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Effect of elevation on extreme precipitation of short durations: evidences of orographic signature on the parameters of Depth-Duration-Frequency curves

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Here, we show how atmospheric circulation and topography rule the variability of depth-duration-frequency (DDF) curves parameters, and we discuss how this variability has physical implications on the formation of extreme precipitations at high elevations. A DDF is a curve ruling the value of the maximum annual precipitation H as a function of duration D and the level of probability F. We consider around 1500 stations over the Italian territory, with at least 20 years of data of maximum annual precipitation depth at different durations. We estimated the DDF parameters at each location by using the asymptotic distribution of extreme values, i.e. the so-called Generalized Extreme Value (GEV) distribution, and considering a statistical simple scale invariance hypothesis. Consequently, a DDF curve depends on five different parameters. A first set relates H with the duration (namely, the mean value of annual maximum precipitation depth for unit duration and the scaling exponent), while a second set links H to F (namely, a scale, position and shape parameter). The value of the shape parameter has consequences on the type of random variable (unbounded, upper or lower bounded). This extensive analysis shows that the variability of the mean value of annual maximum precipitation depth for unit duration obeys to the coupled effect of topography and modal direction of moisture flux during extreme events. Median values of this parameter decrease with elevation. We called this phenomenon “reverse orographic effect” on extreme precipitation of short durations, since it is in contrast with general knowledge about the orographic effect on mean precipitation. Moreover, the scaling exponent is mainly driven by topography alone (with increasing values of this parameter at increasing elevations). Therefore, the quantiles of H(D,F) at durations greater than unit turn to be more variable at high elevations than at low elevations. Additionally, the analysis of the variability of the shape parameter with elevation shows that extreme events at high elevations appear to be distributed according to an upper bounded probability distribution. These evidences could be a characteristic sign of the formation of extreme precipitation events at high elevations.