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Geo-statistical analysis of extreme precipitation by patching up sparse and fragmented rain gauge records

Andrea Libertino (1), Paola Allamano (2), Francesco Laio (1), and Pierluigi Claps (1)
(1) DIATI, Politecnico di Torino, Torino, Italy (andrea.libertino@polito.it), (2) Waterview SRL, Torino, Italy

Rain gauge records are quite simple to obtain, so that activation and dismissal of stations is frequent. Precipitation records are then often plagued by gaps, spatio-temporal discontinuities and inhomogeneities, that affect their suitability for the statistical assessment of extreme rainfall. This constitutes a concrete problem when estimating the spatial risk related to severe storms on wide complex domains. On the one hand, if shorter series are discarded for obtaining robust estimates, a significant amount of information is lost; on the other hand, shorter time series cannot be used alone for estimating design rainfall with large return periods.

We propose a robust statistical framework for dealing with uneven and fragmented rainfall records on a wide spatial domain. The technique, named "patched kriging" allows one to patch up all the available information, independently of the length of the series, and to provide reliable extreme rainfall estimates in ungauged areas. The methodology involves the sequential application of the ordinary kriging equations, producing a homogeneous dataset of synthetic series with uniform length. The reduced temporal variability of the reconstructed series, smoothed by the interpolation, leads to underestimation of the design rainfall. A theoretically-based bias-correction procedure is thus included in the technique. The characteristics of the series are finally analysed by means of weighted L-moments, where data in each year are weighted by the inverse of the kriging variance.

The application to a 25000 km^2 test region in the North West of Italy demonstrates that the technique can produce patched series with L-moments consistent with those of the measured ones. Furthermore, annual maxima quantiles estimators at ungauged sites are unbiased on the wide and complex spatial domain under study. Considering the low computational cost, the results make the "patched kriging" technique particularly interesting from an operational point of view, in the framework of a regional rainfall frequency analysis consistent with the available data.