

A STOCHASTIC FRAMEWORK IMPLEMENTATION TO FORECAST STAGES IN THE EVERGLADES FOR OPERATIONAL PLANNING

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Presentation Outline



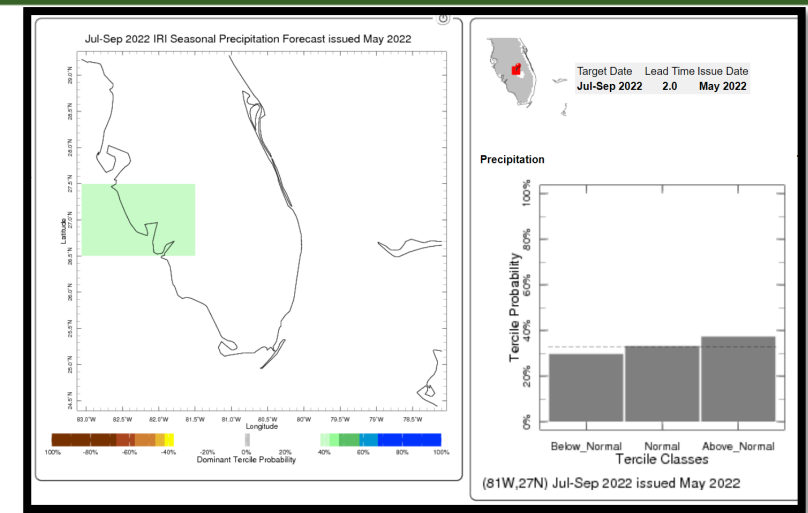
- **Motivation**
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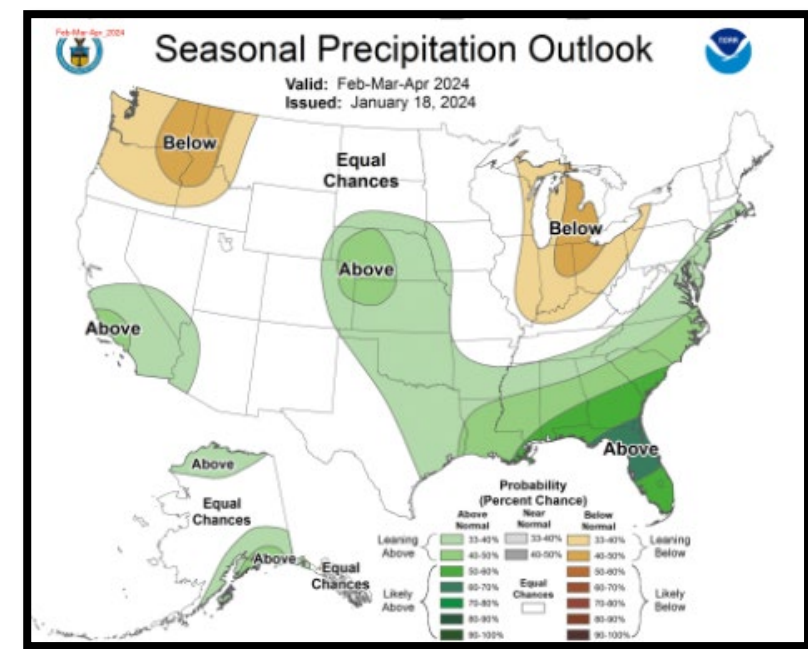
Motivation



- Stage forecasts over seasonal to annual timeframes are important for operational planning in South Florida
- Rainfall is the most important driver of water levels and other conditions in the Everglades
- Rainfall outlooks are uncertain over medium- and long-range
 - information is available in the form of tercile probabilities at 3 monthly seasonal scale
- Drawbacks of currently implemented techniques for stage forecasting
 - historical rainfall instead of rainfall outlook
 - not constrained by operational protocols

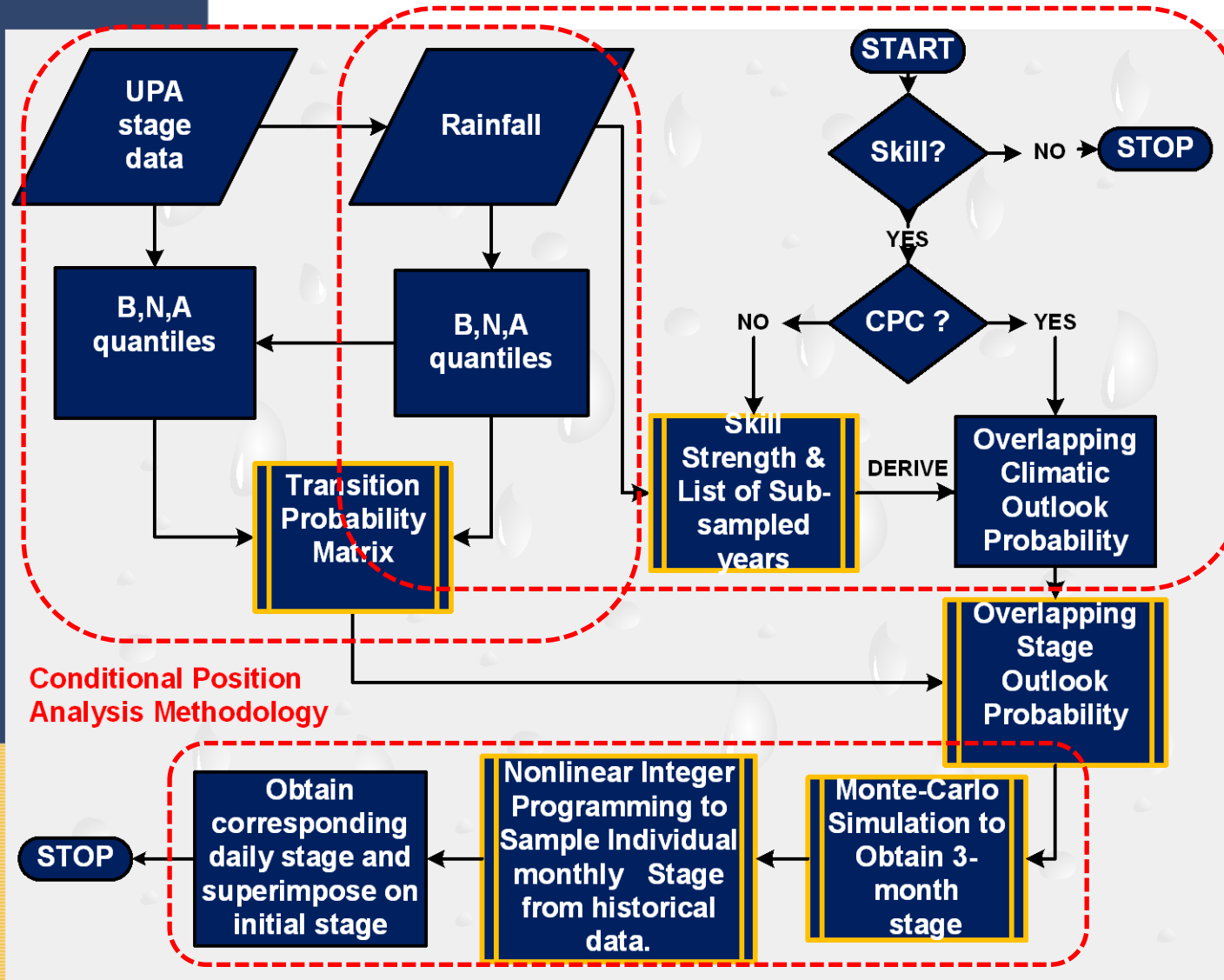


International Research Institute (IRI)



NOAA, Climate Prediction Center (CPC)

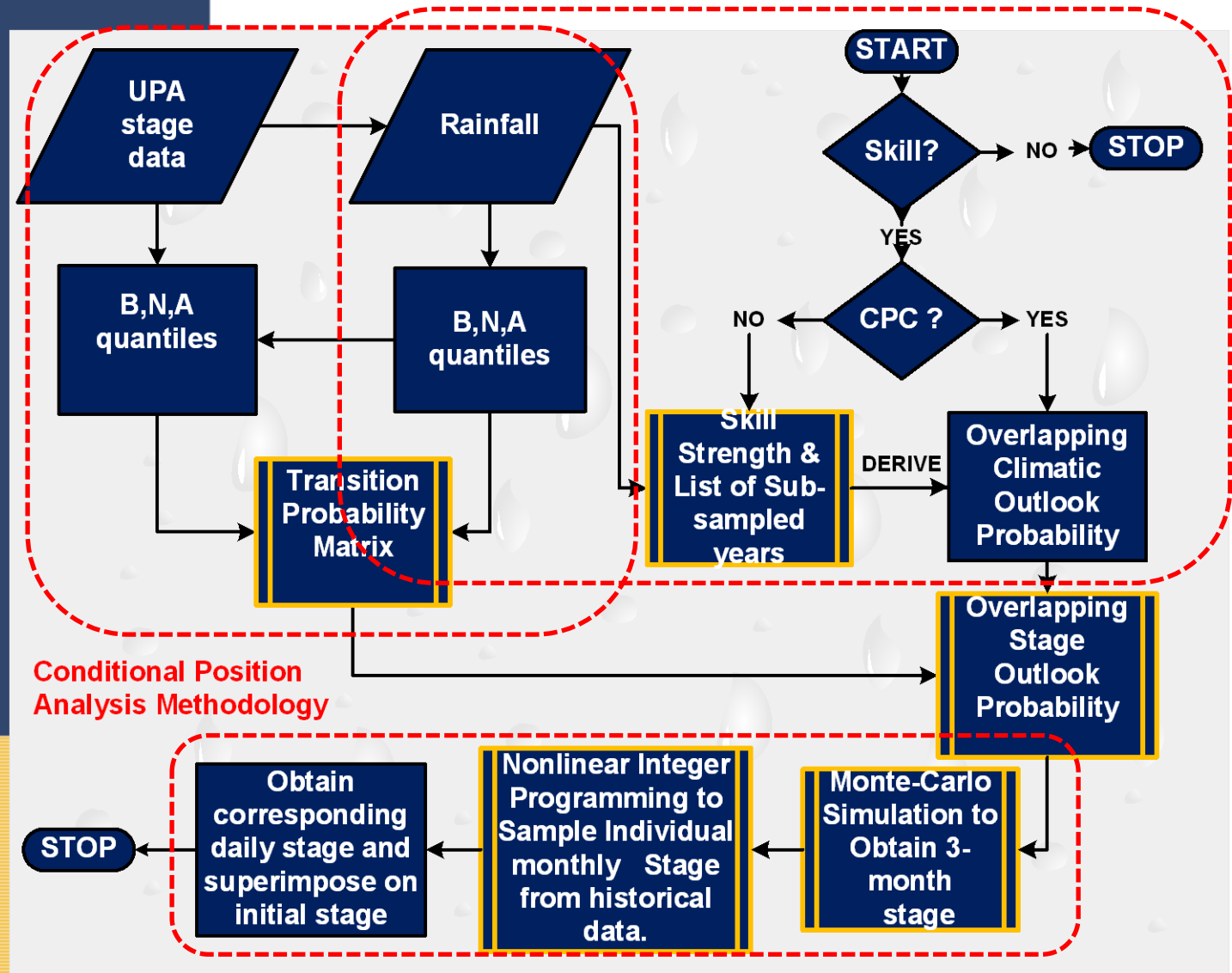
Overview



- **Conditional Position Analysis (CPA)** is a stochastic framework that transforms stages obtained from Dynamic Position Analysis (DPA) based on rainfall outlook over the next twelve months (Ali, 2016).
- DPA uses SFWMM (a process-based model) which simulates stages and flows based on System's Operational Protocols (e.g., LORS2008).
- DPA stage outputs are used as inputs to CPA.

(Ali, 2016)

Methodology



Conditional Position Analysis Methodology

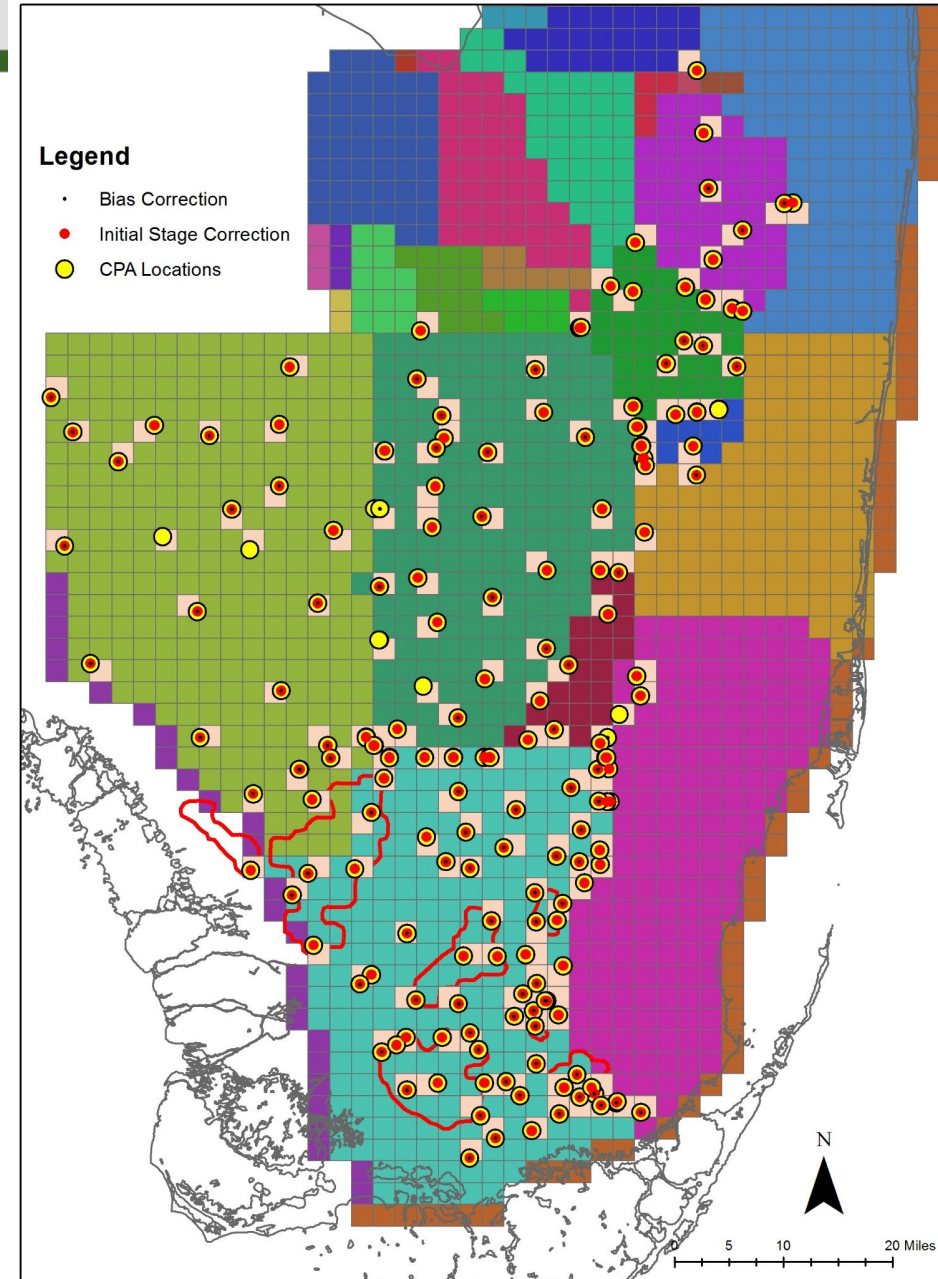
- “rainfall is correlated more with the stage changes than the stage” (Ali 2009)
- Transition Probability Matrix (TPM) is calculated based on DPA stage data and historic rainfall used in DPA
- Monte Carlo Simulation - generate 3 month overlapping $\Delta 3mStage$ using TPM and rainfall outlook
- Nonlinear Integer Programming to sample individual monthly $\Delta mStage$ from DPA stage data
- Objective function:
$$\sum_{i=1}^{10} \left(\sum_{j=i}^{i+2} \Delta mStage_j - \Delta 3mStage_i \right)^2$$
- Add daily $\Delta Stage$ for selected months to DPA initial stage recursively to create a realization of CPA stage
- Repeat above process

(Ali, 2016)

CPA Implementation

- MATLAB based
- Originally developed for Lake Okeechobee
- Expanded to 199 locations in the Everglades (consistent with EverForecast), WCA1_Avg (avg of Site 7, Site 8T, and Site 9) and WCA3A_Avg (avg of Site 63, Site 64, and Site 65)
- 3 rainfall outlooks (climatological, CPC, and Preferred Scenario)
- 2 Operational Protocols – LORS2008 and LOSOM

Everforecast Gages for CPA



CPA Implementation: Rainfall Scenarios



➤ Climatological

- assumes equal chances of below-normal/dry, normal, and above-normal/wet rainfall conditions over next twelve 3 monthly seasons
- connecting link between DPA and all other scenarios simulated under CPA

➤ CPC

- rainfall forecasts published by NOAA's Climate Prediction Center (CPC) every month ([Climate Prediction Center - Forecasts & Outlook Maps, Graphs and tables \(noaa.gov\)](https://www.cpc.ncep.noaa.gov/forecasts/)).
- It is also used by JEM's EverForecast tool for stage prediction

➤ Preferred Scenario (PrefSce)

- tercile probabilities are calculated from projected Niño-3.4 Index ([Climate Prediction Center - El Nino Southern Oscillation \(noaa.gov\)](https://www.cpc.ncep.noaa.gov/ei/)) published by CPC
- typically, more aggressive in terms of shifts from Climatological probabilities



CPA Implementation: Workflow



Step 1

- Create Rainfall Outlook (i.e., Tercile Probability) Scenario Files for Climatological, CPC, and Preferred Scenario

Step 2

- DPA stages extraction for the desired Operational Scenario Protocol (LORS2008 or LOSOM)

Step 3

- Process stage information (correction for known biases and initial stages) to generate inputs for CPA

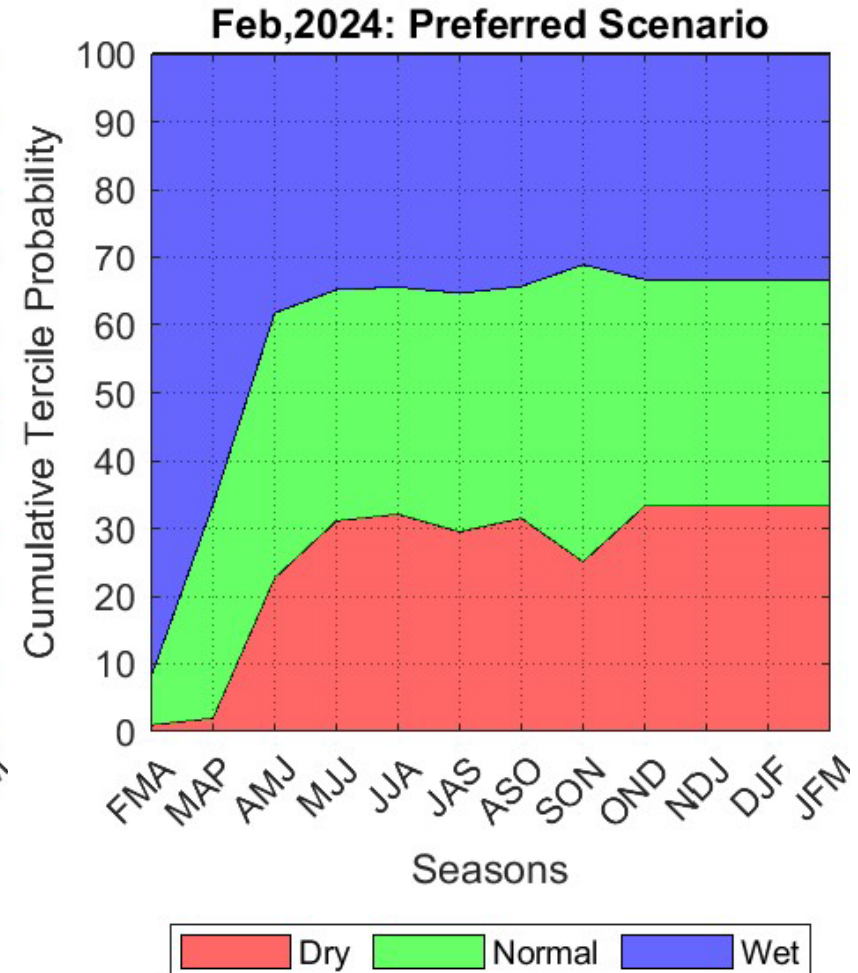
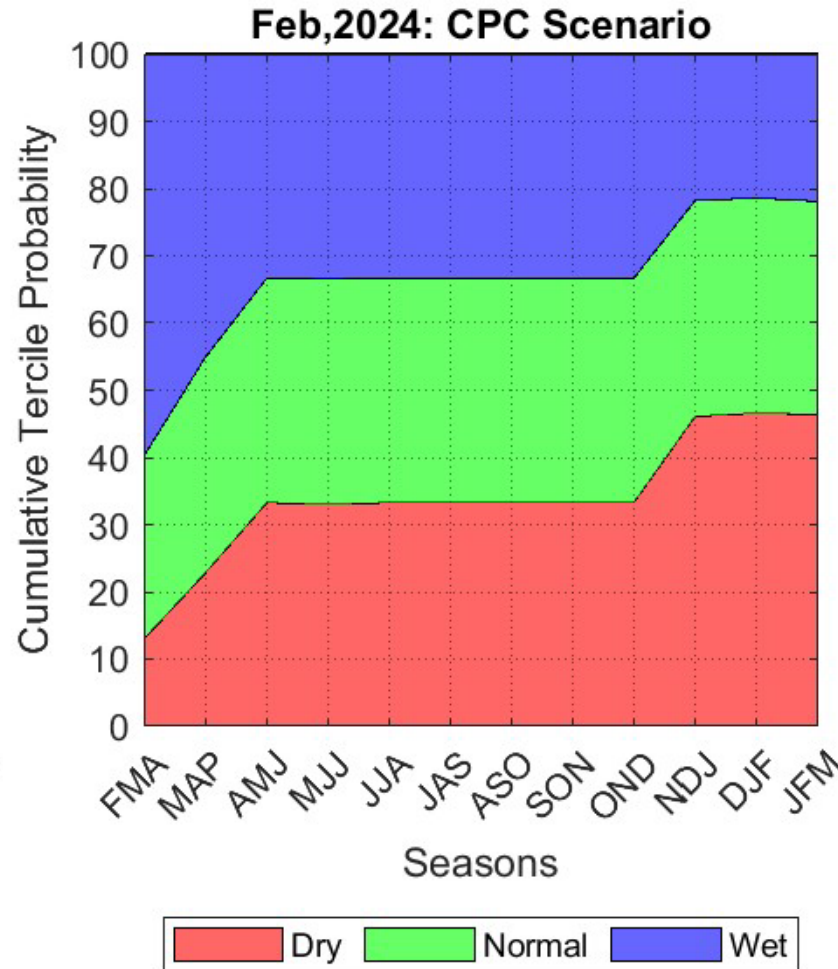
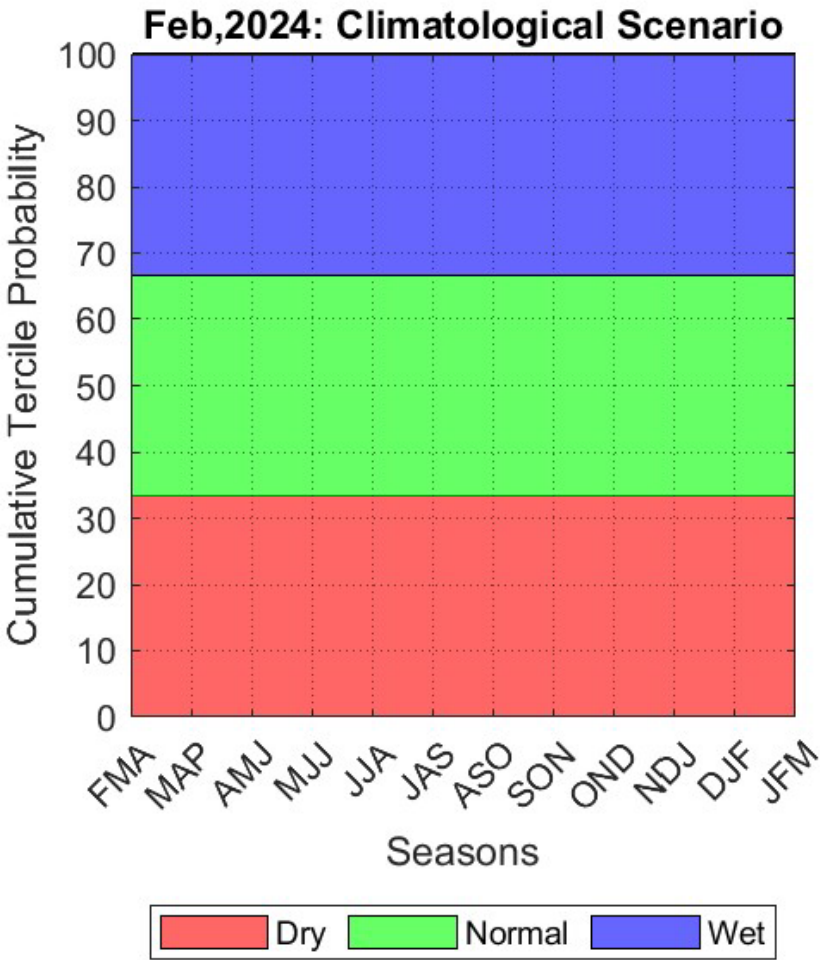
Step 4

- Run CPA on windows server in parallel mode

Step 5

- Post-process stage traces (graphics and stage outputs)

February 2024 CPA: Rainfall Scenarios

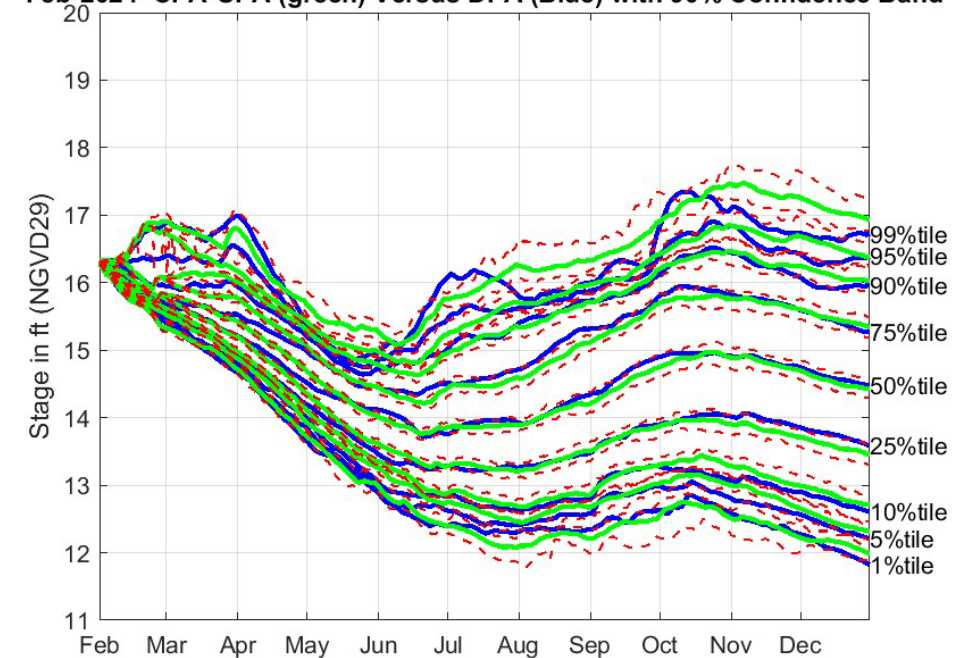


CPA Results



- Raw stage traces obtained from CPA are processed further (bootstrapped) to calculate percentile lines.
- CPA forecasted stage percentiles from 'Climatological' scenario are first collapsed on DPA stage percentiles. Corresponding adjustments are then applied to stage percentile lines for all other rainfall outlook scenarios.

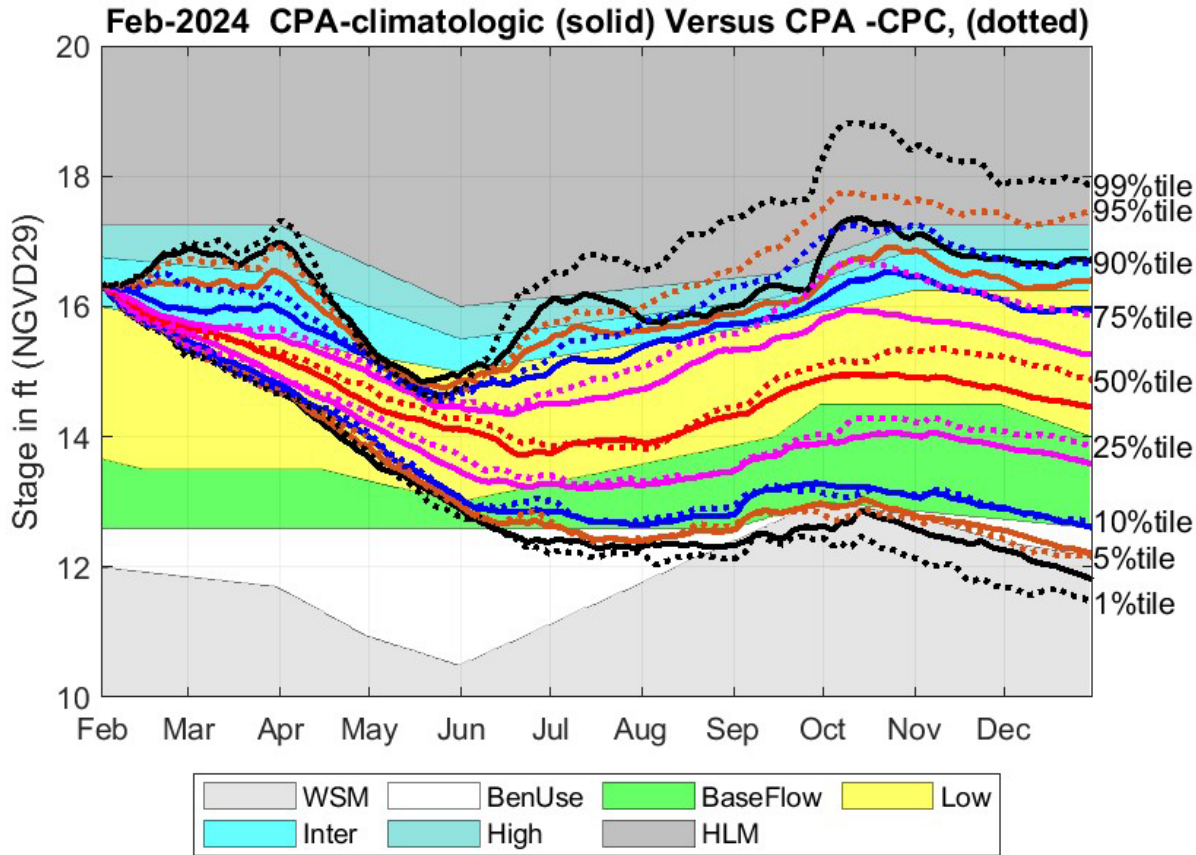
Feb-2024 CPA-UPA (green) Versus DPA (Blue) with 90% Confidence Band



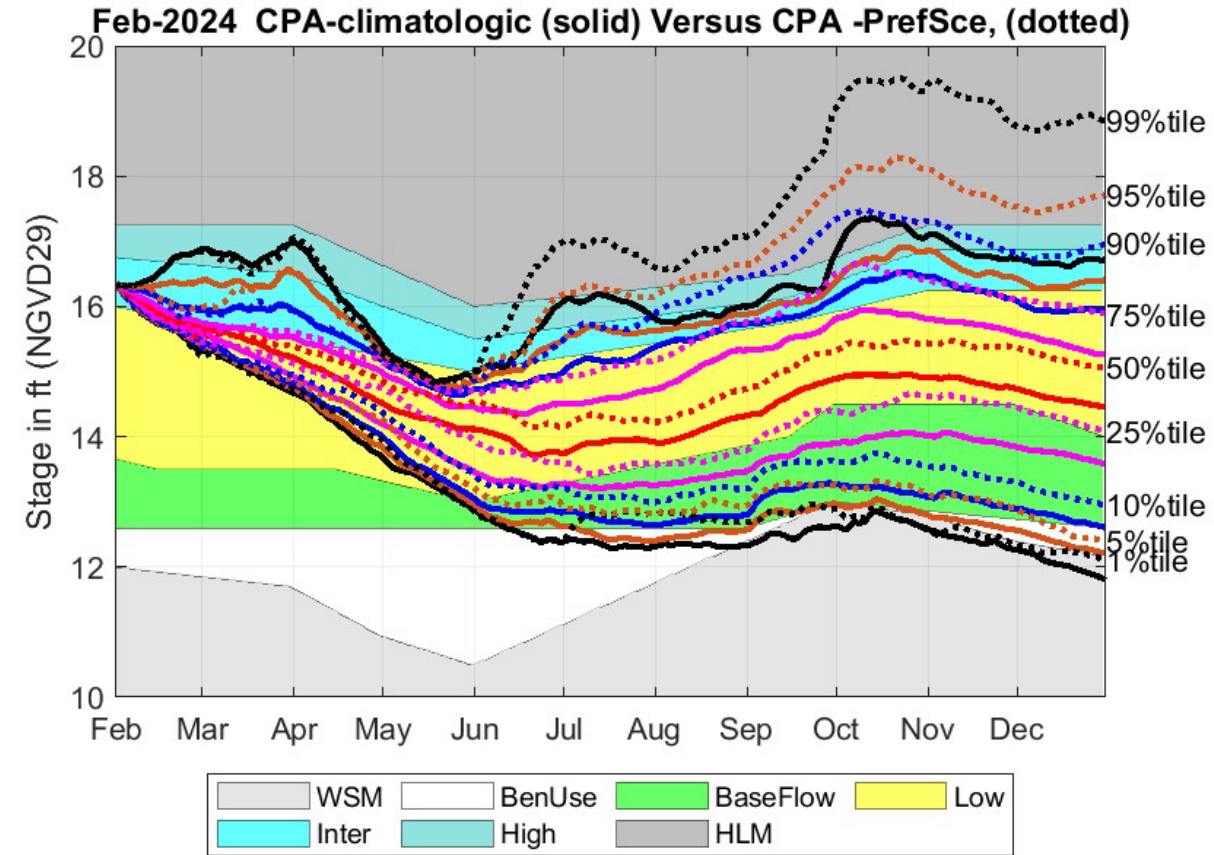
Feb 2024 CPA: LOK under LORS2008



CPC



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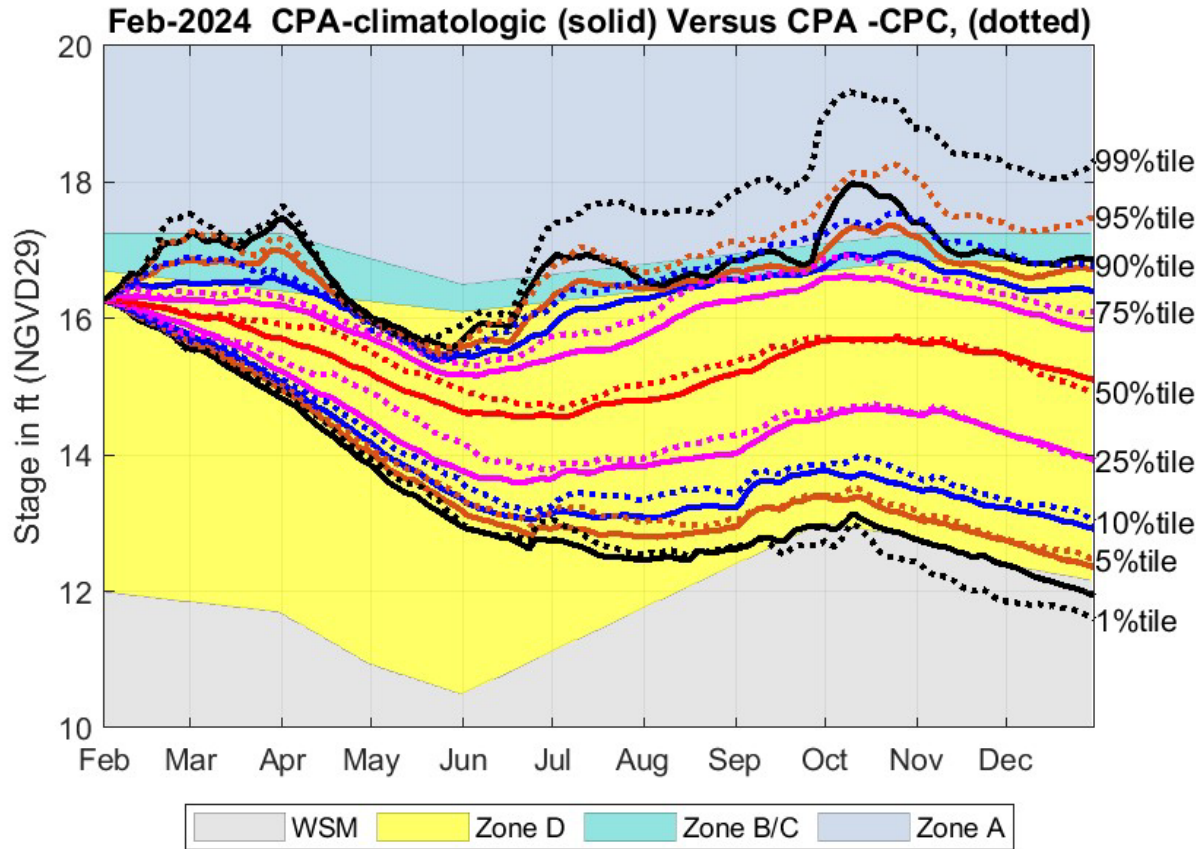




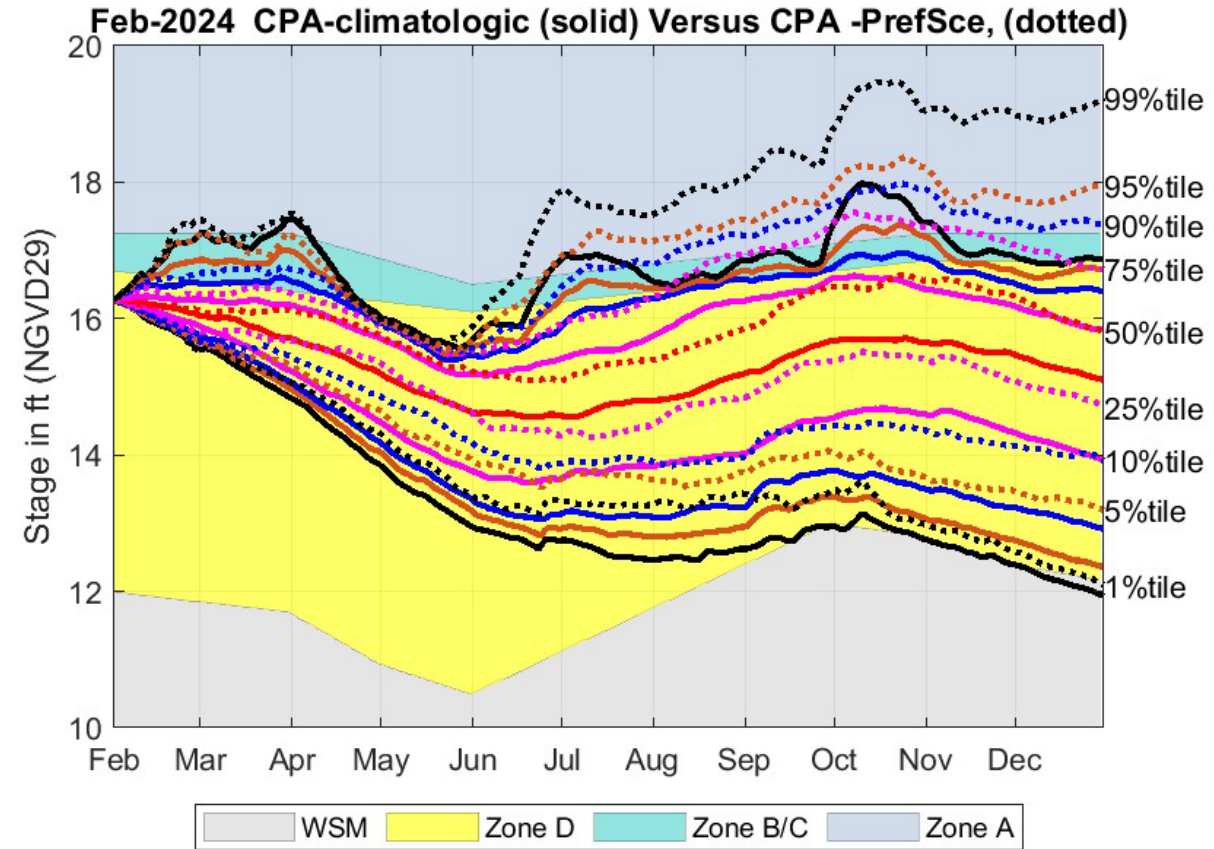
Feb 2024 CPA: LOK under LOSOM



CPC



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Discussion and Summary



➤ Discussion

- CPA may generate raw stage traces that do not appear realistic w.r.t. practical considerations
- Currently, efforts are underway to develop mechanism to further constrain CPA generated stages such that even extreme stages would conform to practically possible stages under current operational protocols

➤ Summary

- CPA methodology transforms DPA forecasted stages based on rainfall outlook, providing a more realistic perspective to water managers on the state of the system
- Monte Carlo Simulation technique with non-linear integer programming to generate stage traces
- Incorporates currently implemented and soon to be implemented operational protocols
- Flexible to simulate any hypothetical rainfall outlook



THANK YOU!