Geophysical Research Abstracts
Vol. 16, EGU2014-15856-2, 2014
EGU General Assembly 2014

Assessing uncertainties in superficial water provision by different bootstrap-based techniques

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An assessment of water security can incorporate several water-related concepts, characterizing the interactions between societal needs, ecosystem functioning, and hydro-climatic conditions. The superficial freshwater provision level depends on the methods chosen for "Environmental Flow Requirement" estimations, which integrate the sources of uncertainty in the understanding of how water-related threats to aquatic ecosystem security arise. Here, we develop an uncertainty assessment of superficial freshwater provision based on different bootstrap techniques (non-parametric resampling with replacement). To illustrate this approach, we use an agricultural basin (291 km^2) within the Cantareira water supply system in Brazil monitored by one daily streamflow gage (24-year period). The original streamflow time series has been randomly resampled for different times or sample sizes (N = 500; ...; 1000), then applied to the conventional bootstrap approach and variations of this method, such as: "nearest neighbor bootstrap"; and "moving blocks bootstrap". We have analyzed the impact of the sampling uncertainty on five Environmental Flow Requirement methods, based on: flow duration curves or probability of exceedance ($Q_{90\%}$, $Q_{75\%}$ and $Q_{50\%}$); 7-day 10-year low-flow statistic ($Q_{7,10}$); and presumptive standard (80% of the natural monthly mean ?ow). The bootstrap technique has been also used to compare those "Environmental Flow Requirement" (EFR) methods among themselves, considering the difference between the bootstrap estimates and the "true" EFR characteristic, which has been computed averaging the EFR values of the five methods and using the entire streamflow record at monitoring station. This study evaluates the bootstrapping strategies, the representativeness of streamflow series for EFR estimates and their confidence intervals, in addition to overview of the performance differences between the EFR methods. The uncertainties arisen during EFR methods assessment will be propagated through water security indicators referring to water scarcity and vulnerability, seeking to provide meaningful support to end-users and water managers facing the incorporation of uncertainties in the decision making process.