

Can We Reliably Forecast the Future without Knowing the Past?

UFA Level Predictions In North Florida

(Study conducted as part of PhD research at University of South Florida)

Fatih Gordu, Ph.D., PE
Chief, Bureau of Groundwater Modeling and Assessment

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Can we reliably predict the future without knowing the past?

ChatGPT 3.5 ▾



F You
Can we reliably predict the future without knowing the past?

ChatGPT
Predicting the future without knowledge of the past is challenging because historical data often provides valuable insights into trends, patterns, and potential future outcomes. While it may be possible to make some predictions based on current trends or observations, a lack of historical context can limit the accuracy and reliability of these predictions. Additionally, understanding the past can help identify potential pitfalls or opportunities that may arise in the future. So, while it's not impossible to make predictions without knowledge of the past, having historical data can greatly improve the reliability of future predictions.



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- Observations
- Historical Patterns
- Climate Cycles
- Has stationarity been dead or never existed?

PAST



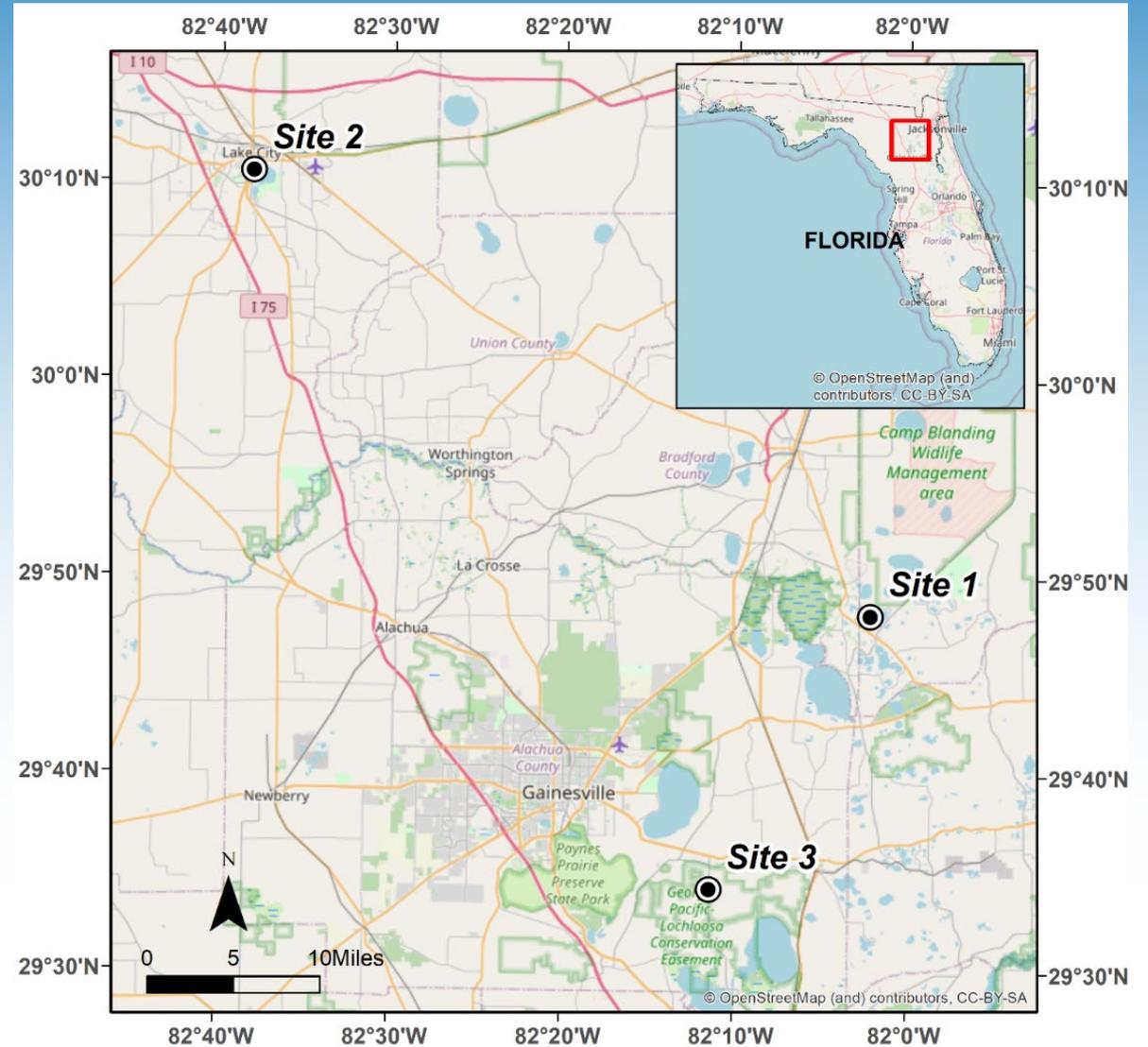
- Global Climate Models
- Rainfall/Temperature projections
- Uncertainty

FUTURE



Site Descriptions

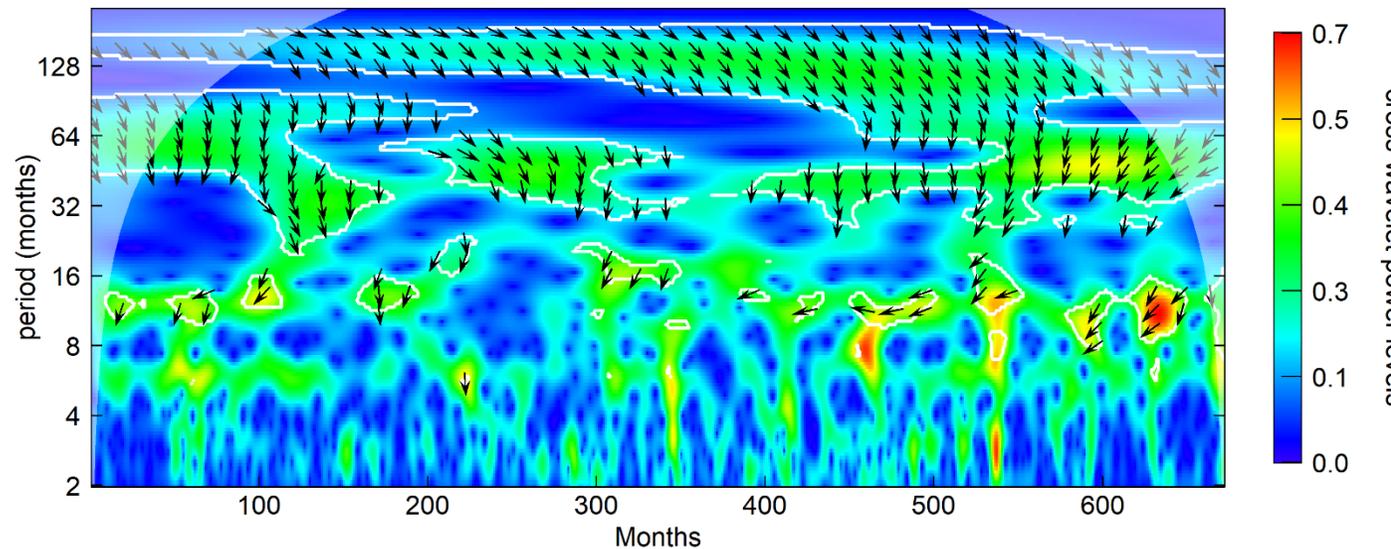
	UFA Levels	POR
Site 1	71 – 91 ft	1960 - present
Site 2	40 – 63 ft	1948 - present
Site 3	57 – 73 ft	1979 - present



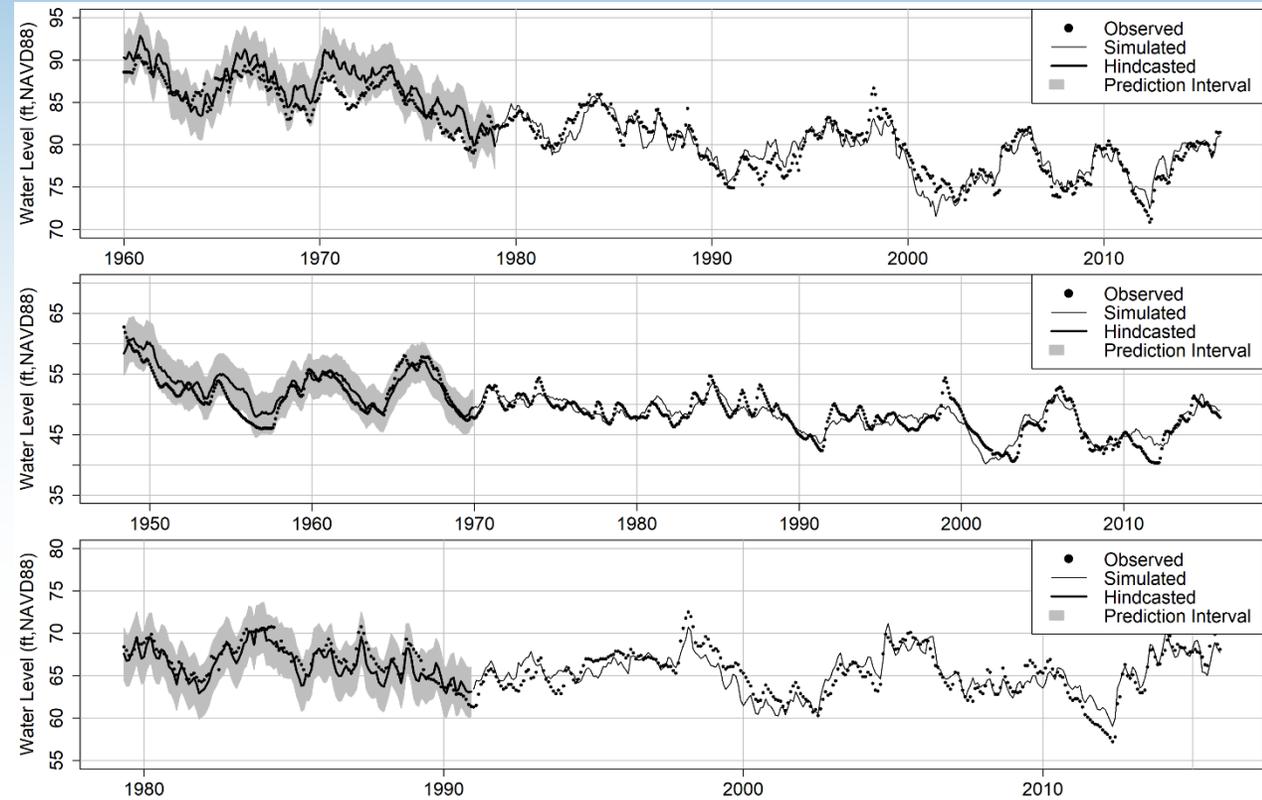
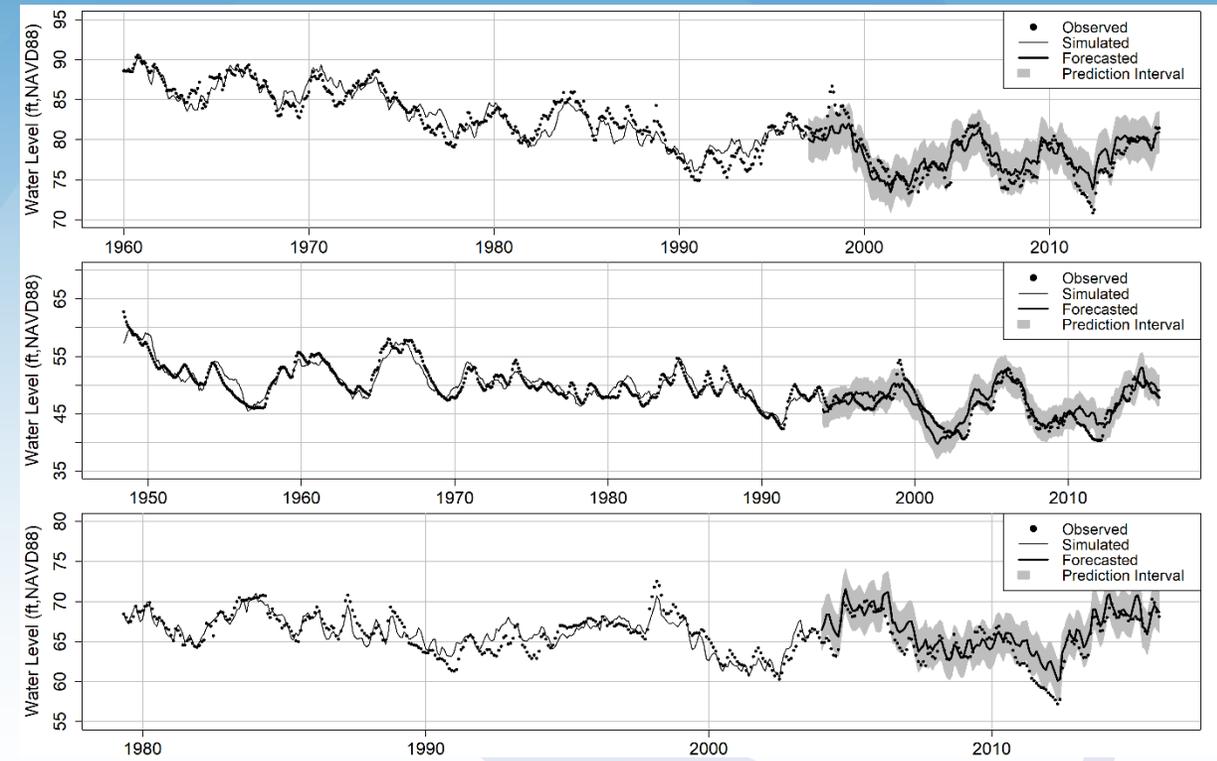
Physically constrained Wavelet-aided Statistical Model (PCWASM)

- Principle of convolution
- Wavelet analysis
- Low frequency signals
- Modified Cooper-Jacob Approximation
- Validated for hindcasting and forecasting

$$h_i = h_0 + \underbrace{\alpha \sum_k^i \lambda_{i-k} R_k}_{\text{Rainfall Term}} - \underbrace{\beta \sum_j^i (PET_j - \overline{PET})}_{\text{ET Term}} - \underbrace{\gamma Q_i - \delta \sum_m^i \Delta Q_m \ln t_{i-m} - \phi \sum_m^i \frac{\Delta Q_m}{t_{i-m}}}_{\text{Pumping Term}}$$



Split Calibration-Validation (Hindcasting/Forecasting)



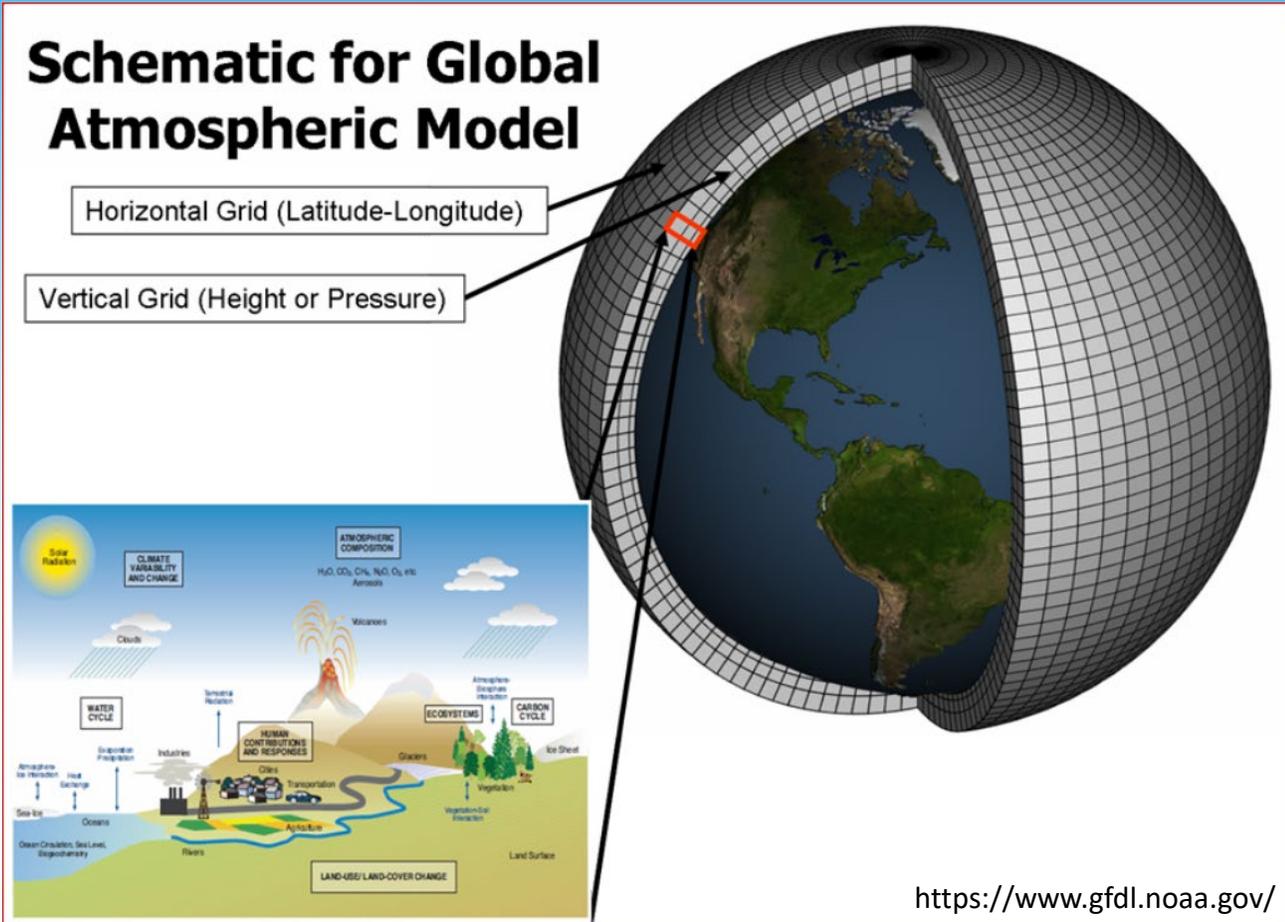
67% used for calibration - 33% used for validation



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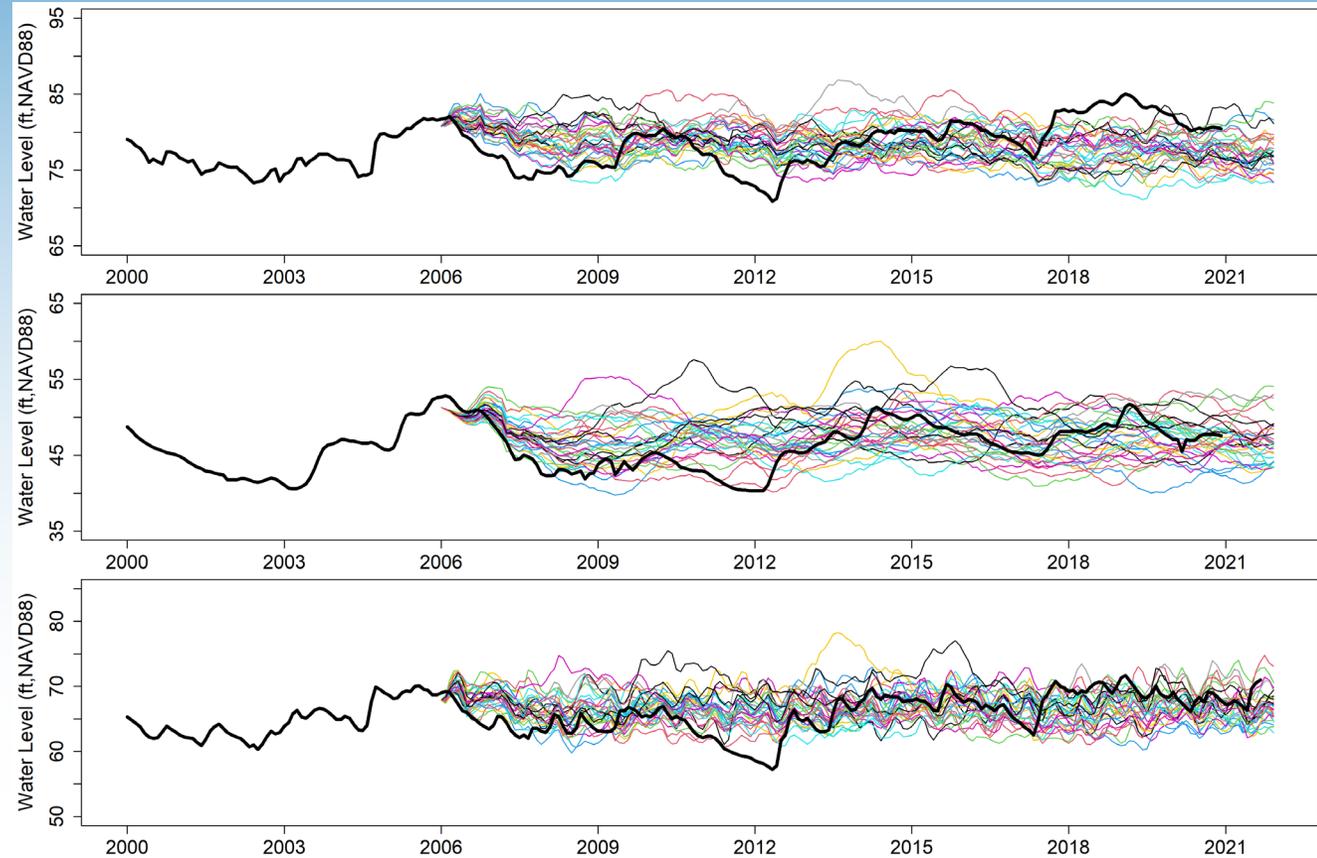
Forecasting the Future

- Utilize 42 downscaled Global Climate Model datasets (CMIP5)
- Forecast groundwater levels to 2100 under low and medium emission scenarios
- Evaluate GCM performance
- Evaluate the discrete effect of each driver separately



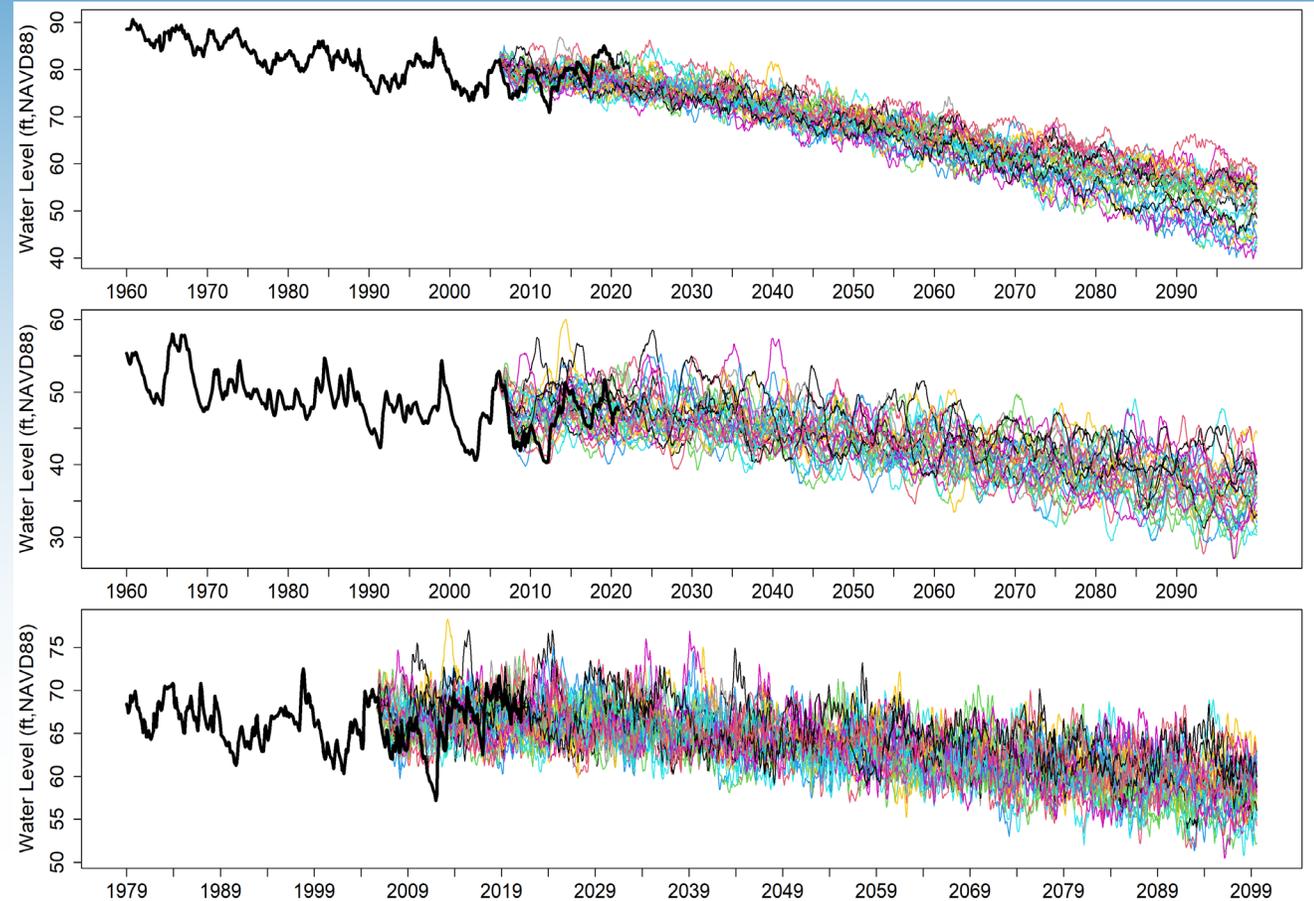
Performance of GCM projections Observed vs Forecasted

- Capture the range of observed levels
- Fail to replicate the timing of high and low extremes
- Fail to capture the timing of climatic cycles, controlling hydrologic memory

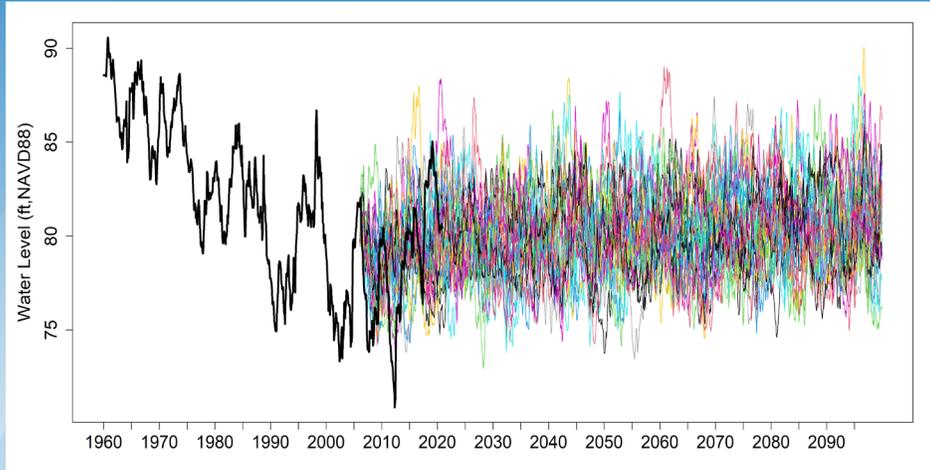


Groundwater Level Forecasts

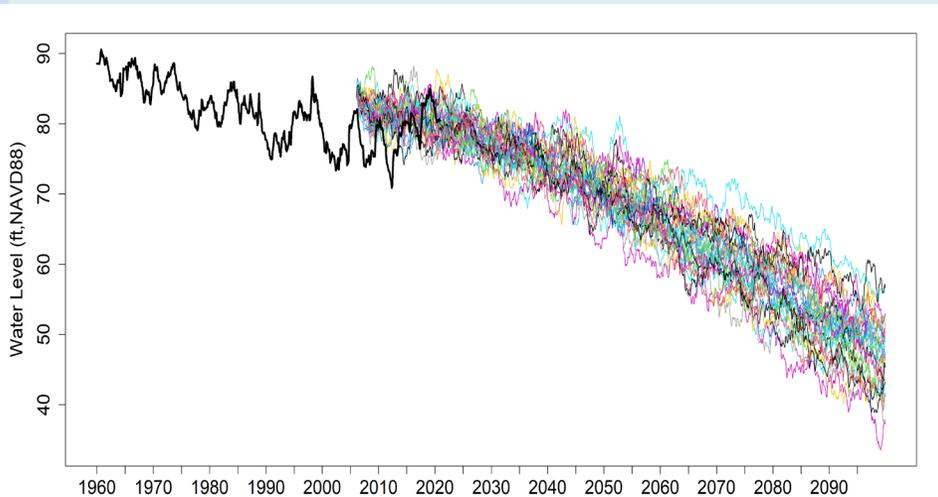
- Very wide range of groundwater level projections
- Weighted average annual declines from 2020 to 2099 are 24 feet at site 1, 10 feet at site 2 and 8 feet at site 3 under medium emission scenario
- The RCP4.6 projections yielded water levels 2 to 4 feet lower than the RCP 2.6
- Declines accelerated after 2040s



Influence of each driver on future trends



Rainfall-only-forecasts show increase in groundwater levels

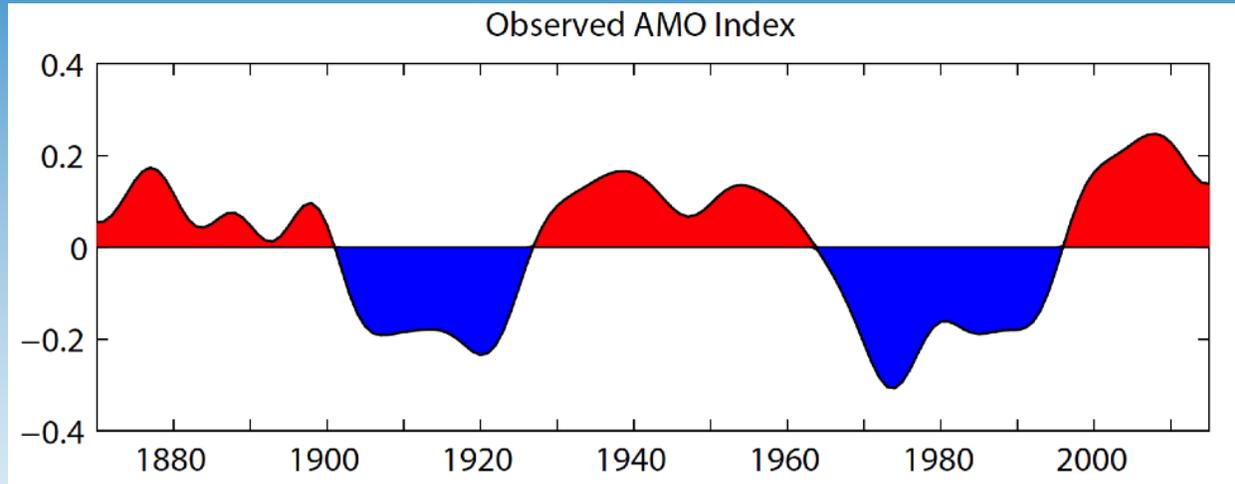


Future declines primarily due to pumping impact and rising temperature



Predicting the Past

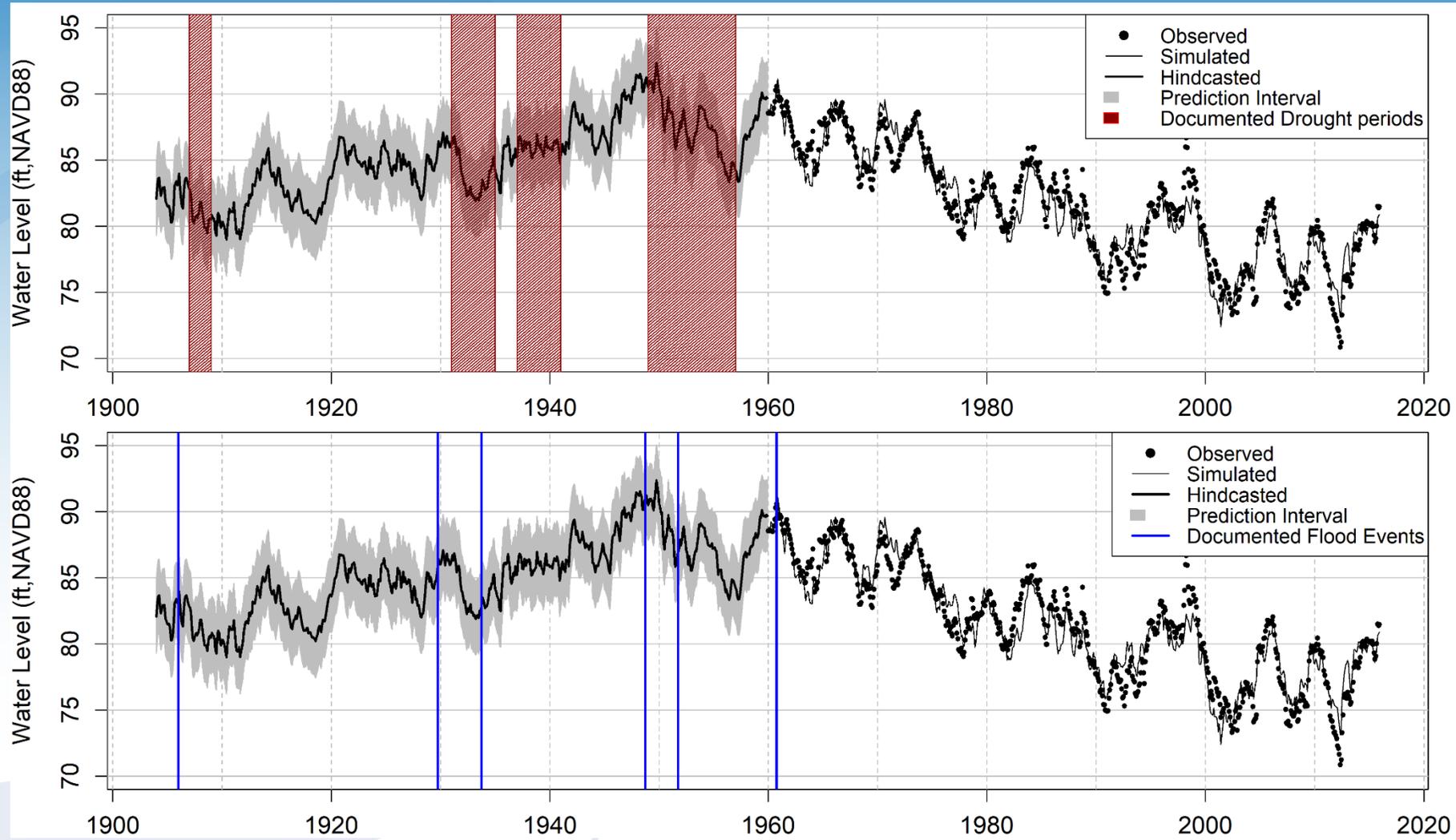
- Lack of long-term historical data
- Need to capture the influence of long-term climatic cycles
- Hindcast water levels to early 1900s
- Assess the validity of the hindcasts
- Analyze return periods of critical low levels



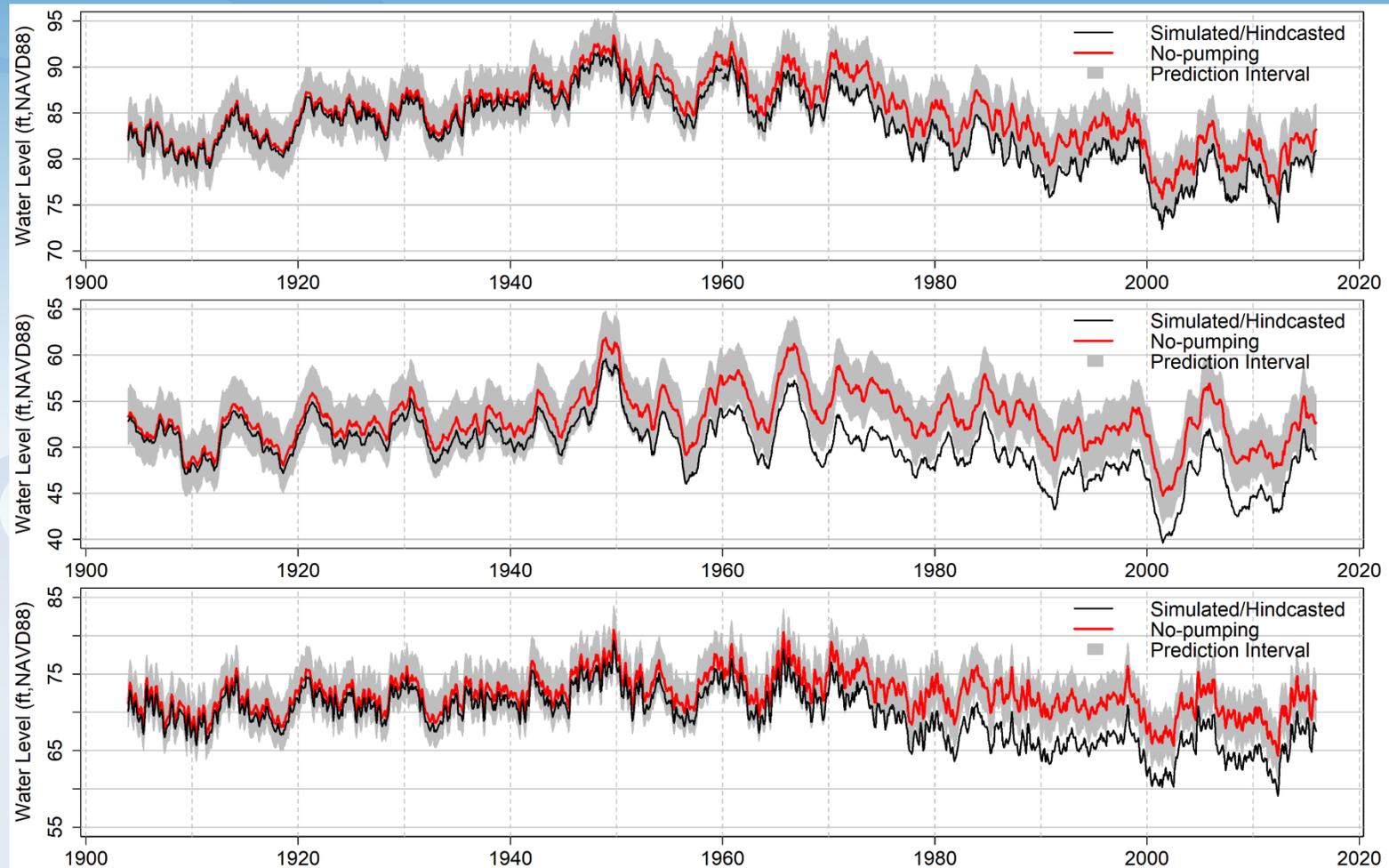
Climate Cycle	Frequency
El Nino Southern Oscillation (ENSO)	3 – 7 years
Pacific Decadal Oscillation (PDO)	15 – 30 years
North Atlantic Oscillation (NAO)	7 – 32 years
Atlantic Multidecadal oscillations (AMO)	50 – 90 years



Long-term Hindcasting (Site 1)



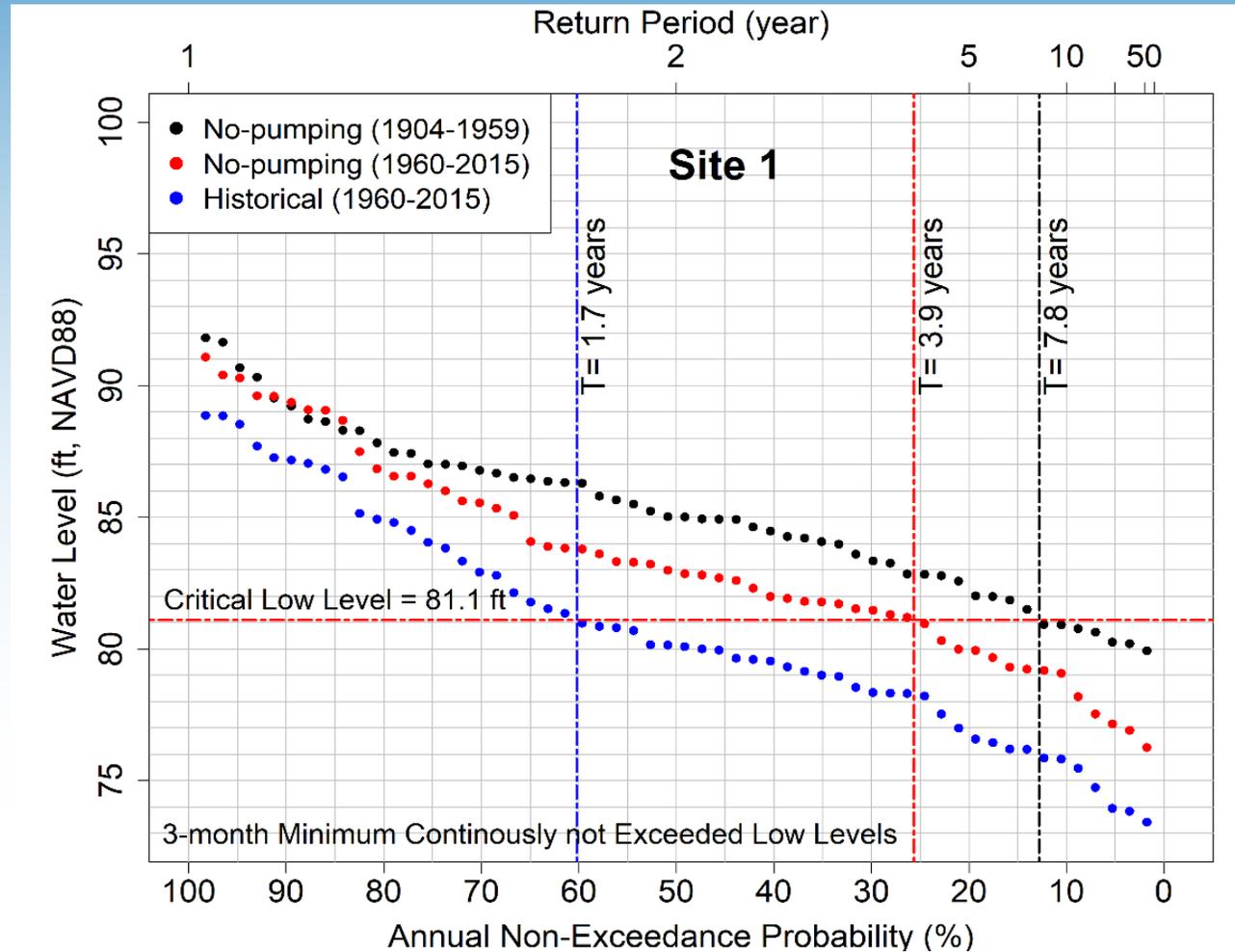
Predicting groundwater levels in the absence of pumping impacts



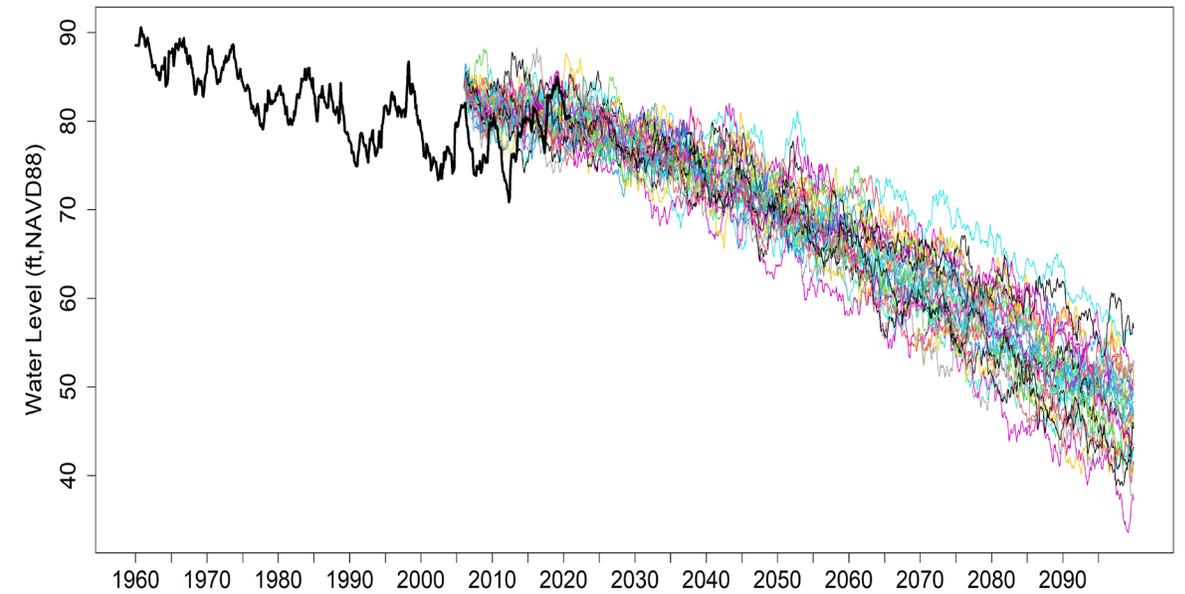
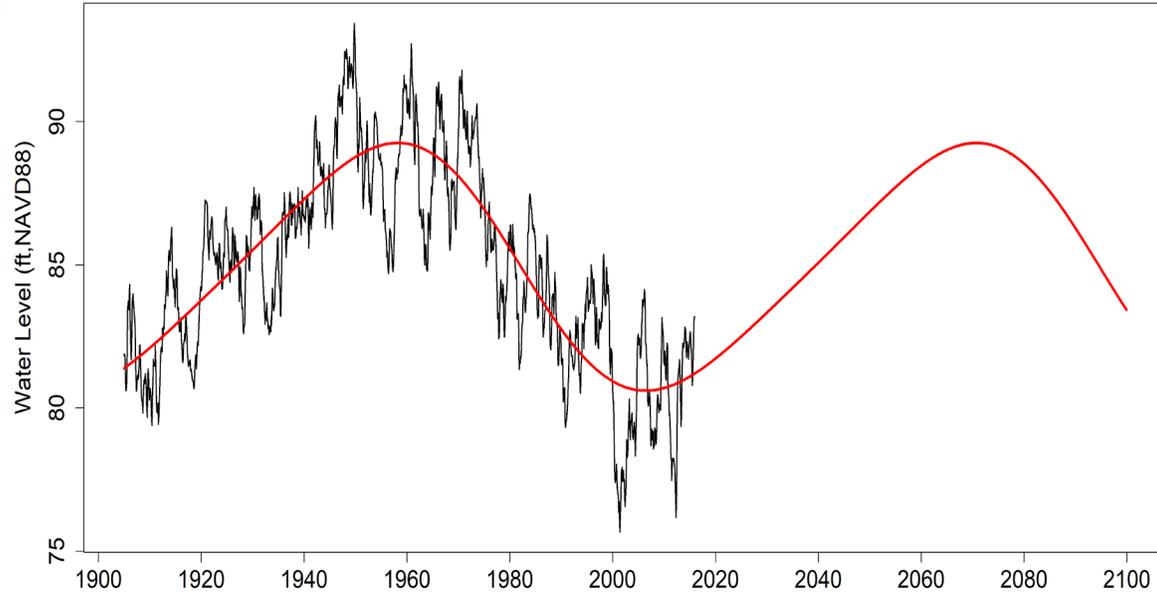
Critical Low-level Frequency Analysis

Site	Critical Low Level (ft) not exceeded for 3 months	Return Period in years		
		No-pumping (1904-1959)	No-pumping (1960-2015)	Historical (1960-2015)
Site 1	81.1	7.8	3.9	1.7
Site 2	48.6	14.4	8.8	1.7
Site 3	68.4	16.4	9.6	1.5

A critical low-level condition was assumed to occur when water levels dropped below the 10th percentile for three consecutive months



Past vs Future



- Harmonic Trend Analysis
 - Predicted future levels based on historical hydroclimatic patterns

- Forecasts using GCMs projections
 - Predicted future levels based on projected rainfall and temperature



Summary of Findings

- Frequencies of critical low levels increase significantly in the 1960-2015 period when compared to the 1904-1959 period due to climate change and pumping
- Future long-term rainfall trend might lead to rising groundwater levels, which, however, might be overshadowed by global warming and increased groundwater pumping, hence, causing declines
- Centennial cyclic trends may exist in groundwater levels, critical for future predictions
- GCM-based forecasts are recommended to be cautiously utilized for groundwater resource planning when significantly departing from historical long-term cyclic patterns



Can we reliably predict the future without knowing the past?

- GCM-based forecasts are recommended to be cautiously utilized for groundwater resource planning when significantly departing from historical long-term cyclic patterns



For more information

- Gordu, F. and Nachabe, M.H., 2021. A physically constrained wavelet-aided statistical model for multi-decadal groundwater dynamics predictions. *Hydrological Processes*, 35(8), p.e14308.
- Gordu, F. and Nachabe, M.H., 2021. Hindcasting multidecadal predevelopment groundwater levels in the Floridan aquifer. *Groundwater*, 59(4), pp.524-536.
- Gordu, F. and Nachabe, M.H., 2023. Inferences of Groundwater Response to Projected Hydroclimatic Changes in North Florida. *Journal of Hydrologic Engineering*, 28(4), p.04023001.



Questions



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