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

Heresy in ENSO teleconnections: atmospheric rivers as disruptors of canonical seasonal precipitation anomalies in the Southwestern US

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WSWC S2S Workshop
May 2025

Luna-Niño and coauthors. 2025. Heresy in ENSO teleconnections: Atmospheric Rivers as disruptors of canonical seasonal precipitation anomalies in the Southwestern US. *Climate Dynamics*, *63*(2), 115.

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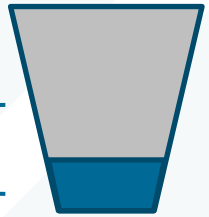
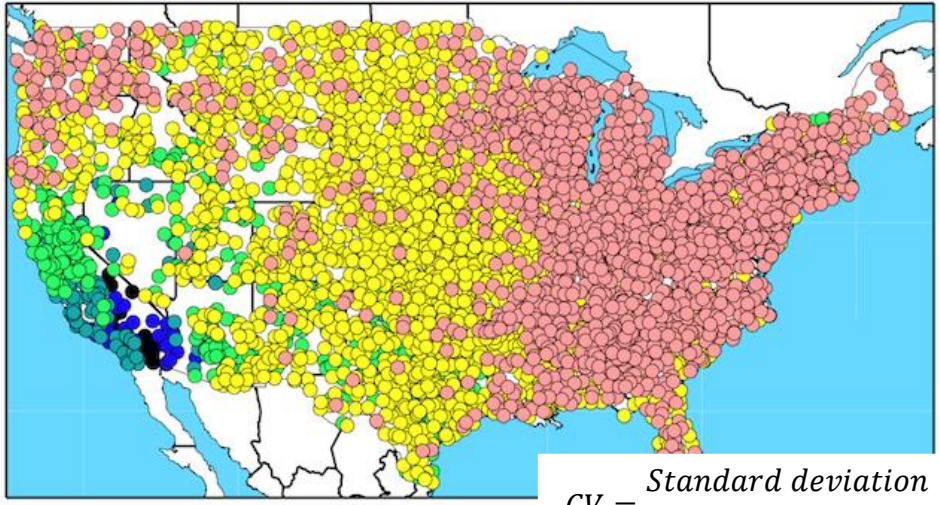
Annual Precipitation Variability (California's volatile hydroclimate)

Annual precipitation "bucket" for southern California



Year-to-year variations ~40-60%

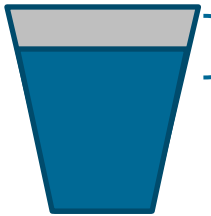
COEFFICENTS OF VARIATION OF TOTAL PRECIPITATION, WY 1951-2008



(Dettinger et al. 2011)

$$CV = \frac{Standard\ deviation}{Mean}$$

Annual precipitation "bucket" for eastern US



Year-to-year variations ~10-20%

California exhibits the greatest interannual variability
(yearly fluctuations are about half of the average annual total)

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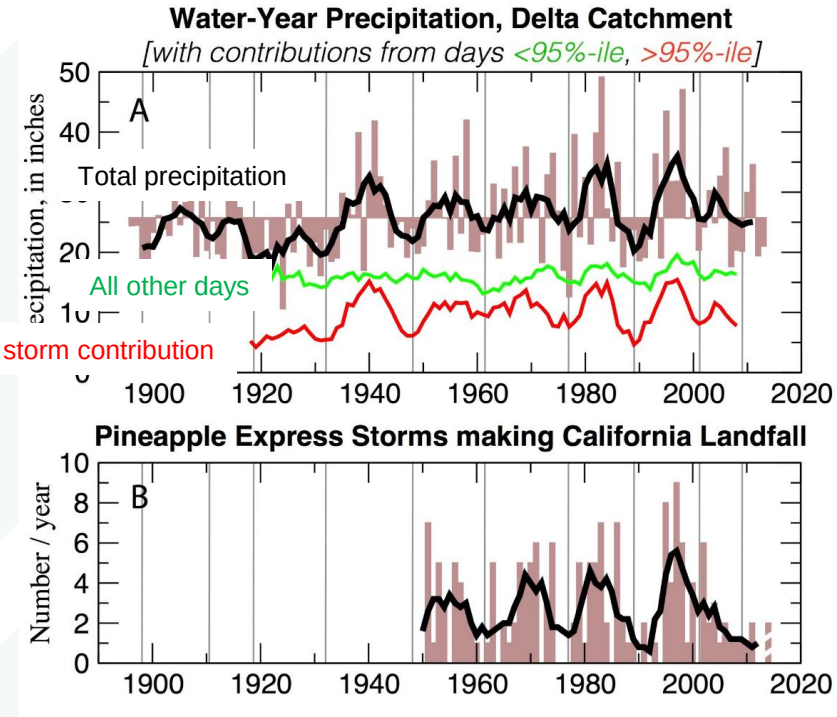
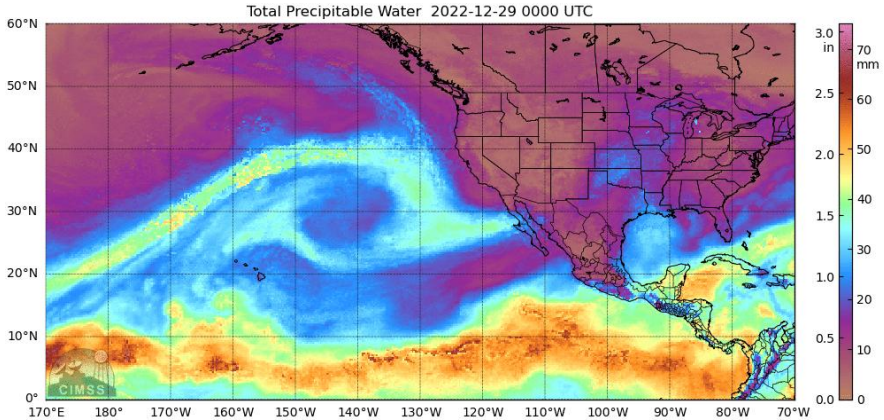
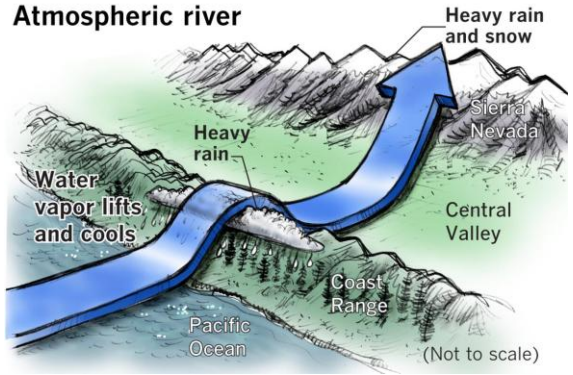
Atmospheric Rivers (ARs)



(Dettinger and Cayan, 2014)





Precipitation variability is linked to the extreme events.
A few large storms (or their absence) account for California's precipitation variability (mostly ARs)

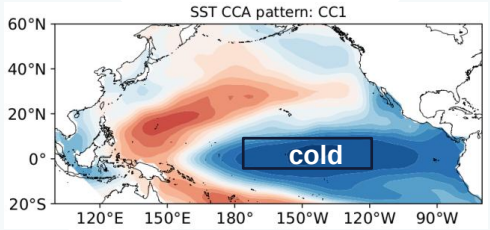
ENSO and precipitation predictability at seasonal scale

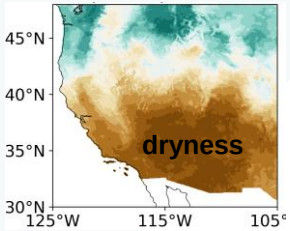
ENSO teleconnection

Sea surface temperature

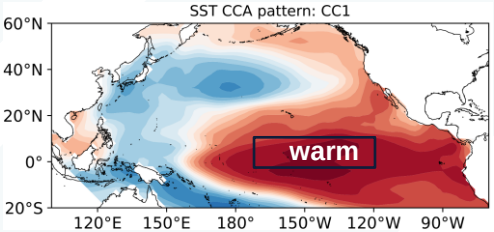
Precipitation

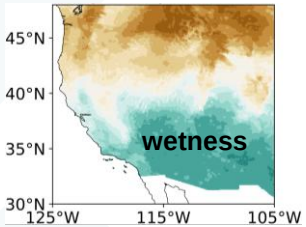
La Niña





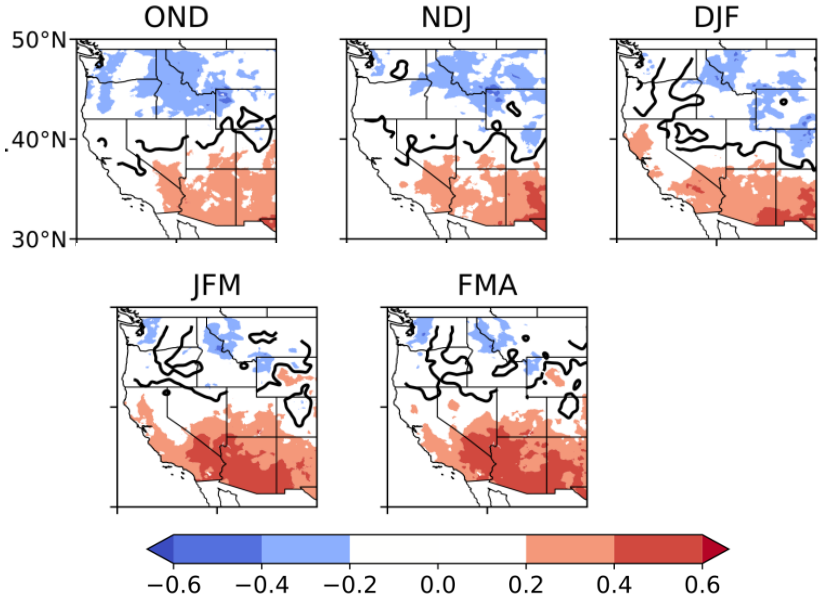
El Niño





ENSO canonical signal in precipitation anomalies

Correlation ONI (El Niño index) and Precipitation



ENSO teleconnection is strongest in late winter (JFM) and early spring (FMA)

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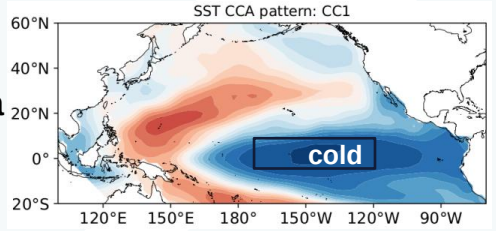
ENSO and precipitation predictability at seasonal scale

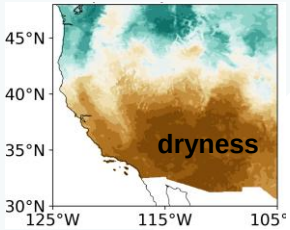
Canonical ENSO signal (strongest in JFM)

Sea surface temperature

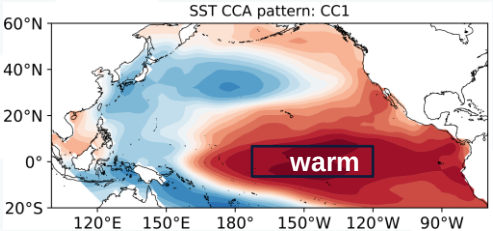
Precipitation

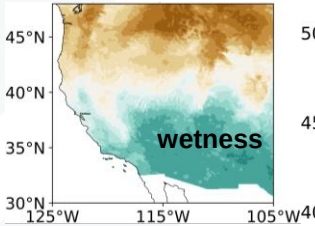
La Niña



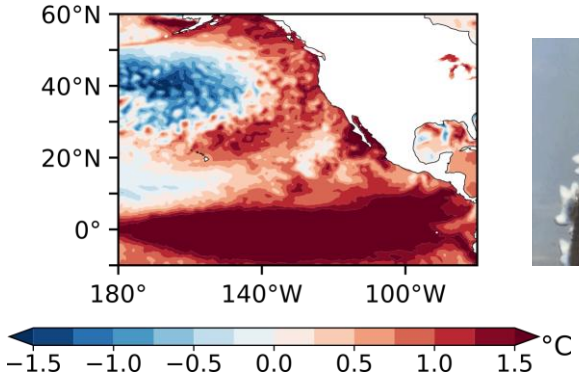


El Niño

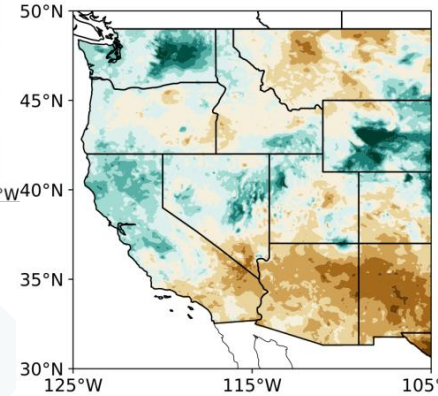




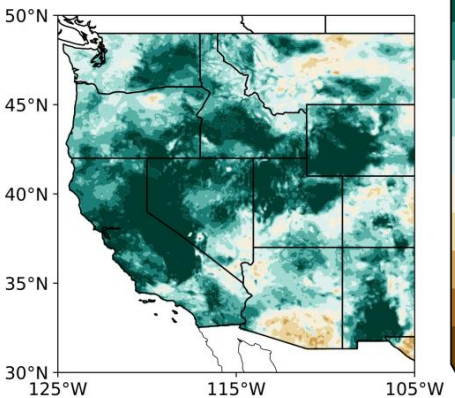
Pacific SST anomalies during JFM 2016

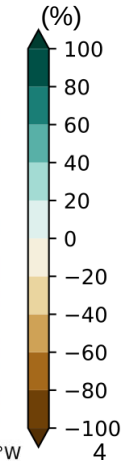


“Godzilla El Niño" 2016



Weak La Niña 2017





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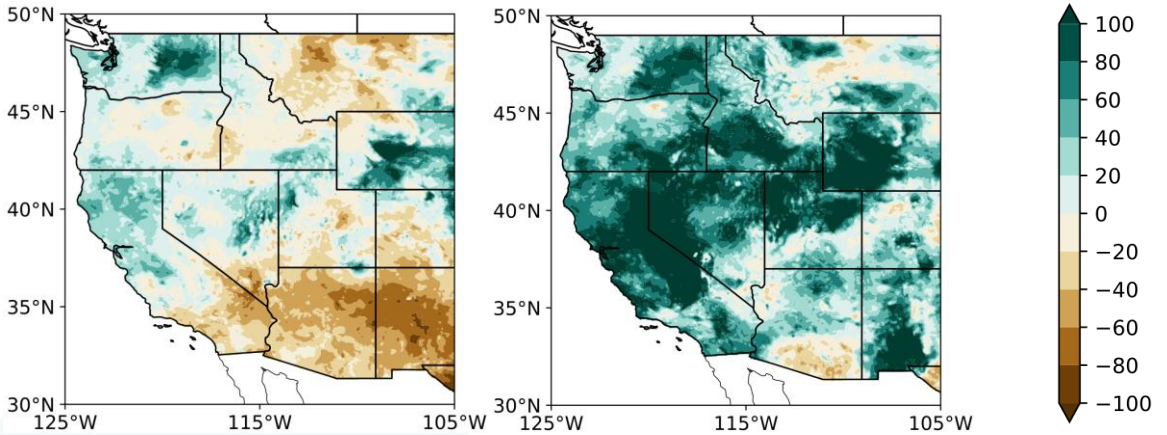
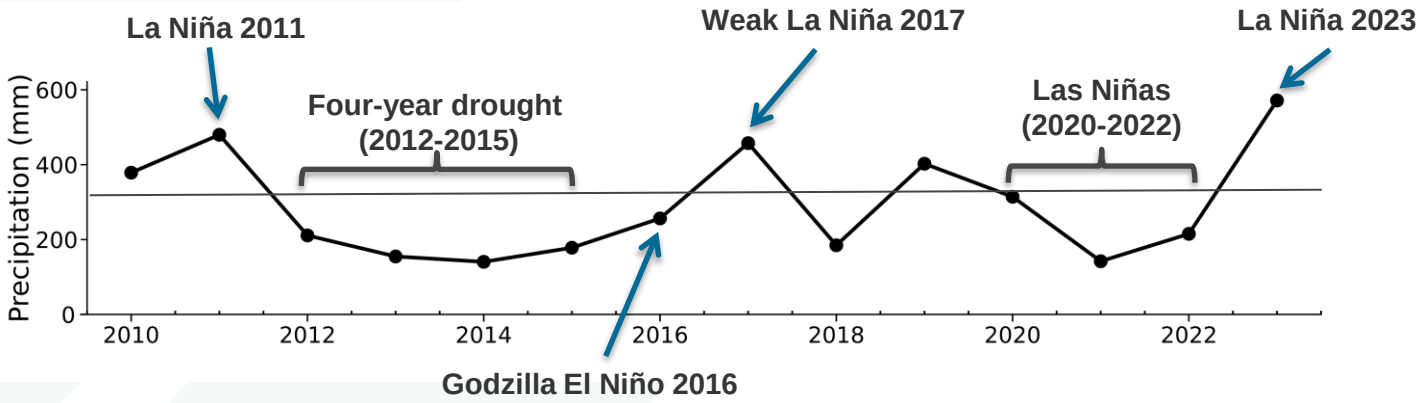
“Godzilla El Niño" 2016

Weak La Niña 2017



ONDJFMA precipitation in SoCal



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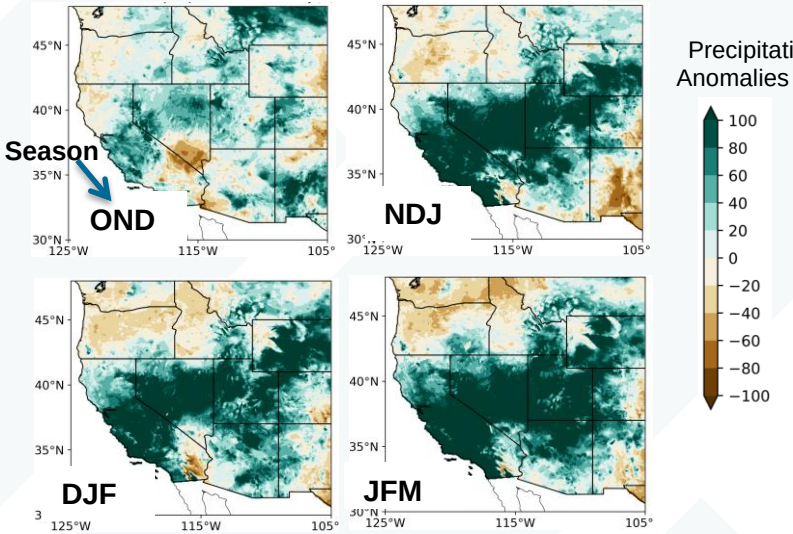
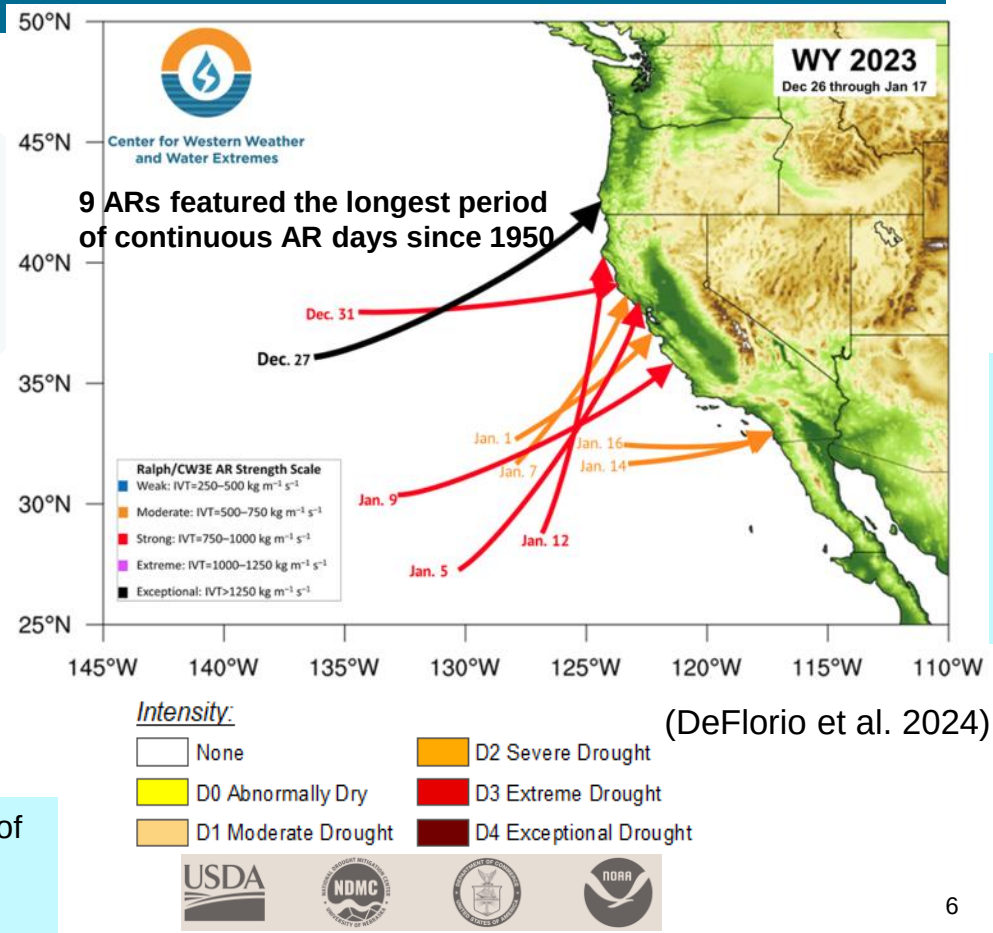
Unexpected precipitation during La Niña 2023

Observed precipitation anomalies during La Niña 2023



(PRISM data: https://prism.oregonstate.edu/)



(DeFlorio et al. 2024)

La Niña 2023 challenged the seasonal precipitation prediction of statistical and dynamical models, which predominantly forecasted canonical La Niña anomalies

Objective: Water years that deviated from ENSO canon and brought opposite precipitation anomalies motivated this study to re-examine ENSO's influence on precipitation in the Western US, focusing on California and, especially on SoCal. We assess the role of ARs in the radical deviation from ENSO canon.

Atmospheric river activity

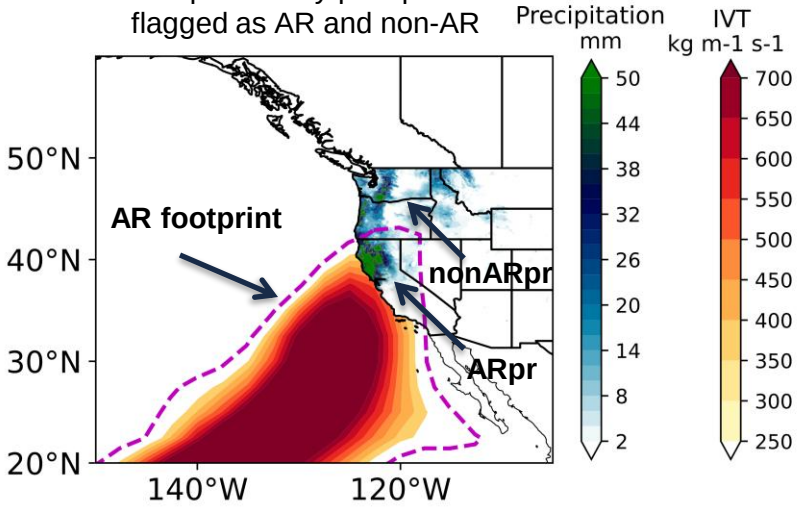
→ ARs that make landfall along the North American West Coast (20°N-60°N). We used the Scripps Institution of Oceanography (SIO)-R1 catalog (Gershunov et al. 2017).

Observed precipitation

→ Daily precipitation observations gridded at 4 km from nClimGrid (Durre et al. 2022).

→ Water Year is defined as the accumulated precipitation during the wet season from October to April (1952-2023)

Example of daily precipitation flagged as AR and non-AR



ENSO conditions

→ Oceanic Niño Index (ONI), which is based on SST in Niño 3.4 region, from the NOAA Extended Reconstructed SST V5 data (https://psl.noaa.gov; Huang et al. 2017).

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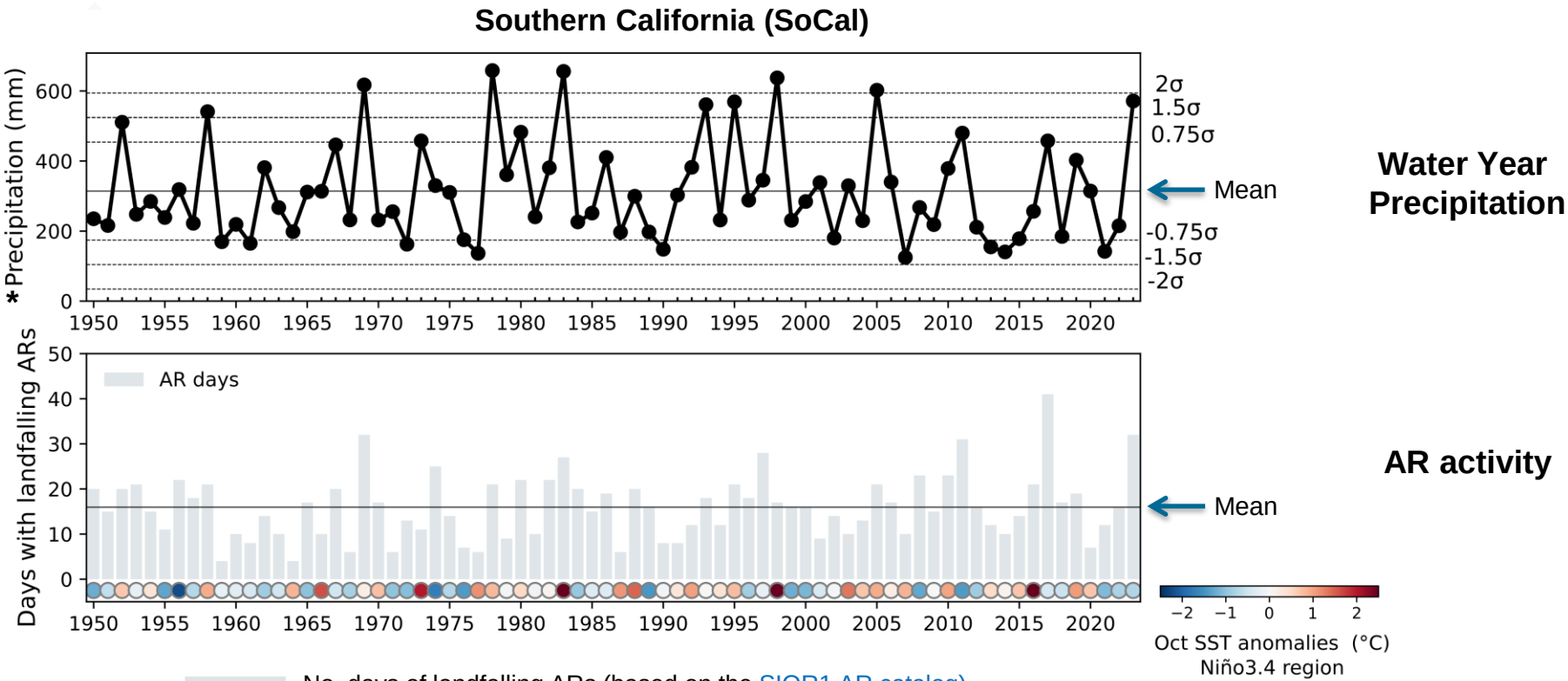
Results

Atmospheric Rivers as wild cards of seasonal precipitation prediction



Water Year Precipitation

AR activity

No. days of landfalling ARs (based on the SIOR1 AR catalog)

*Water Year precipitation

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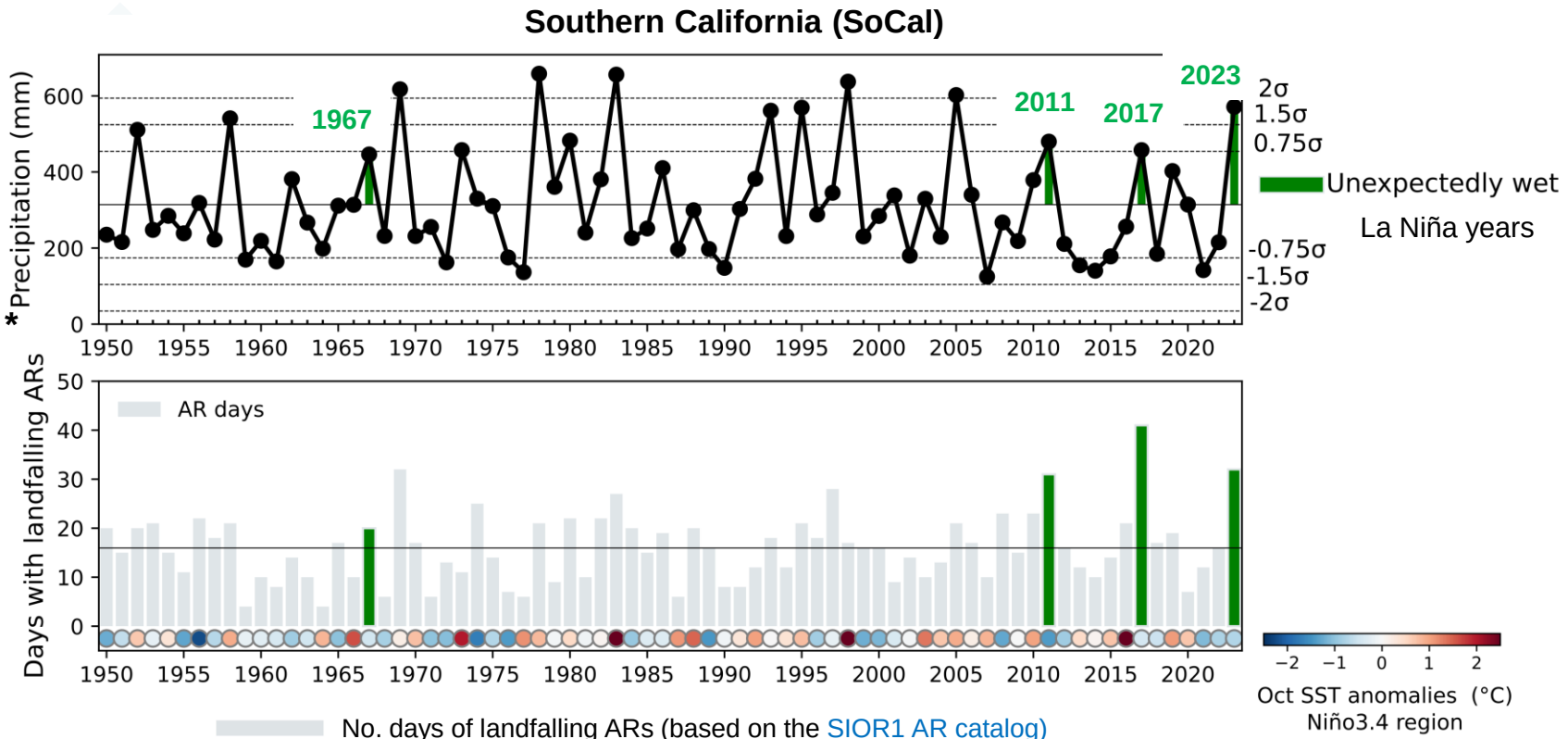
Atmospheric Rivers as wild cards of seasonal precipitation prediction



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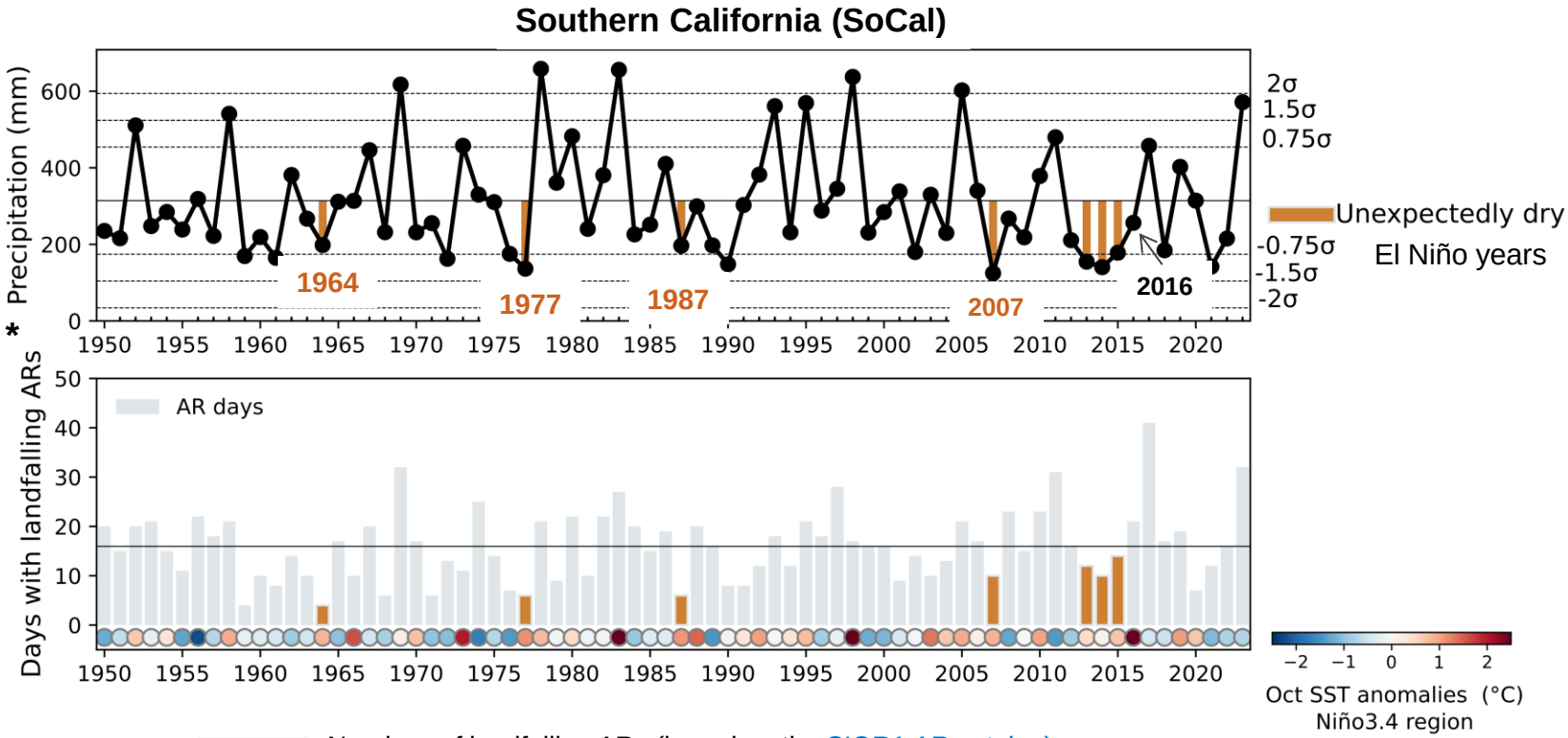
Atmospheric Rivers as wild cards of seasonal precipitation prediction



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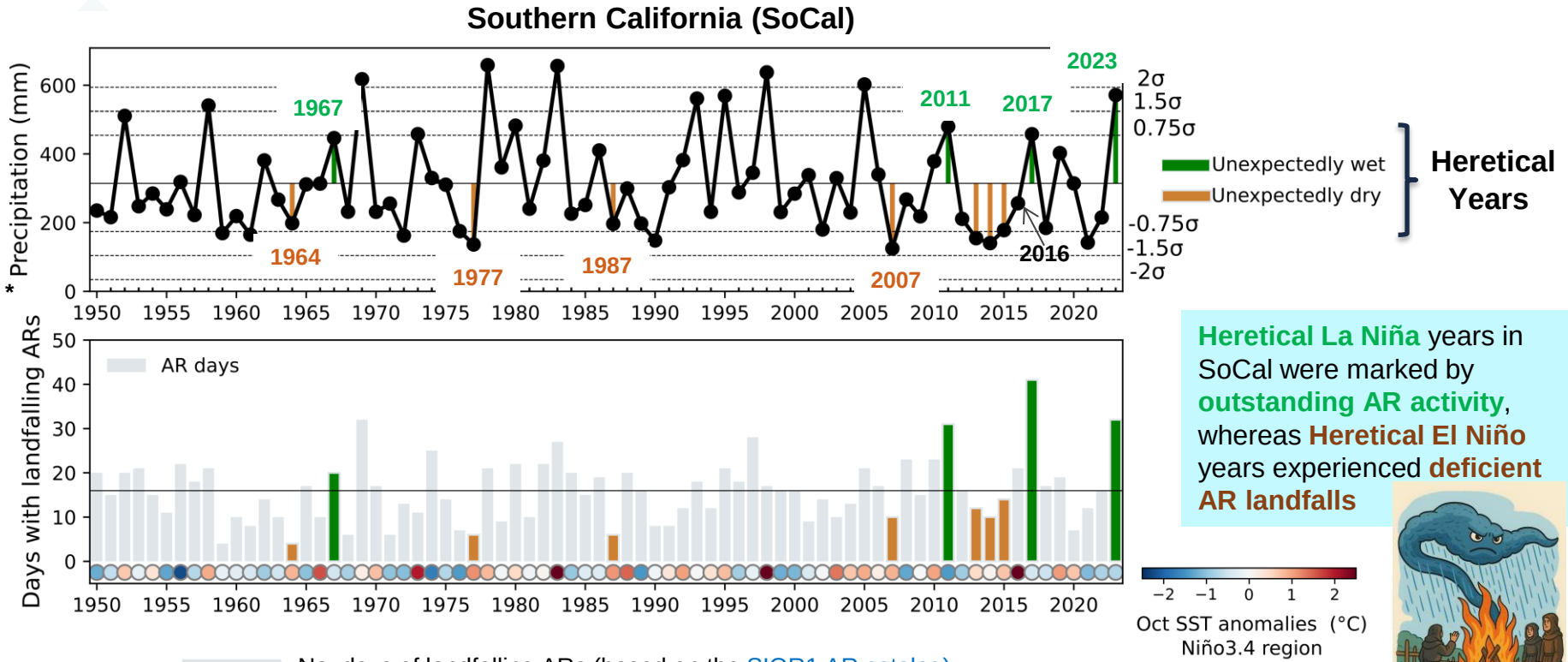
Atmospheric Rivers as wild cards of seasonal precipitation prediction



Heretical La Niña years in SoCal were marked by **outstanding AR activity**, whereas **Heretical El Niño** years experienced **deficient AR landfalls**

No. days of landfalling ARs (based on the SIOR1 AR catalog)

*Water Year precipitation

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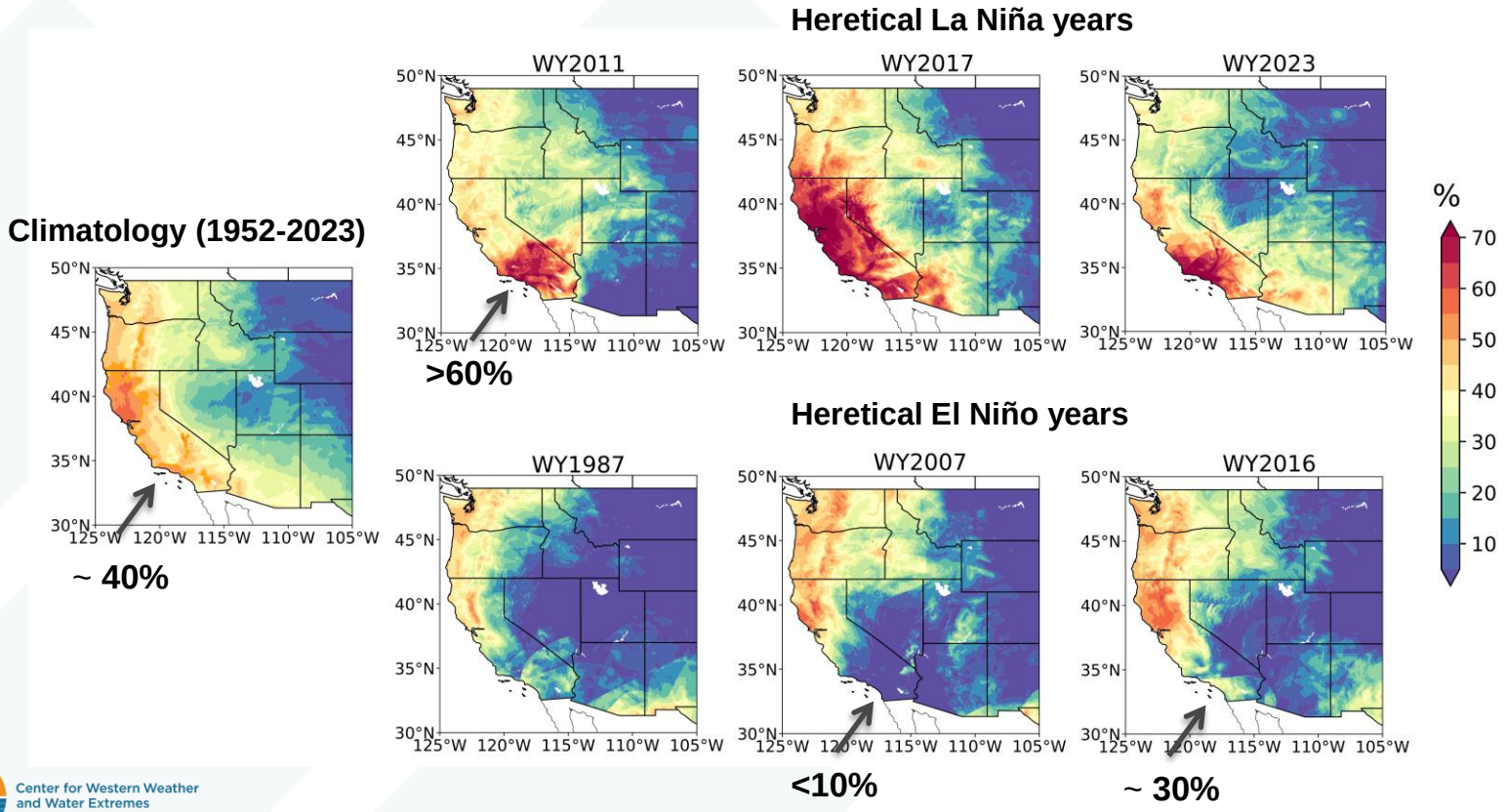
AR precipitation contribution (%) to total WY precipitation



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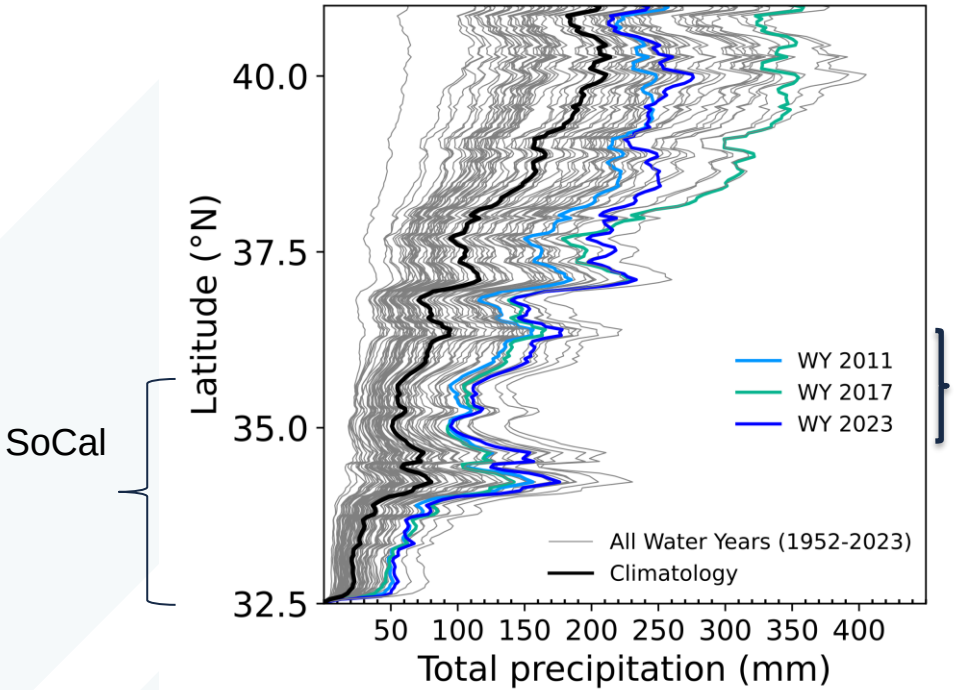
Precipitation during Heretical La Niña years in California

Total zonal mean precipitation (October-April; mm)



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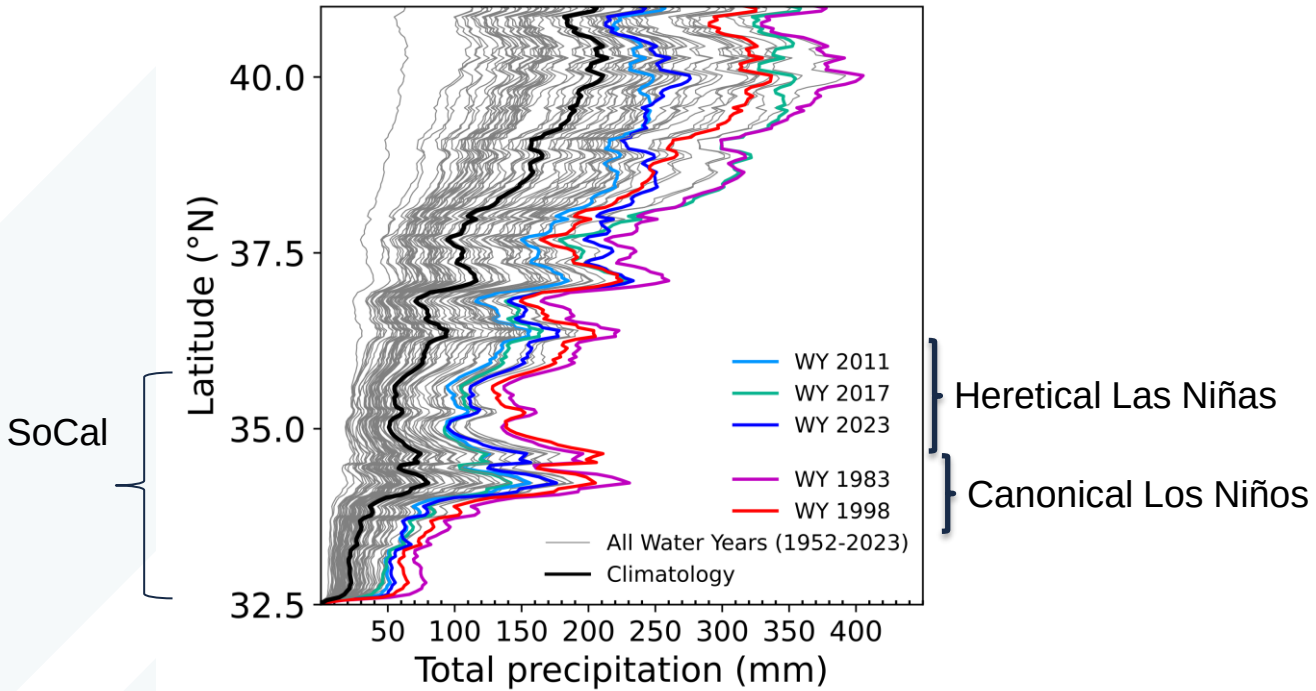
Heretical La Niña years vs Strongest Canonical El Niño years

Total zonal mean precipitation (October-April; mm)



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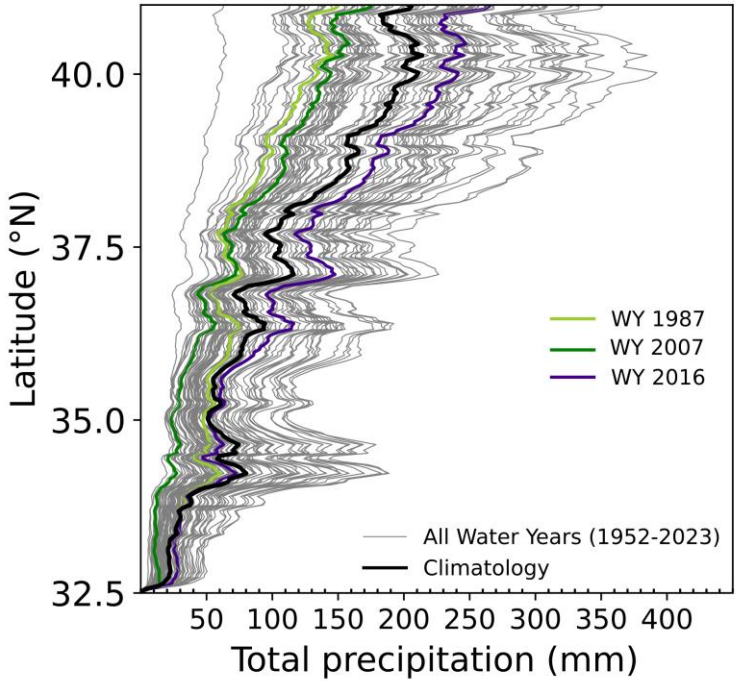
Precipitation during Heretical El Niño years in California

Total zonal mean precipitation (October-April; mm)



SoCal

Heretical Los Niños

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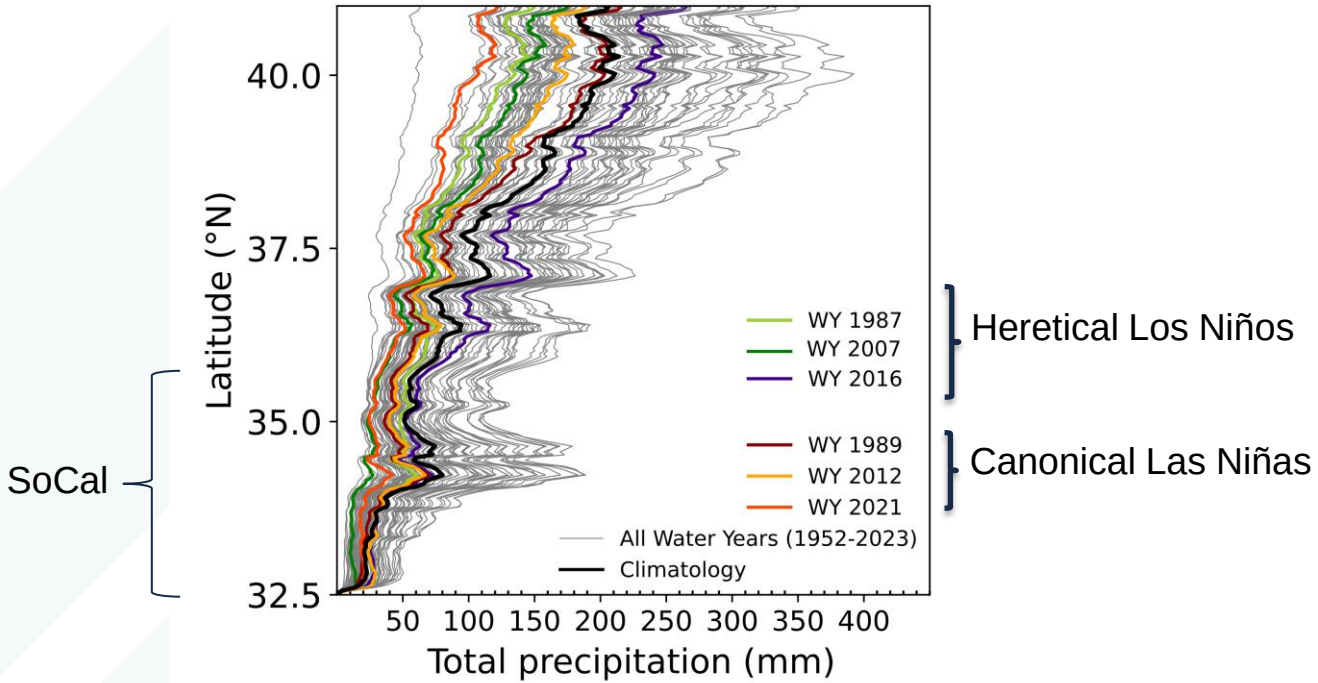
Heretical El Niño years vs Canonical La Niña years

Total zonal mean precipitation (October-April; mm)



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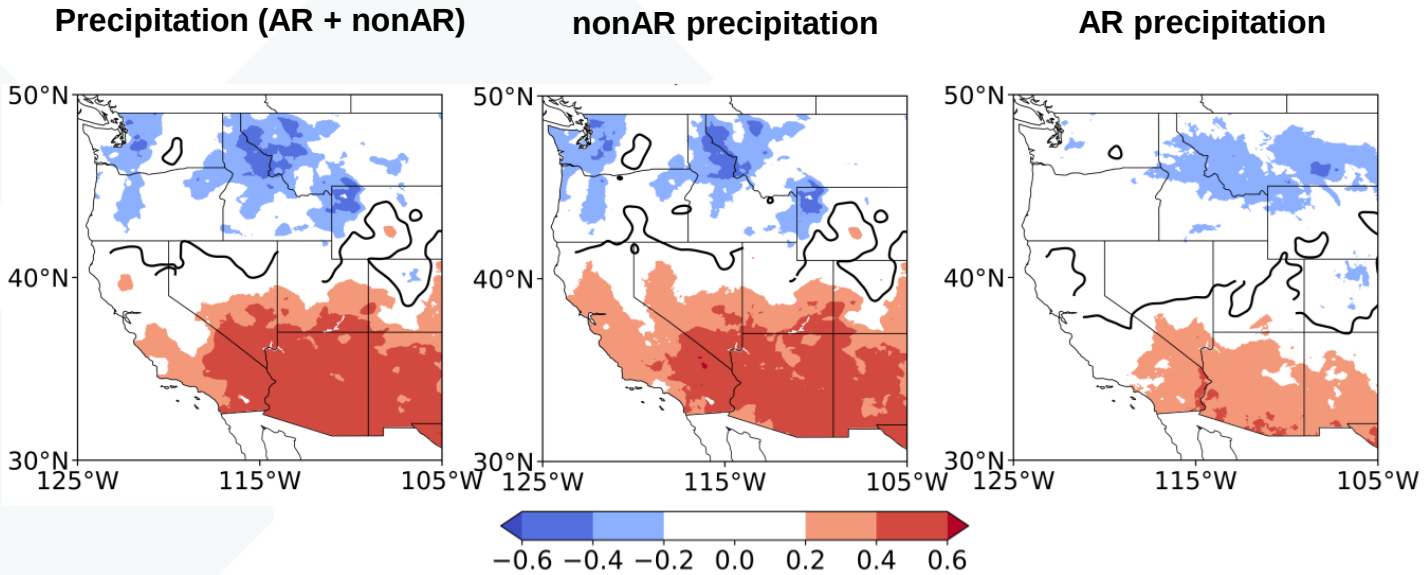
Implications for seasonal prediction

Correlation ONI (SST in Niño3.4) and Total precipitation (ONDJFMA)



The highest correlations for AR precipitation are found over the Sonoran, Arizona, and New Mexico deserts. These regions are highly dependent on the landfalling ARs in Baja California that penetrate into the interior Southwest (Rutz and Steenburg 2012).

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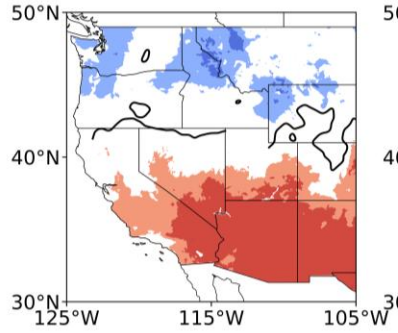
Implications for seasonal prediction

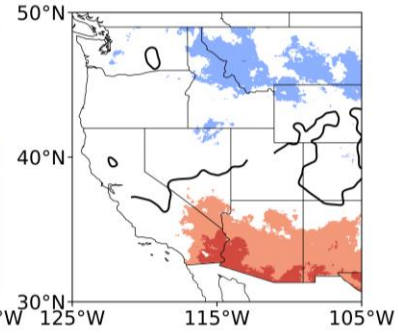
Correlation ONI (SST in Niño3.4) and precipitation (ONDJFMA)

Frequency: No. Days Precip > 1mm

nonARpr frequency

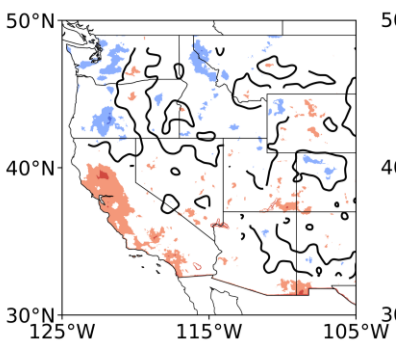


ARpr frequency

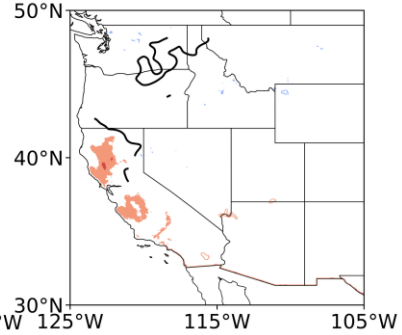


Intensity: AR precip / Frequency

nonARpr intensity



ARpr intensity



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Take-home messages

Role of Atmospheric Rivers

Atmospheric rivers are the disruptors of canonical seasonal precipitation anomalies in the Southwestern US

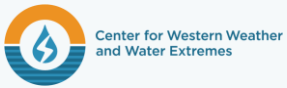
→ The occurrence or absence of ARs can amplify the expected anomalies based on ENSO conditions or completely disrupt predictions, leading to entirely unexpected precipitation anomalies, as observed during the heretical El Niño and La Niña years described in this study. *ARs are the wildcards of seasonal prediction in California.*

→ *ARs don't care to much about ENSO like other storms.* The Desert Southwest may be the one region of the Western US where AR landfalling activity produces a precipitation signal that is somewhat reliably synchronized with contemporaneous ENSO activity.

→ There is a need for the development of a new Seasonal-and-Subseasonal (S&S) prediction framework merging the seasonal signal from Pacific SST conditions with sub-seasonal information related to ARs (e.g. synoptic weather regimes).

Thank you!

rlunanino@ucsd.edu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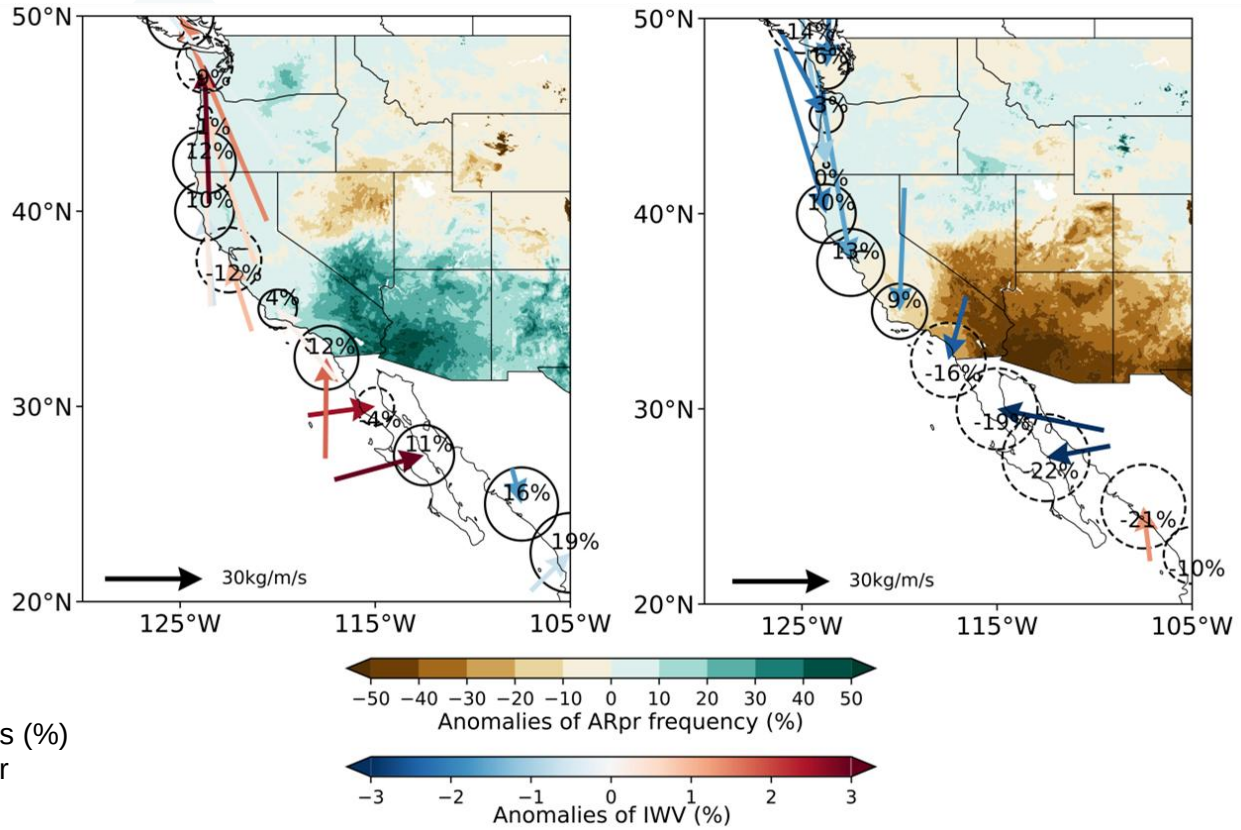
Composites of landfalling ARs during El Niño and La Niña winters (JFM)

During El Niño winters, ARs have a stronger westerly component over Baja California, increasing humidity and resulting in more AR days. During La Niña winters, stronger easterly components lead to lower humidity and fewer AR days in Baja California and the southwestern desert.

The opposite IVT vector anomalies during ENSO phases over the West Coast are consistent with Guirguis et al. (2019).



The shaded colors: ARpr frequency (%)
Numbers within the circles: landfalling ARdays (%)
Direction and magnitude of arrows: IVT vector
Colors of arrows: IWV anomalies (%)

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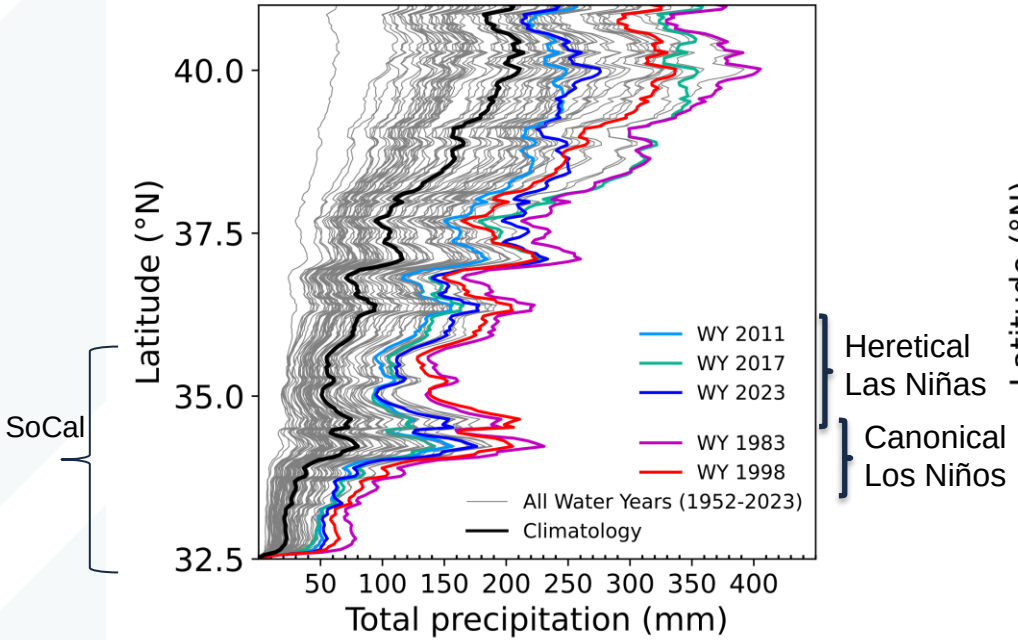
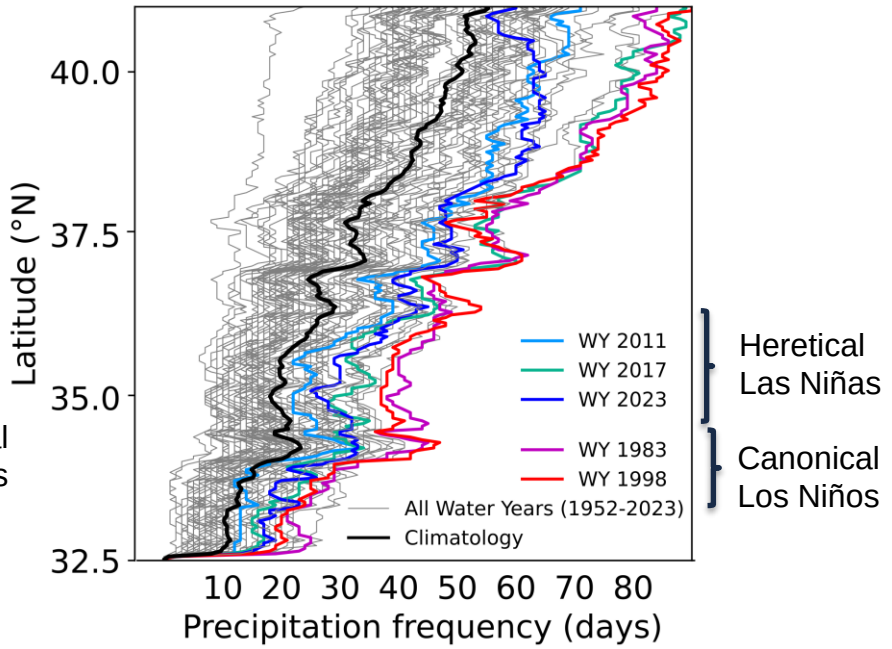
Heretical La Niña years vs Strongest Canonical El Niño years

Total zonal mean precipitation (October-April; mm) and frequency (daily precipitation > 1mm) in California





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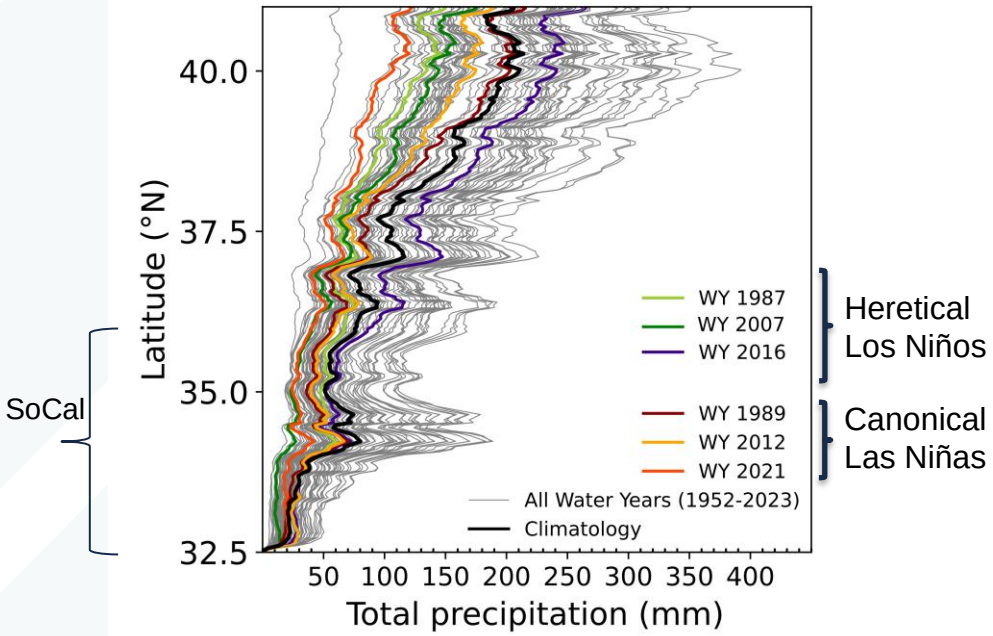
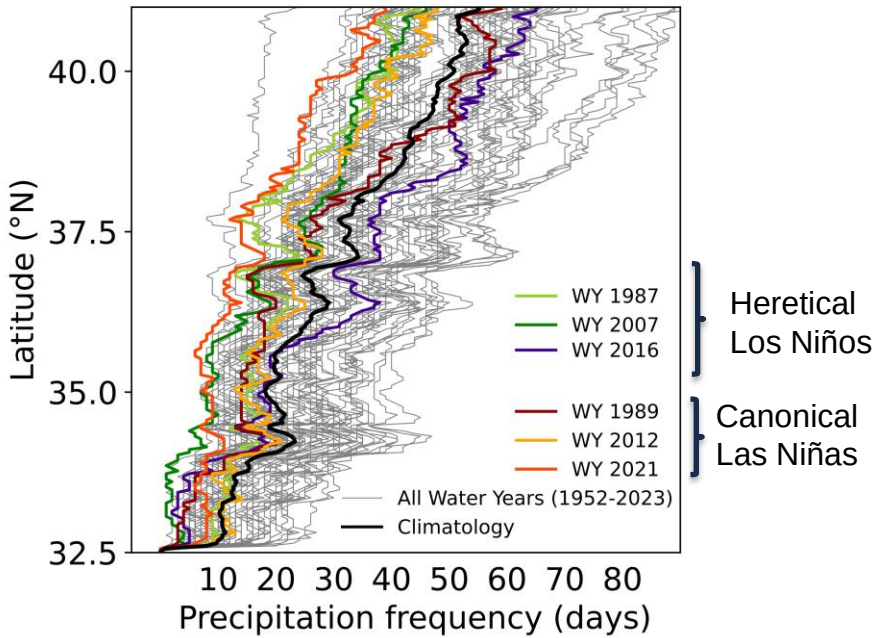
Heretical El Niño years vs Canonical La Niña years

Total zonal mean precipitation (October-April; mm) and frequency (daily precipitation > 1mm) in California





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