NOAA Climate Prediction Center *Experimental* Water Year Outlook

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What is and *Why* a Water Year Outlook?

- Water supply forecast information for the Western U.S. is often conveyed on a "water year" basis, with the water year starting on Oct 1 and going thru March -- "snowpack".
- Filling the need for precipitation forecasts at time scales beyond seasonal in a way that is relevant for water managers.
- Collaborate with water managers and Dir. DeWitt to produce a stakeholder-informed outlook.
- First step is to assess the viability of such an outlook using the North American Multi-Model Ensemble (NMME) which delivers 6-month forecasts of precipitation and temperature initialized each month.

Outline

- Hindcast verification
  - “Raw” NMME
  - Calibrated NMME – Ensemble Regression (Unger et. al. 2009)
- Forecast verification – WYO 2021 ONDJFM
- Current outlook - 2022-2023 WYO ONDJFM

Making the Water Year Outlook

- CPC is working on three WYOs. Start with October starts and leads out 6-months to estimate the sum total precipitation forecast for the target period.
  - 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
- Build sum-total precipitation climatologies as a function of lead.
- Skill assessment of the NMME's covers:
  - "Raw" NMME: OND 1982 – DJF 2020
  - Calibrated NMME: OND 1991 – DJF 2020
  - NMME:
    - **CFSv2** **24 members**
    - GEM_NEMO 10 members
    - **CanCM4i** **10 members**
    - GFDL_FLOR 24 members
    - **NASA_GEOS5v2** **4 members**
    - **NCAR_CCSM4** **10 members**
- Verification dataset: a version of CPC's (gridded) unified gauge precipitation

“Raw” NMME WYO Hindcast Verification

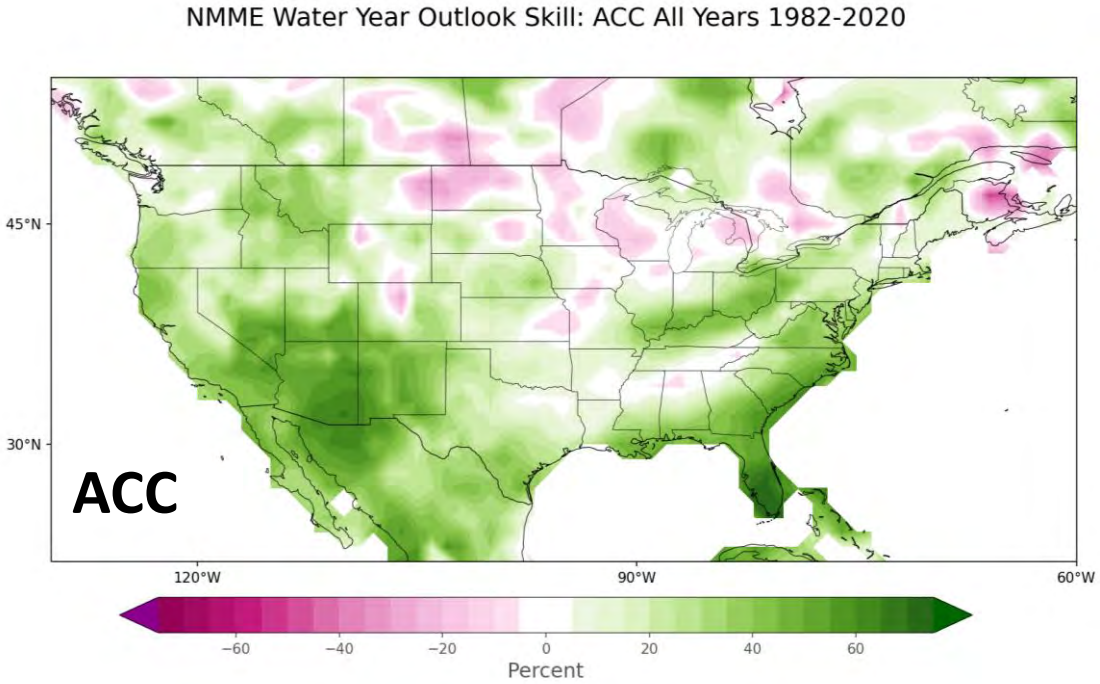
- ONDJFM sum total precipitation anomalies
- All Years
- *Not shown*… Subset by ENSO years based on ONI values
  - La Nina samples
  - El Nino samples

Evaluating the Water Year Outlook

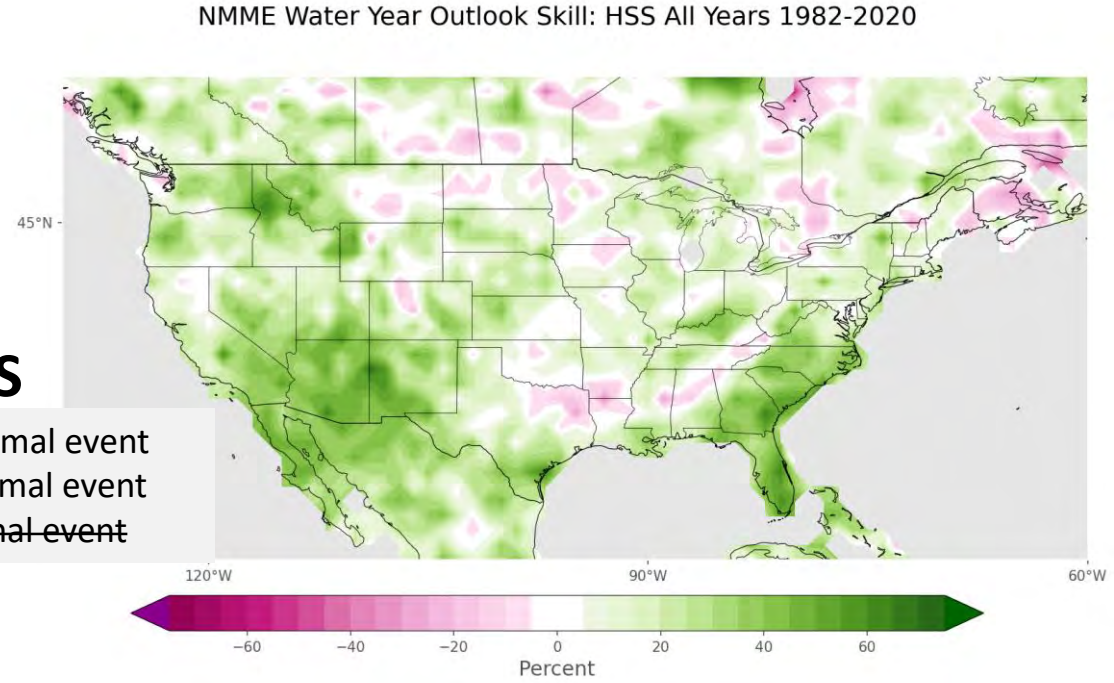
- **Skill assessment of the NMME's WYO for ONDJFM**
  - **common hindcast period: 1982-2020**
- **Typical forecast verification metrics:**
    - **ACC: Anomaly Correlation Coefficient**
      - percent the observed standard deviation of the anomalies is captured by the models
    - **HSS: Heidke Skill Score** – 2-category probabilistic skill score
      - the percent improvement/degradation over using climatology of using the NMME
    - **RPSS: Rank Probability Skill Score** – 3-category probabilistic skill score
      - how skillfully the models capture the observed climatological distribution

WYO ONDJFM Skill Assessment Precipitation Sum Totals

- **All Years** from 1982-2020
  - **ACC:** percent the observed standard deviation of the anomalies is captured by the NMME
  - **HSS:** 2-category probabilistic – the percent improvement/degradation of using the NMME vs climatology
  - **RPSS:** 3-category probabilistic outlook – how skillfully the NMME captures the observed climatological distribution

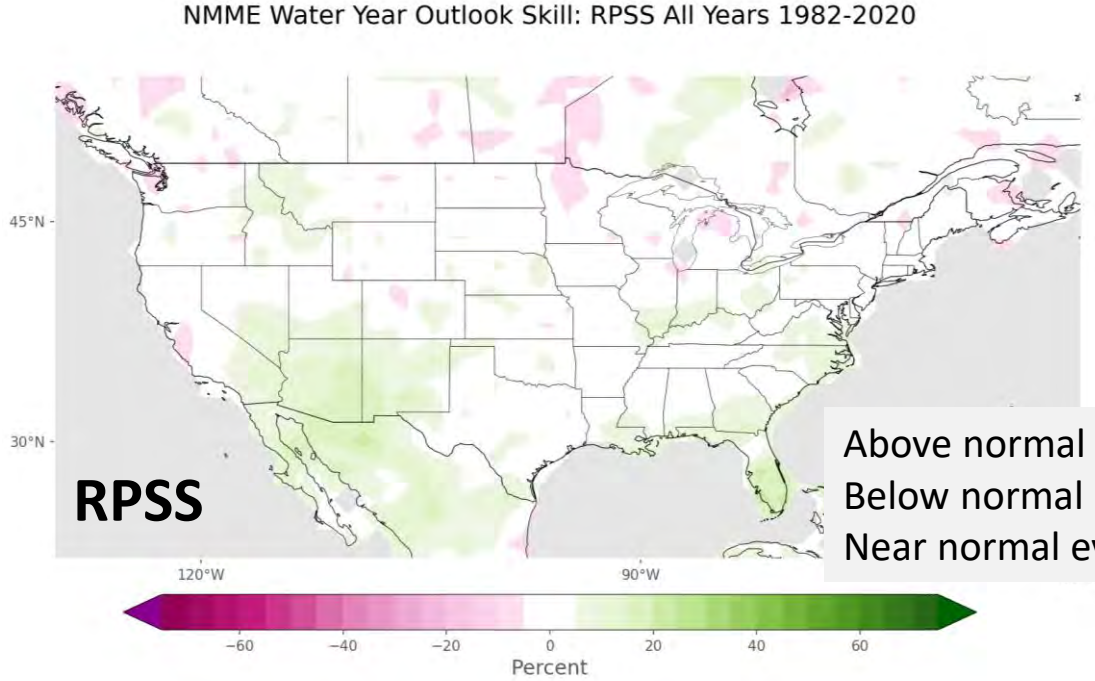


ACC



HSS

Above normal event
Below normal event
~~Near normal event~~



RPSS

Above normal event
Below normal event
Near normal event

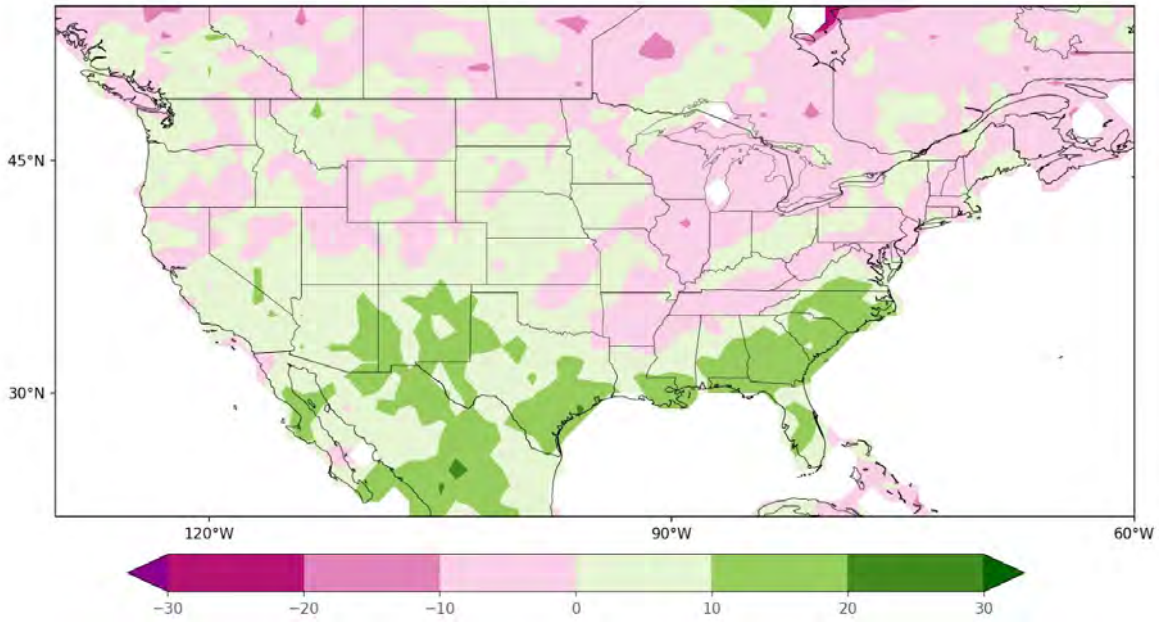
Calibrated NMME WYO Hindcast Verification

- ONDJFM sum total precipitation anomalies
- Different years but same models as "raw"
  - 1991 – 2020
- Approach:
  - Treated the 62 NMME members as from a single model.
  - Anomalies were estimated relative to a grand ensemble mean.
  - Calibration terms are estimated in a LOO framework.
- Based on Unger et al 2009 – and politely poached from his abstract…
- *"Ensemble members are assumed to represent a set of equally likely solutions, one of which will best fit observations. If standard linear regression assumptions apply to the best member, then a regression relationship can be derived between the full ensemble and the observations without explicitly identifying the best member for each case. The ensemble regression equation is equivalent to linear regression between the ensemble mean and the observations, but is applied to each member of the ensemble. The "best member" error variance is defined in terms of the correlation between the ensemble mean and the observations, their respective variances, and the ensemble spread. A probability density function representing the ensemble prediction is obtained from the normalized sum of the best-member error distribution applied to the regression forecast from each ensemble member."*

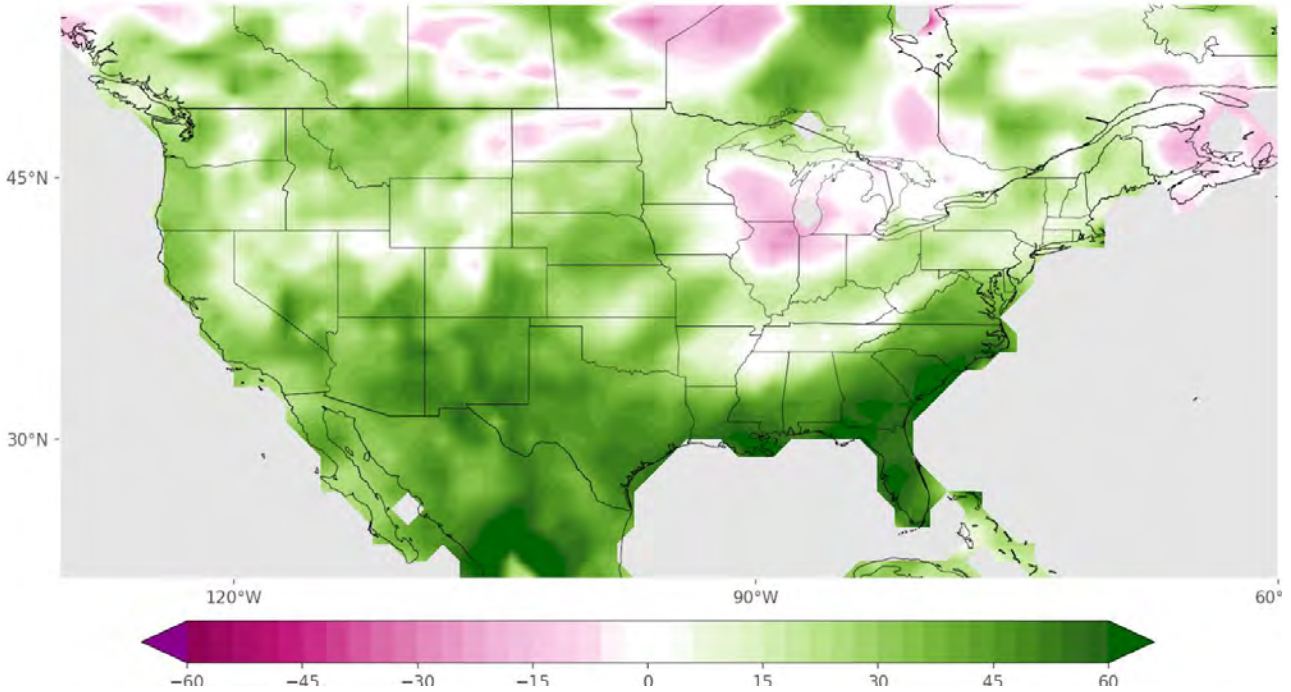
Calibrated WYO ONDJFM Skill Assessment 1991 - 2020

- Anomaly correlations
  - *NMME tends to do well getting the direction of the anomalous forecast*
- Raw 3-category probabilistic
- Calibrated 3-category probabilistic
  - *Calibrated NMME probabilities improve overall performance – especially in areas where climatology was better than the models (pink colors).*

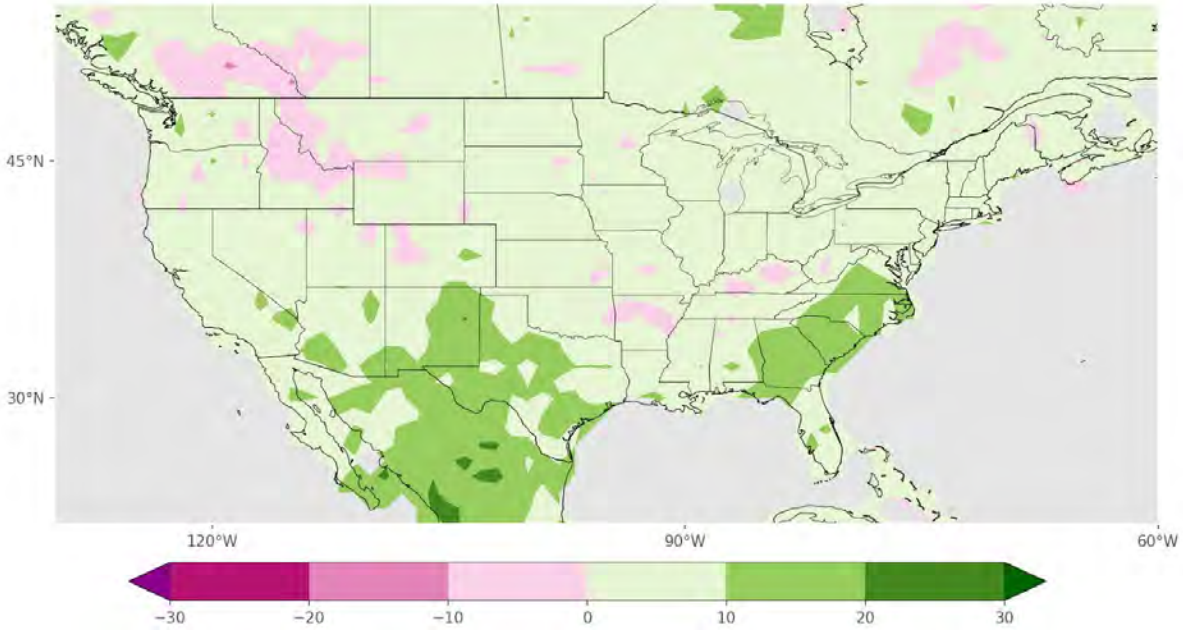
NMME Water Year Outlook Skill: RPSS All Years 1982-2020



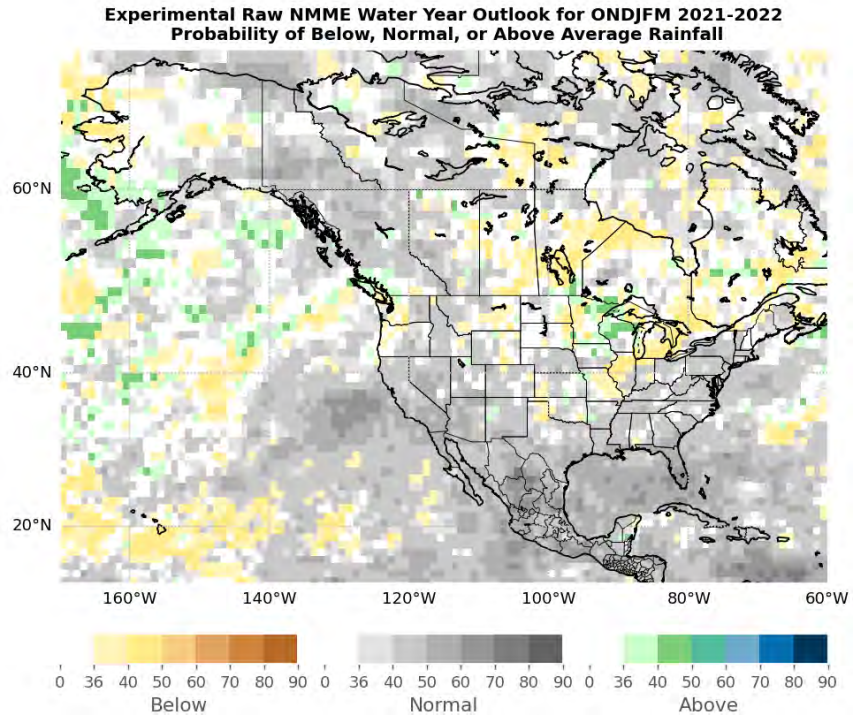
NMME Water Year Outlook Skill: ACC All Years 1982-2020

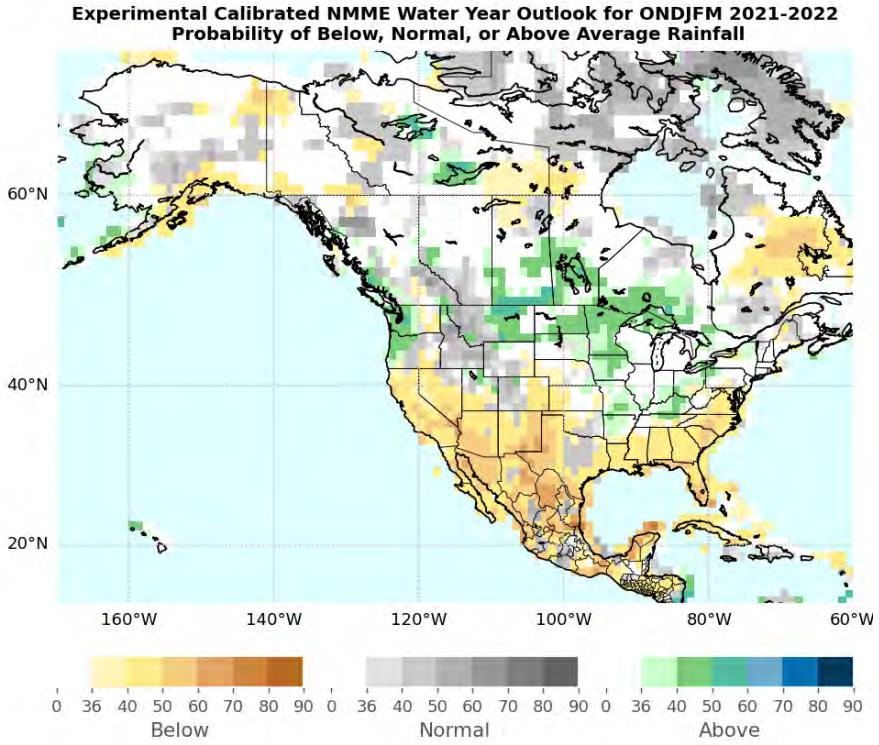


Calibrated NMME Water Year Outlook Skill: RPSS All Years 1991-2020

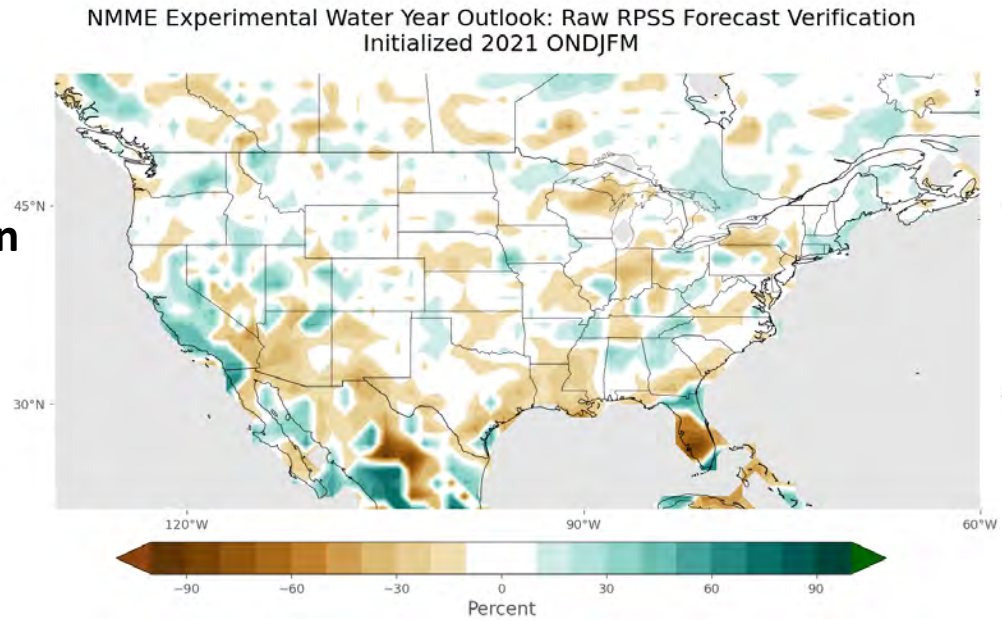


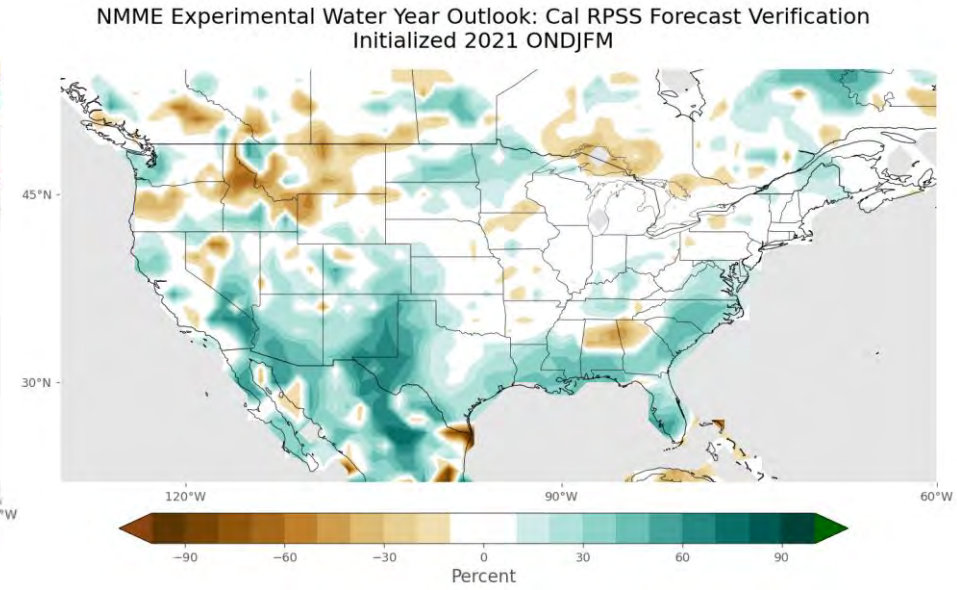
- **Experimental 2021-2022 WYO for Raw and Calibrated NMME 3-category ONDJFM outlooks**

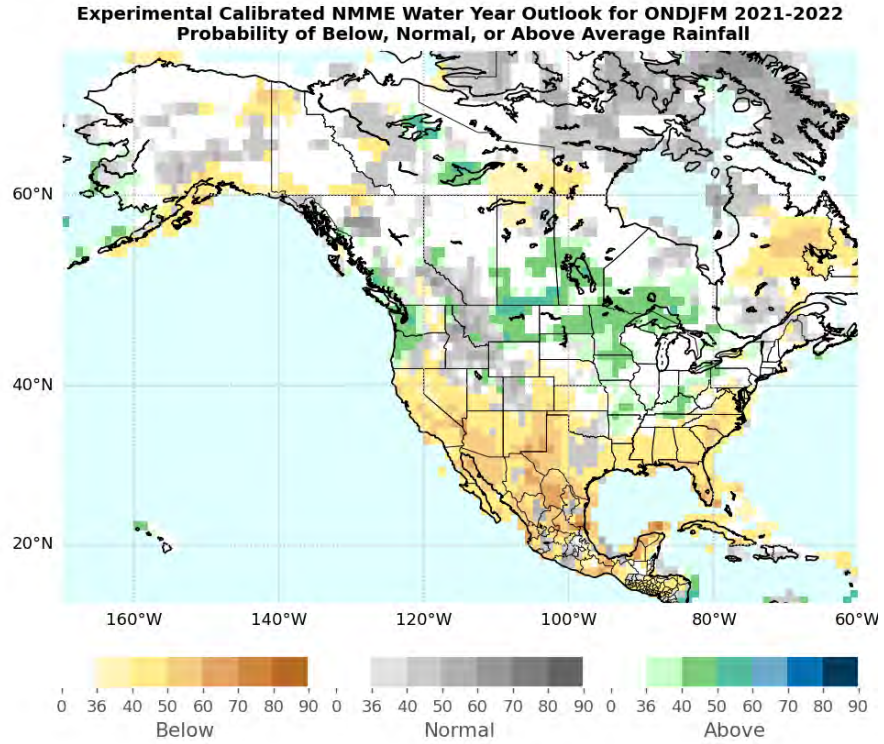


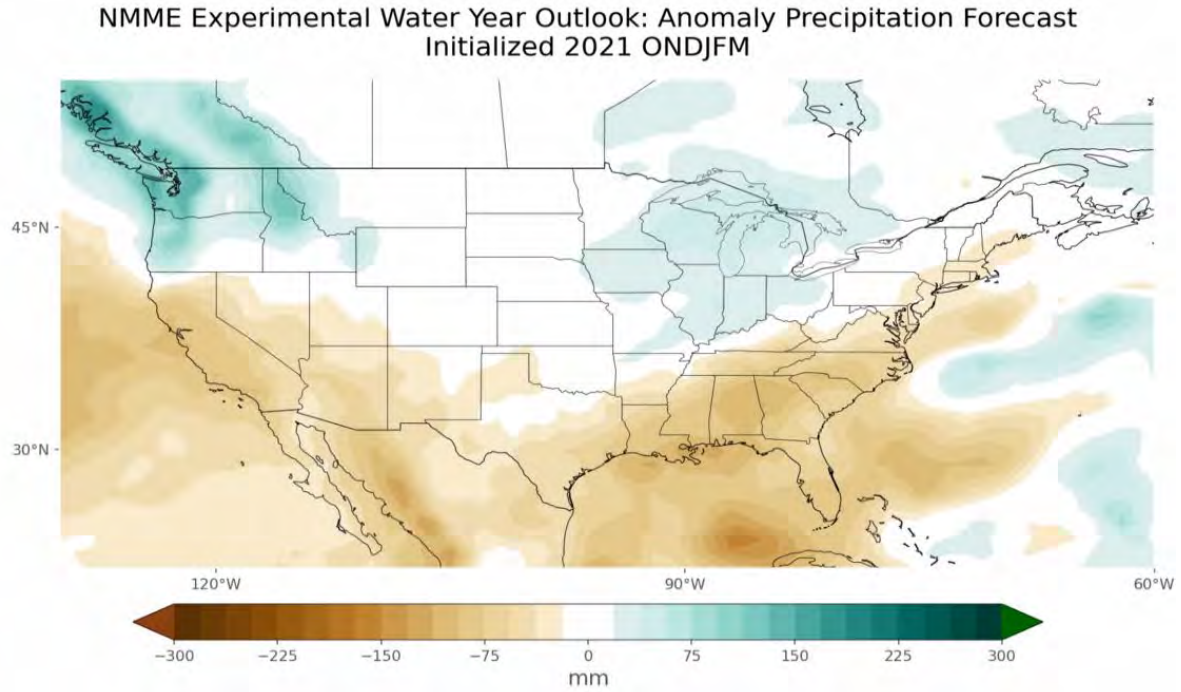


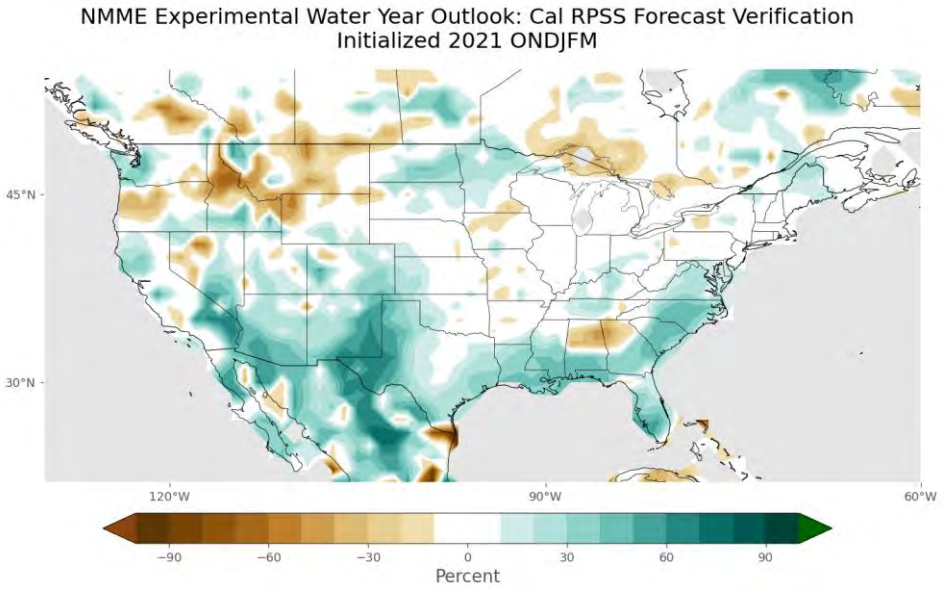
- **RPSS verification of each outlook**

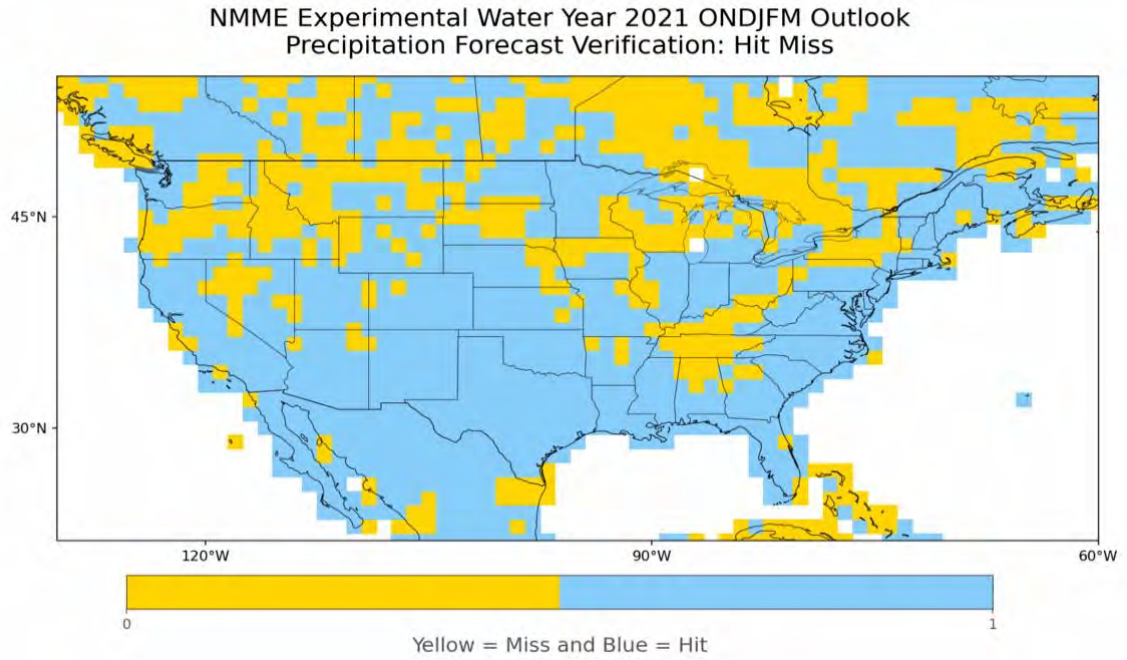


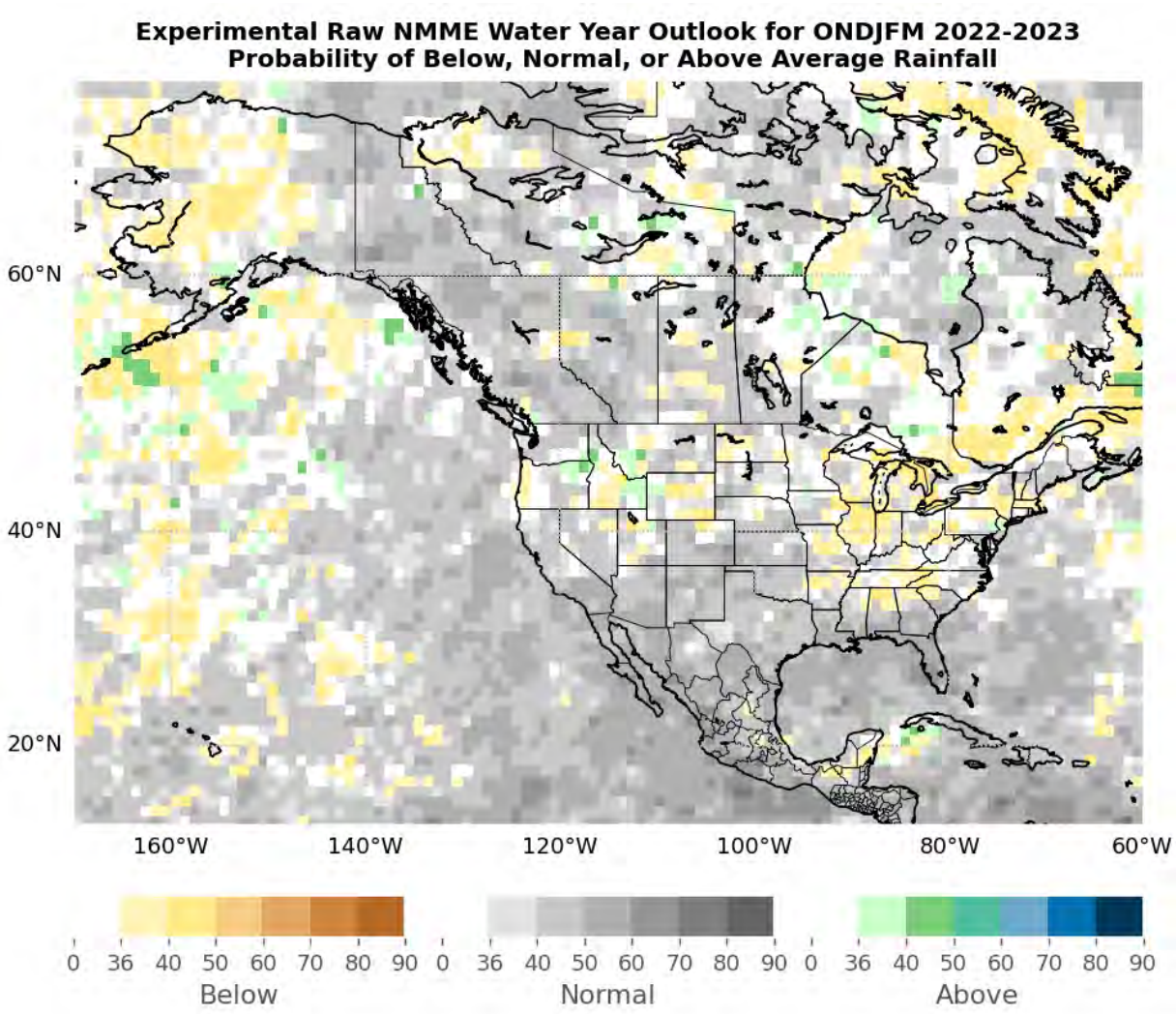


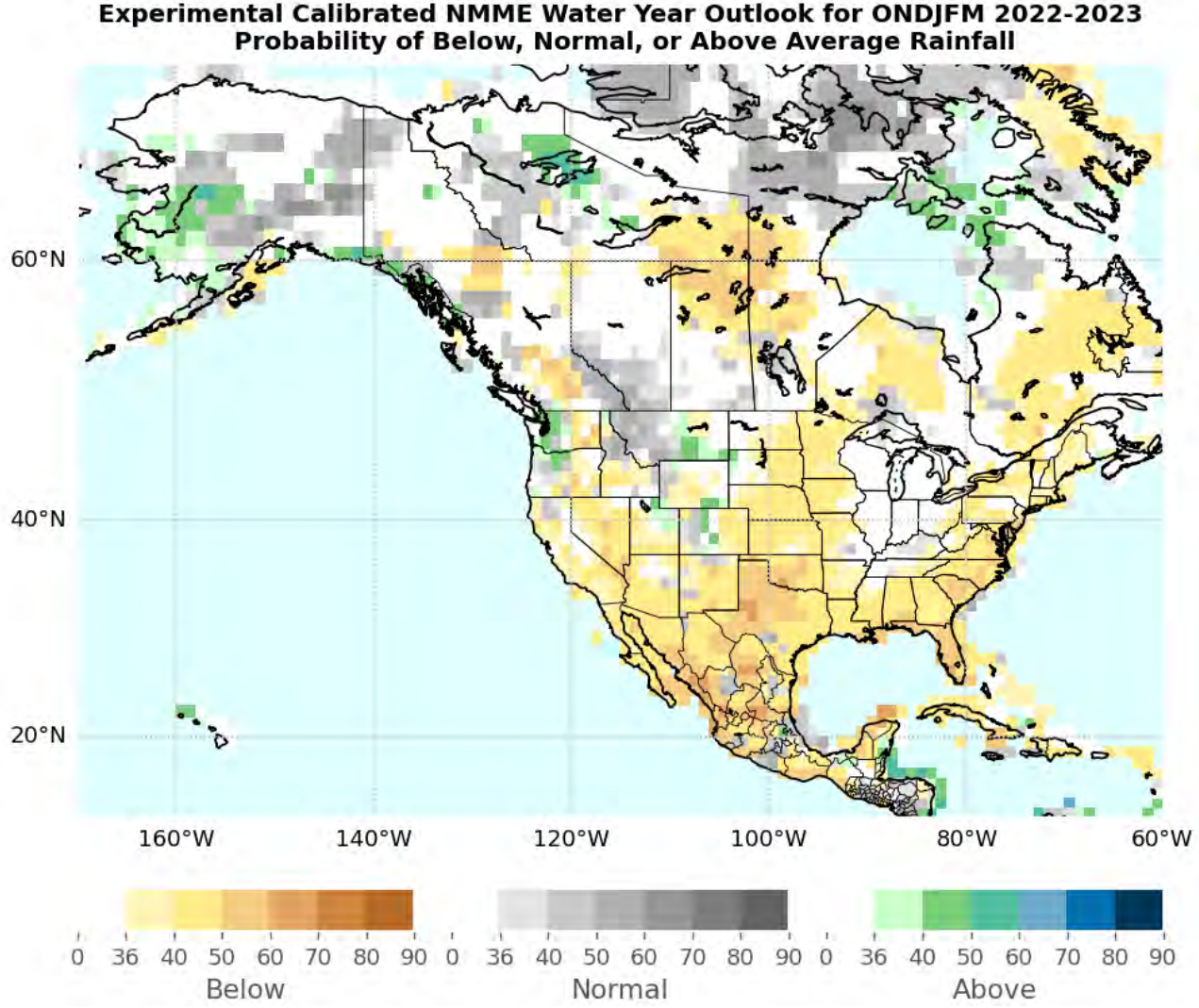

Experimental Calibrated NMME Water Year Outlook for ONDJFM 2021-2022
Probability of Below, Normal, or Above Average Rainfall
60°N
40°N
20°N
160°W
140°W
120°W
100°W
80°W
60°W
0 36 40 50 60 70 80 90
Below
0 36 40 50 60 70 80 90
Normal
0 36 40 50 60 70 80 90
Above

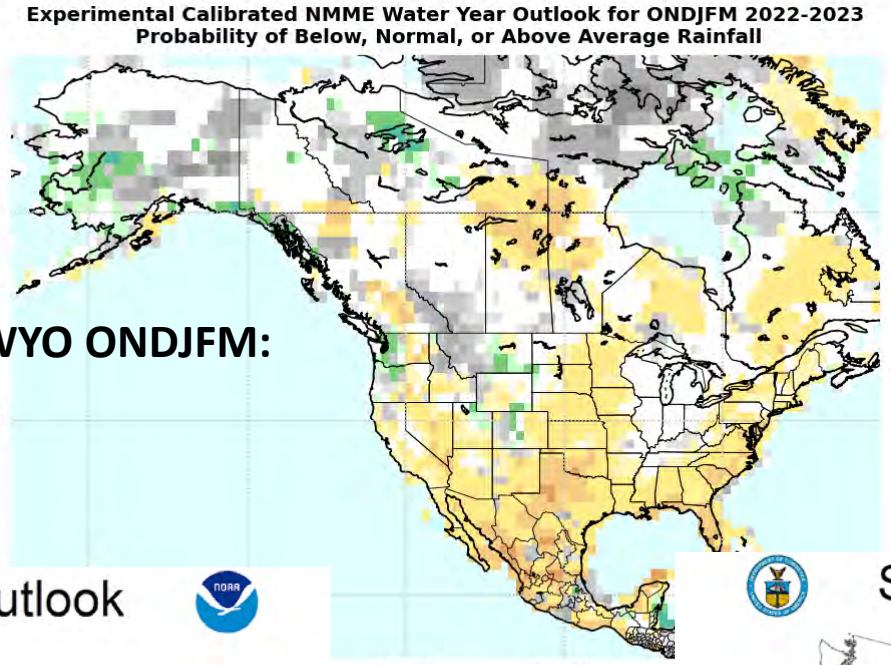

NMME Experimental Water Year Outlook: Anomaly Precipitation Forecast
Initialized 2021 ONDJFM
45°N
30°N
120°W
90°W
60°W
−300 −225 −150 −75 0 75 150 225 300
mm


NMME Experimental Water Year Outlook: Cal RPSS Forecast Verification
Initialized 2021 ONDJFM
45°N
30°N
120°W
90°W
60°W
−90 −60 −30 0 30 60 90
Percent

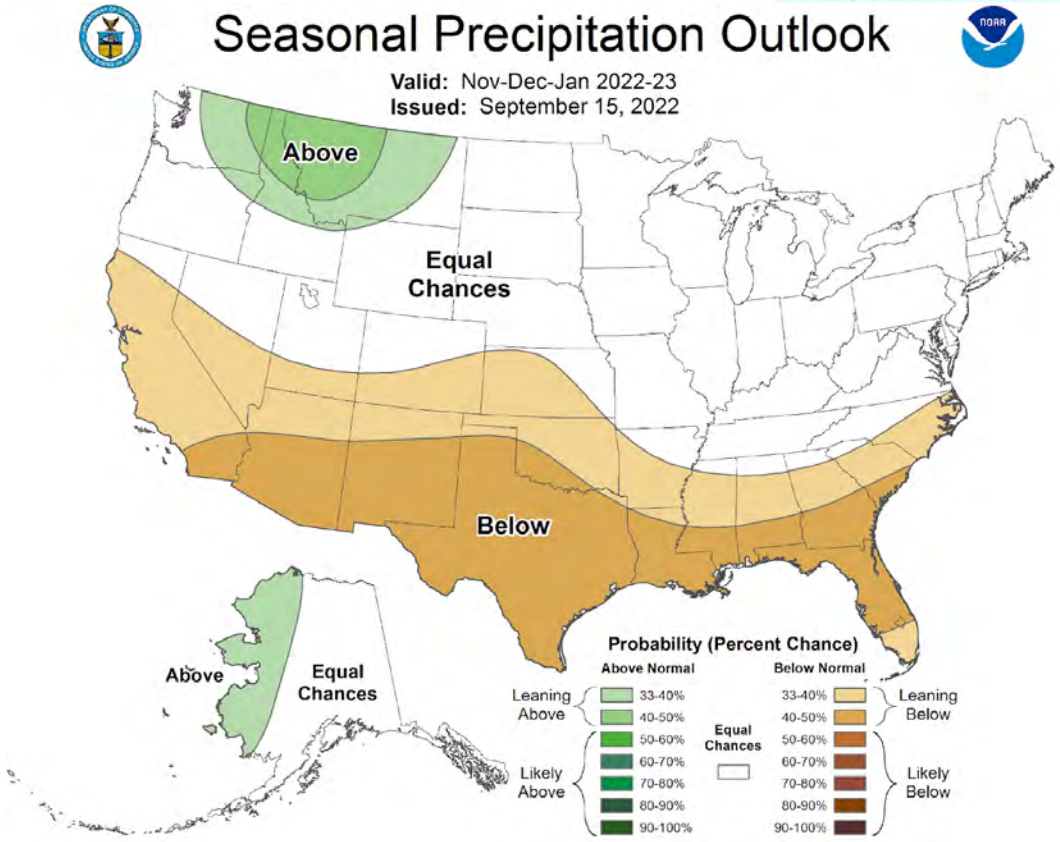

NMME Experimental Water Year 2021 ONDJFM Outlook
Precipitation Forecast Verification: Hit Miss
45°N
30°N
120°W
90°W
60°W
0
1
Yellow = Miss and Blue = Hit


Experimental Raw NMME Water Year Outlook for ONDJFM 2022-2023
Probability of Below, Normal, or Above Average Rainfall
60°N
40°N
20°N
160°W
140°W
120°W
100°W
80°W
60°W
0 36 40 50 60 70 80 90
Below
0 36 40 50 60 70 80 90
Normal
0 36 40 50 60 70 80 90
Above

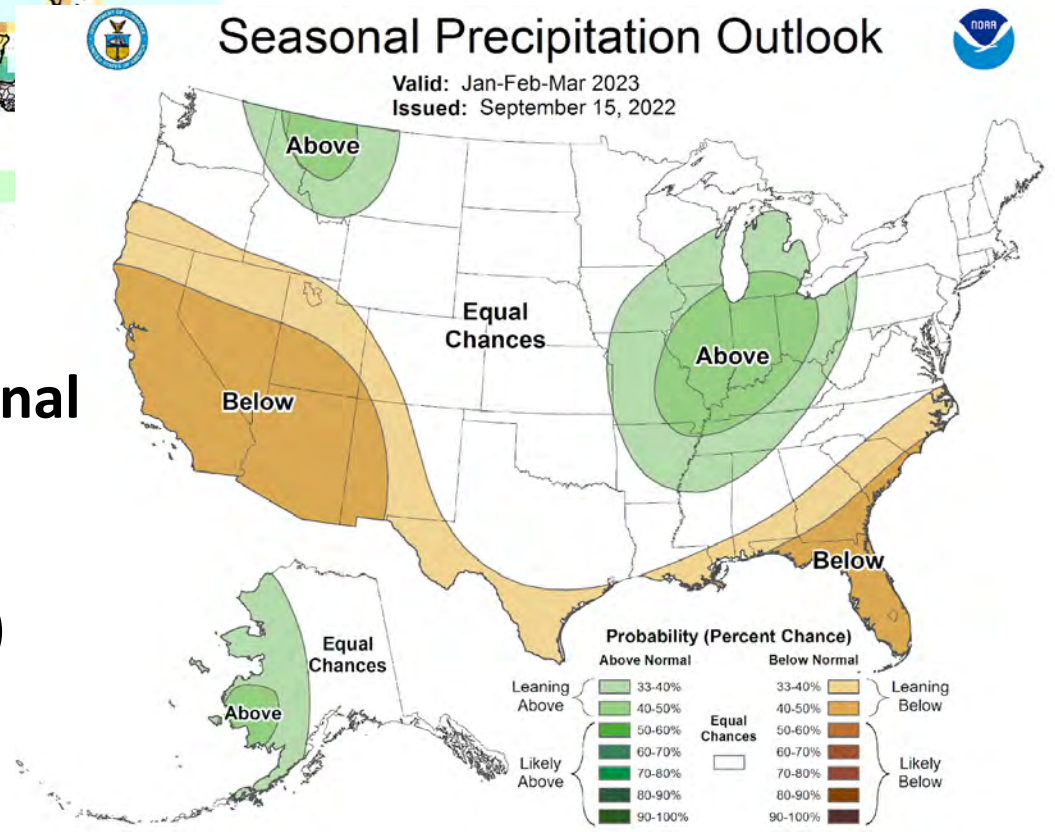

Experimental Calibrated NMME Water Year Outlook for ONDJFM 2022-2023
Probability of Below, Normal, or Above Average Rainfall
60°N
40°N
20°N
160°W
140°W
120°W
100°W
80°W
60°W
0 36 40 50 60 70 80 90
Below
0 36 40 50 60 70 80 90
Normal
0 36 40 50 60 70 80 90
Above

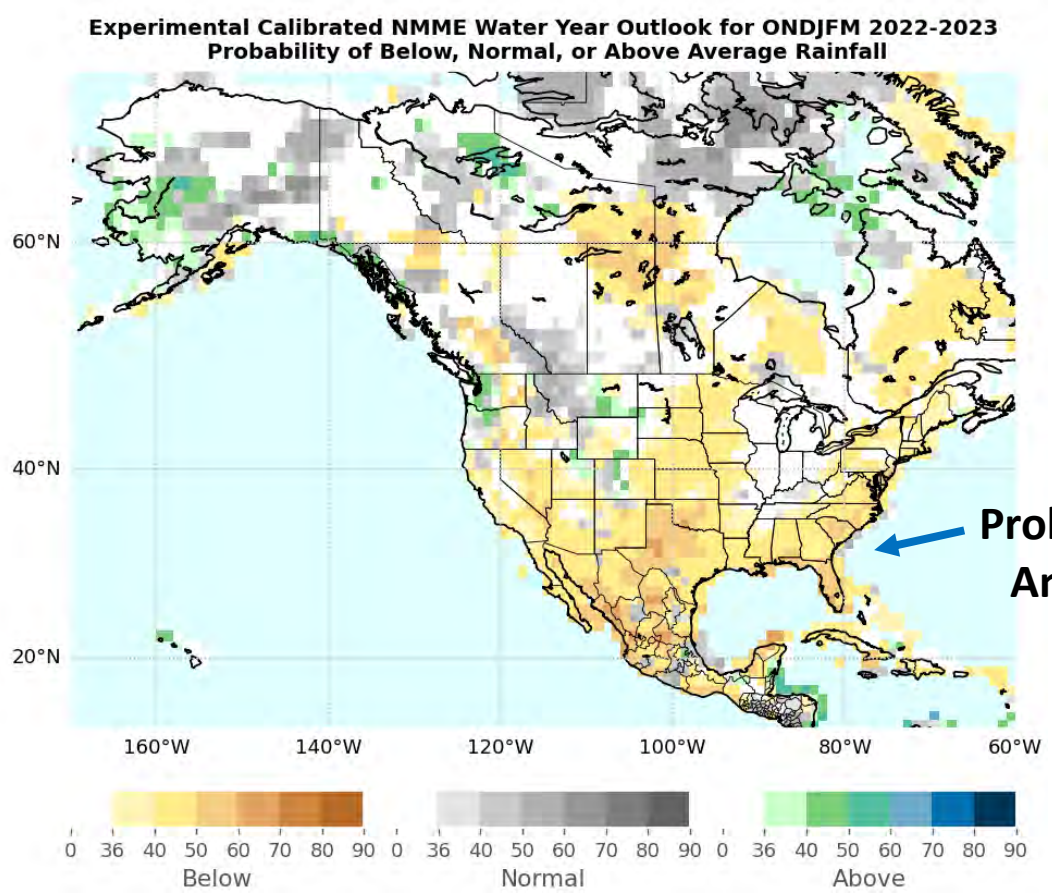


Calibrated WYO ONDJFM:



NMME Seasonal Outlooks:
NDJ (left)
JFM (right)

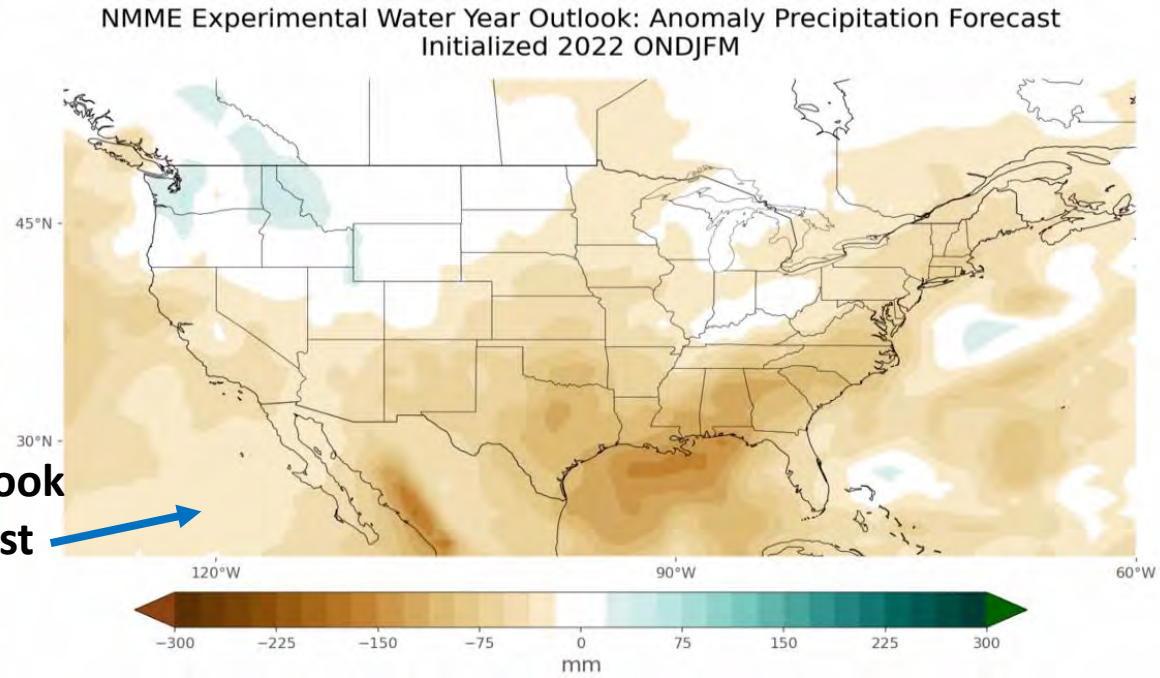


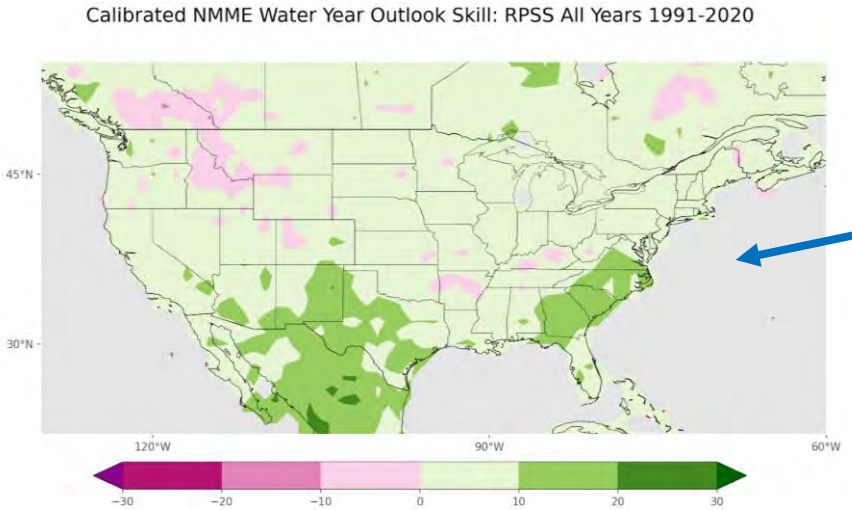


Forecast Maps

Probabilistic Outlook

Anomaly Forecast

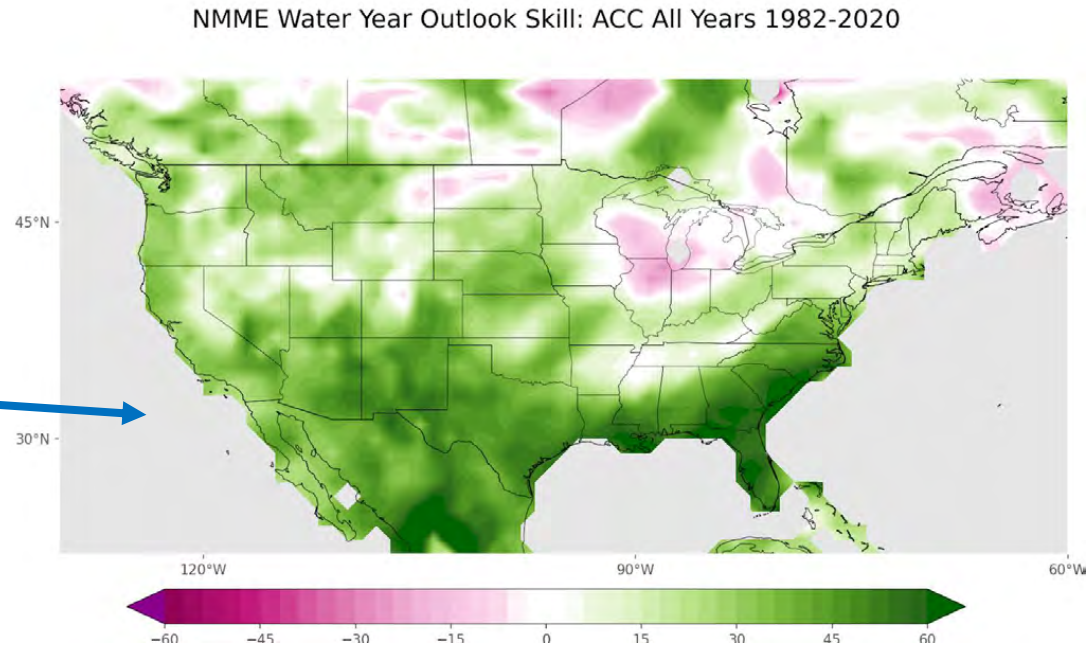




Skill Maps

RPSS

ACC



Next steps…

- **Skill of the 5- and 4-mth outlooks**
- **Additional post processing methods**
  - **Exploring up/down scaling**
- **Explore sensitivity in criteria of ONI years – add lags, choose different months, other measures of ENSO, etc.**
- **Explore hybrid methods – statistical + dynamical tools**
- **Engagement with the hydrology and water resources community to fine tune product(s)**
  - **Long lead temperature outlooks**
  - **Peak Melt**
  - **Dry Season Outlook**

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NMME Forecasts of Precipitation

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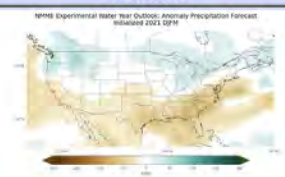
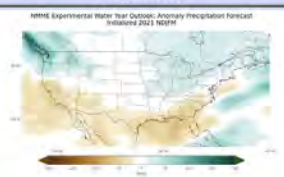
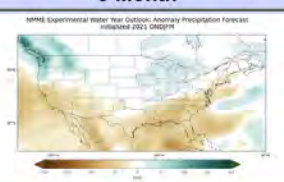
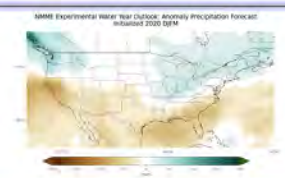
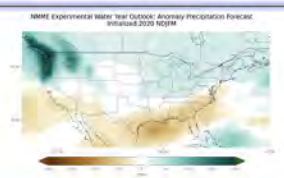
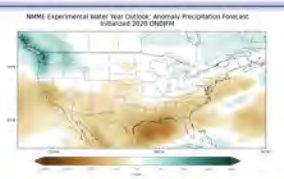
Multi-month spatial totals and anomalies			
	4-Month	5-Month	6-Month
Anomalies 2021			
Anomalies 2020			
Hit/Miss 2020			

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