

Cross-cutting insights for enhancements to Probable Maximum Precipitation estimation

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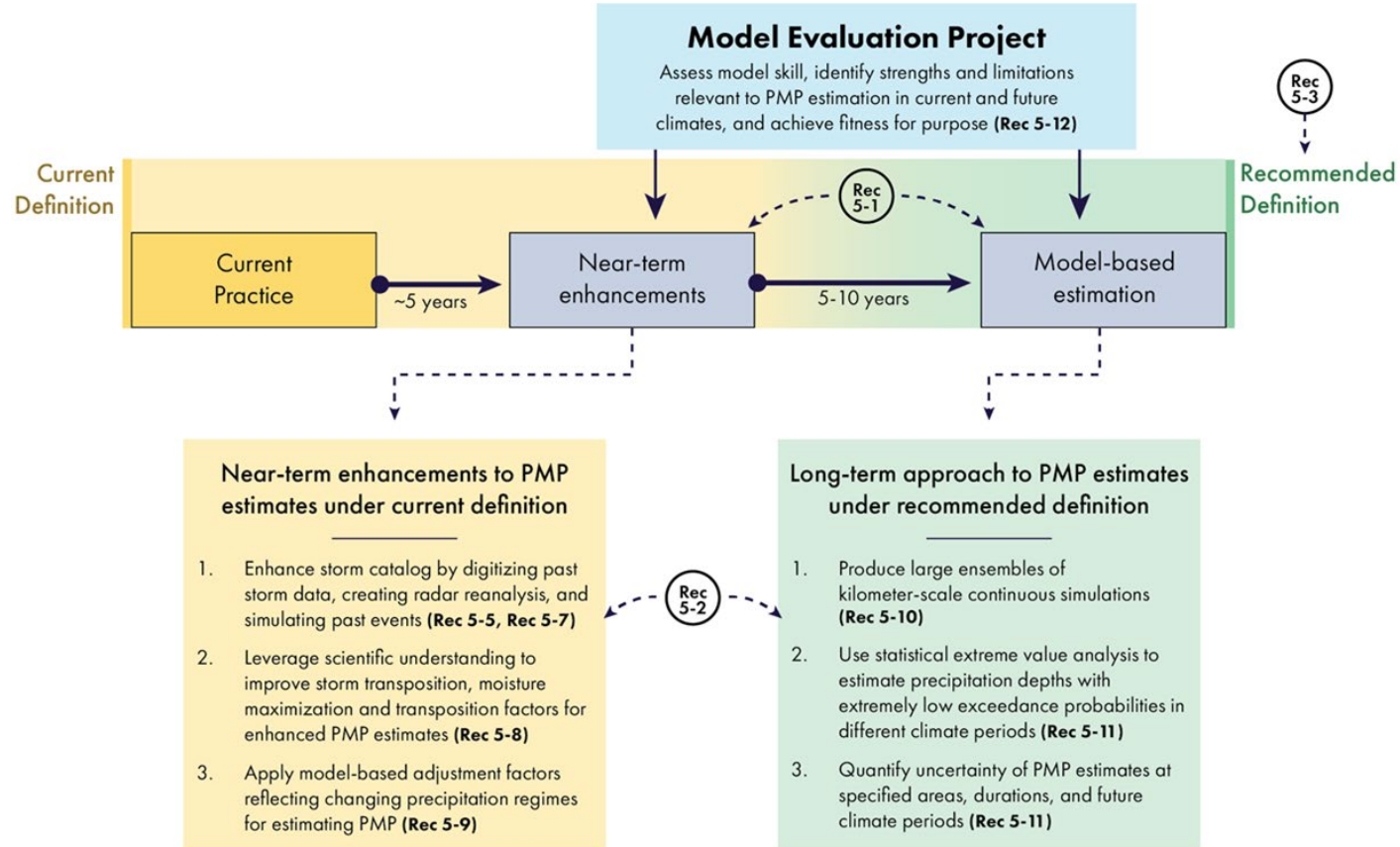
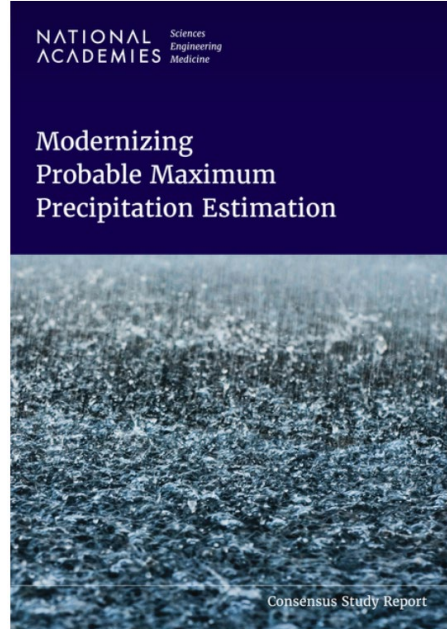
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National Academies Workshop

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Modernizing Probable Maximum Precipitation Estimation



Connections with Probable Maximum Precipitation

Topics relevant to near-term enhancements

- Approaches and guidance for storm transposition
- Considerations for storm maximization
- Methods for developing high-resolution ensembles for case studies
 - Model type and selection
 - Event selection

Topics relevant to long-term model-based approach

- Model considerations
 - Topography and spatial resolution
 - Storm mechanisms and processes
 - Ensemble generation, microphysics, validation, emulators (types)
- Population sizes, statistical distributions, and tail behavior
- Connecting terrain challenges with other large national efforts (FEMA's Future of Flood Risk Data)

Connections with Probable Maximum Precipitation

Topics relevant to the Model Evaluation Project

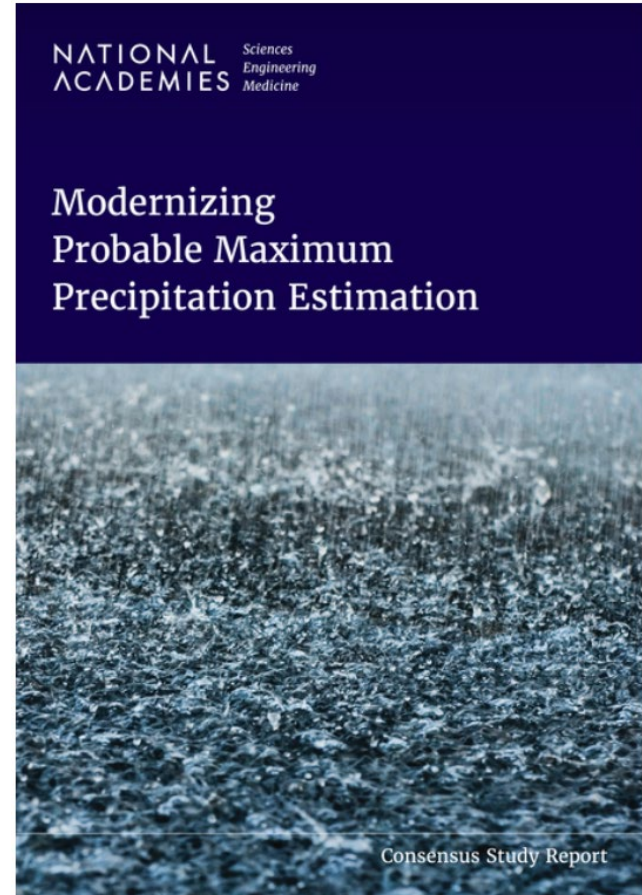
- Field campaigns
 - PMP-aware
- Radar reanalysis dataset
 - More radars
- Establishing best-practices
 - High-res ensemble creation
- Fit for purpose
 - Storm mechanisms, timing, locations, moisture sources, and multi-scale boundary conditions
 - Codevelopment

Remaining challenges

- Data and verification
 - Precip observations (varying terrain), tropospheric temperature data, training datasets
- Modeling complexities
 - Mesoscale convective processes and topography
 - Microphysics
 - Wind (shear, low-level jets, downdrafts)
 - Cold pools
- Guidance for practitioners
 - Methods

Additional progress

Recommendation 5-2: NOAA should deliberately engage the scientific and practitioner communities to enhance understanding of the scientific process, clarify methodological considerations, increase awareness of practitioner needs, and collaboratively shape resulting products in support of modernized PMP estimates.



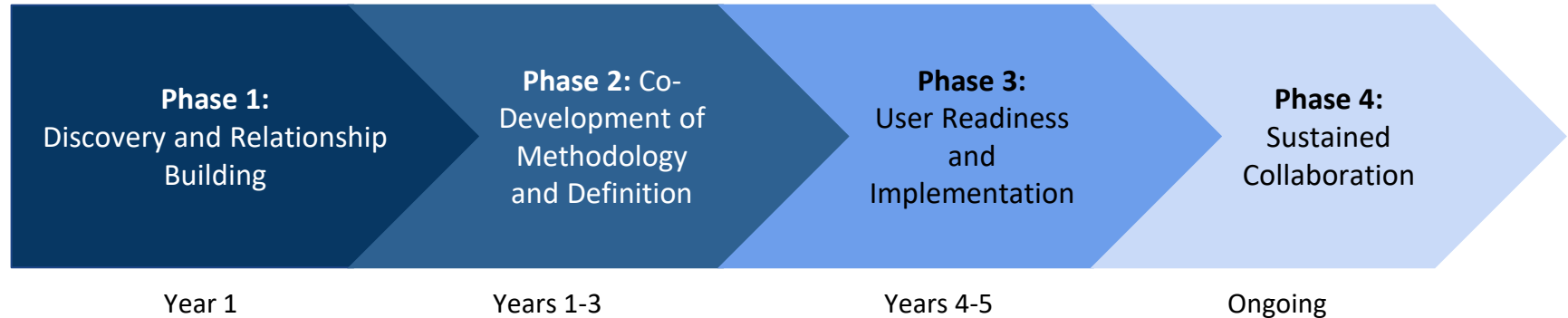
NOAA's partner engagement strategy

The Probable Maximum Precipitation (PMP) partnership engagement strategy aims to:

- Foster collaboration with federal, state, tribal, academic, private, and community stakeholders;
- Collaborate with the user community to leverage commercial sector best practices and incorporate expertise into PMP development;
- Build long-term capacity for updating PMP methodologies and datasets; and
- Facilitate the adoption and implementation of modernized PMP guidance across sectors.

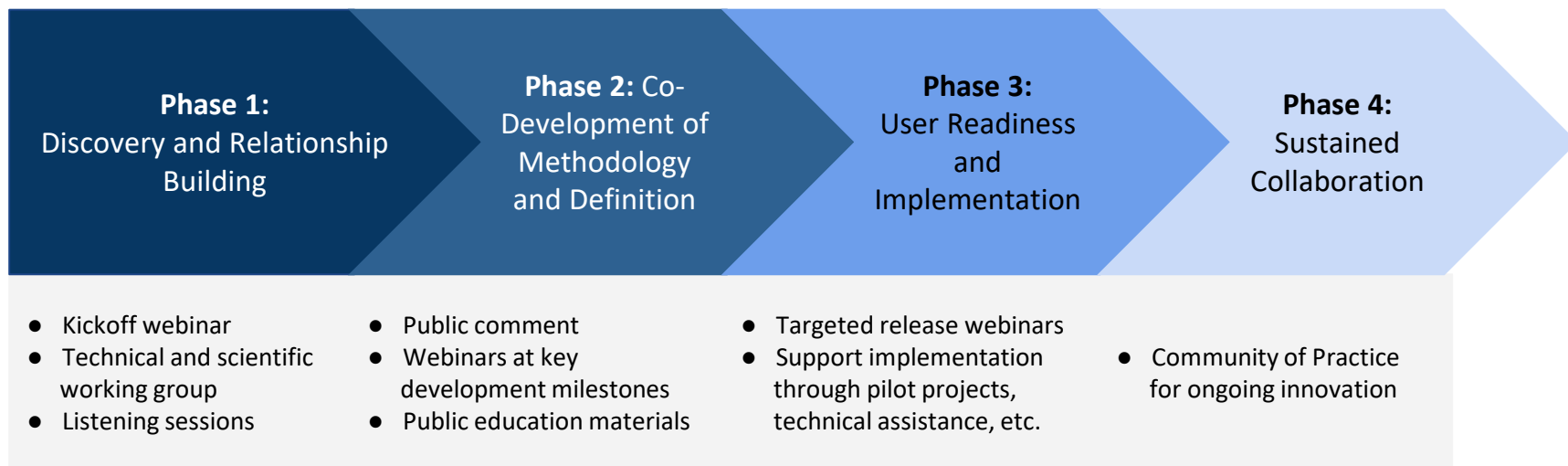
Engagement phases

- User engagement will be phased, which will help meet the goal of building a broader user community and capacity around PMP.
- Each engagement phase builds on those before to **grow trust with the user community, update methods and product, and encourage user readiness and uptake.**



Engagement strategy examples

During each phase, different engagement strategies will be used. Examples of these are included for each phase, below:

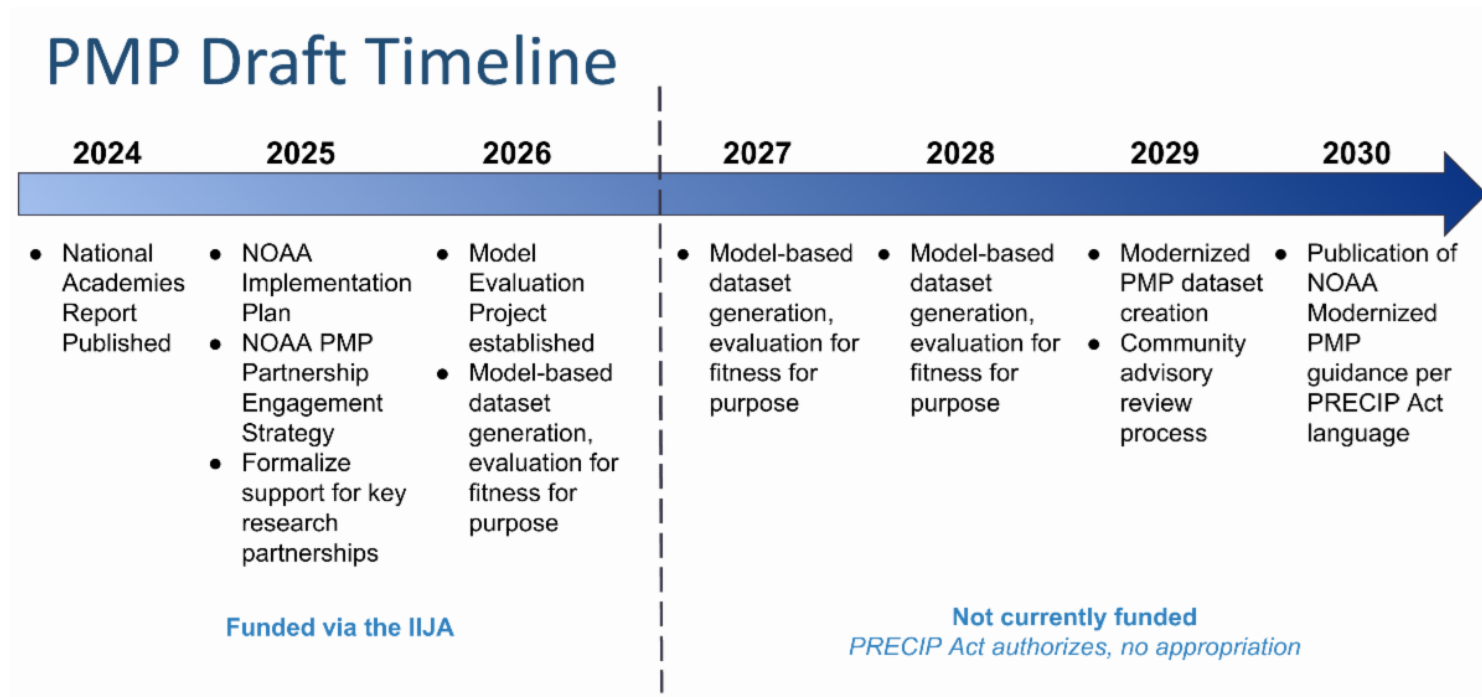


Engagement groups

- PMP must balance top-tier scientific and technical expertise with accessibility for applied users.
- All stakeholders can contribute based on their expertise to guide PMP's development.

User Groups	Sample Agencies
Technical Collaborators, Scientific Experts, Policymakers and Regulators, Applied Users, Industry Groups, International Partners, General Public	Academic institutions, NOAA, USACE, Federal Emergency Management Agency (FEMA); U.S. Geological Survey (USGS); Department of Energy (DOE); FERC; NRCI state and local governments

NOAA's most recent community update (Summer 2025)



- Planning for next community update meeting in progress; will be held ASAP. Outcomes of today's workshop to be further synthesized there.
- 2026 plans may also be affected by availability of financial support

ASDSO - Extreme Precipitation Investigation Committee (EPIC)

Committee Workplan Goal

3. PROMOTING CONTRIBUTIONS FROM THE SCIENTIFIC AND ACADEMIC COMMUNITY (Recommendation 5-2).

NOAA highlighted the research effort needed (model evaluation and development in particular) to achieve the NASEM study goals. The EPIC intends to support NOAA in engaging the research community by relaying information about NOAA needs and plans as they develop, as well as sources of funding and potential collaborations. The committee intends to identify scientists that can be brought into sustained collaboration with NOAA and support two-way communication with practitioners to support the creation of adequate products.

Contact Info for sharing PMP related Research Collaborations

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Concluding thoughts

- Rich content from today's workshop with continued synthesis among interested individuals and groups
- Relationship building among user groups
- Follow on discussions at next PMP engagement meeting
- Appreciation for everyone's time in joining this and future discussions with goal of advancing PMP estimation

Key Partner Categories and Roles

User Groups

The following slides detail the user groups and roles that they would play, along with some example organizations that fit the user groups.

- PMP needs to leverage best-in-class scientific and technical expertise while remaining accessible and useful for applied users.
- All these stakeholders need to provide input to help shape the development of PMP, but the type and focus of that feedback will vary based on expertise.
- The following groups are not a formal taxonomy, but rather a way for the engagement team to consider different user segments to ensure there are not outreach or perspective gaps.

Key Partner Categories

User Group	Role(s)	Example Organizations
Technical Collaborators	● Provide technical expertise to inform method development; ● Provide peer review of technical methodology; ● Participate in model validation and testing.	Academic institutions, NOAA, USACE
Scientific Experts	● Provide scientific expertise to inform method development ● Peer review of scientific methodology; ● Scientific validation and testing.	Academic institutions, NOAA, USACE
Policymakers and Regulators	● Update and align laws/regulations about how and when PMP should be applied; ● Provide feedback on definition/general improvements; ● Share information with the user community	USACE; Federal Emergency Management Agency (FEMA); U.S. Geological Survey (USGS); Department of Energy (DOE); FERC; NRCI state and local governments

Key Partner Categories (cont.)

User Group	Role(s)	Example Organizations
Applied Users	● Share experience using PMP and describe needs; ● Contribute to use cases and case studies; ● Participate in user testing; ● Provide feedback on definition and general improvements	Insurers and reinsurers; engineers; dam owners and operators; nuclear owners and operators; state dam safety programs; Federal Energy Regulatory Commission (FERC); Nuclear Regulatory Commission (NRC), Natural Resources Conservation Service (NRCS)
Industry Groups	● Develop and update guidance and guidelines for applied users ● Share information with user base ● Provide feedback on methodology and definition	Association of State Dam Safety Officials (ASDSO); U.S. Society of Dams (USSD); American Society of Civil Engineers (ASCE); US Nuclear Industry Council (USNIC); Nuclear Energy Institute (NEI)

Key Partner Categories (cont.)

User Group	Role(s)	Example Organizations
International Partners	● Participate in methodological benchmarking ● Share data and best practices ● Provide insights from climate modeling	World Meteorological Organization; United Kingdom Environmental Agency
General Public	● Raise awareness of safety measures related to critical infrastructure; ● Educate individuals on extreme precipitation; ● Share information related to community impacts of extreme precipitation.	N/A

**Extreme Rainfall in Mountainous Terrain:
Modeling and observational challenges for warm-season precipitation:
Workshop findings for PMP Near Term Recommendations**

- **Stochastic storm transposition (SST):**
 - Helene transposition could occur anywhere along the eastern escarpment of the southern Appalachians (Kunkel)
 - SST has benefit of providing AEPs (including low/rare values) and uncertainty; (Wright)
 - SST can incorporate climate model simulations and historical storms fairly easily; (Wright)
 - Can consider transposition factors for mountainous terrain (Wright)
- **Storm maximization**
 - Considerations of optimal balance between TC forward speed (intensity maintenance) and duration (precipitation accumulation) that produces higher storm total rainfall (Kunkel, Helene presentation)
 - Considerations for higher TC intensity (e.g. Camille) increasing orographically-enhanced rainfall (Kunkel)
 - Must also consider role of longer duration frontal precursor events (Kunkel)

Extreme Rainfall in Mountainous Terrain: Modeling and observational challenges for warm-season precipitation: Workshop findings for PMP Long Term Recommendations

- Convection-allowing model (CAM) simulations
 - Some CAM datasets show that extreme convective rainfall in mountainous terrain is less skillful than in coastal regions → implications for model-based PMP, using simulations as a proxy for observations (Schumacher)
 - Can resolve meso-beta processes responsible for extreme precipitation -- but meso-micro-scale terrain variations under-resolved → reliance on subgrid parameterizations → systematic biases. (Kirshbaum)
- Observations: Advances in polarimetric rainfall estimation algorithms combined with developing radar-rainfall reanalysis are needed for estimating rainfall extremes and their uncertainties, especially for PMP-magnitude events. (Witekski)
- SST approach to PMP/PMF can provide opportunities to coordinate with other Federal rain/flood efforts:, e.g, FFRD, Atlas 15, HEC-HMS (Wright)
- Challenges:
 - Ensembles of Large Eddy Simulations of Precipitating Clouds for Past Floods with Actual Orography (Rotunno)
 - Ditto with possible Synoptic/Thermodynamic Environment(s) in Future Climate (Rotunno)

**Extreme Rainfall in Mountainous Terrain:
Modeling and observational challenges for warm-season precipitation:
Workshop findings for PMP Model Evaluation Project**

- Evaluation considerations:
 - Type of storm, boundary layer conditions, role of terrain resolution (Houze)
 - Verification challenges (Lackmann, Rowe, others)
 - Experimentation with microphysics, sensitivity to microphysics, turbulence
 - Could evaluate. intercompare specifically: synoptic environments, mesoscale mechanisms, mechanical forcings, separation of storm inflows/outflows, anchoring, simulation comparisons (observations, LES, CPM) (Kirshbaum)
- Moving from decadal to multi-century timescales and increasing model process representation will also need to leverage AI/ML and computational hardware advances (Newman)
- Some limitations may exist (and require improvements) regardless of terrain (Schumacher)