# Trends of Annual Minimum 7-day Average Flow in Georgia, South Carolina, and North Carolina, Climate Years 1932–2021

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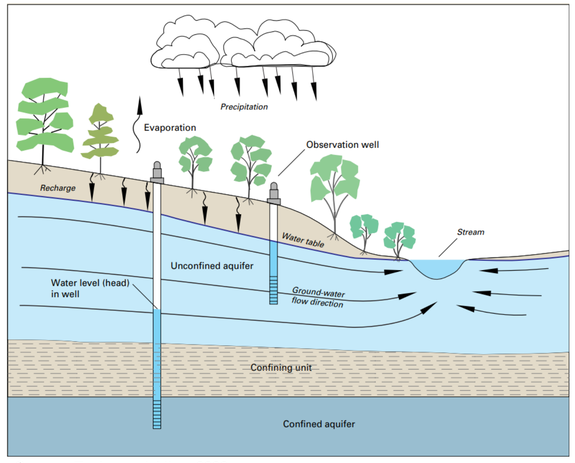
## Introduction

Low flows, often referred to as baseflow, are integral to the hydrological regime of rivers and streams.

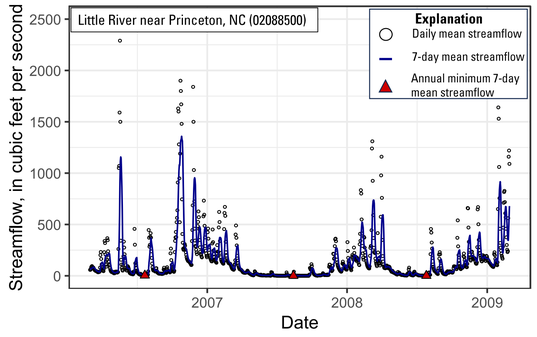
- Low flows are composed largely of groundwater flow from surficial aquifers to streams.
- Low flows are dependent on topographic, geologic, and climatic conditions.
- Low flows tend to occur late summer or early fall at the end of the growing season.




*Source: Taylor and Alley, 2002*

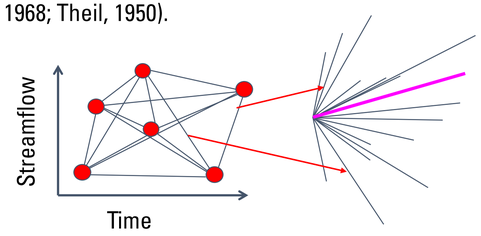
## Minimum 7-day Average Flow

The lowest 7-day average streamflow each year was calculated from daily mean streamflow for 87 continuous-record streamgages with 30 or more years of record.




## Trend Test

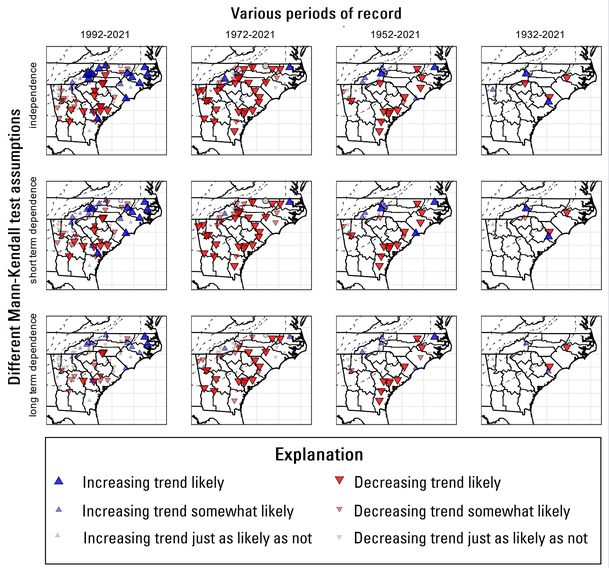
Minimum 7-day average streamflow records of 87 "natural" streams were assessed using the nonparametric test of trend on rank using the Mann-Kendall Theil-Sen slope (Kendall, 1938; Mann, 1945; Sen, 1968; Theil, 1950).




## Modification of Trend Test

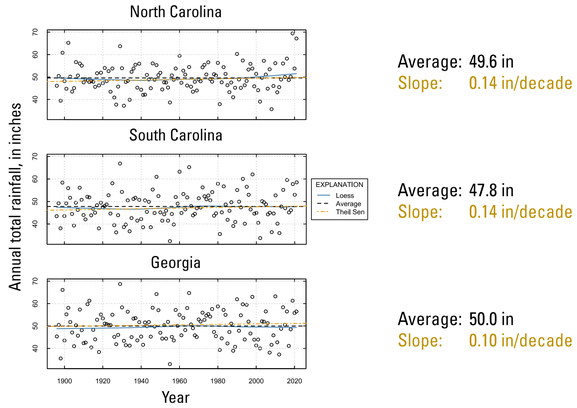
Dry and wet periods may make year-to-year streamflows correlated, complicating trend detection. Thus, modifications of the Mann-Kendall test were also used which account for persistent short- and long-term autocorrelation (Hamed, 2008; Hamed and Rao, 1998). Trends were tested for 30-, 50-, 70-, and 90-year records ending in climate year 2021 (March 31, 2022).

## Trends by Period and Dependence Assumption




## Evaluation of Rainfall Influence

Annual total precipitation and extreme 1-day rainfall were assessed for trends across the South Atlantic (GA, SC, & NC) and Southeastern (AL, FL, GA, SC, NC, & VA) USA.

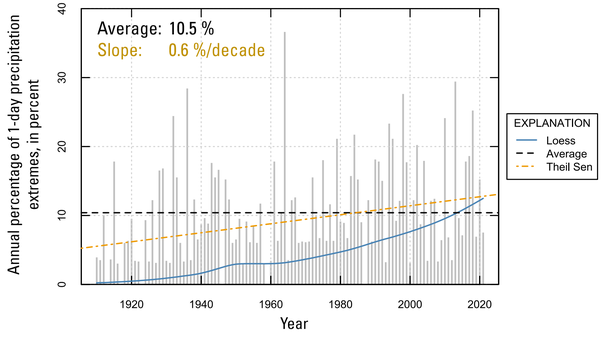



Average: 49.6 in
Slope: 0.14 in/decade

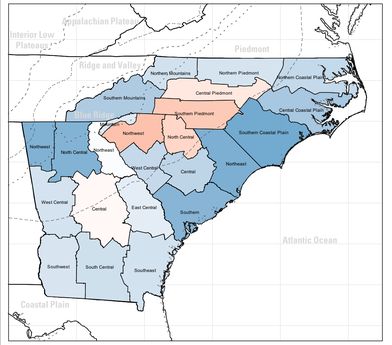
Average: 47.8 in
Slope: 0.14 in/decade

Average: 50.0 in
Slope: 0.10 in/decade

Percentage of the Southeast Covered by 1-day Precipitation Extremes




Annual Rainfall Total Trends by Climate Division



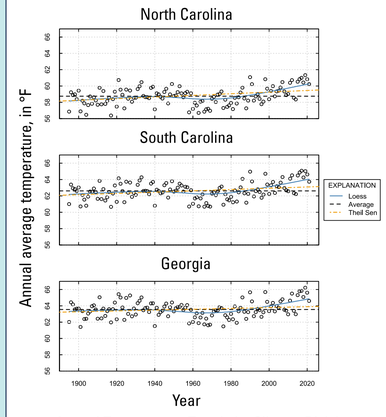

Explanation
Trend Magnitude, in inches per year
0.03
0.02
0.01
0.00
-0.01

Climate divisions with significant trends:

Independence: 2 of 24 (8%)
Short-term: 2 or 24 (8%)
Long-term: 1 or 24 (4%)

## Evaluation of Temperature Influence

Annual average temperatures were assessed for trends across the South Atlantic (GA, SC, & NC).

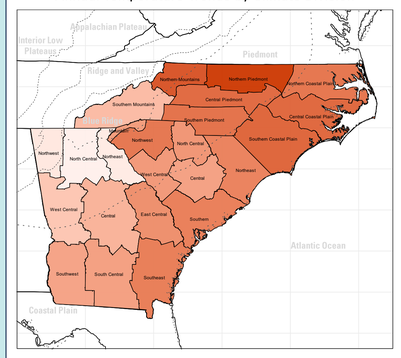



Average: 57.8 °F
Slope: 0.10 °F/decade

Average: 62.6 °F
Slope: 0.07 °F/decade

Average: 63.6 °F
Slope: 0.05 °F/decade

Annual Temperature Trends by Climate Division




Explanation
Trend Magnitude, in ° F per year
0.0125
0.0100
0.0075
0.0050
0.0025

Climate divisions with significant trends:

Independence: 20 of 24 (83%)
Short-term: 17 or 24 (71%)
Long-term: 3 or 24 (13%)

## Conclusions

Few low flow trends were significant, however downward trends dominated all years except from 1992 to 2021. The trends were likely influenced by temperature and rainfall fluctuations.

## References

Hamed, K.H., 2008, Trend detection in hydrologic data: The Mann-Kendall trend test under the scaling hypothesis: Journal of Hydrology, v. 349, no. 3–4, p. 350–363.

Hamed, K. H., & Rao, A. R. (1998). A modified Mann-Kendall trend test for autocorrelated data. Journal of Hydrology, v. 204, p. 182–196.

Kendall, M.G., 1938, A New Measure of Rank Correlation: Biometrika, v. 30, no. 1, p. 81–93.

Mann, H.B., 1945, Nonparametric Tests Against Trend: Econometrica, v. 13, no. 3, p. 245–259.

Sen, P.K., 1968, Estimates of the Regression Coefficient Based on Kendall's Tau: Journal of the American Statistical Association, v. 63, no. 324, p. 1379–1389.

Taylor, C. J., & Alley William M. (2002). *Ground-Water-Level Monitoring and the Importance of Long-Term Water-Level Data.*

Theil, H., 1950, A rank-invariant method of linear and polynomial regression analysis I and II, *in* Indagationes Mathematicae: North Holland Publishing Company, Amsterdam.

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