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Trends in flood quantiles of the Italian alpine basins: statistical testing and directions for attribution

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Among the hydrological impacts of global warming one of the most debated is the possible increase in extreme rainfall and floods. In sensitive environment, like the mountains, global warming directly affects the alternance of snow deposition and melting, with highly likely changes foreseen in the runoff regimes. As regards floods, recent results related to the trends in Europe have highlighted non-uniform evidence for an increase of peaks in cold regions, including high-elevation and high-latitude regions. Reasons for possible reduction of peaks against climate change are that anticipated melting can reduce the rain-on-snow phenomena in some areas. In the Alpine region, however, a closer look to the possible trends of flood peak is in order, as current knowledge indicates that the a dominant positive trend exists.
Considering all discharge stations with historical flood peak data in Italy, a group of 140 mountain basins in the whole Alpine chain has been analysed according to the selection criteria of: i) average elevation of at least 1000 m a.s.l.; ii) absence of significant natural or man-made lakes within the basin; iii) at least 10 years of observation available in the last century. Areas of the selected basins range from 10 to about 10000 km2 and the average elevations reaches 3000 m a.s.l. The full range of observations available encompasses one century, as the oldest values dates 1911 and the most recent ones are recorded in the 2013. Half of the series available have less than 25 observations.
Among the possible techniques for trend analysis, the heterogeneous nature of this unprecedent database led us to initially consider only the quantile regression, due to the its robustness against the patchiness and the insufficient length of the time series. The same weaknesses in the data consistency suggest to complementing empirical statistical results with a subsequent attribution framework.
Quantile regression application to all the flood peaks of a given year versus time provide marked indications of positive trends. Results were positive for quantiles 0.5, 0.75 and 0.95 even reducing the analyzed time span to 1951-2007, where at least 60 contemporaneous active stations can be considered. A specific role in the results of the elevation and of the area of the active station group over time was also investigated, by means of a multivariate quantile regression. Indeed, both the elevation and the area demonstrated to be significant covariates in the trend which, nevertheless, remained clearly positive for the same quantiles.
A bundle application of the geomorphoclimatic attribution model of Allamano et al. (2009) on the 140 basins allowed to start the attribution exercise. Reconstruction of the dependence of the first moment of the time series on elevation provided a first confirmation to the empirical findings.