



## **Impact of warming climate on the monsoon and water resources of a western Himalayan watershed in the Upper Indus Basin**

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This study discusses the impact of a warming climate on the monsoon and on water resources in the Astore watershed, a major tributary of the Upper Indus Basin (UIB). It uses precipitation and temperature time series data from climatic stations, European Reanalysis (ERA) interim precipitation data, and monthly river flow data, all for the 1984-2009 period. Monthly average temperature data show statistically significant increasing trends for November-June through this period, while June and July, which experience episodic and intense precipitation, show statistically significant but opposing trends between the first and second halves of the period. To examine precipitation and flow data in more detail, two equal sub-periods were defined; 1984-1996 (T1) and 1997-2009 (T2). Basin-wide average annual precipitation (based on ERA data) declined by ~29% from 1481 mm/yr in T1 to 1148 in T2, whereas during the same periods flows declined by only ~17% (1245 to 1061 mm/yr), suggesting an increase in glacier melt in the T2 period. Spring to early summer flows increased during the T2 period concomitant with shift in the streamflow peak from July to June. Increasing spring discharge, the shift in timing of annual peak discharge, and an increase in the glacial melt component in river flows have been accompanied by a depletion of glacial storage within the Astore watershed, especially in the T2 period. If recent trends in climate and river flow continue in the future, then river flows will eventually decrease more sharply once the glacial reserves can no longer provide sustained nourishment to the river waters. Thus, there is a vital need to prepare and adopt policies for water resource management and reservoir operation that support sustainable development, agricultural expansion, and increased hydro-power generation.