Climate Change Summary, San Francisco Maritime National Historical Park, California

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Climate Trends for the Area within Park Boundaries

- Average annual temperature has increased at a statistically significant rate since 1950 (Table 1, Figure 1). Trends for winter, spring, and summer have been statistically significant, with the greatest rate of heating in summer (June-August) at 2.3 ± 0.8ºC (2.5 ± 0.8ºF.) per century.
- Precipitation has increased since 1950, but the rate is not statistically significant (Figure 2).
- If the world does not reduce emissions from power plants, cars, and deforestation by 40-70%, models project substantial heating and increased precipitation (Table 1, Figure 3), with the greatest heating in autumn (September-November).
- On average, models project precipitation increases, but some individual models project precipitation decreases (Figure 3).
- Under the highest emissions scenario, models project up to a 10% increase in the number of consecutive dry days in the San Francisco Bay Area and the Sierra Nevada (Walsh et al. 2014). Even with increased total precipitation, the combination of higher temperatures and more consecutive dry periods could increase the frequency of drought.

Historical Impacts Attributed to Climate Change

- The tidal gauge on a wharf off Crissy Field, just west of the park in Golden Gate National Recreation Area, has produced the longest sea level time series in the Western Hemisphere, 1854 to the present. Measurements have shown a statistically significant rise in sea level at a rate of 20 cm (8 inches) per century from 1897 to 2006 (Heberger et al. 2012). Data from this gauge and others has detected a statistically significant rise in global average sea level and analyses of causal factors have attributed the rise to human climate change (IPCC 2013). [See detailed and updated NPS sea level report from Maria Caffrey.]
- Analyses of Audubon Christmas Bird Count data across the United States, including counts in the San Francisco Bay Area, detected a northward shift of winter ranges of a set of 254 bird species at an average rate of 0.5 ± 0.3 km per year from 1975 to 2004, attributable to human climate change and not other factors (La Sorte and Thompson 2007).

Future Vulnerabilities for the Park

- Under all emissions scenarios, climate change would continue to raise sea level globally and along the California coast (IPCC 2013). Modeling under low and high emissions scenarios projects a sea level rise of 77 to 140 cm (30 to 55 inches) at San Francisco by 2100 (Cayan et al. 2012). Modeling under high emissions in 2100 A.D. projects potential increases of 100-year flood conditions to every year (Bromirski et al. 2012). [See detailed and updated NPS sea level report from Maria Caffrey.]
- Increases in sea level and storm surge render roads, wharfs, and other coastal infrastructure more vulnerable to substantially damaging and costly flooding (Biging et al. 2012, Heberger et al. 2012).
- Potential drought under the highest emissions scenario (Walsh et al. 2014) could reduce water supplies or increase water costs (Garfin et al. 2014).

Table 1. Historical rates of change per century and projected future changes in annual average temperature and annual total precipitation (data Daly et al. 2008, IPCC 2013; analysis Wang et al. in preparation). The table gives the historical rate of change per century calculated from data for the period 1950-2010. Because a rate of change per century is given, the absolute change for the 1950-2010 period will be approximately 60% of that rate. The table gives central values for the park as a whole. Figures 1-3 show the uncertainties.

	1950-2010	**2000-2050**	**2000-2100**
Historical			
temperature	+1.6ºC/century (2.9ºF./century)		
precipitation	+22%/century		
Projected (compared to 1971-2000)			
Low emissions (IPCC RCP 4.5)			
temperature		+1.6ºC (+2.9ºF.)	+2.1ºC (+3.8ºF.)
precipitation		+3%	+5%
High emissions (IPCC RCP 6.0)			
temperature		+1.5ºC (+2.7ºF.)	+2.5ºC (+4.5ºF.)
precipitation		+3%	+7%
Highest emissions (IPCC RCP 8.5)			
temperature		+2.1ºC (+3.8ºF.)	+3.8ºC (+6.8ºF.)
precipitation		+5%	+9%

Figure 1. Historical annual average temperature for the area within park boundaries. Note that the U.S. weather station network was more stable for the period starting 1950 than for the period starting 1895. (Data: National Oceanic and Atmospheric Administration, Daly et al. 2008. Analysis: Wang et al. in preparation, University of Wisconsin and U.S. National Park Service).

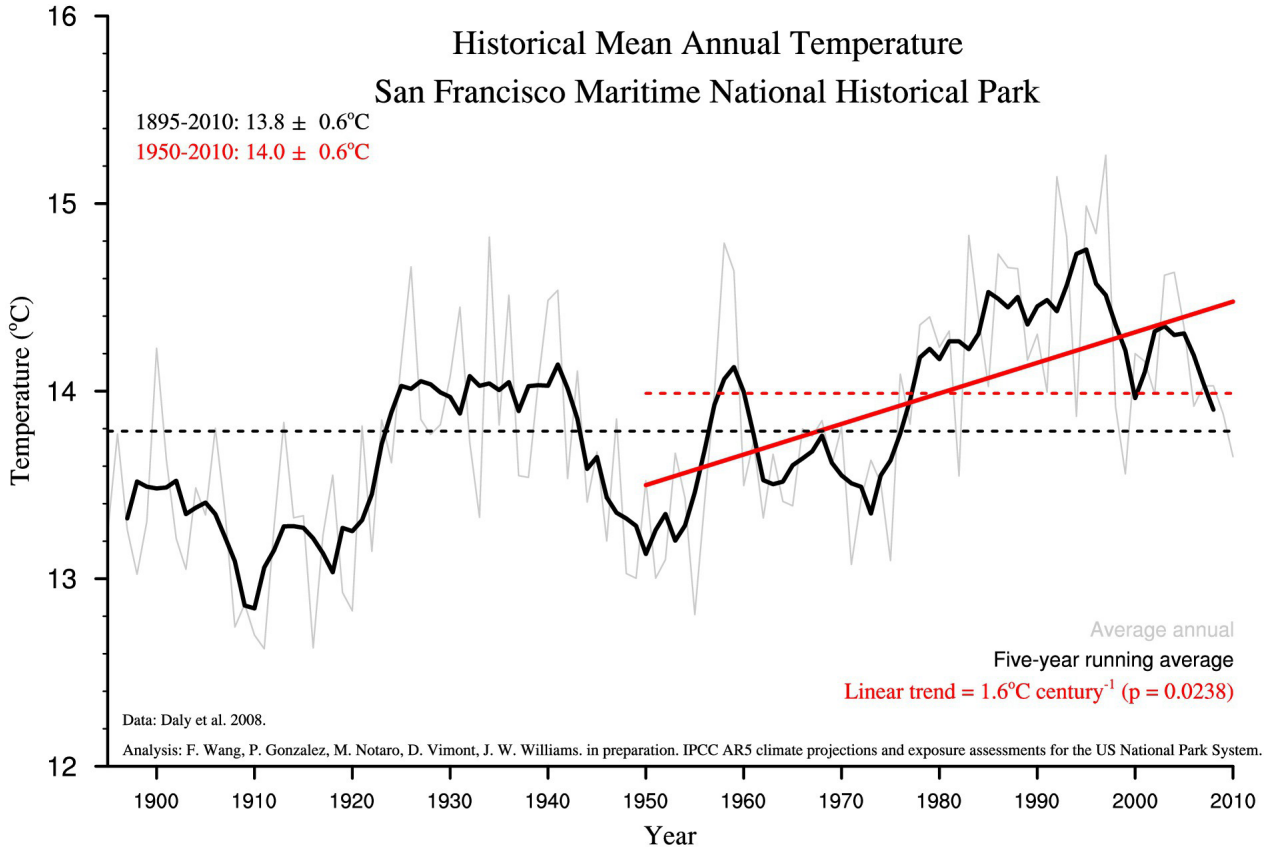


Figure 2. Historical annual total precipitation for the area within park boundaries. Note that the U.S. weather station network was more stable for the period starting 1950 than for the period starting 1895. (Data: National Oceanic and Atmospheric Administration, Daly et al. 2008. Analysis: Wang et al. in preparation, University of Wisconsin and U.S. National Park Service).

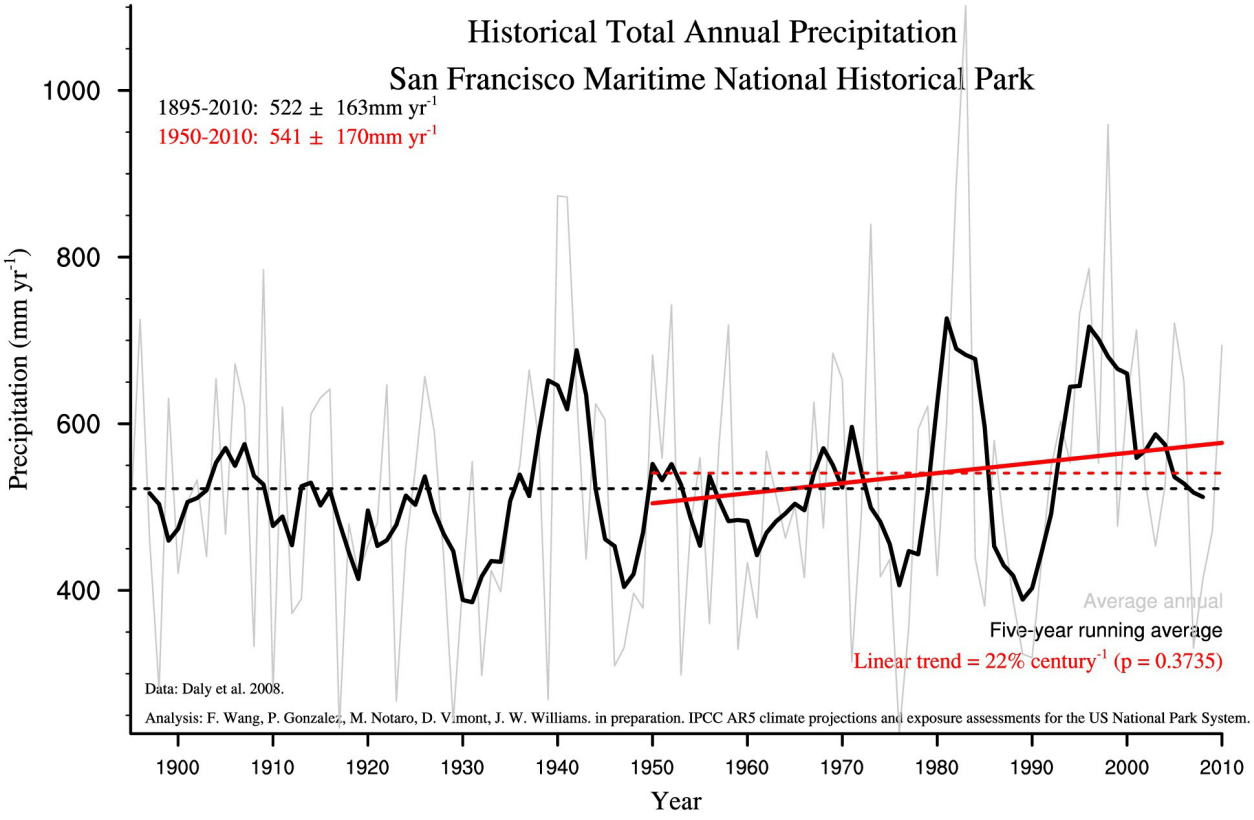
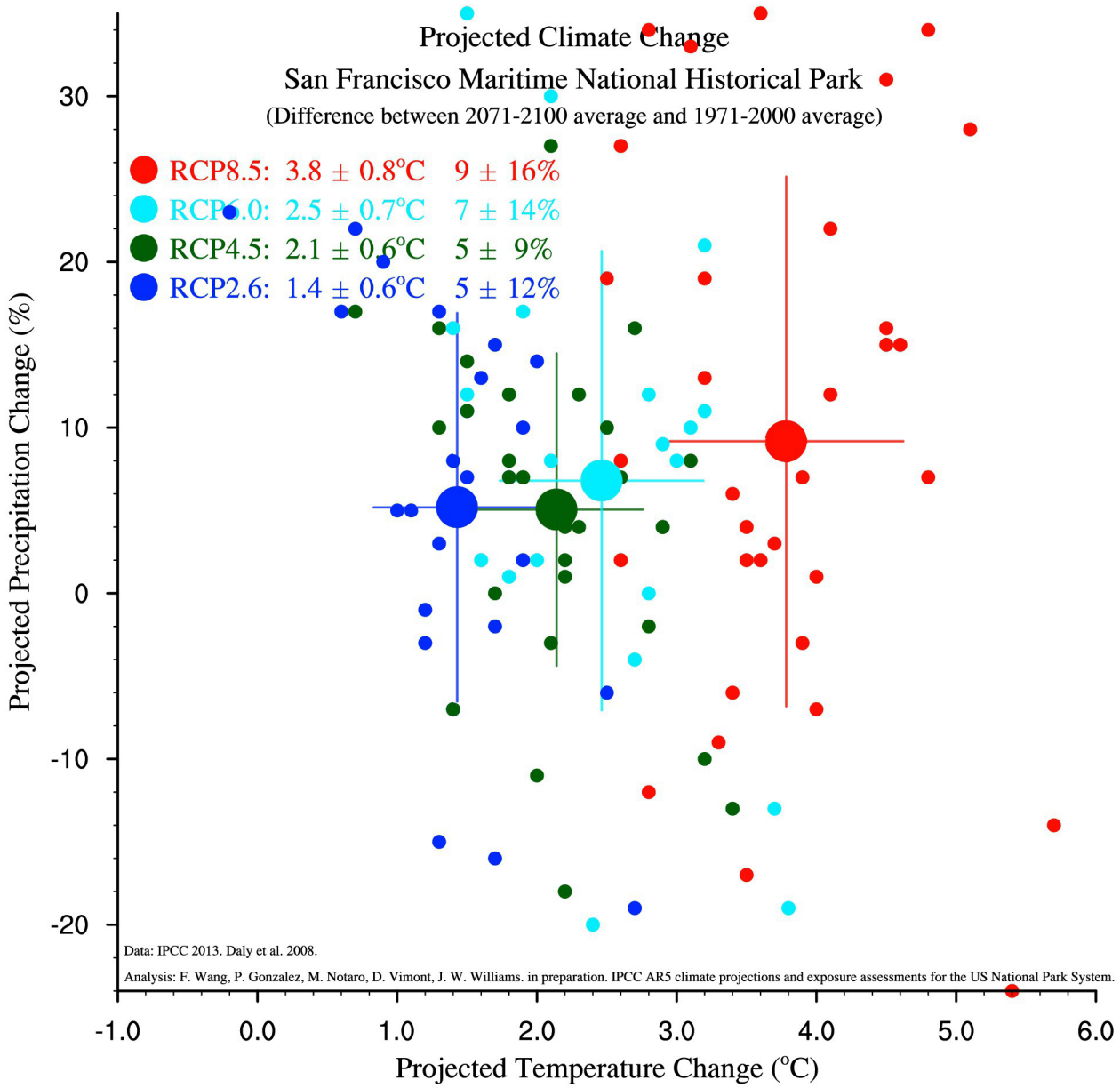


Figure 3. Projections of future climate for the area within park boundaries. Each small dot is the output of a single climate model. The large color dots are the average values for the four IPCC emissions scenarios. The lines are the standard deviations of each average value. (Data: IPCC 2013, Daly et al. 2008; Analysis: Wang et al. in preparation, University of Wisconsin and U.S. National Park Service).



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