# Features of the `mev` R package

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# Some history

The `mev` package was originally introduced to implement the exact simulation algorithm of Dombry, Engelke, and Oesting (2016).

It has grown remarkably since, but its narrow scope reflect my own interests (mostly likelihood based inference).

*Warning*: not everything is robust, file bugs on Github.

# Univariate extremes (1)

- fitting routines, likelihood, score and information matrix of
  - GEV$(\mu, \sigma, \xi)$ for block maxima
  - GP$(\sigma, \xi)$ for threshold exceedances above $u$
  - $r$-largest observations
  - non-homogeneous Poisson process above $u$
- basic diagnostic plots
- confidence intervals based on profile likelihood

# Univariate extremes (2)

- likelihood quantities in many different parametrizations for GEV and GP
  - likelihood function
  - score vector
  - information matrix
  - profile likelihood (and modifications thereof)
- more exotic objects:
  - extended generalized Pareto models
  - Smith (1987) penultimate approximation
  - bias correction for MLE (Cox and Snell 1968)

# Threshold diagnostics

- threshold stability plots (default) with different options for pointwise confidence intervals
- threshold stability plot for extended generalized Pareto distributions
  - Papastathopoulos and Tawn (2013)
- *p*-value path diagnostic based on penultimate approximations
  - Northrop and Coleman (2014)
- Simultaneous threshold stability plot and white noise test based on the asymptotic joint distribution of the maximum likelihood estimator for overlapping samples
  - Wadsworth (2016)
- threshold selection based on the OBRE estimator for GP
  - Dupuis (1999)

# Simulation algorithms

- simulation algorithm of Dombry, Engelke, and Oesting (2016) for exact unconditional sampling of
  - max-stable random vectors
  - their spectral measure $\sigma_1$
- accept-reject algorithm for (generalized) $R$-Pareto processes
- composition sampling for $R$-Pareto processes
  - Brown–Resnick and extremal Student only, min and max risk functionals

Many parametric distributions are covered (see vignette).

# Diagnostic tools for multivariate extremes (1)

- nonparametric estimation of the spectral measure using
  - empirical likelihood (Einmahl and Segers 2009)
  - Euclidean likelihood (Carvalho et al. 2013)
- likelihood for elliptical generalized $R$-Pareto distributions
- exponent measure for Brown–Resnick and extremal Student distribution
- max stability test of Gabda et al. (2012)
- bivariate threshold interpretation for `evd::fbvpot` objects

# Multivariate estimators

- multivariate tail correlation coefficient $\chi$
  - (Coles, Heffernan, and Tawn 1999)
  - based on empirical or beta copula
- tail dependence coefficient $\eta$ -(Ledford and Tawn 1996)
- extremal index (Süveges 2007)
  - weighted least square, likelihood-based
- extremal coefficient
  - $F$-madogram
  - Schlather and Tawn (2003) estimator
  - Smith estimator (Erhardt and Smith 2012)
  - different handling of missing values than `SpatialExtremes`

# Future

- composite pairwise likelihood for multivariate extreme value models in $d > 2$
- fitting routine for generalized $R$-Pareto distribution (see Raphael's presentation)

# References i


Carvalho, Miguel de, Boris Oumow, Johan Segers, and Michał Warchoł. 2013. "A Euclidean Likelihood Estimator for Bivariate Tail Dependence." *Communications in Statistics - Theory and Methods* 42 (7): 1176–92. https://doi.org/10.1080/03610926.2012.709905.

Coles, Stuart, Janet Heffernan, and Jonathan Tawn. 1999. "Dependence Measures for Extreme Value Analyses." *Extremes* 2 (4): 339–65. https://doi.org/10.1023/A:1009963131610.

Cox, D. R., and E. J. Snell. 1968. "A General Definition of Residuals." *J. Roy. Statist. Soc. Ser. B* 30 (2): 248–75.

Dombry, Clément, Sebastian Engelke, and Marco Oesting. 2016. "Exact Simulation of Max-Stable Processes." *Biometrika* 103 (2): 303–17. https://doi.org/10.1093/biomet/asw008.

Dupuis, D. J. 1999. "Exceedances over High Thresholds: A Guide to Threshold Selection." *Extremes* 1 (3): 251–61. https://doi.org/10.1023/A:1009914915709.

# References ii

Einmahl, John H. J., and Johan Segers. 2009. "Maximum Empirical Likelihood Estimation of the Spectral Measure of an Extreme-Value Distribution." *Ann. Statist.* 37 (5B): 2953–89. https://doi.org/10.1214/08-AOS677.

Erhardt, Robert J., and Richard L. Smith. 2012. "Approximate Bayesian Computing for Spatial Extremes." *Computational Statistics & Data Analysis* 56 (6): 1468–81. https://doi.org/https://doi.org/10.1016/j.csda.2011.12.003.

Gabda, Darmesah, Ross Towe, Jennifer Wadsworth, and Jonathan Tawn. 2012. "Discussion of 'Statistical Modeling of Spatial Extremes' by A. C. Davison, S. A. Padoan and M. Ribatet." *Statistical Science* 27 (2): 189–92. https://doi.org/10.1214/12-STS376B.

Ledford, Anthony W., and Jonathan A. Tawn. 1996. "Statistics for Near Independence in Multivariate Extreme Values." *Biometrika* 83 (1): 169–87. https://doi.org/10.1093/biomet/83.1.169.

Northrop, Paul J., and Claire L. Coleman. 2014. "Improved Threshold Diagnostic Plots for Extreme Value Analyses." *Extremes* 17 (2): 289–303. https://doi.org/10.1007/s10687-014-0183-z.

# References iii

Papastathopoulos, Ioannis, and Jonathan A. Tawn. 2013. "Extended Generalised Pareto Models for Tail Estimation." *Journal of Statistical Planning and Inference* 143 (1): 131–43. https://doi.org/http://dx.doi.org/10.1016/j.jspi.2012.07.001.

Schlather, Martin, and Jonathan A. Tawn. 2003. "A Dependence Measure for Multivariate and Spatial Extreme Values: Properties and Inference." *Biometrika* 90 (1): 139–56. https://doi.org/10.1093/biomet/90.1.139.

Smith, Richard L. 1987. "Approximations in Extreme Value Theory." Edited by University of North Carolina Chapel Hill Center for Stochastic Processes. https://www.dropbox.com/s/4t0cnuy3g9ny14u/Smith-1987-Approximations_in_extreme_value_theory.pdf?dl=0.

Süveges, Mária. 2007. "Likelihood Estimation of the Extremal Index." *Extremes* 10 (1): 41–55. https://doi.org/10.1007/s10687-007-0034-2.

Wadsworth, J. L. 2016. "Exploiting Structure of Maximum Likelihood Estimators for Extreme Value Threshold Selection." *Technometrics* 58 (1): 116–26. https://doi.org/10.1080/00401706.2014.998345.