# SEASONAL TEMPERATURE AND PRECIPITATION TRENDS ACROSS IDAHO

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**Abstract**
This study used the Daymet daily surface weather dataset to determine seasonal annual weather trends across Idaho between 1980 and 2022. The weather variables include minimum and maximum temperature, precipitation, and snow water equivalence. Trends were closely examined across two specific regions of the state; the central Idaho Rocky Mountains and the Snake River Plain. Using Mann-Kendall trend analysis significant trends were identified and reported in this paper. Overall, minimum temperature showed a significant positive trend between 1980 and 2022. These trends suggest numerous cascading effects to Idaho's environment and agricultural economy.

**Keywords:** Idaho, climate, weather

**Introduction**
This paper describes the spatiotemporal analysis of minimum and maximum temperature (Tmin and Tmax, respectively), precipitation (Precip), and snow water equivalence (SWE) for various watersheds in Idaho. The purpose of this study was to improve upon previous annual analyses reported by Weber 2025 by providing seasonal temporal granularity, namely growing season and winter metrics.

**Methods**
Daymet datasets for Tmin, Tmax, Precip, and SWE were prepared for analysis as described by Weber (2025). The daily weather datasets were subset by calendar year (including Julian dates 001-365) and seasons within a year. For example, the *growing season* was defined as Julian dates 091-273 (April 1$^{st}$-September 30$^{th}$) while the *winter season* was defined as Julian dates 244-365 (September 1$^{st}$-December 31$^{st}$) for year *Y* in addition to Julian dates 001-120 (January 1$^{st}$-April 30$^{th}$) for year *Y+1*. Subset data files were copied to unique folders and new output raster layers were created containing summary statistics (e.g., mean, median, sum) for all input raster layers within each folder. This was done using the RasterFolderStats[1] tool in ArcGIS Pro.

There are 93 HUC08 watershed basin polygons intersecting the state of Idaho. This study focuses on seven of those watersheds; four henceforth referred to as High Country watersheds and three referred to as Snake River Plain watersheds (**Table 1** and **Figure 1**). These watersheds were selected to represent a (1) contiguous mountainous region and (2) lower elevation region with minimal topographic relief.

*Table 1. Topographic characteristics of the seven watersheds selected for this study.*

| REGION | HUC 08 | AREA (km$^2$) | ELEVATION SUMMARY (meters) | | | | |
|---|---|---|---|---|---|---|---|
| | | | MIN | MAX | RANGE | MEAN | MEDIAN |
| High Country | 17060201 | 6,279 | 1,408 | 3,605 | 2,197 | 2,309 | 2,303 |
| High Country | 17060203 | 4,719 | 918 | 3,347 | 2,429 | 1,974 | 2,015 |
| High Country | 17060205 | 3,890 | 1,221 | 3,184 | 1,963 | 2,197 | 2,206 |
| High Country | 17060206 | 3,563 | 918 | 3,099 | 2,181 | 2,120 | 2,163 |
| Snake River Plain | 17040201 | 1,413 | 1,430 | 2,161 | 731 | 1,506 | 1,476 |
| Snake River Plain | 17040206 | 5,593 | 1,308 | 2,667 | 1,359 | 1,494 | 1,457 |
| Snake River Plain | 17040209 | 8,702 | 1,242 | 2,832 | 1,590 | 1,454 | 1,400 |

[1] This python script was created by Idaho State University's GIS TREC and is available for downloaded from https://giscenter.isu.edu/research/Techpg/nasa_RECOVER2/zip/RasterFolderStats.zip

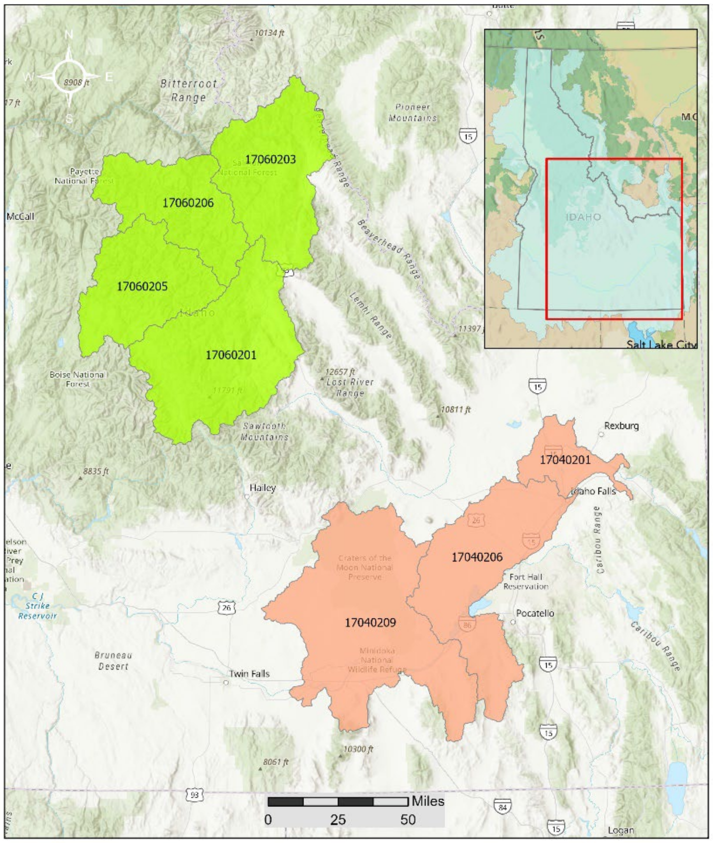


*Figure 1. Seven watersheds were selected to serve as case study regions, four were termed High Country watersheds (green) and three Snake River Plain watersheds (orange).*

Trend analysis was conducted for each of the datasets (Tmin, Tmax, Precip, and SWE) using the Mann-Kendall test and both P-value and M-K score were used to evaluate the results. The Zonal Statistics as Table tool in ArcGIS Pro was used to extract P-value and M-K score as well as seasonal statistics for each of the seven watersheds. The resulting tabular data were exported to Microsoft Excel for data visualization and linear trend calculation.

**Results and Discussion**

Throughout the growing seasons of 1980 through 2022, a positive trend of Tmin was observed ($R^2$ of 0.56 and 0.46 for the High Country and Snake River Plain watersheds, respectively), suggesting minimum mean temperature is increasing. Interestingly, Tmax shows a less steep and almost level trend. Precipitation trends appear to be declining with a more pronounced negative trend observed for High Country watersheds relative to the Snake River Plain watersheds (**Figure 2**).


*Figure 2. Growing season (April 1st through September 30th) trends for three primary weather variables across High Country (left) and Snake River Plain watersheds (right). Tmin (a and b) shows an overall increasing or positive trend, while Tmax (c and d) shows a more stable and nearly level trend. Precip (e and f) show a decreasing or negative trend. NOTE: The linear regression equation and $R^2$ values are for a single watershed and are given to illustrate general trend. In addition, the Y-axis for Tmin graphs (a and b) are not identical simply because of the extreme difference in range of values.*

The results of the Mann-Kendall test analyses provide scores corresponding well with the observed trendlines but also reveal that only the Tmin trends are significant (**Table 2**). This is important to bear in mind to avoid incorrect interpretation or misapplication of these data.

*Table 2. Results of growing season Mann-Kendall trend analyses for the High Country and Snake River Plain watershed explored in this study.*

| REGION | VARIABLE | M-K SCORE | P-VALUE |
|---|---|---|---|
| High Country | Precipitation (sum) | -208.98 | 0.09 |
| Snake River Plain | Precipitation (sum) | -76.37 | 0.45 |
| High Country | Tmax (mean) | 269.46 | 0.04 |
| Snake River Plain | Tmax (mean) | 202.99 | 0.04 |
| High Country | Tmin (mean) | 552.57 | 0.00 |
| Snake River Plain | Tmin (mean) | 438.68 | 0.00 |

Winter season results of 1980 through 2022 indicate minimum temperature is increasing, with a much more pronounced positive trend observed for High Country watersheds relative to the Snake River Plain watersheds. Tmax also shows an increasing or positive trend over time. Precipitation during the winter months has been quite stable while SWE shows a declining or negative trend (**Figure 3**).

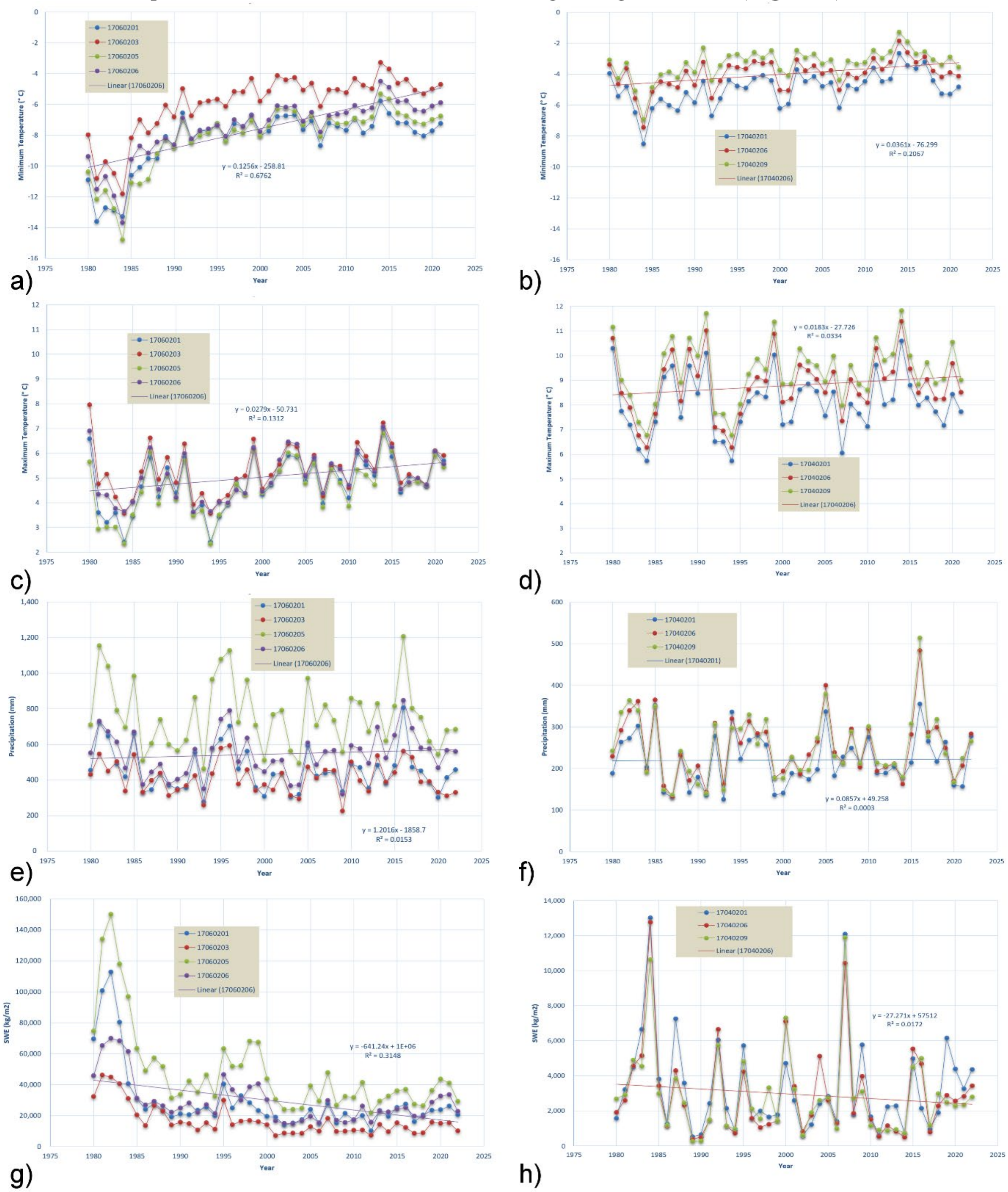


*Figure 3. Winter season (September 1st through April 30th) trends for four primary weather variables across High Country (left) and Snake River Plain watersheds (right). Tmin (a and b) shows an overall increasing or positive trend, while Tmax (c and d) and Precip (e and f) show a more stable and nearly level trend. Snow Water Equivalent (SWE) (g and h) shows a negative trend. NOTE: The linear regression equation and $R^2$ values are for a single watershed and are given to illustrate general trend. In addition, the Y-axis for precipitation (e and f) and SWE (g and h) are not identical simply because of the extreme difference in range of values.*

The Mann-Kendall test results for winter season variables were very similar to those observed for the growing season. That is, only the Tmin trends were significant with both showing a strong positive trend (**Table 3**). It is noted that while not significant, the negative trend in SWE was quite strong (M-K score = -260.69) as was the positive trend in Tmax (M-K score = 228.5). Both of these merits continued monitoring.

*Table 3. Results of winter season Mann-Kendall trend analyses for the High Country and Snake River Plain watershed explored in this study*

| REGION | VARIABLE | M-K SCORE | P-VALUE |
|---|---|---|---|
| High Country | Snow water equivalent (sum) | -260.69 | 0.07 |
| Snake River Plain | Snow water equivalent (sum) | -45.81 | 0.57 |
| High Country | Precipitation (sum) | -39.78 | 0.45 |
| Snake River Plain | Precipitation (sum) | 10.07 | 0.66 |
| High Country | Tmax (mean) | 228.5 | 0.07 |
| Snake River Plain | Tmax (mean) | 84.07 | 0.43 |
| High Country | Tmin (mean) | 482.65 | 0.00 |
| Snake River Plain | Tmin (mean) | 263.17 | 0.02 |

It is important that these weather variables are not treated in isolation but instead are correctly treated as interactive variables. In other words, increasing minimum winter temperature will influence snow pack and SWE (Mote et al 2005). Moreover, during both early and late winter months the study area may likely receive rain instead of snow and an earlier spring snow melt may be experienced (Viviroli et al 2011). In addition, a persistent increase in minimum temperature could result in other cascading effects such as a shift in phenology and an earlier --and prolonged-- growing season. Initially, the latter scenario might appear to be beneficial to vegetation but if High Country SWE also declines, native vegetation like Aspen (*Populous tremuloides*) will most likely be negatively impacted (Brodie et al 2011).

**Conclusions**

Analyzing long term weather and climate trends across specific seasons is arguably more useful than annual analyses which inevitably need to be de-seasoned. In this study, weather trends were analyzed during growing seasons and winter seasons across 1980 through 2022. The results suggest minimum temperatures are increasing ($P < 0.05$) while trends in maximum temperature and other weather variables (precipitation and snow water equivalent) were not significant. The results of this study do not imply causality of these changes as climate is a complex system with numerous non-linear and interacting variables involved. Continued monitoring is merited.

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