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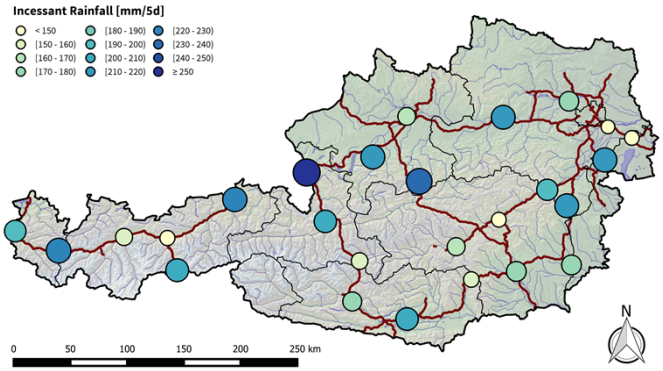
A Comparative Assessment of Statistical Methods for Extreme Weather Analysis

Highlights

- In a changing climate and due to extensive soil sealing, the impacts of **extreme weather events** are likely to **increase** in both **frequency** and **intensity**.
- Information about **probability** and **magnitude** of **severe weather events** is derived from long-term records of weather quantities.
- Different **extreme value approaches** and **fitting methods** exist to estimate recurrence intervals of extreme events.
- Based on an Austrian data set from 26 stations representing diverse meteorological conditions, the **performance** of different approaches with respect to their value for assessing **exposure** of **transport networks** to extreme weather impacts is compared.
- The **use of conditional performance metrics** that focus on rare events only is recommended for assessing goodness-of-fit.
- **Performing multiple approaches simultaneously** in order to select the best suited approach leads to more robust results.
- Findings directly address **road and traffic management**, but can be **transferred** to a range of **other environmental variables** including meteorological and hydrological quantities.



Incessant Precipitation Totals

Overview of the 100-year return levels of 5-day cumulative precipitation extremes at selected hot spots in Austria.

Estimates are based on the best performing combination of extreme value approach and fitting method assessed by the $CRMSE_5$.

Extreme Value Approaches

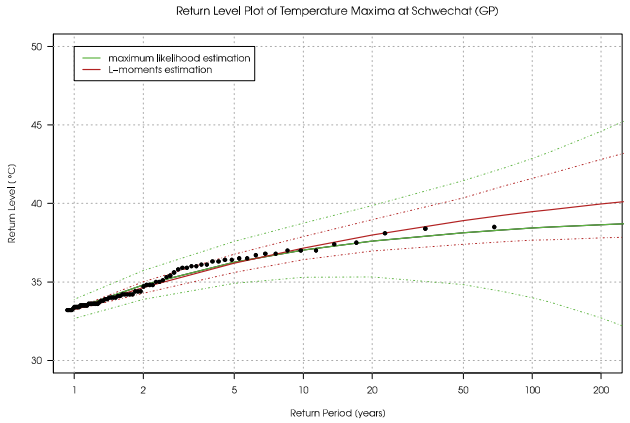
Return level estimation is based on the block maxima approach (employing annual maxima series) and on the threshold excess approach (employing partial duration series) with two different parameter estimation methods (MLE and LMOM-estimation).

Distributions

Based on the Fisher–Tippett–Gnedenko theorem, generalized extreme value (GEV) distributions are appropriate for modelling annual maxima series, while Generalized Pareto (GP) distributions are suited for modelling threshold excesses according to the Pickands–Balkema–de Haan theorem.

Parameter Estimation Methods

Maximum likelihood estimation (MLE) and L-moments estimation (LMOM) are employed in the comparative assessment.



Assessment Method

There are various performance measures that are regularly used in model evaluation, including RMSE and MAE. However, most events of the extreme value series are only moderate and these will have an overly excessive influence on the performance measure.

In order to specifically assess the accuracy of the fitted models for higher quantiles (i.e. for larger return periods), we propose conditional variants These metrics are specifically consider the upper tail of the fitted functions above some return period T^*.

$$\mathrm{CRMSE}_{T^*} = \sqrt{\frac{\sum_{i=1}^{n}(\hat{y}_i - y_i)^2}{n_{T^*}}} \forall y_i : \left[-\frac{1}{\ln\left(\frac{m}{N+1}\right)}\right] \geq T^*$$

$$\mathrm{CMAE}_{T^*} = \frac{\sum_{i=1}^{n}|\hat{y}_i - y_i|}{n_{T^*}} \forall y_i : \left[-\frac{1}{\ln\left(\frac{m}{N+1}\right)}\right] \geq T^*$$

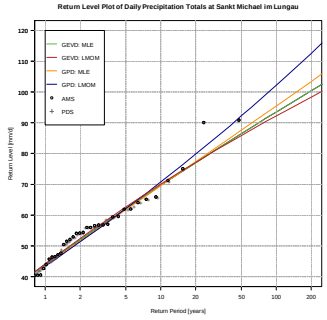
Results

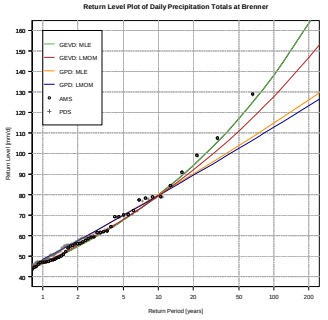
There are various performance Results show the merits of the robust L-moment estimation, which yielded better results than maximum likelihood estimation in 62 % of all cases.

At the same time, results question the general assumption of the threshold excess approach being superior to the block maxima approach due to information gain.

Simultaneous analysis of both approaches (employing synoptic quantile plots) will lead to a more robust selection of the best suited approach:

Both in cases where threshold selection and dependency introduces biases to the PDS approach, but also in cases where the AMS contains non-extreme events that may introduce similar biases.





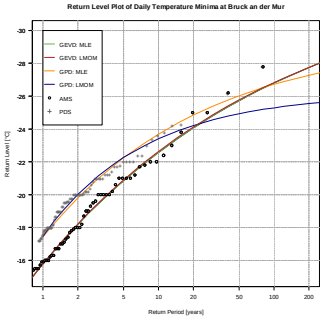
Return Level Plots: Precipitation

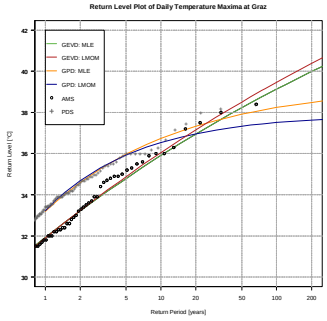
Return level plots of daily rainfall events at hot spots in

(a) Sankt Michael im Lungau, located in the Central Eastern Alps and

(b) Brenner pass, located at the Austro-Italian boarder.

Based on the $CRMSE_5$, GP fitted on the basis of L-moments-estimation was found to be the most appropriate method for Sankt Michael, while GEV with MLE was found to be most suitable at Brenner.





Return Level Plots: Temperature

Return level plots of

(a) temperature minima at Bruck an der Mur, located in Upper Styria, and

(b) temperature maxima at Graz, located in the Graz basin.

Based on the $CRMSE_5$, GP fitted on the basis of MLE was found to be the most appropriate method for both Bruck an der Mur and Graz.

Schlögl, M. and Laaha, G.: Extreme weather exposure identification for road networks – a comparative assessment of statistical methods, *Nat. Hazards Earth Syst. Sci.*, 17, 515-531, doi:10.5194/nhess-17-515-2017, 2017.