Appendix A.1 Temporal distributions of heavy precipitation

1. Introduction

Temporal distributions of heavy precipitation are provided for use with precipitation frequency estimates from NOAA Atlas 14 Volume 5 for 6-hour, 12-hour, 24-hour, and 96-hour durations. The temporal distributions are expressed in probability terms as cumulative percentages of precipitation totals at various time steps. The precipitation cases used to derive the temporal distributions were defined in the similar fashion as those for estimating precipitation frequencies for consistency. To provide detailed information on the varying temporal distributions, separate temporal distributions were derived for four precipitation cases defined by the duration quartile in which the greatest percentage of the total precipitation occurred.

2. Methodology and results

The methodology used to produce the temporal distributions is similar to the one developed by Huff (1967) except in the definition of precipitation cases. Because of that, temporal distribution curves may be different from corresponding temporal distribution curves obtained from the analysis of single storms. In accordance with the way a precipitation case ("event") was defined for the precipitation frequency analysis, a precipitation case for temporal distribution analysis was computed as the total accumulation over a specific duration (6-, 12-, 24-, or 96-hours). As a result, the accumulation may contain parts of one or more storms. Also, a precipitation case was defined to start with precipitation but not necessarily to end with precipitation resulting in potentially more front-loaded cases when compared with distributions derived from the single storm approach. To eliminate potential biases, a constraint was imposed to exclude cases with a continuous dry period that lasted for more than 20% of the duration. This restriction produced a less variant sample. Table A.1.1 shows the number of precipitation cases used to derive the temporal distributions for each duration. By imposing the restriction on continuous dry periods, the number of cases available for temporal distribution analysis decreased with duration because long, continuous precipitation events occurred less frequently than continuous short-duration events.

For each precipitation case, precipitation accumulation was converted into a percentage of the total precipitation amount at one hour time increments. All cases for a specific duration were then combined and probabilities of occurrence of precipitation totals were computed at each hour. The temporal distribution curves for nine deciles (10% to 90%) were smoothed using linear programming method (Bonta and Rao, 1988) and plotted in the same graph. Figure A.1.1 shows temporal distribution curves for the four selected durations; time steps were converted into percentages of durations for easier comparison.

The cases were further divided into four categories by the quartile in which the greatest percentage of the total precipitation occurred. Table A.1.1 shows the numbers and proportion of precipitation cases used to derive the temporal distributions in each quartile. Unlike the cases of 12-, 24-, and 96-hour durations in which the number of data points can be equally divided by four, the cases of 6-hour duration contain only six data points and they cannot be evenly distributed into four quartiles. Therefore, in this analysis, for 6-hour duration, the first quartile contains precipitation cases where the most precipitation occurred in the first hour, the second quartile contains precipitation cases where the most precipitation occurred in the second and third hours, the third quartile contains precipitation cases where the most precipitation occurred in the fourth hour, and the fourth quartile contains precipitation cases where the most precipitation occurred in the fifth and sixth hours. This uneven distribution affects the number of cases contained in each quartile for the 6-hour duration. Figures A.1.2 through A.1.5 show the temporal distribution curves for four quartile cases for 6-hour, 12-hour, 24-hour and 96-hour durations, respectively.

Table A.1.1. Number of all precipitation cases and number (and percent) of cases in each quartile for selected durations.

Duration (hours)	All cases	First-quartile cases	Second-quartile cases	Third-quartile cases	Fourth-quartile cases
6	363	25 (7%)	179 (49%)	45 (12%)	114 (32%)
12	298	60 (20%)	70 (24%)	111 (37%)	57 (19%)
24	205	31 (15%)	57 (28%)	71 (35%)	46 (22%)
96	176	39 (22%)	38 (22%)	43 (24%)	56 (32%)

Temporal distribution data are also available in a tabular form at PFDS web page (http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_temporal.html). For 6-hour, 12-hour and 24-hour durations, temporal distribution data are provided in 0.5-hour increments and for 96-hour duration in hourly increments.

3. Interpretation

Figure A.1.1 shows the temporal distribution curves of all precipitation cases for the 6-, 12-, 24-, and 96-hour durations for the project area. Time steps were converted into percentages of total durations for easier comparison. Figures A.1.2 through A.1.5 show temporal distribution curves for first-, second-, third-, and fourth-quartile cases for 6-hour, 12-hour, 24-hour and 96-hour durations, respectively. First-quartile plots show temporal distribution curves for cases where the greatest percentage of the total precipitation fell during the first quarter of the duration (e.g., the first 3 hours of a 12-hour duration). The second, third, and fourth quartile plots are similarly for cases where the most precipitation fell in the second, third, or fourth quarter of the duration.

The temporal distribution curves represent the averages of many cases and illustrate the temporal distribution patterns with 10% to 90% occurrence probabilities in 10% increments. For example, the 10% curve in any figure indicates that 10% of the corresponding precipitation cases had distributions that fell above and to the left of the curve. Similarly, 10% of the cases had temporal distribution falling to the right and below the 90% curve. The 50% curve represents the median temporal distribution.

The following is an example of how to interpret the results using the figure (a) in the upper left panel of Figure A.1.4 and information from Table A.1.1 for 24-hour first-quartile cases.

- Of the total of 205 24-hour cases, 31 (15%) of them were first-quartile.
- In 10% of the first-quartile cases, 50% of the total precipitation fell by 4.8 hours and 90% of the total precipitation fell by 15.5 hours.
- A median case of this type will drop half of the precipitation (50% on the y-axis) in approximately 8 hours.
- In 90% of the cases, 50% of the total precipitation fell by 12.5 hours and 90% of precipitation fell by 22.8 hours.

Temporal distribution curves are presented in order to show the range of possibilities. Care should be taken in the interpretation and use of temporal distribution curves. For example, the use of different temporal distribution data in hydrologic models may result in very different peak flow estimates. Therefore, they should be selected and used in a way to reflect users' objectives.

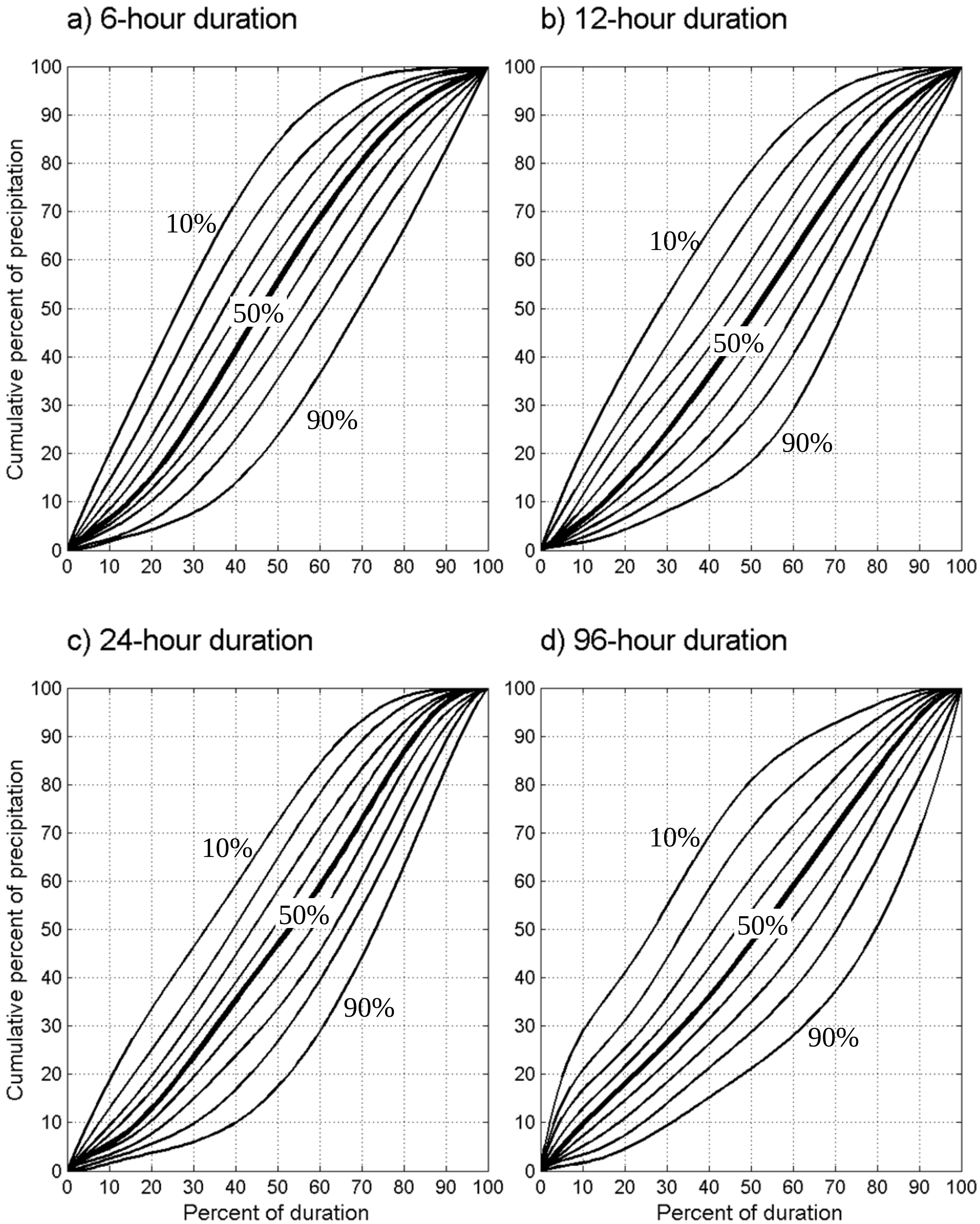

Figure A.1.1. Temporal distribution curves for all cases for: a) 6-hour, b) 12-hour, c) 24-hour, and d) 96-hour durations.

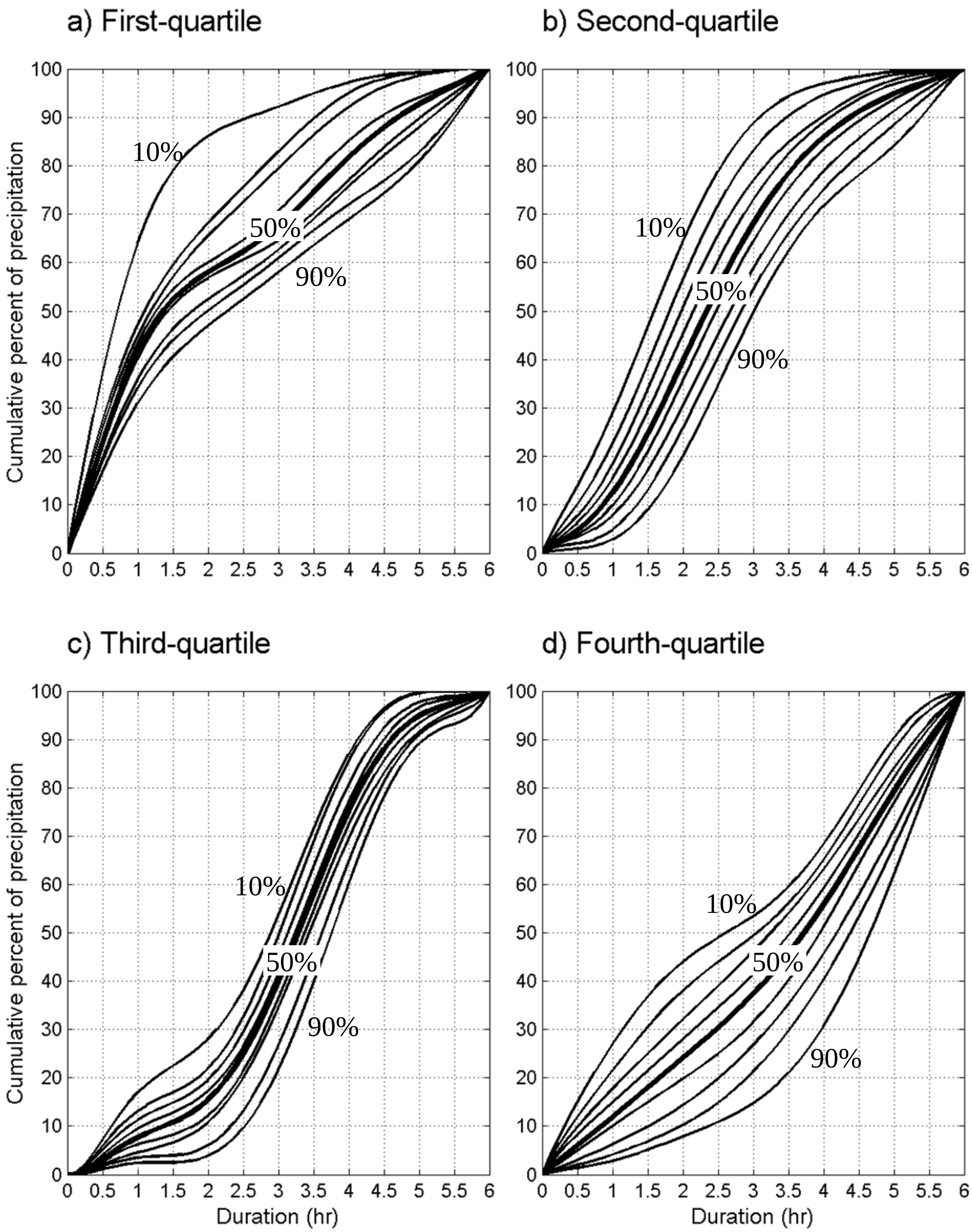

Figure A.1.2. 6-hour temporal distribution curves for: a) first-quartile, b) second-quartile, c) third-quartile, and d) fourth-quartile cases.

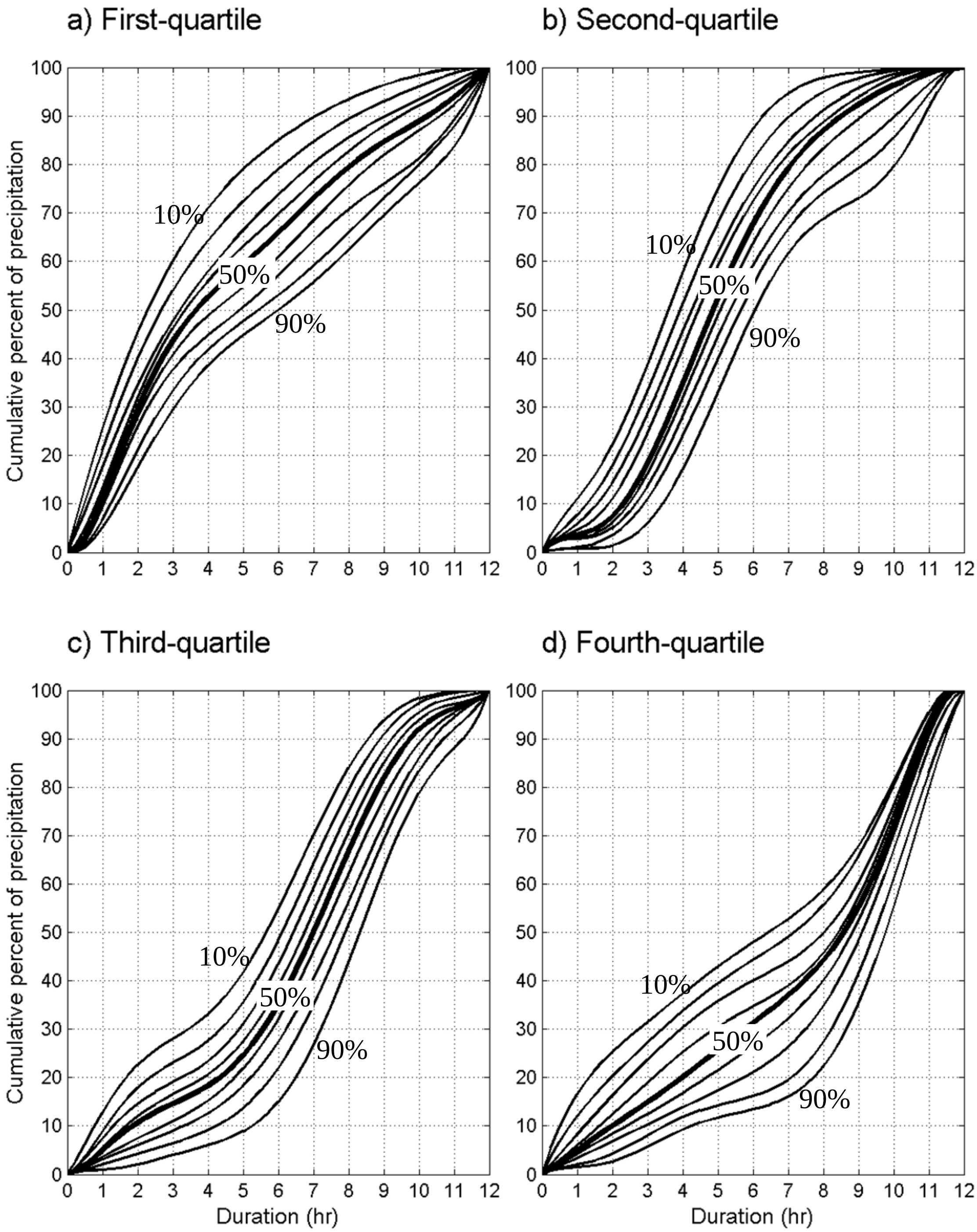

Figure A.1.3. 12-hour temporal distribution curves for: a) first-quartile, b) second-quartile, c) third-quartile, and d) fourth-quartile cases.

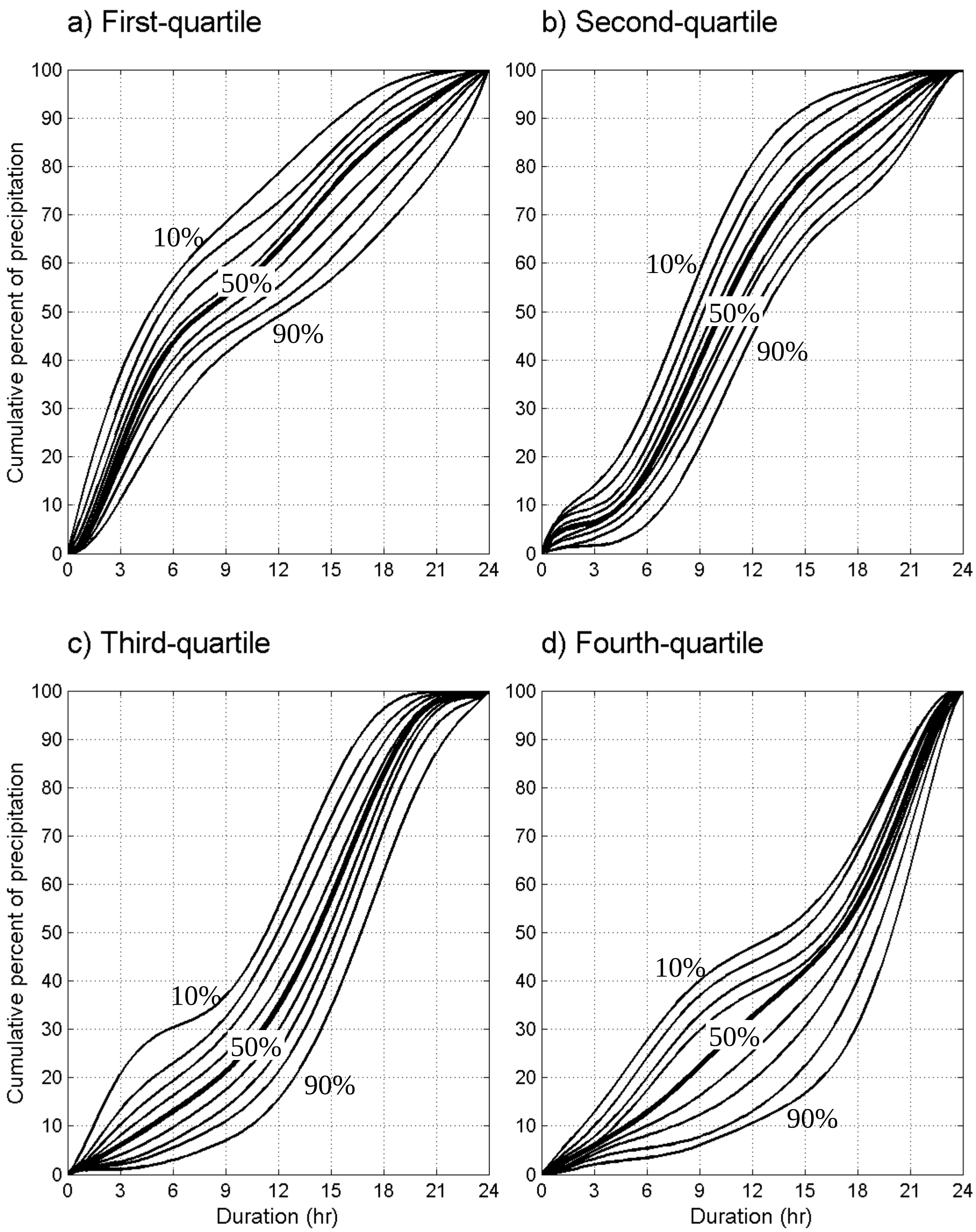

Figure A.1.4. 24-hour temporal distribution curves for: a) first-quartile, b) second-quartile, c) third-quartile, and d) fourth-quartile cases.

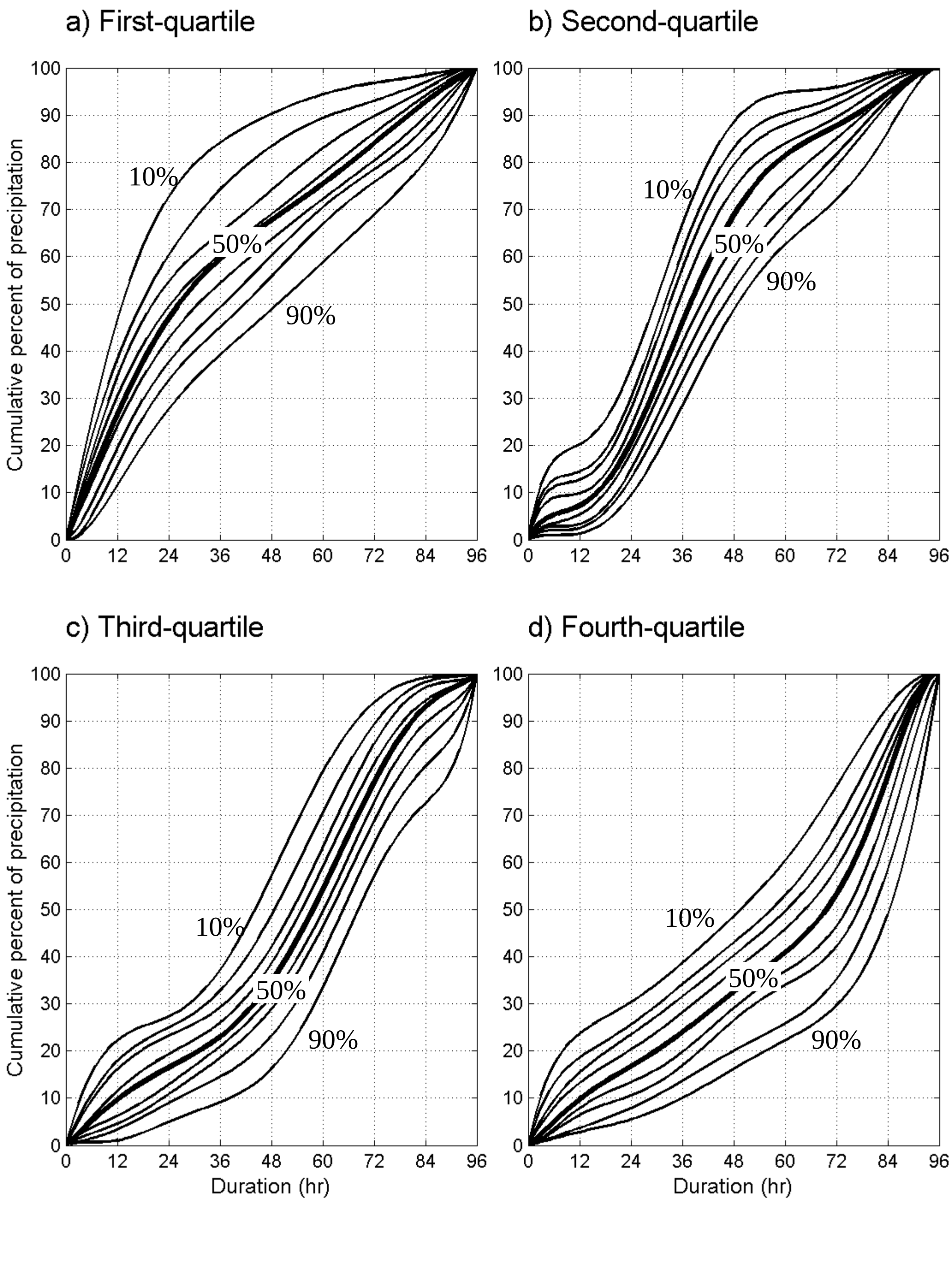

Figure A.1.5. 96-hour temporal distribution curves for: a) first-quartile, b) second-quartile, c) third-quartile, and d) fourth-quartile cases.