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Evidence of river flow regulation loss over time in the Magdalena river basin

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Some of the main problems in hydrological sciences are related to how and why river flows change as a result of environmental change, and what are the corresponding implications for society. This has been described as the Panta Rhei context, which refers to the challenge of understanding and quantifying hydrological dynamics in a changing environment, i.e. under the influence of non-stationary effects. The river flow regime in a basin is the result of a complex aggregation process that has been studied by the scaling theory, which allows river basins to be classified as regulated or unregulated and to identify a critical threshold between these states. Regulation is defined here as the basin's capacity to either dampen high flows or to enhance low flows. This capacity depends on how basins store and release water through time, which in turn depends on many processes that are highly dynamic and sensitive to environmental change. Here we focus on the Magdalena river basin in northwestern South America, which is the main basin for water and energy security in Colombia, and at the same time, it has been identified as one of the most vulnerable regions to be affected by climate change. Building upon some of our previous studies, here we use data analysis to study the evolution of regulation in the Magdalena basin for 1992-2015 based on the scaling theory for extreme flows. In contrast to most previous studies, here we focus on the scaling properties of events rather than on long term averages. We discuss possible relations between changes in the scaling properties and environmental factors such as climate variability, climate change, and land use/land cover change, as well as the potential implications for water security in the country. Our results show that, during the last few decades, the Magdalena river basin has maintained its capacity to regulate low flows (i.e. amplification) whereas it has been losing its capacity to regulate high flows (i.e. dampening), which could be associated with the occurrence of the extremes phases of El Niño Southern Oscillation (ENSO) and anthropogenic effects, mainly deforestation. These results provide foundations for using the scaling laws as empirical tools for understanding temporal changes of hydrological regulation and simultaneously generate useful scientific evidence that allows stakeholders to take decisions related to water management in the Magdalena river basin in the context of environmental change.