

Climate Change Trends for the Draft Tsankawi Unit Management Plan Review, Bandelier National Monument, New Mexico

Prepared by Nicholas Fisichelli and Gregor Schuurman, NPS Climate Change Response Program
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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 and recognition 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 decreasing annual precipitation) but also as changes in climate variability (e.g., more intense heat waves, droughts, storms, and flooding). These changes are likely to alter visitor use patterns and demands on facilities and operations, cause shifts in the composition and structure of natural communities, and accelerate weathering, deterioration, and loss of cultural resources. Put another way, land managers are dealing with both rapid directional change and tremendous uncertainty (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 in the coming decades.

Historical climate trends (1895-2010)

The southern, inland portion of the southwestern U.S. is the hottest and driest part of the country. Annual and seasonal temperatures in the Southwest as a whole over the past 20 years have mostly been above 1901-1960 averages (Kunkel et al. 2013), and the past half-century has been the warmest in centuries (NCADAC 2013). These warmer temperatures and drought in recent decades have generated bigger and more frequent wildfires with significant impacts on humans and natural systems (NCADAC 2013). Heat waves are also occurring more frequently than in the past and cold snaps are becoming less common (NCADAC 2013). Regional precipitation shows high interannual variability, with no significant annual or seasonal linear trends (1901-2011) (Kunkel et al. 2013).

Historical climate trends (1895-2010) for Bandelier National Monument are based on spatial climate data acquired from the PRISM Climate Group (<http://www.prism.oregonstate.edu>). Mean annual temperature showed an increasing linear trend over the 116-year record (1895-2010) (+0.08 °F [0.04 °C] per decade, p-value = 0.02; Figure 1), and increased consistently over the past two decades. Annual precipitation showed strong interannual variability and no significant linear trend across the entire record (p=0.21).

Future climate projections

Future climate projections for the area including Bandelier National Monument are from multi-model averaged data (Kunkel et al. 2012). Mean annual temperature, compared with the 1971-1999 average, is projected to increase 3-5 °F by mid-century and 5-8 °F by the end of the century, depending on the greenhouse gas emissions scenario (Figure 1). Current greenhouse gas emissions are on a trajectory similar to the higher emissions scenarios (Peters et al. 2012). Warming by mid-century is projected for all seasons, with the greatest increases likely in summer (Figure 2). Wide agreement exists among individual climate models in the direction and magnitude of warming over the coming decades. Total annual precipitation may decrease slightly by mid-century (Figure 1, 3; Kunkel et al. 2012); 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. 2012).

In addition to warmer mean temperatures and changes in annual and seasonal precipitation, climate change will manifest itself in many other ways. These include more frequent heat waves, droughts, floods, and an extended frost-free season. The number of consecutive days in the year with maximum temperatures $> 95^{\circ}\text{F}$ is projected to increase 5-10 by mid-century around Bandelier while the number of days with minimum temperatures below freezing is projected to decrease by approximately 25-30 days (high [A2] emissions scenario 2041-2070 compared with 1980-2000; Kunkel et al. 2012). Small changes in total precipitation may mask large shifts in the precipitation regime and associated impacts to ecosystems. Drought is a frequent occurrence in the Southwest and warmer temperatures magnify the impacts of drought on soil moisture and streamflow by enhancing evaporation and evapotranspiration. Significantly warmer temperatures, particularly in summer (Figure 2), 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/>).

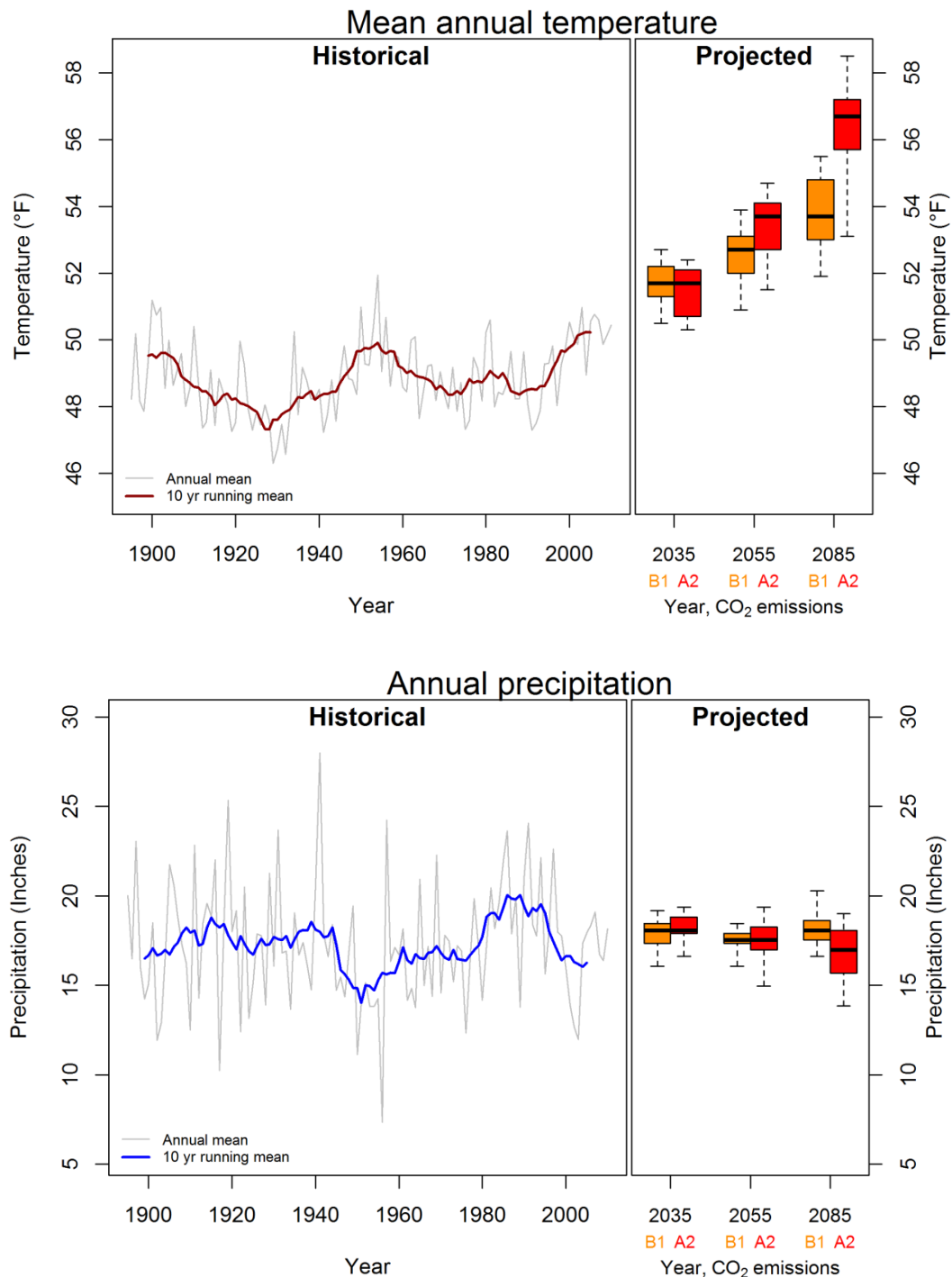


Figure 1. Historical and projected mean annual temperature and annual precipitation for Bandelier National Monument. Historical data (1895-2010) for the entire monument are averaged from PRISM spatial climate data (<http://www.prism.oregonstate.edu>). Projected climate change (30 year means) for the region including the park (data from Kunkel et al. 2012, see Tables 4, 6 and Figures 14, 25) 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 the monument are based on the mean model output for that location and the range of climate model projections for the southwest region: the bold horizontal black line represents the mean among all models, 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.

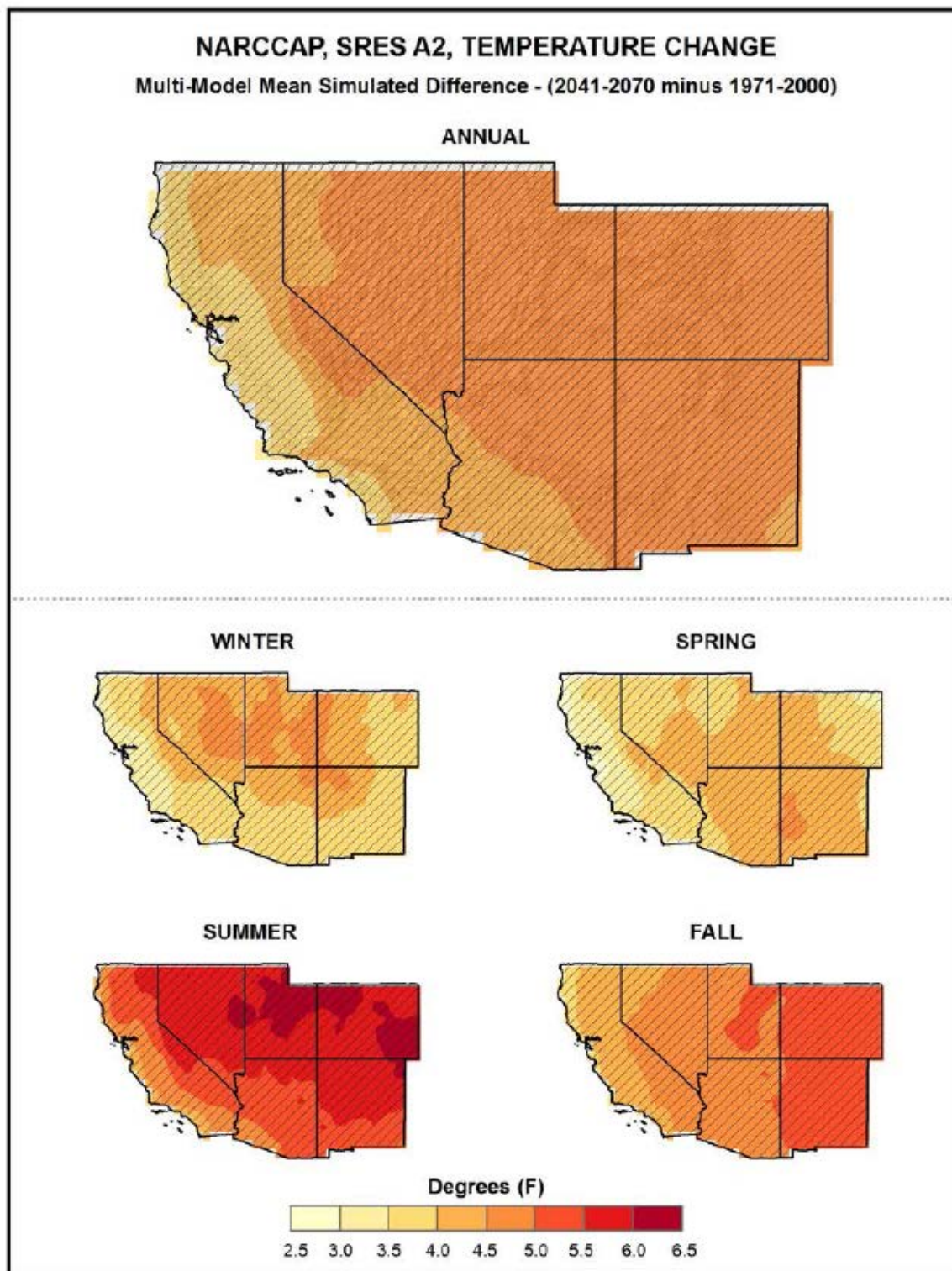


Figure 2. Projected annual and seasonal temperature change. Maps show projected change in average surface air temperature in mid-century (2040-2070) relative to the later part of the last century (1971-1999). Projected changes are averages from 11 NARCCAP regional climate simulations for the high (A2) 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 from Kunkel et al. (2012).

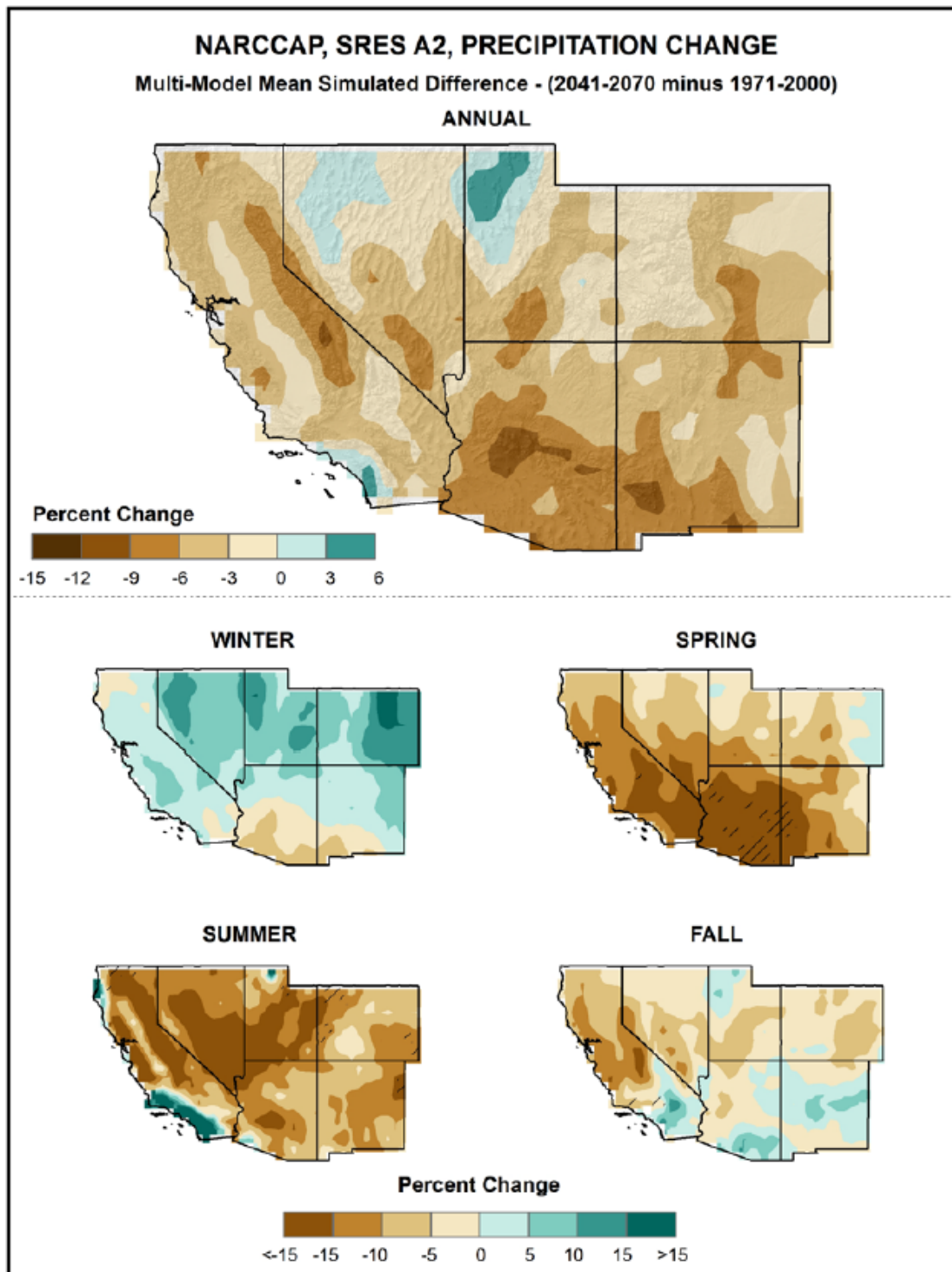


Figure 3. Projected annual and seasonal precipitation change. Maps show projected change in precipitation for mid-century (2040-2070) relative to the later part of the last century (1971-2000). Projected changes are averages from 11 NARCCAP regional climate simulations for the high (A2) emissions scenario. 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 from Kunkel et al. (2012).

References

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