High-resolution analysis of 1 day extreme precipitation in a wet area centred over eastern Liguria

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1. Motivation

Liguria and northern Tuscany experienced several exceptional precipitation episodes and floods during the last century. Rational planning of urban development is indispensable to protect the population. This requires a thorough knowledge of the distributional features of extreme precipitation over their complex territory.

2. Aims

- Perform an investigation of 1-day precipitation extremes based on a dense data-set of high-quality, homogenized station records in 1912-2014;
- Estimate very high quantiles corresponding to 10-, 50- and 100-yr return periods, as predicted by a Generalized Extreme Value (GEV) distribution;
- Produce a high-resolution grid (30 arcsec) of return levels using a regional frequency analysis combined with regression techniques.

3. Data processing

i. Quality control of 912 station records to detect anomalously large precipitation amounts (outliers);

ii. Homogeneity control of quality-controlled records covering at least 25 years (390 station) by means the multiple application of the Craddock test on records and, if necessary, its homogenization to remove all signals of non-climatic origin (Brunetti et al. 2006);

iii. Realization of climatic normals of annul precipitation at 30 arcsec resolution (Fig.1) by means of a local weighted linear regression of precipitation versus elevation (Brunetti et al. 2009, 2014).

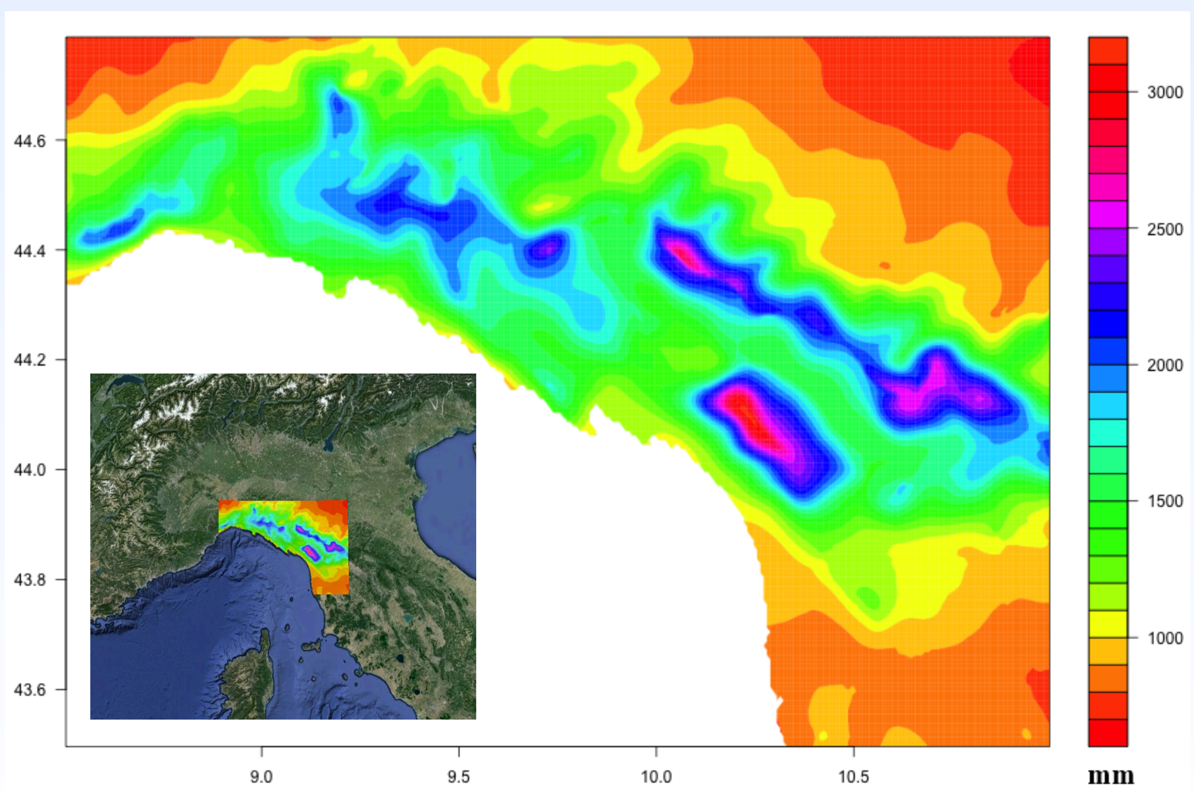


Figure 1: Climatic normals (1961-1990) of annual precipitation at 30 arcsec resolution

4. Methods

i. Rescaling: normalization of annual maxima from 349 single-station records by an appropriate site-specific Index Flood (IF), their own median;

ii. Pooling: assignment to each grid point of a sample of rescaled maxima drawn from the station records falling within a site-dependent distance from the grid-point. To achieve the optimal size of the area of influence we used the Pooled Uncertainty Measure (PUM - Kjeldsen and Jones, 2009). The minimum PUM identifies the optimal upper bound of the pooling distance (Fig. 2a and 2b). The lower bound, required to obtain an independent sample, is identified at 5 km

iii. Fitting: fit of a unique GEV distribution to each grid-point sample and extrapolation of non-dimensional RLs for the given return periods;

iv. Spatialization: interpolation of site-specific IFs on the high-resolution grid by regression with annual mean precipitation totals (Fig. 3a and 3b) and estimation of dimensional RLs.

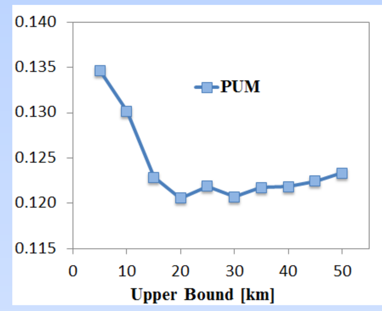


Figure 2a: variation of the avarage PUM as a function of the upper bound of the pooling radius.

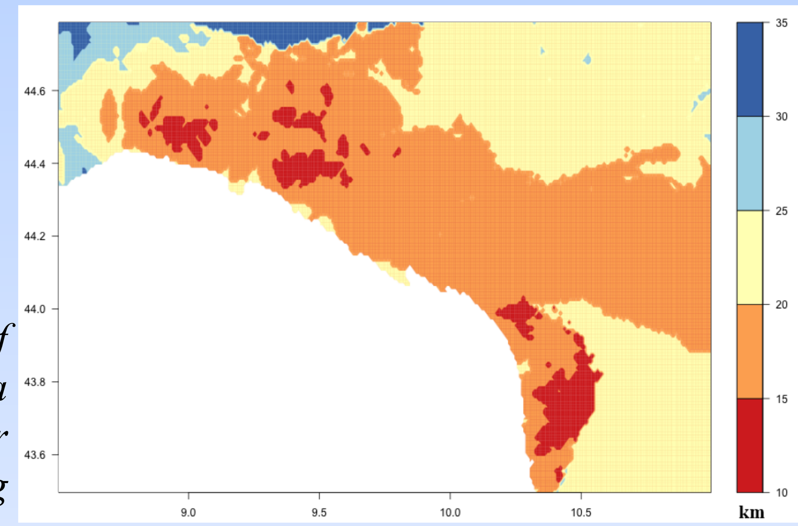


Figure 2b: optimal upper bound of the pooling distance for each grid cell.

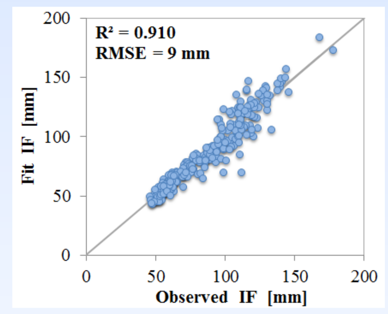


Figure 3a: observed stations IFs vs. estimated IFs on the grid points closest to the station sites.

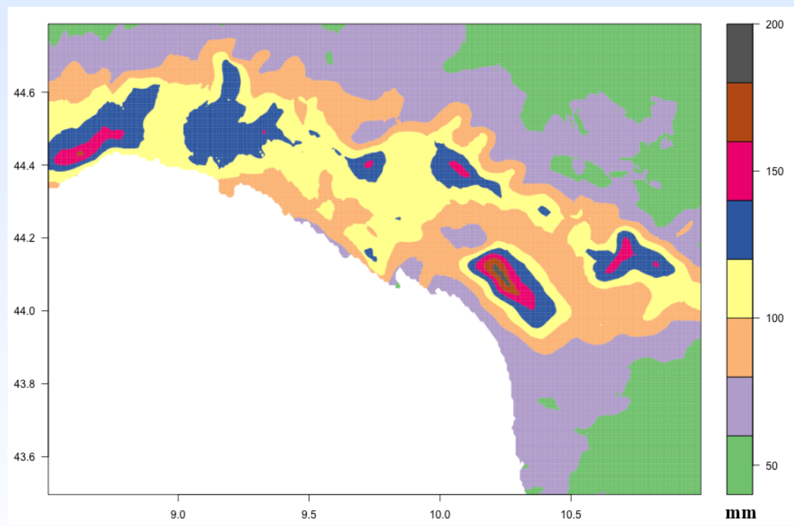


Figure 3b: grid-point Index Flood.

5. Results I

Stationarity:

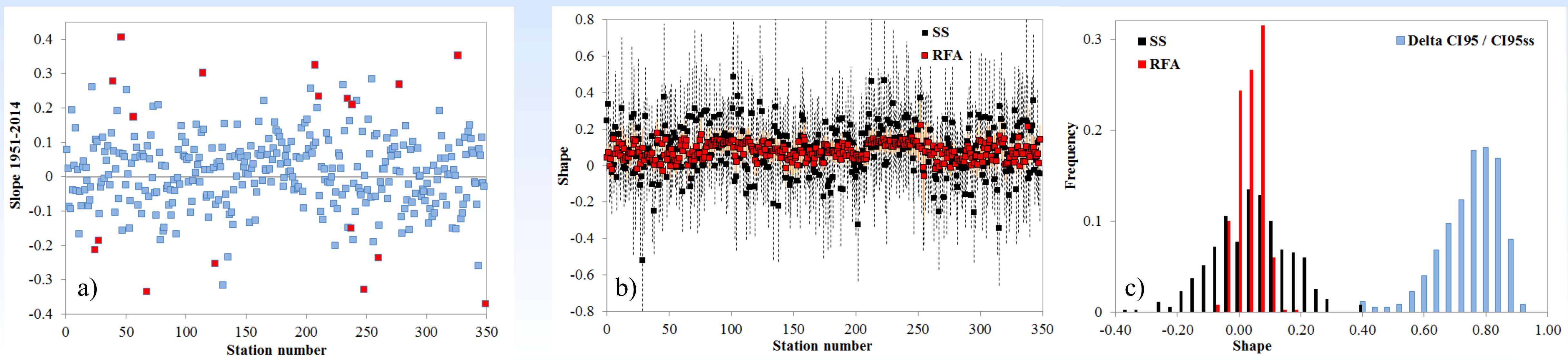
a) during the 1951-2014 period only 5% of the series showing trends, either positive or negative, it is thus confirmed the prerequisite for a stationary GEV-based approach.

GEV parameters, single-station (SS) vs pooled-station (RFA):

b) GEV shape parameter with 95% confidence intervals from fits to single-station (SS) and pooled-station (RFA) data.

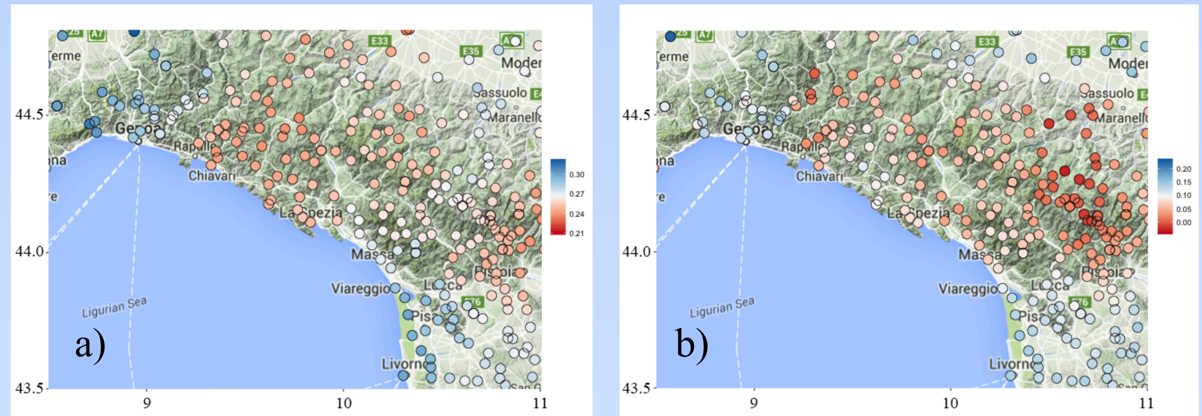
c) Frequency histograms of the SS and RFA estimates of the shape parameter and the fractional reductions of CI95 by RFA.

RFA provides a net reduction of confidence intervals.



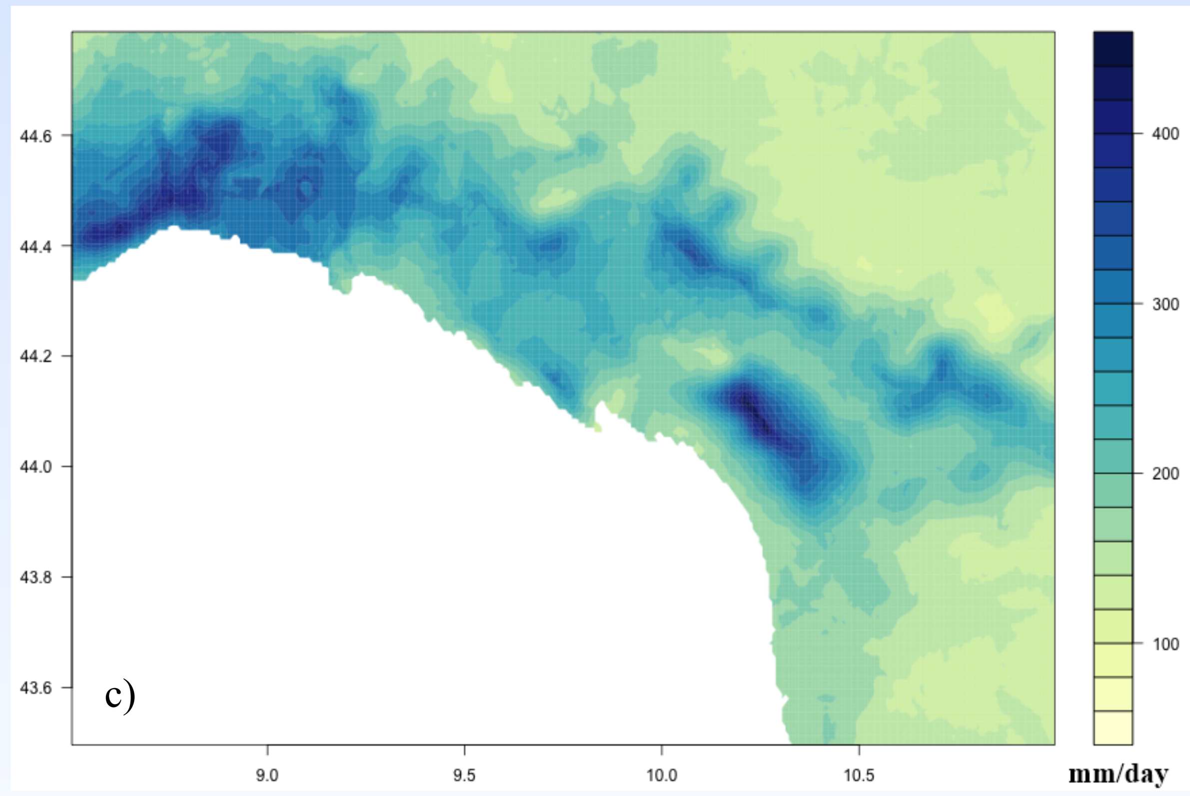
6. Results II

GEV parameters from RFA:



Spatial distribution of best guess values of (a) the scale (IF units) and (b) the shape parameters from RFA fits to rescaled annual maxima at the station points.

High-resolution grid (30 arcsec) RL100:



Grid-point RL100 expressed as absolute precipitation amounts (c). The strongest events are expected in the province of Genoa and in the Apuan Alps, with peaks of 450 mm/day, among the highest in the Mediterranean.

7. Conclusions

i. RFA turned out to be a very effective method to reduce the errors of GEV parameters and RLs;

ii. Both GEV parameters and corresponding RLs exhibit strong spatial gradients over Liguria and northern Tuscany;

iii. The IF estimate on a high-resolution grid allowed us to realize high-resolution estimates of RLs not only for normalized data, but also for the precipitation absolute values.

iv. The province of Genoa and the Apuan alps are the most affected by extreme precipitations with the highest RL100 (about 450 mm/day).

References

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