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Complex shapes of rainfall depth-duration-frequency curves

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Frequency analysis of rainfall intensities or rainfall depths (precipitation totals) is usually performed by estimating respective design values occurring on average once per a given number of years (return period N). Estimates of design rainfall depths R_N (design precipitation totals) with a given frequency $F = 1 / N$ for different rainfall durations D can be fitted with a depth-duration-frequency (DDF) curve defined by a suitable mathematical function. For a given return period, the DDF curve depicts the increase of the design precipitation total when increasing the duration (length of the considered time window). Thus, each DDF curve is monotonically increasing, while its slope gradually decreases with increasing rainfall duration.

For a limited range of rainfall durations (e.g., from 0.5 to 3 hours), design precipitation totals can be fitted by a single power function. However, this statistical model becomes less reliable or even useless when employing either shorter or longer durations, because the DDF curve gets a much more complex shape then. We also provide a possible explanation of such complex shapes of DDF curves as a result of different meteorological conditions producing high precipitation totals of different durations. Two tipping points of the DDF curve can be due to the transition from the scale of single convective cells to the scale of whole multicellular storms, as well as from the scale of multicellular storms to the synoptic scale. Thus, differences of shapes of DDF curves between lowlands and highlands can be explained by changes of representation of convective and stratiform rains among precipitation maxima of different duration.