**Geoscientific
Model Development
Discussions**

Interactive comment on "A pragmatic approach for the downscaling and bias correction of regional climate simulations – evaluation in hydrological modeling" *by* T. Marke et al.

T. Marke et al.

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THE AUTHORS THANK REVIEWER#1 FOR ALL THE COMMENTS AND
SUGGESTIONS. REVIEWER#1 HAS PUT MUCH WORK AND TIME INTO
THIS REVIEW TO HELP US IMPROVE OUR MANUSCRIPT - THANK YOU
VERY MUCH FOR YOUR ENDEAVORS, THEY ARE HIGHLY APPRECIATED!
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————————— Reviewer#1 comment: —————————

However, an error analysis of the small scale patterns for instance through cross-

validation is not provided. This would however be important to quantify the attainable
accuracy of the downscaling approach and to provide statistical evidence for the quality
of the downscaling method which goes beyond the (very helpful and well described)
analysis of the effects upon the hydrological model. The quality of the observation
based model results (Fig. 5a) however is indirect evidence, that the quality of the me-
teorological input data used in the observation based model runs is quite high.

————————— Authors comment: —————————

The reviewer is right in stating that a meteorological validation of the downscaling ap-
proach (e.g. by cross-validation) would be useful to show the accuracy of the methods
applied. Such meteorological evaluation of the applied meteorlogical simulations and
the presented downscaling approach can be found in various publications, the respec-
tive citations have been added to the manuscript. As the key issue of the present
publication is the hydrological evaluation of the downscaling appraoches, no meteoro-
logical evaluation has been carried out in the framework of our paper. The accurancy of
the presented downscaling approach is however evaluated by analyzing the integrated
response to the meteorological input on the catchment scale.

————————— Reviewer#1 comment: —————————

A short overview/review of frequently used downscaling methods to clarify the need for
a new method would be helpful however.

————————— Authors comment: —————————

The respective section in the paper has been updated accordingly.

————————— Reviewer#1 comment: —————————

Page 47, Line 4: "A clear need has been identified to develop appropriate methods...

————————— Authors comment: —————————

The respective section in the paper has been updated accordingly.

——————————— Reviewer#1 comment: ———————————

Page 47, Line 7: It is unclear what you mean with "currently found limitations in the spatial resolution."

——————————— Authors comment: ———————————

The phase refers to the scale mismatch between RCMs and impact models, the respective section in the manuscript has been updated.

——————————— Reviewer#1 comment: ———————————

Page 47, Line 8: Biases are only defined against a reference.

——————————— Authors comment: ———————————

The respective section in the manuscript has been updated accordingly.

——————————— Reviewer#1 comment: ———————————

Page 47, Line 12: Suggestion to rephrase.

——————————— Authors comment: ———————————

The suggestion has been incorporated.

——————————— Reviewer#1 comment: ———————————

Page 47, Line 21: Suggestion to rephrase.

——————————— Authors comment: ———————————

The suggestion has been incorporated.

——————————— Reviewer#1 comment: ———————————

Page 47, Line 21: Suggestion to rephrase the key sentence with respect to the purpose of this paper.

——————————— Authors comment: ———————————

The respective section of the manuscript has been updated according to the suggestions of reviewer#1.

——————————— Reviewer#1 comment: ———————————

Page 47, Line: 27: rephrase: "It is composed of" instead of "It is composed by".

——————————— Authors comment: ———————————

The sentence has been corrected.

——————————— Reviewer#1 comment: ———————————

Page 48, Line 1: skip the word uncalibrated in this context.

——————————— Authors comment: ———————————

The manuscript has been modified according to the reviewers suggestion.

——————————— Reviewer#1 comment: ———————————

Page 48, line 2: Rephrase: The hydrological model has relatively high requirements with respect to the meteorological input data.

——————————— Authors comment: ———————————

The manuscript has been modified according to the reviewers suggestion.

——————————— Reviewer#1 comment: ———————————

Page 48, line 12: rephrase: The complex topography...

——————————— Authors comment: ———————————

The sentence has been rephrased.

——————————— Reviewer#1 comment: ———————————

Page 47, line 22: skip "itself", is the flow direction of the Danube relevant in this context?

————————— Authors comment: —————————

The suggestion has been incorporated. The fact that the Danube leaves the watershed at the gauge in Achleiten is considered relevant for the presented study as all hydrological results are taken from the grid cell representing this gauge.

————————— Reviewer#1 comment: —————————

Page 59, Fig 1: Delete the word "test" in the heading.

————————— Authors comment: —————————

The word has been deleted in the manuscript.

————————— Reviewer#1 comment: —————————

Delete the word "current" in the heading.

————————— Authors comment: —————————

The heading has been corrected.

————————— Reviewer#1 comment: —————————

Page 61, Fig 3: The figure obviously includes the topography, neither this nor the scale is mentioned in the heading. Heading incomplete!

————————— Authors comment: —————————

Figure and heading have been corrected.

————————— Reviewer#1 comment: —————————

Page 49, Line 15: Rephrase: In the current setup, MM5 resolves the atmosphere with 29 layers. . .

————————— Authors comment: —————————

The respective section has been improved in the manuscript.

————————— Reviewer#1 comment: —————————

Page 49, Line 27: "The latter" reference is ambiguous.

————————— Authors comment: —————————

The manuscript has been modified according to the suggestions.

————————— Reviewer#1 comment: —————————

Shouldn't PROMET be translated as (Processes of Radiation, Mass and Energy Transfer) since there is more than one process it should be a plural

————————— Authors comment: —————————

The manuscript has been modified according to the suggestions.

————————— Reviewer#1 comment: —————————

Page 50, Line 7: heading is not precise Suggestion: use Downscaling approach.

————————— Authors comment: —————————

The manuscript has been modified according to the suggestions.

————————— Reviewer#1 comment: —————————

Page 50, Line 10: replace "in alpine-scale complex terrain" with "in a complex, alpine terrain".

————————— Authors comment: —————————

The mansucript has been updated following the suggestions.

————————— Reviewer#1 comment: —————————

Page 50 Line 10: The general concept behind the approach, however, allows for its ap-

plication in downscaling of temperature, wind speed and air humidity as well. Isn't the purpose of the paper to produce proof of this? Thus the sentence should be rephrased.

———————————— Authors comment: ————————————

The manuscript has been modified according to the suggestions.

———————————— Reviewer#1 comment: ————————————

Page 50, line 17: rephrase: . . . , the subgrid-scale variability is estimated with respect to the RCM grid.

———————————— Authors comment: ————————————

The mansucript has been updated accordingly.

———————————— Reviewer#1 comment: ————————————

Page 50, line 22: ..and is generated by the meteorological preprocessor in the hydrological model PROMET as described in detail by Mauser and Bach (2009). Since this is a key component of the approach it is important to spend a few words on the methodology of the preprocessor in order to understand its validity and suitability to generate spatial patterns. Also, it would be necessary to assess the quality of the preprocessor either by referring to previous study results or by using a suitable evaluation method of the preprosessor quality e.g. by providing error estimates generated from omitting individual measurement sites and estimating their values using the PROMET preprocessor.

———————————— Authors comment: ————————————

Additional information on the meteorological preprocessor has been added to the manuscript.

———————————— Reviewer#1 comment: ————————————

Page 50, line 23: Unclear: The mean monthly conditions are aggregated from 1×1

km. . . Obviously, you refer to the mean monthly patterns generated from hourly maps of meterological parameters derived from the PROMET preprocessor. This is not necessarily clear here.

———————————— Authors comment: ————————————

The manuscript has been updated accordingly.

———————————— Reviewer#1 comment: ————————————

Page 50, line 24: Unclear: This is done in such way that every raster element of the aggregated observed climatology Xobs (m) holds the area weighted mean value of all overlapping fine grid cells of xobs (m) Do you mean: The upscaling to the RCM grid is done by calculating the area weighted mean of all high resolution grid cells xobs (m) which are completely or partially within the respective coarse resolution cell Xobs (m).

———————————— Authors comment: ————————————

The manuscript has been updated following the suggestions.

———————————— Reviewer#1 comment: ————————————

Page 50, line 26: rephrase: The coarse grid cells Xobs (m) are subsequently bilinearly interpolated to generate the high resolution grid. The individual cells of the resulting grid are denotes here as: xobs bil (m).

———————————— Authors comment: ————————————

The suggested changes have been incoporated.

———————————— Reviewer#1 comment: ————————————

Page 51, line 1: rephrase: A downscaling function Fvari (m) is finally calculated as...

———————————— Authors comment: ————————————

The manuscript has been updated accordingly.

———————— Reviewer#1 comment: ————————

Page 51, line 2: explain in more detail or more precisely. Why are the mass and energy budgets imposed by the RCM conserved? The main reasoning seems to be, that the downscaling function derived from the observed data are applied for the data generated from the RCM. This however is not mentioned, but merely implied.

———————— Authors comment: ————————

The respective section has been updated in the manuscript.

———————— Reviewer#1 comment: ————————

Page 51, line 7: As biases in terms of deviations from observed climatological conditions exist in simulations of present-generation RCMs, the quality of the hydrological model results are expected to be compromised by applying uncorrected RCM simulations as meteorological drivers. This is only true if a calibration process does not compensate these biases. This is why a clear statement in the introduction to clarify the basic assumptions and experiment setup (e.g. process based, uncalibrated model) is important.

———————— Authors comment: ————————

Both, the introduction and the section above have been updated to make this more clear.

———————— Reviewer#1 comment: ————————

Page 51, line 18: are these systematic errors accounted for in the measurements? If so, state this with mentioning of the methods used.

———————— Authors comment: ————————

No corrections have been applied, this has been made more clear in the current version of the manuscript.

———————— Reviewer#1 comment: ————————

Page 51, line 20: the country scale is not introduced or relevant in this context. I think you mean generally the large scale of RCM's. Is this correct?

———————— Authors comment: ————————

This part of the manuscript was not quite clear, it has been improved.

———————— Reviewer#1 comment: ————————

Page 51, line 22: the related shift of mass and energy within a given RCM grid box... Shouldn't shift be replaced by redistribution, it is not a shift in the sense of an offset meant here, but mass and energy are conserved and merely redistributed.

———————— Authors comment: ————————

"Shift" has been replaced by "redistribution".

———————— Reviewer#1 comment: ————————

Page 51, Line 29: rephrase: . . . where the seasonal storage of water in the snowpack controls to a large degree the discharge at the outlet of the watersheds.

———————— Authors comment: ————————

The suggested changes have been incoporated.

———————— Reviewer#1 comment: ————————

Page 52, Line 1: replace shift with redistributing.

———————— Authors comment: ————————

The manuscript has been updated following the suggestions.

———————— Reviewer#1 comment: ————————

Page 52, line 17. How do you make sure, that the humidity values after rescaling

and redistribution does not exceed the physical viable limits (e.g. more than 100% rel. humidity).

———————— Authors comment: ————————

Information on these quality checks has been added to the manuscript.

———————— Reviewer#1 comment: ————————

Page 52, line 20 ff: The downscaling of temperature follows a very similar approach, with the difference that the multiplicative correction is substituted by an additive correction term. Provide information on the reasons for this deviation of the general method. If the reasoning is, that a multiplication would not allow a change of the sign at 0 âŮȩC, why not use the Kelvin scale instead? Also, both methods are not equivalent. The multiplicative corrections result in a larger value for large input values as compared to small input values. Thus, at large input values of the coarse grid, the spatial variability (expressed here as Max-Min value within the fine scale grid) at the fine grid scale increases in absolute terms as compared small input values. Is this also the case in the observations? If this is so, than a multiplicative stretch indeed does produce a better representation of the spatial patterns and should not be replaced with an additive term, which maintains the same spatial variability throughout the subscale. Page 53, line 6ff: As illustrated, the combined correction of subgrid-scale variability and bias, compared to the correction of subgrid-scale variability alone, remarkably reduces simulated temperature in large parts of the Alpine foreland, whereas temperatures in the southern part of the Alps are slightly increased Rephrase by using a direct reference: such as: As shown in figure 4, the . . . Do you really mean remarkably in the sense of surprisingly or do you mean, significantly, strongly, largely, Also rephrase: remarkably reduces the simulated temperature in large parts of the Alpine foreland, whereas temperatures in the southern part of the Alps slightly increase.

———————— Authors comment: ————————

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All suggestions have been incorporated in the new version of the manuscript. Explanation for the different treatment of precipitation and temperature has been added.

———————— Reviewer#1 comment: ————————

Page53,line9:Both approaches reflect altitudinal gradients by increasing temperatures in the Alpine valleys and reducing temperatures in the higher elevated parts of the Alps. Verb "reflect" is not appropriate, also briefly elude of the significance of this. Particularly the snow water storage term should be affected by this.

———————— Authors comment: ————————

The respective section has been updated and improved in the manuscript.

———————— Reviewer#1 comment: ————————

Page 53, line 12: For the hydrological evaluation of the presented downscaling approaches, the statistical downscaling of vari and vari&bias is combined with a physically based approach used for the downscaling of surface pressure which is also required as input for the hydrological model. I do not see, why this is important "For the hydrological evaluation of the downscaling approach". Isn't the physical based downscaling approach for a variable such as surface pressure due to its simplicity and accuracy the preferred method anyways, irrespective of the application?

———————— Authors comment: ————————

The reviewer is totally right suggesting that a physical based downscaling approach is most appropriate for remapping of surface pressure. However, as we mention the different variables required as input for the hydrological model, we think it is important to at least mention the downscaling of surface pressure for the sake of completeness.

———————— Reviewer#1 comment: ————————

Page 53, line 17: rephrase: As recordings of incoming longwave and shortwave radiation are scarce Also, is the scarcity of the data really the main issue here? Or isn't the

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fact, that variation along altitudinal gradients – which is a basic prerequisite in the application of the PROMET meteo. preprosessor- is by far less important than variations due to cloud cover? The scarcity of the data would - to my judgement - even warrant the use of a downscaling approach, if this approach would be applicable to the variable at all. Thus the reasoning provided here is not conclusive.

——————————— Authors comment: ———————————

Our downscaling approach is based on the availability of high-resolution long-time meteorlogical observation data, which are not available in the case of long- and shortwave radiation. This 'scarcity of data' does not warrant the use of the downscaling approach presented in this paper, but rather makes its use impossible.

——————————— Reviewer#1 comment: ———————————

Page 53: line 25: rephrase: To provide a spin-up time for the hydrological model of one year, the period considered in the subsequent evaluation is limited to the years 1972–2000.

——————————— Authors comment: ———————————

The manuscript has been updated following the suggestions.

——————————— Reviewer#1 comment: ———————————

Page 55: Line 9: Rephrase: Compared to a model run using meteorological site measurements instead of meteorological data from a downscaled RCM, the model results obtained with PROMET shows, persistent deviations from the runoff measurements at Achleiten. These differences which cannot be traced back to biases in precipitation, temperature, humidity and wind speed.

——————————— Authors comment: ———————————

The respective section has been updated and improved in the manuscript.

——————————— Reviewer#1 comment: ———————————

Page 55, line 26: rephrase: ... never reproduce exactly the observed temporal evolution.

——————————— Authors comment: ———————————

The section has been updated and improved in the manuscript.

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THANK YOU VERY MUCH FOR YOUR COMMENTS!!!

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