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Estimating Return Level Bounds for Continuous and Discrete Random Variables: Precipitation and Dry-spells

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For a wide range of applications in hydrology and climate studies, the return level is a fundamental quantity to build dykes, propose flood planning policies and study weather and climate phenomena linked to the behavior of the upper tail of a distribution. More precisely, z_t is called the return level associated with a given return period t if the level z_t is expected to be exceeded on average once every t years. To estimate this level in the independent and identically distributed setting, Extreme Value Theory (EVT) has been classically used by assuming that exceedances above an high threshold approximately follow a Generalized Pareto distribution. This approximation is based on an asymptotic argument but the rate of convergence may be slow in some cases, e.g. Gaussian variables, and the choice of an appropriate threshold difficult. As an alternative, we propose and study simple estimators of lower and upper return level bounds. This approach has several advantages. It works for both small and large samples and for discrete and continuous random variables. In addition, no threshold selection procedure is needed. Still, there is a clear link with EVT because our bounds can be viewed as extensions of the concept of the probability weighted moments that has been particularly used in hydrology. In particular, some moment conditions have to be satisfied in order to derive the asymptotic properties of our estimators.

To show the potential of our approach, we analyze return levels associated with large precipitation and dry spells for the city of Fort Collins (Colorado, USA). For example, our method could help the american National Weather Service (NWS) to maintain precipitation and dry spells atlases to provide lower and upper return level bounds for this city.