CMSC 6950 Final Project

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Abstract

Growing degree days (GDD) are values used in phenology measuring total heat accumulation in a region, in order to predict rates of development in plants or animals. Using the historical climate data available from the Government of Canada, this project aims to create a coherent workflow leading to the calculation and analysis of GDD for a number of Canadian cities.

Contents

1 Motivations

Plants require a number of things in order to grow: sunlight, water, CO_2, and nutrients. Though sunlight does provide the energy needed for plants to undergo photosynthesis, their development and maturation is also largely dependant on daily air temperatures.

Growing degree days (GDD) are a way to monitor the total heat accumulated by the plant through the ambient temperature, over a period of time. Many species will only hit development milestones after a certain accumulated amount of heat, so GDD can be used to keep track of the heat that has been available in a region over time.

GDD proves an important tool for biologists, horiculturists, and agriculturers, allowing them to predict things like crop harvest dates, nutrient timing, or even dates when insects will emerge.

2 Calculating GDD

Growing degrees are defined as the number of degrees the average daily temperature is, above a set base value (Tbase). This base value is usually defaulted to 10 $^{\circ}$C, though each species may have a more accurate value, and signifies the temperature below which no growth will occur. If the daily average happens to be below Tbase, the GDD value for that day is set to zero.

The value of daily GDD is calculated with the formula:

$$GDD_{daily} = \max\left(\frac{\text{Tmax}+\text{Tmin}}{2} - \text{Tbase}, 0\right)$$

For accumulated GDD, the daily values are summed:

$$\sum_{i=1}^{n}\left(\frac{\text{Tmax}+\text{Tmin}}{2} - \text{Tbase}\right)$$

Climate data is available for a multitude of Canadian weather stations, provided by the Government of Canada, where temperatures and precipitation values are reported. Using this data, GDD values can be calculated for specific regions and time periods, allowing for analysis of climate trends and patterns.

3 Results

3.1 Task 1.2

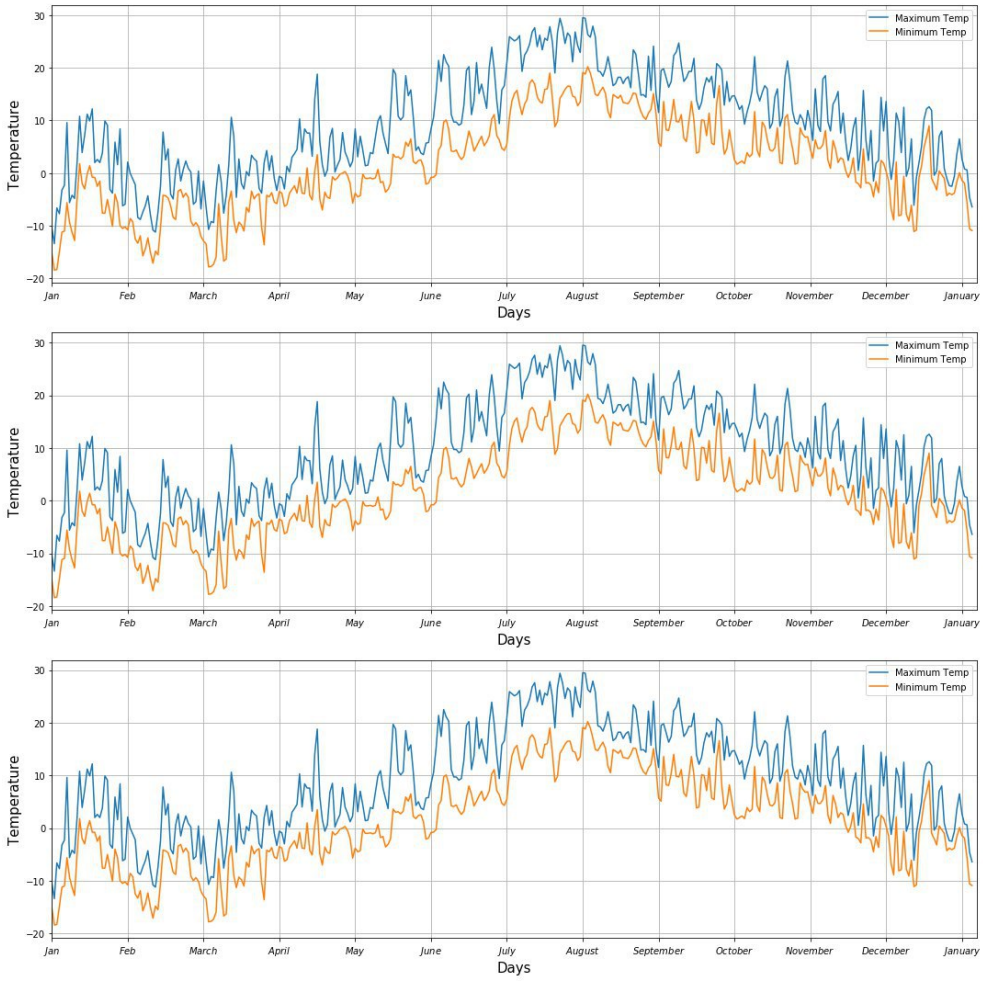

Figure 1: Annual cycle of min/max daily temperatures for Montreal, Toronto, and Victoria

3.2 Task 1.4

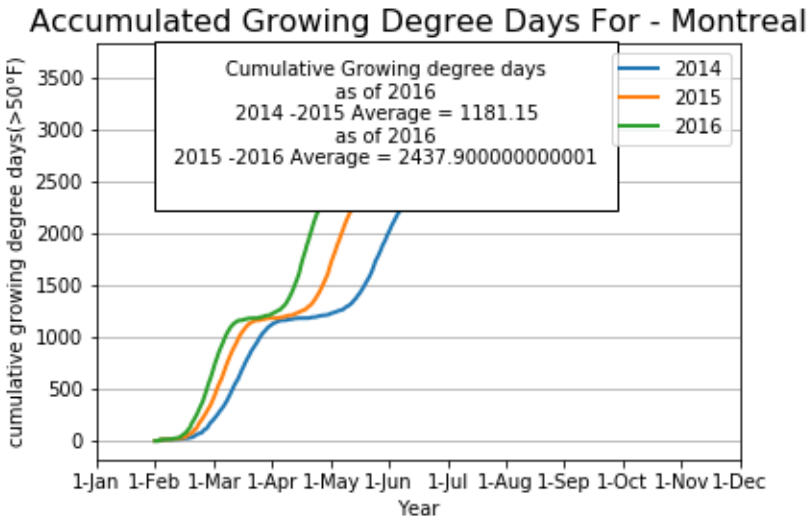

Figure 2: Accumulated GDD for Montreal

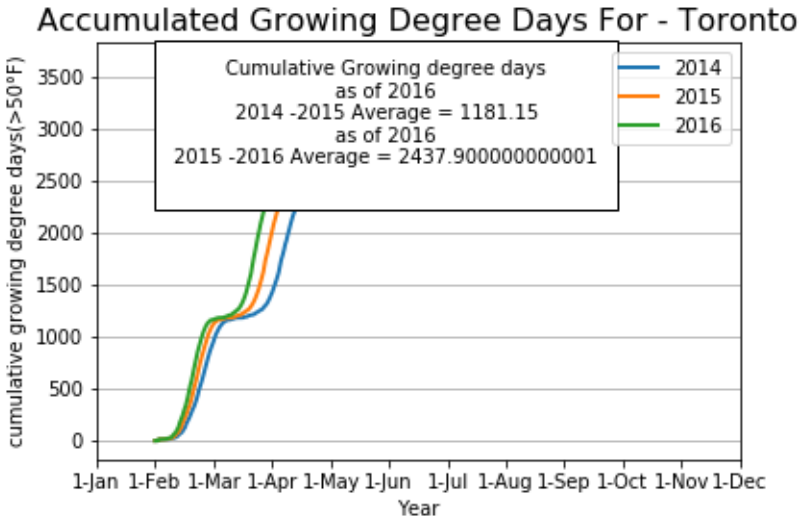

Figure 3: Accumulated GDD for Toronto

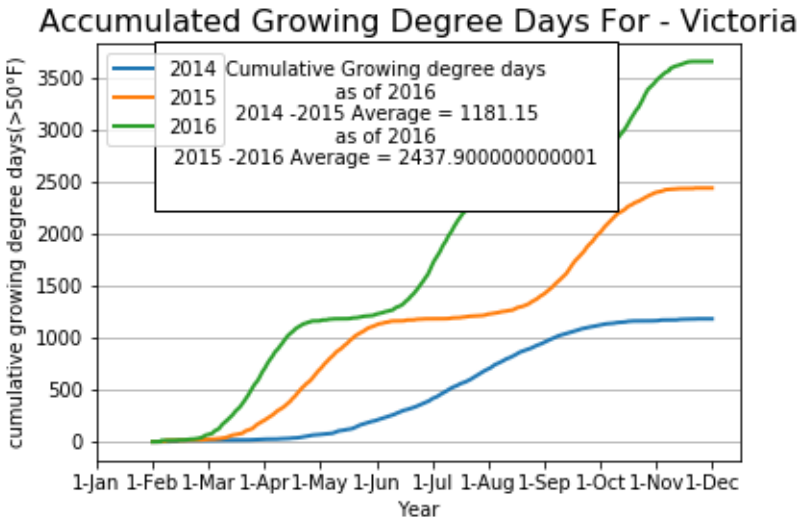

Figure 4: Accumulated GDD for Victoria

3.3 Task 2.1

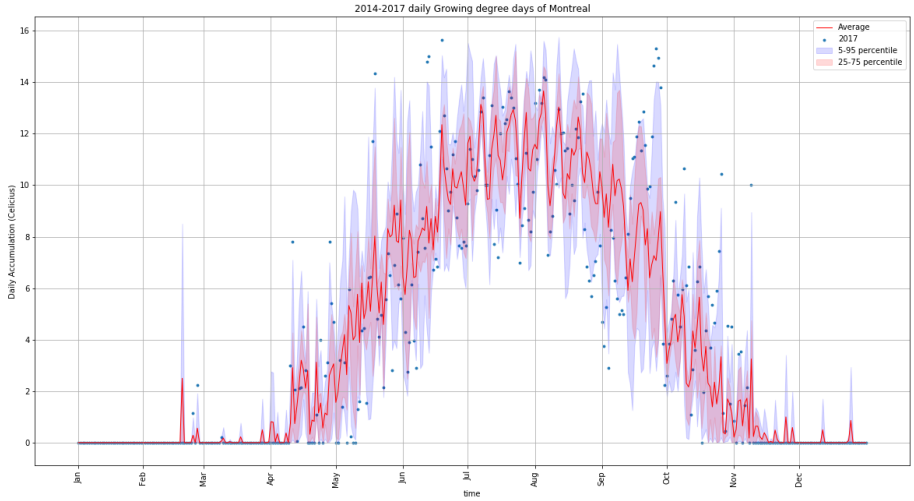

Figure 5: GDD for Montreal with 5-95% and 25-75% percentiles

3.4 Task 2.4

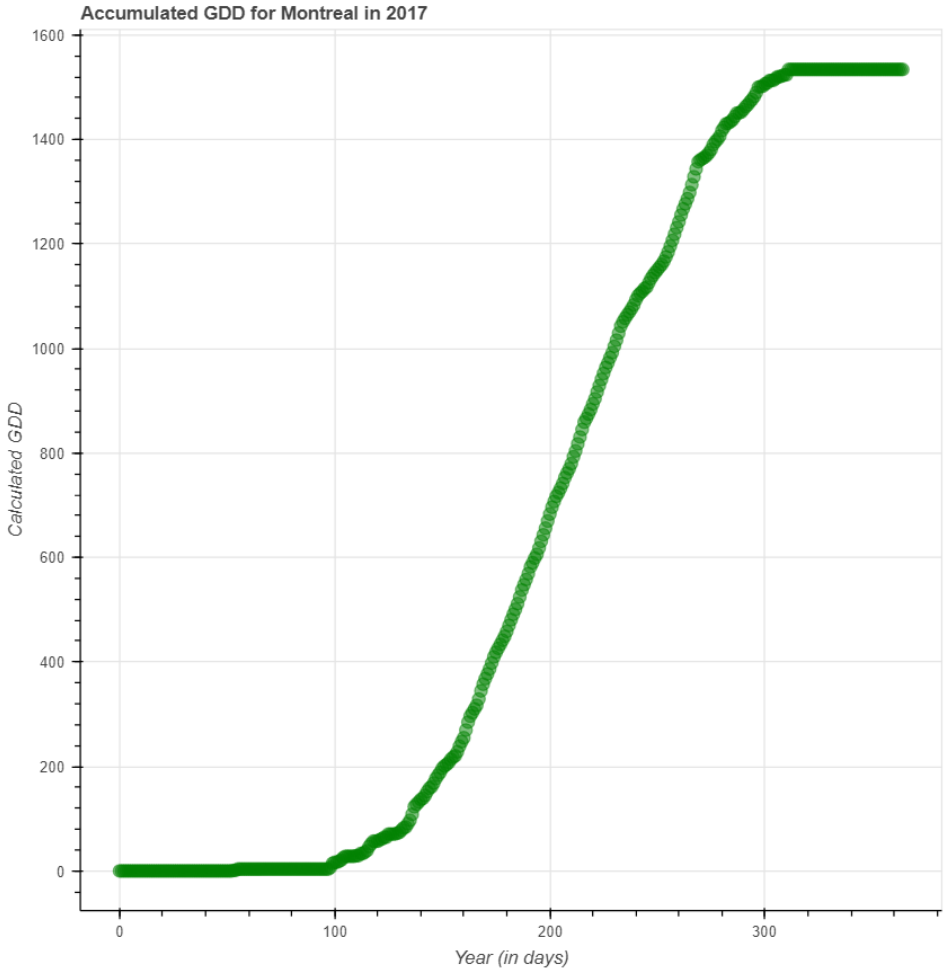

Figure 6: Bokeh plot of accumulative GDD for Montreal in 2017 (Static snapshot)

3.5 Task 2.6

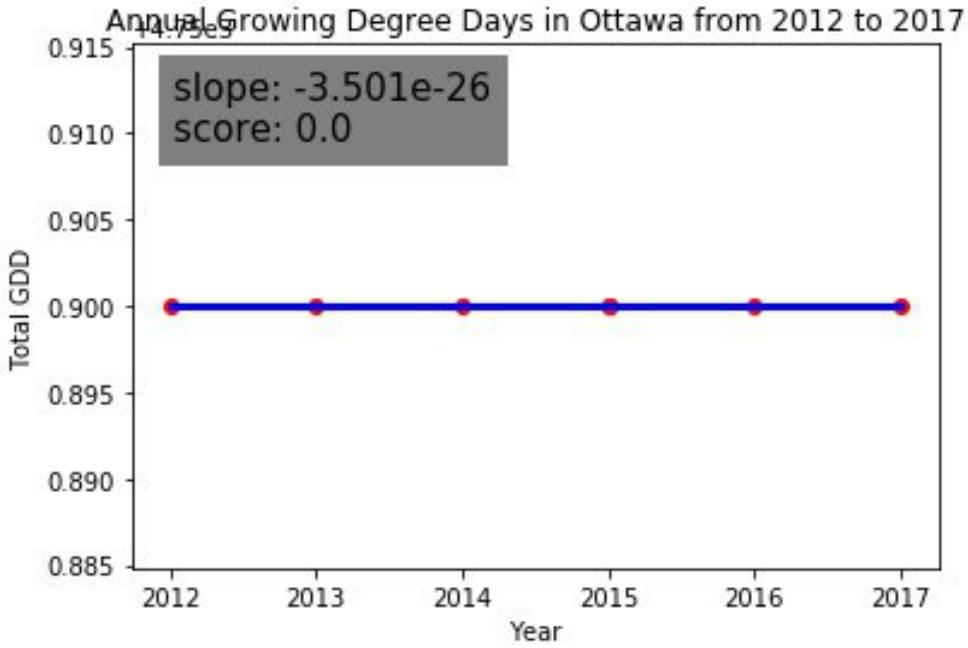

Figure 7: Statistical analysis of GDD year-over year for Ottawa

3.6 Optional Task 1.1

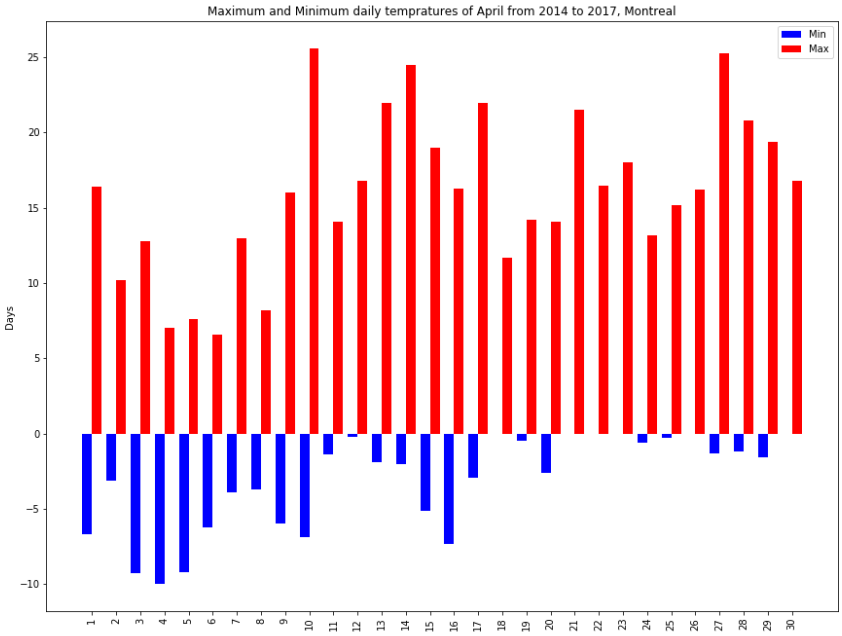

Figure 8: Maximum and minimum temperatures through the month of April in Montreal

3.7 Optional Task 1.2

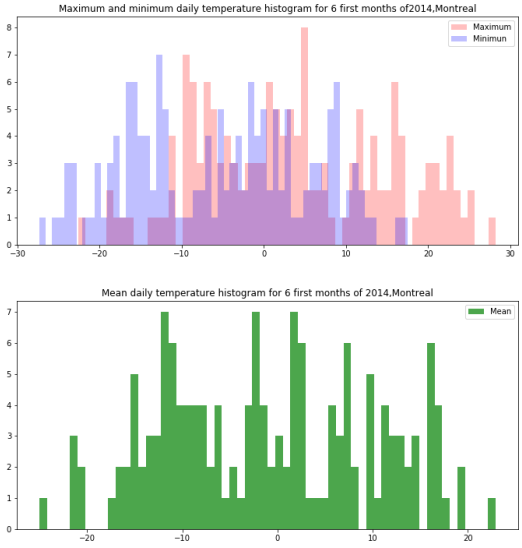

Figure 9: Histograms of temperature trends in Montreal for 2014

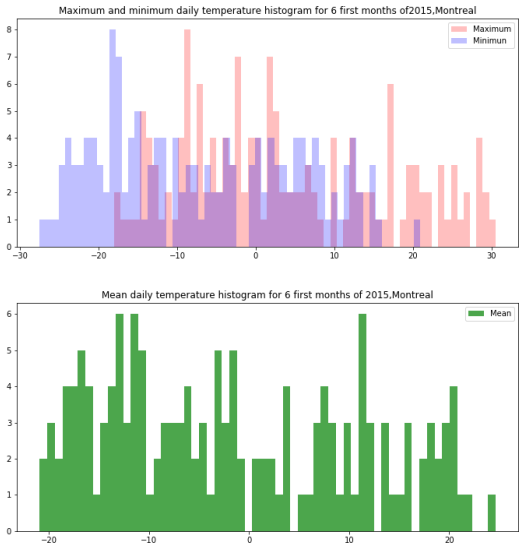

Figure 10: Histograms of temperature trends in Montreal for 2015

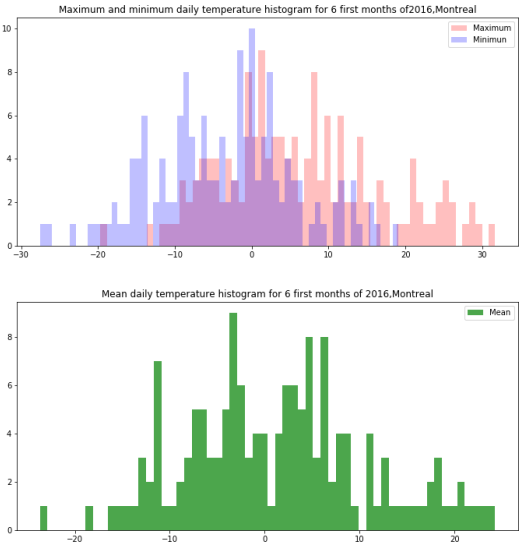

Figure 11: Histograms of temperature trends in Montreal for 2016

3.7 Optional Task 1.2

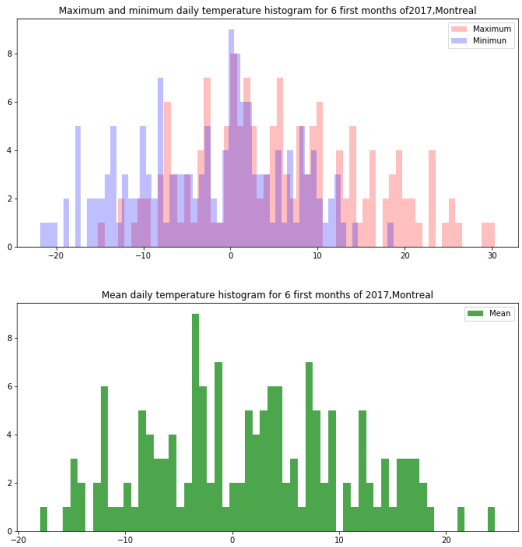

Figure 12: Histograms of temperature trends in Montreal for 2017

References

[1] Historical Climate Data — Environment and Climate Change Canada
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[2] Understanding growing degree days — Michigan State University
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[3] Growing Degree Days — Farmwest
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