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

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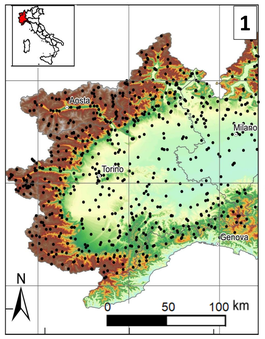
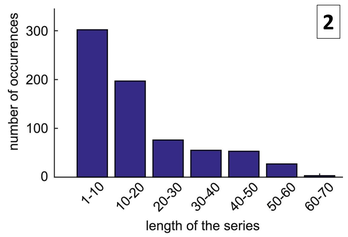
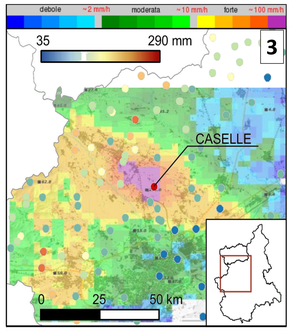
The problem

Rain gauge data are plagued by gaps and spatio-temporal discontinuities that could affect their suitability for rainfall frequency analyses. Furthermore, the need to discard the shorter series leads to ignore a significant amount of information that can be essential, especially when large return period are sought.

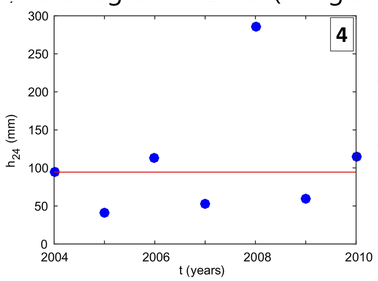


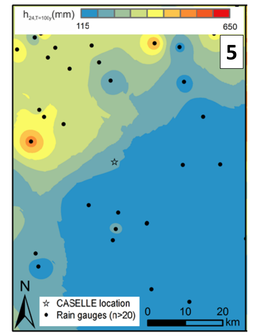
Annual maxima for 1-3-6-12-24 h durations from the Piemonte region are considered (1). Gaps and discontinuities in the evolution of the nework (more than 550 gauge locations in 70 years) leads to more than 50% of the series shorter than 20 years (2).





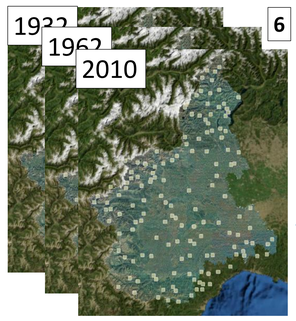
All the information on the extreme event occurred in the region in 2008 (in fig.3 the radar map and the gauges) is contained in a 7-year time series (Caselle, fig.4) that would be ignored using the classical frequency analysis methods (5).



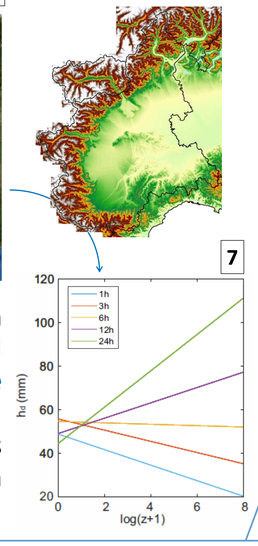


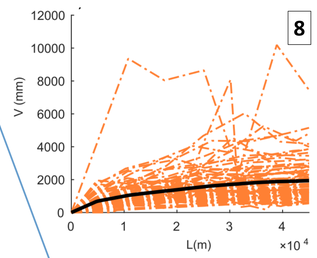
A study case

The patched kriging

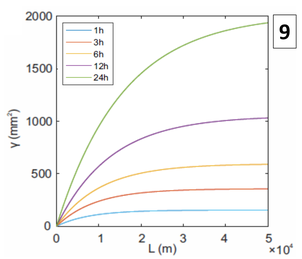


For each duration each record is considered just a point in the (*x, y, t*) space (6). Trend with elevation is removed (regression lines in fig.7).

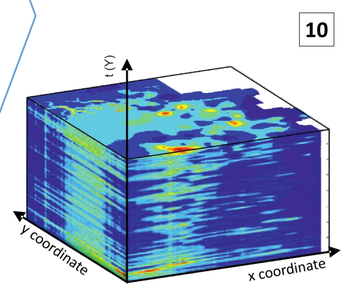


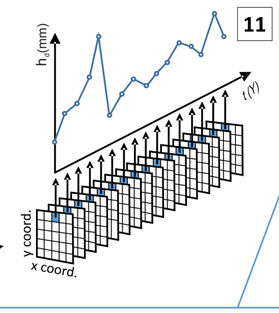


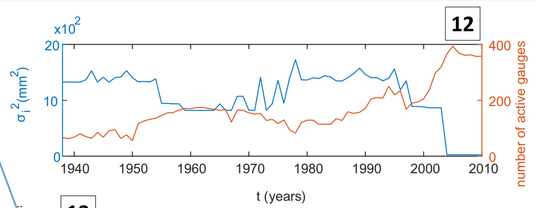
For each duration the sample variogram (black line in fig.8, referred to 24-h) is evaluated as the mean of the annual variograms (orange lines) weighted on the number of active rain gauges every year. Exponential theoretical variograms are then adopted and fitted to the sample ones for each duration (fig.9).

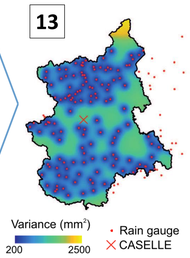


Applying year by year the ordinary kriging equation a «rainfall cube» and a «variance cube» can be obtained in the (*x, y, t* space) (10). Coring the cube along the *t*-axis one can obtain a complete «cored series» (11) that is analysed using L-moments weighted on the related «kriging variance series».





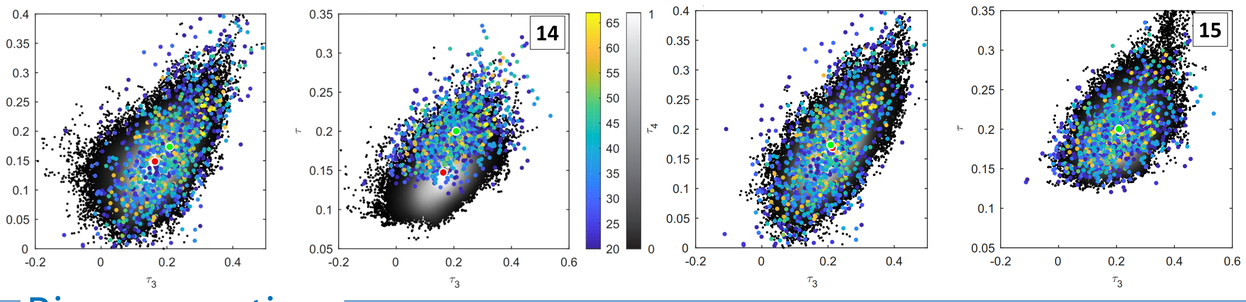




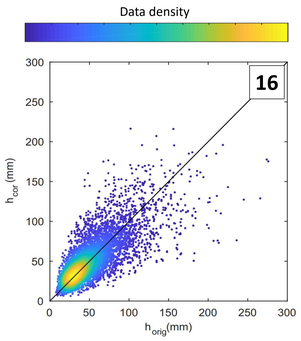
The kriging variance is larger in cells far from gauged locations (in fig.13 year 1970) and, for a fixed cell, it increases/decreases oppositely to the number of gauges in its proximity (in fig.12 the series of the Caselle station). It is thus used for giving differential weights to the data when estimating the sample L-moments.

Bias-correction

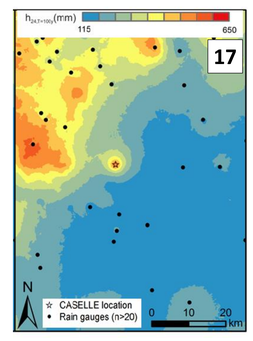
Interpolation reduces the coefficient of variation of the estimates (14). A bias-correction procedure, based on the distance of each cell from the nearest gauged ones, have been developed (15).



Results



The patched kriging is able to provide not only series with L-moments consistent with those of the original ones, but also to reconstruct reliable annual maxima at ungauged areas (fig.16, in crossvalidation) preserving the information contained in the short series (17).



References

Libertino A., P. Allamano, F. Laio, and P. Claps. Regional-scale analysis of extreme precipitation from short and fragmented records. Advances in Water Resources 2018, 112, 147-159