Interactive comment on: Determining spatial variability of dry spells; Markov based method, applied to the Makanya catchment, Tanzania by B. M. C. Fischer, M. L. Mul and H. H. G. Savenije

We would like to thank Dr. J. Bazrafshan for his time to review our paper and his valuable comments. Concerning Dr. Bazrafshan's general comment, we will strengthen the section on the uniqueness of this study using the regionalized Markov properties in developing spatially distributed dry spell maps. Below we respond to the specific comments made.

Introduction

1) Thank you for pointing out this issue. We will add Mathugama and Peiris, 2011 to the reference list (Mathugama, S. C. & Peiris, T. S. G.: Critical Evaluation of Dry Spell Research, International Journal of Basic & Applied Sciences, 11 (6), 153-160, 2011).

2) We have cross checked the references and will update them accordingly:

    - *Savenije, should be 1998 and 2000*
    - *Wilhit and Glantz should be 1985*
    - *Sivakumar should be 1992*

Methodology

1) De Groen (2002) used in equation 4.35 n_m (days month^{-1}). In our case in equation (9) this is n_{ls} (days season^{-1}). This will be added to the manuscript.

2) $n_{dry,max}$ has a cumulative distribution functions see figure 5. This can be obtained from equation (9) calculating for each probability of non-exceedance F its $n_{dry,max}$ This will be added to the manuscript.

3) Thank you for reminding us to give the units of equation (10). We will provide the units of the equations in the manuscript. In the case of equation (10) this is for critical dry spell length n_{cr} [d], available soil moisture Θ [mm] and potential evaporation E_p [mm d^{-1}].

4) We agree with changing the coefficients with parameters, we have also modified Table 2 accordingly, see below:

Table 2 Parameters and statistics of the seasonal derived Multiple Linear Regression model of the Pangani basin.

	parameter	par. value	95% confidence intervals		R^2 statistic	F statistic
***b*₀₁**	*α*	2.48E-01	1.66E-01	3.29E-01	0.41	1.41
	ß	5.11E-05	-7.47E-05	1.77E-04		
	ε	-1.43E-04	-3.88E-04	1.03E-04		
***b*₁₁**	*α*	2.07E-01	1.61E-01	2.53E-01	0.54	2.37
	ß	5.15E-05	-1.93E-05	1.22E-04		
	ε	-7.99E-05	-2.18E-04	5.82E-05		

5) Thank you for pointing out this format issue of R^2 in table 2. The nr. 2 should be off course in the superscript.

6) Depending on the method used to calculate the correlation, the values can become negative for poor fitting data. The table presented in the first draft presented the r (and not R^2 as indicated in the label) and can therefore become negative. However for the consistency of the paper we recalculated the correlation

coefficient R^2, and we will update table 1 (see below the new values). In equation (1) y_i ,$\hat{y}$,$\bar{y}$ are the original, modelled and mean of the original values respectively.

$$R^2 = 1 - \frac{\sum_i^n (y_i - \hat{y})^2}{\sum_i^n (y_i - \bar{y})^2} \quad (1)$$

Table 1 Markov properties for both transition probabilities p01 and p11 for the eight rain gauges of the Pangani basin for Masika season, on monthly and seasonal basis.

trans.prop.	parameter	rain gauge							
		9337004	9337021	9337028	9437003	9438003	9538003	9538004	953801
Monthly									
p_{01}	$a_{var\ a}$	0.03	0.05	0.03	0.05	0.07	0.04	0.03	0.02
	$b_{var\ a}$	0.46	0.41	0.43	0.38	0.33	0.42	0.42	0.56
	R^2	0.90	0.94	0.68	0.89	0.55	0.92	0.80	0.92
	$\bar{a}_{fixed}$	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
	$b_{fixed\ a}$	0.42	0.44	0.39	0.41	0.43	0.44	0.39	0.39
	R^2	0.88	0.94	0.66	0.90	0.54	0.92	0.78	0.88
p_{11}	$a_{var\ a}$	0.16	0.15	0.38	0.37	0.12	0.10	0.11	0.06
	$b_{var\ a}$	0.26	0.28	0.05	0.07	0.34	0.36	0.31	0.43
	R^2	0.90	0.89	0.66	0.53	0.84	0.86	0.81	0.83
	$\bar{a}_{fixed}$	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
	$b_{fixed\ a}$	0.24	0.25	0.22	0.24	0.25	0.26	0.23	0.21
	R^2	0.88	0.88	0.66	0.62	0.73	0.78	0.74	0.54
Seasonal									
p_{01}	$a_{var\ a}$	0.03	0.24	0.02	0.03	0.05	0.09	0.02	0.01
	$b_{var\ a}$	0.35	0.06	0.40	0.37	0.32	0.23	0.42	0.49
	R^2	*0.80*	*0.11*	*0.84*	*0.64*	*0.84*	*0.30*	*0.77*	*0.85*
	$\bar{a}_{fixed}$	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
	$b_{fixed\ a}$	0.26	0.26	0.23	0.24	0.28	0.29	0.25	0.26
	R^2	*0.79*	*0.37*	*0.90*	*0.59*	*0.79*	*0.30*	*0.61*	*0.65*
p_{11}	$a_{var\ a}$	0.16	0.29	0.10	0.07	0.08	0.35	0.10	0.16
	$b_{var\ a}$	0.22	0.15	0.28	0.37	0.35	0.12	0.29	0.22
	R^2	0.60	0.92	0.31	0.94	0.73	0.53	0.76	0.19
	$\bar{a}_{fixed}$	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
	$b_{fixed\ a}$	0.23	0.25	0.21	0.23	0.24	0.25	0.22	0.21
	R^2	0.60	0.86	0.30	0.90	0.72	0.23	0.73	0.24

7) The focus of our paper is to present a method which can be used to identify regions that are vulnerable to dry spells. Although we agree with the importance of model testing and to choose the appropriate one, we choose not to present such test in this paper, so as not to distract from our main focus. We did however do the analysis. The table below shows that the results of the different semivariogram models are very similar. The exponential model is performing slightly better than the other three tested models (see table below). We will include a short section in the paper referring to this analysis.

Table 3 Ordinary Co-Kriging models and cross validation results for Masika season, ME (Mean Error), RMSE (Root Mean Square Error), ASE (Average Standard Error), MSE (Mean Standardized Error), RMSSE (Root-Mean-Squared Standardized Error).

Interpolation type	Model	**ME**	**RMSE**	**ASE**	**MSE**	**RMSSE**
OCK	Exponential	-5.07	59.46	57.68	-0.07	1.03
	Stable	-9.80	71.63	46.5	-0.15	1.58
	Spherical	-5.78	61.18	51.05	-0.08	1.23
	Gaussian	-10.03	71.43	46.74	-0.16	1.56

8) We agree that evaporation is a dynamic process and not constant in time. We used the average daily E_p ratio in a way to express the typical critical dry spell length rather than developing a dynamic model incorporating the long stochastic time series of E_p as well. We realise this is a simplification of the natural processes but it was used to demonstrate the method, rather than to provide absolute values. We will strengthen the section on E_p to highlight our assumption.

References

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