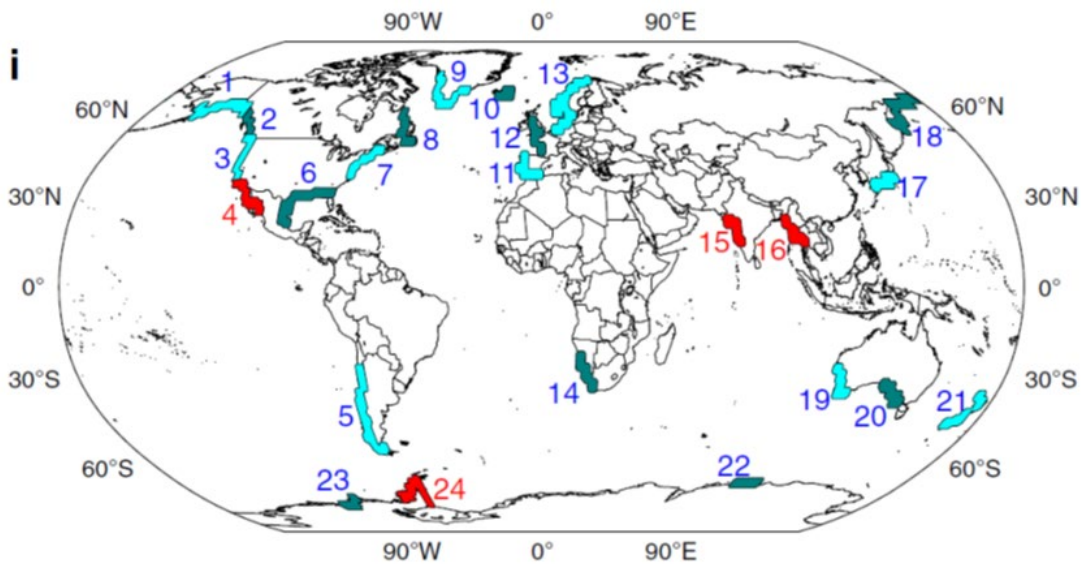
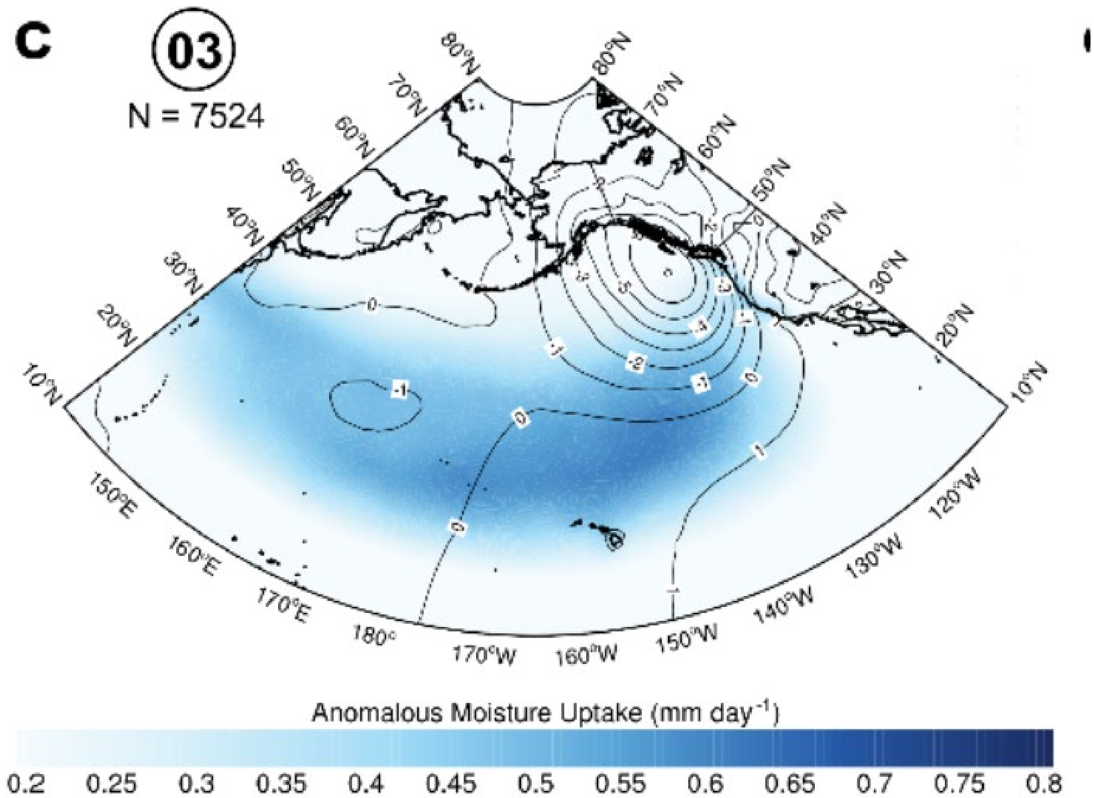
From: Deirdre Des Jardins <ddj@cah2oresearch.com>
Sent: Thursday, March 20, 2025 3:02 PM
To: Delta Council ISB <disb@deltacouncil.ca.gov>

Subject: Decline in precipitation in landfalling atmospheric rivers on west coast of North America

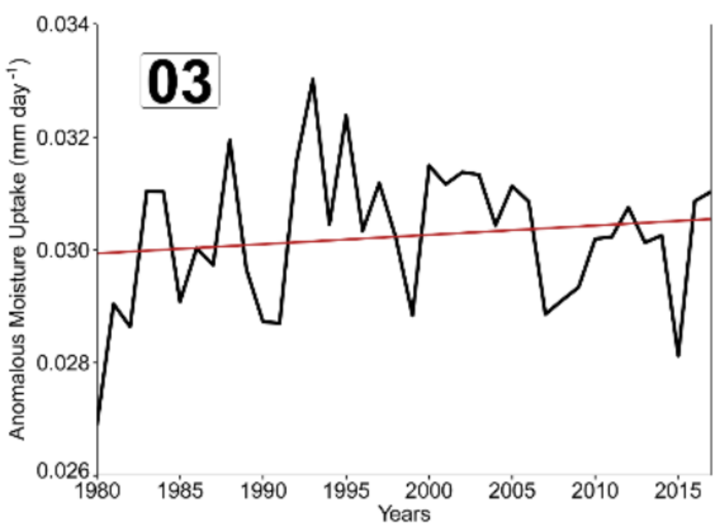
This is from a study by Spanish & Portuguese researchers Iago Algarra, Raquel Nieto, and Alexander Ramos et al. (Significant increase of global anomalous moisture uptake feeding landfalling Atmospheric Rivers, 2020.) They used the AR catalog developed by Guan and Waliser to find the 24 coastal locations worldwide with the most landfalling atmospheric rivers each year. From Figure 1 (cc 4.0):



Algarra et al. used a Langrangian model forced by ERA interim reanalysis data and ran air parcels from ARs backwards to see where the ARs picked up moisture over the oceans. This is the region of anomalous moisture uptake for landfalling atmospheric rivers on the west coast of North America. From Supplementary Figure 1.

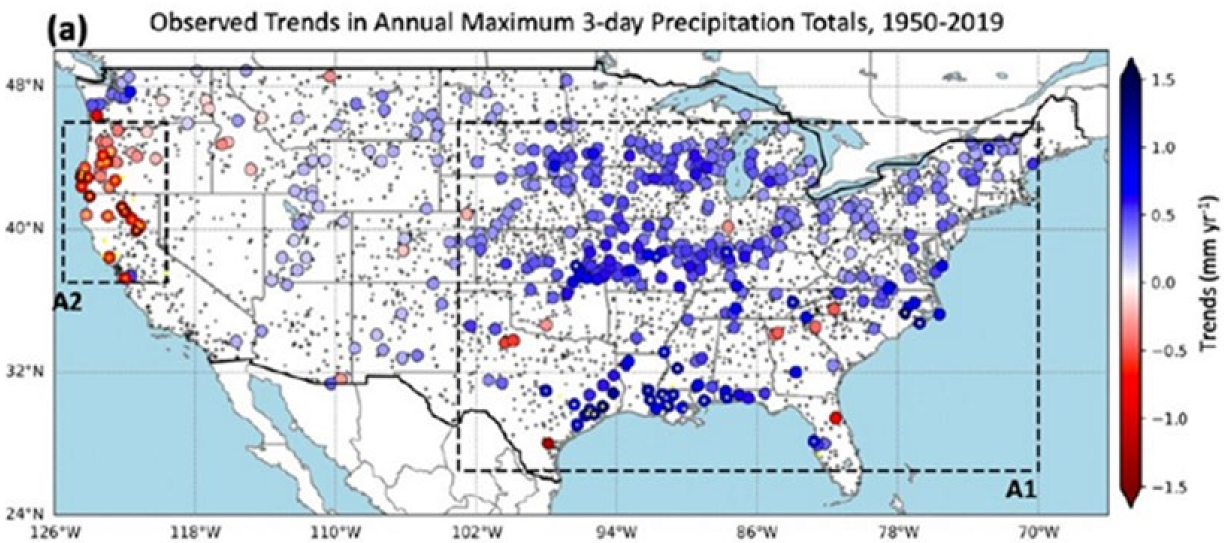


They found a peak in anomalous moisture uptake by ARs landfalling on the west coast of North America in the early 1990s. Trenberth & Hoar previously associated the period of 1990-1995 with anomalously persistent warm SST anomalies in the Central Pacific. ([The 1990–1995 El Niño-Southern Oscillation Event: Longest on Record](), 1996) But since then, anomalous moisture uptake by ARs has declined. From Supplementary Figure 5:

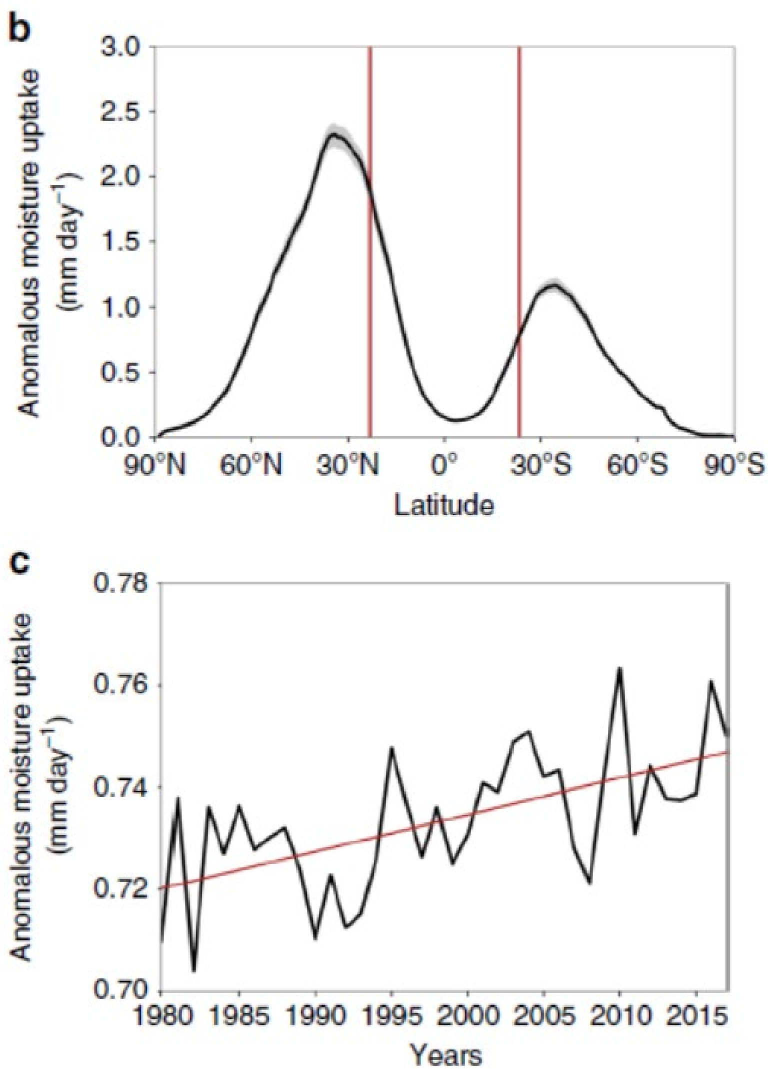


This helps explain the anomalous decline since 1950 in maximum 3-day precipitation found by Maryam Lamjiri, Marty Ralph, and Mike Dettinger in

Recent Changes in United States Extreme 3-Day Precipitation Using the R-CAT Scale. J. Hydrometeor., 21, 1207–1221.



Except for regions adjacent to the North Pacific, almost every other AR region in the world has seen a significant increase in anomalous moisture uptake, consistent with the Clausius-Clapeyron relationship. From Figure 3.



A 2019 study by Gershunov and the Scripps CW3E folks (with Mike Dettinger) had similar findings: [Precipitation regime change in Western North America: The role of Atmospheric Rivers | Scientific Reports (nature.com)]

Although the study focused mostly on GCM projections, the authors also analysed the Livneh precipitation database and found an overall decrease in AR-related precipitation from 1951-2000 on the West coast, and more in California.

In the supplementary information,

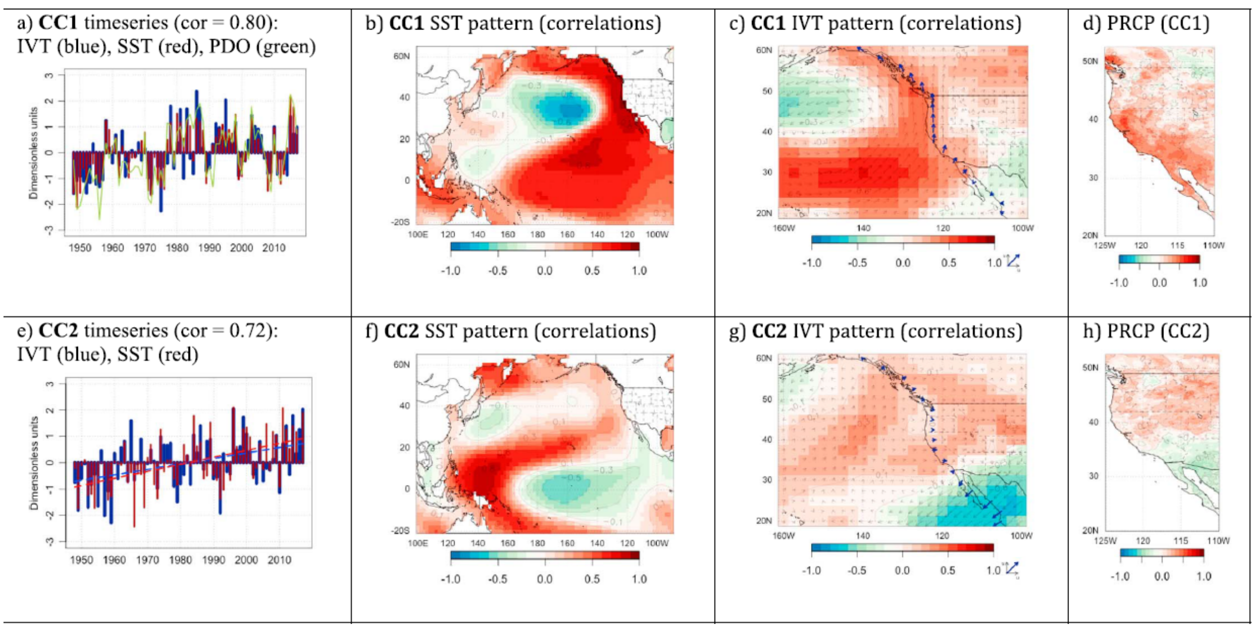
Table S6 shows a reduction in annual AR precipitation on the West coast of -16 mm (14%), compensated for by an increase in non-AR precipitation of +47 mm (9 %)

Table S5 shows a reduction in annual AR precipitation in California of -70 mm (32%), compensated for by an increase in non-AR precipitation of +112 mm (28%).

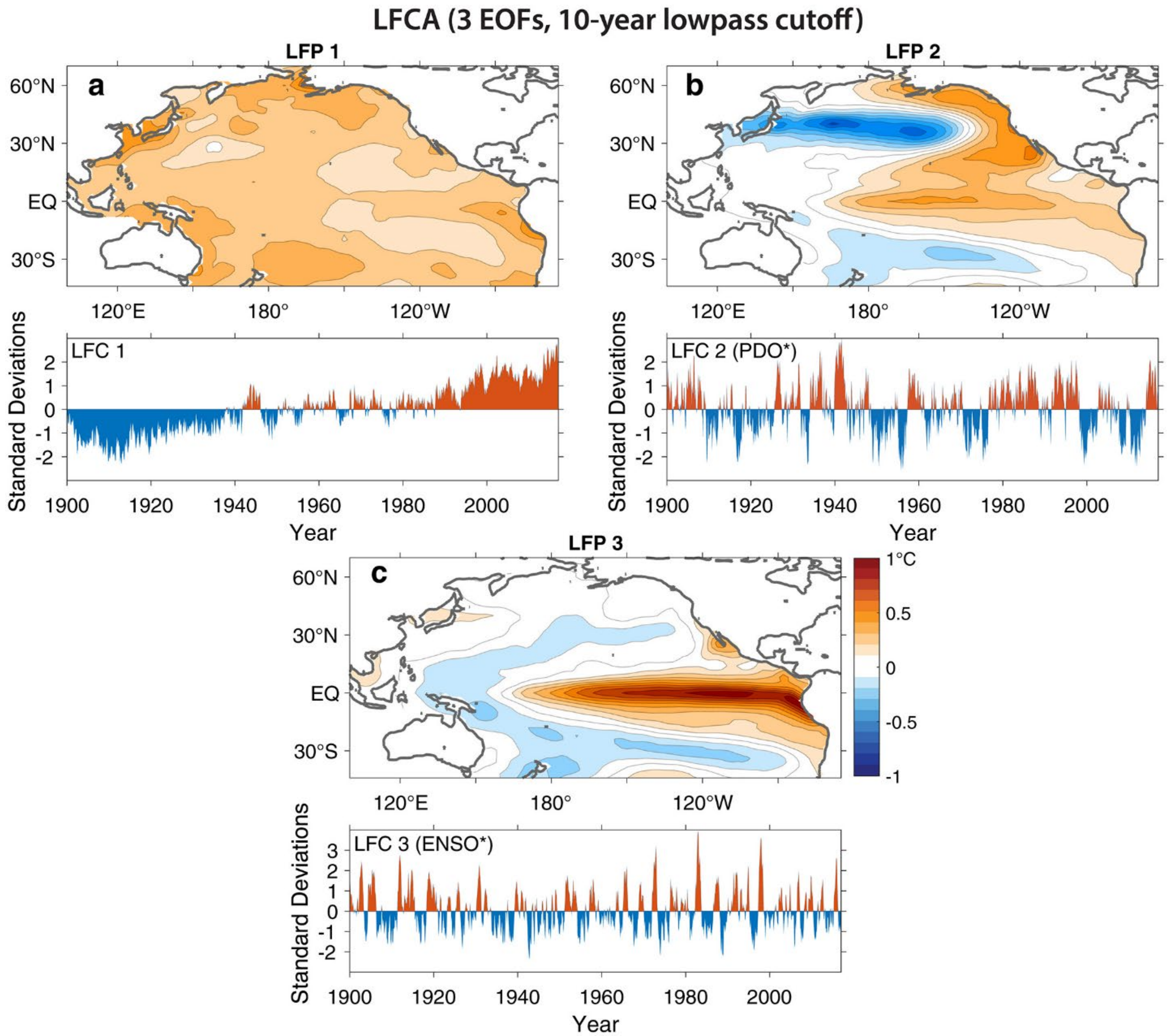
Leaving aside the increase in non-AR precipitation, which may have reversed since 2000, -70mm (32%) seems like a LARGE decrease in average annual AR precipitation in California. The decline may be associated with the fairly persistent cold PDO pattern since the North Pacific climate shift after the 1997/98 strong El Nino.

Gershunov and the CW3E folks did a nice study in 2017 of NCEP-NCAR reanalysis data from January-March. Assessing the climate-scale variability of atmospheric rivers affecting western North America - Gershunov - 2017 - Geophysical Research Letters - Wiley Online Library They did automated detection of ARs, and then used Canonical Correlation Analysis to find time correlations. Below are the first two leading canonical correlates and their associated spatial correlations with SSTs and Integrated Vapor Transport (IVT).

The first canonical correlate shows that IVT in land-falling ARs in Jan-March is strongly correlated with the Pacific Decadal Oscillation, and that we see more IVT with positive phases of the PDO.



The first two canonical correlates found by Gershunov et. al. are related to the low-frequency component analysis (LFCA.) by Wills et. al., Their LFCA analysis found three Low Frequency Patterns, which they associated with long term global warming, PDO, and ENSO:



Low-frequency components (LFCs) of Pacific sea surface temperature anomalies. (a)–(c) Low-frequency patterns (LFPs) and the corresponding LFCs, obtained from a linear transformation of the first three Empirical Orthogonal Functions (EOFs) of Pacific sea surface temperature anomalies (45°S–70°N) that maximizes their ratio of low-frequency (decadal) to total variance. They represent (a) global warming, (b) the Pacific Decadal Oscillation (PDO), and (c) the El Niño–Southern Oscillation (ENSO). Throughout the rest of the text, LFCs 2 and 3 are referred to as the PDO* and ENSO* indices, respectively.

This relates landfalling ARs to the pattern effect.

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Deirdre Des Jardins

California Water Research
Integrative scientific synthesis

"We aren't just failing to address the growing climate crisis to come; we're unprepared even for the impacts already here—in part because they keep surprising us with their intensity and in part because we can't seem to fathom our genuine vulnerability." – David Wallace Wells

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