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Impacts of global warming on the hydrology of the Upper Indus Basin, Pakistan

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Temperature data for seven instrumental records in the Karakoram and Hindu Kush Mountains of the Upper Indus Basin have been analysed for seasonal and annual trends over the period 1961-2000 and compared with neighbouring mountain regions and the Indian sub-continent. Strong contrasts are found between the behaviour of winter and summer temperatures and between maximum and minimum temperatures. Winter mean and maximum temperature show significant increases whilst mean and minimum summer temperatures show consistent decline. Increase in diurnal temperature range (DTR) is consistently observed in all seasons and the annual data set, a pattern shared by much of the Indian sub-continent but in direct contrast to both Global Climate Model projections and the narrowing of DTR seen worldwide. This divergence commenced around the middle of the 20^{th} century and is thought to result from changes in large-scale circulation patterns and feedback processes associated with the Indian monsoon.

The impact of observed seasonal temperature trend on runoff is explored using derived regression relationships. Decreases of $\sim$20 % in summer runoff in the Rivers Hunza and Shyok are estimated to have resulted from the observed 1 ^{o}C fall in mean summer temperature since 1961, with even greater reductions in spring months. This decrease in runoff has been concurrent with an increase in summer precipitation since 1961. This sensitivity to small fluctuations in mean temperature suggests that global warming may have large impacts in mountainous regions where summer runoff is dependent upon winter snow fall and summer ablation. The observed downward trend in summer temperature and runoff is consistent with the observed thickening and expansion of Karakoram glaciers, in contrast to widespread decay and retreat in the Eastern Himalaya. This suggests that the Western Himalaya is showing a different response to

global warming than other parts of the globe.