Mini-Project 1: Historical Weather Data
Part 3, Final Submission
COMPFOR 131
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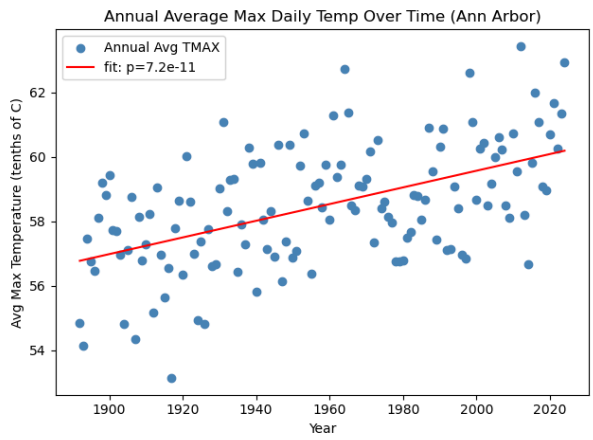
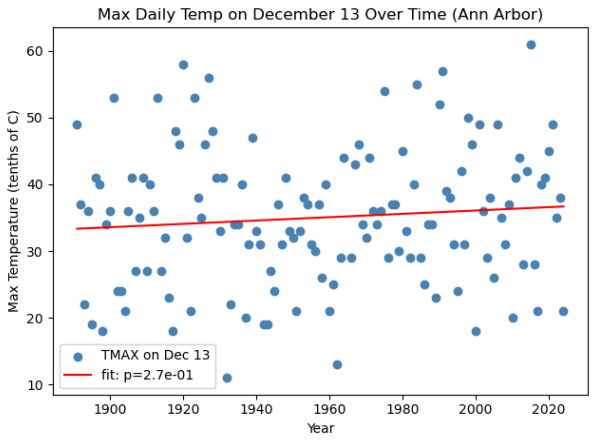
## Overview

For this project, I looked at historical weather data from NOAA for a bunch of different cities across the US. The datasets go back to the late 1800s and include things like daily high temps, daily low temps, and precipitation. I used Python with Pandas and Matplotlib to write functions that could load and process the data, and then used those to make a bunch of plots. Most of the analysis is focused on Ann Arbor, but I also compared it to Blue Hill, MA, Houston, TX, Los Angeles, CA, and Fairbanks, AK to see how different places compare (as I thought a comparison of different climates/regions would show a variety of results).

## Results

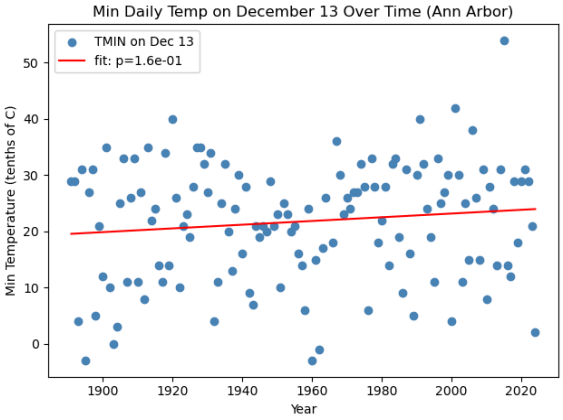
### Question 1

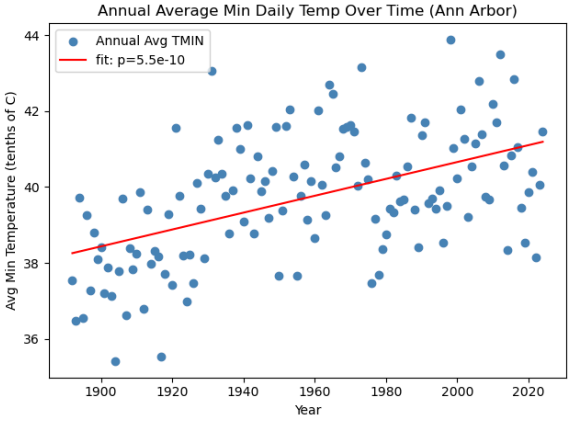


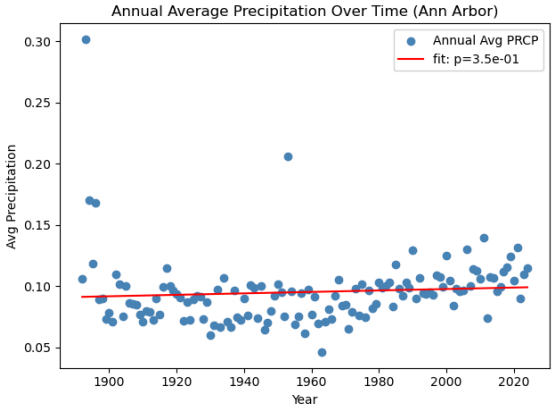




The first plot (Max Daily Temp, shown left) shows the max temperature on December 13th (my birthday) for every year in the Ann Arbor dataset. The trend line has p=2.7e-1, so there's no statistically significant trend on that single day (there's just too much random variation from year to year). The second plot (Annual Average Max Daily Temp, shown right) shows the annual average max temp across all years. This one has p=7.2e-11, which is very significant. Averaging over the whole year cuts out the noise and the warming trend becomes really obvious.

## Question 2

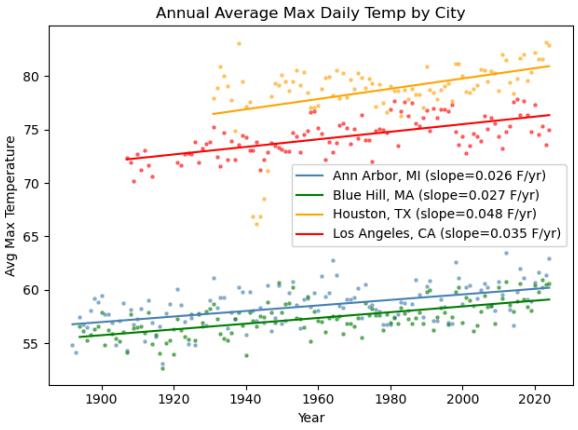


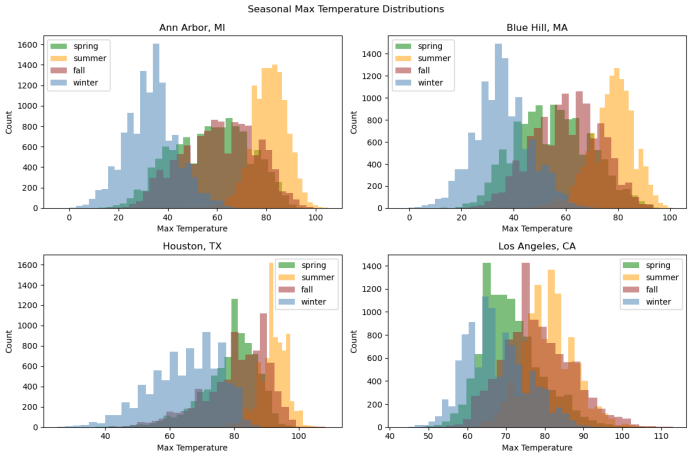

The first two plots (side by side) show minimum daily temperature on December 13th (shown left) and annual average minimum temperature (shown right). The third plot shows annual average precipitation. For TMIN on December 13th, p=1.6e-1 (same story as TMAX), so no significant trend on a single day. But the annual average TMIN has p=5.5e-10, so minimum temps are warming just as clearly as maximum temps over time (I prefer the cold, especially in December which is considered normal in our region, so this is a bit depressing). For precipitation, p=3.5e-1, no significant trend at all, so precipitation in Ann Arbor hasn't really changed over this time period.

**Question 3**



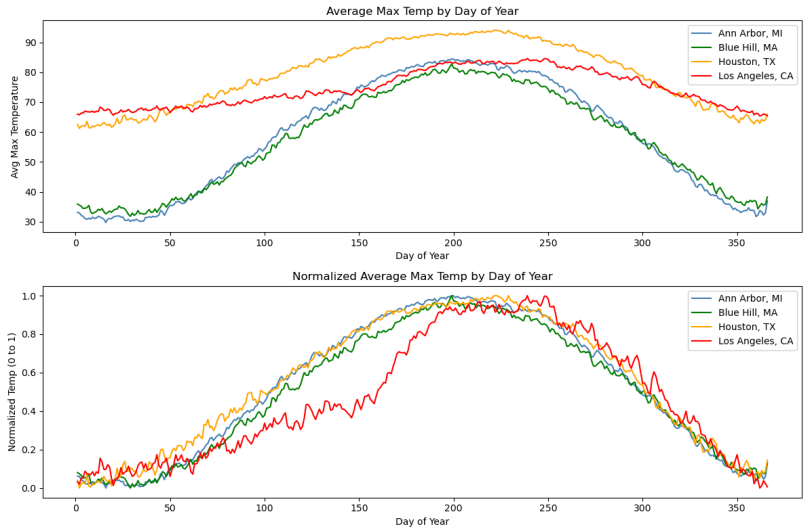

This plot shows the annual average max temp for Ann Arbor, Blue Hill, MA, Houston, TX, and Los Angeles, CA all on the same axes. All four cities show a warming trend. Houston has the steepest slope at 0.048 F/yr, meaning it's warming faster than the others. Los Angeles is second at 0.035 F/yr, then Blue Hill at 0.027 F/yr, and Ann Arbor at 0.026 F/yr. Houston saw the largest change overall.

**Question 4**



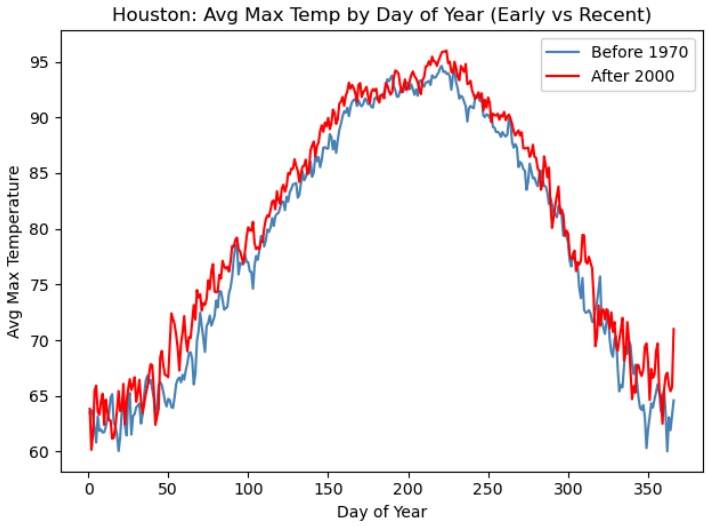

These histograms show the distribution of max daily temperatures broken down by season for all four cities. Ann Arbor and Blue Hill have really wide separation between their winter and summer distributions, which makes sense for cold-winter climates. Houston's seasons overlap a lot more since even winter is pretty warm there. Los Angeles has the tightest seasonal spread of all, consistent with its mild climate where temperatures don't change much throughout the year.

**Question 5**




The top plot shows average max temp by day of year for all four cities. Houston is warmest overall and Ann Arbor and Blue Hill get the coldest in winter. Los Angeles barely changes throughout the year. The bottom plot shows the same data normalized between 0 and 1. This makes it easier to compare the shape of the seasonal cycles. Ann Arbor, Blue Hill, and Houston all have similar shapes — a sharp rise in spring and drop in fall. Los Angeles is noticeably flatter, meaning its seasons transition much more gradually.

**Question 6**




I picked Houston for this one since it had the biggest warming trend. I split the data into years before 1970 and years after 2000 and plotted the average max temp by day of year for each

group. The two lines are pretty close in winter but the post-2000 line is noticeably higher in spring (roughly days 60-150) and fall (roughly days 260-330). This suggests the shoulder seasons have warmed the most in Houston, basically meaning summers are starting earlier and ending later (which yes, I'm talking about Houston specifically here, but interesting to see this quantitatively, especially when people talk about this phenomenon on social media, etc.).

**Takeaway**

I was excited when we were first given information about future projects in this course and that the first one would involve weather data; as a climate science student, that's really all I could ask for. The big takeaway is that warming trends are very real and show up clearly once you average out the year-to-year noise. Every city I looked at showed a significant increase in average max temps over the last century, with Houston warming the fastest (wish Texas lawmakers would take this data seriously, instead of pandering to fossil fuel companies, but I digress). The single-day plots were a good reminder that climate signals are hard to see in noisy data (you need to zoom out to the annual scale to really see what's going on). It was also interesting to see how different cities have totally different seasonal profiles, and how places like Los Angeles have different seasonal trends compared to somewhere like Ann Arbor (for the most part this is obvious, but seeing it in a data format like this helps reinforce what we're taught in our EARTH courses).