Sub-Seasonal to Seasonal Prediction Tools Developed at the Climate Prediction Center (CPC) for Sectoral Application Including Water Resources:

Review of experimental 2022-2023 ONDJFM, NDJFM, and DJFM rainfall outlooks

by Dr. Emerson LaJoie

Collaborators: Dr. Hui Wang, Dr. David DeWitt, Dr. Wanqiu Wang, Dr. PingPing Xie, Dr. Shaorong Wu, Dr. Cory Baggett

Outline

- Background
- Seasonal to Subseasonal North American Multi-Model Ensemble (NMME)-based S2S precipitation prediction tool (S2SFS)
  - Overview
  - Realtime verification of the ONDJFM / NDJFM / DJFM 2022-2023 rainfall outlooks
- CPC colleague Dr. Hui Wang has been developing an *SVD and SST-Based Tool for Seasonal Prediction of CONUS Precipitation (SVD-SST)*
  - Overview
  - Realtime verification of the ONDJFM / NDJFM / DJFM 2022-2023 rainfall outlooks
- What went wrong?
  - La Nina variability, potential QBO influences, weather noise
- Summary

Background

- The Climate Prediction Center is developing seasonal prediction tools that can potentially be utilized by various sectors including water resources.
- These tools will provide prediction of seasonal mean temperature and precipitation.
- Work to date has focused on deterministic and tercile-class probabilistic predictions.
- The tools include cross-validated estimates of forecast skill and will have at least 30 years of reforecasts available for testing in application models such as those used for water supply.
- Development to date has focused on precipitation but temperature will be added shortly.
- The National Weather Service (NWS) produces water supply forecasts through the River Forecast Centers (RFCs) for use internally and by many federal, state, and local stakeholders.

S2SFS: Seasonal to Subseasonal Dynamical Forecast System Based on NMME

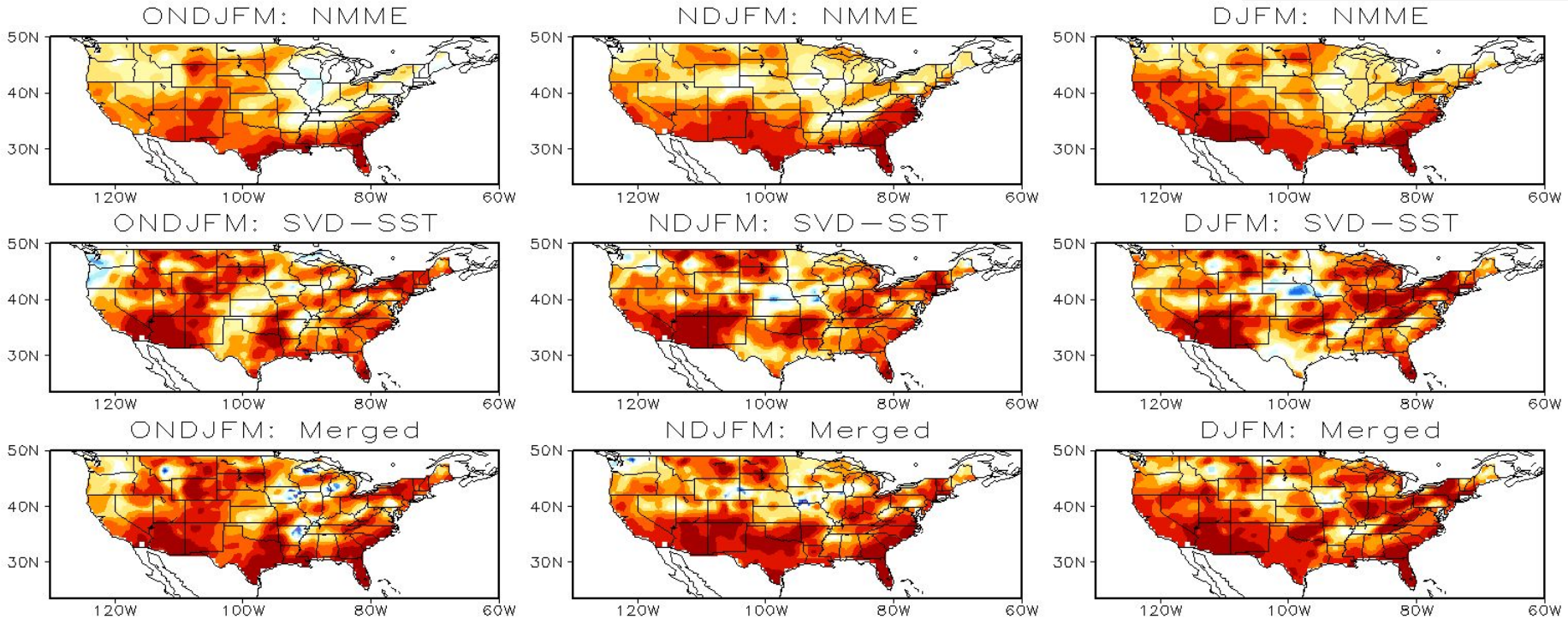
- CPC is working on three NMME-based **S2SFS** outlooks for water resources. Start with October initializations and target 6-months to March for the sum total precipitation outlook for the target period. Then update the outlook with November and December initializations:
  - 6-month outlook initializing in October and running thru March --> **ONDJFM**
  - 5-month outlook initializing in the following month, November, and running thru March --> **NDJFM**
  - 4-month outlook initializing in December and running thru March --> **DJFM**
- S2SFS Outlooks are probabilistic and indicate the dominant ensemble category from Above, Near Normal, or Below climatology. Outlooks are calibrated using the standard CPC approach *Ensemble Regression* (Unger et al., 2009).
- Historic skill assessment was computed for the 1982 to 2020 period using various standard performance metrics such as the Anomaly Correlation Coefficient (ACC), Heidke Skill Score (HSS), and Rank Probability Skill Score (RPSS). Cross-validation is handled using a leave one year out procedure. Realtime verification uses similar metrics.
- S2SFS Models (from the NMME):
  - CFSv2 24 (28) members
  - CanCM4i 10 (10) members
  - NASA_GEOS5v2 4 (10) members
  - NCAR_CCSM4 10 (10) members

Statistical Precipitation Forecasts for Water Resources

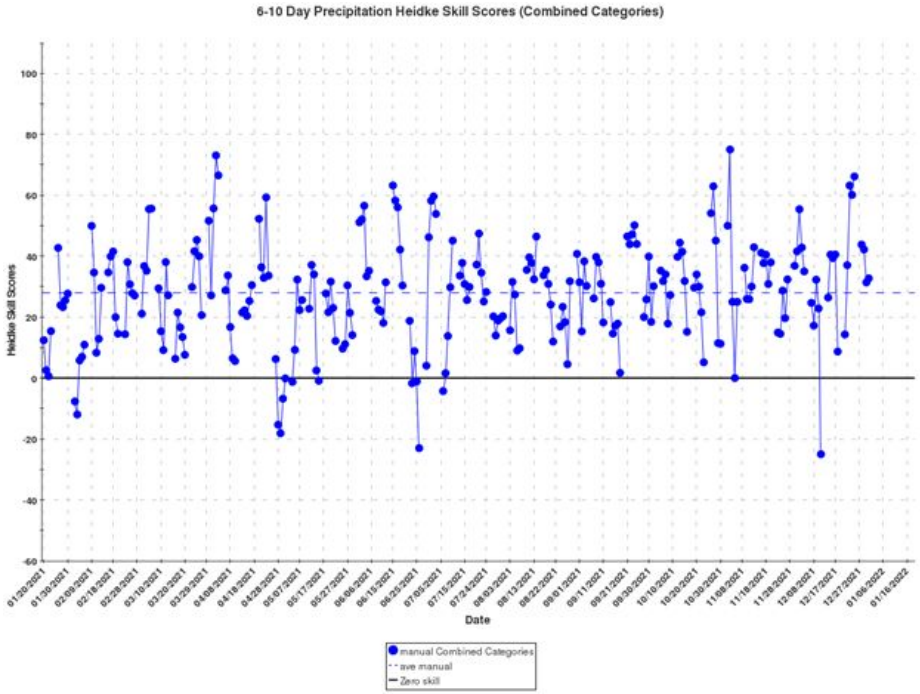
- CPC colleague Dr. Hui Wang has been developing an *SVD and SST-Based Tool for Seasonal Prediction of CONUS Precipitation (**SVD-SST**)*
- The **SVD-SST** model is the mixed methods of Switanek et al. (2020, Combined Lead SST-based model, CLSST) and Wang et al. (1999, SVD-based forecast).
- The statistical forecast is based on the lag relationships between SST (**30°S–60°N**, **1–18-month leads**) and seasonal precipitation over CONUS.
- The lag relationships are objectively identified by the singular value decomposition (SVD) for each SST lead time.
- **The skill values of anomaly correlation (AC) are used as weights for combining different SST-lead forecasts**.
- Forecasts are cross-validated over 1982–2021 with the leave 5-year out approach and **compared with the NMME forecasts**.

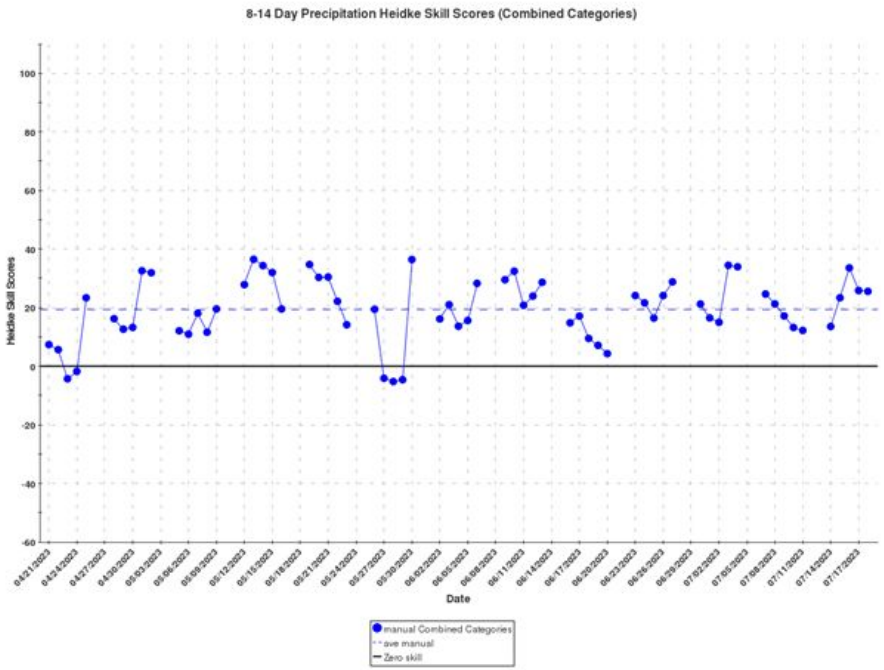
AC Skill: Precipitation 1982/83 – 2021/22
0-Month Lead Forecast

Courtesy of Hui Wang (CPC)



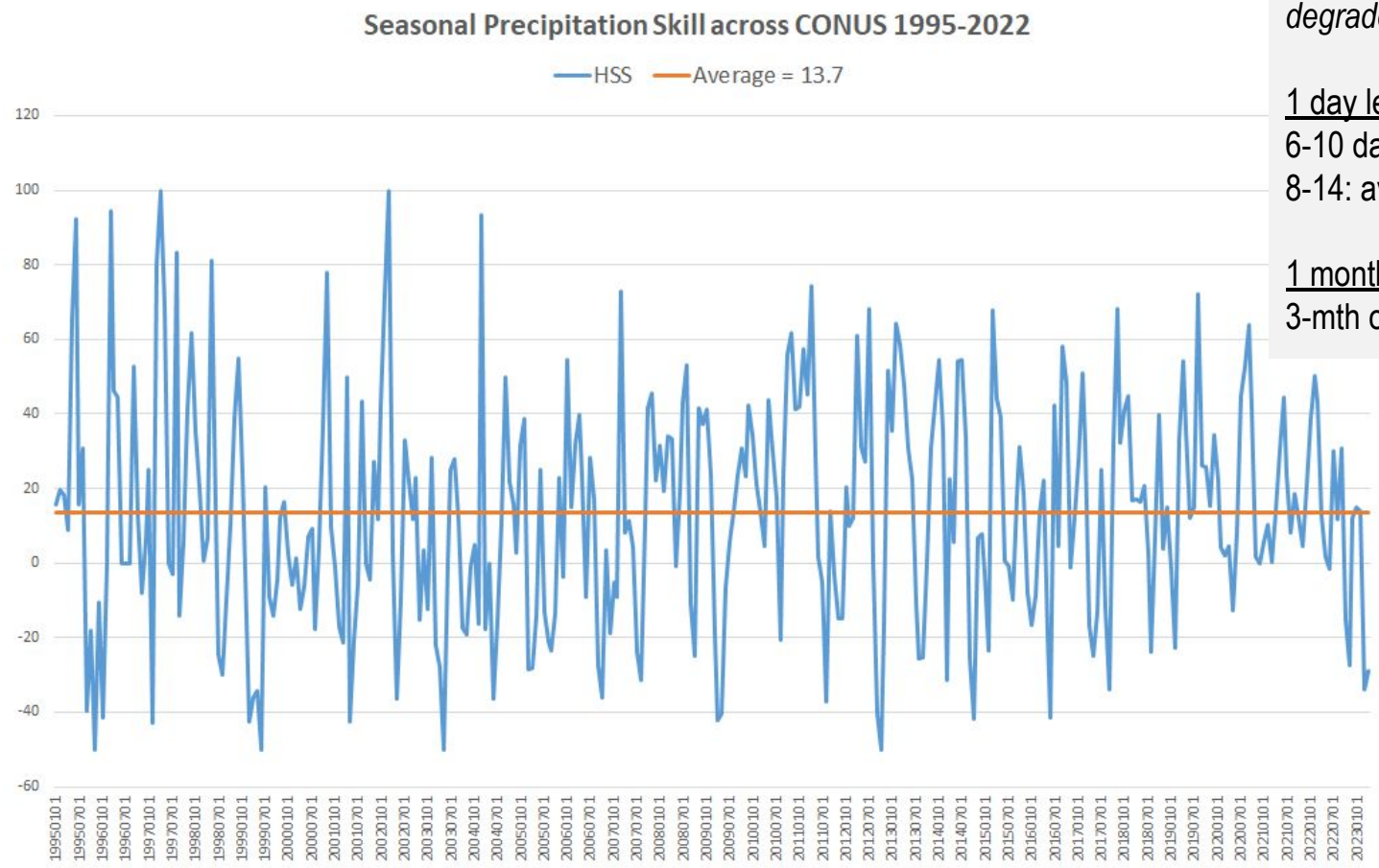
Some comments on skill scores





Key points:

- **6-10 day precipitation** forecasts skill scores (HSS) over about a year
- **Average score = 28**
- **8-14 day precipitation** forecast skill scores (HSS) over the same year
- **Average score = 20**

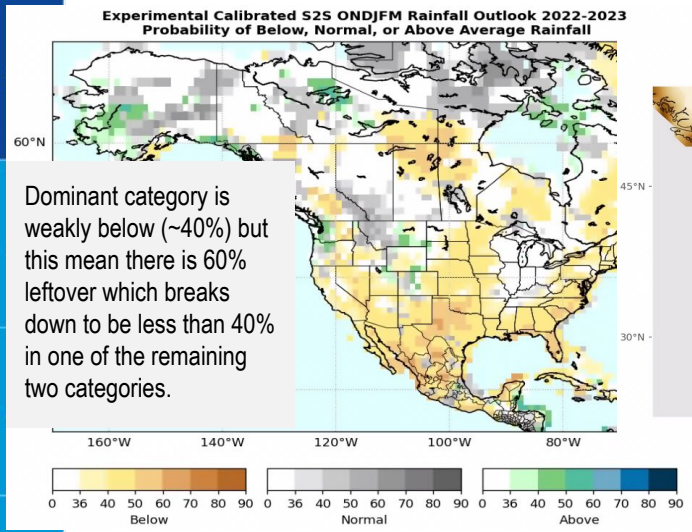


Skill of precipitation forecasts degrade as a function of lead time.

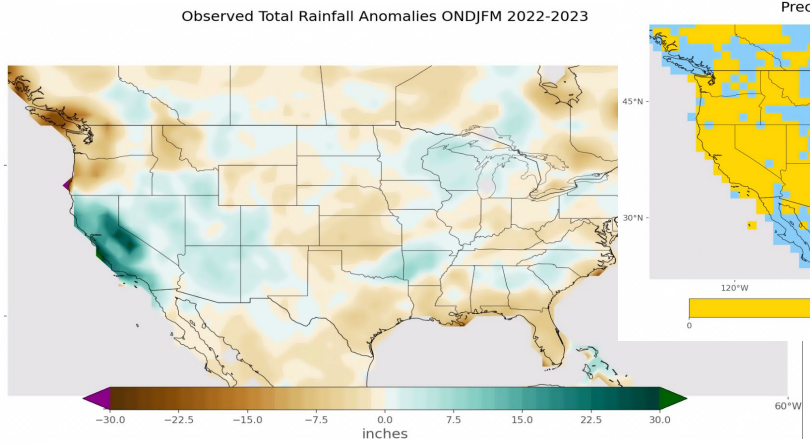
<u>1 day lead</u>
6-10 day: avg HSS = 28
8-14: avg HSS = 20

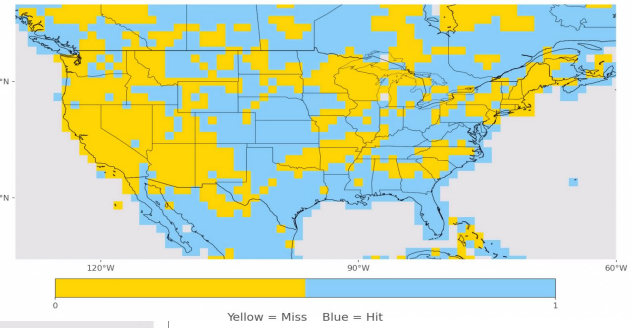
<u>1 month lead</u>
3-mth outlook: avg HSS = 14

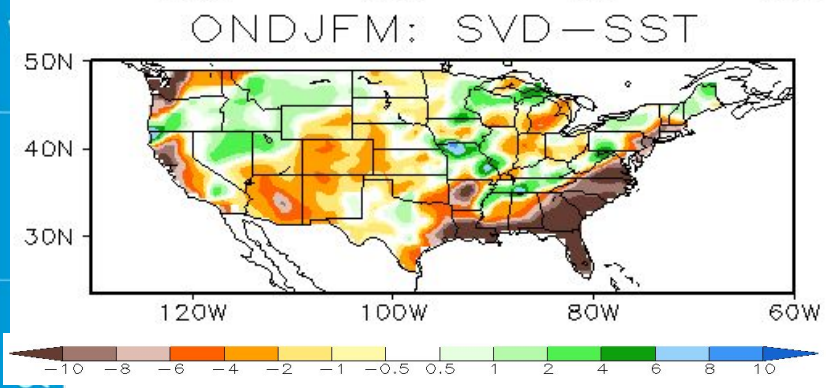
Verification of the ONDJFM, NDJFM, DJFM outlooks for total rainfall 2022-2023



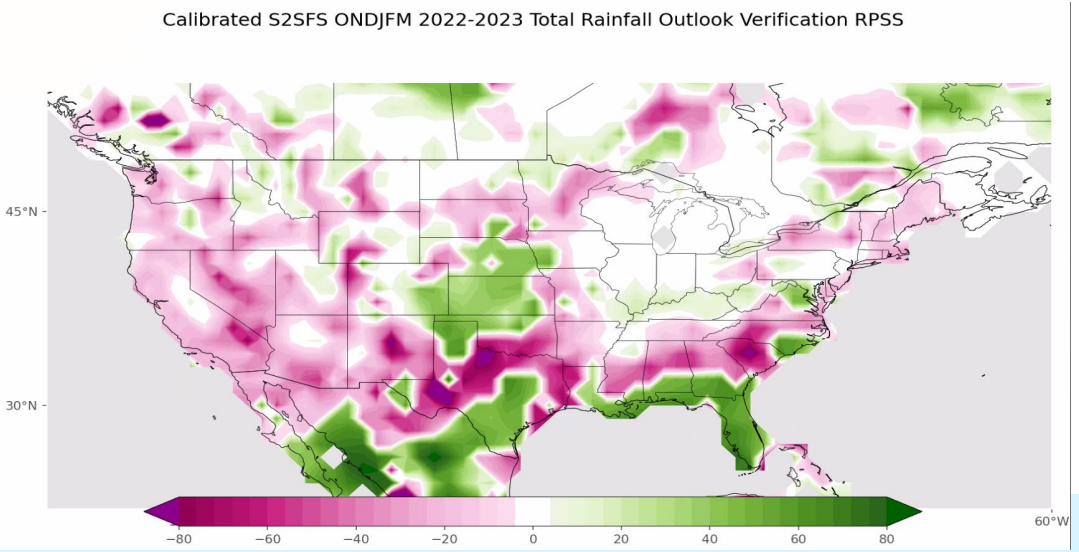
Dominant category is weakly below (~40%) but this mean there is 60% leftover which breaks down to be less than 40% in one of the remaining two categories.

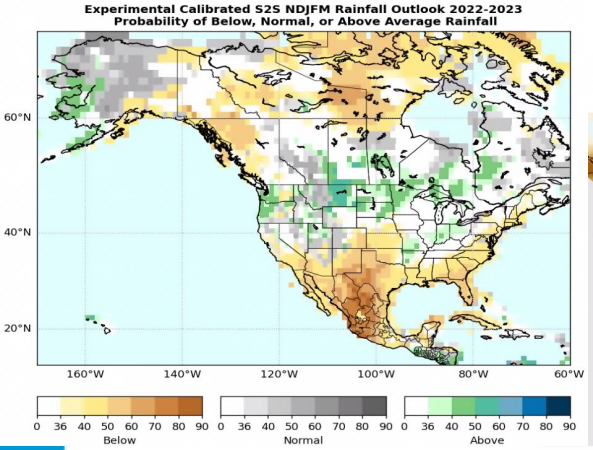


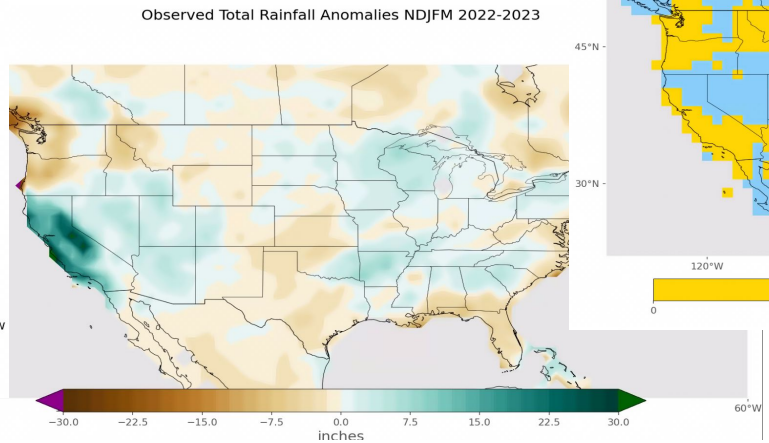


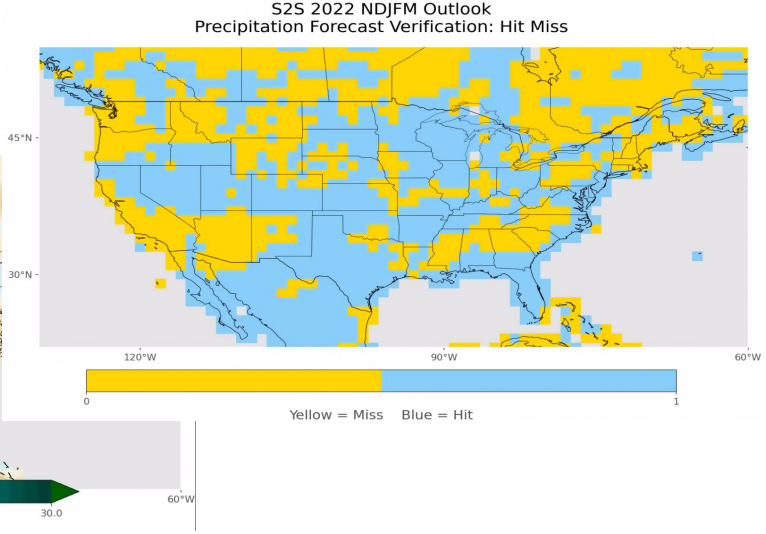


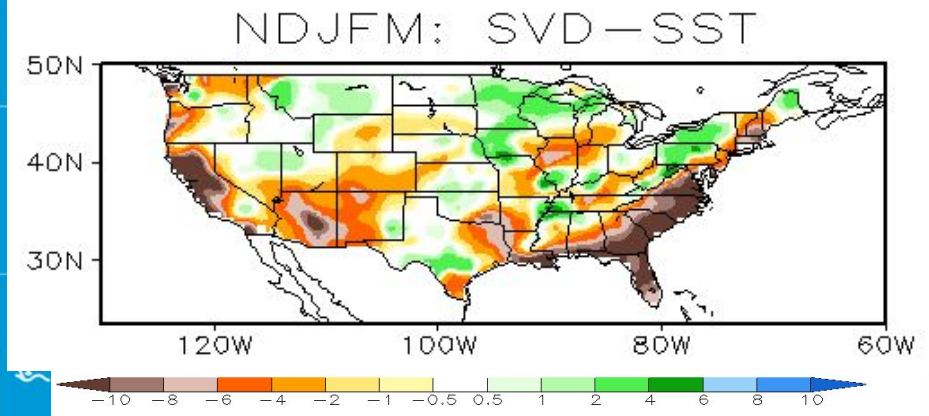
Precipitation Anomaly (inches)

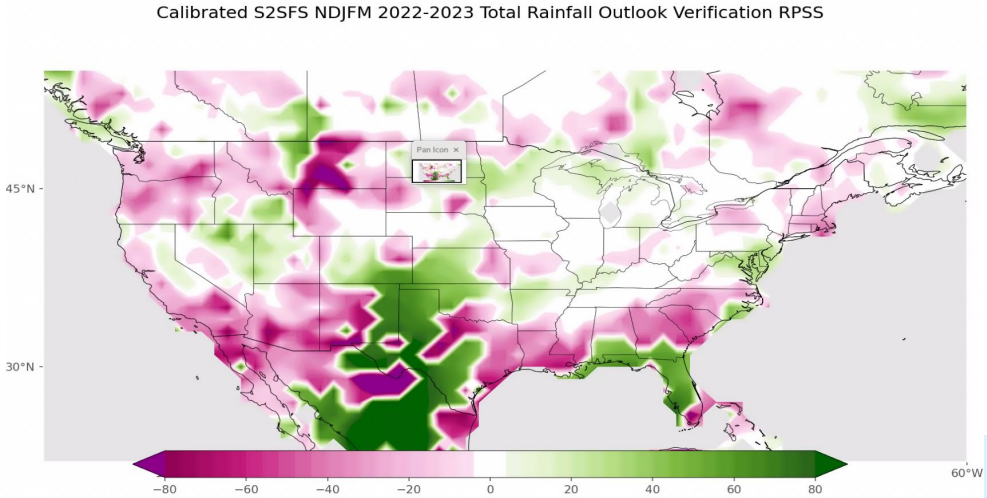




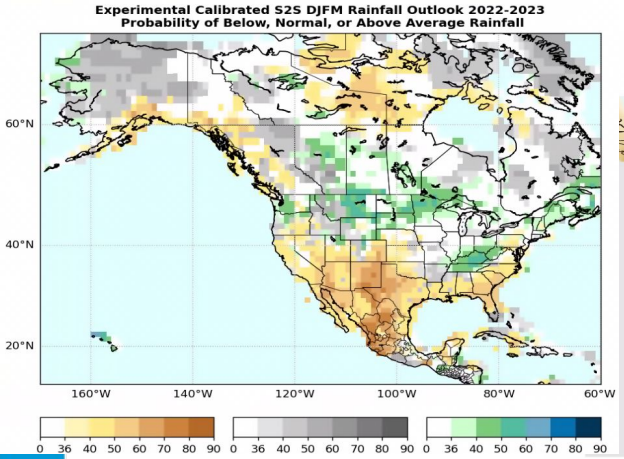


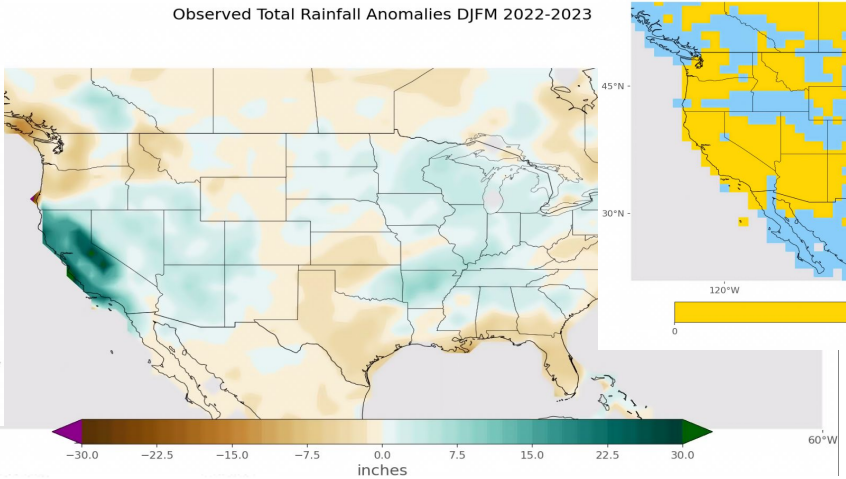


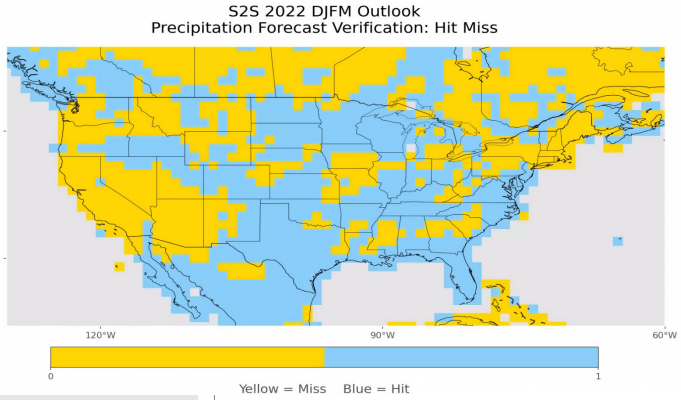


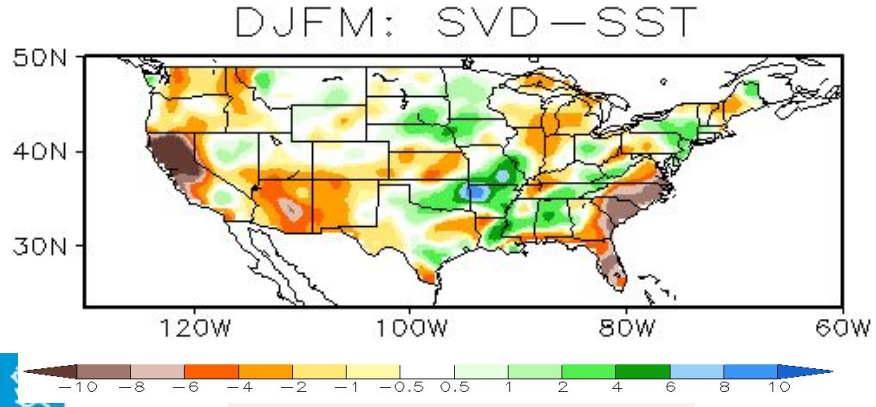


Precipitation Anomaly (inches)

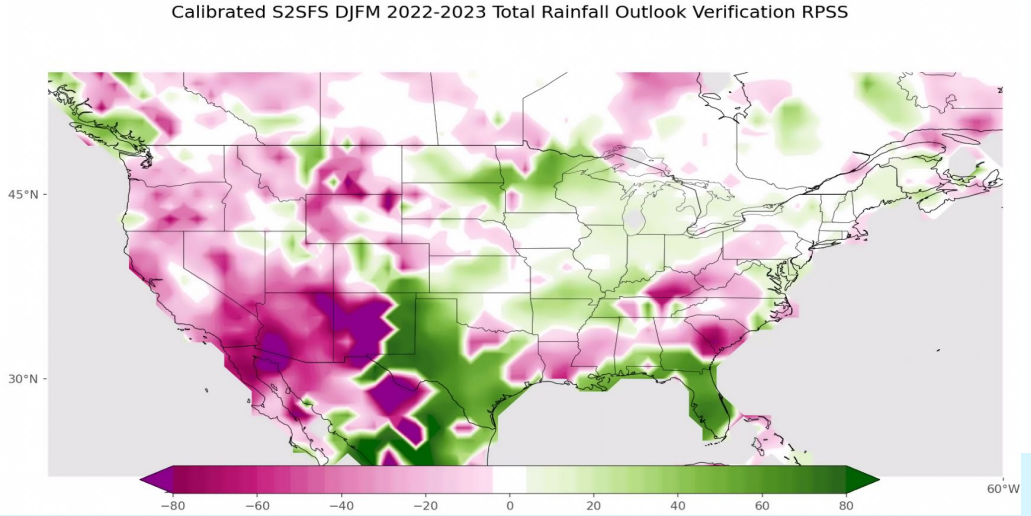


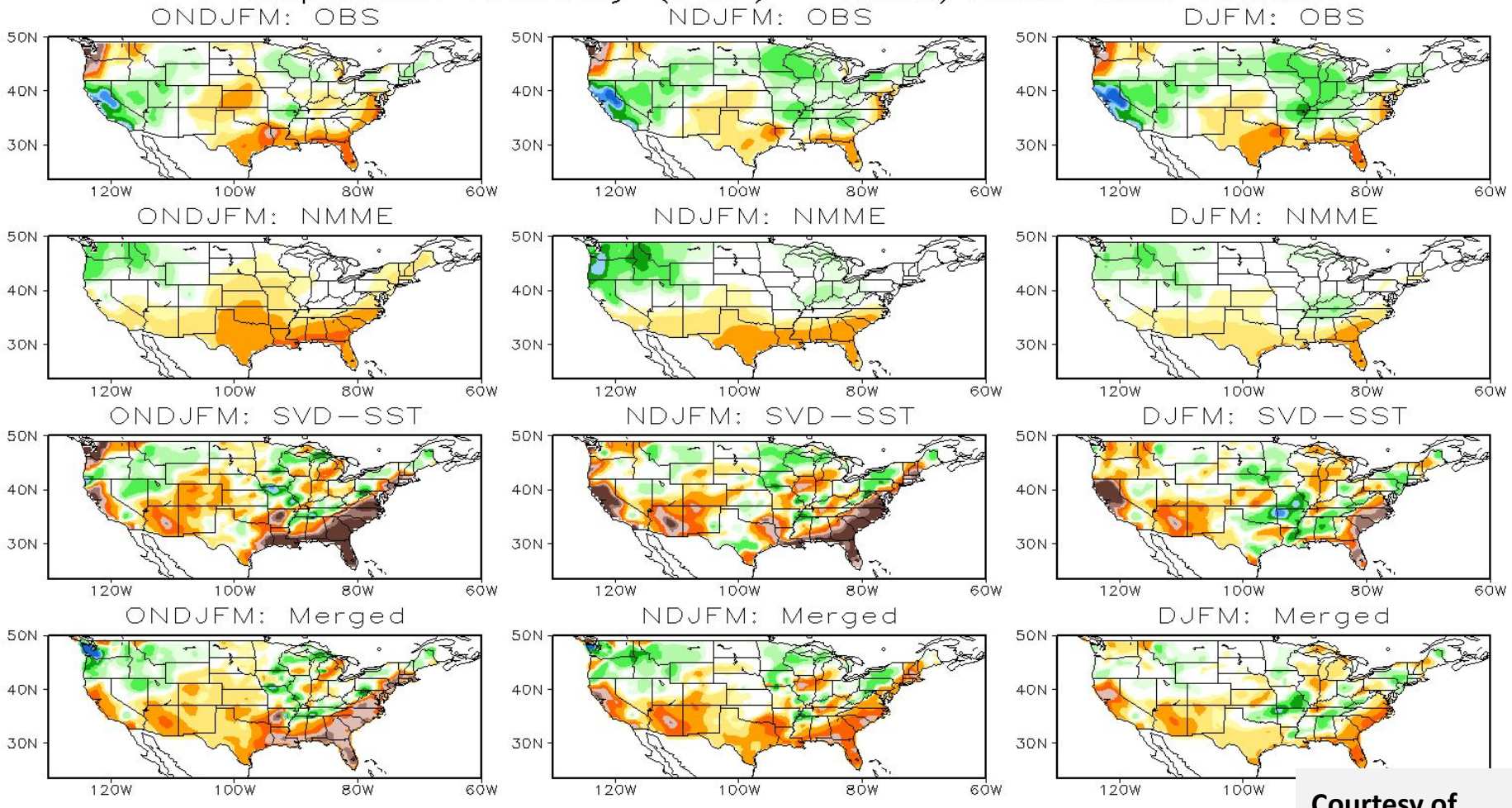




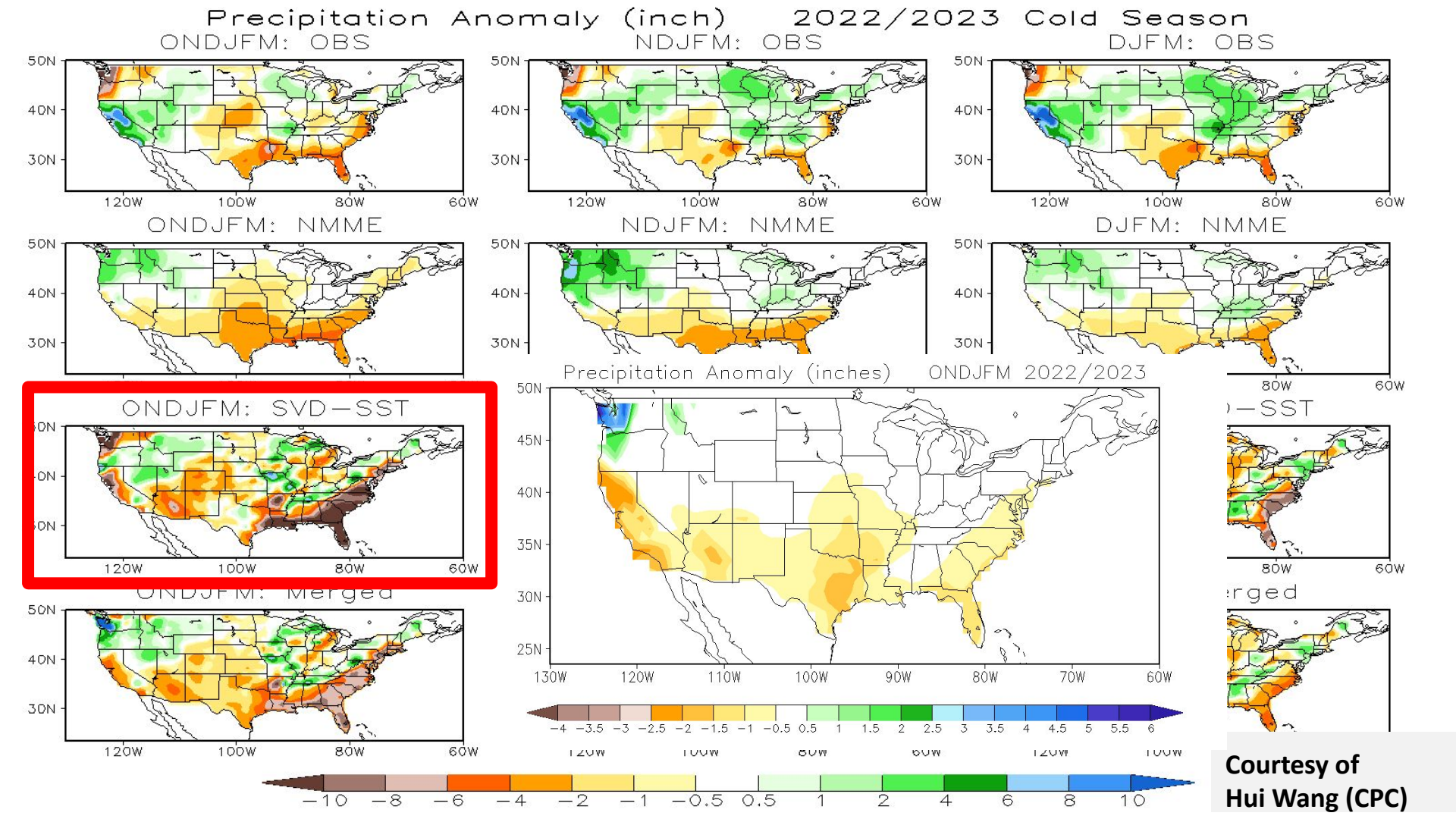


Precipitation Anomaly (inches)





Courtesy of Hui Wang (CPC)



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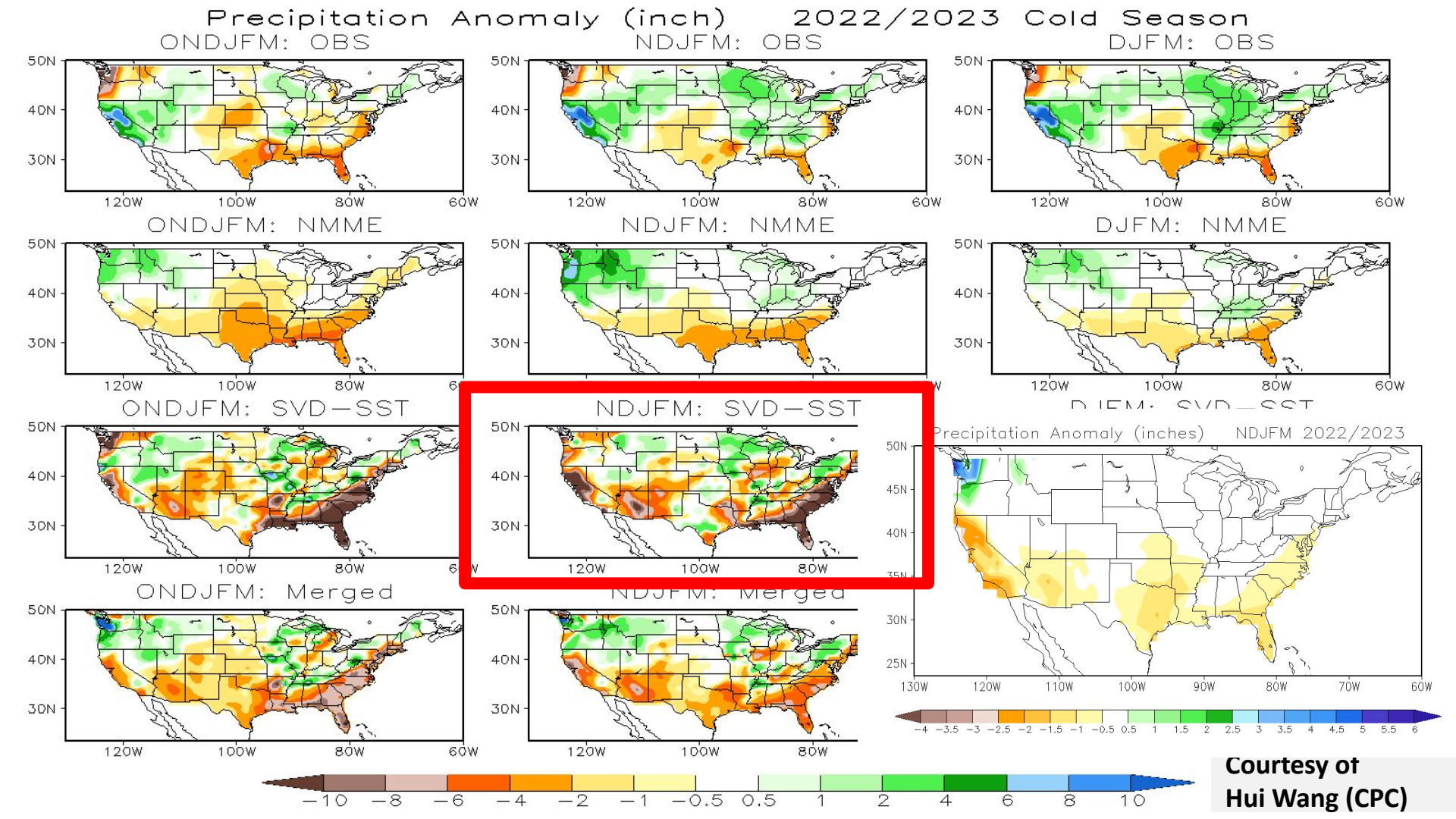

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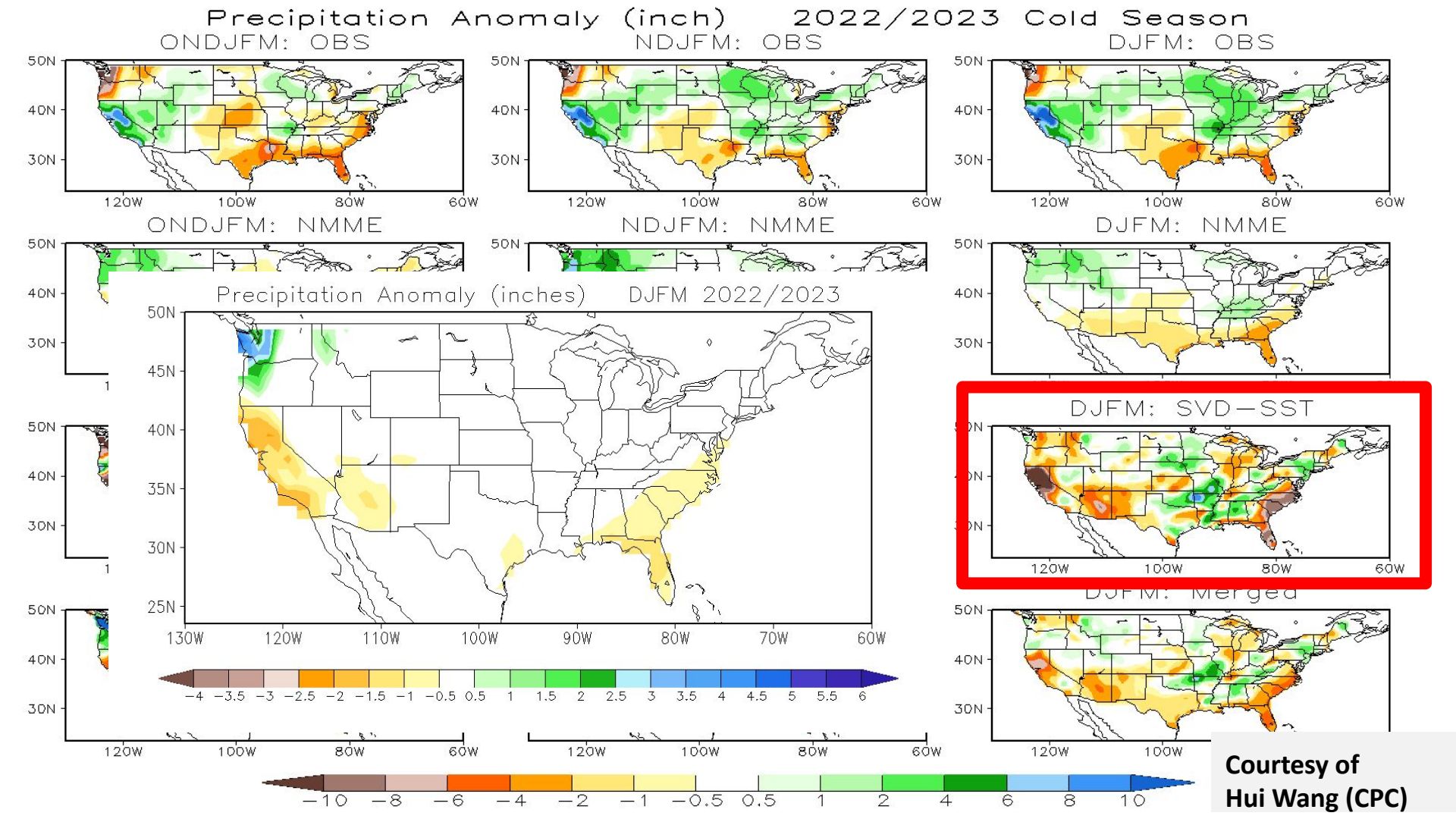

Precipitation Anomaly (inch) 2022/2023 Cold Season
ONDJFM: OBS
NDJFM: OBS
DJFM: OBS
ONDJFM: NMME
NDJFM: NMME
DJFM: NMME
Precipitation Anomaly (inches) DJFM 2022/2023
DJFM: SVD—SST
DJFM: Merged
−4 −3.5 −3 −2.5 −2 −1.5 −1 −0.5 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6
−10 −8 −6 −4 −2 −1 −0.5 0.5 1 2 4 6 8 10
Courtesy of
Hui Wang (CPC)

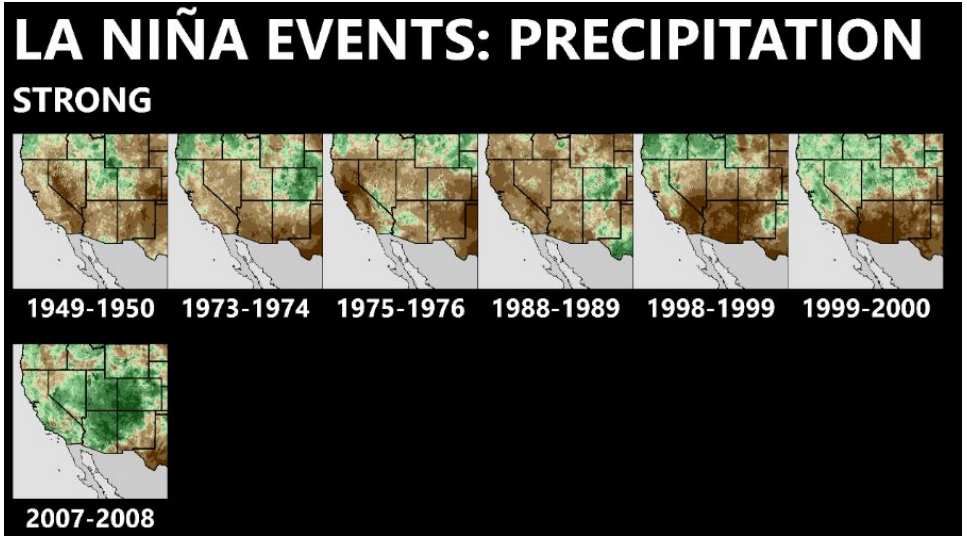
What went wrong?

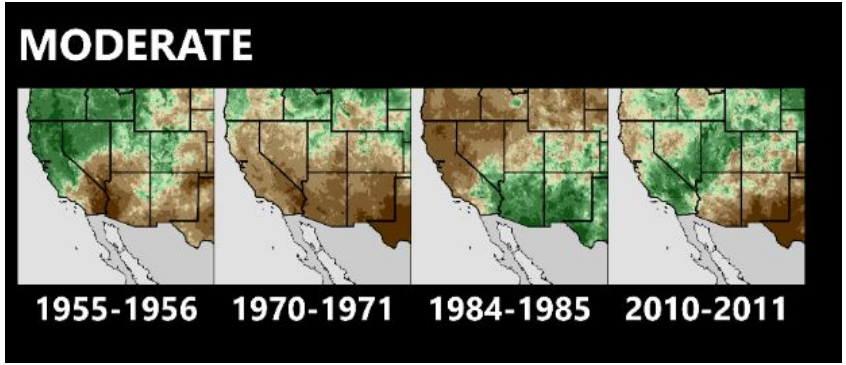
[Insert whatever intelligent information here that we have to answer this question. Thanks!]

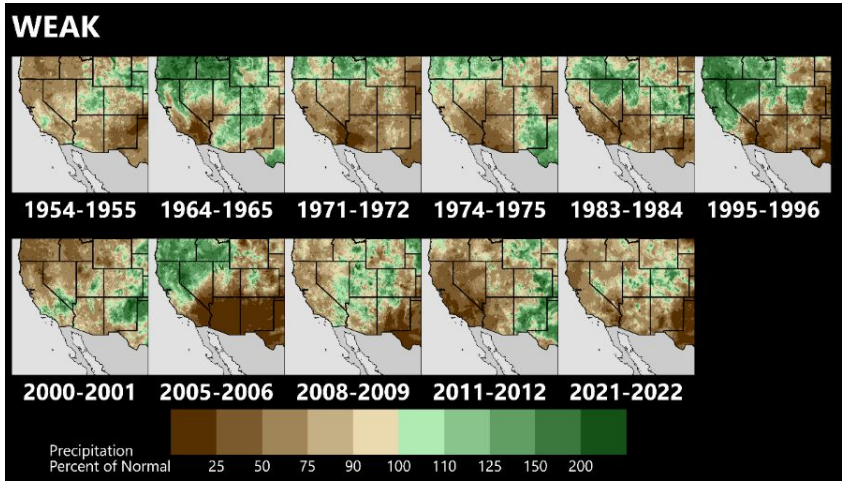
- Even though there is a statistical tilt toward drier conditions in the west during La Nina, there is still a great deal of variability.
  - Figures from NWS Showcase and Nat Johnson Article

- Some research indicates that QBO might be a helpful predictor.

Wet in the Southwest during La Niña?







- Variability of La Niña precipitation during DJF as a function of La Niña strength

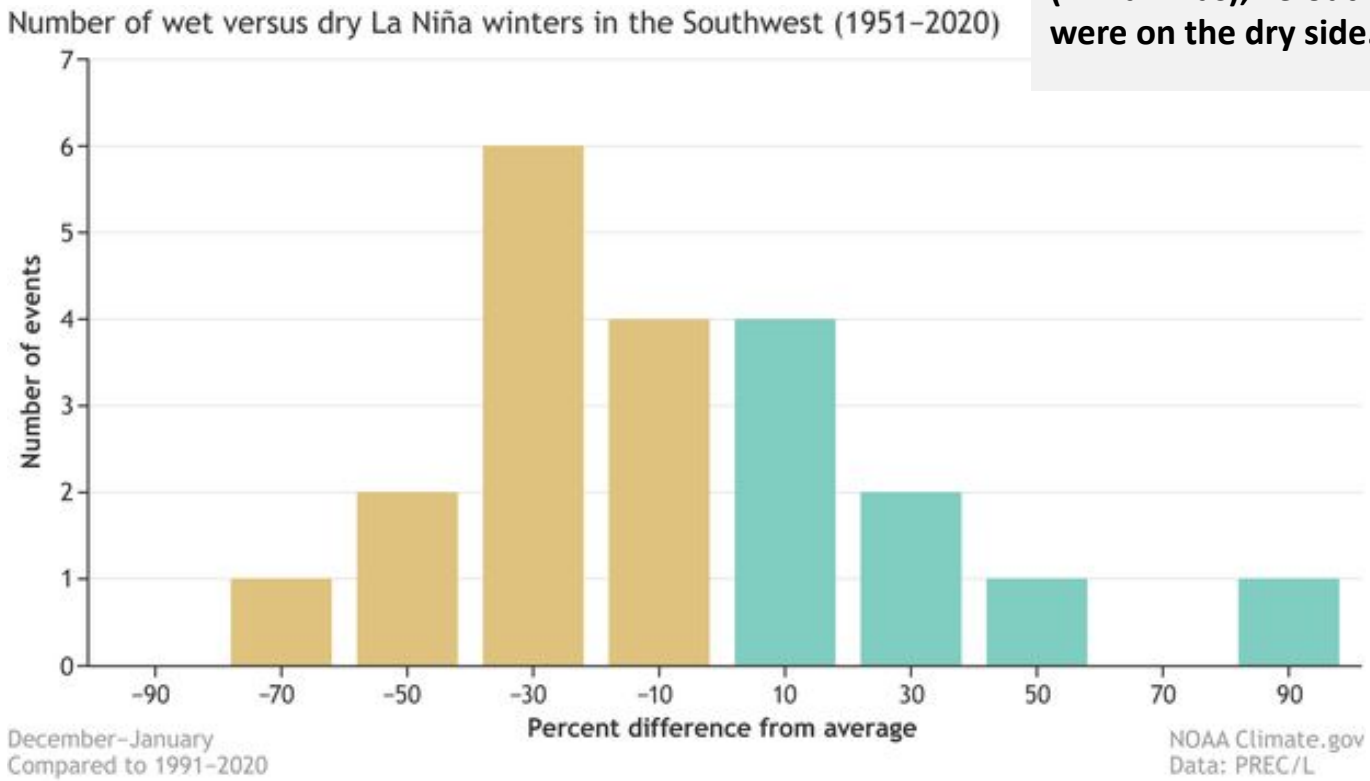
From NWS Climate Services and Webinars - Winter Outlook Messaging Showcase - September 28, 2022

Cindy Matthews (WFO Sacramento) - Tom Dang (WFO Tucson) - Chelsea Peters (WFO Sacramento)

Slide courtesy of C. Baggett (CPC)

Nat Johnson's Analysis

Dec-Jan precip: a statistical tilt toward dry in this record (21 LaNinas), 13 out of 21 were on the dry side.

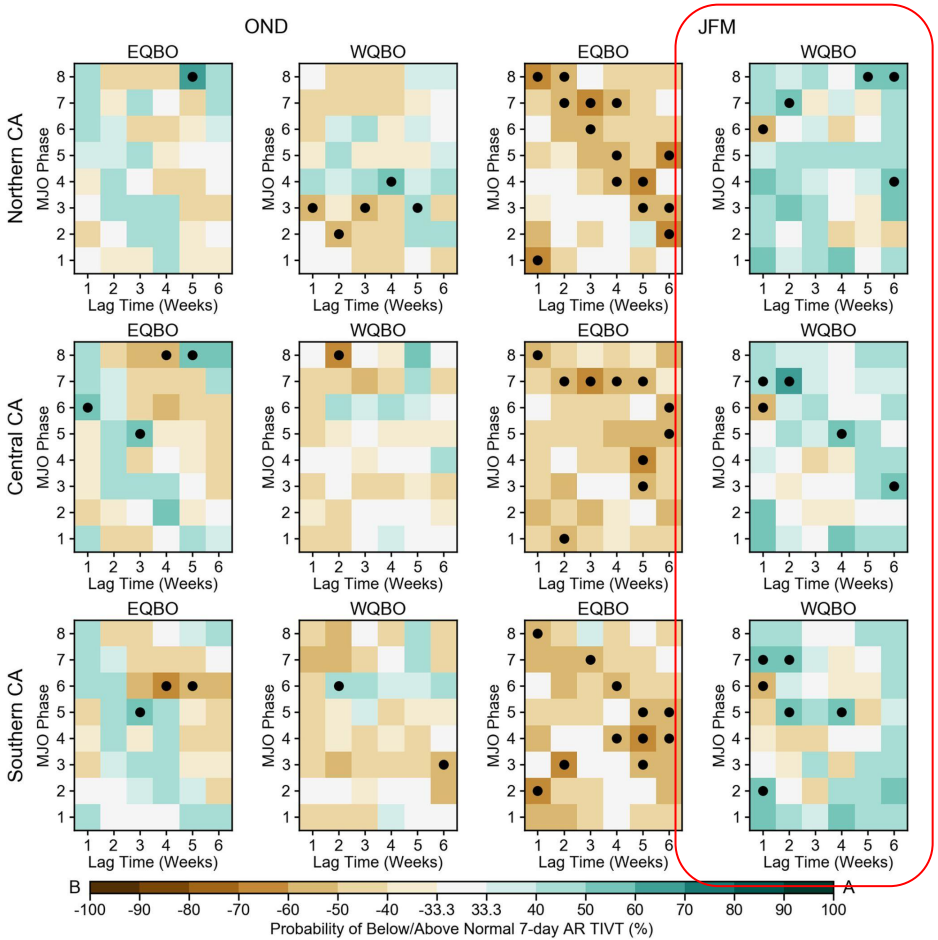


"Distribution of December–January precipitation anomalies (percent of the 1991-2020 climatology) in the Southwest U.S. (region defined in the figure above) for all 21 La Niñas from 1951-2020. This figure indicates that the Southwest December-January precipitation was below the 1991-2020 average in 13 of 21 La Niñas during the period."

Slide courtesy of C. Baggett (CPC)

Castellano et al. (2023)'s Analysis

Up to 6 weeks ahead



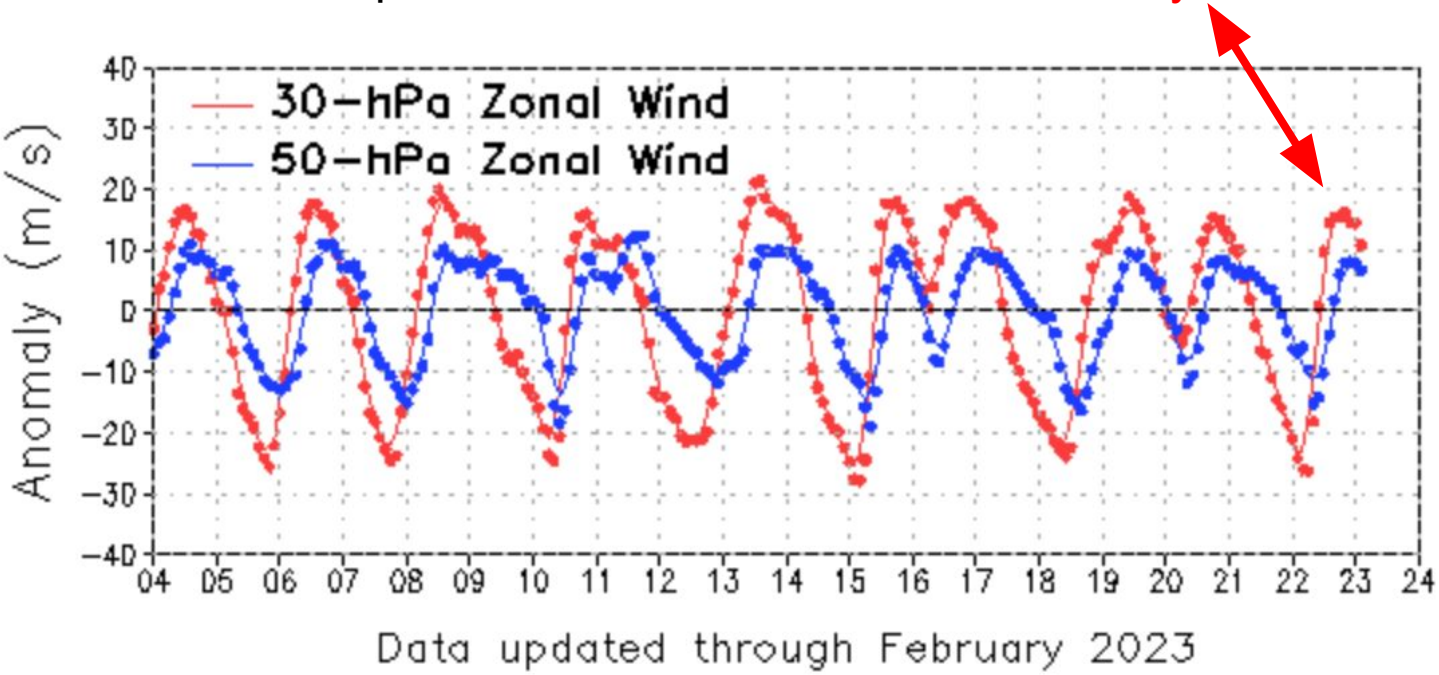
Recent paper by Castellano et al. (2023; Group at Scripps): [Development of a Statistical Subseasonal Forecast Tool to Predict California Atmospheric Rivers and Precipitation Based on MJO and QBO Activity]

- Looked at AR-related precipitation variability as a function of season, QBO phase, MJO phase, lead time, and geographic location in California.
- **Big result:** all regions of California are more or less wet during Westerly QBO during JFM, regardless of MJO phase and lead time.

Slide courtesy of C. Baggett (CPC)

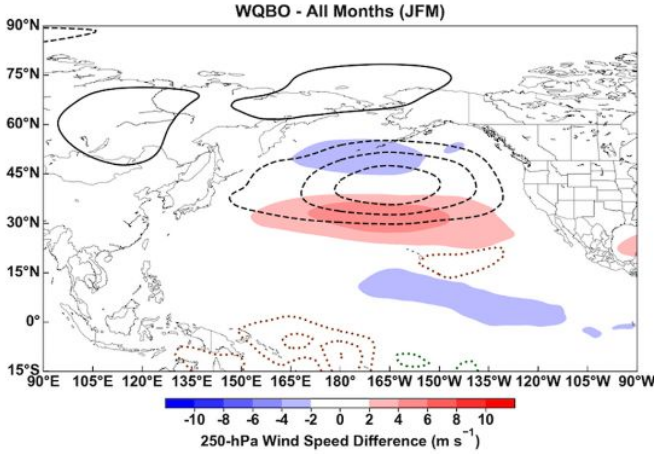
Castellano et al. (2023)'s Analysis

And what phase of the QBO are we in? Westerly.



Slide courtesy of C. Baggett (CPC)

Castellano et al. (2023)'s Analysis



Recent paper by Castellano et al. (2023; Group at Scripps): [Development of a Statistical Subseasonal Forecast Tool to Predict California Atmospheric Rivers and Precipitation Based on MJO and QBO Activity]

- During Westerly QBO, there are anomalously low heights in the North Pacific, and the Pacific Jet is extended.
- A major caveat still exists: sample sizes are small.
- **However, insomuch as this QBO connection exists, one should not expect climate models to do well with it, as many have demonstrably low skill in the stratosphere.**

Slide courtesy of C. Baggett (CPC)

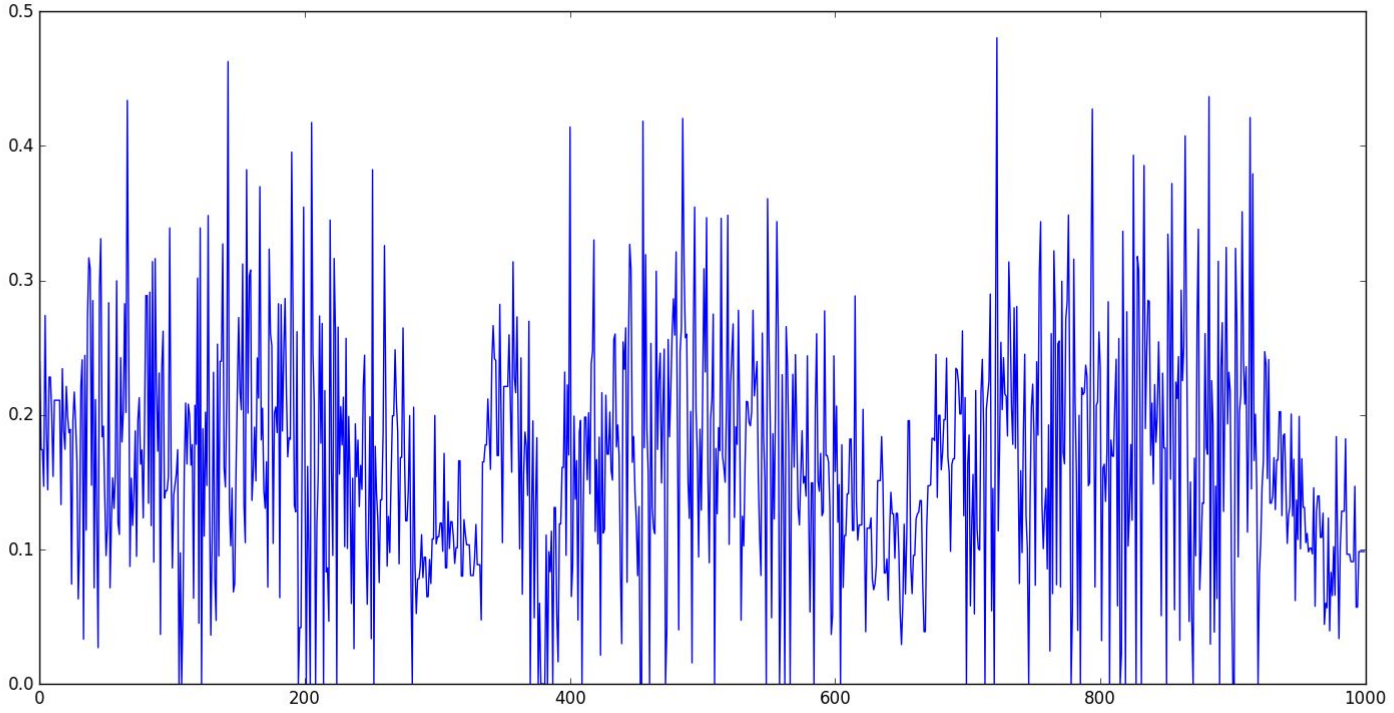
Summary

- **Experimental ONDJFM, NDJFM, and DJFM dynamical and statistical outlooks missed the above-average rainfall in the west.**

- **While LaNina climate states statistically tilt toward drier conditions in the west, there is significant variability in the historic record.**

- **Other influences include: weather noise (MJO), model deficiencies in resolving physical interactions or potentially important layers like the stratosphere and QBO.**
  - **Experiment with the QBO in the SVD-SST tool.**

Extra Slides



S2SDFS Anomaly Correlation Forecast Skill for Retrospective Forecasts for 1982 to 2020