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Hydrological modelling improvements required in basins in the Hindukush-Karakoram-Himalayas region

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Millions of people rely on river water originating from basins in the Hindukush-Karakoram-Himalayas (HKH), where snow- and ice-melt are significant flow components. One such basin is the Upper Indus Basin (UIB), where snow- and ice-melt can contribute more than 80% of total flow. Containing some of the world's largest alpine glaciers, this basin may be highly susceptible to global warming and climate change, and reliable predictions of future water availability are vital for resource planning for downstream food and energy needs in a changing climate, but depend on significantly improved hydrological modelling. However, a critical assessment of available hydro-climatic data and hydrological modelling in the HKH region has identified five major failings in many published hydro-climatic studies, even those appearing in reputable international journals. The main weaknesses of these studies are: i) incorrect basin areas; ii) under-estimated precipitation; iii) incorrectly-defined glacier boundaries; iv) under-estimated snow-cover data; and v) use of biased melt factors for snow and ice during the summer months. This paper illustrates these limitations, which have either resulted in modelled flows being under-estimates of measured flows, leading to an implied severe water scarcity; or have led to the use of unrealistically high degree-day factors and over-estimates of glacier melt contributions, implying unrealistic melt rates. These effects vary amongst sub-basins. Forecasts obtained from these models cannot be used reliably in policy making or water resource development, and need revision. Detailed critical analysis and improvement of existing hydrological modelling may be equally necessary in other mountain regions across the world.