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Hydrology and Earth System Sciences Discussions

Interactive comment on "Modelling the hydrologic role of glaciers within a Water Evaluation and Planning System (WEAP): a case study in the Rio Santa watershed (Peru)" *by* T. Condom et al.

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The authors are grateful to the Referee n°2 W. Buytaert for the comments on our paper that would help to increase the quality of the revised manuscript. Before responding for each point we re-affirm that the paper focuses on the use of a semi-distributed hydrological model to compute the water flows in the catchments and the retreat of the glaciers under the present climate which is quite unusual.

In the following we detail the response for each major comment.

Comment 1: "I find the author's claim that existing experimental methods of the type of Mark and Seltzer (2003) are less useful for water resources management than model

simulations of the type they represent in the paper."

Response to comment 1: We don't think that we oppose the experimental methods with the model simulations presented in this paper. And we don't think at all that the experimental methods given in Mark and Seltzer are useless. We think that the two approaches are complementary. This point is true because we compare our model results obtained for the Querococha sub-watershed with the results obtained by Mark and Seltzer (2003). (See 895 L27-28)

Comment 2: "The main issue of the model however is the extremely poor performance. Table 3 states Nash Sutcliffe efficiencies as low as 0.19 with only few values exceeding 0.6".

Response to comment 2: We don't agree with this comment and concerning the Nash Sutcliffe efficiencies. Considering the 16 sub-watersheds and the two periods (validation and calibration) the table 3 shows that we have 16 Nash Sutcliffe with values exceeding 0.6. The other important point was to simulate the glacier's retreat and the table 5 shows that a good agreement exist between simulated and observed areas.

Comment 3: "Just looking at the model performance on the Artesoncocha catchment on which it was calibrated (Fig 4) shows that the model severely and consistently underestimates the dry season flows (e.g., in 2004)."

Response to comment 3: In this site, data was used to calibrate the three glacier parameters T0, aice and asnow. Given the high position of the Artesoncocha catchment and its small size, the majority of the low flows in this watershed are not given by the groundwater flows but by the glacier meltwater. The reviewer is right in that there is some portions of the hydrograph that show underestimation, but we are not clear which metric he used to assess that the model 'severely' underestimates dry season flows. The correlation coefficient includes provides what we consider an acceptable value for this type of model.

Comment 4: "The calibration of the model is not clear".

Response to comment 4: We agree with this comment and propose to develop this point in the revised version. As written in the reply to the first comment (see Hydrol. Earth Syst. Sci. Discuss., 8, C202–C207, 2011 www.hydrol-earth-syst-sci-discuss.net/8/C202/2011/) , the strategy for the model calibration and validation was : - first, a calibration of the glacier's parameters (aice, asnow and T0) for the period 2000-2007 on the small subwatershed "Artesoncocha" (see figure 4) considering the outflows. - second, using the same calibrated glacier parameters for all sub-watersheds (aice, asnow and T0) a calibration of the hydrological parameters for the period 1969-1979 considering the outflows. - third, the validation of the parameters for the period 1979-1989. For the glacier's extent, we initialised each sub-watershed with the observed area in 1970 and then we computed the areas for 1987 an 1999, which where then compared to observations for the same years.

Comment 5: "For instance, it is very unlikely that "roughly one million people" live in the upper portion of the Rio Santa watershed".

Response to comment 5: We agree with this comment in that the million people don't live in the upper watershed. The sentence should have said: "roughly one million people live in the Rio Santa watershed" (see values below, data from INEI - CPV2005). These numbers were used in the simulations to estimate water demands, which were located in the model at their corresponding locations within the watershed. POPULATION : Huaraz province (Urban population : 102,486 and Rural population : 40,929) - Carhuaz province (Urban population : 14,147 and Rural population : 29,505) - Casma province (Urban population : 28,151 and Rural population : 13,326) - Corongo province (Urban population : 3,783 and Rural population : 4,003) - Huaylas (Urban population : 16,740 and Rural population : 36,105) - Pallasca province (Urban population : 15,032 and Rural population : 13,548) - Recuay province (Urban population : 10,088 and Rural population : 8,038) - Santa province (Urban population : 362,046 and Rural population : 28,125) - Yungay province (Urban population : 11,771 and Rural population :

42,718) - Guadalupito province (Urban population : 5,301 and Rural population : 616) - Caraz province (Urban population : 16,740 and Rural population : 36,105) - Santiago de chuco province (Urban population : 19,769 and Rural population : 37,757) - Total population equals to 896,829 roughly one million people (Urban population : 606,054 and Rural population : 290,775).

Comment 6: Similarly, the statement that "large populations rely on glacier melt for water and hydropower at the level of the Andes" is highly contested.

Response to comment 6: We agree with this comment and this statement should be seen for each case and each cordillera in the Andes. A general statement shouldn't be given here and we propose to change this sentence in the revised version of the paper. In the Rio Santa watershed we think that the glacier melt is important.

Reply on specific comments :

873/25 : The sentence in which the number of one million was used was wrong. We will rewrite the sentence as indicated above.

876 : The definition used here comes from Yates et al. 2005 (page 491) where effective precipitation is computed as function of snowmelt. However, the reviewer is right in that in this specific application of WEAP the effective precipitation is the same as precipitation since snowmelt is dealt with the new algorithm and is accounted in the streamflow differently from the way in which it is accounted from in Yates et al. 2005

881/16 to 882/2: We agree with this comment and propose to revise and explain better this section for the next revised version.

887/4: NSE can range from -∞ to 1,0. An efficiency of 1,0 corresponds to a perfect match of modeled discharge to the observed data. A value of 0,0 indicates that the model predictions are no better than just taking the mean of the observed data and an NSE of less than zero means that in general (i.e. over the entire model period) just taking the mean of the observed data performs better as a predictor of the observa-

tions than the predictions made by the model. In both last cases, the performance of the model would be considered to be unacceptable. Essentially, the closer the model efficiency is to 1, the more accurate the model is.

889/16: Yes, the DEM used was derived from the contour lines.

890/12: What we meant by saying “a per capita water use of 300 l/day” is that we estimated 300 l/day per capita or per person, which is the same as 300 l/p/day

890/24: It was tested during in a previous work but the quality of the simulations was equivalent.

893: The reviewer is right in that what we meant is that after the glacier parameters were calibrated, we continued to perform streamflow calibration. Streamflow calibration was done manually matching observations and modelled results following an iterative process. Regarding the values of the root zone capacity, it is a calibration parameter that is not only dependent on soil types but also on the timestep of the model. No information about soils is provided because we did not incorporate soils details in the model.

897: We agree with this comment and propose to revise and explain better this section for the next revised version.

Table 2 : These are calibrated parameters

Table 2: We will translate the land covers in english for the revised version

Table 3: In the caption of the figure 3 it should be indicated that no long time series exist for Artesoncocha watershed. We will precise this in the revised version.

Table 5: in the caption of the figure 5 it should be written "lowest point" instead of "lowest pour point"

All the technical corrections would be taken into account for the revised version.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 869, 2011.