

U.S. Department of Commerce
National Oceanic and Atmospheric
Administration

U.S. Nuclear Regulatory
Commission
NUREG/CR-1486

Hydrometeorological Report No. 53

SEASONAL VARIATION OF 10-SQUARE-MILE PROBABLE MAXIMUM
PRECIPITATION ESTIMATES, UNITED STATES EAST OF THE
105TH MERIDIAN

Prepared by
Francis P. Ho and John T. Riedel
Hydrometeorological Branch
Office of Hydrology
National Weather Service
Washington, D.C.
April 1980

TABLE OF CONTENTS

	Page
Abstract.	1
1. Introduction	1
1.1 Authorization.	1
1.2 Purpose.	1
1.3 Scope.	1
1.4 Definitions.	2
1.5 Previous study	2
2. Basic data	2
2.1 Background	2
2.2 Available station rainfall data.	3
2.2.1 Storm rainfall	3
2.2.2 Maximum 1-day or 24-hour values, each month.	3
2.2.3 Maximum 6-, 12- and 24-hr values, each month	3
2.2.4 Maximum recorded rainfall at first-order stations.	3
2.2.5 Data tapes, selected stations.	3
2.2.6 Data tapes, 1948-73.	5
2.2.7 Canadian data.	5
3. Approach to PMP.	5
3.1 Summary.	5
3.2 Selected major storm values.	5
3.3 Moisture maximization.	6
3.3.1 The concept.	6
3.3.2 Atmospheric moisture	6
3.3.3 Representative storm dew point	15
3.3.4 Maximum dew point.	15
3.3.5 Moisture adjustment.	15
3.3.6 Elevation and barrier considerations	15
3.4 Transposition.	16
3.4.1 Definition	16
3.4.2 Transposition limits	16
3.4.3 Transposition adjustment	17
3.4.4 Distance-from-coast adjustment for tropical storm rainfall.	17
3.5 Total storm adjustment	17
3.6 Envelopment.	20
3.6.1 Durationally	20
3.6.2 Seasonally	20
3.6.3 Regionally	20
4. Analysis	20
4.1 Introduction	20
4.2 Minimum PMP at 20 grid points.	21
4.3 Statistical computations of taped rainfall data (1948-73).	21
4.4 Maximum observed rainfall values	28
4.5 Maximum atmospheric moisture	28

	Page
4.5.1 Precipitable water in soundings.	28
4.5.2 Surface dew points	29
4.5.3 Seasonal variation of maximum moisture	29
4.6 Seasonal variation of rainfall at selected long record stations (1912-61)	29
4.7 Rainfall depth-duration relations.	29
4.7.1 Within storms.	29
4.7.2 Among storms	38
4.7.3 Analyses	38
4.8 Regional PMP gradients	46
4.9 Some observations on PMP patterns.	46
5. Resulting PMP.	48
6. Example of Use of PMP maps	48
7. Special problems	48
7.1 Stippled regions on PMP maps	48
7.2 Extreme precipitation at Mt. Washington, N.H.	80
7.3 Point rainfall vs. 10-mi ² average rainfall.	80
7.4 Storm adjustments greater than 150 percent	81
8. Observed storms within 50 percent of PMP	81
Acknowledgements	86
References	87

FIGURES

1a Storms controlling PMP (September through June) for 6 hours. .	11
1b Storms controlling PMP (September through June) for 24 hours .	12
1c Storms controlling PMP (September through June) for 72 hours .	13
2 Grid points used for transposition	18
3 Distance-from-coast adjustment for transposing tropical storm rainfall (from HMR No. 51)	19
4 6-, 24-, and 72-hr PMP for grid point 11, (37°N, 89°W) (Data are moisture maximized and transposed storm rainfall depths.	22
5a 4% probability values for 6-hr duration for November	24
5b Ratios of 4% probability values for 6-hr duration for November or December to the highest of the 12 monthly values.	25

5c	Seasonal variation of ratios of monthly maxima to the highest monthly 4% probability values for 6-hr duration (grid points 3, 6, 12, 13, 17, 20)	26
5d	Month of maximum 4% probability values for 6 hours. . .	27
6a	Example of analyzed maps of greatest observed 6-hr rainfall (November)	30
6b	Example of analyzed maps of greatest observed 24-hr rainfall (November)	31
6c	Example of analyzed maps of greatest observed 72-hr rainfall (November)	32
6d	Seasonal variation of ratios of monthly maxima to the highest monthly maxima for maximum observed 6-hr rainfall (for grid points 3, 6, 12, 13, 17, 20) . . .	33
7a	Contiguous United States, maximum w_p (mm), surface to 500-mb, by half months, January through June (from Ho and Riedel, 1979)	34
7b	Maximum 12-hr persisting 1000-mb dew points ($^{\circ}\text{C}$) for October (Environmental Data Service, 1968).	35
7c	Seasonal variation of ratios of atmospheric moisture for each month to that for the highest month (grid points 3, 6, 12, 13, 17, 20).	36
8	Example of seasonal variations of 1% and 4% probability values, the maximum of record, and the ratio of each month's 4% probability value to that for the highest month. Three day rainfall for Duluth, Minnesota and Kansas City, Missouri (1912-61). Vertical scale gives both percentages, and depths in tenths of an inch	37
9	Seasonal variation of within storm 6/24-hr rain ratios for major storms in the study region	39
10a	Within storm 6/24-hr rain ratios, January	40
10b	Within storm 6/24-hr rain ratios, July.	41
11	Within storm 6/24-hr rain ratios vs. magnitude of 24-hr depths.	42
12	Seasonal variation of within storm 72/24-hr rain ratios for major storms in the study region.	43

	Page
13 Within storm 72/24-hr rain ratios vs. magnitude of 72-hr depths.	44
14 Depth-duration plots for November (grid points 3, 6, 12, 13, 17, 20). Upper curves are the ratios of rainfall for various durations to the 24-hr value (+ from PMP; X from 4% probability values). Lower curves show PMP values. Maximized rainfall values transposed to the grid point are shown with storm number (table 2).	45
15 Latitudinal variation by month of 6-hr PMP along longitude 91°W	47
16-25 6-hr 10-mi ² PMP, January through December, (in.)	49-58
26-35 24-hr 10-mi ² PMP, January through December, (in.).	59-68
36-45 72-hr 10-mi ² PMP, January through December, (in.).	69-78
46 Example of variation of PMP depths with duration for mid- month of March and April for 40.5°N, 87.5°W (see sec. 6). . .	79
47 Number of separate storms with rainfall \geq 50% of PMP for 6, 24, and 72 hours (number of storms \geq 50% of PMP for July and August can be obtained from Riedel and Schreiner 1980).	82

TABLES

1 Data sources for determining maximum station precipitation of record.	4
2 Major storms selected for moisture maximization and transposition.	7-10
3 Important storms centered in Canada near the U.S. border . .	14
4 Statistical analyses for 1948-73 station precipitation on magnetic tapes	23
5 Extreme precipitation amounts observed at Mt. Washington, N.H. (44°16N; 71°18W) during the winter season	81
6 Known storm rainfalls for 6, 24, and 72 hours that are within 50 percent of mid-month PMP for the month in which the storm occurred (July and August storms not included) .	84-85

SEASONAL VARIATION OF 10-SQUARE-MILE PROBABLE MAXIMUM
PRECIPITATION ESTIMATES UNITED STATES EAST OF
THE 105th MERIDIAN

Francis P. Ho and John T. Riedel
Hydrometeorological Branch
Water Management Information Division
Office of Hydrology
National Weather Service, NOAA
Silver Spring, Maryland

ABSTRACT. Estimates of the upper limit to rainfall that the atmosphere can produce (probable maximum precipitation) are given in this study for durations from 6 to 72 hours for each month of the year for 10 mi² areas. The results are in a generalized form, that is, on maps allowing use for planning and design of any present or proposed hydrologic structure for the United States east of the 105th meridian. The probable maximum precipitation estimates show a smooth variation with duration, season, and location.

1. INTRODUCTION

1.1 Authorization

This study was authorized and funded through Interagency Agreement No. NRC-01-77-113 between the Nuclear Regulatory Commission (NRC) and the National Oceanic and Atmospheric Administration (NOAA) dated June 2, 1977. The Agreement was extended to October 1, 1979, by an amendment dated May 20, 1979.

1.2 Purpose

The purpose of the study is to give seasonal variation of probable maximum precipitation (PMP) estimates for 10 mi² areas for the United States east of the 105th meridian. PMP estimates for durations of 6 to 72 hours, by 6-hr increments are required.

1.3 Scope

PMP estimates for 6, 24, and 72 hours are given on generalized maps for each midmonth for 10 mi² areas. While smaller sized areas have greater PMP values, especially for the warm season, they will not be defined in this study. For the winter season, PMP for smaller areas are not appreciably different from the 10-mi² values in this study.

All-season estimates of PMP, Hydrometeorological Report (HMR) No. 51, *Probable Maximum Precipitation Estimates, United States East of the 105th Meridian*, (Schreiner and Riedel 1978) set the greatest values that can be

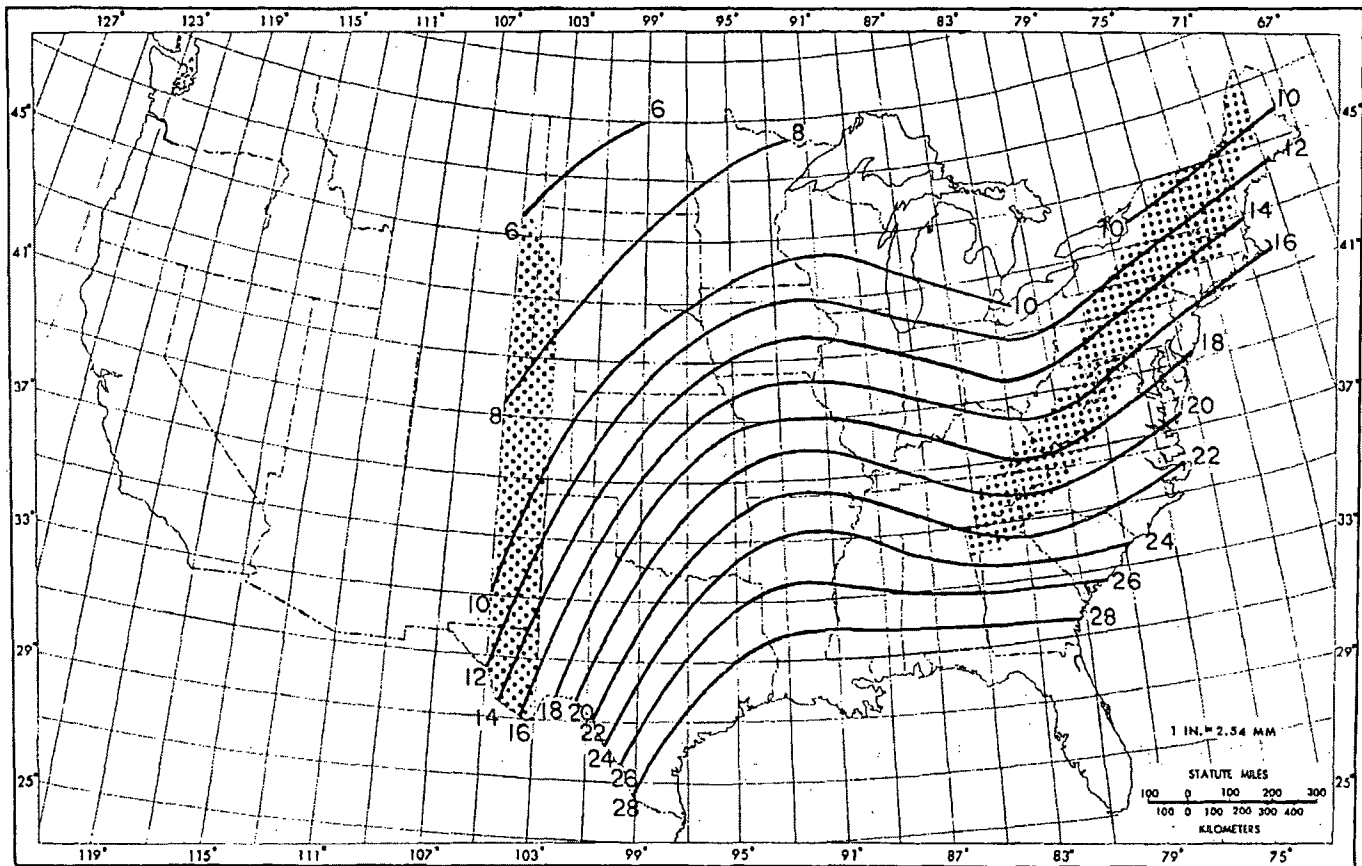


Figure 35.--24-hr 10-mi² PMP, December, (in.).

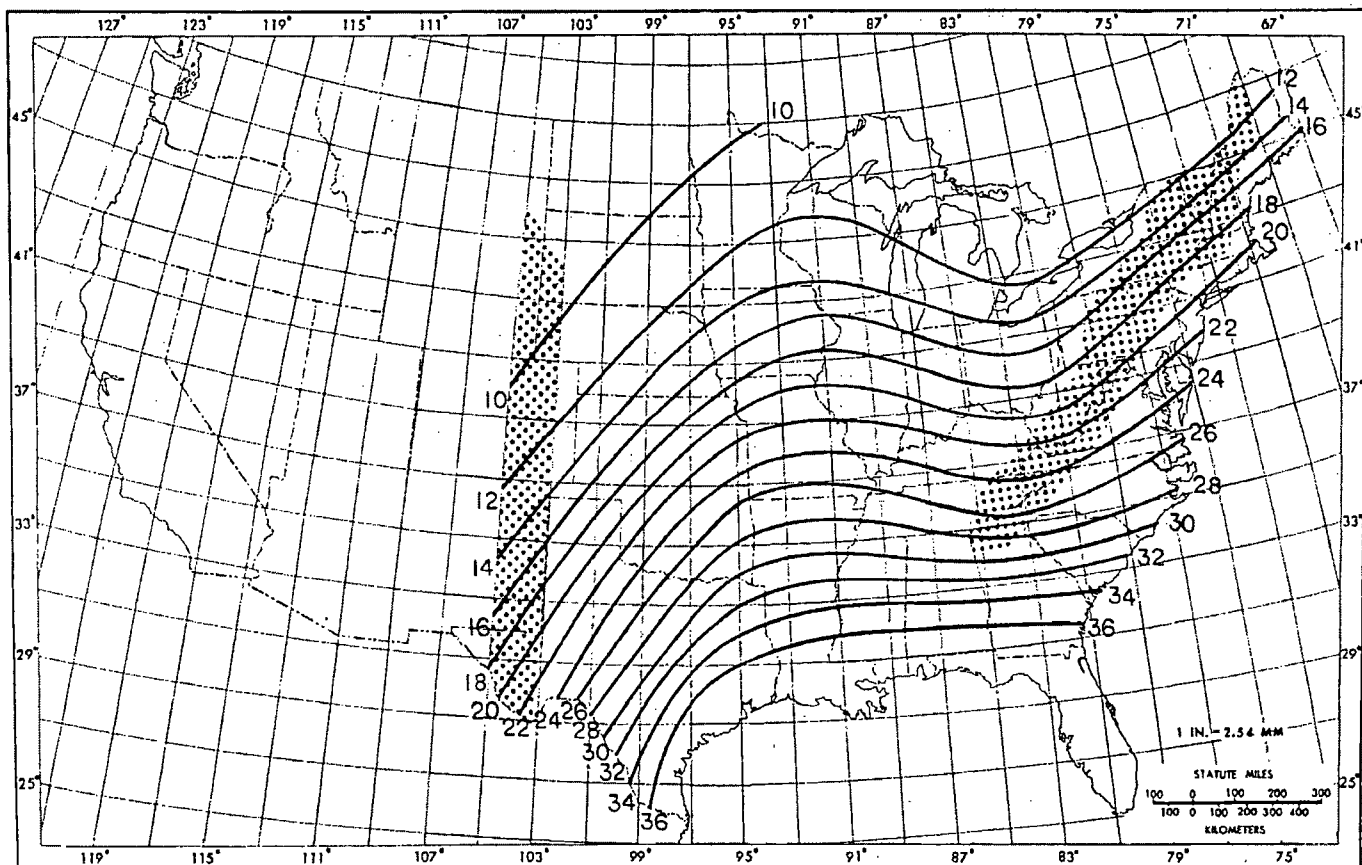


Figure 45.--72-hr 10-mi² PMP, December, (in.).