CW3E SEASONAL FORECASTING OF PRECIPITATION TO BENEFIT WESTERN U.S. WATER RESOURCE MANAGEMENT

BACKGROUND

The Center for Western Weather and Water Extremes (CW3E) has assembled a team of experts in weather and climate prediction to improve subseasonal-to-seasonal (S2S; 2-week to 6-month lead time) prediction of precipitation, atmospheric rivers (ARs), and ridging events over the western U.S. region. As part of this overall effort to benefit water resource management across the western U.S., researchers at CW3E have implemented and tested an optimized canonical correlation analysis model (OCCA)[1], to develop an experimental seasonal precipitation prediction over the Southwestern United States (SWUS). Precipitation forecasts are generated early each month starting in September targeting subsequent three-month periods spanning the remaining active part of the water year ahead.

The initial experimental seasonal prediction (ESP) effort is based on the tropical and north Pacific monthly sea surface temperature (PSST) anomalies to predict total seasonal precipitation over the SWUS on a 6 x 6 km grid—the resolution of the observational precipitation training data set spanning 1948–2015[2]. This model will be further improved (e.g., by including new predictors) as well as expanded to the prediction of new variables (e.g., temperature, snowpack, streamflow) in subsequent years. Below, we summarize and verify the performance of our ESP effort in its initial year of operation.

EXPERIMENTAL SEASONAL PREDICTION (ESP) AT CW3E FOR WATER YEAR 2020

Figure 1 presents the forecast precipitation anomaly for January-March 2020 issued in early November 2019, along with the observed October SST predictor field, the expected skill, and subsequently observed precipitation anomaly.

Although much of the seasonal prediction skill is predicated on ENSO phase, fall 2019 was ENSO-neutral, but it was marked by a distinctive PSST anomaly pattern featuring a warm anomaly around the Aleutian Islands (Figure 1a). The predicted precipitation anomaly was essentially a NNW-SSE-oriented dipole of dry-wet anomalies (Figure 1b). Expected skill was significant in the west and south

JANUARY–MARCH (JFM) 2020 PRECIPITATION PREDICTED FROM OCTOBER 2019 PSST

a) October PSST predictor (°C)

b) JFM '20 forecast Precip. anomaly (%)

c) Observed Precip anomaly (%)

d) Skill (correlation coefficient)
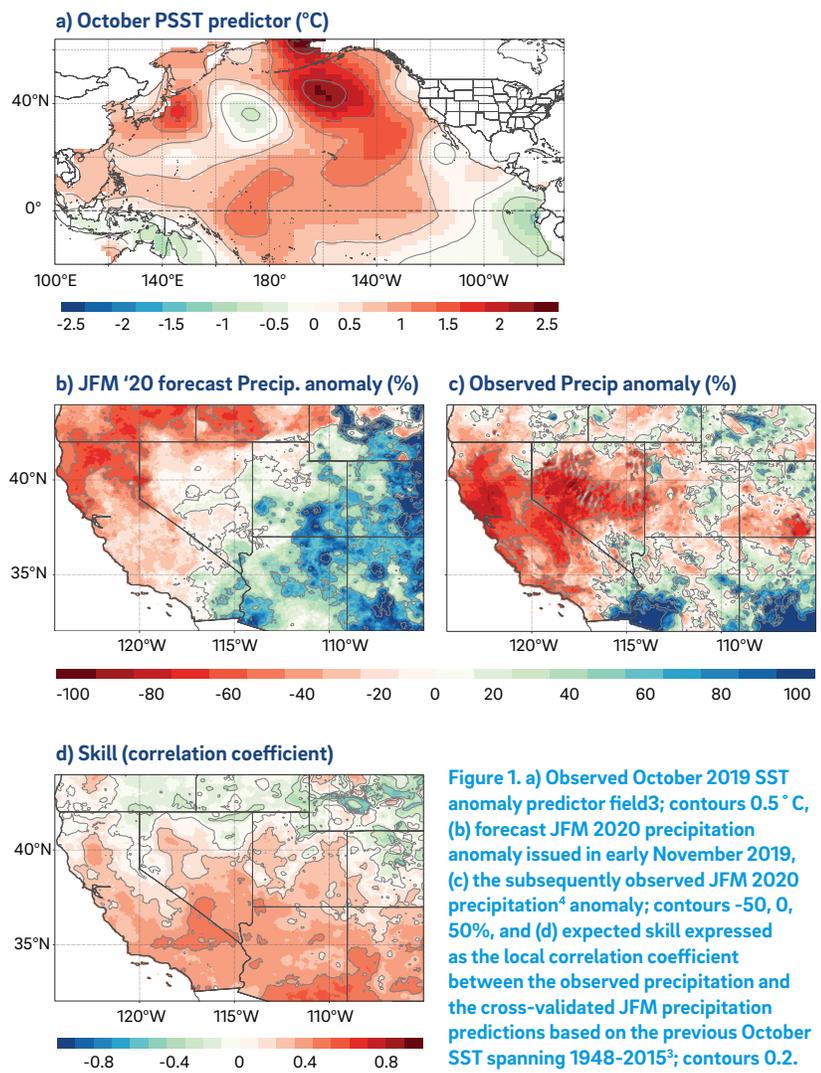
Figure 1. a) Observed October 2019 SST anomaly predictor field3; contours 0.5 ̊C, (b) forecast JFM 2020 precipitation anomaly issued in early November 2019, (c) the subsequently observed JFM 2020 precipitation[4] anomaly; contours -50, 0, 50%, and (d) expected skill expressed as the local correlation coefficient between the observed precipitation and the cross-validated JFM precipitation predictions based on the previous October SST spanning 1948-2015[3]; contours 0.2. Precipitation anomalies are calculated as % of JFM climatology relative to 1948-2015

parts of the Southwestern domain (Figure 1d), and in these regions, the forecast performed rather well. The observed precipitation anomaly (Figure 1c) generally resembled the forecast (Figure 1b) everywhere except, most notably, in southeastern Colorado. In California, the general pattern of dry north-center and wet in the southern desert was well predicted.

FORECAST VALIDATION FOR WATER YEAR 2020

In general, JFM is the most predictable season[1]. JFM 2020 was predicted with the CCA model trained and optimized on 68 years (1948 – 2015). The most accurate prediction was made with October 2019 PSST (Figure 2a), i.e., at 3-month lead-time. September and November 2019 PSST anomalies also predicted the JFM 2020 precipitation pattern with reasonable accuracy, but the magnitude of the predicted anomalies was more biased. December PSST failed to correctly predict the observed anomaly pattern, in spite of the expectation for the shortest lead-time forecasts to be the most skillful. Skills can vary with lead-time from year to year rather differently compared to the expected skill averaged over all years. Performance varied across all active seasons in WY2020 (Figure 2b) with fall and early winter (October – January) being most skillfully predicted at one-month lead-time. It is important to note that performance in one year and season does not guarantee similar performance in the following years, given the intrinsic variability within the climate system.

ACKNOWLEDGEMENT

Authors

Alexander Gershunov, Tamara Shulgina, Kristen Guirguis, Julie Kalansky, Michael DeFlorio, and Luca Delle Monache

References

[1] Gershunov, A. and D. Cayan, 2003: Heavy daily precipitation frequency over the contiguous United States: Sources of climatic variability and seasonal predictability. *J. Climate*, **16**, 2752-2765.

[2] Livneh, B. et al., 2015: A spatially comprehensive, hydrometeorological data set for Mexico, the U.S., and Southern Canada 1950–2013. *Sci. Data* **2**, 150042.

[3] NOAA Extended Reconstructed Sea Surface Temperature: https://psl.noaa.gov/data/gridded/data.noaa.ersst.v4.html

[4] Given that the Livneh (2015) data set has been updated through 2015 only, we use PRISM (https://prism.oregonstate.edu) data for forecast validation.

SEASONAL WY2020 FORECAST VALIDATION METRICS

a) JFM 2020 skill at various lead times
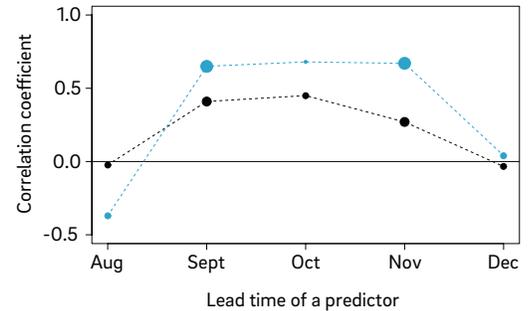
b) Seasonal skill at 1 month lead time
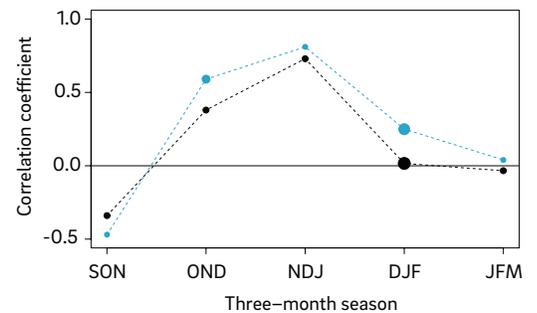
- ● Southwest
- ● California

RMSE:
- ○ 0–50
- ○ 50–100
- ○ 100–150
- ○ 150–200 mm

Figure 2. (a) Pattern correlation (y-axis) between observed and predicted precipitation anomalies at lead times spanning 1 – 5 months (x-axis). Root mean square error (RMSE – circle size) represents the bias of the predicted anomaly relative to that observed. High correlation coefficient and low RMSE represent good forecasts. The middle values representing retrospective skill of the JFM 2020 forecast made at 3-month lead time (i.e. with October 2019 PSST) reflect the quantitative comparison between patterns shown in Figure 1b and Figure 1c. (b) Active overlapping 3-month seasons of WY2020 predicted with PSST at one-month lead-time. At this shortest lead-time, NDJ was the most accurately predicted season (October PSST).