

# Changes in Temperature and Snowfall in the Midwestern United States

## Primary Questions

Has the Northern Plains of the United States experienced a significant increase in snowfall? Has the Southern Plains experienced a significant decrease in snowfall? Have both regions experienced shortening snow seasons as well as an increasing temperature? We investigate these questions using weather station data published during the years 1970-2010.

## Experimental Design

Here we take the Northern Plains to consist of North Dakota, South Dakota, Minnesota, Iowa, and Nebraska. Additionally, we take the Southern Plains to consist of Texas, Oklahoma, and Kansas. The dependent variables consist of the first 3-4 eigenvalues resulting from a principal component analysis (PCA) calculated over the time period from 1970-2010 for either region. The explanatory variables consist of weather station elevation, latitude, proximity to the ocean, and time. We compare the Northern Plains to the Southern Plains by visualizing the apparent spatiotemporal trends in eigenvalues using standardized eigenvectors reproducibly. In our analysis of snowfall, we consider only stations that regularly report snowfall in the winter.

## Background

As has been claimed previously<sup>1</sup>,

- Warmer temperatures are associated with less snowfall overall.
- Parts of the Northern Plains have seen more snow since the 1970's.
- The Southern Plains have seen an overall drop in snowfall since the 1970's.
- Snow-seasons in either region are shortening.

Figure 1 (A) High-level method of identifying weather stations regularly reporting outlier weather data. (B) (top) Mean observed snowfall in inches and (bottom) the first three eigenvectors that result from the corresponding principal component analysis (PCA) from 1970-2010 for South Dakota, a state located in the Northern Plains. (C) Workflow summary. (D) (top) Mean observed snowfall depth in inches and (bottom) the first three eigenvectors for North Dakota, which does not exhibit stable eigenvectors, indicating some weather station discrimination is necessary. (E) (top) Mean observed temperature (degrees Fahrenheit) in North Dakota from 1970-2010 and (bottom) the first three eigenvectors that result from the corresponding PCA.

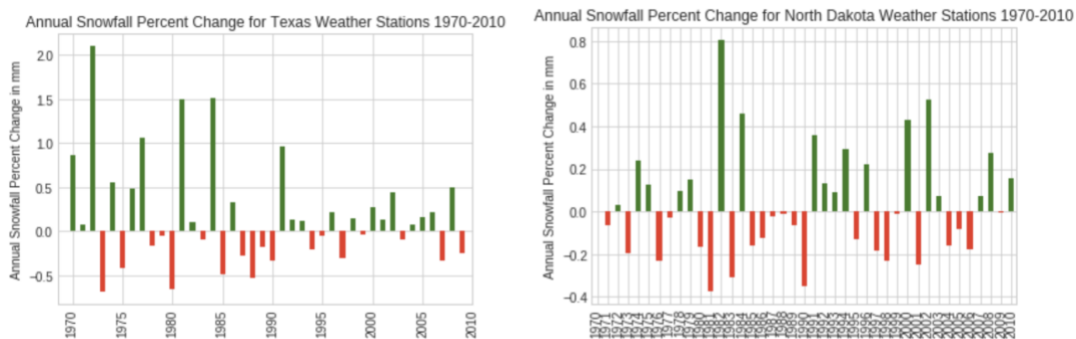
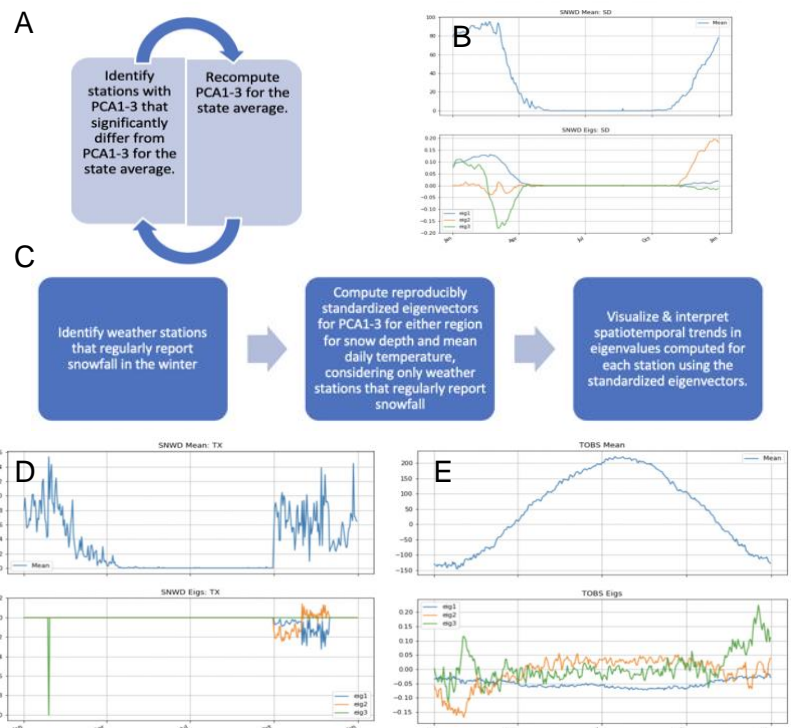


Figure 2 Annual percent change in snowfall for a state located in the Southern Plains (left) and the Northern Plains (right).

<sup>1</sup> <https://weather.com/safety/winter/news/2020-02-05-snow-season-shorter-us-climate-central-study>