Climate change loads the dice for hot summers

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With long days, comfortable temperatures, little rain, and ample sunshine, the Pacific Northwest is one of the nicest places to be during the heart of summer. Summer temperatures are also ideal for the region's agriculture. Although the region has historically experienced occasional "hot" summers, they are likely to become the new norm in the 21st century under climate change.

While a hot summer may be a boon for the air conditioning salesman, increasing summer temperatures may prove a challenge for farmers making cropping decisions, and they can be detrimental to wheat production if temperatures rise too high during critical growth stages. In order to better understand the implications of climate change on future summer temperatures, REACCH scientists at the University of Idaho are looking at models of possible futures and comparing them to historical observations in order to understand how seasonal temperature trends are projected to change.

IMPACT

Pacific Northwest summer temperatures are projected to increase over the 21st century, and temperatures that were considered heat extremes in the 20th century likely will become increasingly widespread and the new normal. By understanding these observed trends and projected regional climate in the summer months, we can help agricultural producers develop climate-appropriate agricultural plans to maximize their production over the long term.

Observed trends in mean annual temperature in the Pacific Northwest show a long-term warming trend. Increases in temperature have not been monotonic, but rather follow an irregular incline, with warming rates waxing and waning under the influence of natural climate variability. However, the year-to-year variability in summer temperatures throughout the Pacific Northwest is only approximately half as great as that seen in winter temperatures.

One explanation for this is that the year-to-year variability in summer temperatures is reduced due to the limited influence of large-scale climate cycles, such as El Niño, since the jet stream is displaced well to the north during this season. The overall result is that the reduced variability in summer temperatures makes the influence of anthropogenic warming more apparent in the summer than in other seasons. Figure 1 shows long-term observations of summer temperatures for the Pacific Northwest, where a warming trend is particularly notable since 1970. Summer temperatures (June through August) have increased by nearly 1°C.

Small year-to-year variability in summer temperatures means that a "hot" summer, one that might be expected only once ever 20 years (or has a 5% chance of occurring in any given summer), may actually be only a couple degrees (e.g., 2°C) above the long-term normal. For instance, if the baseline summer temperatures across the region increase by 1°C, instead of needing exceptional conditions to achieve a "hot" summer, a modestly warm summer (e.g., 1°C above the new baseline) would qualify as a "hot" summer with respect to the longer term perspective.

Some of the warmest summers in the Pacific Northwest have occurred over the past 10 years. The gray bars in Figure 2 show the percentage of landmass in the Pacific Northwest experiencing a 1-in-20 warmest summer, as defined over the historic period. More than 90% of the region was "hot" in the summer of 1961. While parts of the Pacific Northwest may experience hot temperatures in any given summer, widespread hot temperatures across the region (those affecting at least 25% of the area) were observed in 1958, 1961, 1967, 2003, 2006, 2007, 2012, and 2013. Overall, the number of years with widespread summer heat has increased significantly. Thus, the increase in baseline summer temperatures has acted to "load the dice" on hot summers by increasing the odds of experiencing a hot summer from 1 in every 20 years on average to 1 in every 5 years on average.

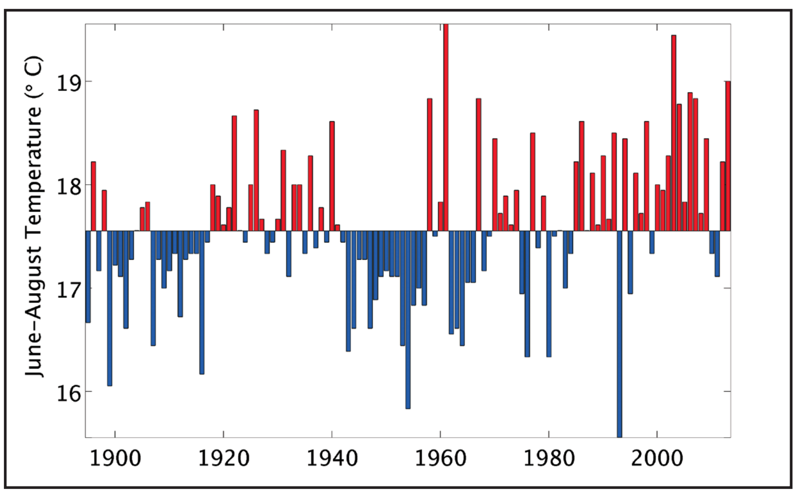

Figure 1. *Average summer (June, July, August) temperatures for the Pacific Northwest (Washington, Oregon, Idaho) from 1900 to 2013 are shown as anomalies from the average over the entire period (about 63°F). Blue bars indicate colder than average, and red bars indicate warmer than average summer temperatures. A significant increase in summer temperatures is seen for the past 60 years, with summer temperatures over the past decade being the highest in the observational record (1895–2013).*

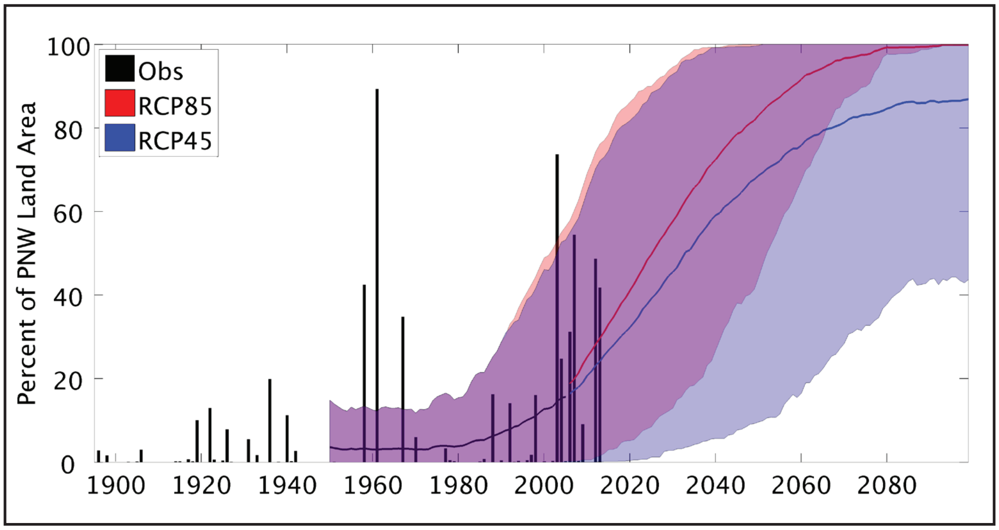

Figure 2. *Percentage of Pacific Northwest landmass experiencing summer (June, July, August) temperatures greater or equal to the warmest 5% of summer temperatures in the historical record (or approximately 1-in-20-year temperatures). Observed ("Obs") percentages are the grey bars. They consider the observational record from 1895 through 2013. The projected percentages under the RCP85/RCP45 future scenarios of CMIP5 are shown smoothed by a 21-year moving window, with red and blue lines representing the multi-model mean. Pink and blue shading represent the range of model projections. Model projections over the historical period (1950–2005) were run using historical forcing.*

How will climate change further alter the odds of a "hot" summer for the Pacific Northwest? To address this question we used output from a suite of global climate models from phase 5 of the Coupled Model Intercomparison Project (CMIP5) down-scaled to the spatial scales needed to understand local climate impacts. We considered two possible "futures," called Representative Concentration Pathways (RCPs), which account for the additional energy trapped in the earth's atmosphere due to increased greenhouse gas concentrations and land use changes. The two scenarios we used included the "business as usual" RCP85 and the "curtailed emissions" RCP45 pathways. A historical scenario that considered observed changes in natural and human-induced climate influences was also considered from 1950 through 2005. Down-scaled data from 14 different climate models under the 2 future scenarios were used to examine how future human-made changes in climate may impact the frequency of hot summers in the Pacific Northwest.

Climate projections for the Pacific Northwest generally suggest that the highest rates of warming will occur during the summer months. Figure 3 shows the projected changes in temperature over the Pacific Northwest for the 14-model average under RCP85. These projections place the most acute warming over the interior Pacific Northwest, with reduced warming for areas with significant maritime influence. Although projected warming varies from model to model, by the 2030s and 2040s, all models show warming exceeding 1°C, and some models show warming exceeding 4.5°C above the historical baseline. This warming is anticipated to continue through the 21st century and is particularly acute for pathway RCP85. By century's end, summer temperatures are projected to increase between 2 and 8.5°C above historical baseline temperatures.

Under the RCP85 future pathway, the currently rare 1-in-20-year "hot" summer becomes increasingly common, and by the 2030s–2040s occurs 3 out of every 4 years on average (Figure 2). By the 2060s–2070s, it becomes exceedingly rare to not experience a summer that we currently consider "hot." The alternative pathway, RCP45, shows a more modest increase in the number of "hot" summers among models with the lowest warming rates. However, the observed increase in the extent of such hot summers in recent decades is consistent with model projections and anthropogenic forcing, suggesting that these changes are already underway.

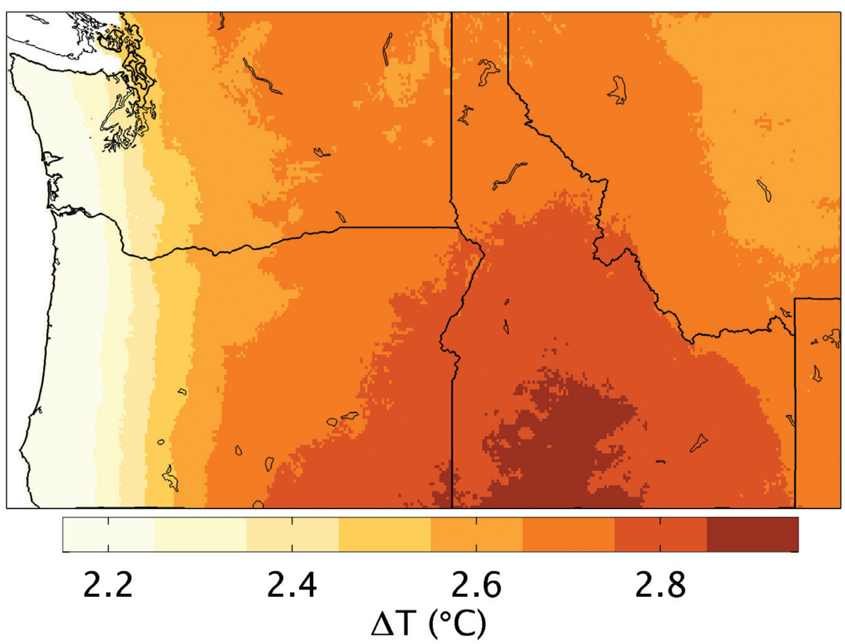

Figure 3. *Projected changes in average summer (June, July, August) temperatures for 2031–2050, as compared to averages from 1950–1999, are shown for the 14-model average under the RCP85 future scenario. Greater warming (up to nearly 3°C) is anticipated for the inland Pacific Northwest, with less warming (nearly 2°C) expected in coastal regions.*