Geophysical Research Abstracts, Vol. 9, 07070, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-07070

Multifractal analysis of river discharge extremes

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River discharge is known to be extremely variable, depending much on climatic regimes (namely the rainfall input) and complex rainfall-runoff processes occurring at a variety of scales in time and across the drainage basin. The characterization of extreme discharge is a challenging task: discharge records are often lacking for flood events; the violent behaviour of river discharge is not adequately described by many models. This issue is of great importance in hydrological studies and engineering design, in particular, because extremes often lead to flood situations which can endanger property and human life.

This work reports results of scale invariant and multifractal analyses of river discharges from Mainland Portugal, concentrating on the statistics of extreme events. Multifractals predict heavy tails (i.e., power-law tails) in the flow rate probability distributions, whereas models based on non-scaling type processes usually involve only weak variability (e.g. exponential probability tails). This has important implications for the estimation of the probability of exceeding certain large events. Moreover, in a non-scaling framework, two or more different distributions are often necessary to fit different regimes such as the “low-flow”, the “regular” and the “extreme” events. Multifractal theory offers a single framework to deal with these different regimes simultaneously.

The data used in this study are from drainage basins having different geometric, geological and climatic characteristics, as well as land use. The drainage area varies from about 5 to 62000 km2. The time span of the records is more than 70 years for some of the data sets.