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Integrating glacier flow in hydrological modelling for water resources management

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The climate emergency will drive changes in the cryosphere and hydrology of high mountain catchments, with subsequent influences on water resources availability. Process-based hydrological and glaciological models require significant amounts of data which are often unavailable in high mountainous catchments, especially in developing countries, and are unable to explicitly integrate human-induced factors on river flows (Momblanch et al. 2019). This can be overcome by water resources systems models that take a more conceptual approach. However, they currently have limited capability to represent glacier evolution and thus river discharge dynamics, especially in long-term simulations required for climate change impact and adaptation analysis. There is, therefore, a clear need for improved representation of the spatio-temporal response of glaciers within water resources systems models to support the strategic water resources planning and management and ensure future water security.

The Water and Evaluation and Planning system (WEAP; Yates et al. 2005) is widely used in water resources management studies by both the scientific and decision-making communities around the world. WEAP includes a glacier module which accounts for ice accumulation and melt using the enhanced temperature-index method, but overlooks other processes such as glacier area change, snow redistribution, sublimation and ice flow. These omissions will severely impact the validity and utility of long-term simulations, especially in regions with very rough topography such as the Himalayas.

This research reports the development and application of an enhanced glacier modelling capability in the WEAP software that introduces ice flow dynamics. Through the integration of elevation bands and remote sensing-derived glacier velocities, a 'plug-in' extension into WEAP's Application Programming Interface allows glacier routing to be represented. The Aleo catchment in the upper reaches of the Indus basin in the Western Himalayas is used as a case study to showcase the 'plug-in' and to compare outputs with other process-based models. The results show that the enhanced glacier model significantly improves the simulation of the main glacier variables, i.e. mass balance, depth and volume, with respect to the original glacier model in WEAP. The research outputs contribute to a better understanding of climate change impacts on high mountain hydrology, which is key for regional development.

References

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