SUPPLEMENTARY INFORMATION FOR:

On the disequilibrium response and climate change vulnerability of the mass balance glaciers in the Alps

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**Table S1**. Geographic location, main geomorphometric characteristics and change, and mass balance results for the period from 2004 to 2014 for the 46 mass balance glaciers of the European Alps.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Glacier | Country | Area in 2003 (km2) | Mean elevation (m a.s.l.) | Elevation range (m) | 2004-13 average ba (m w.e. y-1) | 2004-13 average AAR | 2003-14 area change (%) |
| Argentiere | France | 13.2 | 2856 | 2453 | -1.381 | 0.40 | -8 |
| Bionnassay | France | 4.1 | 2979 | 2416 | -0.677 | 0.49 | -6 |
| Gebroulaz | France | 3.1 | 3027 | 890 | -1.082 | 0.33 | -7 |
| Saint Sorlin | France | 2.8 | 2935 | 777 | -2.021 | 0.17 | -25 |
| Sarennes | France | 0.3 | 2941 | 183 | -2.696 | 0.03 | -78 |
| Tre La Tete | France | 8.4 | 2946 | 1822 |  | 0.35 | -11 |
| Adler | Switzerland | 2.1 | 3459 | 1132 | -0.347 | 0.48 | -2 |
| Basodino | Switzerland | 2.1 | 2884 | 626 | -0.940 | 0.21 | -19 |
| En Darrey | Switzerland | 1.3 | 3011 | 924 |  | 0.29 | -23 |
| Findelen | Switzerland | 13.0 | 3270 | 1293 | -0.425 | 0.56 | -5 |
| Gries | Switzerland | 5.4 | 2900 | 917 | -1.501 | 0.07 | -16 |
| Murtel | Switzerland | 0.4 | 3170 | 300 |  | 0.31 | -21 |
| Pizol | Switzerland | 0.1 | 2678 | 164 | -1.220 | 0.12 | -52 |
| Plaine Morte | Switzerland | 8.1 | 2741 | 490 | -1.323 | 0.02 | -10 |
| Rhone | Switzerland | 15.8 | 2967 | 1376 |  | 0.51 | -6 |
| Sankt Anna | Switzerland | 0.2 | 2729 | 288 | -0.490 | 0.18 | -39 |
| Schwarzbach | Switzerland | 0.1 | 2763 | 137 |  | 0.25 | -46 |
| Sex Rouge | Switzerland | 0.4 | 2816 | 167 | -0.996 | 0.01 | -19 |
| Silvretta | Switzerland | 2.9 | 2785 | 637 | -0.849 | 0.24 | -9 |
| Tsanfleuron | Switzerland | 2.9 | 2765 | 507 | -1.340 | 0.12 | -16 |
| Campo N | Italy | 0.3 | 3000 | 321 | -1.322 | 0.15 | -22 |
| Careser | Italy | 2.8 | 3057 | 462 | -1.788 | 0.01 | -53 |
| Ciardoney | Italy | 0.6 | 3045 | 347 | -1.419 | 0.04 | -15 |
| Fontana Bianca | Italy | 0.5 | 3174 | 417 | -1.088 | 0.11 | -34 |
| Grand Etret | Italy | 0.5 | 2955 | 508 | -0.946 | 0.24 | -22 |
| La Mare | Italy | 4.1 | 3289 | 1091 | -0.763 | 0.26 | -14 |
| Lunga | Italy | 2.0 | 3111 | 716 | -1.195 | 0.12 | -18 |
| Lupo | Italy | 0.2 | 2586 | 327 | -0.272 | 0.31 | -11 |
| Malavalle | Italy | 6.9 | 2981 | 942 | -0.825 | 0.23 | -9 |
| Pendente | Italy | 0.9 | 2806 | 380 | -1.231 | 0.04 | -16 |
| Riess Occidentale | Italy | 1.9 | 2982 | 606 | -0.694 | 0.28 | -11 |
| Sforzellina | Italy | 0.3 | 2902 | 287 | -1.399 | 0.27 | -15 |
| Suretta Meridionale | Italy | 0.2 | 2789 | 223 | -0.824 | 0.22 | -29 |
| Timorion | Italy | 0.5 | 3306 | 361 | -0.778 | 0.30 | -10 |
| Goldberg | Austria | 1.2 | 2706 | 681 | -0.823 | 0.24 | -23 |
| Hallstaetter | Austria | 3.0 | 2551 | 698 | -0.886 | 0.41 | -8 |
| Hintereis | Austria | 8.1 | 3034 | 1258 | -1.177 | 0.24 | -17 |
| Jamtal | Austria | 3.3 | 2781 | 713 | -1.000 | 0.14 | -16 |
| Kesselwand | Austria | 3.8 | 3172 | 726 | -0.440 | 0.43 | -10 |
| Kleinfleiss | Austria | 0.8 | 2860 | 333 | -0.582 | 0.33 | -6 |
| Mullwitz | Austria | 3.0 | 3093 | 770 | -0.838 | 0.39 | -9 |
| Pasterze | Austria | 17.2 | 2891 | 1421 | -1.139 | 0.43 | -9 |
| Sonnblick | Austria | 1.2 | 2783 | 512 | -0.857 | 0.31 | -18 |
| Venediger | Austria | 2.1 | 2920 | 976 | -0.780 | 0.49 | -12 |
| Vernagt | Austria | 8.6 | 3156 | 813 | -0.780 | 0.24 | -15 |
| Wurten | Austria | 0.8 | 2768 | 580 | -0.911 | 0.16 | -21 |

**Table S2**. Spearman correlation coefficients between geomorphometric characteristics, geometric changes and mass balance results for the 46 mass balance glaciers of the European Alps. Correlations significant at the 0.05, 0.01, and 0.001 levels are indicated with one, two or three asterisks, respectively.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Mean elevation | Median elevation | Southern exposure | Mean slope | Mean annual balance | Mean AAR | % area change (upper half) | % area change (lower half) | % area change | Elevation range1 | Hypsometric index | AAR sensitivity | AAR sensitivity (upper half) | Perimeter change (upper half)2 | Perimeter change (lower half)2 | Perimeter change2 |
| Area | 0.251 | 0.310\* | 0.181 | -0.423\*\* | 0.014 | 0.363\* | 0.512\*\*\* | 0.576\*\*\* | 0.628\*\*\* | 0.807\*\*\* | -0.416\*\* | -0.814\*\*\* | -0.761\*\*\* | 0.004 | -0.232 | -0.168 |
| Mean elevation |  | 0.986\*\*\* | 0.244 | -0.039 | 0.125 | 0.226 | 0.293\* | 0.096 | 0.207 | 0.349\* | -0.213 | -0.370\* | -0.325\* | 0.016 | -0.061 | 0.006 |
| Median elevation |  |  | 0.239 | -0.053 | 0.110 | 0.253 | 0.323\* | 0.103 | 0.229 | 0.386\*\* | -0.301\* | -0.404\*\* | -0.346\* | 0.002 | -0.031 | 0.013 |
| Southern exposure |  |  |  | -0.376\* | -0.037 | -0.003 | -0.092 | 0.058 | -0.030 | 0.035 | 0.176 | -0.035 | -0.048 | -0.011 | -0.010 | 0.031 |
| Mean slope |  |  |  |  | 0.194 | 0.184 | -0.088 | -0.238 | -0.197 | -0.039 | 0.199 | 0.031 | -0.001 | 0.082 | 0.245 | 0.194 |
| Mean annual balance |  |  |  |  |  | 0.650\*\*\* | 0.418\*\* | 0.367\* | 0.428\*\* | 0.205 | 0.080 | -0.175 | -0.265 | -0.179 | -0.452\*\* | -0.355\* |
| Mean AAR |  |  |  |  |  |  | 0.660\*\*\* | 0.481\*\*\* | 0.665\*\*\* | 0.555\*\*\* | -0.083 | -0.550\*\*\* | -0.583\*\*\* | -0.300\* | -0.419\*\* | -0.443\*\* |
| % area change (upper half) |  |  |  |  |  |  |  | 0.517\*\*\* | 0.846\*\*\* | 0.530\*\*\* | -0.288 | -0.561\*\*\* | -0.547\*\*\* | -0.508\*\*\* | -0.425\*\* | -0.572\*\*\* |
| % area change (lower half) |  |  |  |  |  |  |  |  | 0.871\*\*\* | 0.442\*\* | -0.106 | -0.479\*\*\* | -0.497\*\*\* | -0.182 | -0.764\*\*\* | -0.607\*\*\* |
| % area change |  |  |  |  |  |  |  |  |  | 0.539\*\*\* | -0.210 | -0.570\*\*\* | -0.571\*\*\* | -0.406\*\* | -0.693\*\*\* | -0.681\*\*\* |
| Elevation range1 |  |  |  |  |  |  |  |  |  |  | -0.239 | -0.979\*\*\* | -0.965\*\*\* | 0.074 | -0.158 | -0.068 |
| Hypsometric index |  |  |  |  |  |  |  |  |  |  |  | 0.242 | 0.096 | 0.046 | 0.063 | 0.096 |
| AAR sensitivity |  |  |  |  |  |  |  |  |  |  |  |  | 0.976\*\*\* | -0.090 | 0.169 | 0.064 |
| AAR sensitivity (upper half) |  |  |  |  |  |  |  |  |  |  |  |  |  | -0.060 | 0.196 | 0.089 |
| Perimeter change (upper half)2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0.349\* | 0.714\*\*\* |
| Perimeter change (lower half)2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0.848\*\*\* |