Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

AN INSTRUMENTAL AND PALEOCLIMATE PERSPECTIVE ON SPRING PRECIPITATION AND MIRACLE MARCH IN CALIFORNIA

THE CHALLENGE

The Center for Western Weather and Water Extremes (CW3E) and the University of Arkansas have investigated the frequency of Miracle March in California with instrumental precipitation records and specialized tree-ring chronologies of earlywood, latewood, and total ring width that can be used to independently estimate winter (October-February) and spring (March-April) precipitation variations for a region in the American River basin since 1750. The instrumental and tree-ring records indicate that the 1991 Miracle March was unprecedented in terms of the magnitude of change from winter to spring and the geographic impact of spring precipitation. Heavy spring precipitation is usually not enough to eliminate a wet season precipitation deficit (Figure 1), but spring moisture can mitigate drought established earlier in the wet season and analysis indicates that this type of drought alleviation tends to cluster in decadal to multidecadal regimes based on the instrumental and paleoclimate records.

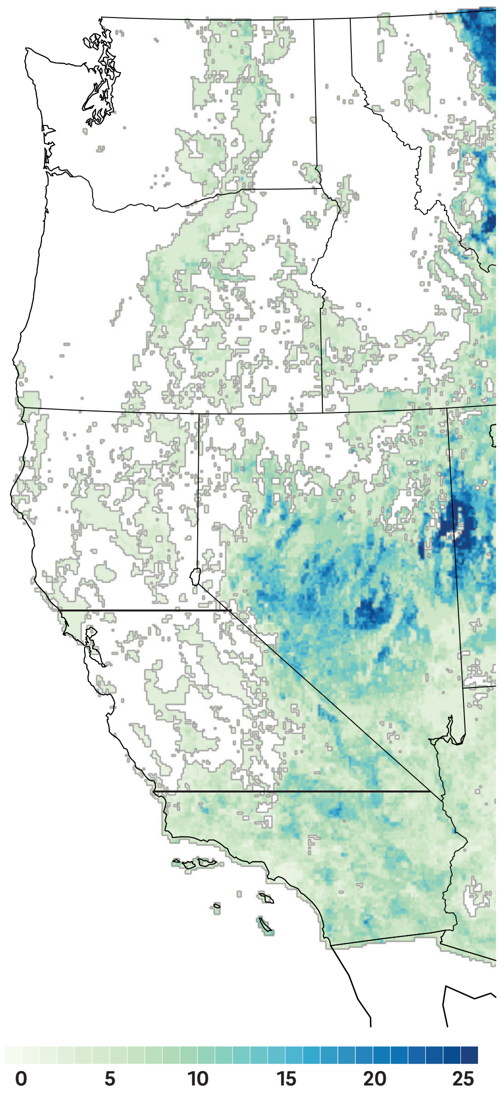

Figure 1. The probability that the wet season (October-May) percent of normal precipitation will be above average when the first five months (October-February) of the wet season were less than 75% of normal using PRISM monthly precipitation data, 1895-2022. There is little to no chance that spring precipitation can bring the full wet season total to normal over central or northern California, but the probabilities improve in the southern half of the state. Horizontal lines demarcate the boundaries between southern, central, and northern California.

WHAT MADE THE ORIGINAL MIRACLE MARCH (1991) UNIQUE?

The 1991 Miracle March was highly anomalous given the extreme antecedent drought conditions. Beginning in late-February of 1991, an AR-4 atmospheric river event, based on the Ralph et al. (2019) ARScale, reversed the dryness and brought wet season totals to near and in some areas above normal over California. In southern California, total precipitation changed from 61% of normal for October-February to 112% of normal for October-May, the largest increase (for these seasons) in the instrumental record. Similar reversals were observed in central and northern California in 1991, though the spring totals were not large enough to bring the wet season total to average. The instrumental record highlights that outside of 1991 most often spring drought relief and Miracle March have more sub-state rather than state-wide impacts.

A 273-YEAR TREE-RING PERSPECTIVE ON MIRACLE MARCH IN NORTHERN CALIFORNIA

Tree-ring chronologies from northern California with separate winter (October-February) and spring (March-April) precipitation signals (Figure 3) were developed making it possible to compare inter-seasonal precipitation variability and phenomenon like Miracle March prior to the modern era (Figure 2). Percent of normal series computed using the tree-ring reconstructions are plotted to illustrate years of major dry to wet reversals and to provide a long-term perspective for the 1991 Miracle March. The tree-ring reconstructions suggest that prior to 1895 there was only one year (1808) that matched the magnitude of precipitation change from winter to spring observed in 1991 (Figure 2). There are several decadal to multi-decadal periods when spring alleviation years occur at a greater frequency, especially the early-1800s (Figure 2b) and from 2010 to present (Figure 2a).

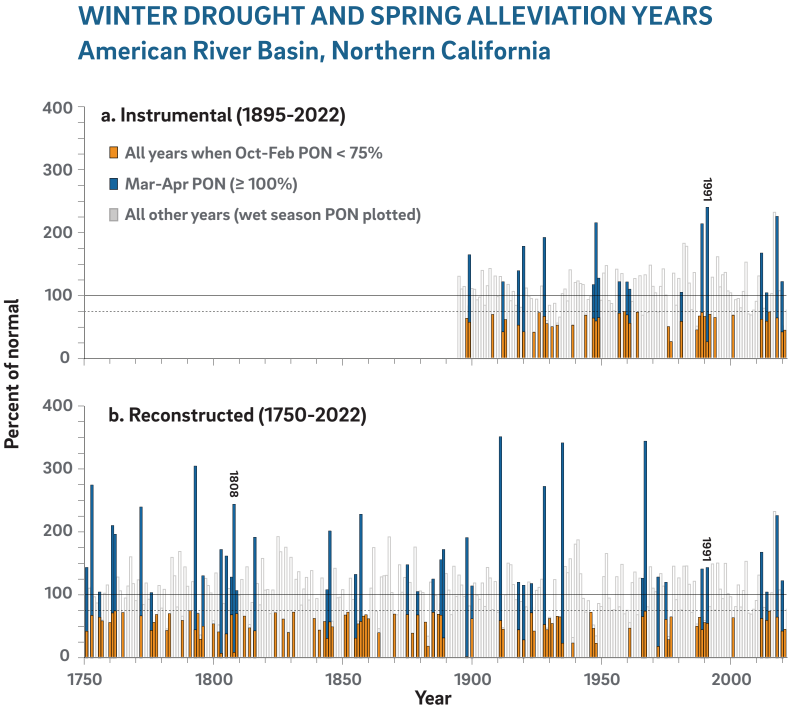

Figure 2. Percent of normal (PON) precipitation was calculated using (a) PRISM data from 1895-2022 and (b) tree-ring reconstructions of winter (October-February) and spring (March-April) precipitation from 1750-2003 (instrumental data appended to the reconstruction after 2003). The red bars are the percent of normal values for the years when October-February was dry (<75% of normal). The blue bars represent years of drought alleviation when above normal spring precipitation (≥100% of normal) followed dry conditions during winter. The year 1808 is noted because it represents the only year in the reconstruction before 1895 that matches the magnitude of precipitation change from winter to spring observed in the instrumental data for the "Miracle Spring" 1991.

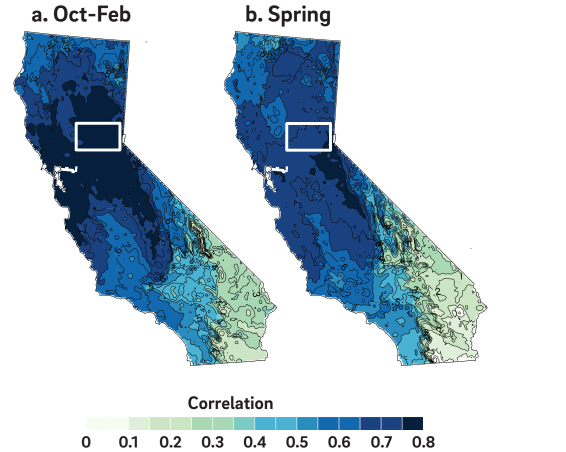

Figure 3. Correlation of (a) tree-ring reconstructions of winter (October-February, based on blue oak ring width) and (b) spring precipitation (March-April, based on ponderosa pine latewood width) instrumental winter and spring precipitation totals statewide (1949-2003 for the winter and 1948-2017 for the spring reconstruction). The two seasonal reconstructions are not strongly correlated to each other, similar to the weak correlation observed for the instrumental totals in the study area.

FUTURE WORK

Future work will focus on extending the sub-annual tree-ring chronologies temporally and spatially across California to better estimate seasonal precipitation variability. Preliminary results from southern California indicate that high-quality reconstructions of spring precipitation will be possible using latewood width of Jeffrey pine for comparison with winter precipitation reconstructions based on blue oak and other conifers. A global climate model ensemble approach will also be used to develop a robust characterization for how unusual the 1991 Miracle March may have been and to identify the ocean-atmospheric dynamics responsible for spring alleviation events.

Cody Poulsen taking a tree core sample of an old growth Jeffrey Pine at Mt. Laguna in the Cleveland National Forest.

Authors

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References

Howard, I.M., D.W. Stahle, M.C.A. Torbenson, D. Granato-Souza, and C. Poulsen, 2022: The Flood Risk and Water Supply Implications of Seasonal Precipitation Reconstructions in Northern California. *Accepted in San Francisco Estuary and Watershed Science.*

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