A Century of Climate Change in Skagway, Alaska

Klondike Gold Rush National Historical Park

National Park Service
U.S. Department of the Interior

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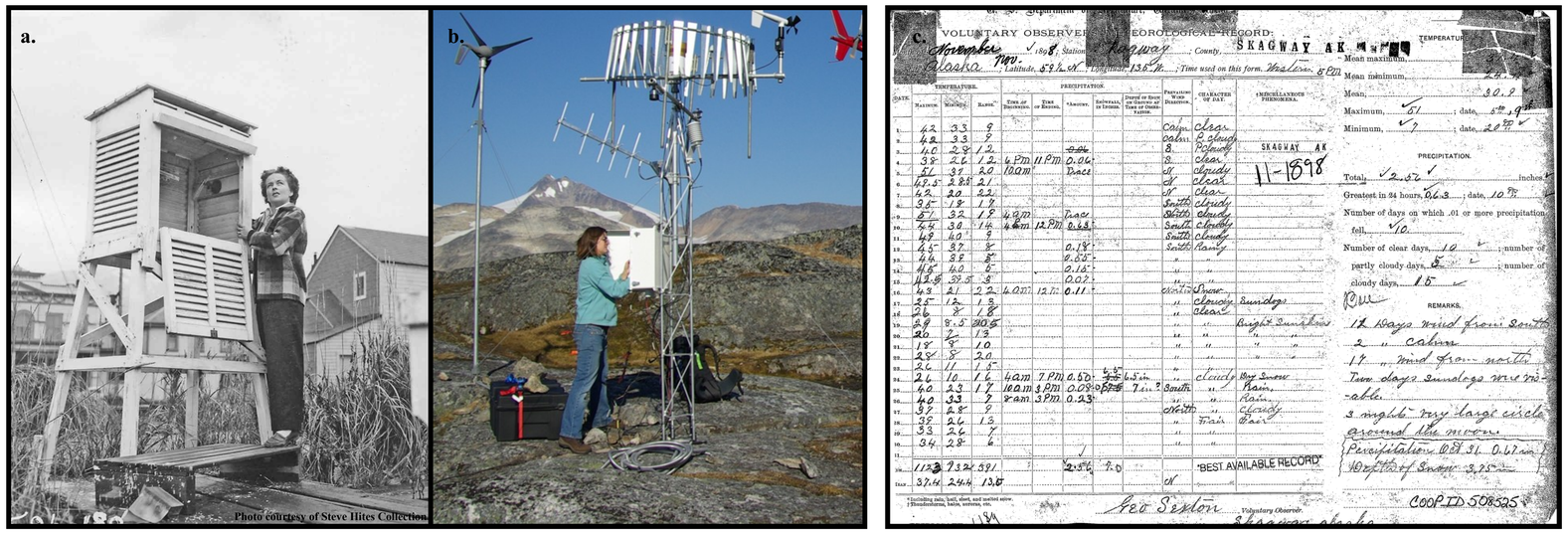


Figure 1. Skagway's weather record dates back to 1898. a. Weather observer in front of Skagway weather station, 1952. b. KLGO technician Jessica Wilbarger at Chilkoot Pass Weather Station, 2009. c. First weather observation record for Skagway, 1898.

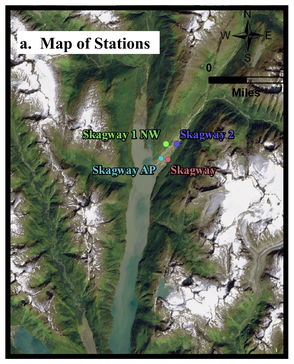
Introduction

Temperatures in coastal Alaska are affected by a pattern of oceanic and atmospheric circulations in the North Pacific Ocean called the Pacific Decadal Oscillation (PDO).[1] The PDO goes through warm and cool phases, each lasting 20-30 years. These phase shifts can obscure or exaggerate long-term climate trends.

Luckily, the historical weather record in Skagway dates to the town's origin during the Klondike Gold Rush. The first temperature data was taken in November, 1898 (Figure 1). This record provides an opportunity to study local climate trends over a period of 112 years, long enough to distinguish the effects of the PDO from underlying longer-term trends.

Data

Daily maximum and minimum temperature recordings from five local stations were available for study (Figure 2). Each station, however, had an incomplete record. Since climate in Skagway is sensitive to location and elevation, data was taken preferentially from the low-elevation stations on the valley floor. On any given day, the data from the station labeled 'Skagway' was used if available. Otherwise, data was taken from the stations labeled 'Skagway 2' and 'Skagway AP,' with preference given to 'Skagway 2' over 'Skagway AP' due to ocean effects at 'Skagway AP.' From 1972 to 1981, when none of these was recording, the gap was filled by the nearby station 'Skagway 1 NW' at an elevation of 570 feet.



From the compiled dataset, years with less than 70% of the daily data available were removed from the study, leaving 73% of years, with an average coverage of over 95%, in the annual analysis. Each year's daily maximum temperatures, as well as its daily minimum temperatures, were averaged. Monthly averages were analyzed separately, with a threshold of 60% coverage necessary for inclusion in the study. Months included in the analysis had an average coverage of 98%.

All temperature recordings used in this study were collected by the National Oceanic and Atmosphere Administration (NOAA) Cooperative Observer Network (COOP) and are available on the National Climatic Data Center (NCDC) website (http://www.ncdc.noaa.gov/oa/ncdc.html).

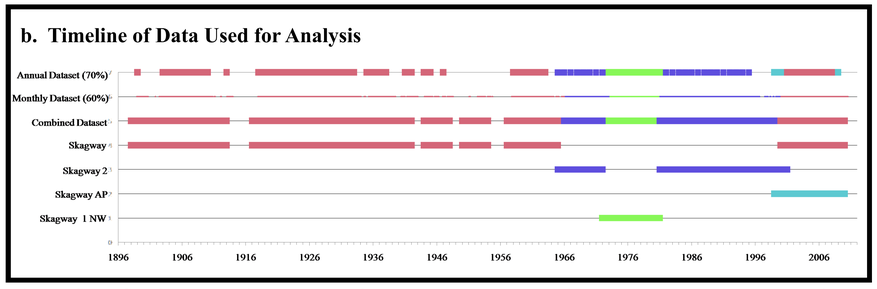


Figure 2. a. Stations used in the analysis were less than two miles apart. b. Data was combined in the order shown for consistency of operating conditions. Incomplete years and months were excluded, with a 70% coverage threshold for annual analysis, and 60% for monthly analysis.

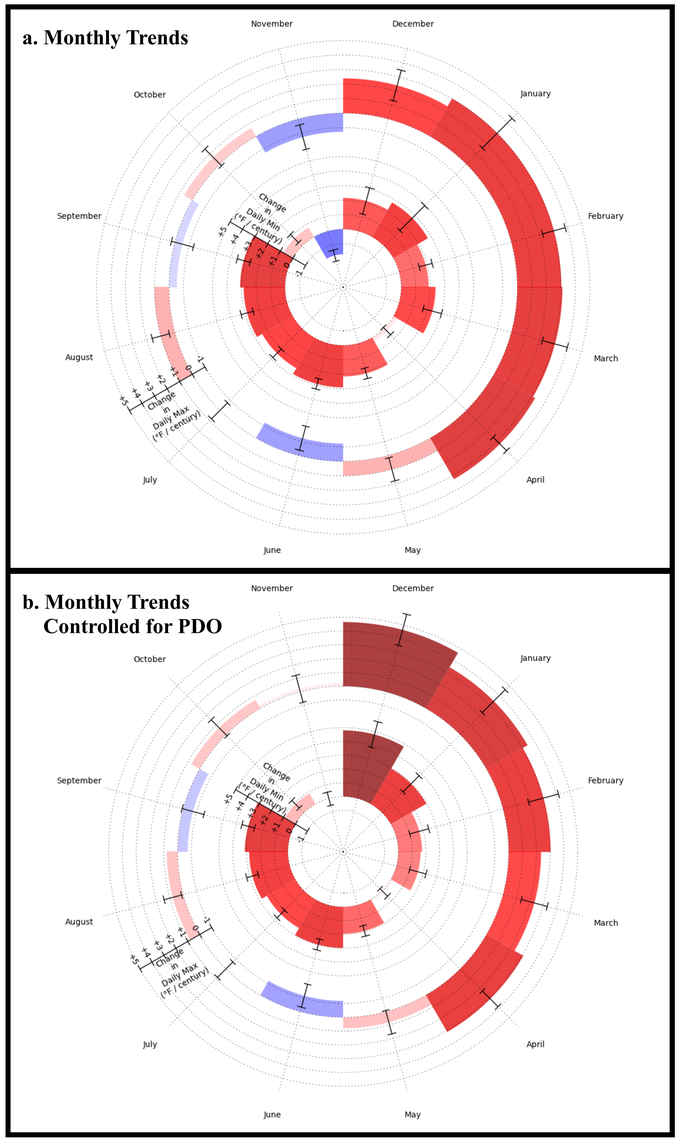


Figure 5. a. Monthly trends over the last 112 years show the seasonal distribution of local climate change. b. Long-term monthly trends are isolated by removing the estimated contribution of the Pacific Decadal Oscillation (PDO).

Controlling for the Pacific Decadal Oscillation (PDO)

Monthly PDO indices, available from the Joint Institute for the Study of the Atmosphere and Ocean website (http://jisao.washington.edu/data/), describe the phase of the PDO (Figure 3). These indices, plotted against observed monthly temperature averages, give a trend line with normally distributed residuals. This suggests a linear relationship between PDO index and local temperature, the slope of which estimates the contribution of the PDO to monthly averages. Similarly, annual PDO indices (averages of monthly indices) estimate the contribution of the PDO to each annual average. The estimated contribution of the PDO was subtracted from the observed data to investigate long-term trends.

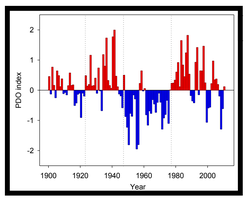


Figure 3. Pacific Decadal Oscillation (PDO) Index, 1900-2010.

Analysis

On both the actual dataset and the dataset controlled for PDO, a 30-year running average smoothed the data and bridged periods of low coverage. Although running averages reduce the resolution of data (obscuring patterns on scales less than the running average window), they also reduce noise from the calculations of long-term trends. Long-term trends are not only robust to smoothing, they are more precisely measured with smoothing. Linear regressions fit to each set of smoothed data extracted trends.

Results

Annual average high and low temperatures have significantly positive trends: lows are increasing at a rate of 1.9±0.4°F/century, and highs are increasing at a rate of 1.2±0.7°F/century. This does not change when the data is controlled for the contribution of the Pacific Decadal Oscillation (PDO) (Figure 4).

The most interesting results are the monthly trends, both observed and controlled for PDO (Figure 5). Observed trends show that nearly all of the warming occurs in winter and summer (summer lows but not summer highs), while there is even some cooling, especially in November.

- Nighttime lows are increasing mainly in two discrete periods: December-March and May-September. Lows in these months are increasing at rates of 1.9±0.5°/century to 3.1±0.5°F/century.
- Increasing highs are restricted to only one period: December-April, where highs increase at rates of 2.4±1.1°/century to 3.3±0.7°F/century.
- Cooling trends are found in the average highs for June, September and November, as well as for average lows in November. These cooling trends are from -0.5±0.9°/century to 1.7±0.4°F/century.

The estimated contribution of the PDO seems to account entirely for the November cooling, and it also seems to have been tempering the warming trends in December, and increasing the warming trends in March. Controlled for the PDO, long-term trends are for November temperatures to remain about the same, and for December temperatures to increase dramatically (December highs at a rate of 4.6±0.7°F/century). The distribution of warming trends could disproportionately affect certain seasonal processes.

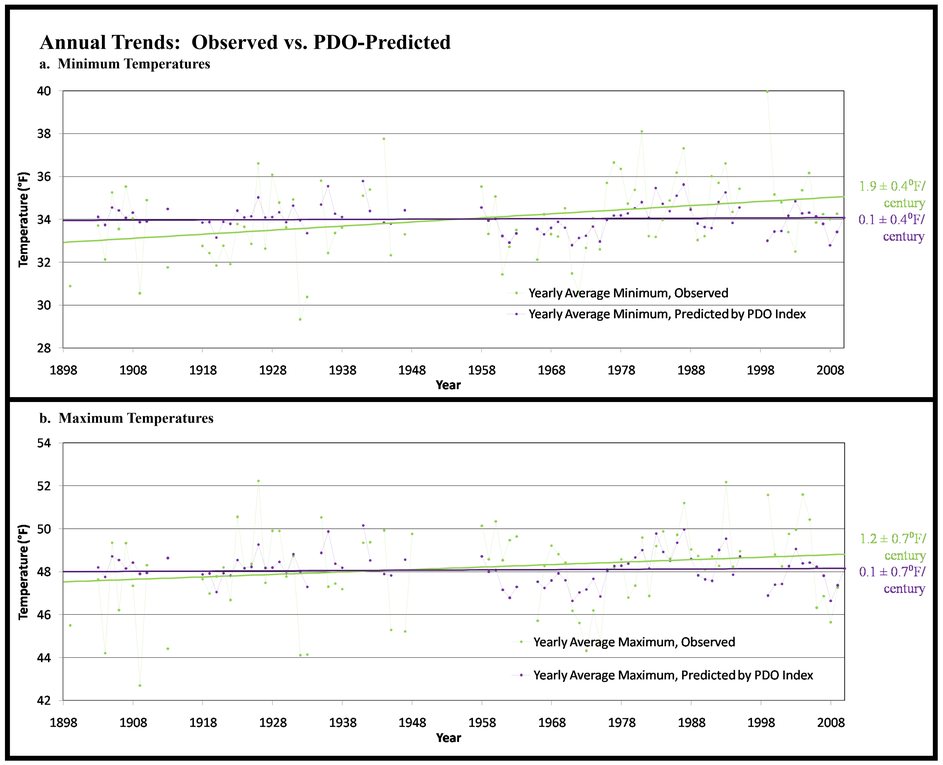


Figure 4. If the Pacific Decadal Oscillation (PDO) were the sole driver of climate in Southeast Alaska, Skagway, AK would see almost no change in annual averages of high and low temperatures over the last century (purple). Observed warming trends (green) are longer-term.

[1] Hartmann B. and G. Wendler. 2005. The Significance of the 1976 Pacific Climate Shift in the Climatology of Alaska. *Journal of Climate* 18:4824-4839.

Southeast Alaska Network Inventory and Monitoring Program
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