Climate Change in the Delaware River Basin:

Applying LOCA2 CMIP-6 Data to Evaluate Projected Air Temperature, Precipitation, and Drought Indices

ACCC • August 26, 2026

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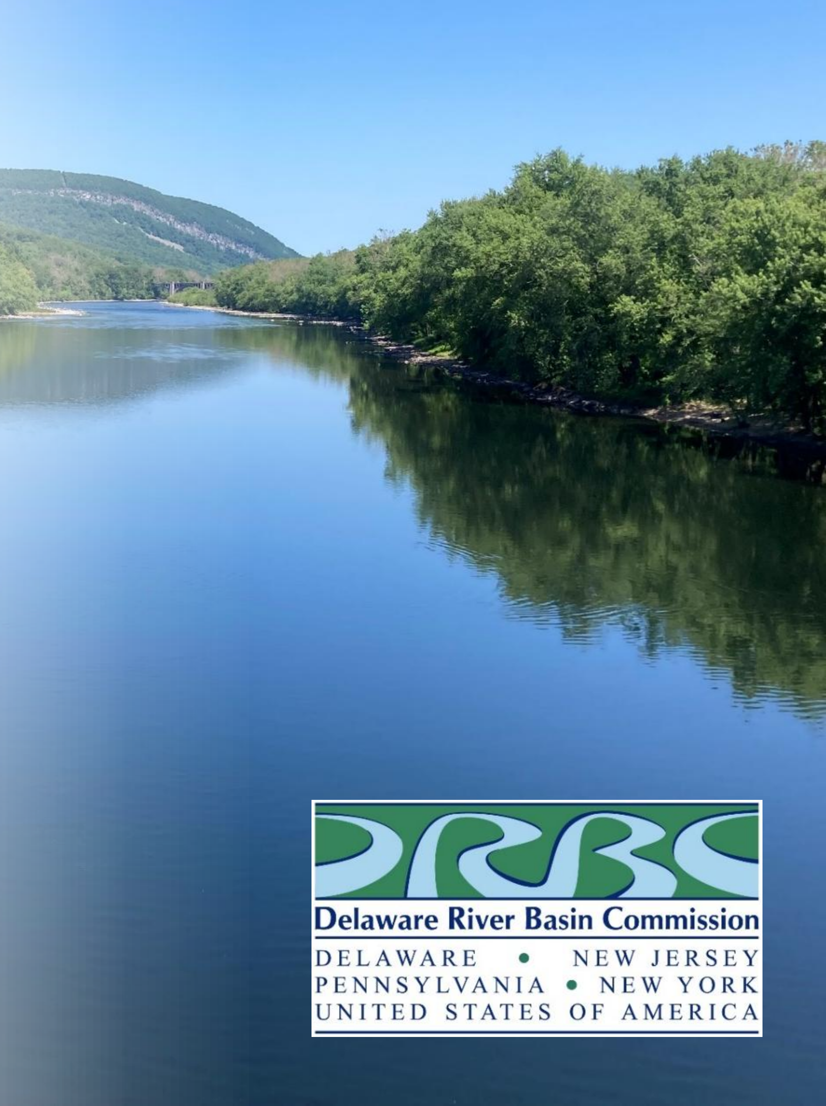
Avery Lentini, *Community Engagement Specialist, DRBC*
Amanda Khalil, *Water Resource Scientist, DRBC*



DRBC is using the latest projections as the foundation for its ongoing climate change work

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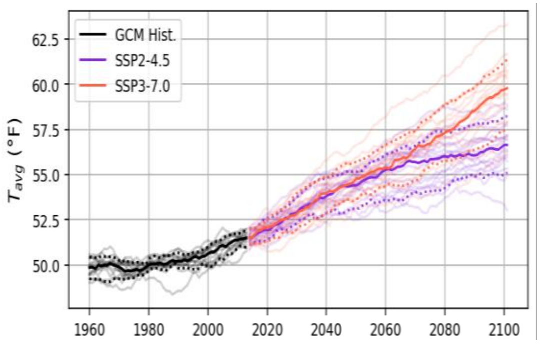
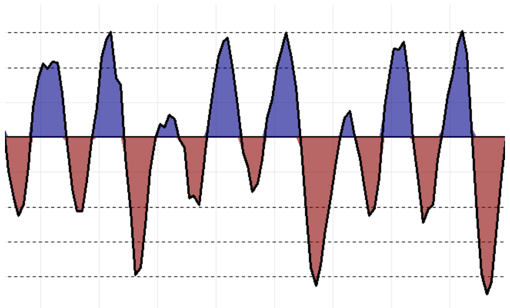
- CMIP-5 projections were released in 2014 alongside the IPCC's Fifth Assessment Report, and **updated CMIP-6 projections were released in 2023**.

- DRBC will jointly release two complementary technical reports this fall:
  - *Observed and evolving trends in climate and hydrology in the Delaware River Basin*: Multi-year study applying CMIP-5 projections to study **potential impacts on hydrology**.
  - *Projected Climate, Drought Indices, and Storm Characteristics for the Delaware River Basin through 2100*: Update of some analyses with CMIP-6 data.

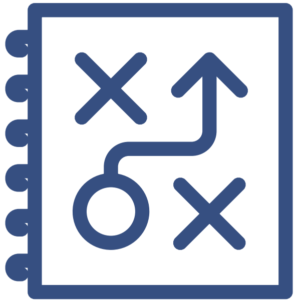
CMIP = Coupled Model Intercomparison Project
IPCC = Intergovernmental Panel on Climate Change



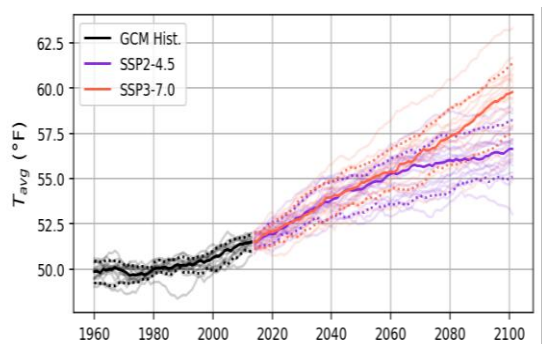
Projected air temperature and precipitation for the DRB



Evaluating future drought potential



Next steps and discussion



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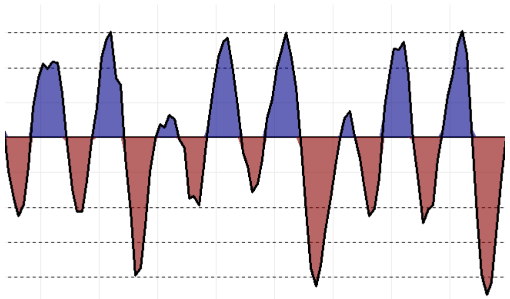

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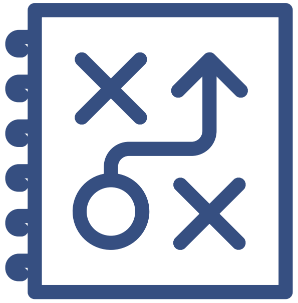

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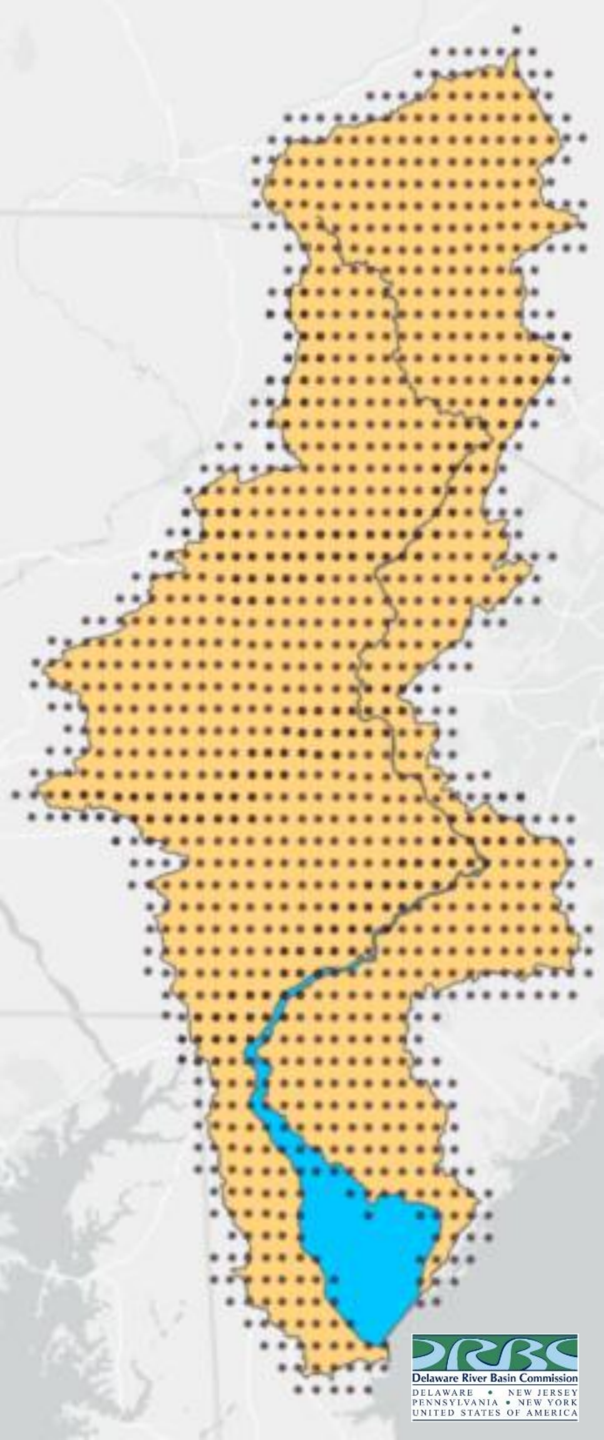
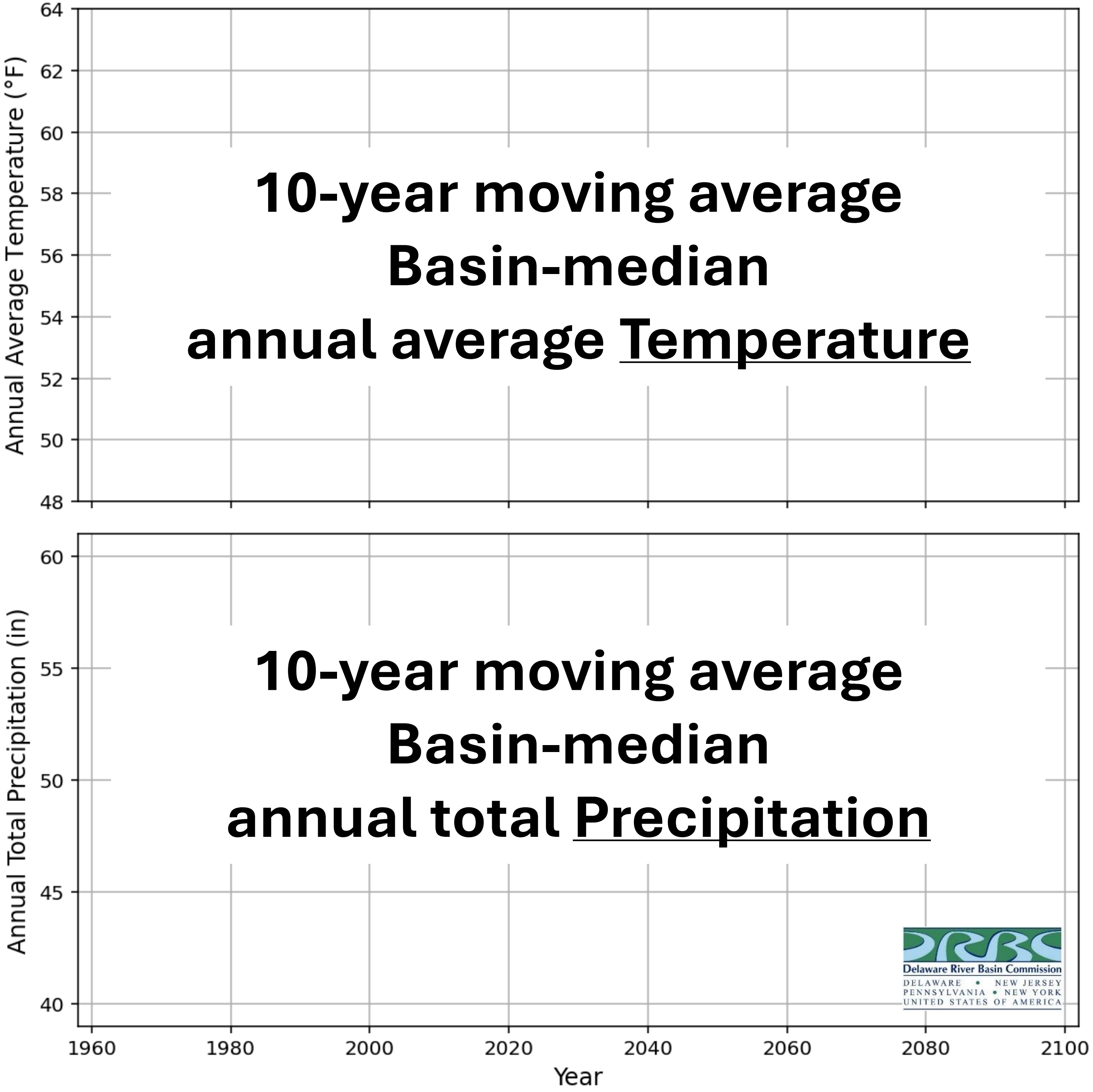


DRBC has obtained and processed CMIP-6 LOCA2 data for the DRB

- LOCA2 grid for the DRB: **1194** cells/locations
- **16** General Circulation Models (GCMs)
  - Daily temperature and precipitation
- Two Shared Socioeconomic Pathways (SSPs):
  - **SSP2** = Moderate emissions (SSP2-4.5)
  - **SSP3** = High emissions (SSP3-7.0)


Annual Average Temperature (°F)
64
62
60
58
56
54
52
50
48
10-year moving average
Basin-median
annual average Temperature
Annual Total Precipitation (in)
60
55
50
45
40
10-year moving average
Basin-median
annual total Precipitation
1960
1980
2000
2020
2040
2060
2080
2100
Year
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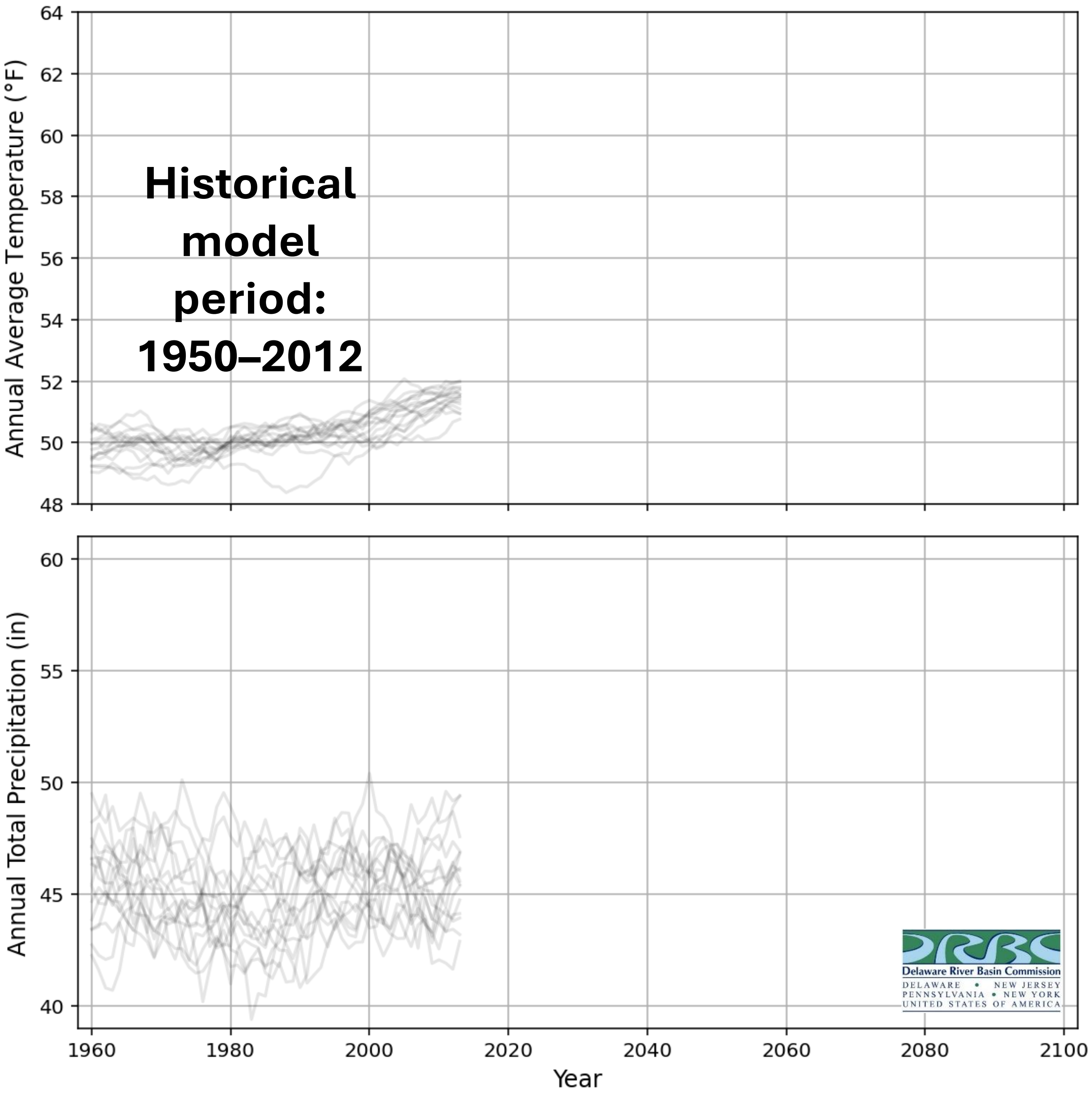
Historical model period: 1950–2012
Annual Average Temperature (°F)
Annual Total Precipitation (in)
Year
1960
1980
2000
2020
2040
2060
2080
2100
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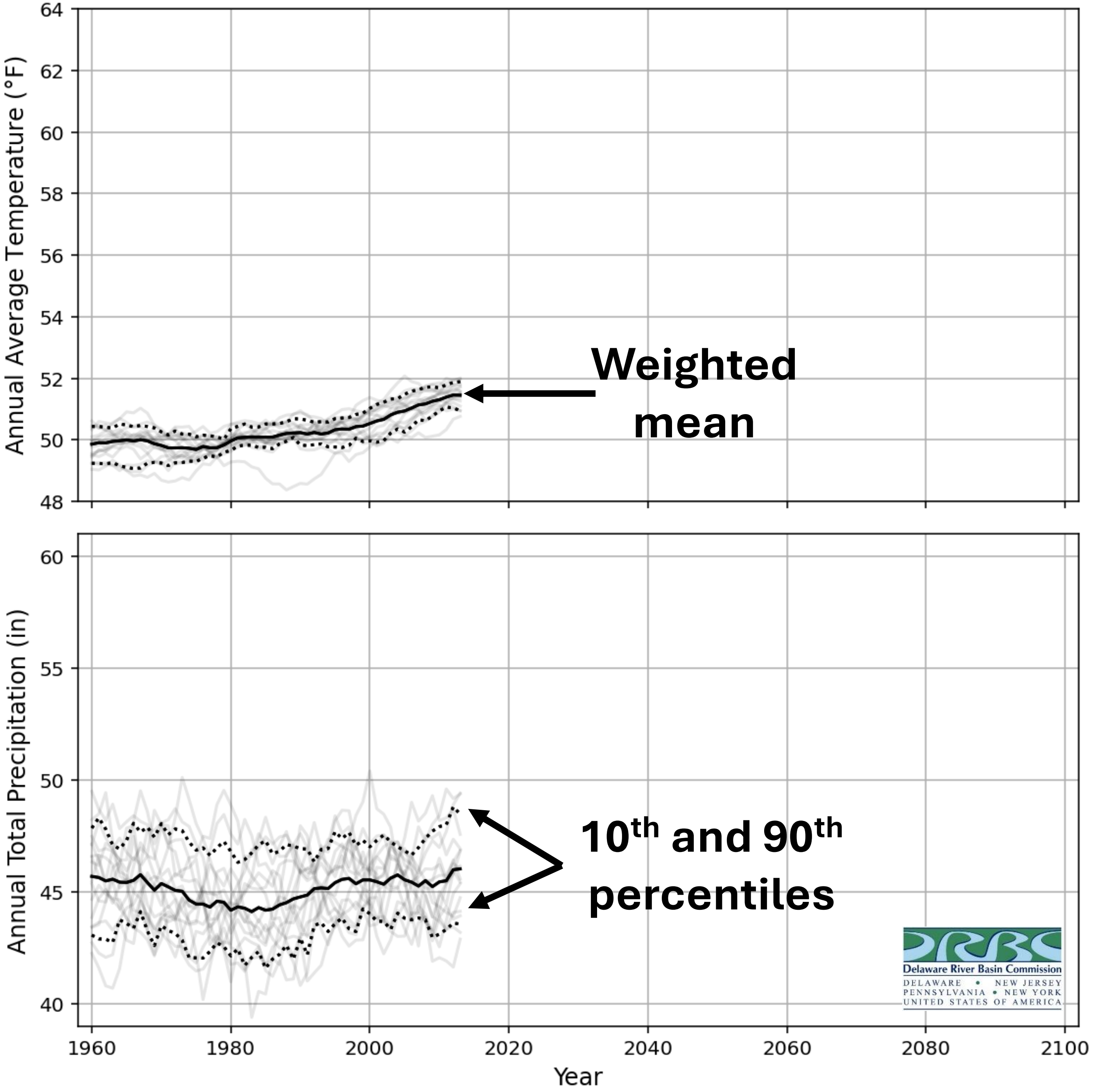
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64
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Weighted mean
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60
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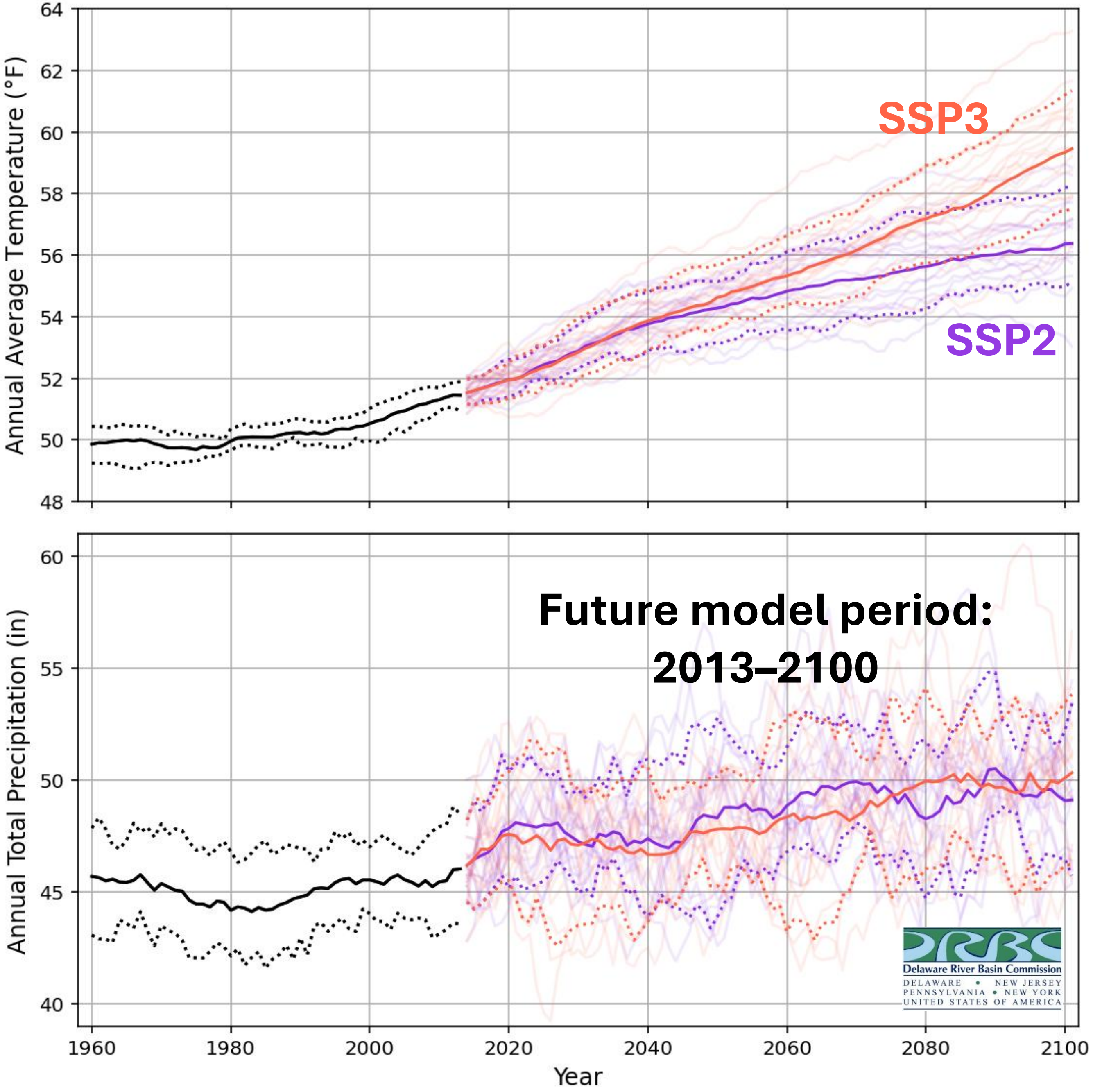
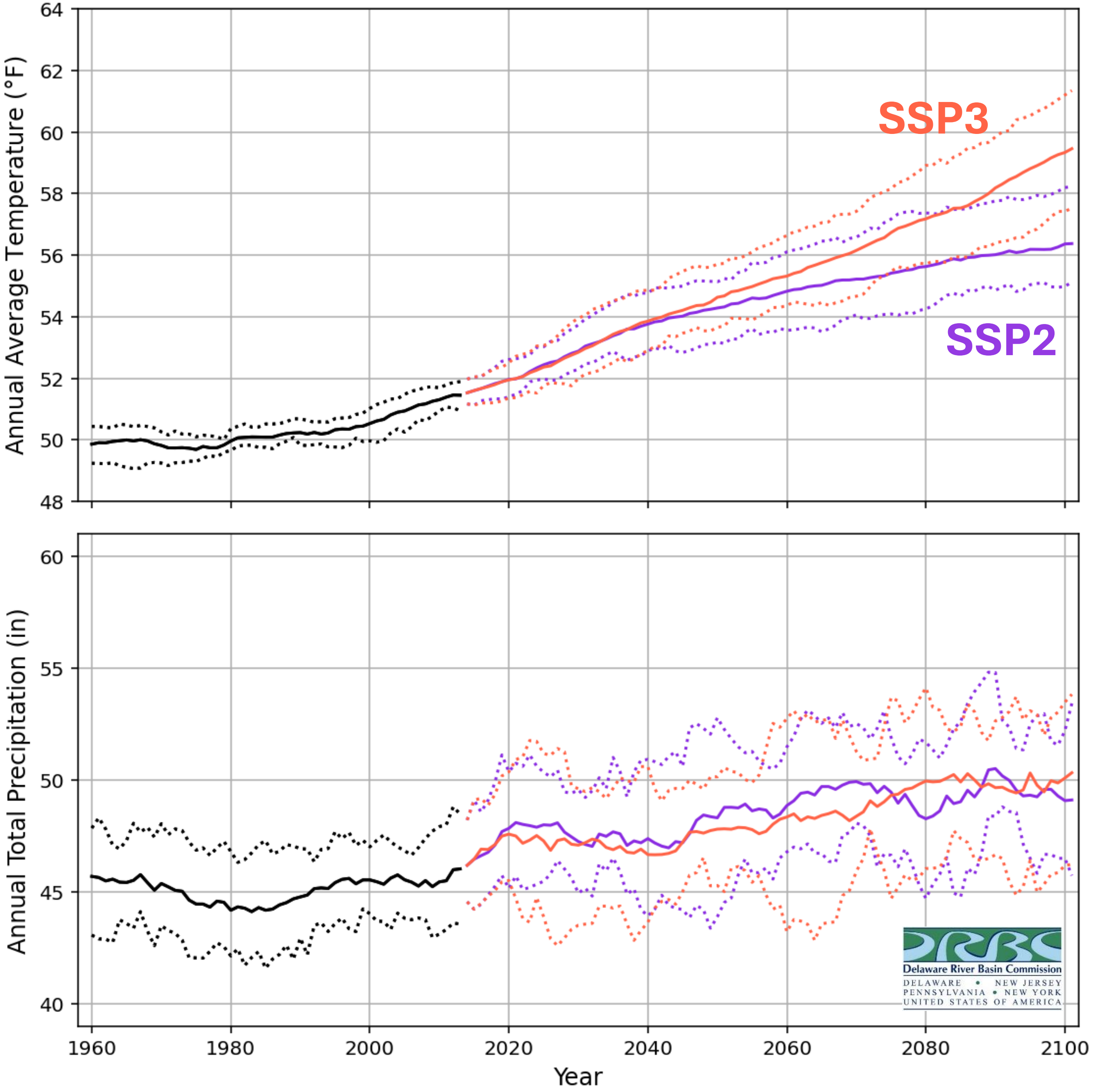
45
40
10th and 90th percentiles
1960
1980
2000
2020
2040
2060
2080
2100
Year



CMIP-6 models project a range of future conditions for the Delaware River Basin (DRB).



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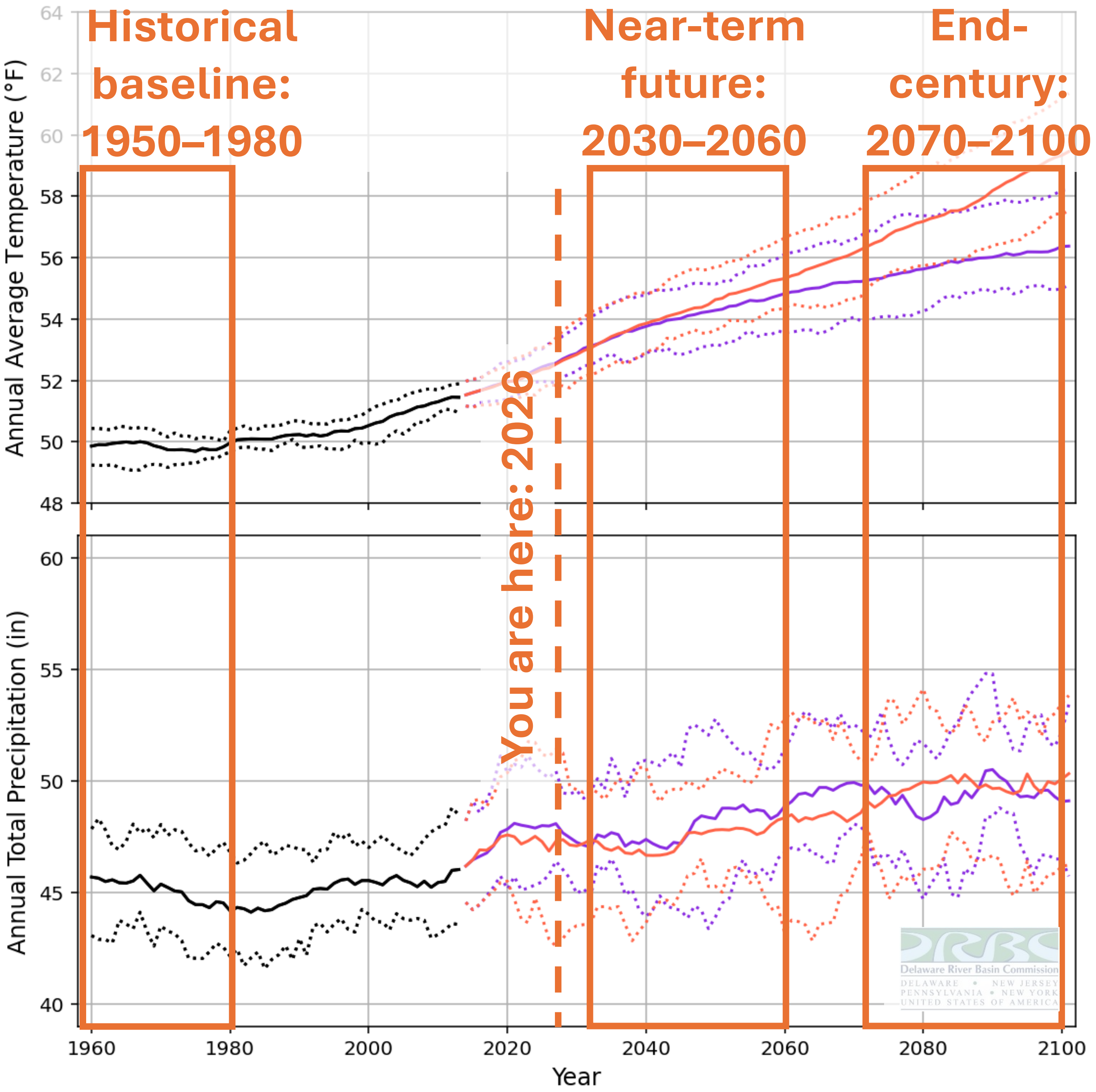

Next slides will compare historical baseline, near-term future, and end-century results.

Compared to mid-20th century, the DRB can expect **~4.5°F of warming by 2060 and 6–8°F by 2100**.

	1950–1980	2030–2060		2070–2100	
	Hist. GCMs	SSP2	SSP3	SSP2	SSP3
Avg. temp. (°F)	49.9	54.2 (+4.3°F)	54.6 (+4.7°F)	55.9 (+6.0°F)	58.1 (+8.2°F)

Basin-median results are presented for the weighted mean among 16 GCM simulations.

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Compared to mid-20th century, the DRB can expect **~2.7 in more rainfall each year by 2060 and 4.3–4.9 in by 2100**.

	1950–1980	2030–2060		2070–2100	
	Hist. GCMs	SSP2	SSP3	SSP2	SSP3
Avg. temp. (°F)	49.9	54.2 (+4.3°F)	54.6 (+4.7°F)	55.9 (+6.0°F)	58.1 (+8.2°F)
Annual precip. (in)	44.7	47.6 (+2.9 in)	47.2 (+2.5 in)	49.0 (+4.3 in)	49.6 (+4.9 in)

Basin-median results are presented for the weighted mean among 16 GCM simulations.

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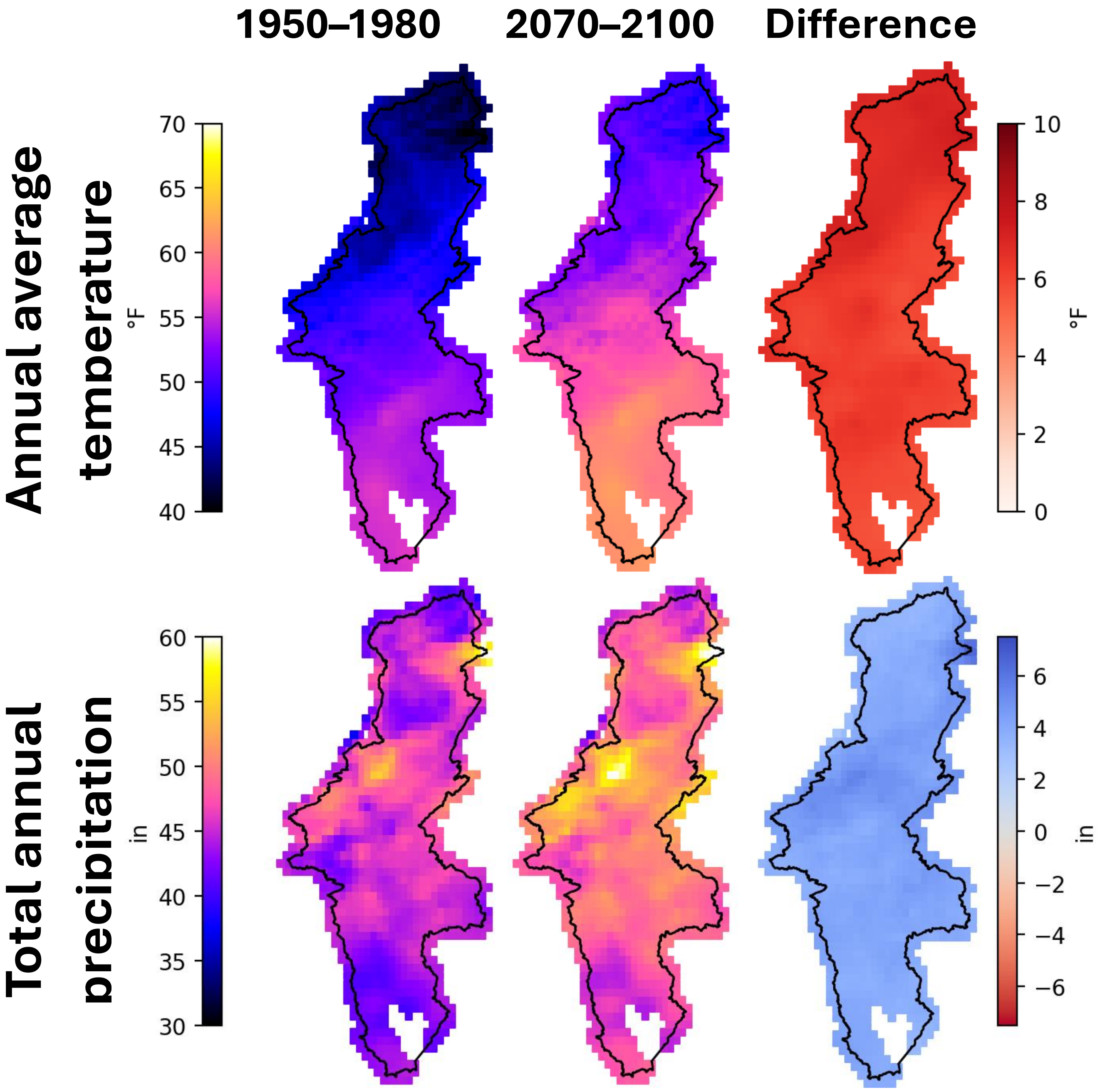

SSP2: Moderate emissions scenario

Projected changes to average temperature and precipitation are **fairly uniform across the Basin**.

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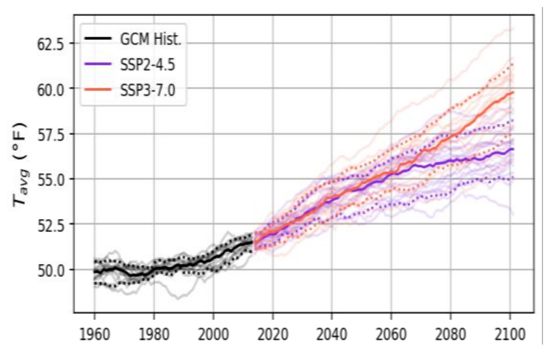
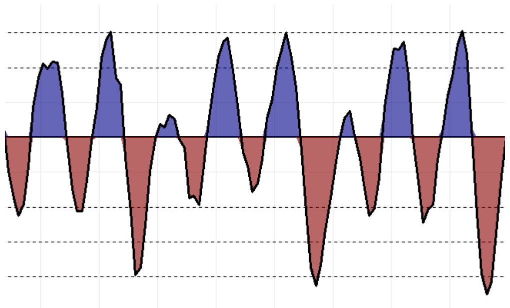


By 2100, the DRB can expect warmer temperatures (+6–8°F) and more precipitation (+10%)



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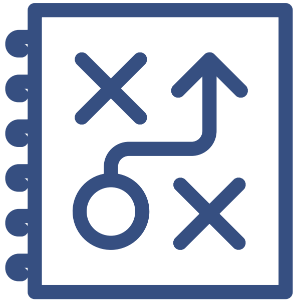
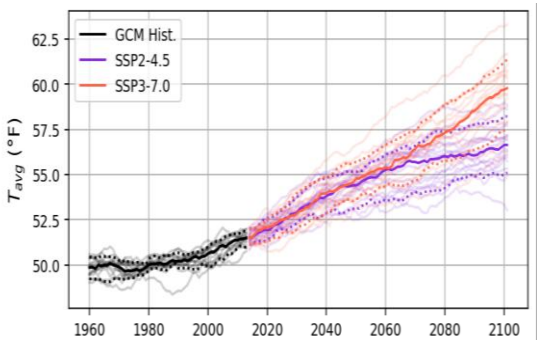


Next steps and discussion



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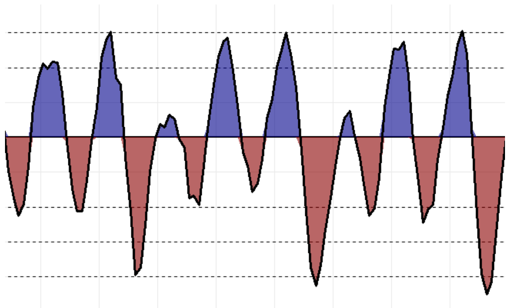

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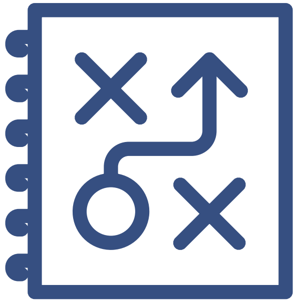
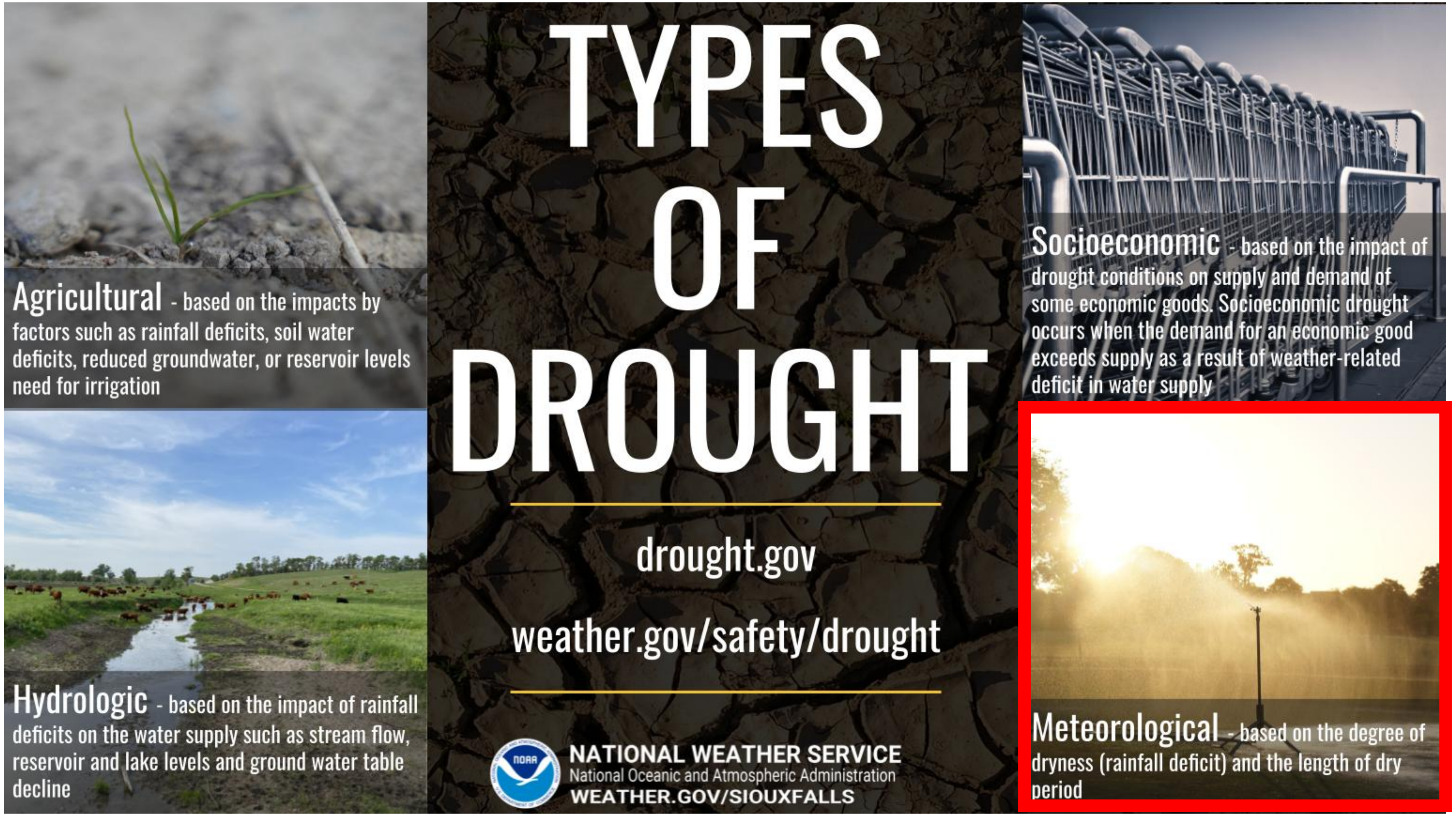


Next steps and discussion

DRBC developed a workflow to assess future drought potential



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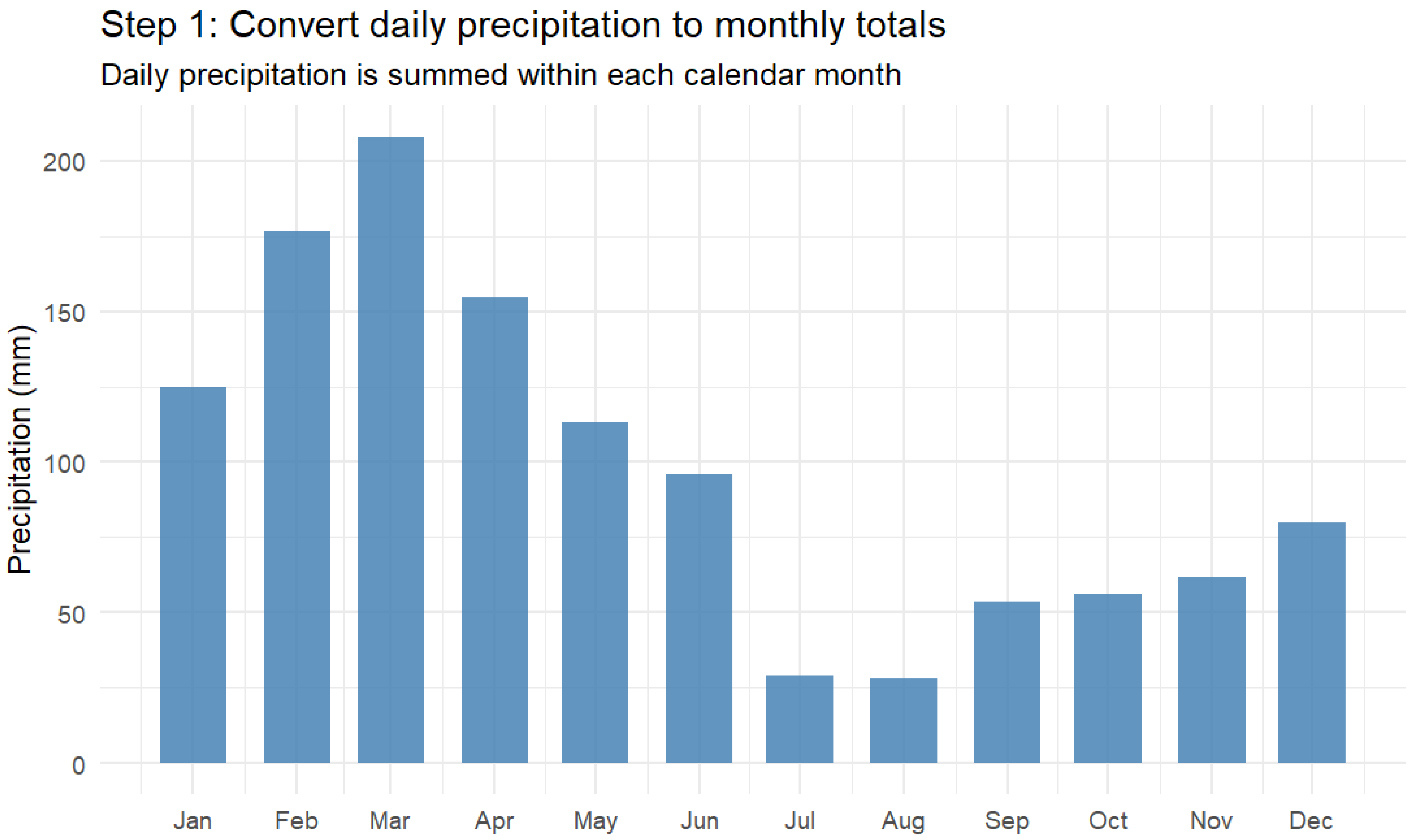
Quantifying meteorological drought using SPEI

- ***Standardized Precipitation Evapotranspiration Index (SPEI)*** is a drought index that measures how wet or dry conditions are relative to the historical climate over different timescales
  - Climatic Water Balance = Precipitation – Potential Evapotranspiration
    - Accounts for atmospheric water supply (precip.) and demand (temperature/PET)

Calculating SPEI: Monthly Precipitation



This plot is for conceptual purposes only, it is not based on actual data for the DRB

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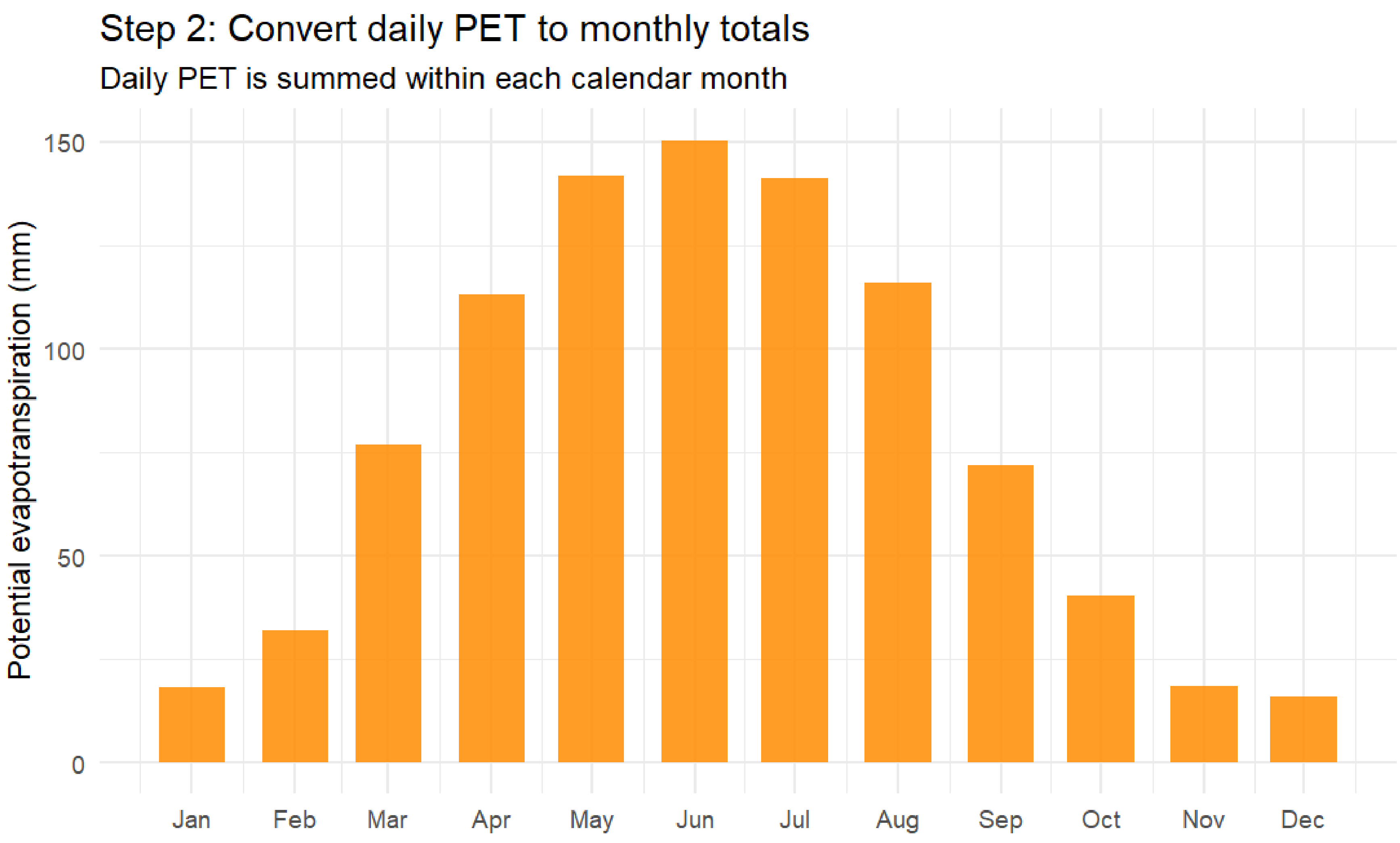
Calculating SPEI: Monthly Potential Evapotranspiration



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Calculating SPEI: Monthly Potential Evapotranspiration

Assumptions:

- PET = max amt. of water lost through evapotranspiration
  - PET computed using simplified FAO-56 Penman-Monteith Method with missing climatic variables
- Our current assumption is that daily variation in PET is driven alone by temperature (assumes constant RH = 65% → historical avg.)
  - Would it be better to assume RH ∝ Daily Max Temperature? We will come back to this.

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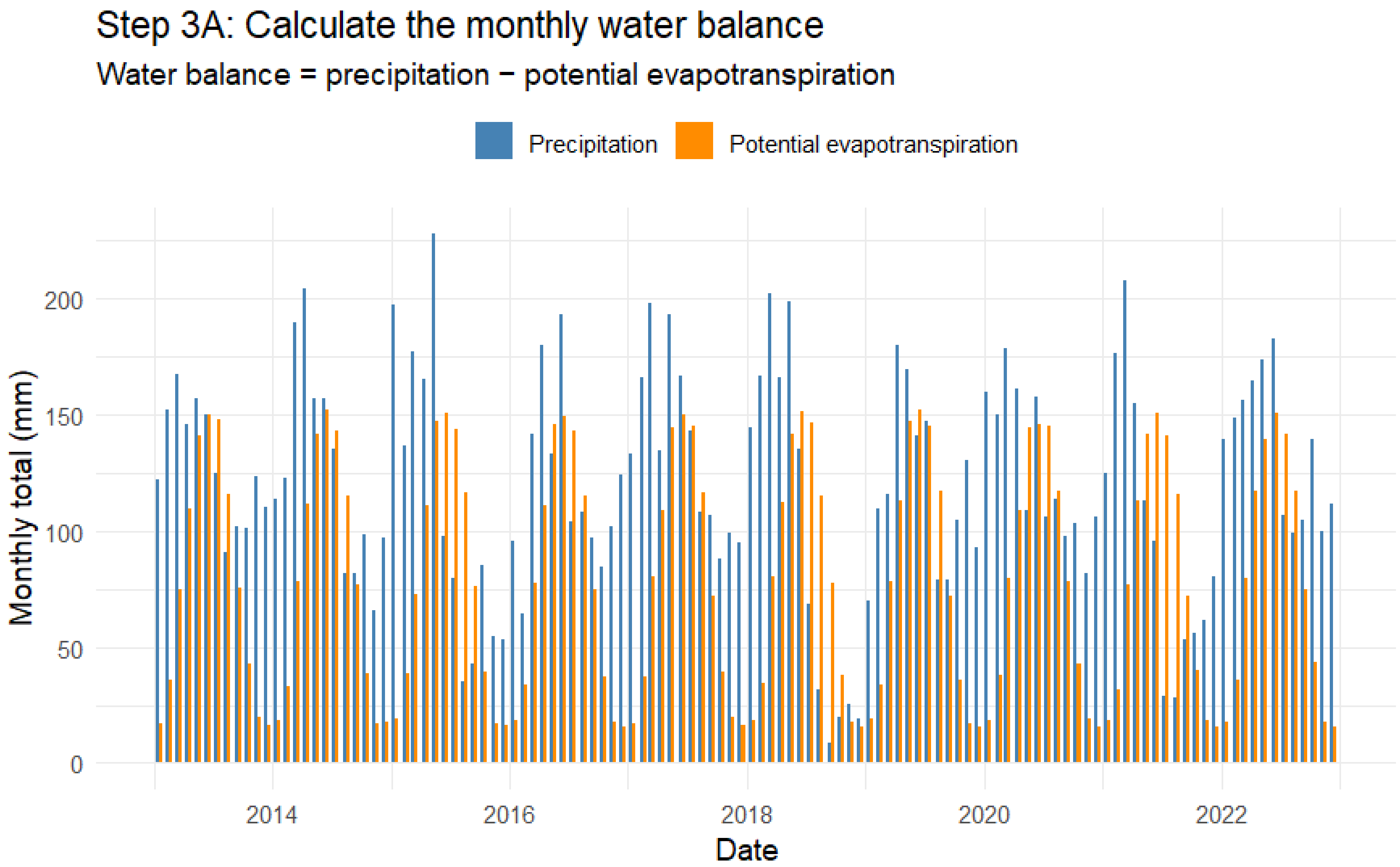
Calculating SPEI: Monthly Climatic Water Balance



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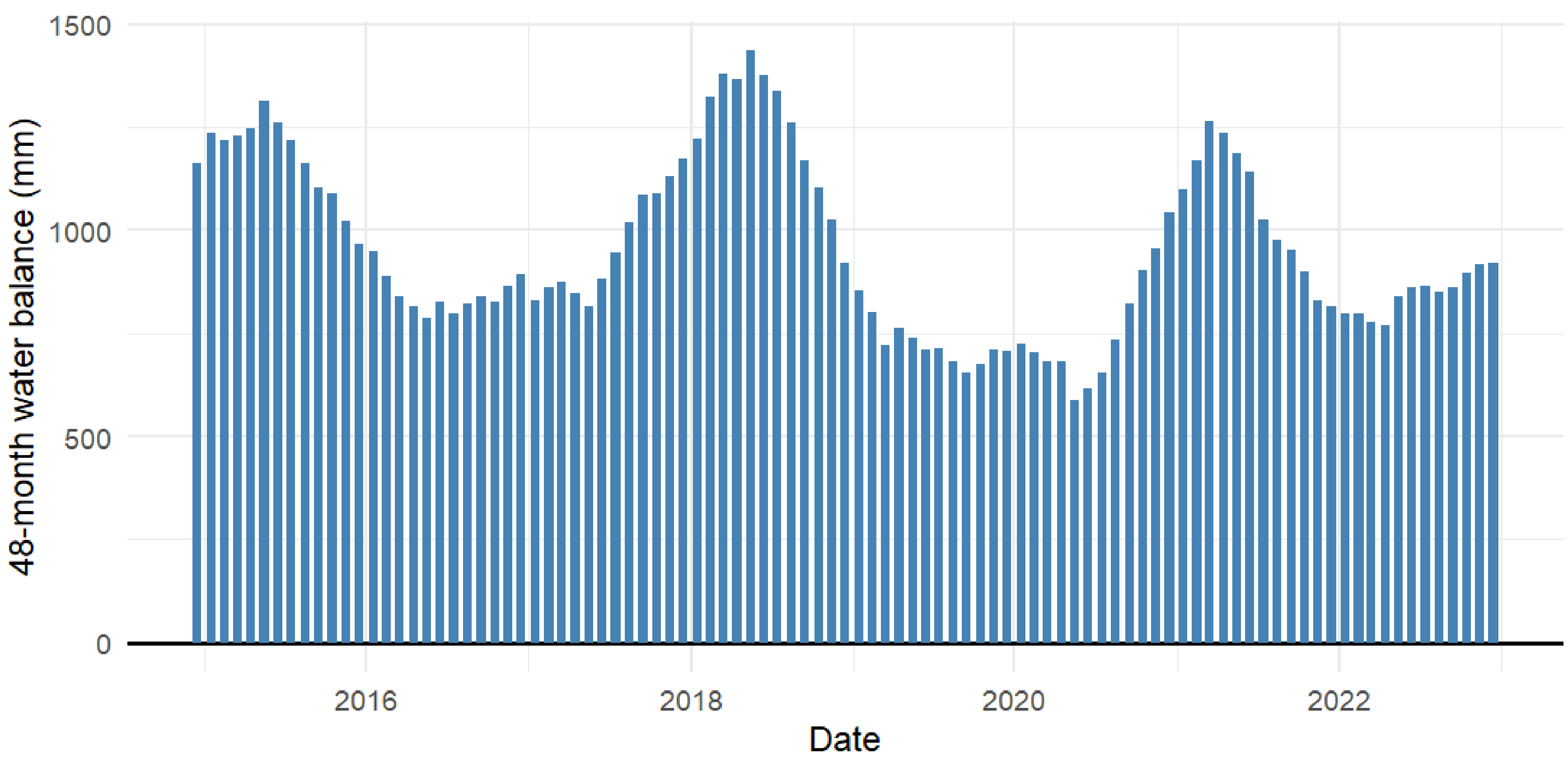
Calculating SPEI: n-Month Climatic Water Balance

Step 3B: Accumulate the water balance over n months

Example: 48-month accumulated water balance



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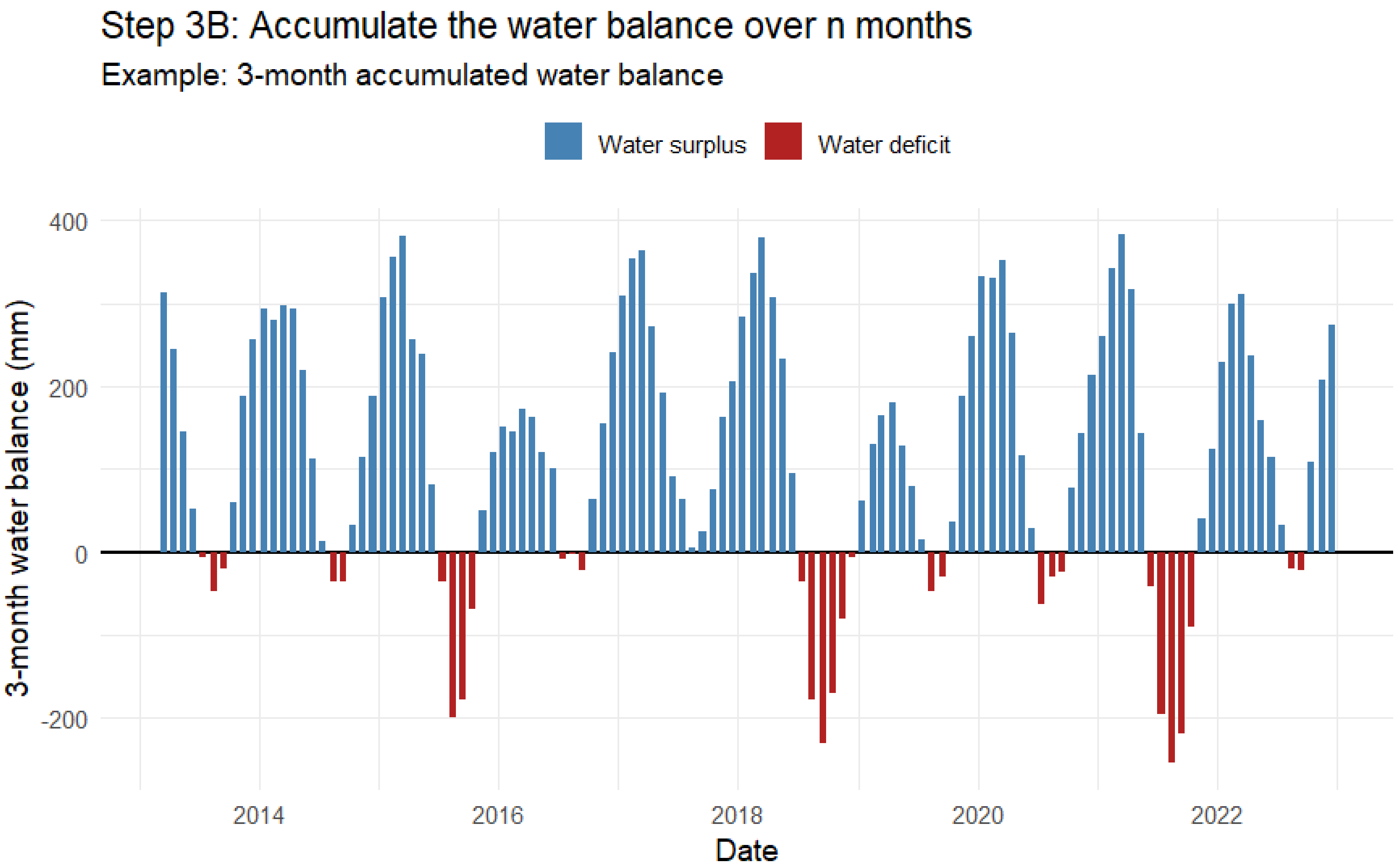
Calculating SPEI: n-Month Climatic Water Balance



Is GCM data reliable for characterizing "flash" drought? At what point do month-to-month variations become too noisy?

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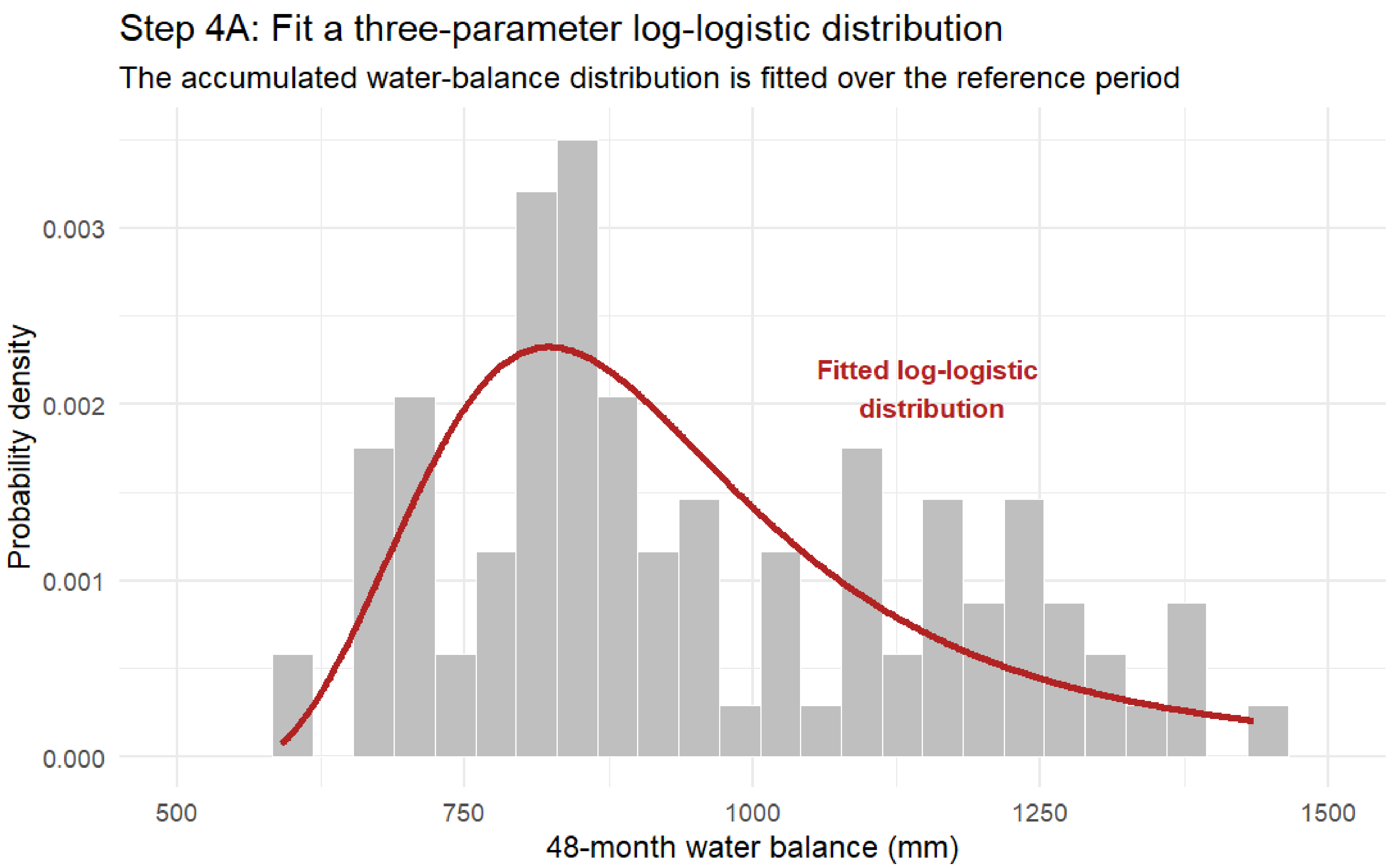
Calculating SPEI: Log-Logistic Probability Distribution



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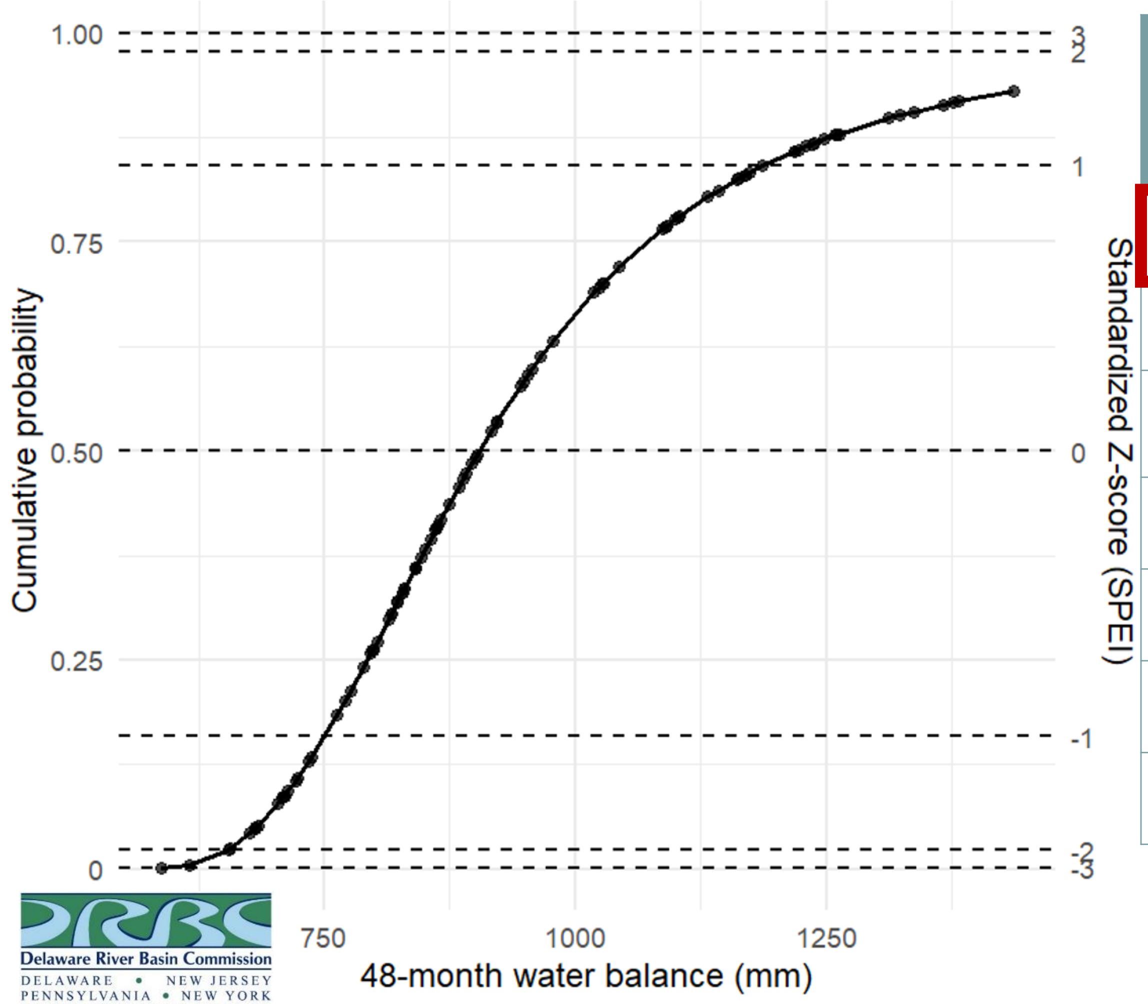
Calculating SPEI: Log-Logistic Probability Distribution

Step 4: Convert water balance to cumulative probability

Cumulative probability is transformed to a Z-score to obtain SPEI



SPEI	Cumulative Probability	Interpretation
< -2.0	< 0.02	Extremely dry
-2.0 to -1.5	0.02–0.07	Severely dry
-1.5 to -1.0	0.07–0.16	Moderately dry
-1.0 to 1.0	0.16–0.84	Near normal
1.0 to 1.5	0.84–0.93	Moderately wet
1.5 to 2.0	0.93–0.98	Very wet
> 2.0	> 0.98	Extremely wet

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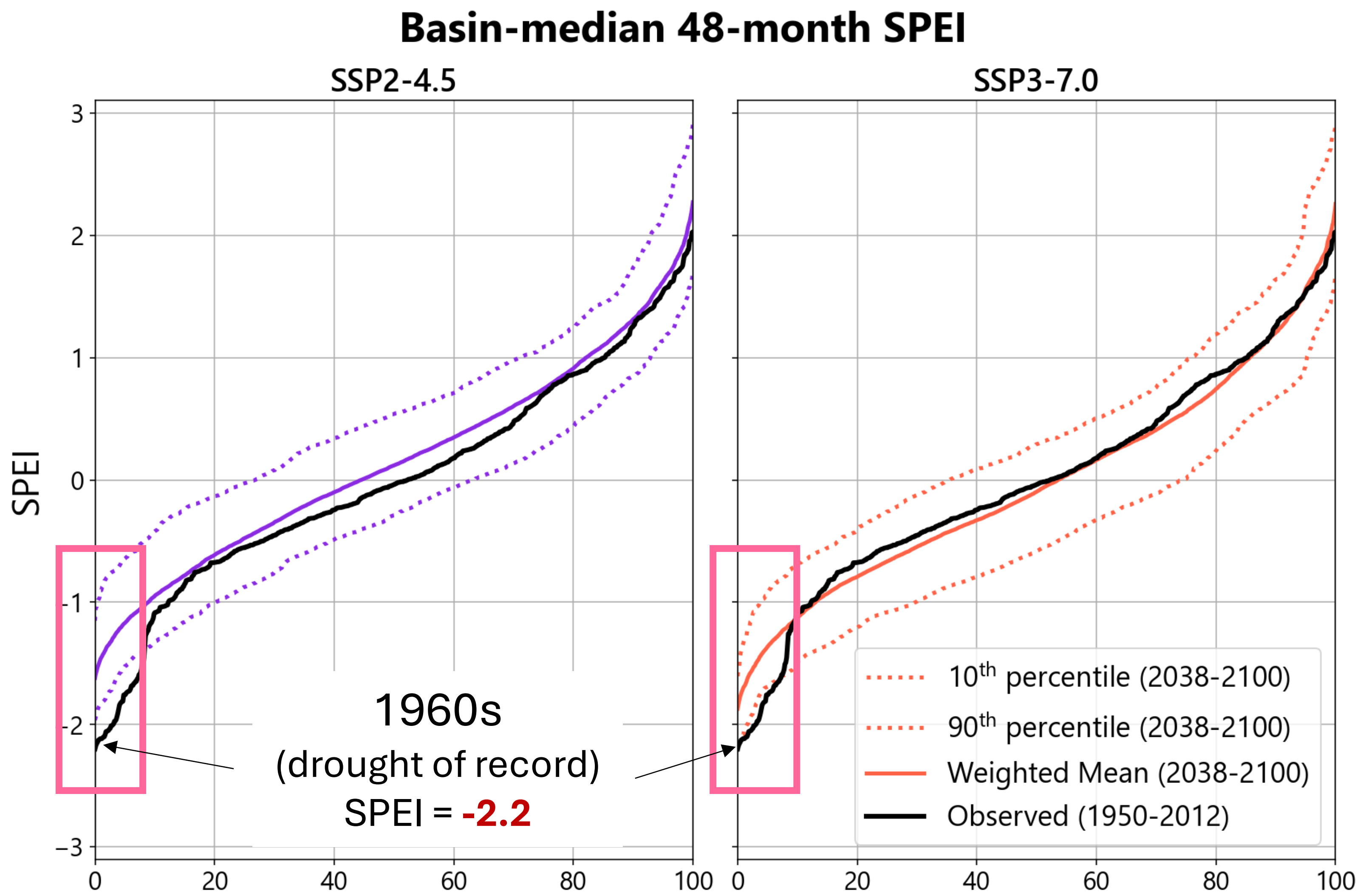

Drought Index Example: SPEI

- 48-month time frame emphasizes multi-year drought conditions.
- The minimum SPEI for all SSP2 models is greater (less dry) than observed during the 1960s drought of record.
  - Similarly, 90% of SSP3 models have minimum SPEI greater than the 1960s.

SPEI	Interpretation
< -2.0	Extremely dry
-2.0 to -1.5	Severely dry
-1.5 to -1.0	Moderately dry
-1.0 to 1.0	Near normal

SPEI	Interpretation
-1.0 to 1.0	Near normal
1.0 to 1.5	Moderately wet
1.5 to 2.0	Very wet
> 2.0	Extremely wet

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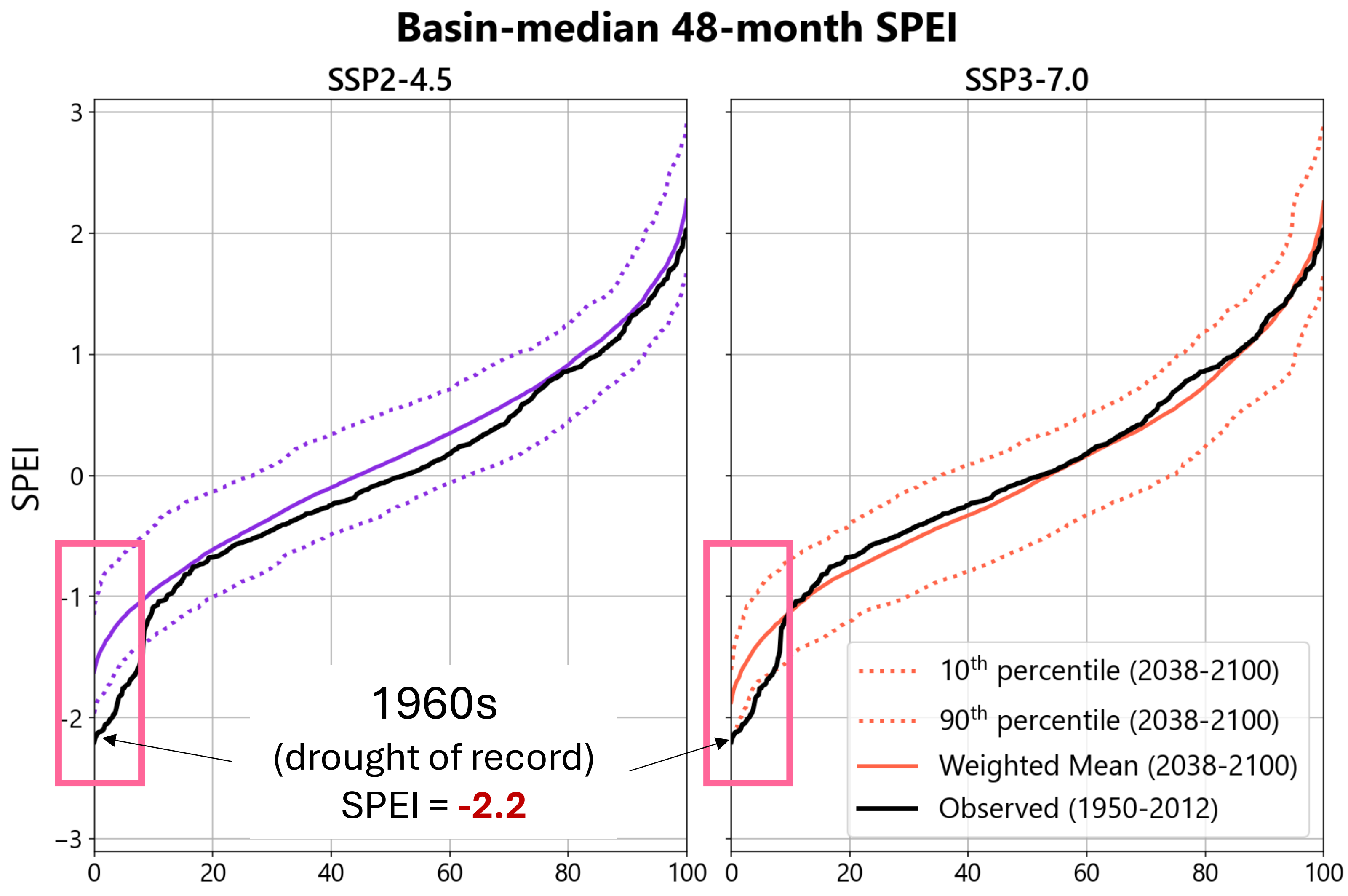

Drought Index Example: SPEI

How to convey changes in future drought strength?

Should we translate projected SPEI (relative scale) back into water deficit (absolute scale)?

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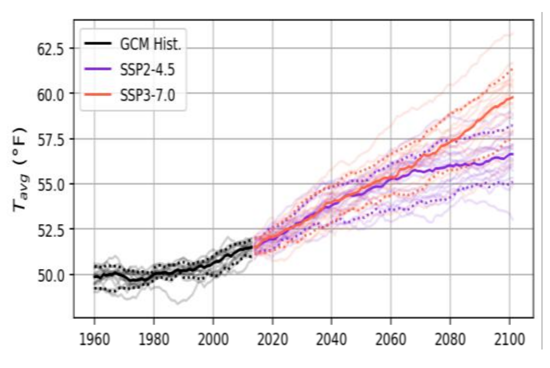

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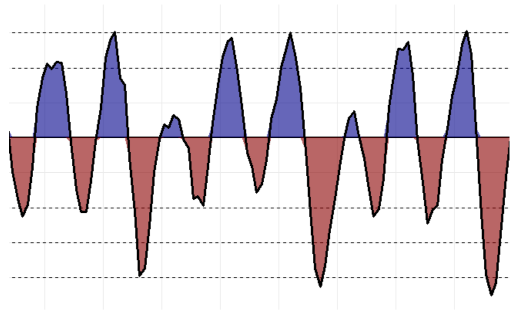
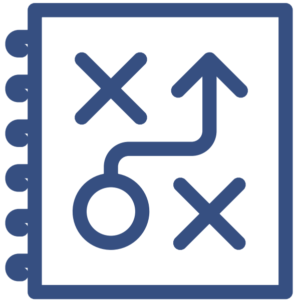


DRBC developed a workflow to assess future drought potential with SPEI



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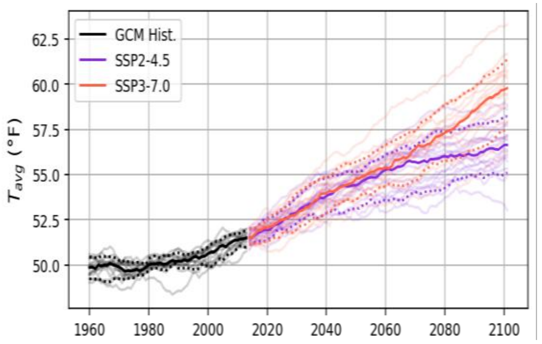

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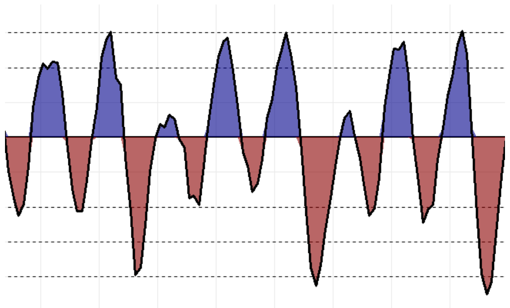

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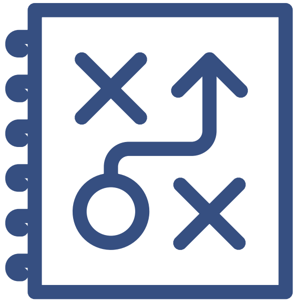

Next steps and discussion

DRBC is using the latest projections as the foundation for its ongoing climate change work

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- Having CMIP-6 data in-house will support DRBC's work that involves future planning
  - Water Resources Resilience Plan
  - Water Resource Planning for 2060
  - Hydrologic and water quality modeling
- *Many* ways to analyze this data—we intend to keep our preliminary analysis streamlined
  - Are there specific indicators or calculations that you see as crucial for analyzing projected climate data?

Discussion questions

1. *Are there specific indicators or calculations that you see as crucial for analyzing projected climate data?*
2. *Is it better to assume relative humidity is constant or a function of daily temperature?*
3. *Is LOCA2 data reliable for representing “flash” drought? At what point do month-to-month variations become too noisy?*
   - *Any other approaches for evaluating future “flash” droughts?*
4. *How to visualize the “magnitude” of SPEI extremes?*
   - *Should we convert SPEI back to water deficit?*
5. *What other questions or feedback do you have?*