

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 editor’s comment, while the authors’s answers are in normal font.

I thank the reviewers for their comments and the authors for their reply. The reviewers raise interesting points. For example reviewer 1 asked a valid question about the domains, which the authors have addressed by an additional experiment. This argument is expanded by reviewer 2, who asks for irregular domains as a rectangular shape is counter intuitive to the concave patterns observed. The authors respond that in an earlier study no significant difference was found and that the computational burden would be to high. I am agree with the reviewer and

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believe that a future study should concentrate on non rectangular shapes (the study the authors quote was published in 2004 and technology has significantly advanced, which should allow to mitigate the additional computational burden)

The authors would like to thank the Editor for this comment. Indeed, the relevance maps in this work indicate that non-rectangular domains might be best suited for geopotential predictors. Referee #2 (T. Sauter) suggested in his comments a promising way to identify such domains. The proposed algorithm could be implemented for a given target location, in a similar setup as presented by Sauter and Venema (2011). However, as indicated in the responses, applying it to the 608 target zones paving France would be much more computationally demanding than the current algorithm that has been especially selected for looking at numerous target locations. Furthermore, even if the computational burden could be mitigated, we still feel that the usefulness of using more complicated domains might be limited since the earlier study (Bontron, 2004) showed no significant improvement using non-rectangular flow-dependent predictor domains. Additionally the risk of overfitting would increase and the question arisen by Referee #1 (general comment #2) on the robustness under climate change conditions would become even more urgent.

The reviewers question: “Why did you use ERA reanalysis data and not ERA-Interim?”. The authors respond: “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.” ERA-Interim data length is 32 years and of higher resolution. The sensitivity analysis is performed with respect to 20 years, thus it could have been also done with ERA- Interim. Indeed the authors show (and quote references) indicating that there is not much impact for time series beyond 20 years. Thus I feel the rebuttal needs to address this issue in a revised manuscript better.

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The authors provided some response to the open question by Referee #2 (T. Sauter) about the choice of ERA-40 as a large-scale reanalysis archive instead of ERA-Interim. The authors agree with the Editor that these responses were not complete enough, even if the submitted first version of the revised manuscript included some additional grounds for this choice. The Editor suggests the use of ERA-Interim as the large-scale archive, arguing for a higher resolution and a sufficient data length. We definitely agree that ERA-Interim is indeed a more state-of-the-art product but the following paragraphs bring some more information to understand our choice of ERA-40. These additional points have been now added in the revised manuscript.

1. Concerning the higher spatial resolution, we believe that it would not bring much to the present work based on the following points:
 - First, the downscaling method used here has been developed by Ben Daoud et al. (2011) based on a 2.5 degree large-scale archive. Consequently, the variables used in steps 1, 3 and 4 (temperature, vertical velocity and humidity, respectively) are considered over the 2.5 degree grid cell nearest to the target location. This method thus implicitly makes the hypothesis that the largest information content for these variables is located at the nearest grid cell, which seems reasonable at this coarse resolution. However, using a much higher resolution like the 0.75 degree resolution of ERA-Interim may imply that the hypothesis of using the nearest grid cell is not appropriate anymore. One may think of humidity over the Mediterranean that is responsible for high precipitation events in the inland Cévennes area. If on the other hand the domain size for these variables is kept identical by using more grid cells, it would imply to consider and understand the impact of the spatial structure of these predictors, which would add complexity to the method and make it less parsimonious (see on this point general comment #2 from Referee #1).

- Second, using an archive with a higher resolution may indeed lead to higher skill scores with the current method. Preliminary tests have been performed by Ben Daoud (2010) with a 1.125 degree version of ERA-40 and the version of the downscaling method developed by Bontron and Obled (2005) that considers only two analogy levels on geopotential and humidity. He found only very small improvements in skill for three locations close to the Saône case study zone compared to the 2.5 degree version. Moreover, the optimised domains found for geopotential with the higher resolution archive were quite similar to the ones found with the 2.5 degree archive.
 - Third, the present work showed that geopotential domains differing by one 2.5 degree grid cell in latitude and/or longitude lead to very similar skill scores, exemplifying the equifinality issue when using the CRPSS as the objective function for optimising the domains. Using a higher resolution large-scale archive would naturally lead to numerous potential domains with a skill score higher than a given threshold. Exploring the equifinality issue in that case would therefore necessitate to retain a much higher number of near-optimum domains to find out a diversity of domains as large as the one identified here qualitatively in a 5-member ensemble.
 - Fourth, a higher resolution for geopotential height fields would dramatically increase the computational time for (1) computing the similarity shape criterion for a given domain and (2) exploring the potential domains during the optimisation phase.
2. Concerning the length of the archive, ERA-40 with a 44 yr data length was preferred over ERA-Interim for the following reasons:
- First, to reiterate our response to the comment from Referee #2 (T. Sauter), having the longest large-scale and fine-scale archives makes it possible to increase the potential skill of the analogue method by providing a larger archive for searching for analogue dates.

- Second, and more relevant to the present work, using a 44 yr reanalysis made it possible to look at the sensitivity of the archive length, by considering periods of 20 yr and 44 yr for optimising the predictor domains. It highlighted that if for some locations the predictor domains found were fairly similar, it was definitely not the case for the Ardèche zone where quite different domains were found when considering a 44yr archive. As suggested in the manuscript, this could be due to the high internannual variability of precipitation in this zone located in the Cévennes region. The references quoted in the manuscript and mentioned by the Editor in his comment (Timbal et al., 2003) indeed found that using a period longer than 20 yr did not reduced significantly the error, but the predictand variable considered in their study was daily minimum and maximum temperature. Such variables have presumably a smaller interannual variability than precipitation at some specific locations like the Cévennes area (Vidal et al., 2010). The above comment on this specific reference has been now added to the corresponding discussion section of the manuscript.
- Third, using only a 20 yr period out of a longer archive for optimising the predictor domains further gave the opportunity to answer the following comment by P. Horton “The influence of the archive length is interesting (section 3.3.3, p. 4035). As you identified different predictor domains according to the archive length, it would be interesting to quantify the loss of CRPSS when you switch the domains”. Additional calculations could thus be performed to quantify the skill loss for the Ardèche case study zone when using the domain optimised over a given period for application over a shorter or longer period. Results are provided in the submitted revised version of the manuscript: “A slight reduction of skill over these 20 yr (0.282 to .275) can be observed for the Ardèche zone when considering the domains optimised over 44 yr. Additionally, the skill computed over the 44 yr is slightly lower (0.305 to 0.310) for the domains optimised over 20 yr compared to the ones

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- optimised over 44 yr."
- Fourth, and even more critically, using a 20 yr period out of 44 yrs allows to have a totally independent period for validation purposes. Validation experiments are currently underway to quantify the time transferability of the optimised domains, building further on the comment by P. Horton recalled above. Indeed, one may use the last 20 yr period (1) to optimise the predictor domains as done in the present work and (2) as an archive of analogue dates. The downscaling method defined in such way may then be tested on a totally independent period, e.g. the first 20 yr of data, not previously used in any way by the method, in a rigorous split-sample approach as defined by Klemeš (1986). Using data this way also allows for further cross-validation set-ups, e.g. using an archive of the same length that has not been used for the optimisation or based on climate characteristics of sub-periods (wet years vs. dry years).
3. Finally, the Safran local-scale reanalysis has used ERA-40 as a first guess for computing vertical profiles of near-surface variables. Using the same reanalysis thus definitely ensures consistency between the large-scale and local-scale archives used by the downscaling method.

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