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Discussions

Interactive comment on "Optimising predictor domains for spatially coherent precipitation downscaling" *by* S. Radanovics et al.

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Text in bold face correspond to the reviewer's comment, while the authors's answers are in normal font.

Summary: This study presents an optimization algorithm for predictor domains for precipitation downscaling. The method is applied to 608 target zones (obtained from Safran) in France. The authors optimize the locations and sizes of individual geopotential predictor domains, and use these domains as data pool for the analogue downscaling method. The spatial distribution of the shapes and locations of these domains are discussed, and analyzed regarding optimization parameters and archive length. The authors conclude that the extended version

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of the growing rectangular domain algorithm finds the most relevant predictor domain and improves the prediction skill. The study covers an interesting subject which is rarely addressed.

The authors would like to thank the reviewer for the positive consideration of the presented subject.

However, some comments need to be addressed to clarify the approach, results, and their analysis. I think the following issues must be discussed in more detail:

General comments

1. The computational cost of the algorithm seems to be comparatively low, but the optimization is restricted only to the geopotential predictor domain. What are the reasons for your decision? Is the method not applicable for more complex predictors (domains)?

Please see the response to specific comment 7 from reviewer 1. In brief, geopotential was chosen because it is the most important predictor in this method. Optimising only one variable moreover allowed us to explore near-optimum domains for a large number of target locations.

2. Why did you use ERA reanalysis data and not ERA-Interim?

ERA-40 still has a slightly longer archive than ERA-Interim and a long archive is very important for the analogue method, because the analogue method can not create situations that are not in the archive. The longer the archive the more rare situations will be included. Additionally, the longer archive made it possible to look at the sensitivity to the archive length. Thirdly, the method has been developed using ERA-40 data, so the use of this reanalysis here ensured consistency with previous works. Changes were made to the text in section 2.1.1.

3. In the first paragraph in Section 2.1.2 (L 18/19) you write "These as well as the

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case study zones are colored in Fig. 1". It is not obvious what you are referring to, the relevance maps (which you have mentioned in the sentence before), the country border or the Safran zones.

These refer to the Safran zones at the geographical limits of the country. The sentence has been changed to clarify that.

4. In Section 2.2 you need to give a short overview of the downscaling method before describing each step in detail.

A short overview of the downscaling method has been added in section 2.2.

5. On Page 4024 (L9-18) the Teweles and Wobus criteria is introduced, what measures the similarity of zonal- meridional gradients between "different points" of the predictor domain. Do you mean the gradient between each grid point and its surrounding neighbors? If not, what do you mean with "between different points"?

The gradients are calculated between each grid point and all other gridpoints on the same longitude or latitude. It has been clarified in the text.

6. Is there a reason why the grid for the relevance maps consists of a 2x2 ERA40 grid? Why not just taking one grid cell?

The reason is the use of the Teweles and Wobus shape criteria that is based on the calculation of gradients i.e. differences between two grid points.

7. The optimization method extend the predictor domain in all 4 directions by adding on grid point and then selects the best domain according to the CRPS. Thus, the predictor domains can only take rectangular shapes. However, most patterns in the relevance plots show a concave shape, which are difficult to capture by this method. You probably receive better results, if each grid cell is allowed to extend the domain and not only the entire box. This would guarantee to find non-rectangular shapes as they appear in the plot.

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This is a very interesting comment. Probably we could get better results this way, but Bontron (2004) did an experiment using non-rectangular but still convex predictor domains that were dynamically adapted to the daily flow conditions, i.e., varying from day to day, and did not find them to be more skillfull than a static rectangular domain. In addition allowing each gridcell to extend the domain would considerably increase the computation time and for this study it has been decided to invest the computation time rather in exploring a large number of target locations. A comment has been added in Section 2.5.

8. In the last paragraph of Section 3.2.1 the differences in the skills between the best and the fifth best domain is discussed, and differences are very small. At some locations the domains have different aspect ratios, but the performance is almost the same. Could you please discuss in more detail why there is almost no difference. (Maybe this is related to the correlation length).

The almost same performance despite the different aspect ratios of the domains exemplifies the equifinality thesis i.e., that sometimes quite different parameter sets can have the same performance. The equifinality arises because the objective function, the CRPS in this study, temporally aggregates differences. So the same CRPS can be obtained for different reasons. The authors did not fully understand the final part of the comment on the correlation length.

9. I had really difficulties to understand the Figures 5-8. Could you please describe the figures in more detail.

The figure captions have been extended trying to better explain the meaning of the colour schemes.

10. On P4034/L2 you write: "... comprise the large scale grid cell". I do not understand what you are referring to. Do you mean "... comprises only of one large scale grid cell"?

The large scale grid cells that belong to the starting domain will be included in the final domains because the growing rectangular domain algorithm only adds rows or columns of grid cells in each step and never subtracts some. The paragraph has been reformulated.

11. The optimization method has been started from different starting points and the same predictor domains have been found (P4034/L11-26). This is probably not always the case and should therefore be discussed.

This is indeed not always the case as exemplified for the Saône case study zone. This has already been discussed in section 3.3.1 of the submitted manuscript. Changes have been made in section 4.2 to better highlight and explain this point.

12. P4034/L21: "... indeed better domains can be found if more possible domains are explored through the extended algorithm and ...." What are better domains? (downscaling results, spatial pattern etc.) I cannot see why these patterns should be better.

Better means higher CRPSS here. This has been clarified in the text.

13. How much better are the optimized domains compared to other (arbitrary) domains or even one grid point?

An additional experiment has been performed optimising predictor domains for the mean precipitation over the whole country. For details see answer to specific comment number 22 of referee1, the new figure 5 and the revised section 3.2.1.

14. In the conclusion you write: " . . . that the performance of this method (common predictor domain) is far from optimal ...". You need to prove that the proposed method is indeed better than other methods. Without any results it is nearly impossible to see why the proposed method is superior.

The analysis shown in the new figure 5 using a domain optimised for the mean precipitation over the whole country shows that even if the average improvement is moderate

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it is large for the south-eastern part of the country and very large for specific locations. (See also answer to comment 13.)

SPECIFIC COMMENTS

1. P 4018 line 4: Please write "Model Output Statistics (MOS)"

Changed as requested.

2. P 4019 lines 4-5: Please make two sentences: " . . . here precipitation. These predictors should be ..."

Changed as requested.

3. P 4019 line 19: Please change to " Some studies tested . . ."

Changed as requested.

4. P 4019 lines 21-26: "... close to the target location, and therefore ...", "... likely to be sufficient. The predictor domains ..."

Changed as requested.

5. P 4019 lines 25-29: Please write something like "... Italy and compared the performance with those of all groups together."

Changed as requested.

6. P 4020 L 1: What do you mean with center?

Center means the barycentre of all groups of stations. This has been clarified in the text.

7. P 4020 L 2: What do you mean with "... benefit from individual prediction domains"?

For the groups far from the barycentre of all groups the skill was clearly better using

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the individually optimised domains. This has been clarified in the text.

8. P 4020 L 21: Change "will be" to "is"

Changed as requested.

9. P 4020 L 21: Change to "... question: Is ..."

Changed as requested.

10. P 4021 L18: "... are used as predictand ..."

Changed as requested.

11. P 4025 L 11: "... pressure levels, time and the number of analogues at each step . . . . . ., where they were ...", "It has also to be noted, that ..."

Changed as requested.

12. P 4025 L 23: Change to "Heaviside"

Changed as requested.

13. P 4026 L 1: "... as described in Hersbach (2000). The CRPS ..."

Changed as requested.

14. P 4026 L 17: Change "spatial unit" to "location"

Changed as requested.

15. P 4027 L 13: "For these 4 resulting domains the CRPS are calculated ..."

Changed as requested.

16. P 4027 L 14: "... is then used ..."

Changed as requested.

17. P 4027 L 19: Is there so much improvement using 5 domains? In the result

section you describe that there are hardly any differences.

The improvement lies in the use of different domains that lead to similar skill, recognizing the principle of equifinality instead of relying solely on a numerical optimisation with the temporally aggregated CRPS as an objective function.

18. P 4028 L 17-22: This is a very long sentence.

The sentence has been divided.

19. P 4029 L 5: "... (cf. Fig. 1) calculated from the 20 yr ..."

Changed as requested.

20. P 4037 L 5: ". . . this choice. The Saone case study zone is situated north ..."

Changed as requested.

21. P 4037 L 7-8: "... while the rest is the same ..."

The paragraph has been reformulated.

22. P 4037 L 14: Please change the expression "... validity of the assumption ..."

Changed to "hypothesis".

23. P 4038 L 4: "dsclim" in italics

Changed as requested.

24. P 4040 L 9: "guaranteed"

Changed as requested.

25. Figure 1: Enlarge the figure and better highlight the corresponding zones in the map. It is really difficult to locate the zones.

Figure changed as requested.

26. Figures 3-11: It would be better to provide a discrete color scale.

We prefer to keep the continuous colour scales. A discrete colour scale for figures 3-6 and 9-11 would require to set arbitrary and relevant thresholds for CRPSS, which is not straightforward. For figures 7 and 8, it seems quite relevant to identify where there are or not smooth gradients and this requires a continuous colour scale.

27. Figure 7-8: Please provide the outline of France in the inlets (like in figure 7a)

This does not make sense for figures other than 7a since only in figure 7a the colour corresponds to a geographical location while in figure 7b and 8a the colour corresponds to a length or distance measured in degrees longitude or latitude and in figure 8b to a ratio of two lengths. This has been clarified in the figure captions.

References

Bontron, G. (2004). *Prévision quantitative des précipitations : adaptation probabiliste par recherche d'analogues. Utilisation des réanalyses NCEP/NCAR et application aux précipitations du Sud-Est de la France*. Thèse de doctorat, Institut National Polytechnique de Grenoble. (in French).

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