Thank you for signing in early

The webinar will begin promptly at
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SERDP and ESTCP Webinar Series

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    - Required webinar ID: 745-473-317
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Developing Adaptation Strategies to Address Climate Change and Uncertainty

June 20, 2019

SERDP
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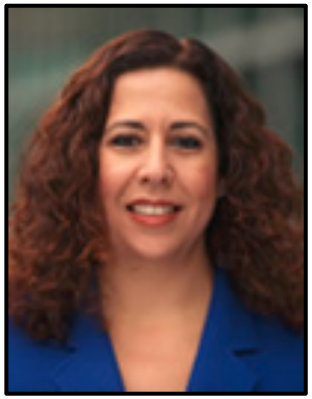
Welcome and Introductions



Rula A. Deeb, Ph.D.
Webinar Coordinator

SERDP DOD • EPA • DOE | ESTCP

Webinar Agenda

- **Webinar Logistics** (5 minutes)
  Dr. Rula Deeb, Geosyntec Consultants
- **Overview of SERDP and ESTCP** (5 minutes)
  Dr. Kurt Preston, SERDP and ESTCP
- **Linked Rainfall and Runoff Intensity-Duration-Frequency in the Face of Climate Change and Uncertainty** (25 minutes + Q&A)
  Dr. Yonas Demissie, Washington State University
- **Next Generation Intensity-Duration-Frequency Curves for Improved Hydrologic Design** (25 minutes + Q&A)
  Dr. Mark Wigmosta, Pacific Northwest National Laboratory
- **Final Q&A session**

In Case of Technical Difficulties

- Use a compatible browser (Firefox, IE or Edge)
- If material is not showing on your screen or if screen freezes
  - Key in Ctrl + F5 to do a hard refresh of your browser
- If connecting to computer audio
  - Click the arrow next to the "*Join Audio*" button
  - Select test "*Speaker and Microphone*"
  - Follow prompts
- If you continue to experience difficulties, call into the conference line
  - (669) 900-6833 or (929) 205-6099
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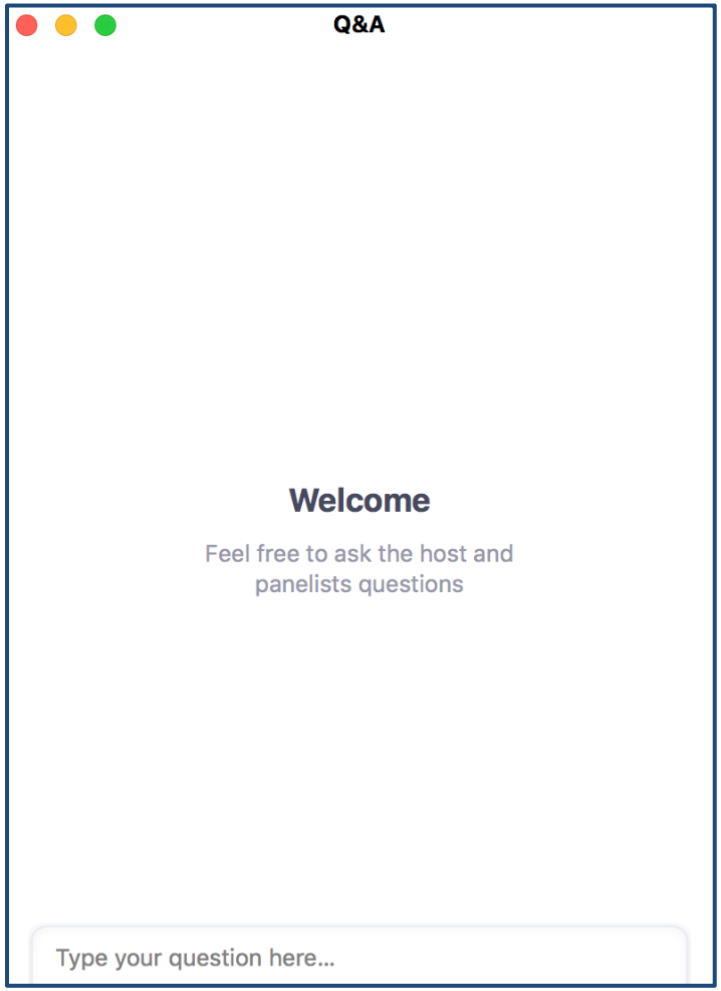
How to Ask Questions

- Find the Q&A button on your control bar and type in your question(s)
- Make sure to add your organization name at the end of your question so that we can identify you during the Q&A sessions



SERDP and ESTCP Overview

Kurt Preston, Ph.D.
Resource Conservation and Resiliency Program Manager

SERDP
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SERDP

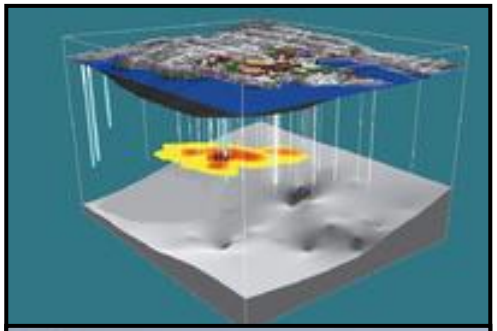
- Strategic Environmental Research and Development Program
- Established by Congress in FY 1991
  - DoD, DOE and EPA partnership
- SERDP is a requirements driven program which identifies high-priority environmental science and technology investment opportunities that address DoD requirements
  - Advanced technology development to address near term needs
  - Fundamental research to impact real world environmental management

ESTCP

- Environmental Security Technology Certification Program
- Demonstrate innovative cost-effective environmental and energy technologies
  - Capitalize on past investments
  - Transition technology out of the lab
- Promote implementation
  - Facilitate regulatory acceptance

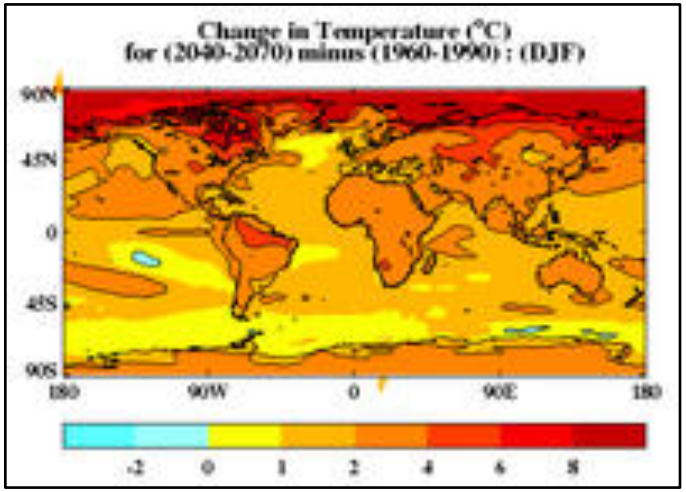
Program Areas

1. Environmental Restoration
2. Installation Energy and Water
3. Munitions Response
4. Resource Conservation and Resiliency
5. Weapons Systems and Platforms



Resource Conservation and Resiliency

- Natural resources
  - Ecological forestry
  - Arid lands ecology and management
  - Cold regions ecology and management
  - Pacific island ecology and management
  - Coastal and estuarine ecology and management
  - Living marine resources ecology and management
  - Species ecology and management
  - Watershed processes and management
- Resilience
  - Vulnerability and impact assessment
  - Adaptation science
  - Land use and carbon management
- Air quality
  - Wildland fire dynamics
  - Fugitive dust



SERDP and ESTCP Webinar Series

Date	Topic
July 11, 2019	Vapor Intrusion: Modeling Tools and Cost Effective Mitigation
July 25, 2019	Understanding Underwater Munitions Mobility and Behavior on the Beach Face and in Shallow Muddy Environments
August 8, 2019	Building Energy and Water Efficiency Solutions
August 22, 2019	Pacific Island Ecology and Management: Recovery of Native Plant Communities
September 5, 2019	The Use of Advanced Molecular Biological Tools in Groundwater Contaminated with Chlorinated Solvents
September 19, 2019	Life Cycle Assessment and Developmental Environment Safety and Occupational Health Evaluation: Tools for Sustainment and Health

For upcoming webinars, please visit

http://serdp-estcp.org/Tools-and-Training/Webinar-Series

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Save the Date!

SERDP • ESTCP
SYMPOSIUM

A three-day symposium showcasing the latest technologies that enhance DoD's mission through improved environmental and energy performance

December 3-5, 2019

Washington Marriott Wardman Park

Registration is open

Linked Rainfall and Runoff Intensity-Duration-Frequency in the Face of Climate Change and Uncertainty

Yonas Demissie, Ph.D.
Washington State University

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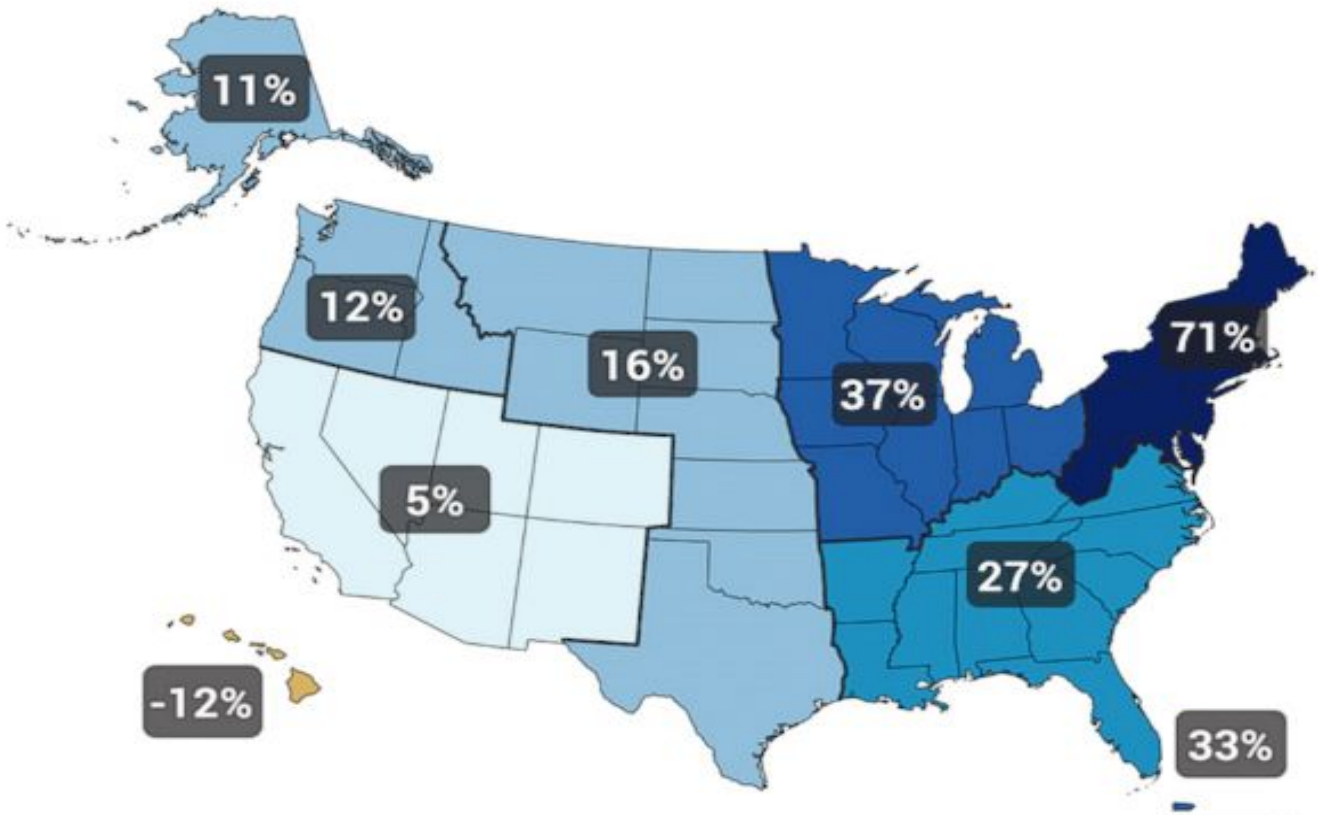
Agenda

- Trends in extreme storms
- Impacts on DoD installations
- Objectives and benefits to DoD
- Improved IDF curves
- Flooding risk
- Runoff IDF curves
- Web-based decision-making GIS tool
- Conclusions

Trends in Extreme Storms

Observed Extreme Precipitation

Change in 1-day heavy precipitation events, 1958 to 2012



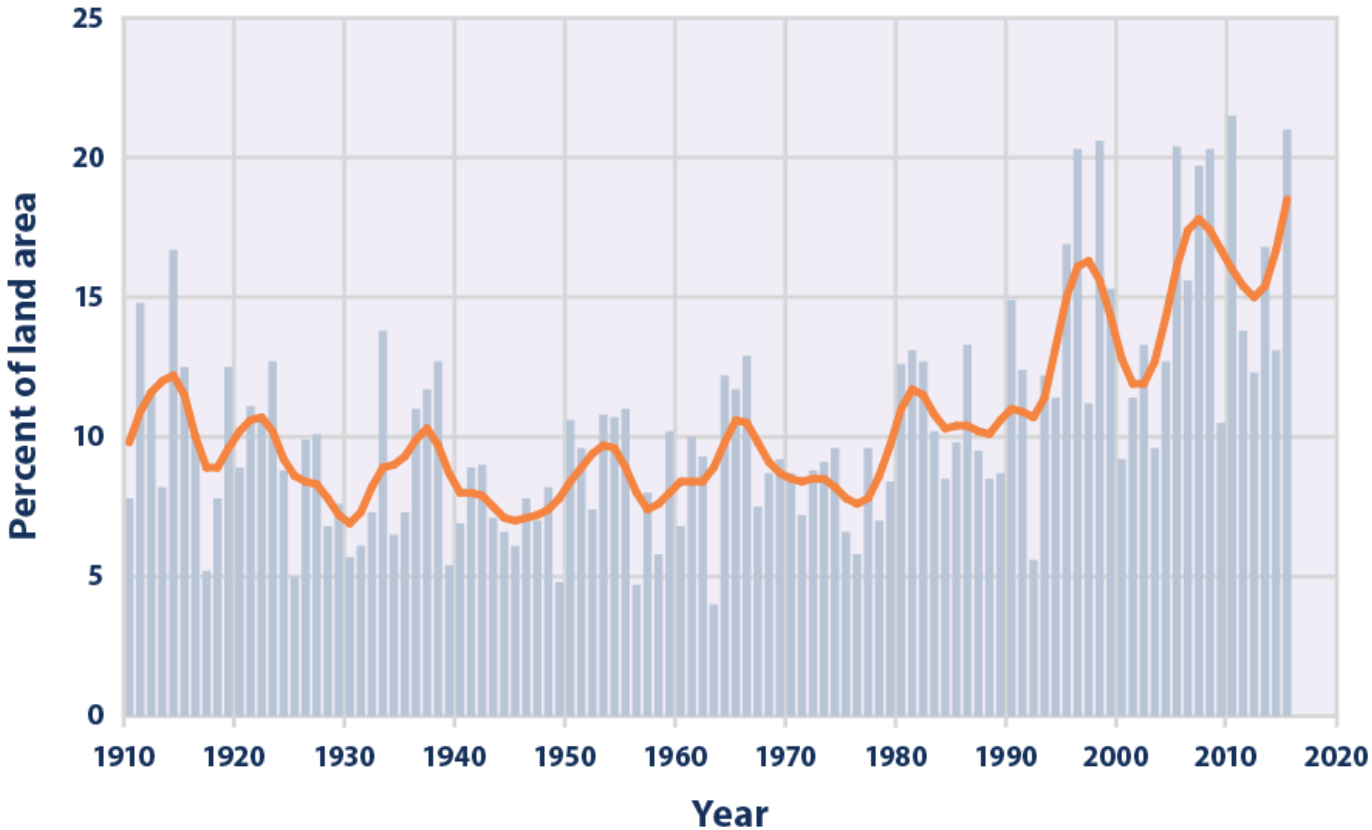
Increasing magnitude, frequency, area coverage

Source: National Climate Assessment Report, 2014

Trends in Extreme Storms

Observed Extreme Precipitation

Change in 1-day heavy precipitation area, 1910-2014



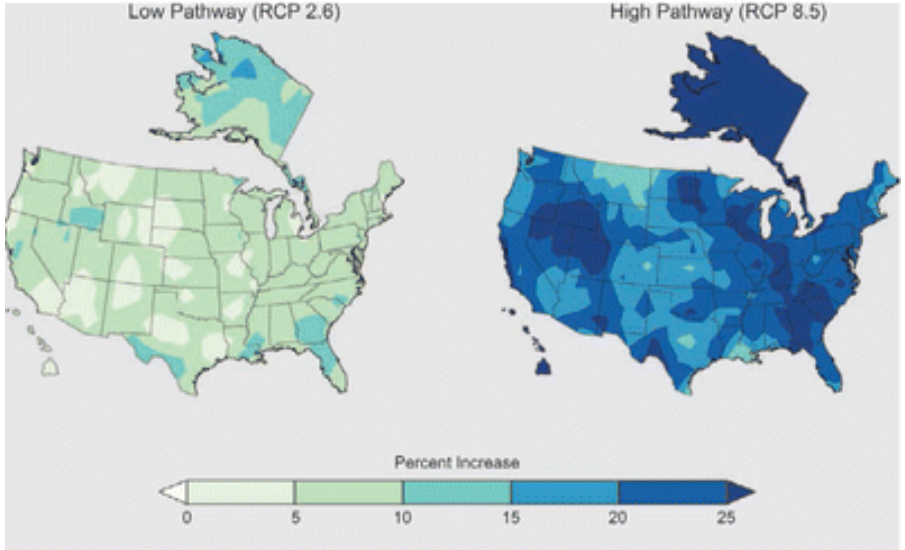
Increasing magnitude, frequency, area coverage

Source: Climate Change Indicators in the United States (EPA 2016)

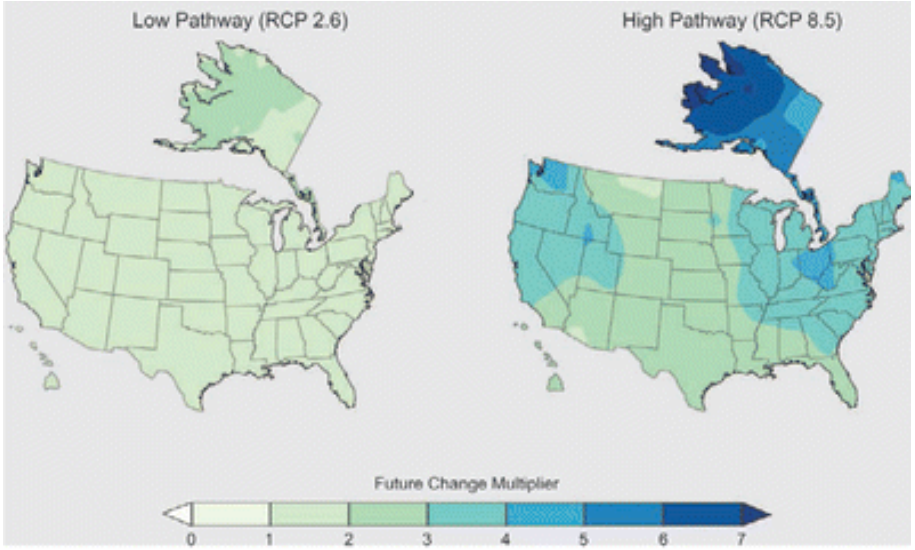
Trends in Extreme Storms

Future Extreme Precipitation

20-Year Daily Storm Amount



20-Year Daily Storm Relative Rate of Occurrence

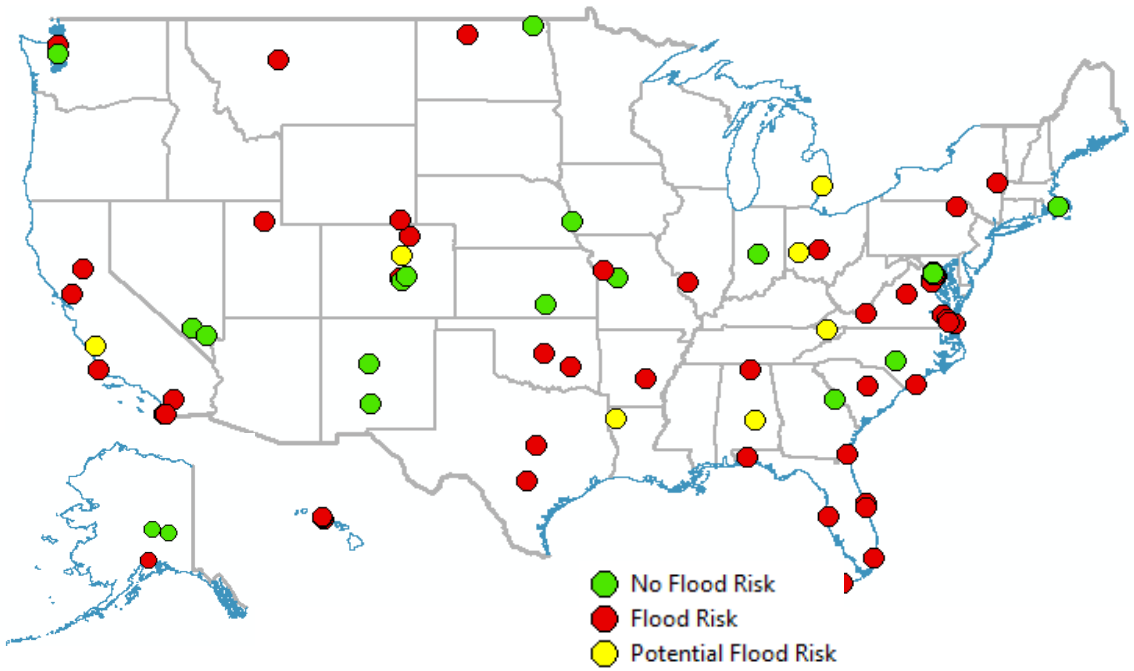


2081-2100 vs. 1986-2005

Source: Wuebbles et al. 2014

Flood Impacts on DoD Installations

- 930+ sites, 48 states in past 30 years
- Increased storm frequency 12 out of 15 installations
- 2/3 installations vulnerable to flooding



Sources: GAO 2014; DoD 2018; DoD 2019

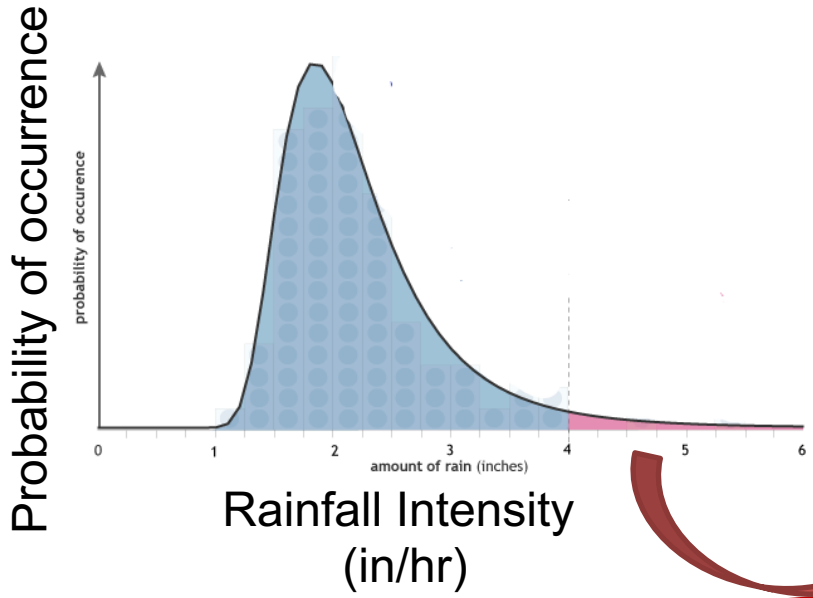
Flood Impacts on DoD Installations

- $5B to rebuild Tyndall and Offutt Air Force Bases from recent damages

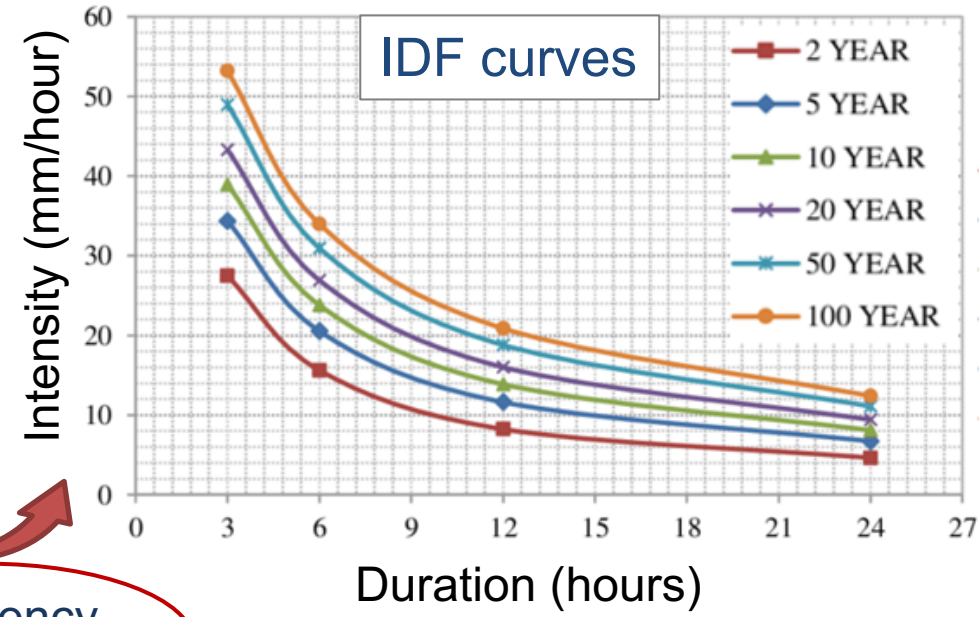
Image source: vox.com

Assess and Mitigate Flood Risk

- Revise the rainfall Intensity-Duration-Frequency (IDF) curves to reassess and update flood control infrastructures



Frequency Analysis

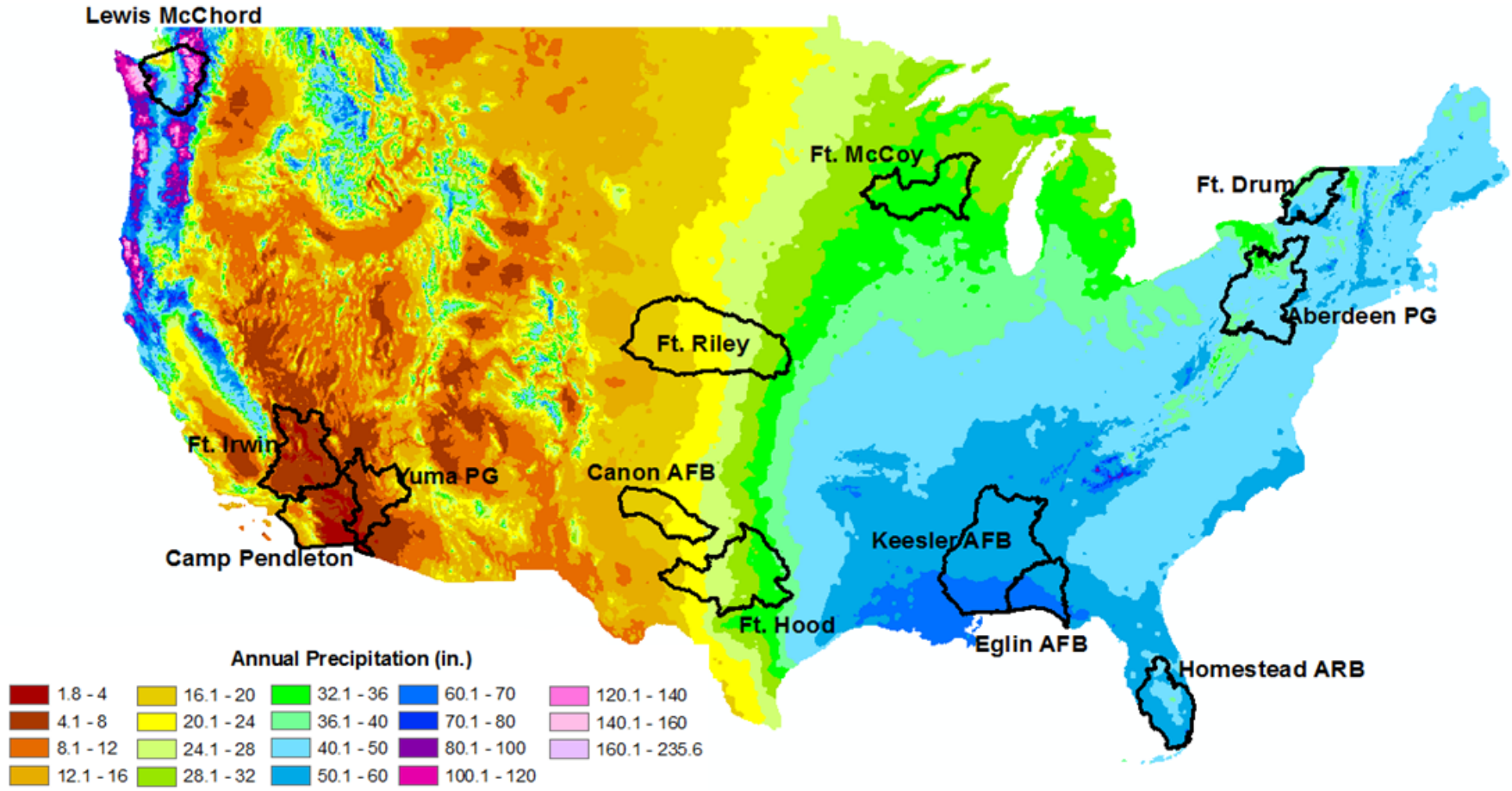


Objectives and Benefits to DoD

- Develop and update IDF curves considering the following:
  - Change in storms
  - Snow effects
  - Modeling and data uncertainty
- Better understand flood risk to military installations posed by changing climate
- Provide web-based GIS decision-making tool
- Contribute to military's readiness and resilience to climate threats

Study Sites and Data

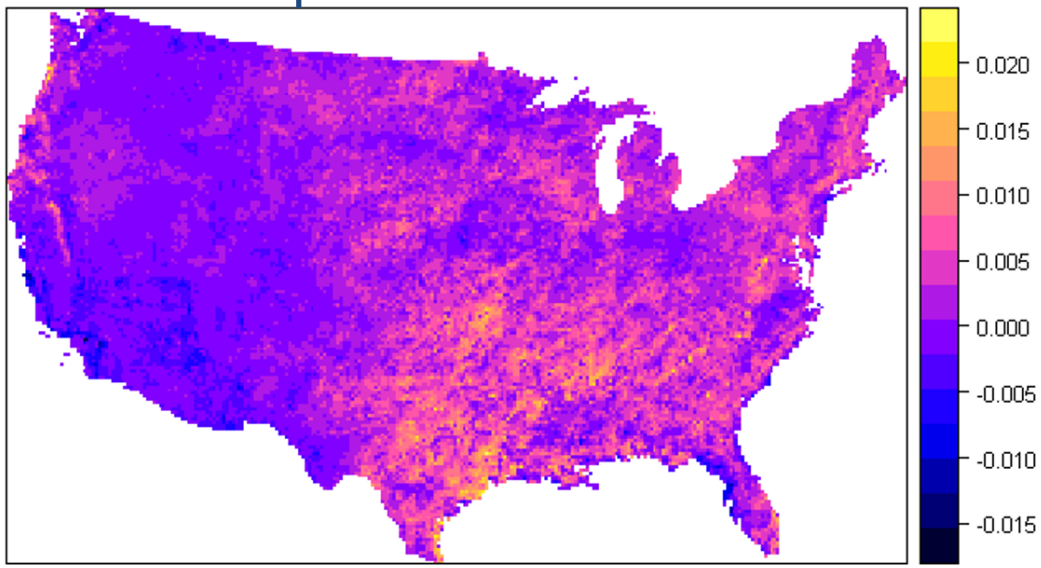
13 military installations across the U.S. with history of flooding



Projection Data

Global Climate Projections → Regional Dynamic Downscaling → Bias Correction → Adaptive IDF (non-stationary)

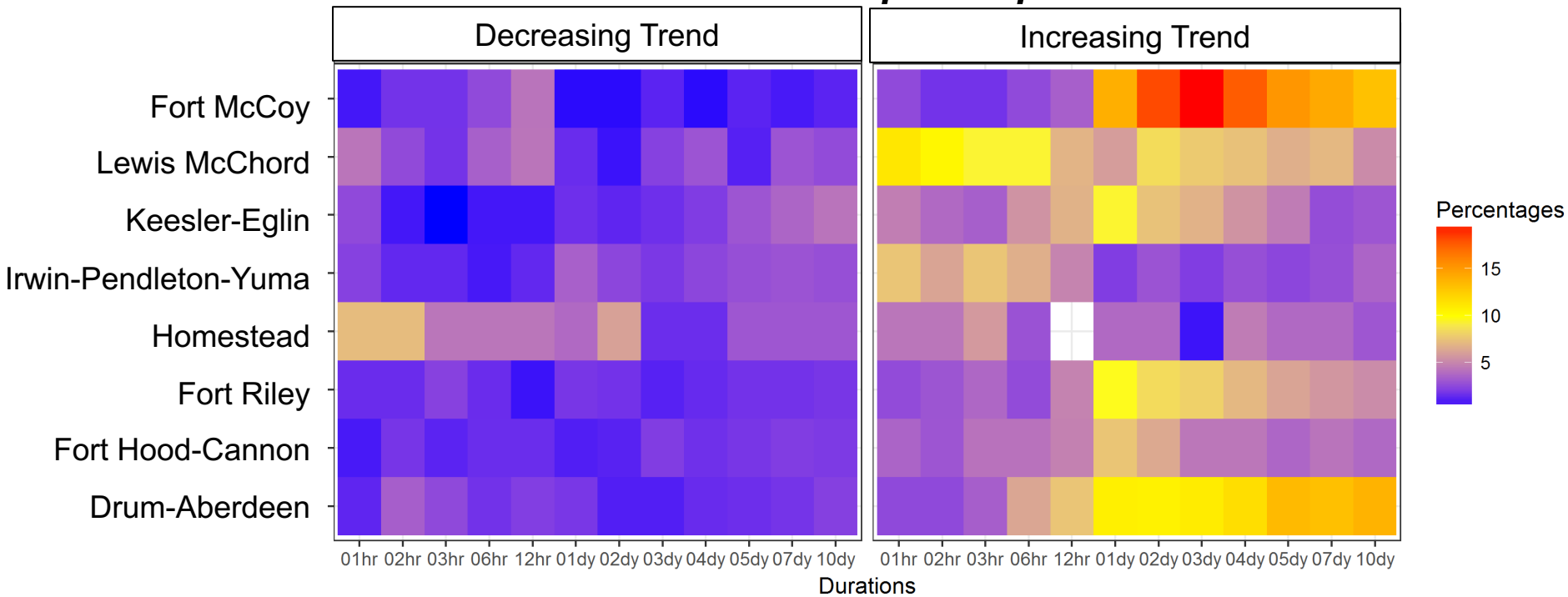
Impacts on IDF curves



Positive trend if location parameter increases with time

Past Trends

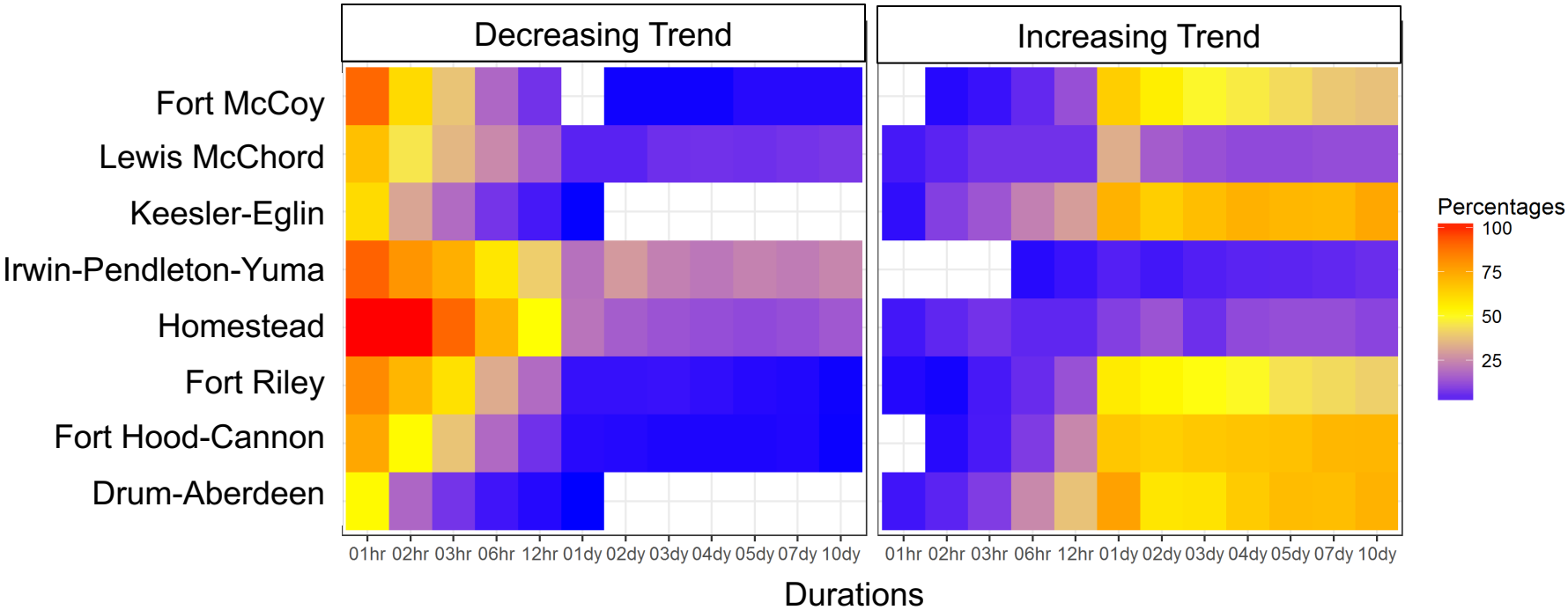
Annual maximum precipitation



Past: 5 to 20% of the stations show increased intensity of storms

Future Trends

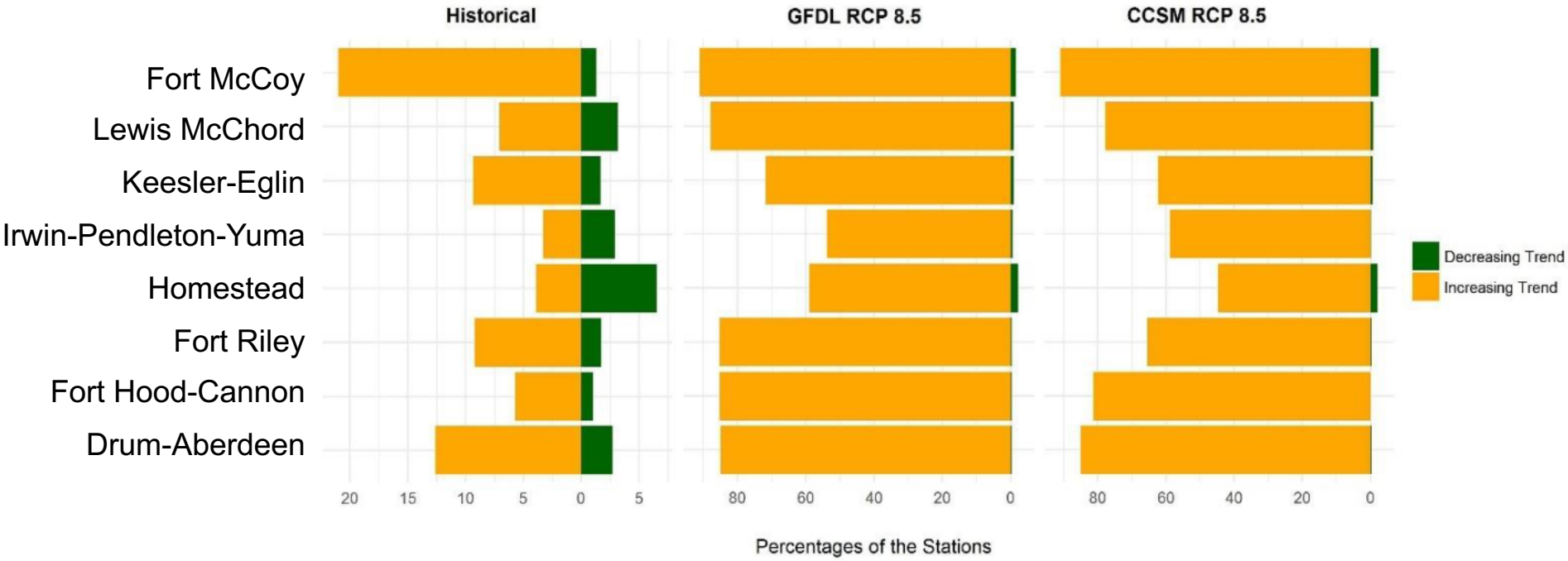
Annual maximum precipitation



Future: Increasing trend in long-duration storms but decreasing trend in short-duration storms

Future Trends

Frequency (number of heaviest (1%) daily precipitation)

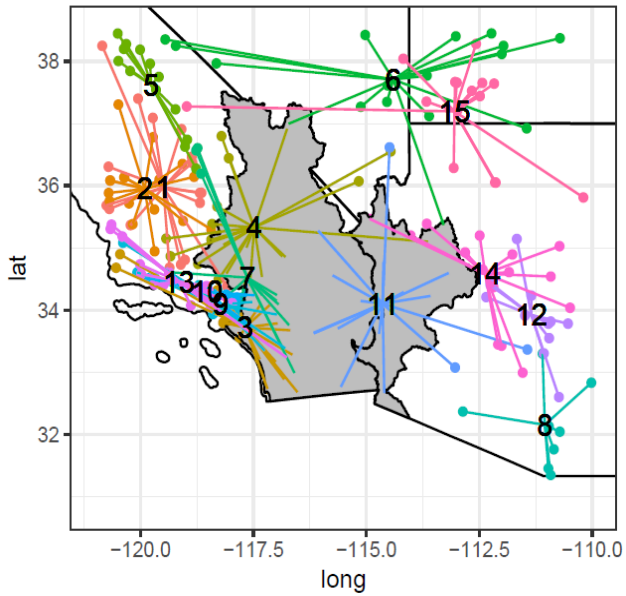


Past: 5-20% stations showed increasing trends

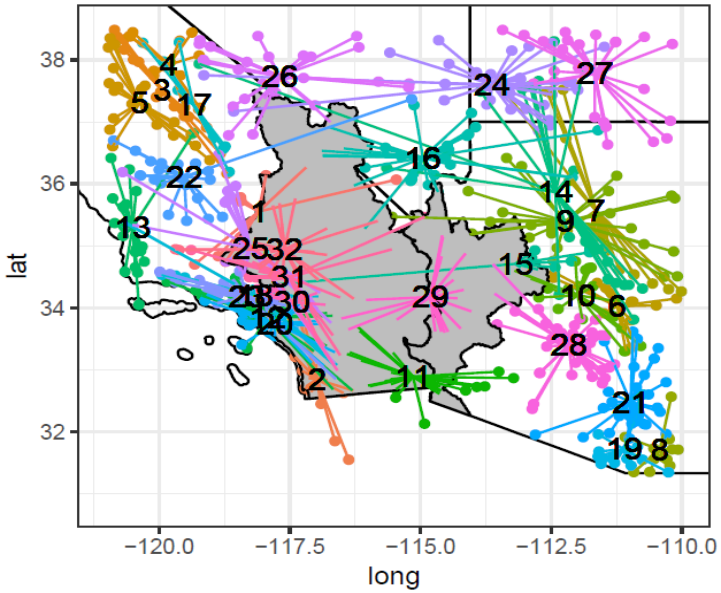
Future: 50-80% stations showed increasing trends

IDF Curves (Regional)

Irwin-Yuma-Pendelton
(Hourly precipitation)



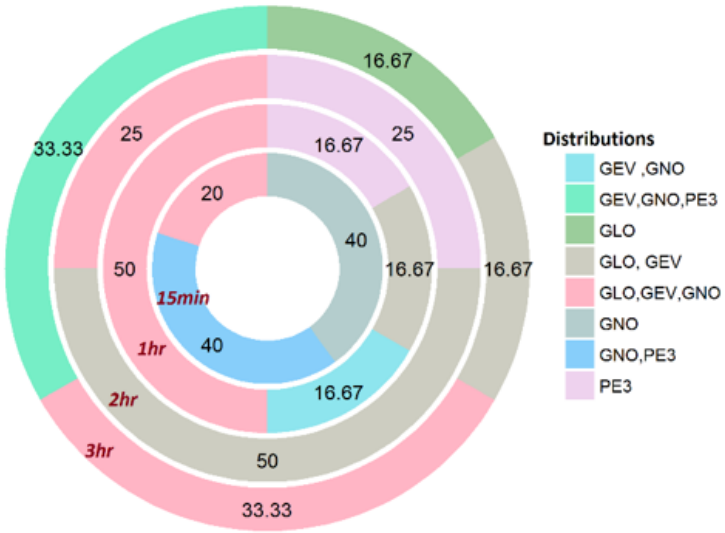
(Daily precipitation)

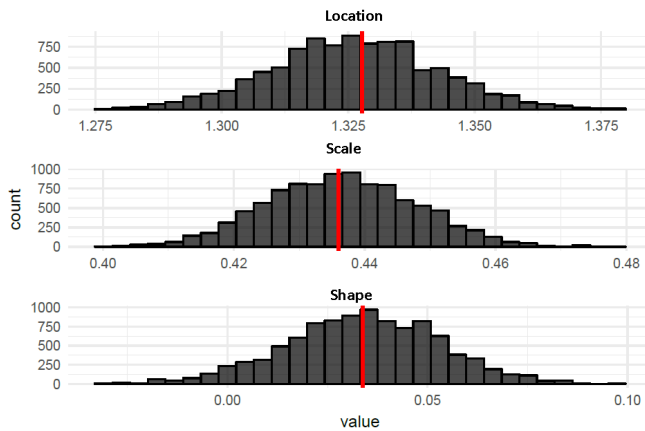


- Identify climatological homogenous regions for each durations (1 hr to 10 d)
- Pool data from stations within a region to develop IDF curves

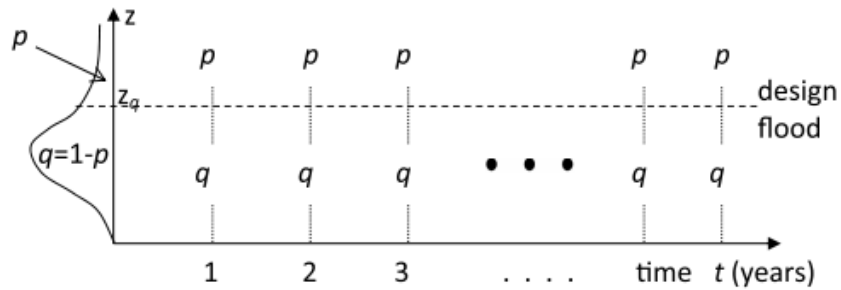
IDF Curves (Nonstationary, Probabilistic)

Model and parameter uncertainty

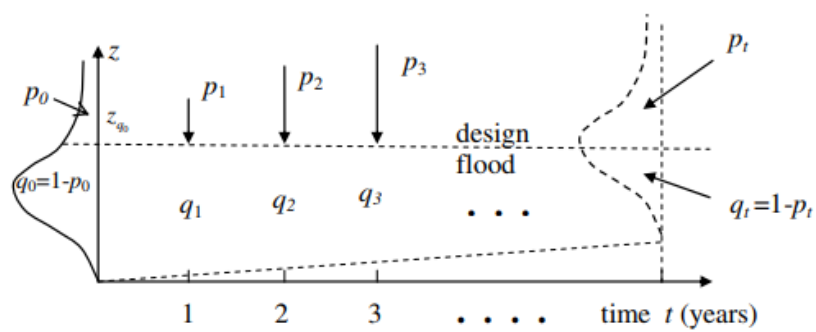




Stationary IDF

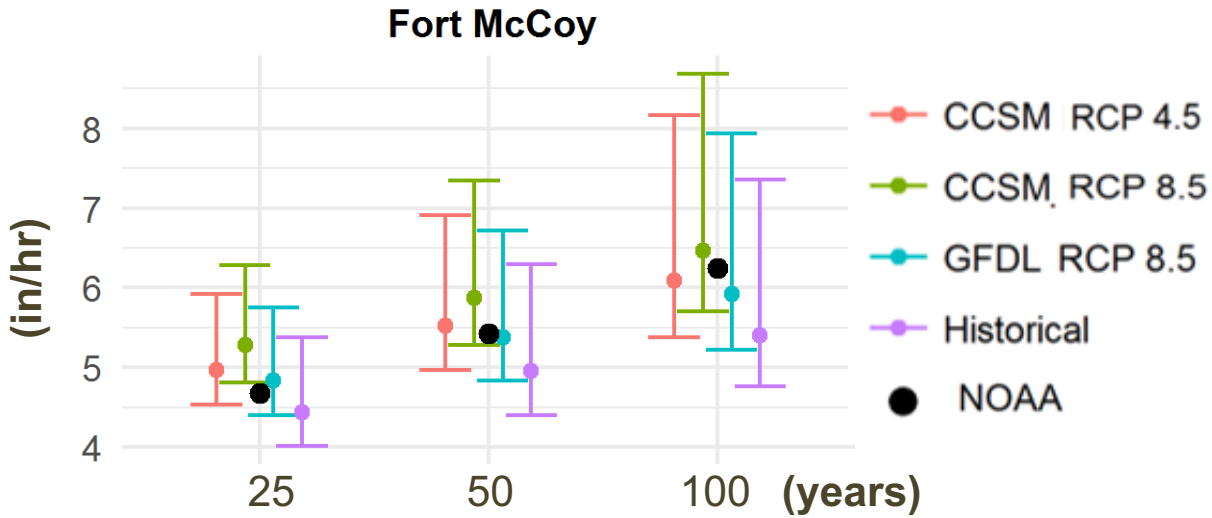


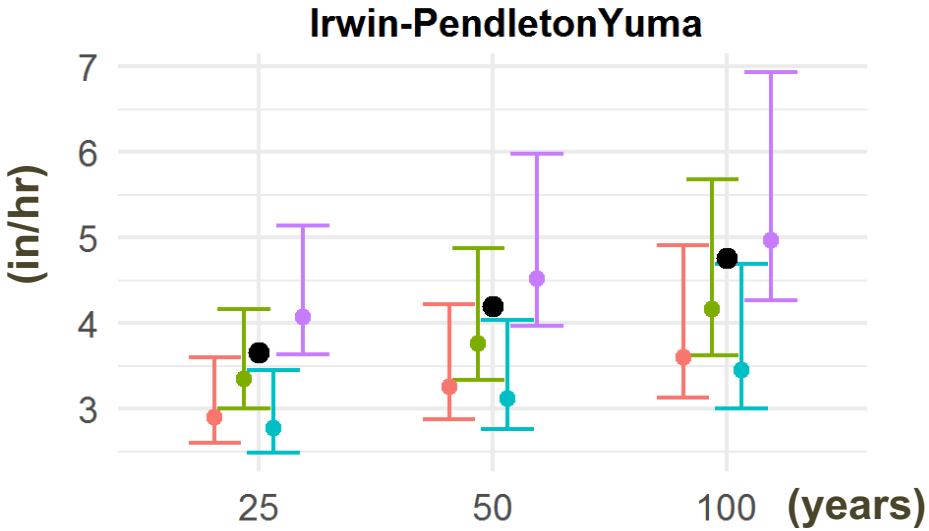
Non-Stationary IDF



Current and Updated IDF Curves

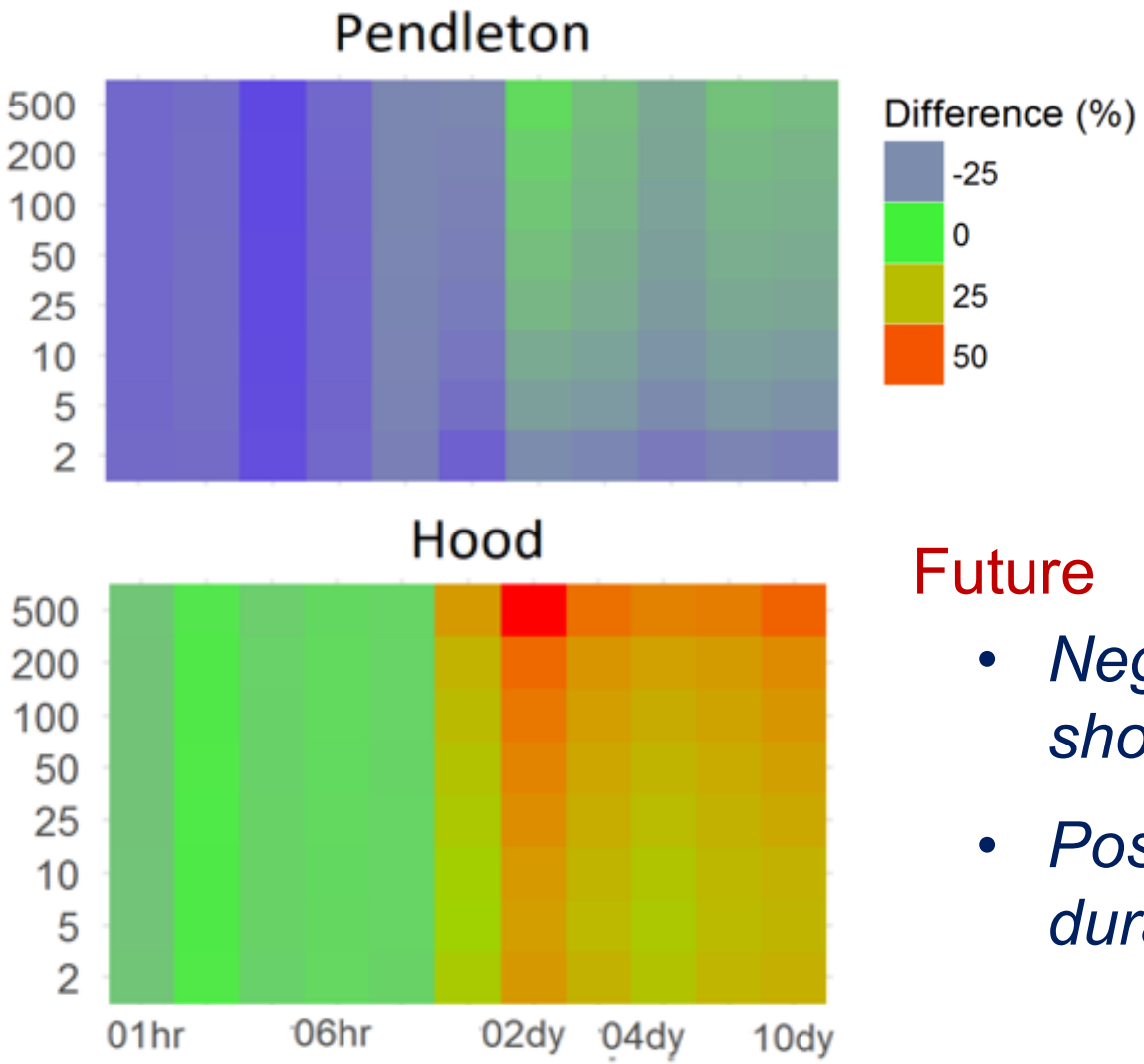
One-Day Precipitation





- *Increased IDF values at Ft. McCoy*
- *Decreased IDF values at Ft. Irwin, Camp Pendleton and Yuma PG*

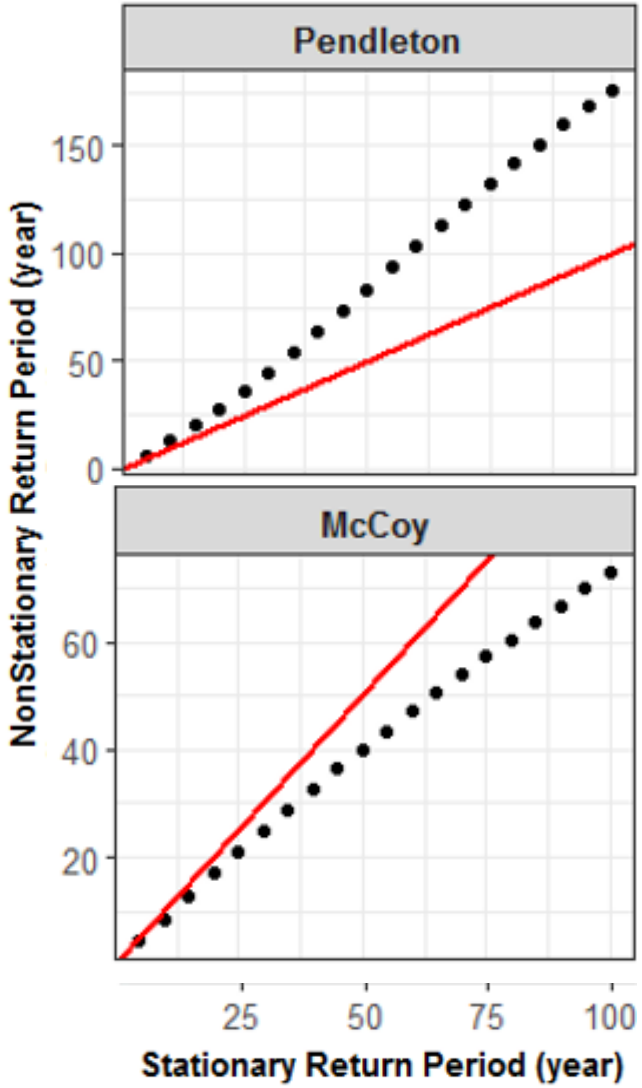
Current and Updated IDF Curves

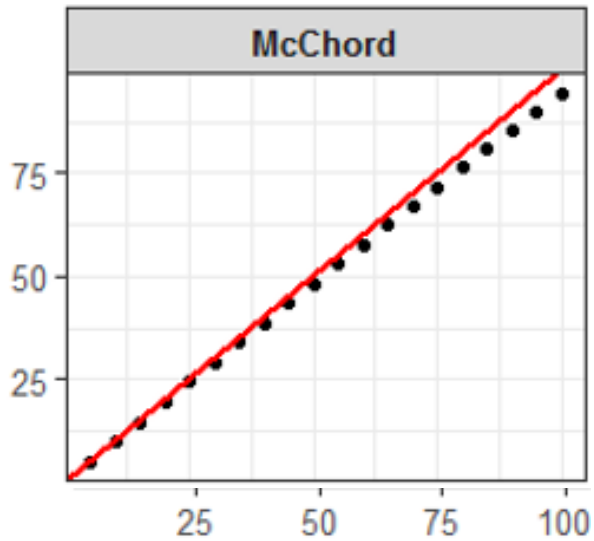


Future

- *Negative or no change in shorter durations storms*
- *Positive change in longer duration storms*

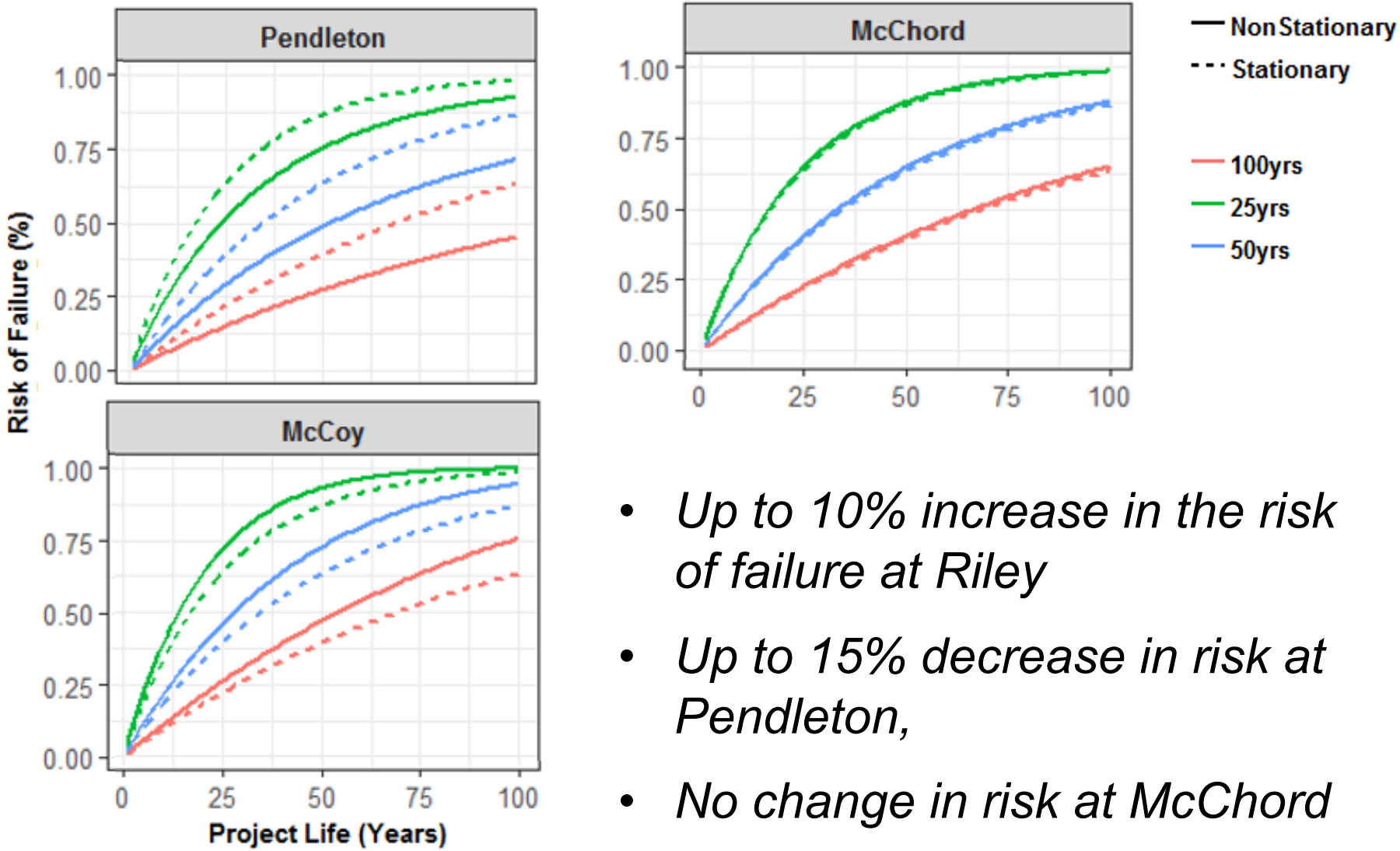
Non-Stationary IDF Curves





- *Return periods decrease in Midwest (McCoy), increase in the Southwest (Pendleton), not changed in Pacific (McChord)*

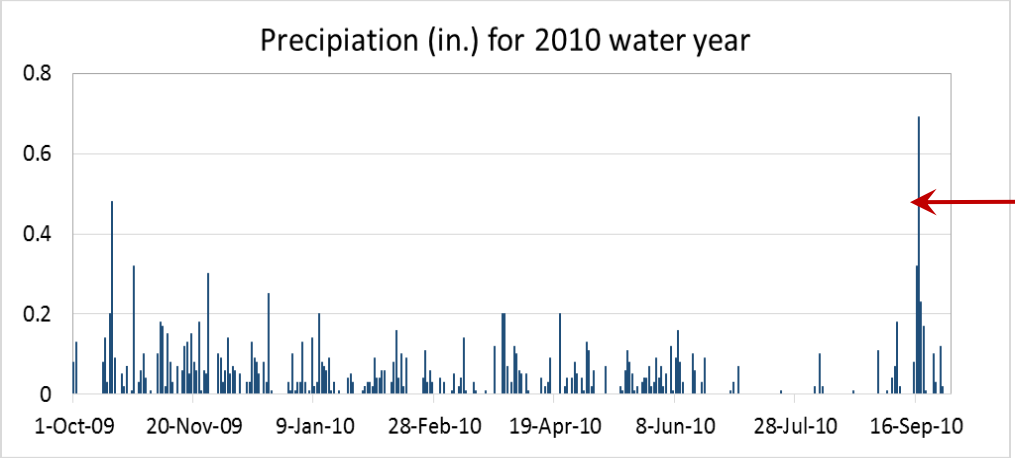
Risk of Instructure Failure



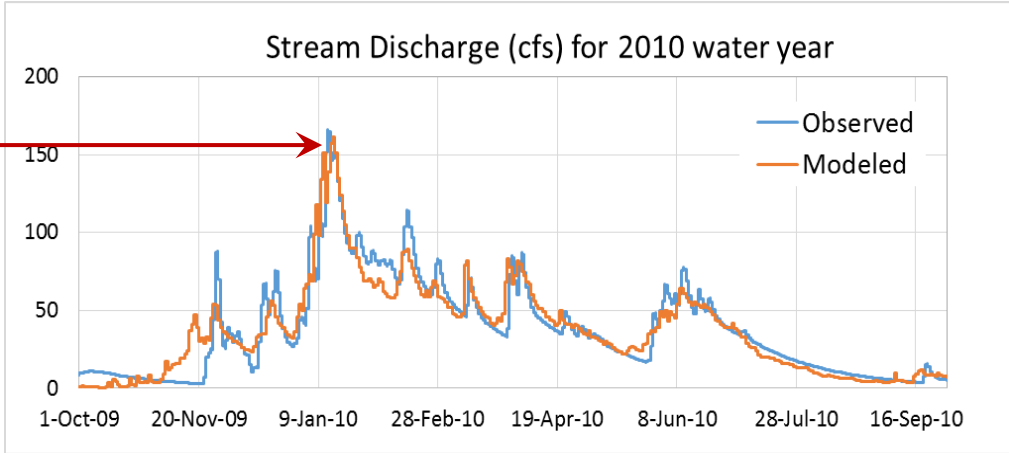
- *Up to 10% increase in the risk of failure at Riley*
- *Up to 15% decrease in risk at Pendleton,*
- *No change in risk at McChord*

Storm vs. Flood

Storm may not be a good indicator of flood risk



Annual Maximum Rainfall

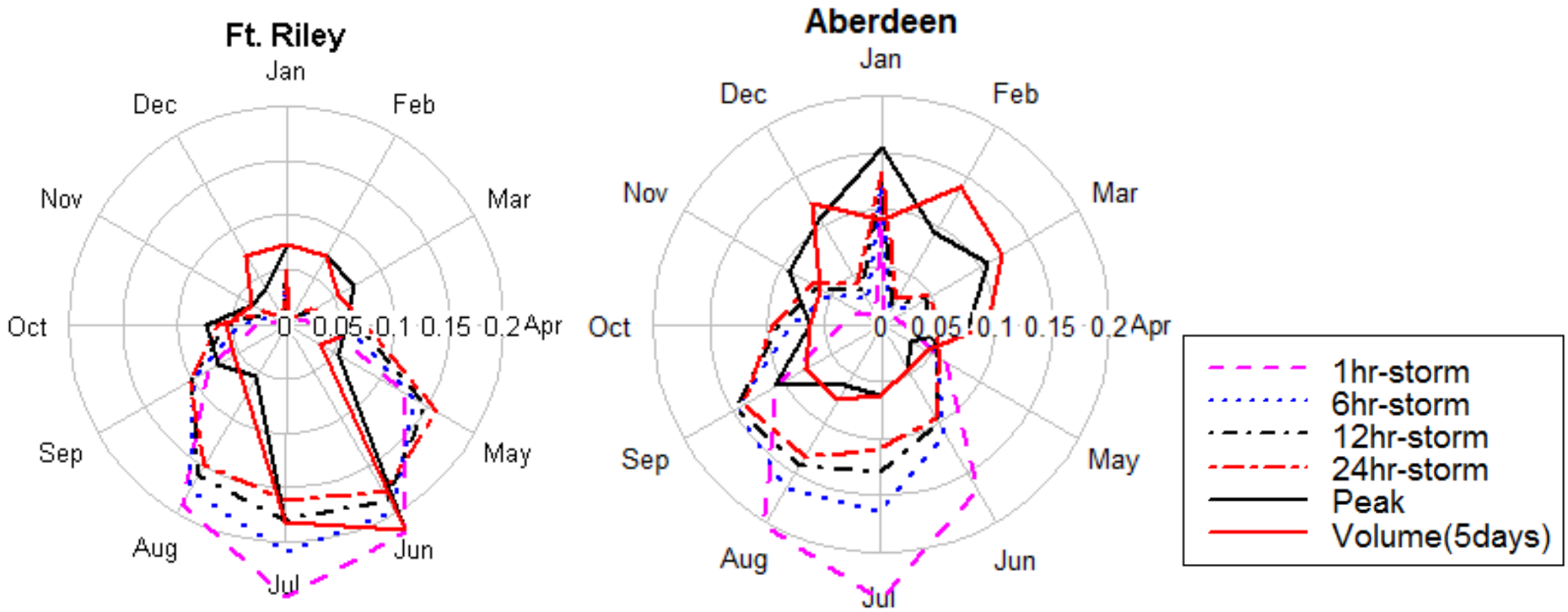


Annual Maximum Flow

May impact the use of IDF Curves for stormwater designs

Storm vs. Flood

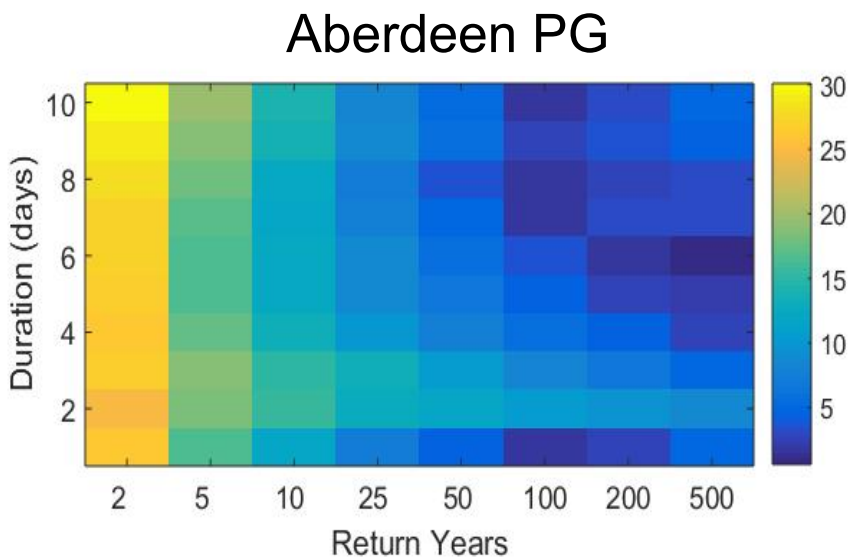
Difference in storm and flood seasons

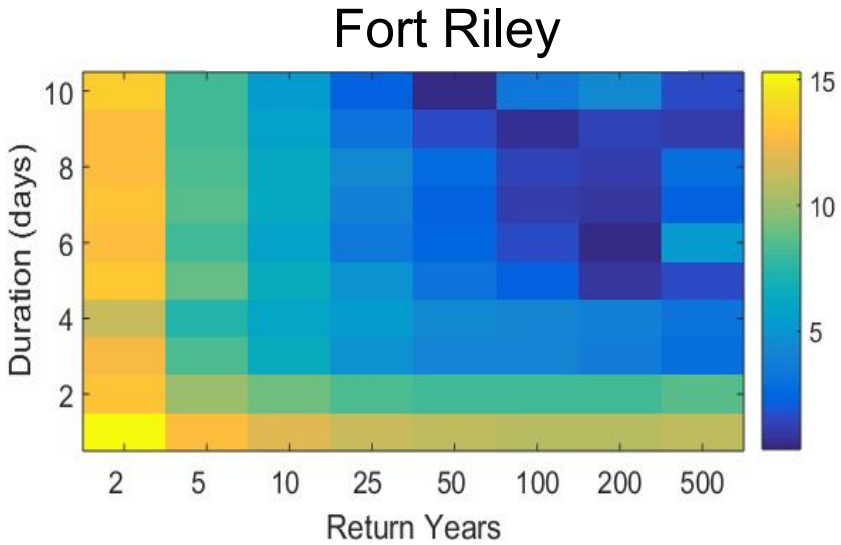


Better overlaps in storm and flood seasons at Ft. Riley than Aberdeen PG

Effect of Storm and Flood Seasons

Percentage change between IDF curves with and without considering the flood and storm seasons

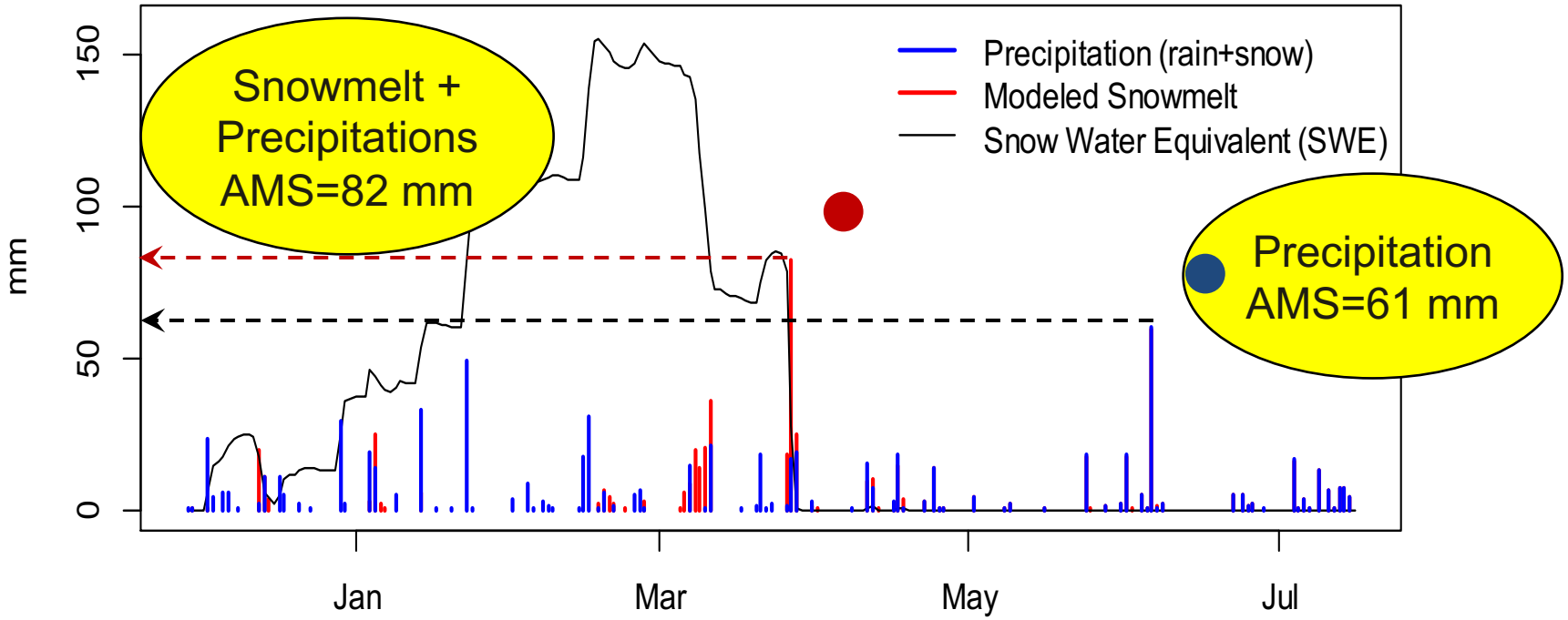




Storm-based (rainfall IDF) tend to over predict flood risk, particularly those with short return periods

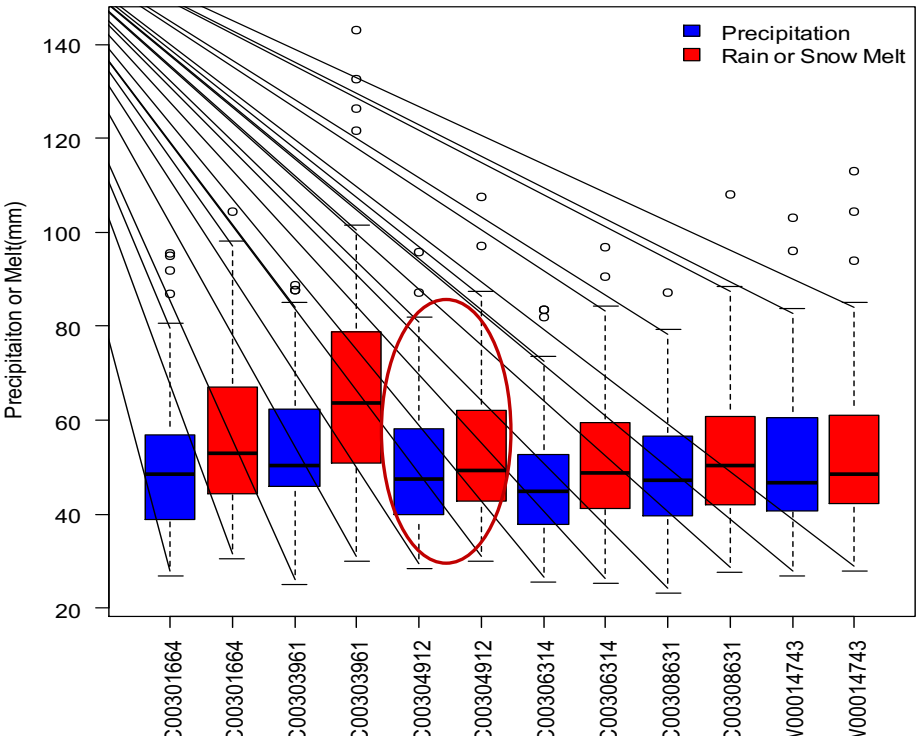
Effect of Snow

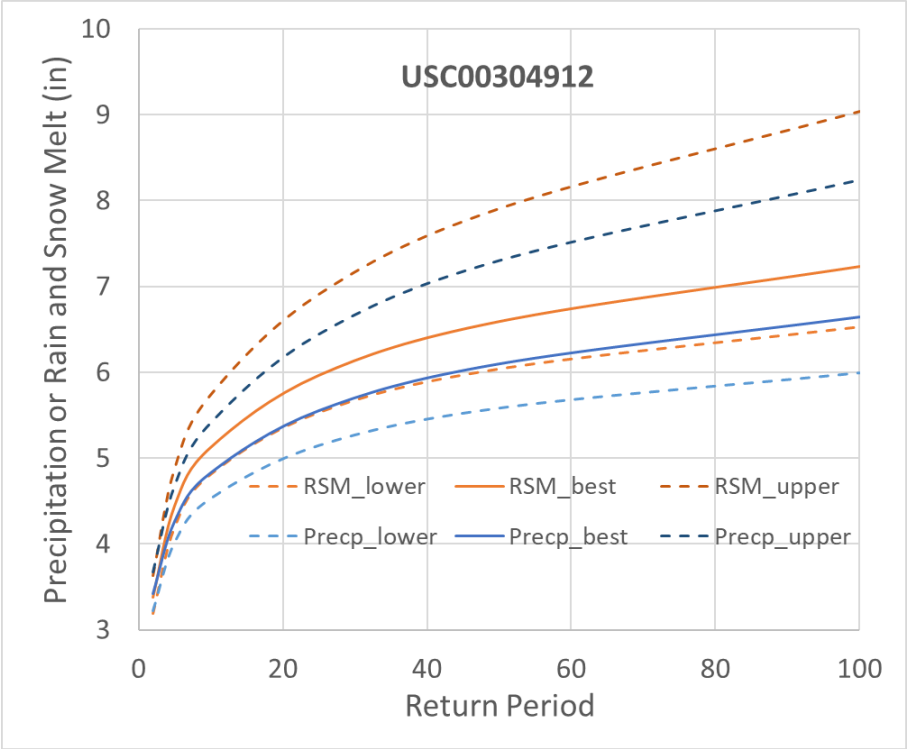
Snowmelt increases water availability for runoff, while snow accumulation will decrease



Effect of Snow

Increases in annual maximum water availability for runoff increased in IDF values

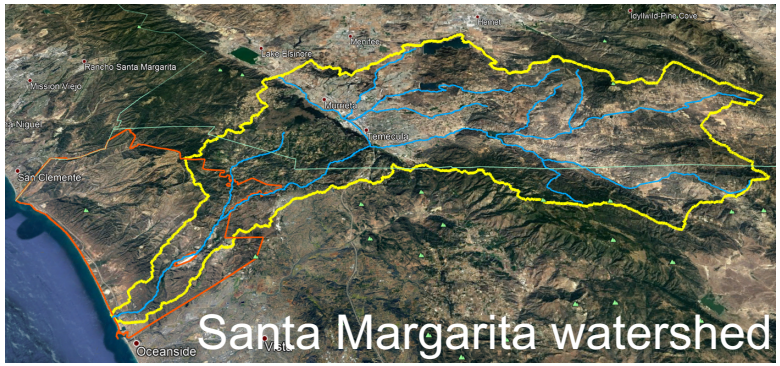


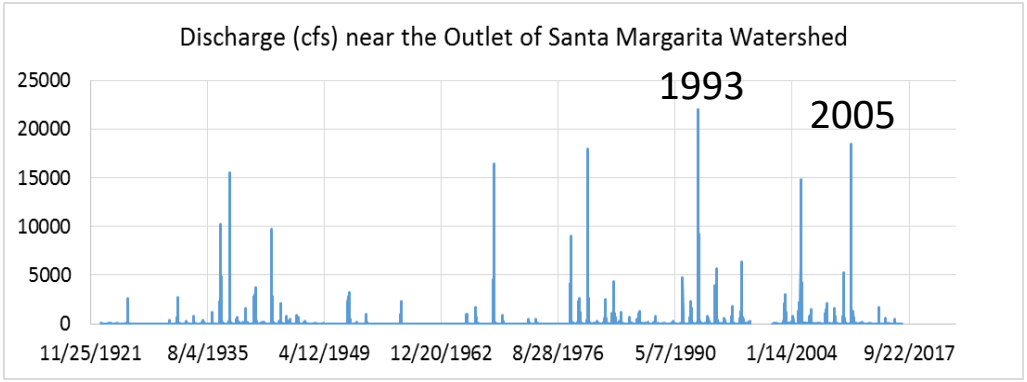


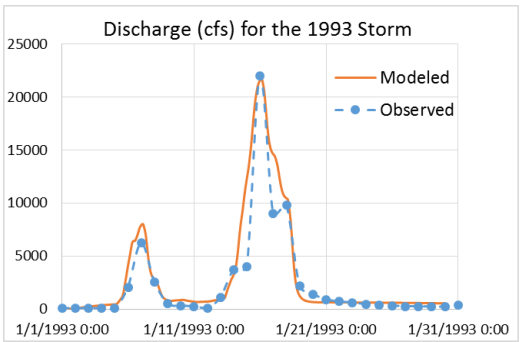
Ft. Drum: Up to a 25% increase in the 100-year storm magnitudes

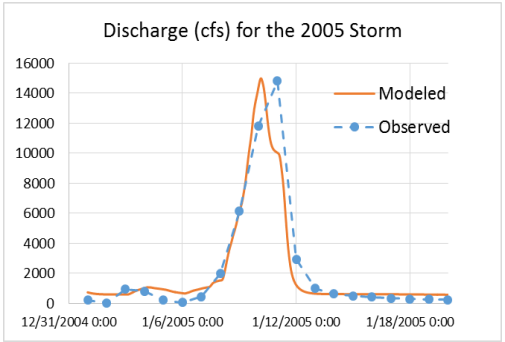
Runoff IDF Curves

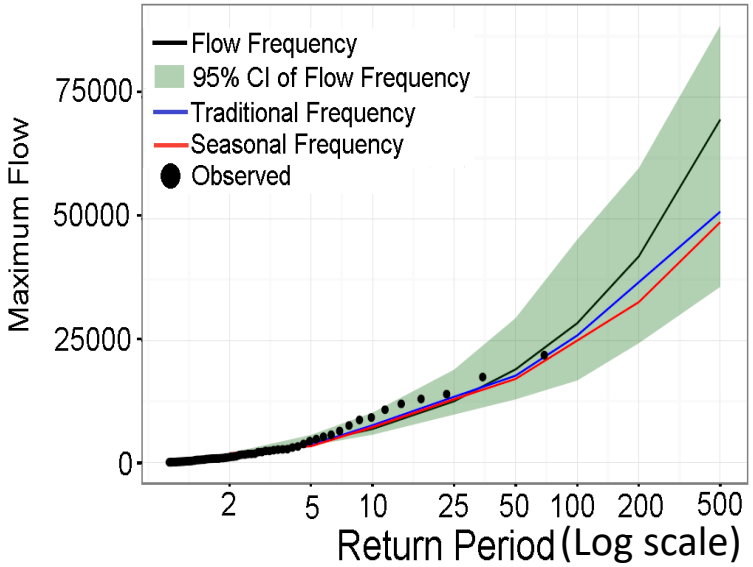
- HEC-HMS simulate the peak runoff
- IDF values with time of concentration are used for runoff IDF curves



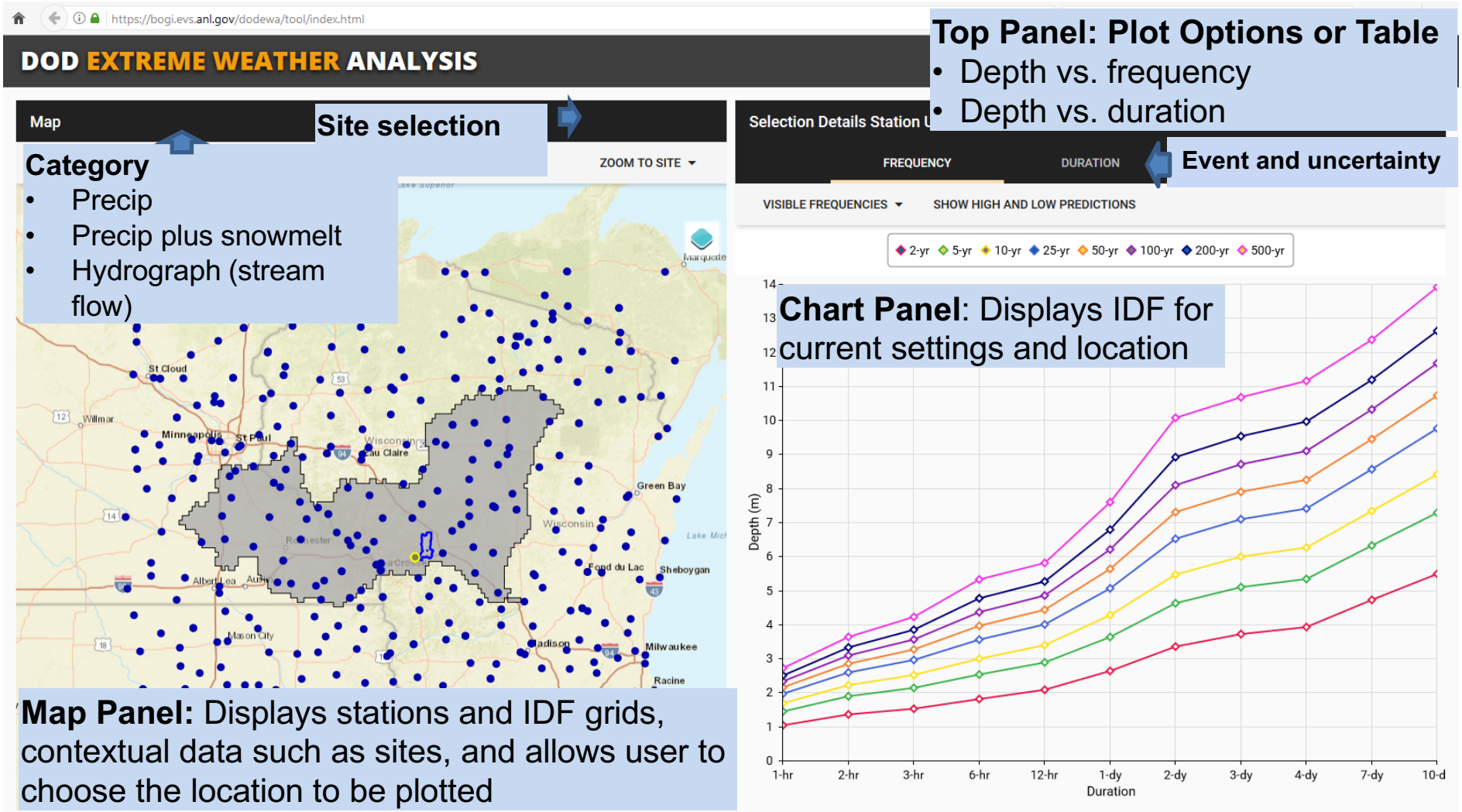








Web Portal for IDF Tool



Top Panel: Plot Options or Table
- Depth vs. frequency
- Depth vs. duration

Site selection

Category
- Precip
- Precip plus snowmelt
- Hydrograph (stream flow)

Event and uncertainty

Chart Panel: Displays IDF for current settings and location

Map Panel: Displays stations and IDF grids, contextual data such as sites, and allows user to choose the location to be plotted

https://bogi.evs.anl.gov/dodewa

Conclusions

- Increasing storm intensity and frequency at most sites
  - Trends expected to accelerate
- IDF curves for 13 sites were updated by considering change in the following
  - Storm
  - Uncertainty
  - Flood season
  - Snow effect
- Flooding risk was assessed under stationary and non-stationary storms
- Runoff IDF curves were developed for most sites
- Web-based GIS tool was developed for interactive access to IDF data and figures

Acknowledgements

- Co-PIs
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For additional information, please visit
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Q&A Session 1

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Next Generation Intensity-Duration-Frequency Curves for Improved Hydrologic Design

Mark Wigmosta, Ph.D.
Pacific Northwest National Laboratory

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Agenda

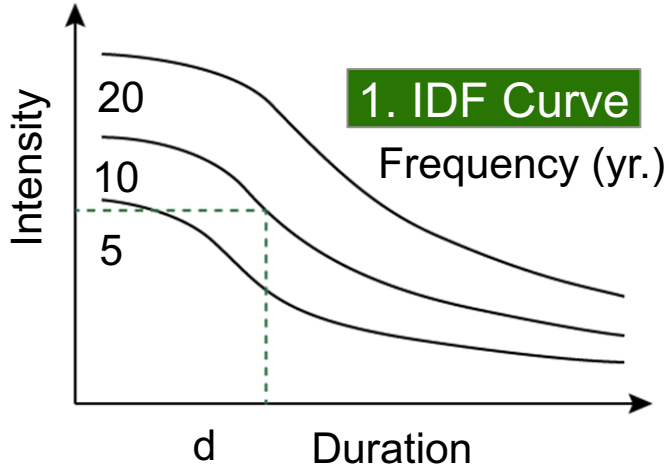
- Benefits to DoD
- IDF based hydrologic design
- NG-IDF curves from observational data
- Precipitation-based vs. NG-IDF curves
- Development of NG-IDF curves for CONUS
- Impacts of non-stationary climate on NG-IDF curves
- Conclusions

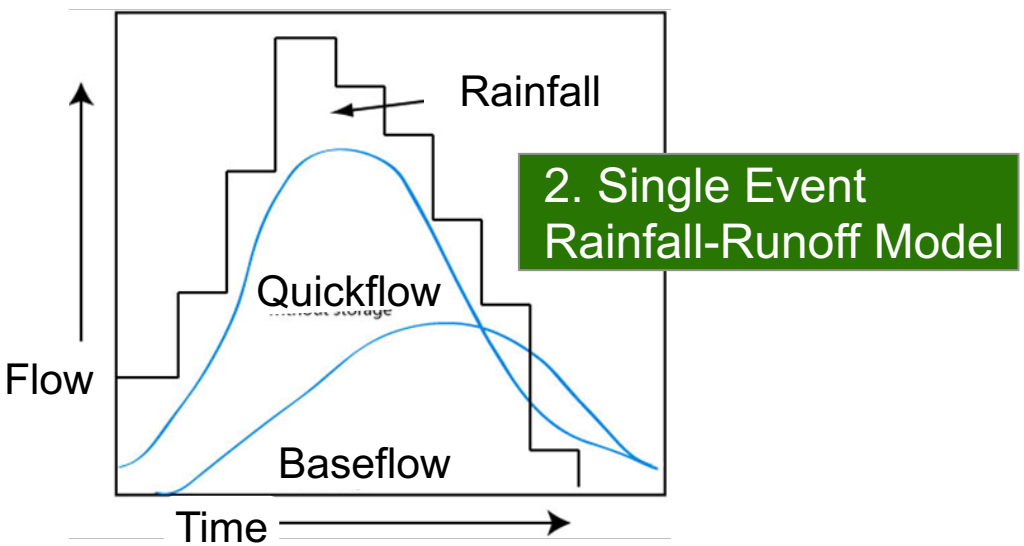
Notes: *CONUS = continental United States; IDF = intensity-duration-frequency; NG = next-generation*

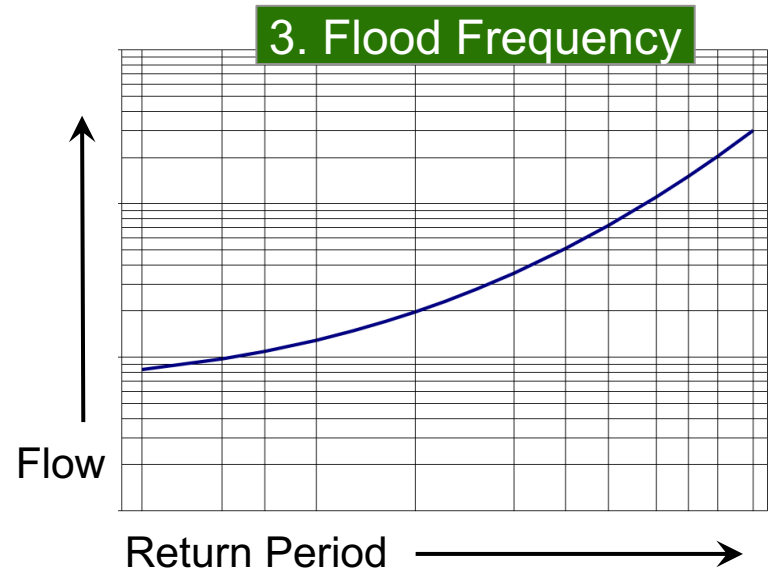
Benefits to DoD

- 1/6 of the world live in snowmelt-dominated regions
- 70%+ nation's roads are in snowy regions
- Advanced physically based modeling approach for hydrologic design is costly and labor intensive
- NG-IDF curves can improve design in snow dominated locations with minimal cost or training

Traditional IDF-Based Hydrologic Design



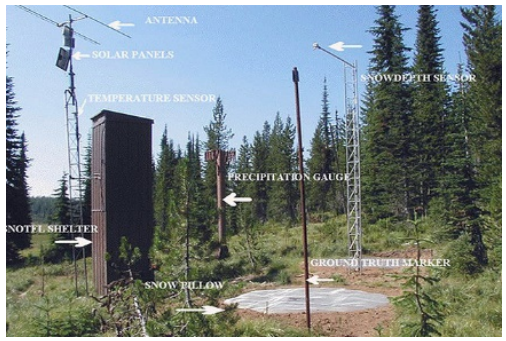




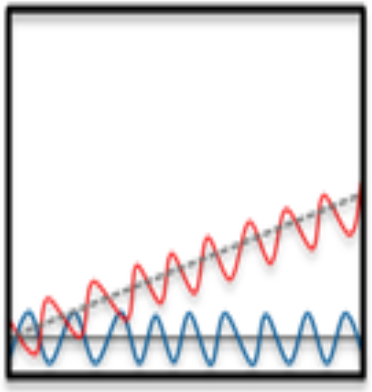
4. Hydrologic Design

NG-IDF Curve Development

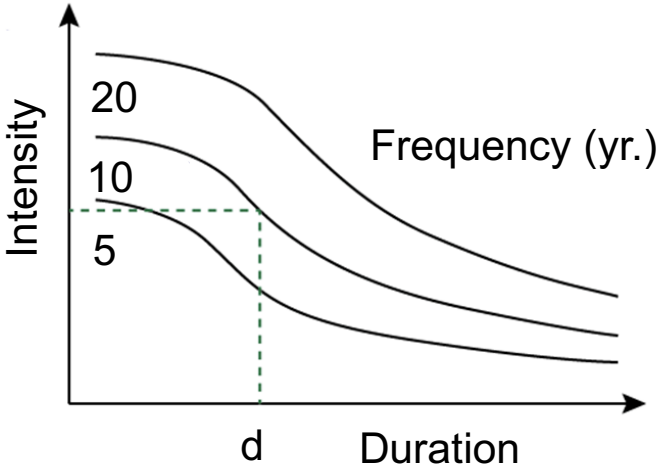
From SNOTEL Observations



SNOTEL observations of precipitation and SWE



Non-stationarity and trend analysis; Detrending



IDF's

- Precipitation (P)
- Water available for runoff (NG-IDF)

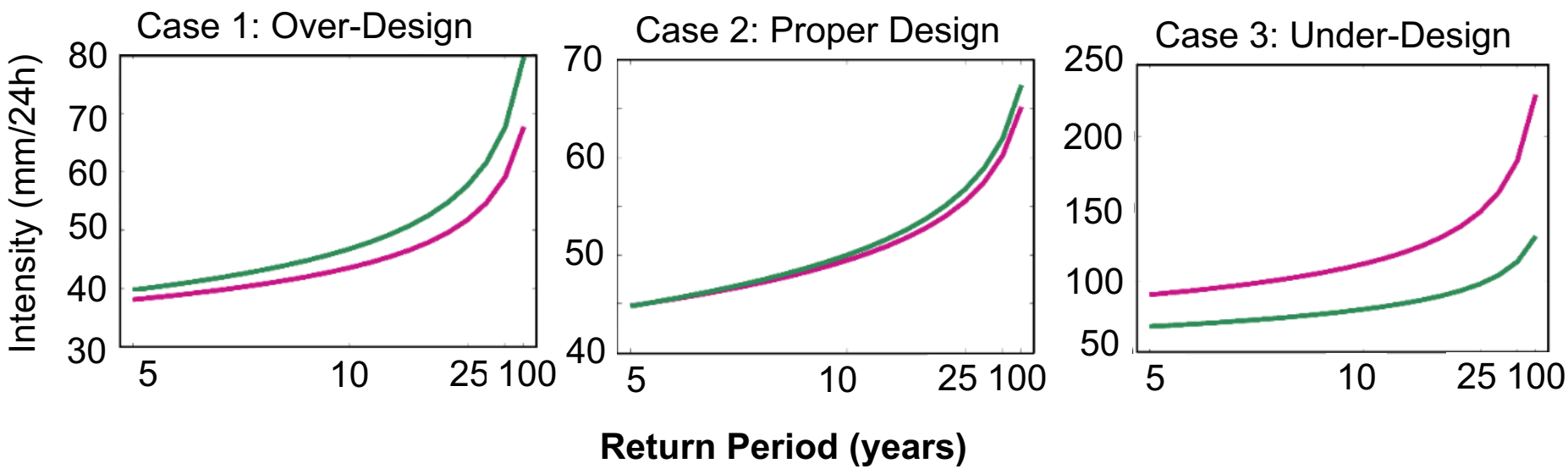
Water Available for Runoff (W) from mass balance:

$W = P - \Delta SWE$ (any combination of rainfall/snowmelt/ROS)

***Notes**: P = precipitation; SWE = snow water equivalent; ROS = rain-on-snow*

Precipitation vs. Next-Generation IDF Curves

Overdesign vs. Under-Design

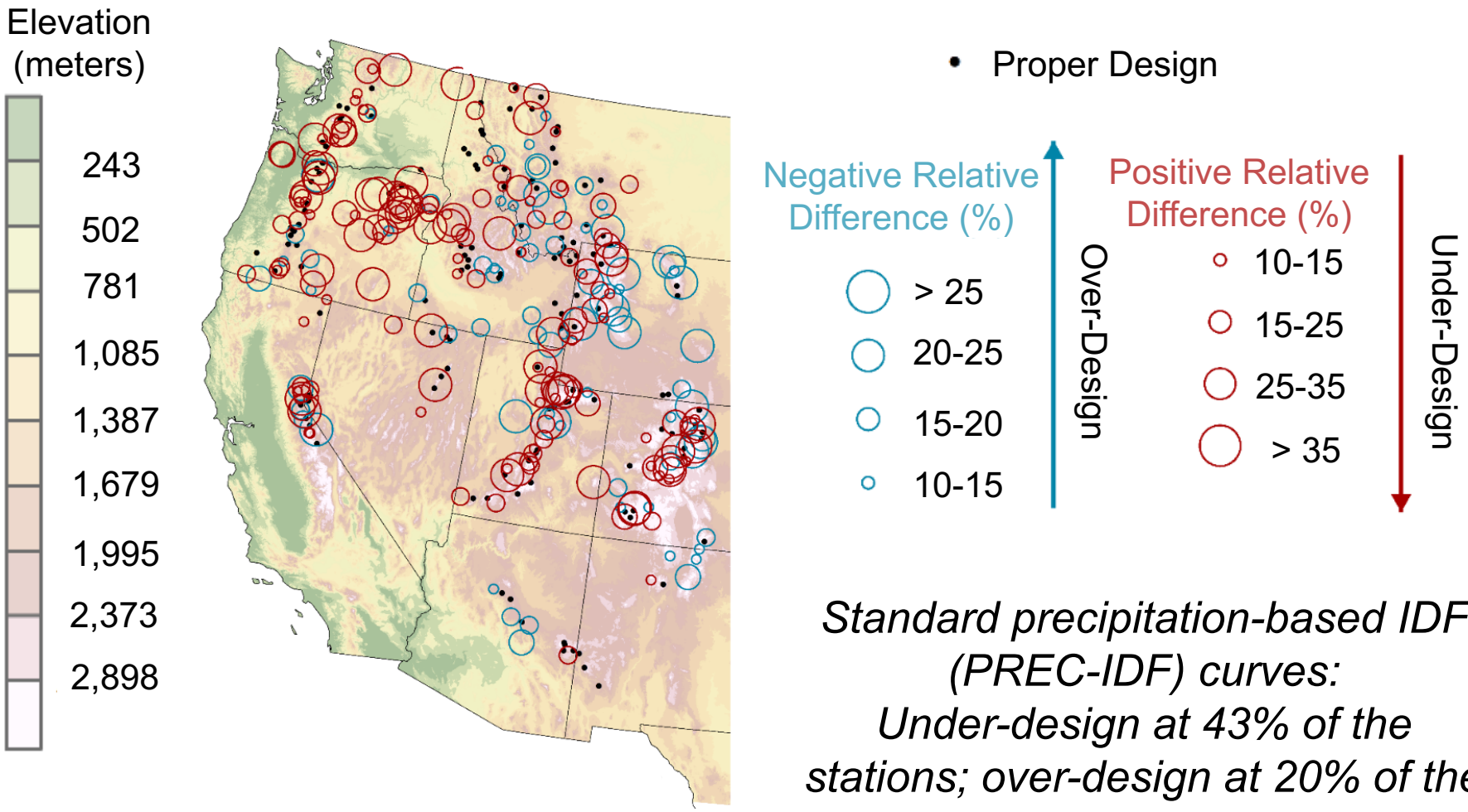


NG-IDF

Precipitation-based IDF

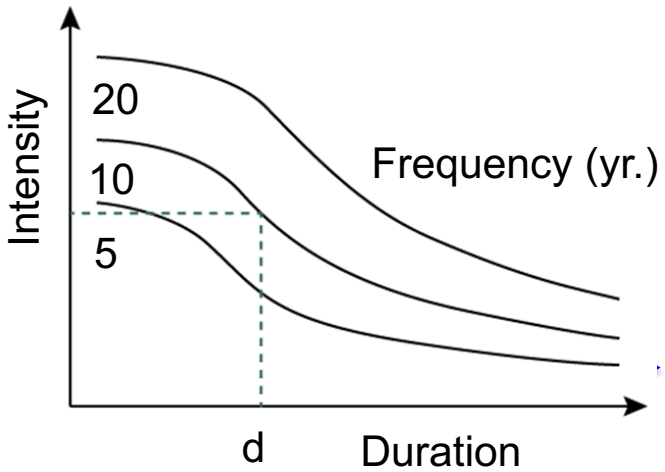
Precipitation vs. Next-Generation IDF Curves

24-Hour, 100-Year Event

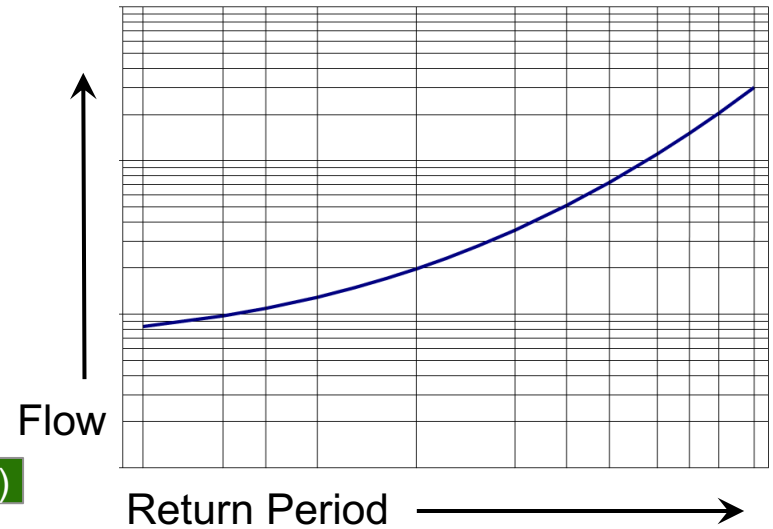


Standard precipitation-based IDF (PREC-IDF) curves: Under-design at 43% of the stations; over-design at 20% of the stations

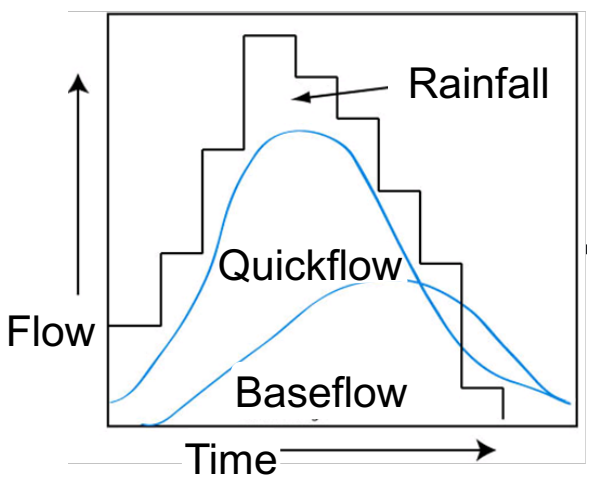
Estimation of Flood Frequency



1. IDF's: Precipitation (P); Water Available for Runoff (NG-IDF)



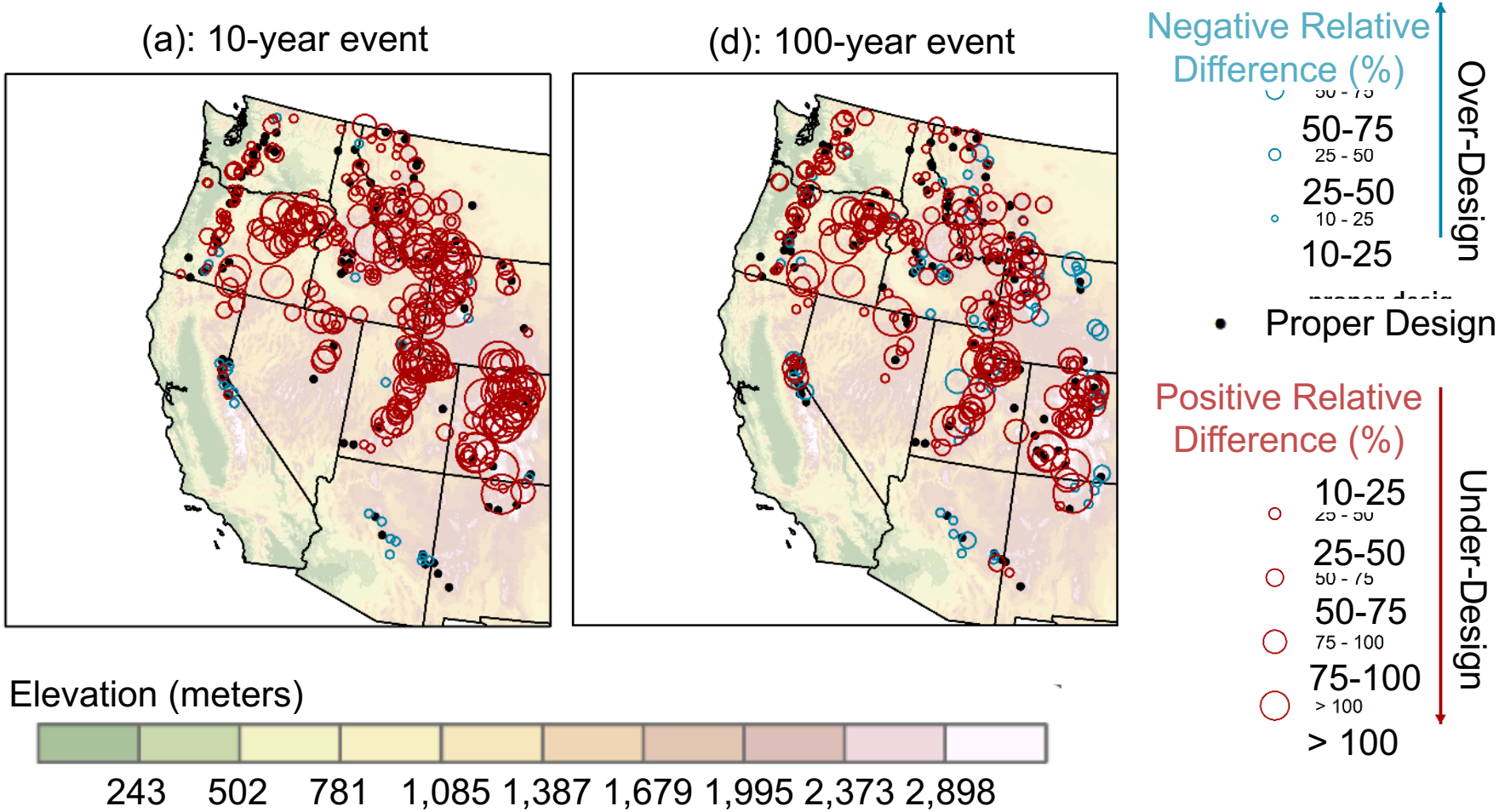
3. Flood Frequency



2. TR-55 Single Event Hydrologic Model

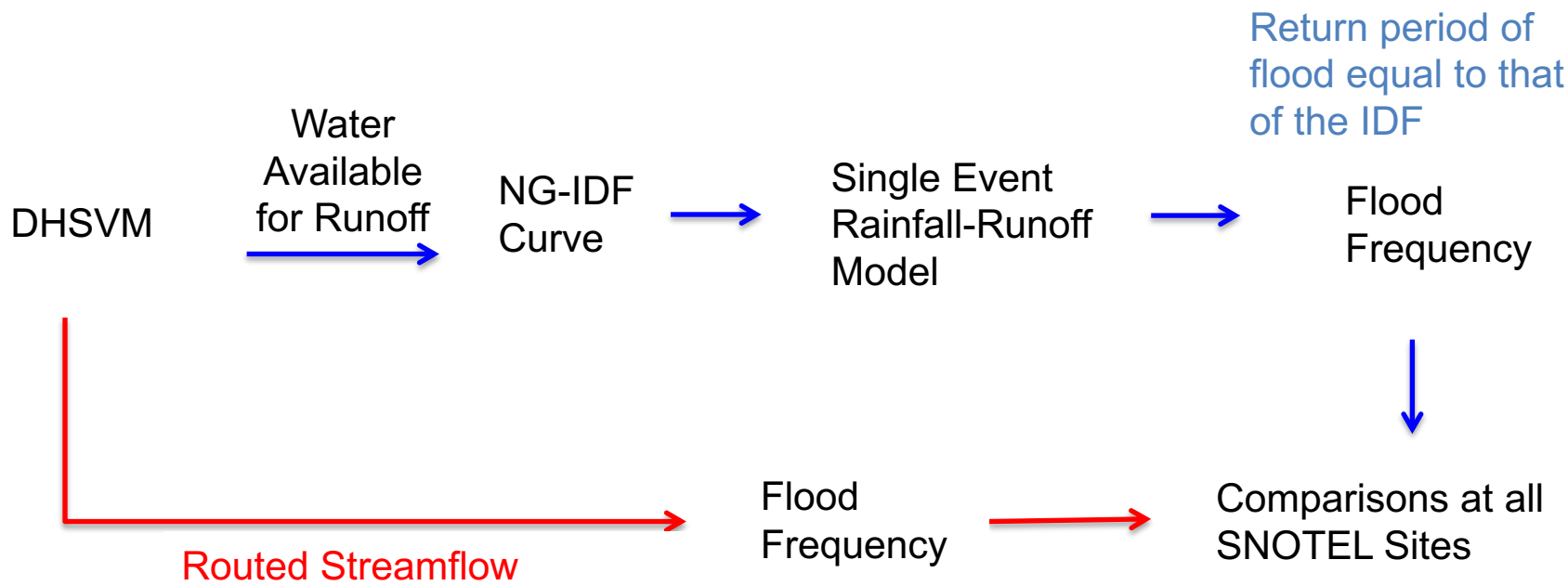
Note: *TR55 = single event hydrologic model described in USDA Soil Conservation Service Technical Release 55 - Urban Hydrology for Small Watersheds*

PRCP-IDF vs. NG-IDF Flood Frequency Estimates



Benchmarking NG-IDF Performance

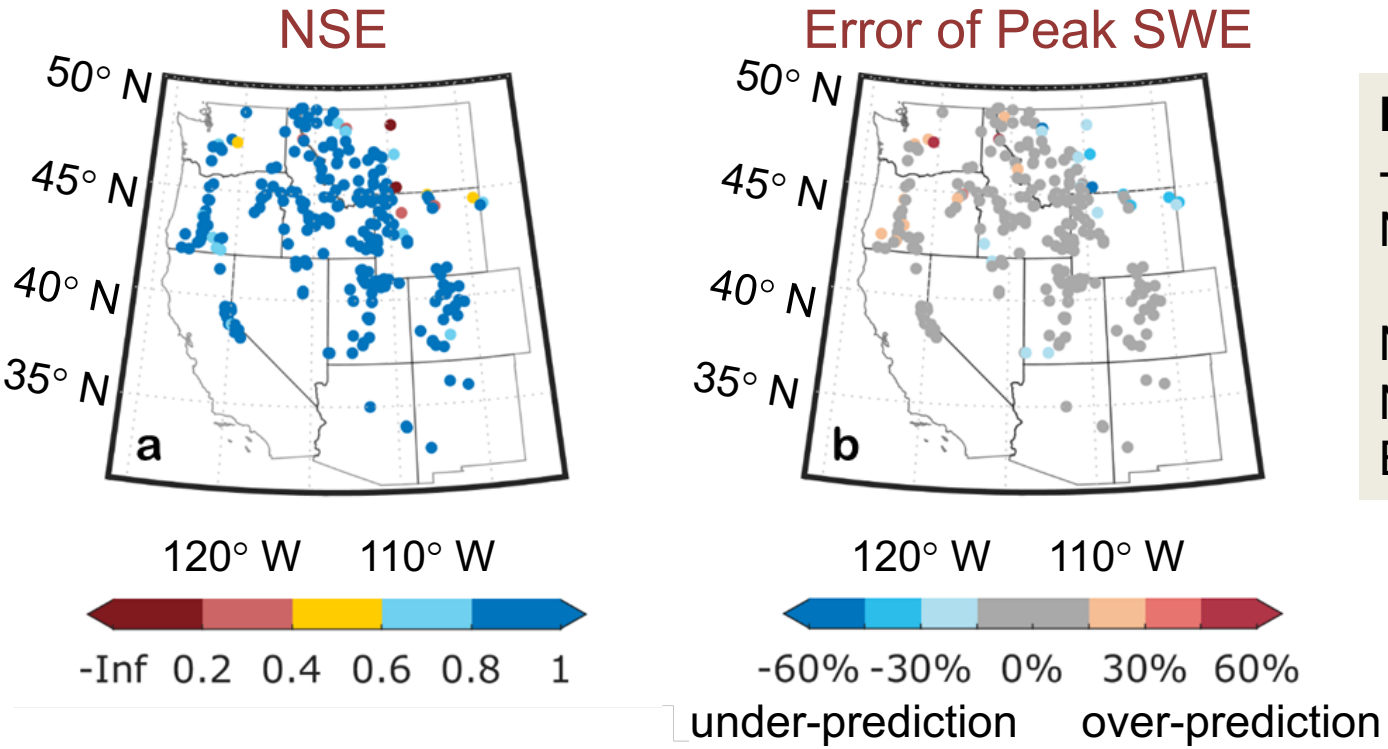
Using DHSVM Simulated Streamflow



How do flood frequencies based on NG-IDF curves compare with those from a complex continuous simulation model?

Assessment of DHSVM Snow Modeling Skill

246 SNOTEL Stations, WY 2007-2013



Notes:
-Inf = Negative Infinity

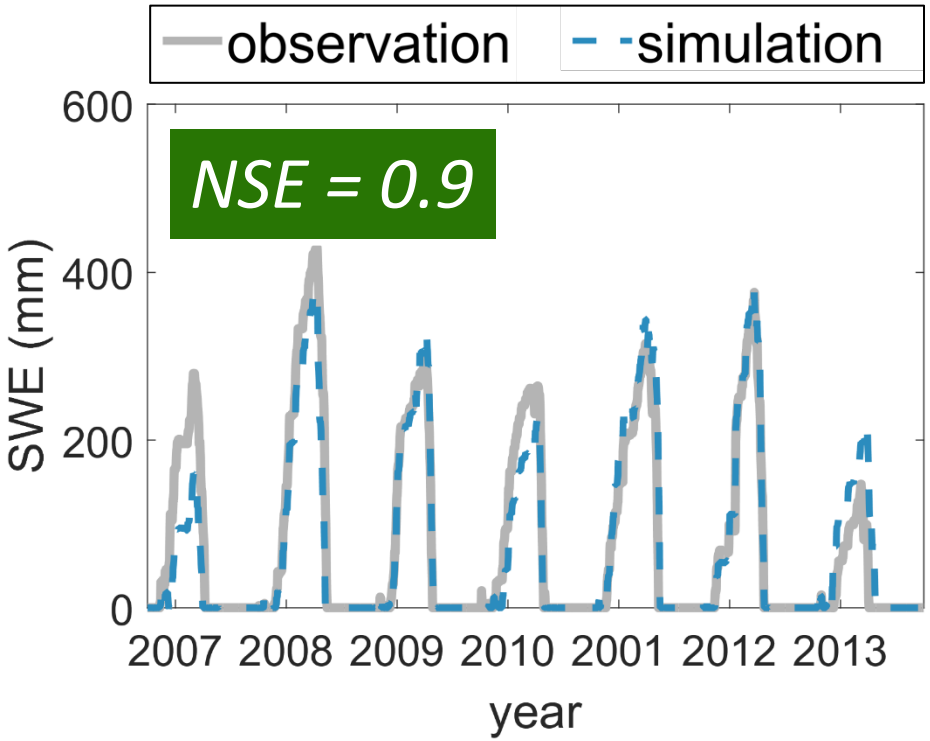
NSE = Nash-Sutcliffe Efficiency

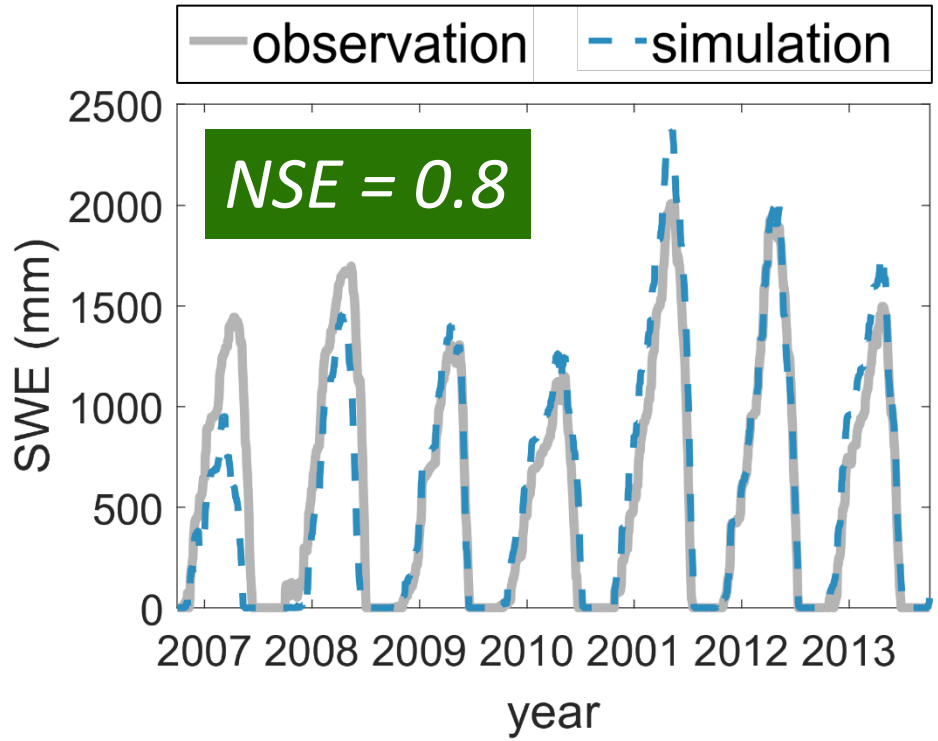
DHSVM simulated SWE

- NSE > 0.8 at 91% of stations (mean NSE = 0.9)
- Error of peak SWE is within ±15% at 88% of stations
- NSE < 0.6 at only eight sites (Rocky Mountains)

DHSVM Simulated and Observed SWE

For Selected Stations

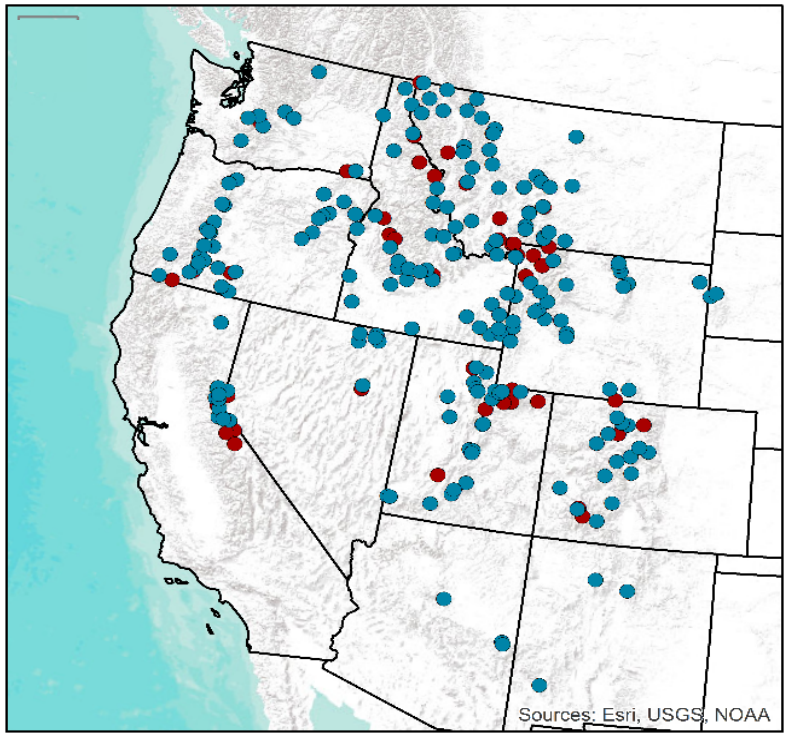


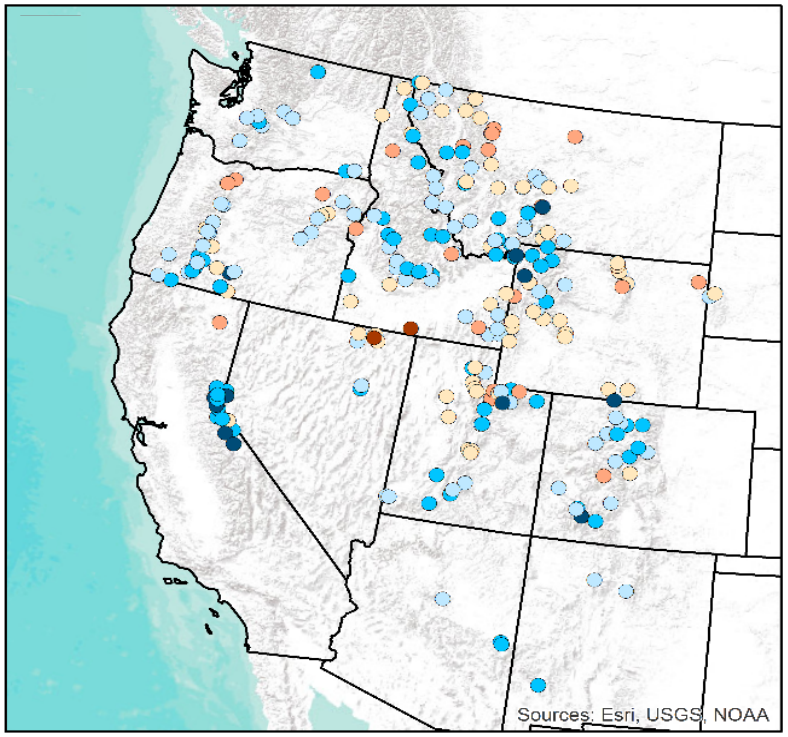


NSE ranges from -∞ to 1. The closer to 1, the more accurate the model is. Farida et al. (2012) and Yang et al. (2013) suggested that the simulated values can be regarded as satisfactory when ***NSE > 0.5***

Daily Annual Maximum W from DHSVM

Compared to SNOTEL Observations





- P-value>5%: 82% stations
- P-value≤5%: 82% stations

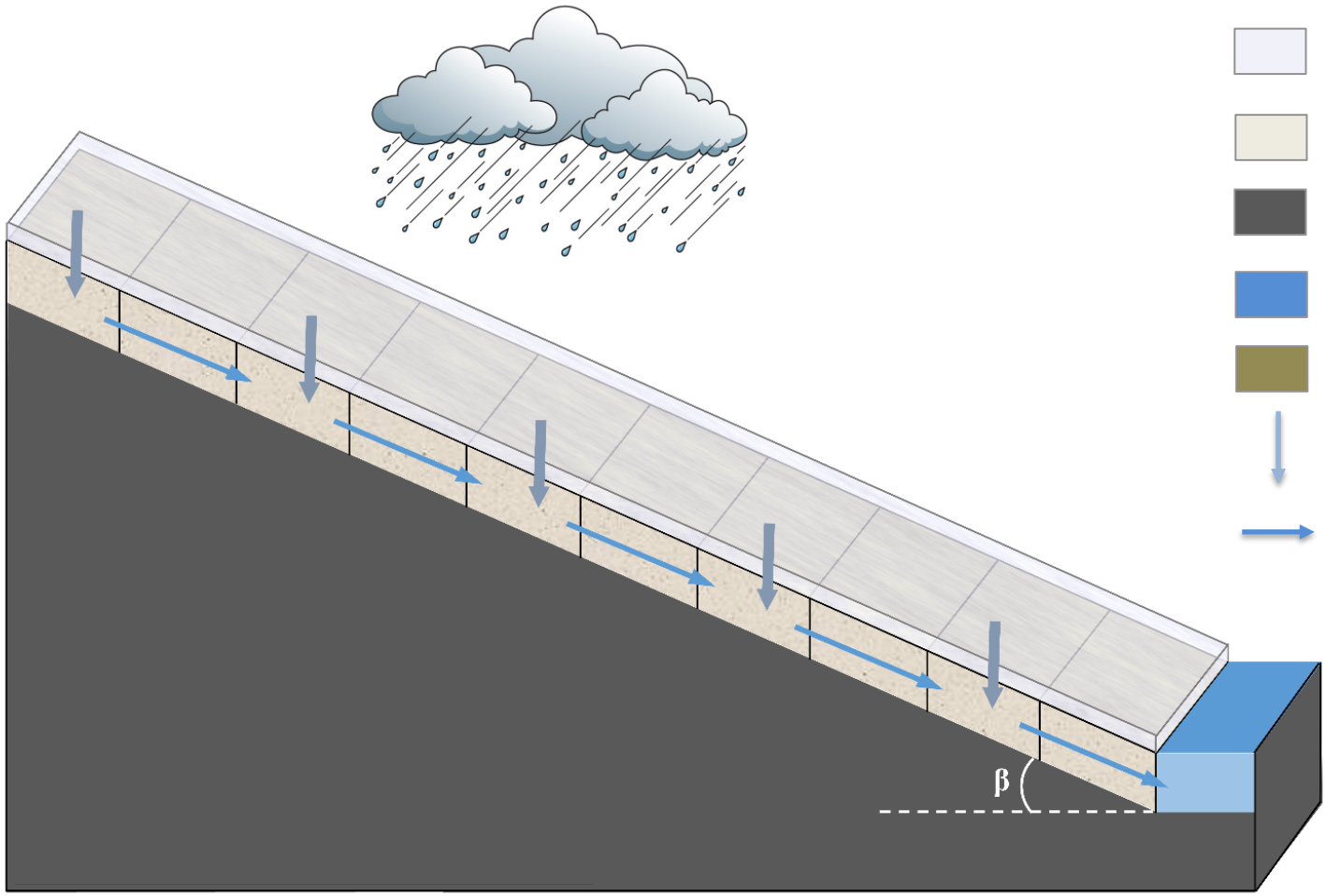
-30% -20% -10% 0% 10% 20% 30%

Under-prediction Over-prediction

82% stations accepted null hypothesis that the two annual maximum W were drawn from the same distribution; 94% stations errors < 20%

Experimental Hillslope

Flood Frequency Estimates



Snowpack

Soil

Bedrock

Stream segment

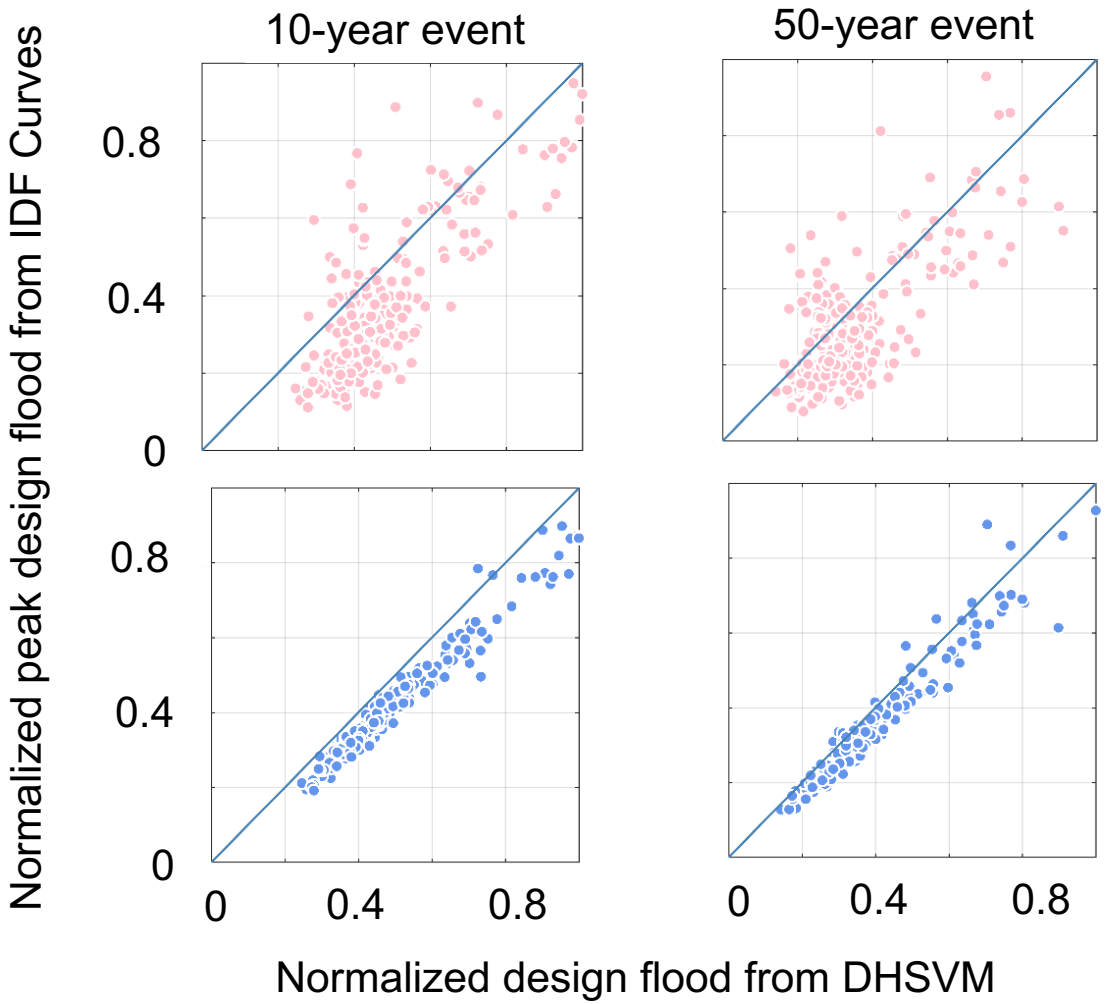
DHSVM grid cell

Infiltration

Subsurface flow

IDF vs. DHSVM

Continuous Streamflow-based Flood Estimates



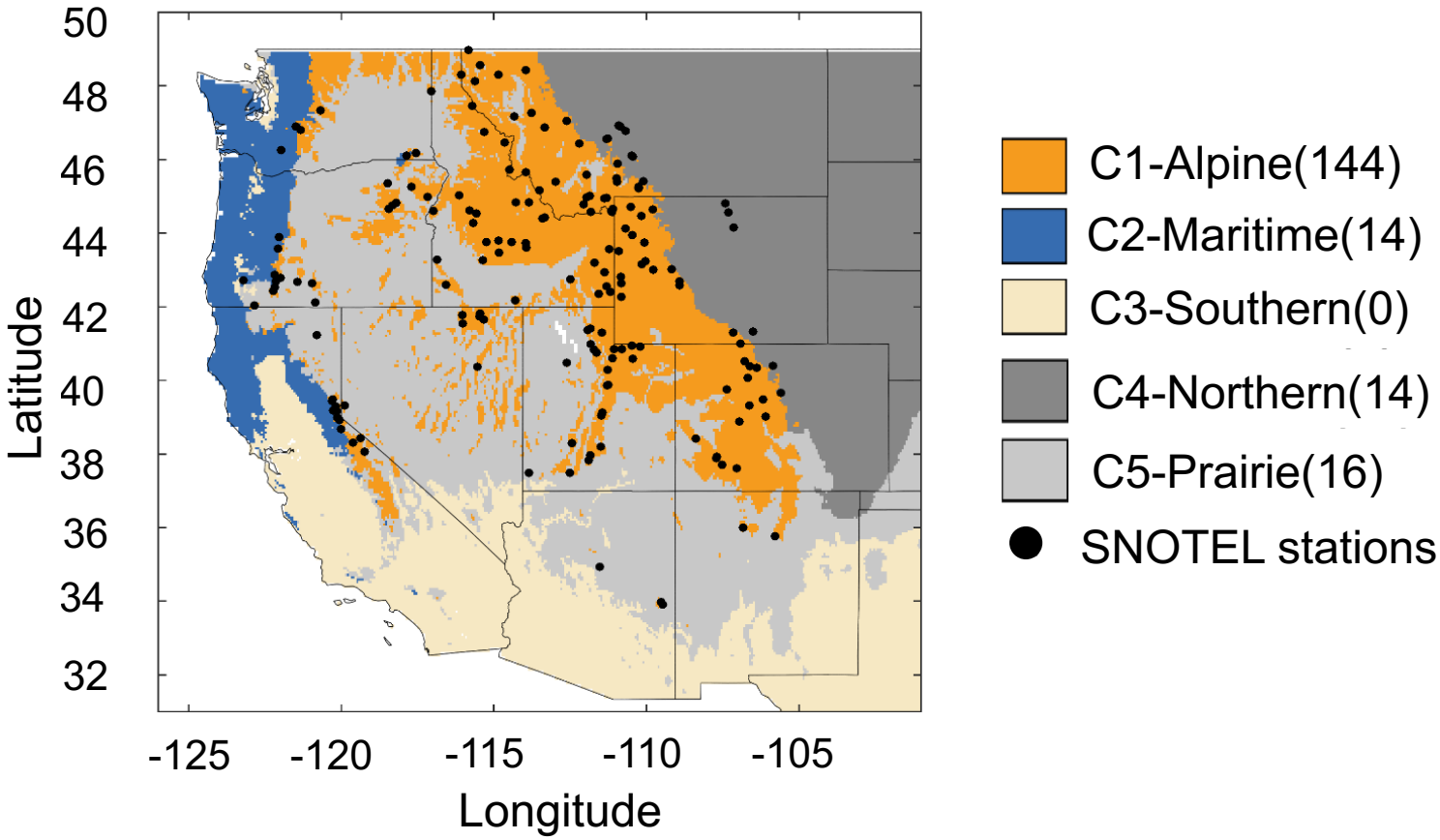
- 399 SNOTEL Stations
- Precipitation IDF
  - 31-33% error
- NG-IDF
  - 12-14% error

Precipitation IDF

NG-IDF

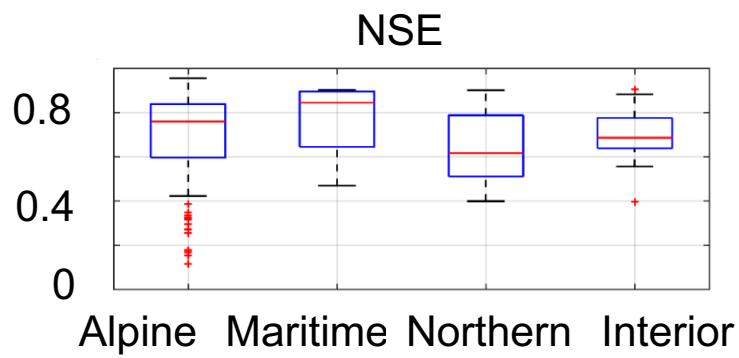
Successful Snow Modeling

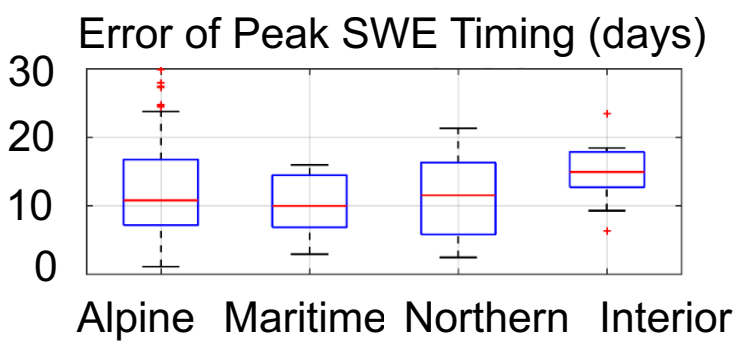
Using Regional Snow Parameters

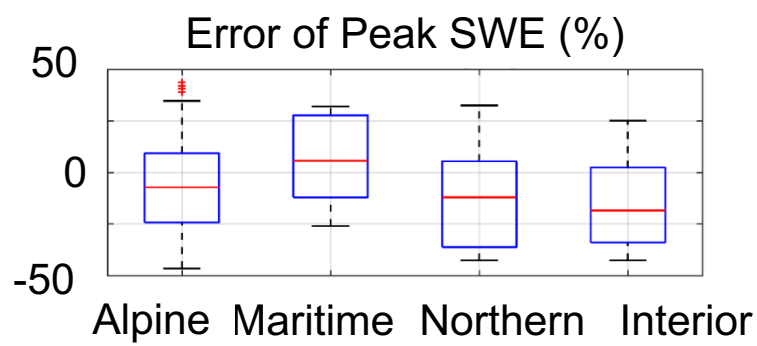


Successful Snow Modeling

Using Regional Snow Parameters



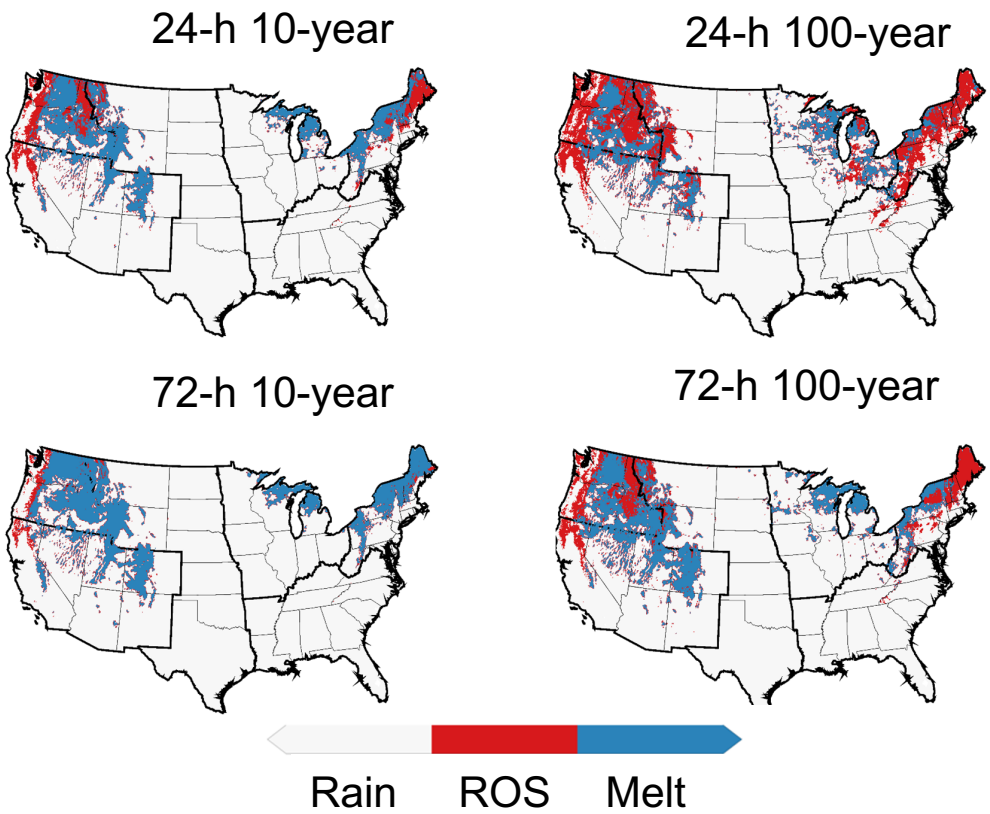




The use of climate-based regional snow parameters allows NG-IDF curves to be generated across the CONUS

Historical Extreme W Events

Dominant Drivers



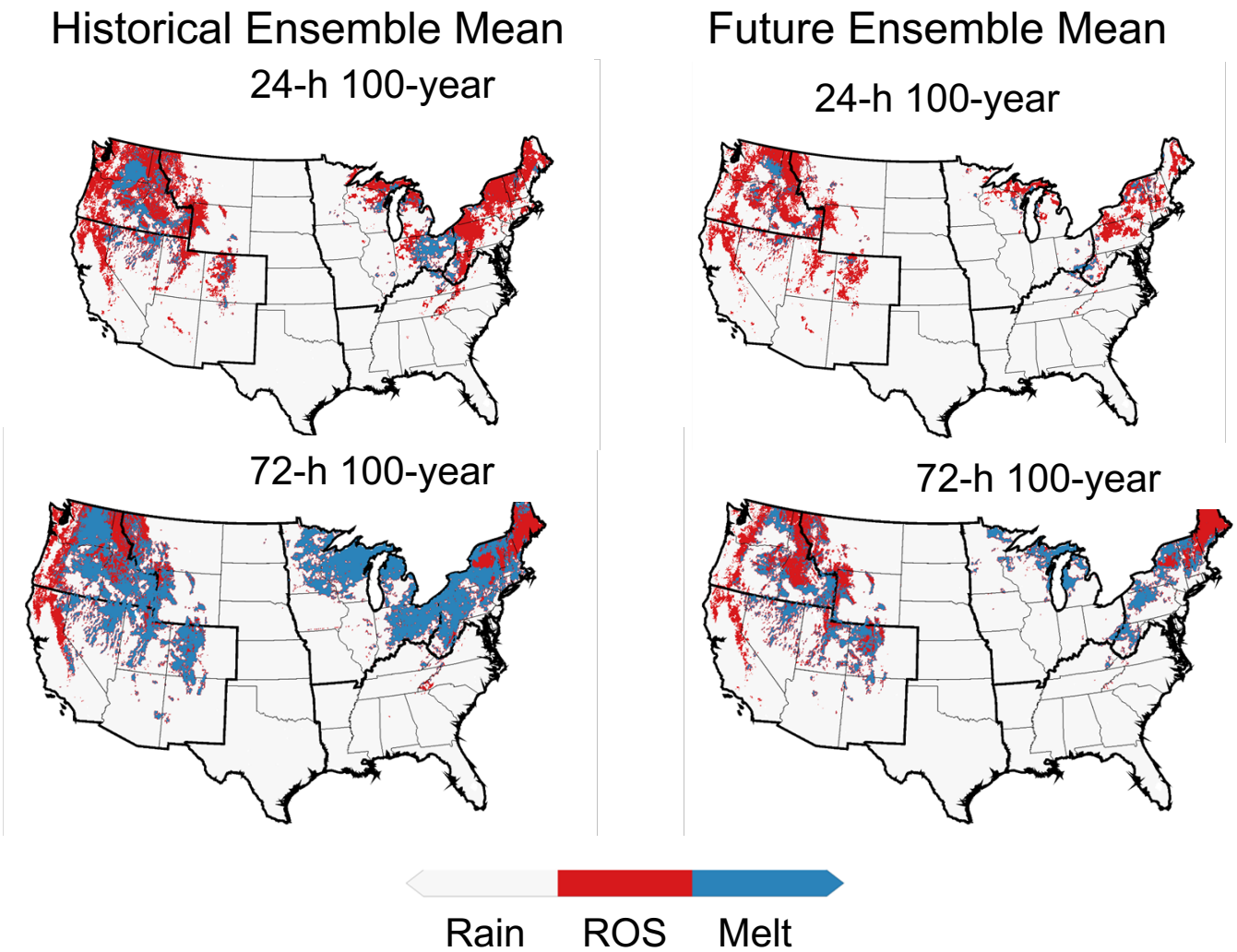
- Northwest:
  - 10-yr events: rain, snowmelt
  - 100-yr events: snowmelt, ROS
- Northeast:
  - 10-yr events: rain, snowmelt
  - 100-yr events: rain, ROS

Notes: ROS = rain-on-snow

With longer duration: ROS-driven event magnitude decreases; melt-driven event magnitude increases

Future Extreme Events

Shift from Snow- to Rain-Dominated

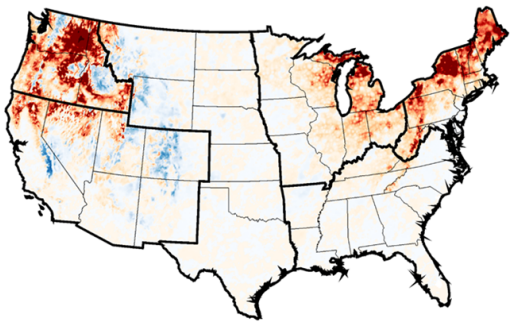


Precipitation IDF vs. NG-IDF Extreme Events

Historical (1950–2005) and Future (2044–2099)

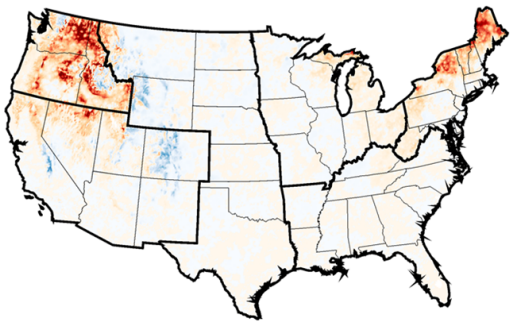
Historical Ensemble Mean

24-h 100-year

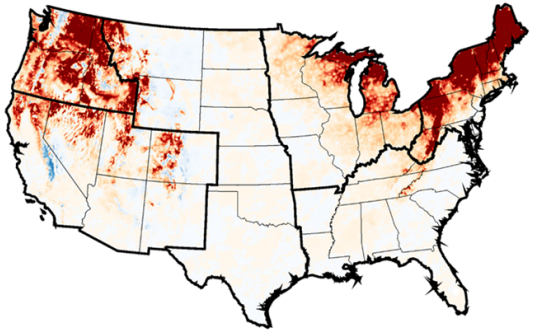


Future Ensemble Mean

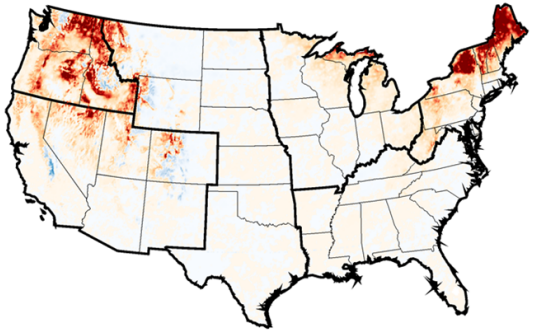
24-h 100-year



72-h 100-year



72-h 100-year



24-h events

- Locations with under-design decrease from 14% to 9% from historical to future

72-h events

- Locations with under-design decrease from 23% to 9% from historical to future

Conclusions

- Standard precipitation-based IDF curves under-estimate design flood peaks at most SNOTEL locations
- DHSVM accurately reproduces annual maximum daily water available for runoff
  - Allows construction of NG-IDF curves across CONUS
- Design flood peaks from NG-IDF curves coupled with TR-55
  - Compared favorably with continuous streamflow simulation
- NG-IDF curves in standard engineering design may replace complex simulation models
  - Lower-risk hydrologic design in snow dominated regions

For additional information, please visit

https://www.serdp-estcp.org/Program-Areas/Resource-Conservation-and-Resiliency/Natural-Resources/Cold-Regions-Ecology-and-Management/RC-2546

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Q&A Session 2

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Vapor Intrusion: Modeling Tools and Cost Effective Mitigation

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Please take a moment to complete the survey that will pop up on your screen when the webinar ends

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