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Econometric approaches to attributing trends in streamflow

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Nearly all of the world's rivers have been affected by humans, threatening water security for both people and ecosystems. In most regions, multiple anthropogenic impacts have occurred simultaneously, making it difficult to attribute observed changes to specific causes. Merging natural science and economic approaches can improve our ability to model and predict the complex inter-relationships between humans and water. Here, econometric models designed to identify causal relationships were adapted to attribute changes in low streamflow across the eastern United States. A spatial and temporal "panel" data set was created including streamflow data from 174 US Geological Survey gages over 1950-2010 along with annual time series of precipitation, temperature, land use, irrigation, and water withdrawals. With stream gage-specific intercepts and slopes, fixed, random, and mixed effects models were compared to evaluate the relative contribution of each factor in explaining annual low flows. Elasticities, or the sensitivity of annual low flows to each of the covariates, were compared. For this region, annual changes in precipitation, temperature, irrigation, and impervious cover were found to have important and statistically-significant effects on annual minimum streamflow. The relationship between annual low flows and water withdrawals was not as clear, possibly due to low resolution of water withdrawal data or confounding with other factors. Although this work focused on trends in low streamflow, these types of modeling approaches could also be used to attribute changes in flood peaks. With time series of land use and other relevant covariates increasingly available, models such as these can be used exploit both spatial and temporal dimensions. To mitigate the impacts of droughts, an understanding of the relative contribution of various factors will be necessary. Looking to other fields, such as economics, can provide insights to advance these efforts within hydrology.