

Historical and Projected Climate Trends, Marsh-Billings-Rockefeller National Historical Park, Vermont

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Climate Change and National Parks

Climate change, in conjunction with other stressors, impacts all aspects of park management from natural and cultural resources to park operations and visitor experience. Effective planning and management must be grounded in our comprehension of past dynamics as well as the realization that future conditions may shift beyond the historical range of variability. Climate change will manifest itself not only as shifts in mean conditions (e.g., increasing mean annual temperature and sea level) but also as changes in climate variability (e.g., more intense storms and flooding). These changes may alter vegetation composition and structure of the landscape and accelerate weathering, deterioration, and loss of cultural resources. Park managers are dealing with both rapid directional change and multiple uncertainties (Heller and Zavaleta 2009). Understanding climate change projections and associated levels of uncertainty will facilitate planning actions that are robust regardless of the precise magnitude of change experienced in the coming decades.

Historical climate trends

Historical climate trends (1893-2012) for Marsh-Billings-Rockefeller are based on data from a nearby long-term weather station (Hanover, NH station 273850, approximately 13 miles east northeast of the park) acquired from the United States Historical Climatology Network (www.ncdc.noaa.gov). Over the 120 year instrumental record, mean annual temperature showed an increasing linear trend (+0.17 °F [0.09 °C] per decade, $p < 0.0001$; Figure 1). The rate of warming has been more rapid since 1960 (+0.49 °F [0.27 °C] per decade, $p < 0.0001$). Warming since 1893 was also statistically significant across all four seasons, with the most rapid rate in winter (+0.26 °F [0.14 °C] per decade, $p < 0.0001$; Figure 2). Annual precipitation also showed an increasing trend, due in part to numerous high annual totals over the past two decades (6 of the 10 wettest years have occurred since 1996; Figure 1). Seasonally, only fall precipitation showed a significant increasing trend ($p < 0.05$; Figure 3). Additional climate trends in the Northeast include a > 10 day expansion of the frost free season (1991-2011 relative to 1901-1960) and a strong increase (+74%) in the amount of precipitation falling in the heaviest rain events (NCADAC 2013).

Future climate projections

Future climate projections for the area including Marsh-Billings-Rockefeller are from multi-model averaged data (Kunkel et al. 2013). Mean annual temperature, compared with the 1971-1999 average, is projected to increase 3-5 °F (1.7-2.8 °C) by mid-century and 5-8 °F (2.8-4.4 °C) by the end of the century, depending on the greenhouse gas emissions scenario (Figure 1). Past greenhouse gas emissions, the residence time of these gases in the atmosphere, and our current emissions trajectory suggest that climate change will be substantial (Wigley 2005, Peters et al. 2013). Warming by mid-century is projected for all seasons (Figure 4), and there is wide agreement among individual climate models in the direction and general magnitude of warming over the coming decades. Total annual precipitation may increase slightly and summer precipitation decrease slightly by mid-century compared with late 20th century values (Figure 1,

5); however, precipitation variability is likely to remain large over the coming decades, and there is greater uncertainty in precipitation than temperature projections (Kunkel et al. 2013).

In addition to warmer mean temperatures and changes in annual and seasonal precipitation, climate change will exhibit itself in many other ways within the region including Marsh-Billings-Rockefeller. These include more frequent heat waves, droughts, floods, and an extended frost-free season. The number of days with maximum temperatures $> 95^{\circ}\text{F}$ is projected to increase 3-6 days/year by mid-century around the park while the number of days with minimum temperatures below 10°F and 32°F are both projected to decrease by approximately 3 weeks (high [A2] emissions scenario 2041-2070 compared with 1980-2000; Kunkel et al. 2013). Small changes in total precipitation may mask large shifts in the precipitation regime and associated impacts to ecosystems. The annual number of days with heavy rainfall (> 1 inch) is projected to increase 20 % (high [A2] emissions scenario, 2041-2070 compared with 1980-2000; Kunkel et al. 2013). Significantly warmer temperatures and a more variable precipitation regime may lead to both more frequent droughts and more severe flooding and erosion. See the draft National Climate Assessment for more in-depth information on climate change projections and impacts (NCADAC 2013; <http://ncadac.globalchange.gov/>).

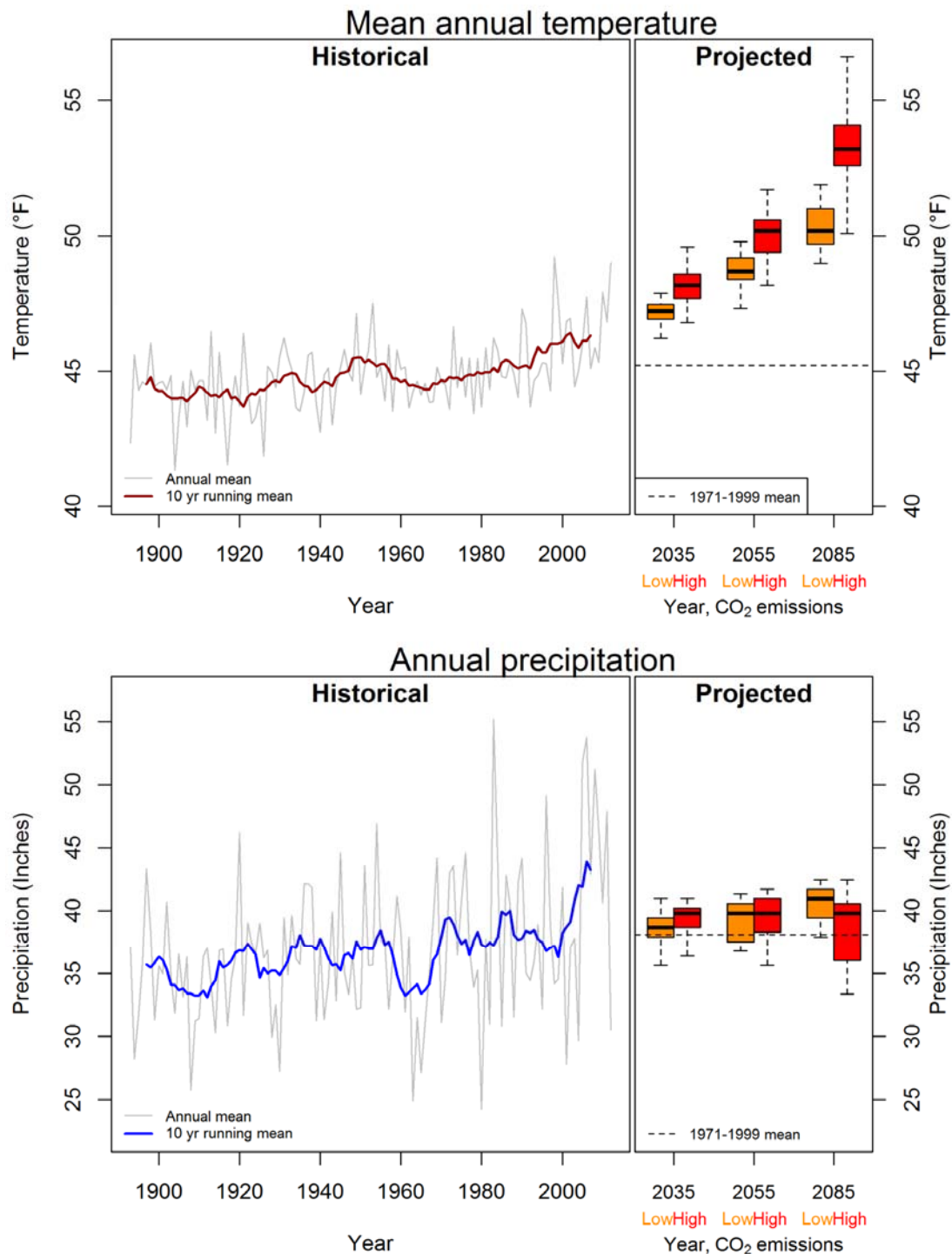


Figure 1. Historical and projected mean annual temperature and annual precipitation for Marsh-Billings-Rockefeller National Historical Park. Historical data (1893-2012) are from the Hanover, NH weather station (ncdc.noaa.gov). Projected climate change (30 year means) for the region including the park (data from Kunkel et al. 2013, see Tables 4, 6 and Figures 16, 27) are for three future periods centered on 2035 (2021-2050), 2055 (2041-2070), and 2085 (2070-2099). Two greenhouse gas emissions scenarios are presented, the **low** (B1) and **high** (A2) scenarios (IPCC 2007). Projected climate boxplots indicate the variability in future projections among 14-15 CMIP3 climate models. Values for the area including Marsh-Billings are based on the mean model output for that location (bold horizontal black line) and the range of climate model projections for the northeast region (the upper and lower bounds of the boxes indicate the 25th and 75th percentile model output values and the whiskers show the minimum and maximum change).

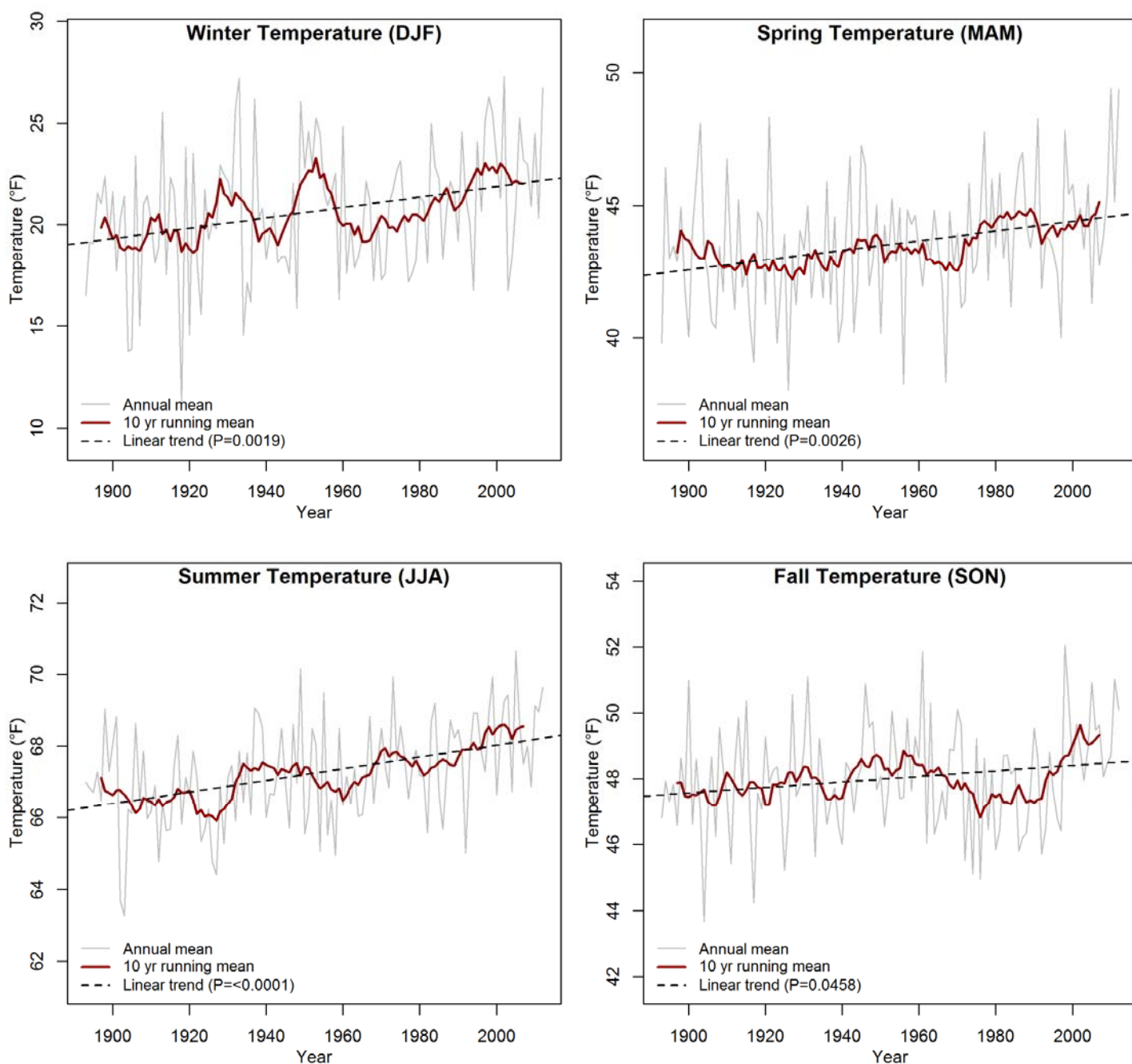


Figure 2. Seasonal temperature trends (1893-2012) from the Hanover, NH long-term weather station (ncdc.noaa.gov).

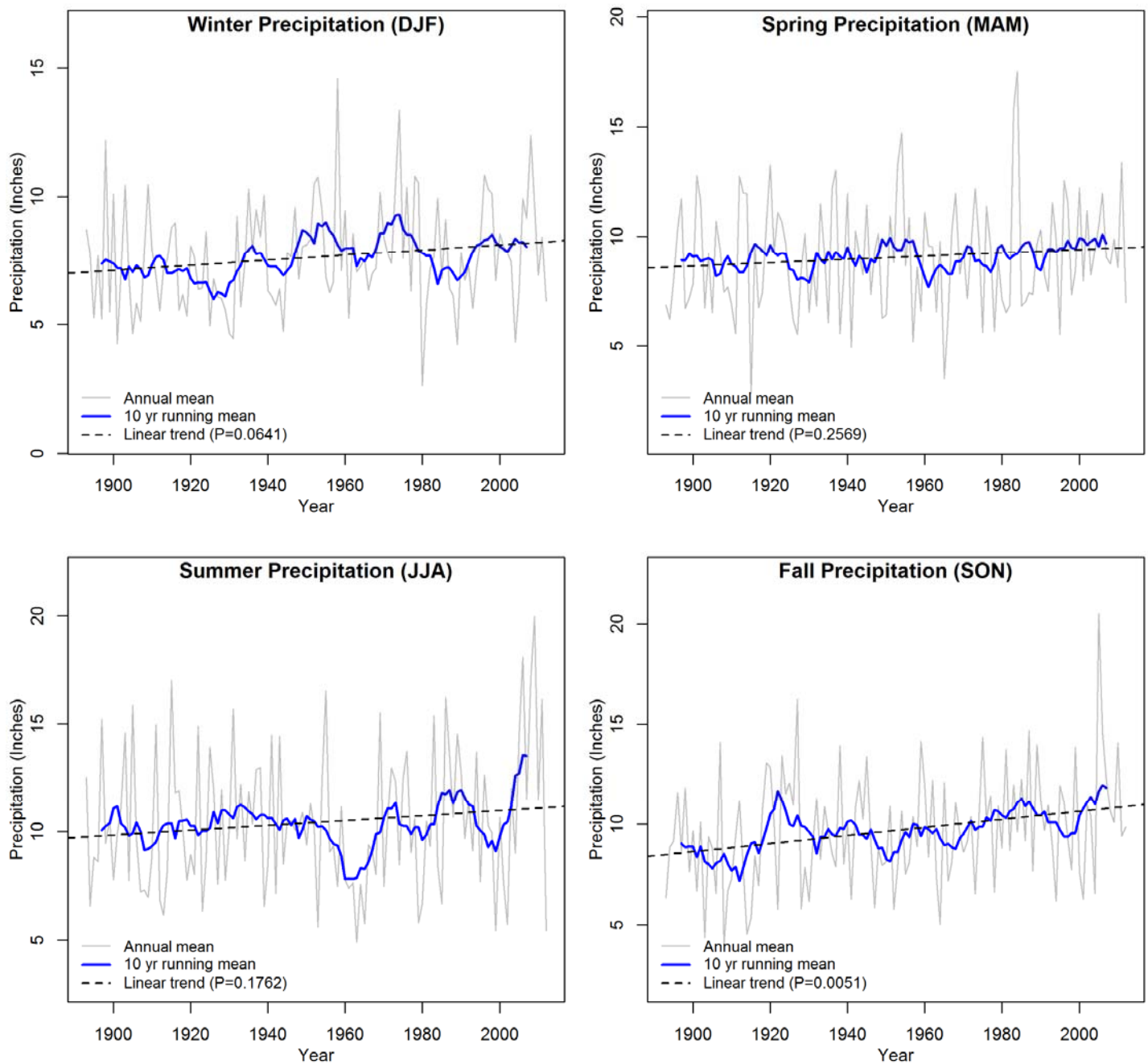


Figure 3. Seasonal precipitation trends (1893-2012) from the Hanover, NH long-term weather station (ncdc.noaa.gov).

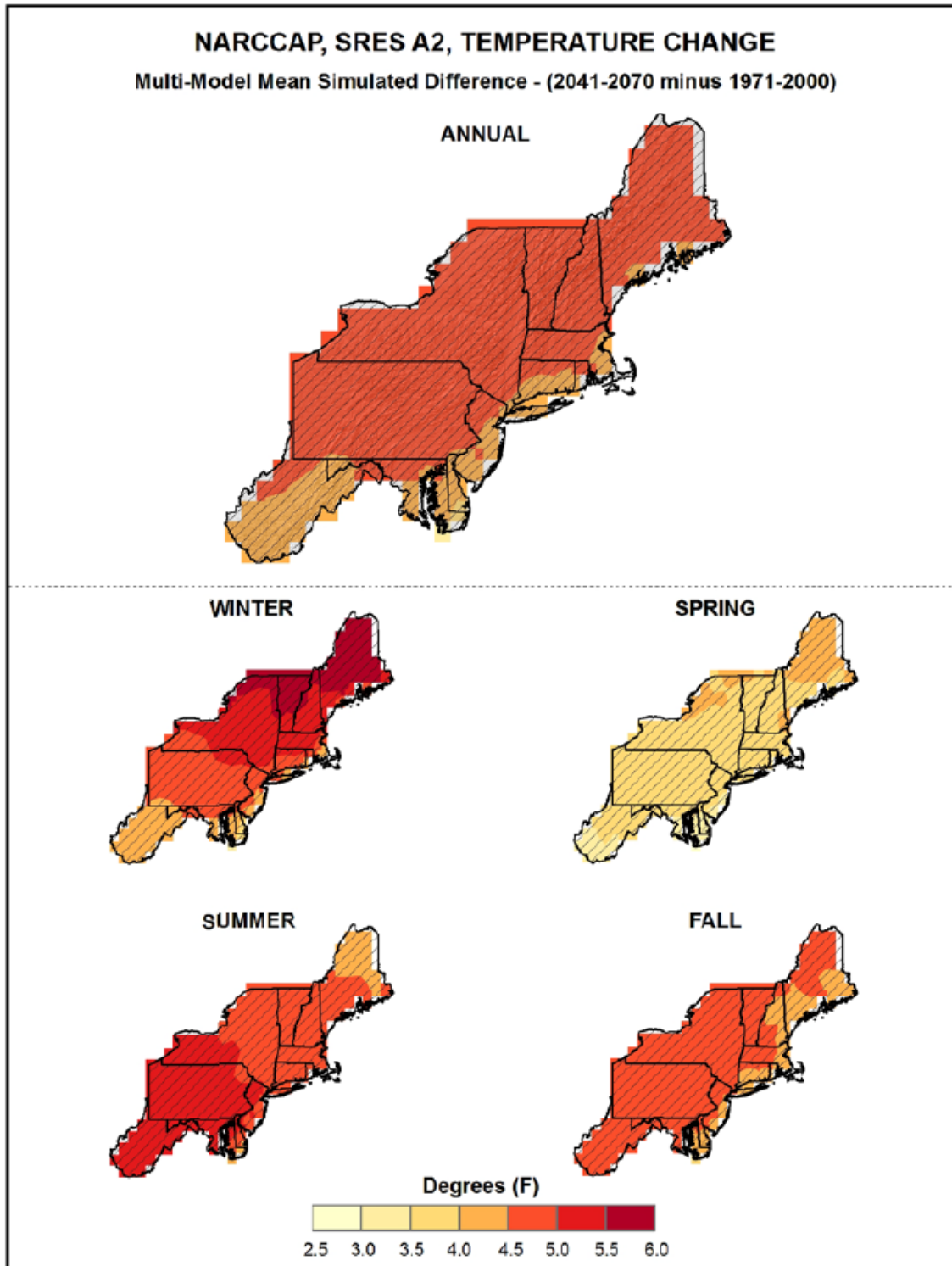


Figure 4. Projected annual and seasonal temperature change. Maps show projected change in average surface air temperature in mid-century (2041-2070) relative to the later part of the last century (1971-2000). Projected changes are averages from 11 NARCCAP regional climate simulations for the high (A2) CO₂ emissions scenario. Color with hatching indicates that more than 50% of the models show a statistically significant change in temperature, and more than 67% agree on the sign of the change. Figure and legend from Kunkel et al. (2013).

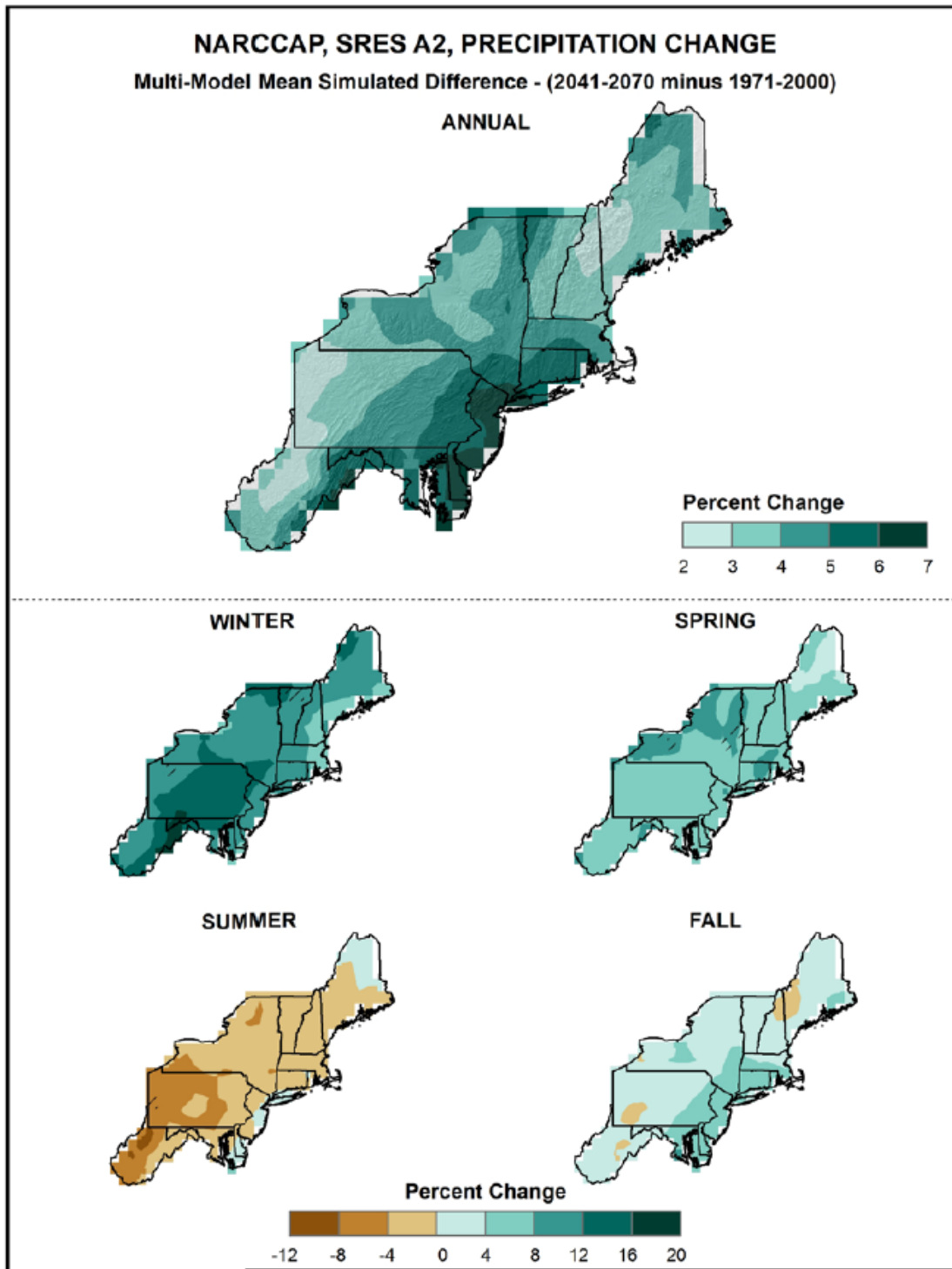


Figure 5. Projected annual and seasonal precipitation change. Maps show projected change in precipitation for mid-century (2041-2070) relative to the later part of the last century (1971-2000). Projected changes are averages from 11 NARCCAP regional climate simulations for the high (A2) CO₂ emissions scenario. Color only indicates that less than 50% of the models show a statistically significant change in precipitation. Color with hatching indicates that more than 50% of the models show a statistically significant change in temperature, and more than 67% agree on the sign of the change. Figure and legend from Kunkel et al. (2013).

References

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