For each meteorological variable, to compare the bias before and after downscaling, the multi-year average values of original GCMs and downscaled GCMs subtract the corresponding values of ERA5, respectively. The bias comparison map for every variable between ERA5 and EC-Earth3, MPI-ESM1-2-HR, MRI-ESM2-0 is shown in Fig. S1, S2 and S3, respectively. For each variable in each GCM, the bias from ERA5 become significantly smaller after downscaling.
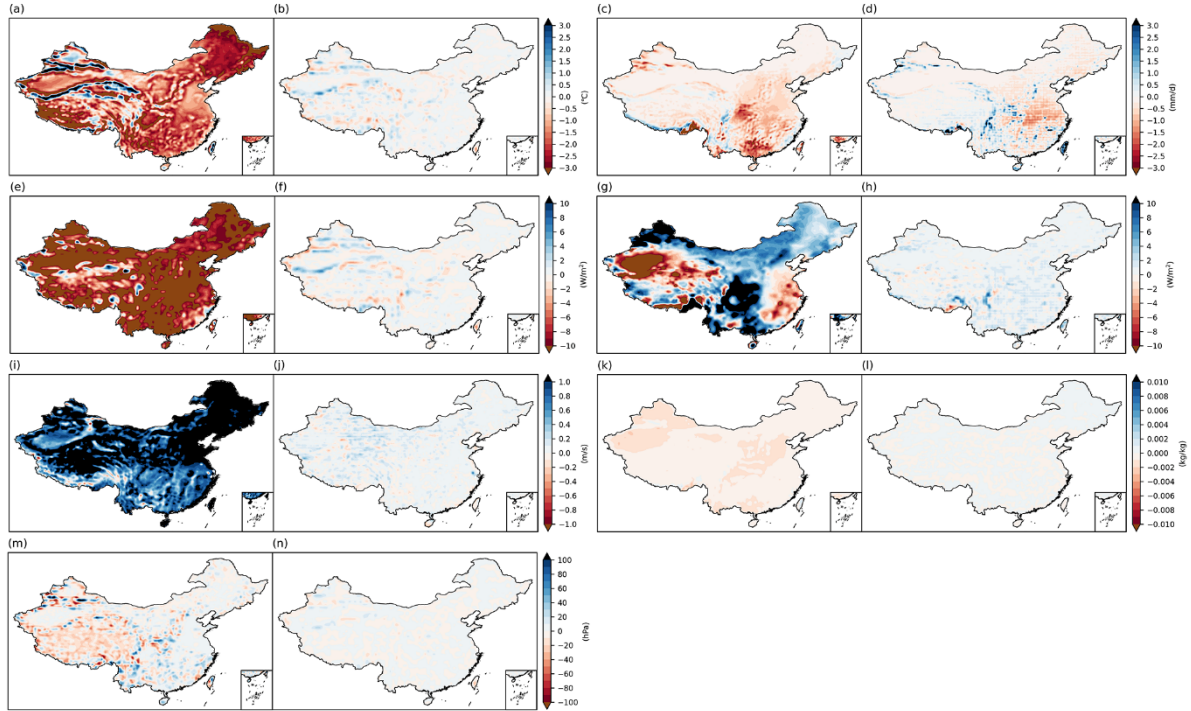
Figure S1. Bias comparison map for muti-year average daily surface temperature (a, b), precipitation (c, d), longwave radiation (e, f), shortwave radiation (g, h), wind speed (i, j), specific humidity (k, l) and surface pressure (m, n) between ERA5 and original EC-Earth3 (a, c, e, g, i, k, m), ERA5 and downscaled EC-Earth3 (b, d, f, h, j, l, n)
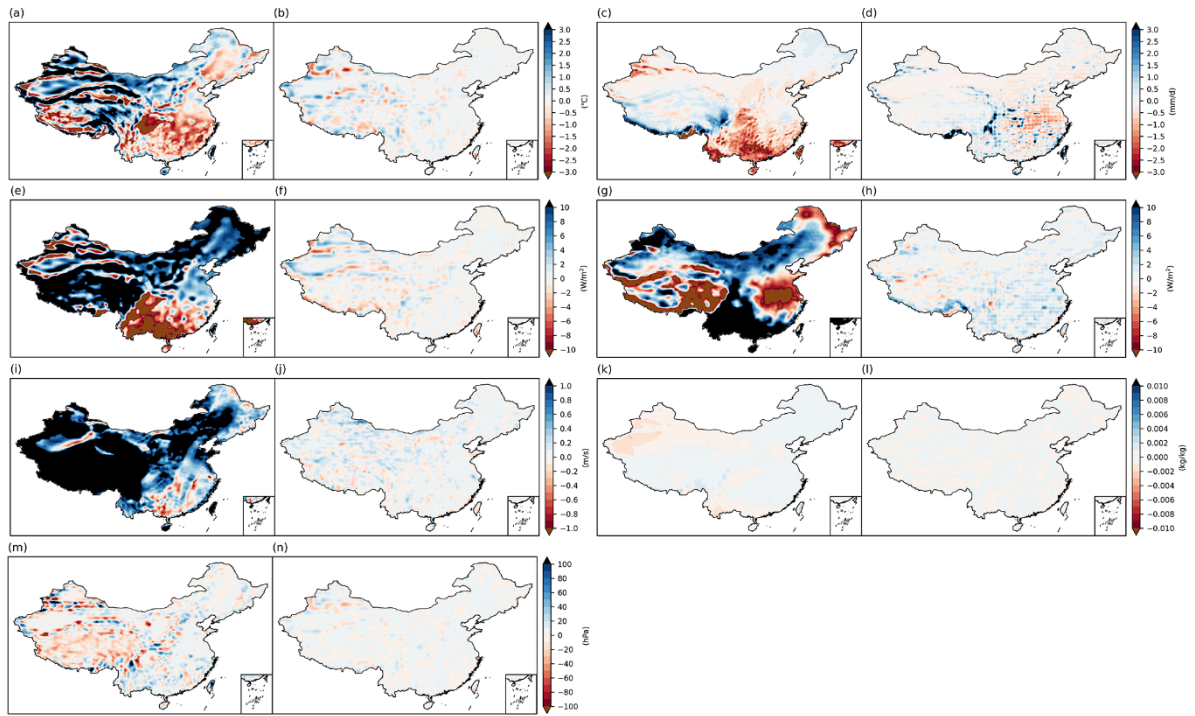
Figure S2. Bias comparison map for muti-year average daily surface temperature (a, b), precipitation (c, d), longwave radiation (e, f), shortwave radiation (g, h), wind speed (i, j), specific humidity (k, l) and surface pressure (m, n) between ERA5 and original MPI-ESM1-2-HR(a, c, e, g, i, k, m), ERA5 and downscaled MPI-ESM1-2-HR (b, d, f, h, j, l, n)
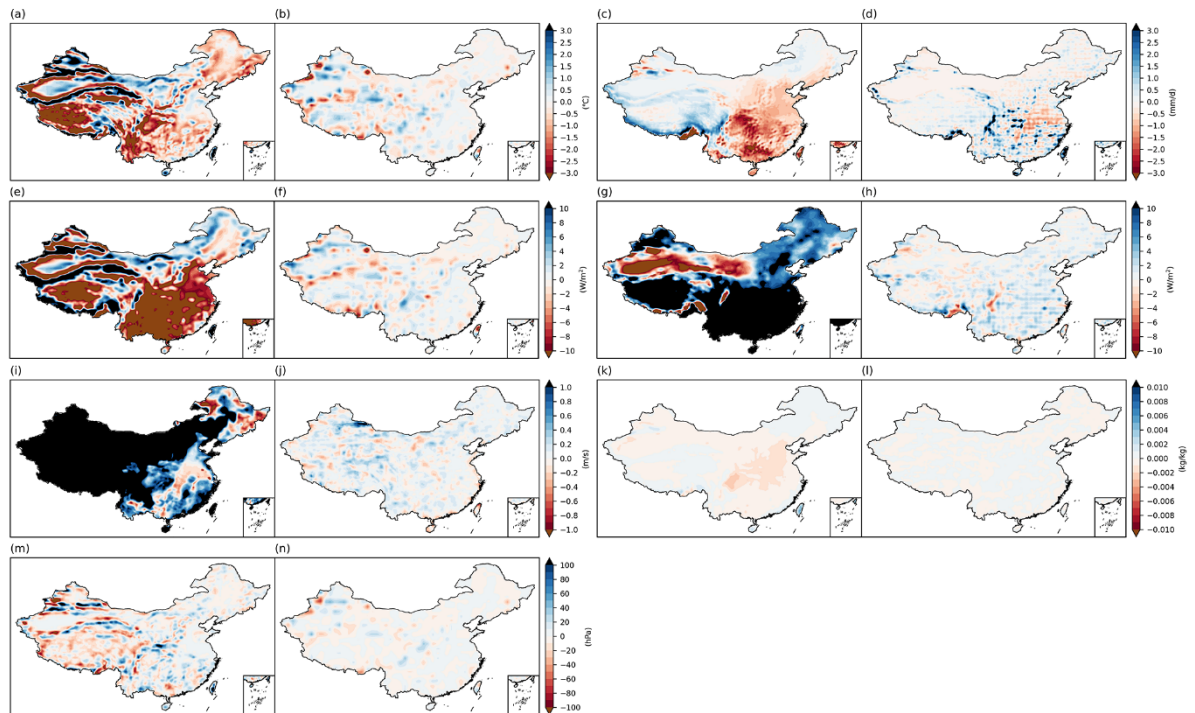
Figure S3. Bias comparison map for muti-year average daily surface temperature (a, b), precipitation (c, d), longwave radiation (e, f), shortwave radiation (g, h), wind speed (i, j), specific humidity (k, l) and surface pressure (m, n) between ERA5 and original MRI-ESM2-0 (a, c, e, g, i, k, m), ERA5 and downscaled MRI-ESM2-0 (b, d, f, h, j, l, n)
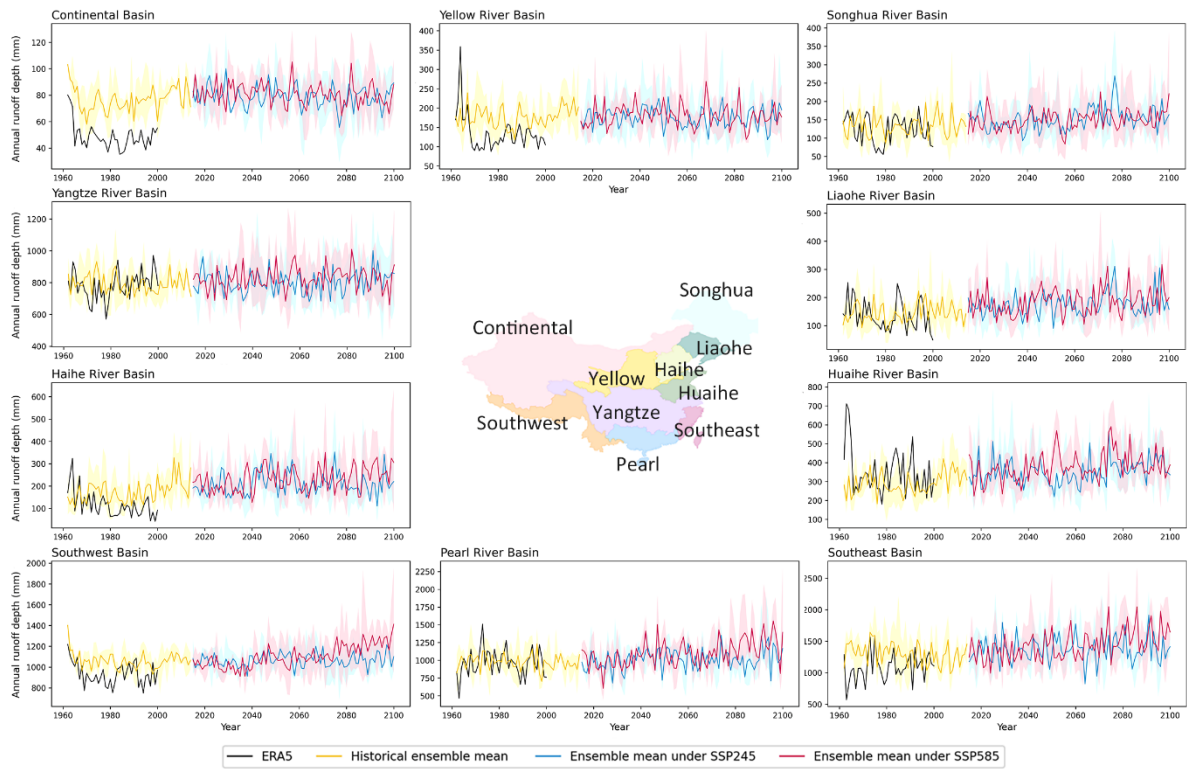
Figure S4. Annual runoff depth over each watershed. The black line is the simulated runoff based on ERA5. The yellow, blue and red line are the ensemble mean simulated runoff driving by three GCMs in historical, under SSP245 and SSP585, respectively. The shaded areas indicate the maximum and minimum ranges of simulated runoff depth based on three GCMs.
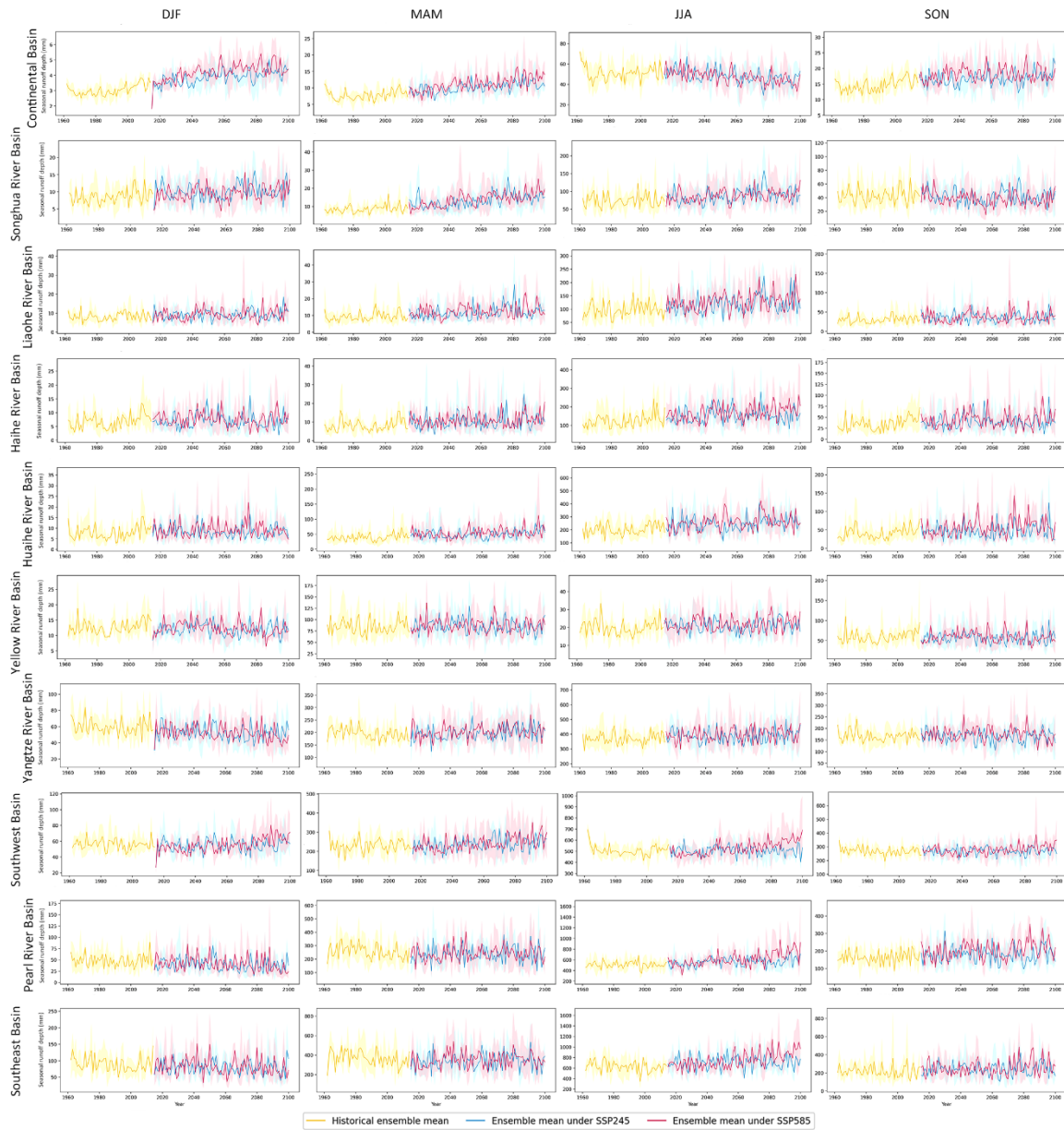
Figure S5. Seasonal runoff depth change over each watershed. The yellow, blue and red line are the ensemble mean simulated runoff driving by three GCMs in historical, under SSP245 and SSP585, respectively. The shaded areas indicate the maximum and minimum ranges of simulated runoff depth based on three GCMs.
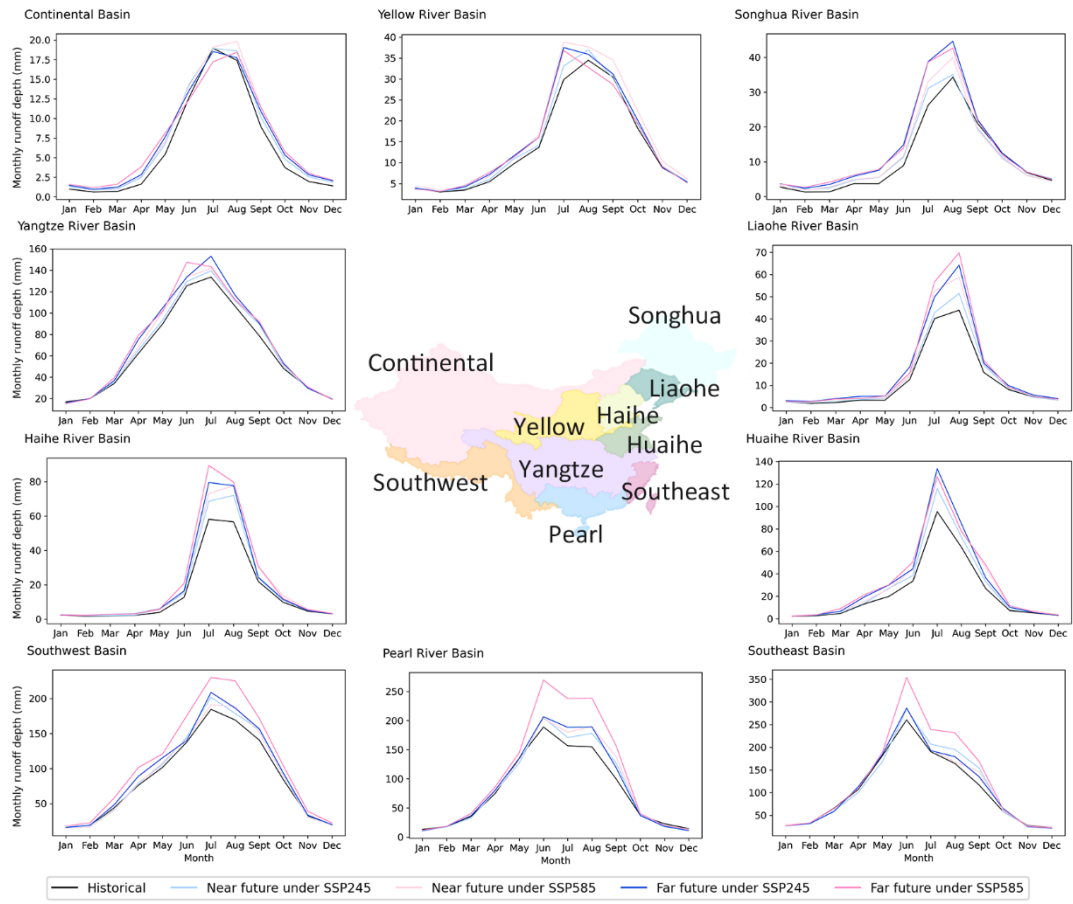
Figure S6. Muti-year annual cycle of runoff over each watershed.