

# Water and Climate Resilience Metrics Initiative at the SFWMD

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# Water and Climate Resilience Metrics

## Goals

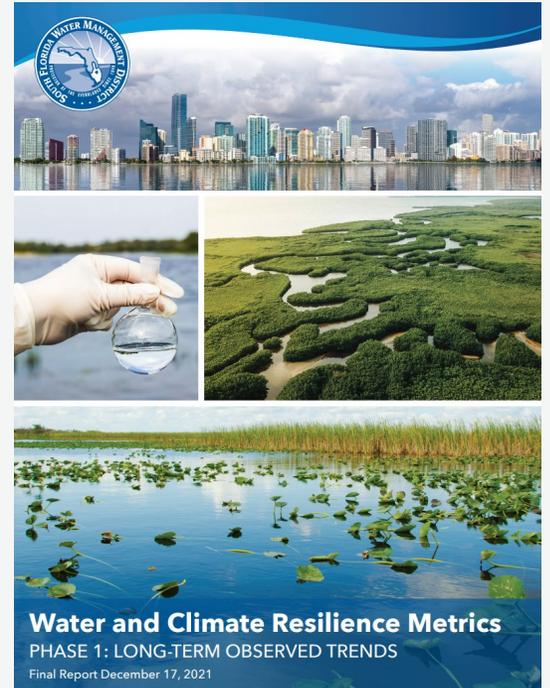
- Track and document trends and shifts in water and climate data monitored by the District.
- Support long-term term planning by incorporating trends into future scenario formulation.
- Advances the District's resiliency goals by informing infrastructure investments and operational decisions of ensuring flood protection, water supply, and ecosystem restoration mission elements under current and future climate conditions.

## Phase I

Initiated in 2020, focused on implementing an initial set of priority metrics and automating the trend analyses of metrics data stored DBHYDRO.

## Phase II

Initiated in 2025, focuses on refining and expanding the assessment of changing water and climate conditions.



# Water and Climate Resilience Metrics

## Climate Metrics

Indicators that reflect the primary drivers of observed changes in climate conditions and influence the hydrological cycle.

## Resilience Metrics

Indicators that represent the observed effects of changing climate conditions. These may be managed or mitigated through water management operations and/or by implementing adaptation strategies.

Phase	METRIC	CATEGORY	TREND ANALYSIS	AUTOMATION
I	Rainfall	Climate	✓ <sup>1</sup>	✗
I	Evapotranspiration (ET)	Climate	✓	✓
I	Tidal Elevations at Coastal Structures	Climate	✓	✓
I	High Tide Events (Limited Flood Control Capacity Events)	Climate	✓ <sup>2</sup>	✗
I	Groundwater Levels/Elevations/Stages	Resilience	✓	✓
I	Saltwater Intrusion/ Saltwater Interface – Chloride Levels	Resilience	✓ <sup>1</sup>	✓
I	Minimum Flows and Minimum Water Levels (MFLs) – Exceedances/ Violations	Resilience	✓	✓
I	Flooding Events	Resilience	✓	✗
I	Water Temperature	Resilience	✓	✓
I	Dissolved Oxygen (DO)	Resilience	✓	✓
I	pH	Resilience	✓	✓
I	Specific Conductance	Resilience	✓	✓
I	Estuarine Inland Migration – Everglades	Resilience	✓	✗
I	Soil Subsidence	Resilience	✓	✗
I	Salinity in the Everglades and Biscayne Bay	Resilience	✓	✗
II	Drought	Climate	✓ <sup>2</sup>	✗
II	Freshwater Lens	Resilience	⊠	⊠
II	Stormwater Volume and Flow	Resilience	⊠	⊠
II	Algal Blooms	Resilience	⊠	⊠
II	Atlantic Multidecadal Variability (AMV)	Climate	⊠	⊠

- ✓ Trend analysis and/or tool automation were completed for the metric.
  - ✗ Trend analysis and/or automation were not completed for the metric.
  - ⊠ Trend analysis and/or automation are pending development for the metric.
- <sup>1</sup>Updated analysis pending publication March 1, 2026.  
<sup>2</sup>First analysis pending publication March 1, 2026.



# Water and Climate Resilience Metrics

## Technical Reports

The 2022 South Florida Environmental Report (SFER) documents an important year of restoration, scientific, and engineering accomplishments in the Resilience Sector. Key "Highlights" include:
 

- Water Year 2021 (May 1, 2020-April 30, 2021)
- Fiscal Year 2021 (Oct. 1, 2020-Sept. 30, 2021)

Chapter 2B: Water and Climate Resilience Metrics (2023 SFER) highlights:
 

- Emerging Trends in Regional Resiliency
- Early Insights in Regional Resiliency
- Future Outlook in Regional Resiliency
- Regional Rainfall
- Evapotranspiration Trends in South Florida
- Tidal Elevations at Coastal Structures and Sea Level
- Saltwater Intrusion in Coastal Aquifers
- Salinity in the Everglades
- Estuarine and Mangrove Inland Migration
- Soil Subsidence in South Florida

[sfwmd.gov/SFER](https://sfwmd.gov/SFER)

## Online Resources

Emerging Trends in Regional Resiliency: Latest trends identified from historical data and insights into evolving conditions.

Early Insights in Regional Resiliency: Efforts for data collection and preliminary data analysis.

Future Outlook in Regional Resiliency: Projections based on current data and models to inform long-term planning and decision-making.

South Florida Flood Information Resource: A resource for collecting and consolidating flood information to help us better understand working flood systems associated with King, Lake, Branch, Royal, St. Johns, and St. Lucie Rivers.

WebApp: Future Extreme Rainfall Change Factors for Flood Resiliency Planning in South Florida Web Application. This tool provides access to future extreme rainfall change factors for resiliency planning for the 16 counties and 14 rainfall areas within...

Enhanced Tide Predictions: Locally Relevant Tide Forecasts to Support Effective Planning and Response.

SFWMD Data and Support: DBHydro Insights, SFWMD GIS Open Data Hub, and SFWMD SFER 2024.

DBHydro Insights: DBHydro is the South Florida Water Management District's corporate environmental database that stores hydrologic, meteorologic, hydrogeologic, and water quality data.

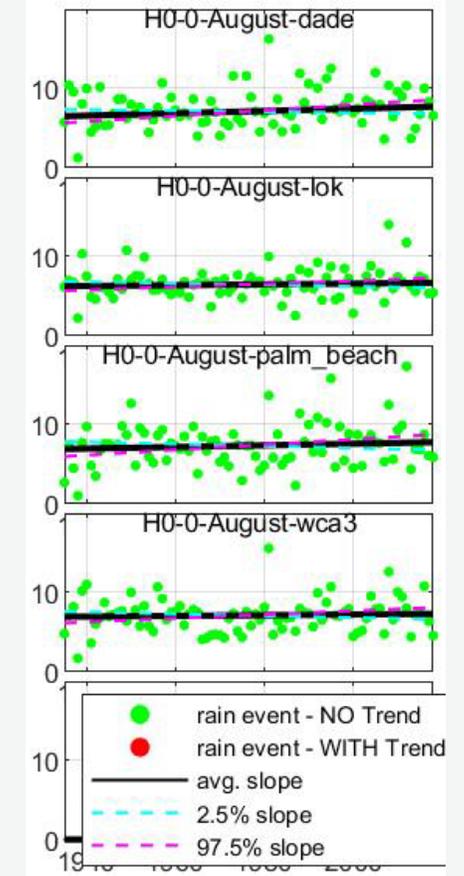
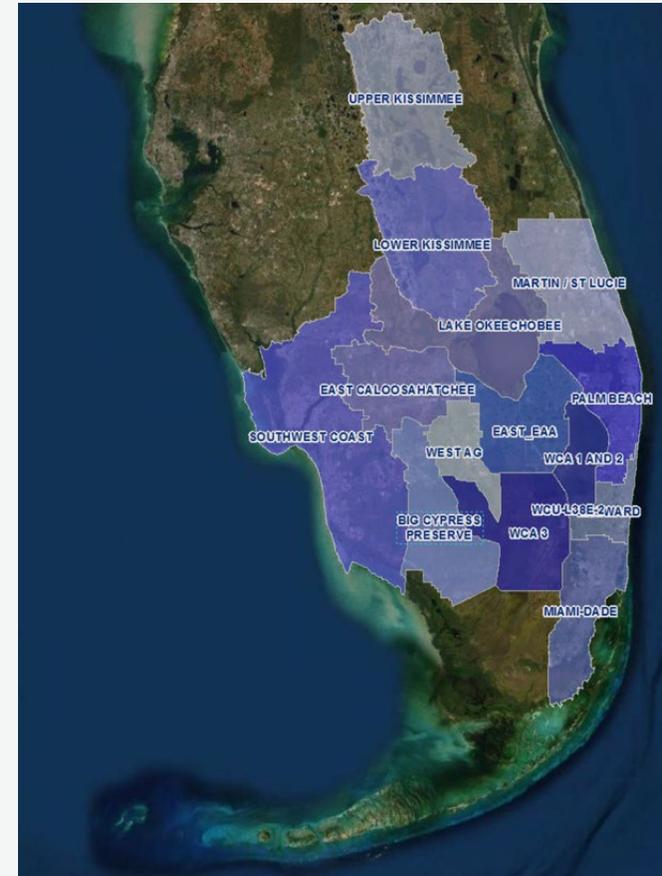
[sfwmd.gov/ResilienceMetricsHub](https://sfwmd.gov/ResilienceMetricsHub)



# Rainfall Trend Analysis

## Strategy

1. Spatially interpolate rainfall using Thiessen-10 method on the “super grid” (2x2 rainfall binary file).
2. Calculate continuous regional rainfall daily time series for the 14 management basins.
3. Calculate monthly, seasonal and annual rainfall time series for each basin.
4. Perform Frequency Analysis for 1-, 3- and 5-day maxima for each basin.
5. Perform trend analysis on the time series resulting from steps 3 and 4.



Rainfall Trend Analysis results for August and POR 1935-2018

# Rainfall Cluster Analysis

## MATLAB Executable

Created by Dr. Alaa Ali (Technical Lead for Rainfall).

## Variables

1. Peak Over Threshold  
4.0 to 9.0 inches
2. Minimum Data Points for Period of Record (POR)  
5 or 10
3. Minimum Data Locations to Form a Cluster  
5 (~5 mi<sup>2</sup>), 7 (~10 mi<sup>2</sup>), or 10 (~20 mi<sup>2</sup>)
4. Trend Analysis Significance Level  
0.01, 0.05, or 0.1

Data points in POR x Data locations to form cluster x Significance level								
5 x 5 x 0.01	1	1	1	2	6	11	15	10
5 x 5 x 0.05	1	1	1	2	6	11	15	10
5 x 5 x 0.1	1	1	1	2	6	11	15	10
5 x 7 x 0.01	1	1	1	2	6	11	11	7
5 x 7 x 0.05	1	1	1	2	6	11	11	7
5 x 7 x 0.1	1	1	1	2	6	11	11	7
5 x 10 x 0.01	6	6	8	7	10	14	16	8
5 x 10 x 0.05	6	6	8	7	10	14	16	8
5 x 10 x 0.1	6	6	8	7	10	14	16	8
10 x 5 x 0.01	1	1	5	6	10	5	6	2
10 x 5 x 0.05	1	1	5	6	10	5	6	2
10 x 5 x 0.1	1	1	5	6	10	5	6	2
10 x 7 x 0.01	1	1	5	8	6	6	3	1
10 x 7 x 0.05	1	1	5	8	6	6	3	1
10 x 7 x 0.1	1	1	5	8	6	6	3	1
10 x 10 x 0.01	6	7	9	11	11	4	3	1
10 x 10 x 0.05	6	7	9	11	11	4	3	1
10 x 10 x 0.1	6	7	9	11	11	4	3	1
Peak over threshold (in)	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5

Total number of clusters for different variables.

# Rainfall Cluster Analysis

Name	Peak over threshold (in)	Results: Clusters	Results: Trend	Cluster with trend				Cluster with trend			
				Cluster number	Cluster location	Data points	Observed trend (avg slope)	Cluster number	Cluster location	Data points	Observed trend (avg slope)
5 x 10 x 0.05	4.0	6	2	2	Lower East Coast	1297	4.81	6	Upper East Coast	745	4.84
5 x 10 x 0.05	4.5	6	2	2	Lower East Coast	842	5.3	6	Upper East Coast	505	5.4
5 x 10 x 0.05	5.0	8									
5 x 10 x 0.05	5.5	7									
5 x 10 x 0.05	6.0	10	2	4	Near LO	20	7.31	6	Near LO	27	6.64
5 x 10 x 0.05	6.5	14	2	11	Near WCA12	35	7.45	14	Near WEAA	50	-8.51
5 x 10 x 0.05	7.0	16	1	7	Near MSL	25	-7.82				

## Persistent clusters

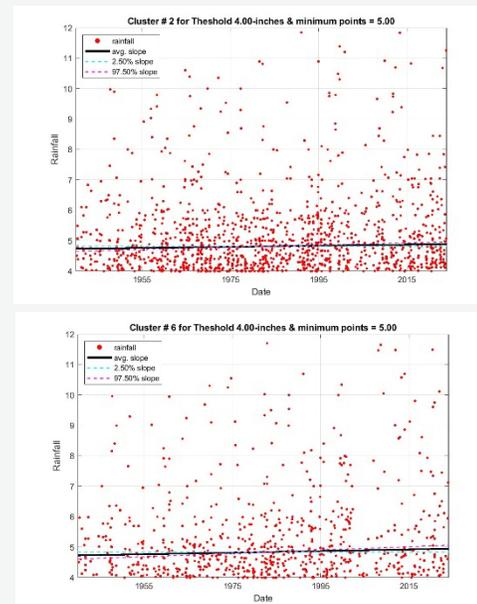
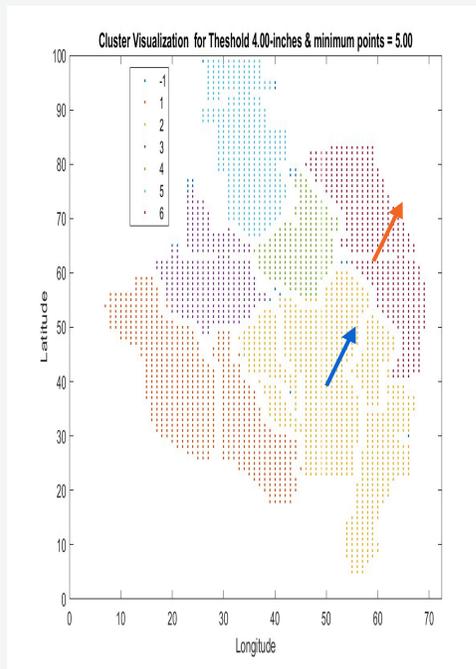
- Represent zones of stable hydrological behavior over time.
- Consistently exhibit elevated rainfall exceedances across thresholds and years.
- Should be prioritized for resilience infrastructure (base-level infrastructure investment and long-term risk planning).

## Emerging clusters

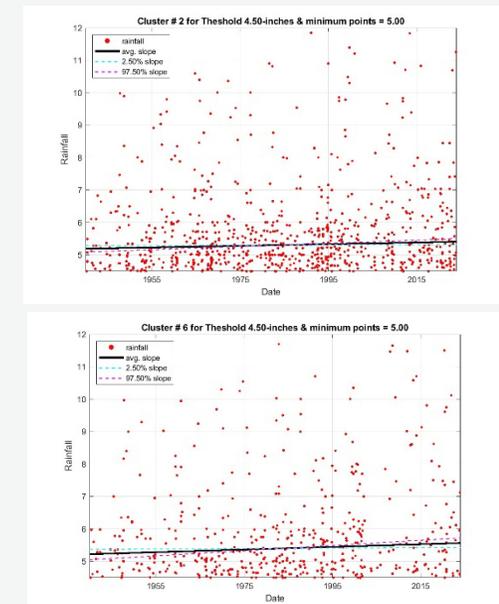
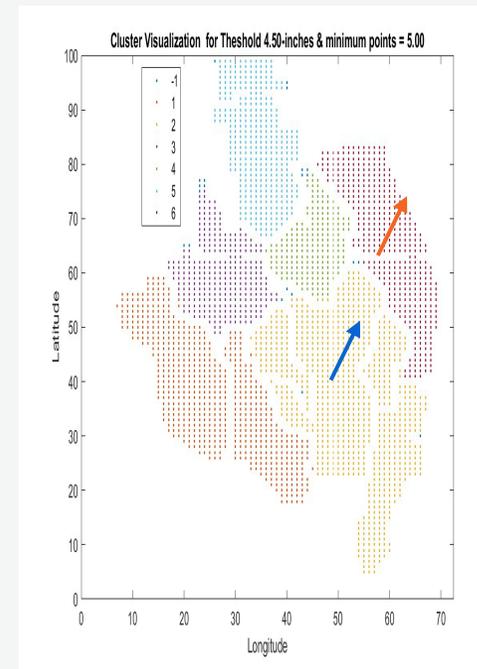
- Represent dynamic hotspots where rainfall intensity increases during extreme weather events.
- More prominent in the updated period (2035–2024) and for higher thresholds (5.00 and 6.00 in).
- Demand heightened attention in both climate adaptation strategies and emergency response planning (significant challenges to unprepared infrastructure systems).

# Rainfall Cluster Analysis

Name	Peak over threshold (in)	Results: Clusters	Results: Trend	Cluster with trend				Cluster with trend			
				Cluster number	Cluster location	Data points	Observed trend (avg slope)	Cluster number	Cluster location	Data points	Observed trend (avg slope)
5 x 10 x 0.05	4.0	6	2	2	Lower East Coast	1297	4.81	6	Upper East Coast	745	4.84
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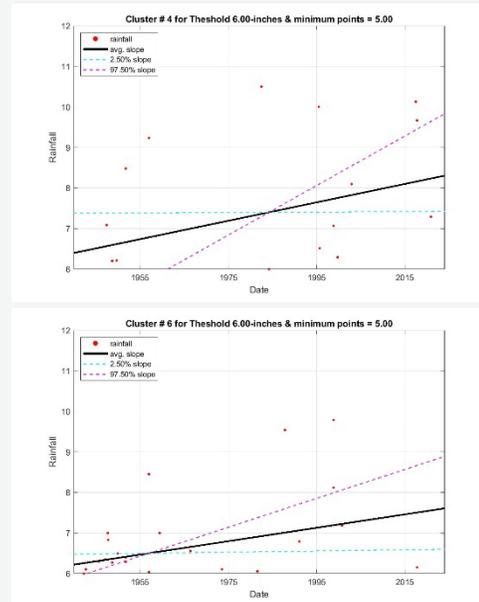
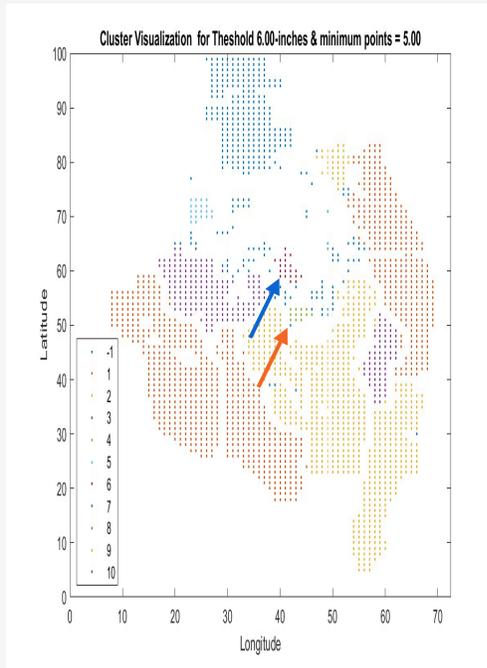
Rainfall Trend Analysis results for POT 4.00 inches and POR 1935-2024



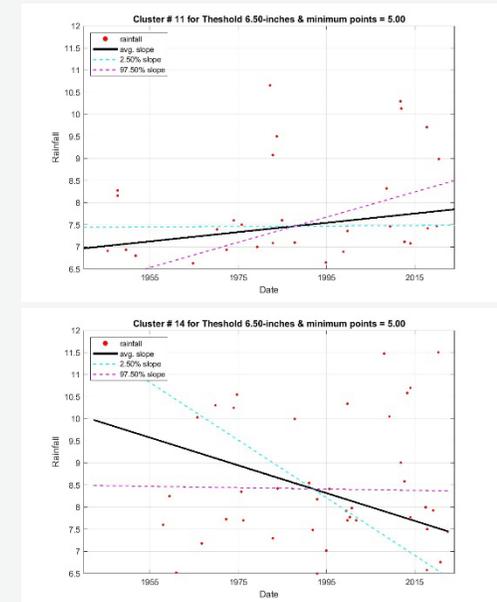
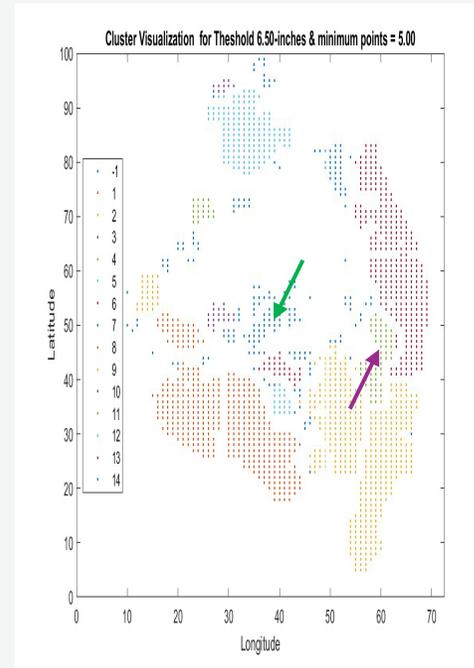
Rainfall Trend Analysis results for POT 4.50 inches and POR 1935-2024

# Rainfall Cluster Analysis

Name	Peak over threshold (in)	Results: Clusters	Results: Trend	Cluster with trend				Cluster with trend			
				Cluster number	Cluster location	Data points	Observed trend (avg slope)	Cluster number	Cluster location	Data points	Observed trend (avg slope)
5 x 10 x 0.05	6.0	10	2	4	Near LO	20	7.31	6	Near LO	27	6.64
5 x 10 x 0.05	6.5	14	2	11	Near WCA1	35	7.45	14	Near WEEA	50	-8.51



Rainfall Trend Analysis results for POT 6.00 inches and POR 1935-2024



Rainfall Trend Analysis results for POT 6.50 inches and POR 1935-2024

# Summary

## Water and Climate Resiliency Metrics

- The Initiative provides a framework for understanding how water and climate data are changing across the District.
- Phase I built the foundation with initial metrics and automation.
- Phase II refines, expands, and adds new metrics.

## Rainfall Trend Analysis

- Temporal and spatial trends have been identified for rainfall.
- First analysis identified trends across 14 rainfall areas.
- Cluster analysis revealed trends across persistent and emerging rainfall zones.

# Any questions?

Thank you