Fitted parameters and simulation results obtained from Uccle rain gauge records

Table 51. Farameters for KDL1-sivi model using Occle gauge data, constraint. $\alpha > 4$						
Month	λ	$\mu_X$	α	$\alpha/v$	κ	φ
Jan	0.0312	1.4325	4.0000	11.2265	0.6220	0.0382
Feb	0.0292	1.2587	4.3719	11.7573	0.6821	0.0355
Mar	0.0264	1.7237	4.4055	13.6137	0.5027	0.0284
Apr	0.0276	2.1658	4.4212	14.3049	0.3504	0.0255
May	0.0220	5.6546	4.9294	12.5411	0.1498	0.0264
Jun	0.0234	6.3752	4.0167	13.4742	0.1266	0.0249
Jul	0.0192	11.8100	7.0919	10.5139	0.0473	0.0145
Aug	0.0215	8.0093	4.6929	17.5926	0.1851	0.0275
Sep	0.0198	6.3025	5.8359	12.9166	0.1310	0.0200
Oct	0.0208	2.7673	4.0000	12.7023	0.3509	0.0239
Nov	0.0289	1.5216	4.0000	11.9214	0.6308	0.0316
Dec	0.0316	1.4374	4.0000	11.3080	0.7974	0.0440

## S1 Fitted parameters

Table S1: Parameters for RBL1-sM model using Uccle gauge data; constraint:  $\alpha > 4$ .

Table S2: Parameters	for RBL1-sM-NC	model using	Uccle gauge	data; constraint:	$\alpha > 1$ .

Month	λ	$\mu_X$	α	$\alpha/\nu$	κ	arphi
Jan	0.0343	1.4108	3.3881	12.6733	0.5782	0.0362
Feb	0.0292	1.2587	4.3719	11.7573	0.6821	0.0355
Mar	0.0264	1.7237	4.4055	13.6137	0.5027	0.0284
Apr	0.0276	2.1658	4.4212	14.3049	0.3504	0.0255
May	0.0220	5.6546	4.9294	12.5411	0.1498	0.0264
Jun	0.0240	7.1189	3.8463	17.0309	0.1322	0.0230
Jul	0.0192	11.8100	7.0919	10.5139	0.0473	0.0145
Aug	0.0215	8.0093	4.6929	17.5926	0.1851	0.0275
Sep	0.0198	6.3025	5.8359	12.9166	0.1310	0.0200
Oct	0.0211	2.7642	3.8870	12.9703	0.3474	0.0236
Nov	0.0289	1.5505	4.0132	12.3049	0.6381	0.0313
Dec	0.0357	1.4108	3.0943	11.4573	0.6227	0.0420

Month	λ	l	α	$\alpha/v$	κ	φ
Jan	0.0190	0.1716	2.0000	7.8090	0.8590	0.0315
Feb	0.0191	0.2311	2.0000	4.7657	0.6986	0.0399
Mar	0.0173	0.2155	2.0000	7.5279	0.5924	0.0285
Apr	0.0187	0.2124	2.0000	11.0930	0.4506	0.0235
May	0.0144	0.9419	2.0000	6.0164	0.1701	0.0323
Jun	0.0125	1.2773	2.0000	4.5878	0.0975	0.0226
Jul	0.0148	1.9052	2.0000	5.7903	0.0391	0.0141
Aug	0.0126	1.0308	2.0000	7.6725	0.1675	0.0267
Sep	0.0144	0.8538	2.0000	7.0427	0.1438	0.0238
Oct	0.0132	0.4097	2.0000	6.8927	0.4265	0.0255
Nov	0.0186	0.1977	2.0000	7.3750	0.7982	0.0295
Dec	0.0188	0.2057	2.0005	6.2271	0.9681	0.0380

Table S3: Parameters for RBL2-sM model using Uccle gauge data; constraint:  $\alpha > 2$ .

Table S4: Parameters for RBL2-sM-NC model using Uccle gauge data; constraint:  $\alpha > 0$ .

Month	λ	l	α	$\alpha/v$	κ	$\varphi$
Jan	0.0184	0.1667	0.8916	7.0433	0.8755	0.0303
Feb	0.0193	0.1418	1.1752	7.7308	0.8913	0.0307
Mar	0.0174	0.1807	1.0397	8.3865	0.6499	0.0262
Apr	0.0177	0.2662	1.0258	7.4436	0.4143	0.0260
May	0.0140	0.7176	0.5419	5.8314	0.3311	0.0453
Jun	0.0111	0.9796	0.5020	5.5849	0.2113	0.0284
Jul	0.0164	1.8740	0.5951	4.5455	0.0715	0.0289
Aug	0.0117	0.8669	0.6822	8.4479	0.2144	0.0254
Sep	0.0153	0.8065	0.5603	5.9595	0.2095	0.0340
Oct	0.0130	0.4246	0.8648	5.5144	0.4307	0.0265
Nov	0.0183	0.1833	1.1245	7.4460	0.8371	0.0280
Dec	0.0184	0.0942	0.7892	13.4873	1.1568	0.0199

## S2 Simulation results

## S2.1 Standard statistics



Fig. S1: Coefficient of variation (CV) by month at Uccle: the observed calculated with block (Obs-bM, orange circle markers) vs. standard (Obs-sM, blue cross markers) methods, the fitted with RBL1 (RBL1-bM, light orange line; RBL1-sM, light blue line) models, and the fitted with RBL2 (RBL2-bM, orange lines; RBL2-sM, blue lines) models.



Fig. S2: Autocorrelation lag-1 by month at Uccle: the observed calculated with block (Obs-bM, orange circle markers) vs. standard (Obs-sM, blue cross markers) methods, the fitted with RBL1 (RBL1-bM, light orange line; RBL1-sM, light blue line) models, and the fitted with RBL2 (RBL2-bM, orange lines; RBL2-sM, blue lines) models.



Fig. S3: Coefficient of skewness by month at Uccle: the observed calculated with block (Obs-bM, orange circle markers) vs. standard (Obs-sM, blue cross markers) methods, the fitted with RBL1 (RBL1-bM, light orange line; RBL1-sM, light blue line) models, and the fitted with RBL2 (RBL2-bM, orange lines; RBL2-sM, blue lines) models.



Fig. S4: Coefficient of variation (CV) by month at Uccle: the observed vs. the fitted using RBL2 models with the original and the new solution spaces of  $\alpha$  (RBL2-sM, light blue lines and boxplots; RBL2-sM-NC, black lines and boxplots).



Fig. S5: Autocorrelation lag-1 by month at Uccle: the observed vs. the fitted using RBL2 models with the original and the new solution spaces of  $\alpha$  (RBL2-sM, light blue lines and boxplots; RBL2-sM-NC, black lines and boxplots).



Fig. S6: Coefficient of skewness by month at Uccle: the observed vs. the fitted using RBL2 models with the original and the new solution spaces of  $\alpha$  (RBL2-sM, light blue lines and boxplots; RBL2-sM-NC, black lines and boxplots).





Fig. S7: Observed (round markers) and simulated (lines) return levels of rainfall at different timescales at Uccle. The simulated is sampled from the RBL1 and RBL2 models fitted with selected statistical properties calculated using bM and sM methods, respectively; and the median return levels obtained from 250 simulations, each of 105 years, are illustrated.



Fig. S8: Observed (round markers) and simulated (lines) return levels of rainfall at multiple time-scales at Uccle. The simulated is sampled from the RBL2 models fitted with the original (blue lines) and the new (black lines) solution spaces of  $\alpha$ . The median and the 95- and 5-percentile return levels obtained from 250 simulations, each of 105 years, are plotted with solid and dashed lines, respectively.



Fig. S9: Observed (round markers) and simulated (lines) return levels of rainfall at multiple time-scales at Uccle. The simulated is sampled from the RBL1 (grey lines) and RBL2 (black lines) models fitted with the new solution spaces of  $\alpha$ . The median and the 95- and 5-percentile return levels obtained from 250 simulations, each of 105 years, are plotted with solid and dashed lines, respectively.

## S2.1 Coarse-scale variances



Fig. S10: Daily Variances by month at Uccle: the observed calculated with standard (Obs-sM, blue cross markers) methods, the fitted with RBL1 (RBL1-bM, light orange line; RBL1-sM, light blue line; RBL1-sM-NC, grey line) models, and the fitted with RBL2 (RBL2-bM, orange lines; RBL2-sM, blue lines; RBL2-sM-NC, black line) models.