Review of the HYDROL21431 paper:

**Using genetic algorithms to optimize the analogue method for precipitation downscaling in the Swiss Alps**

*by Horton P., Jaboyedoff J., and Obled C.*

# Summary

The authors present a methodology to optimize the parameters of an analogue-based precipitation downscaling system using genetic algorithms (GA). The GA is not only an optimization technique but allows discovering parameter inter-dependencies and possibly give a better understanding of the dynamics that lead to high precipitation accumulations in Canton Valais, Switzerland.

The paper is well written and a pleasure to read. I believe that the use of genetic algorithms within analogue-based forecasting techniques is an interesting idea. In fact, it increases the objectivity of current “rule-of-thumb” decisions that are done to drive the selection of analogue situations. Consequently, I recommend the publication of the paper after having addressed the remarks that I list hereafter.

# Major comments

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| Page 4, Line 66  Page 5, line 97  Page 5, line 8-9  Page 6, line 122  Page 9, line 200-202  Page 10, line 226  Page 13, line 316  Page 14, lines 351- 356 | I would rather put the equation just after mentioning the Teweless-Wobus criterion S1.  Here I would also mention that the skill of analogue forecasts that include as predictor variable the moisture index depends on the skill of the NWP model in predicting moisture fields (when used in real-time).  Does the AM perform well also when looking for analogues for a single rain gauge? What is the consequence of computing a local average given the high spatial variability and intermittency of precipitation, e.g. for convective cases? There is no need to do analysis to answer this question  Is the climatological distribution of precipitation over a single day sufficiently stable as reference to account for seasonality? Have you tried to include a temporal smoothing or pool the data over days before and after the given day?  A harder reference to beat could be the Eulerian persistence forecast (the precipitation observed on the previous day).  What is the overlapping constraint? The expression “what the sequential calibration cannot do” is not clear to me.  It would be very interesting to show a plot with the CP and VP error as a function of number of predictors to illustrate that the VP error reaches an optimum around 4 predictors while the CP error keeps decreasing for increasing number of predictors (overfitting).  You could add that there are multiple local optima in very different regions of the parameter space that provide sufficiently good performance. Instead of using only one single optimal solution for the selection of analogues, you could use an ensemble of optimal solutions. This way you could both account for the parameter uncertainty of the analogue technique and increase the number of samples contributing to the empirical distribution of precipitation at the rain gauge (ensemble size). This could be considered for future studies.  When optimizing an error function depending on precipitation totals, the |

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| Page 17, line 435-438  Page 17, line 450  Page 20, line 536 Figures and Tables | large precipitation values (and errors) will contribute more to the total error. Thus, using GA allows to minimize the forecast error in particular for days with high precipitation accumulations. Therefore, it is quite reasonable that you beat the reference method, which has no optimization of an error function.  Could the over-parametrization of the regions be due to the larger spatial variability of moisture fields? Pressure fields are known to be smoother and could be expected to generalize more to close regions than moisture fields.  It would be interesting to mention that there is an interdependence between the location (or size) of the spatial window and the temporal window. In fact, if we follow Taylor’s hypothesis, space and time could be easily related if we consider a moving precipitation system (or other) that has no significant growth and decay processes. More we go backwards in time more we have to move upstream the analogy window.  I wonder whether it would be useful to compute and show a correlation matrix between the different predictors.  The number of figures and tables in the paper is quite high, but I do not know which ones could be removed, perhaps those that are not discussed in detail in text or that are giving redundant conclusions. |

**Minor comments**

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| Abstract, line 2  Abstract, par 2, line 2  Page 2, line 9  Page 2, Line 15  Page 2, Line 21  Page 3, Line 26  Page 3, lines 27-29  Page 3, Line 30  Page 3, Line 31  Page 3, Line 44  Page 4, Line 74  Page 5, Line 81  Page 5, line 102 | “provided by global models” is a bit too general. I would rather use general circulation models or numerical weather prediction models.  “strong limitations”. You could complete the sentence by listing a couple of them.  “Other predictands are also often considered”. Here I would also add which ones, e.g. …  “get down”  resolve, compute, forecast. I would use a more appropriate term.  “made”  “designed”?  “criterion itself” or “criteria themselves”  Here you could also mention that ad-hoc techniques for the selection of predictors were also used by Panziera et al. (2011) and Foresti et al. (2015) for ensemble radar rainfall nowcasting. The GA technique could also be adapted for these applications.  I would find a better term for “reconsidering” “pressure levels”  “optimal pressure levels”  “on precipitation predicting”  “for precipitation prediction”  “of the geopotential height”. I would add “, which represent better the upper level flow direction”  “both North and East directions”  “Predictors are generally extracted from reanalysis datasets” |

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| Page 6, line 111  Page 7, line 133  Page 8, line 165  Page 9, line 196  Page 9, line 204  Page 9, 205  Page 9, line 209  Page 9, line 211  Page 10, line 225  Page 10, line 229  Page 10, line 239  Page 11, line 263  Page 11, line 276  Page 14, lines 360-365  Page 15, line 382  Page 18, line 481  Page 20, line 522  Page 21, line 544  Page 21, line 555  Figure 2 and 7  Table 1-3  Table 6 | It would be interesting to mention that you are trying to verify the performance of an ensemble-probabilistic forecast technique.  “complex surface”. You could add that you are trying to find the global optimum of a complex high-dimensional error function having multiple local optima.  Here you could add that the high spatial variability of precipitation is due to complex orography.  “are not provided in this paper”  “respectively, w.r.t. the reference method based on Z500 and Z1000” “tremendous”  “very significant”, “large”  “other parameters (…)” “and may”  “but may”  “but always more to a smaller extent” could be rephrased  “another region than Valais” to clarify that it is not another region within your domain.  “name”  “named”  “cross-compatibility and spatial coherence of the optimized parameters” “significant preference in the AM” is not clear.  Does this mean that the two levels of analogy bring complementary information (not independent)? This is a good finding.  “spatial shift”? “does not”  “what the sequential calibration” is a strange expression to me. “dependence in the selected parameters”  “significantly more improved”  “improved further” or other  Would it be better to put the actual pressure levels (Z500, Z1000, etc) instead of the four levels (Z1, …, Z4)?  It is not clear if the provided hour (12h, 24h) is for the day before the target day that we want to forecast.  In the caption I would make clear whether the improvement is w.r.t. climatology or the reference method. |

**References**

* Panziera L, Germann U, Gabella M, Mandapaka PV (2011) NORA -nowcasting of orographic rainfall by means of analogues. Q. J. R.Meteorol. Soc.137(661): 2106–2123.
* Foresti, L., Panziera, L., Mandapaka, P. V., Germann, U., and Seed, A. (2015) Retrieval of analogue radar images for ensemble nowcasting of orographic rainfall, Meteorol. Appl., 22, 141–155.