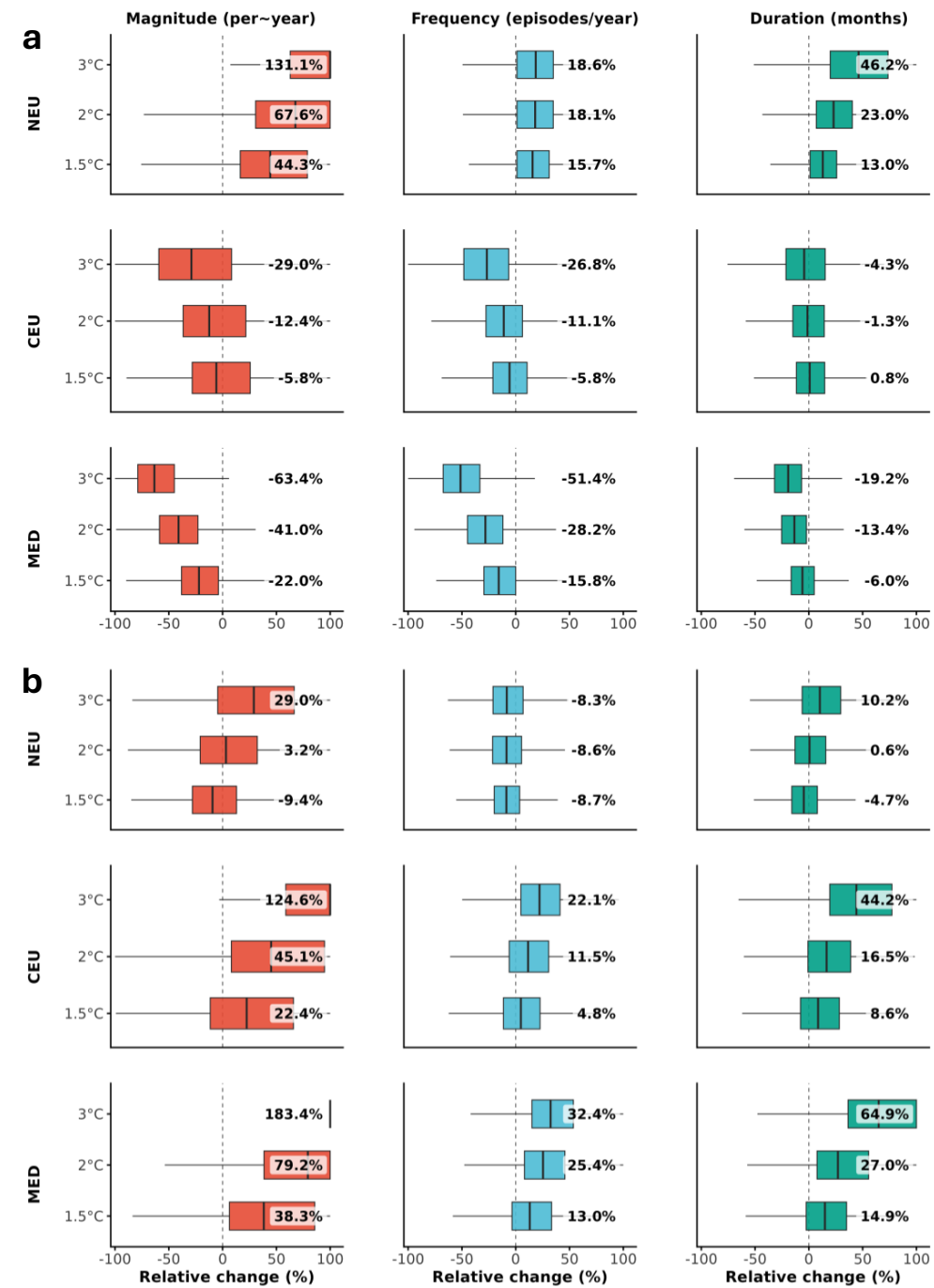
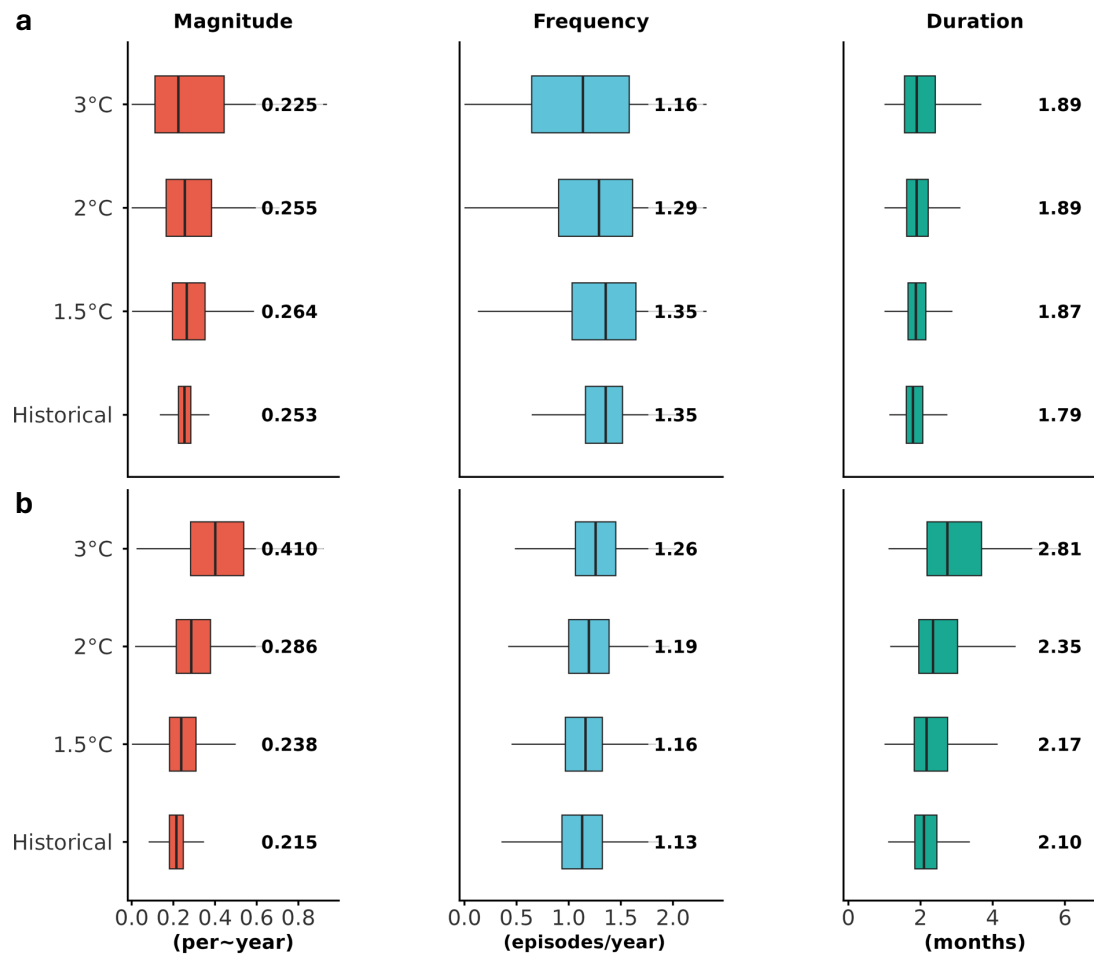
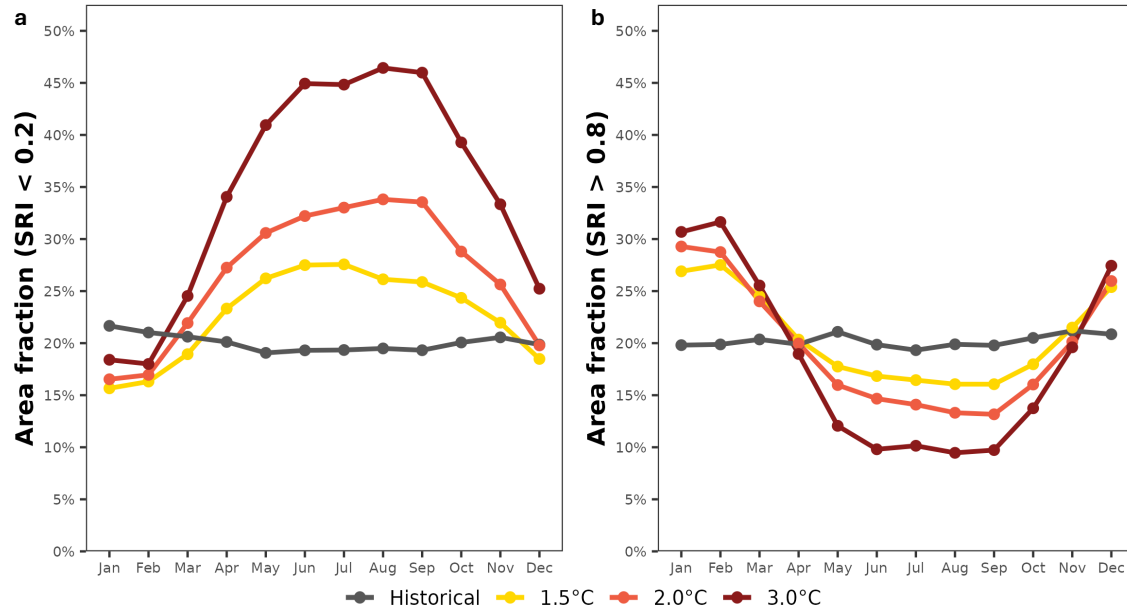




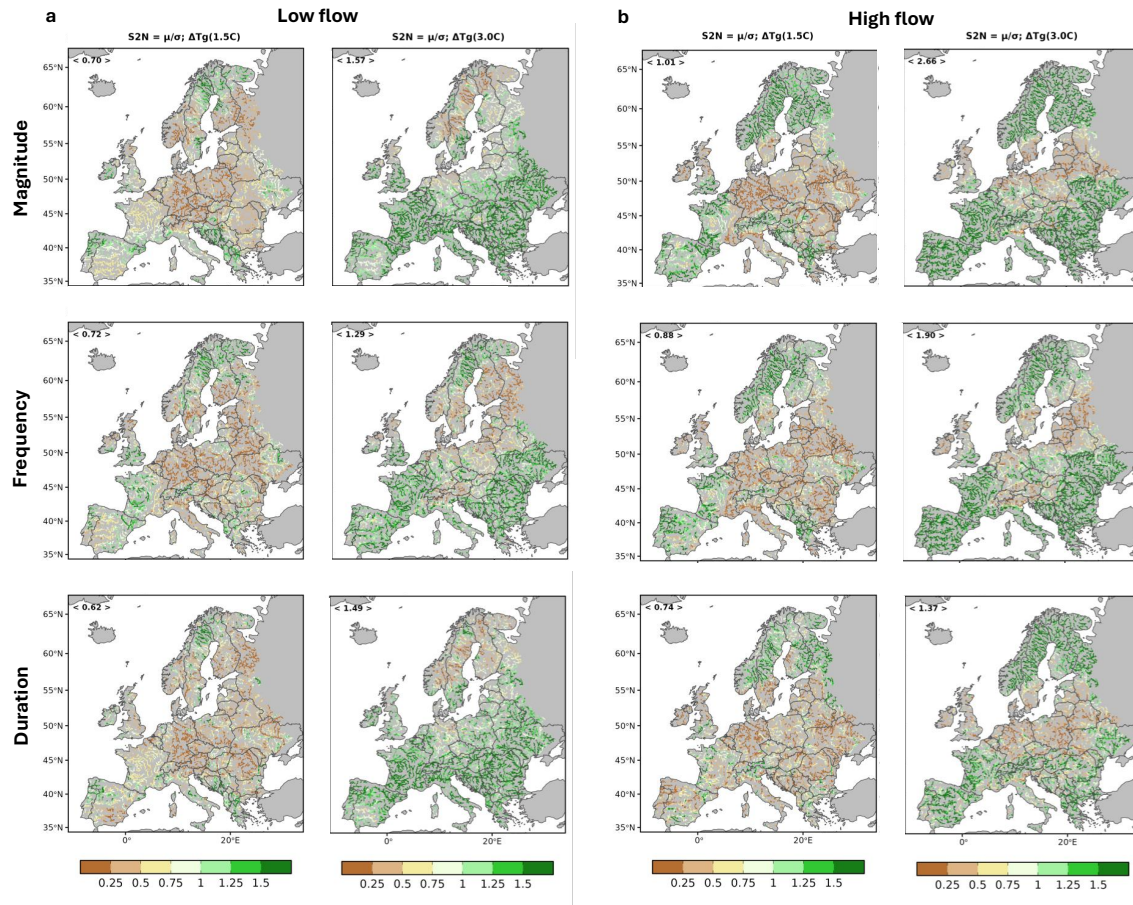
Supplementary Fig. 1 | Regional responses of streamflow condition characteristics to warming. Same as Fig. 1, but stratified by three European regions: Northern Europe (NEU), Central Europe (CEU), and Mediterranean (MED). Panel **a** shows high-flow conditions; panel **b** shows low-flow conditions. Bars show interquartile range across pixels within each region; vertical lines indicate median values. Percentage labels denote median relative change.



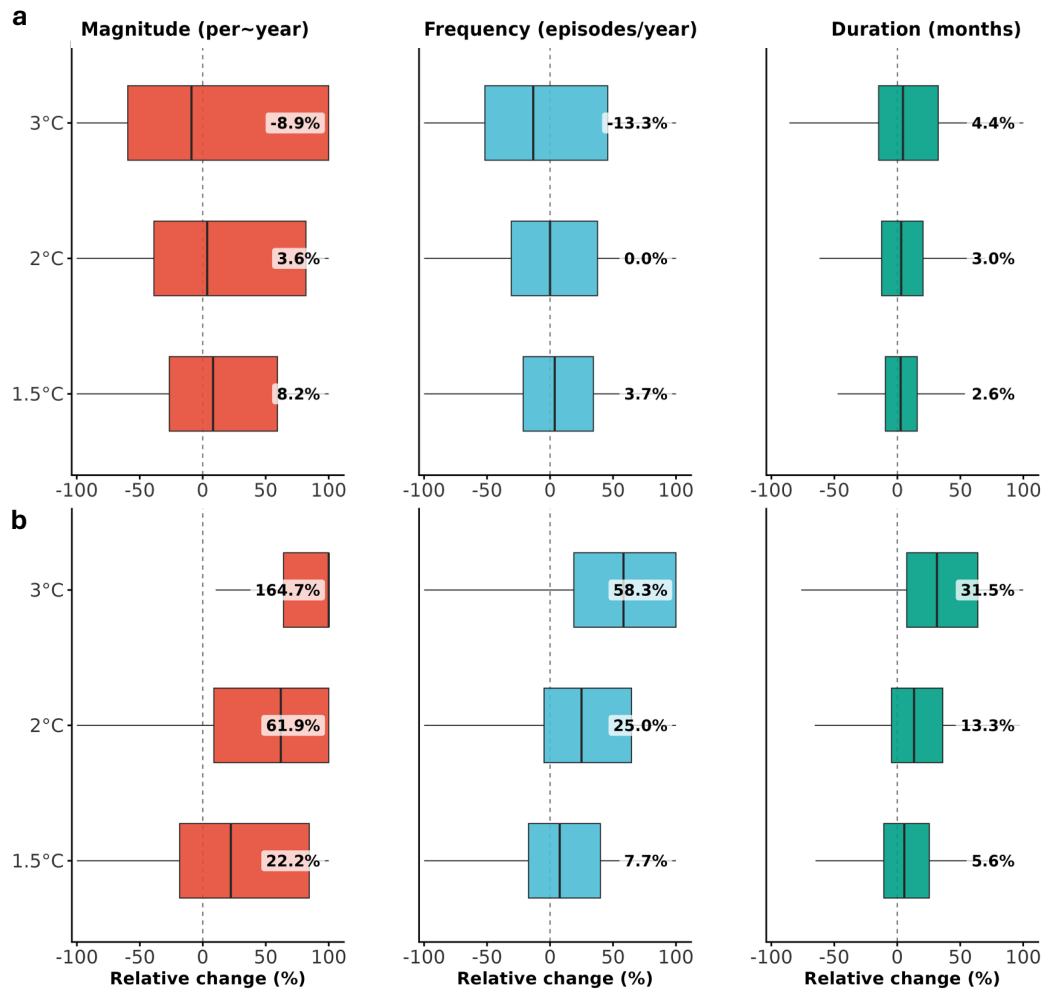
Supplementary Fig. 2 | Absolute values of low- and high-condition characteristics. The same as Fig.1, but showing the actual values of magnitude, frequency, and duration during the historical period and at 1.5°C, 2°C, and 3°C warming levels. Panels show (a) high-flow and (b) low-flow conditions.



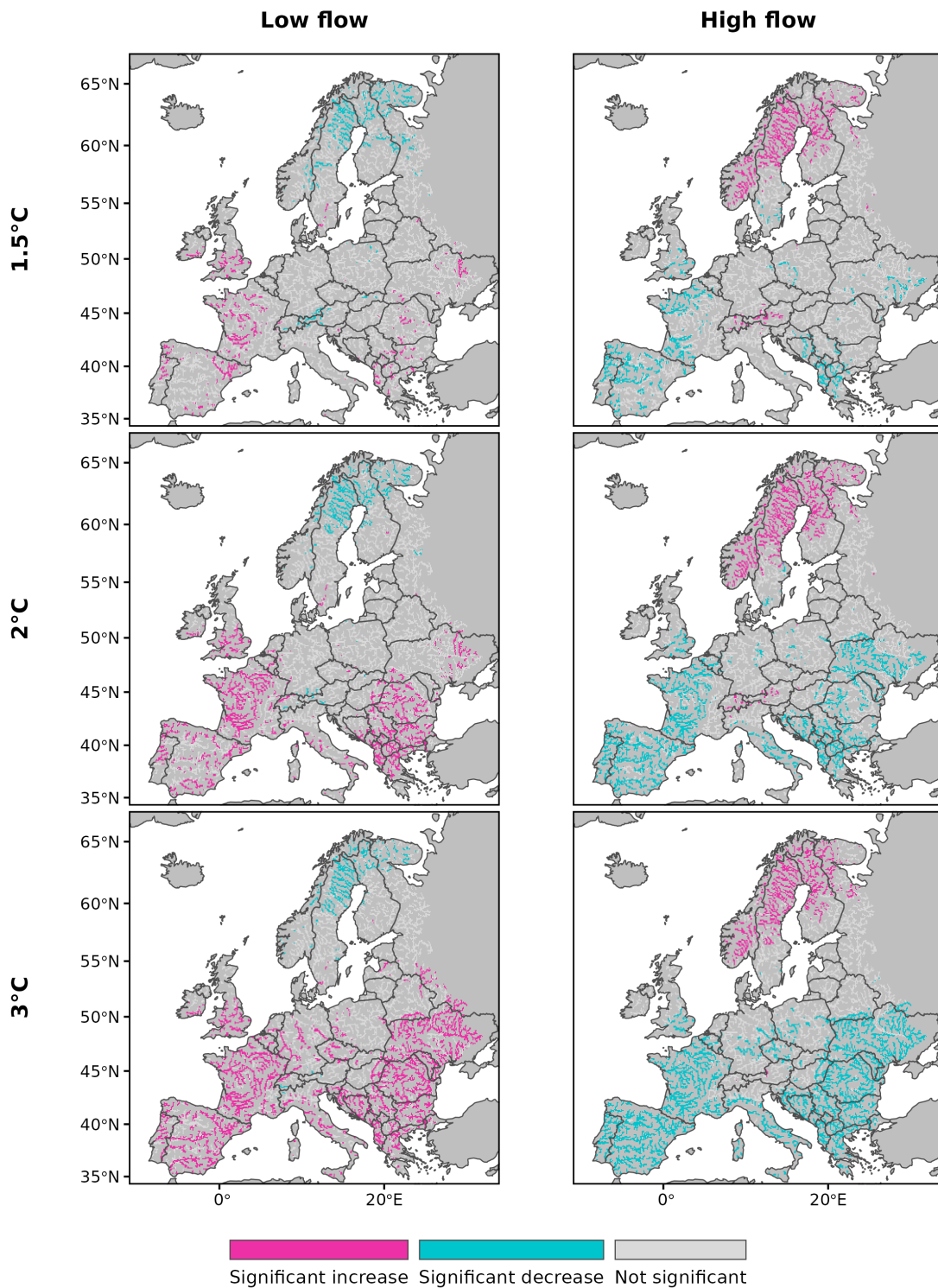
Supplementary Fig. 3 | Annual cycle of streamflow condition occurrence under continuous warming. Monthly area-weighted fraction of river grid cells across Europe experiencing low-flow (**a**) and high-flow (**b**) for historical baseline and warming levels: 1.5°C, 2°C, 3°C. Low-flow peaks in summer intensify with warming; high-flow peaks in winter-spring and decline with warming. Values represent the mean fraction across all years within each warming level, weighted by grid cell area (see Methods).



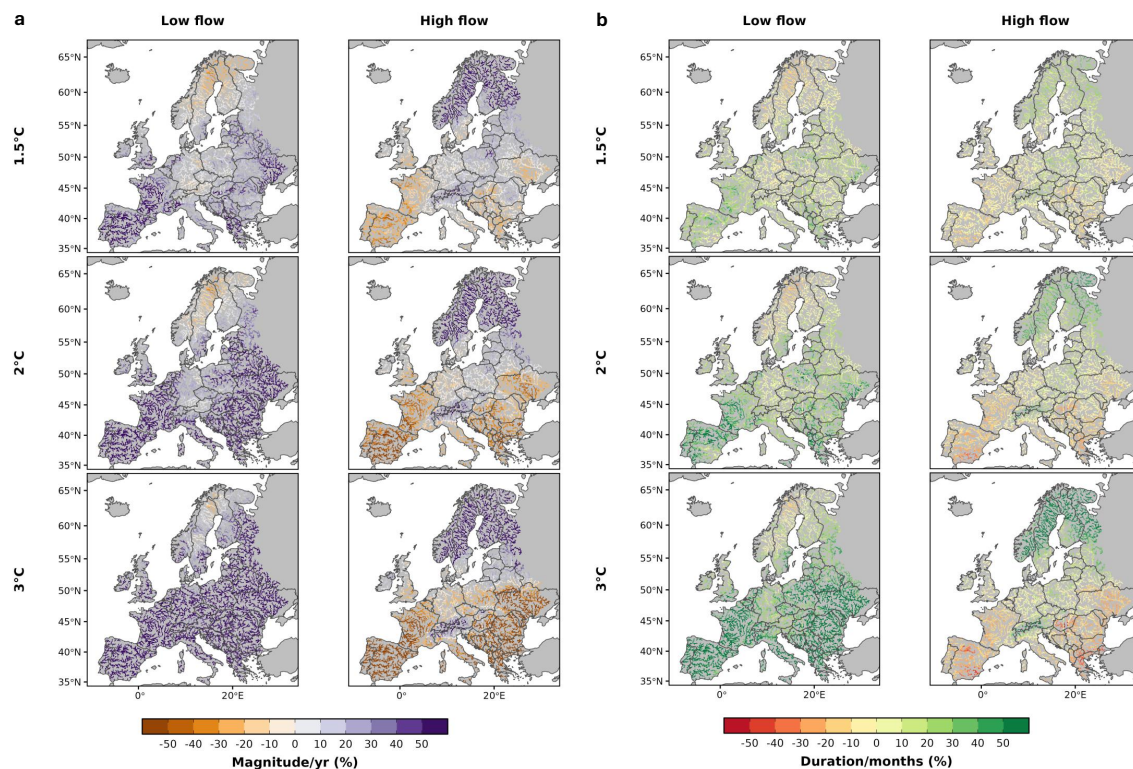
Supplementary Fig. 4 | Signal-to-noise ratio for projected changes in low- and high-condition characteristics. Signal-to-noise ratio ($S2N = \frac{|\mu|}{\sigma}$) for low-flow (a, left panel) and high-flow (b, right panel) condition characteristics at 1.5°C and 3°C warming levels. Rows show magnitude (top), frequency (middle), and duration (bottom); columns show warming levels. S2N represents the ratio of absolute multi-model mean change to inter-model standard deviation across five GCMs. Numbers in the upper-left corners show median S2N across Europe. Green (> 1.0) indicates robust model agreement; brown-orange (< 0.5) indicates high uncertainty.



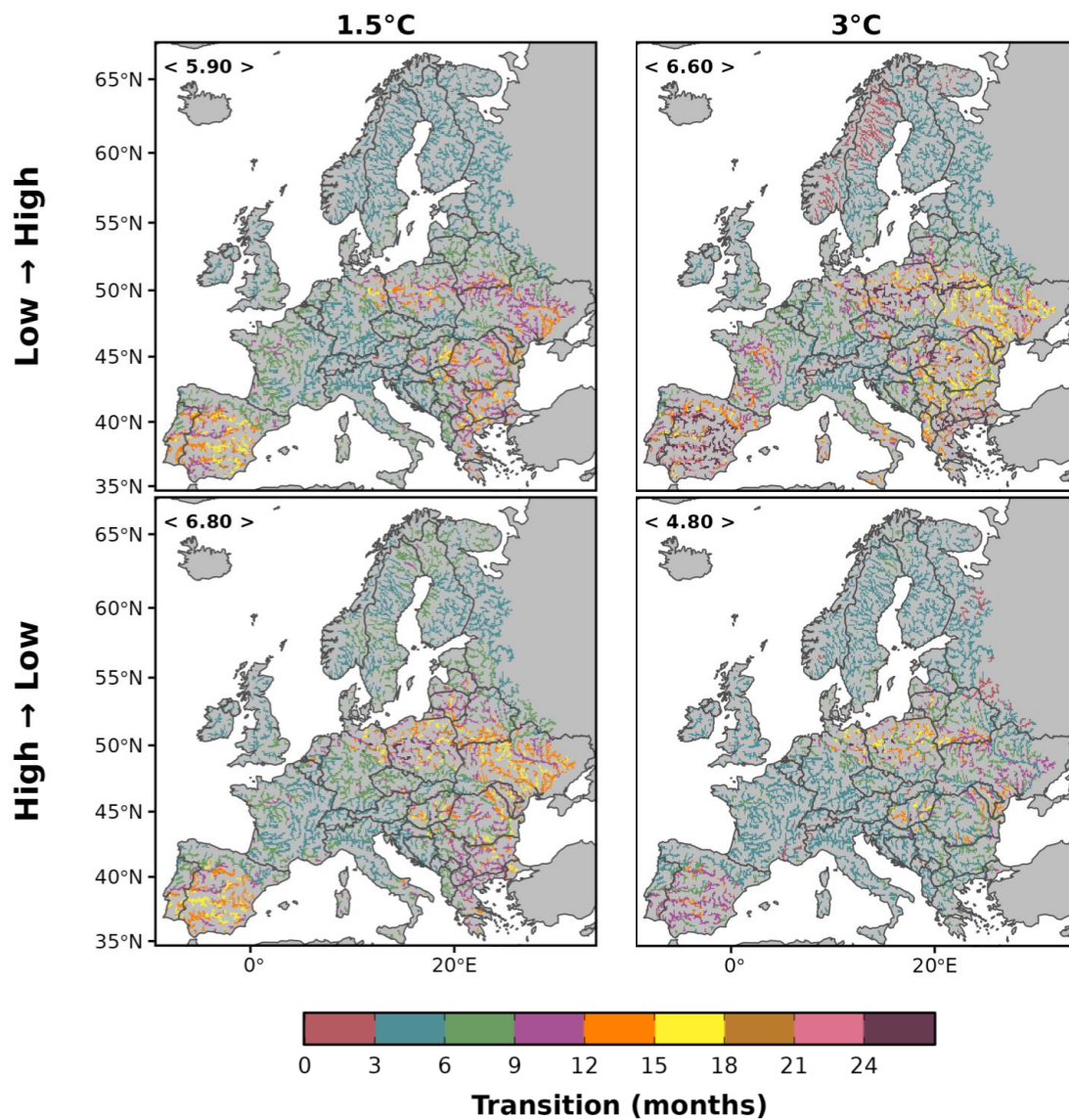
Supplementary Fig. 5 | Low- and high-flow condition characteristics under warming using stricter thresholds. The same as Fig. 1, but using the 10th and 90th SRI percentile thresholds. Row (a) shows the high-flow condition and row (b) shows the low-flow condition.



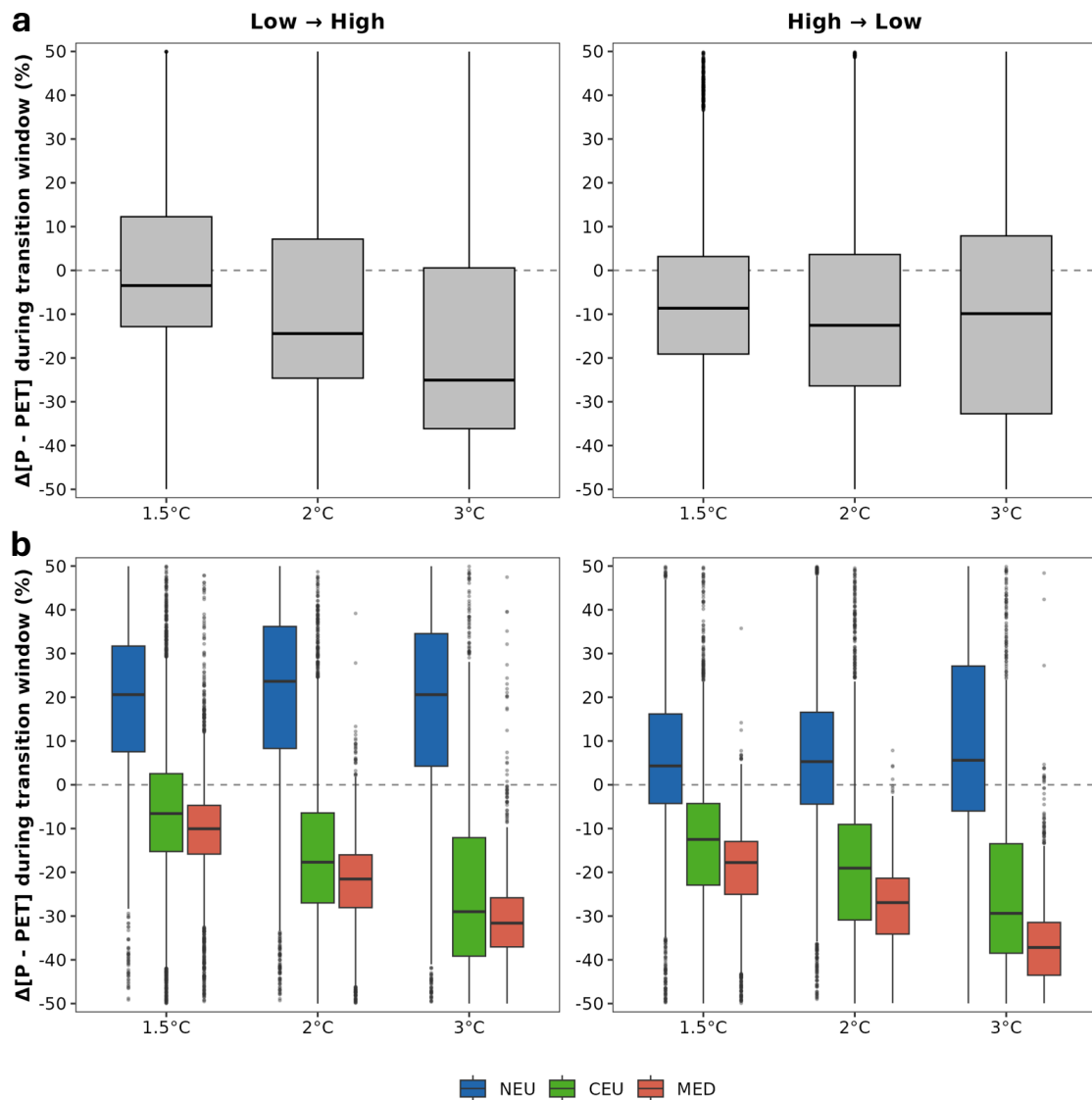
Supplementary Fig. 6 | Spatial extent⁶⁴ of statistically significant changes in frequency across Europe. Statistically significant map of Fig. 2. Purple and turquoise indicate significant frequency increases and decreases relative to the 1980–2010 (one-sample t-test against zero, $p < 0.05$; $n = 5$ GCMs). Grey shading indicates no significant change.



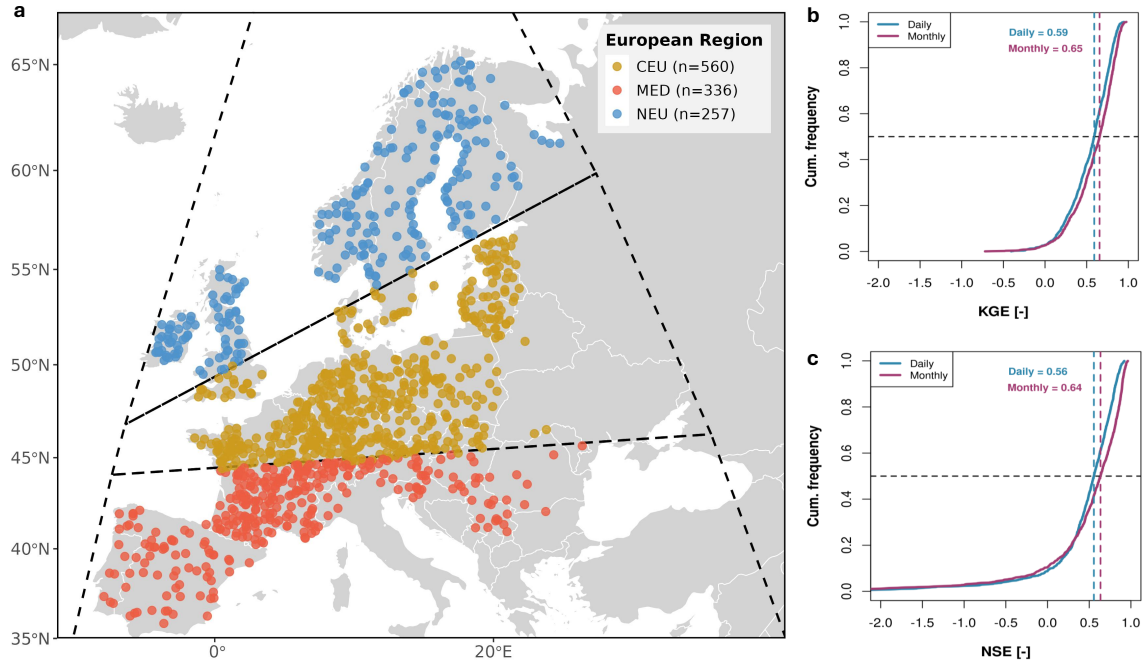
Supplementary Fig. 7 | Spatial patterns of magnitude and duration changes for streamflow conditions. Same as Fig. 2, but for magnitude (a) and duration (b) for low-flow (left columns) and high-flow (right columns).



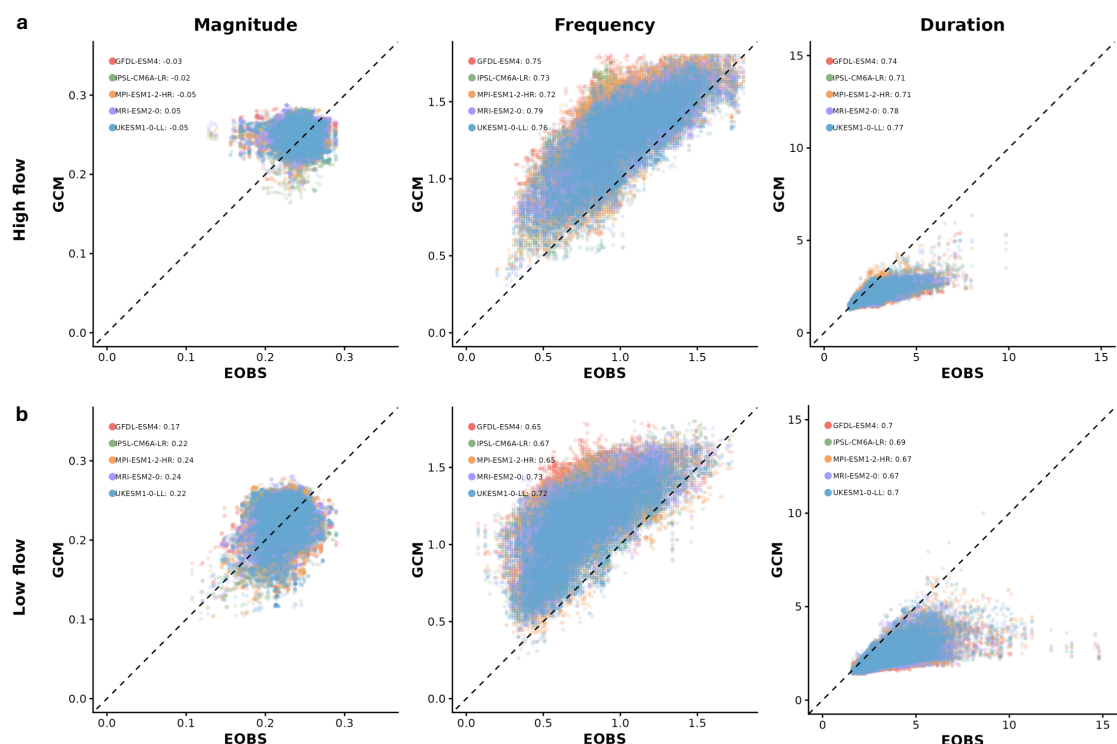
Supplementary Fig. 8 | Spatial map of inter-condition transition times between opposite streamflow episodes under progressive warming. Spatial distribution of Fig.4a for warming levels of 1.5°C and 3°C. Top row: low→high. Bottom row: high→low.



Supplementary Fig. 9 | Relative changes in upstream catchment $P - PET$ during transition windows. Boxplots show the relative change in monthly $P - PET$ during transition windows between low- and high-flow conditions under 1.5°C, 2°C, and 3°C warming levels, relative to the reference historical period. $P - PET$ is calculated at the upstream catchment scale by accounting for all contributing headwater or river grid cells draining to each routed river cell. Panel (a) shows the distribution across the whole European domain, while panel (b) shows the distributions for NEU, CEU, and MED.



Supplementary Fig. 10 | Evaluation of mHM-simulated discharge against GRDC station observations (1960–2024). Spatial distribution of 1,153 GRDC stations (**a**) across three European regions (see Methods): Northern Europe (NEU, blue, $n=257$), Central Europe (CEU, yellow, $n=560$), and Mediterranean (MED, red, $n=336$). Cumulative frequency distribution (**b**) of Kling-Gupta Efficiency (KGE) values for daily and monthly discharge across all selected stations. Vertical dashed lines indicate median values, and the horizontal dashed line marks the 50% cumulative frequency. The same cumulative frequency distribution (**c**), but using Nash-Sutcliffe Efficiency (NSE).



Supplementary Fig. 11 | Validation of high- and low-flow condition characteristics: GCM versus E-OBS driven simulations (1960–2024). Comparison of condition magnitude, frequency, and duration between ISIMIP3b bias-corrected GCM-driven and E-OBS-driven mHM simulations across European grid cells, for high-flow (**a**) and low-flow (**b**) regimes, with model results shown on the y-axis and observations on the x-axis. Colors represent five GCMs: GFDL-ESM4 (red), IPSL-CM6A-LR (green), MPI-ESM1-2-HR (orange), MRI-ESM2-0 (purple), UKESM1-0-LL (blue). The dashed line shows a 1:1 agreement. Legend values indicate median Pearson correlation coefficients across all pixels for each GCM.