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Influence of morphology on the spatial variability of rainstorms over Italy

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The investigation of the influence of terrain morphology on rainfall extremes has never been conducted over the entire Italy, where some studies have been carried out over limited areas. We then present the first systematic investigation of the role of elevation and other morphological attributes on rainfall extremes over Italy, that is made possible by using the Improved Italian – Rainfall Extreme Dataset (I^2-RED). I^2-RED is a database of short duration (1 to 24 hours) annual maximum rainfall depths collected from 1916 until 2019 by more than 5200 rain gauges.

The analyses involved the relations between morphology and the mean annual rainfall extremes (index rainfall) using univariate and multivariate regressions. These relations, built countrywide, demonstrated that the elevation alone can explain only a part of the spatial variance. The inclusion of regression covariates as longitude, latitude, distance from the coastline, indexes of obstructions and the mean annual rainfall depth demonstrated to be significant in relations built at the national scale.

However, high local bias with notable spatial correlation derives from the national-scale analysis. This led us to focus on smaller areas. We started dividing Italy into 4 main regions: the Alps, the Apennines, and the two main islands (i.e. Sicily and Sardinia). A dedicated multiple linear regression analysis was conducted over each of these areas. Evident improvements were obtained through this approach; nevertheless, clusters of high residuals persisted, especially in orographically-complex areas. A different approach was then undertaken, based on a preemptive subdivision of Italy in morphologically similar regions, to both reduce the clustering of errors and better define the role of elevation. Using four morphological classifications of Italy from the literature, we applied simple regression models to the rain gauges available inside each region. Among all, the classification that embeds hydrological information turned out to produce the best results in terms of local bias, MAE and RMSE, outperforming the multivariate relations obtained at the national scale. This approach proved to better reproduce the effects of geography and morphology on the spatial variability of rainfall extremes.

Our analysis confirmed a general increase of 24-hour rainfall depths with elevation, as already pointed out by studies conducted over smaller areas. For 1-hour rainfall depths, in flat or in pre-hill zones a modest increase with elevation is visible, while over the Alps and in most of the

Apennines a reverse orographic effect (i.e., a reduction of rainfall depth with increasing elevation) is clearly detected, confirming previous outcomes in those areas.