Atmospheric rivers: the main driver of California's volatile water supply and flood risks

2025 State of Bay-Delta Science

Delta Science Program

DELTA STEWARDSHIP COUNCIL

What are atmospheric rivers?

California's climate naturally swings between wet and dry years. Most of the state's rain or snow arrives in large storms called **atmospheric rivers**. These storms carry a vast amount of moisture in their paths, almost like rivers flowing through the atmosphere.

A few large atmospheric rivers each winter can make the difference between a wet or a dry year. Atmospheric rivers are expected to become wetter and stronger by the end of this century while other storms become less frequent, making California's climate even more variable and prone to drought and flood.

How do atmospheric rivers affect the Delta?

When **floods** occur in the Sacramento-San Joaquin Delta (Delta) they are typically associated with extreme runoff from atmospheric rivers. Levee improvements and water management actions have reduced major flood events in recent years. California has also not experienced its most extreme storms in the last quarter century. However, climate models suggest that precipitation events on the scale of those that caused the devastating New Year's 1997 floods could be twice as likely by the end of this century.

Flooding threatens the lives and homes of Delta residents and impacts water quality. As the hub of the state's water supply, flooding in the Delta affects Californians all across the state.

Trends

California's water future is expected to become even more variable, with stronger atmospheric rivers but less frequent precipitation from other storms and a diminishing snowpack at lower elevations.

Challenges

Tremendous and increasing natural climate variability makes it difficult to detect changes or new trends for atmospheric rivers and precipitation.

? Uncertainties

Water management faces uncertainties due to a lack of accurate seasonal forecasting tools and unknown changes to total annual precipitation.

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What are we learning?

Atmospheric rivers are expected to become more intense over the 21st century. However, this has not yet been observed. California's naturally variable climate appears to be masking trends such that changes in storm intensity patterns might not emerge until much later this century – long after their impacts begin.

What is matching projections, however, is that California's snowpack is declining. More rain and less snow is falling at lower elevations. During future atmospheric river storms, this trend is expected to cause flashier runoff where streams and rivers rapidly rise, increasing flood risks and stressing reservoirs and downstream infrastructure.

Atmospheric rivers are responsible for the biggest floods in California and catastrophic flooding from these storms can happen in any winter, even during drought years. Atmospheric rivers are not necessarily associated with predictable wet or dry seasonal patterns or the phenomena known as El Niño and La Niña.

Modernizing dams, levees, and aqueducts has helped reduce flood issues in recent decades, and new initiatives aimed at improving flood protection through multi-benefit approaches and nature-based solutions are underway. These and other planning efforts would strongly benefit from longer lead-time weather forecasts and advanced monitoring networks.

Three key takeaways

Looking ahead, California will need to manage water resources with less reliable snowpacks, fewer but stronger storms, and more flooding.

Atmospheric rivers aren't associated with typical wet or dry season patterns, making it difficult to predict how and where they will occur more than a few weeks out.

Flexible water management frameworks that balance flood control, groundwater recharge, and sustainability will be increasingly important in the future.

About the State of Bay-Delta Science

The State of Bay-Delta Science is a synthesis and communication project coordinated by the Delta Science Program to summarize the scientific understanding, or "state of the science," of important topics in the Bay-Delta system. For more information, visit the SBDS website at https://sbds.deltacouncil.ca.gov.

This summary is based on the 2025 State of Bay-Delta Science article by Gershunov et al. (2025).

Gershunov A, Hatchett B, Weyant A, Dettinger M, Su L, Rhoades A, et al. 2025. Atmospheric Rivers and Floods in California's Changing Hydroclimate. San Francisco Estuary and Watershed Science 23(3).

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