Influence of tree cover and urban area on streamflow in the United States using multiple statistical attribution techniques

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There is still limited quantitative understanding of the effects of tree cover and urbanisation on streamflow at large scales, making it difficult to generalize these relationships. We use the globally consistent European Space Agency (ESA) Climate Change Initiative (CCI) Global Land Cover dataset to estimate the relationships between streamflow, calculated as high (Q0.99), median (Q0.50), and low (Q0.01) flow quantiles, and urbanization or tree cover changes in 2865 catchments between the years 1992 through 2018. We apply three statistical modelling approaches and examine the consistencies and inconsistencies between them. First, we use distributional regression models -- generalized additive models for location, scale, and shape (GAMLSS) -- at each site and assess goodness-of-fit. Model fits suggested a strong association between land cover, especially urban area, and low and median flows at sites with statistically significant trends in streamflow. We then examine the sign of the distributional regression model coefficients to determine whether the inclusion of a land cover variable in the regression models results in a relative increase or decrease in flow, regardless of the overall direction of trends in streamflow. Finally, we use fixed effects panel regression models to estimate the average effect across all sites. Panel regression results suggested that a 1% increase in urban area corresponds to between a < 1% and 2.1% increase in streamflow for all quantiles. Results for the tree cover panel regression models were not significant. We highlight the value of statistical approaches for large-sample attribution of hydrological change, while cautioning that considerable variability exists across catchments and modelling approaches.