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Hydrology and Earth System Sciences Discussions

HESSD

8, C981–C990, 2011

Interactive Comment

Interactive comment on "A framework for the quantitative assessment of climate change impacts on water-related activities at the basin scale" *by* D. Anghileri et al.

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We wish to thank the reviewer for his/her comments and suggestions. We hope we addressed all the issues raised and we are willing to modify the paper accordingly.

Below is a list of specific reply to the reviewer comments.

Page 587, Line 9: The study by ...
Reply: Yes, there is a quantitative analysis in Abbaspour et al., 2009 relative to climate and hydrology, while the discussion of possible implication for agriculture, water quality and ecosystems is mainly qualitative (see section 4 of that paper). This is

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why according to our classification that work should go with the list of papers focusing on the hydrological response (maybe better after [Groves et al, 2008]).

Page 591, Line 25: In this study the authors use different types of modelling approaches ...
Reply: The study describes the catchment (statistical) models, the reservoir model, and the decision model for reproducing optimal reservoir operation.

Page 594, Line 26: Why did you derive annual-seasonal correction functions (CF) ...
Reply: It is true that the intra-annual variation of the PCP simulated by the RCMs is different from the one observed in the backcast period. We did not derive monthly correction function because the historical time series of observation was too short to derive robust monthly CFs, which would likely be overfitted.
As for the choice between seasonal and annual CFs, we preferred the latter because forecast and backcast intra-annual pattern of PCP (as simulated by the RACMO model, i.e. before downscaling) are quite different and so assuming that the seasonal CF estimated over the backcast will hold for the future is highly questionable.
Finally, different intra-annual pattern of PCP actually affects the irrigation indicator but not the hydropower indicator. In fact, as stated on page 599 line 11-18, the hydropower reservoir capacity is enough to compensate variation in the intra-annual pattern of PCP, while this is not the case for Lake Como.

Page 595, Line 1-5: How did you measure the goodness of fit ...
Reply: We used (i) the quantile-quantile plot over the validation period and (ii) comparison of the annual pattern of downscaled and observed variable. Based on this analysis and the considerations given in the previous reply, we made our choice between the annual and seasonal CFs.
Figure 1 below compare observed and downscaled data for the baseline period. You

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may notice that patterns of observations (points) and backcast (solid line) are quite similar but for monthly precipitation (which is not surprising since we used annual correction). However, this comparison is not fully fair because the statistics of the backcast scenario refer to the period 1961-1990, while those of observations refer to 1967-1980.

Page 595, Line 11: Please give a brief explanation on your model selection...
Reply: The lumped modelling approach guarantees efficient parameterization even with limited historical time series, as in our case, at the price of neglecting spatial processes. In our case study spatial heterogeneity is not significant, but for elevation. Nonetheless comparison with an elevation-based model previously identified on the same case study [1] shows that lumping does not induce significant loss of information (we cannot directly compare the R2 values because they are defined over slightly different time horizon, but the order of magnitude is the same, i.e. around 0.65-0.70).

Page 595, Line 25-28: R2 (Coefficient of determination) may not be a proper criterion ...
Reply: When evaluating the catchment model we used also other performance indicators (e.g. mean absolute error, maximum error) and graphical tools (duration curve, scatter plot) to compare simulated and observed flow. We agree this should be clarified in the paper, not to give the wrong suggestion that R2 is the only criterion for model selection. As for BR2: in the lake Como catchment, linear regression between simulated and observed flow provides a slope value of approximately 1, so that BR2 is almost equal to R2; in the model of the hydropower reservoir catchment, the slope is again approximately 1, even if the scatter plot of observed vs simulated flow shows a tendency to underestimation of high flow (see Figure 2 below). However, this cannot be captured by BR2, so we are not sure this indicator would be really informative in our case study, while we agree that introducing a graph of simulated and observed flows (e.g. Figure 2 below) would be significant.

Page 595, last paragraph: Please list the parameters...
Reply: See Table 1 below. These values were identified by an iterative procedure of model calibration. Specifically, we started by optimizing a subset of the model parameters (ALFA,BETA,K,MAXBAS) while keeping to zero the others (FC, LP, K4, PERC, CFLUX), which corresponds to assuming only the upper tank in the soil water balance. The obtained parametrization was used as the initialization for a new optimization, where the Soil Moisture unit was added (meaning that all parameters but K4, PERC, CFLUX are re-optimized). Finally, we repeated model calibration once again for all parameters, starting from the final estimate of previous iteration. As you can notice in the table, in this last iteration the calibration procedure actually did not introduce changes in CFLUX and (for the hydropower reservoir catchment) PERC parameters, which remained zero.

Page 598, Line 17: Please list the pareto optimal policies ...
Reply: Each Pareto-optimal policy is given in the form of a lookup table that associates each possible storage-time pair with one or more (equivalent) optimal decision values. We may include such lookup tables into the paper but we do not think they would be easily readable.

Page 598, section 3.5: Please list the objective functions ...
Reply: The objective functions are given by equations (2) and (3). The optimal control problem used to derive the Pareto-optimal policies does not have any other constraints (but the model itself). The probability distribution of the inflow is cyclostationary (one pdf for each day of the year), so we may introduce a graph to show it but we are not sure it would be easily readable.

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Page 600, Line 2 and Line 20: How were the different simulation horizons of 10 or 14 years alternatives selected...

Reply: The 14 years horizon (1967-1980) is the one where historical data (rainfall, temperature and flow) were available. The choice of h=10 years horizon is a compromise between conflicting needs: on the one hand we would like to have as many IPFs as possible (and then we should reduce h, in fact, within the period 1967-1980 we can compute 14 – h + 1 IPFs over sub-periods of length h); on the other hand, we would like to keep h high so that each indicator evaluation be statistically significant.
Uncertainty bands are the envelopes of the 14-h+1 IPFs (see caption of figure 5 in the paper). Of course this result may change if one considered a different time horizon length. Assessing the intra-annual variability is in fact a difficult issue, here we propose a method to infer at least an estimate of the order of magnitude of such variability, but the issue remains open and certainly deserves further study.

Page 600, Lines 22-26: You are comparing a single backcast scenario ...

Reply: Yes, we may compare uncertainty ranges rather than single predictions. In practice, we would look at several (30-14+1=17), less statistically significant (because based on 14 years) IPFs, rather than one, more statistically significant (because based on 30 years) IPF. What is the most informative approach is, in our opinion, an open question.
Anyway, following your suggestion we computed the uncertainty band under downscaled RACMO-RCM forecast scenario with sliding window of 14 years, and the result (Figure 3 below) is that the uncertainty region is very wide (meaning that inter-annual variability will increase in the future) but still there is no overlapping with the uncertainty region under backcast scenario, meaning that, once again, uncertainty in impact assessment does not preclude the qualitative conclusion that impacts will be highly negative.

Table 1. Parameter values for the catchment model of lake Como (LC) and hydropower reservoir (HR) catchments.

		LC	HR
FC	maximum soil moisture content (mm)	251.9	238.5
LP	limit for potential evapotranspiration	1	0.9
ALFA	response box parameter	0.04	0.02
BETA	exponential parameter in soil routine	0.14	1.06
K	recession coefficient for upper tank (day)	0.29	0.11
K4	recession coefficient for lower tank (day)	0.04	0.04
PERC	maximum flow from upper to lower tank (mm/day)	6.98	0
CFLUX	maximum value of capillarity flow (mm/day)	0	0
MAXBAS	transfer function parameter (day)	1.01	1.21

Page 613, Fig 3: The unit for Fig3b ...
Reply: Yes, labels in the paper are wrong. Units of measures are (a) Celsius degrees, (b) mm per month, (c) mm from the beginning of the year (units of measure changed). Please refer to figure 1 below to check the corrections we made.

Page 616, Fig 6: Why was simulation horizon of 14 years...
Reply: The uncertainty region in Figure 6 is the same as in Figure 5b. We chose h=14 for consistency with the length of the observation time series.

REFERENCES

[1] Consorzio dell'Adda, Gli Afflussi al Lago di Como, Analisi statistiche e modelli di previsione e simulazione [*The lake Como inflows: Statistical Analisys and forecasting and simulation models*], Milano 1986.

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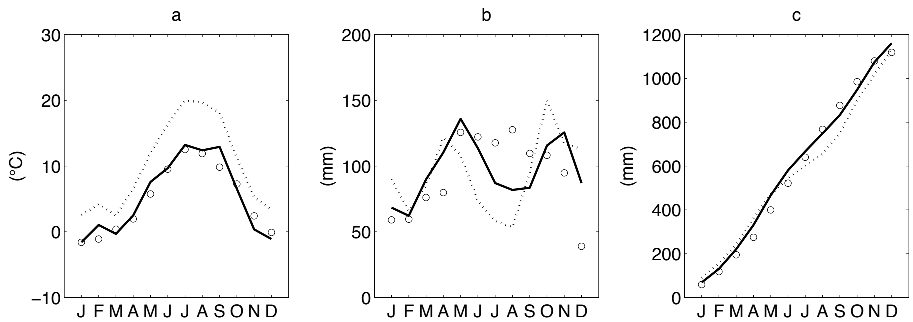

Fig. 1. Mean monthly temperature in the backcast (solid) and forecast (dotted) scenario (a); total monthly precipitation (b); and cumulate precipitation over the year (c) with downscaled RACMO RCM.

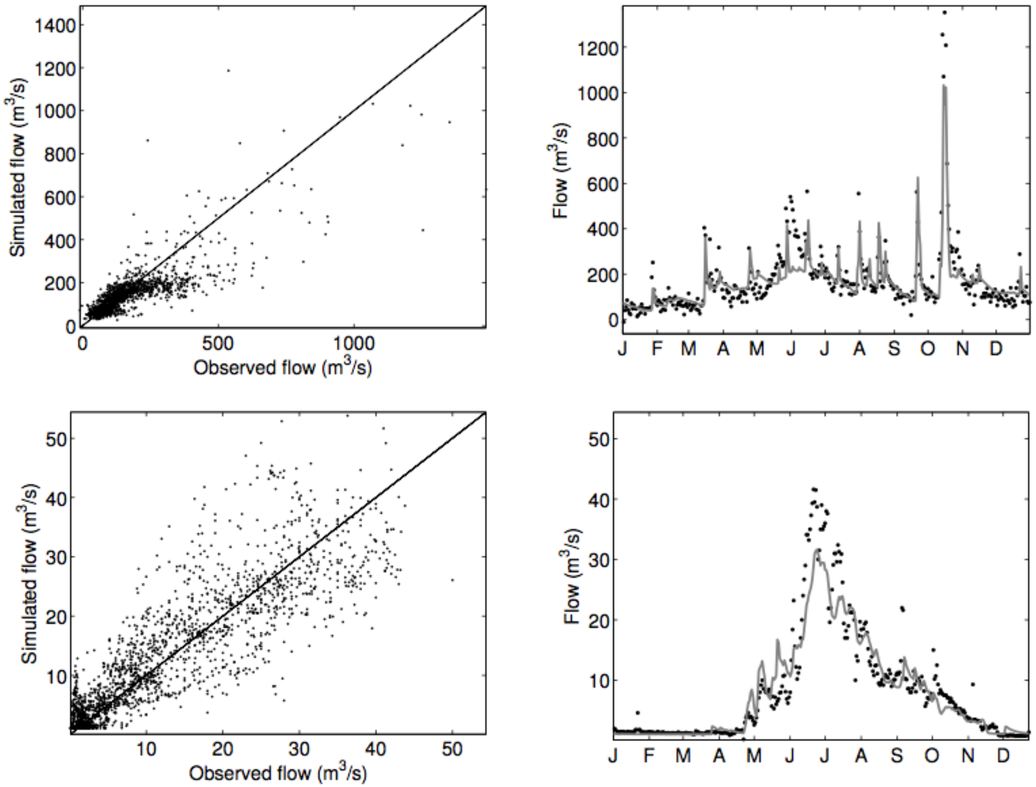

Fig. 2. Left: observed vs simulated flow from lake Como catchment (top) and hydropower reservoir catchment (bottom), validation period (1977-1980). Right: pattern in 1980.

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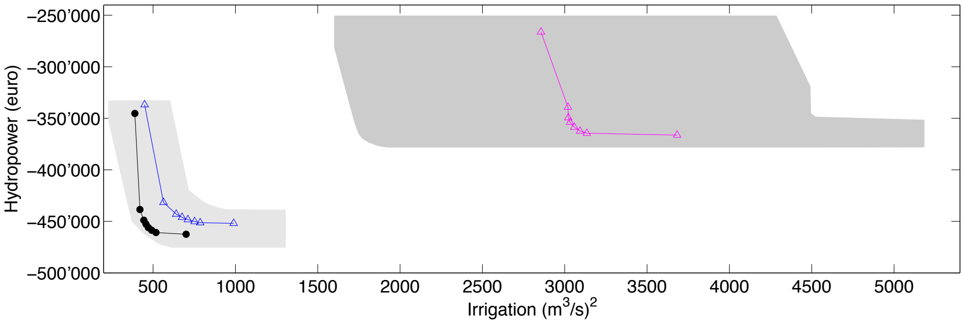

Fig. 3. IPF under historical inflow 1967-1980 (black dots), backcast 1961-1990 (blue triangles) and forecast 2071-2100 (magenta triangles) inflow scenario by RACMO-RCM.