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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Efficient Bootstrap Estimates for Tail Statistics" *by* Øyvind Breivik and Ole Johan Aarnes

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How to Bootstrap Extremes if You Must

GENERAL COMMENTS:

The focus of the manuscript is on efficient use of the bootstrap, a resampling technique, to quantify uncertainty (e.g., in the form of a confidence interval) in estimated extreme statistics such as return levels. Justification is provided for a simplified bootstrap procedure in which the resamples are generated through only drawing from the highest values in the original sample, not the entire sample. This common sense result is consistent with conventional statistical modeling of extremes, with the common assumption that the uncertainty in estimating the rate of exceedance of a high threshold can be ignored (e.g., Chapter 4 in Coles, 2001). Perhaps the present paper serves to

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place this conventional approach on firmer footing.

Nevertheless, there are a number of alternative techniques for uncertainty quantification in extreme value analysis not even mentioned in the manuscript. These alternatives include different implementations of the bootstrap, as well as ones in which no resampling need be performed (e.g., profile likelihood technique; Coles, 2001). At the least, these alternatives should be mentioned.

For this reason, I recommend that the manuscript be accepted for publication subject to minor revision.

SPECIFIC COMMENTS:

(1) Nonparametric versus parametric bootstrap

A nonparametric bootstrap is used in which the resamples are created by drawing with replacement from the original sample. When fitting extreme value distributions (e.g., the generalized Pareto in Sec. 3.3), it has been suggested that a parametric bootstrap would be preferable for constructing confidence intervals for return levels (i.e., resamples are created by Monte Carlo simulation from the fitted distribution) (Kysely, 2008).

(2) Refined bootstrap techniques

Bootstrap-based confidence intervals can be too short, especially for return levels with long return periods. Consequently, alternative more involved bootstrap techniques (e.g., the so-called "test inversion" bootstrap) have been proposed to improve the performance of such confidence intervals (Schendel and Thongwichian, 2015).

(3) Alternatives to bootstrap

When estimating the parameters of an extreme value distribution by maximum likelihood, an alternative technique for obtaining confidence intervals for return levels is profile likelihood (Coles, 2001). This technique does not require any resampling, but does

require repeated fits of the extreme value distribution under parameter constraints. It is competitive with resampling for obtaining confidence intervals of return levels (e.g., Schendel and Thongwichian, 2015).

REFERENCES:

Kysely, J.: A cautionary note on the use of nonparametric bootstrap for estimating uncertainties in extreme-value models, Journal of Applied Meteorology and Climatology, 47, 3236–3251, 2008.

Schendel, T. and Thongwichian, R.: Flood frequency analysis: Confidence interval estimation by test inversion boostrapping, Advances in Water Resources, 83, 1–9, 2015.

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