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Interactive Comment

Interactive comment on "Tradeoffs for the implementation of a process-based catchment model in a poorly gauged, highly glacierized Himalayan headwater" *by* M. Konz et al.

M. Konz et al.

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We are grateful for the constructive comments of the two reviewers and the editor. They indeed provide some challenges, and we will modify our manuscript and reply in detail to every single comment when we will carry out major revisions of the manuscript for submission to HESS. In the following, we would like address three mainly general comments that came up in the reviews.

1. Does it make sense to develop a relative complex model to a poorly gauged catchment?

We fully agree with the referees and the editor that there are equifinality problems due

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to the large number of parameters of the applied model (cf. Beven and Binley 1992). This problem and the connected uncertainty was shown for a number models (most of them have even less parameters than models like TAC-D) in a number of catchments world-wide (> 20 papers in peer-reviewed journals). We also agree that much simpler models could be calibrated in such a way that they fit the observed hydrograph with reasonable model efficiency values. This was also demonstrated in many many many studies (cf. Jakeman and Hornberger 1992; data-based model approaches). Considering the input data quality of the study catchment, we do not think that it makes sense to repeat these findings for the study area.

The objective in this study was much more to discuss the tradeoffs for the implementations of a more complex, process-oriented model in a poorly gauged Himalayan headwater. Generally such models are needed to make predictions for future conditions; note that for instance many climate models predict that this region is very sensitive to climate change. In the revised manuscript we will add to section, where we compare the TAC-D results with the application of the some what simpler, semi-distributed HBV-ETH model, which is frequently used in high-alpine environments. We would rate the applied version of TAC-D as a compromise between a full physically based model (e.g. Mike-SHE) and HBV-type of model, as it is fully distributed (raster-based) but it still uses relatively simple box approaches to conceptualise runoff generation processes. The comparison with the HBV model demonstrated that the more complex runoff generation routine of TAC-D was not necessary for discharge simulation in some seasons (i.e. monsoon), but yielded better results in simulating winter discharge. Interesting was that the increase in complexity of the snow and glacier routine did not significantly improve the simulation for the given data sets.

We do not agree that used literature values for parameters are not process based. The most sensitive parameters of the snow and glacier routine were taken from experimental studies conducted in the catchment (mostly on Yala glacier).The fact that an extensive evaluation of the model concept is missing due to data and other limitations

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is discussed critically (and will be improved in the revised manuscript) - unfortunately this seems to be true for the very most published model applications. Obtaining more process data (remote sensing, targeted tracer studies) should be the focus of future research. The modeling exercise so far, help us to design such experiments appropriately in such a way that data is collected that can directly be used by a model like TAC-D.

We kept the delineation of hydrological response units (HRUs) simple and selected the most obvious units where distinct dominant runoff generation processes can be assumed in such an environment. The delineation of the units is based on topographic and physiographic data, which are widely available in the Nepalese Himalayas. A more accurate delineation would require much more experimental efforts (tracer studies etc.). Such field studies are very difficult to carry out in such a high-alpine, remote catchment in a development country. The way the delineation was carried out was fed also by extensive experiences by some of the authors obtained in hydro-glaciological research projects at European and tropical glaciers in the last decades. The plausibility of the spatial delineation of HRUs was discussed with local experts supported by field observations during different seasons.

2. Just a blended version of existing methods, or an innovative approach?

The referee is completely right with the statement that the conceptual ideas behind the simplified version of TAC-D were widely taken from existing models and methods (as clearly stated in the manuscript at many places). Conceptual catchment models are a standard tool in hydrology. However, in order to adapt the model to the data availability and the special circumstances in this Himalayan catchment some new concepts were introduced, i.e. the regionalization of snow and ice melt based on potential sunshine durations or the conceptualization of the runoff generation routine that was specifically developed based on the HRU delineation for the study area (see above). To evaluate these process descriptions we compared measured and simulated glacier mass balances. Since, data availability is limited discharge data and mass balances are the

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only data source to evaluate the model. A fact which was critically discussed (will be improved in the revised version). With our modelling approach we intended to provide a tool for water resources managers, working in remote areas. Thus, we took existing, generally known concepts and tried to simplify them in a way that they can be used in remote areas with limited data. To the best of our knowledge, something like this is not available for the Himalayan mountains, and in practice every coarse methods (e.g. rational formula) are common, which suitability is certainly questionable.

3. Why is it important to develop process based models for a data-scarce, remote, high-alpine Himalayan catchment?

Hydrological processes in mountainous areas are crucial for water resources availability in the surrounding areas, e.g. spatio-temporal distribution of precipitation, snow/ice storage and melt, and runoff generation in glacierized catchments. We tried to address these processes in our model approach in process-based way considering the data availability. This is particularly important for the Himalayan region which feeds major river systems (e.g. Indus, Ganges, Brahmaputra, Salween, Mekong, Yangtze and the Yellow River). These rivers contribute to the water supply of several hundred million people, of which a large percentage live in arid areas and, consequently, depend heavily on the resource coming from the mountains. One example of the regional importance of runoff generation from the Himalayas is that they generate 70% of the mean annual discharge of the Indus and its tributaries through snow- and ice melt.

It is worth noting, that the Langtang Khola catchment is the best observed Nepalese Himalayan catchment and the data published in this paper are unique and of high importance for water resources management. However, we agree with the reviewer #1 that the data quality is far away from research basins in Europe and North-America.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 3, 3473, 2006.