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Topographic metrics for unveiling fault segmentation and tectono-geomorphic evolution with insights into the impact of inherited topography, Ulsan Fault Zone, South Korea

Cho-Hee Lee et al.

Correspondence to: Yeong Bae Seong (ybseong@korea.ac.kr)

Supplementary #1: Sensitivity analysis

We conducted sensitivity analysis to identify how the model input parameter affects the χ and relief values and χ anomaly and relief difference across the main drainage divide. We picked several values for the parameters that we want to test (i.e., n–channel slope exponent, θ–channel concavity index, and K–erodibility coefficient). The values for each parameter that we tested are listed below (Table S1).

Table S1. The tested values for each parameter

	Parameters		
	n	θ	K
Simulation 1	0.6494	0.36	1.00E-07
Simulation 2	0.6494	0.65	1.00E-07
Simulation 3	0.6494	0.505	1.00E-07
Simulation 4	5.0419	0.36	1.00E-07
Simulation 5	5.0419	0.65	1.00E-07
Simulation 6	5.0419	0.505	1.00E-07
Simulation 7	2.8457	0.36	1.00E-07
Simulation 8	2.8457	0.65	1.00E-07
Simulation 9	2.8457	0.505	1.00E-07
Simulation 10	0.6494	0.36	1.00E-04
Simulation 11	0.6494	0.65	1.00E-04
Simulation 12	0.6494	0.505	1.00E-04
Simulation 13	5.0419	0.36	1.00E-04
Simulation 14	5.0419	0.65	1.00E-04
Simulation 15	5.0419	0.505	1.00E-04
Simulation 16	2.8457	0.36	1.00E-04
Simulation 17	2.8457	0.65	1.00E-04
Simulation 18	2.8457	0.505	1.00E-04

About n (slope exponent), we selected its minimum value as 0.6494 and its maximum value as 5.0419 according to the previously calculated values for environments (e.g., rock type, climate, seismicity, tectonic activity, and the presence of glacier) similar to our study area (Harel et al., 2016). We also selected the median value (2.8457) between the minimum and maximum values. We selected the minimum value of θ as 0.36 and maximum value as 0.65, following the previous research (Snyder et

al., 2000; Wobus et al., 2006; Cyr et al., 2010; Kirby and Whipple, 2012) and tested their median value (0.505) as well. Lastly, we selected the minimum value of K as 1.00E-07 because we used 5.56E-07 in this research, which is average value from the environments similar to this study area (Harel et al., 2016) so that we can find out whether we used quite uncertain value or not. The maximum value of K is selected as 1.00E-04, which is generally used in the reported cases (e.g., Stock and Montgomery, 1999; Kirby and Whipple, 2001; Zondervan et al., 2020).

We ran 72 landscape evolution models with the values in Table S1 for the configurations of all modelling cases (i.e., Cases A1, A2, B1, and B2). Then, we analysed topographic metrics (χ index and relief) from the modelled topographies and calculated their anomalies. The metrics' values are documented in supplementary 2 (excel file), and we made some scatter plots to identify how those parameters affect the results.

1. Influence of slope exponent (n)

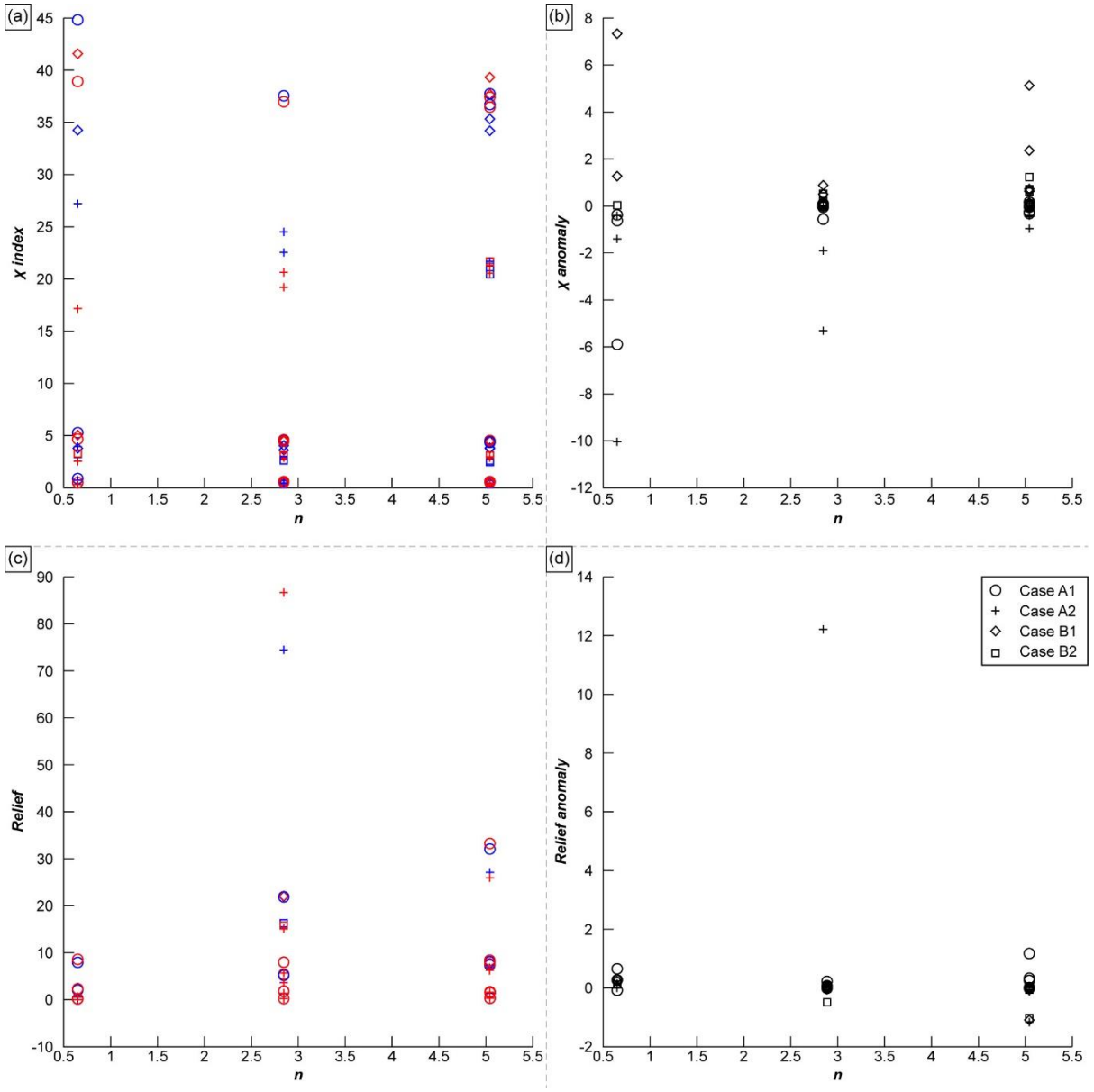

Figure S1. Influence of slope exponent (*n*) on the χ index, χ anomaly, relief, and relief anomaly. The anomalies are the subtraction of the mean value of each metric on the eastern side from that on the western side. (a) χ index, (b) χ anomaly, (c) relief, and (d) relief anomaly variation on each tested *n* value.

It seems that the variation of *n* has very weak or no relationship with χ index, χ anomaly, and relief anomaly (Figs. S1a, S1b, and S1d). However, relief (Fig. S1c) generally increases as *n* increases.

2. Influence of channel concavity index (θ)

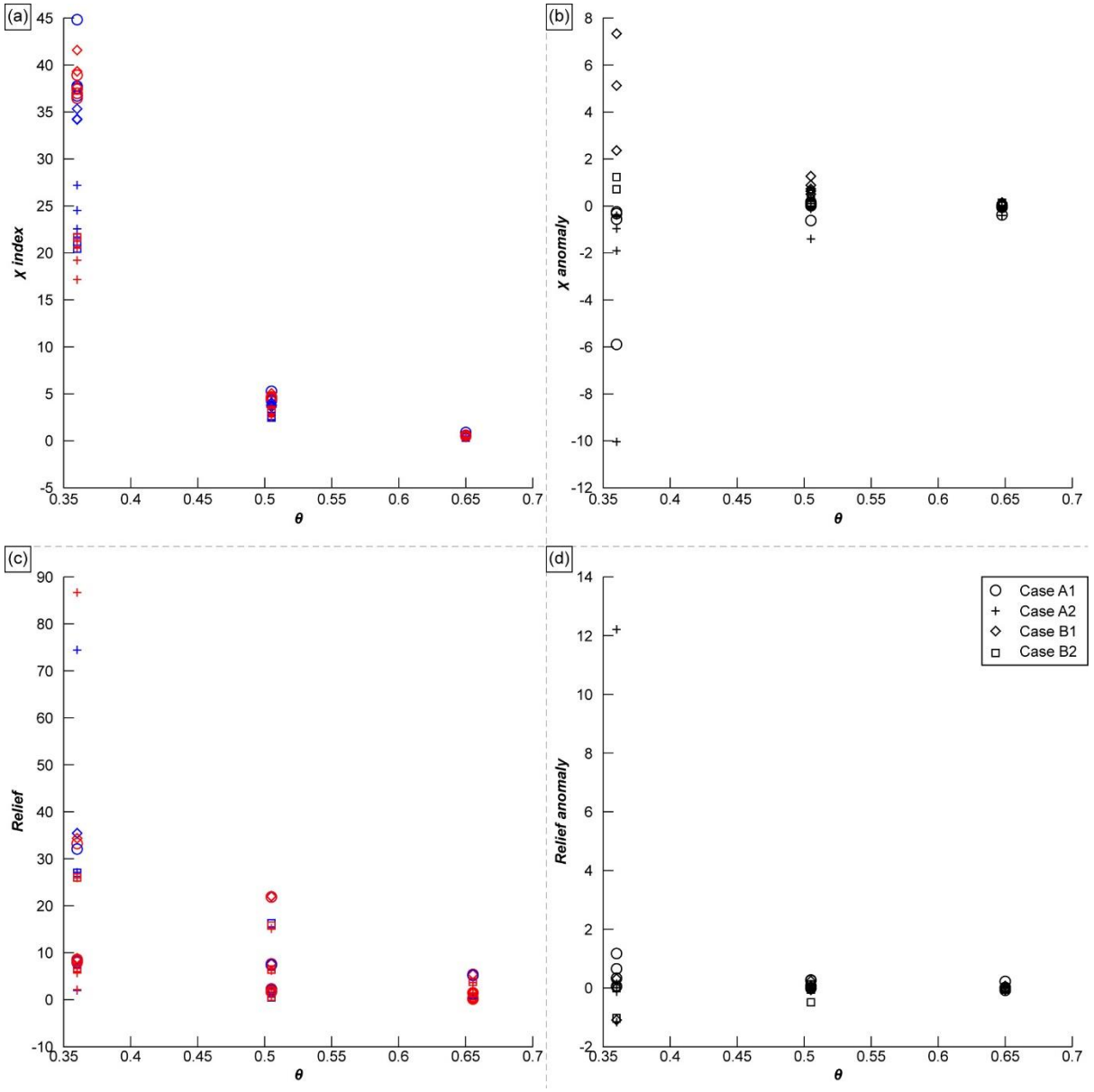

Figure S2. Influence of channel concavity index (θ) on the χ index, χ anomaly, relief, and relief anomaly. The anomalies are the subtraction of the mean value of each metric on the eastern side from that on the western side. (a) χ index, (b) χ anomaly, (c) relief, and (d) relief anomaly variation on each tested θ value.

As θ increases, both χ index and relief decrease (Figs. S2a and S2b), and the range (both in positive and negative direction) of the χ anomaly and relief anomaly also decrease (Fig. S2b and S2d).

3. Influence of erodibility coefficient (*K*)

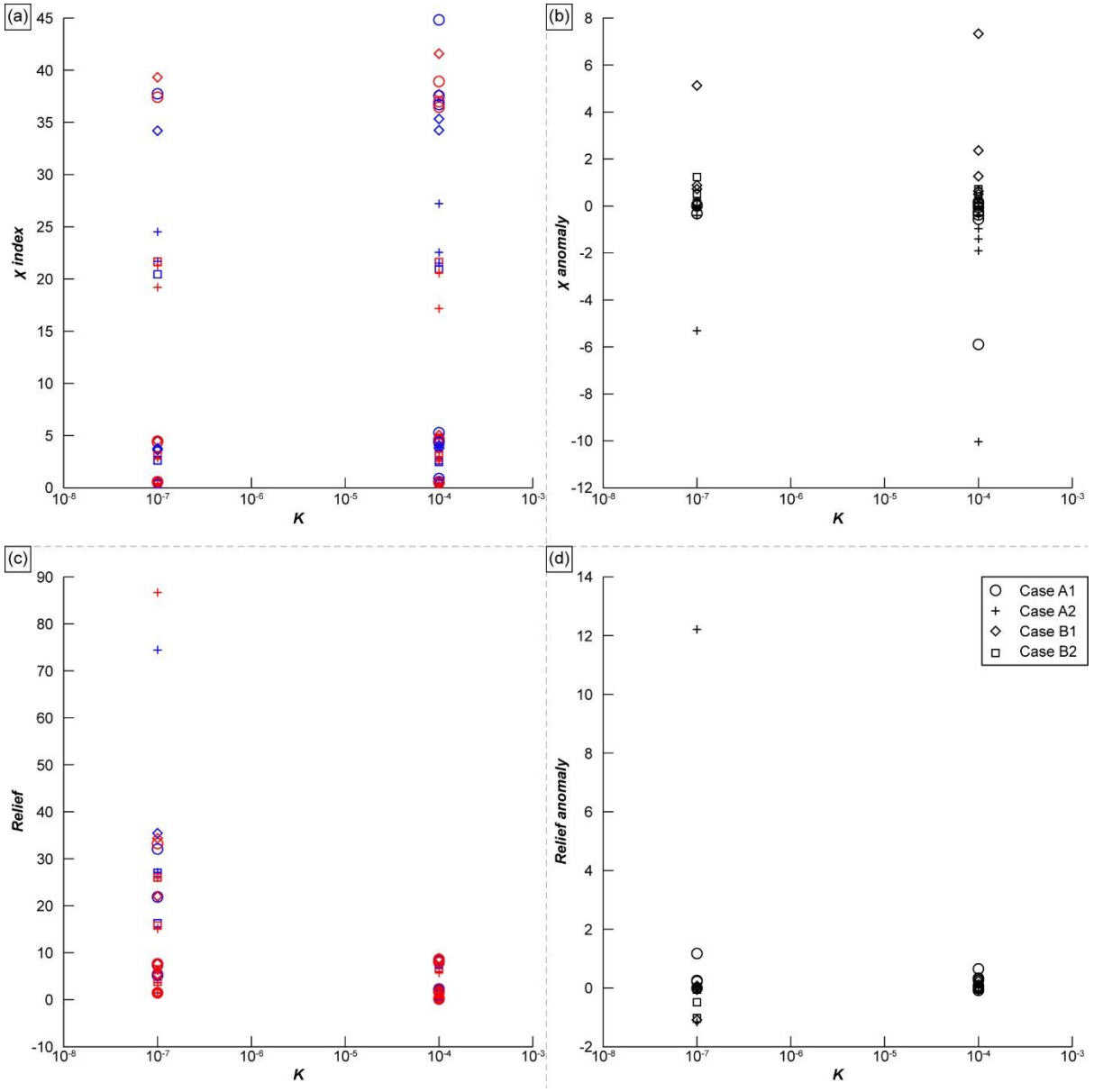

Figure S3. Influence of erodibility coefficient (*K*) on the χ index, χ anomaly, relief, and relief anomaly. The anomalies are the subtraction of the mean value of each metric on the eastern side from that on the western side. (a) χ index, (b) χ anomaly, (c) relief, and (d) relief anomaly variation on each tested *K* value.

As *K* increases, the range of χ anomaly increases (Fig. S3b), and both relief and the range of relief decrease (Figs. S3c and S3d).

Supplementary 2

Result values												
	Parameters				Modelling cases							
					A1		A2		B1		B2	
	n	theta	K		West	East	West	East	West	East	West	East
Simulation 1	0.6494	0.36	1.00E-07	X								
				Relief								
Simulation 2	0.6494	0.65	1.00E-07	X								
				Relief								
Simulation 3	0.6494	0.505	1.00E-07	X								
				Relief								
Simulation 4	5.0419	0.36	1.00E-07	X	37.42 ± 2.14	37.74 ± 2.56	21.28 ± 1.53	21.69 ± 1.54	39.32 ± 1.91	34.20 ± 2.31	21.67 ± 1.81	20.44 ± 1.54
				Relief	33.25 ± 9.94	32.08 ± 4.53	25.95 ± 4.20	27.11 ± 4.35	34.36 ± 15.10	35.45 ± 12.09	26.02 ± 5.09	27.04 ± 3.26
Simulation 5	5.0419	0.65	1.00E-07	X	0.58 ± 0.06	0.58 ± 0.05	0.42 ± 0.05	0.42 ± 0.05	0.61 ± 0.07	0.46 ± 0.06	0.45 ± 0.06	0.34 ± 0.06
				Relief	1.48 ± 0.12	1.48 ± 0.08	1.48 ± 0.14	1.43 ± 0.12	1.45 ± 0.18	1.50 ± 0.08	1.44 ± 0.14	1.49 ± 0.10
Simulation 6	5.0419	0.505	1.00E-07	X	4.43 ± 0.40	4.40 ± 0.34	2.87 ± 0.27	2.94 ± 0.34	4.49 ± 0.36	3.77 ± 0.31	3.12 ± 0.28	2.61 ± 0.27
				Relief	7.65 ± 0.95	7.39 ± 0.80	6.23 ± 0.90	6.27 ± 0.65	7.70 ± 1.33	7.67 ± 0.83	6.42 ± 1.03	6.45 ± 0.59
Simulation 7	2.8457	0.36	1.00E-07	X			19.21 ± 1.61	24.52 ± 2.09				
				Relief			86.67 ± 7.98	74.46 ± 17.15				
Simulation 8	2.8457	0.65	1.00E-07	X	0.59 ± 0.06	0.56 ± 0.07	0.44 ± 0.07	0.42 ± 0.06	0.60 ± 0.06	0.47 ± 0.06	0.48 ± 0.05	0.34 ± 0.06
				Relief	5.41 ± 0.39	5.19 ± 0.35	3.67 ± 0.34	3.65 ± 0.34	5.42 ± 0.52	5.35 ± 0.33	3.80 ± 0.35	3.82 ± 0.30
Simulation 9	2.8457	0.505	1.00E-07	X	4.46 ± 0.42	4.45 ± 0.47	2.89 ± 0.35	3.02 ± 0.35	4.49 ± 0.38	3.61 ± 0.46	3.14 ± 0.34	2.63 ± 0.35
				Relief	21.87 ± 2.95	21.89 ± 2.92	15.12 ± 1.99	15.20 ± 0.83	22.06 ± 4.31	21.99 ± 1.61	15.80 ± 2.47	16.29 ± 2.10
Simulation 10	0.6494	0.36	1.00E-04	X	38.92 ± 2.55	44.82 ± 2.28	17.17 ± 1.25	27.21 ± 1.63	41.58 ± 4.17	34.25 ± 4.09		
				Relief	8.59 ± 1.24	7.94 ± 0.44	2.15 ± 0.26	1.99 ± 0.21	8.82 ± 1.07	8.50 ± 0.98		
Simulation 11	0.6494	0.65	1.00E-04	X	0.51 ± 0.07	0.89 ± 0.12	0.32 ± 0.07	0.73 ± 0.08				
				Relief	0.16 ± 0.06	0.24 ± 0.03	0.02 ± 0.004	0.01 ± 0.002				
Simulation 12	0.6494	0.505	1.00E-04	X	4.66 ± 0.44	5.28 ± 0.46	2.54 ± 0.22	3.95 ± 0.33	5.05 ± 0.63	3.79 ± 0.32	3.29 ± 0.37	3.26 ± 0.28
				Relief	2.32 ± 0.27	2.05 ± 0.13	0.63 ± 0.04	0.53 ± 0.03	2.32 ± 0.28	2.08 ± 0.16	0.65 ± 0.04	0.53 ± 0.02
Simulation 13	5.0419	0.36	1.00E-04	X	36.46 ± 2.33	36.71 ± 2.66	20.55 ± 1.76	21.51 ± 1.66	37.69 ± 2.86	35.33 ± 2.22	21.62 ± 1.91	20.90 ± 1.53
				Relief	8.41 ± 2.89	8.08 ± 1.80	6.66 ± 1.07	6.79 ± 0.91	8.54 ± 2.88	8.53 ± 2.43	6.76 ± 1.61	6.73 ± 0.56
Simulation 14	5.0419	0.65	1.00E-04	X	0.55 ± 0.08	0.60 ± 0.06	0.41 ± 0.06	0.48 ± 0.05	0.53 ± 0.08	0.48 ± 0.06	0.44 ± 0.06	0.43 ± 0.06
				Relief	0.32 ± 0.04	0.30 ± 0.03	0.32 ± 0.03	0.30 ± 0.03	0.30 ± 0.03	0.31 ± 0.04	0.31 ± 0.03	0.31 ± 0.02
Simulation 15	5.0419	0.505	1.00E-04	X	4.53 ± 0.32	4.36 ± 0.41	2.97 ± 0.18	2.88 ± 0.28	4.45 ± 0.30	3.82 ± 0.40	3.08 ± 0.23	2.47 ± 0.29
				Relief	1.66 ± 0.27	1.67 ± 0.22	1.56 ± 0.18	1.53 ± 0.17	1.65 ± 0.34	1.70 ± 0.27	1.55 ± 0.22	1.61 ± 0.15
Simulation 16	2.8457	0.36	1.00E-04	X	36.98 ± 1.88	37.55 ± 2.29	20.64 ± 1.54	22.55 ± 1.52				
				Relief	7.99 ± 1.95	7.93 ± 1.23	5.70 ± 1.38	5.69 ± 0.73				
Simulation 17	2.8457	0.65	1.00E-04	X	0.54 ± 0.07	0.60 ± 0.06	0.41 ± 0.04	0.49 ± 0.05	0.55 ± 0.10	0.46 ± 0.05	0.45 ± 0.05	0.43 ± 0.05
				Relief	0.23 ± 0.03	0.22 ± 0.02	0.23 ± 0.01	0.22 ± 0.02	0.21 ± 0.03	0.23 ± 0.03	0.22 ± 0.02	0.22 ± 0.02
Simulation 18	2.8457	0.505	1.00E-04	X	4.60 ± 0.37	4.50 ± 0.35	2.91 ± 0.25	2.91 ± 0.29	4.56 ± 0.34	4.05 ± 0.37	3.05 ± 0.30	2.64 ± 0.29
				Relief	1.84 ± 0.20	1.76 ± 0.15	1.37 ± 0.15	1.30 ± 0.12	1.78 ± 0.25	1.77 ± 0.22	1.38 ± 0.15	1.35 ± 0.13

* About the shaded simulation cases, distance between the channel heads on the one side and another side are so far that they are not recognized as a paired basins.
* The mean and 1σ standard deviation values are used.

Anomalies

	Parameters				Cases			
	n	theta	K		A1	A2	B1	B2
Simulation 1	0.6494	0.36	1.00E-07	χ				
				Relief				
Simulation 2	0.6494	0.65	1.00E-07	χ				
				Relief				
Simulation 3	0.6494	0.505	1.00E-07	χ				
				Relief				
Simulation 4	5.0419	0.36	1.00E-07	χ	-0.3237	-0.4072	5.1247	1.2324
				Relief	1.1756	-1.1637	-1.0888	-1.0255
Simulation 5	5.0419	0.65	1.00E-07	χ	0.0012	0.0013	0.1436	0.1100
				Relief	0.0003	0.0433	-0.0533	-0.0523
Simulation 6	5.0419	0.505	1.00E-07	χ	0.0267	-0.0680	0.7202	0.5057
				Relief	0.2585	-0.0435	0.0248	-0.0314
Simulation 7	2.8457	0.36	1.00E-07	χ		-5.3102		
				Relief		12.2103		
Simulation 8	2.8457	0.65	1.00E-07	χ	0.0261	0.0185	0.1389	0.1343
				Relief	0.2254	0.0180	0.0717	-0.0197
Simulation 9	2.8457	0.505	1.00E-07	χ	0.0083	-0.1277	0.8811	0.5142
				Relief	-0.0101	-0.0824	0.0689	-0.4879
Simulation 10	0.6494	0.36	1.00E-04	χ	-5.8943	-10.0377	7.3338	
				Relief	0.6549	0.1530	0.3200	
Simulation 11	0.6494	0.65	1.00E-04	χ	-0.3814	-0.4118		
				Relief	-0.0783	0.0043		
Simulation 12	0.6494	0.505	1.00E-04	χ	-0.6229	-1.4050	1.2657	0.0297
				Relief	0.2740	0.1059	0.2406	0.1168
Simulation 13	5.0419	0.36	1.00E-04	χ	-0.2514	-0.9675	2.3603	0.7154
				Relief	0.3321	-0.1287	0.0047	0.0251
Simulation 14	5.0419	0.65	1.00E-04	χ	-0.0512	-0.0735	0.0464	0.0144
				Relief	0.0145	0.0171	-0.0034	0.0065
Simulation 15	5.0419	0.505	1.00E-04	χ	0.1660	0.0960	0.6294	0.6092
				Relief	-0.0117	0.0243	-0.0585	-0.0534
Simulation 16	2.8457	0.36	1.00E-04	χ	-0.5659	-1.9062		
				Relief	0.0557	0.0088		
Simulation 17	2.8457	0.65	1.00E-04	χ	-0.0594	-0.0797	0.0962	0.0222
				Relief	0.0167	0.0092	-0.0188	0.0003
Simulation 18	2.8457	0.505	1.00E-04	χ	0.0990	0.0073	0.5042	0.4096
				Relief	0.0775	0.0726	0.0140	0.0255

* About the shaded simulation cases, distance between the channel heads on the one side and another side are so far that they are not recognized as a paired basins.
* The anomaly is the difference between the mean of each metric on the western and eastern flank (mean value on the western flank minus mean value on the eastern flank).