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# An improved modelling chain for bias-adjusted high-resolution climate and hydrological projections for Norway

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**Table S1. Summary of the 14 GCM-RCM combinations available for SSP3-7.0. The combinations in bold were selected for downscaling and bias-adjustment for the mainland of Norway.**

| Model combination name | GCM modelling institute | GCM | RCM modelling institute | RCM | Data coverage |
|---|---|---|---|---|---|
| **cnrm-r1i1p1f2-hclim** | CNRM-CERFACS | CNRM-ESM2-1 | HCLIMcom | HCLIM43 | 1951–2100 |
| **cnrm-r1i1p1f2-racmo** | CNRM-CERFACS | CNRM-ESM2-1 | KNMI | RACMO23E | 1956–2100 |
| **ecearth-r1i1p1f1-racmo** | EC-Earth-Consortium | EC-Earth3 | KNMI | RACMO23E | 1956–2100 |
| **ecearthveg-r1i1p1f1-cclm** | EC-Earth-Consortium | EC-Earth3-Veg | KIT (CLMcom) | CCLM-6-0-clm | 1951–2099 |
| **ecearthveg-r1i1p1f1-hclim** | EC-Earth-Consortium | EC-Earth3-Veg | HCLIMcom | HCLIM43 | 1951–2100 |
| **miroc-r1i1p1f1-icon** | MIROC | MIROC6 | BTU (CLMcom) | ICON-2-6-5-rc | 1950–2099 |
| **mpi-r1i1p1f1-hclim** | DKRZ & MPI-M | MPI-ESM1-2-HR | HCLIMcom | HCLIM43 | 1951–2100 |
| **mpi-r1i1p1f1-icon** | DKRZ & MPI-M | MPI-ESM1-2-HR | BTU (CLMcom) | ICON-2-6-5-rc | 1950–2099 |
| **mpi-r1i1p1f1-racmo** | DKRZ & MPI-M | MPI-ESM1-2-HR | KNMI | RACMO23E | 1956–2100 |
| **noresm-r1i1p1f1-hclim** | NCC | NorESM2-MM | HCLIMcom | HCLIM43 | 1951–2100 |
| ecearthveg_r1i1p1f1_icon | EC-Earth-Consortium | EC-Earth3-Veg | BTU (CLMcom) | ICON-2-6-5-rc | 1950-2100 |

| | | | | | |
|---|---|---|---|---|---|
| ecearthveg_r1i1p1f1_racmo | EC-Earth-Consortium | EC-Earth3-Veg | KNMI | RACMO23E | 1956–2100 |
| miroc_r1i1p1f1_hclim | MIROC | MIROC6 | HCLIMcom | HCLIM43 | 1951–2100 |
| noresm_r1i1p1f1_racmo | NCC | NorESM2-MM | KNMI | RACMO23E | 1956–2100 |

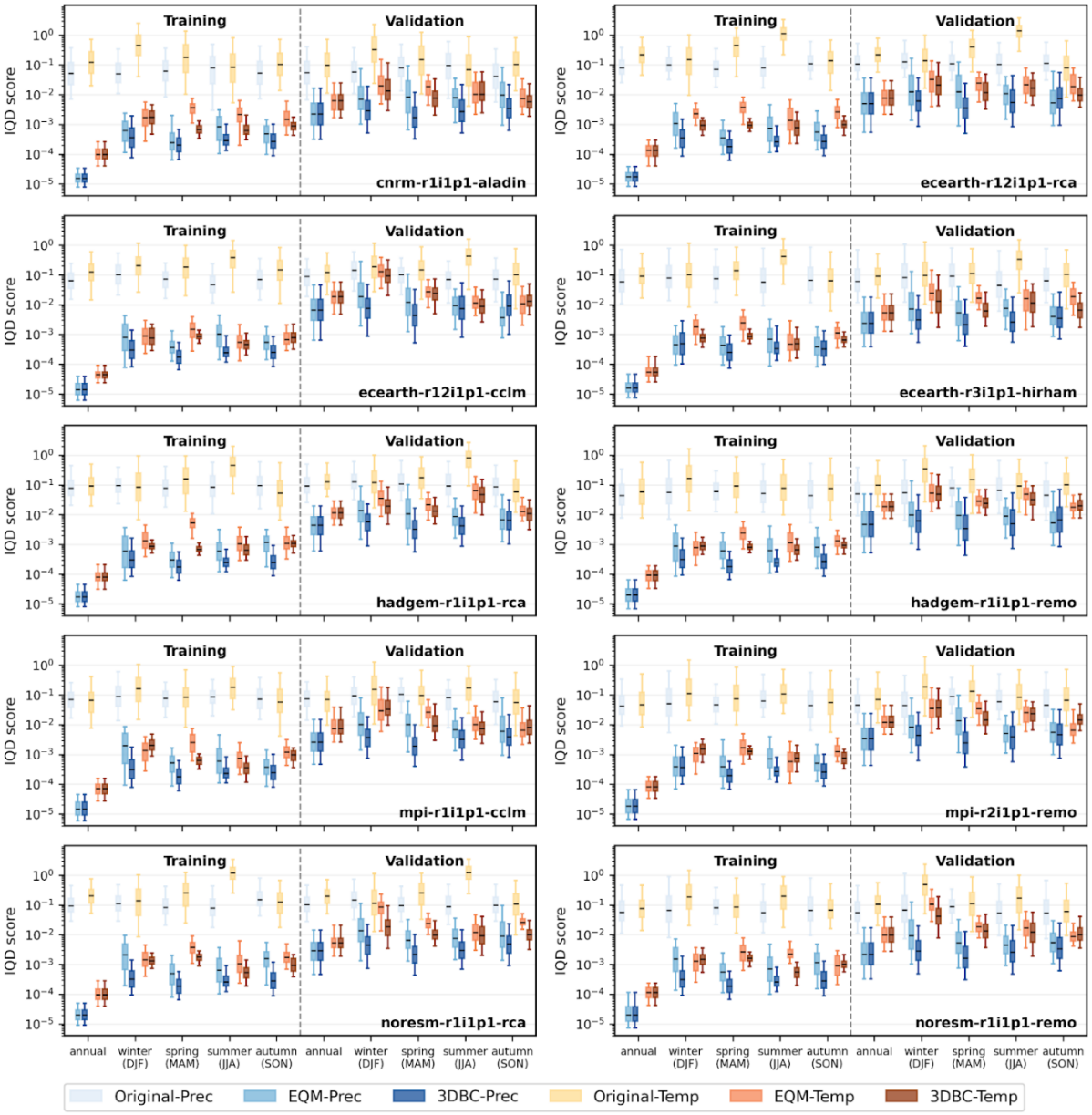


**Figure S1: Integrated quadratic distance (IQD) scores for precipitation (blue tones) and temperature (reddish brown tones). One panel for each CMIP5-based GCM-RCM combination. Bias-adjusted results from EQM and 3DBC in addition to the original model outputs are compared with the reference datasets seNorge2018 v20.05 over the training (1985–2014) and validation (1960/70–1984) periods. The black line on the box indicates the median value. The lower and upper boundaries of the box are the 25$^{th}$ and 75$^{th}$ percentiles. The lower and upper ends of the whiskers refer to the 5$^{th}$ and 95$^{th}$ percentiles.**

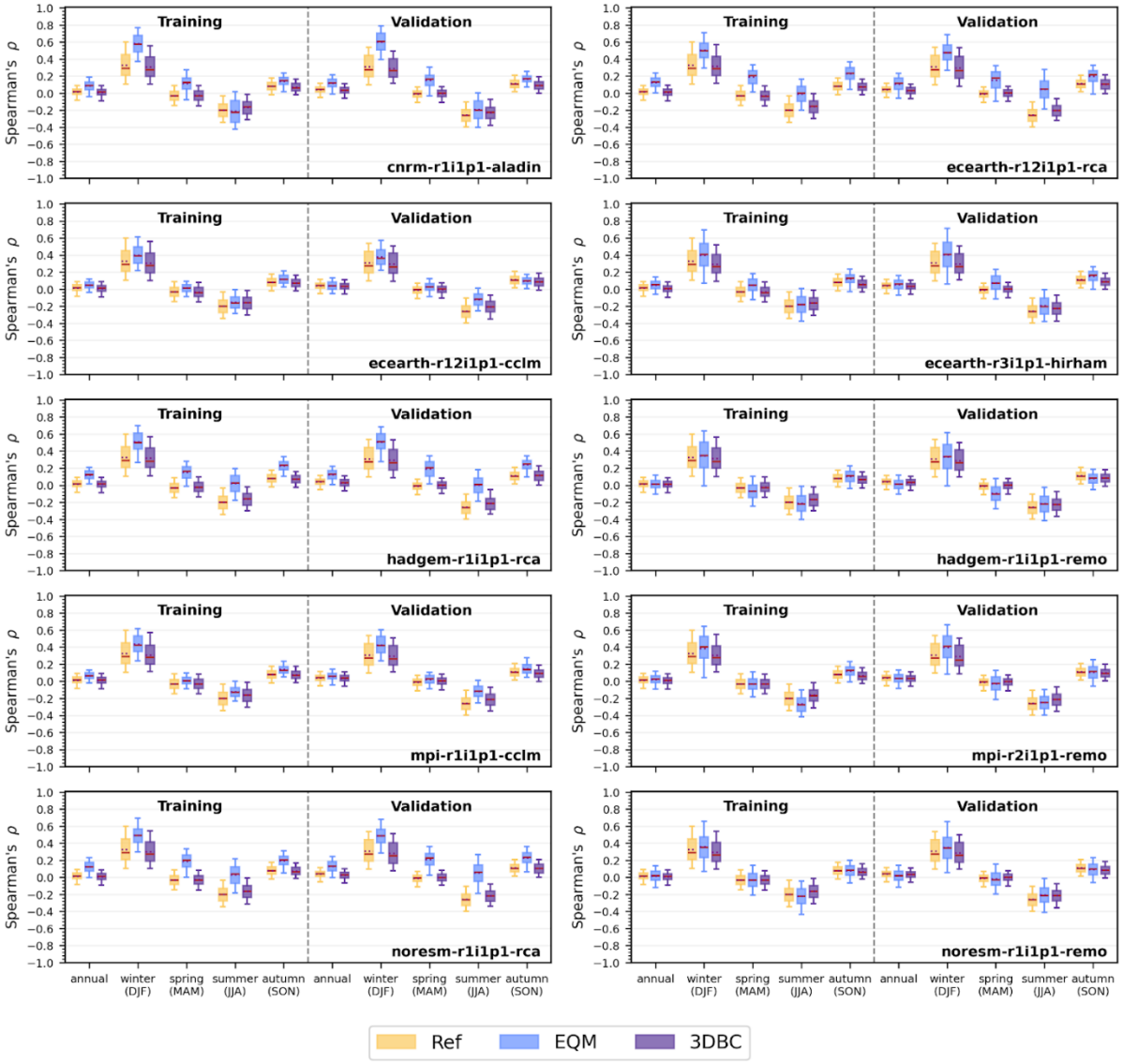


**Figure S2: Spearman's rank correlation coefficients ρ derived from two bias-adjustment approaches (EQM and 3DBC) in addition to reference datasets seNorge2018 v20.05 over the training (1985–2014) and validation (1960/70–1984) periods. One panel for each CMIP5-based GCM-RCM combination. The red line on the box indicates the median value whilst the dotted line represents the mean. The lower and upper boundaries of the box are the 25$^{th}$ and 75$^{th}$ percentiles. The lower and upper ends of the whiskers refer to the 5$^{th}$ and 95$^{th}$ percentiles.**

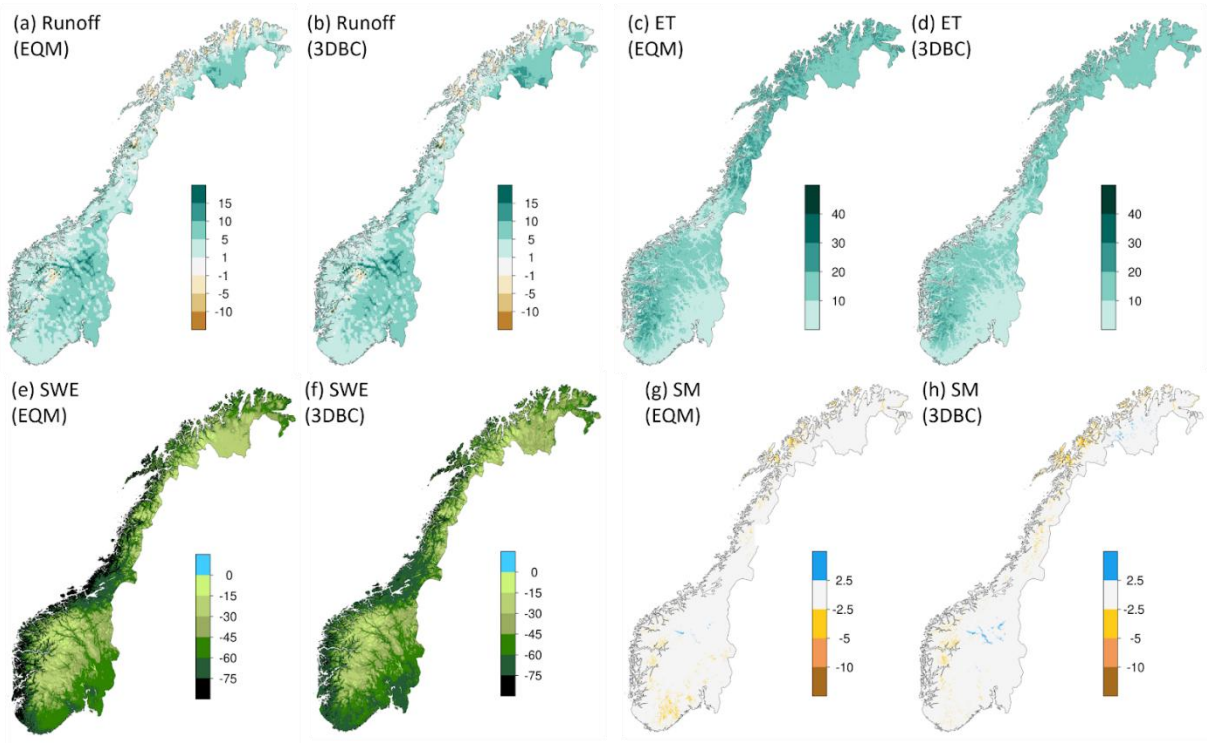


**Figure S3: ensemble mean changes (%) in annual runoff (a and b), evaporation (ET) (c and d), snow water equivalent (SWE) (e and f) and soil moisture (SM) (g and h) using two bias-adjustment methods in the scenario period 2071–2100 relative to the reference period 1991–2020 under the RCP4.5 scenario for mainland Norway.**

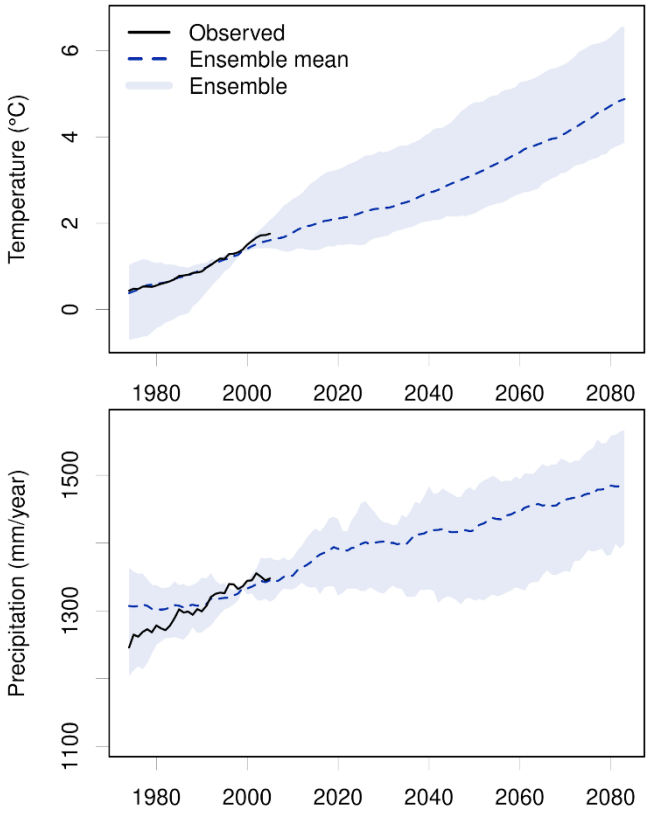


**Figure S4: Simulated 30-year running means of temperature (top) and precipitation (bottom) from the COR-BA-2025 ensemble of 20 climate projections (10 GCM-RCM combinations x 2 bias-adjustment methods) for Norway under the SSP3-7.0 emission scenario.**

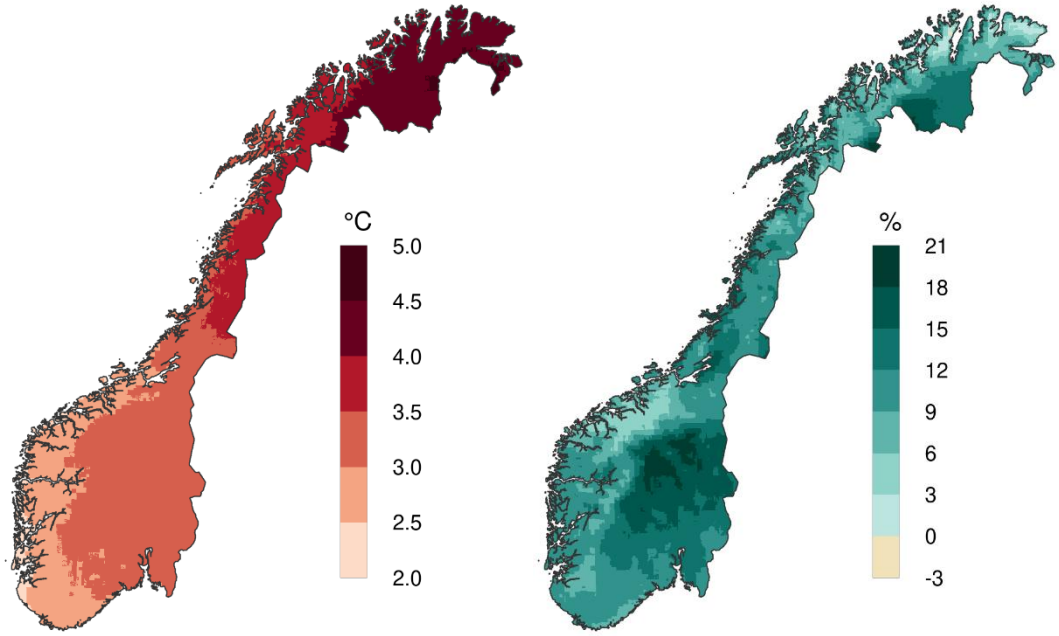


**Figure S5: COR-BA-2025 ensemble mean (left) changes in temperature (°C) and (right) relative changes in precipitation (%) in the scenario period 2071–2100 relative to the reference period 1991–2020 under the SSP3-7.0 scenario for mainland Norway.**

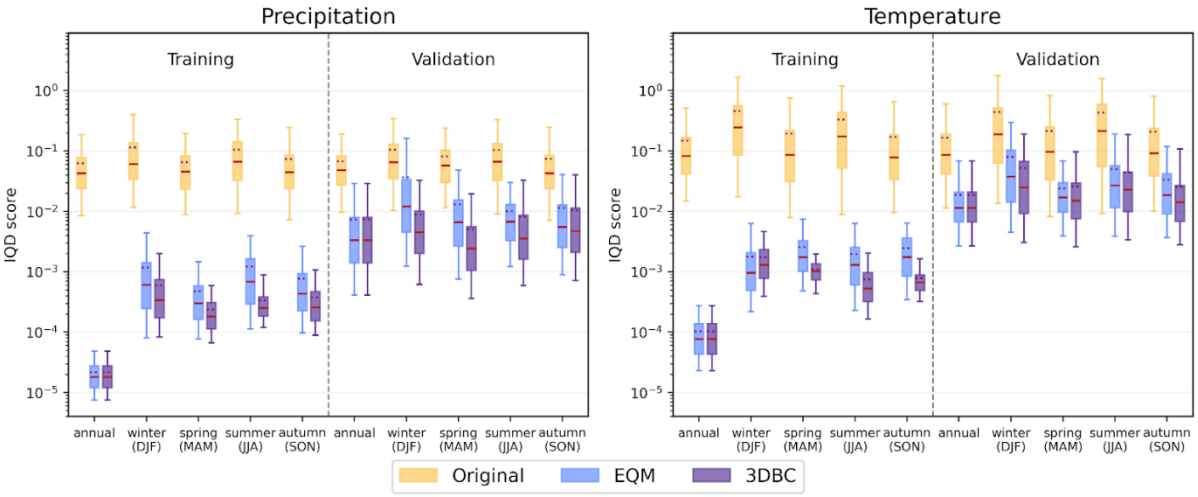


**Figure S6: Integrated quadratic distance (IQD) scores for precipitation (left panel) and temperature (right panel) based on the CMIP6 model ensemble. Bias-adjusted results from EQM and 3DBC in addition to the original model outputs are compared with the reference datasets seNorge2018 v20.05 over the training (1985–2014) and validation (1960–1984) periods. The red line on the box indicates the median value whilst the dotted line represents the mean. The lower and upper boundaries of the box are the 25$^{th}$ and 75$^{th}$ percentiles. The lower and upper ends of the whiskers refer to the 5$^{th}$ and 95$^{th}$ percentiles.**

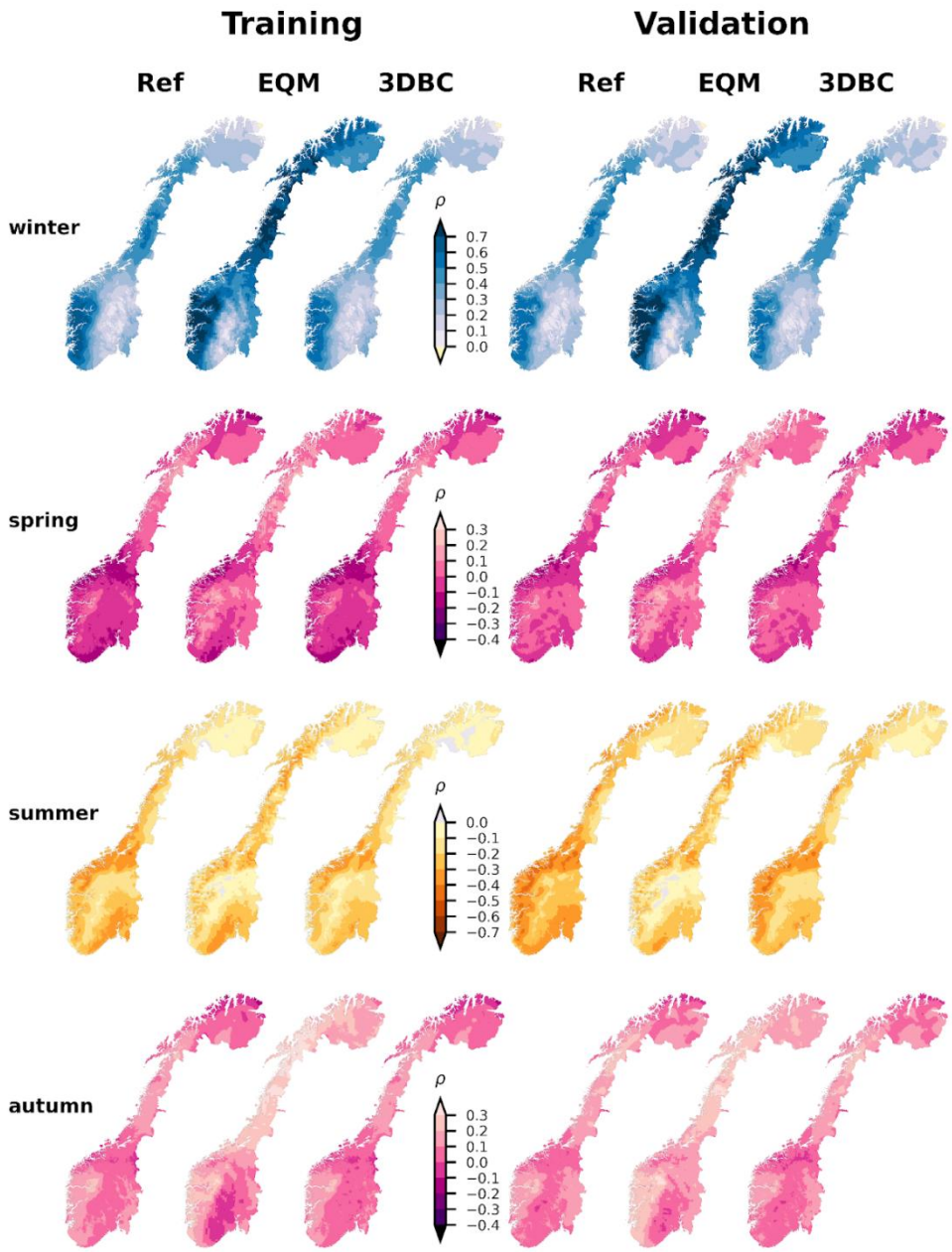


**Figure S7: Spatial distribution of Spearman's rank correlation coefficient ρ of daily precipitation and temperature in winter (DJF), spring (MAM), summer (JJA) and autumn (SON) for the two bias-adjustment methods. For training (1985–2014) and validation (1960–1984) periods, the two bias-adjusted datasets, EQM and 3DBC are based on historical run from CMIP6-based mpi-r1i1p1f1-hclim and compared with reference datasets seNorge2018 v20.05.**

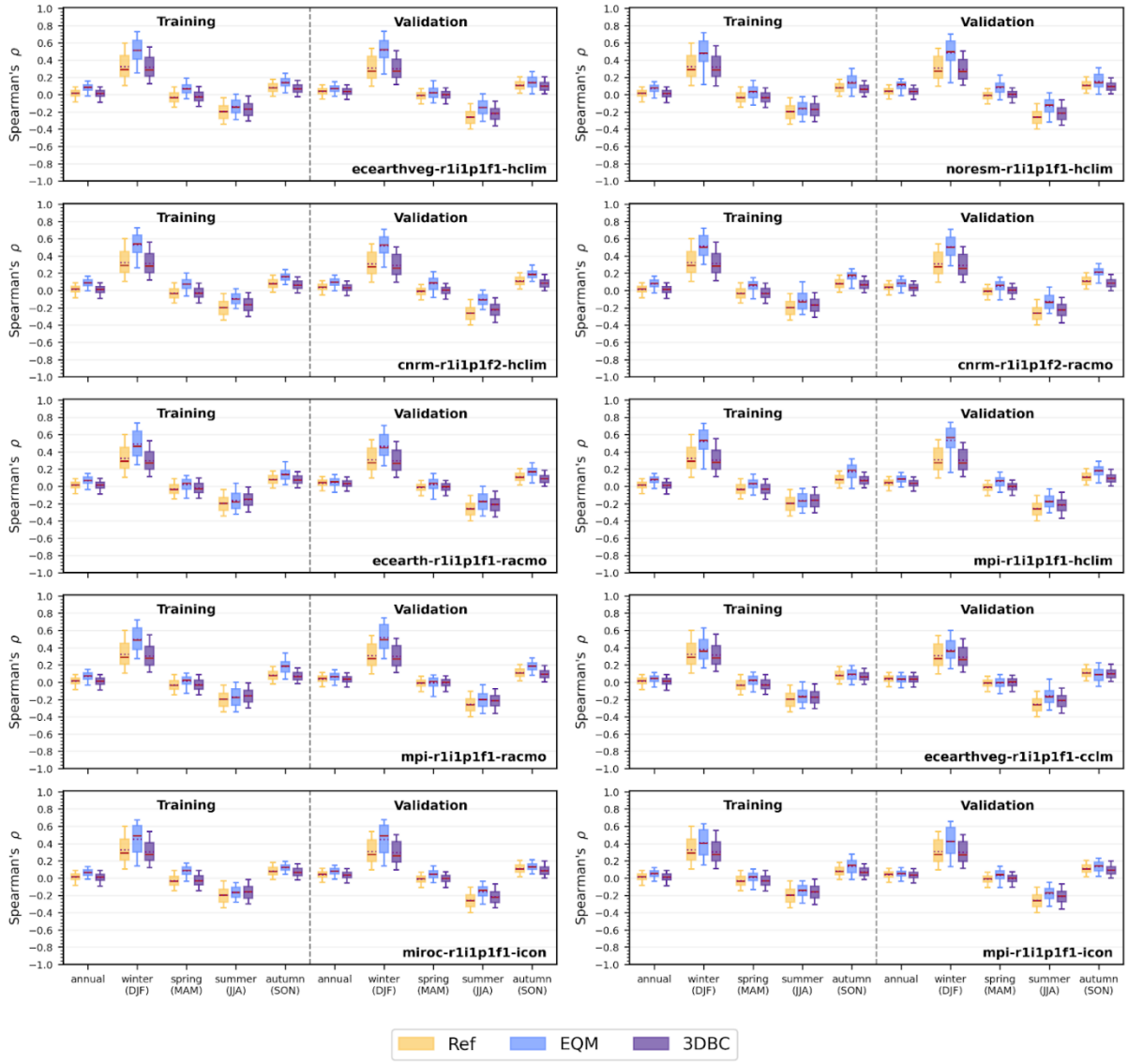


**Figure S8: Spearman's rank correlation coefficients ρ derived from two bias-adjustment approaches (EQM and 3DBC) in addition to reference datasets seNorge2018 v20.05 over the training (1985–2014) and validation (1960/70–1984) periods. One panel for each CMIP6-based GCM-RCM combination. The red line on the box indicates the median value whilst the dotted line represents the mean. The lower and upper boundaries of the box are the 25$^{th}$ and 75$^{th}$ percentiles. The lower and upper ends of the whiskers refer to the 5$^{th}$ and 95$^{th}$ percentiles.**

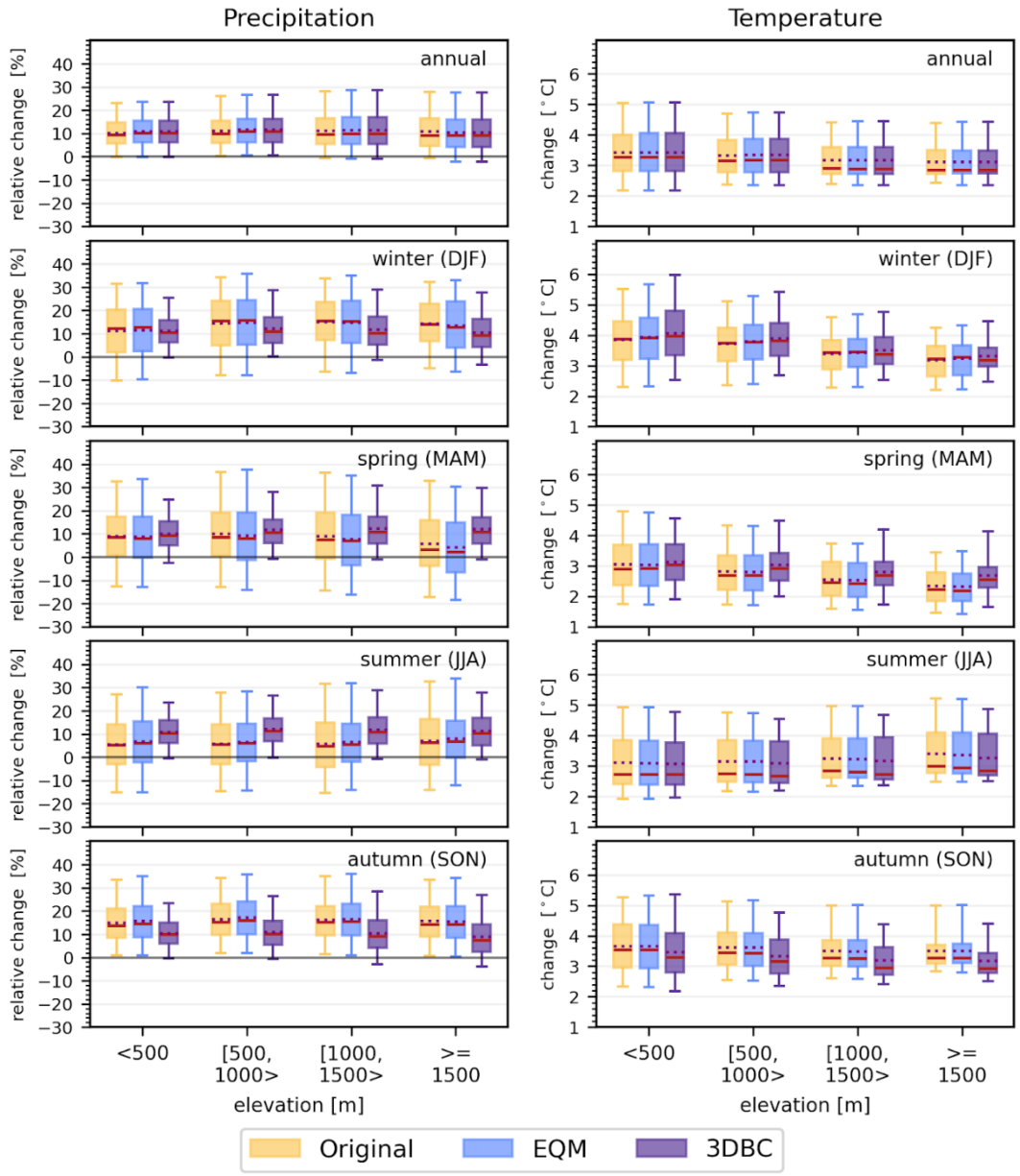


**Figure S9: Projected annual and seasonal changes in precipitation (relative change in %, left column) and temperature (change in °C, right column) from 1991–2020 to 2071–2100 for SSP3-7.0 in terms of elevation. Results grouped in four elevation bands from two bias-adjustment procedures, EQM and 3DBC, are compared to the original RCM projections. The red line on the box indicates the median value whilst the dotted line represents the mean. The lower and upper boundaries of the box are the 25$^{th}$ and 75$^{th}$ percentiles. The lower and upper ends of the whiskers refer to the 5$^{th}$ and 95$^{th}$ percentiles.**

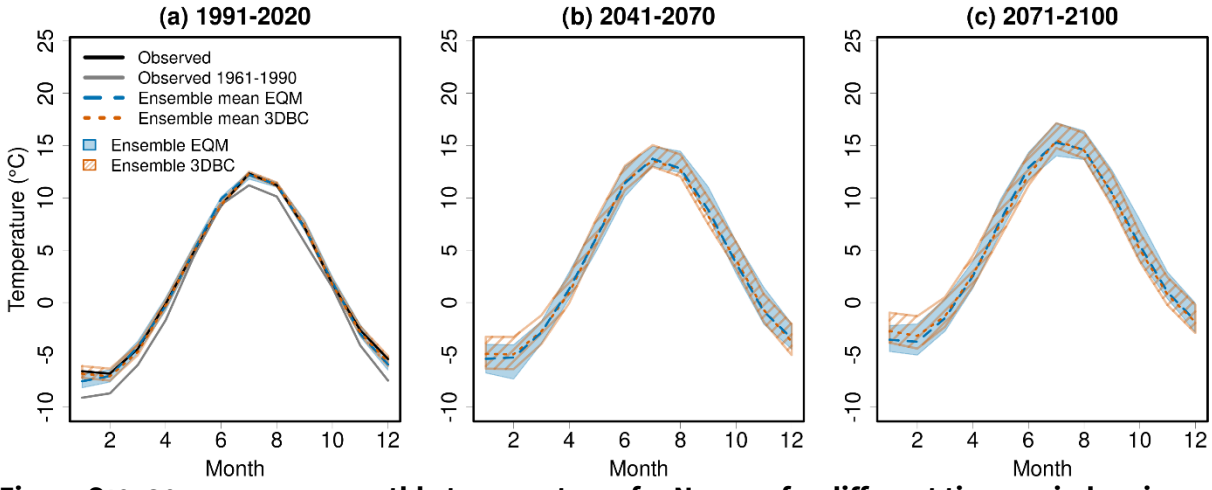


**Figure S10: 30-year mean monthly temperatures for Norway for different time periods using the EQM and 3DBC bias-adjusted climate projections under the SSP3-7.0 scenario. Black line: Observed temperature in 1991–2020. Grey line: Observed temperature in 1961-1990. Blue and orange lines: ensemble means of simulated temperature. Blue and orange striped areas: ensemble spread of 10 projections.**

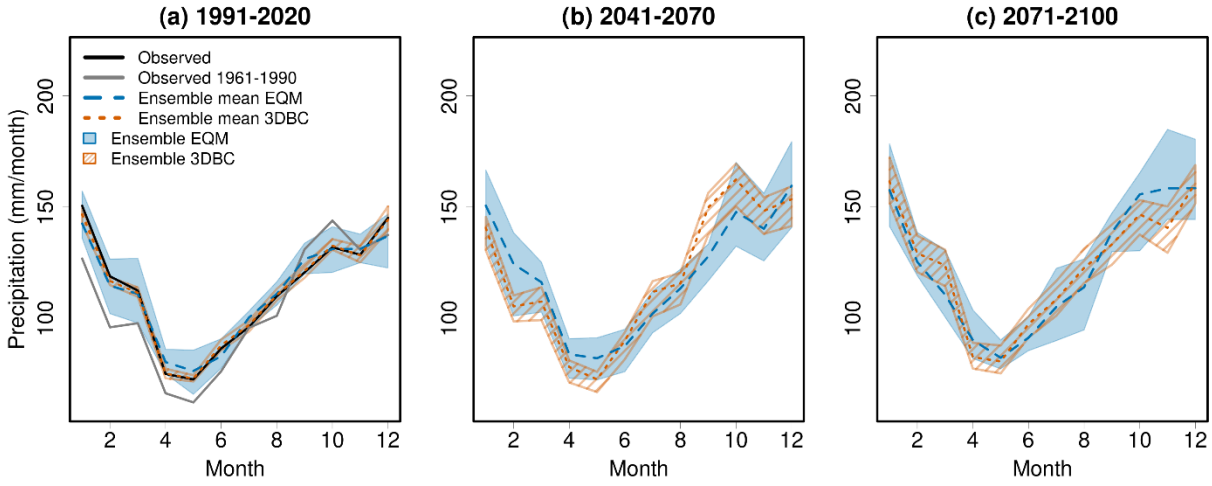


**Figure S11: 30-year mean monthly precipitation amounts for Norway for different time periods using the EQM and 3DBC bias-adjusted climate projections under the SSP3-7.0 scenario. Black line: Observed precipitation in 1991–2020. Grey line: Observed precipitation in 1961-1990. Blue and orange lines: ensemble means of simulated precipitation. Blue and orange striped areas: ensemble spread of 10 projections.**

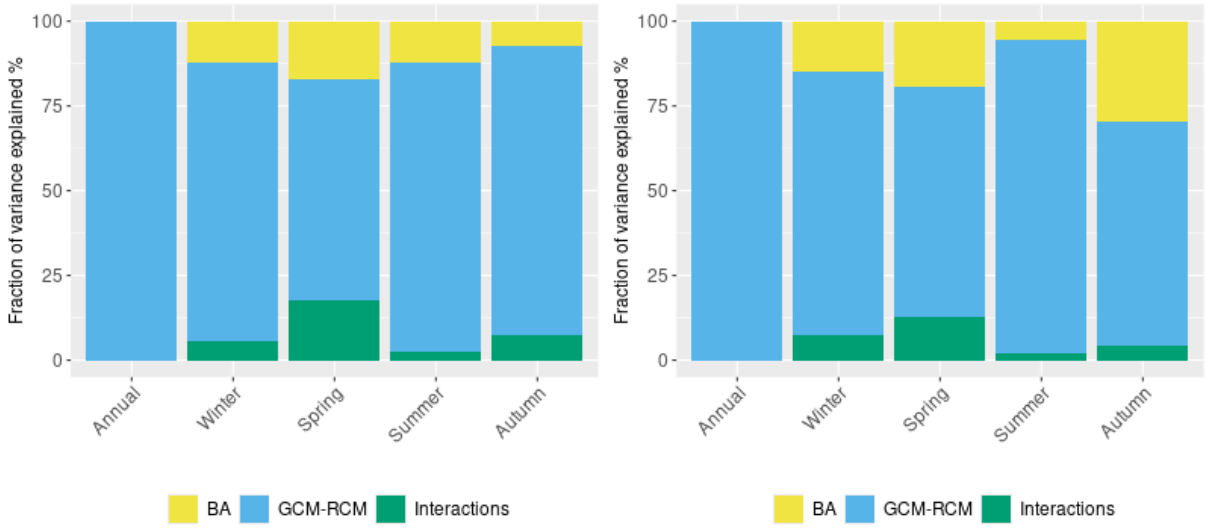


**Figure S12: the fraction of variance in projected temperature changes explained by bias-adjustment methods (BA), GCM-RCM combinations and their interactions for the near-future period (2041–2070, left) and far-future period (2071–2100, right) under the SSP3-7.0 scenario.**

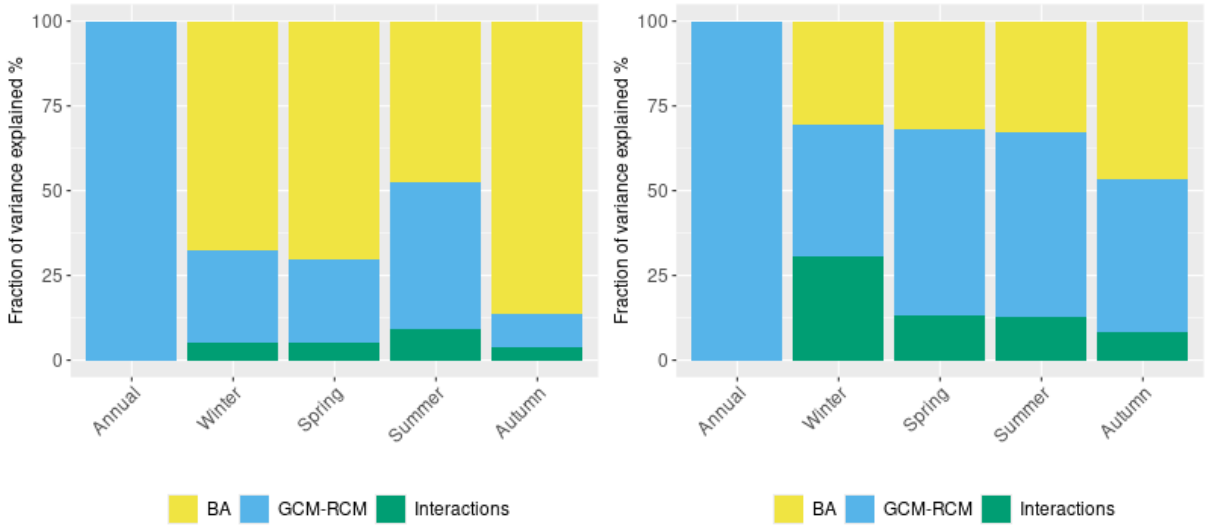


**Figure S13: the fraction of variance in projected precipitation changes explained by bias-adjusted methods (BA), GCM-RCM combinations and their interactions for the near-future period (2041–2070, left) and far-future period (2071–2100, right) under the SSP3-7.0 scenario.**

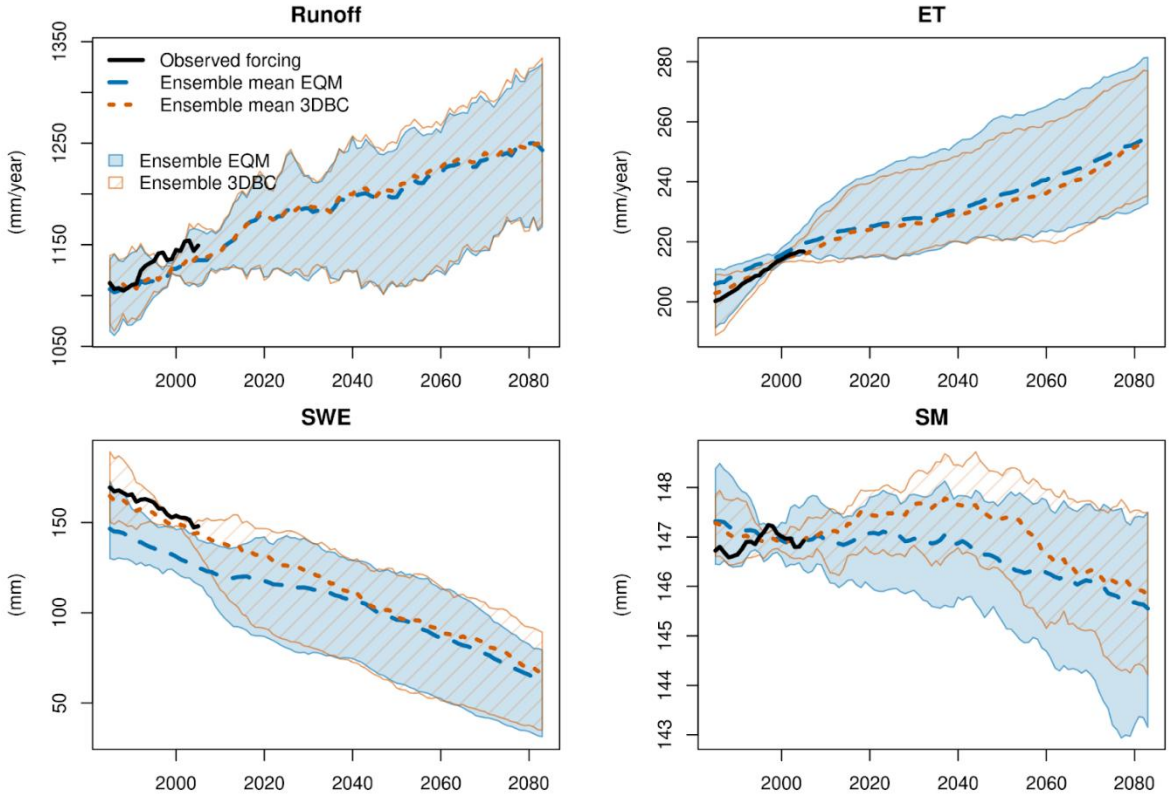


**Figure S14: Simulated 30-year running means of annual runoff, evaporation (ET), mean snow water equivalent (SWE) and mean soil moisture (SM) driven by the ensemble of 20 climate projections (10 GCM-RCMs x 2 bias correction methods) under the SSP3-7.0 scenario. The black line is the simulated water components driven by the observed forcing data.**

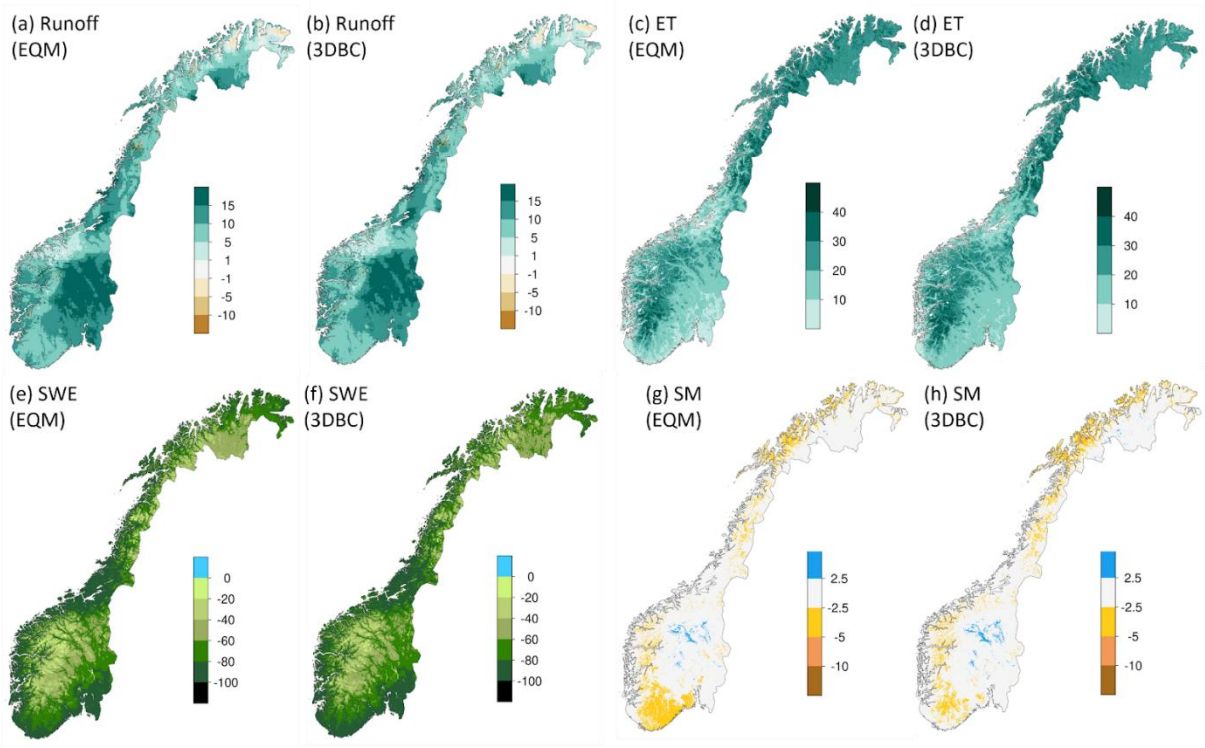


**Figure S15: ensemble mean changes (%) in annual runoff (a and b), evaporation (ET) (c and d), snow water equivalent (SWE) (e and f) and soil moisture (SM) (g and h) using two bias-adjustment methods in the scenario period 2071–2100 relative to the reference period 1991–2020 under the SSP3-7.0 scenario for mainland Norway.**

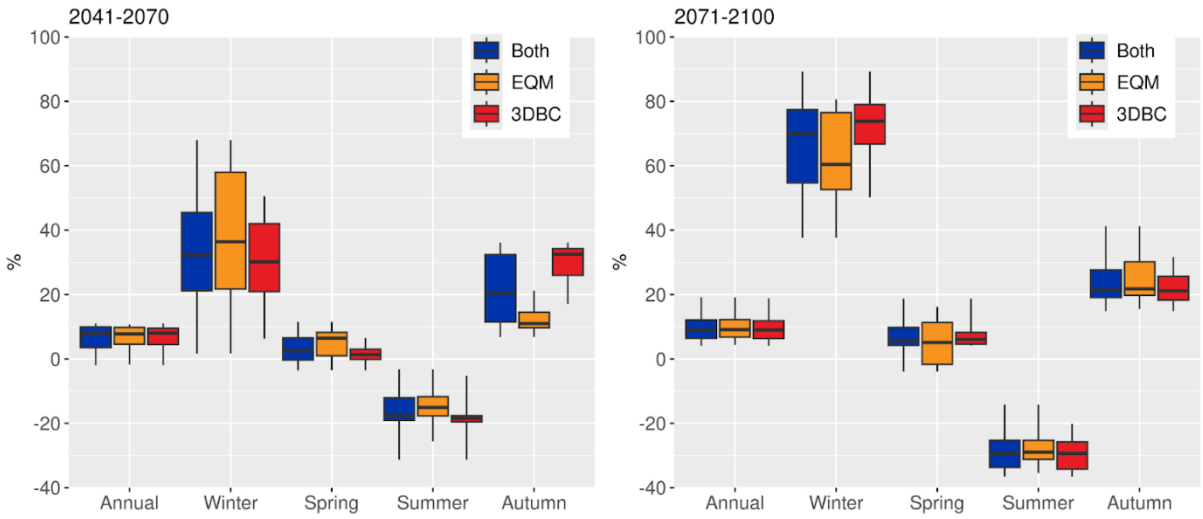


**Figure S16: relative changes in runoff for different seasons in the scenario periods 2041–2070 (left) and 2071–2100 (right) relative to the reference period 1991–2020 under the SSP3-7.0 scenario for mainland Norway.**

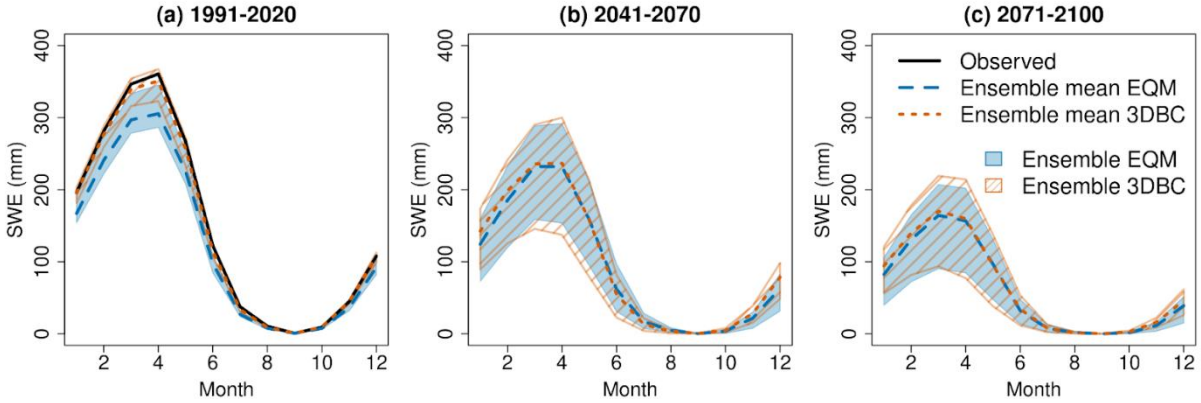


**Figure S17: Simulated monthly snow water equivalent (SWE) for mainland Norway using the EQM and 3DBC bias-adjusted climate projections in the reference period (a), near future (2041-2070) and far future (2071-2100) under the SSP3-7.0 scenario.**

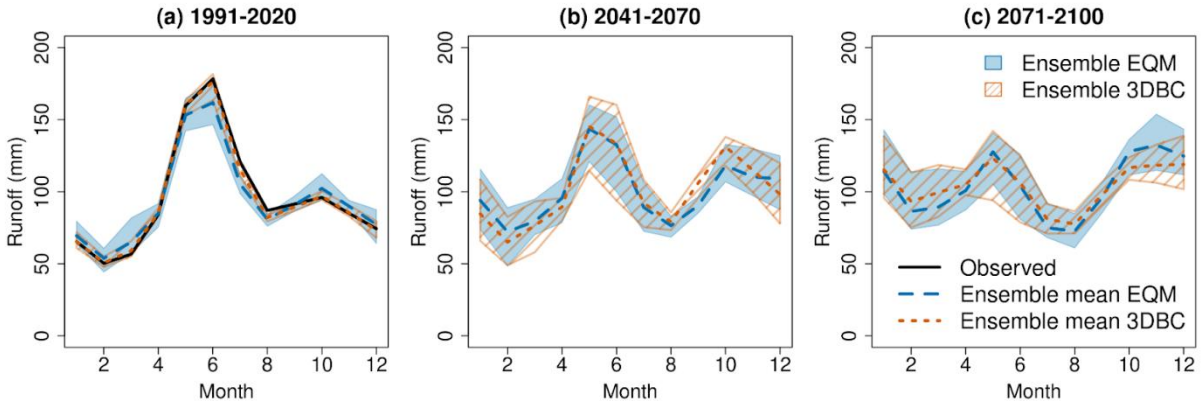


**Figure S18: Simulated monthly runoff for mainland Norway using the EQM and 3DBC bias-adjusted climate projections in the reference period (a), near future (2041-2070) and far future (2071-2100) under the SSP3-7.0 scenario.**

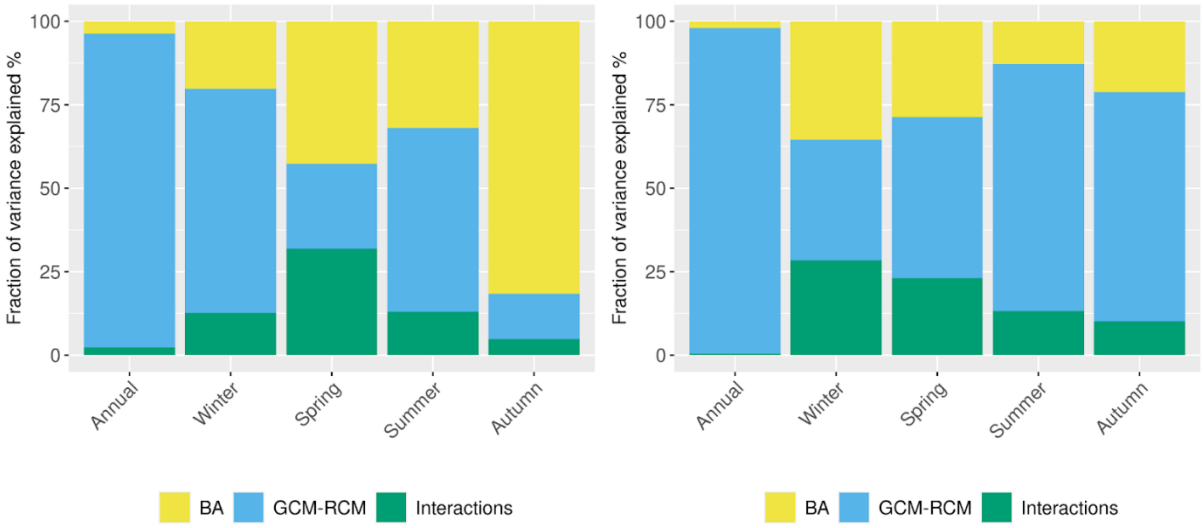


**Figure S19: the fraction of variance in runoff change projections explained by bias-adjustment methods (BA), GCM-RCM combinations and their interactions for the near-future period (2041-2070) (left) and far-future period (2071-2100) under the SSP3-7.0 scenario.**