Hydrol. Earth Syst. Sci. Discuss., 6, C1048–C1054, 2009
www.hydrol-earth-syst-sci-discuss.net/6/C1048/2009/

Hydrology and Earth System Sciences Discussions

Interactive comment on "Impacts of climate change scenarios on runoff regimes in the southern Alps" *by* S. Barontini et al.

S. Barontini et al.

barontin@ing.unibs.it

Received and published: 2 June 2009

General comments

The interactive comment was posted on Saturday, May 30th, just a couple of working days before the deadline for the on–line discussion for HESS–Discussion. As a consequence our on–line feedback will not be detailed enough as the Referee would maybe expect. A more detailed comment will be made available to the Editors as soon as we will receive all the Referees' reports and the Editor's comments for the final publication (if any will occur) on HESS.

A general comment is that the Referee requires several additional simulations, sensi-

tivity analyses and an assessment of uncertainty. But the paper is already 53 HESSD pages and 20 HESS pages long, which is a sort of upper limit to HESS papers' size. So to leave space to the requested analyses we should cancel most of our work. We believe the progress of hydrological sciences proceeds by small steps and a few great ideas. We intended to provide just a very small step by:

1. describing in a comprehensive way a GCM downscaling procedure for precipitation that is relatively simple to be applied, has sufficient physical background, provides satisfactory results;
2. describing in a comprehensive way a GCM downscaling procedure for temperature based on observations;
3. perform a climate change impact on total annual runoff and monthly runoff regime for two areas of the Alps less investigated than others, in terms of climate change and hydrology, but relevant being part of the 'Water tower' of Europe.

We agree that a thorough analysis of uncertainties in both the climate forcing and in the hydrological modelling approach would be useful as well. We acknowledge the comments and will provide in the final paper version some further information, but an additional paper would be needed for a comprehensive analysis of all the suggestions made. Then in our opinion a theoretical framework for a sound estimation of uncertainty in distributed hydrological models is not set up yet in the literature and we would open an endless debate which was far from our plans for this paper.

The first point was raised also by Referee #1 and concerns the use of GCM instead of RCM. One of the reason we used standard GCMs is exactly that pointed our by the Referee: several of the RCMs used in the recent past (see Christensen & Christensen, 2007) have a resolution of some tens of kilometres which is still too coarse for the basins we investigated. Therefore a downscaling of precipitation and temperature would be needed in any case. Also using RCMs one could argument that they are too coarse. For instance I could say: why not using a mesoscale non–hydrostatic 1 km resolution model? Our experience when we investigated precipitation prediction with mesosecale models in an area including the Lys basin (see Bacchi & Ranzi, 2003, and the Special Issue of HESS Volume 7(6), 2003) was that using different mesoscale models (with a resolution down to 2 km and also of the non–hydrostatic type) quite different results can be obtained. So probably neither RCMs would be sufficient to simulate realistic precipitation patterns. So we preferred to use GCMs to 'capture' the monthly regimes and their time–structure at large scale predicted by climate modelling. Our stochastic downscaling in space was based on observations.

The second reason is that when we started our research, in 2005, we were looking for GCMs output with daily time resolution, in order to simplify at least the problem of time–downscaling. At that time and also in the following year we had access only to GCM data with this property.

A third reason was that PCM, HADCM and ECHAM are standard GCM widely used in climate change impact studies. Several of the IPCC conclusions concerning precipitation (and also runoff) and important political decisions (e.g. Kyoto protocol) were based mainly on results of that 'family' of GCMs, at the time we started our research. So, we believe it was worth to be investigated how GCMs output, after downscaling, would impact runoff. We do not ignore RCMs, probably if we started now the research we would use RCMs, but our was a decision based on a cost–benefit analysis. Otherwise the use of GCM as meteorological forcing to hydrological model in basin similar to those investigated is still a standard practice. Stahl et al. (2008) use the CGCM3 for IPCC AR4 to force the HBV model for a glacierized basin 152.4 km^2 in size.

Then, we selected PCM because, as Table 3 shows, its objective performances were (slightly) better than ECHAM and definitely better that HADCM. For 8 months out of 12 the monthly rainfall is closer than ECHAM to the observed one. Yes, we could also simulate with other models (and we considered other possibilities), but a selection was made.

Because the hydrological model was not the core of our research, we provided a brief description of some key processes only, i.e. evapotranspiraton losses and soil moisture dynamics which basically control runoff production. We will provide more information on how melt is treated and about the partitioning of precipitation in snow and rain, thus acknowledging the concern of Referee #1 as well. A comprehensive description of the model is described in detail at the website www.watflood.ca we indicated. The average values and the range of variation of the calibration parameters was chosen, as a first trial, after both literature values, the suggestions of the program manual and our experience made with direct field and laboratory measurement. Some parameters, for instance hydraulic conductivity at soil saturation, were chosen on the basis of field and laboratory measurements (see e.g. Barontini et al., 2005, 2009 for the Oglio basin, where about one hundred of sites were sampled) and maps derived from pedotransfer functions: for the Lys basin as reference value we used those obtained from the Benoit et al. (2003) WATFLOOD simulation of the Toce basin, a neighbour basin to the Lys one. Just to say a few, other calibration parameters were the upper soil layers water storage, the lower soil layers water storage, besides those cited at Page 3116, line 25–26. Then the calibration by trial and error of the parameters was performed until the timing and intermittency of the peaks, the runoff volumes and the recession limb of the low flows were satisfactorily reproduced.

In Table 4 we provided data for the bias in the monthly runoff regime, and in the text the correlation coefficient. So it cannot happen that we have double runoff with high correlation coefficient. (Page 3117) Our aim was to assess the impact of climate change on future runoff volumes and regimes (not statistics of extremes and low flows for which a GCM is not suitable) we thought our data were sufficient. Anyway we will provide in the version for HESS other performance criteria.

We do not intend to compare hydrological simulations driven by GCM data with observed runoff on a day–by–day basis, of course! (Page 3117) We provided in Figure 5b a simulation on a daily basis in order to show:

1. how realistic is the pattern of downscaled precipitation considering how smoothed was the original GCM output (see also Figure 3 for the corresponding pdf);
2. how realistic are both the runoff regime and the runoff peaks intensity and intermittency, resulting from the downscaled precipitation.

Page 3112: WATFLOOD was used worldwide, also to simulate basins in the Alps close to our target areas (see the above reference). To better convince the readers that WATFLOOD is a suitable model not better and not worse that other hundreds of hydrological models we can provide off–line some simulations on the hydrological response of different land covers.

Because of the equifinality concept we can try to convince the readers, on the basis of the overall simulation performances, that the used parameterisation is just a suitable one, one out of many others. Because of the distributed type of the model there will be many parameter values (and models) which will provide results as good as ours and maybe better. Our aim was not to find the best modelling framework to simulate recent and future hydrology, but to use in a reasonable way standard tools, applied worldwide, to have some indication on how runoff regimes might change in the current century.

Concerning the way we applied the Kunh's concept a discussion is posted on our reply to the Referee #1 (Page 3113).

In the downscaling procedure we intended to preserve at the best the physics of the GCM model, in order to achieve coherent comparison between actual and future climate scenario. Therefore we chose not to correct the monthly precipitation because this would have altered the GCM provided regime, and to apply the same regime correction to future scenarios would have been arbitrary. The same approach was adopted in order to downscale the temperature. The monthly correction, which the Referee addresses to, was in fact a merely spatial correction, as we did also in the precipitation downscaling. The temperature regime provided by GCM was not changed indeed, as

it is stated in equation 24.

We will change the units of equation 28 (used in the original model) to SI units (Page 3115).

The English can be improved, and the last sentence was not very clear, indeed: probably we arrived there exhausted.

We adapted the structure according to the first editorial comments. We intended to frame our research in the state of the art of climate modelling impact on hydrology and so a reduction of 90% of the introduction leaving a couple of the paragraphs we wrote is not compatible with this objective. We will try to shorten it a little and give, as suggested, more information on the methods used, within the 20 pages limit.

References

- Bacchi, B. and Ranzi, R.: Hydrological and meteorological aspects of floods in the Alps: an overview, Hydrol. Earth Syst. Sci., 7, 785-798, 2003.
- Barontini, S., Clerici, A., Ranzi, R., and Bacchi, B.: Saturated Hydraulic Conductivity and Water Retention Relationships for Alpine Mountain Soils, in: Climate and Hydrology of Mountain Areas, edited by: de Jong, C., Collins, D., and Ranzi, R., John Wiley and Sons, Ltd., 101–121, 2005.
- Barontini, S., Clerici, A., Ranzi, R., and Bacchi, B.: Mapping the upper soil layers saturated hydraulic conductivity in mesoscale alpine basins: a methodology and its applications, in: Hydrology in Mountain Regions: Observations, Processes and Dynamics, HS1003 July 2007 Post–publication, edited by: Marks, D., Red Books, IAHS-AISH Publ. 326: 112–118, 2009.
- Benoit, R., Kouwen, N., Yu, W., Chamberland, S., and Pellerin, P.: Hydrometeorological aspects of the Real-Time Ultrafinescale Forecast Support during the

Special Observing Period of the MAP*, Hydrol. Earth Syst. Sci., 7, 877-889, 2003.

- Christensen, J.H. and Christensen, O.B.: A summary of the PRUDENCE model projections of changes in European climate by the end of this century, Climatic Change, ISSN:0165-0009, Volume 81(1):7–30, DOI: 10.1007/s10584–006–9210–7, 2007.

- Stahl K., Moore, R. D., Shea, J. M., Hutchinson, D. and Cannon, A. J.: Coupled modelling of glacier and streamflow response to future climate scenarios, Water Resour. Res., 44, W02422, doi:10.1029/2007WR005956, 2008.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 6, 3089, 2009.