



Causal analyses reveal changing land-atmosphere patterns and soil moisture control under warming

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Supplementary 1

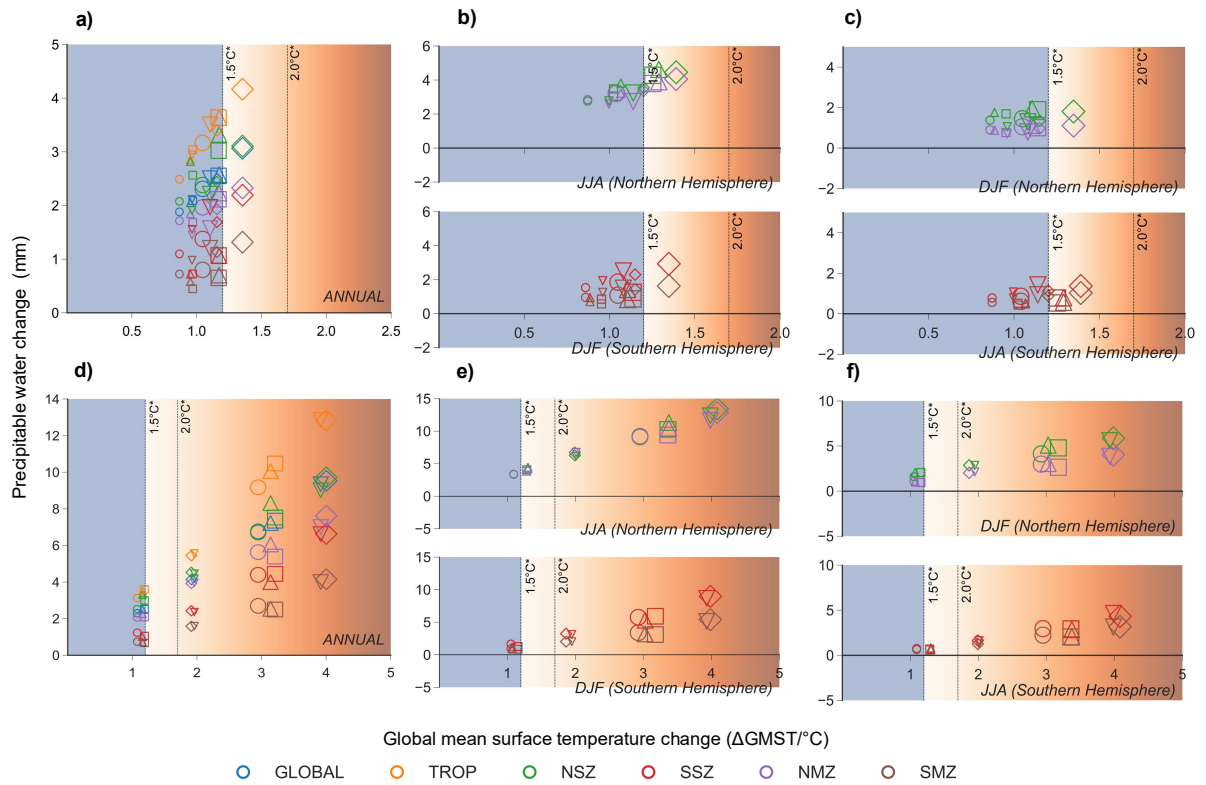


Figure S1: **Sensitivity of regional precipitable water to GSMT across a,b,c) mid- (2021–2050); and d,e,f) end of century (2071–2100) periods, relative to the 1971–2000 baseline.** Panels (a,d) show annual results, while panels (b,c,e,f) show seasonal results.

Legend definitions are consistent with Fig. 2 in the main text.

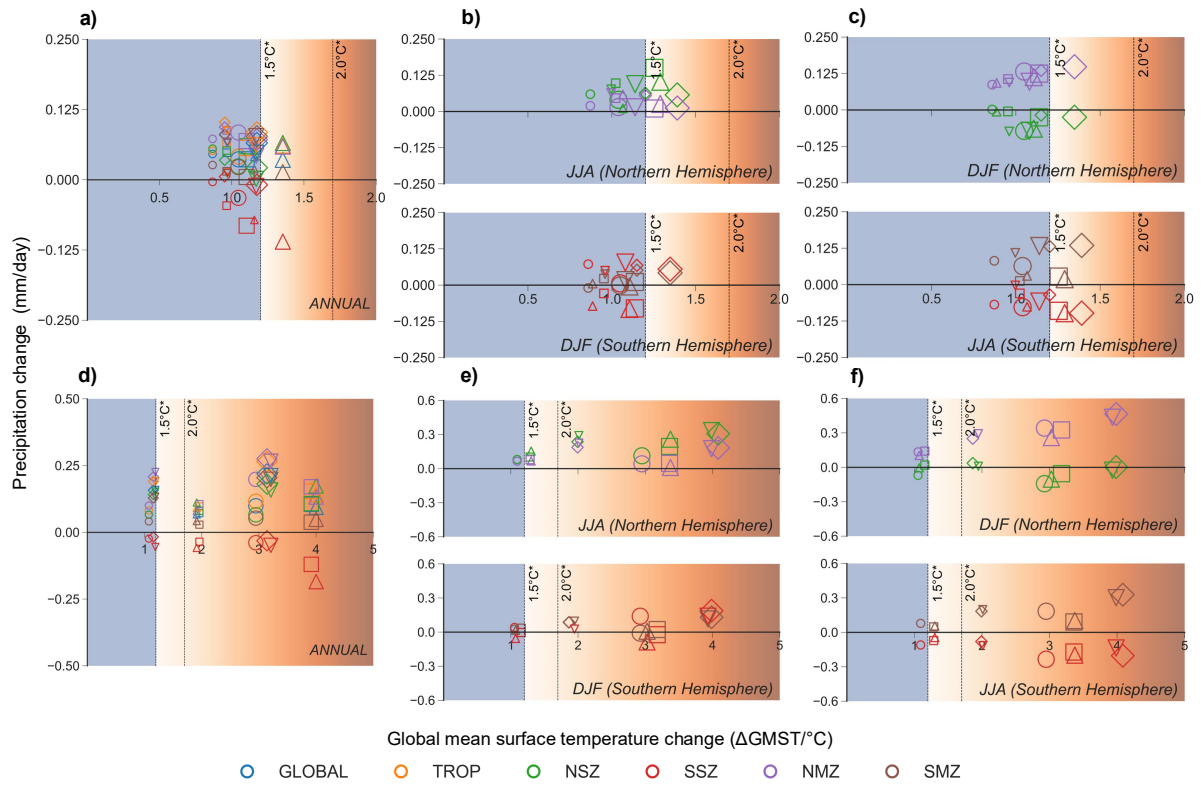


Figure S2: **As S1, but for precipitation.**

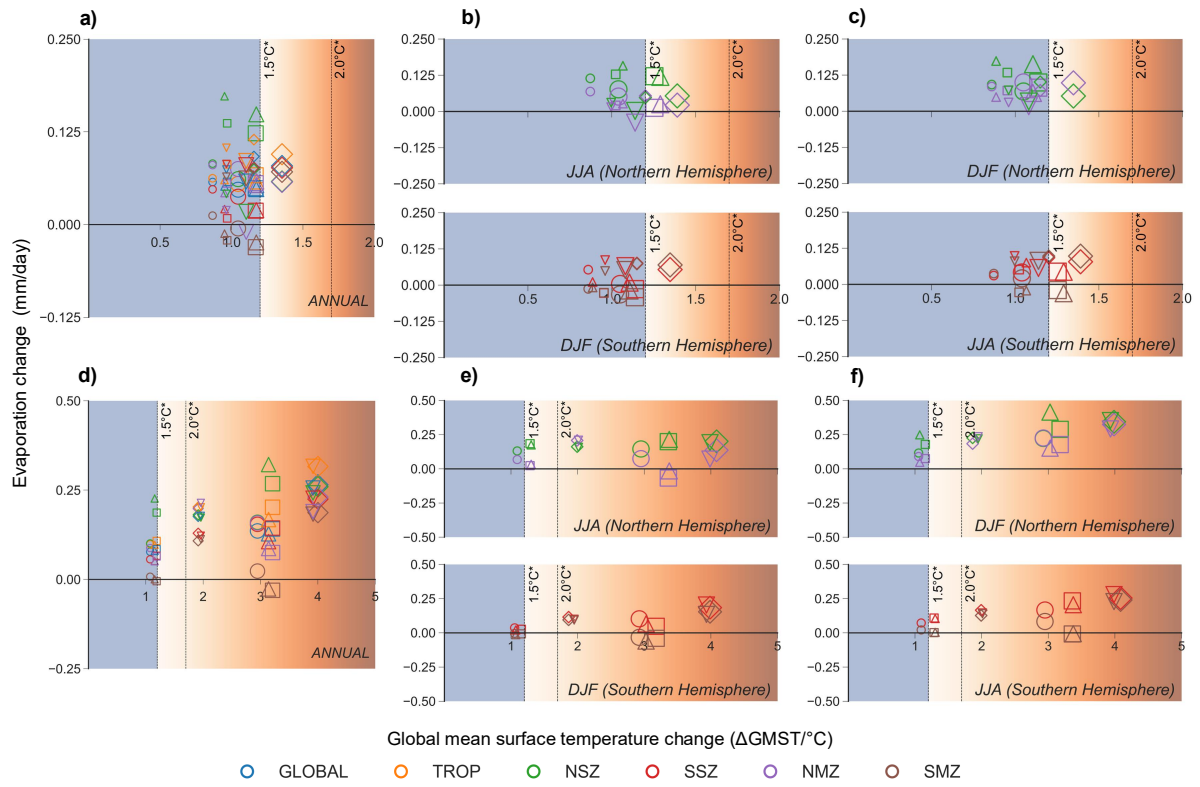


Figure S3: **As S1, but for evaporation.**

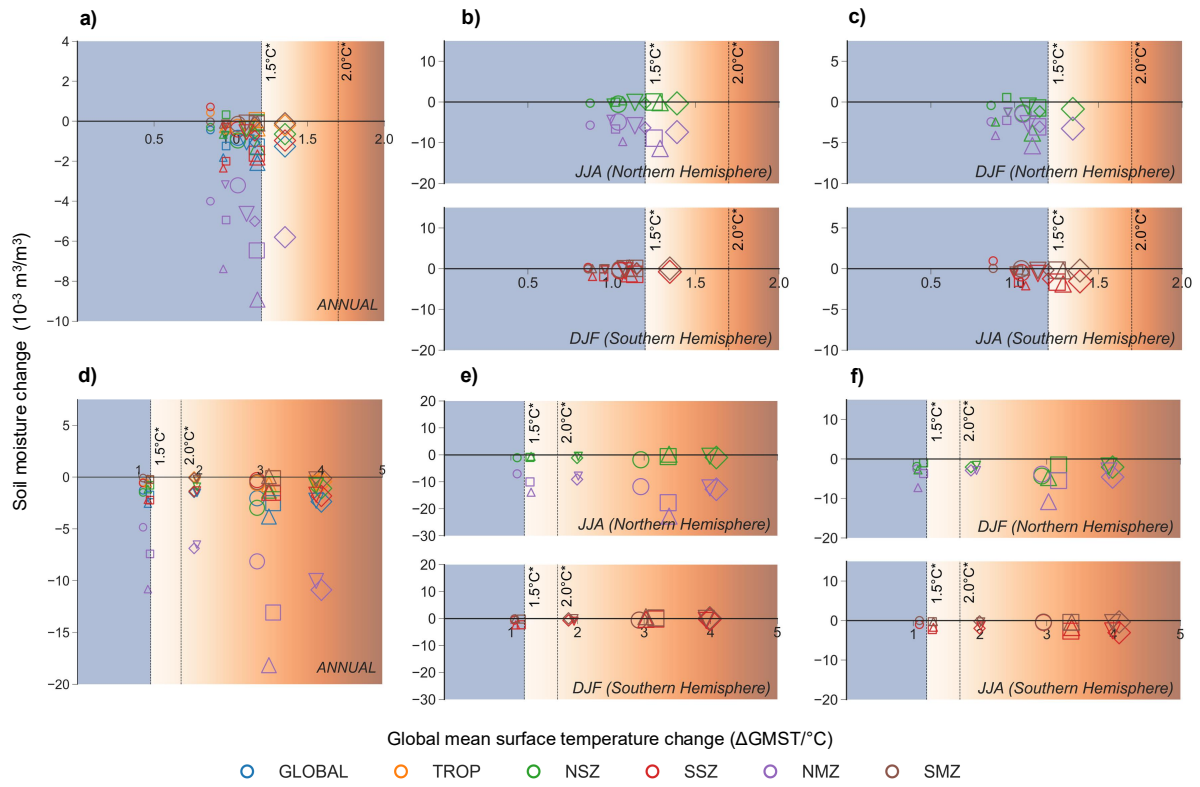


Figure S4: **As S1, but for soil moisture.**

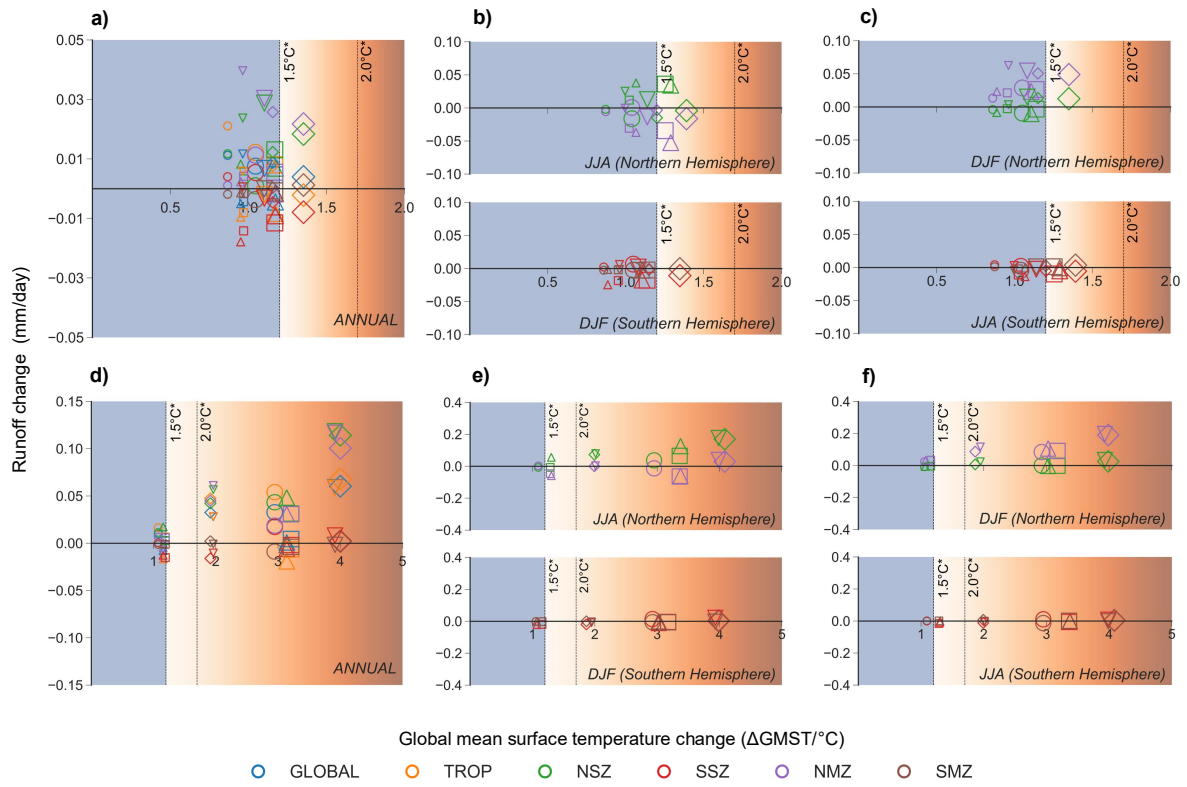


Figure S5: As S1, but for runoff.

Supplementary 2

Mid-century (2021–2050)

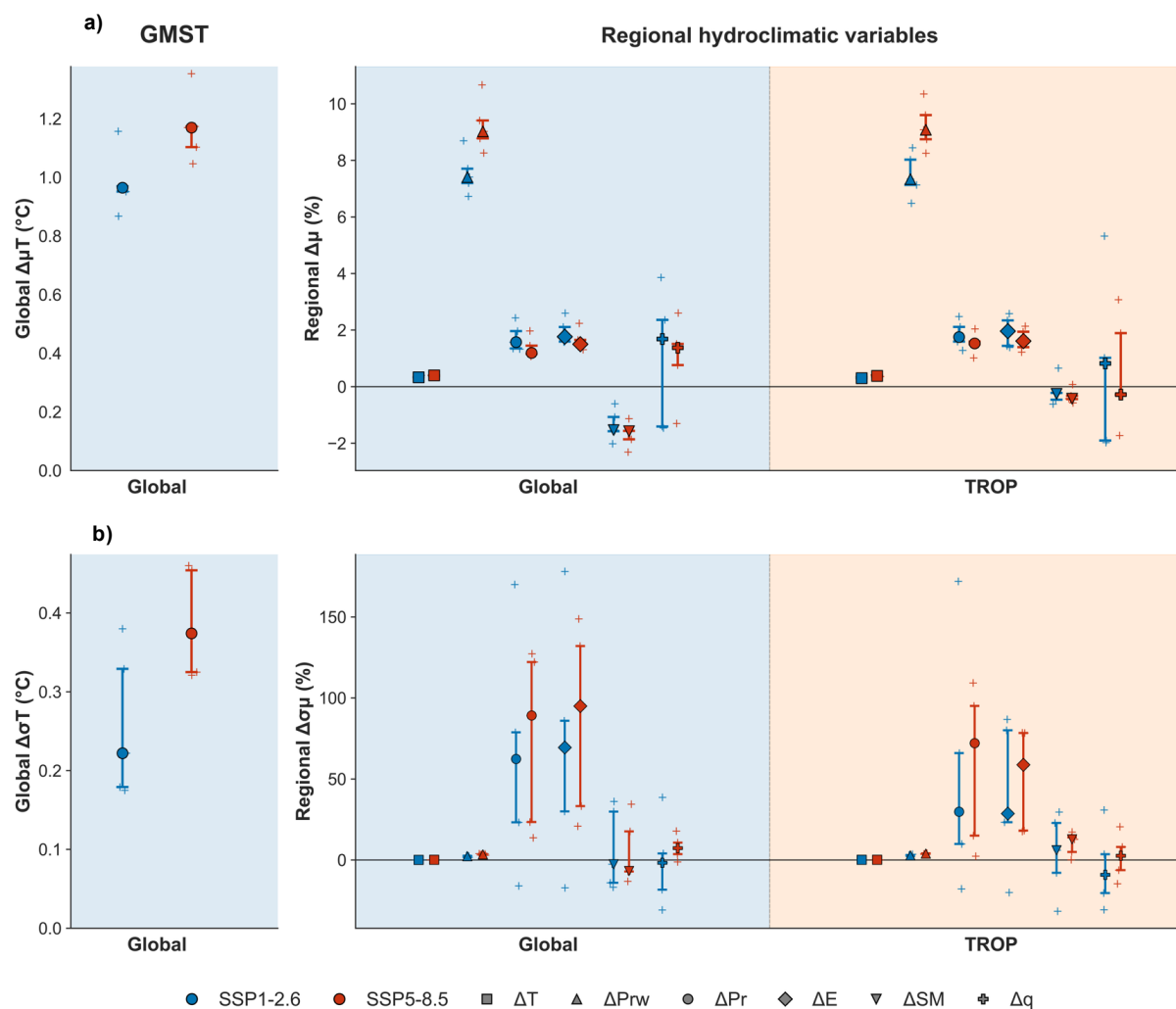


Figure S6: **Annual changes in a) mean; and b) variability of hydroclimatic variables across global and tropical region during mid-century (2021–2050) relative to the baseline (1971–2000) periods from CMIP6 model ensembles.** Region colors are consistent with Fig. 3 in the main text.

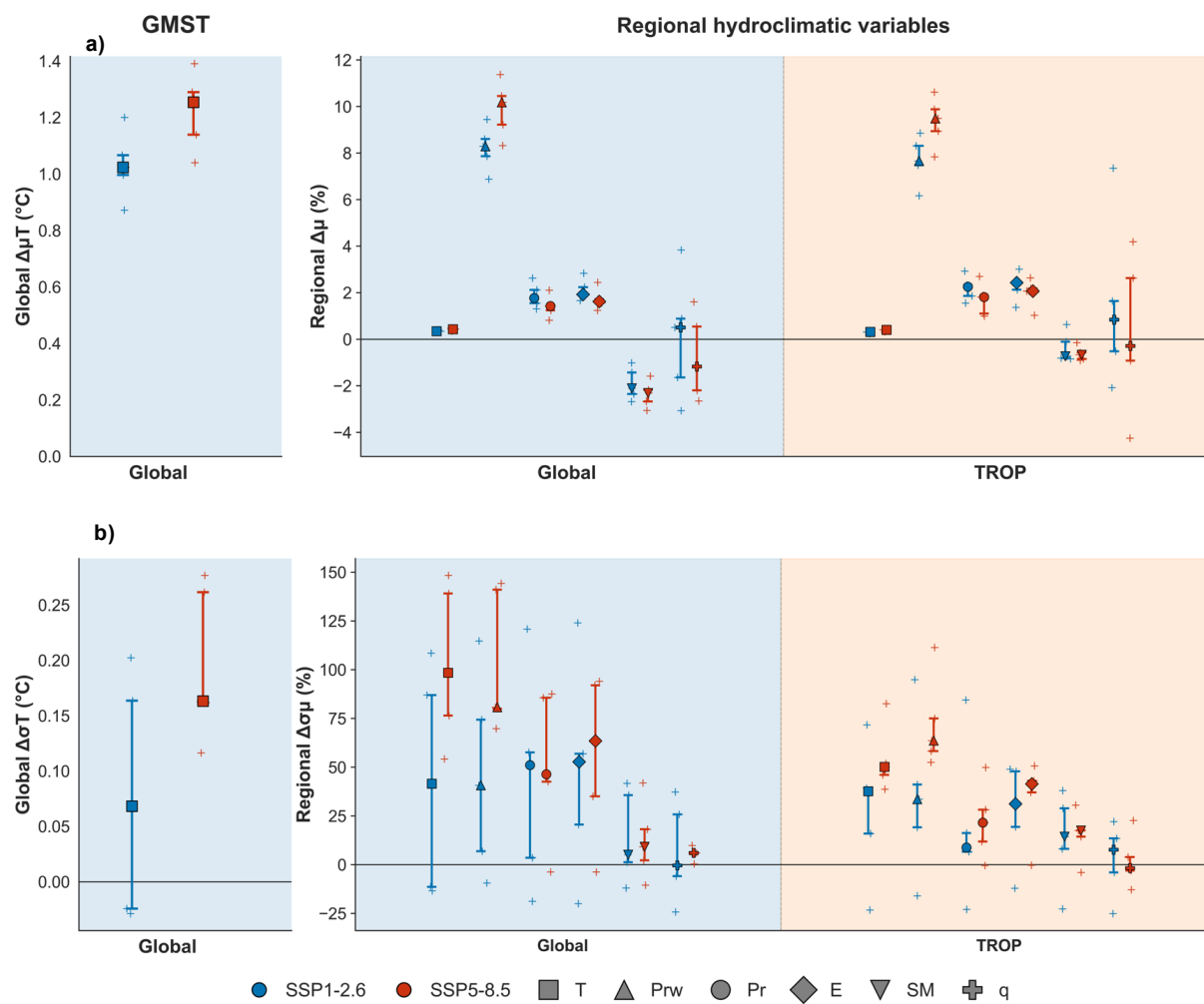


Figure S7: **As S6, but for JJA season.**

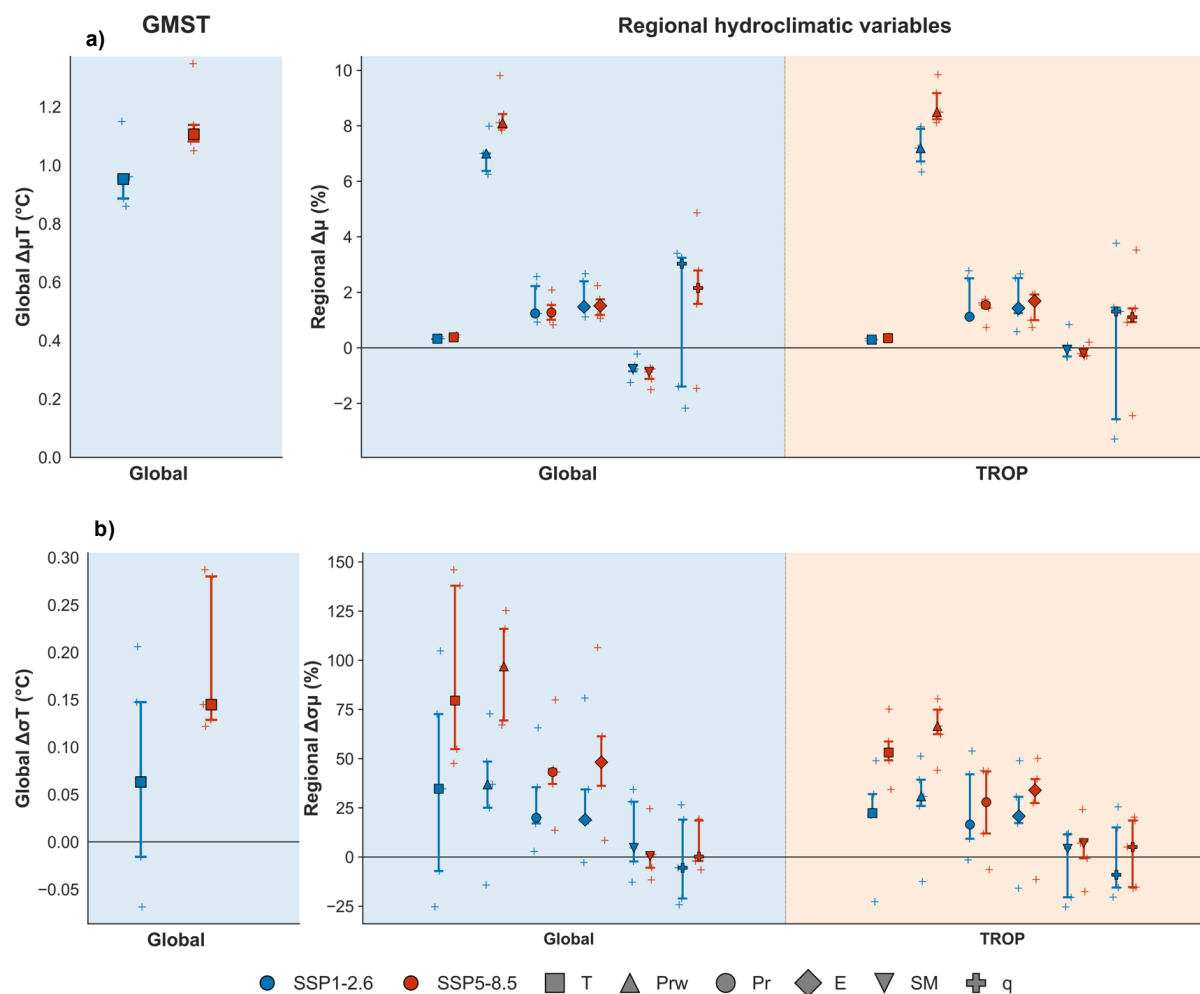


Figure S8: **As S6, but for DJF season.**

End of century (2071-2100)

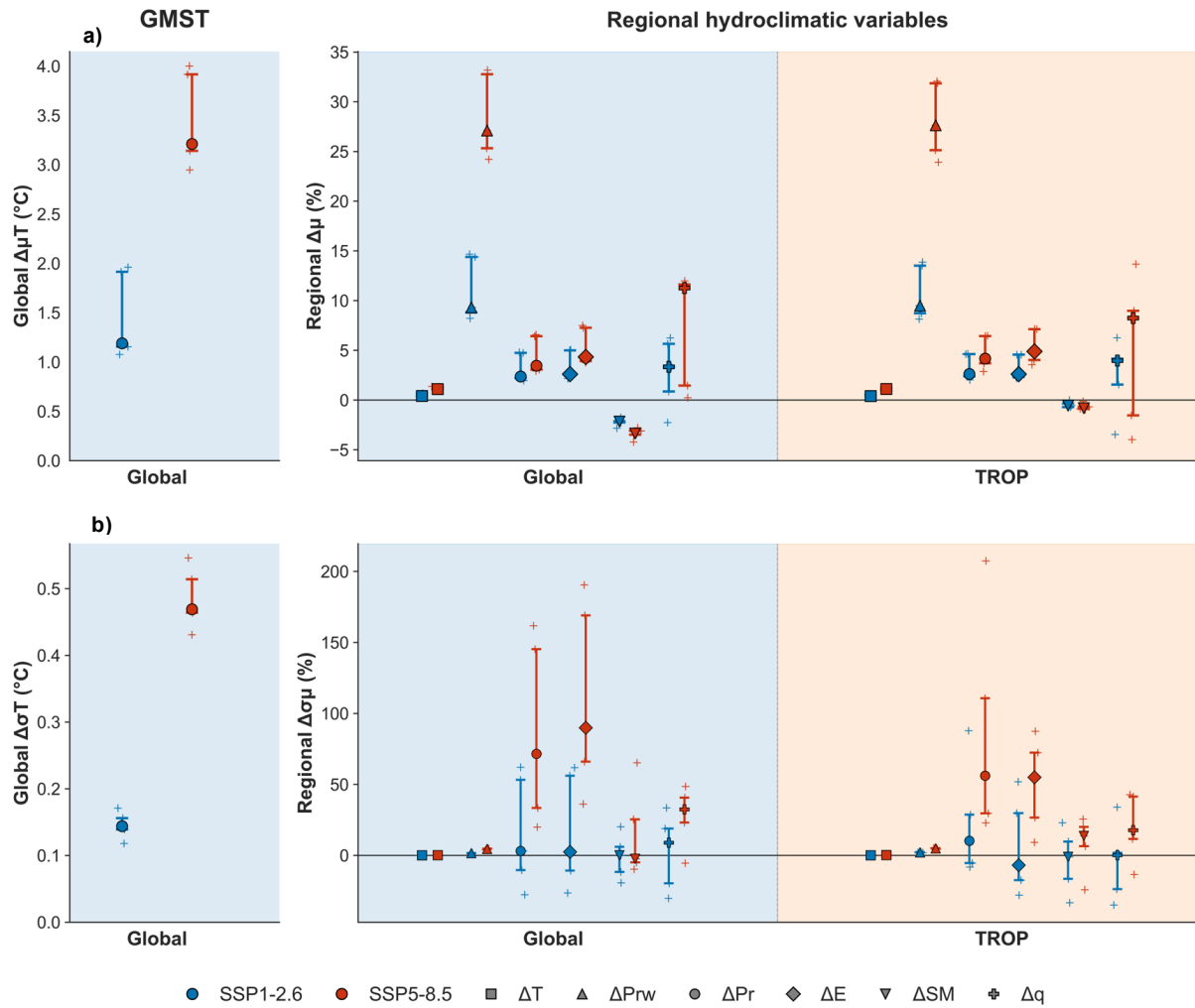


Figure S9: As S6, but for annual changes across end of century projections (2071–2100) relative to the baseline period (1971–2000).

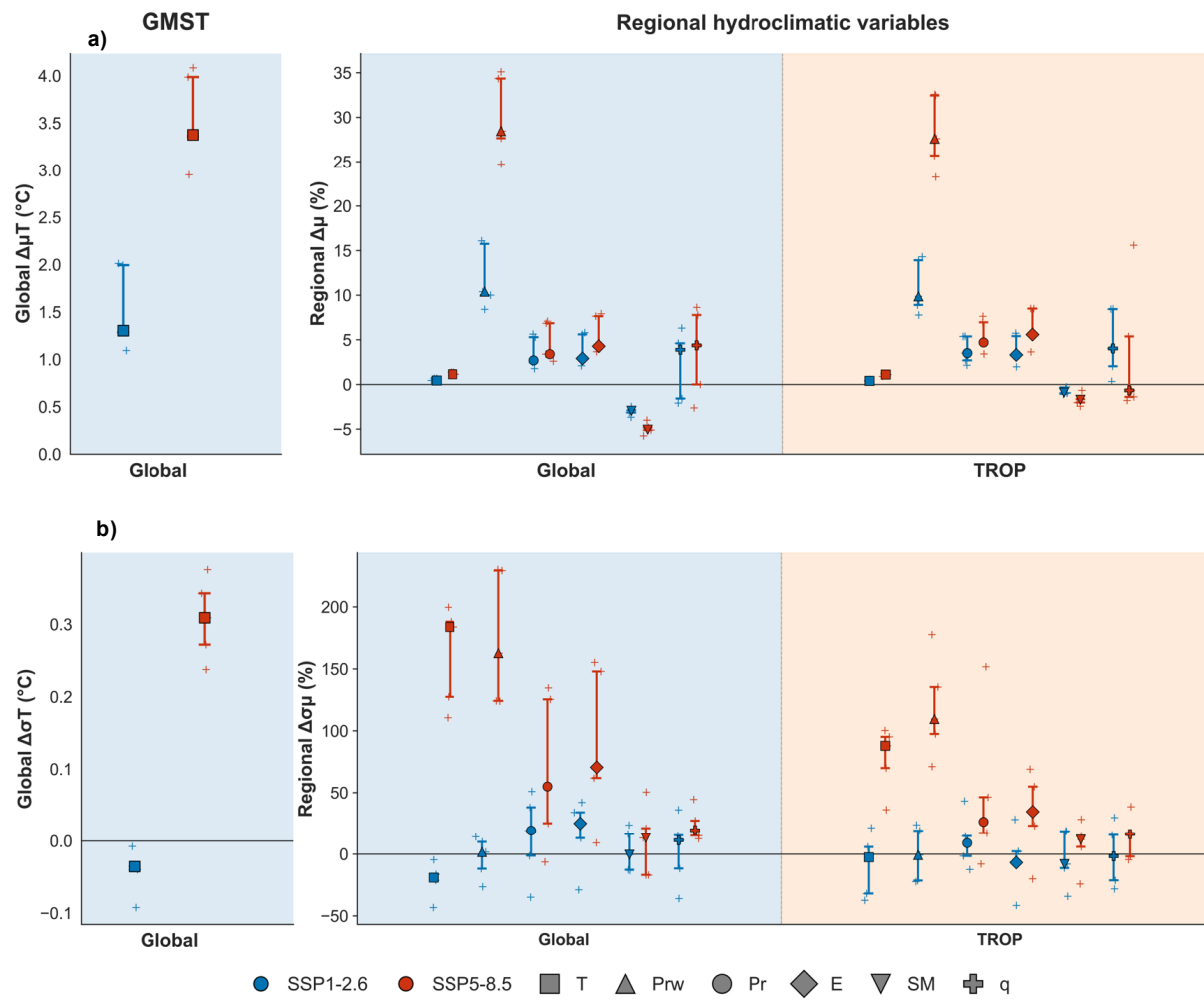


Figure S10: As S9, but for JJA season.

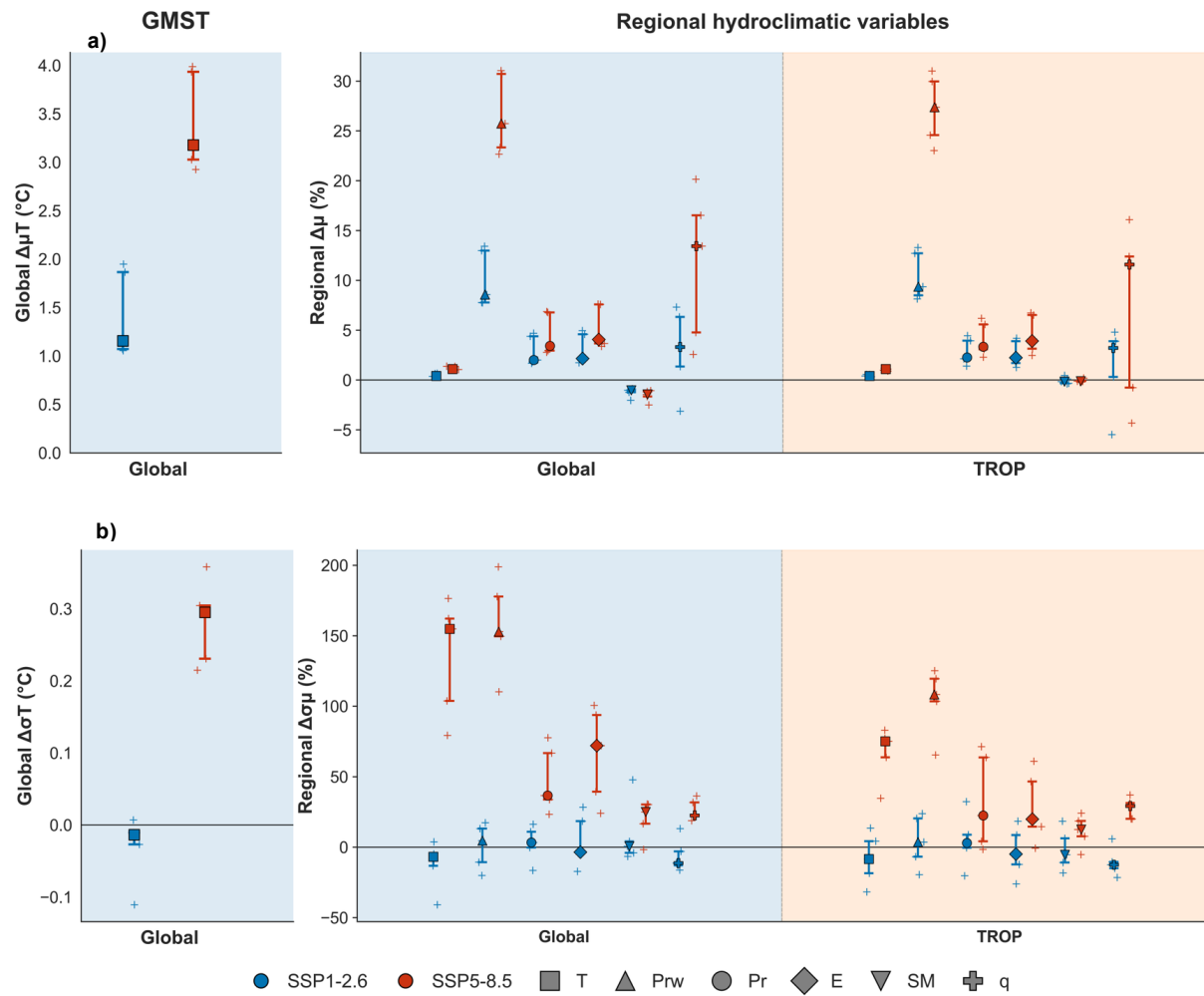


Figure S11: As S9, but for DJF season.

Supplementary 3

Mid-century (2021-2050)

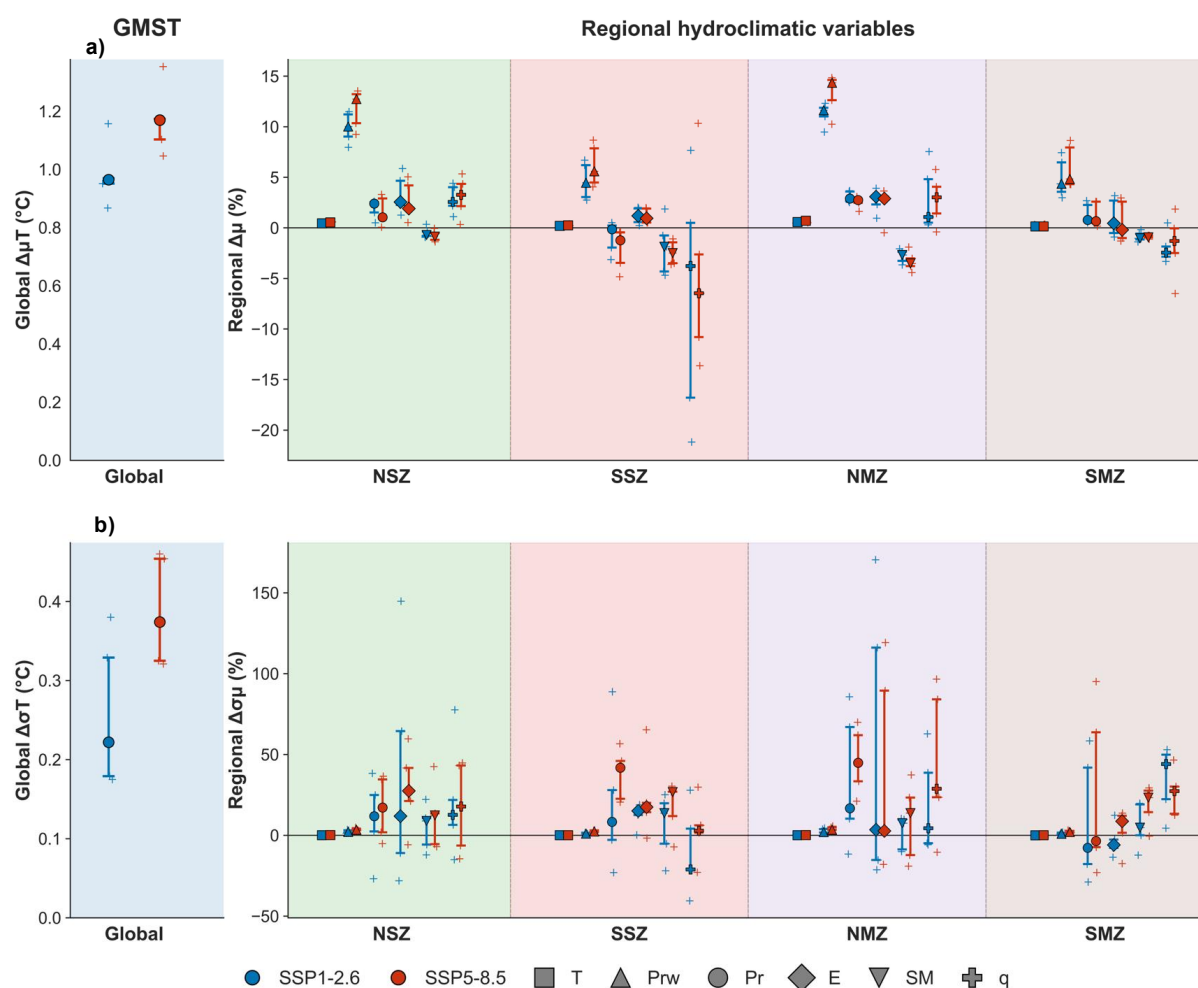


Figure S12: **Annual changes in a) mean; and b) variability of hydroclimatic variables across non-tropical regions during mid-century (2021–2050) relative to the baseline (1971–2000) periods from CMIP6 model ensembles.** Region colors are consistent with Fig. 3 in the main text.

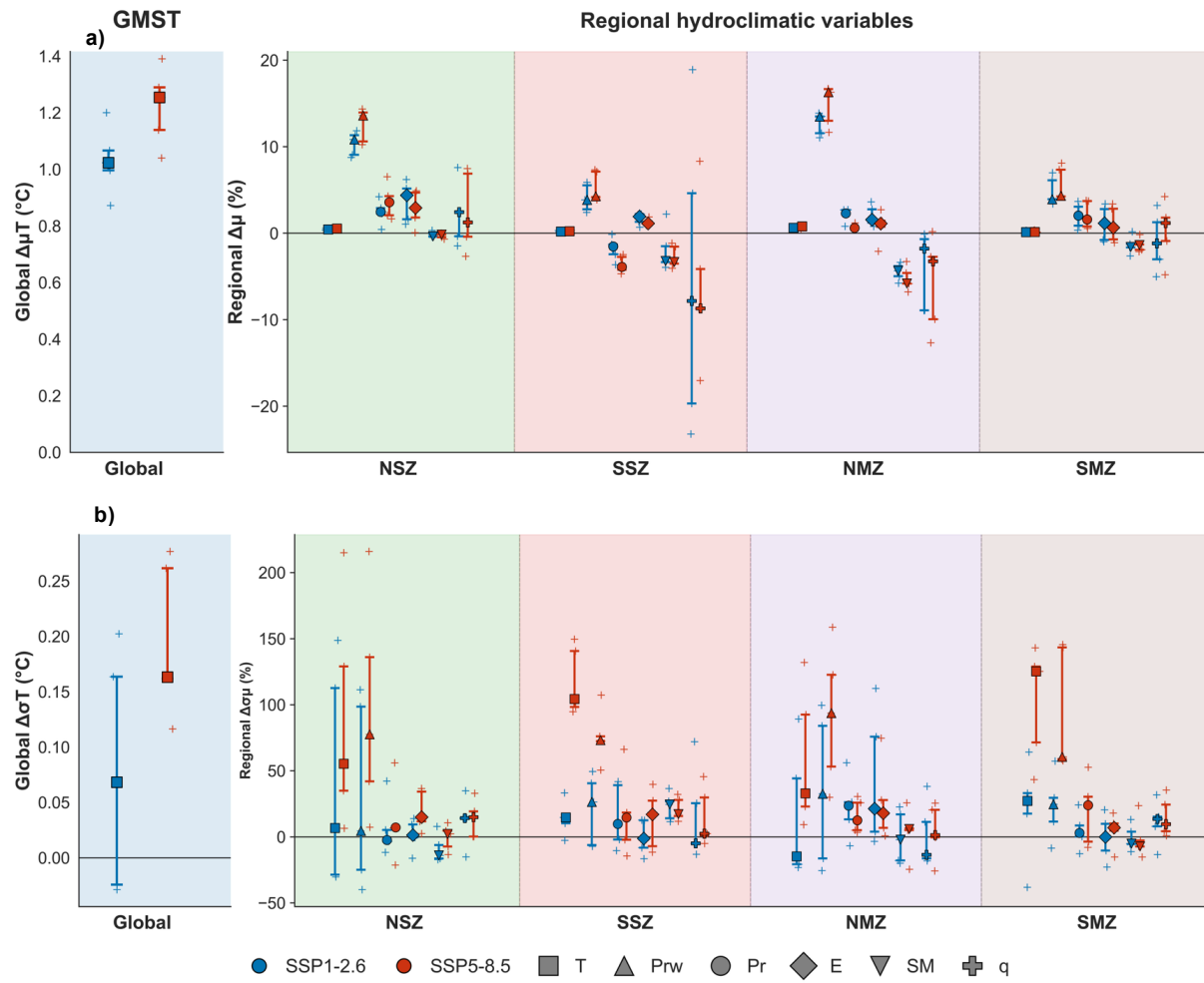


Figure S13: As S12, but for JJA season.

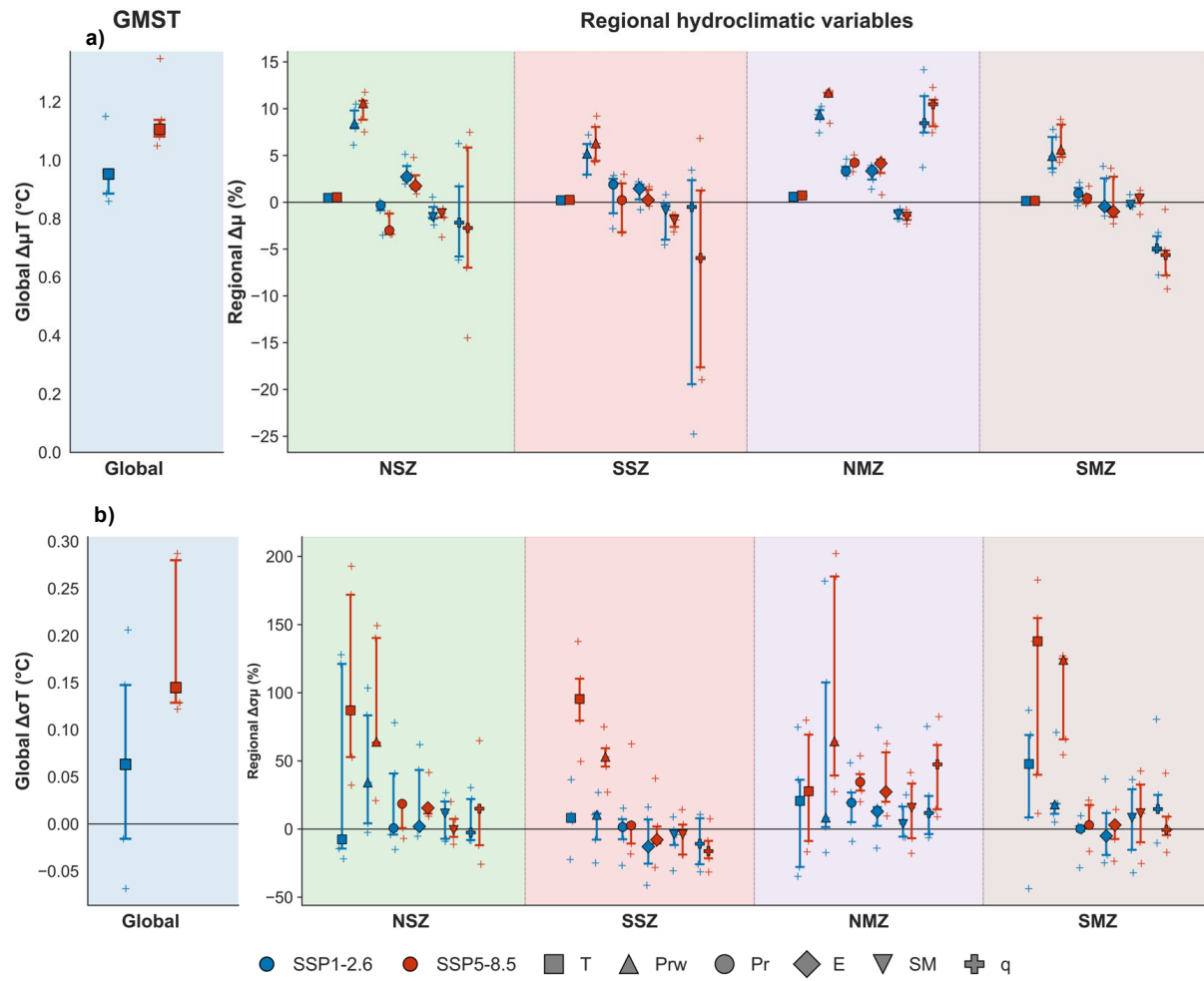


Figure S14: **As S12, but for DJF season.**

End of century (2071-2100)

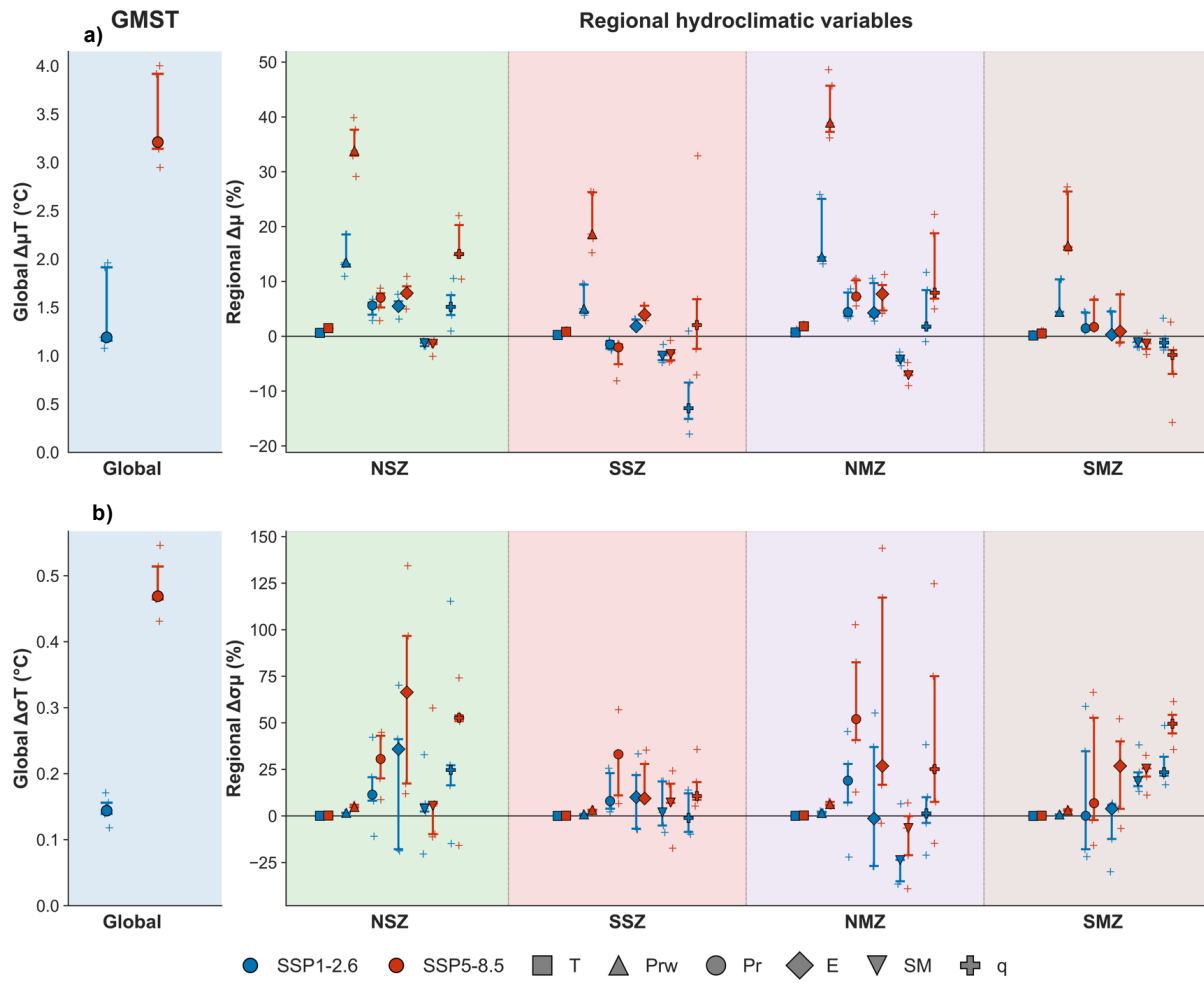


Figure S15: As S12, but for annual across end of century projections (2071-2100) relative to the baseline (1971-2000) periods.

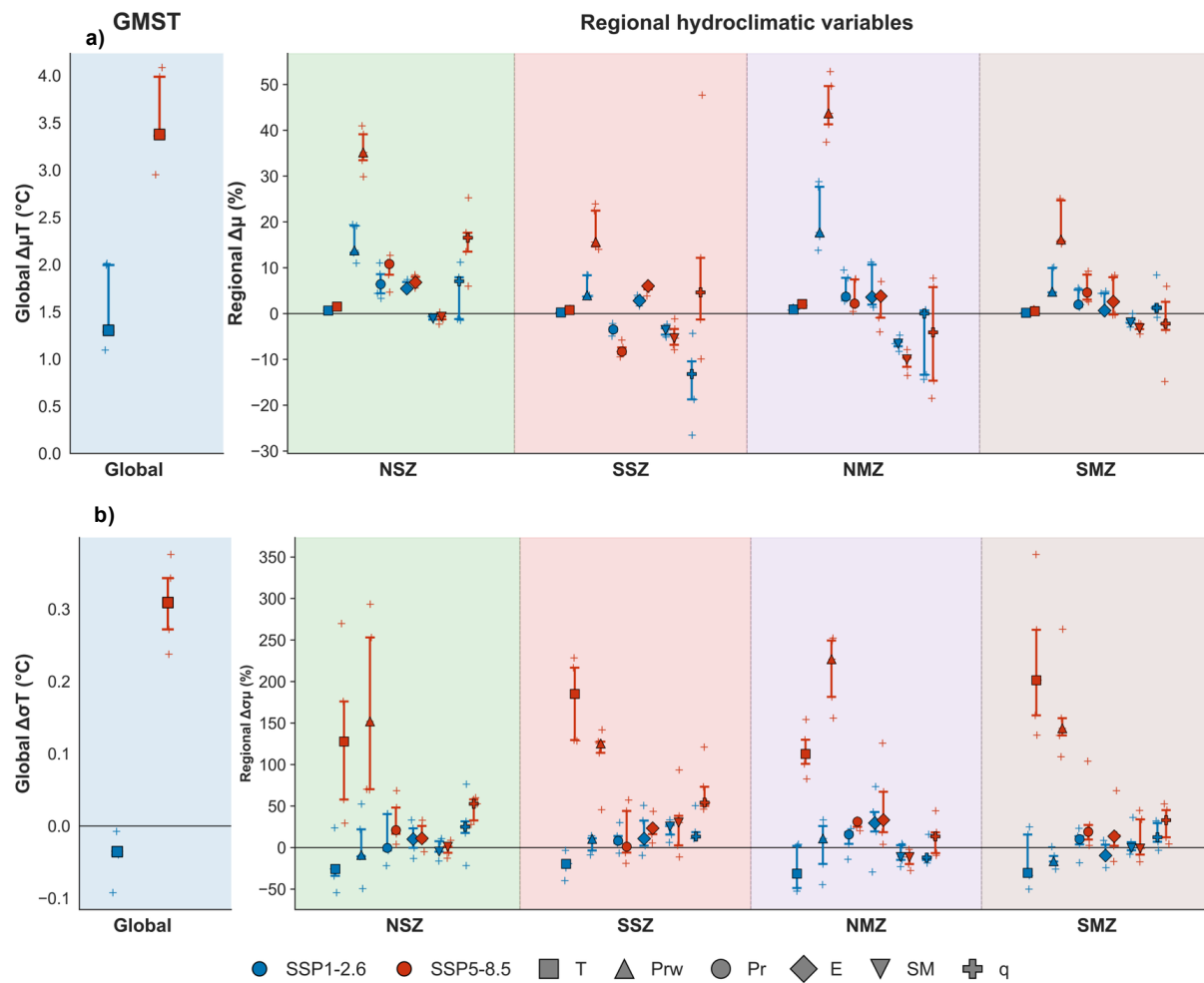


Figure S16: As S15, but for JJA season.

Supplementary 4

JJA

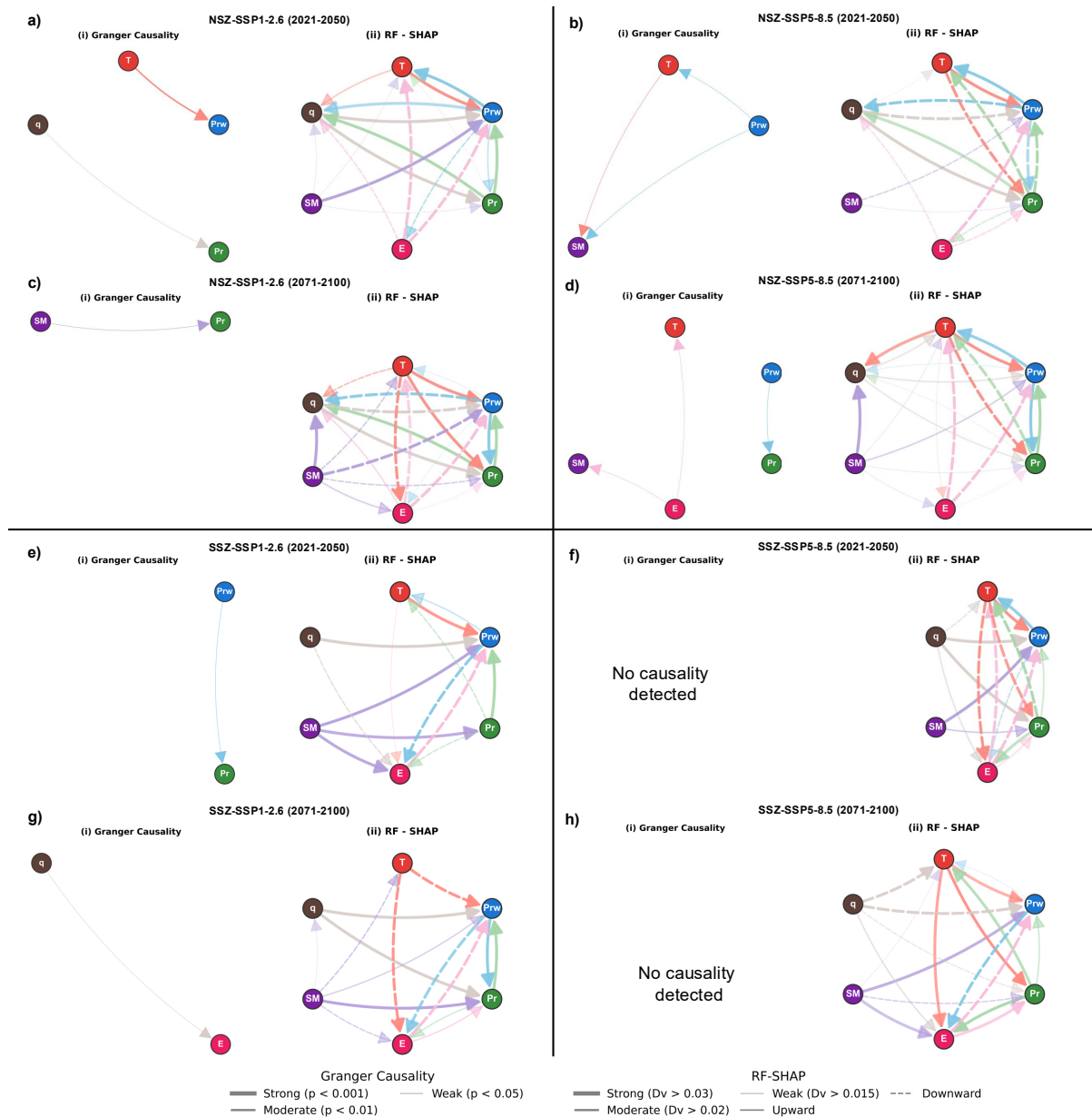


Figure S17: **Regional interdependence of JJA season: climate and hydrological variables during mid- (2021-2050) and end of century (2071–2100) in the NSZ and SSZ regions for MIROC6.** Legend definitions are consistent with Fig. 4 in the main text.

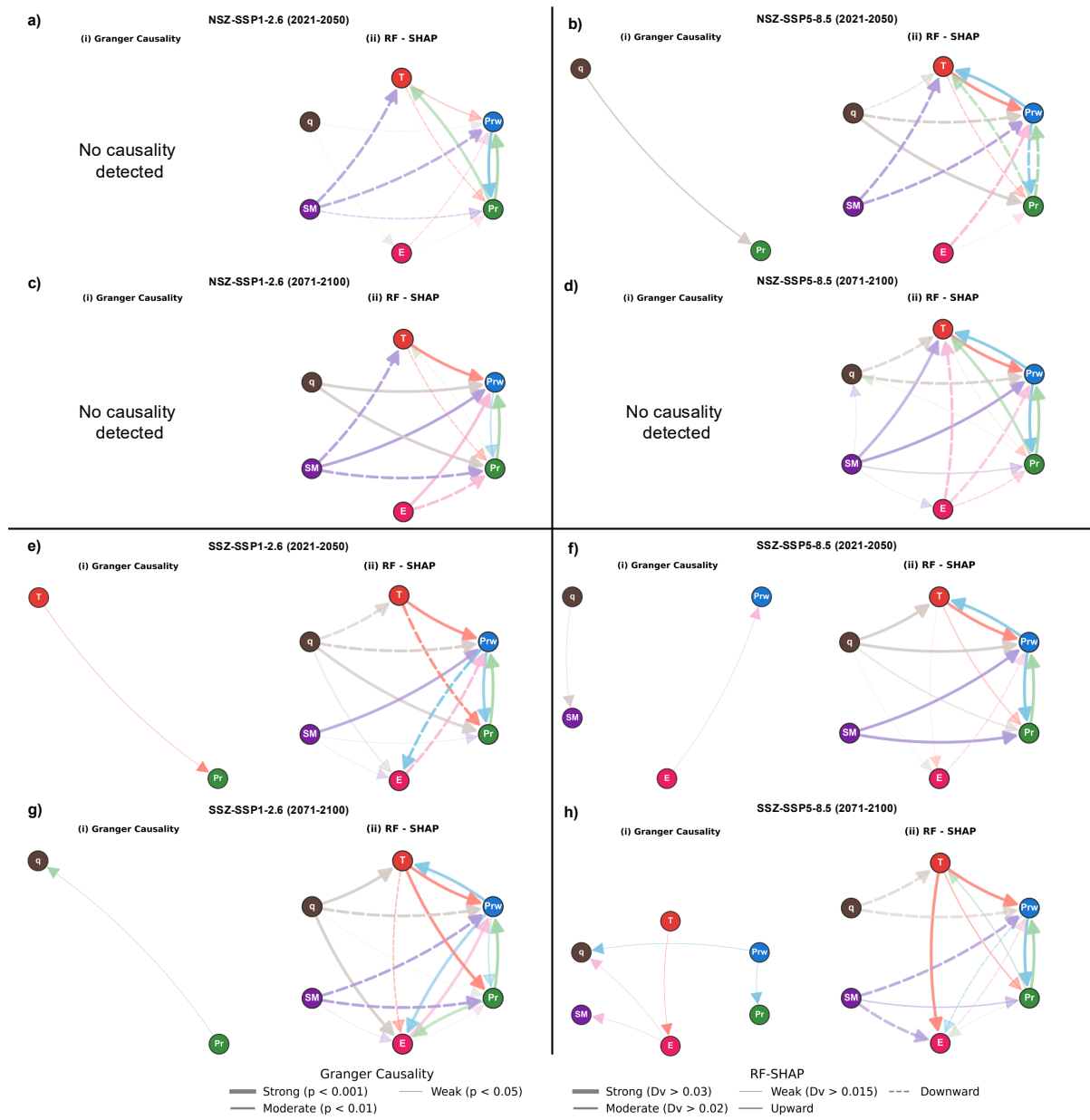


Figure S18: As S17, but for NorESM2-MM.

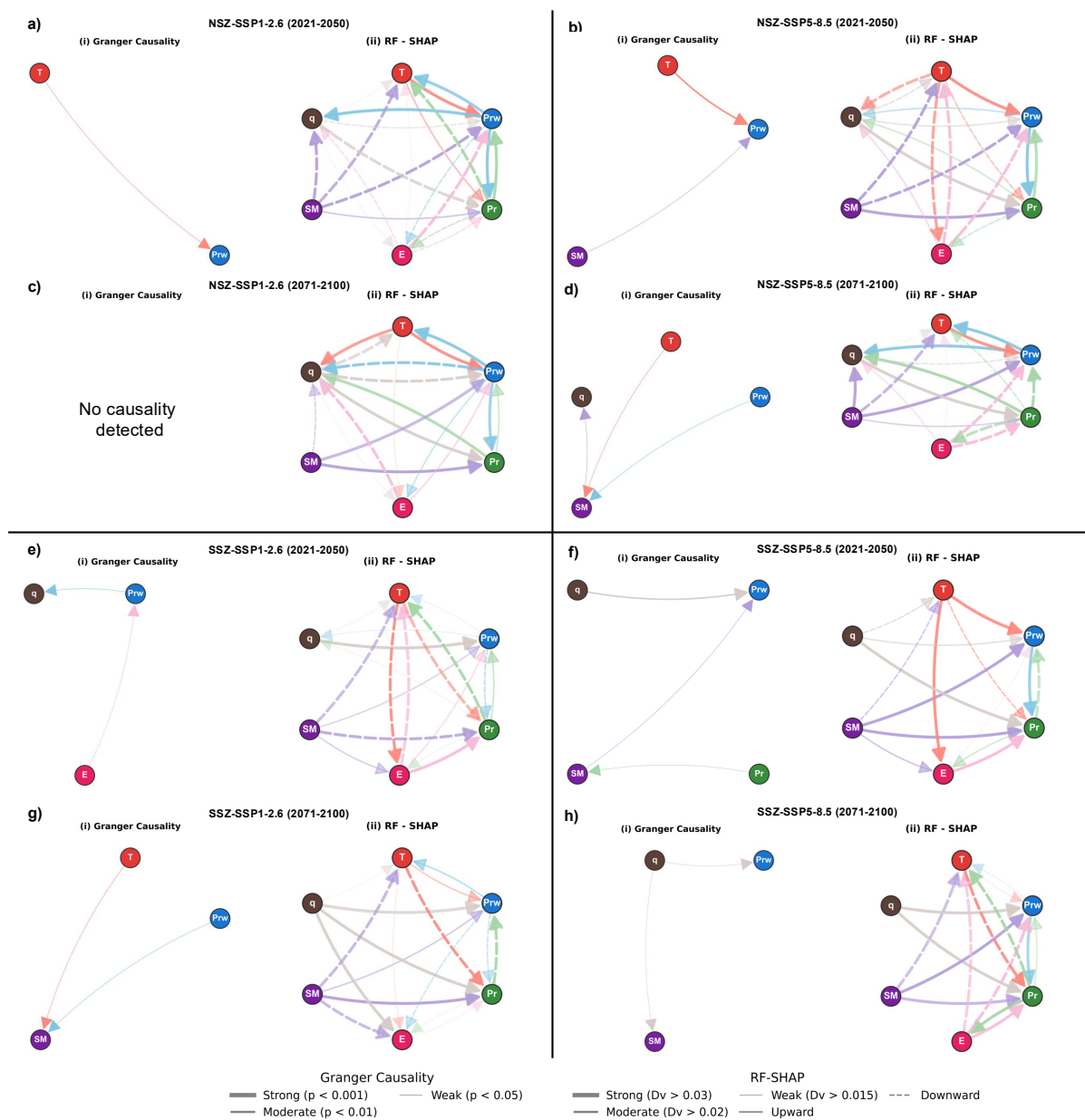


Figure S19: As S17, but for CMCC-CM2-SR5.

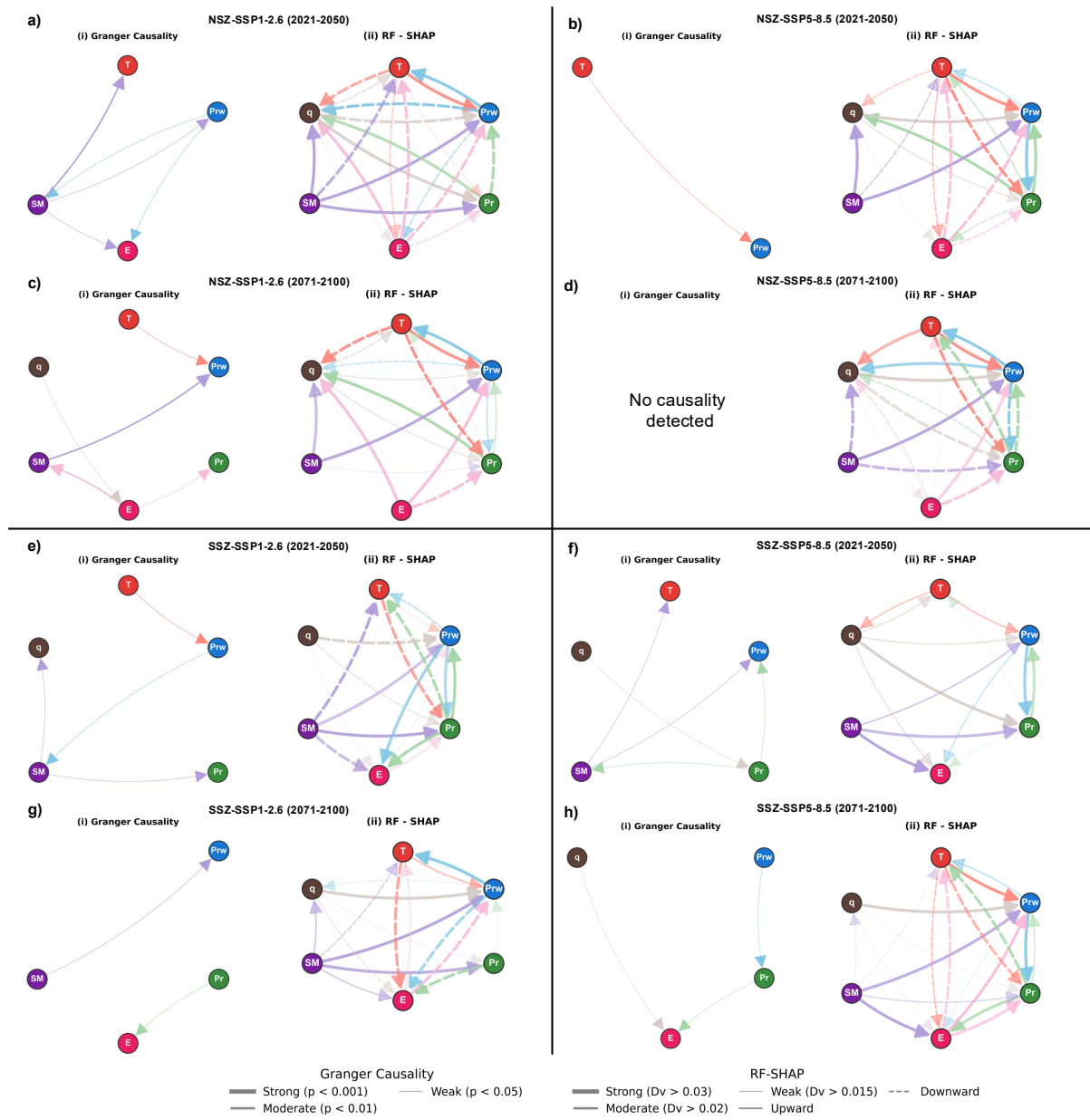


Figure S20: As S17, but for CMCC-ESM2.

DJF

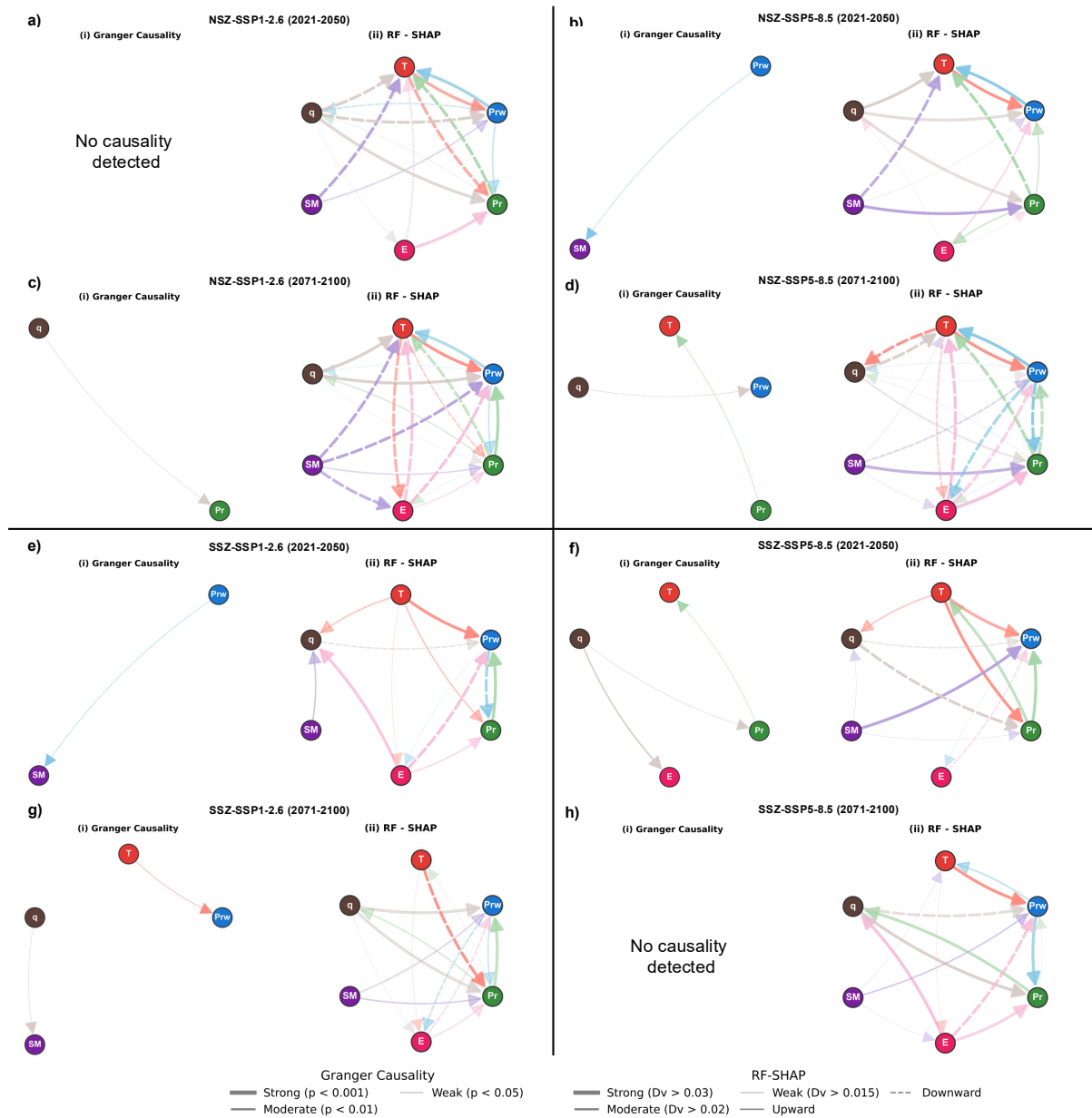


Figure S21: **Regional interdependence of DJF season: climate and hydrological variables during mid- (2021-2050) and end of century (2071–2100) in the NMZ and SMZ regions for MIROC6.** Legend definitions are consistent with Fig. 4 in the main text.

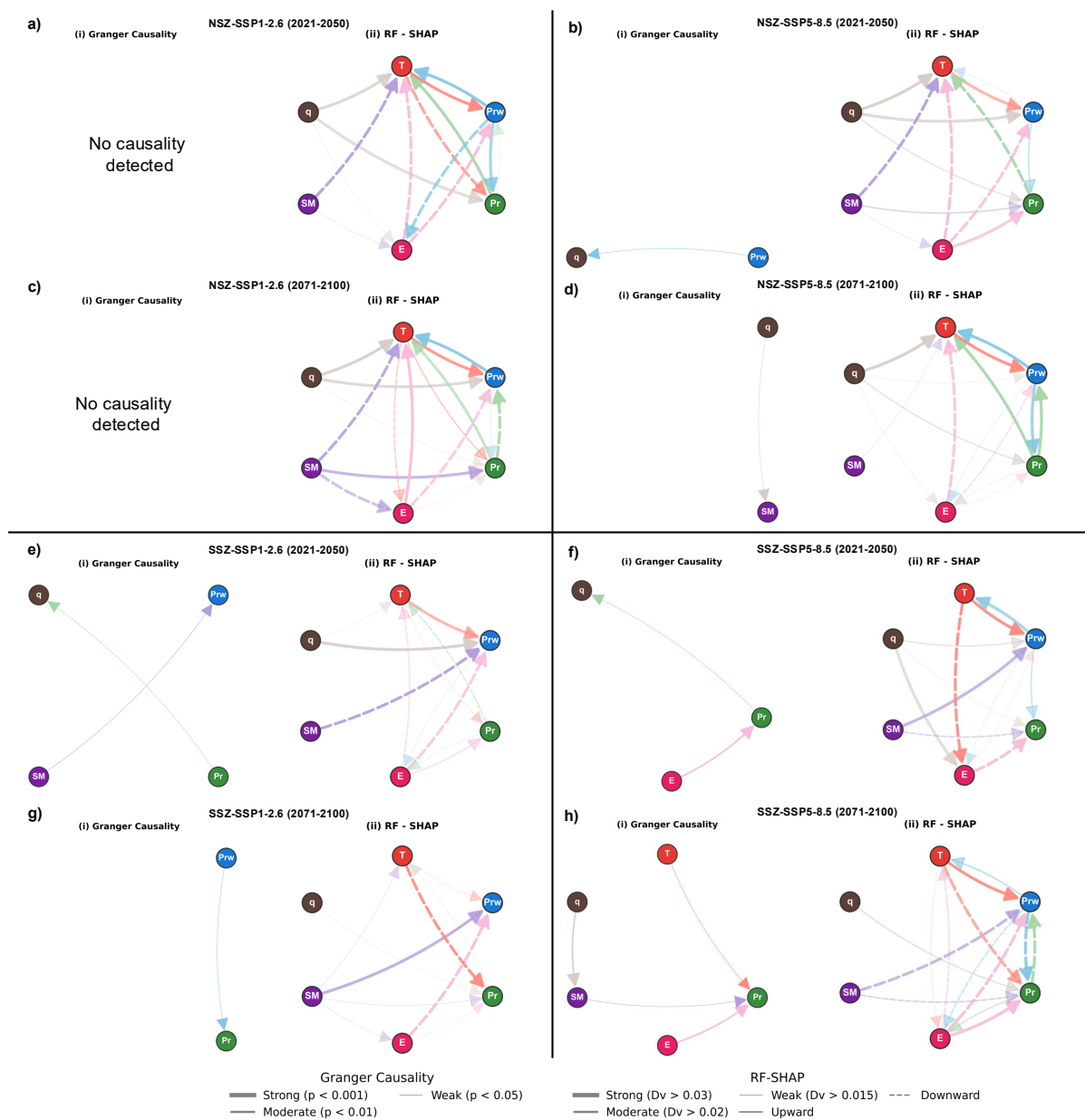


Figure S22: As S21, but for NorESM2-LM.

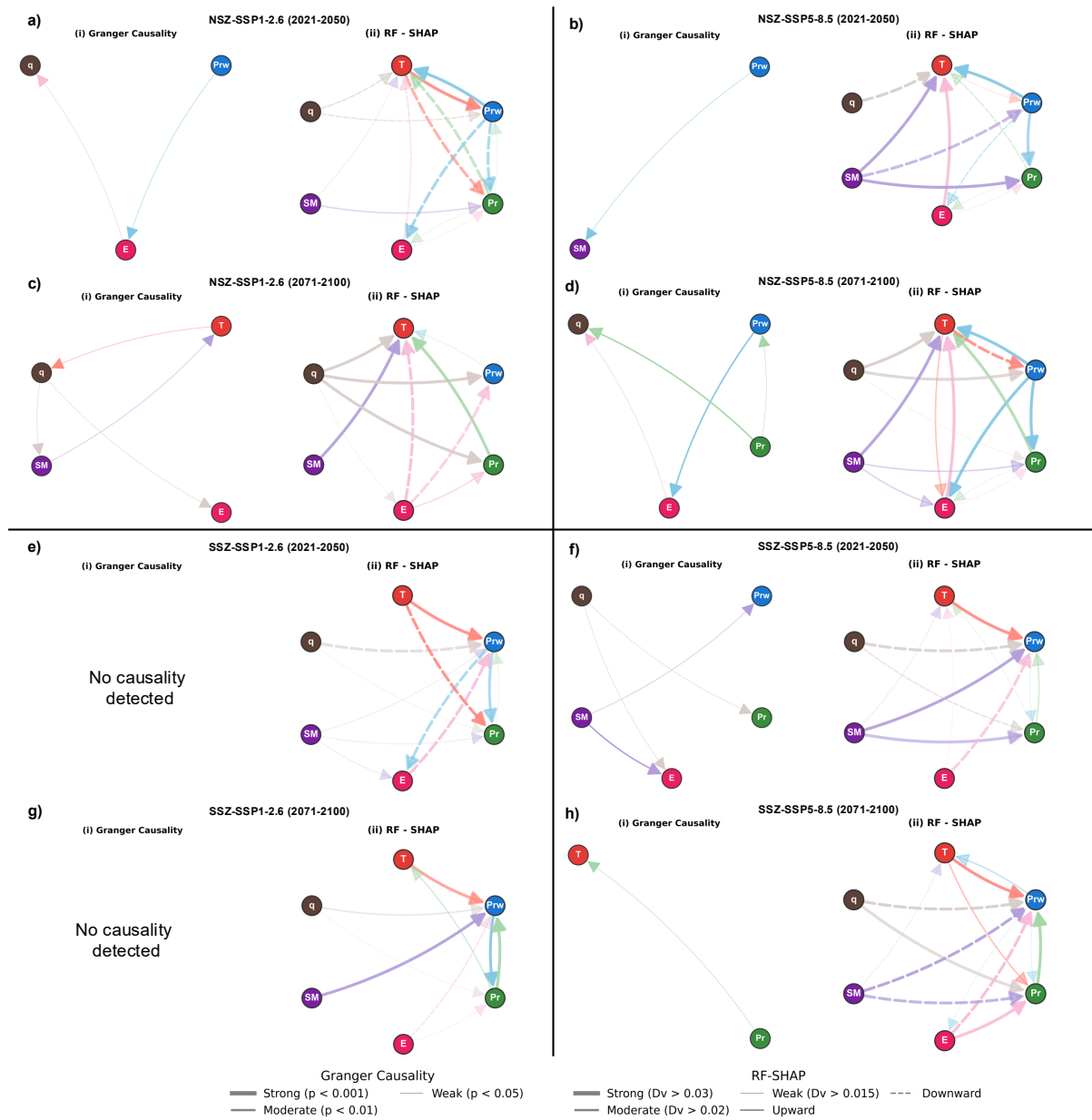


Figure S23: As S21, but for NorESM2-MM.

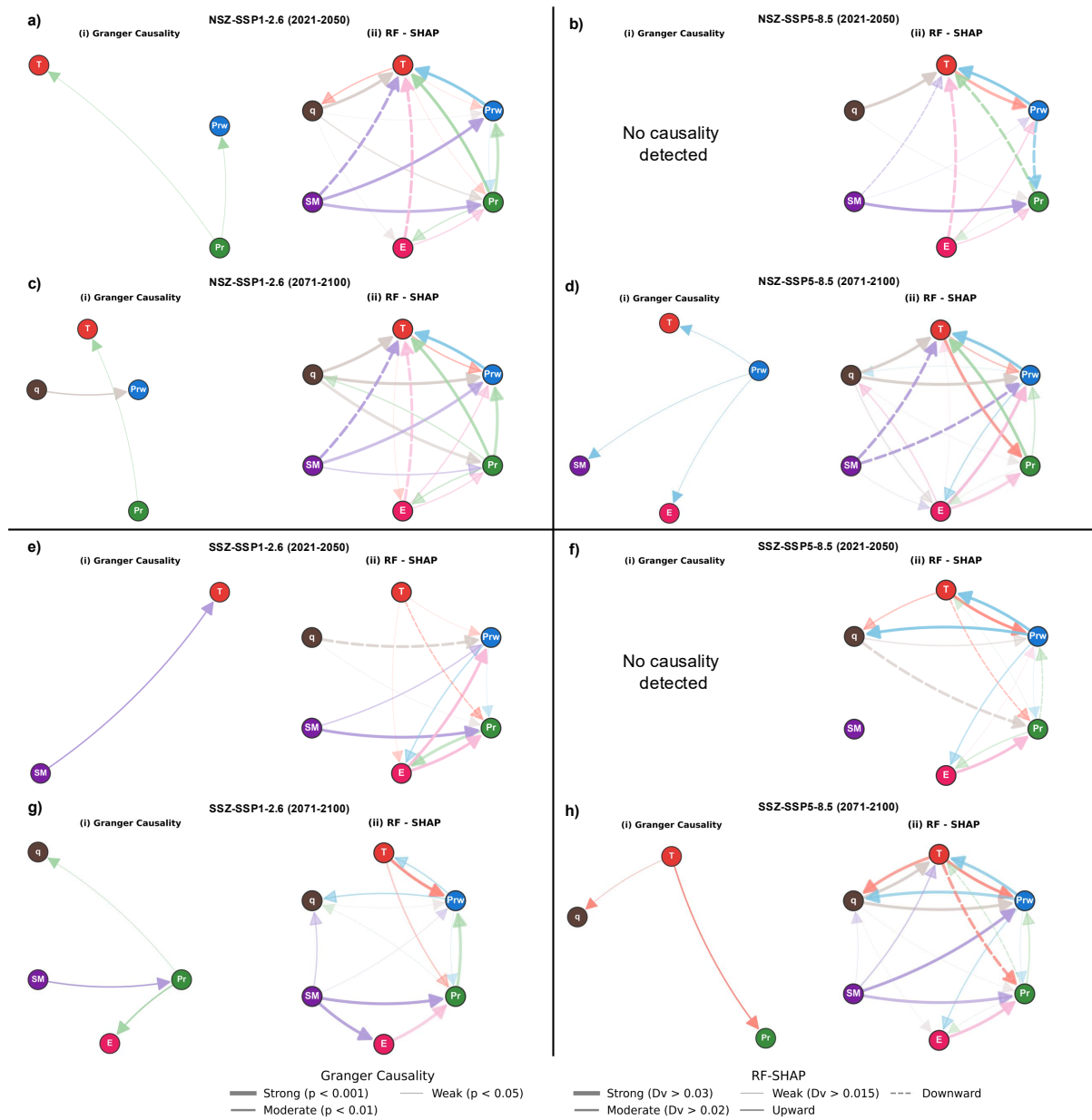


Figure S24: As S21, but for CMCC-CM2-SR5.

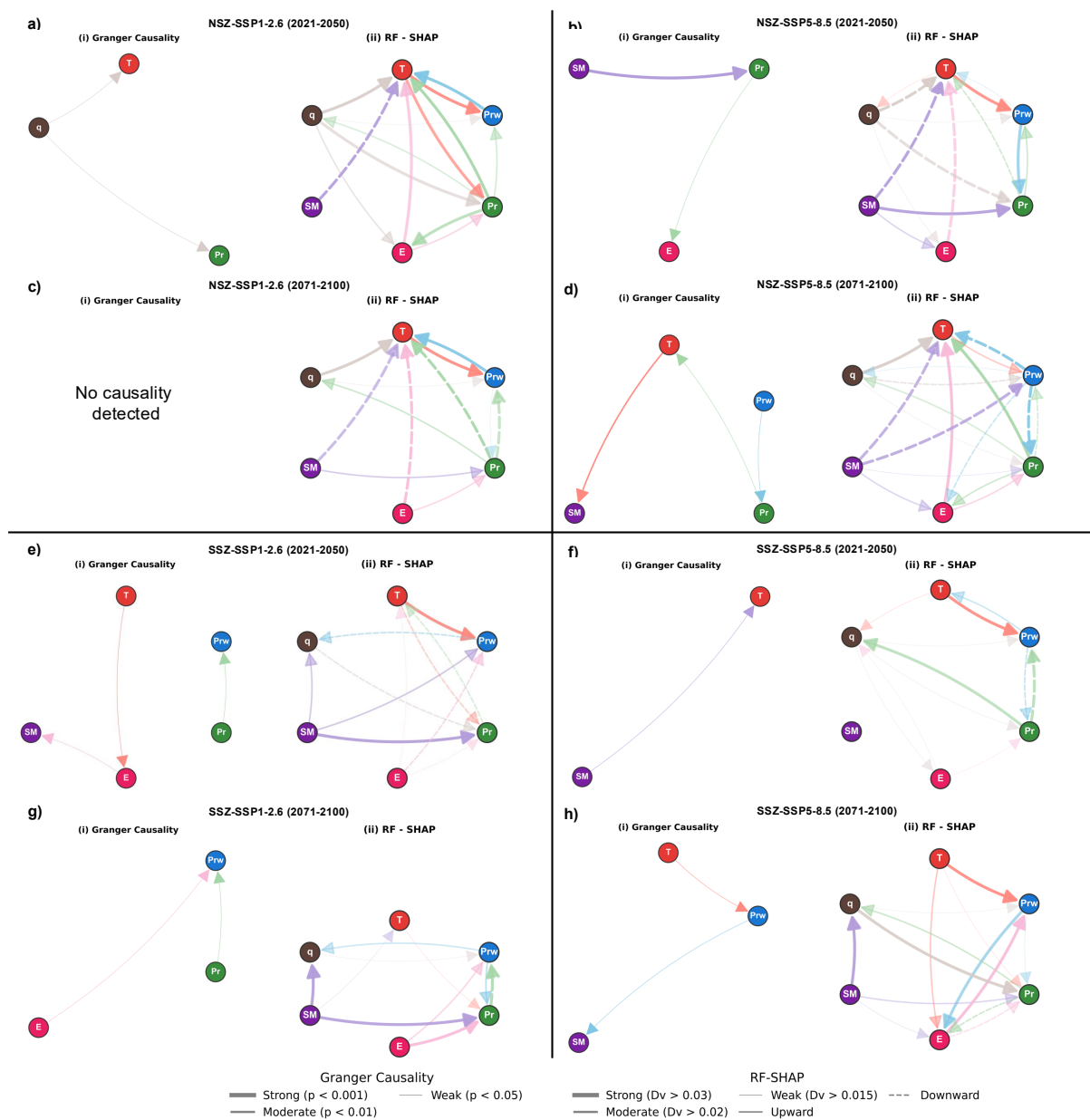


Figure S25: As S21, but for CMCC-ESM2.

Supplementary 5

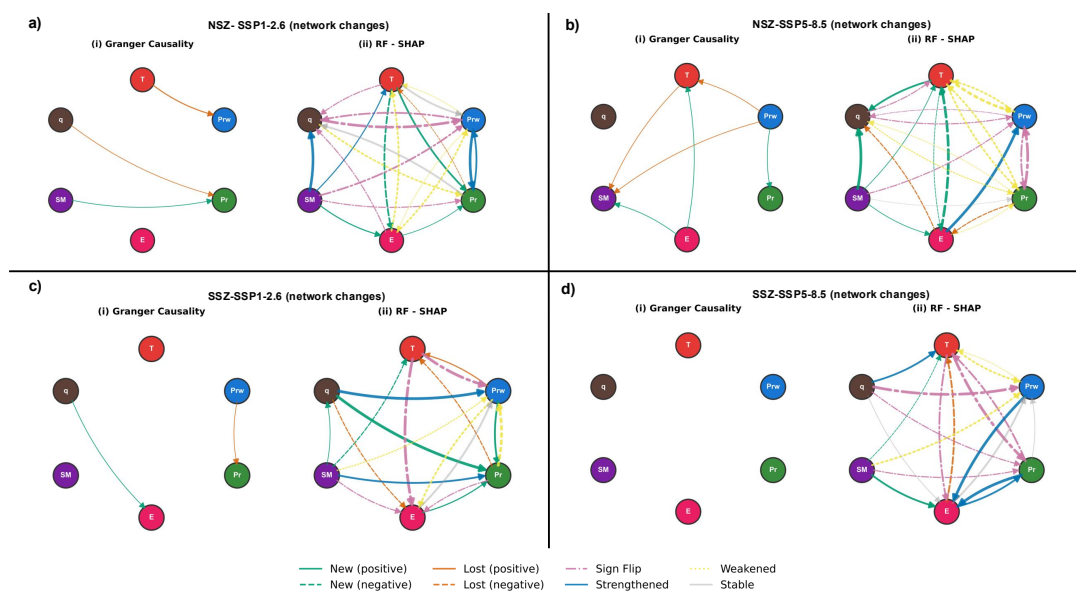


Figure S26: **Network changes across mid and end of century projection during JJA season across the NSZ and SSZ regions under MIROC6.**

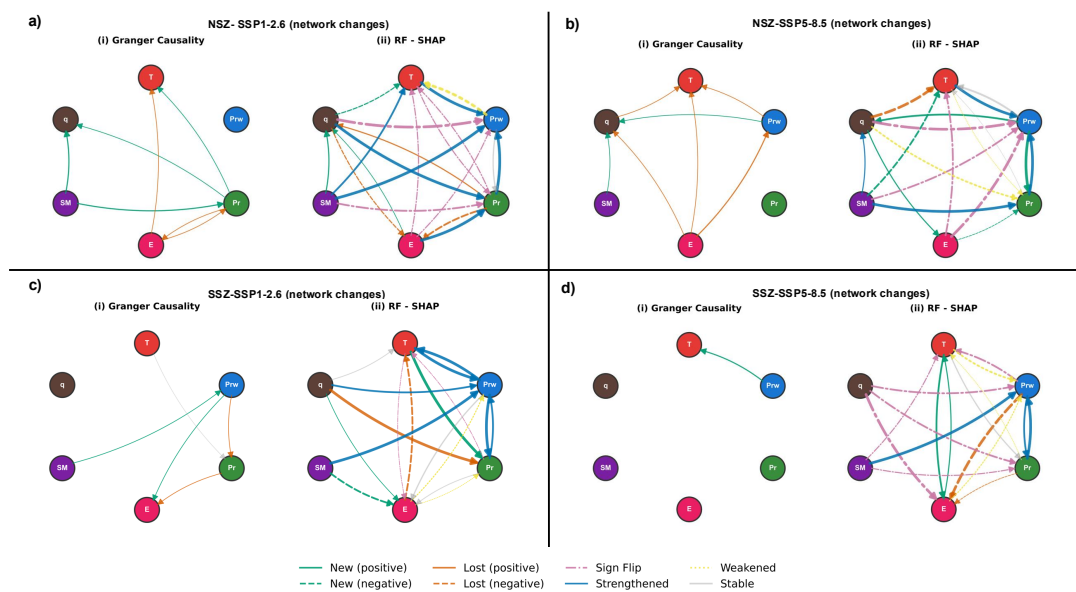


Figure S27: **As S26, but for NorESM2-LM.**

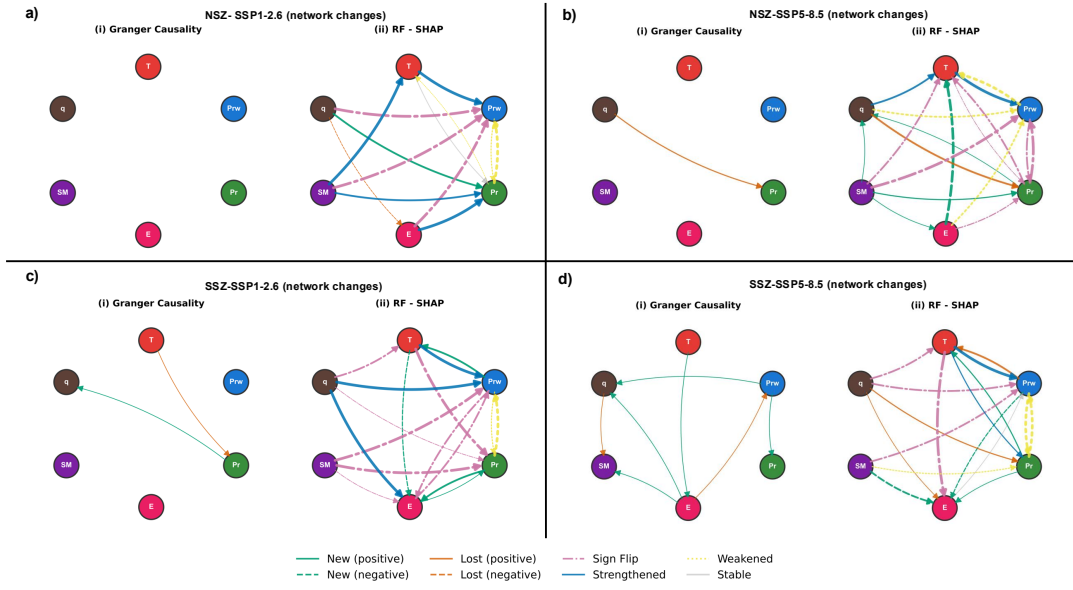


Figure S28: As S26, but for NorESM2-MM.

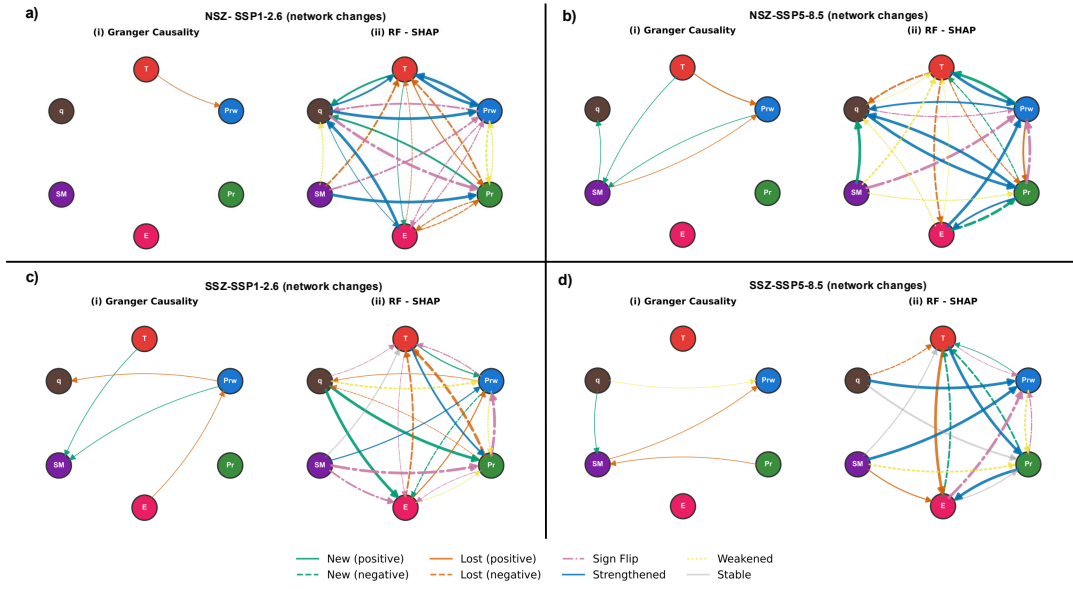


Figure S29: As S26, but for CMCC-CM2-SR5.

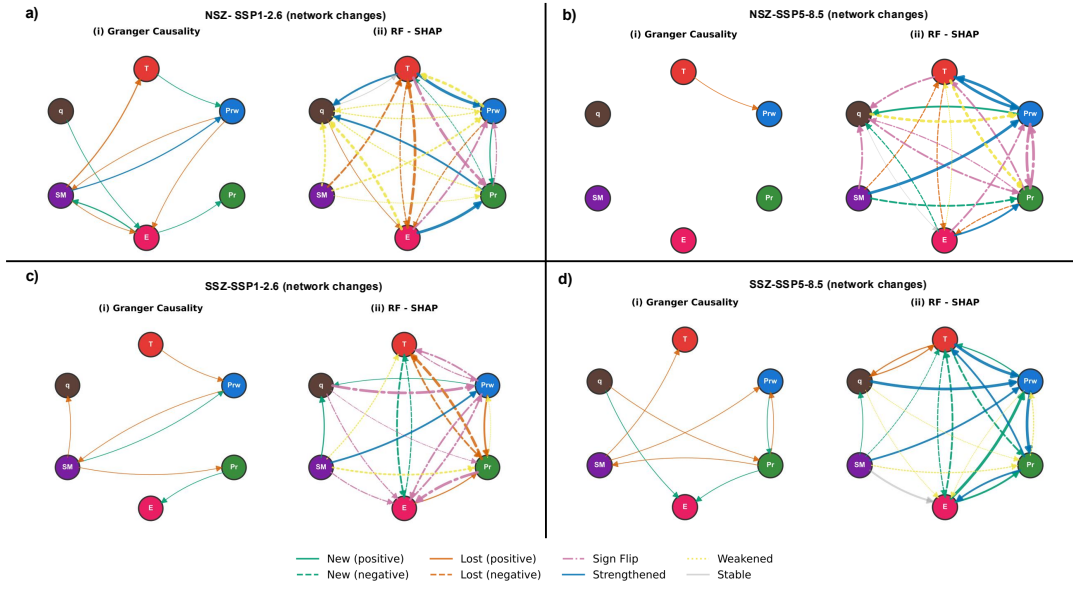


Figure S30: As S26, but for CMCC-ESM2.

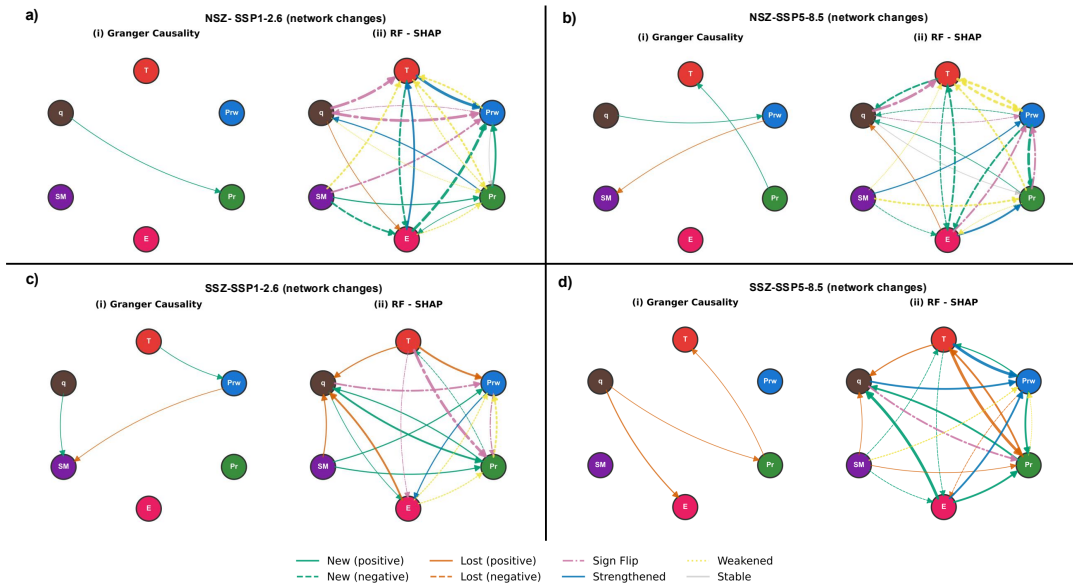


Figure S31: As S26, but during DJF across the NMZ and SMZ under MIROC6.

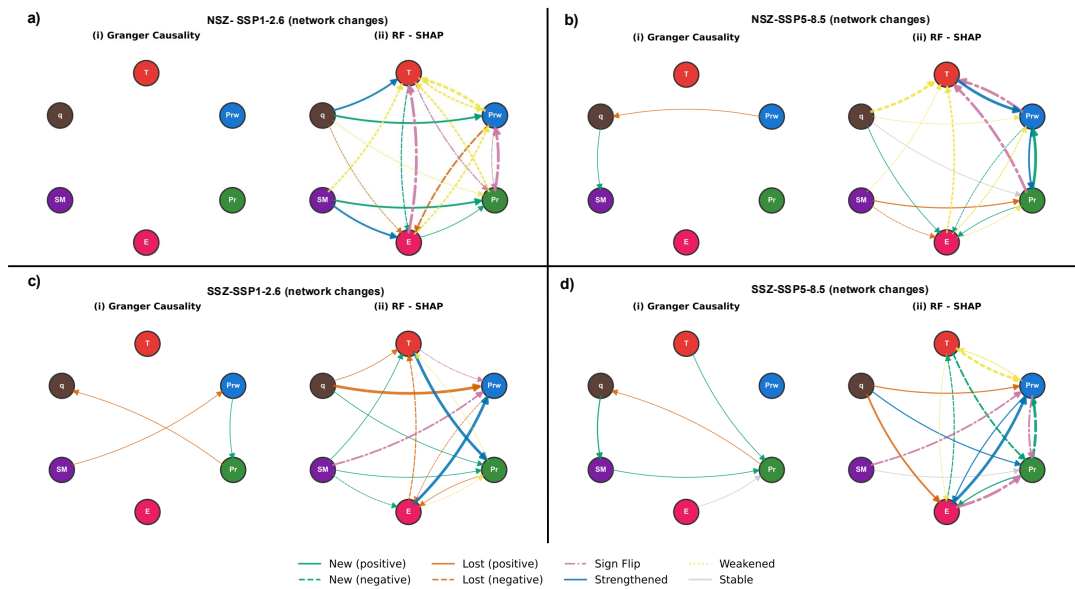


Figure S32: As S31, but for NorESM2-LM.

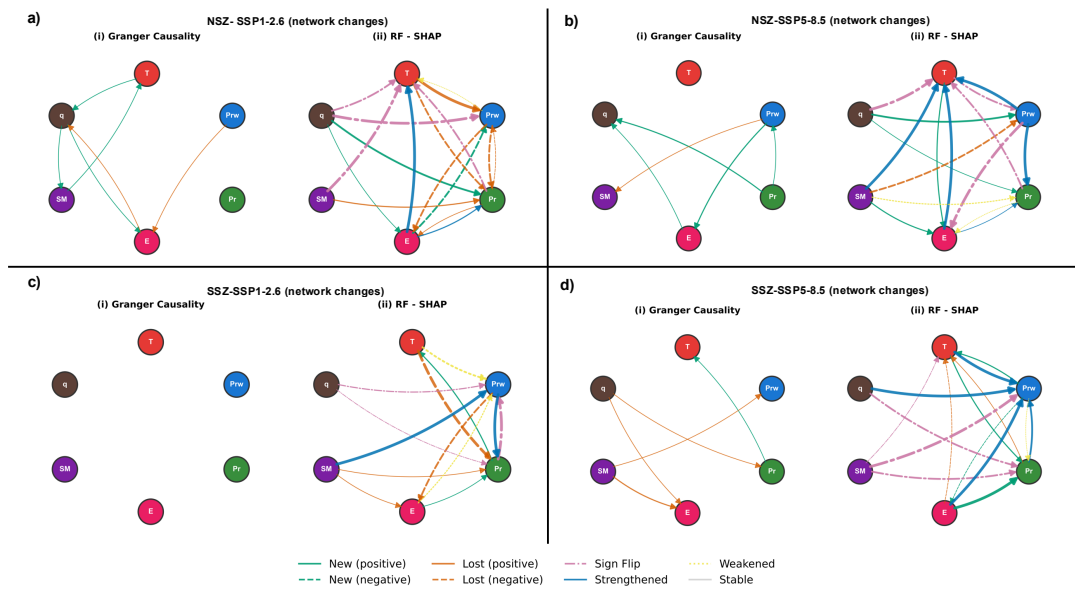


Figure S33: As S31, but for NorESM2-MM.

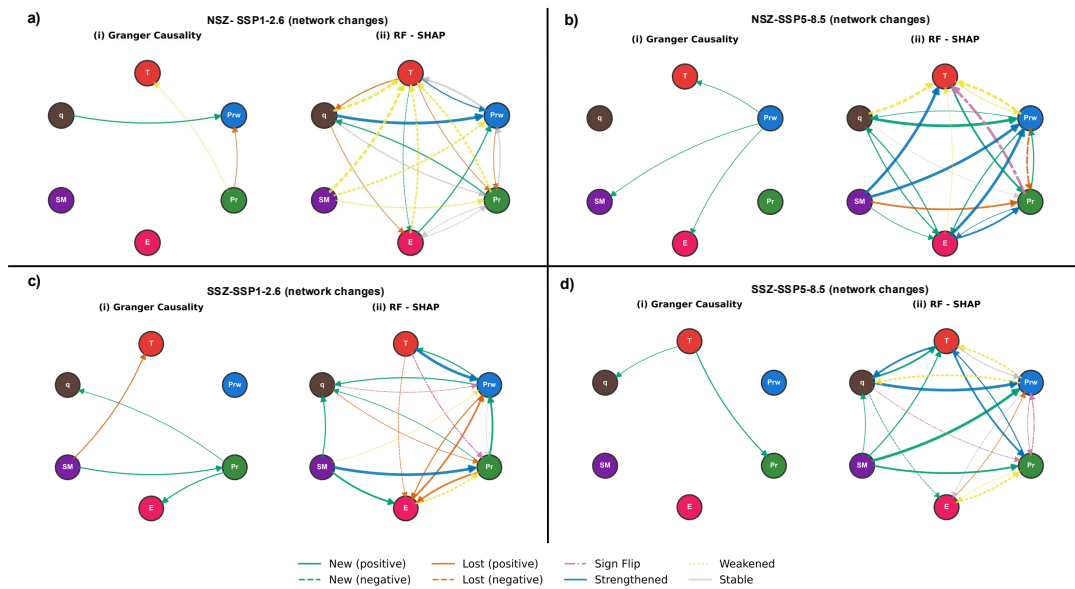


Figure S34: **As S31, but for CMCC-CM2-SR5.**

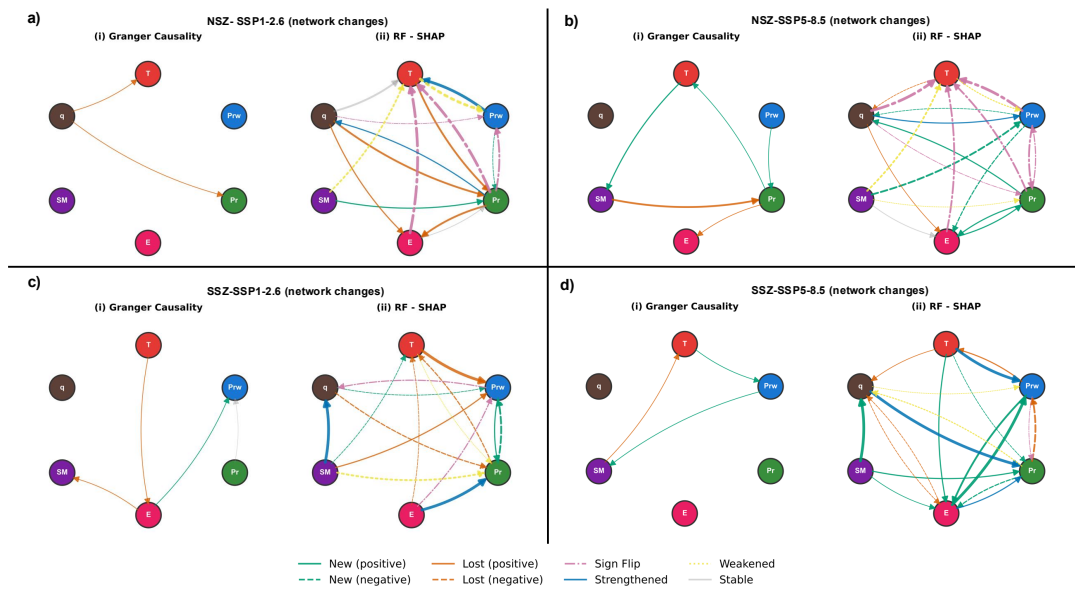


Figure S35: **As S31, but for CMCC-ESM2.**

Supplementary 6

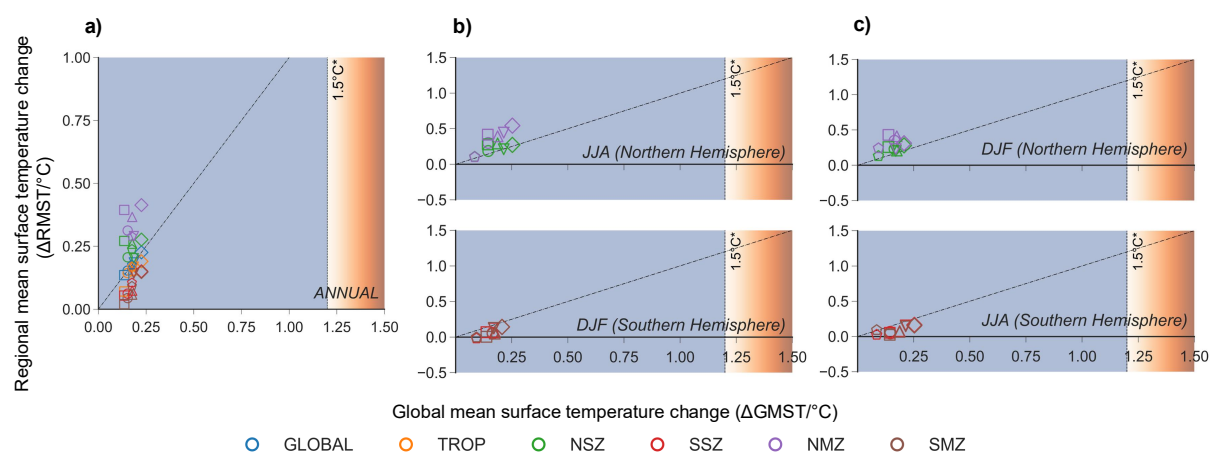


Figure S36: **Sensitivity of RMST to GSMT across *early century* (1981–2010) relative to the 1971–2000 baseline.** Panel (a) shows annual results, (b) summer, and (c) winter season. Legend definitions are consistent with Fig. 2 in the main text.

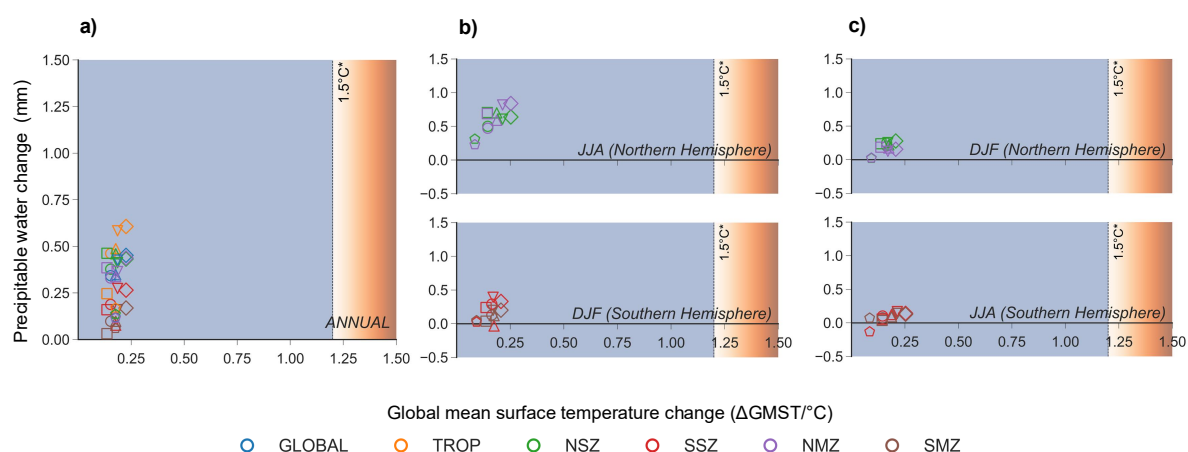


Figure S37: **As S36, but for precipitable water.**

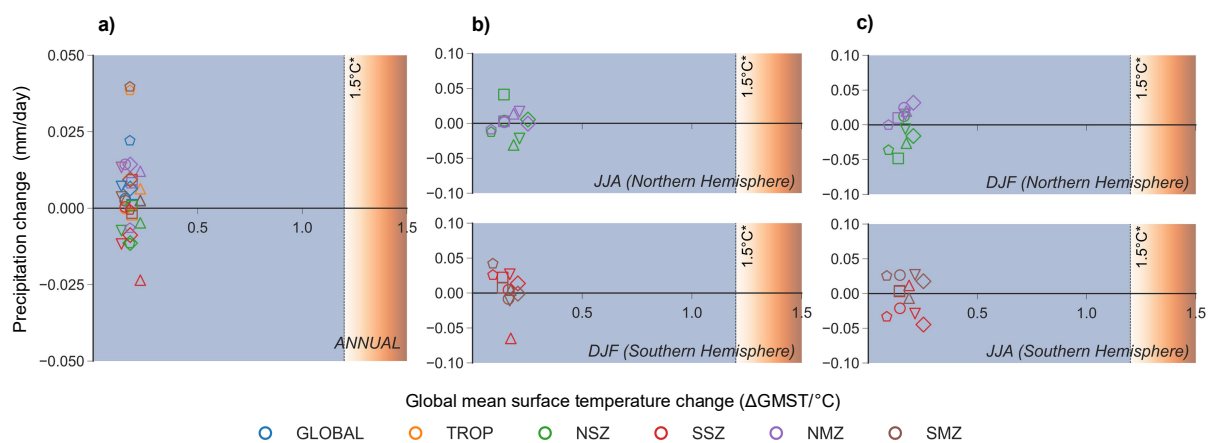


Figure S38: As S36, but for precipitation.

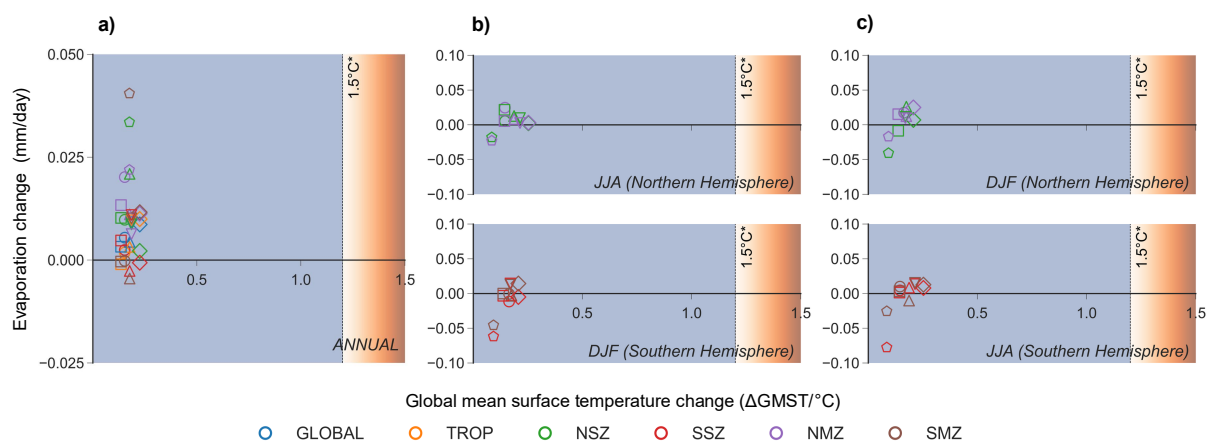


Figure S39: As S36, but for evaporation.

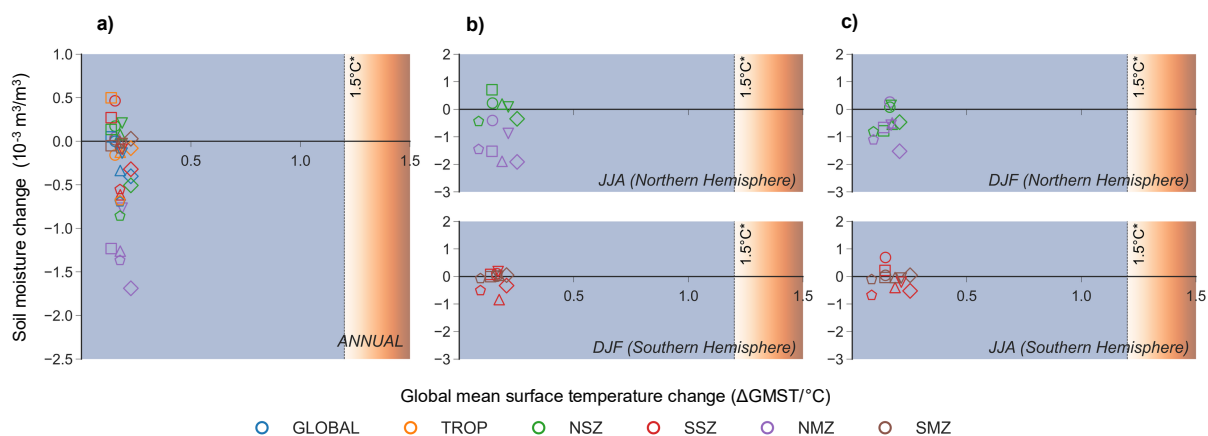


Figure S40: As S36, but for soil moisture.

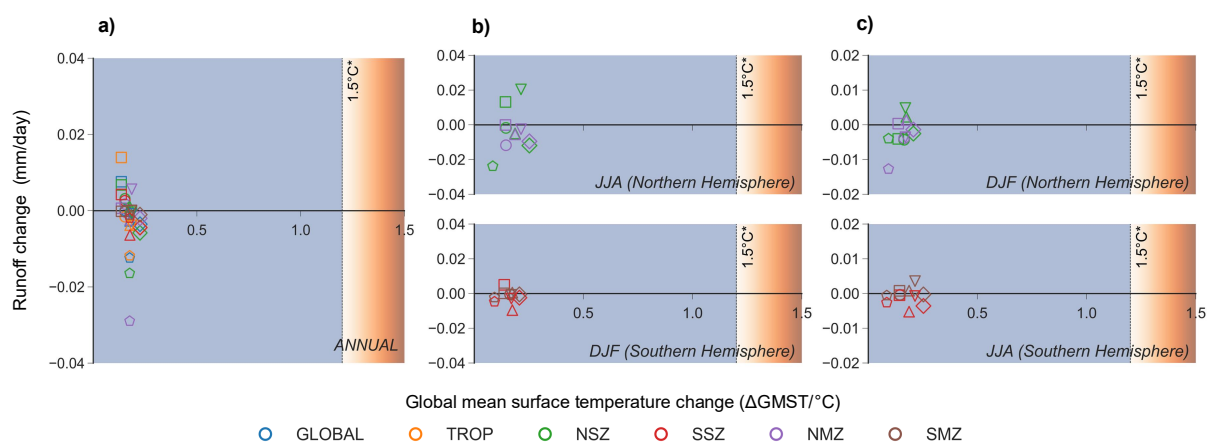


Figure S41: As S36, but for runoff.