

Historical and Projected Climate Trends for Mount Rushmore National Memorial

Prepared by Nicholas Fisichelli, NPS Climate Change Response Program February 19, 2013

Historical climate trends (1895-2011)

The northern Great Plains region is dominated by a continental climate with warm summers, very cold winters, and generally dry conditions. As a region, annual and seasonal temperatures over the past 20 years have mostly been above 1901-1960 averages (Kunkel et al. 2013). The northern Great Plains has warmed considerably more than other portions of the nation over the past 130 years. Overnight low temperatures and winter seasonal averages have increased most strongly, concomitant with the projected effects of increased atmospheric greenhouse gas concentrations (NCADAC 2013). Regional precipitation shows high interannual variability, with no significant annual or seasonal linear trends (1901-2011) (Kunkel et al. 2013). Important climate factors for the region include drought, floods, winter storms, convective storms, heat waves, and cold spells.

Local climate trends for the Mount Rushmore National Memorial area were similar to regional patterns, as indicated by historical climate data from the nearest long-term weather station to the park (Rapid City, SD, station 396947, 18 miles northeast of the memorial) acquired from the United States Historical Climatology Network (cdiac.ornl.gov) (Table 1). Over the 117 year instrumental record (1895-2011) mean annual temperature showed an increasing trend (+0.1 °F (+0.06 °C) per decade, $p=0.01$) (Figure 1). Seasonal temperature changes were strongest in winter (+0.2 °F (+0.14 °C) per decade, $p=0.02$) and spring (+0.1 °F (+0.06 °C) per decade, $p=0.13$) (Figure 2). Annual precipitation did not exhibit a strong linear trend ($p=0.96$), though winter precipitation, historically low over the past 3 decades, showed a decline over time (-0.004 inches (-0.1 mm) per decade) (Figures 1, 3). Annual variability in precipitation totals dominated trends for the other three seasons.

Future climate projections

Future climate projections for the area including Mount Rushmore National Memorial are from multi-model averaged data (Kunkel et al. 2013). Projected conditions through mid-century were based on the A2 higher CO₂ emissions scenario (IPCC 2007). This was deemed the most likely trajectory of atmospheric CO₂ over the next half century, as global emissions are currently on a trajectory similar to the higher emissions scenarios (Friedlingstein et al. 2010). By mid-century (2041-2070), mean annual temperatures around Mount Rushmore will rise roughly 5.0 °F (2.8 °C) compared with the 1971-2000 average, and the frost-free season will expand by 20 days (Table 1). The number of days with temperatures above 95 °F (35 °C) is projected to double (15 additional days) and days below 32 °F (0 °C) will decrease by 15% (21 fewer days). Temperatures over the next decade (2011-2020) are likely to be similar to 2001-2010 (NCADAC 2013). There is wide agreement among individual climate models in the direction and magnitude of warming over the coming decades.

There is greater uncertainty in precipitation than temperature projections for mid-century (Table 1). Annual variability is likely to remain the strongest precipitation trend over the coming decades. Annual precipitation may increase slightly (+1 to +5%), with the greatest increase coming in winter (+10 to +15%) and a projected decrease in summer (-5 to -10%), compared with 1971-1999 values (Kunkel et al. 2013). It must be noted that similar precipitation amounts

as in past decades in conjunction with warming temperatures will result in drier conditions within the park.

Table 1. Historical climate (1971-2000) and projected changes (2041-2070) for Mount Rushmore National Memorial. Climate modeling (Kunkel et al. 2013) was based on the A2 CO₂ emissions scenario (IPCC 2007). Historical data are from the Rapid City, SD weather station (cdiac.ornl.gov).

Temperature	Mean (1971-2000)	Projected change for 2041-2070 compared with 1971-2000 period
Mean annual temperature	46.5 °F (8.0 °C)	+5.0 °F (4.3-5.3 °F: 25th-75th percentiles)
Frost-free season	130 days	+20 (standard deviation = 4 days)
days with max temp > 95 F	15 days	+15 (standard deviation = 6 days)
days with min temp < 32 F	140 days	-21 (standard deviation = 3 days)
Precipitation		
Annual precipitation	18.1 in. (460 mm)	+3 % (0 to +9 %: 25th-75th percentiles) +12 % (+6 to +16 %: 25th-75th percentiles)
Winter precipitation	0.9 in. (24 mm)	
Spring precipitation	6.2 in. (156 mm)	+5 % (+1 to +12 %: 25th-75th percentiles)
Summer precipitation	7.7 in. (196 mm)	-7 % (-24 to +8 %: 25th-75th percentiles)
Fall precipitation	3.3 in. (84 mm)	0 % (-13 to +3 %: 25th-75th percentiles)

Figure 1. (a) Mean annual temperature and (b) annual precipitation (1895-2011) from the Rapid City, SD long-term weather station (cdiac.ornl.gov).

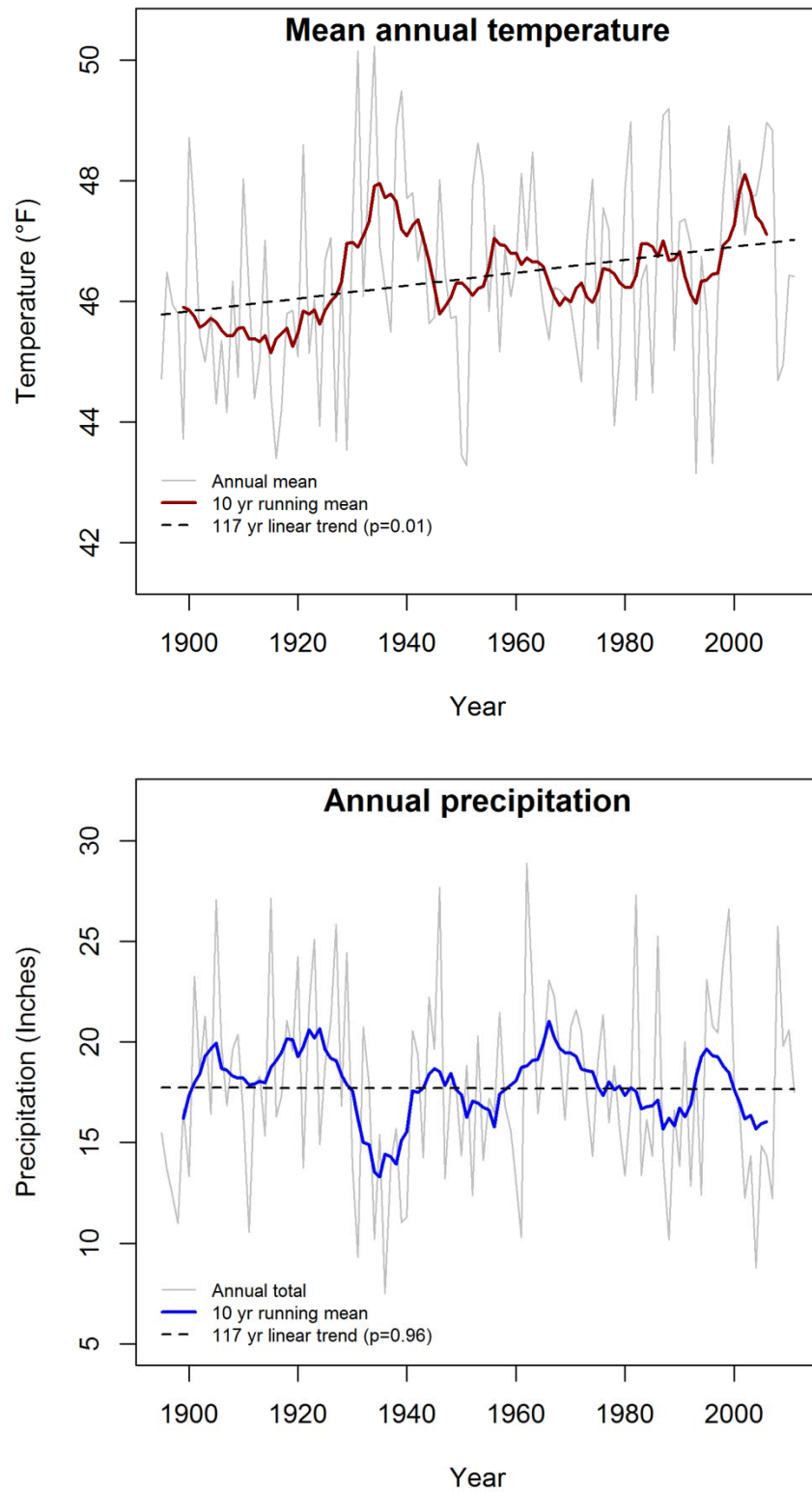


Figure 2. Seasonal temperature trends (1895-2011) from the Rapid City, SD long-term weather station (cdiac.ornl.gov).

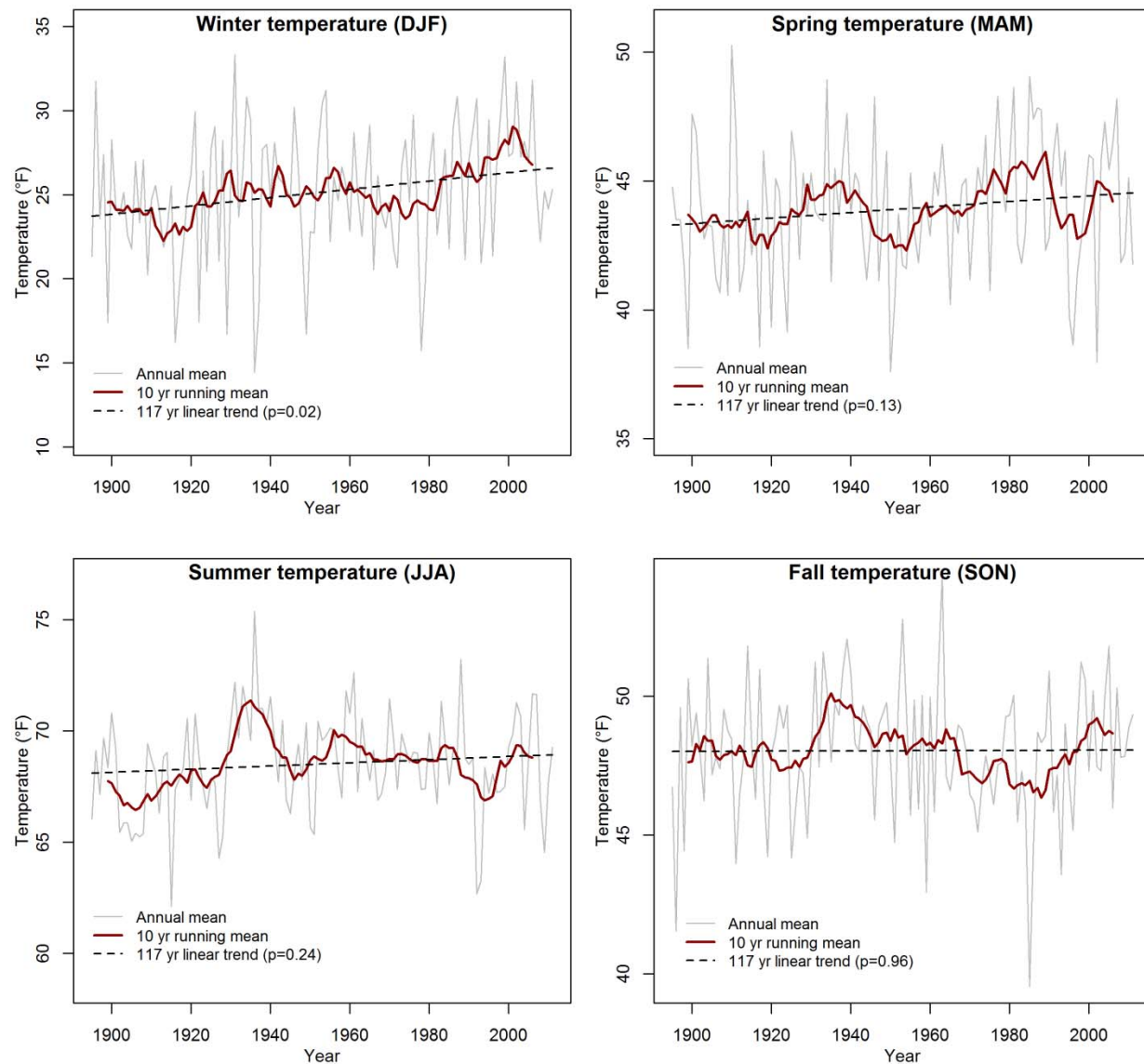
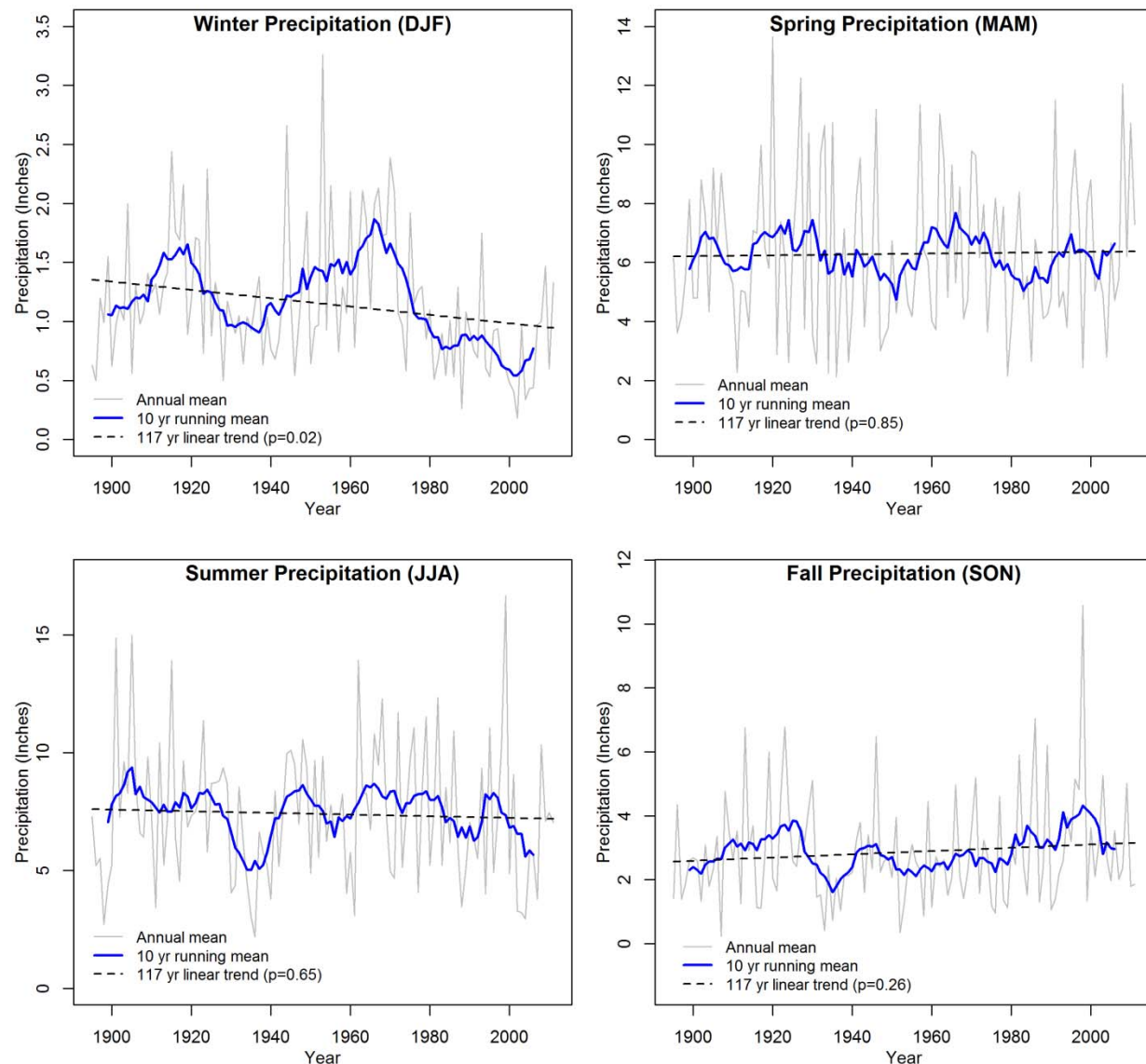


Figure 3. Seasonal precipitation trends (1895-2011) from the Rapid City, SD long-term weather station (cdiac.ornl.gov).



References

Friedlingstein P., R. Houghton, G. Marland, J. Hackler, T. A. Boden, T. Conway, J. Canadell, M. Raupach, P. Ciais, and C. Le Quéré. 2010. Update on CO₂ emissions. *Nature Geoscience* 3:811-812.

Intergovernmental Panel on Climate Change (IPCC). 2007. *Climate Change 2007: The Physical Science Basis*. Cambridge University Press, Cambridge, UK.

Kunkel, KE; Stevens LE; Stevens SE; Sun L; Sun L; Janssen E; Wuebbles D; Kruk M; Thomas DP; Shulski MD; Umphlett NA; Hubbard KG; Robbins K; Romolo L; Akyuz A; Pathak TB; Bergantino TR; Dobson JG. 2013. Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 4. Climate of the U.S. Great Plains. NOAA Technical Report NESDIS 142-4.

National Climate Assessment and Development Advisory Committee (NCADAC). 2013. U.S. National Climate Assessment v. 11 Jan 2013 DRAFT. <http://ncadac.globalchange.gov/>