Abstract

This study investigates temperature impacts to snowpack and runoff-driven flood risk over the Sierra Nevada during the extremely wet year of 2016–2017, which followed the extraordinary California drought of 2011–2015. By perturbing near-surface temperatures from a 9-km dynamically downscaled simulation, a series of offline land surface model experiments explore how Sierra Nevada hydrology has already been impacted by historical anthropogenic warming and how these impacts evolve under future warming scenarios. Results show that historical warming reduced 2016–2017 Sierra Nevada snow water equivalent by 20% while increasing early-season runoff by 30%. An additional one third to two thirds loss of snowpack is projected by the end of the century, depending on the emission scenario, with middle elevations experiencing the most significant declines. Notably, the number of days in the future with runoff exceeding 20 mm nearly doubles under a mitigation emission scenarios and triples under a business-as-usual scenario. A smaller snow-to-rain ratio, as opposed to increased snowmelt, is found to be the primary mechanism of temperature impacts to Sierra snowpack and runoff. These findings are consequential to the prevalence of early-season floods in the Sierra Nevada. In the Feather River Watershed, historical warming increased runoff by over one third during the period of heaviest precipitation in February 2017. This suggests that historical anthropogenic warming may have exacerbated runoff conditions underlyng the Oroville Dam spillway overflow that occurred in this month. As warming continues in the future, the potential for runoff-based flood risk may rise even higher.

Plain Language Summary

This study investigates temperature impacts to snowpack and runoff-driven flood risk over the Sierra Nevada during the extremely wet year of 2016–2017. Significant findings have been revealed related to recent public aware precipitation extremes. With a reasonably accurate representation of the historical precipitation and snowpack over the Sierra Nevada, results from the offline simulations with perturbed near-surface temperature reveal significant impacts of warming on snow water equivalent loss and flood risk. As the drought condition predicts to be more severe and precipitation to be more extreme, the loss of snowpack and intensified flood risk informs policymakers for better climate adaptation strategies for water resources supply and flood control.