Signal of change in ordinary and extraordinary precipitation extremes over Italy

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In Italy, few national-scale analyses were performed to investigate possible changes in the frequency and intensity of extreme rainfall events (Libertino et al., 2019; Mazzoglio et al., 2022) while several studies at the regional level have been carried out in the last two decades (see e.g. Bonaccorso et al., 2005; Persiano et al., 2020; Treppiedi et al., 2021; Avino et al., 2024). This lack of comprehensive studies is the consequence of the extreme fragmentation that characterizes the Italian hydrologic data, that does not allow a nationwide comparison among the results.
Using the Improved Italian – Rainfall Extreme Dataset (I^2-RED; Mazzoglio et al., 2020), a collection of short-duration (1 – 24 h) annual maximum rainfall depths measured by more than 5000 rain gauges from 1916 up to 2022, we investigated the possible presence of trends in rainfall extremes over the whole country.
In a first step, the Mann-Kendall test was applied to all the time series with at least 30 years of data (more than 1600). The results confirm that rainfall extremes of different durations are not increasing uniformly over Italy and that different trend signs emerge even in neighboring areas. Considering that the time series considered cover different time periods and, thus, this may affect the results obtained in wide areas, we extended the analysis by using an approach that can cope with data fragmentation, both in space and in time.
We first divided Italy using a coarse grid size of the order of 20 km resolution. Then, for each cell we applied a quantile regression, by pooling together all the time series available within a certain search radius, without imposing limitation to the length of the time series used. For each rainfall duration, several quantiles were tested again trend: q = 0.5 (i.e., the median), 0.9, 0.95, and 0.99. By using this approach, a common period (1960-2022) can be used in each part of the Italian territory, allowing to obtain results that can be directly compared.
With this approach, positive variations in short-duration annual maxima have been found all over the country, especially when considering 1 h extremes. When moving to longer durations (24 h), negative trends emerge over large areas. An additional result found is that the quantile regression shows that lower quantiles (0.5) are characterized by smaller variations with respect to higher quantiles (such as 0.95 or 0.99).

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