Spatial interpolation of extreme-precipitation with intermittent records

Paola Allamano, Elisa Bartolini, Pierluigi Claps, Francesco Laio & Stefania Scarsoglio

Politecnico di Torino, Italy

Depth/Intensity-Duration-Frequency (DDF or IDF) curves are the standard tools used to estimate design rainfall. The DDF curve estimation at gauged sites requires the elaboration of precipitation extremes, which are traditionally recorded as the annual maximum precipitation depths measured in time intervals of predefined duration. The information from the DDF curve is usually transposed to ungauged sites by estimating the DDF parameters at all locations where data are available, and then interpolating in space these parameter-values, for instance by applying a kriging technique. The methodological hindrance to this procedure resides in the intermittent nature of precipitation records, both in space and time. Precipitation gauging stations, in fact, are sometimes subjected to activation, relocation or dismissal. Tracing the historical consistence and migration of the measuring points requires either a direct expertise or the set up of specifically-conceived methods.

A. Background

Fig 1: Study domain

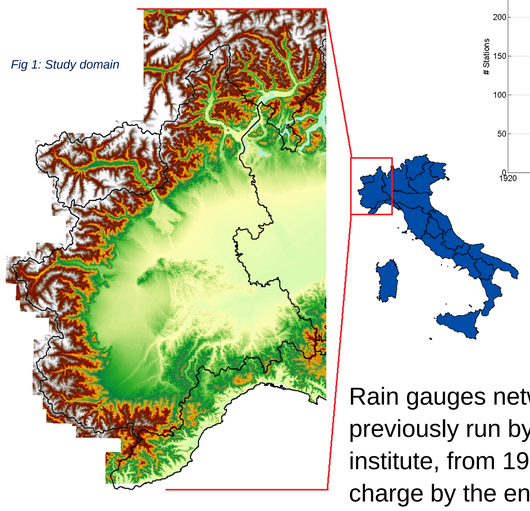
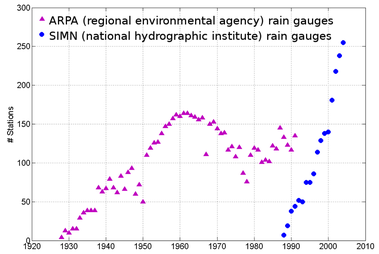


Fig 2: Variability in the number of active rain gauges over the study domain for the years 1928-2004



The study domain is located in North-Western Italy (Piemonte and Valle d'Aosta regions)

Rain gauges network management, previously run by the national hydrographic institute, from 1988 was gradually taken in charge by the environmental agency ARPA.

B. Method

1. **On the whole dataset** (all years and durations): removal of the trend between precipitation and elevation

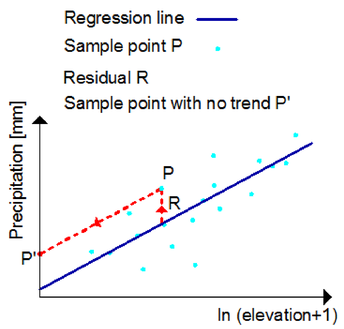
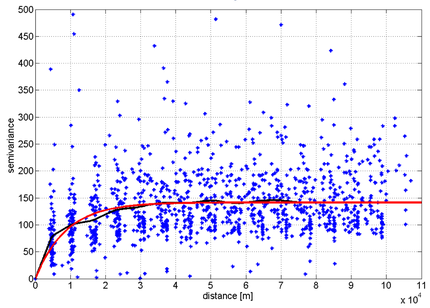


Fig 3: Trend detection and elimination

2. **For each year**: evaluation of the annual variogram

   For each duration: evaluation of the theoretical variogram by averaging the annual variograms, weighted by the number of stations active in each year.

Fig 4: Sample and theorical variogram calculation for d=1h



3. **For each year and for each duration**: application of the ordinary kriging equations to obtain a map of interpolated precipitations and of the corresponding estimation variances.

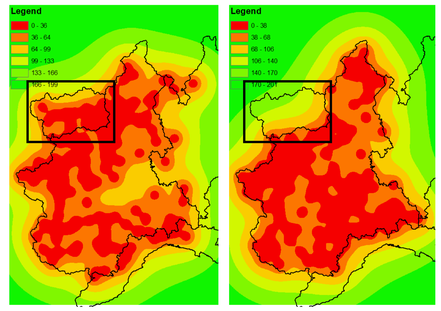


Fig 5: Variance of the predictions, year 1960 (left) and 2000 (rigth), for d=1h

The variance will be larger in years with fewer active station and in regions with more sparse measurements

4. Single-year maps are then combined by averaging the cell-values (weighted by the inverse of their respective variance). An average map is obtained for each duration.

C. Results

1. Maps of the annual maximum of precipitation depth for a given duration. Scope: evaluation of the temporal variability of extreme precipitations (Fig. 7 and 8)

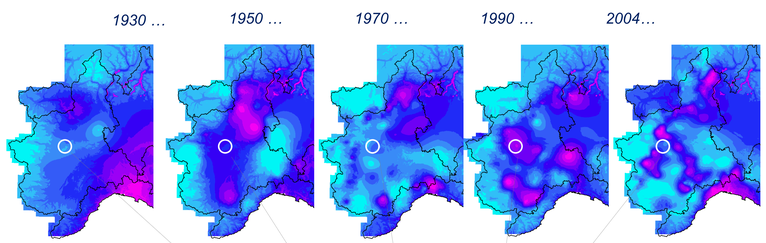


Fig 7:Annual maximum precipitation for d=1h

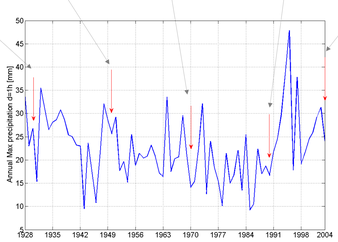


Fig 8: Time series of the annual maximum precipitation for d=1h

2. Maps of the average maximum depth of precipitation for each duration (Fig. 10-14). Scope: evaluation of the design rainfall also at ungauged sites

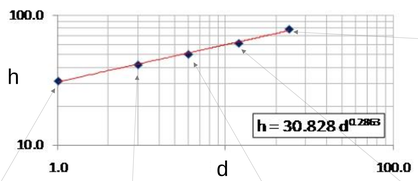


Fig 9: Example of DDF curve (power law form) for one point in the study domain

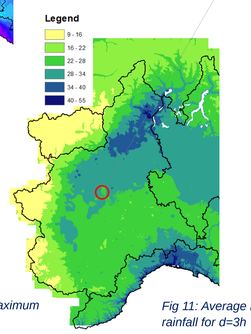


Fig 10: Average Maximum rainfall for d=1h

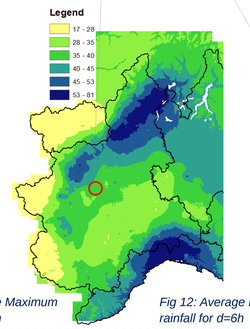


Fig 11: Average Maximum rainfall for d=3h

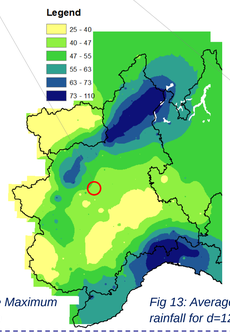


Fig 12: Average Maximum rainfall for d=6h

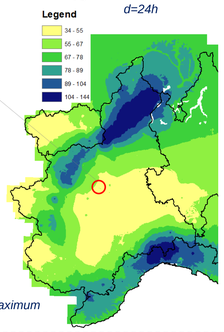


Fig 13: Average Maximum rainfall for d=12h

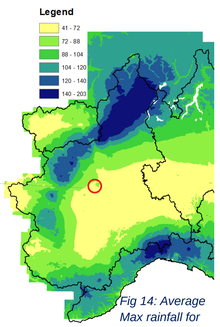


Fig 14: Average Max rainfall for d=24h

D. Discussion and conclusions

- The proposed procedure is amenable for application with any spatial interpolation method

-This example represents a rather common situation (in Italy): nearly 250 stations but only very few of these have long uninterrupted records

- The technique allows one to obtain reliable estimates of the DDF/IDF curve in the region of study.

Aknowledgements: The work is part of the RISKNAT and FLORA projects (both framed in the Interreg IV program) in collaboration with ARPA Piemonte. The ARPA staff (ing. S. Barbero, ing. M. Graziadei, ing. M. Zaccagnino) is gratefully aknowledged for assistance in data preparation and technical support.