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A stochastic methodological framework for uncertainty assessment of hydroclimatic predictions

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In statistical terms, the climatic uncertainty is the result of at least two factors, the climatic variability and the uncertainty of parameter estimation. Uncertainty is typically estimated using classical statistical methodologies that rely on a time independence hypothesis. However, climatic processes are not time independent but, as evidenced from accumulating observations from instrumental and paleoclimatic time series, exhibit long-range dependence, also known as the Hurst phenomenon or scaling behaviour. A methodology comprising analytical and Monte Carlo techniques is developed to determine uncertainty limits for the nontrivial scaling case. It is shown that, under the scaling hypothesis, the uncertainty limits are much wider than in classical statistics. Also, due to time dependence, the uncertainty limits of future are influenced by the available observations of the past. The methodology is tested and verified using a long instrumental meteorological record, the mean annual temperature at Berlin. It is demonstrated that the developed methodology provides reasonable uncertainty estimates whereas classical statistical uncertainty bands are too narrow. Furthermore, the framework is applied with temperature, rainfall and runoff data from a catchment in Greece, for which data exist for about a century. The uncertainty limits are then compared to deterministic projections up to 2050, obtained for several scenarios from several climatic models combined with a hydrological model. It is obtained that climatic model outputs for rainfall and the resulting runoff do not display significant future changes as the projected time series lie well within uncertainty limits assuming stable climatic conditions along with a scaling behaviour.