**Supplementary material**

**Combining rainfall–runoff model and regionalization approach for flood and water resource assessment in the western Po Valley (Italy)**

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**S1 Building correlation matrix between all pairs of the model parameters of MISDc**

The correlation was evaluated using the Pearson correlation coefficient *ρ* (Pearson 1895). Table S1 shows the results of this statistical analysis.

Table S1. Correlation matrix between all pairs of the model parameters of MISDc using the Pearson correlation coefficient.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *|ρ|* | *W(t*0*)* | *W*max | *m* | *Ks* | *θ* | *η* | *b* | *λ* | *a* | *Cm-*snowpack | *k*glacier | *Cm-*glacier |
| *W(t*0*)* | - | 0.122 | 0.068 | 0.302 | 0.081 | 0.096 | 0.341 | 0.069 | 0.114 | 0.010 | 0.005 | 0.272 |
| *W*max | 0.122 | - | 0.185 | 0.088 | 0.353 | 0.014 | 0.013 | 0.152 | 0.186 | 0.222 | 0.123 | 0.119 |
| *M* | 0.068 | 0.185 | - | 0.202 | 0.238 | 0.054 | 0.104 | 0.229 | 0.183 | 0.027 | 0.069 | 0.131 |
| *Ks* | 0.302 | 0.088 | 0.202 | - | 0.440 | 0.059 | 0.183 | 0.109 | 0.361 | 0.143 | 0.150 | 0.083 |
| *θ* | 0.081 | 0.353 | 0.238 | 0.440 | - | 0.166 | 0.008 | 0.226 | 0.299 | 0.145 | 0.235 | 0.112 |
| *η* | 0.096 | 0.014 | 0.054 | 0.059 | 0.166 | - | 0.124 | 0.379 | 0.151 | 0.055 | 0.299 | 0.075 |
| *b* | 0.341 | 0.013 | 0.104 | 0.183 | 0.008 | 0.124 | - | 0.198 | 0.132 | 0.164 | 0.265 | 0.231 |
| *λ* | 0.069 | 0.152 | 0.229 | 0.109 | 0.226 | 0.379 | 0.198 | - | 0.047 | 0.087 | 0.005 | 0.181 |
| *a* | 0.114 | 0.186 | 0.183 | 0.361 | 0.299 | 0.151 | 0.132 | 0.047 | - | 0.175 | 0.091 | 0.230 |
| *Cm-*snowpack | 0.010 | 0.222 | 0.027 | 0.143 | 0.145 | 0.055 | 0.164 | 0.087 | 0.175 | - | 0.030 | 0.146 |
| *k*glacier | 0.005 | 0.123 | 0.069 | 0.150 | 0.235 | 0.299 | 0.265 | 0.005 | 0.091 | 0.030 | - | 0.117 |
| *Cm-*glacier | 0.272 | 0.119 | 0.131 | 0.083 | 0.112 | 0.075 | 0.231 | 0.181 | 0.230 | 0.146 | 0.117 | - |

**S2 Building correlation matrix between all pairs of the catchment descriptors**

The selection of the most representative catchment descriptors is a complex task. No clear choices were found in the hydrological literature because most studies used an extremely large set of physical properties, and in most cases is led by empirical remarks (Carrillo *et al*. 2011, Sanborn and Bledsoe 2006, Sawicz *et al*. 2011, Toth 2013, Wagener *et al*. 2007, Yadav *et al*. 2007).

To avoid redundancies in independent variables for the regionalization procedures, several studies conducted a selection through correlation matrix. In the present study, the procedure consisted in: (i) providing an exhaustive overview of physiographic, topographic (DEM-derived), land use, soil properties variables; (ii) evaluating such catchment descriptors using the available data (Table 3); (iii) building a correlation matrix between all pairs of catchment descriptors using the Pearson correlation coefficient *ρ* (Pearson, 1895) (Table S2); (iv) grouping the catchment attributes that were found to be correlated with |*ρ*| > 0.70 (Table 4); and (v) selecting one of the catchment attributes from each correlated groups.

Table S2. Correlation matrix between all pairs of the catchment descriptors using the Pearson correlation coefficient.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | CN | XS | YS | AREA | Zm | Zmin | Zmax | SLOPE | AGR |
| CN |  | 0.421 | 0.002 | 0.020 | 0.442 | 0.362 | 0.427 | 0.053 | 0.141 |
| XS | 0.421 |  | 0.589 | 0.033 | 0.175 | 0.294 | 0.137 | 0.585 | 0.128 |
| YS | 0.002 | 0.589 |  | 0.032 | 0.147 | 0.143 | 0.200 | 0.614 | 0.205 |
| AREA | 0.020 | 0.033 | 0.032 |  | 0.243 | 0.375 | 0.459 | 0.154 | 0.038 |
| Zm | 0.442 | 0.175 | 0.147 | 0.243 |  | 0.613 | 0.884 | 0.620 | 0.645 |
| Zmin | 0.362 | 0.294 | 0.143 | 0.375 | 0.613 |  | 0.297 | 0.233 | 0.499 |
| Zmax | 0.427 | 0.137 | 0.200 | 0.459 | 0.884 | 0.297 |  | 0.596 | 0.494 |
| SLOPE | 0.053 | 0.585 | 0.614 | 0.154 | 0.620 | 0.233 | 0.596 |  | 0.539 |
| AGR | 0.141 | 0.128 | 0.205 | 0.038 | 0.645 | 0.499 | 0.494 | 0.539 |  |
| WOOD | 0.078 | 0.016 | 0.046 | 0.131 | 0.746 | 0.549 | 0.597 | 0.521 | 0.930 |
| URB | 0.122 | 0.234 | 0.345 | 0.272 | 0.495 | 0.297 | 0.452 | 0.158 | 0.160 |
| MAP | 0.070 | 0.406 | 0.774 | 0.132 | 0.265 | 0.134 | 0.257 | 0.543 | 0.446 |
| Dstd | 0.135 | 0.081 | 0.429 | 0.149 | 0.027 | 0.080 | 0.083 | 0.122 | 0.181 |
| MOUN | 0.265 | 0.115 | 0.033 | 0.136 | 0.912 | 0.667 | 0.772 | 0.600 | 0.729 |
| L | 0.036 | 0.112 | 0.260 | 0.891 | 0.163 | 0.394 | 0.382 | 0.038 | 0.092 |
| TWI | 0.059 | 0.700 | 0.619 | 0.019 | 0.395 | 0.166 | 0.334 | 0.882 | 0.544 |
| HIGHp | 0.256 | 0.603 | 0.701 | 0.028 | 0.129 | 0.288 | 0.089 | 0.365 | 0.129 |
| MEDp | 0.073 | 0.317 | 0.551 | 0.190 | 0.085 | 0.167 | 0.155 | 0.298 | 0.105 |
| LOWp | 0.575 | 0.555 | 0.347 | 0.259 | 0.368 | 0.240 | 0.412 | 0.162 | 0.058 |
| PVAR | 0.081 | 0.249 | 0.412 | 0.117 | 0.203 | 0.068 | 0.163 | 0.396 | 0.208 |
| FC | 0.145 | 0.499 | 0.552 | 0.114 | 0.324 | 0.243 | 0.245 | 0.602 | 0.567 |
| NP | 0.271 | 0.428 | 0.550 | 0.276 | 0.455 | 0.007 | 0.559 | 0.724 | 0.402 |
| MMA | 0.153 | 0.356 | 0.470 | 0.354 | 0.264 | 0.074 | 0.321 | 0.095 | 0.074 |
| Tmo | 0.534 | 0.561 | 0.120 | 0.132 | 0.832 | 0.606 | 0.709 | 0.187 | 0.516 |
| Z5 | 0.307 | 0.119 | 0.093 | 0.210 | 0.791 | 0.883 | 0.493 | 0.508 | 0.616 |
| Z95 | 0.493 | 0.251 | 0.113 | 0.338 | 0.940 | 0.447 | 0.969 | 0.545 | 0.534 |
| RWD | 0.421 | 0.256 | 0.486 | 0.183 | 0.435 | 0.127 | 0.459 | 0.511 | 0.420 |

Table S2. (continued).

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | WOOD | URB | MAP | Dstd | MOUN | L | TWI | HIGHp | MEDp |
| CN | 0.078 | 0.122 | 0.070 | 0.135 | 0.265 | 0.036 | 0.059 | 0.256 | 0.073 |
| XS | 0.016 | 0.234 | 0.406 | 0.081 | 0.115 | 0.112 | 0.700 | 0.603 | 0.317 |
| YS | 0.046 | 0.345 | 0.774 | 0.429 | 0.033 | 0.260 | 0.619 | 0.701 | 0.551 |
| AREA | 0.131 | 0.272 | 0.132 | 0.149 | 0.136 | 0.891 | 0.019 | 0.028 | 0.190 |
| Zm | 0.746 | 0.495 | 0.265 | 0.027 | 0.912 | 0.163 | 0.395 | 0.129 | 0.085 |
| Zmin | 0.549 | 0.297 | 0.134 | 0.080 | 0.667 | 0.394 | 0.166 | 0.288 | 0.167 |
| Zmax | 0.597 | 0.452 | 0.257 | 0.083 | 0.772 | 0.382 | 0.334 | 0.089 | 0.155 |
| SLOPE | 0.521 | 0.158 | 0.543 | 0.122 | 0.600 | 0.038 | 0.882 | 0.365 | 0.298 |
| AGR | 0.930 | 0.160 | 0.446 | 0.181 | 0.729 | 0.092 | 0.544 | 0.129 | 0.105 |
| WOOD |  | 0.510 | 0.311 | 0.108 | 0.853 | 0.026 | 0.399 | 0.263 | 0.190 |
| URB | 0.510 |  | 0.201 | 0.139 | 0.586 | 0.289 | 0.180 | 0.398 | 0.260 |
| MAP | 0.311 | 0.201 |  | 0.627 | 0.245 | 0.351 | 0.529 | 0.498 | 0.429 |
| Dstd | 0.108 | 0.139 | 0.627 |  | 0.072 | 0.296 | 0.139 | 0.143 | 0.097 |
| MOUN | 0.853 | 0.586 | 0.245 | 0.072 |  | 0.075 | 0.409 | 0.273 | 0.161 |
| L | 0.026 | 0.289 | 0.351 | 0.296 | 0.075 |  | 0.166 | 0.093 | 0.080 |
| TWI | 0.399 | 0.180 | 0.529 | 0.139 | 0.409 | 0.166 |  | 0.367 | 0.197 |
| HIGHp | 0.263 | 0.398 | 0.498 | 0.143 | 0.273 | 0.093 | 0.367 |  | 0.831 |
| MEDp | 0.190 | 0.260 | 0.429 | 0.097 | 0.161 | 0.080 | 0.197 | 0.831 |  |
| LOWp | 0.158 | 0.283 | 0.186 | 0.096 | 0.224 | 0.297 | 0.332 | 0.423 | 0.152 |
| PVAR | 0.154 | 0.056 | 0.278 | 0.327 | 0.101 | 0.000 | 0.357 | 0.371 | 0.342 |
| FC | 0.424 | 0.175 | 0.589 | 0.338 | 0.387 | 0.326 | 0.751 | 0.260 | 0.069 |
| NP | 0.288 | 0.150 | 0.509 | 0.231 | 0.346 | 0.135 | 0.712 | 0.341 | 0.386 |
| MMA | 0.163 | 0.263 | 0.506 | 0.415 | 0.235 | 0.465 | 0.115 | 0.464 | 0.333 |
| Tmo | 0.627 | 0.474 | 0.108 | 0.060 | 0.755 | 0.136 | 0.012 | 0.454 | 0.136 |
| Z5 | 0.682 | 0.387 | 0.261 | 0.022 | 0.793 | 0.300 | 0.387 | 0.124 | 0.025 |
| Z95 | 0.651 | 0.498 | 0.219 | 0.069 | 0.842 | 0.287 | 0.285 | 0.169 | 0.090 |
| RWD | 0.323 | 0.104 | 0.409 | 0.313 | 0.339 | 0.044 | 0.510 | 0.081 | 0.143 |

Table S2. (continued).

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | LOWp | PVAR | FC | NP | MMA | Tmo | Z5 | Z95 | RWD |
| CN | 0.575 | 0.081 | 0.145 | 0.271 | 0.153 | 0.534 | 0.307 | 0.493 | 0.421 |
| XS | 0.555 | 0.249 | 0.499 | 0.428 | 0.356 | 0.561 | 0.119 | 0.251 | 0.256 |
| YS | 0.347 | 0.412 | 0.552 | 0.550 | 0.470 | 0.120 | 0.093 | 0.113 | 0.486 |
| AREA | 0.259 | 0.117 | 0.114 | 0.276 | 0.354 | 0.132 | 0.210 | 0.338 | 0.183 |
| Zm | 0.368 | 0.203 | 0.324 | 0.455 | 0.264 | 0.832 | 0.791 | 0.940 | 0.435 |
| Zmin | 0.240 | 0.068 | 0.243 | 0.007 | 0.074 | 0.606 | 0.883 | 0.447 | 0.127 |
| Zmax | 0.412 | 0.163 | 0.245 | 0.559 | 0.321 | 0.709 | 0.493 | 0.969 | 0.459 |
| SLOPE | 0.162 | 0.396 | 0.602 | 0.724 | 0.095 | 0.187 | 0.508 | 0.545 | 0.511 |
| AGR | 0.058 | 0.208 | 0.567 | 0.402 | 0.074 | 0.516 | 0.616 | 0.534 | 0.420 |
| WOOD | 0.158 | 0.154 | 0.424 | 0.288 | 0.163 | 0.627 | 0.682 | 0.651 | 0.323 |
| URB | 0.283 | 0.056 | 0.175 | 0.150 | 0.263 | 0.474 | 0.387 | 0.498 | 0.104 |
| MAP | 0.186 | 0.278 | 0.589 | 0.509 | 0.506 | 0.108 | 0.261 | 0.219 | 0.409 |
| Dstd | 0.096 | 0.327 | 0.338 | 0.231 | 0.415 | 0.060 | 0.022 | 0.069 | 0.313 |
| MOUN | 0.224 | 0.101 | 0.387 | 0.346 | 0.235 | 0.755 | 0.793 | 0.842 | 0.339 |
| L | 0.297 | 0.000 | 0.326 | 0.135 | 0.465 | 0.136 | 0.300 | 0.287 | 0.044 |
| TWI | 0.332 | 0.357 | 0.751 | 0.712 | 0.115 | 0.012 | 0.387 | 0.285 | 0.510 |
| HIGHp | 0.423 | 0.371 | 0.260 | 0.341 | 0.464 | 0.454 | 0.124 | 0.169 | 0.081 |
| MEDp | 0.152 | 0.342 | 0.069 | 0.386 | 0.333 | 0.136 | 0.025 | 0.090 | 0.143 |
| LOWp |  | 0.101 | 0.348 | 0.023 | 0.282 | 0.585 | 0.180 | 0.449 | 0.090 |
| PVAR | 0.101 |  | 0.203 | 0.319 | 0.038 | 0.055 | 0.186 | 0.136 | 0.179 |
| FC | 0.348 | 0.203 |  | 0.488 | 0.197 | 0.065 | 0.385 | 0.238 | 0.556 |
| NP | 0.023 | 0.319 | 0.488 |  | 0.183 | 0.221 | 0.248 | 0.463 | 0.596 |
| MMA | 0.282 | 0.038 | 0.197 | 0.183 |  | 0.372 | 0.114 | 0.317 | 0.088 |
| Tmo | 0.585 | 0.055 | 0.065 | 0.221 | 0.372 |  | 0.673 | 0.796 | 0.271 |
| Z5 | 0.180 | 0.186 | 0.385 | 0.248 | 0.114 | 0.673 |  | 0.609 | 0.222 |
| Z95 | 0.449 | 0.136 | 0.238 | 0.463 | 0.317 | 0.796 | 0.609 |  | 0.435 |
| RWD | 0.090 | 0.179 | 0.556 | 0.596 | 0.088 | 0.271 | 0.222 | 0.435 |  |

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