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A statistical approach to resolve incompatibilities between measured runoff data and daily estimates of spatially averaged rainfall

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For many hydrological applications, such as calibration of rainfall-runoff models, estimation of river discharges at the outlet of a basin, and quantification of runoff extremes, one needs accurate estimates of spatial rainfall averages. When a relatively dense raingauge network is available, simple methods like Thiessen polygons and Kriging can be effectively used to weight point rainfall measurements at different locations inside the catchment, to calculate spatial rainfall averages.

In the case of catchments covered by a single raingauge (i.e. a frequent case for medium and large- sized catchments in Greece), one approximates spatially averaged rainfall intensities using point rainfall measurements. Since the marginal and joint statistics of the two processes are quite different, one faces important problems when calibrating hydrological models and calculating annual water-budgets. Those problems are amplified by measurement errors, incompleteness of the historical records and topographic influences.

In this work, we develop an approach to adjust point rainfall measurements to better resemble the statistical structure of spatial rainfall averages. This is done by developing a statistical tool that a) identifies incompatibilities between daily rainfall measurements and river discharges, and b) adjusts rainfall measurements to better resemble the observed changes of daily river runoff. The latter incorporate important information on the occurrence and amount of spatially averaged rainfalls. The suggested model adjusts rainfall time-series by minimally operating on the fraction of dry days, while reproducing the distribution of rainfall intensities on wet days conditional on the same- and previous-day river discharges.

In an application study to a 19-year record of daily rainfalls and river discharges, we find that the suggested statistical approach efficiently identifies and resolves rainfall-runoff incompatibilities at daily level, while respecting the seasonal character and the clustered nature of rainfall. Although the statistical correction is applied at a daily time scale, the method demonstrates significant skill in resolving imbalances of annual rainfall and river discharge volumes that cause inconsistencies in annual water budgets.