U.S. Department of the Interior
Bureau of Reclamation
Research and Development Office
Science and Technology Program

Assessment of Potential Future Changes in Atmospheric Rivers Over the Western Coast of the United States

Research Bulletin S&T Project 1816

This project enhances our understanding of atmospheric river events across the Sierra Nevada and in the West by analyzing regional climate model projections of precipitation, snowfall, and other controls on western U.S. hydrology.

Mission Issue

Improved understanding of atmospheric river events allows for long-range planning for solutions such as forecast-informed reservoir operations and managed aquifer recharge.

Principal Investigator

Michael Wright
Water Resource Modeler
California–Great Basin Region
mwright@usbr.gov

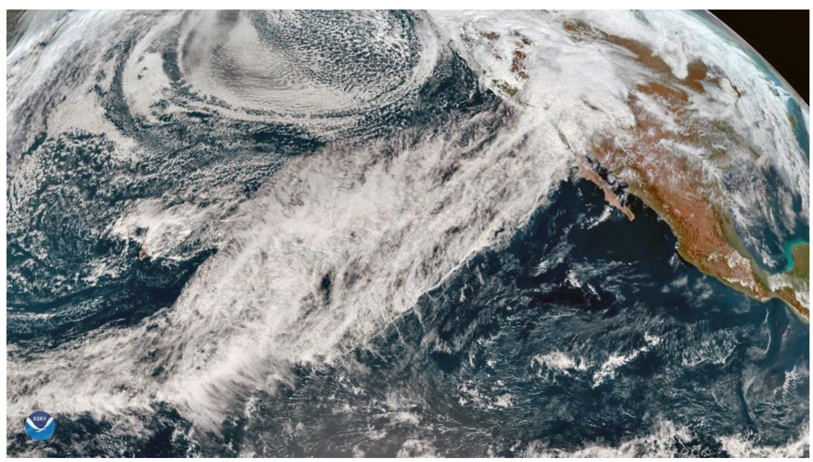
Research Office Contact

Kenneth Nowak
Water Availability Research Coordinator
knowak@usbr.gov

Problem

Understanding future precipitation changes is critical for water supply management and flood risk applications in the western United States. Forecasts and projections of climate variability and change on these time scales can be generated using dynamical downscaling, where global climate models (GCMs), capable of simulating large-scale circulation patterns but often lacking in regional-scale detail, are used to drive higher resolution dynamical regional climate models (RCMs) in areas of interest. Of crucial interest are atmospheric rivers (ARs), major water vapor transport events carrying moisture into California and driving orographic precipitation.

The Sierra Nevada mountain range is the source of much of California's water supply, which is held mostly in the form of snowpack. Potential shifts in rain-snow mix, location and intensity of those storms will have a major effect on water supply in decades to come. Water managers need supply estimates that account for possible future changes in precipitation amount and phase (rain or snow).



An atmospheric river impacts Baja California and the West Coast of the United States.

Solution

The North American COordinated Regional Downscaling EXperiment (NA-CORDEX) matrix of global and regional climate models at multiple resolutions (~50-km and 25-km grid spacings) is used to evaluate mean monthly precipitation, extreme daily precipitation, and snow water equivalent (SWE) over the western United States, with a sub-regional focus on California.

The NA-CORDEX matrix' mix of climate models creates an ensemble from which conclusions can be drawn by decision makers and practitioners of climate-adjacent disciplines such as water resources management. More information is available at: https://na-cordex.org/.

"An increase in the magnitude of cool-season, western US daily extreme (99th percentile) precipitation is a consistent finding that can be useful in both scenario planning and to inform inputs for secondary application models."

Kelly Mahoney
Research Scientist
National Oceanic and Atmospheric Administration

Collaborators

Kelly Mahoney
Research Scientist
National Oceanic and Atmospheric Administration

Mimi Hughes
Research Scientist
National Oceanic and Atmospheric Administration

More Information

https://www.usbr.gov/research/projects/detail.cfm?id=1816

https://psl.noaa.gov/news/2021/022321.html

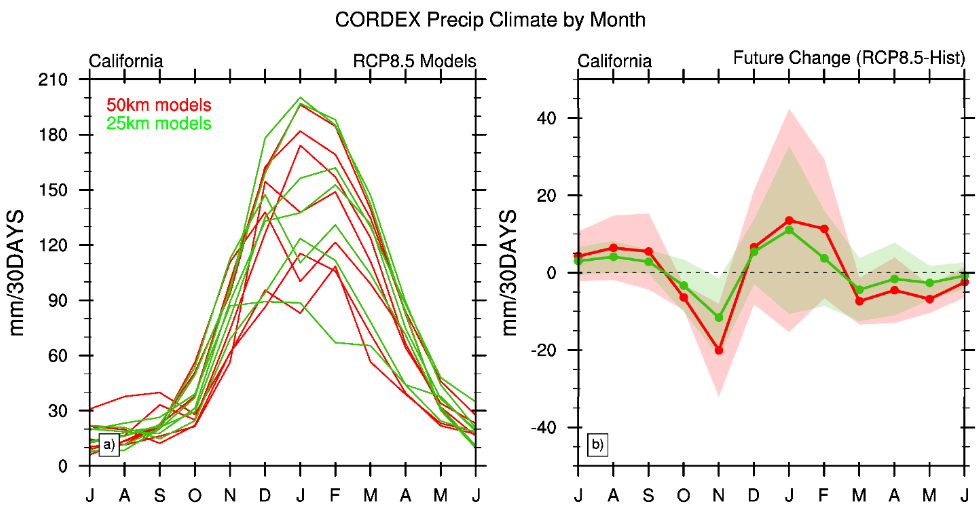
Mahoney, K., Scott, J.D., Alexander, M. et al. Cool season precipitation projections for California and the Western United States in NA-CORDEX models. *Clim Dyn* (2021).

https://doi.org/10.1007/s00382-021-05632-z

Application and Results

The NA-CORDEX model ensemble (Mearns et al. 2017) is composed of 6 regional climate models (RCMs), driven by one or more of six global climate models (GCMs; see https://na-cordex.org/). For the historical period (1976 – 2005), precipitation values from the NA-CORDEX simulations are compared to values from two high-resolution precipitation datasets developed by Livneh et al. (2013) and Newman et al. (2015).

Results indicate significant model spread in mean monthly precipitation in several key water-sensitive areas in both historical and future projections, but suggest model agreement on increasing daily extreme precipitation magnitudes, decreasing seasonal snowpack, and a shortening of the wet season in California in particular. While the beginning and end of the California cool season are projected to dry according to most models, the core of the cool season (December, January, February) shows an overall wetter projected change pattern. By the end of the century, extreme AR events increase in frequency whereas moderate AR events decrease in frequency. Projected precipitation changes during AR events also depend on event intensity. In the future, precipitation across the Sierra Nevada generally increases during extreme AR events and decreases during moderate AR events.



a) Seasonal mean monthly future precipitation (mm/30 days) averaged over the state of California for individual 50-km (25-km) simulations shown in red (green) lines; b) Future – historical projected changes in mean monthly precipitation (mm/30 days) for 50-km (red) and 25-km (green) simulations. Red (green) shaded area shows +/- 1 sigma of 50-km (25-km) grid spacing models for projected Future – Historical mean monthly change.

Future Plans

A follow-on S&T research project downscales model results to a 4-km grid using the Intermediate Complexity Atmospheric Research (ICAR) model before passing rain- and snowfall projections on to Variable Infiltration Capacity (VIC) runoff modeling. The runoffs generated by VIC modeling will be used as inputs to CalSim 3, a water supply and demand model of the Central Valley watershed of California, to model changes in future water supplies given the findings of this research.