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Hydrology and Earth System Sciences Discussions

Interactive comment on "Modelling the impact of prescribed global warming on water resources of headwater catchments of the Irrawaddy River and their implications for Loktak Lake, northeast India" *by* C. R. Singh et al.

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We thank the anonymous referee for the constructive comments on the paper. Our responses to the specific issues identified are detailed below:

1. Reduction in uncertainty in GCM projected output

The major uncertainty revealed in the paper is the variation in predicted river flows and hence lake water levels associated with different GCMs. This confirms the findings of others who have used the same combinations of GCM / climate change scenarios (e.g. Kingston and Taylor, 2010; Thorne 2010). In response to the referee's comments we propose to include within the discussion reference to approaches that have been advocated to address uncertainty between different GCMs. These include the development of reliability ratings for GCMs through comparisons with observed climate (e.g. Perkins et al., 2007; Maxino et al., 2008; Ghosh and Mujumdar, 2009) and probabilistic climate change scenarios (Manning et al., 2009).

2. Title of the paper

We acknowledge that in terms of impacts on Loktak Lake the paper does focus on the changes to the lake's water level regime although some implications of these changes are discussed such as deterioration of the floating islands (phumdis) within the lake and the implications for wildlife as well as the inundation of lake-side communities. We consider it is beyond the scope of the current paper to provide an in-depth discussion of these impacts (which will be the focus of a further paper currently in preparation). In light of the referee's comments we propose a slight modification to the title of the paper to reflect the focus on the water level regime: "Modelling the impact of prescribed global warming on runoff from headwater catchments of the Irrawaddy River and their implications for the water level regime of Loktak Lake".

3. Lapse rates

Unfortunately precipitation and evapotranspiration data for the area are limited to records from seven rain gauges and four meteorological stations, respectively. In the case of evapotranspiration data are in the form of potential evapotranspiration (calculated using Penman Monteith) rather than "raw" meteorological data which could (at least in the case of temperature) be adjusted for elevation. In the absence of data on variations in precipitation and evapotranspiration with elevation we have used the available data. We have acknowledged this constraint within the paper and will make it clearer when the paper is revised.

4. Model grid size

As stated in the paper the selected grid size of 600 m × 600 m was a compromise between representing catchment attributes such as topography and land use and logistically appropriate simulation times. This trade-off is common in distributed hydrological models (e.g. McMichael et al., 2006). During model development a series of experimental runs were undertaken varying grid sizes of between 300 m × 300 m and 1000 m × 1000 m. Following the results of Vásquez et al. (2002) there was little change in model performance with change in grid over this range. A grid size in the middle of the investigated range was considered justified and resulted in run times for the Thoubal model of approximately two hours on a 3 GHz Intel CoreDuo PC with 2 MB RAM. Smaller grid sizes, and hence longer run times, were considered inappropriate given the requirement to run a large number of consecutive model simulations during calibration. The impact of the selected grid size on representation of catchment attributes, specifically topography, was investigated by the derivation of hypsometric curves using the original SRTM data and the resampled topographic data. The very similar shape of these two curves suggested that the resampled data retains a good representation of catchment topographic characteristics. In revising the paper we propose to briefly outline these issues. Since meteorological inputs to the model (i.e. precipitation and evapotranspiration) are spatially distributed using Thiessen polygons they are not significantly impacts by grid size, at least over the range of grid size investigated.

5. Climate change and parameter values

We acknowledge that climate change might result in modifications to model parameter values. For example, shifts in the distribution of vegetation driven by climate change would modify leaf area index, root depth and surface roughness. This is a common

issue in the use of models for climate change assessments and we have adopted the widespread approach (employed by all the papers within the special issue for which this paper is submitted – e.g. Hughes et al., 2010; Kingston and Taylor, 2010; Nóbrega et al., 2010; Thorne 2010) of maintaining parameter values from the calibrated models whilst forcing meteorological inputs. In revising the paper we will explicitly refer to this issue.

6. MIKE SHE models for un-gauged catchments

Our original intention at the outset of the study was to follow the approach advocated by the referee and Pradhan et al. (2008). However, this was prevented by the incomplete spatial coverage of all of the data employed within the models of the three gauged sub-catchment. For example, no information on the channel networks was available for the un-gauged catchments. Additionally, the Western sub-catchment is comprised over more than 20 streams and rivulets which would probably require individual models potentially with much smaller grid sizes. Therefore rather than develop MIKE SHE models for some of the ungauged sub-catchments and use the alternative weighting by area for the others we considered a consistent approach for all these sub-catchments to be most appropriate.

7. Sediment and volume-level-area relationships

The referee raises an interesting issue related to sedimentation of water bodies within and downstream of the Himalayas (Jain et al., 2002; Rai et al., 2007). In the case of Loktak Lake there are no reliable estimates of current sedimentation rates let alone those could be expected given the higher discharges projected by the climate change simulations. This prevents the modification of the lake bathymetry and subsequent re-evaluation of the lake volume-level-area relationship used in Equation 1. It could be expected that raised lake bed levels would result in higher water levels which would exacerbate the dominant trend for raised levels from the climate change results. In revising the paper we propose to refer to this issue as an additional potential source of change to the lake's water level regime.

8. Past tense and %

We thank the referee for identifying these issues and will make the suggested changes when revising the paper.

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