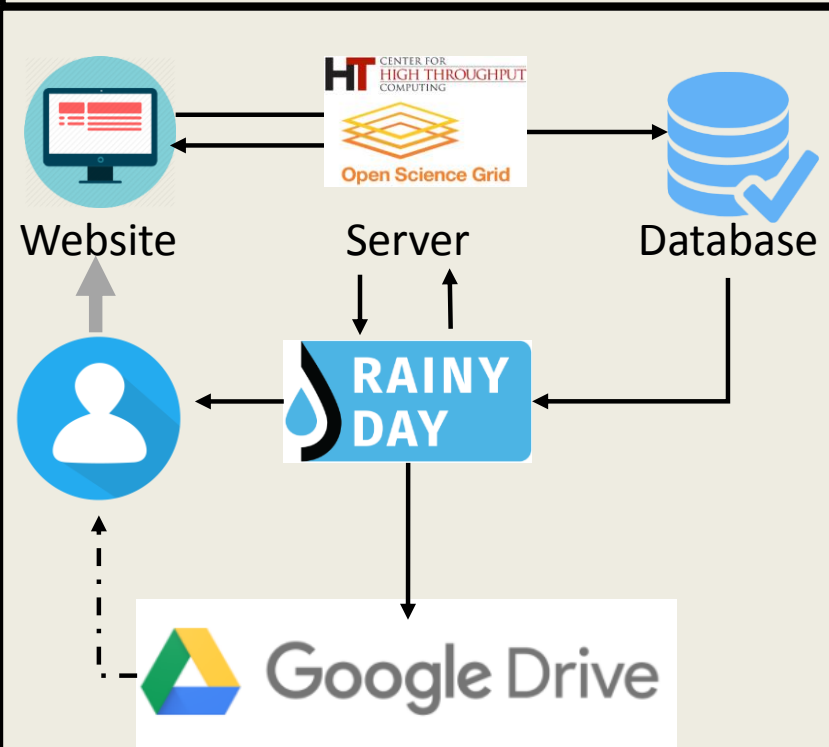


Application of Stochastic Storm Transposition and Hydrologic Modelling to Flood Frequency Analysis:

A Case Study for Turkey River, Iowa



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

OUTLINE

A New Framework

I. Conventional Methods:

- Limitations

II. RainyDay:

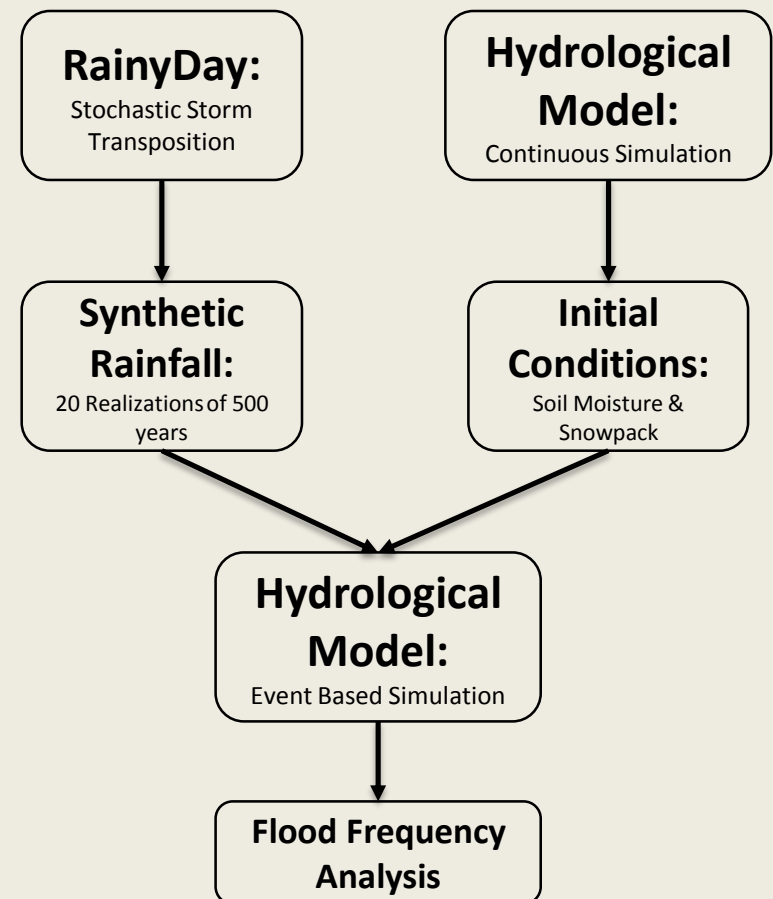
- Stochastic Storm Transposition

III. Hydrological Modelling:

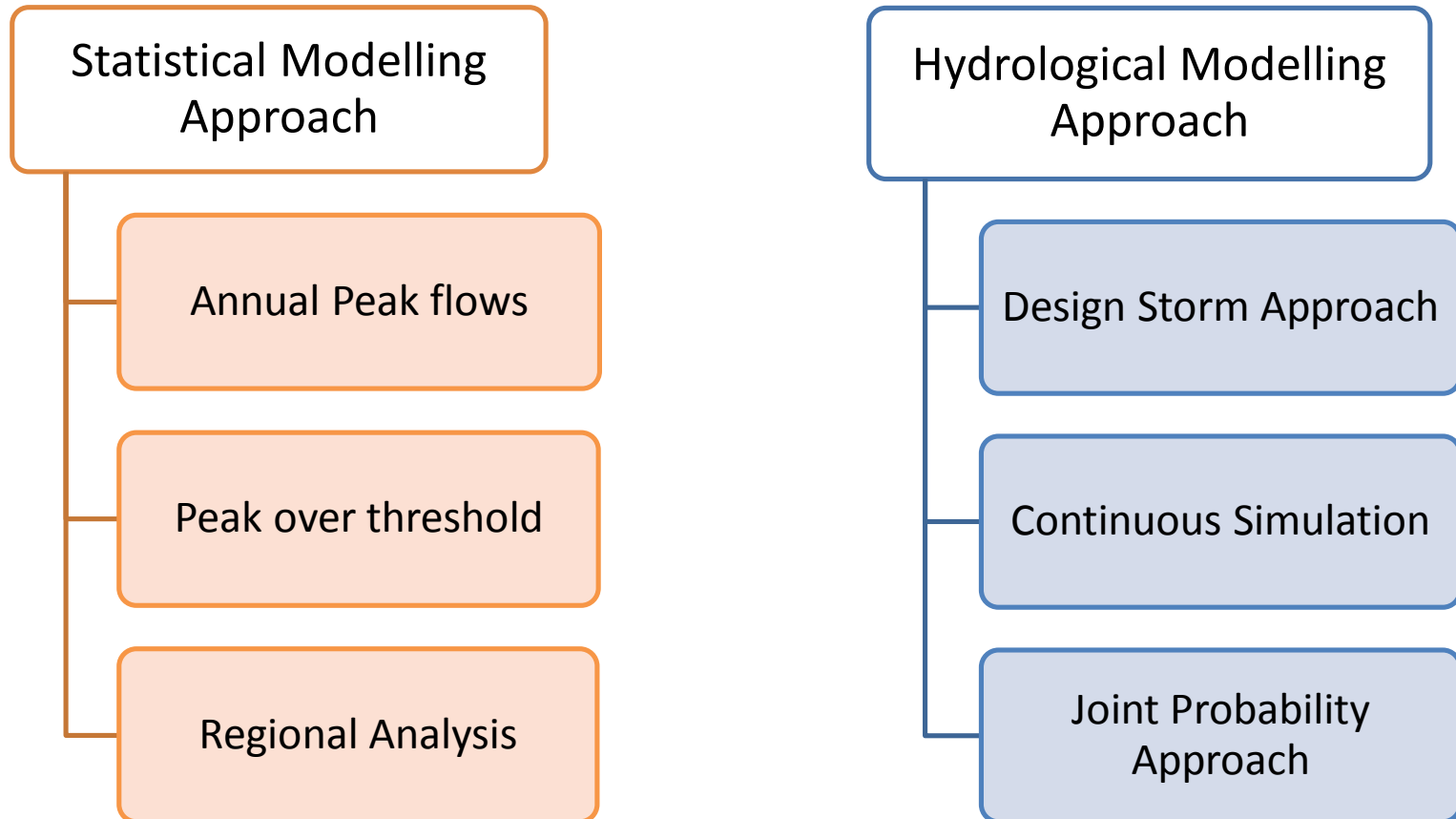
- Coupled with RainyDay

IV. Case Study:

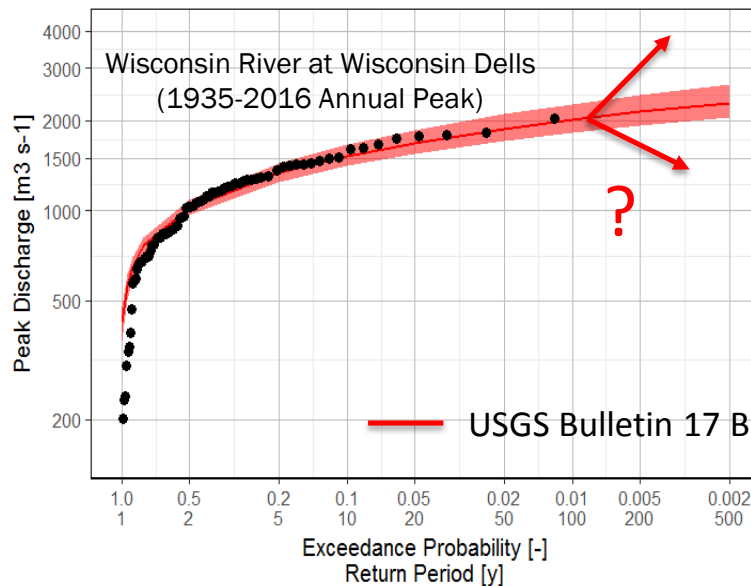
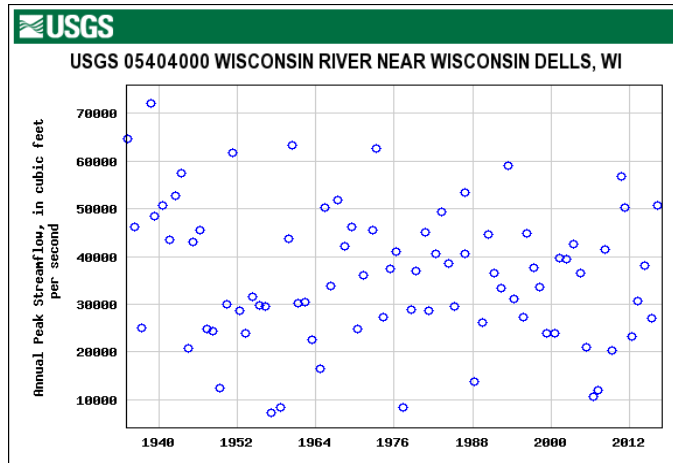
- Hydroclimatology of Turkey River Basin
- Derived Flood Frequency Analysis



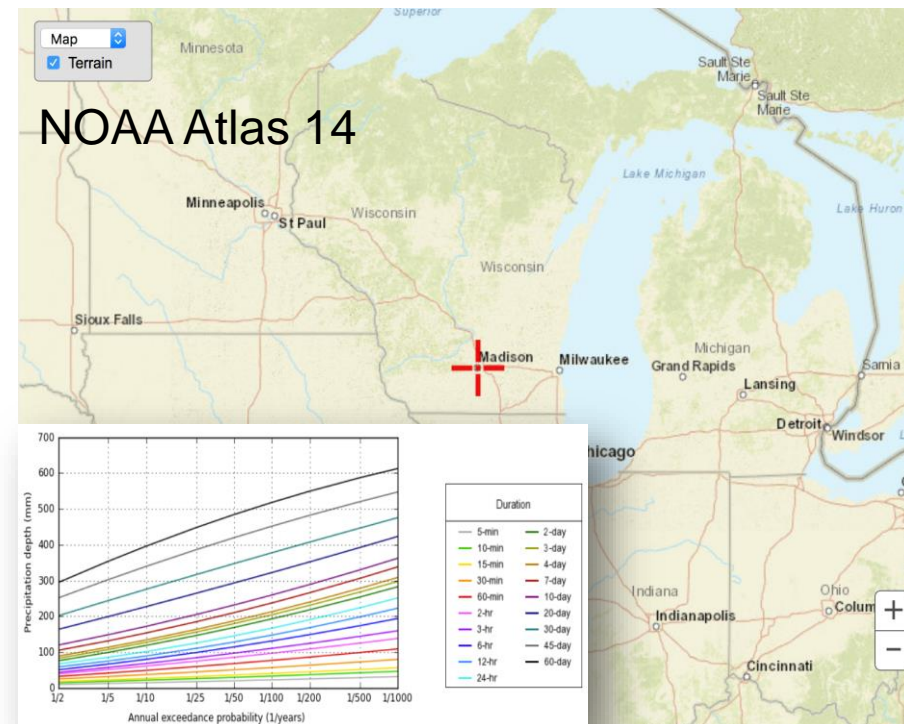
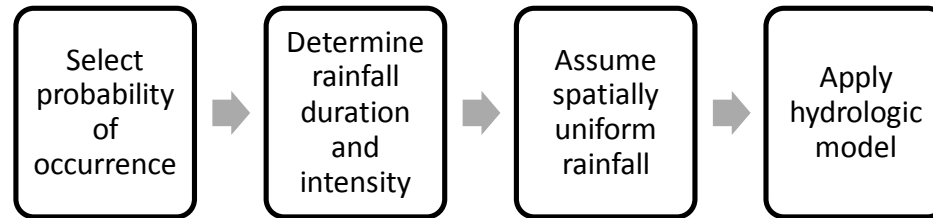
Existing methods of flood frequency analyses



Statistical



Hydrological



OUTLINE

A New Framework

I. Conventional Methods:

- Limitations

II. RainyDay:

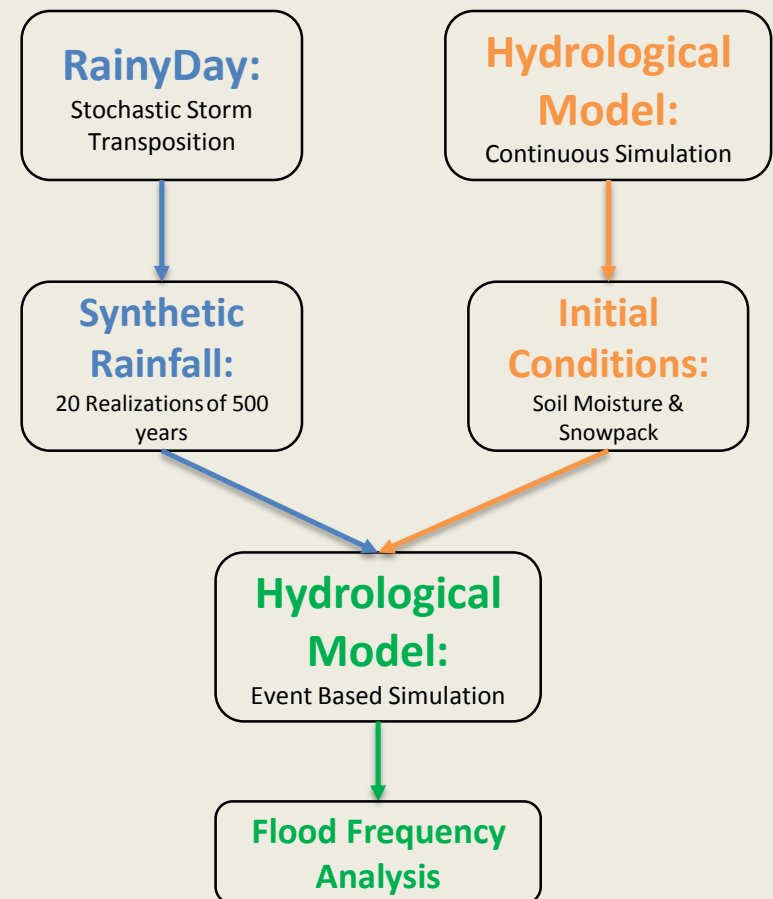
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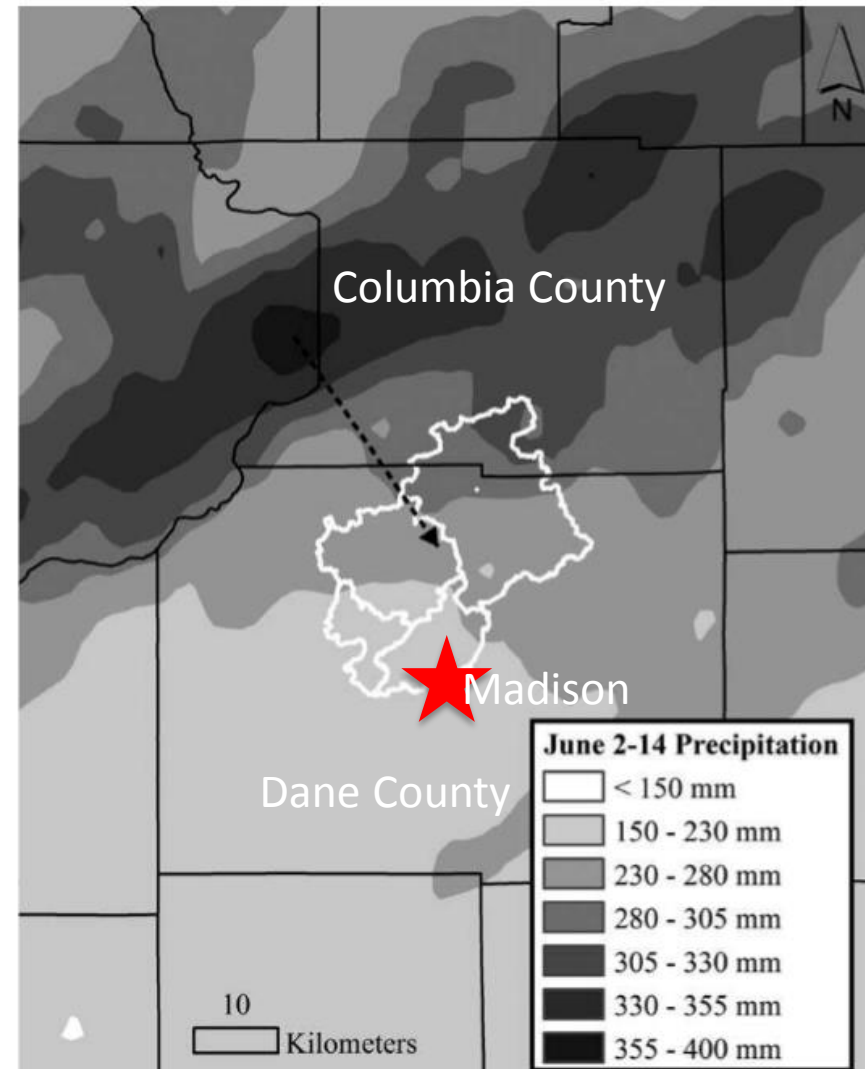


Stochastic Storm Transposition (SST)

Storm Transposition + dynamical flood simulations

Gives “worst case scenarios,” but not the likelihood that they happen...

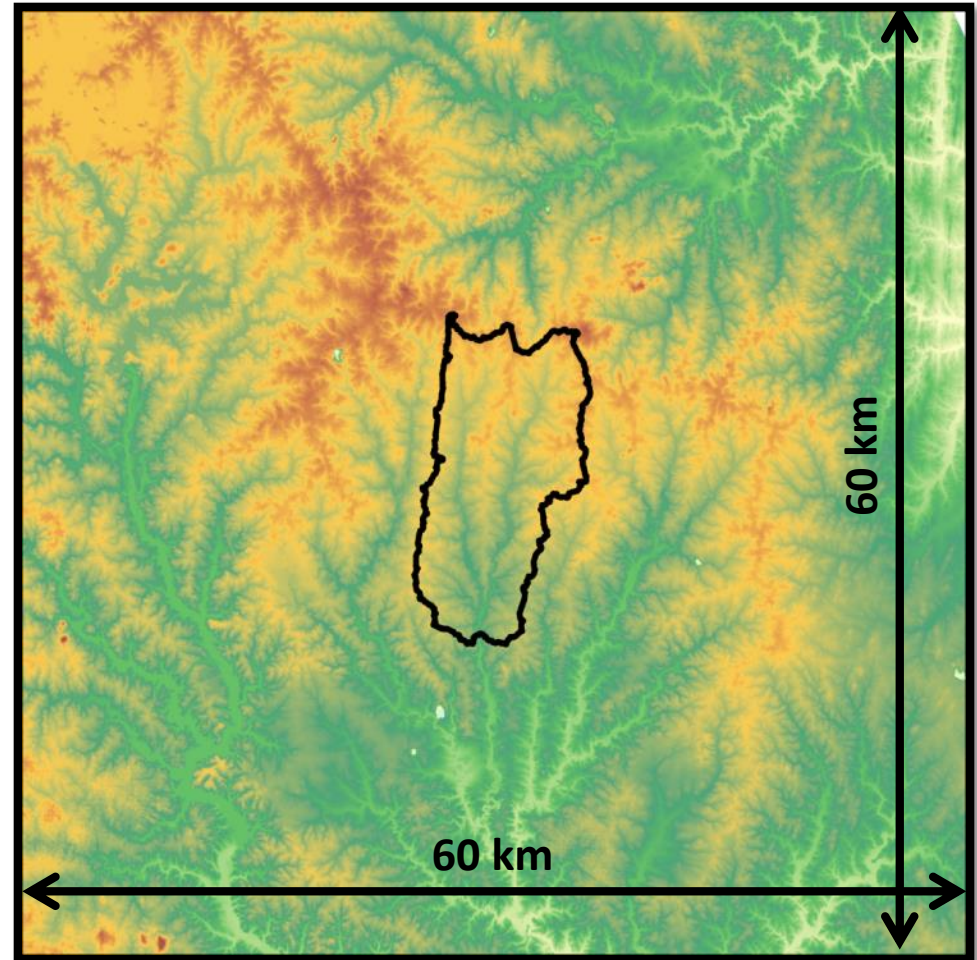
Hayden, N. G., K. W. Potter, and D. S. Liebl (2016). Evaluating Infiltration Requirements for New Development Using Extreme Storm Transposition: A Case Study from Dane County, WI. JAWRA



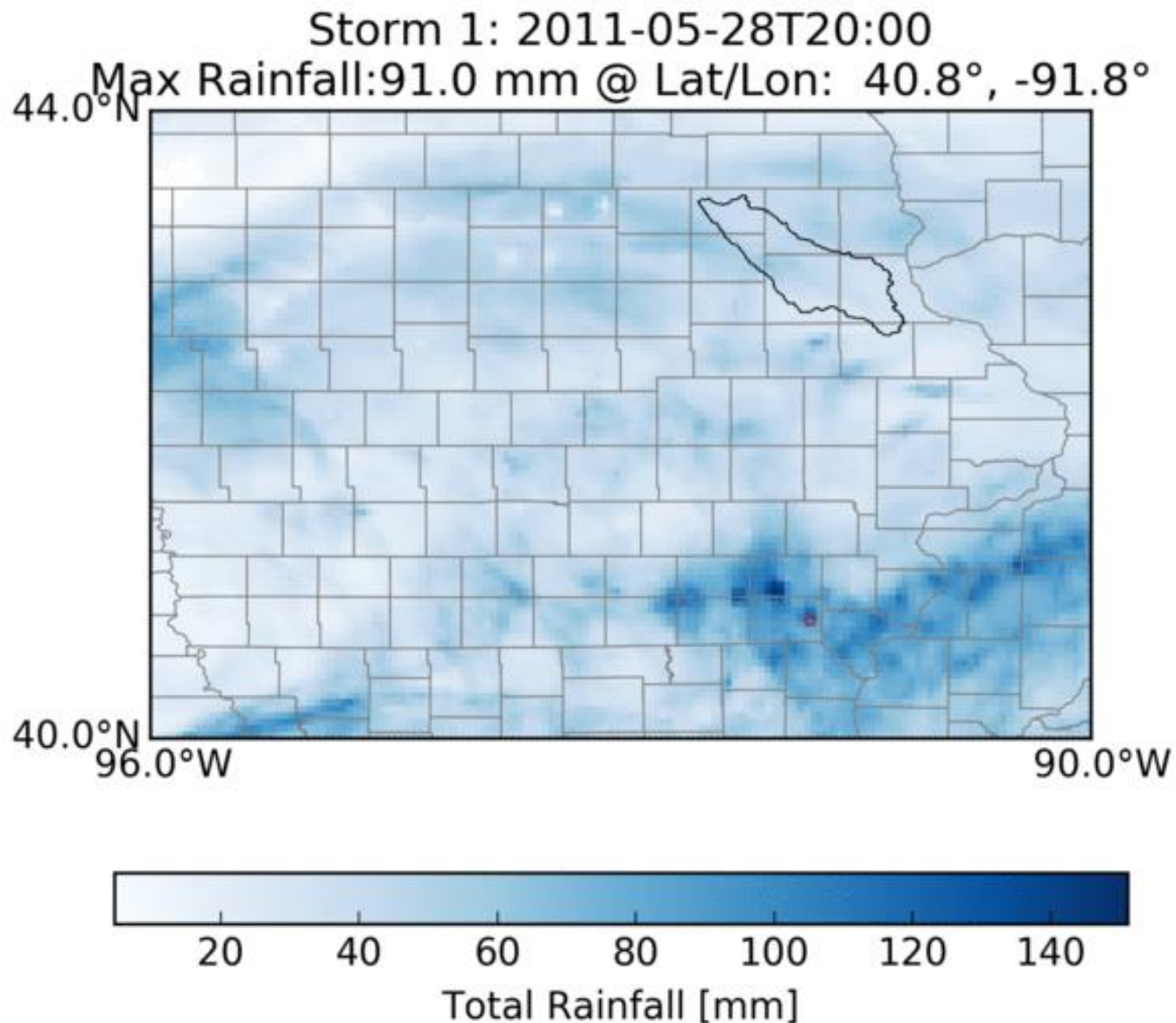
Stochastic Storm Transposition (SST)

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



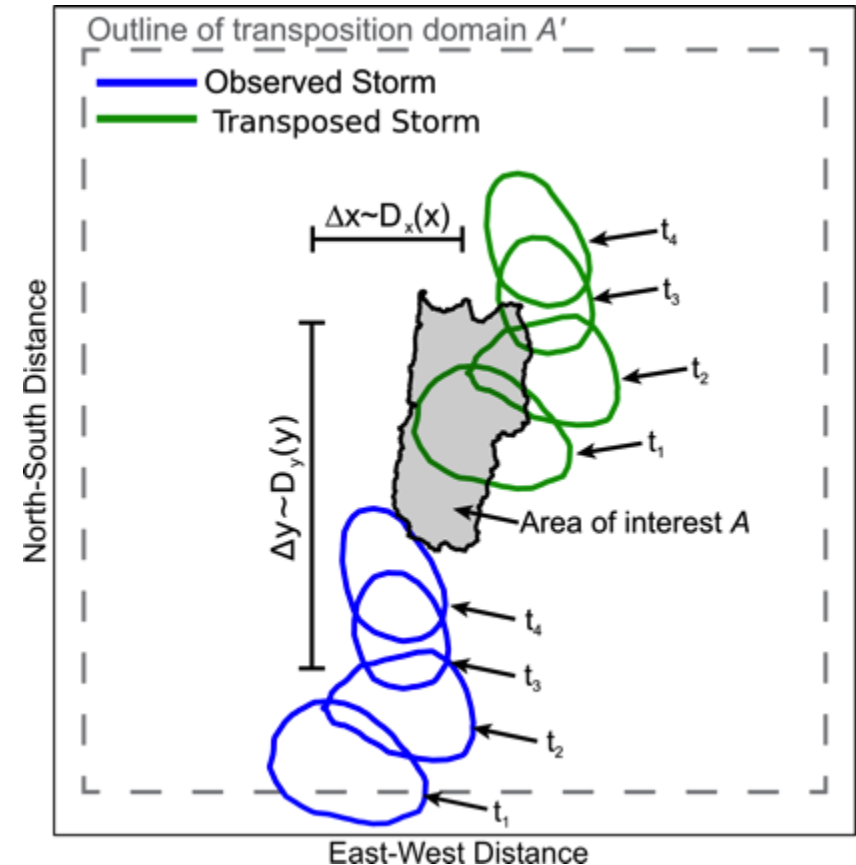
Stochastic Storm Transposition (SST)

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:
 $k \sim \text{Poisson}(\lambda = X/N \text{ storms/year})$
6. Repeat step 5 to generate thousands of synthetic rainfall scenarios

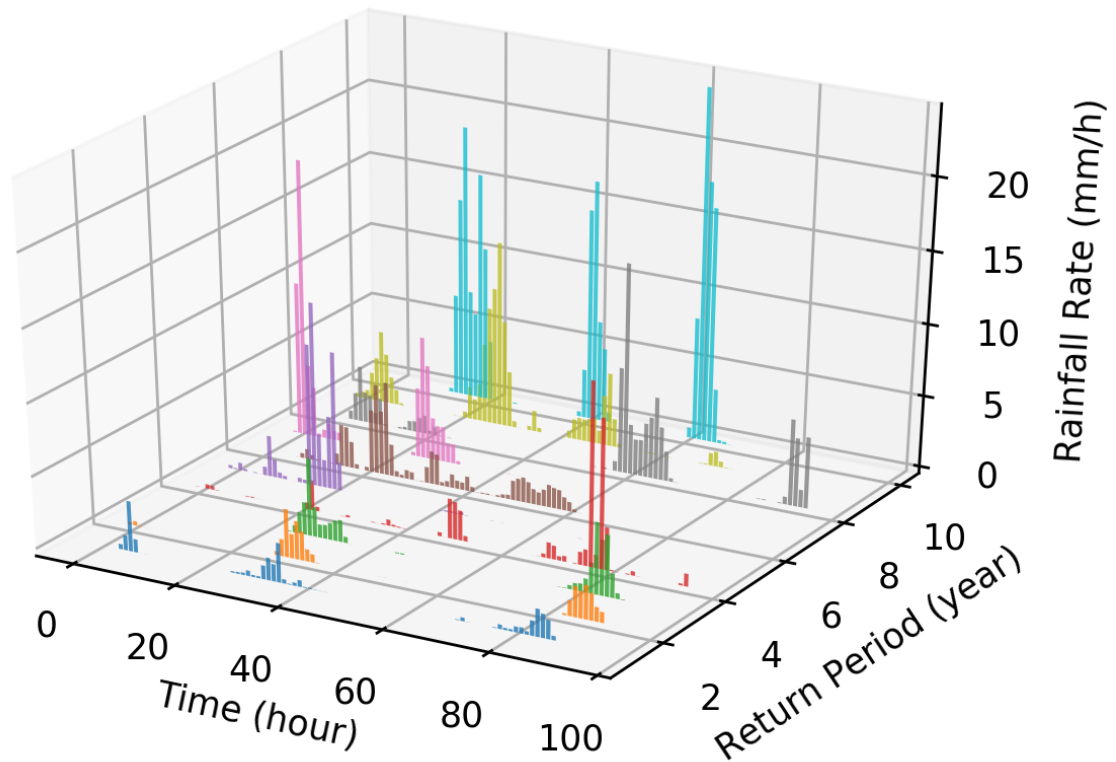


RainyDay Application: Turkey River Basin

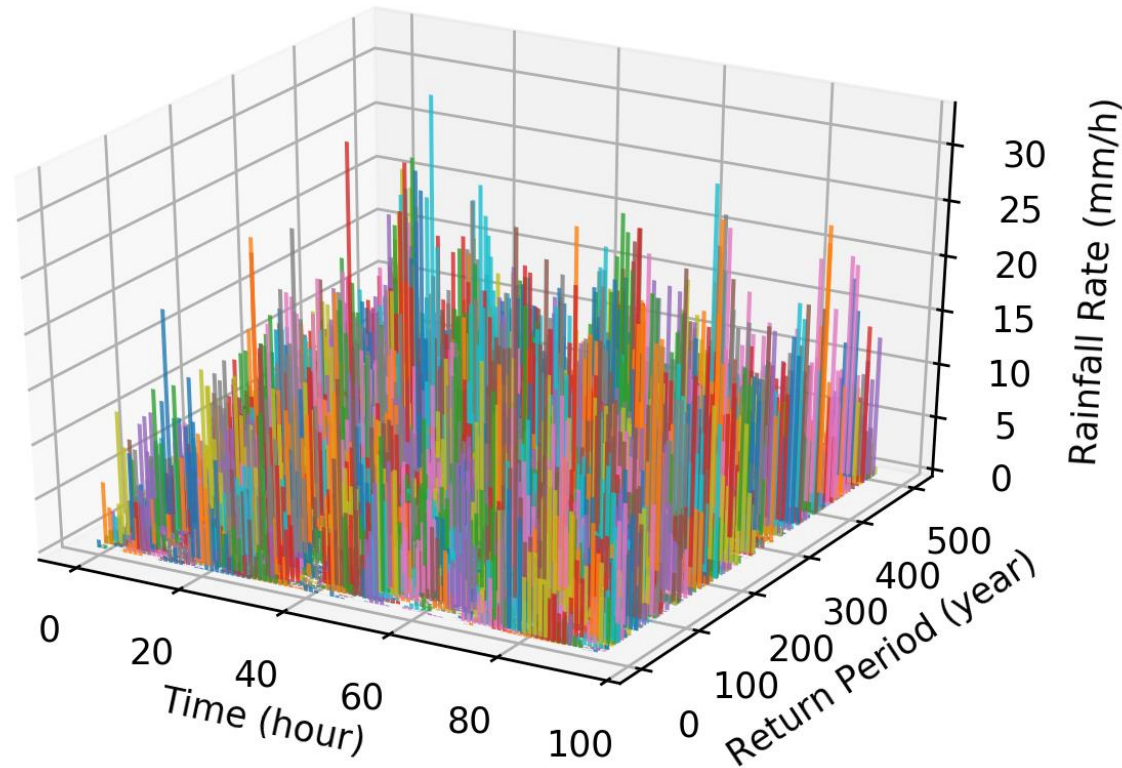
A synthetic year:

- k events/year
- $k \sim \text{Poisson}$
- The largest of these k events is analogous to an annual rainfall maximum

Synthetic annual rainfall maximum



RainyDay Application: Turkey River Basin

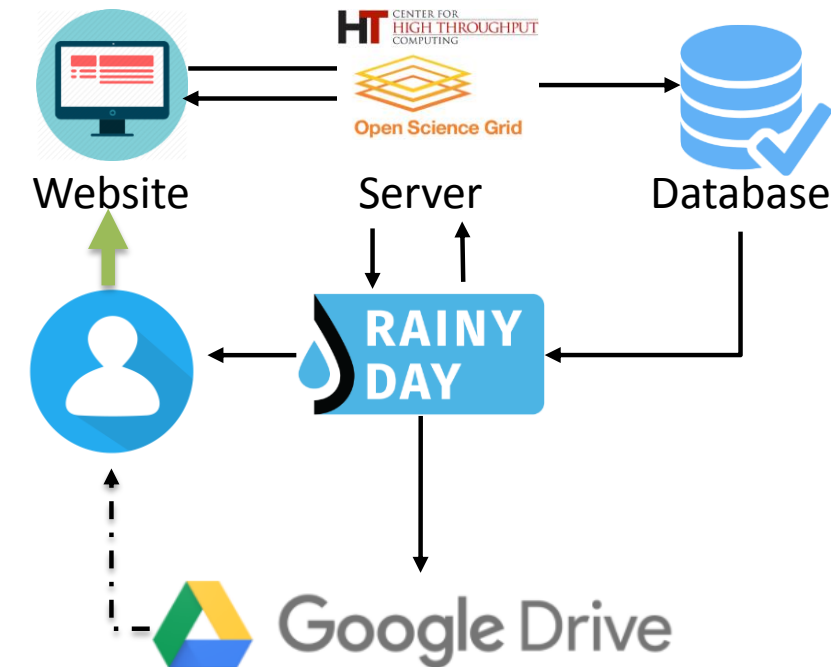


Output Format

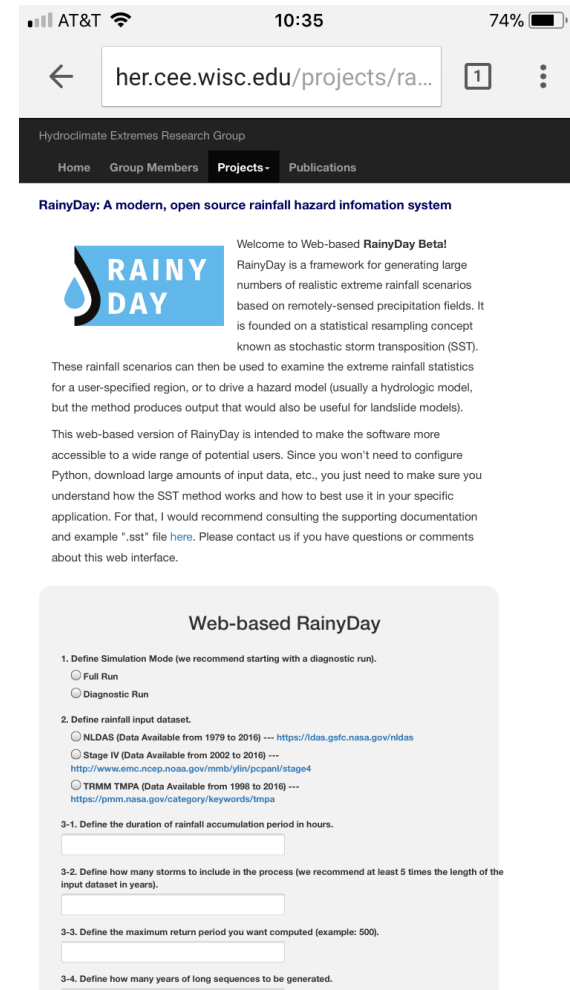
- Basin Averaged Rainfall Time Series (.txt, .csv, etc.)
- Realistic, Spatially Distributed Rainfall (netcdf)

Web RainyDay: Accessible to Everyone

her.cee.wisc.edu/projects/rainyday



Project funded by US
Bureau of Reclamation



The screenshot shows the mobile interface of the Web RainyDay website. The top status bar shows 'AT&T', '10:35', and '74%' battery. The address bar shows 'her.cee.wisc.edu/projects/ra...'. The navigation bar includes 'Home', 'Group Members', 'Projects', and 'Publications'. The main content area is titled 'RainyDay: A modern, open source rainfall hazard information system'. It includes a welcome message, a description of the system, and a list of simulation parameters to be defined.

RainyDay: A modern, open source rainfall hazard information system

Welcome to Web-based RainyDay Beta!

RainyDay is a framework for generating large numbers of realistic extreme rainfall scenarios based on remotely-sensed precipitation fields. It is founded on a statistical resampling concept known as stochastic storm transposition (SST). These rainfall scenarios can then be used to examine the extreme rainfall statistics for a user-specified region, or to drive a hazard model (usually a hydrologic model, but the method produces output that would also be useful for landslide models).

This web-based version of RainyDay is intended to make the software more accessible to a wide range of potential users. Since you won't need to configure Python, download large amounts of input data, etc., you just need to make sure you understand how the SST method works and how to best use it in your specific application. For that, I would recommend consulting the supporting documentation and example ".sst" file [here](#). Please contact us if you have questions or comments about this web interface.

Web-based RainyDay

- Define Simulation Mode (we recommend starting with a diagnostic run).
 - ☐ Full Run
 - ☐ Diagnostic Run
- Define rainfall input dataset.
 - ☐ NLDAS (Data Available from 1979 to 2016) --- <https://ldas.gsfc.nasa.gov/nldas>
 - ☐ Stage IV (Data Available from 2002 to 2016) --- <http://www.emc.ncep.noaa.gov/mmb/ylin/pcpan/stage4>
 - ☐ TRMM TMPA (Data Available from 1998 to 2016) --- <https://pnm.noaa.gov/category/keywords/tmpa>
- Define the duration of rainfall accumulation period in hours.
- Define how many storms to include in the process (we recommend at least 5 times the length of the input dataset in years).
- Define the maximum return period you want computed (example: 500).
- Define how many years of long sequences to be generated.

OUTLINE

A New Framework

I. Conventional Methods:

- Limitations

II. RainyDay:

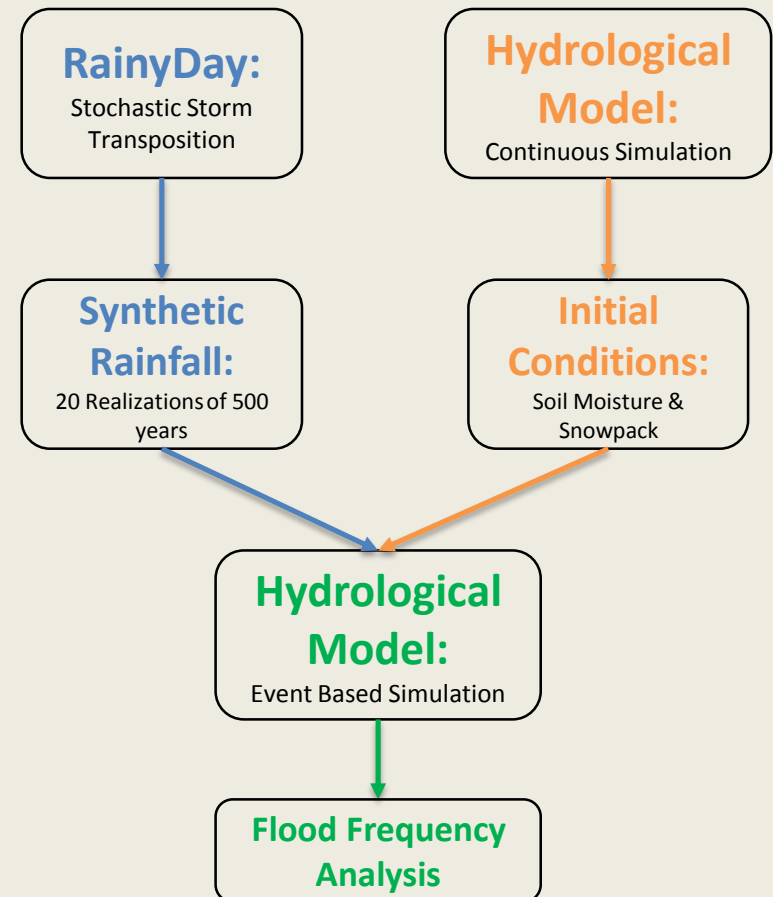
- Stochastic Storm Transposition

III. Hydrological Modelling:

- Coupled with RainyDay

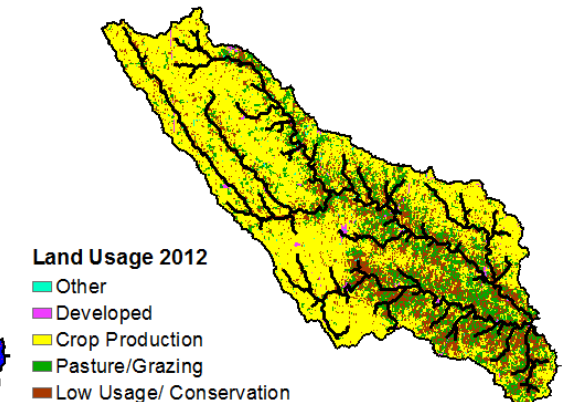
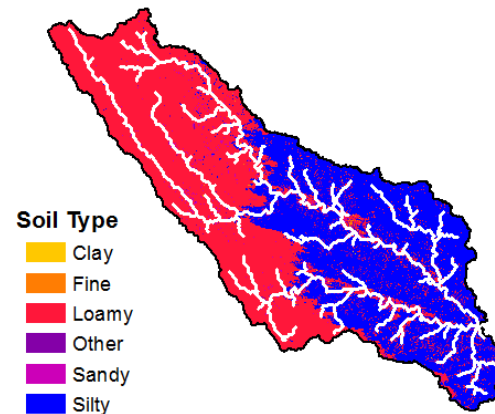
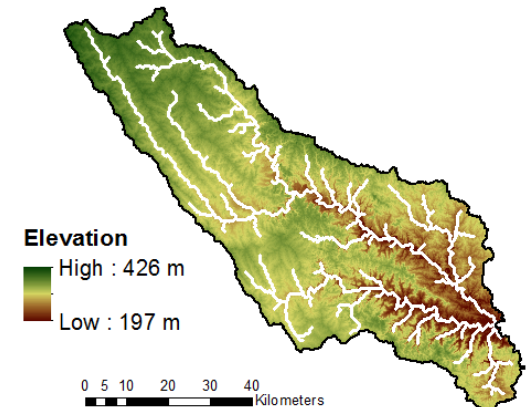
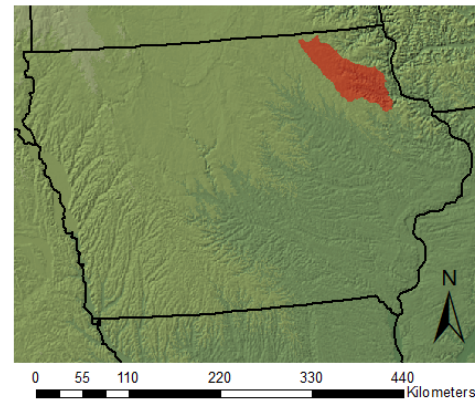
IV. Case Study:

- Hydroclimatology of Turkey River Basin
- Derived Flood Frequency Analysis



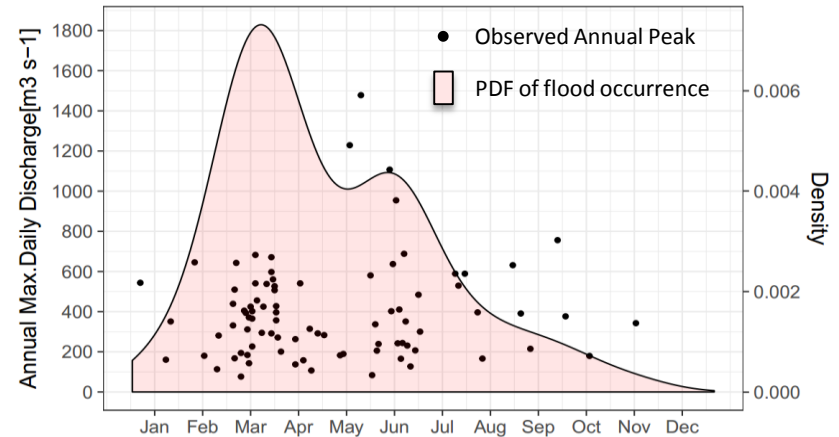
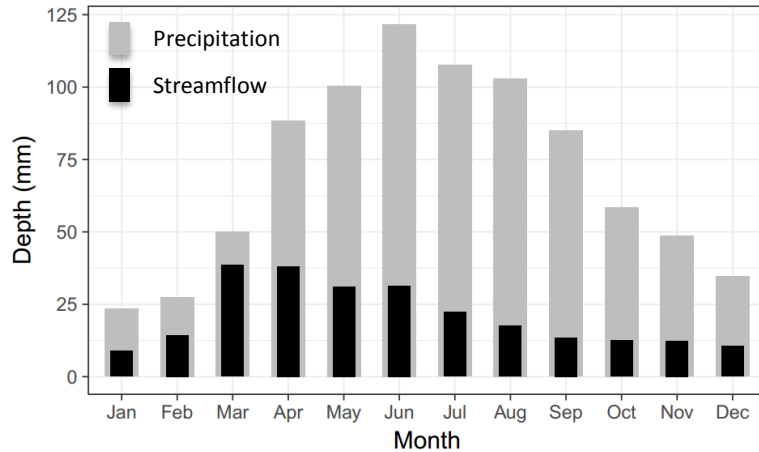
A Case Study for Turkey River, Iowa

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

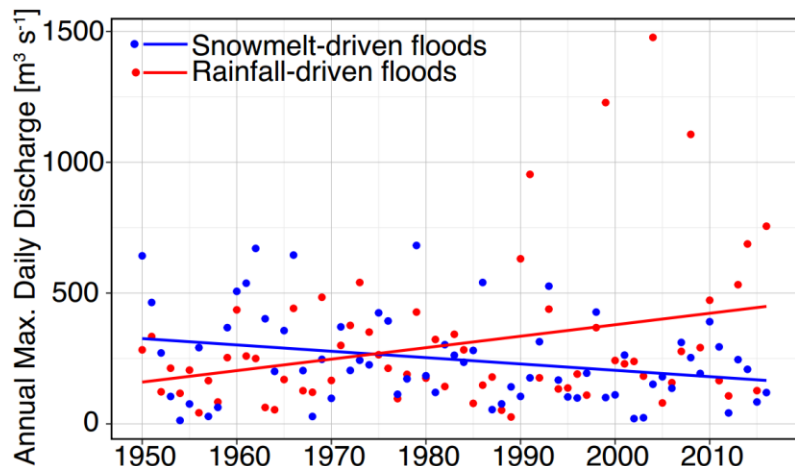
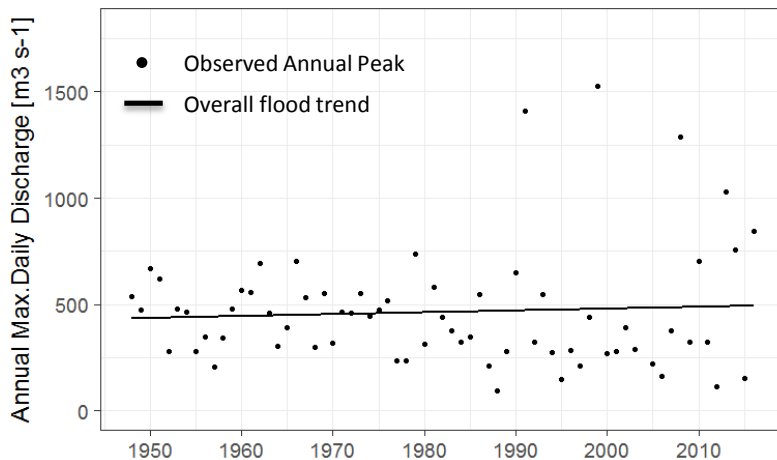


Hydroclimatology of Turkey River Basin

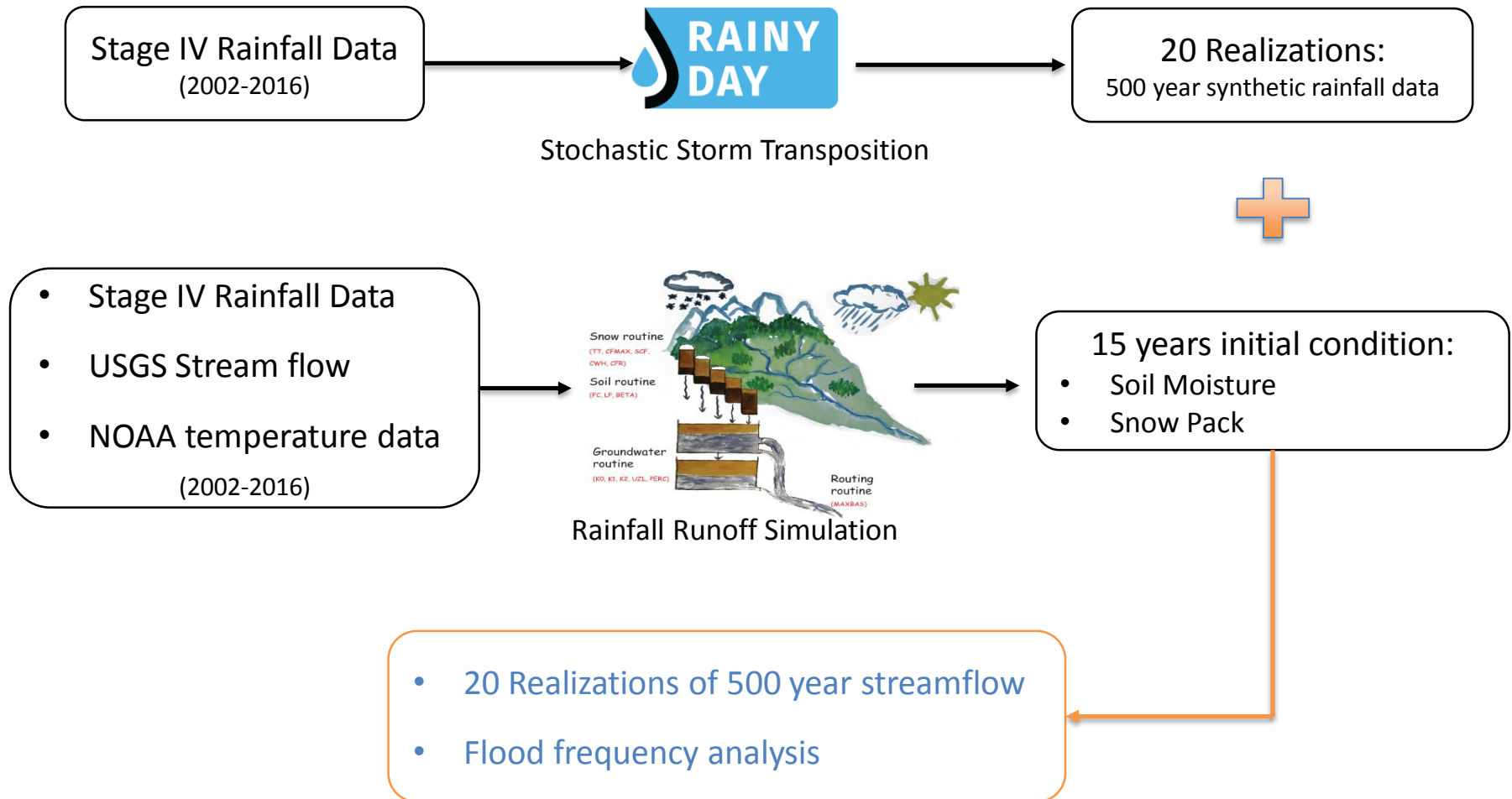
Seasonality



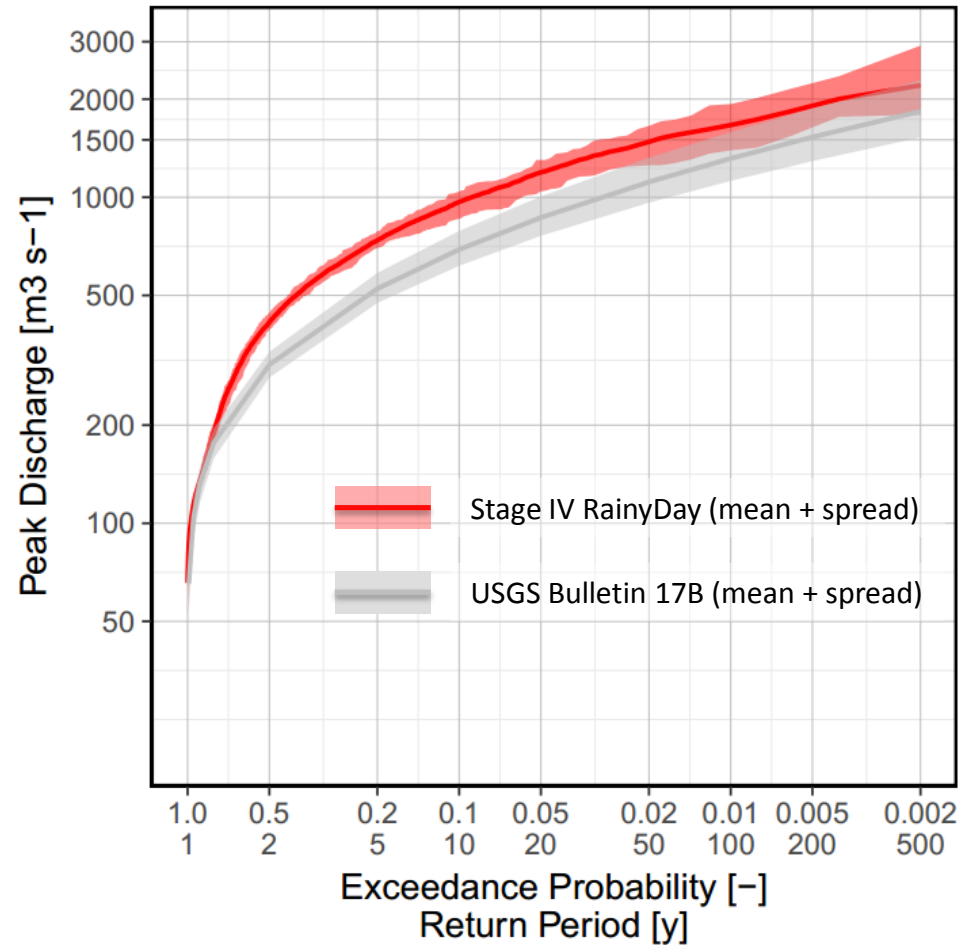
Trend Analysis



A Case Study for Turkey River, Iowa

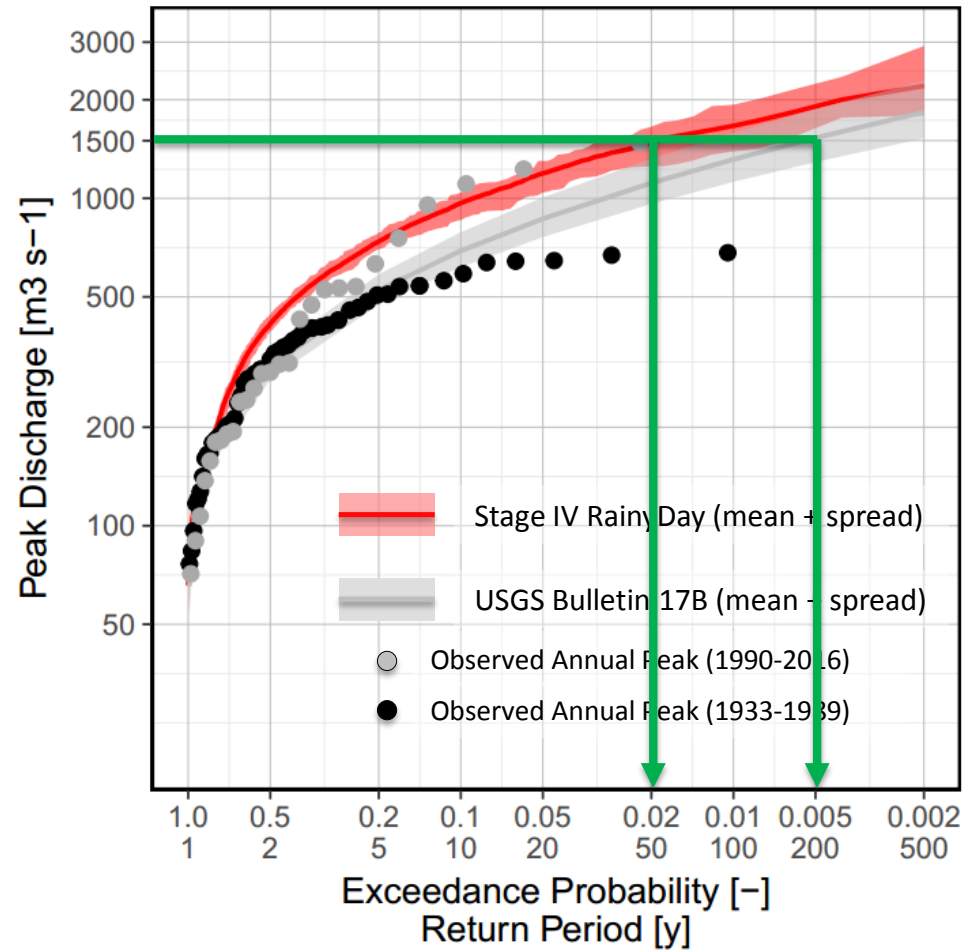


Results: Flood Frequency Analysis



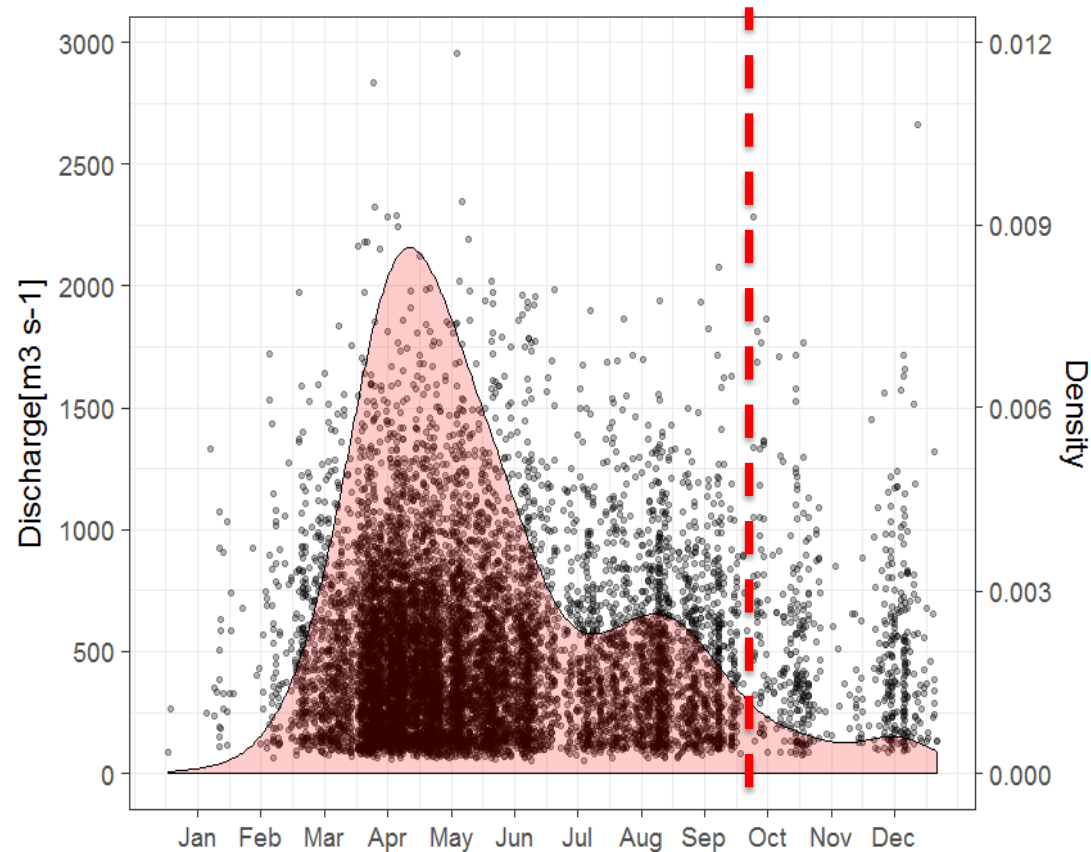
Results: Flood Frequency Analysis

- The rainyday seems able to capture “recent” flood behavior.
- 1500 m³/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!

- 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.

Questions?

