Comments on Development of a National Guidance Document to Review Site-Specific PMPs

Presentation to the Subcommittee on Hydrology, Extreme Storm Events Work Group

Relevance to the June 2018 *Extreme Rainfall Products Needs Proposal*

August 20, 2018

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Presentation Overview

- Probable Maximum Precipitation (PMP) Background
- Main Factors Affecting Site-specific PMP (SSPMP) Estimates
  - Storm Selection
  - Storm Reconstruction
  - Storm Transposition
  - Precipitable Water Estimation
  - Storm Maximization
  - Orographics
- Comments on *Extreme Rainfall Product Needs Proposal* recommendations

PMP Background

- Conventional PMP
  - Deterministic (static) design value
  - Generalized estimates (NOAA/NWS HMRs)
  - Has not been updated since 1980s
- SSPMP estimates
  - Incorporate new and more complete storm data
  - Generally follow HMR procedures
    - However, based on ORNL review, current SSPMPs mostly produce estimates lower than HMRs
  - Involve a large number of subjective professional judgments
    - Guidance is lacking to help agencies review and confirm these sensitive factors

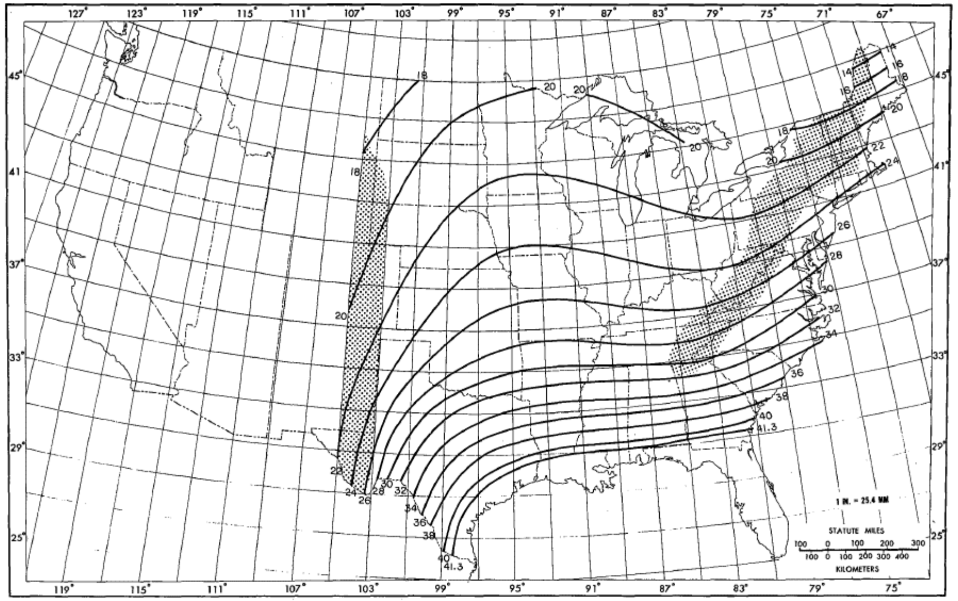
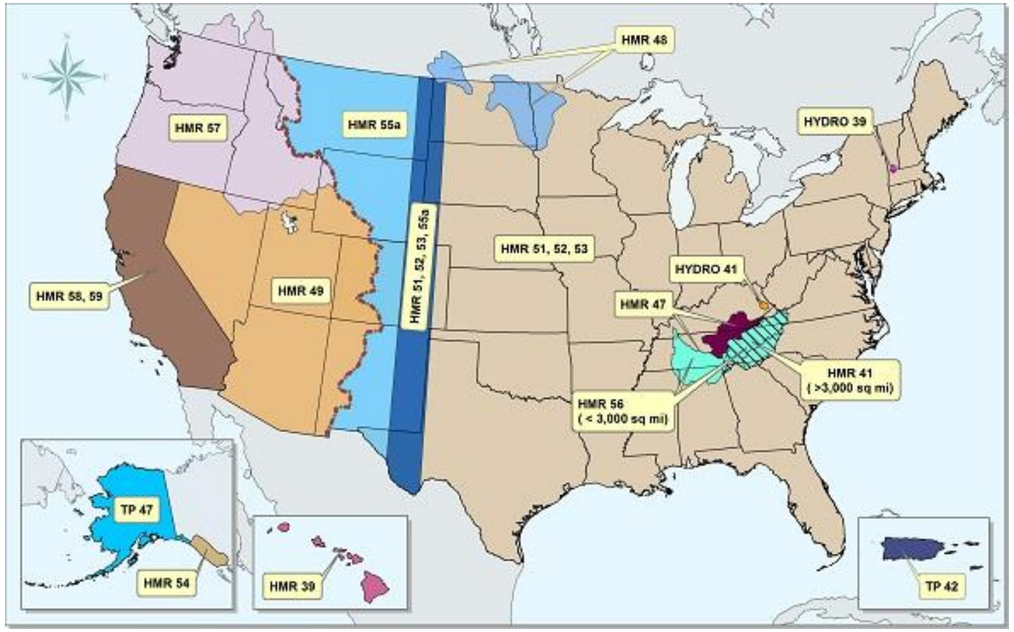


Figure 32.--All-season PMP (in.) for 72 hr 1,000 mi^2 (2,590 km^2). Source: HMR 51



Source: NOAA

Storm Selection

- Operational PMP method:
  - Based on selected "short-list" historic storms
  - Assume that the collection of adjusted historic storms can produce an (operational) upper limit of precipitation across a variety of areas and durations
- Challenges
  - Lack of a comprehensive inventory of major historic storms
    - USACE "Black Book" & HMR 51
    - Various commercial databases
    - *SOH-ESEWG Product Needs Proposal* outlines a plan for developing and maintaining an archive of extreme precipitation events
  - Whether a storm is selected involves subjective professional judgments
  - The treatment of multi-center storm events can be subjective

3. U.S. Extreme Precipitation Database

Marian Baker, NOAA/NWS; George Hayes and Charles McWilliams, USACE

3.1. Product Background

In February of 1946, the USACE in cooperation with the US Weather Bureau (USWB) and the US Bureau of Reclamation (USBR) published the first version of the Extreme Storm Catalog (Figure 3-1). The catalog was comprised of a collection of unusually large storms based on precipitation data, meteorological information and anecdotal reports collaborated by all three agencies.

Figure 3-1. Front cover of the first version of the Extreme Storm Catalog

The Extreme Precipitation Database (EPD) will build on this history of archiving storms for use in dam safety and planning, providing a repository for exceptional precipitation event data. Once completed, the EPD will provide a source of digital historical storm data in several formats ranging from simple text files to detailed depth-area-duration curves of extreme events. GIS data will be included in the database in various formats for download. Future plans would include the creation of a permanent digital repository for all future storm data analysis.

Extreme Rainfall Product Needs Page 15

from June 8, 2018 SOH-ESEWG Product Needs Proposal

Source: ESEWG (2018)

All of these factors demonstrate a need for an updated extreme storm database with periodic updates

Storm Reconstruction

- Maximum rainfall depth across areas & durations
  - Analyzed in terms of depth-area-duration (DAD) tables/curves
  - USACE/HMR storm assessments relied on manual calculation using mapped gage data
  - Modern software can leverage more diverse, high-resolution precipitation products and other meteorological data
- Challenges
  - Significant differences can exist in DAD generated by different modern software & processing scripts
    - No clear understanding about the reasons of these differences
    - Not just a software issue, how gauge observations (inputs) were "processed" play an even more important role
  - Guidance needed on the quality control, quality assurance, and validation procedures

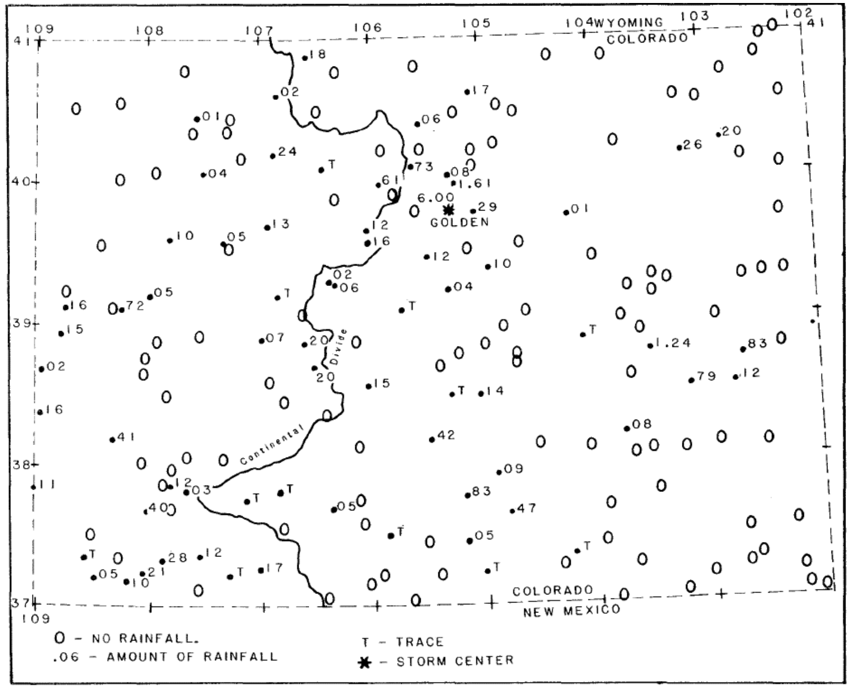


Figure 12.6.--Precipitation map, June 7, 1948 - the Golden, CO storm (67).

Source: HMR 55A

STORM INDEX NO. 74 (OR 9-23) DATE 7/17-18/1942
RAINFALL CENTER SMETHPORT,PA MOIST.ADJ.=110

MAXIMUM AVERAGE DEPTH OF RAINFALL IN INCHES

AREA	DURATION OF RAINFALL IN HOURS			
SQ.MI.	6	12	18	24
10	24.7	26.7	28.7	29.2
100	16.4	19.4	21.8	22.4
200	13.1	16.8	19.3	19.9
1000	6.4	10.3	12.6	13.3

Source: HMR 51

Oak Ridge National Laboratory

Storm Transposition

- Transposition: to relocate a storm DAD and some storm features to other locations
  - To increase the number of “short-list” storms to support the calculation of operational PMP
  - Involve subjective professional judgments
  - In an ideal world with sufficient historic records, storm transpositioning would not be required
- Challenges
  - No guidance and/or consistent standard regarding when and where a storm can be transpositioned
    - Some major historical storms tend to control PMP wherever they are transpositioned
  - No guidance on the minimum number of storms for PMP development
  - How can one tell if there are sufficient historic storms to support the calculation of SSPMP?
    - Hurricane Harvey partially exceeded HMRs

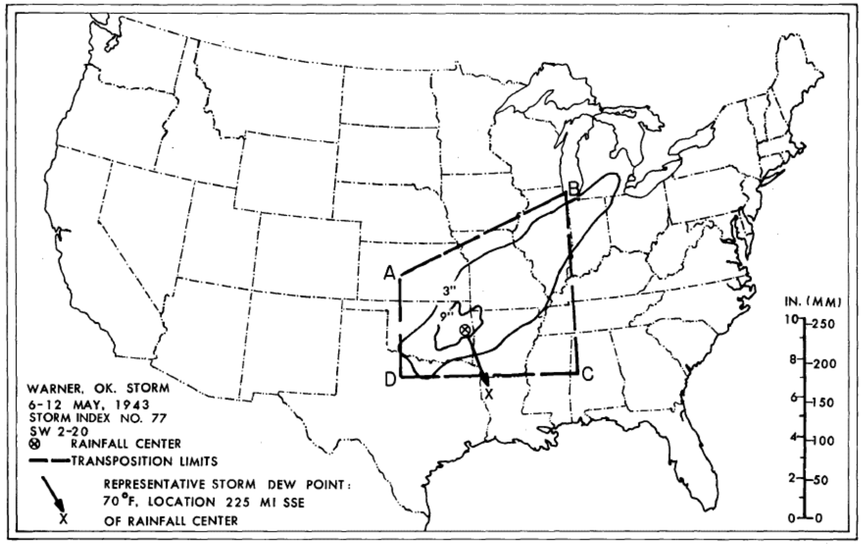
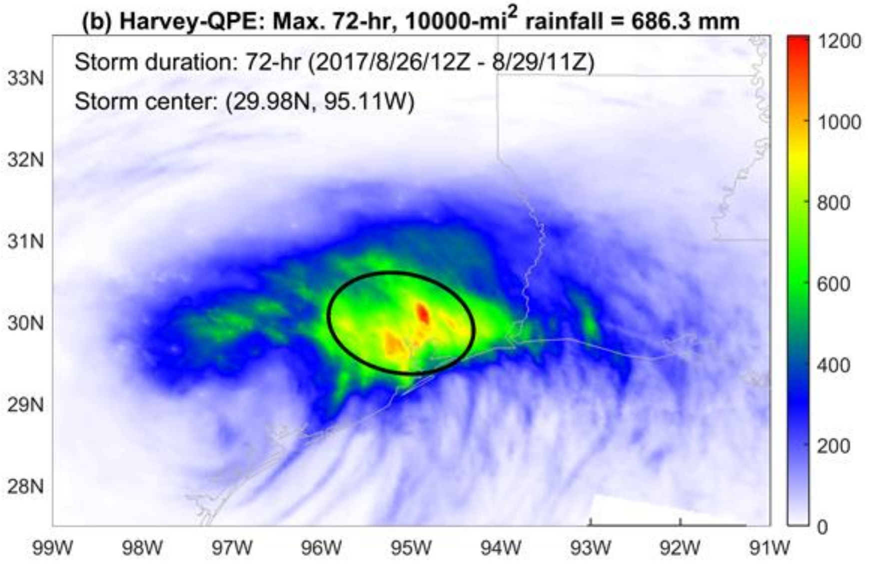


Figure 4.--Example of data used for storm adjustments. [May 6-12, 1943 storm, Warner, Okla.]

Source: HMR 51



Source: ORNL (2018)

Precipitable Water (PW_{obs}) Estimation

- Storm (DAD) enhancement
  - Scale up from PW_{obs} to PW_{max}
- Current methods rely on several major assumptions:
  - PW_{obs} can be represented by either surface-based dew point temperature or sea surface temperature (SST)
  - PW_{obs} of the entire storm can be represented from a snapshot of dew point or SST before landfall
- The most subjective element within the SSPMP assessment
- Challenges
  - Lack of guidance on the selection of representative dew point timing and locations
  - Lack of guidance on the calculation of dew point
    - HMRs used 12-h persisting dew point temperatures
    - Modern studies considered alternative approaches (e.g., 6-, 12-, or 24-h average dew point temperatures)
  - While there are new attempts to improve PW_{obs} estimation (e.g., using meteorological reanalysis or numerical weather model), they are not yet operational

APPENDIX C

Table of Precipitable Water

DEPTH OF PRECIPITABLE WATER (W, .01 in.)
BETWEEN 1000-MB SURFACE AND INDICATED HEIGHT (H, 1000 ft) ABOVE 1000-MB SURFACE,
AS A FUNCTION OF 1000-MB TEMPERATURE (T_{1000}, F),
IN A SATURATED ATMOSPHERE WITH PSEUDOADIABATIC LAPSE RATE

Height 100's ft	Temperature at 1000 mb																				
	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1	02	02	02	02	02	02	02	02	02	02	02	02	02	02	03	03	03	03	03	03	03
2	03	03	03	04	04	04	04	04	04	04	04	05	05	05	05	05	05	06	06	06	06
3	05	05	05	05	05	06	06	06	06	06	07	07	07	07	07	08	08	08	08	09	09
4	06	06	07	07	07	07	08	08	08	08	09	09	09	10	10	10	11	11	11	12	12
5	08	08	08	09	09	09	10	10	10	11	11	11	12	12	12	13	13	14	14	15	15
6	09	10	10	10	11	11	11	12	12	13	13	13	14	14	15	15	16	16	17	17	18
7	11	11	12	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	21
8	12	13	13	14	14	15	15	16	16	17	17	18	18	19	20	20	21	21	22	23	24
9	14	14	15	15	16	16	17	17	18	19	19	20	21	21	22	23	23	24	25	26	27
10	15	16	16	17	17	18	19	19	20	21	21	22	23	23	24	25	26	27	28	28	29
11	17	17	18	19	19	20	20	21	22	23	23	24	25	26	27	28	28	29	30	31	32
12	18	19	19	20	21	22	22	23	24	25	25	26	27	28	29	30	31	32	33	34	35
13	20	20	21	22	22	23	24	25	26	27	27	28	29	30	31	32	33	34	36	37	38
14	21	22	22	23	24	25	26	27	28	28	29	30	31	32	34	34	36	37	38	39	41
15	22	23	24	25	26	27	27	28	29	30	31	32	34	35	36	37	38	39	41	42	43
16	24	25	26	26	27	28	29	30	31	32	33	35	36	37	38	39	41	42	43	45	46
17	25	26	27	28	29	30	31	32	33	34	35	37	38	39	40	42	43	44	46	47	49
18	26	27	28	29	30	32	33	34	35	36	37	39	40	41	43	44	45	47	48	50	52
19	28	29	30	31	32	33	34	35	37	38	39	41	42	43	45	46	48	49	51	53	54
20	29	30	31	32	34	35	36	37	38	40	41	42	44	45	47	48	50	52	53	55	57
21	30	32	33	34	35	36	38	39	40	42	43	44	46	47	49	51	52	54	56	58	60
22	32	33	34	35	37	38	39	41	42	43	45	46	48	49	51	53	55	56	58	60	62
23	33	34	36	37	38	39	40	42	44	45	47	48	50	52	53	55	57	59	61	63	65
24	34	36	37	38	40	41	42	44	45	47	48	50	52	54	56	57	60	61	63	65	68
25	36	37	38	40	41	43	44	46	47	49	50	52	54	56	58	60	62	64	66	68	70
26	37	38	40	41	43	44	46	47	49	50	52	54	56	58	60	62	64	66	68	70	73
27	38	40	41	43	44	46	47	49	51	52	54	56	58	60	62	64	66	68	71	73	75
28	39	41	42	44	45	47	49	50	52	54	56	58	60	62	64	66	68	70	73	75	78
29	41	42	44	45	47	49	50	52	54	56	57	60	62	64	66	68	70	73	75	78	80
30	42	43	45	47	48	50	52	54	55	57	59	61	64	66	68	70	73	75	78	80	83

Source: HMR 55A

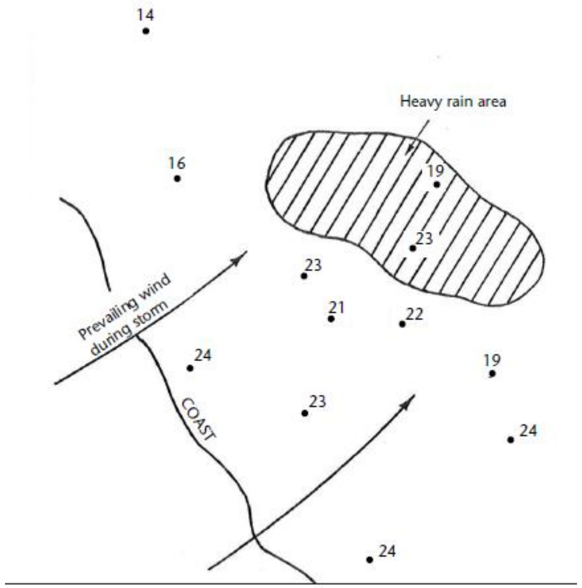


Figure 2.2. Determination of maximum dewpoint in a storm. Representative dewpoint for this weather map is the average of values in boxes.

Source: WMO (2009)

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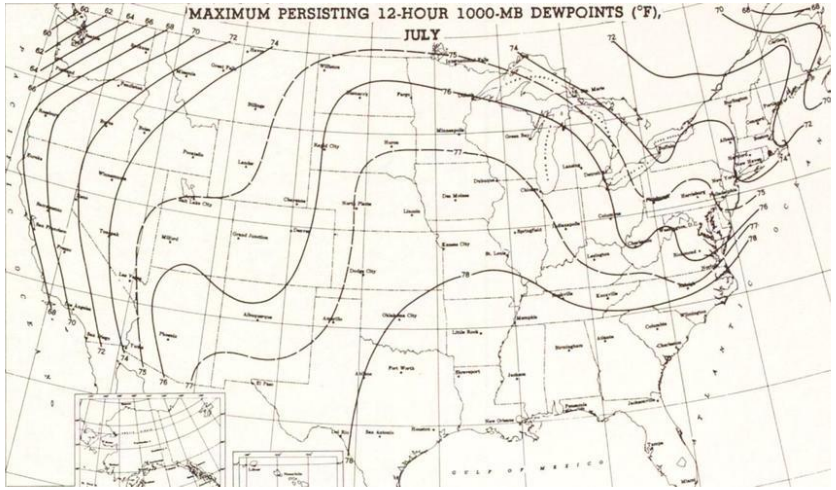
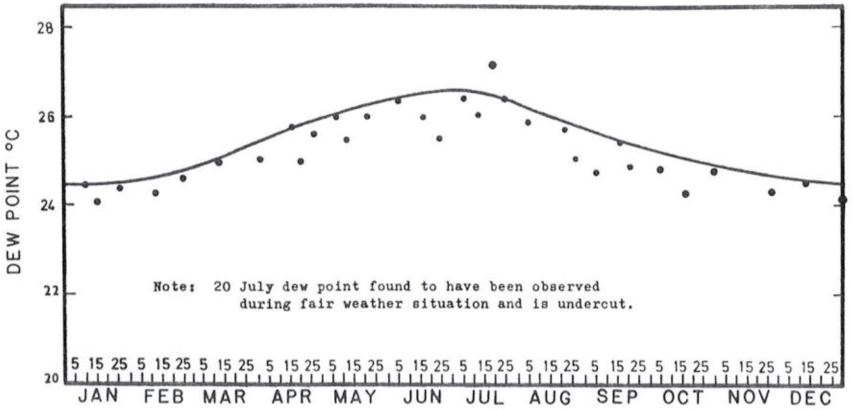
Storm Maximization

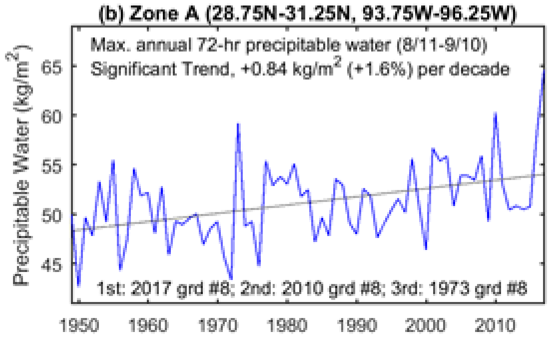
- Current methods rely on several major assumptions:
  - Precipitable water is used as a proxy for maximization (PW_{obs} to PW_{max})
  - Climatologically maximum dew point (or SST) are suitable for moisture maximization and transposition
    - Moisture maximization: the process of adjusting observed precipitation amounts upward based on the hypothesis of increased moisture inflow to the storm (WMO, 2009)
    - Moisture transposition: the process of adjusting maximized precipitation amounts according to geographic variation in maximum moisture levels (e.g., dew point or SST climatologies)
  - Maximized rainfall depths vary linearly with precipitable water
- Challenges
  - Lack of updated, federal dew point climatology maps
  - Trends in dew point observations are not considered



Source: EDS (1968)



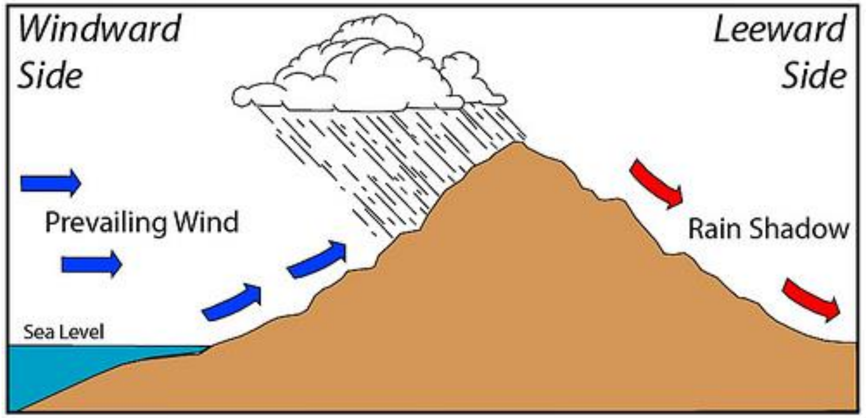
Source: WMO (2009)

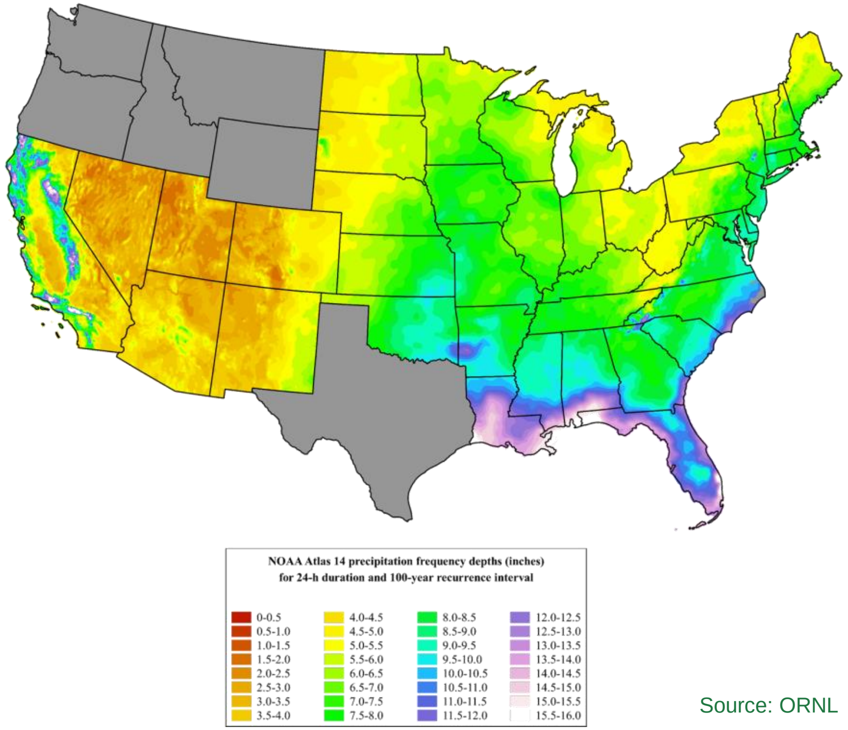


Source: ORNL (2018)

Orographics

- Orographic effects: rain which is caused entirely, or mostly, by the forced lift of moist air over high ground (WMO, 2009)
- Conventional HMR approaches
  - **Moisture depletion due to barriers**: physically-based approach but cannot capture uplift effects
  - **Storm separation method**: physically-based approach requiring rigorous application and subjectivity
- Modern studies
  - Geographically rescale rainfall using point-based precipitation frequency products (e.g., NOAA Atlas 14)
    - Sensitive to multiple factors (e.g., storm center location, calculation method, data reliability)
- Challenges
  - The HMR storm separation approach is difficult to replicate
  - The research community has not developed a physically-based alternative to replace the storm separation method

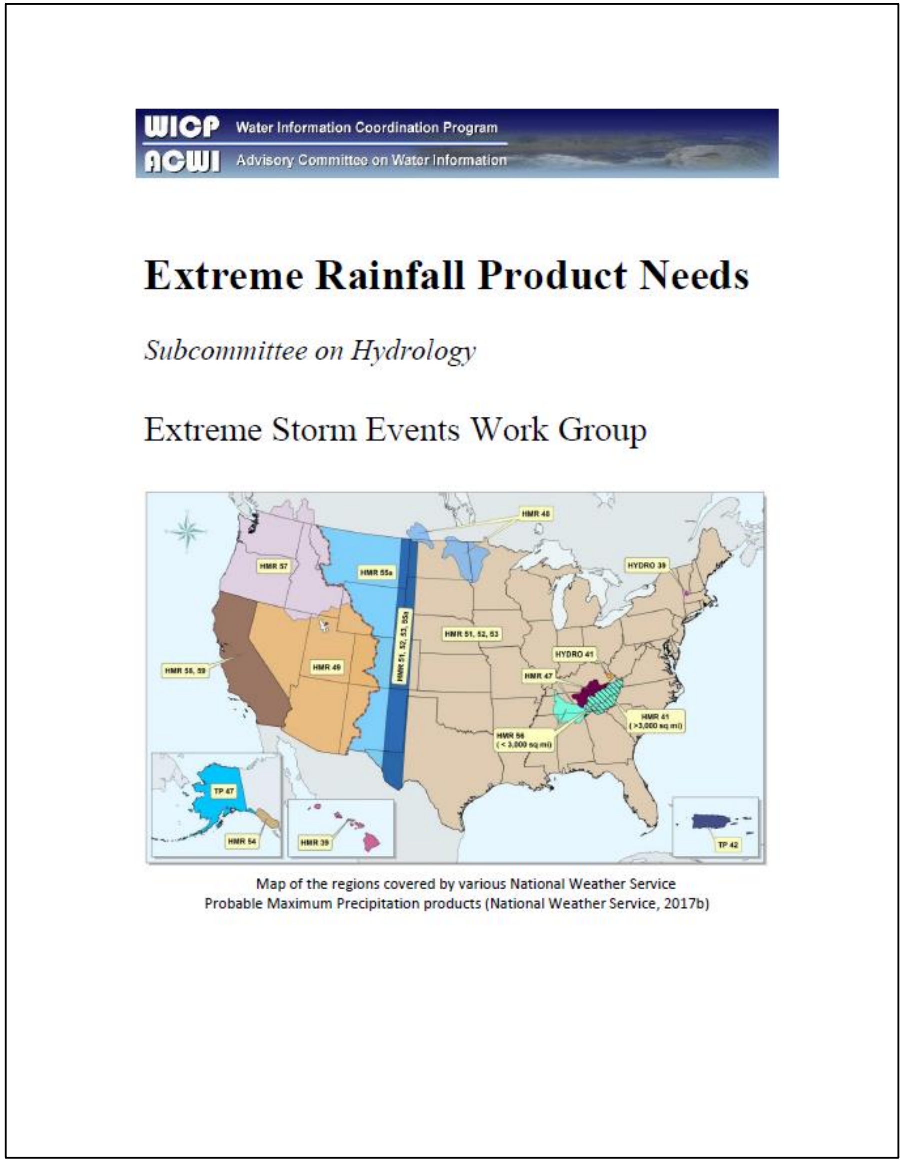




Source: ORNL

Summary and Recommendation

- Conventional deterministic PMP methods require a number of subjective professional judgments
- SSPMP estimates at a location could vary from one study to the next (statewide vs basin-specific)
  - Importance of key factors
    - Storm selection, reconstruction, and transposition
    - Precipitable water estimation and maximization
    - Orographic adjustments
- A national guidance document would provide significant benefit and clarity to Federal and State regulatory agencies and private consultants who develop, review, and approve SSPMP estimates
- Continued research is needed in the field of PMP and extreme precipitation estimation


WICP Water Information Coordination Program
ACWI Advisory Committee on Water Information

Extreme Rainfall Product Needs

Subcommittee on Hydrology

Extreme Storm Events Work Group

Map of the regions covered by various National Weather Service Probable Maximum Precipitation products (National Weather Service, 2017b)

from June 8, 2018 SOH-ESEWG Product Needs Proposal

Source: ESEWG (2018)

Thank you for your attention!

Questions?

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SOURCES:

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