

A framework to characterize flood events of defined return period ranges using functional boxplots



University of
Zurich^{UZH}

Maria Staudinger, Reinhard Furrer, and Daniel Viviroli

contact: maria.staudinger@geo.uzh.ch

Motivation

To assess the safety of dams, typically design floods are used as a basis. However, both the peaks and even more the flood volumes of rare events are subject to large uncertainties due to limited length and spatial coverage of gauge records. In this study we make use of very long simulated hydrographs to test a framework utilizing functional data analysis that should provide a better basis for safety assessments.

Framework

1 Assign simulated annual maximum flood events to desired return period (RP) classes

2 Cluster similar events within each return period class by functional clustering

3 Create functional boxplots of hydrographs for each cluster

Each of the steps requires choices to be made e.g.:

- Event characterization (univariate, bivariate)
- Number of B-splines
- Latent mixture model within functional clustering
- Number of clusters

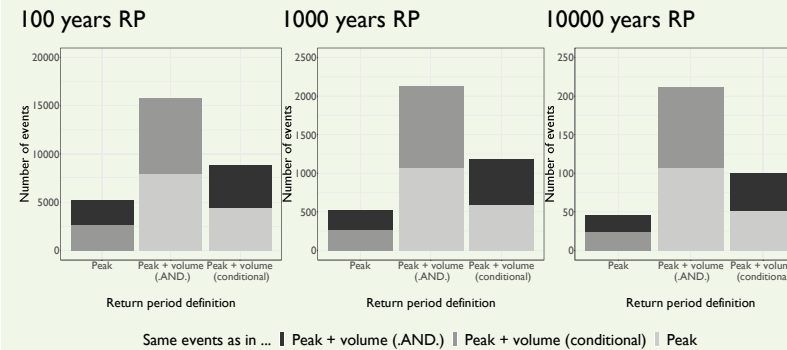
Sensitive analysis for functional clustering will be crucial.

Data

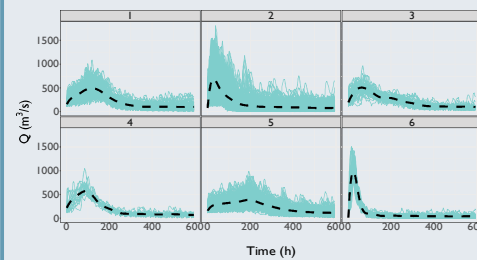
Very long simulated hydrographs in hourly resolution

- for Swiss catchments (scale range: ~300–18'000 km²)
- spanning about 300'000 years each
- from a hydro-meteorological modelling chain starting with a stochastic multi-site weather generator

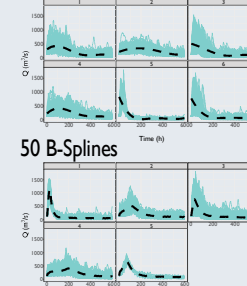
Choice of event definition influences assignment to RP class strongly. Not included here: choice of criteria to find largest event per year, threshold for specific requirements for application, and baseflow separation.



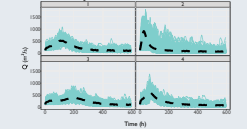
Mixture model 1 (AkBkQkDk) 15 B-Splines



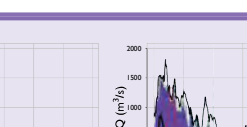
b) 5 B-Splines



50 B-Splines



150 B-Splines

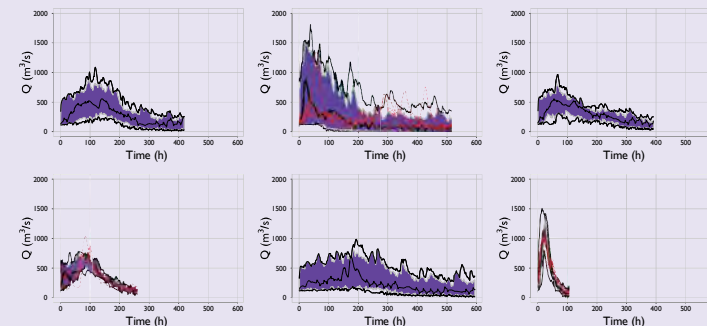


Choice of number of B-splines to describe the hydrograph a) and **choice of latent mixture model** for funHDDC b) influences cluster result. Example is shown for 1000 years RT. Choosing the number of B-Splines too small does not reflect the hydrograph properties in the functional description (b), upper)

Resulting functional boxplots for 1000

year return period class with following choices per step:

- bivariate peak + volume joint .AND.
- 15 B-splines
- latent mixture model 1 (AkBkQkDk)



Take home message

By utilizing functional data analysis our framework allows not only for a characterization of design floods through a realistic hydrograph but also envelopes the most central observations. This ultimately helps to better communicate the range of typical and possible outcomes.

The final functional boxplots are sensitive to:

- Event definitions. A clear specification of the requirements is necessary.
- Clustering parameters. These influence the robustness of the functional boxplot and have to be set carefully.

Outlook

The framework has to still extensively be tested for the effects of the choices and their combinations on the final functional boxplots in various locations.

We are currently evaluating the sensitivity to choices made in the framework merging both statistical considerations and features that are interesting for hydrological applications. This should ultimately allow for recommendations on the choices to take.

References

Yassouridis et al., 2018, Generalization, Combination and Extension of Functional Clustering Algorithms: The R Package funcy. Journal of Statistical Software, 85(9), 1-25.

Bouveyron, and Jacques, 2011, Model-based clustering of time series in group-specific functional subspaces. Adv Data Anal Classif 5, 281-300

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