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Trends of the timing and volume of streamflow and their relationship with climate variables in Northwestern China

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Snowmelt is a significant recharge source of arid basins in Northwestern China. Climate warming has a great impact on the snowmelt in the spring and thus changes the hydrographs of those river basins. In this study, change in the triggering of snowmelt in winter/spring (January 1 to May 31) of the Kaidu River (KD) was analyzed by the temporal centroid of streamflow or 'center time' (CT) for each year from the years 1972 to 2008. CT is the flow-weighted timing which is a reflection of the climatic conditions and is generally sufficient for estimating the timing of snowmelt. The analysis revealed that winter/spring center time (WSCT) data generally has a significant decreasing trend according to Mann–Kendall test ($P<0.05$). Smoothed by locally weighted scatter plot smoothing model, after 1989, there is a clear decreasing trend illustrating the change in timing of snowmelt which could be caused by earlier spring snowmelt. From 1989 and on, the WSCT data ranged from 87 to 98 in Julian days, and it was observed that the timing of snowmelt is earlier by 11days in KD basin. WSCT dates were correlated with March air temperatures (R=-0.48) and with February precipitation(R=0.45) using Pearson's correlation, which indicates WSCT data was sensitive to warmer temperature in March and earlier precipitation accumulation in February. February precipitation is positive correlated with WSCT, may be because of the higher albedo of fresh snow which delays the melting process. Changes in climate variables have the potential to modify streamflow regimes. Annual precipitation and temperature have an increasing trend ($P<0.01$) in the basin, but on the monthly scale the trends were different. A climate elasticity model was applied to quantify the impacts of temperature and precipitation change to streamflow volume and WSCT date. Annually, the precipitation elasticity of streamflow is 0.72 while the temperature increase 1 kelvin may results in streamflow increase of 16.7%. In the case of spring, the elasticity of streamflow in relation to precipitation is 0.27 but the spring temperature change 1 kelvin only leads to 0.96% streamflow change. Noteworthy, the elasticity of WSCT in relation to precipitation and temperature are 0.06 and -0.16 respectively. Overall, it was found that streamflow is sensitive to precipitation and temperature on an annual and seasonal scale in the KD basin. However, the timing of snowmelt in spring is generally controlled by warmer temperatures.

Keyword:

The timing of snowmelt; Mann–Kendall test; Pearson's correlation; Climate elasticity