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Atmospheric river influence on the intensification of extreme hydrologic events over the Western United States under climate change scenarios

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The Western United States shares limited snowmelt driven water supplies amongst millions of people, a multi-billion dollar agriculture industry and fragile ecosystems. The climatology of the region is highly variable, characterized by the frequent occurrences of both flood and drought conditions that cause increasingly challenging water management issues. Although variable year to year, up to half of California's total precipitation can be linked to atmospheric rivers (ARs). Most notably, ARs have been connected to nearly every major historic flood in the region, establishing its critical role to water supply. Numerous prior studies have considered potential climate change impacts over the Western United States and have generally concluded that warmer temperatures will reduce snowpack and shift runoff timing, causing reductions to water supply. Here we examine the role of ARs as one mechanism for explaining projected increases in flood and drought frequency and intensity under climate change scenarios, vital information for water resource managers. A hierarchical modeling framework to downscale 11 coupled global climate models from CMIP5 is used to form an ensemble of high-resolution dynamically downscaled regional climate model (via RegCM4) simulations at 18-km and hydrological (via VIC) simulations at a 4-km resolution for baseline (1965-2005) and future (2010-2050) periods under RCP 8.5. Each ensemble member's ability to capture observational AR climatology over the baseline period is evaluated. Baseline to future period changes to AR size, duration, seasonal timing, trajectory, magnitude and frequency are presented. These changes to the characterizations of ARs in the region are used to determine if any links exist to changes in snowpack volume, runoff timing, and the occurrence of daily and annual cumulative extreme precipitation and runoff events. Shifts in extreme AR frequency and magnitude are expected to increase flood risks, which without adequate multi-year reservoir storage solutions could further strain water supply resources.