U.S. Geological Survey - National Climate Change Viewer

Summary of Texas

October 5, 2023

1 Definitions

LOCA2 – The second version of the Localized Constructed Analogs statistical downscaling method, which is applied to Coupled Model Intercomparison Project phase 6 (CMIP6) climate model output.

MWBM – A Monthly water-balance model that accounts for the partitioning of water through the various components of the hydrologic system.

Mean Temperature – Monthly average of the daily mean temperature. (source: LOCA2)

Maximum temperature – Monthly average of the daily maximum temperature. (source: LOCA2)

Minimum temperature – Monthly average of the daily minimum temperature. (source: LOCA2)

Precipitation – Monthly total precipitation. (source: LOCA2)

Snow – Snow water equivalent (SWE), the liquid water stored in the snowpack. Snow is simulated in the MWBM using monthly mean temperature and monthly total precipitation and may be considered the end-of-month amount. (source: LOCA2+MWBM)

Runoff – The sum of direct runoff (DRO) that occurs from precipitation and snow melt and surplus runoff (RO) which occurs when soil moisture is at 100% capacity. (source: LOCA2+MWBM)

Soil Storage – The water stored in soil column (source: LOCA2+MWBM)

Evaporative Deficit – The difference between potential evapotranspiration (PET), which is the amount of evapotranspiration that would occur if unlimited water were available, and actual evapotranspiration (AET) which is what occurs but can be water limited (source: LOCA2+MWBM)

2 Mean temperature

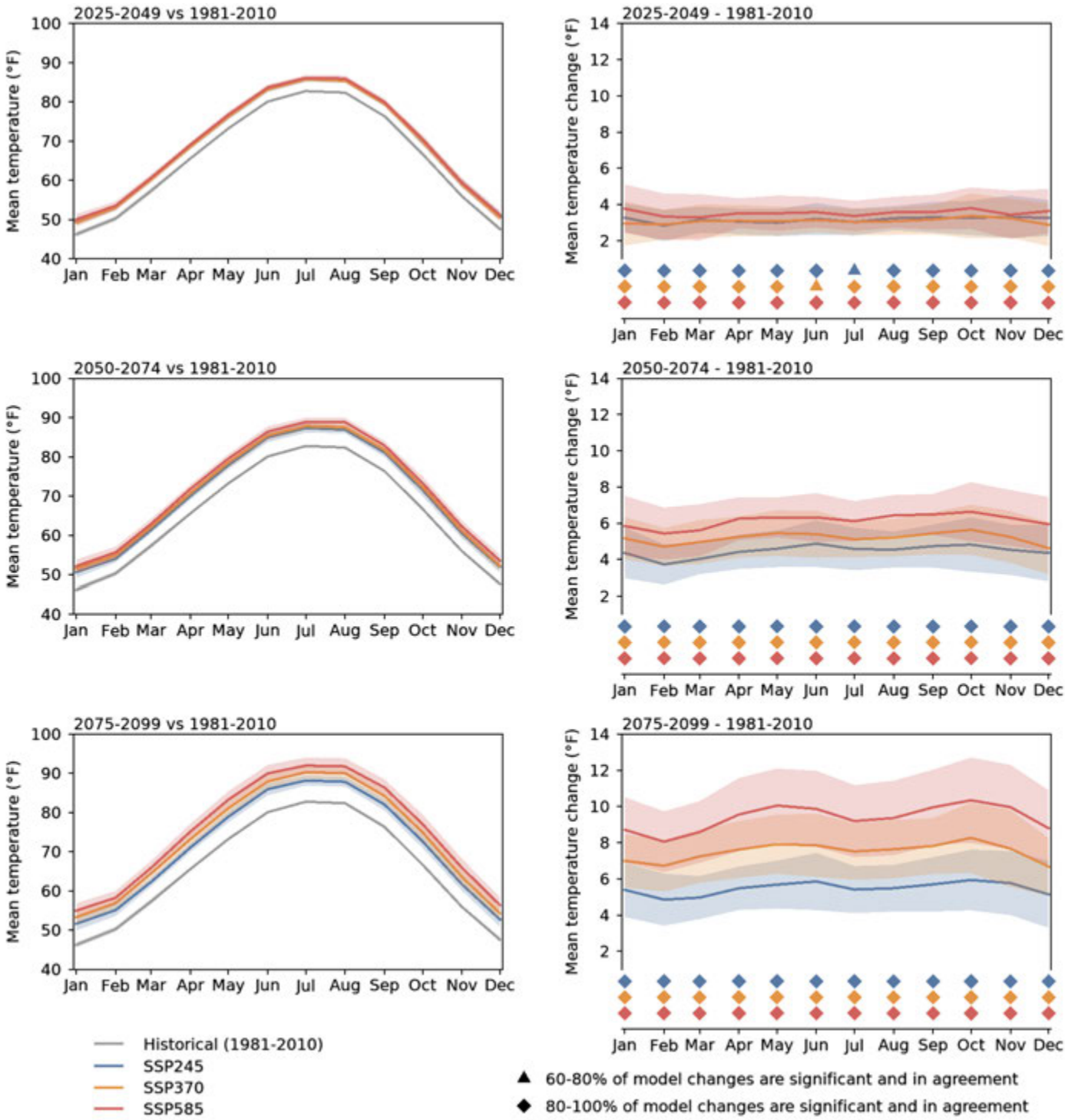

Figure 1: Monthly mean temperature for the three future time periods for the ssp245, ssp370, ssp585 simulations. The median of all CMIP6 models is indicated by the solid lines and the 10th to 90th percentile range of the models is indicated by the respective shaded envelopes. Raw values relative to the historical simulation (1981-2010) are shown in the left column and future minus historical changes are shown in the right column. Triangle and diamond symbols indicate the percent of models that simulate future minus present changes that are of the same sign and statistically significant at a 95% confidence level based on a Mann-Whitney rank test.

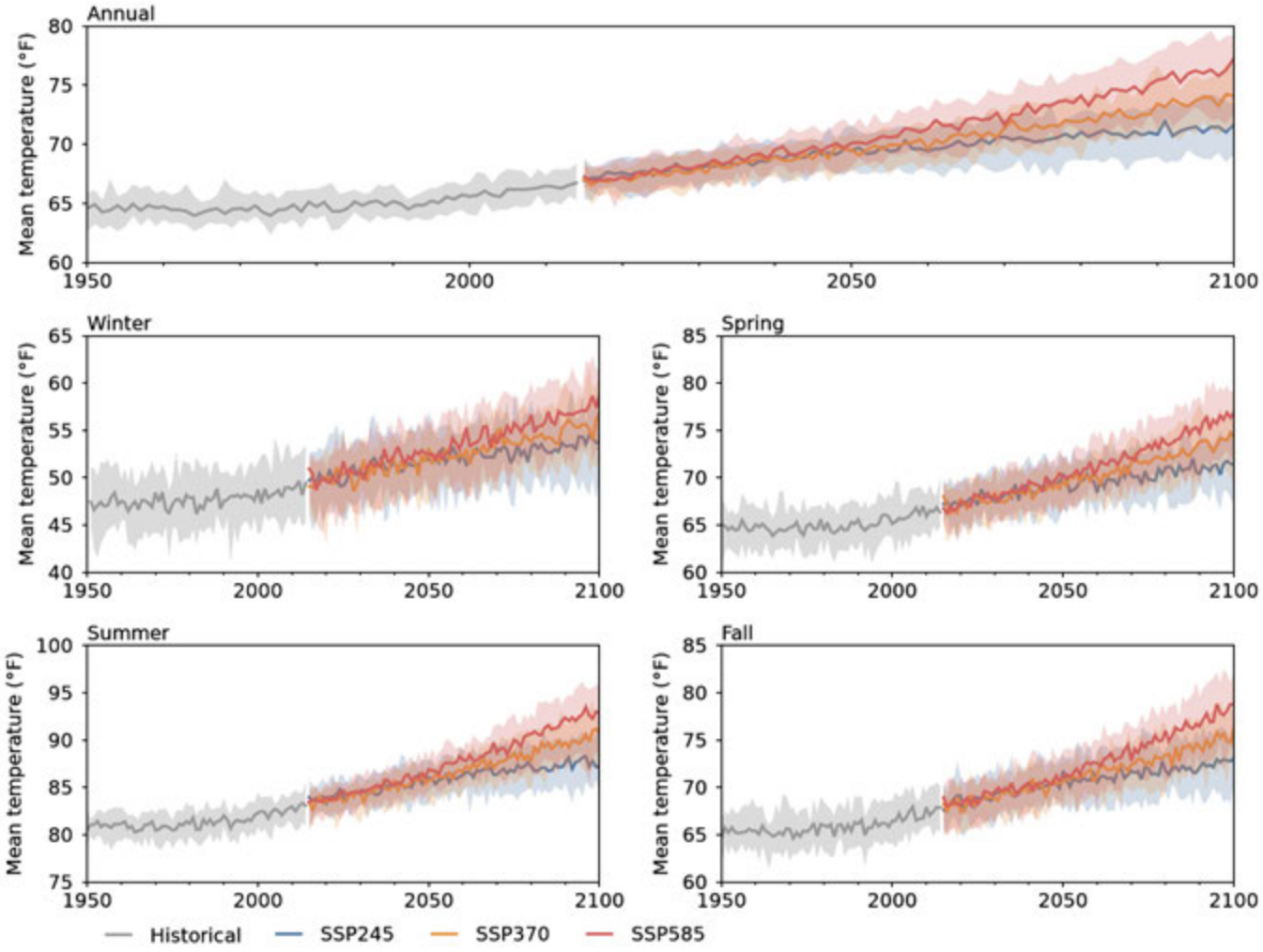

Figure 2: Annual and seasonal time series of mean temperature for historical (gray), ssp245 (blue), ssp370 (orange), and ssp585 (red). The historical period ends in 2014 and the future periods begin in 2015. The median of CMIP6 models is indicated by the solid lines and the ensemble 10th to 90th percentile range of the model is indicated by the respective shaded envelopes.

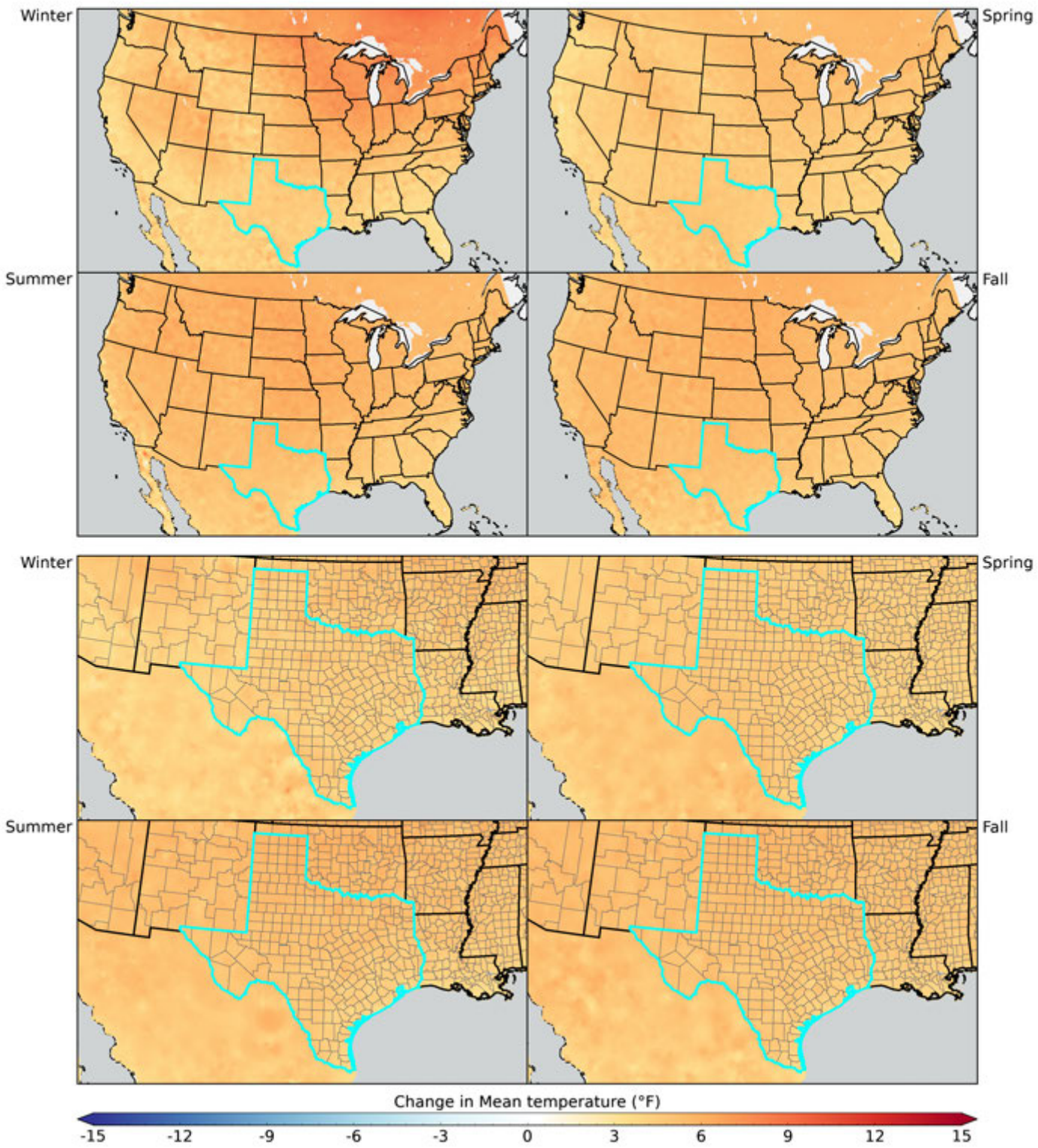

Figure 3: Seasonal maps of mean temperature for ssp245 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

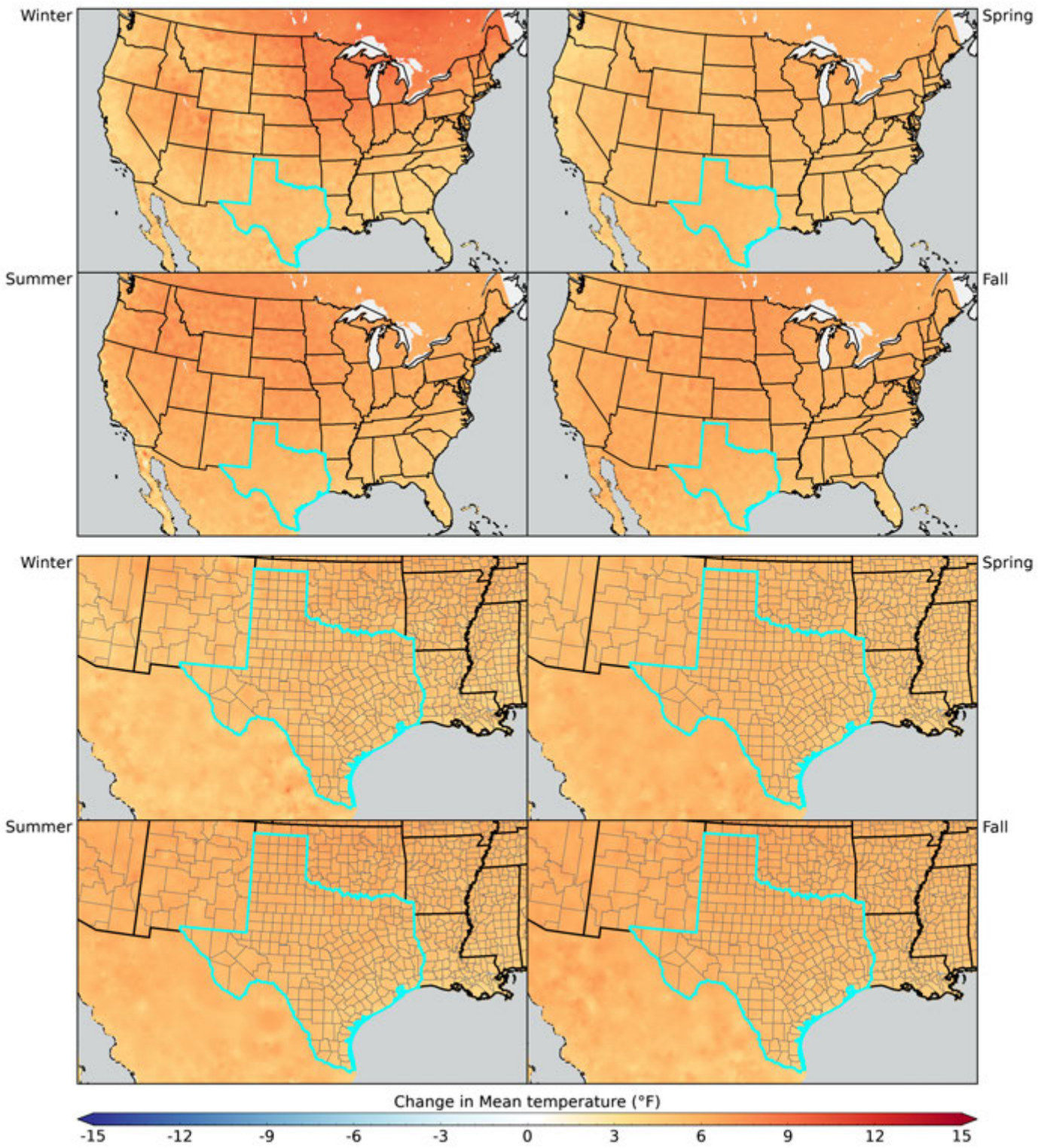

Figure 4: Seasonal maps of mean temperature for ssp370 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

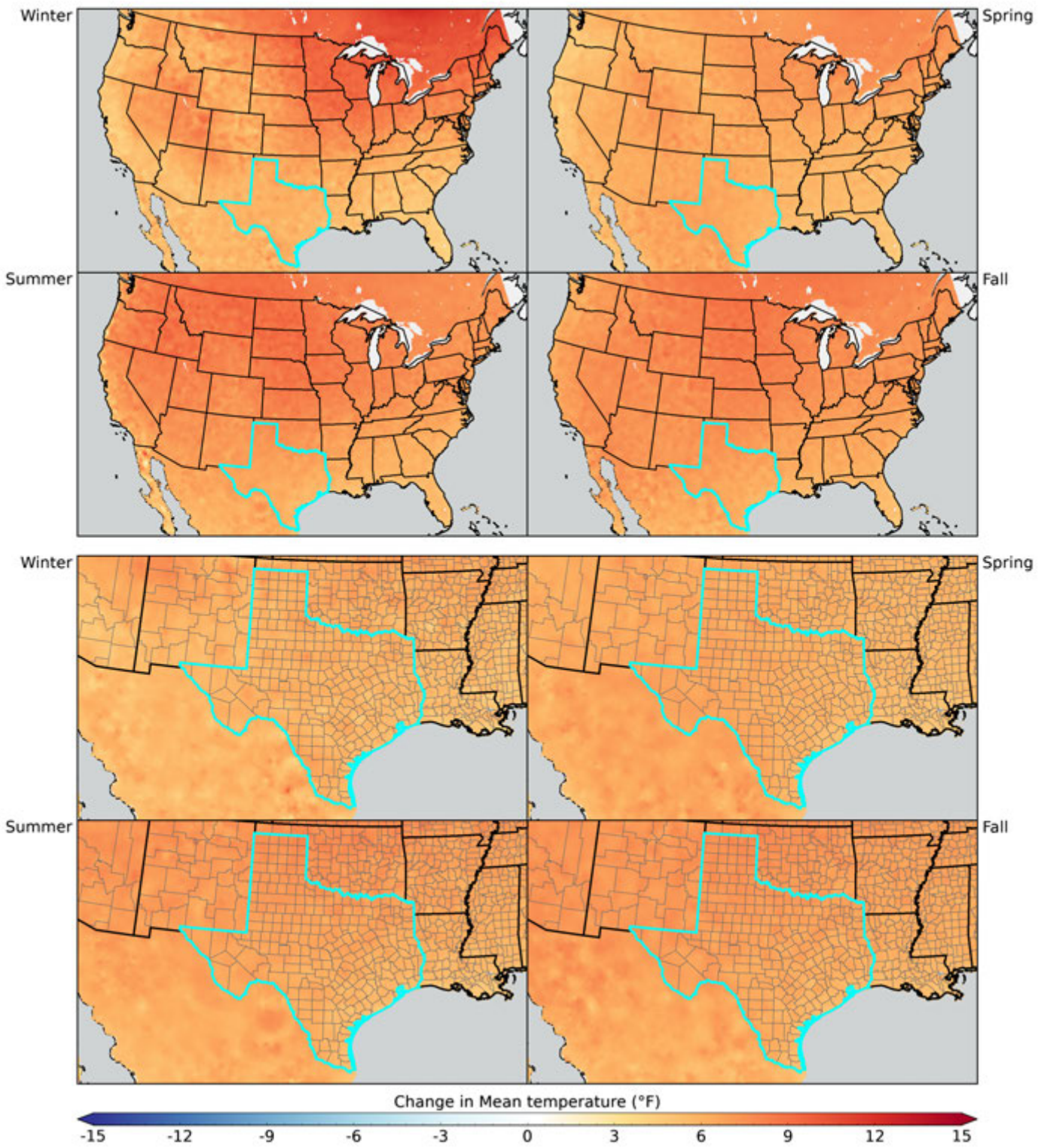

Figure 5: Seasonal maps of mean temperature for ssp585 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

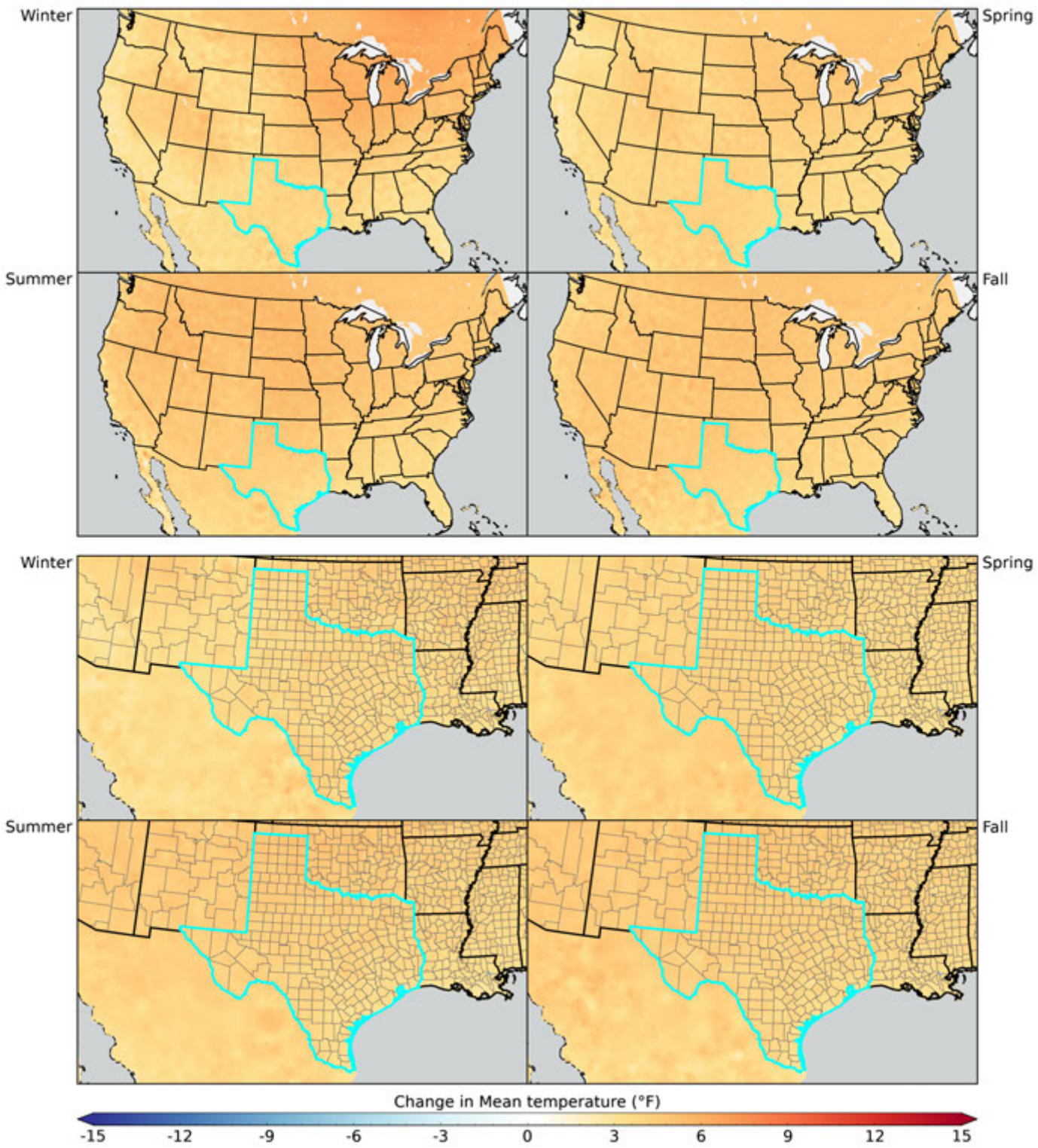

Figure 6: Seasonal maps of mean temperature change for Global Warming Level $2°C$ (GWL2, relative to 1981-2010) for the ensemble mean. Global Warming Levels include all models and all scenarios (n=72 model simulations) and are referenced to the 20-year period when the global average temperature simulated by each climate model warms by $2°C$ above the 1850-1900 pre-industrial average.

3 Maximum temperature

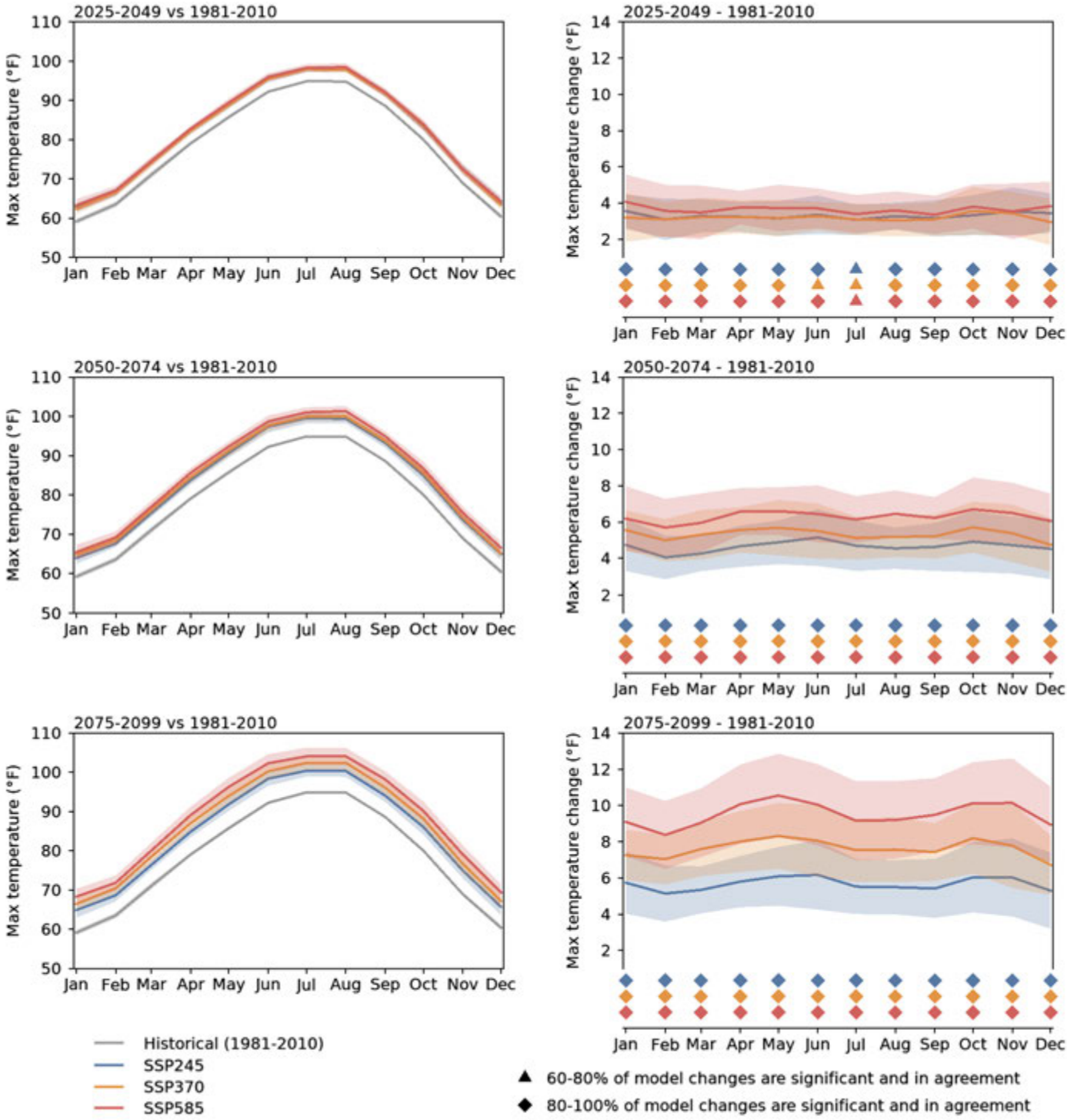

Figure 7: Monthly maximum temperature for the three future time periods for the ssp245, ssp370, ssp585 simulations. The median of all CMIP6 models is indicated by the solid lines and the 10th to 90th percentile range of the models is indicated by the respective shaded envelopes. Raw values relative to the historical simulation (1981-2010) are shown in the left column and future minus historical changes are shown in the right column. Triangle and diamond symbols indicate the percent of models that simulate future minus present changes that are of the same sign and statistically significant at a 95% confidence level based on a Mann-Whitney rank test.

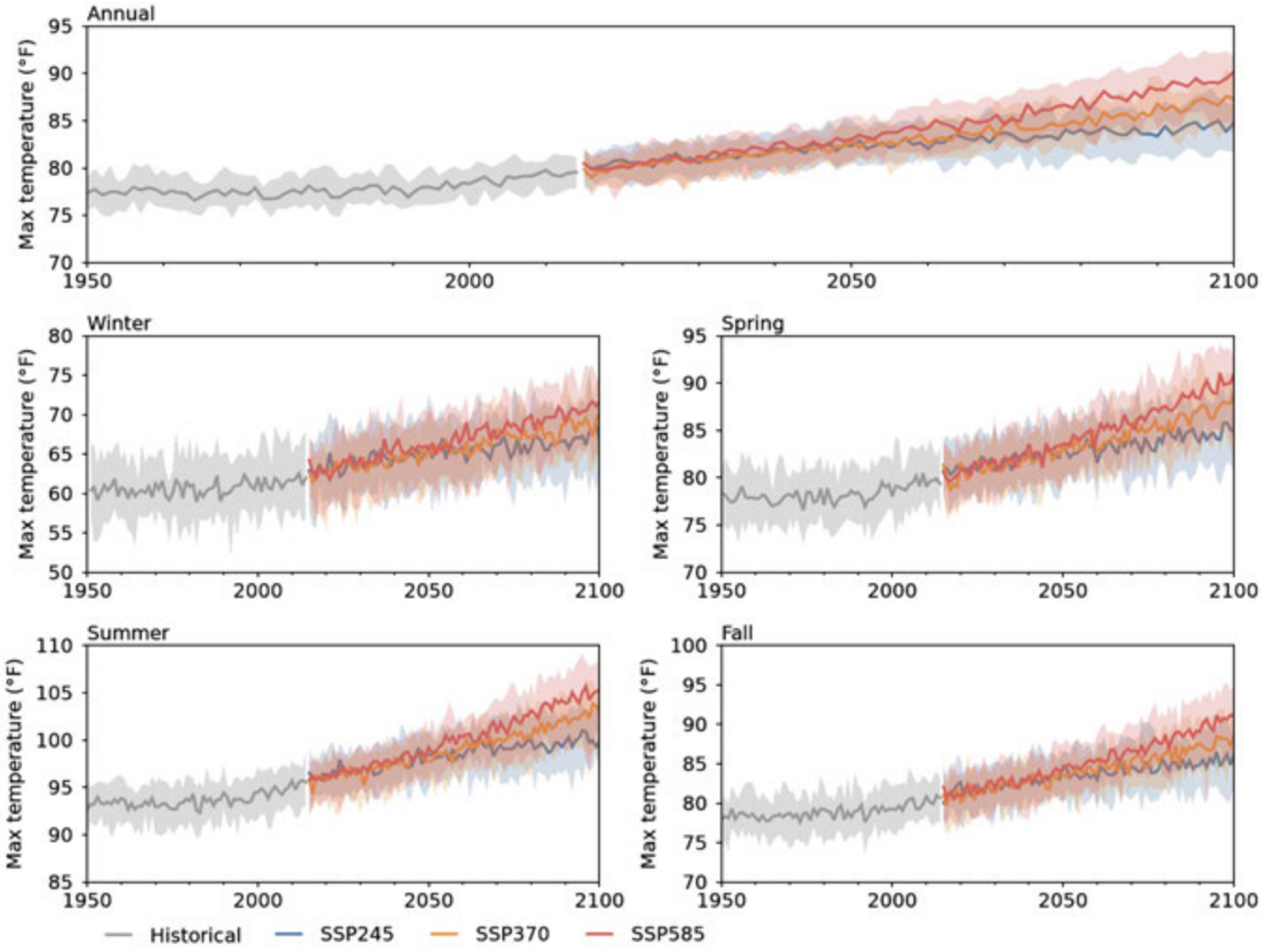

Figure 8: Annual and seasonal time series of maximum temperature for historical (gray), ssp245 (blue), ssp370 (orange), and ssp585 (red). The historical period ends in 2014 and the future periods begin in 2015. The median of CMIP6 models is indicated by the solid lines and the ensemble 10th to 90th percentile range of the model is indicated by the respective shaded envelopes.

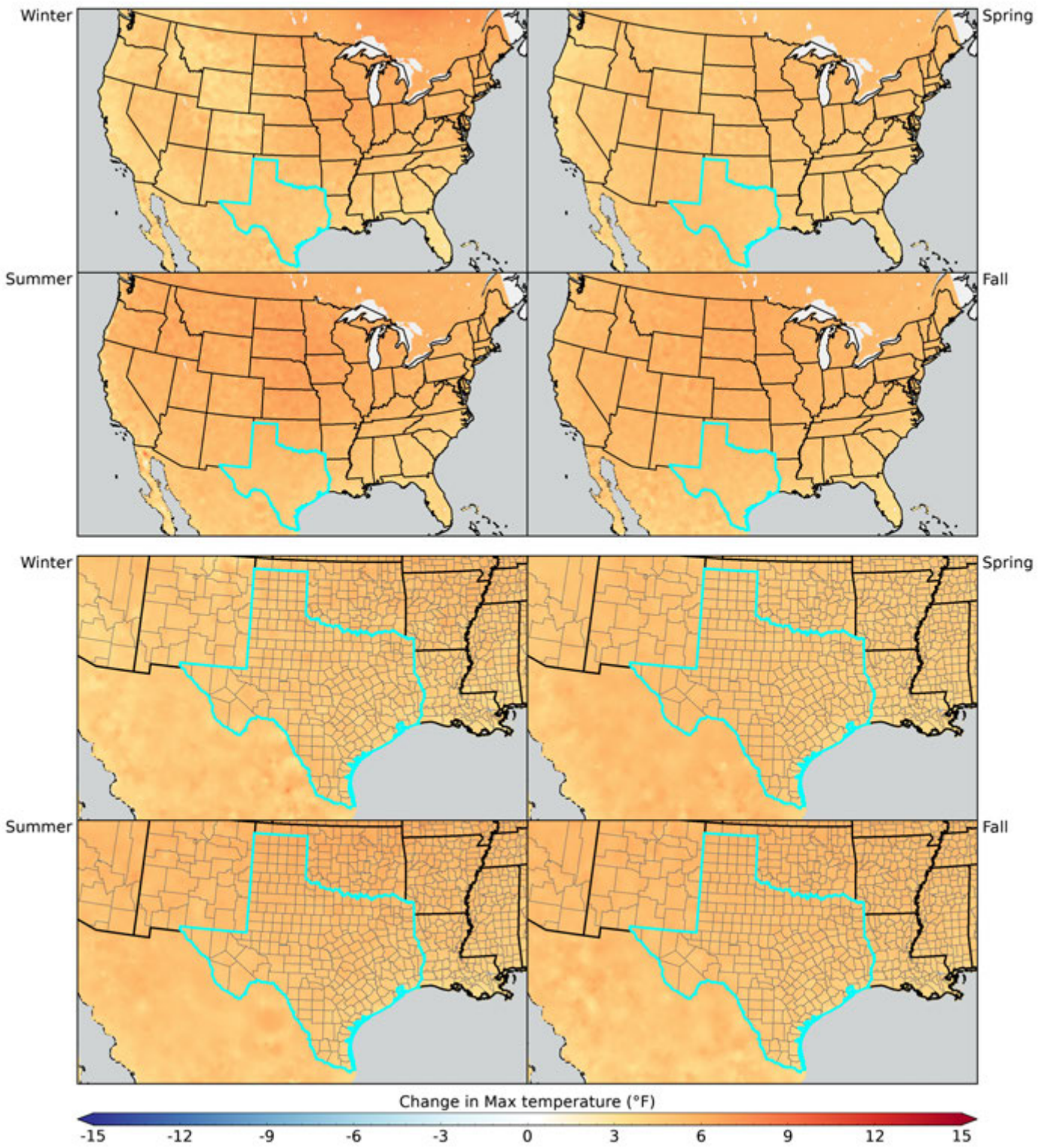

Figure 9: Seasonal maps of maximum temperature for ssp245 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

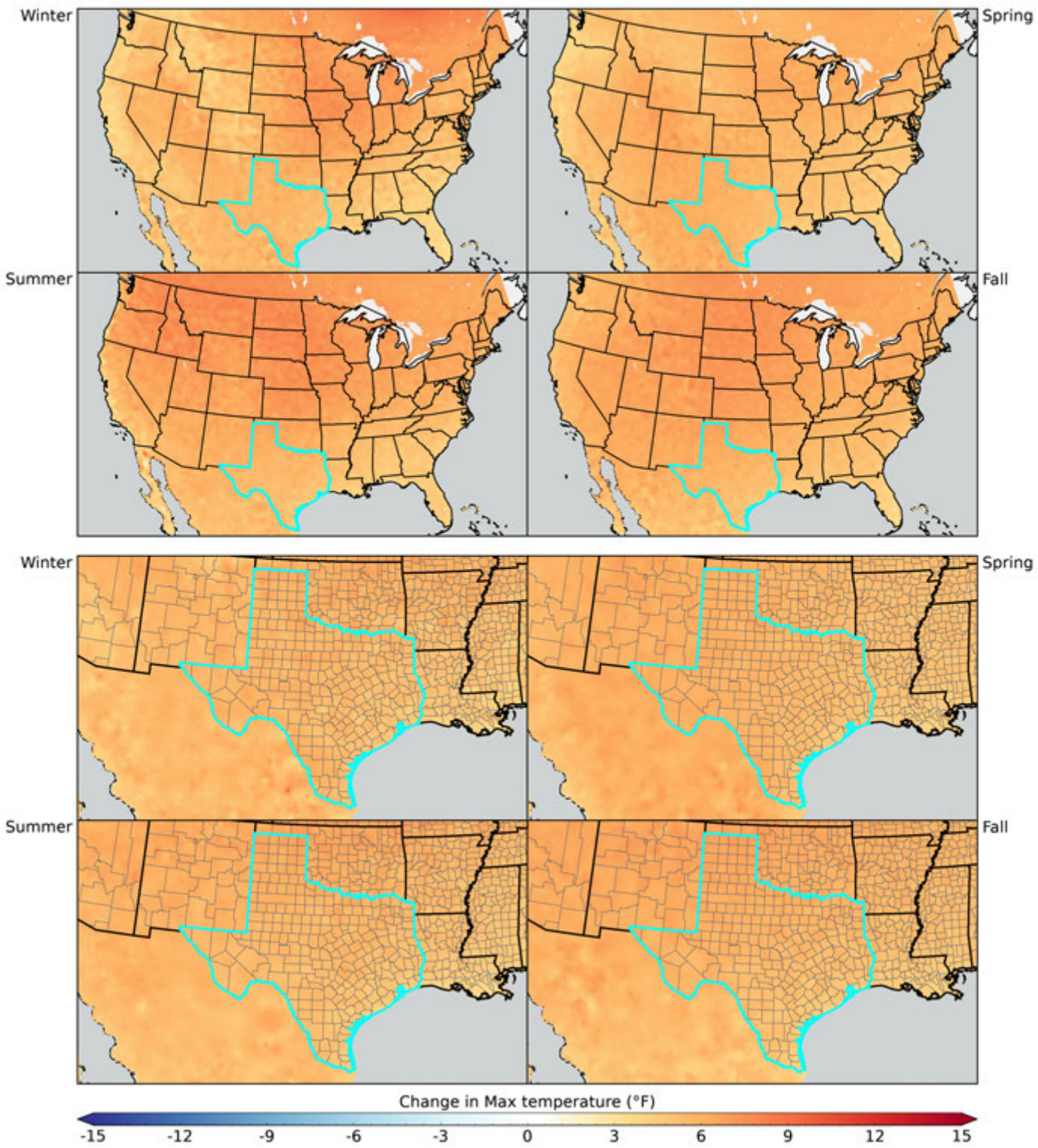

Figure 10: Seasonal maps of maximum temperature for ssp370 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

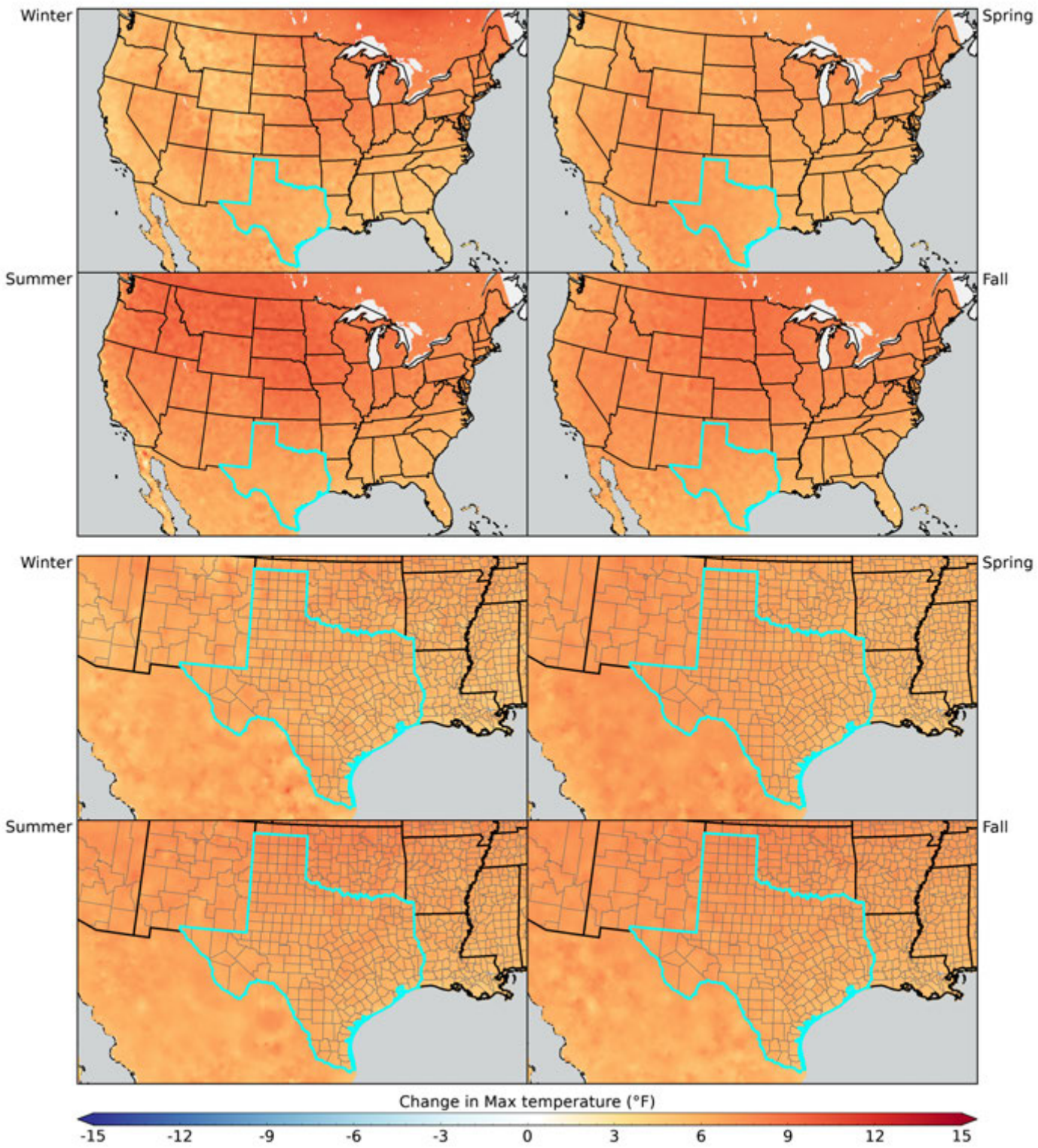

Figure 11: Seasonal maps of maximum temperature for ssp585 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

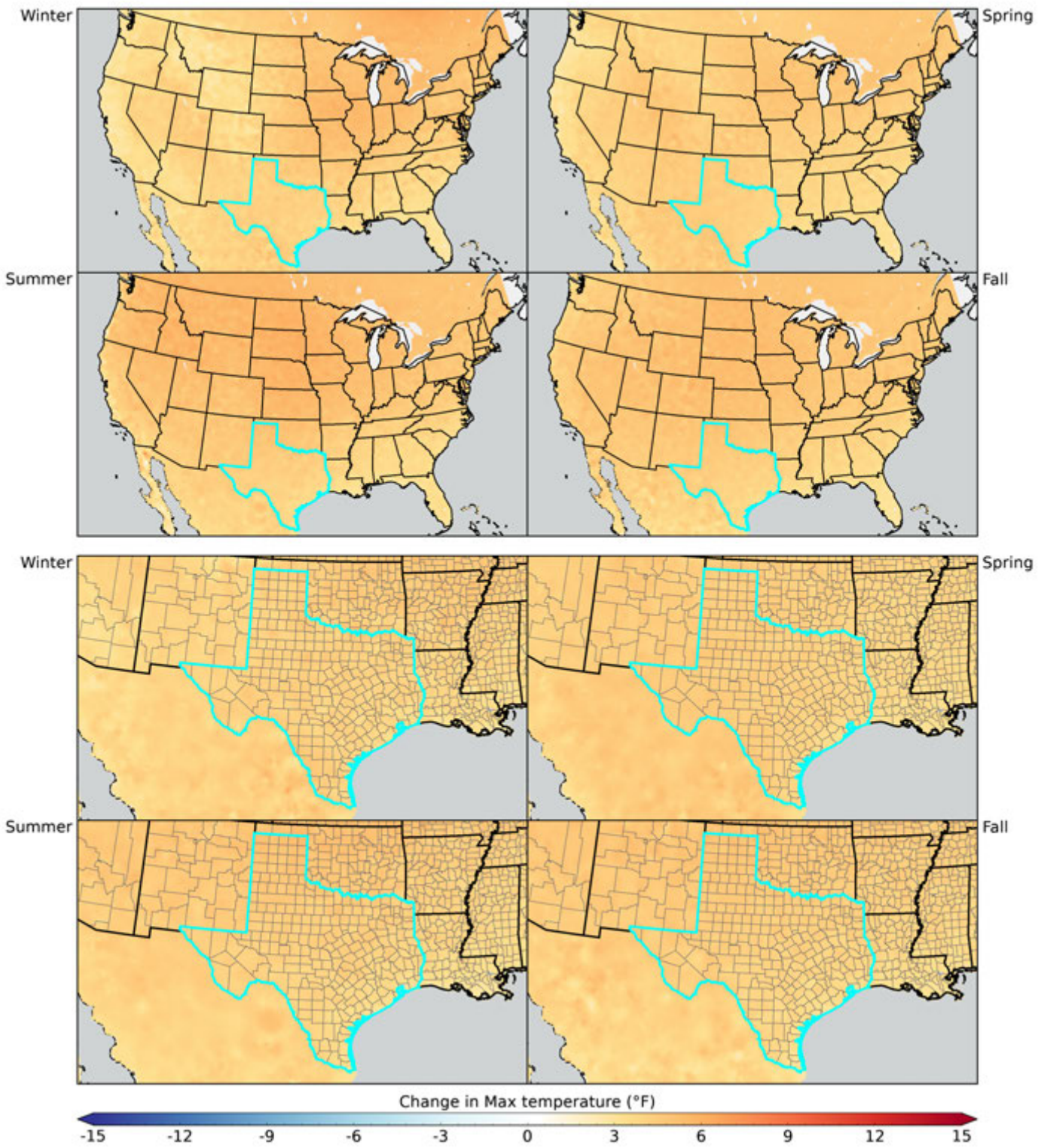

Figure 12: Seasonal maps of maximum temperature change for Global Warming Level $2°C$ (GWL2, relative to 1981-2010) for the ensemble mean. Global Warming Levels include all models and all scenarios (n=72 model simulations) and are referenced to the 20-year period when the global average temperature simulated by each climate model warms by $2°C$ above the 1850-1900 pre-industrial average.

4 Minimum temperature

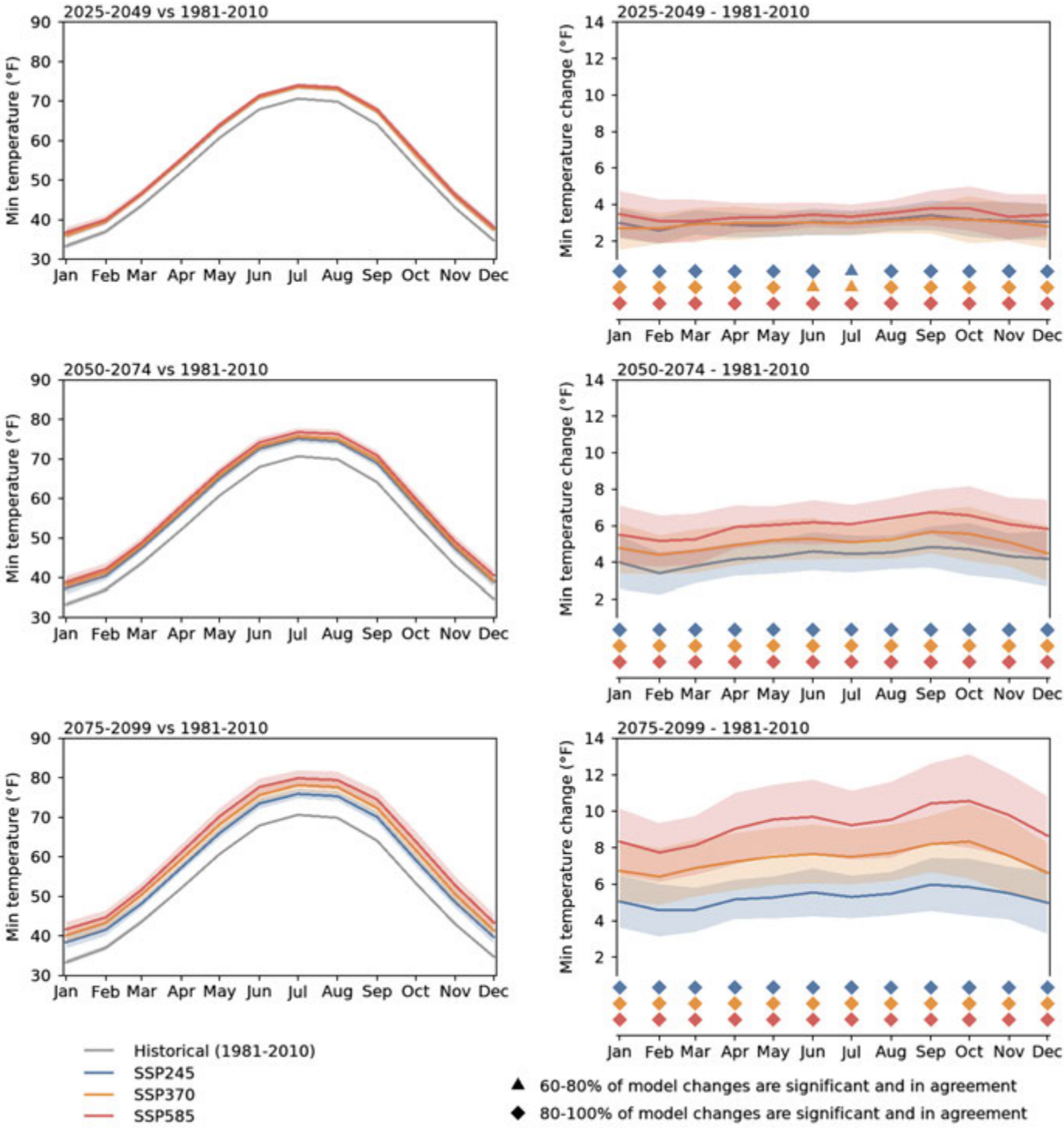

Figure 13: Monthly minimum temperature for the three future time periods for the ssp245, ssp370, ssp585 simulations. The median of all CMIP6 models is indicated by the solid lines and the 10th to 90th percentile range of the models is indicated by the respective shaded envelopes. Raw values relative to the historical simulation (1981-2010) are shown in the left column and future minus historical changes are shown in the right column. Triangle and diamond symbols indicate the percent of models that simulate future minus present changes that are of the same sign and statistically significant at a 95% confidence level based on a Mann-Whitney rank test.

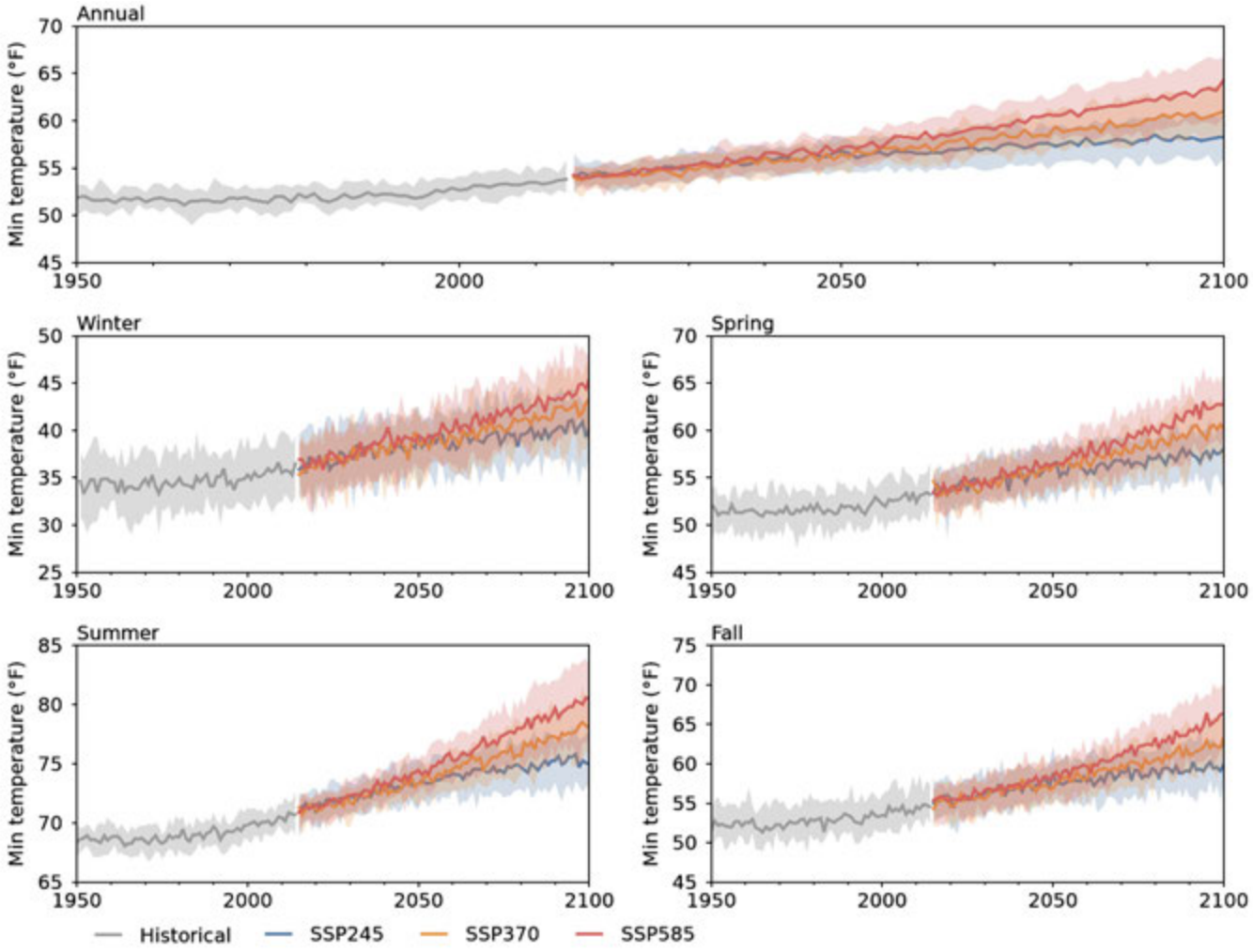

Figure 14: Annual and seasonal time series of minimum temperature for historical (gray), ssp245 (blue), ssp370 (orange), and ssp585 (red). The historical period ends in 2014 and the future periods begin in 2015. The median of CMIP6 models is indicated by the solid lines and the ensemble 10th to 90th percentile range of the model is indicated by the respective shaded envelopes.

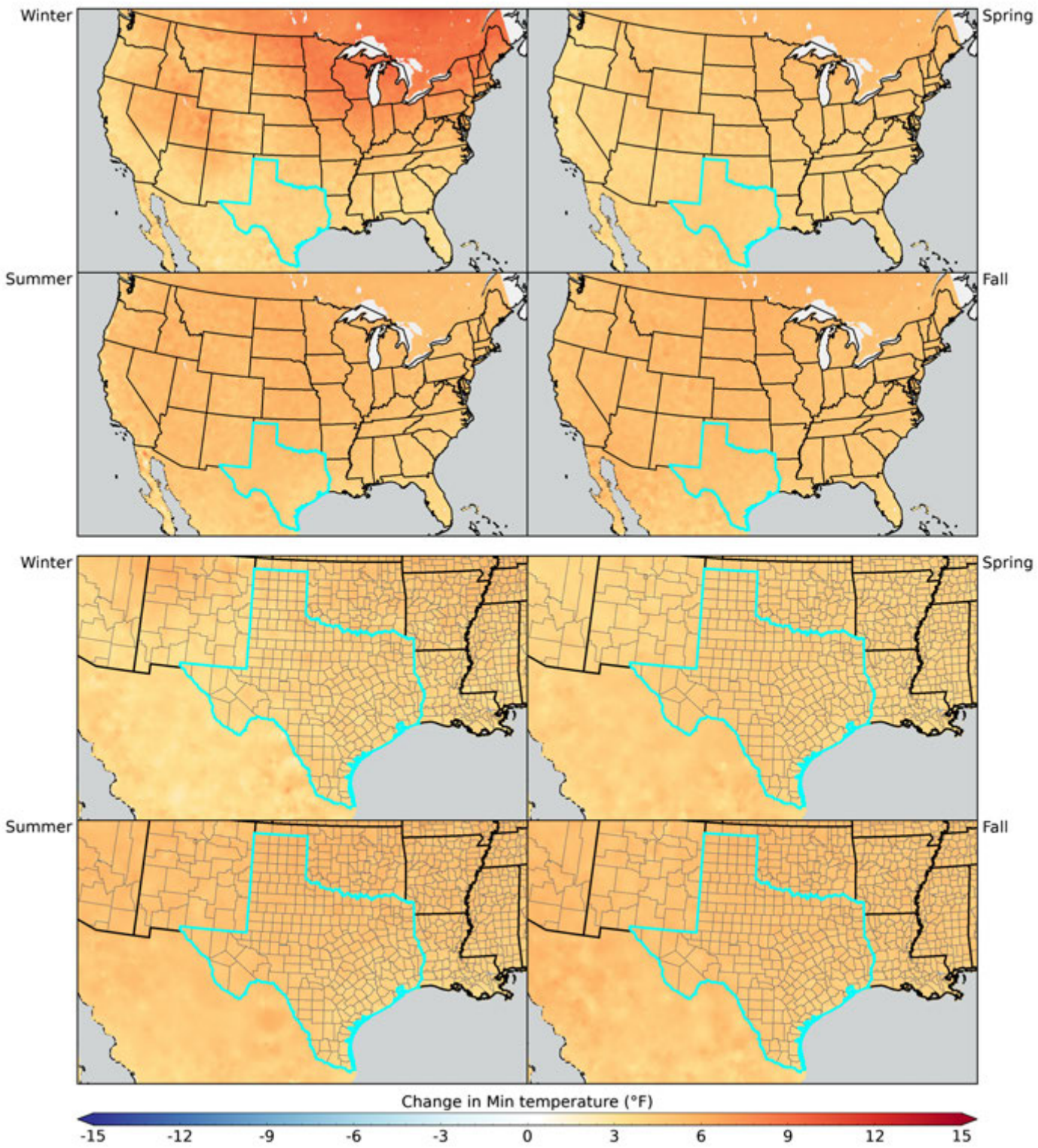

Figure 15: Seasonal maps of minimum temperature for ssp245 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

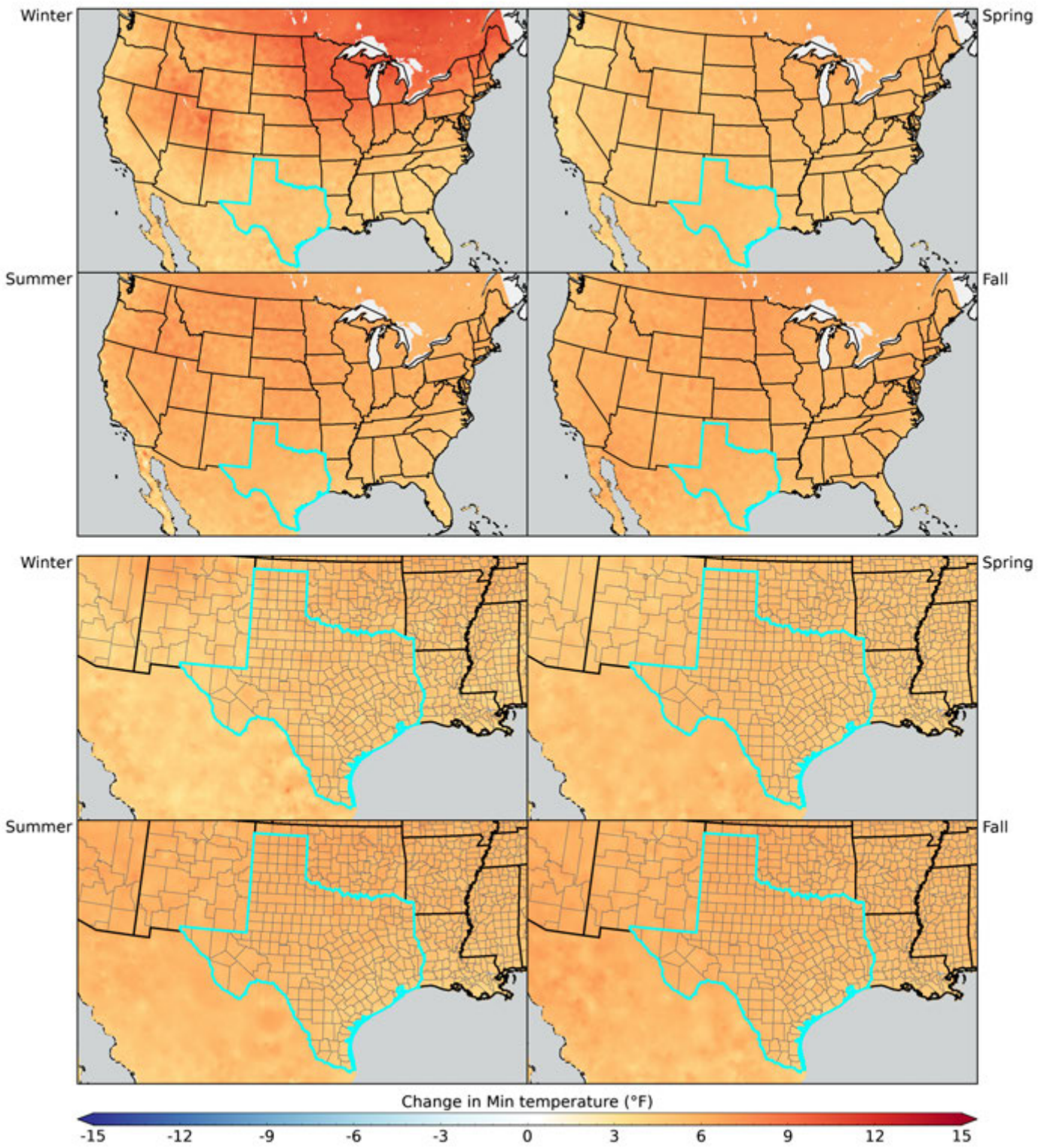

Figure 16: Seasonal maps of minimum temperature for ssp370 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

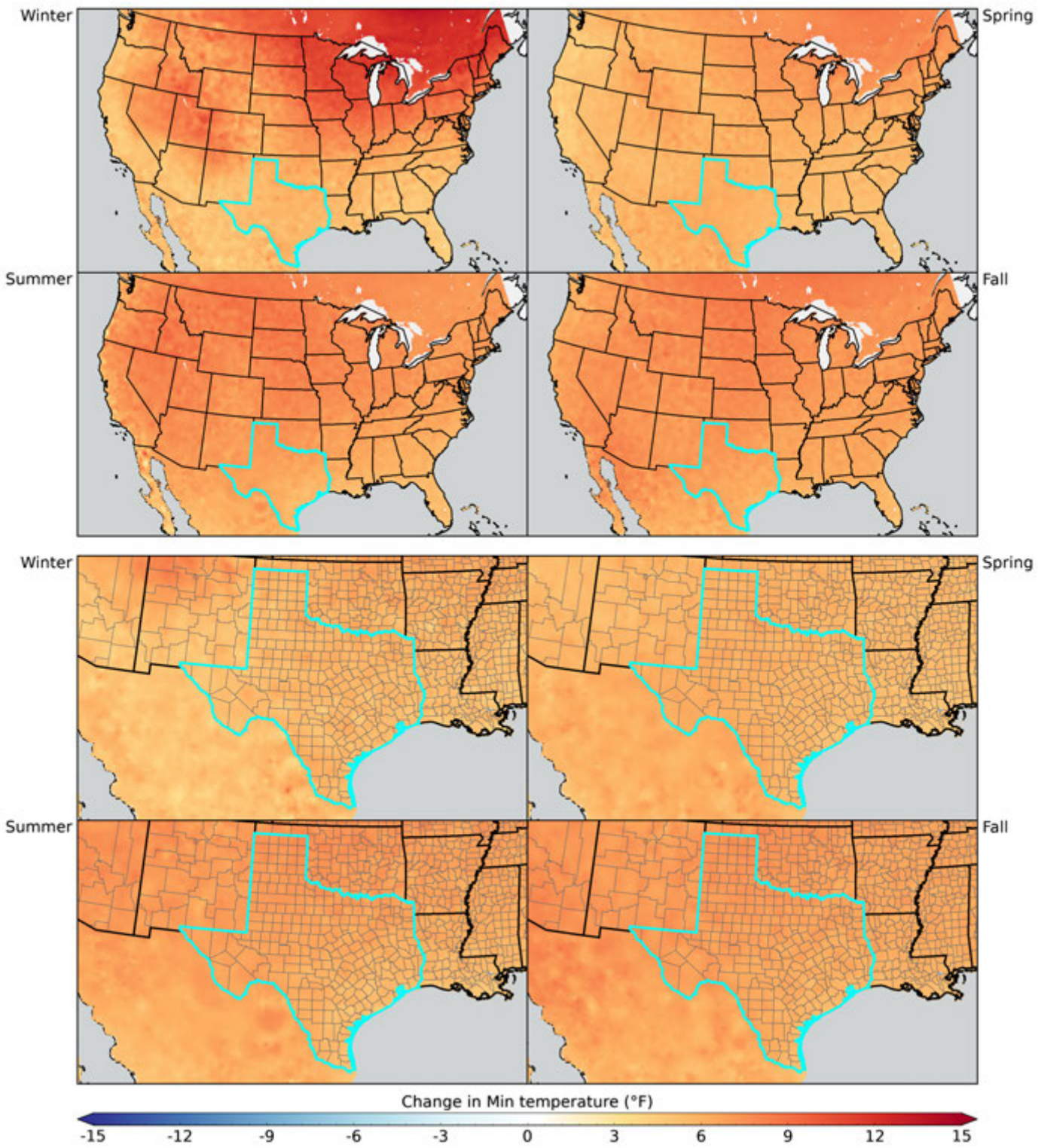

Figure 17: Seasonal maps of minimum temperature for ssp585 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

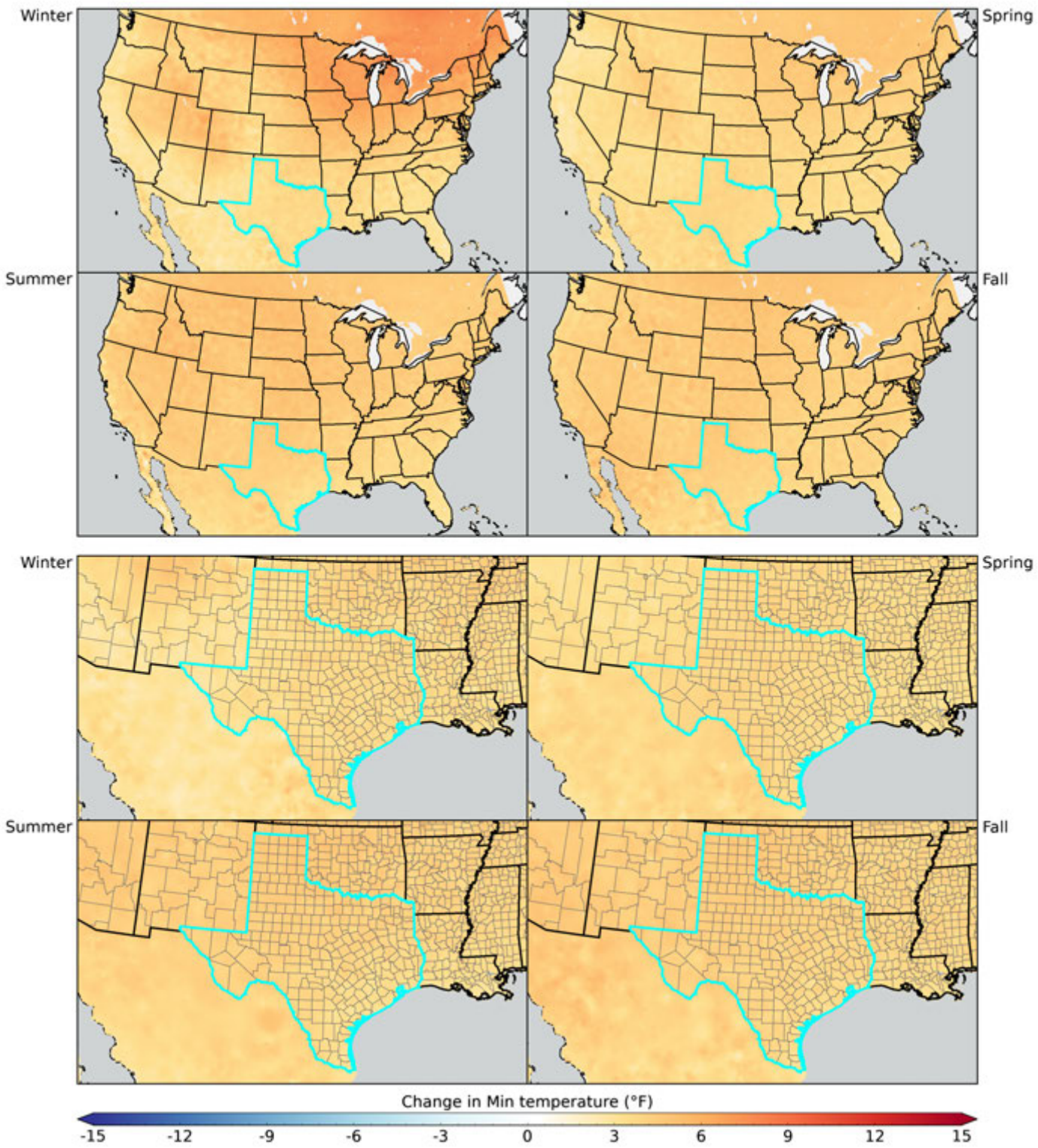

Figure 18: Seasonal maps of minimum temperature change for Global Warming Level $2°C$ (GWL2, relative to 1981-2010) for the ensemble mean. Global Warming Levels include all models and all scenarios (n=72 model simulations) and are referenced to the 20-year period when the global average temperature simulated by each climate model warms by $2°C$ above the 1850-1900 pre-industrial average.

5 Precipitation

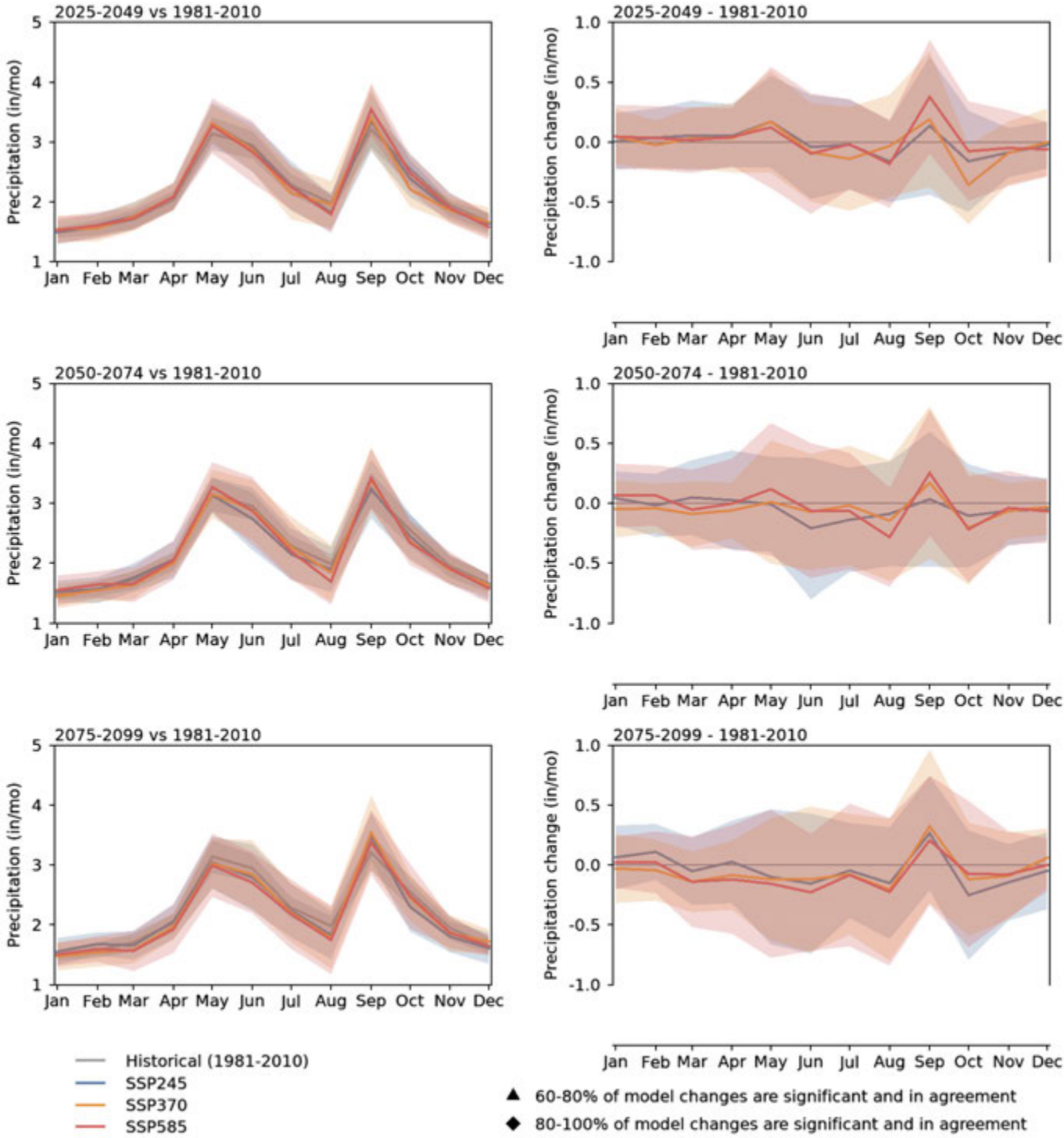

Figure 19: Monthly precipitation for the three future time periods for the ssp245, ssp370, ssp585 simulations. The median of all CMIP6 models is indicated by the solid lines and the 10th to 90th percentile range of the models is indicated by the respective shaded envelopes. Raw values relative to the historical simulation (1981-2010) are shown in the left column and future minus historical changes are shown in the right column. Triangle and diamond symbols indicate the percent of models that simulate future minus present changes that are of the same sign and statistically significant at a 95% confidence level based on a Mann-Whitney rank test.

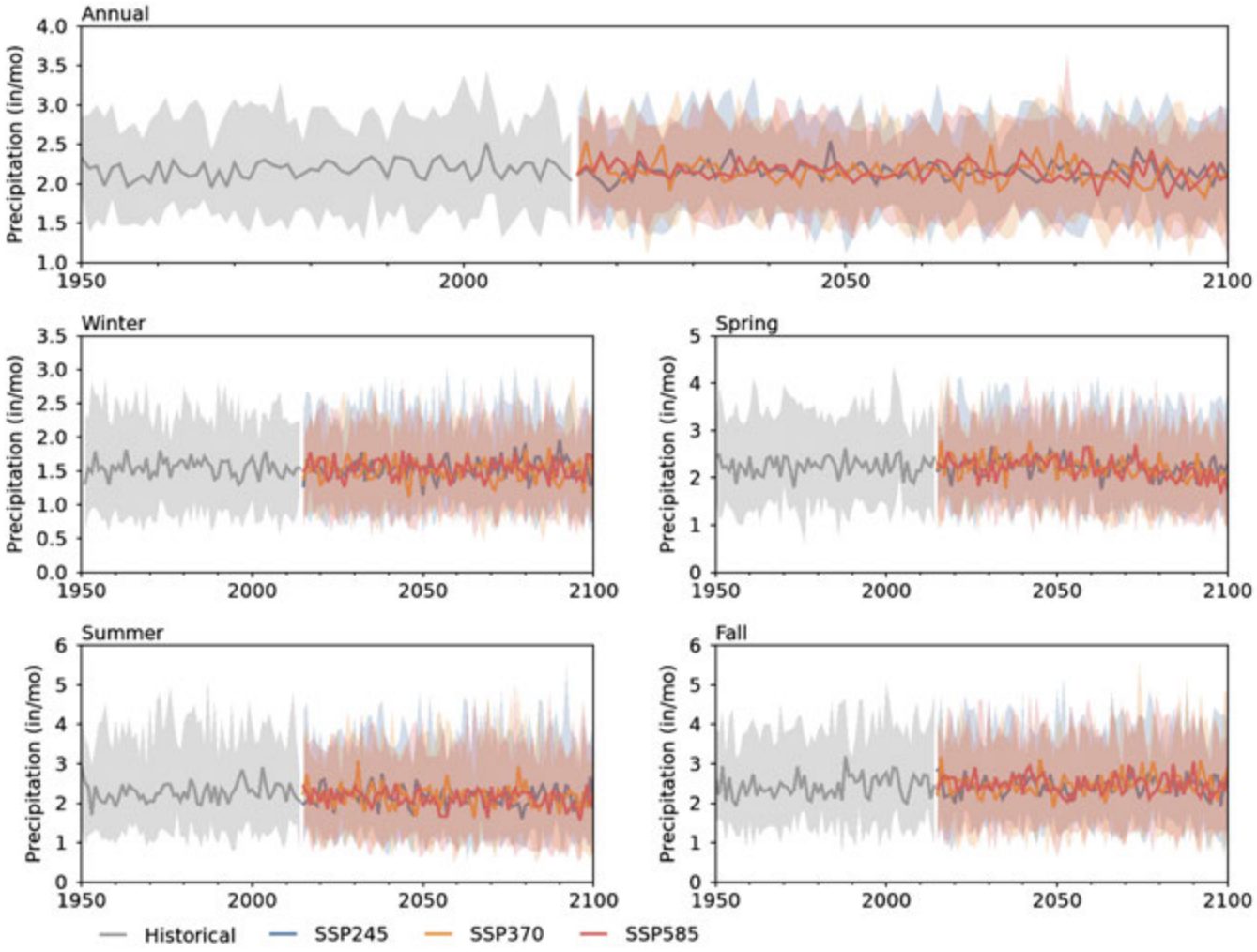

Figure 20: Annual and seasonal time series of precipitation for historical (gray), ssp245 (blue), ssp370 (orange), and ssp585 (red). The historical period ends in 2014 and the future periods begin in 2015. The median of CMIP6 models is indicated by the solid lines and the ensemble 10th to 90th percentile range of the model is indicated by the respective shaded envelopes.

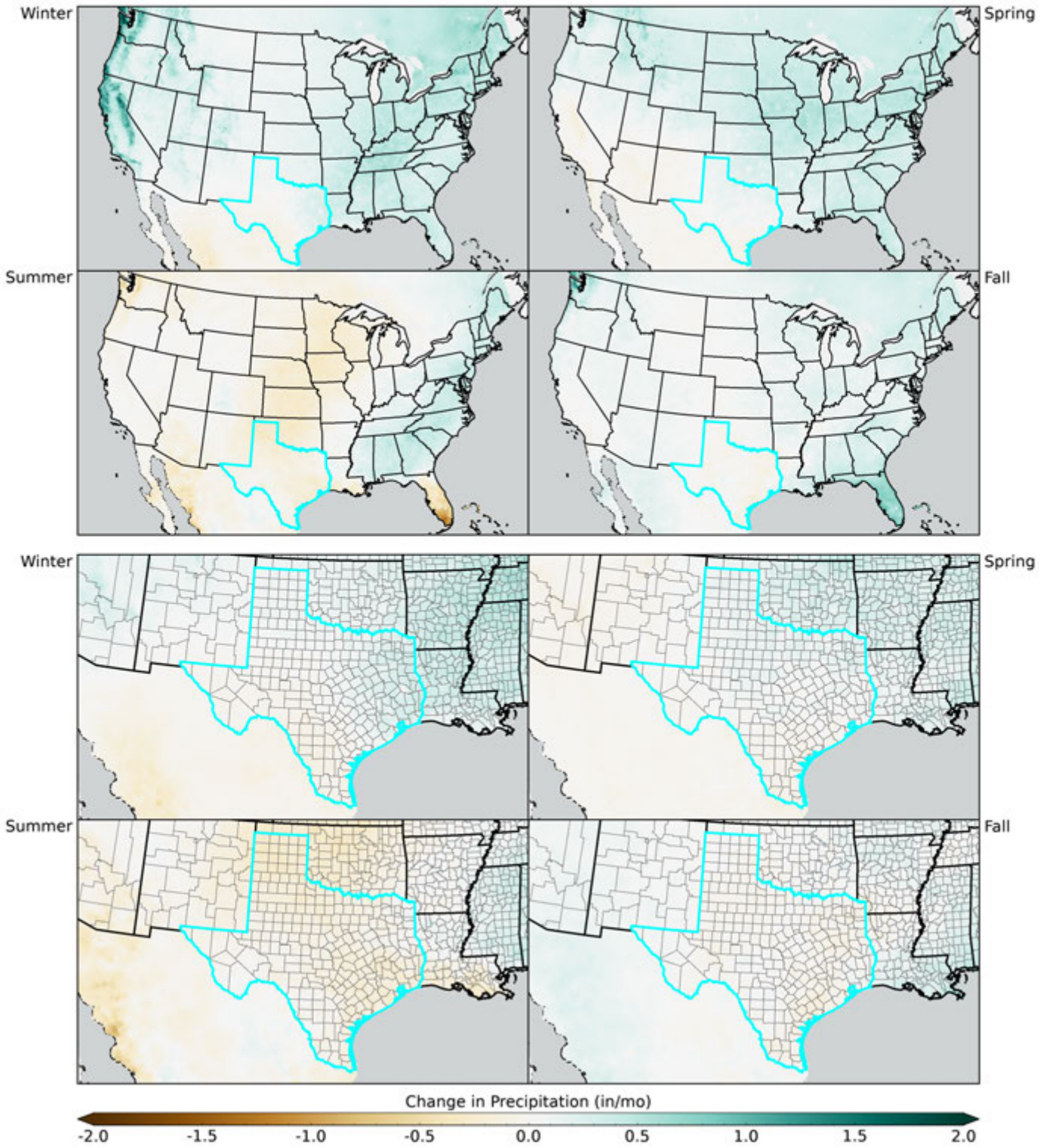

Figure 21: Seasonal maps of precipitation for ssp245 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

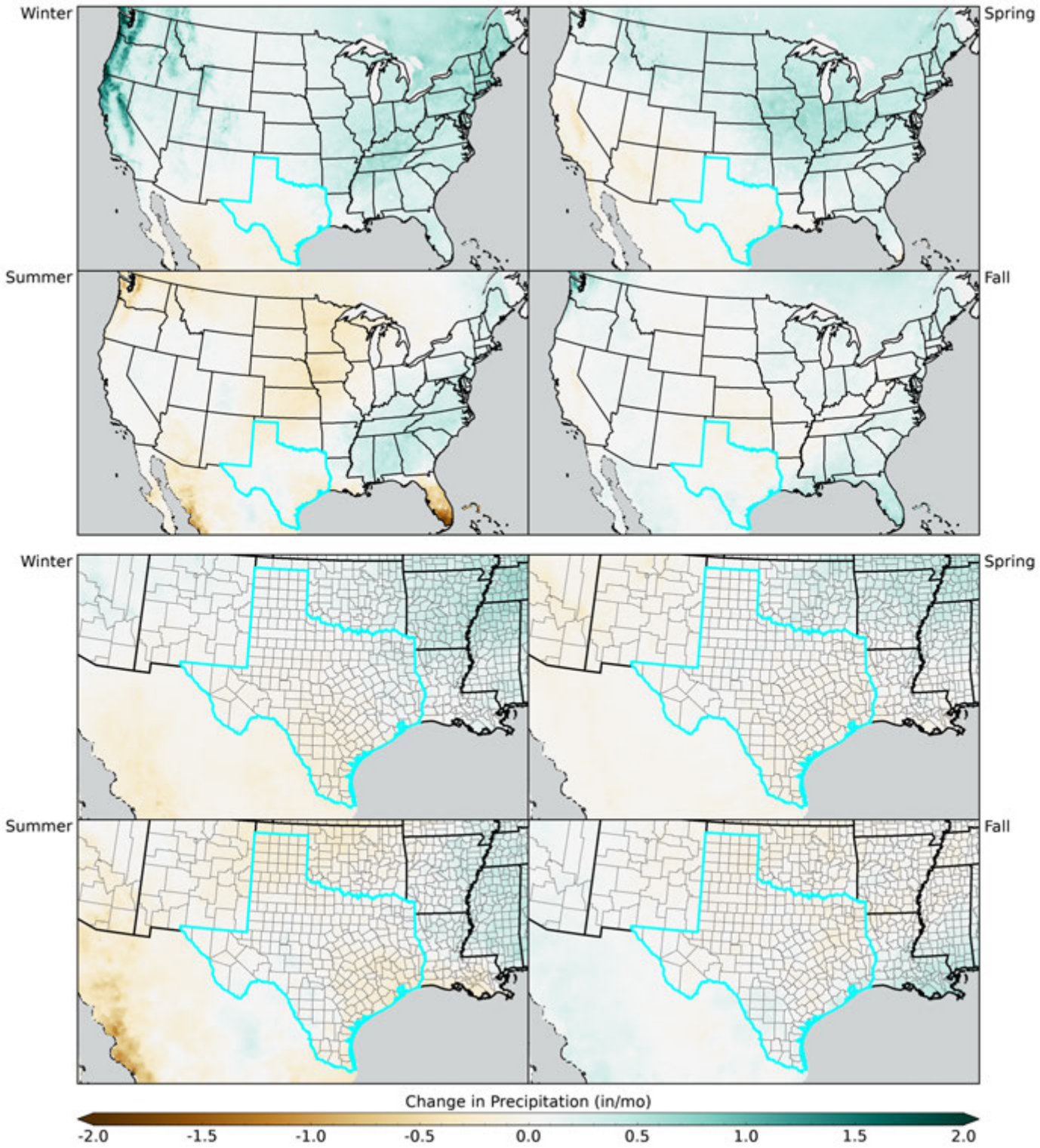

Figure 22: Seasonal maps of precipitation for ssp370 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

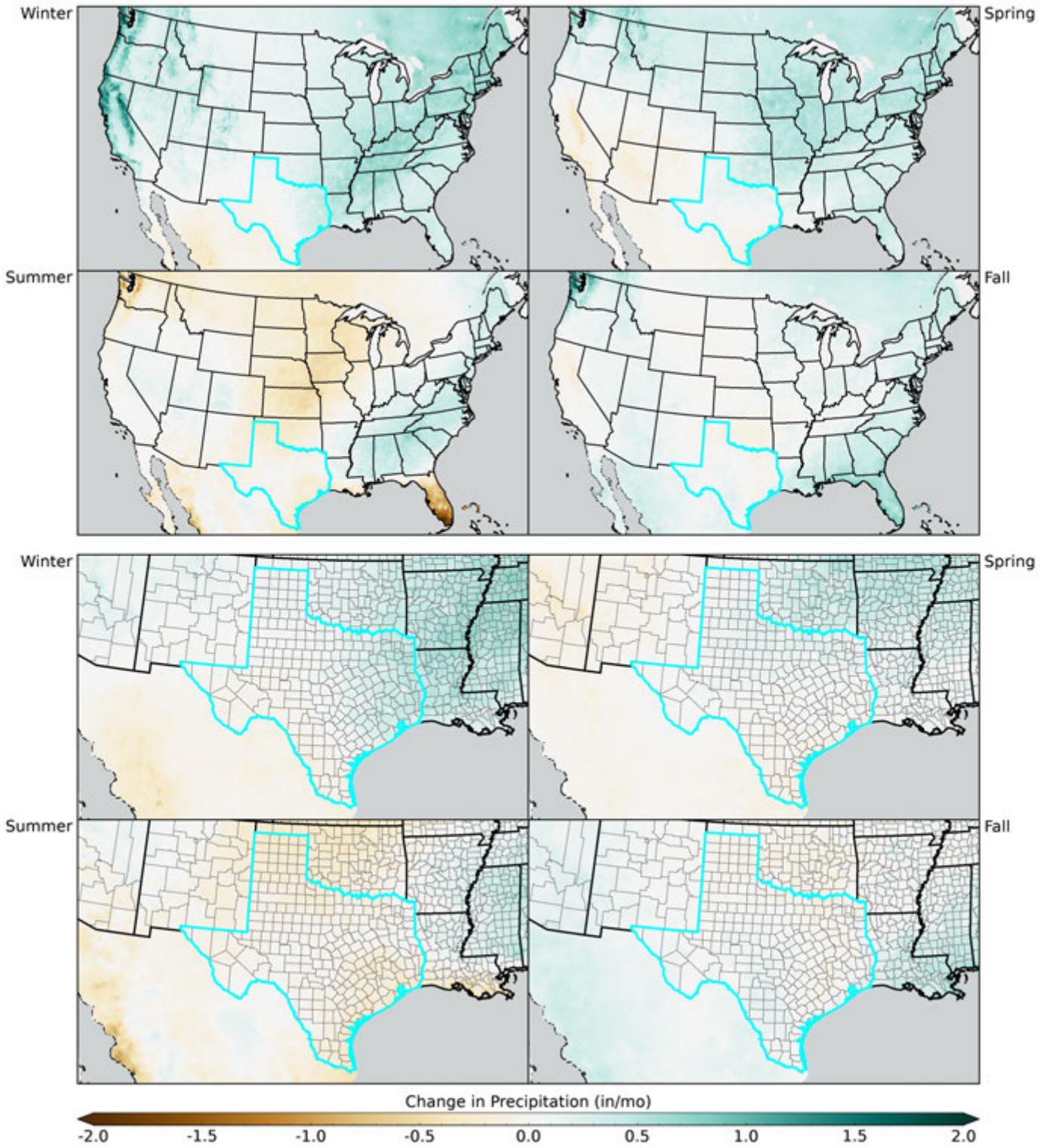

Figure 23: Seasonal maps of precipitation for ssp585 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

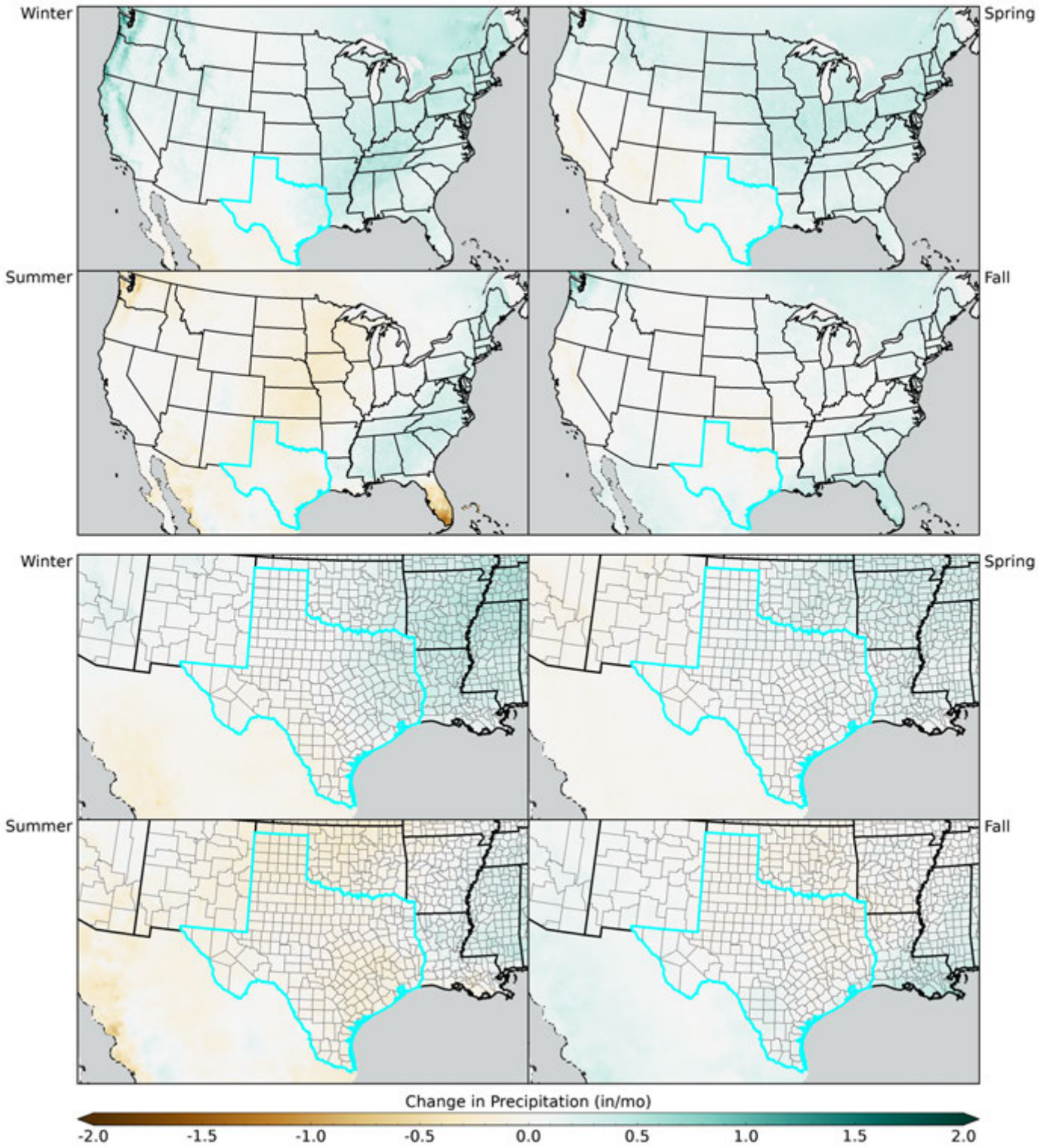

Figure 24: Seasonal maps of precipitation change for Global Warming Level $2°C$ (GWL2, relative to 1981-2010) for the ensemble mean. Global Warming Levels include all models and all scenarios (n=72 model simulations) and are referenced to the 20-year period when the global average temperature simulated by each climate model warms by $2°C$ above the 1850-1900 pre-industrial average.

6 Snow

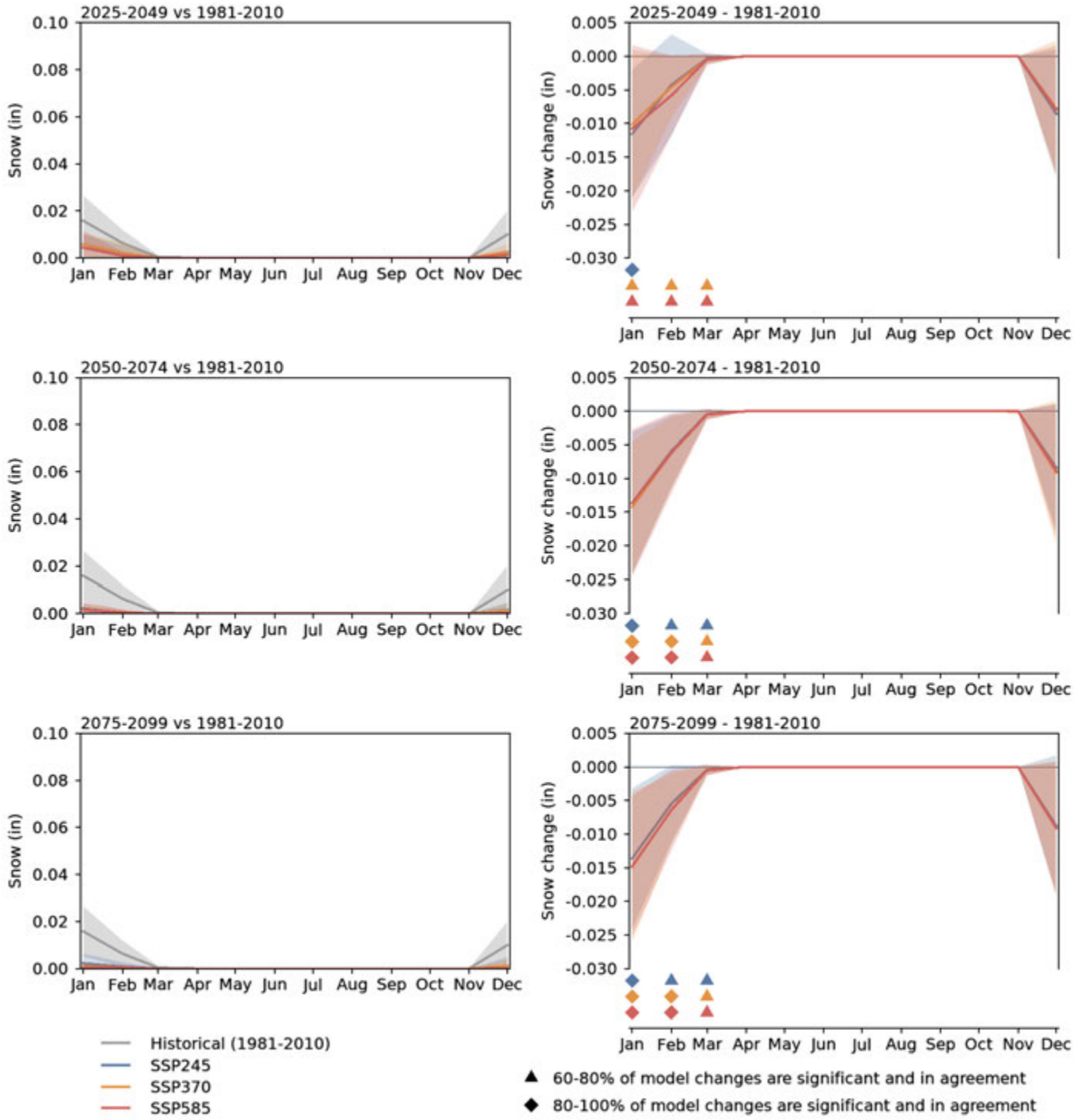

Figure 25: Monthly snow for the three future time periods for the ssp245, ssp370, ssp585 simulations. The median of all CMIP6 models is indicated by the solid lines and the 10th to 90th percentile range of the models is indicated by the respective shaded envelopes. Raw values relative to the historical simulation (1981-2010) are shown in the left column and future minus historical changes are shown in the right column. Triangle and diamond symbols indicate the percent of models that simulate future minus present changes that are of the same sign and statistically significant at a 95% confidence level based on a Mann-Whitney rank test.

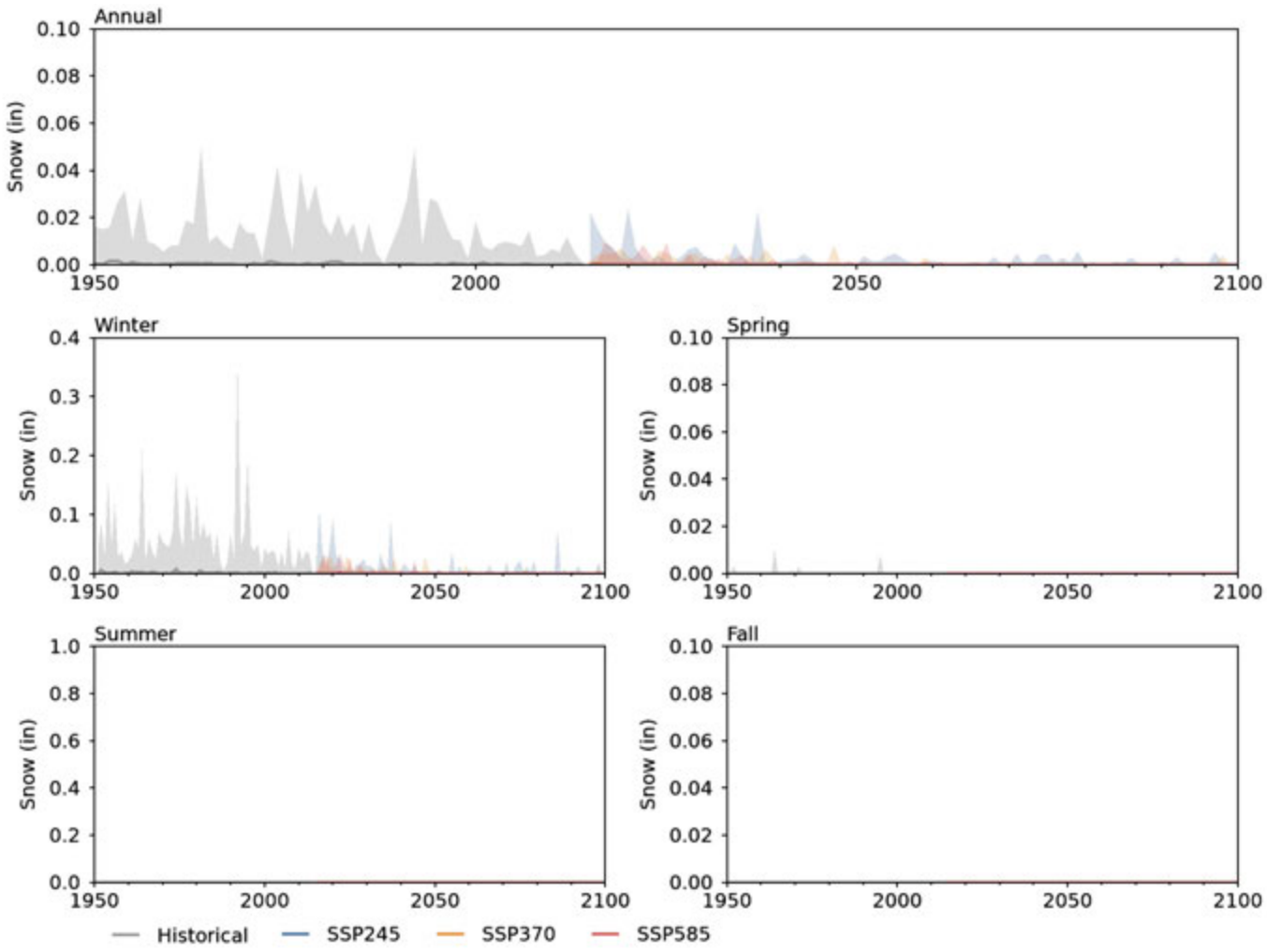

Figure 26: Annual and seasonal time series of snow for historical (gray), ssp245 (blue), ssp370 (orange), and ssp585 (red). The historical period ends in 2014 and the future periods begin in 2015. The median of CMIP6 models is indicated by the solid lines and the ensemble 10th to 90th percentile range of the model is indicated by the respective shaded envelopes.

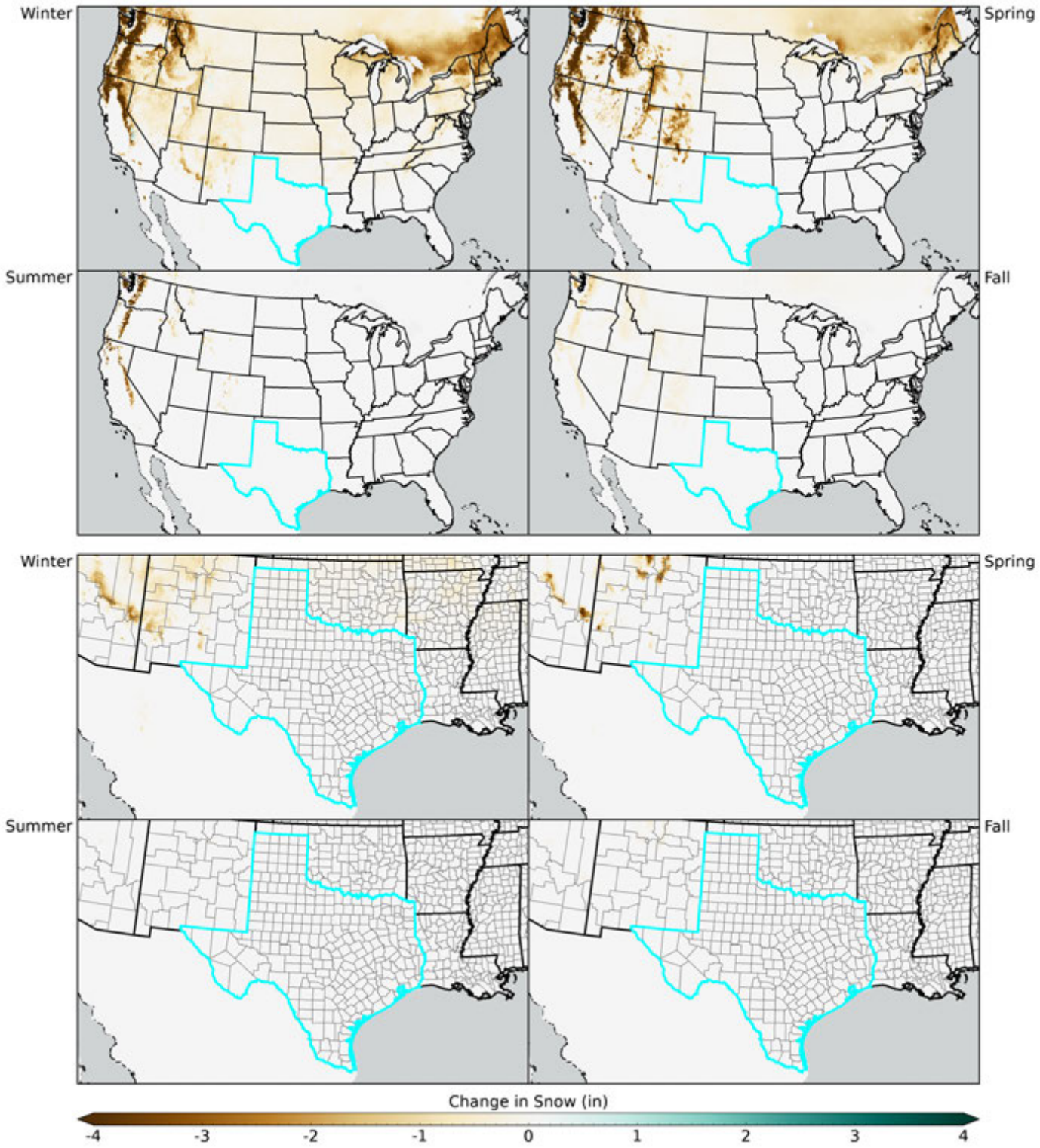

Figure 27: Seasonal maps of snow for ssp245 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

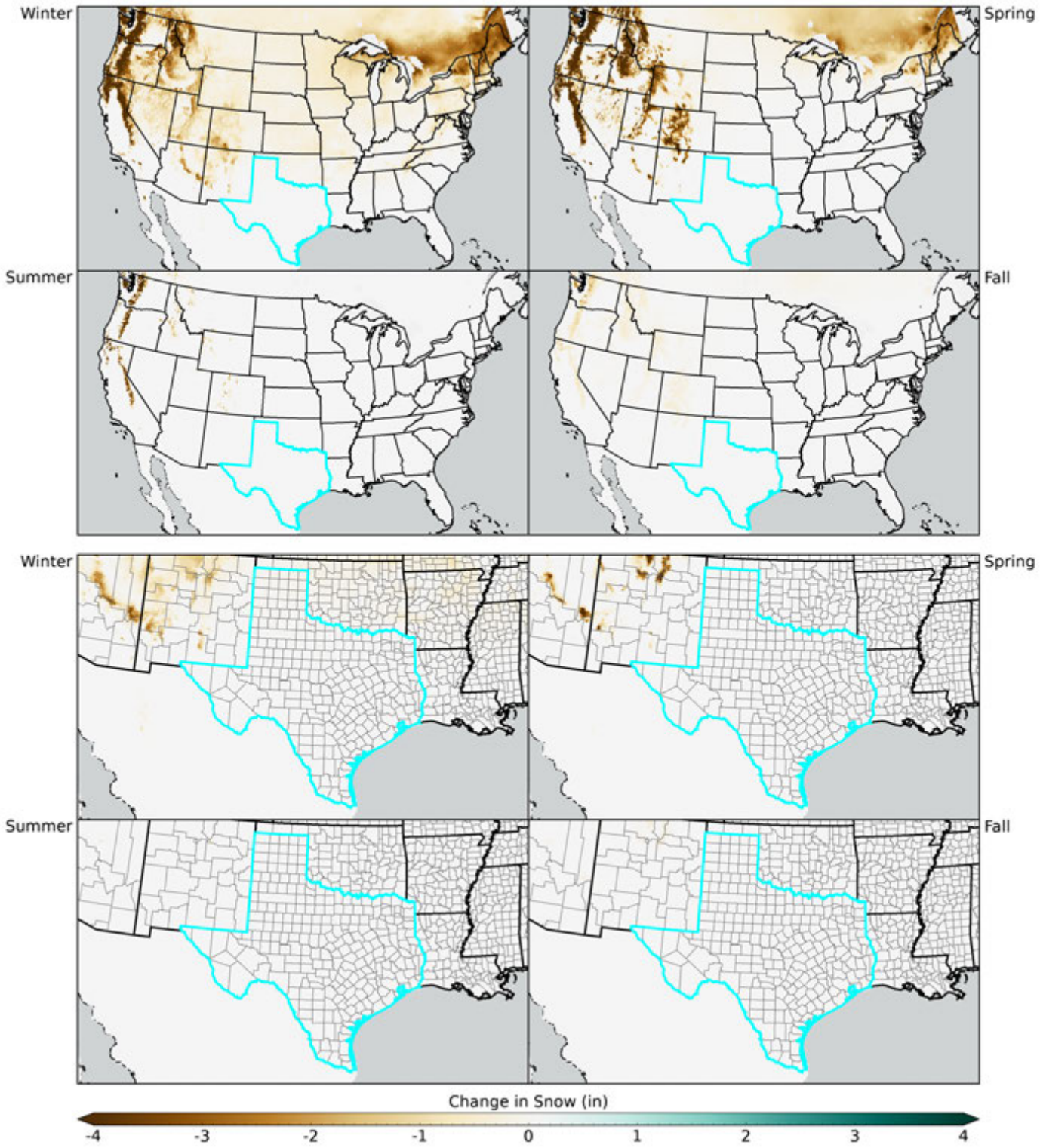

Figure 28: Seasonal maps of snow for ssp370 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

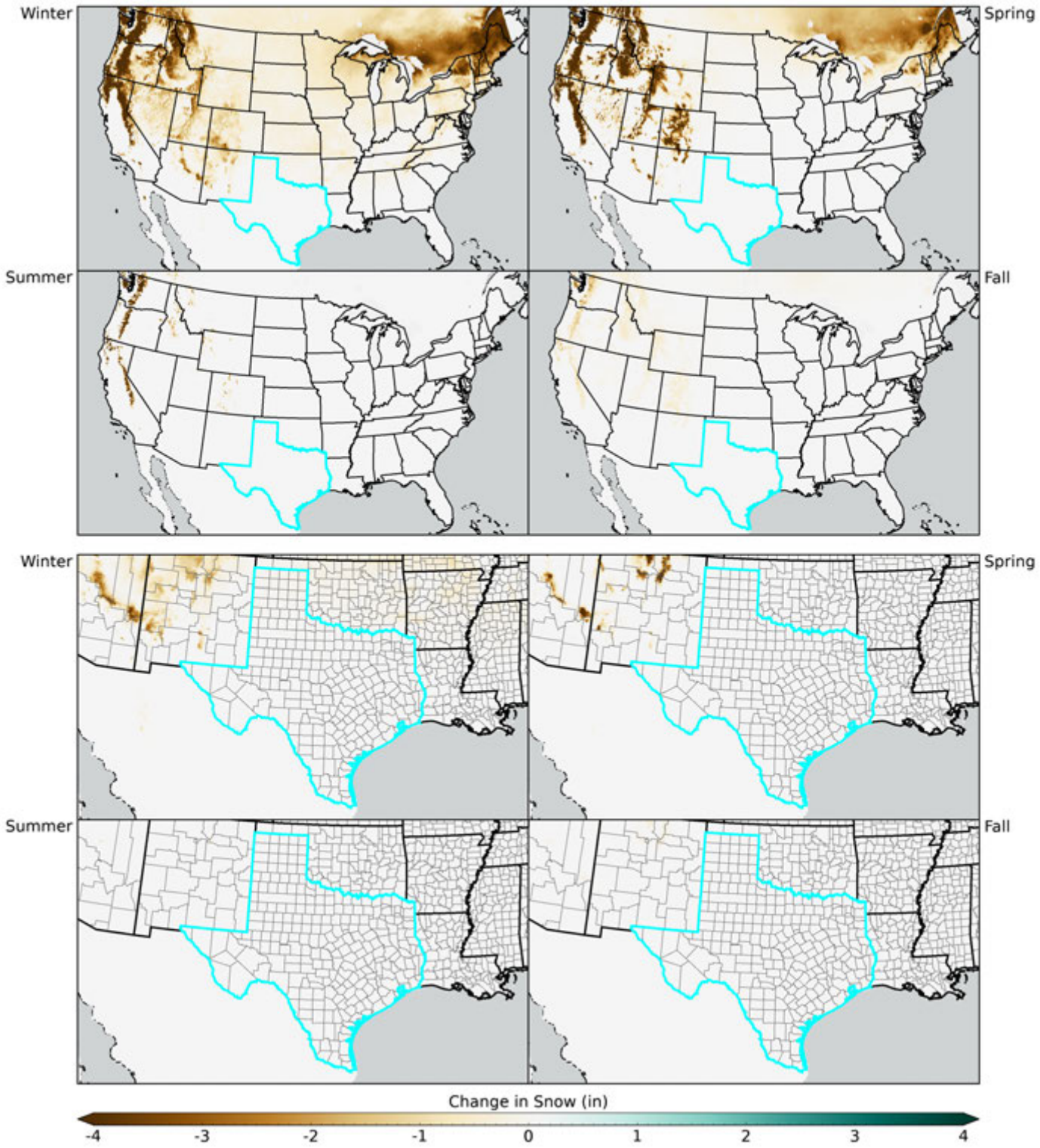

Figure 29: Seasonal maps of snow for ssp585 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

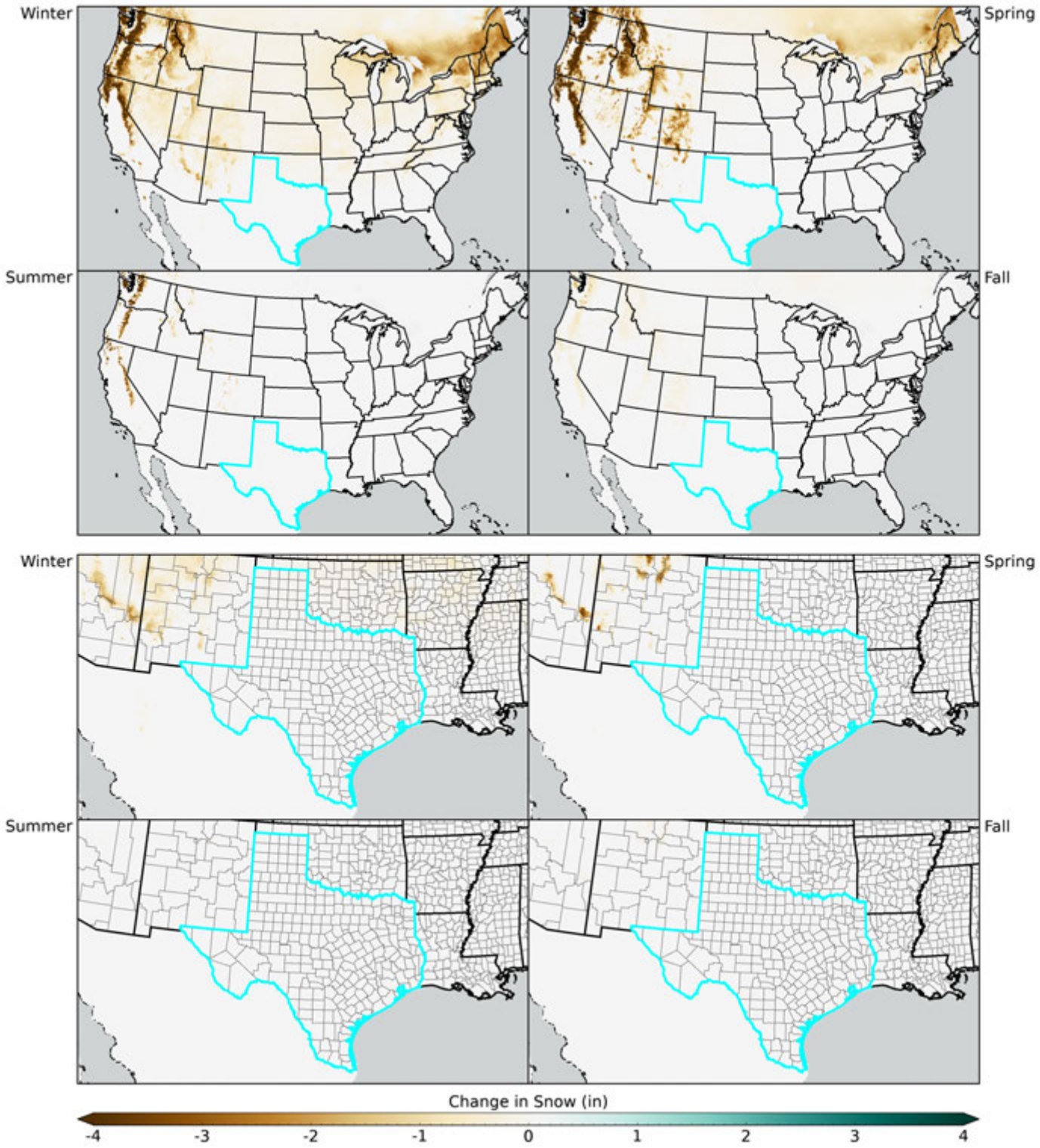

Figure 30: Seasonal maps of snow change for Global Warming Level $2°C$ (GWL2, relative to 1981-2010) for the ensemble mean. Global Warming Levels include all models and all scenarios (n=72 model simulations) and are referenced to the 20-year period when the global average temperature simulated by each climate model warms by $2°C$ above the 1850-1900 pre-industrial average.

7 Runoff

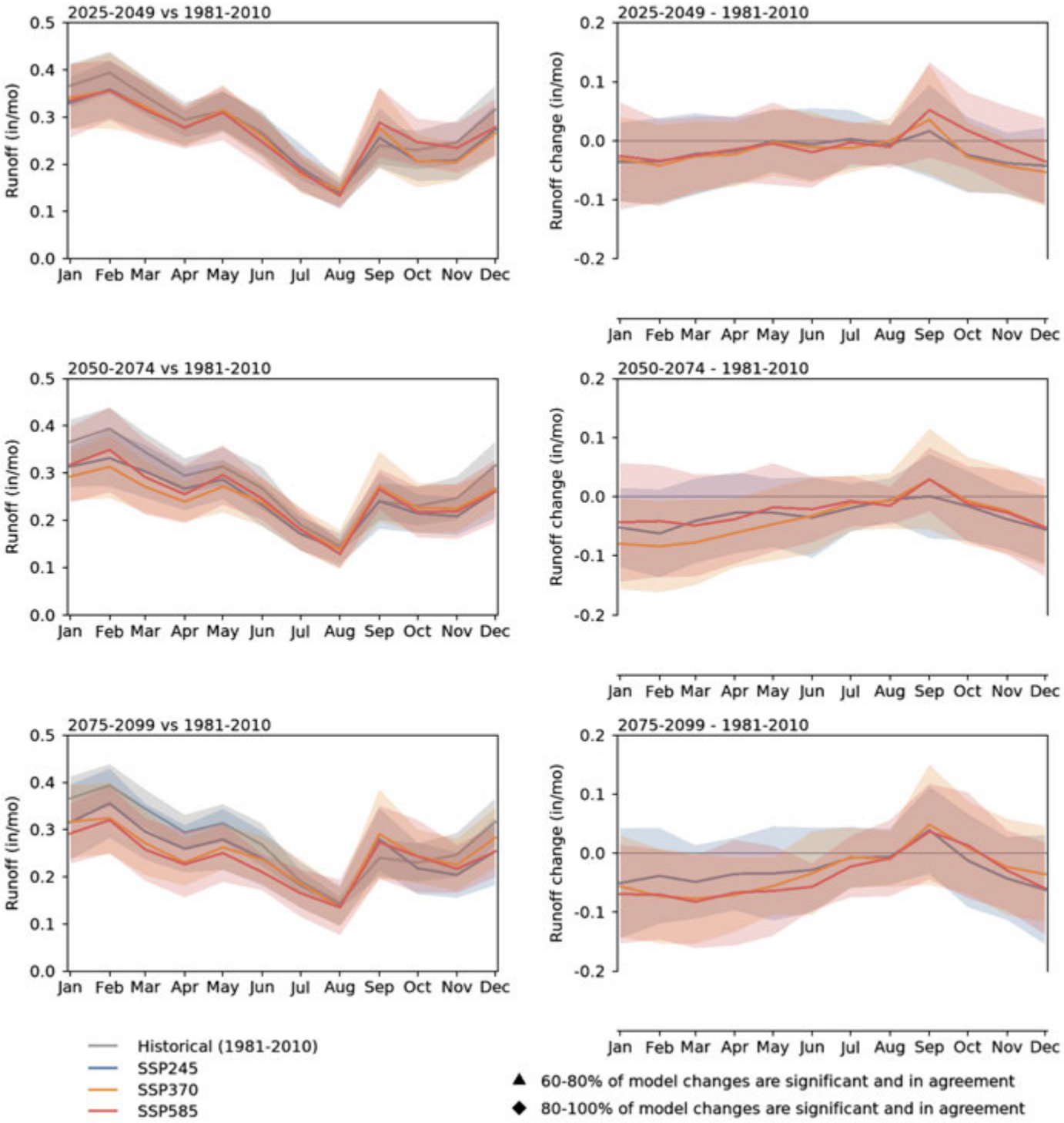

Figure 31: Monthly runoff for the three future time periods for the ssp245, ssp370, ssp585 simulations. The median of all CMIP6 models is indicated by the solid lines and the 10th to 90th percentile range of the models is indicated by the respective shaded envelopes. Raw values relative to the historical simulation (1981-2010) are shown in the left column and future minus historical changes are shown in the right column. Triangle and diamond symbols indicate the percent of models that simulate future minus present changes that are of the same sign and statistically significant at a 95% confidence level based on a Mann-Whitney rank test.

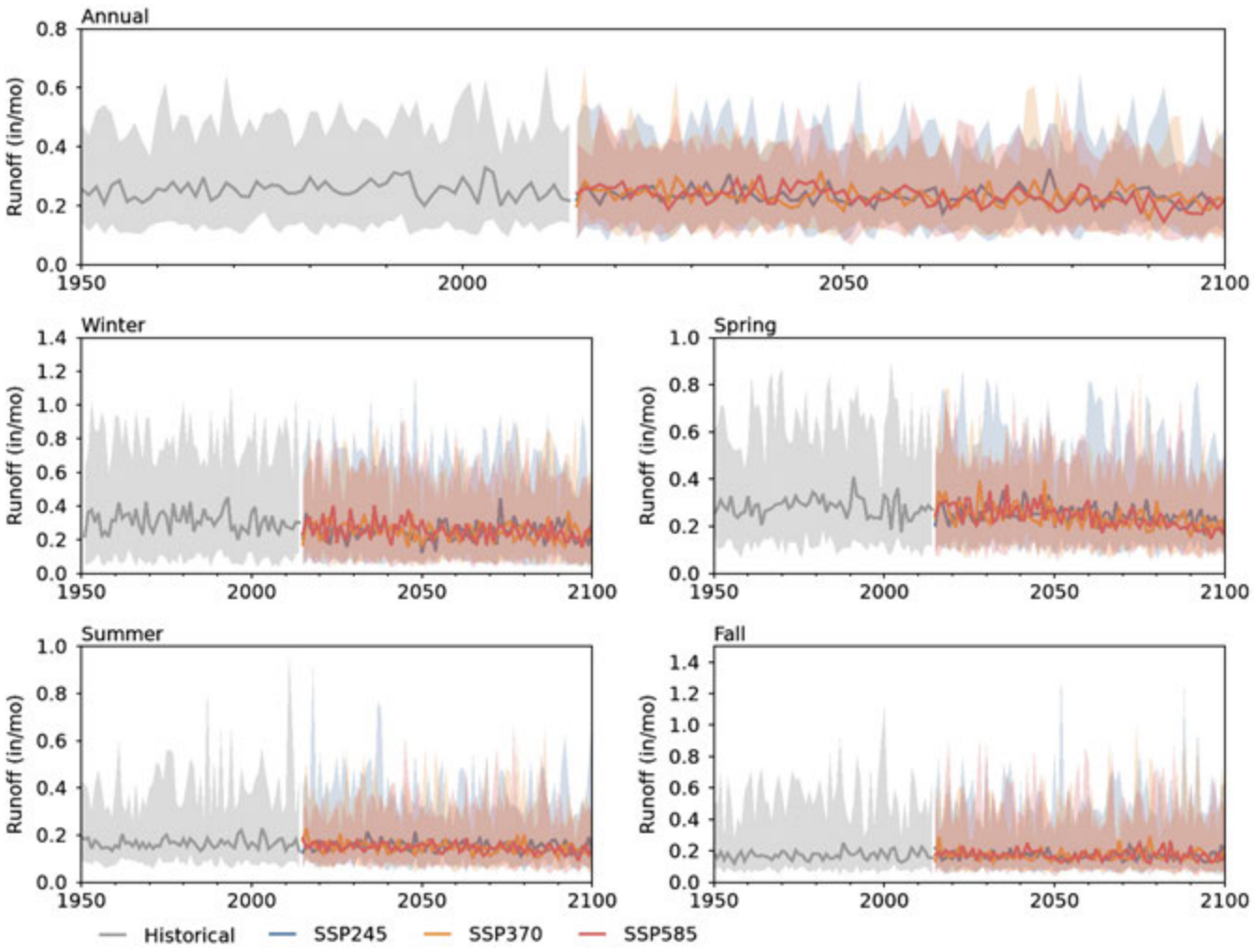

Figure 32: Annual and seasonal time series of runoff for historical (gray), ssp245 (blue), ssp370 (orange), and ssp585 (red). The historical period ends in 2014 and the future periods begin in 2015. The median of CMIP6 models is indicated by the solid lines and the ensemble 10th to 90th percentile range of the model is indicated by the respective shaded envelopes.

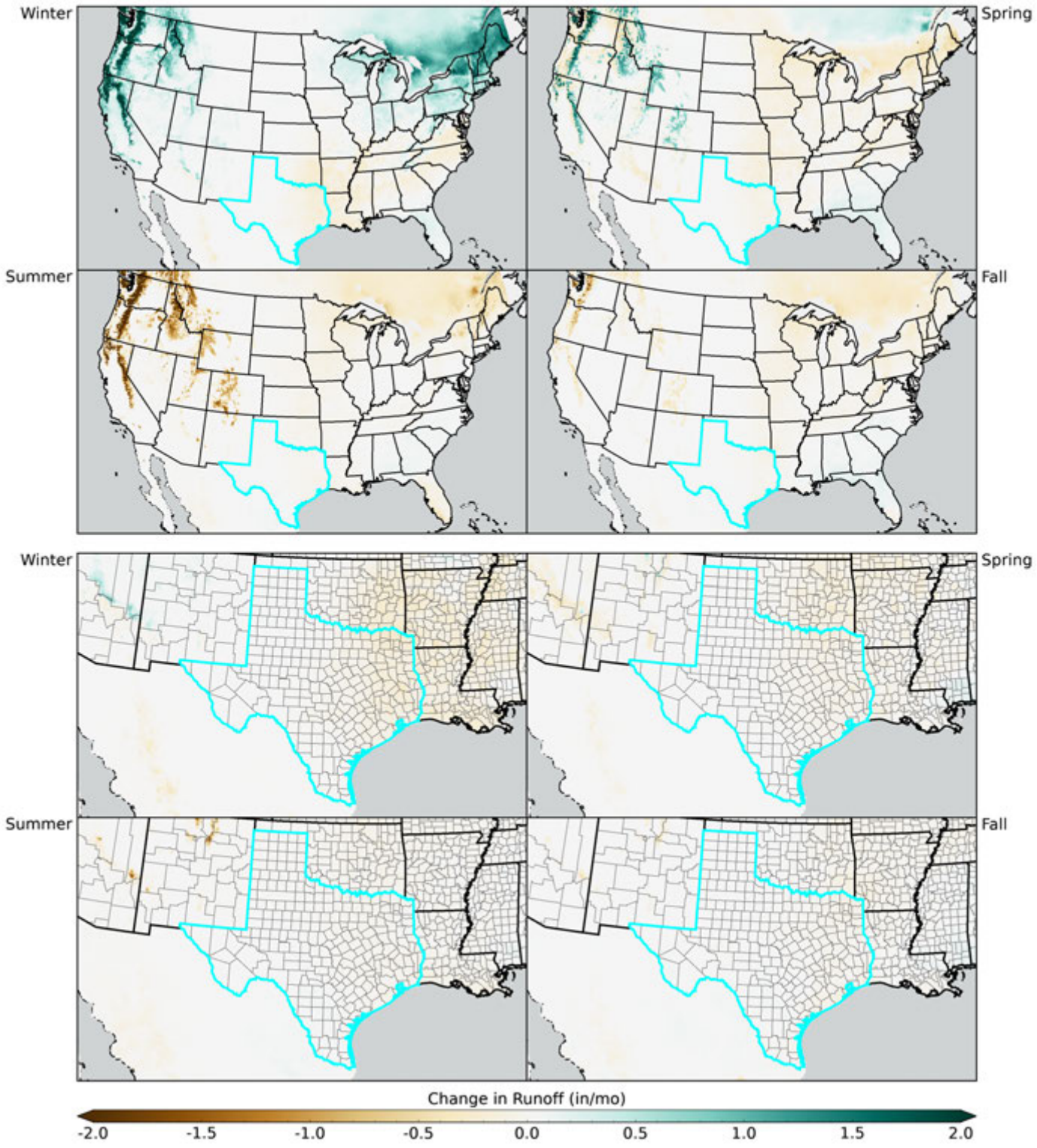

Figure 33: Seasonal maps of runoff for ssp245 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

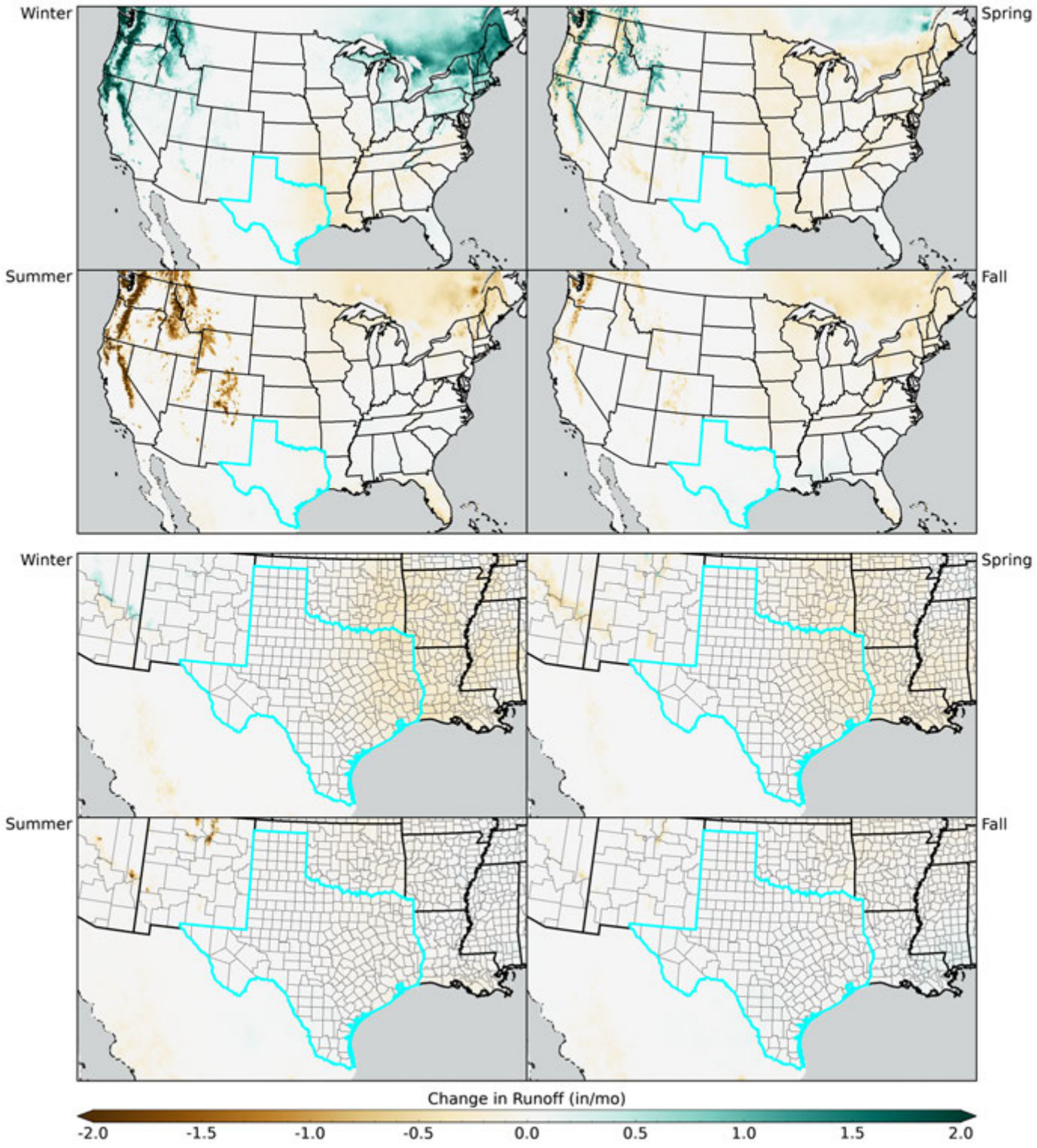

Figure 34: Seasonal maps of runoff for ssp370 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

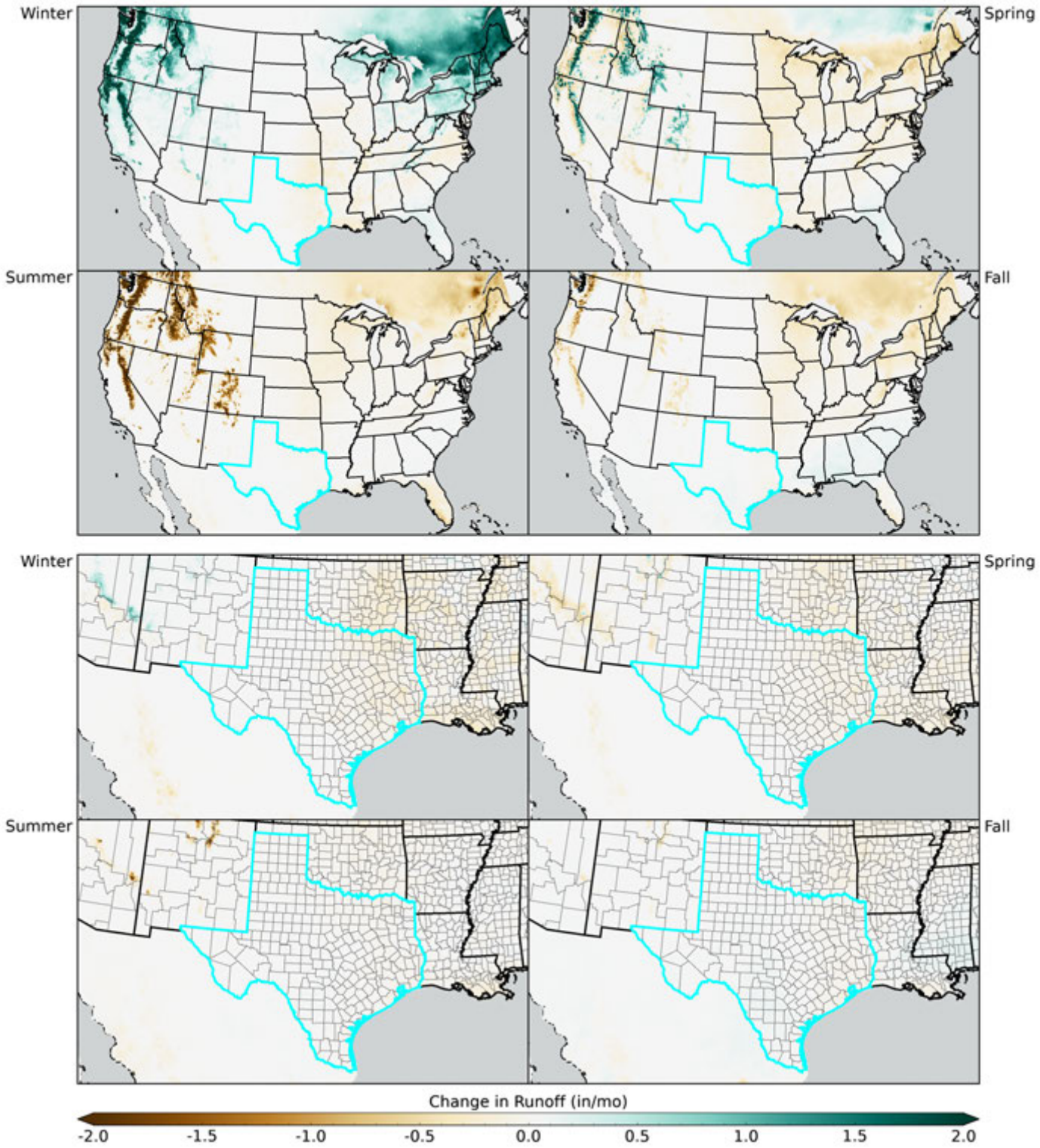

Figure 35: Seasonal maps of runoff for ssp585 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

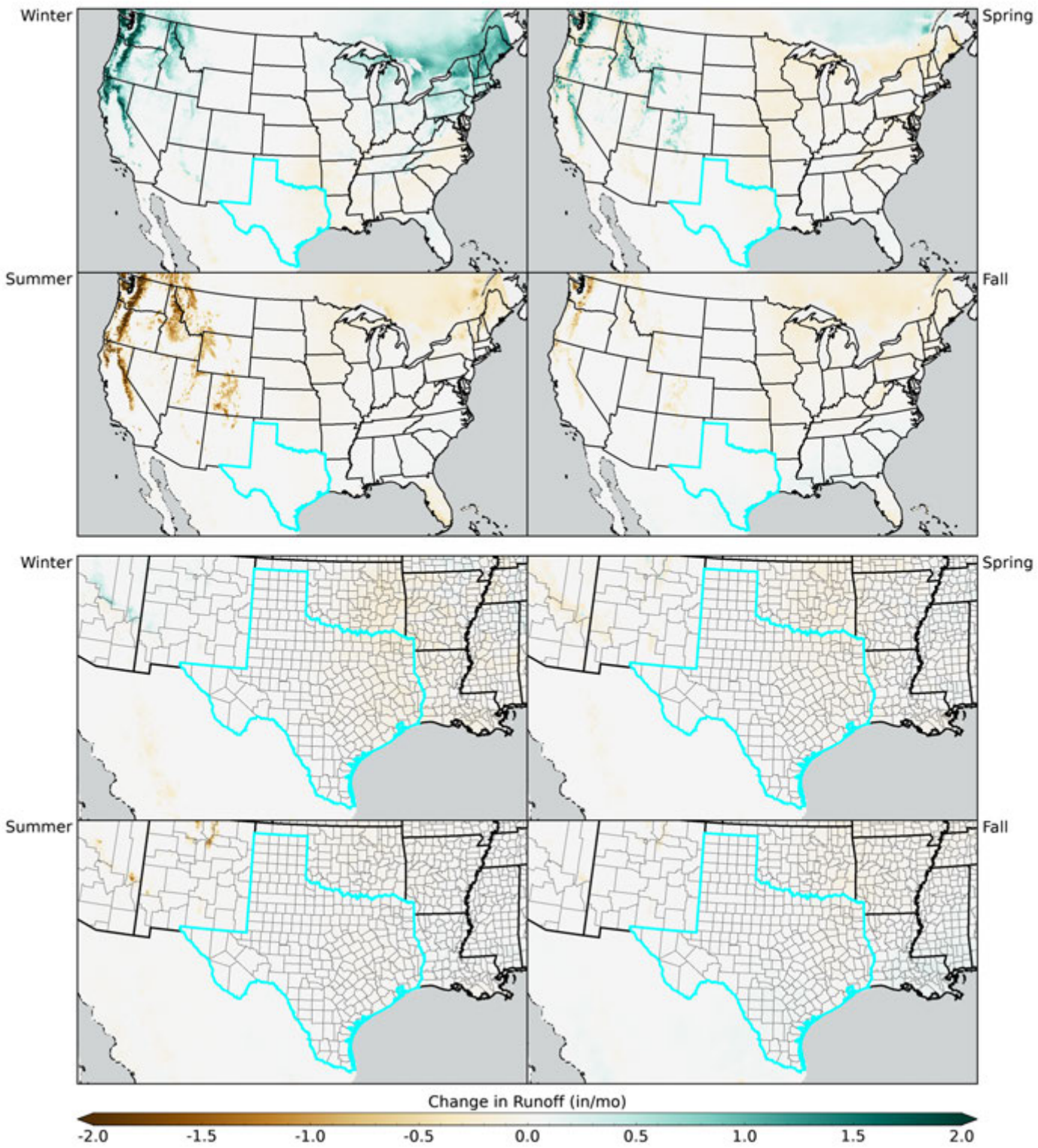

Figure 36: Seasonal maps of runoff change for Global Warming Level $2°C$ (GWL2, relative to 1981-2010) for the ensemble mean. Global Warming Levels include all models and all scenarios (n=72 model simulations) and are referenced to the 20-year period when the global average temperature simulated by each climate model warms by $2°C$ above the 1850-1900 pre-industrial average.

8 Soil Storage

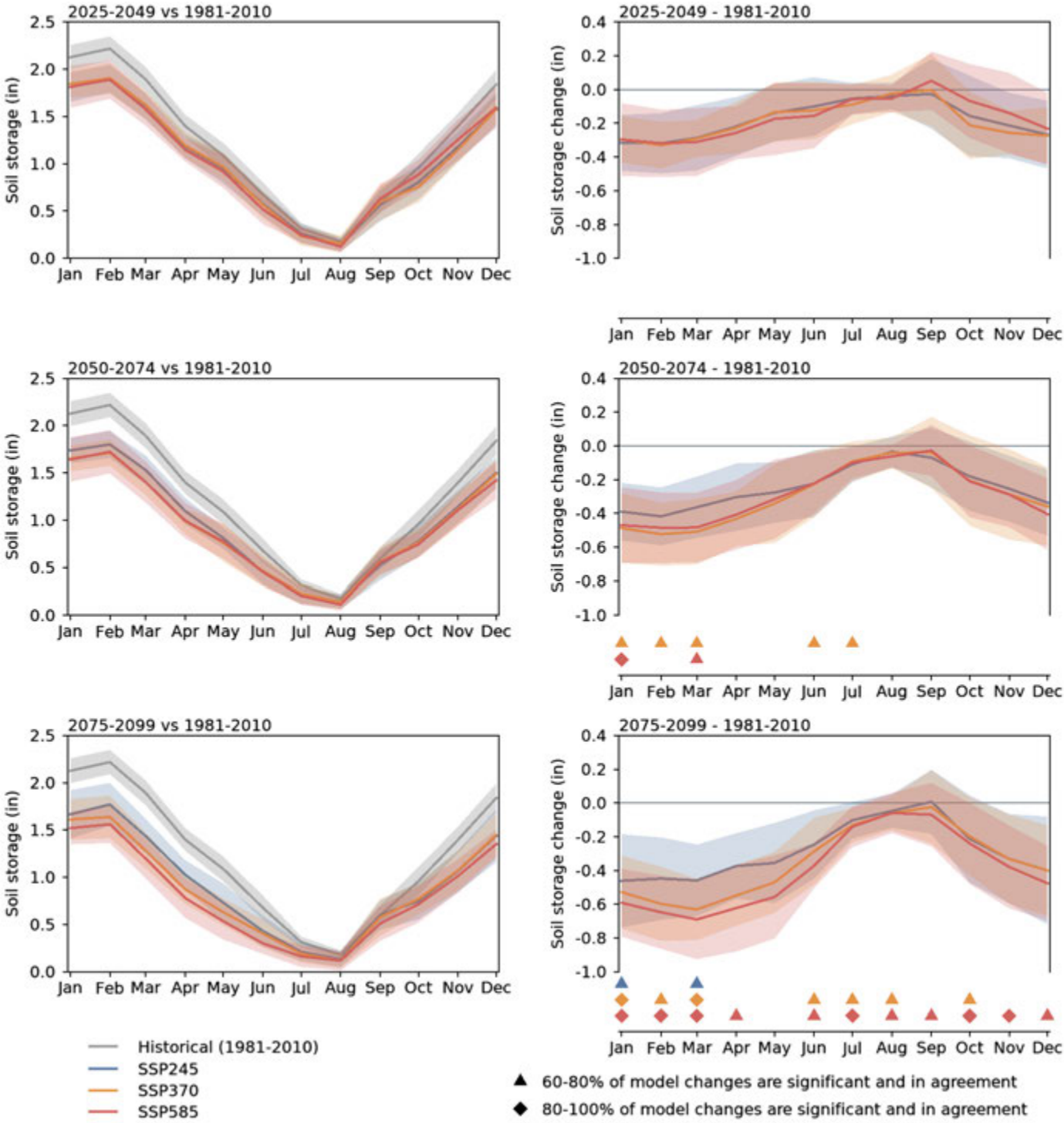

Figure 37: Monthly soil storage for the three future time periods for the ssp245, ssp370, ssp585 simulations. The median of all CMIP6 models is indicated by the solid lines and the 10th to 90th percentile range of the models is indicated by the respective shaded envelopes. Raw values relative to the historical simulation (1981-2010) are shown in the left column and future minus historical changes are shown in the right column. Triangle and diamond symbols indicate the percent of models that simulate future minus present changes that are of the same sign and statistically significant at a 95% confidence level based on a Mann-Whitney rank test.

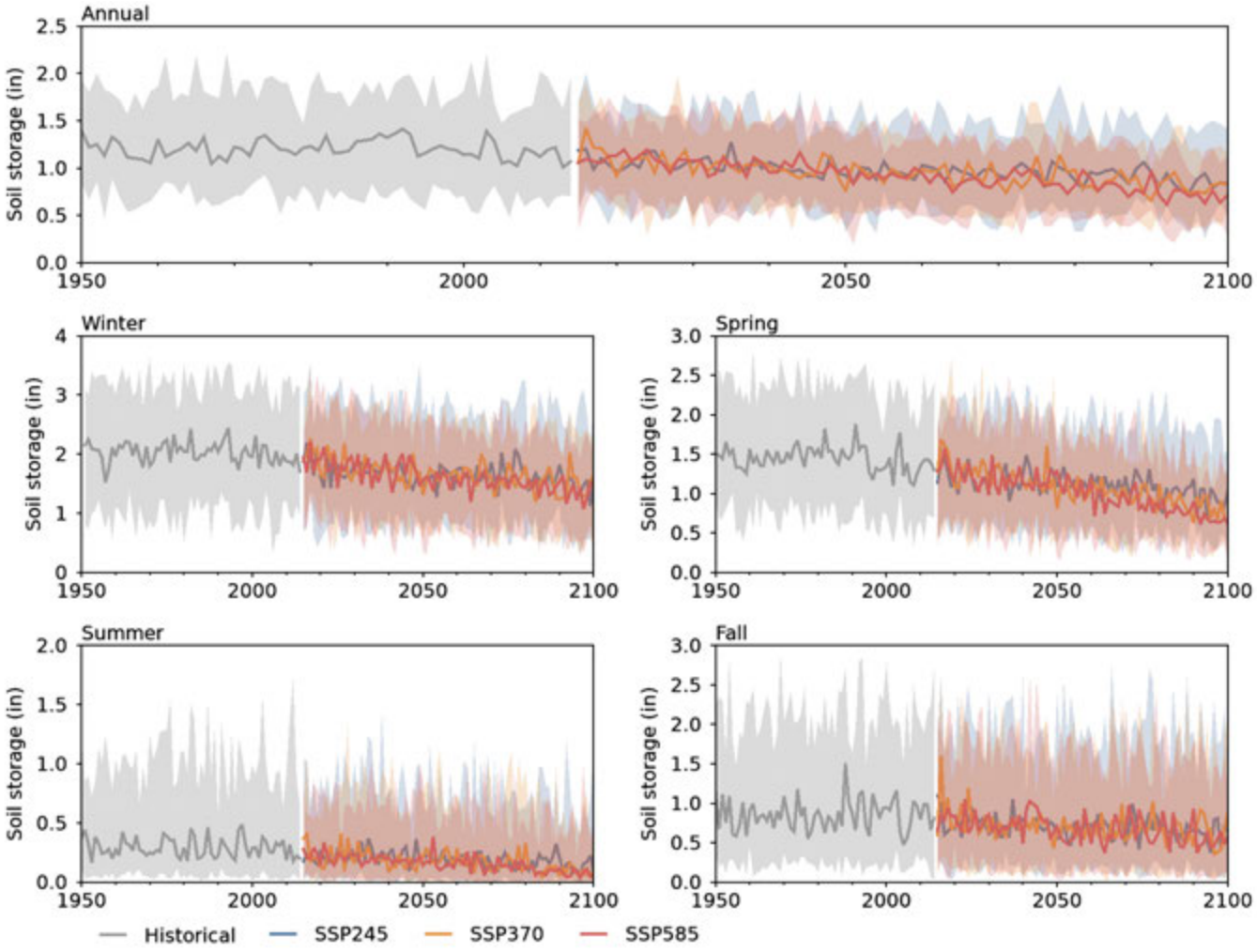

Figure 38: Annual and seasonal time series of soil storage for historical (gray), ssp245 (blue), ssp370 (orange), and ssp585 (red). The historical period ends in 2014 and the future periods begin in 2015. The median of CMIP6 models is indicated by the solid lines and the ensemble 10th to 90th percentile range of the model is indicated by the respective shaded envelopes.

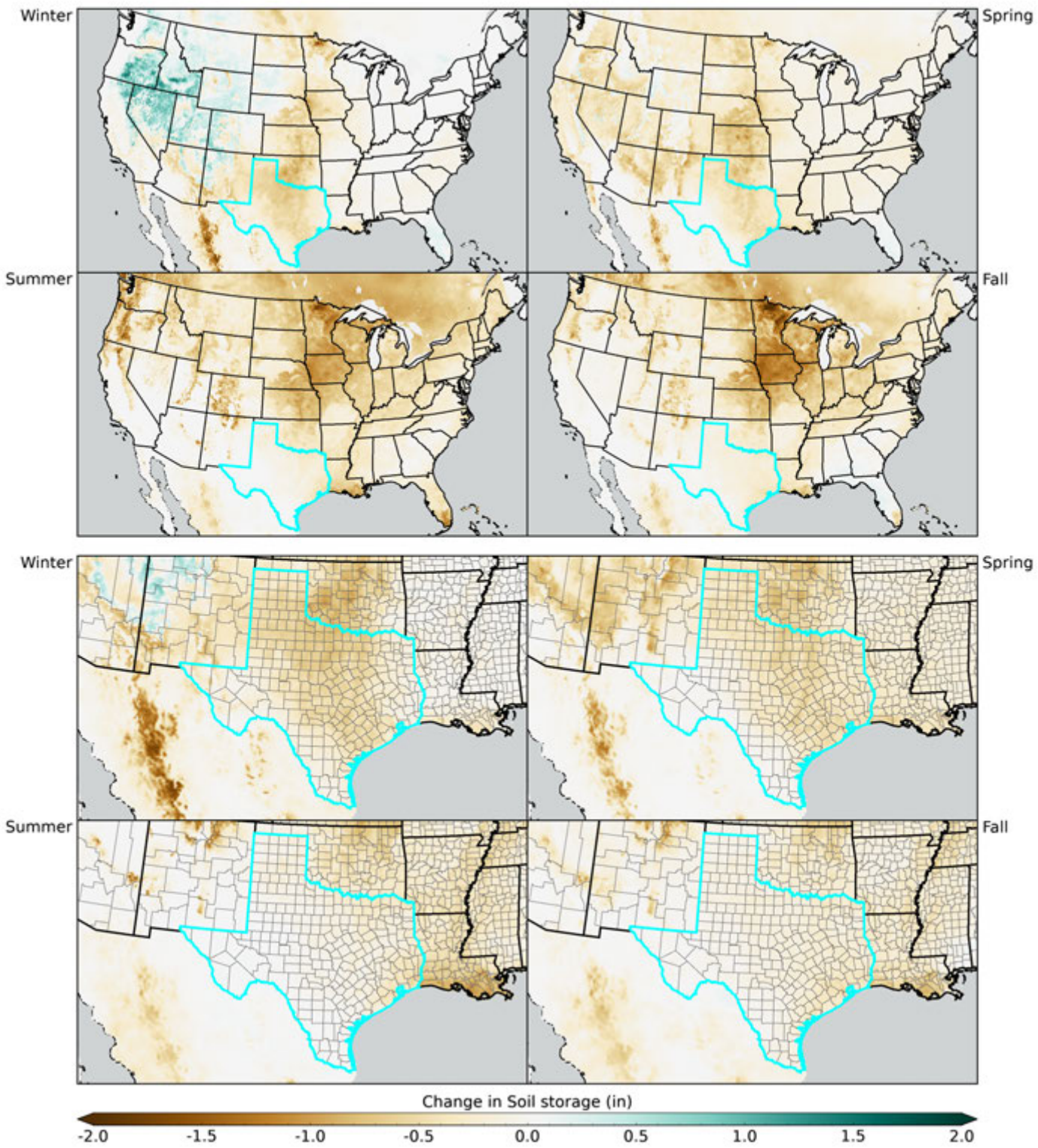

Figure 39: Seasonal maps of soil storage for ssp245 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

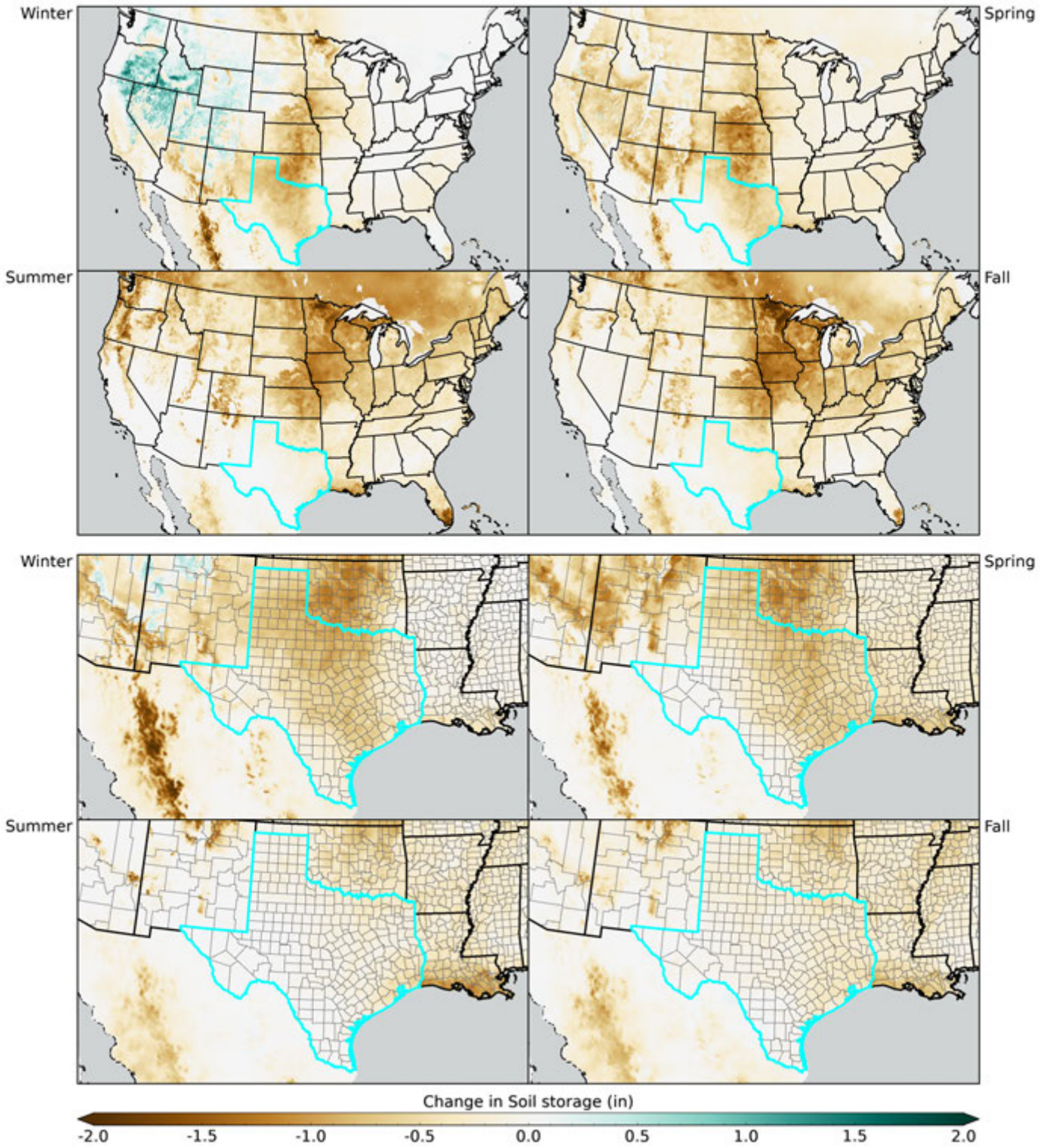

Figure 40: Seasonal maps of soil storage for ssp370 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

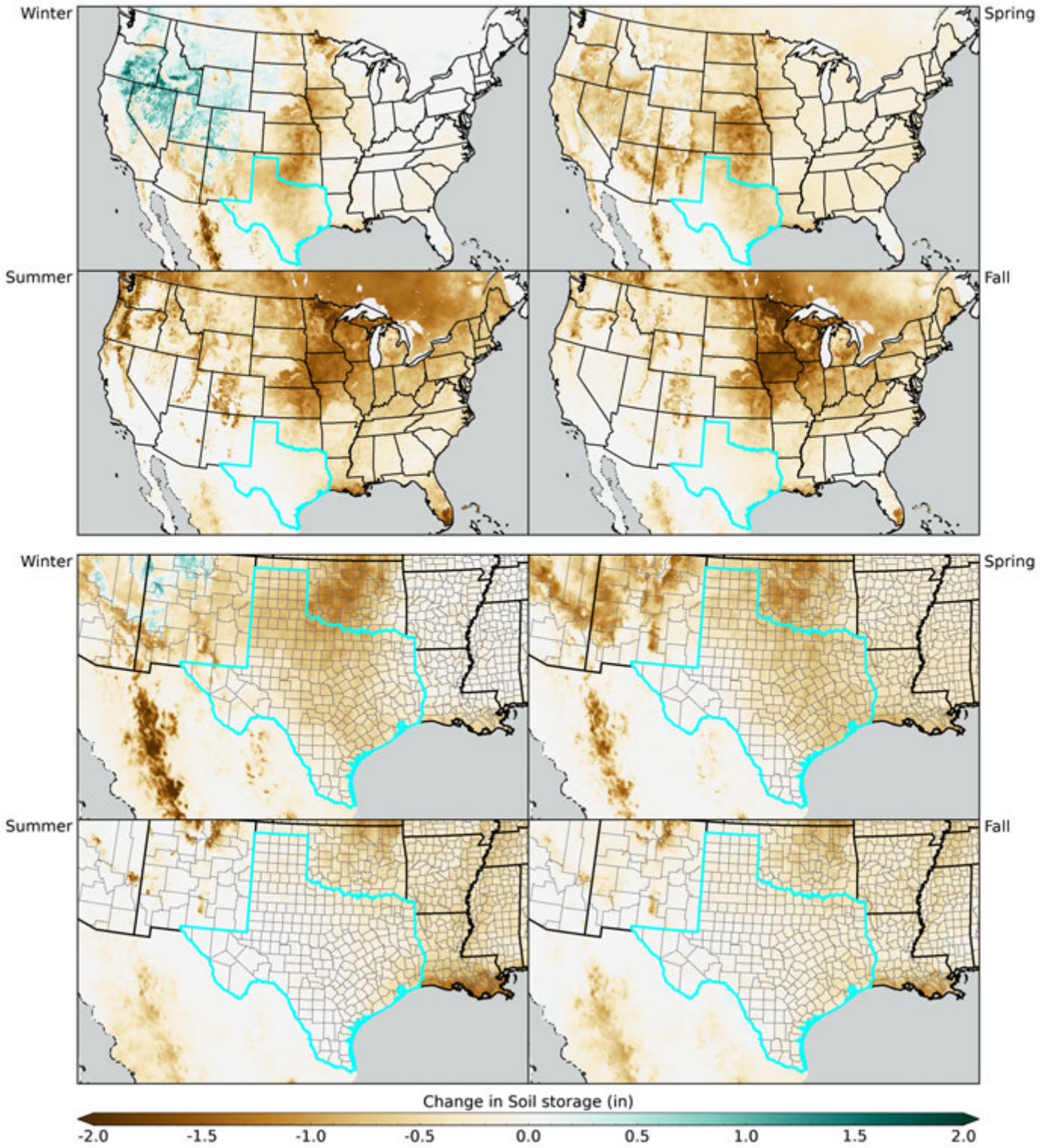

Figure 41: Seasonal maps of soil storage for ssp585 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

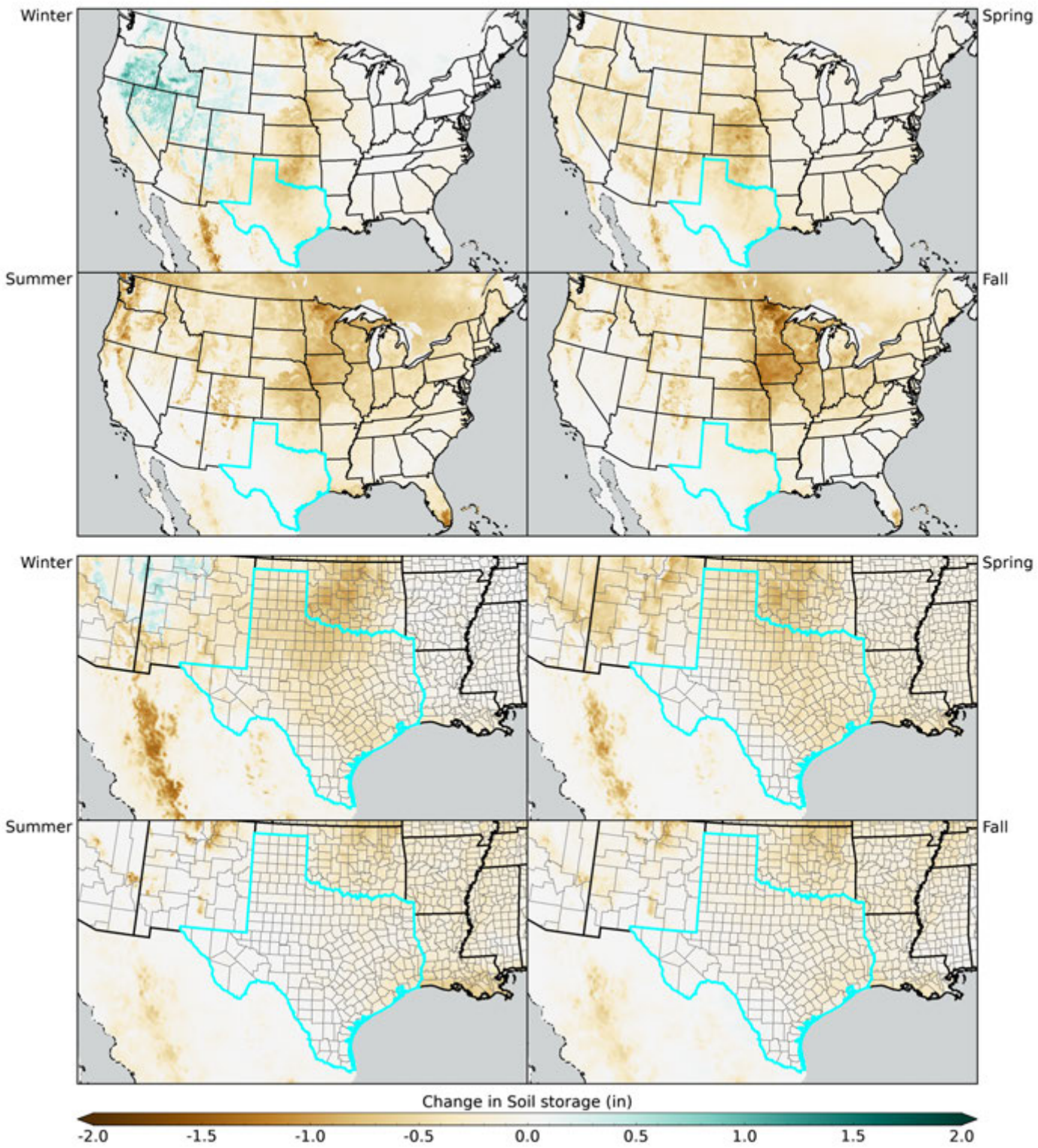

Figure 42: Seasonal maps of soil storage change for Global Warming Level $2°C$ (GWL2, relative to 1981-2010) for the ensemble mean. Global Warming Levels include all models and all scenarios (n=72 model simulations) and are referenced to the 20-year period when the global average temperature simulated by each climate model warms by $2°C$ above the 1850-1900 pre-industrial average.

9 Evaporative Deficit

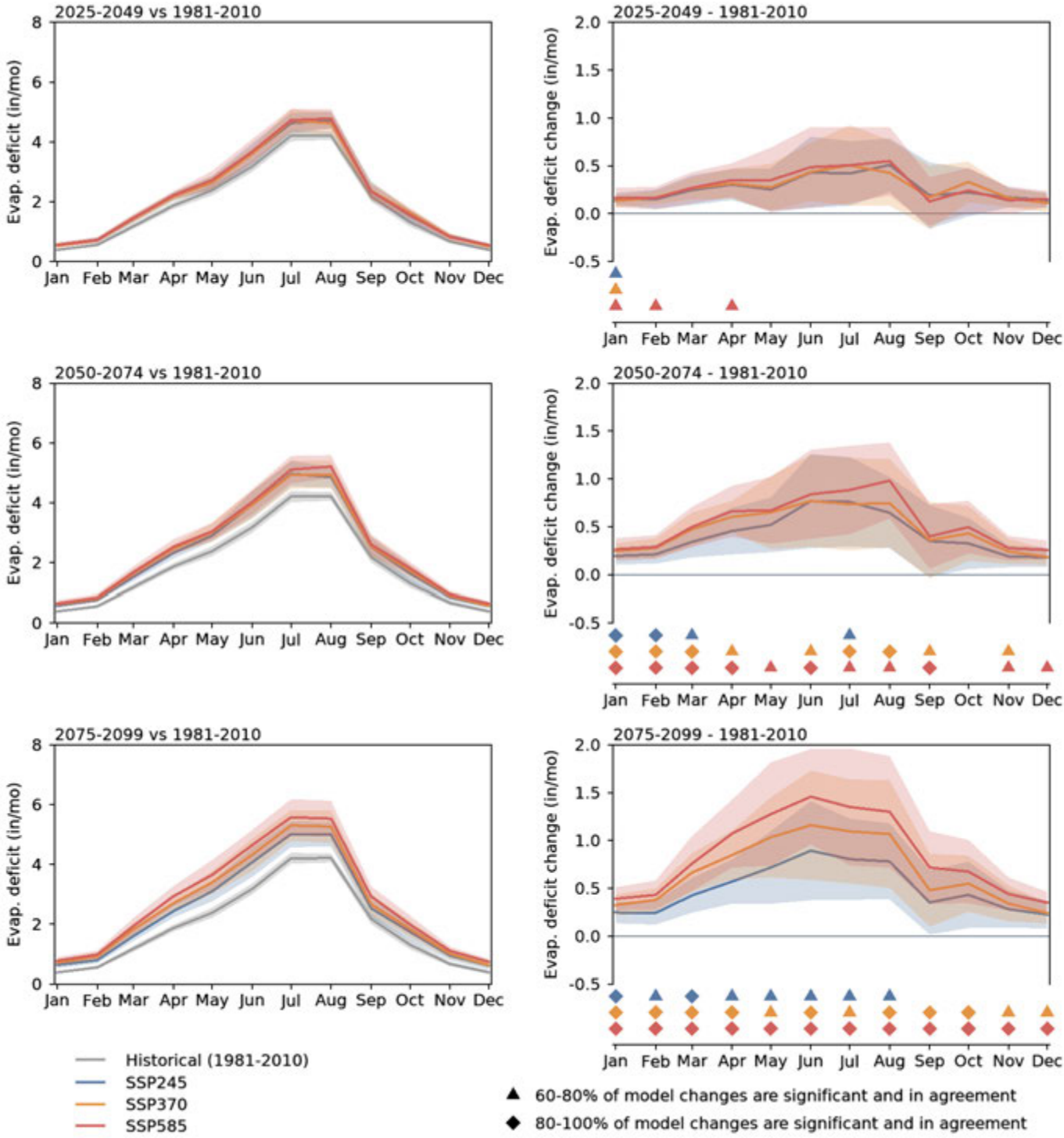

Figure 43: Monthly evaporative deficit for the three future time periods for the ssp245, ssp370, ssp585 simulations. The median of all CMIP6 models is indicated by the solid lines and the 10th to 90th percentile range of the models is indicated by the respective shaded envelopes. Raw values relative to the historical simulation (1981-2010) are shown in the left column and future minus historical changes are shown in the right column. Triangle and diamond symbols indicate the percent of models that simulate future minus present changes that are of the same sign and statistically significant at a 95% confidence level based on a Mann-Whitney rank test.

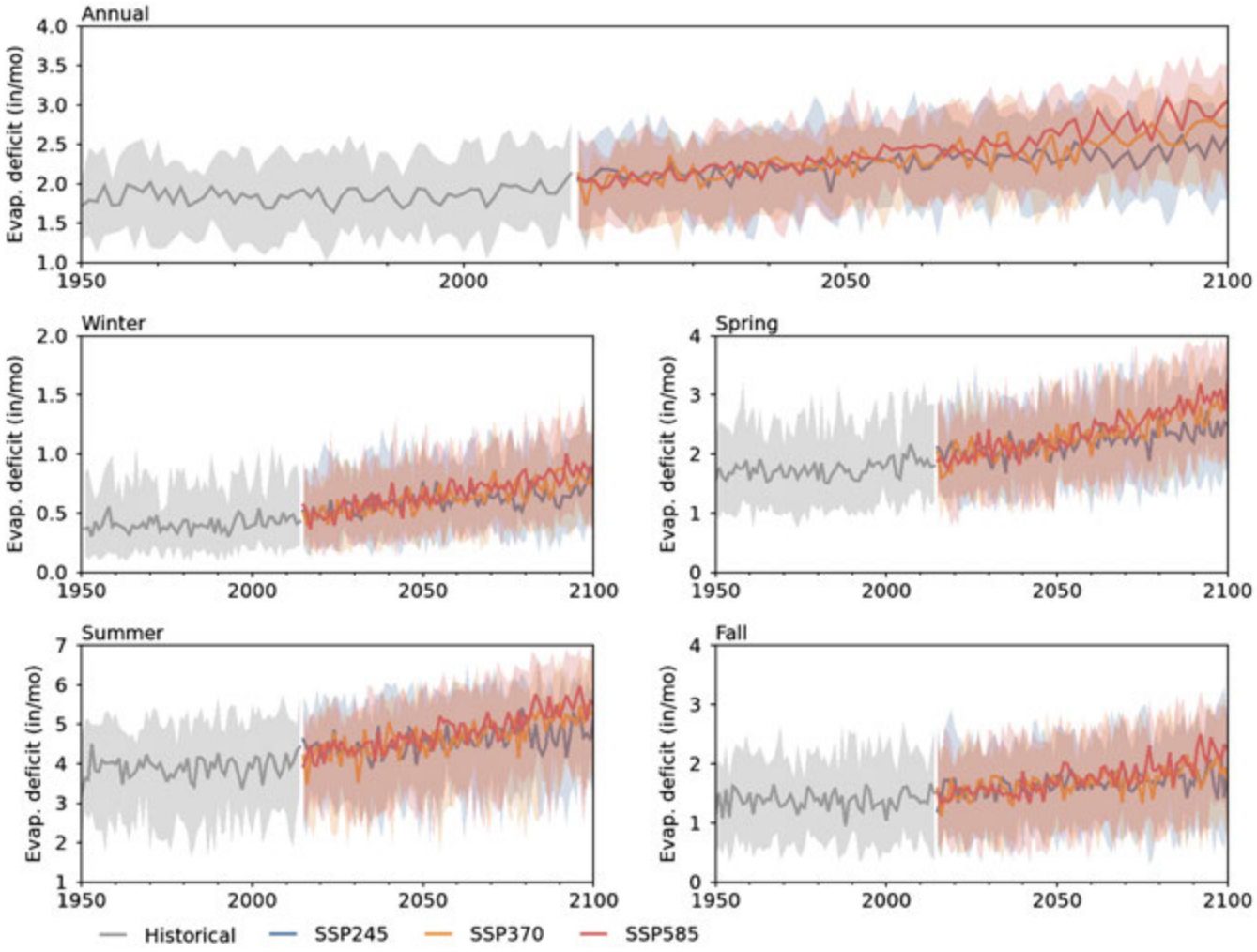

Figure 44: Annual and seasonal time series of evaporative deficit for historical (gray), ssp245 (blue), ssp370 (orange), and ssp585 (red). The historical period ends in 2014 and the future periods begin in 2015. The median of CMIP6 models is indicated by the solid lines and the ensemble 10th to 90th percentile range of the model is indicated by the respective shaded envelopes.

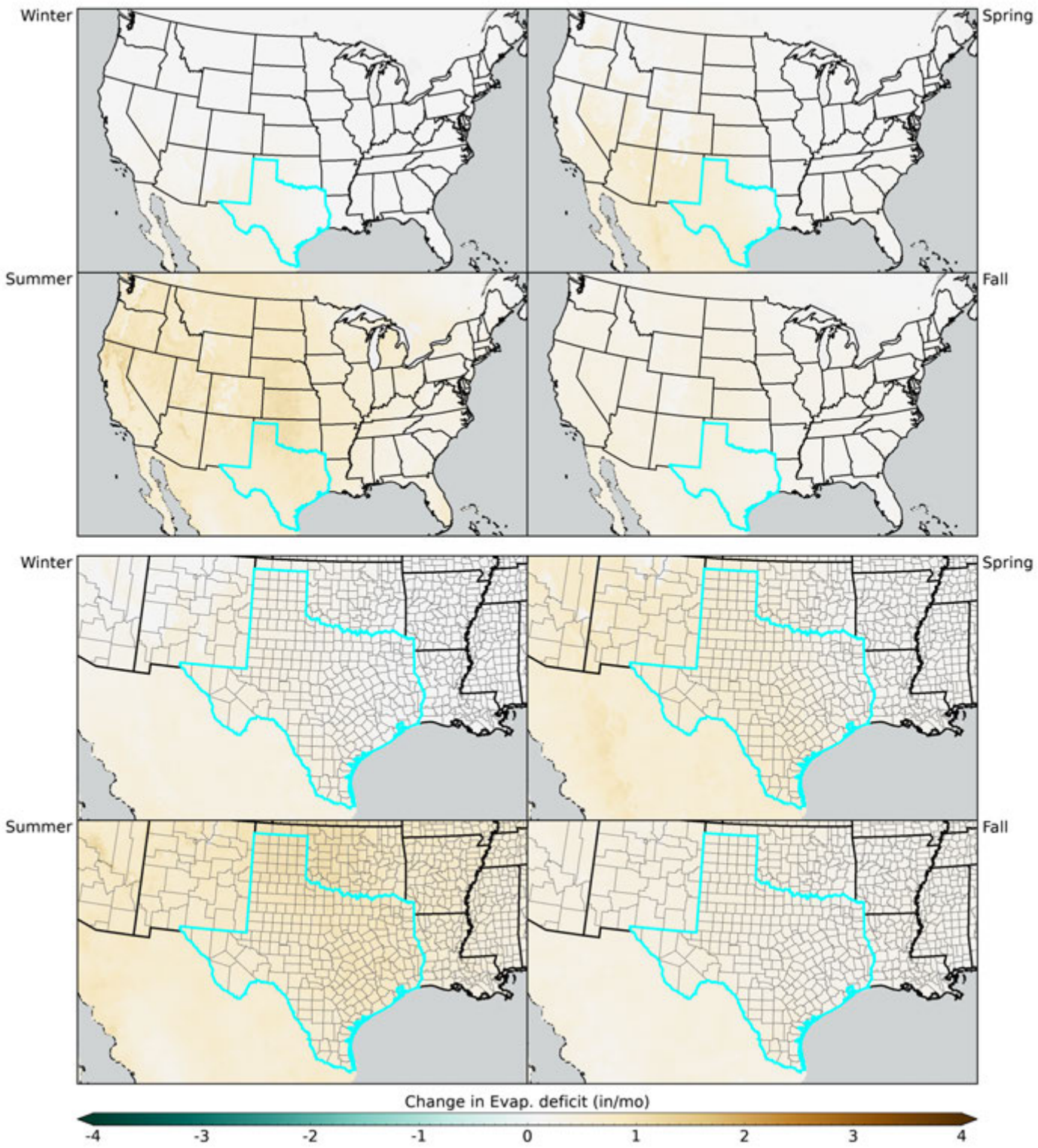

Figure 45: Seasonal maps of evaporative deficit for ssp245 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

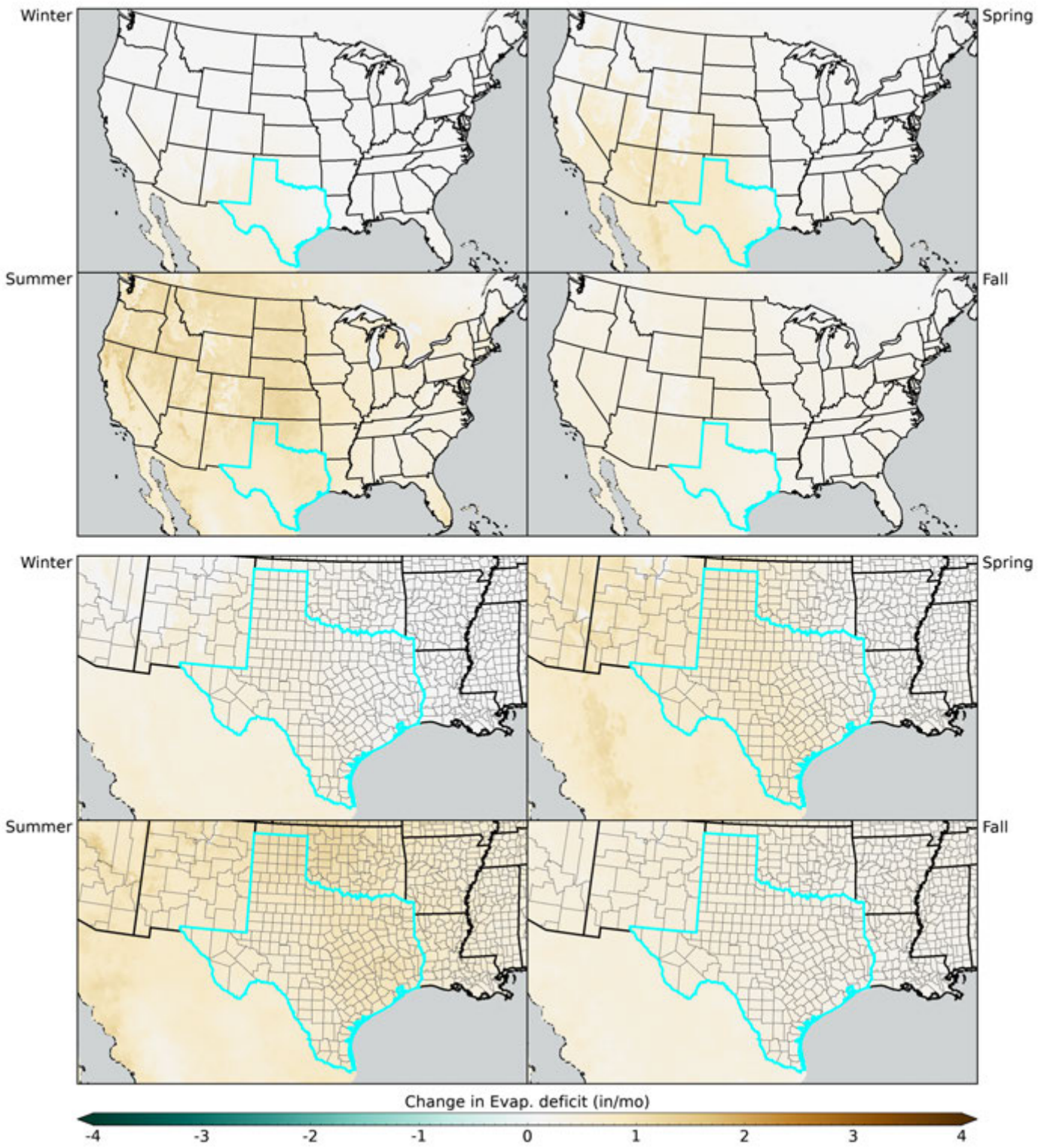

Figure 46: Seasonal maps of evaporative deficit for ssp370 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

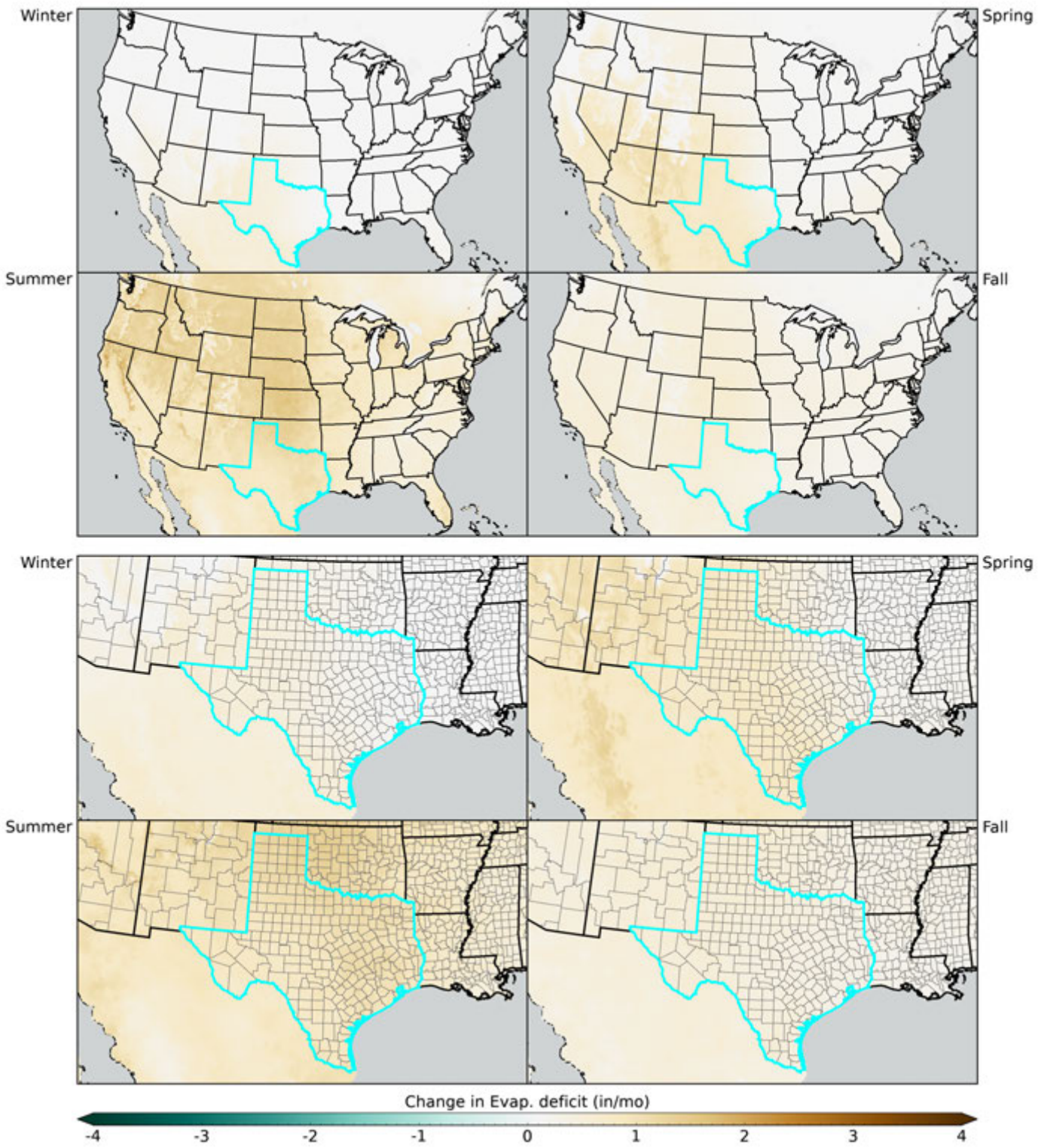

Figure 47: Seasonal maps of evaporative deficit for ssp585 2050-2074 minus 1981-2010 for the ensemble mean of all CMIP6 models.

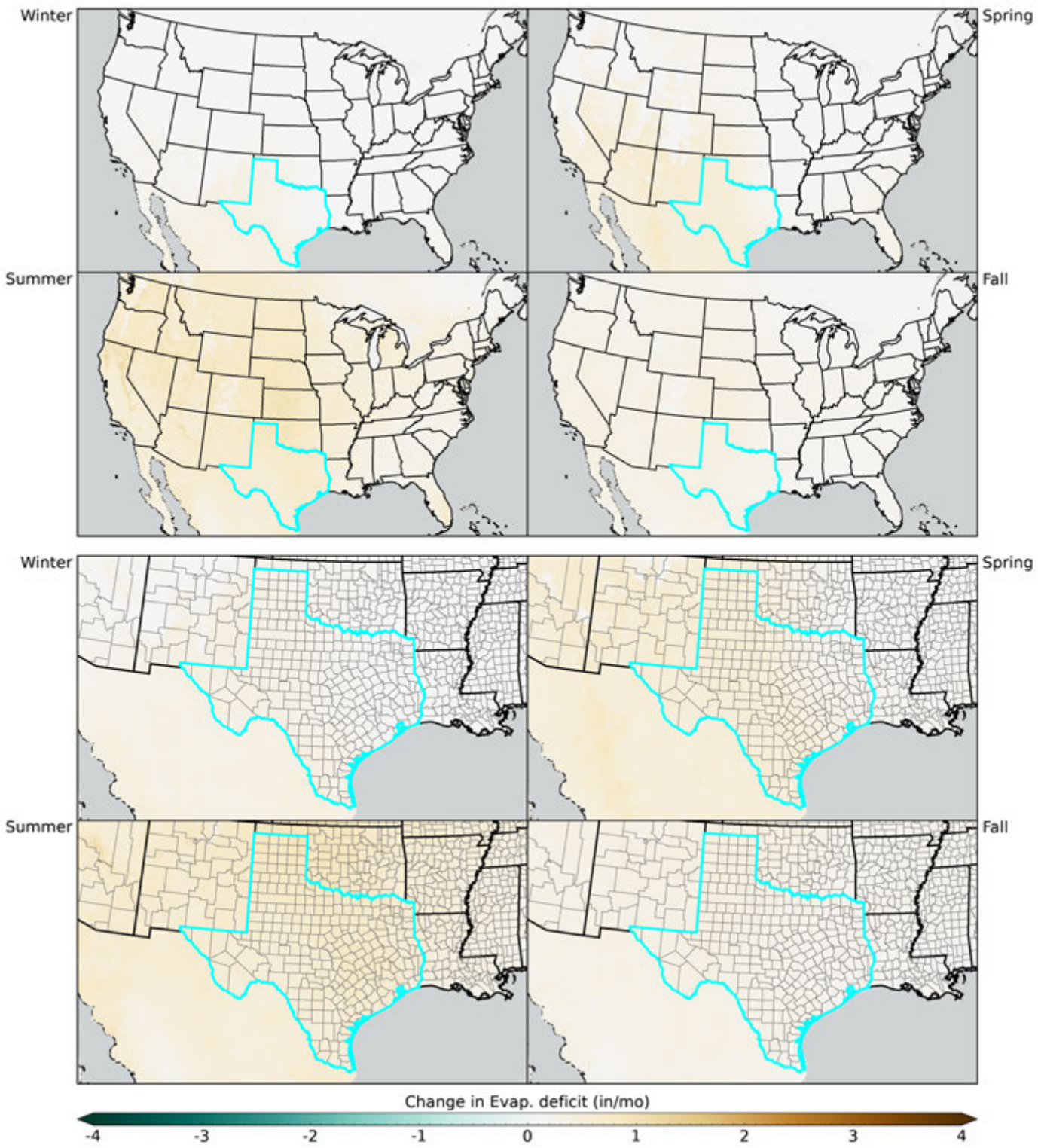

Figure 48: Seasonal maps of evaporative deficit change for Global Warming Level $2°C$ (GWL2, relative to 1981-2010) for the ensemble mean. Global Warming Levels include all models and all scenarios (n=72 model simulations) and are referenced to the 20-year period when the global average temperature simulated by each climate model warms by $2°C$ above the 1850-1900 pre-industrial average.

10 Data

The temperature and precipitation summaries are created by spatially averaging the CMIP6-LOCA2 data set (Pierce et al, 2023). Climate data in LOCA2 were drawn from a statistical downscaling of global climate model (GCM) data from the Coupled Model Intercomparison Project 6 utilizing an updated version of the Localized Constructed Analogs method (CMIP6-LOCA2, Pierce et al, 2023) with a modified version of the Livneh2015 observational dataset as training data (Pierce et al, 2021, https://cirrus.ucsd.edu/~pierce/nonsplit_precip/).

The water-balance variables snow water equivalent, runoff, soil water storage and evaporative deficit are simulated by using the CMIP6-LOCA2 temperature and precipitation as input to a simple water-balance model (McCabe and Wolock, 2007). Mean temperature used as input to the water-balance model is derived as the average of maximum and minimum temperature in the LOCA2 data set. The water-balance model accounts for the partitioning of water through the various components of the hydrologic system, but does not account for groundwater, diversions, or regulation by impoundments.

11 CMIP6 Models

ACCESS-CM2 (r1i1p1f1)	ACCESS-ESM1-5 (r1i1p1f1)	AWI-CM-1-1-MR (r1i1p1f1)	BCC-CSM2-MR (r1i1p1f1)
CESM2-LENS (r1i1p1f1)	CNRM-CM6-1 (r1i1p1f2)	CNRM-CM6-1-HR (r1i1p1f2)	CNRM-ESM2-1 (r1i1p1f2)
CanESM5 (r1i1p1f1)	EC-Earth3 (r1i1p1f1)	EC-Earth3-Veg (r1i1p1f1)	FGOALS-g3 (r1i1p1f1)
GFDL-CM4 (r1i1p1f1)	GFDL-ESM4 (r1i1p1f1)	HadGEM3-GC31-LL (r1i1p1f3)	HadGEM3-GC31-MM (r1i1p1f3)
INM-CM4-8 (r1i1p1f1)	INM-CM5-0 (r1i1p1f1)	IPSL-CM6A-LR (r1i1p1f1)	KACE-1-0-G (r1i1p1f1)
MIROC6 (r1i1p1f1)	MPI-ESM1-2-HR (r1i1p1f1)	MPI-ESM1-2-LR (r1i1p1f1)	MRI-ESM2-0 (r1i1p1f1)
NorESM2-LM (r1i1p1f1)	NorESM2-MM (r1i1p1f1)	TaiESM1 (r1i1p1f1)	

12 Citation Information

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Hostetler, S.W. and Alder, J.R., 2016. Implementation and evaluation of a monthly water balance model over the U.S. on an 800 m grid. Water Resources Research, 52, doi:https://doi.org/10.1002/2016WR018665

Pierce, D.W., Cayan, D.R., Feldman, D.R., Risser, M.D., 2023. Future Increases in North American Extreme Precipitation in CMIP6 Downscaled with LOCA. Journal of Hydrometeorology, 24(5), 951–975. https://doi.org/10.1175/JHM-D-22-0194.1

13 Disclaimer

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