STATISTICS OF EXTREMES IN CLIMATE CHANGE

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DESCRIPTION

This short course covers the application of the statistical theory of extreme values to climate, in general, and to climate change, in particular. The statistical theory of extreme values is briefly reviewed, both the extremal types theorem with its application via the block maxima approach (i.e., fitting the generalized extreme value distribution) and the point process model with its application via the peaks over threshold approach (i.e., fitting Poisson and generalized Pareto distributions).

The climate applications treat the incorporation of both trends and physically-based covariates into extremal analysis. The issue of risk communication, such as the interpretation of return periods and return levels under both stationary and non-stationary climates, is treated as well. The course includes a tutorial, making use of the library `extRemes`, GUIs for extreme value analysis available within the open source statistical programming language `R`.

OUTLINE

Lecture 1 (*9:00 – 10:30*)

“Background on Extreme Value Theory with Emphasis on Climate Applications”

Break (*10:30 – 10:45*)

Tutorial 1 (*10:45 – 12:00*)

“Introduction to Extremes Toolkit and Climate Applications”

Lunch break (*12:00 – 13:30*)

Lecture 2 (*13:30 – 15:00*)

“Application of Extreme Value Theory to Climate Change”

Break (*15:00 – 15:15*)

Tutorial 2 (*15:15 – 16:30*)

“Use of Extremes Toolkit in Climate Change Applications”

LECTURE 1

BACKGROUND ON EXTREME VALUE THEORY WITH EMPHASIS ON CLIMATE APPLICATIONS

(**1**) Traditional Statistical Methods

(**2**) Rationale for Extreme Value Analysis

(**3**) Extremal Types Theorem

(**4**) Block Maxima Approach

(**5**) Tails of Distributions

(**6**) Choice of Threshold

(**7**) De-Clustering

(**8**) Point Process / Peaks Over Threshold

(**9**) Risk Communication (Under Stationarity)

TUTORIAL 1

INTRODUCTION TO EXTREMES TOOLKIT AND CLIMATE APPLICATIONS

(**1**) Overview of Software for Extremes

(**2**) Extremes Toolkit (`extRemes`)

(**3**) Climate Applications (Under Stationarity)

(**3.1**) GEV/Block maxima

Simulated data from GEV

Fort Collins annual maximum precipitation

(**3.2**) GP/Distribution tails

Simulated data from GP

Economic damage from hurricanes

Phoenix daily minimum temperature

(**3.3**) Point process model

Fort Collins daily precipitation

(**3.4**) Return levels

Fort Collins annual maximum precipitation

(**4**) Exercise

Block maxima approach:

Annual maximum and minimum temperature and maximum precipitation at Pergamino or Pilar

LECTURE 2

APPLICATION OF EXTREME VALUE THEORY TO CLIMATE CHANGE

(**1**) Non-Stationarity

(**2**) Trends in Extremes

(**3**) Other Forms of Covariates

(**4**) Risk Communication (Under Non-Stationarity)

(**5**) Economic Impacts / Random Sums

(**6**) Extreme Weather Spells

(**7**) Origin of Bounded and Heavy Tails

(**8**) Multivariate Extremes

(**9**) Spatial Extremes

TUTORIAL 2

USE OF EXTREMES TOOKIT IN CLIMATE CHANGE APPLICATIONS

(**1**) Using Covariates in `extRemes`

(**2**) Climate Change Applications

(**2.1**) Block maxima approach

Simulated data from GEV with trend

Phoenix summer minimum temperature

Port Jervis winter maximum temperature

(**2.2**) Poisson-generalized Pareto approach

Fort Collins daily precipitation

(**2.3**) Point process model

Fort Collins daily precipitation

(**2.4**) Random sums

Economic damage from hurricanes

(**3**) Exercise

Block maxima approach:

Annual maximum and minimum temperature and maximum precipitation at Pergamino or Pilar (trends or ENSO signal)

PREREQUISITES

Statistics: Some training in statistics essential (say, at least one introductory course)

Extreme Value Theory: At least limited exposure to this theory would be preferable, but not required

PREPARATION (if use own laptop)

Statistical programming language `R` (open source): Download and install on laptop (Prior experience with R not assumed)

Extremes Toolkit (open source): Install `extRemes` package within `R` (No familiarity with `extRemes` assumed)

RESOURCES

`R`: The `R` Project for Statistical Computing (`www.r-project.org`)

Introducción a R: `cran.r-project.org/doc/contrib/R-intro-1.1.0-espanol.1.pdf`

Extremes Toolkit: `www.isse.ucar.edu/extremevalues/evtk.html`

Tutorial: `www.isse.ucar.edu/extremevalues/tutorial.pdf` (pdf) or `www.isse.ucar.edu/extremevalues/tutorial` (html)

Reference manual: `cran.r-project.org/web/packages/extRemes/extRemes.pdf`

Statistics of Weather and Climate Extremes:
`www.isse.ucar.edu/extremevalues/extreme.html`

REFERENCES

Coles, S., 2001: *An Introduction to Statistical Modeling of Extreme Values*. Springer, London.

Katz, R.W., M.B. Parlange, and P. Naveau, 2002: “Statistics of extremes in hydrology.” *Advances in Water Resources*, **25**, 1287–1304.

Stephenson, A., and E. Gilleland, 2006: “Software for the analysis of extreme events: The current state and future directions.” *Extremes*, **8**, 87–109.