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Development of an integrated suite for estimating Intensity Duration Frequency curves in a climate change perspective

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This study introduces a comprehensive suite of methodologies for estimating Intensity Duration Frequency (IDF) curves, critical for engineering planning in the face of expected variations in extreme precipitations induced by climate change. Indeed, in recent years the climate proofing design of hydraulic infrastructures (e.g. sewage systems) arose increasing interest but, at the moment, there is a lack of clear understanding of the differences between approaches and the relative weight of the individual phases of the process on the final estimates (approaches to fit the statistical parameters, differences between simulation chains, variations induced by socio-economic scenarios driving climate models). To investigate such issue, four consolidated approaches to assess the potential variations induced by CC in IDF curves are compared: Padulano et al., 2018 [doi.org/10.1002/hyp.13449, QDM-CMCC], Hassanzadeh et al., 2019 [doi.org/10.1016/j.advwatres.2019.07.001; QQD], Alzahrani et al., 2022 [doi.org/10.1007/s11269-022-03265-3; EQM], Hassanzadeh et al., 2019 [doi.org/10.1016/j.advwatres.2019.07.001; SIM]. More specifically: QDM-CMCC combines a simple delta change with quantile delta mapping; the Quantile-Quantile downscaling (QQD) spatiotemporally downscales extreme rainfall quantiles through a parametric relationship; Equidistant Quantile Mapping (EQM) spatiotemporally downscales extreme rainfall quantiles using a two-step parametric procedure; Scale-Invariance Method (SIM) derives the distributions of short-duration local extreme rainfalls based on those of longer duration using the scaling relationships between non-central moments over different rainfall durations.

Precipitation values are provided by 14 climate simulation chains made available in the framework of the EURO‑CORDEX initiative; 1981-2010 is adopted as the current period while, as the future time horizon, 2036-2065 is adopted under three different Representative Concentration Pathways, RCP2.6, RCP4.5 and RCP8.5. As pilot case, the reference IDF curve adopted to design hydraulic infrastructures in the Ischia Island (30 km from Naples, Southern Italy) is used.

The investigation is aimed at exploring not only the spread among the findings returned by exploiting the different approaches in a real-world scenario but also to improve the understanding about how the theorical differences in the approaches can lead to very different estimates. Results show that the three main sources of uncertainty (statistical parameter fitting, climate modelling

and RCP scenarios) play a comparable role inducing an increasingly evident spread as the return times increase.

Finally, it is worth noting that two libraries in R and Python for the four approaches, available upon request, have been developed to permit assessments over test cases in different precipitation regimes and by exploiting different climate simulation chains to replicate the findings achieved in the present investigation.