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Numerical modeling of a remote Himalayan glacier constrained by satellite data

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Himalayan glaciers are amongst the least studied and understood glaciers on Earth, yet their future behavior and water budget is crucial for densely-populated areas in south, central, and eastern Asia. Here, we use remotely-sensed glacier-surface velocities from a glacier in the upper Tons valley of western Uttaranchal in the Indian Himalaya, to evaluate the results from a numerical glacier model. We estimate present-day ice thickness distribution from surface topography with an approach based on mass conservation and principles of ice-flow dynamics. The numerical glacier model is based on the shallow ice approximation, and requires a mass-balance profile and glacier-bedrock topography as input. Optical-satellite imagery is used for mapping glacier extents and deriving glacier-surface velocities from cross correlation of multi-temporal ASTER and SPOT images. Modeling results, employing a mass balance profile from nearby monitored glaciers with a better data base, indicate good agreement between observed and modeled glacier extents and surface velocities. Discrepancies between model and observation in the lower part of the glacier are likely related to (1) poorly constrained effects of debris cover, and (2) the present disequilibrium and down-wasting of the glacier. Our technique will be useful for comparative analyses of glacial behavior worldwide as most data for our study has been obtained from analysis of remote-sensing data, virtually available for any region on Earth.