Temporal Distributions of Heavy Precipitation in the Ohio River Basin and Surrounding States

Introduction. Temporal distributions of heavy precipitation are provided for use with precipitation frequency estimates in the Ohio River Basin and Surrounding States Project area for 6-, 12-, 24- and 96-hour durations. The temporal distributions are expressed in probabilistic terms as cumulative percentages of precipitation and duration at various percentiles. The starting time of precipitation accumulation was defined in the same fashion as it was for precipitation frequency estimates for consistency.

Temporal distributions for each duration are presented in Figure 1. The data were also subdivided into quartiles based on where in the distribution the most precipitation occurred in order to provide more specific information on the varying distributions that were observed. Figures 2 through 5 depict temporal distributions for each quartile for the four durations. Table 1 lists the number and proportion of cases in each quartile for each duration.

Methodology. This project largely follows the methodology used by the Illinois State Water Survey (Huff, 1990) except in the definition of the precipitation accumulation. This project computed precipitation accumulations for specific (6-, 12-, 24- and 96-hour) time periods as opposed to single events or storms in order to be consistent with the way duration is defined in the associated precipitation frequency project. As a result, the accumulation cases may contain parts of, one, or more than one precipitation event. Accumulation computations were made moving from earlier to later in time resulting in an expected bias toward front loaded distributions when compared with distributions for single storm events.

For every precipitation observing station in the project area that recorded precipitation at least once an hour, the three largest precipitation accumulations were selected for each month in the entire period of record and each of the four durations. A minimum threshold was used to make sure only heavier precipitation cases were being captured. The precipitation with an Average Recurrence Interval (ARI) of 2 years at each observing station for each duration was used as the minimum threshold at that station.

A minimum threshold of 25-year ARI was tested. It was found to produce results similar to using a 2-year ARI minimum threshold. The 25-year ARI threshold was rejected because it reduced the number of samples sufficiently to cause concern for the stability of the estimates.

To determine whether distributions varied appreciably across the project area, temporal distributions based on data only from the Southeast coast and the extreme Northwest portion of the project area were computed separately, and compared to the distributions computed for the project area as a whole. The distributions were nearly identical. As a result the temporal distributions presented here are based on the entire project area because of the larger sample size and because the distributions varied so little by region.

Each of the accumulations was converted into a ratio of the cumulative hourly precipitation to the total precipitation for that duration, and a ratio of the cumulative time to the total time. Thus, the last value of the summation ratios always had a value of 100%. The data were combined, cumulative deciles of precipitation were computed at each time step, and then results were plotted to provide the graphs presented in Figure 1. The data were also separated into categories by the quartile in which the greatest percentage of the total precipitation fell to produce the graphs shown in Figures 2 through 5. A moving window weighted average smoothing technique was performed on all the curves.

Interpreting the Results. Figure 1 presents cumulative probability plots of temporal distributions for the 6-, 12-, 24- and 96-hour durations for the project area. Figures 2 through 5 present the same information but for categories based on the quartile of greatest precipitation. The x-axis is the cumulative percentage of the time period. The y-axis is the cumulative percentage of total precipitation.

The data on the graphs represent the average of many events illustrating the cumulative probability of occurrence at 10% increments. For example, the 30% of cases in which precipitation is concentrated closest to the beginning of the time period will have distributions that fall above and to the left of the 30% curve. At the other end of the spectrum, only 10% of cases are likely to have a temporal distribution falling to the right and below the 90% curve. In these cases the bulk of the precipitation falls toward the end of the time period. The 50% curve represents the median temporal distribution on each graph.

First-quartile graphs consist of cases where the greatest percentage of the total precipitation fell during the first quarter of the time period. i.e., the first 1.5 hours of a 6-hour period, the first 3 hours of a 12-hour period, etc. The second, third and fourth quartile plots, similarly are for cases where the most precipitation fell in the second, third or fourth quarter of the time period.

The time distributions consistently show a greater spread, and therefore greater variation, between the 10% and 90% probabilities as the duration increases. This is mainly because the longer durations are more likely to have captured more than one event separated by drier periods. The median of the distributions gradually becomes steeper at longer durations.

The following is an example of how to interpret the results using Figure 4A and Table 1. Of the 18,453 cases at the 24-hour duration, 6,675 of them were first-quartile events:

- In the 10% of these cases where the precipitation falls closest to the beginning of the time period, 50% of the total precipitation (y-axis) fell in the first 1.8 hours of event time (7.5% on the x-axis). By the 11th hour (46% on the x-axis), all of precipitation (100% on the y-axis) had fallen and it was dry for the rest of the 24-hour period.
- A median case of this type will drop half of its total precipitation (50% on the y-axis) in the first 4.6 hours (19% on the x-axis).
- In 90% of these cases where the precipitation falls closest to the beginning of the time period, 50% of the total precipitation fell in the first 9.4 hours (39% on the x-axis).

Summary and General Findings. The results presented here can be used for determining temporal distributions of heavy precipitation at particular durations and amounts and at particular levels of probability. The results are designed for use with precipitation frequency estimates and may not be the same as the temporal distributions of single storms or single precipitation events. The time distributions show a greater spread between the percentiles with increasing duration. The median of the distributions becomes steeper with increasing duration. A majority of the cases analyzed were first-quartile regardless of duration (Table 1). Fewer cases fell into each of the subsequent quartile categories with the fourth quartile containing the fewest number of cases at all durations.

Reference

Huff, F. A., 1990: Time Distributions of Heavy Rainstorms in Illinois. Illinois State Water Survey, Champaign, 173, 17pp.

FIGURE 1
TEMPORAL DISTRIBUTION: ALL CASES
OHIO RIVER BASIN AND SURROUNDING STATES

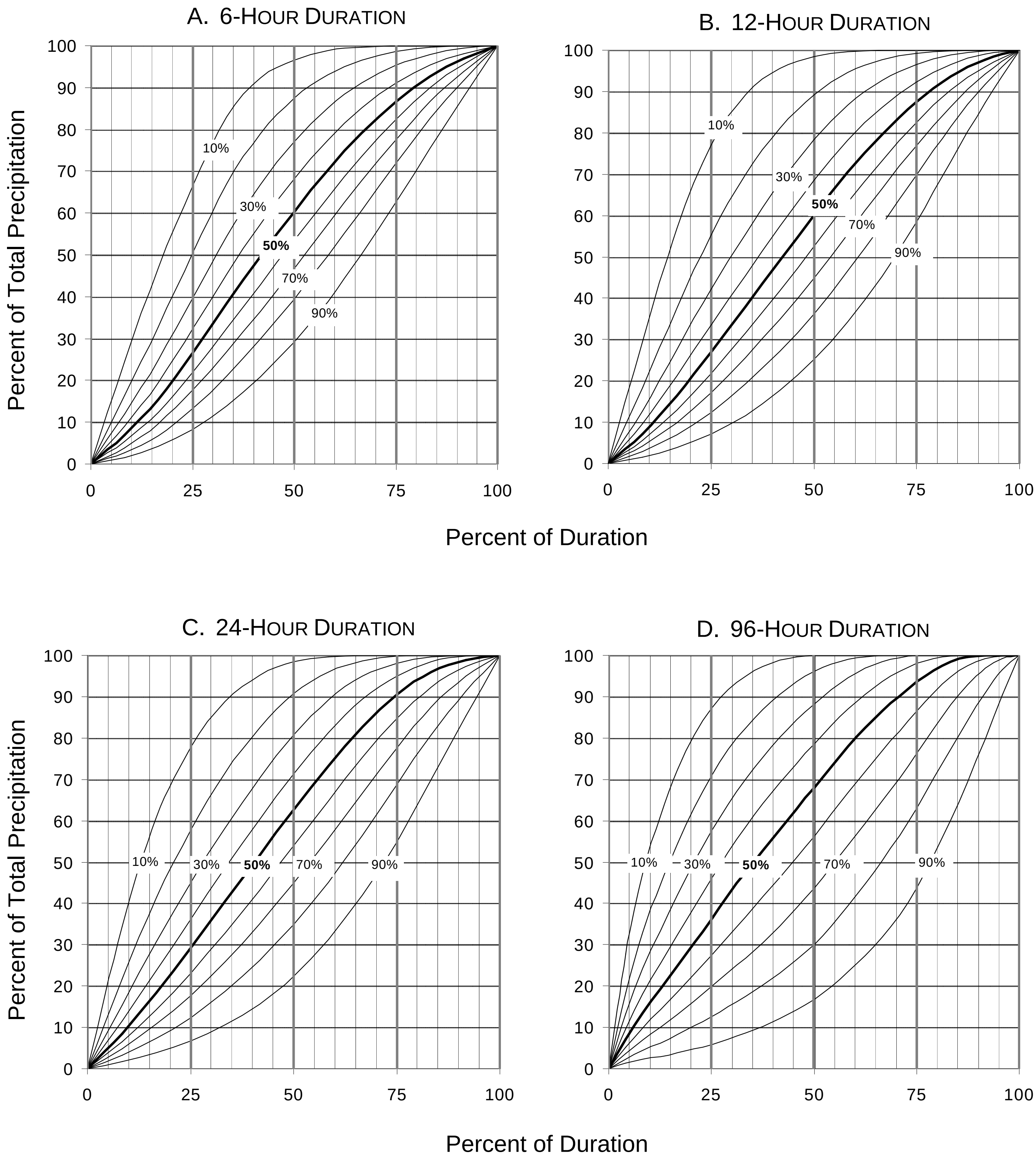


FIGURE 2
TEMPORAL DISTRIBUTION: 6-HOUR DURATION
OHIO RIVER BASIN AND SURROUNDING STATES

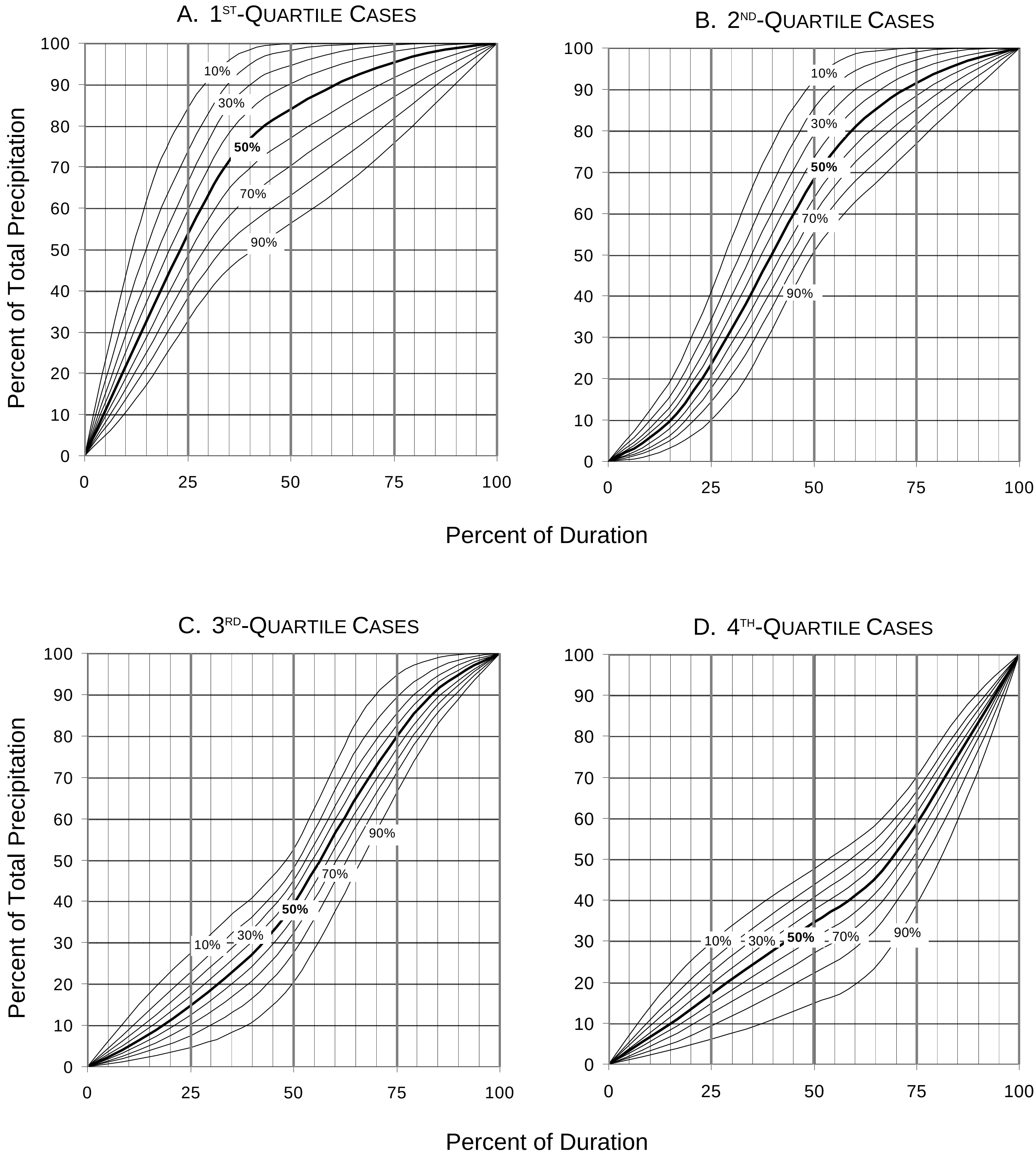


FIGURE 3
TEMPORAL DISTRIBUTION: 12-HOUR DURATION
OHIO RIVER BASIN AND SURROUNDING STATES

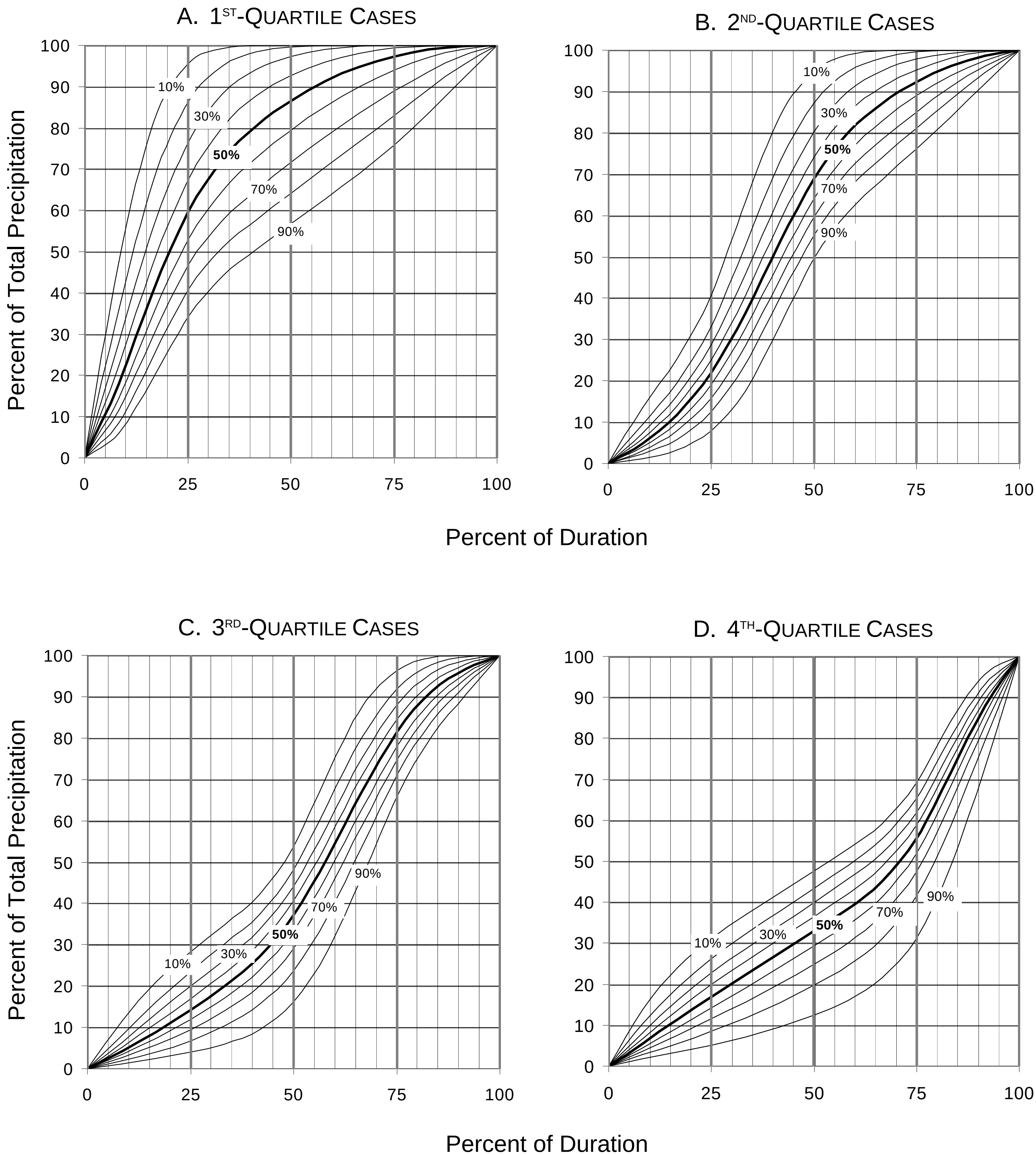


FIGURE 4
TEMPORAL DISTRIBUTION: 24-HOUR DURATION
OHIO RIVER BASIN AND SURROUNDING STATES

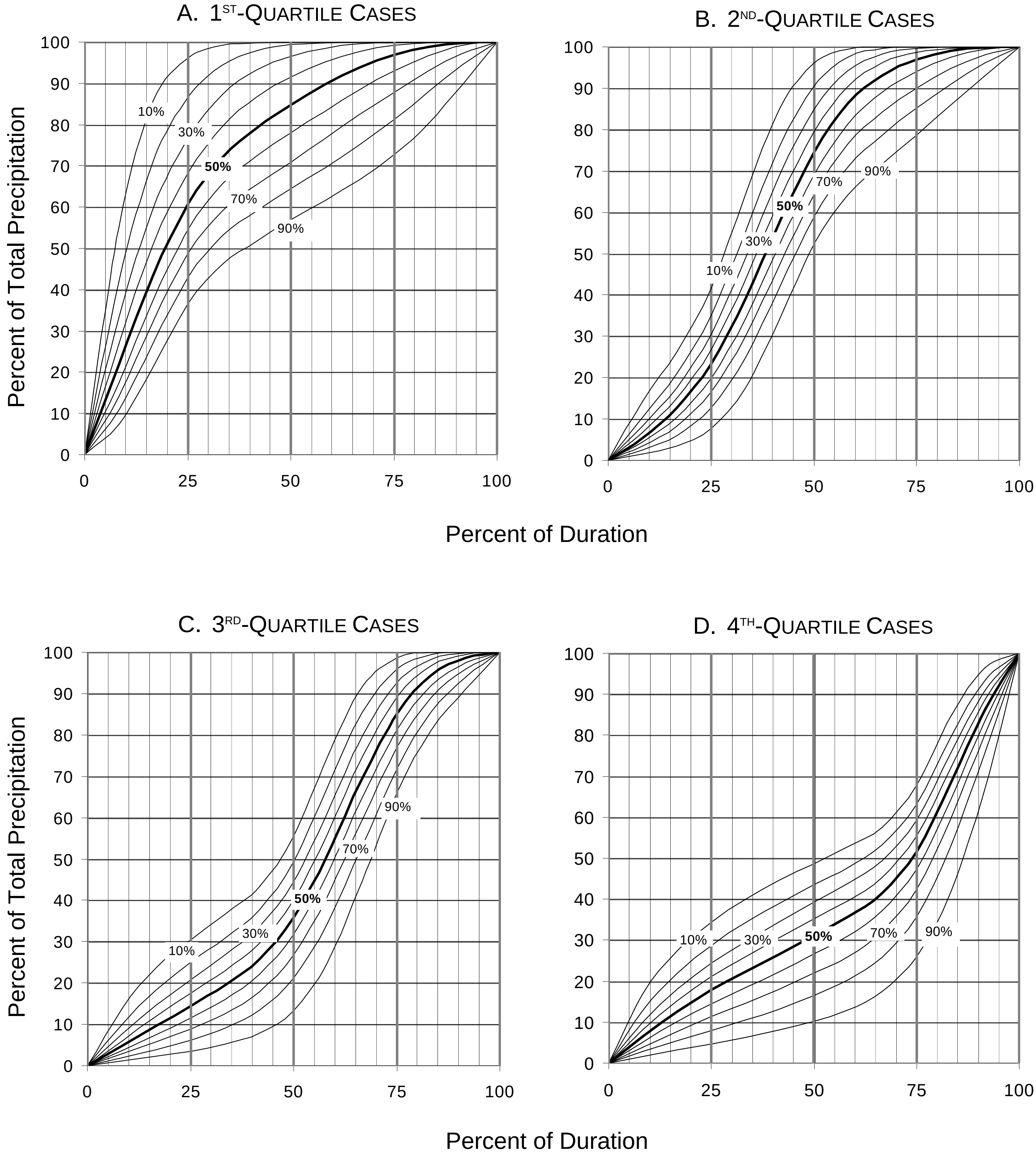
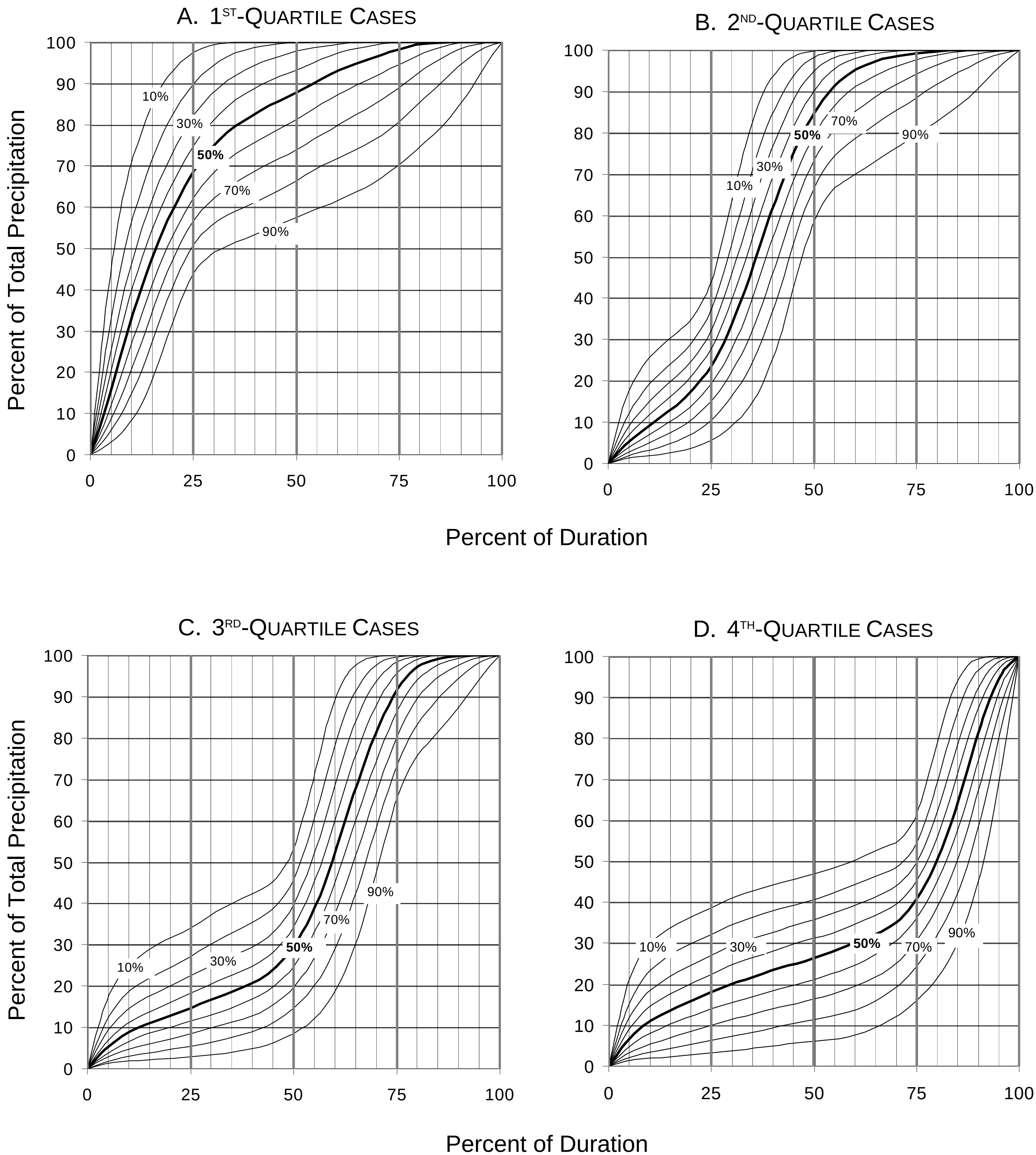


FIGURE 5
TEMPORAL DISTRIBUTION: 96-HOUR DURATION
OHIO RIVER BASIN AND SURROUNDING STATES



Number of Cases					
	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	Total number of cases
6-hr	5803 (34%)	5164 (30%)	3916 (23%)	2195 (13%)	17078
12-hr	6412 (35%)	4833 (27%)	4099(23%)	2757 (15%)	18101
24-hr	6675 (36%)	4821 (26%)	4139 (23%)	2818 (15%)	18453
96-hr	8242 (43%)	3947 (21%)	3595 (19%)	3324 (17%)	19108

Table 1.