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Interactive comment on "Long-range forecasting of intermittent streamflow" *by* F. F. van Ogtrop et al.

F. F. van Ogtrop et al.

floris.vanogtrop@sydney.edu.au

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Thank you for your thorough and insightful review of our paper, which has allowed us to improve some components of the paper.

p682l4: Point taken on the tautology. We use a statistical approach to get a probabilistic outcome as opposed to a volumetric outcome.

p686l14: Indeed, we, as have others, have made the additive assumption [i.e. Sharma, A., Luk, K. C., Cordery, I., and Lall, U.: Seasonal to interannual rainfall probabilistic forecasts for improved water supply management: Part 2âĂŤPredictor identification of quarterly rainfall using ocean-atmosphere information, Journal of Hydrology, 239, 240-248, 2000.]. However, as you suggest it may be worthwhile checking this assumption

by, for example, comparing the additive model to surface smoothing [Xiang, D.: Fitting generalized additive models with the GAM procedure, SAS Institute Paper P, 256, 2001.]. However, an option for surface smoothing has not yet been implemented in the gamlss package for B-splines and this is work in progress. We did perform a test using a loess smooth function in gamlss and cubic spline in the mgcv package and found little difference between the surface smoothing and additive models. Following your advice, we will mention this in the revised text.

p688l3: We have only used the time covariate on the analysis of the Balonne River data. Our justification of this is that river extraction has and is occurring along this river system. We hypothesised that a flexible spline of time may be able to account for river water extraction. It is understood that it will be very difficult to pre-empt farmer decisions and shifts in government policy which will have an impact on our forecast skill in this system and this coupled with climate variability. As a result we have also used the naturalised streamflow dataset for the Balonne which has been adjusted for water extraction. The use of the naturalised dataset does introduce a new source of uncertainty into the model and at this stage this is difficult to take into account.

p705tbl4: The use of a stepwise approach is certainly a point of discussion. Economist Paulo Santos or biometricians such as Frank Harrel, would warn against using a stepwise approach. They would argue that given knowledge of the process that you are investigating, you should be able to choose covariates accordingly to form the model, Even if the covariates are not necessarily significant. In fact, if the choice to include or reject a term in a regression is based on a p-value, this p-value may be something of the order of 0.5 rather than 0.05. One could argue that this could also be done here, and indeed full models using these few simplistic predictors were tested and found to perform slightly better in some cases (in terms of skill) than the reduced (or parsimonious) models. With the limited number of covariates in this study this would not be an issue. However, if more covariates were to be considered (such as SST anywhere in the world) we could use the stepwise approach to reduce the number of covariates (for example using the STATA package we can use 100s of covariates without running into memory problems) or we could adopt the partial mutual information approach suggested in the paper by Sharma [Sharma A. (2000) Seasonal to interannual rainfall probabilistic forecasts for improved water supply management: Part 3 - A nonparametric probabilistic forecast model. Journal of Hydrology 239:249-258.]. This is why we persist with using the stepwise approach as a point of demonstration, and we will include this point in the revised manuscript.

I also agree that it may be worth comparing backward and forward backward stepwise approaches for covariate selection but this is probably better for larger models. However, one nice feature of the approach is that both linear and nonlinear terms may be selected so we are really selecting for a parsimonious model.

We will acknowledge the text mentioned [Sharma A. (2000) Seasonal to interannual rainfall probabilistic forecasts for improved water supply management: Part 3 - A nonparametric probabilistic forecast model. Journal of Hydrology 239:249-258.] as a potential means of selecting covariates based on a global dataset. However, we are keen to report this simple and computationally efficient method using a limited set of covariates as we believe it can be effectively applied anywhere. Furthermore, and to our knowledge, the comparison has not been made between GAMs and the kernel density estimate techniques suggested in Sharma (2000). However, if these results have been published please let us know. As a preliminary test, I conducted a test to compare gamlss (solid line) with the kernel method (dotted line) suggested by Sharma (2000) and found pretty similar results (Fig 1). By manually changing the degrees of freedom in the smoother or the bandwidth in the kernel density estimate, the results become closer. The initial, notable, difference was the overall computing time, with GAMs running significantly faster. We believe this is an area to explore in the future. Interestingly, I have considered using a kernel density estimate of the population distribution in the gamlss framework but have not yet thought about the validity of this approach.

It is acknowledged that there may be an upper limit to seasonal rainfall predictability, and indeed this may not be very high. However, as it is stated in the paper by Westra and Sharma [Westra S., Sharma A. (2010) An upper limit to seasonal rainfall predictability? Journal of Climate 23:3332-3351. DOI: 10.1175/2010JCLI3212.1.] there is room for improvement and this is what we were aiming to do. In this case we expected gamlss (as opposed to linear models or gam) to push these potential boundaries because more flexible relationships can be considered between SST and/or other predictors not considered here. p707t6: Indeed, the stepwise approach is the reason for these models being different. Based on the cross correlation between the Parroo and Bulloo rivers, one might expect more similarity in the models based on the selection criteria (Fig 2). This probably adds weight to using the full model. However, we decided to use a stepwise approach for reasons discussed above.

It is possible to demonstrate the stability of the models by reporting each of the models from the leave one out cross-validation steps, but this would make for a very large Table in the paper. This information could potentially be added later as supplementary data. From our experiments we observed that the models do not change much as one steps through time. Using the full models, we do find some spatial heterogeneity in the models. Although we do not investigate this further, a likely reason is the relative "slowness" of the systems in this region. Hydrological events may take months to move from the northern and eastern extremes of the catchments to the south western catchments. Thus the relationship between signals will be different at any point in time. I suppose what is important is that this difference is consistent in time which in this case it generally is. Considering that streamflow is seasonal, it would also be expected that aggregating the data to seasonal would go some way towards eliminating this heterogeneity because any lag between and within catchments will be absorbed in the average.

p712fig4 We can include the following plot for the Thomson river in the final document (Fig 3). It is indeed rather busy but it does show how the forecast probability changes based on wetter and drier periods. Currently the predict function in the gamlss package does not output standard errors hence the confidence intervals have not been estimated at this stage. This function is currently being developed. We will keep the output strictly probabilistic as opposed to volumetric for reasons well argued by Krzysztofowicz [Krzysztofowicz, R.: The case for probabilistic forecasting in hydrology, Journal of Hydrology, 249, 2-9, 2001.].

It has been suggested that there may be problems associated with edge effects. However, one nice property of using B or P splines is that these do not suffer from boundary problems or edge effects as do, for example, kernel density estimates. The paper by Eilers and Marx [Eilers, P. H. C., and Marx, B. D.: Flexible smoothing with B-splines and penalties, Statistical Science, 11, 89-101, 1996.] discusses this in detail.

In summary, we have considered all and incorporated most of the suggestions and references given by the reviewer. The beauty of the method we have suggested is its flexibility, keeping in mind robustness, simplicity and computational efficiency. It is also open source and we would hope that others that pick it up may work towards developing and improving current models and thus help us approach or even exceed the asymptotes suggested by Westra and Sharma (2010).

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 681, 2011.

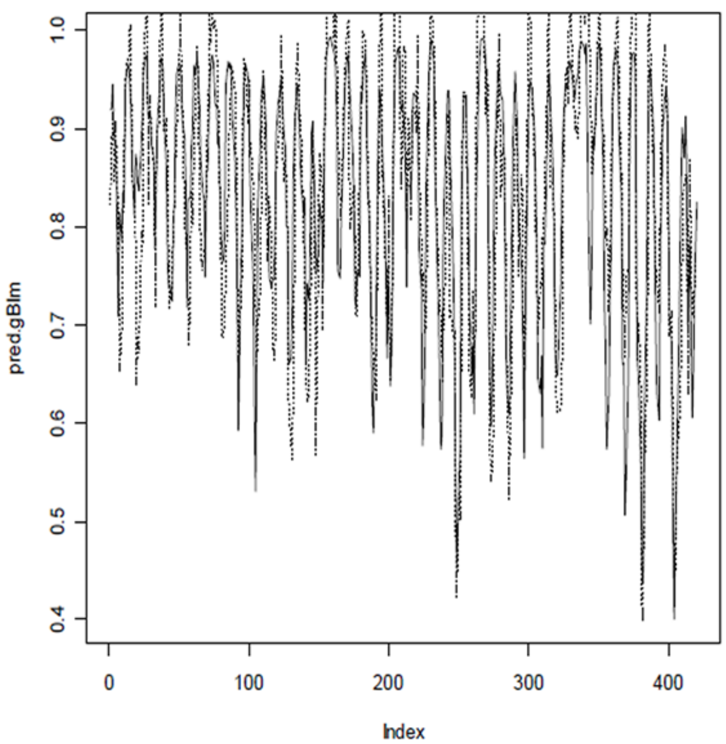

Fig. 1.

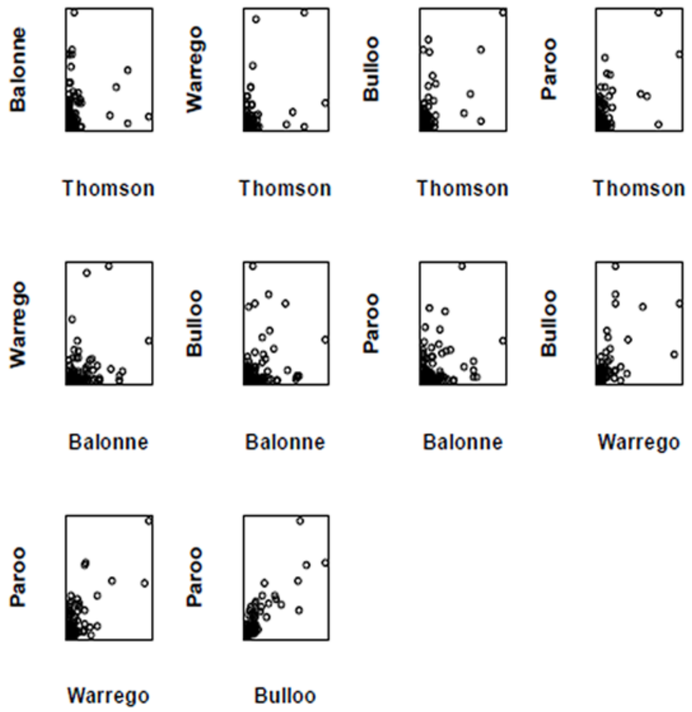
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Fig. 2.

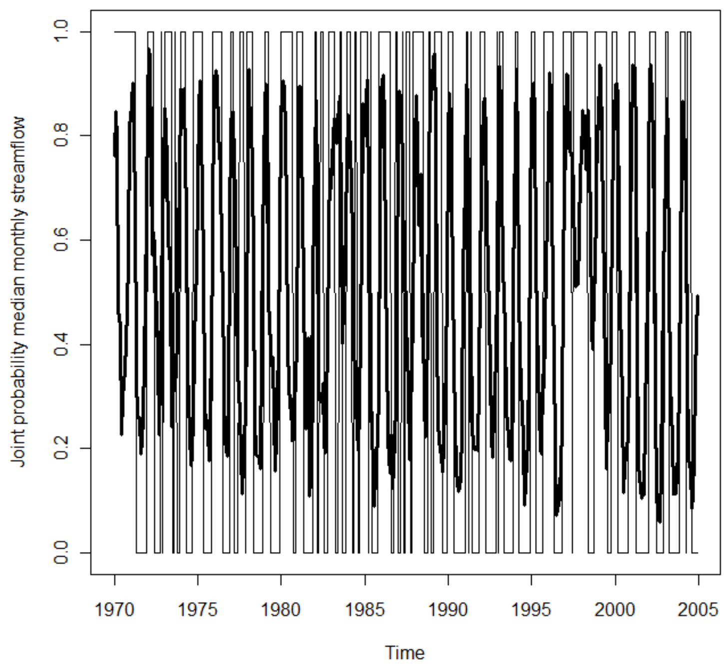
Joint probability median monthly streamflow
0.0
0.2
0.4
0.6
0.8
1.0
1970
1975
1980
1985
1990
1995
2000
2005
Time

Fig. 3.