Exploring the Potentials and Limitations of Flood Frequency Analysis on Water Stages

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Abstract

Flood risk assessment and the design of protection measures often require the estimation of high water levels of a given probability of exceedance, i.e. design flood levels. The common approach for the estimation of design flood levels has typically three main steps. First, direct measurements of annual maximum water levels in a river cross-section are converted into annual maximum flows by using a rating curve. Second, a probability distribution function is fitted to these annual maximum flows to derive discharges of a desired probability of exceedance, i.e. design peak flows. Third, a hydraulic model is applied to derive the corresponding design flood levels. Each of the three steps is associated with significant uncertainties, affecting the accuracy of estimated design flood levels. In this study, we compare this common approach with an alternative one based on the statistical analysis of time series of annual maximum water levels. The rationale behind this study is that high water levels are directly measured and often come along with higher precision and accuracy than peak flows. While the direct use of high water levels is typical in coastal flood hazard and risk assessment, the potential of this approach in the context of river flooding has not been sufficiently explored. In this study we compare the common approach with an alternative approach based on statistical analysis of annual maximum water levels.

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Motivation of the work

Flood risk assessment and the design of protection measures often require the estimation of high water levels of a given return period, i.e. design flood levels. The **common approach** adopted for this estimation problem involves three main steps. First, a probability distribution model is fitted to a record of annual maximum flows, which are typically derived from a (uncertain) rating curve. The parameterised model is then used to for estimating design floods corresponding to the desired return periods. These design floods are often used as input of a (uncertain) hydraulic model to derive corresponding flood water stages, which are then used for design purposes (e.g. levee height). In this study we compare the common approach with an **alternative approach** based on statistical analysis of annual maximum water levels.

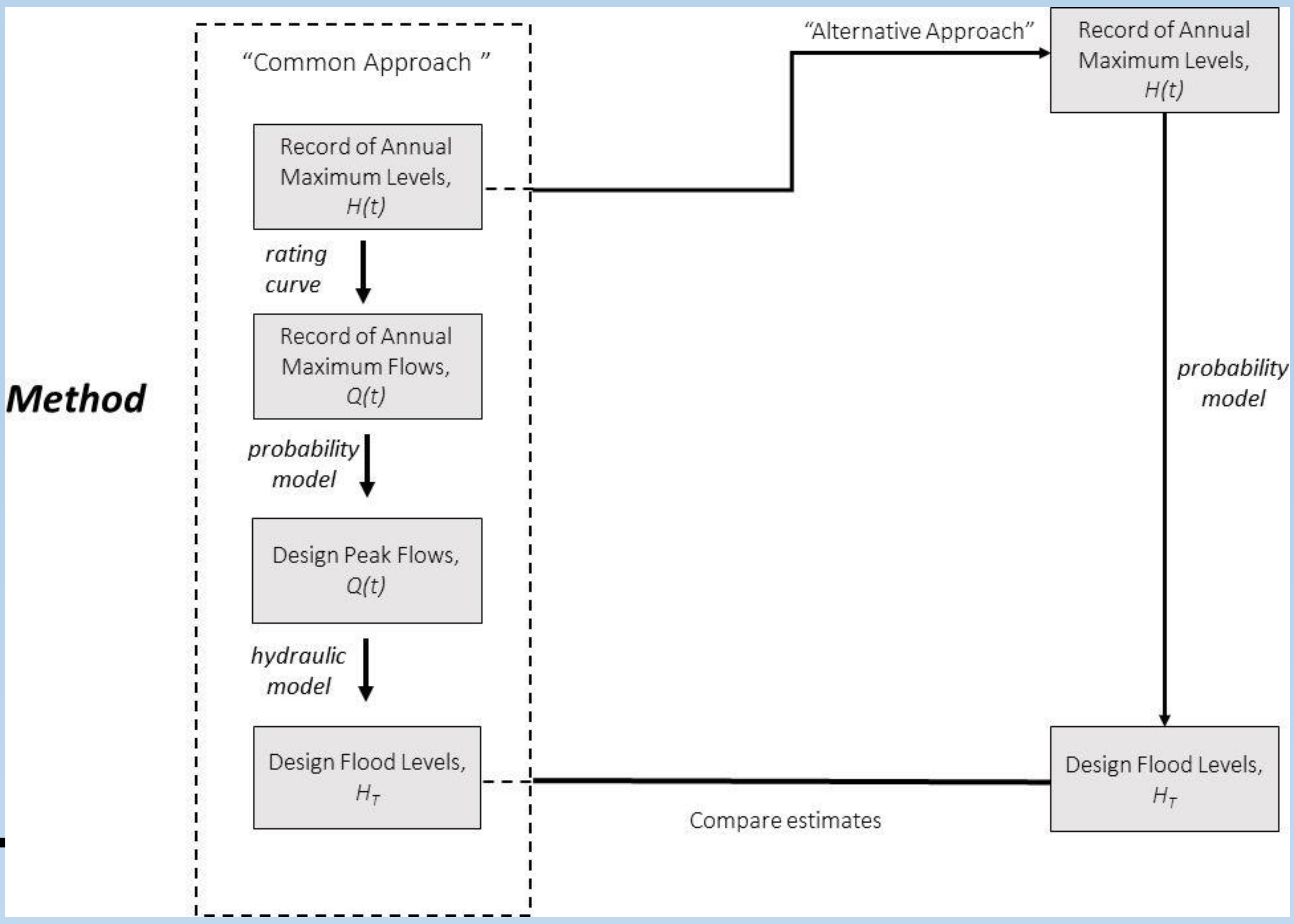

Fig 1. Simulation framework

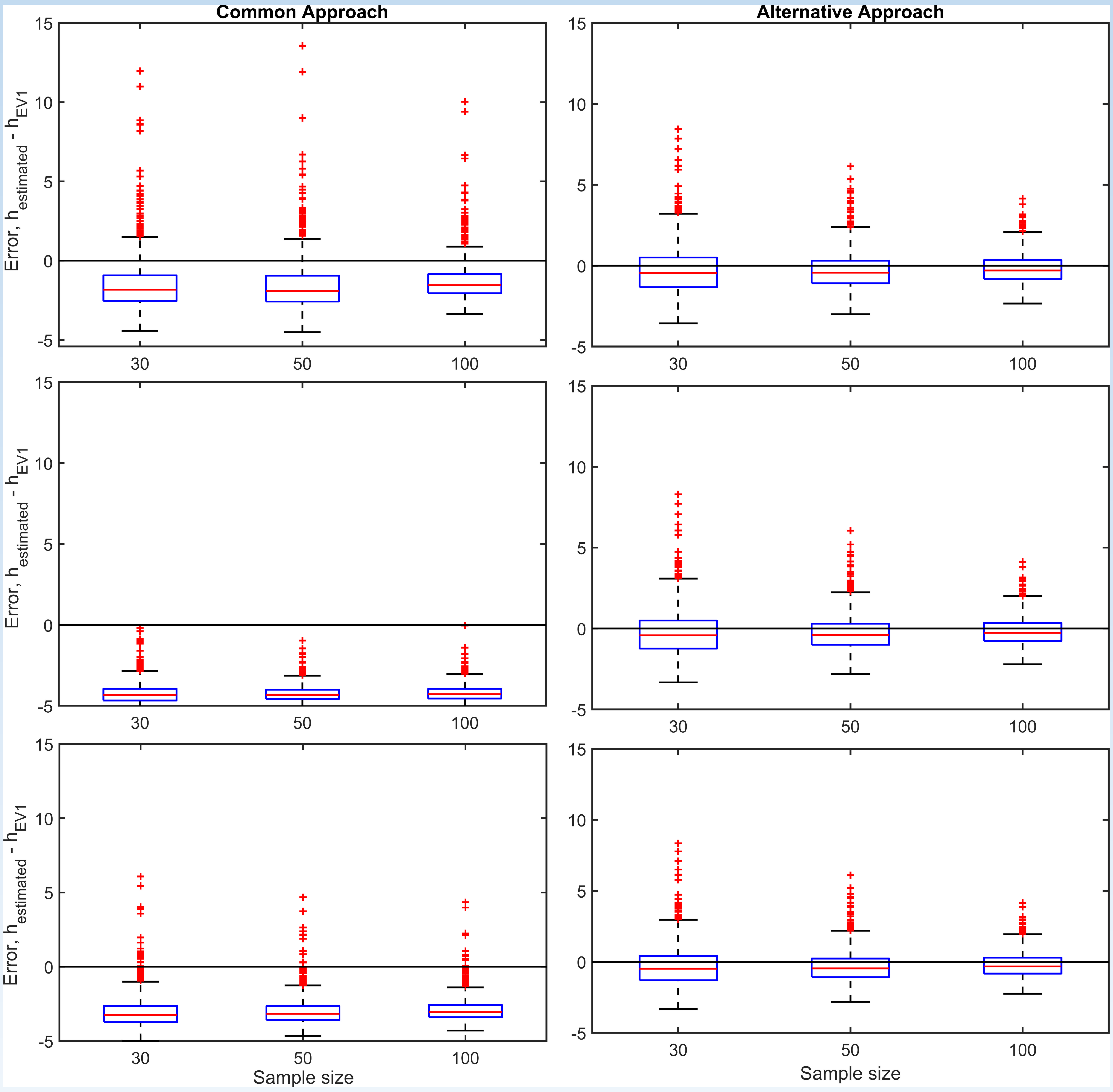

Fig 2. A comparison of the two approaches tested at three locations within a 98 Km reach of the Po River in Italy.

Method

- A parameterised GEV model was used for estimating a "true" design flood and its corresponding design flood level. Synthetic flows were generated (using the fitted GEV model) and used as input into a HEC-RAS to derive water levels.
- The EVI distribution was used for fitting in both approaches.
- For a given sample size, and 1000 model runs, the errors were estimated as a difference between the estimated and the true design flood level.
- The 100-year design flood level is the event of interest in this study.

Conclusion

- Conducting the frequency analysis directly on water levels can improve estimates of the design flood levels when compared to the common approach.
- This approach may be used for rivers with their floodplain geometries relatively stable.

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