J7.4 DETECTING THE IMPACTS OF CLIMATE CHANGE ON PRECIPITATION EXTREMES FOR SOUTHERN COASTAL ALASKA

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1. INTRODUCTION

An impact of climate change that is becoming increasingly important is the aspect of heavy precipitation events, specifically their recurrence frequency and spatial distribution in a warming climate. Future increases or decreases in extreme precipitation events have the potential to impact broad aspects of society through flooding and related natural disasters, but also through impacts on water resources and related civil infrastructure. While the current literature states that episodes of extreme precipitation are likely to increase as the climate continues to warm, especially in mid- to high-latitudes (Christensen et al. 2007; CCSP 2008), much of the details regarding the spatial distribution of any observed increases or decreases in precipitation due to climate change remains uncertain.

This issue is confounded by a lack of long-term records in remote locations where changes in precipitation will have substantial impacts. This issue is especially true for the state of Alaska, where long-term climate records are confined to a few locations in cities and towns, and not necessarily representative of the state's vast area and diverse climatic regions. However, Alaska's southern coasts are the part of the state where climate records can cover relatively long periods, since this is where settlements have been for the longest periods.

In general, there have been very few studies of long-term variability and trends in precipitation in Alaska. Those studies that have addressed this issue have focused on seasonal variations based on monthly data, and not specifically on extreme precipitation events. Diaz (1980) studied seasonal precipitation changes covering the period 1931-1977 and found that precipitation changes during the cold (Oct-Mar) season have shown little change, although the data suggest a slightly wetter period during the 1930s and 1940s. In contrast, precipitation during the warm season (Apr-Sep) peaked during the 1950s and 1960s, and decreased significantly during the 1970s. In addition to using monthly data, these results were based on including data from across the state without examining any specific regional signal.

The analysis presented herein stems from the use of the so-called Frich climate indices (Frich 2002), which have been used to assess trends in climate variables owing to climate change. These indices contain thresholds for maximum and minimum temperature, growing degree days, various precipitation parameters, and others. For the study presented here, the following precipitation climate change indices were selected for analysis:

- Annual number of days > 50 mm (R50)
- Annual number of days > 10 mm (R10)
- Simple Daily Intensity Index (SDII)
- Average Annual Precipitation

The SDII is determined by dividing the number of days with rainfall > 1 mm into the total annual rainfall (mm). These indices were specifically chosen to represent changes in precipitation extremes, and were all based on daily data. The following section provides an overview of specific issues related to the data and methods used in this study.

2. DATA AND METHODS

The data used in the analysis was derived from the Global Historical Climate Network (GHCN) daily data[1]. Stations were selected for coastal Alaska from the provided inventory list. For southern coastal Alaska, stations were further selected by their regional latitude and longitude (discussed in section 3). In order to process the Frich Indices computation code[2], the period of record and available data had to meet certain requirements. Without modification, the code requires stations to have only three (3) days per month missing, and a maximum of 15 days per year missing. The initial runs using these criteria drastically reduced the number of available stations to be used in assessing precipitation trends. A sensitivity analysis was performed (not shown) to determine what criteria would allow the maximum of number of stations while resulting in an analysis that was robust enough to draw conclusions from resulting statistics. The new criteria were then set at a maximum of nine (9) missing days per month and 45 missing days per year. Linear trends were used to assess a first approximation of how extreme precipitation events have varied through time.

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[1] Available online at http://www.ncdc.noaa.gov/oa/climate/ghcn-daily/
[2] Available online at http://cccma.seos.uvic.ca/ETCCDI/software.shtml

3. RESULTS

Due to the size of Alaska, and the nature by which locations in southern coastal Alaska receive their precipitation, the coastline was split into three sections: southeast, south-central, and southwest (Fig. 1). In this case, the definition of “coastal” was determined to be within 40 km inland from the coastline. The analysis began in 1920, which was determined as the first year with an adequate number of stations for assessing regional variability.

3.1 *Southeast*

The southeast coastline of Alaska is characterized by the geographic region bounded by 140°W and 120°W longitude, and between 50°N and 60°N latitude. This includes such locations as Juneau, Sitka, and Annette. There has been a slight downward trend in the average annual precipitation (Fig. 2), but the trend is not statistically significant. There is, however, a statistically significant trend (above the 97% confidence level) for both the SDII and R10 indices (Fig. 3). Interestingly, for the heavier rain events above 50 mm, the trend is essentially neutral and was found to be not statistically significant (Fig 3).

3.2 *South Central*

The south central coastline of Alaska is bounded by the region 150°W to 140°W longitude, and between 50°N and 62°N latitude. This region includes locations such as Anchorage, Cordova, and Valdez. For the south-central coast a strong negative trend has been apparent since 1920 (Fig 5) in the SDII, R10, and R50 climate change parameters. All of these trends were found to be statistically significant above the 98% confidence level ($\alpha = 0.02$). In terms of average annual precipitation (Fig. 2), there has been a statistically significant negative trend since 1920 in this region. During the 1920s, average annual values were near 1500 mm, but by 2007 this had decreased to just over 1000 mm.

3.3 *Southwest*

The southwest portions of Alaska are primarily composed of the Aleutian Islands, but were generalized to include the region bounded by 170°W and 150°W longitude, and 50°N to 60°N latitude. This region includes cities such as Cold Bay and Kodiak. Unlike the other two south-coastal regions of Alaska, there has been an upward trend in the SDII (i.e., precipitation intensity), and in the number of days with >10 mm of rain (Fig 5). However, only the trend in SDII was statistically significant, reaching the 99% confidence level ($\alpha < 0.01$). While the graph in Fig. 5 also shows a decreasing trend in the R50 parameter, its trend was not statistically significant at the 95% level. For the average annual precipitation (Fig. 2), there has been a strong upward trend in this region since the 1920s, and it is statistically significant above the 99% confidence level ($\alpha < 0.01$). Average annual precipitation totals were just over 2000 mm in the early part of the record, but have since averaged near 3500 mm since roughly the 1970s, verifying the trend to wetter conditions in this region over the past few decades.

4. SUMMARY AND CONCLUSIONS

Climate change impacts on coastal communities are often discussed with attention to sea-level rise, freshwater availability, and coastal erosion impacts. However, heavy precipitation events are also important, as increases could result in more flooding episodes and risks to water resources, while decreases could result in agricultural impacts and decreases to water supply.

In Alaska, two regions, the south-central and southeast, were found to exhibit strong decreasing trends in heavy precipitation events. In contrast, in the southwest region of the state, heavy precipitation events were shown to be increasing. There is currently a dearth of peer-reviewed literature on precipitation trends in Alaska under the influences of climate change with which to compare these results. However, generalized studies, such as that from the Arctic Climate Impact Assessment (ACIA, 2005), suggest that precipitation along Alaska’s southern coastline should be increasing (especially in the boreal autumn and winter seasons), owing to increased global evaporation as well as an already observed northward shift in extra-tropical storm tracks (CCSP 2008).

Clearly, it is still too early to say for certain the direction of the future change in heavy rain events across this region, but if the results presented here are an indicator, such events may in fact be decreasing. Future work will focus on narrowing the uncertainties in these results and will explore more conceptually and quantitatively (e.g., through the use of more complex statistical methods) the magnitude and direction of the historically observed trends in Alaskan precipitation.

5. REFERENCES

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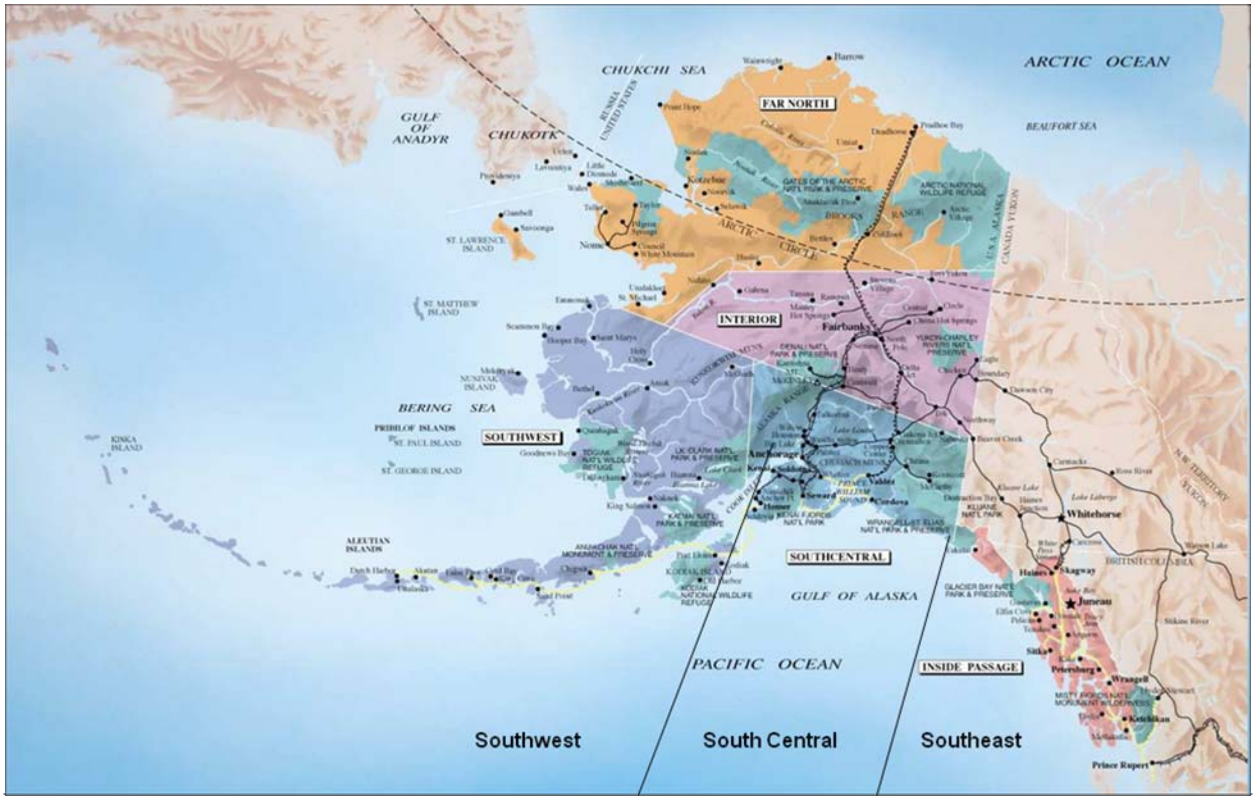

Figure 1. Map of Alaska and the climate regions along the southern coast used in this study (Southwest, South Central, and Southeast).

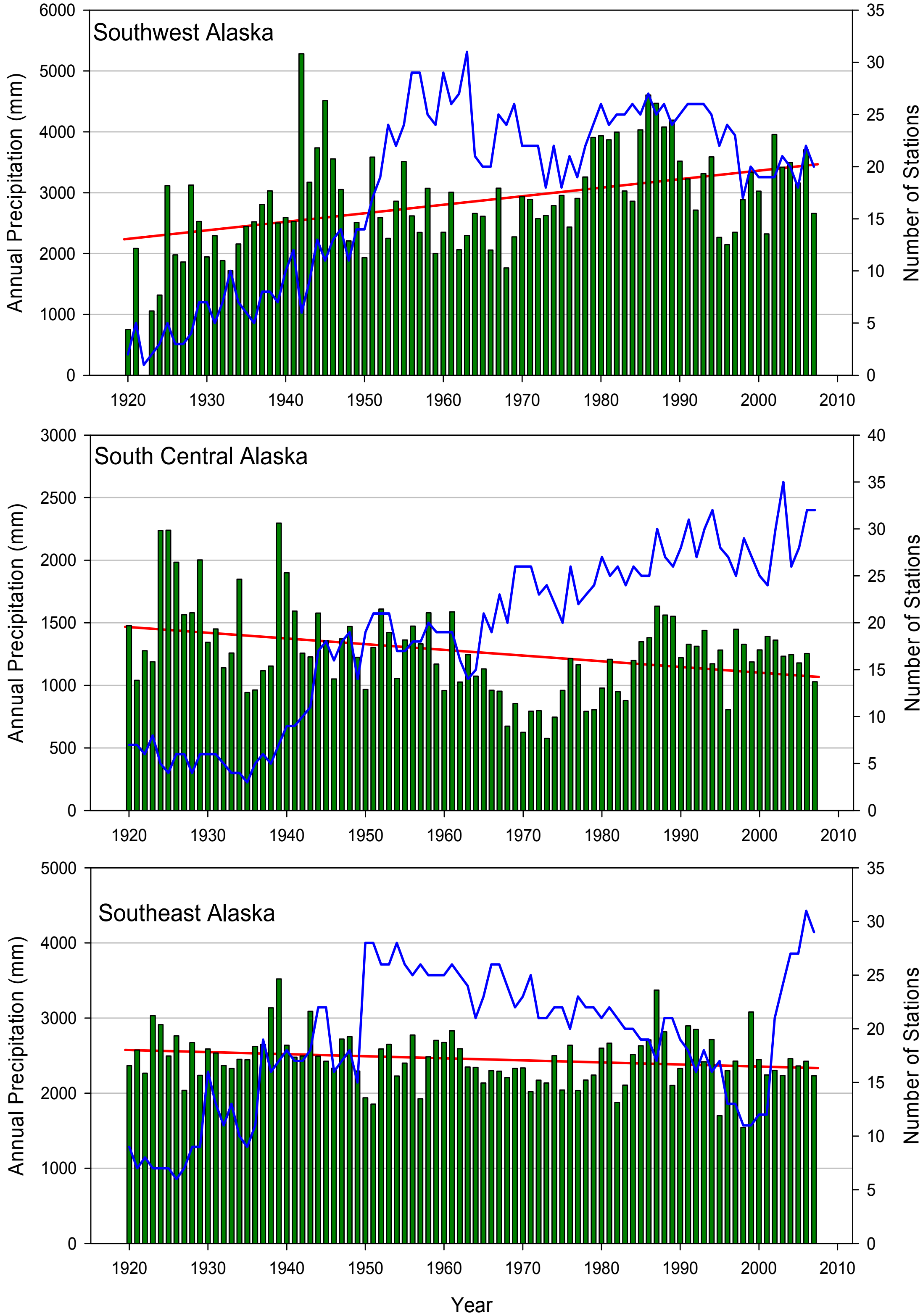

Figure 2. Annual precipitation for three southern coastal regions of Alaska based on GHCN-Daily data: Southwest (top), South Central (middle), and Southeast (bottom). Red line denotes linear regression for each time series and blue line denotes number of stations used in the analysis for each region.

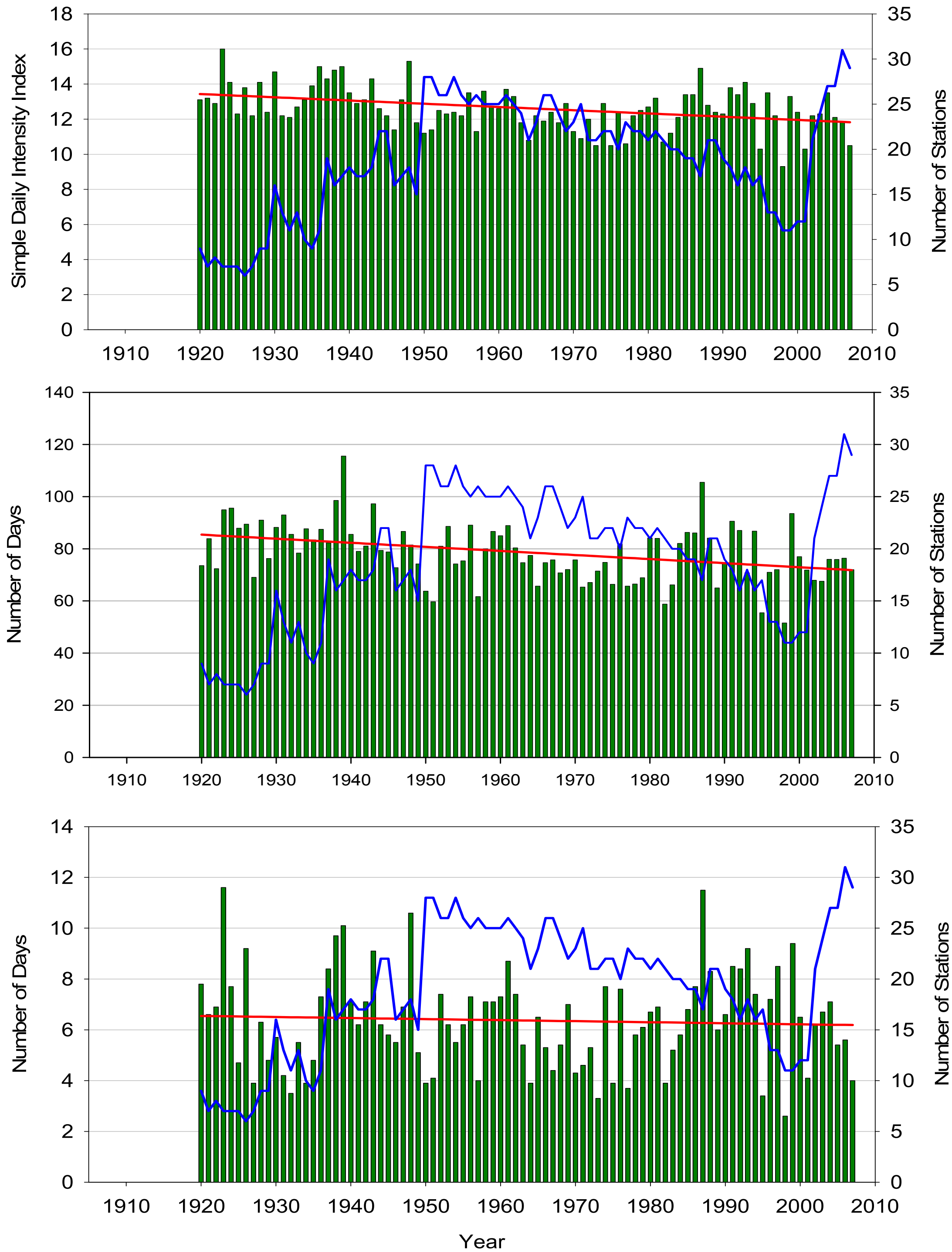

Figure 3. Precipitation indices for Southeast Alaska based on GHCN-Daily data. Top panel: SDII, middle panel: annual number of days with >10 mm of rain, and bottom panel: annual number of days with >50 mm of rain. Red line denotes linear regression for each time series, and blue line denotes number of stations used in the analysis.

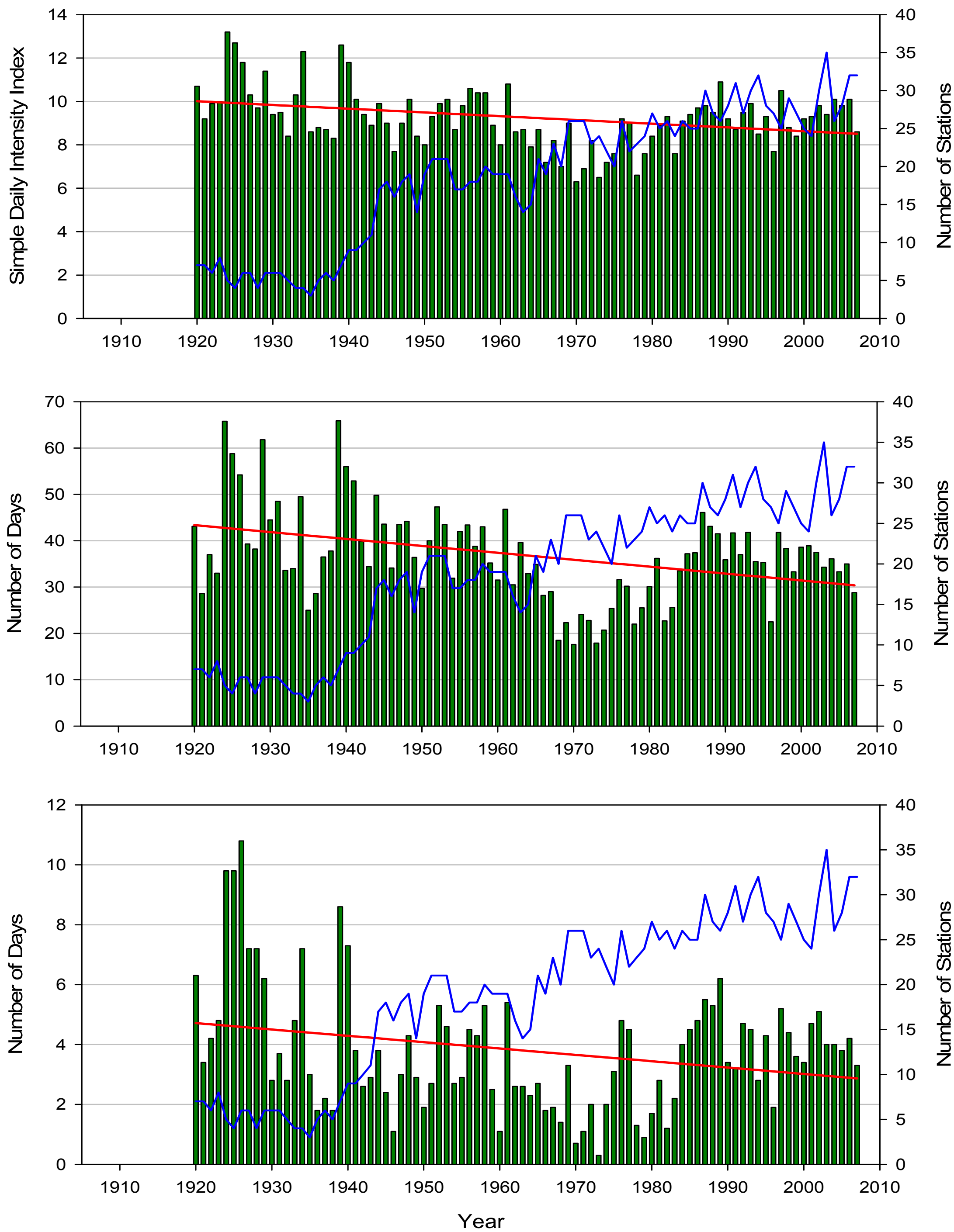

Figure 4. Precipitation indices for South-Central Alaska based on GHCN-Daily data. Top panel: SDII, middle panel: annual number of days with >10 mm of rain, and bottom panel: annual number of days with >50 mm of rain. Red line denotes linear regression, and blue line denotes number of stations used in the analysis.

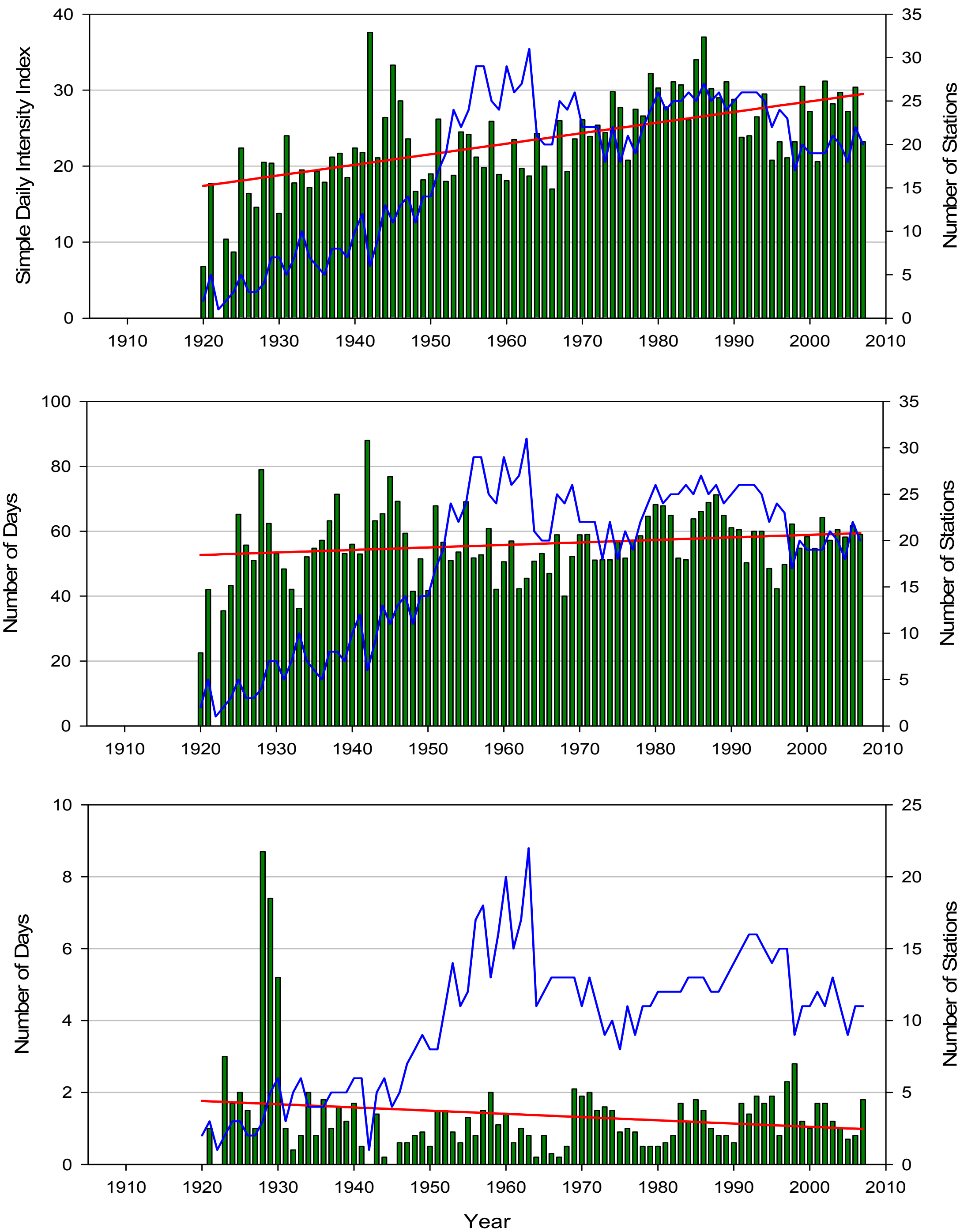

Figure 5. Precipitation indices for Southwest Alaska based on GHCN-Daily data. Top panel: SDII, middle panel: annual number of days with >10 mm of rain, and bottom panel: annual number of days with >50 mm of rain. Red line denotes linear regression, and blue line denotes number of stations used in the analysis.