Aggregation of GEV Parameters with varying components using EWA/EG algorithms

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Stochastic weather generators (SWGs) are widely used to produce long synthetic meteorological time series for climate impact assessments and adaptation planning. In recent years, several extensions have been developed to improve their ability to capture extreme events, such as heavy rainfall or heatwaves, which standard SWGs often underestimate. Examples include rainfall generators incorporating heavy-tailed distributions for extremes, multisite approaches calibrated for high quantiles, and hybrid models explicitly designed to improve tail behavior. Some SWGs focus specifically on simulating extremes, such as the LARS-WG extension for extreme weather events, or more recently, non-stationary climate-informed weather generators that integrate large-scale climate covariates for flood risk assessment. These extreme-event SWGs represent a crucial step toward bridging the gap between synthetic weather simulation and realistic risk assessment.

In this work, we focus on annual maxima, which are naturally modeled using the Generalized Extreme Value (GEV) distribution. We assume that different GEV models, are provided to us from different estimation procedures or contexts. Since such GEV estimates can vary at each time step and differ among models, the main question is how to optimally combine them according to the time series at hand. As it is trivial to simulate random draws from a univariate GEV with varying parameters, GEVs can also be viewed as natural SWGs for yearly maxima. This perspective places our method as a post-processing complement to existing SWGs: while traditional SWGs simulate daily sequences, the GEV-based approach focuses specifically on reproducing extremes.

To combine multiple candidate parameterizations, we rely on online learning algorithms, specifically, the Exponentially Weighted Average (EWA)and Exponentiated Gradient (EG)methods. These algorithms adaptively weight models according to their predictive performance, yielding a robust estimator for extremes that balances flexibility with stability.

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The proposed aggregation approach offer multiple advantages. First, it mitigates the risk associated with relying on a single model specification, particularly in the tails of the distribution where predictive uncertainty is highest. Second, the linear parametrization allows for interpretable trends in extreme events over time, facilitating better understanding of underlying risk factors. Third, the use of online learning algorithms ensures that the aggregation can respond to shifts in the data distribution without requiring retraining from scratch, which is computationally efficient and work for real-time applications.

We evaluate the performance of our aggregation methodology using synthetic experiments designed to validate the ability of the aggregation scheme to track varying GEV parameters over time. Comparative analyses with classical static GEV fitting and naive averaging approaches illustrate the robustness of the EWA/EG-based aggregation in capturing dynamic patterns in extremes.

In conclusion, our study highlights the potential of combining parametric extreme value models with adaptive aggregation algorithms to enhance robustness in predicting rare events. The integration of linear parameter variations with EWA and EG techniques provides a flexible, interpretable, and computationally efficient tool for extreme value analysis, with promising applications as a post-treatment to extreme-event SWGs in climate science, as well as in finance and engineering risk management.

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