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Some problems in inference from time series of geophysical processes

Demetris Koutsoyiannis

National Technical University of Athens, Faculty of Civil Engineering, Department of Water Resourses and Environmental Engineering, Zographou, Greece (dk@itia.ntua.gr, +30-210-7722832)

Due to the complexity of geophysical processes, their modelling and the conducting of typical tasks, such as estimation, prediction and hypothesis testing, heavily rely on available data series and their statistical processing. The classical statistical approaches, which are often used in geophysical modelling, are based upon several simplifying assumptions, which are invalidated in natural processes. Central among these is the (usually tacit) time independence assumption which is regarded to simplify modelling and statistical testing at no substantial cost for the validity of results. Moreover, the perception of the general behaviour of the natural processes and the implied uncertainty is heavily affected by the classical statistical paradigm that is in common use. However, the study of natural behaviours reveals the dominance of change at a multitude of time scales, which in statistical terms is translated in strong time dependence, decaying very slowly with lag time. In its simplest form, this dependence, and equivalently the multi-scale change, can be described by a Hurst-Kolmogorov process using a single parameter additional to those of the marginal distribution. Remarkably, the Hurst-Kolmogorov stochastic dynamics results in much higher uncertainty in comparison to either nonstationary descriptions, or to typical stationary descriptions with independent random processes and common Markov-type processes. In addition, as far as typical statistical estimation is concerned, the Hurst-Kolmogorov dynamics implies dramatically higher intervals in the estimation of location statistical parameters (e.g., mean) and highly negative bias in the estimation of dispersion parameters (e.g., standard deviation), not to mention the bias and uncertainty in higher order moments. Surprisingly, all these differences are commonly unaccounted for in most studies of geophysical processes, which may result in inappropriate modelling, wrong inferences and false claims about the properties of the processes studied. Several real-world and synthetic examples are used to demonstrate the degree of misleading conclusions about natural processes and how these could be avoided by correct account of the differences from the classical statistical paradigm.