Hydrol. Earth Syst. Sci. Discuss., 9, C4287–C4293, 2012
www.hydrol-earth-syst-sci-discuss.net/9/C4287/2012/

Hydrology and Earth System Sciences Discussions

Interactive comment on "How will climate change modify river flow regimes in Europe?" *by* C. Schneider et al.

Anonymous Referee #2

Received and published: 17 September 2012

General remarks

This study uses the WaterGap Model to assess the impact of climate change on the river flow conditions in different European basins and climatic zones. As forcing data, the authors utilize climate projections for the mid 21^{st} century from three different climate models to account for the uncertainty of these projections. They derive hydrological flow indicators to characterize the river flow and evaluate the influence of climate change by comparing the projected indicators between the projected and present day results. The strongest impacts are simulated for the Mediterranean and continental regions. Finally, the authors conclude that these results indicate a possible threat to river

ecosystems as well as for the water demanding industry. However, they point out that in Northern Europe climate change might provide an opportunity for water management in accordance with natural flow conditions.

In my option this study is a relevant contribution to our knowledge about possible climate change impacts and fits well into the scope of HESS. I recommend to publish it as soon as some necessary revisions are done.

Major remarks

The Introduction contains a comprehensive overview about the anthropogenic water flow alterations and their possible impacts on economics and environment. I also appreciate the clear formulation of the research questions which are investigated in this study.

However, there is no paragraph about the state of the art in modeling such impacts. Thus, the reader has no information about whether the authors are the first at all to look into this issues, what work has already been done by other groups or how the actual study can be distinguished from similar ones. A quick google search already lists two studies which seem to be related to this topic (*S. Reaney and H. Fowler. Uncertainty estimation of climate change impacts on river flow incorporating stochastic downscaling and hydrological model parameterisation error sources. BHS 10th National Hydrology Symposium, Exeter, 2008* and *Nohara, Daisuke, Akio Kitoh, Masahiro Hosaka, Taikan Oki, 2006: Impact of Climate Change on River Discharge Projected by Multimodel Ensemble. J. Hydrometeor, 7, 1076–1089.*), thus, a short overview about related studies is certainly needed.

The Methodology section describes the model setup and forcing data. While the future simulations were driven with bias corrected projection from GCMs, the baseline run is driven with re-analyzed observation data. However, the analysis of climate

change impact would be much more consistent if the results of the projection data would have been compared to the results of the respective baseline data for the same model, e.g. WaterGap results forced with the IPSL projections compared to WaterGap results forced with IPSL baseline. To my knowledge, the baseline period data is available for all of these models. Thus, the authors need to explain why they choose to compare GCM driven results to observation based (though reanalyzed) results and, thus, introduced additional uncertainty. Also, it would be important to include whether the authors assume this additional uncertainty would affect their overall conclusions or not.

Furthermore, no information about model spin up are given. Is spin-up an issue in WaterGap at all? And if yes, how were the water storages initialized for the different simulations?

On page 9200 L17 the authors state that the Watch Forcing Data are the reference for the bias correction of the GCM projections. However, they are also the reference of the bias correction of the GCM control periods (see above). As reference for the dataset the Harding et al. (2011) paper is cited which is an overview paper about the WATCH project. It would be more appropriate to cite the study which actually generated this data which is *Hagemann, S., C. Chen, J.O. Haerter, J. Heinke, D. Gerten and C. Piani. Impact of a statistical bias correction on the projected hydrological changes obtained from three GCMs and two hydrology models. J. Hydrometeor. 12, 10.1175/2011JHM1336.1: 556-578, 2011*

In the result sections the authors constantly state that the changes in flow indicators and other variables are *significant*. As their database includes a lot of samples and the changes are usually in the range of several percent, I do not doubt this statement. However, significance is a statistical phrase and to use it in scientific literature an analysis should be done to check whether the results are indeed statistically significant. (Unfortunately, this is seldom done but almost always a good thing to check.) If the authors disapprove of such analysis I would recommend to use a phrase like *relevant*

instead.

In the section about flow regimes in different climate zone, the authors use whiskerplots which display the percentiles of grid cells that show a change signal in a climate zone. Here I would like to know how they deal with the different projections. Moreover, the authors state that this percentile analysis is a measure of the robustness of their results. Here I have to disagree. As I understand the explanation of the whiskerplots, the authors did a spatial analysis which indicates the spatial coherence of the change signal. While this is an interesting information it does not say anything about the robustness of the change signal. Instead, it indicates how homogeneous the river flow in a regions reacts to climate change which, of course, does not only depend on the the projected climate change signal but also on topography and other parameters. In order to actually analyse the robustness of the results, the authors have to do a significance analysis.

Minor remarks

- P9195 L8: *Population growth has caused . . .* I wouldn't phrase it as such a direct relation as the increasing demands of our society require land-use changes and this is not due to growth alone.
- 9195 L27: *unfavourable* is a bad choice of phrasing. First, you need to specify to what/whom it is unfavourable (environment, society, all? because for sure it would also be favourable for someone/thing) and second, such a strong statement in the introduction requires proof / a citation.
- P9198 L20: please specify what you mean with *modified* flow conditions. To be comparable to your baseline simulation I guess your projection setup also refers to natural flow condition but changed climatic forcing?

- P9199 L5: As your study is based on the statistic of just two time slices, I cannot see how you would get a *rate* of departure in a most probable non-linear system.
- P9200 L2: A bit more explanation of the calibration (or a citation to the respective article) would be needed here. Is the whole baseline period used for calibration? It is also important to know which parameters are calibrated to be able to judge whether a calibration under present day climate conditions would hold for future simulations under changed climate conditions.
- P9201 L17: I am sure the explanation is given in the reference, but it would save some readers some time to explain the not really obvious indicator *1-day minimum and maximum flow* with a short sentence.
- P9201 L22: Please state clearly whether these indicators were calculated for all four simulations or just for the baseline period and an average of the projections.
- P9204 L13: Please give more specific information about how you used the ensemble median. Did you apply it for all output variables already on the grid cell scale or was it applied after calculating the hydrological indicators. . .
- P9212 L11: The authors explain the wide range of change in winter with *rain on snow events* and emphasize that such events are already observed in nature. However, I expect it should be possible to check in the model whether it is really this process that causes the wider range in the signal.
- P9213 L27: Again I wonder about the *modified*. Do you compare present day natural flow regimes with future, climate change impacted but otherwise not human influenced flow regimes or does the *modified* include more than just climate change?
- P9215 L14-16 While I agree with the authors about the severity of climate change impacts I would rephrase this sentence. This study is not an ecological study. It is

not concerned with ecological projections and anyway they would also have considerable uncertainties. If you speculate about future developments you should not phrase you conclusions in this matter-of-fact fashion. Also you have to rephrase it anyway because not the loss in biodiversity might be the cause of extinction but the other way around.

Technical remarks

- P9195 L 8: domestic *purposes* and others.
- P9195 L9 and 10: *through* doesn't seem to be the right word. Rephrase like: Urbanisation and deforestation result in large sealed areas that alter. . .
- P9195 L23: *higher or lower*: being such vague better write *alteration of*
- P9214 L4: *beside other anthropogenic factors*: This study did not investigate anthropogenic factors beside climate change, thus you cannot make a statement about these.
- P9214 L24: *threat to other anthropogenic factors*? I guess you rather mean that climate change poses a threat additional to other factors.

Please note that I am not a native speaker. So please review my spellings and grammar correction critically instead of just following them without question.

Figures and Tables

- Table 2: Please remind the reader that the threshold exceedances are the *number of indicators* which exceed a certain threshold.

- Figure 1: The color assigned to the polar region and the color of the northernmost part of the map do not match.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 9193, 2012.