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Publication date
2019

Document Version
Final published version

Citation (APA)
van Nooijen, R., Kolechkina, A., & Zhou, C. (2019). *How hard is it to detect abrupt changes in the statistics of time series?*. 43-43. Abstract from 62nd ISI World Statistics Congress 2019, Kuala Lumpur, Malaysia.

STS555: Recent Non-Parametric Approaches: Applications to Environnementales, Hydrological, Oceanological and Economic Data Analyses

How hard is it to detect abrupt changes in the statistics of time series?

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An excess or a shortage of water may place human life in jeopardy. The history of the construction of canals, dikes, and reservoirs to serve and protect society goes back thousands of years. The proper design and management of such structures is dependent on estimates of extremes of precipitation, run-off, river discharge, and, in some cases, tides. Today statistical techniques are applied to time series of the yearly maxima or minima of precipitation, run-off, or river discharge to estimate such extremes. These time series tend to be relatively short and their analysis is complicated by the possibility of the presence of trends or even abrupt changes in the underlying processes. Examples of such abrupt changes would be human intervention, for instance, dam construction or river training, and abrupt natural changes such as river bed changes due to floods or the collapse of debris dams. An estimate of the probability of extreme events that ignores such changes is likely to be incorrect. As these estimates form the basis for the design of large civil engineering projects, this could have serious consequences.

The question is how reliably analysis of the time series can detect such abrupt changes.

It will be shown that even in the ideal case of a sequence of independent random variables with at most one change, this is not a trivial task. While extreme value theory proposes limit distributions for extremes, it is not known how close the actual series will be to that limit. For that reason only non-parametric, in other words distribution free, methods will be considered. The classical method of Pettitt, a CUSUM based method, a method based on the Cramér-von Mises two sample statistic and a novel confidence set based method will be examined. Of these methods only the confidence set method provides an intrinsic measure of uncertainty.