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The mechanism of snow shift affect seasonal streamflow in the contiguous US

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Climate warming has caused in a significant decrease in snowpack, increase in precipitation intensity and earlier melt onset. Based on earlier work published in 2014 on changes in streamflow resulting from a shift from snow towards rain, we analysed the sensitivity of seasonal streamflow to the average annual snow fraction in 253 catchments in CAMELS dataset, which have a record length more than 28 years and mean annual snow fraction larger than 15%. The result shows that places (or years) with higher mean annual snow fraction tend to have higher seasonal streamflow. We quantified seasonal sensitivity as a ratio of change in seasonal flow to change in annual snow fraction, for a given annual precipitation. There are 91% 57% and 51% catchments which showed a positive sensitivity value for Spring, Summer and Winter streamflow, respectively. According to the results of seasonal sensitivity analysis in climate space, we found the largest seasonal sensitivity normally happens at the same regional climate. Places with higher average annual snow fraction tend to have the largest sensitivity in summer, while for places with lower annual snow fraction this largest sensitivity occurs in spring.

In order to explore the mechanism(s) by which snow fraction change affects seasonal streamflow, we summarized four hypothesised mechanisms from the literature: water-energy synchrony (Mechanism I), inputs exceed threshold (Mechanism II), demand-storage competition (Mechanism III), and energy partitioning (Mechanism IV). Most of the catchments in the western part of the contiguous US can be explained by the mechanism I, II, III and IV, while for catchments in the central US can be explained by mechanism II, III and IV. Catchments in the eastern part (and some scattered in the northern part) can be explained by mechanism III. Other types of evidence are required to further distinguish between mechanisms in much of the USA. In further research we will use detailed data or hydrologic model to reproduce the hydrological process to find what are the hydrological processes responsible for precipitation phase partitioning changing with climate warming to influence catchment response. These findings would provide an evidence for how does snow affect hydrology, which may help to understand the effect of climate warming on future water resources in snow-dominated regions.