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Non stationary probabilistic characterization of drought severity

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Traditional probabilistic methods applied in hydrology and water resources planning and management studies assume that extreme hydrologic series are stationary and broadly independent in time. Over the last decade however, a growing interest has arisen both from a scientific as well as engineering point of view, toward the development of tools able to cope with the apparent non stationary features (either natural or anthropogenic) observed in many hydrological processes. While most works deal with extreme precipitation and floods, less attention has been devoted to modeling droughts, in particular multiyear droughts, assuming non-stationarity either with reference to the climatic forcings or to the implicit demand levels. This may be partly ascribed to the difficulty of applying an inferential approach, i.e. fitting a non stationary distribution to the identified drought characteristics, due to the limited number of droghts generally observed even in relatively long hydrometeorological series.

In the present work, we propose a quasi-analytical framework for deriving probabilities of drought severity, i.e. negative run sum according to the run theory scheme, assuming non-stationarity in the underlying hydrological series. More specifically, capitalizing on previous findings (Bonaccorso, 2003; Cancelliere and Bonaccorso, 2016), analytical approximations for the probability distribution of drought severity are derived, assuming a time dependent structure for the underlying hydrological series distribution and/or of the threshold level. The analytical expressions are derived with reference to several non stationary distributions for the hydrological series, assuming different parametric forms to express the variability of the parameters with time.

An example of application of the developed methods to several precipitation series in Sicily, Italy, exhibiting different degrees of trends is also presented. Results indicate the fesibility of the proposed expressions, which enable to overcome the difficulties of applying an inferential approach.