Decoupling of mountain snowpacks from hydrology due to climate warming

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Storage of winter snowfall in the seasonal snowpack and its subsequent release in spring as meltwater is key to understand runoff generation and its seasonality in many mountain basins. It is widely accepted that a warmer climate will reduce duration and magnitude of snowpack, will reduce spring runoff and probably will also affect the annual water balance. It is often assumed that the magnitude of these processes will be proportional to the intensity of the warming. This paper uses bias-corrected reanalysis data and the Cold Regions Hydrological Model to simulate snowpack and streamflow regimes of idealized catchments in 44 mountain regions of the world. The simulations are used to illustrate the existence of complex behaviour and substantial deviation from the hypotheses mentioned above, with very strong regional differences in the sensitivity of snow accumulation and duration to climate warming. As temperature increases, the river regimes tend to synchronize to the precipitation regimes, and the contribution of snowmelt to annual runoff is reduced. But, annual runoff is not strongly affected by changes in the seasonal snowpack. Overall the result show increased decoupling of snow regimes, snow hydrology and basin hydrology with increased warming, but with substantial regional variations in how this occurs. There are substantial regional variations in the magnitude of these changes in the hydrograph which are not always well related with the observed sensitivity of snowpack. Identifying the drivers of the variable response of snowpack and snow hydrology can help explain the desynchronization of snowpack and streamflow regimes with warming. This permits identification of the most vulnerable mountain areas to projected climate change.