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Interactive comment on "Modeling glacier melt and runoff in a high-altitude headwater catchment in the Cordillera Real, Andes" *by* T. Kinouchi et al.

Anonymous Referee #2

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Hydrology and Earth System Sciences - Discussions Review of the manuscript number 10, 13093-13144, 2013. Title: Modeling glacier melt and runoff in a high-altitude catchment in the Cordillera Real, Andes

Summary The proposed manuscript presents an original glacier-fed Andean watershed hydrological model and its application to a small partially glacierized catchment of the Cordillera Real in Bolivia. The model can be classified as conceptual and semi-distributed. The study is based on a two years long meteorological dataset that includes different meteorological measuring points as well as a gauging station. The authors present first an analysis of the meteorological dataset with a specific emphasis on the temperature and precipitation lapse-rates. After calibration the model exhibits fair performances in reproducing daily discharge at the study watershed outlet. Model

outputs are then used to analyse runoff components variation on the two years of the study. The second part of the manuscript describes the application of the model to six different climate change scenarios. The first one that can be seen as a reference scenario represents the repetition of the 2 years of meteorological observations on the 38 coming years, with no change in precipitation or in temperature. The four next scenarios project similar meteorological pattern with a forced temperature increase of 0.1 to 0.4°C/decades. The last one is produced by a GCM using one of the SRES emission scenarios. Projections are then used to depict predicted changes in glacierized area for each scenario and to analyse the evolution of the runoff components in a changing climate.

General comments

Several aspects of the manuscript represent a significant interest for the HESSD readers. The paper presents an hydro-meteorological dataset from a region of the tropical Andes that has not been extensively studied yet and the density of weather stations presented by the authors makes it of particular interest. The hydrological model developed for the study exhibits originalities in the structure. The use of supplementary measured variables such as the albedo for the calibration of model parameters appears as a promising approach. The subsurface and deep groundwater parts of the model especially are designed to better take into consideration these two hydrological components compared with what is typically done in similar environments. Unfortunately, the paper includes several doubtful facets that will require major revisions before publishing. Among those, the use of a conceptual model for analysing parameters it was not validated for represents the weakest point of the manuscript. The length of the time series chosen for model calibration is also a major handicap for the representativeness of the model outputs, especially when those are generated based on hypothetical climatic scenarios. Finally, there is an apparent lack of rigour in data analysis, some statements made at different points of the manuscript not being supported by robust evidences. The meteorological dataset collected so-far by the authors at the Huayna

–Potosi West headwater does not appear being sufficient to allow proper calibration and validation of a semi-distributed conceptual model at a daily time step. I therefore encourage the authors to reshape the manuscript by placing more emphasis on the modeling and calibration techniques and less on model outputs based hydrological analysis.

Specific remarks

- The hydrological model used in the study uses more than 16 parameters, factors, coefficients that are either fixed arbitrarily either estimated during a calibration exercise. In these conditions, the two years of field observations and measurements are not enough to realise a proper calibration and validation. Using the model to assess watershed hydrological response to climate change scenarios without verification of its ability to do so is not appropriate. - Model outputs are used to depict runoff components evolution with time, both for calibration years and for future projections. The ability of the model to reproduce such characteristic was not verified and not intended to be. The way the model is designed makes that the simulation output are highly influenced by the way parameters, factors and coefficient are fixed. As seen here above, nothing in the calibration process justify using the model simulation in such way. - The length of the field measurements, limited to two years, does not allow long term evaluation of climatic and hydrological watershed specificities. A different occasions, the authors overstate on these limited monitoring results or does not provide evidences for affirmations: o Page 13098; lines 17-19. "Therefore, both the wetland and the lake likely play a role in retarding the runoff from the glacierized and non-glacierized areas." o Page 13099; lines14-16. "A good correlation for air temperature was found between MH1 and MHG (R2=0.77) during the two years, implying that similar variation may have occurred in the ablation zone." o Pages 13099 - 13100; lines 25-29 and 1-3. Especially: " We found that air temperature was more strongly correlated with flow rate during this period, with a phase lag of about 5 days, ..." o Page 13114; lines 19-21. "This implies that wetlands and lakes in the tropical Andes play significant roles in buffering runoff

from glacier melt and supply this water gradually" o Pages 13120; lines 25-27. "The trend of relative humidity derived from historical records is not significant (Vuille et l., 2008); thus if this trend continue into the future, the effect on melting and runoff would be minimal" - Maintaining a weather station during two years on a glacier surface is a challenge, mainly due to the motion of the ice as well as the effect of melt or accumulation of the surface. The manuscript lacks of description of how the measures from the MHG station remained unaffected by these factors.

Technical remarks :

- The use of objective functions to evaluate the performance of the model in reproducing measured parameters is sometimes inconsistent. It goes from three objective functions at page 13114 paragraph two to none at the third paragraph of the same page. - Page 13094. The use of the world "validate" in the abstract is misleading as no validation of the model performance (comparing model outputs to measurements not used for the model calibration) was conducted in the study. - Page 13100. There is no unit given for the dry adiabatic lapse rate. - Page 13101. The first paragraph of the page proposes a comparison between the Cordillera Real and the Cordillera Blanca melting conditions that can be considered as speculative. - Pages 13102 to 13108. The presentation of the model could be improved to make it easier to read: Some parameters are explained at the wrong place (Inf); Some symbols are used to describe two different parameters (α); the presentation of equations in groups of six to seven make them difficult to understand; in equation (29) ri is used instead of γi. - Page 13109. The use of data from the Zongo glacier for melting factors calibration may generate an error as the Zongo glacier orientation differs from the studied one. - Page 13110 first paragraph. There is a general lack of details on the way some parameters are fixed in this section. - Page 13132 – Figure 1. The maps provided could be improved by enlarging the study catchment, adding streams and placing the stations names directly on the maps. - Page 13136 – Figure 5. Variables should be explained.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 13093, 2013.