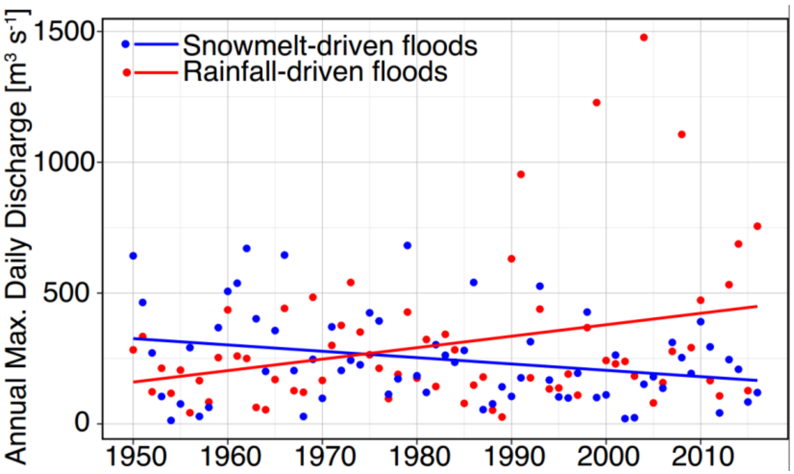
- Seasonality





- Trend Analysis





A Case Study for Turkey River, Iowa

Stage IV Rainfall Data
(2002-2016)

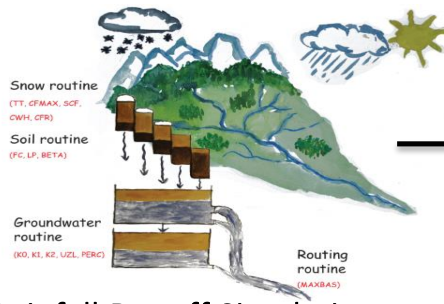
RAINY DAY

Stochastic Storm Transposition

20 Realizations:
500 year synthetic rainfall data

- Stage IV Rainfall Data
- USGS Stream flow
- NOAA temperature data

(2002-2016)

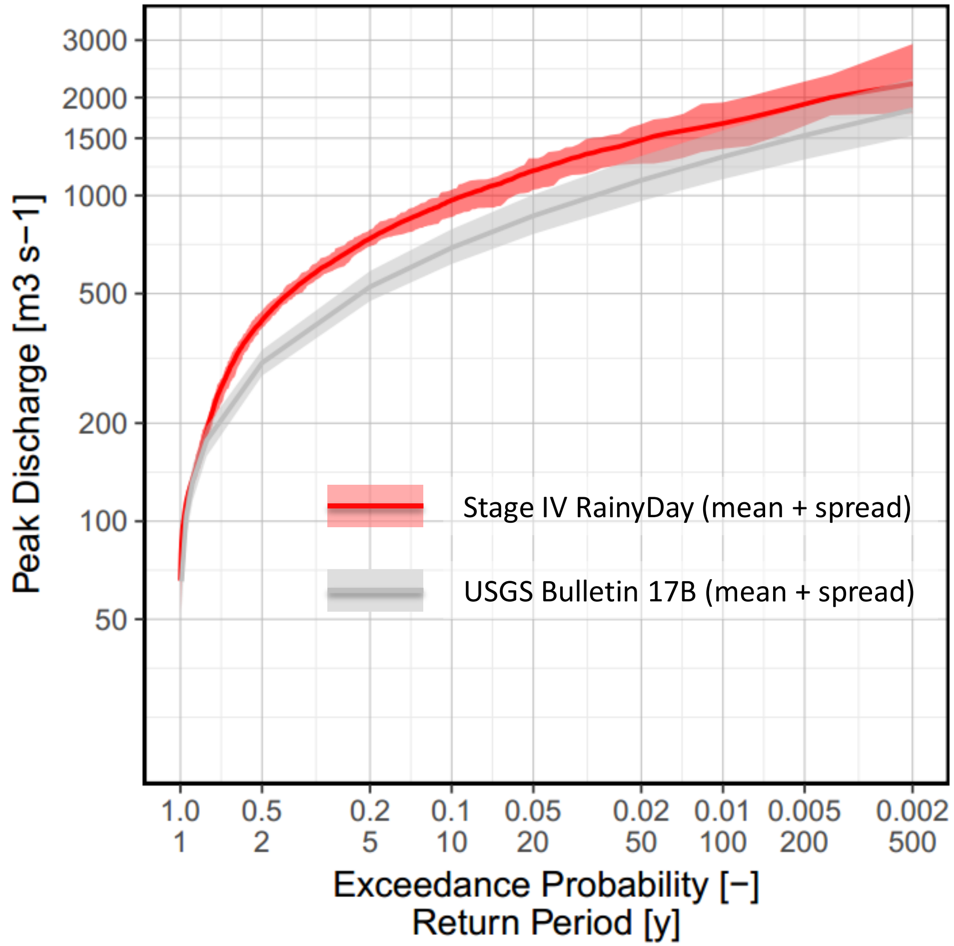


Rainfall Runoff Simulation

15 years initial condition:
- Soil Moisture
- Snow Pack

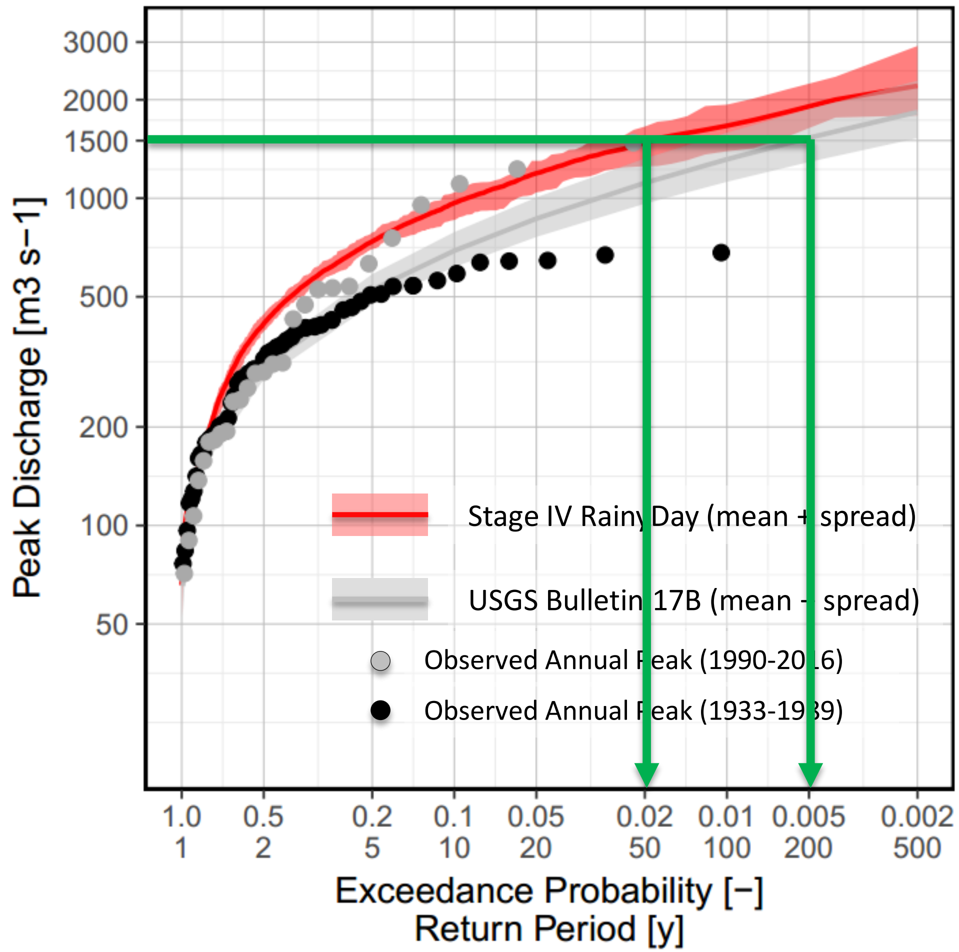
- 20 Realizations of 500 year streamflow
- Flood frequency analysis

Results: Flood Frequency Analysis



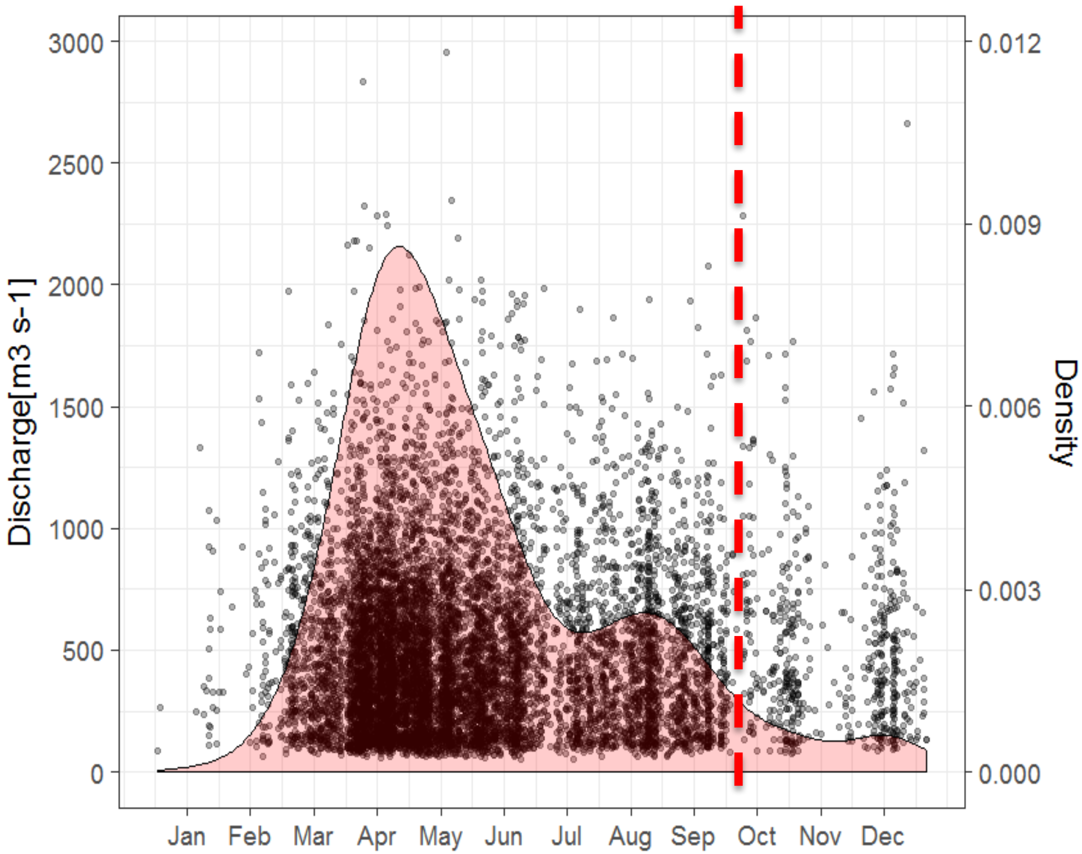
Results: Flood Frequency Analysis

- The rainyday seems able to capture "recent" flood behavior.
- 1500 m^3/s is 50-year flood using RainyDay but 200-year flood using USGS 17B.
- Extreme events happens more frequently in recent years.
- Is it time to reevaluate how to define "extreme"?



Results: Flood Frequency Analysis

- The correlation coefficient of rainfall and discharge return period is 0.56
- Rainfall is not the only factor causes flood
- Antecedent conditions play a key role in driving the flood



Summary

- RainyDay , a open source system, can provide spatially detailed rainfall pattern.
- Our derived flood frequency analysis can account for recent changes in extreme rainfall.
- Exploring the flood-generating processes in terms of variability between extreme rainfall and flooding can assist predictions of flooding.
- We'll help everyone who wants to try it.

Thanks! Questions?

- Thanks to HER (Hydroclimate Extremes Researchers).
- Special thanks to my advisor: *Daniel Wright*
- Thanks to Lauren Michael, Christina Koch, and the rest of the crew at the UW Center for High-Throughput Computing
- This research was partially supported by the Wisconsin Alumni Research Foundation, and the US Bureau of Reclamation.