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A Budyko guide to understanding resistance versus resilience of catchment water yields in response to anthropogenic climate change.

Simple, transferable models are needed to estimate effects of climate change on catchment water yields. The Budyko Curve suggests that the primary control on the partitioning of precipitation (P) into discharge (Q) and evapotranspiration (ET) is climate. We used a North American network of long term monitoring catchments on forested landscapes to establish Budyko behaviour before and after the onset of climate change. We hypothesized that water balance elasticity reflects the ability of a catchment to maintain Budyko-like behaviour under natural climatic oscillations and that it is a good indicator of the magnitude and direction of the long-term deviation from the Budyko Curve due to climate change. Elasticity was calculated as the ratio of the maximum range in values of the dependant (potential evapotranspiration (PET)/P) to independent (actual evapotranspiration (AET)/P) variables of the Budyko Curve. Breakpoints in the time series of mean annual temperature signifying the onset of a linear increasing or decreasing climate change trend were identified using an autoregressive integrated moving average method. The period before the breakpoint was used to establish reference conditions reflecting natural climatic oscillations, and the period after was used to explore if anthropogenic climate change resulted in a deviation in the partitioning of P into Q and ET from the reference condition. We found that (1) deviations in the partitioning of P into Q and ET occurred in all sites; (2) the direction of deviation was correlated to forest type, with deciduous forests typically observing an increase in discharge and coniferous forests showing a decrease in discharge due to climate change; (3) the magnitude of deviation was correlated to the rate of increase in temperature; and (4) elasticity showed a non-linear relationship; where, inelastic catchments were resistant to change, maintaining lower deviations at low temperature increases, but higher deviations as temperature increased above a threshold (i.e., elastic breaks); and elastic catchments were resilient to change, with increasing deviations as temperatures started to rise but with a buffering effect as temperatures continued to rise (i.e., elastic stretches). If a temperature threshold exists for the elastic catchments, it is at a much higher threshold than for the inelastic catchments. Using this approach it is possible to apply a simple hydrological model to estimate the effects of climate change on discharge that is easily transferable across different geographic regions.