

# Extreme Rainfall in Mountainous Terrain: Modeling and observational challenges for warm-season precipitation

*Jim Smith, Princeton University*

*Chair, Committee for Modernizing Probable Maximum Precipitation Estimation*



# **Extreme Rainfall in Mountainous Terrain: Modeling and observational challenges for warm-season precipitation**

**Objective** - Advance understanding and modeling of extreme warm-season precipitation processes in mountainous terrain to provide a scientific foundation for PMP estimation and to inform modeling of extreme floods.



# Two Big Recommendations

Change the definition of PMP from an upper bound on rainfall to a rainfall accumulation with very low annual exceedance probability.

Estimate PMP using extreme value analysis applied to rainfall fields derived from long climate model simulations.

## Modernizing Probable Maximum Precipitation Estimation



# Vision

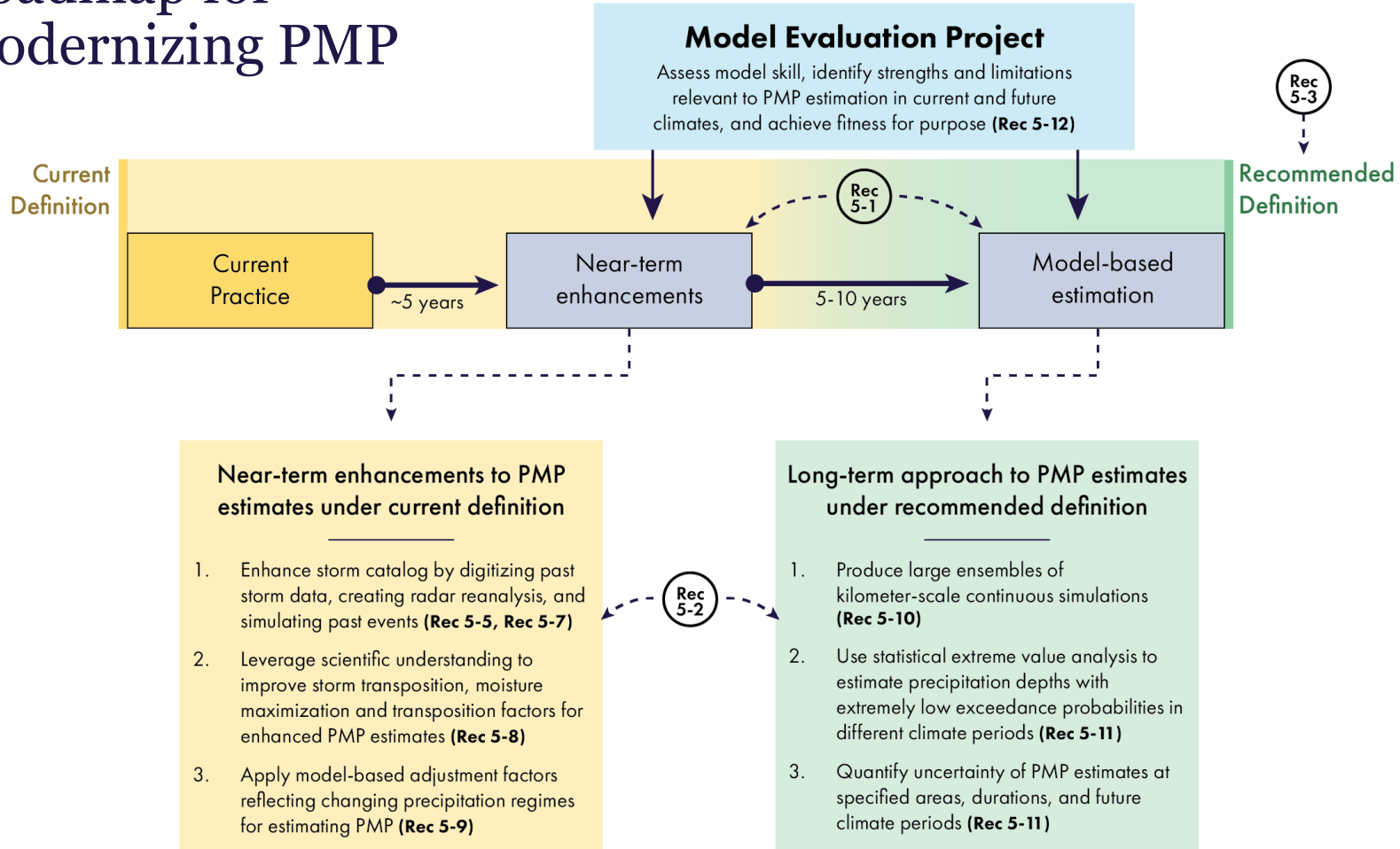
Model-based probabilistic estimates of extremely low exceedance probability precipitation depths under current and future climates will be attainable at space and time scales relevant for design and safety analysis of critical infrastructure within the next decade.

# Challenges and Opportunities

Achieving the Vision requires significant **research and modeling advances** and it will require collaboration between federal agencies, academia, and the private sector.

This effort will benefit a wide array of high-profile problems concerning hydroclimatological extremes.

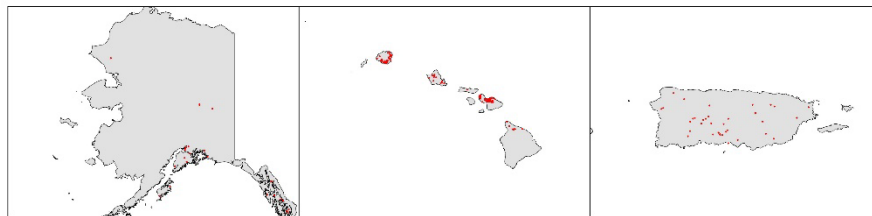
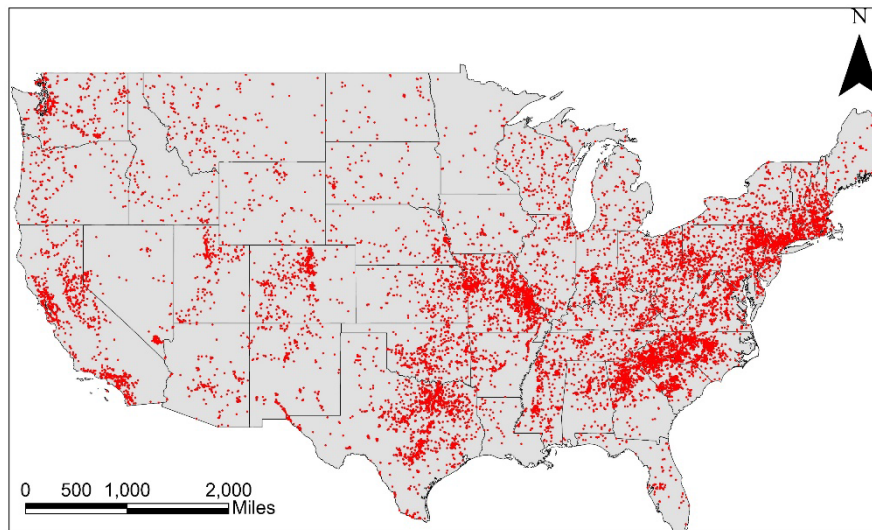
# Roadmap for modernizing PMP



# PMP and Dam Safety

- More than 16,000 high-hazard dams in the US.
- Concentration of high-hazard dams in and adjacent to mountainous terrain.
- The majority are in watersheds with drainage area less than 100 square miles, highlighting the importance of short-duration, small-area PMP estimates.

## High-Hazard Dams in the US



# Orographic Precipitation

*From the PMP study –*

*“The challenges of estimating PMP in mountainous terrain were highlighted in the 1994 National Academies study **Estimating Bounds on Extreme Precipitation Events: A Brief Assessment** and remain largely unresolved.”*

*“Observational, modeling, and theoretical advances are required to effectively estimate PMP in mountainous regions.”*

## Workshop Focus:

### *Warm Season Rainfall Extremes*

- *Orographic Convection*
- *Tropical Cyclones*



# PMP and Extreme Rainfall

Unionville MD, 4 July 1956

1 minute – 31 mm

D'Hanis TX, 31 May 1935

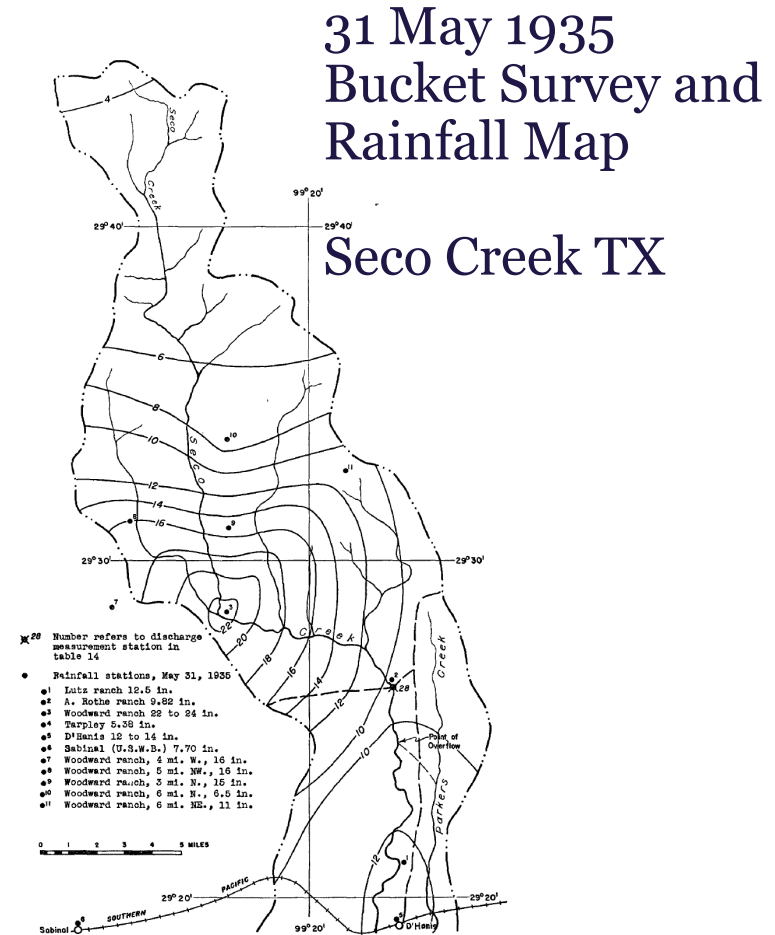
165 minutes – 560 mm [cattle trough]

Seco Creek: 6500 cms; 370 km<sup>2</sup>

Smethport PA, 18 July 1942

10 minutes – 165 mm [milk pail]

285 minutes – 780 mm [mason jar]



# PMP and Extreme Rainfall

South Fork Guadalupe, 4 July 2025

Peak Discharge :  $\sim 7000$  cms;  $250 \text{ km}^2$

- \* Big Observational Challenges
- \* Big Science Challenges
- \* Big Modeling Challenges

