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# Growing Degree Day

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CMSC 6950 - COMPUTER BASED RESEARCH TOOLS AND APPLICATIONS

TERM PROJECT

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SUBMITTED BY

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# Abstract

We selected the following cities: St.John's, Halifax, Toronto and Vancouver to complete the task in the project. Firstly, we created a auto-download python program to download the historical climate data from web. Moreover, we created a python data to calculate the accumulated GDDs and plot them for the selected cities. We also plot the accumulated GDD for several years in a selected city and for several cities in the same year. The plot for different base temperature was also included in out project. The address of our git hub repository: <https://github.com/cw7734/CMSC6950-Growing-Degree-Days.git>

## 1 Introduction

Growing degree days (GDD) is a statistical tool to measure heat accumulation and can be used to predict plant and animal development rates such as the date that a flower will bloom, an insect will emerge from dormancy, or a crop will reach maturity ?.

In our project we selected four major cities in Canada which are St.John's, Halifax, Toronto and Vancouver. We downloaded the historical data for the selected cities between 2013 and 2016, using the formula of calculating GDD, we calculated the accumulated GDD for each cites in the selected years and plotted several graphs.

Besides the plot of accumulated GDD for several years, we also did accumulated GDD plot for different cities in the same year. From those plot we could compare accumulated GDD through years or cities.

## 2 Data Processing

### 2.1 Data Collection

In our project, firstly, we wrote a autodownload python code to automatically download all data from web for selected cities. After downloading, we read the data using python package pandas and stored maximum and minimum daily temperature into data files.

Secondly, we wrote a python code to calculate the GDD and accumulated GDD for the selected cities from year 2013 to 2016. In the calculation we need Moreover, we plotted the accumulated GDD for different cities and years and saved them into png files.

### 2.2 Growing Degree Day Calculation

Growing Degree Day(GDD) are calculated by taking the integral of warmth above a base temperature. Or simply, approximately equivalent to take the average temperature and minus base temperature in the following equation:

$$\text{GDD} = \left( \frac{T_{max} + T_{min}}{2} \right) - T_{base} \quad (1)$$

$T_{max}$ ,  $T_{min}$ , and  $T_{base}$  are the daily maximum, daily minimum and base temperatures, respectively. Normally the maximum and minimum daily temperatures are pre-calculated before the above equation. If the maximum or minimum daily temperature is lower than the base temperature, then we set the maximum or minimum daily temperature equal to the base temperature.

For example, if the maximum daily temperature is 20, the minimum daily temperature is 5 and the base temperature is 10, we will have the GDD in the following equation:

$$\text{GDD} = \frac{20 + 10}{2} - 10 = 5 \quad (2)$$

### 3 Graphs and Analysis

#### 3.1 St.Johns

We analyzed the historical data in 2013 for St.John's. The maximum and minimum daily temperature as figure (1). From the figure (1), we see that the maximum daily temperature for St.John's is happened in the middle of June and its value is closed to 30°C, the minimum daily temperature is happened in January and its value is closed to -20°C.

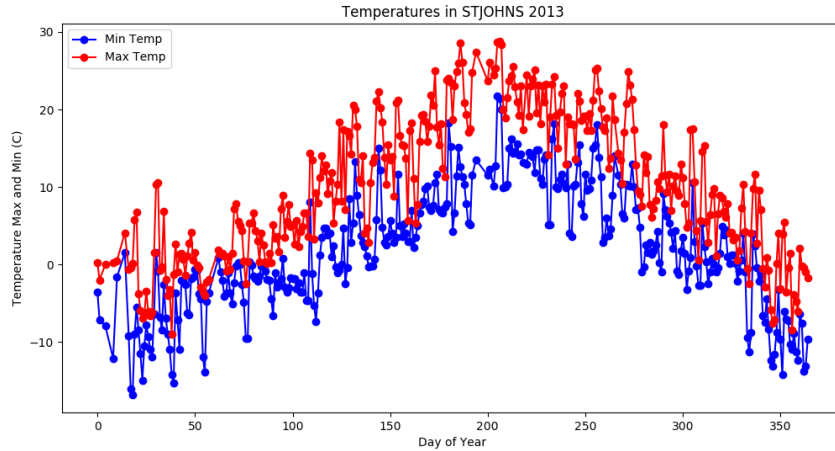


Figure 1: Cycle of minimum and maximum daily temperatures for St.Johns.

### 3.2 Halifax

Now we turn our attention to Halifax. From figure (2) The maximum daily temperature of Halifax is happened to be in the end of June and its value is slightly higher than  $30^{\circ}\text{C}$  which is higher than the maximum daily temperature of St.John's. However, the minimum daily temperature is happened in the middle of February and its value is lower than  $-20^{\circ}\text{C}$  which is lower than the minimum temperature of St.John's.

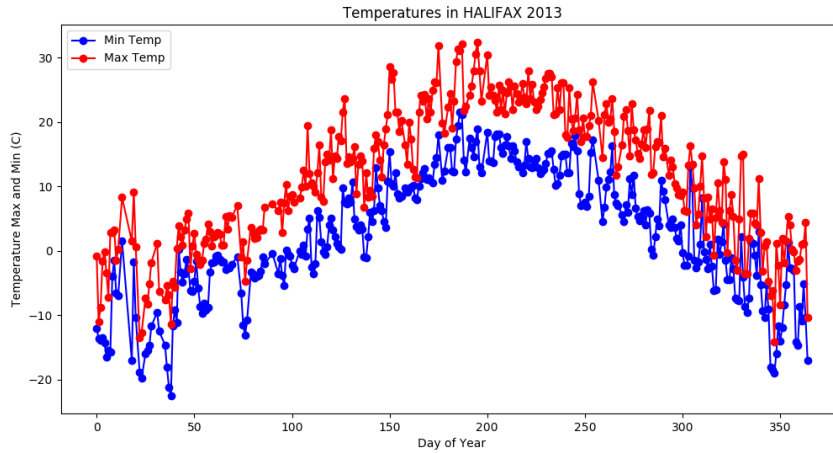


Figure 2: Cycle of minimum and maximum daily temperatures for Halifax

### 3.3 Toronto

From figure (3), we can identify the value of maximum daily temperature is around  $35^{\circ}\text{C}$ , and the value of minimum daily temperature is closed to  $-20^{\circ}\text{C}$ . Toronto has a relatively hot summer compare to St.John's and Halifax.

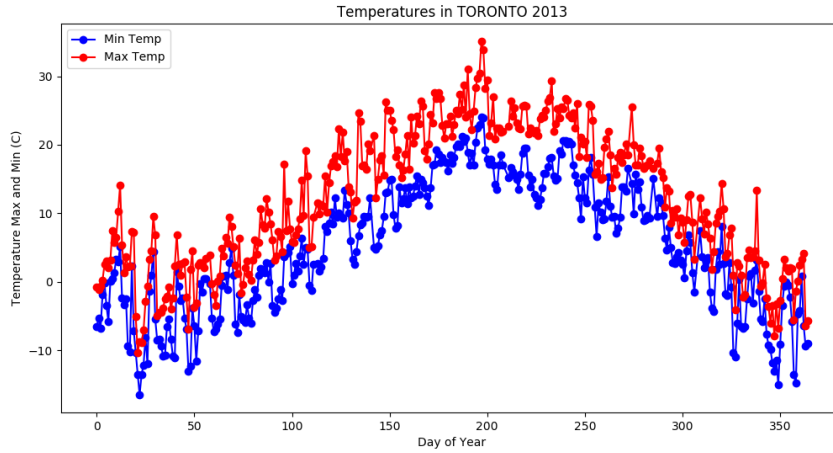


Figure 3: Cycle of minimum and maximum daily temperatures for Toronto.

### 3.4 Vancouver

Now let us take a look at our last selected city Vancouver. From figure (4), we see the value of maximum daily temperature is around  $25^{\circ}\text{C}$  and it happened in the end of August, however, the value of maximum daily temperature are very close through the whole summer. The minimum daily temperature is happened in the middle of December and its value is around  $-5^{\circ}\text{C}$ . Therefore, Vancouver has a mild summer and winter.

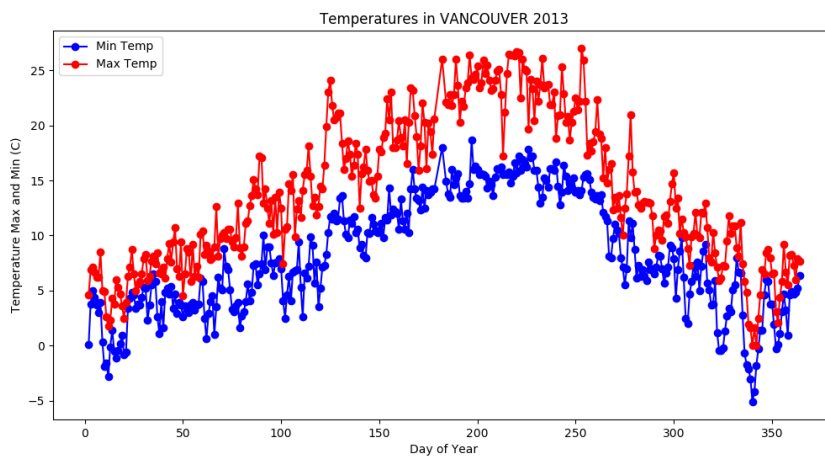


Figure 4: Cycle of minimum and maximum daily temperatures for Vancouver.

### 3.5 Accumulated GDD in Same Year

### 3.6 Year 2013

In year 2013, the accumulated GDD of Toronto takes the lead, followed by Vancouver, Halifax and St.John's.

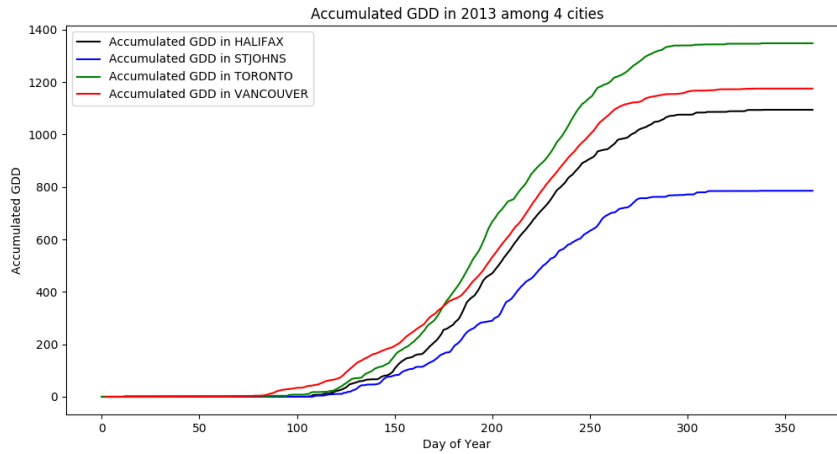


Figure 5: Accumulated GDD in 2013

### 3.7 Year 2014

In year 2014, the accumulated GDD of Vancouver takes the lead, followed by Toronto, Halifax and St.John's.

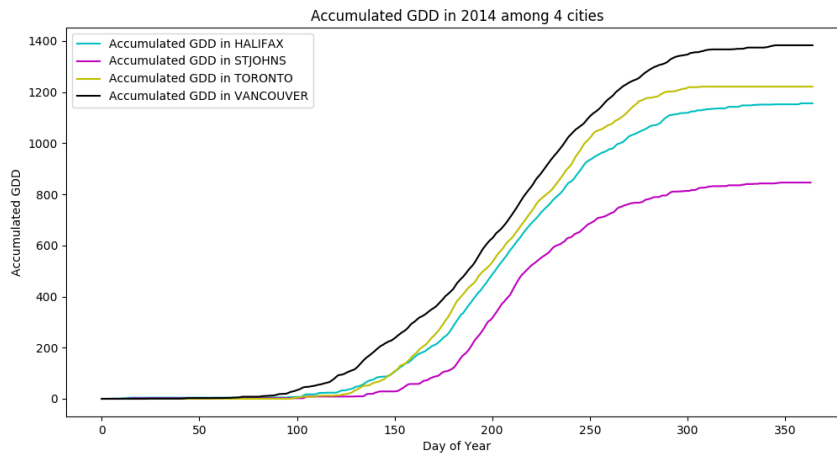


Figure 6: Accumulated GDD in 2014

### 3.8 Year 2015

In year 2015, the accumulated GDD of Vancouver takes the lead, followed by Toronto, Halifax and St.John's.

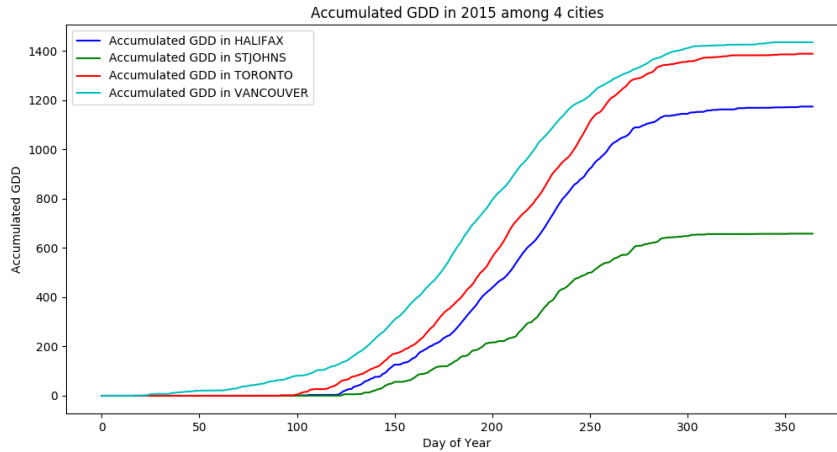


Figure 7: Accumulated GDD in 2015

### 3.9 Year 2016

In year 2016, the accumulated GDD of Toronto takes the lead, followed by Vancouver, Halifax and St.John's.

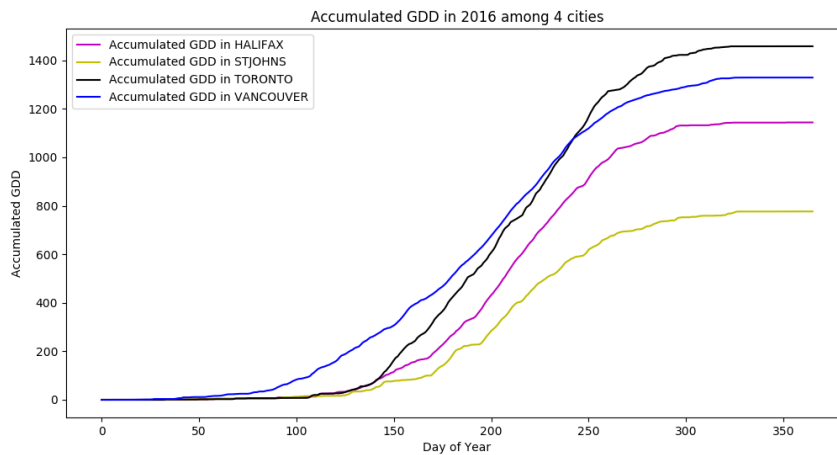


Figure 8: Accumulated GDD in 2016

In conclusion, between year 2013 and 2016, Toronto or Vancouver has the highest value of accumulated GDD, the accumulated GDD value of Halifax stays in the middle, St.John's has the lowest accumulated GDD.

### 3.10 Year to Year Accumulated GDD

### 3.11 St.John's

From figure (9), in year 2014, St.John's has the highest accumulated GDD among year 2013 to 2016. Moreover, its value is around 850. In year 2015, the value of accumulated GDD for St.John's is around 600, it is the lowest value of accumulated GDD among year 2013 to 2016.

The difference of accumulated GDD between highest value to lowest value is around 250 for St.John's among year 2013 to 2016.

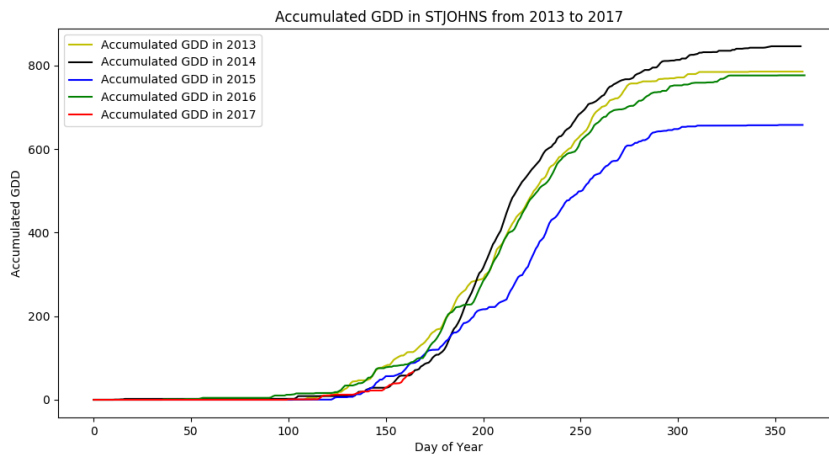


Figure 9: Accumulated GDD from 2013 to 2017 for St.John's.

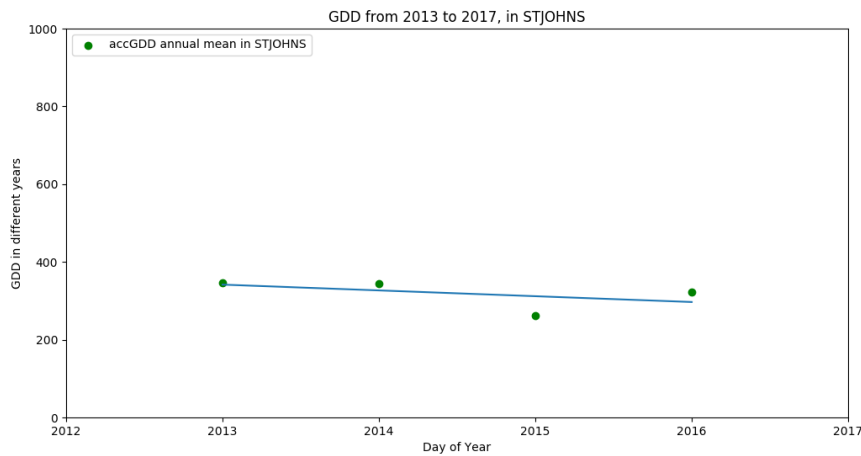


Figure 10: linear regression of accumulated GDD for St.John's.



Figure (10) is the linear regression of accumulated GDD for St.John's from year 2013 to year 2016. From the plot we can see the overall accumulated GDD decrease among these years.

### 3.12 Halifax

From figure (11), in year 2015, Halifax has the highest accumulated GDD among year 2013 to 2016, its value is around 1100. In year 2013, the value of accumulated GDD for Halifax is around 1000, it is the lowest value of accumulated GDD among year 2013 to 2016.

The difference of accumulated GDD between highest value to lowest value is around 100 for Halifax among year 2013 to 2016.

Compared to St.John's, the relative difference of accumulated GDD among year 2013 to 2016 is not as big as St.John's.

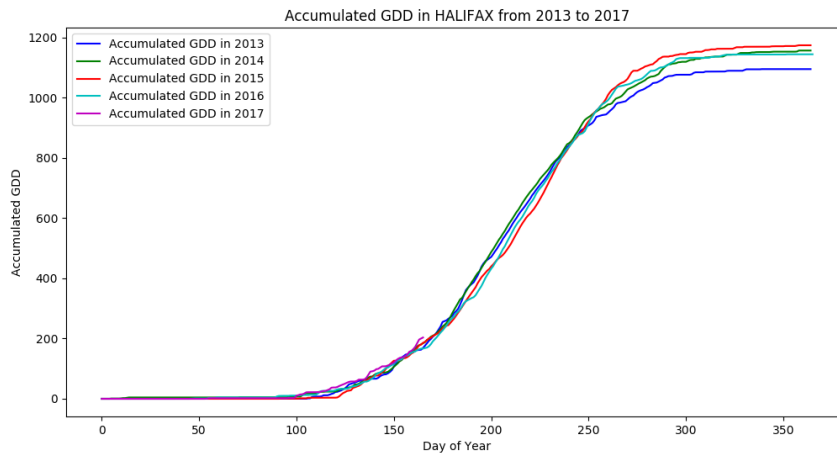


Figure 11: Accumulated GDD from 2013 to 2017 for Halifax.

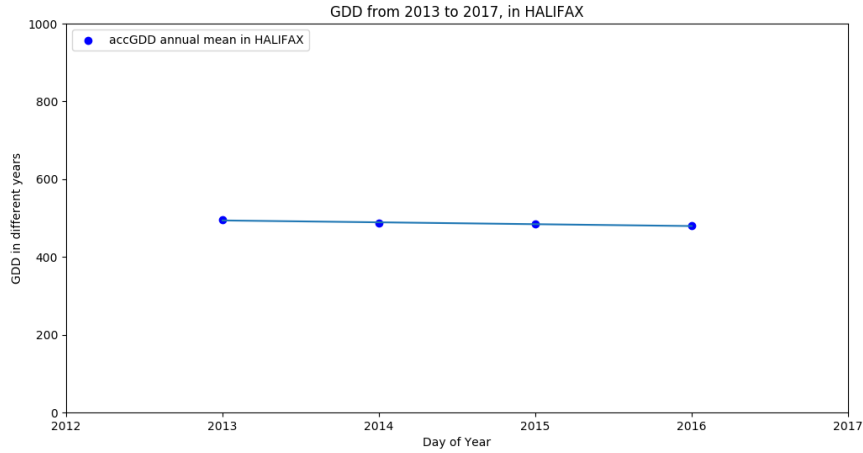


Figure 12: linear regression of accumulated GDD for Halifax.

From figure (12) we see that the linear regression of accumulated GDD of Halifax is almost flat from year 2013 to year 2016.

### 3.13 Toronto

From figure (13), in year 2016, Toronto has the highest accumulated GDD among year 2013 to 2016, its value is around 1500. In year 2014, the value of accumulated GDD for Halifax is around 1100, it is the lowest value of accumulated GDD among year 2013 to 2016.

The difference of accumulated GDD between highest value to lowest value is around 400 for Toronto among year 2013 to 2016.

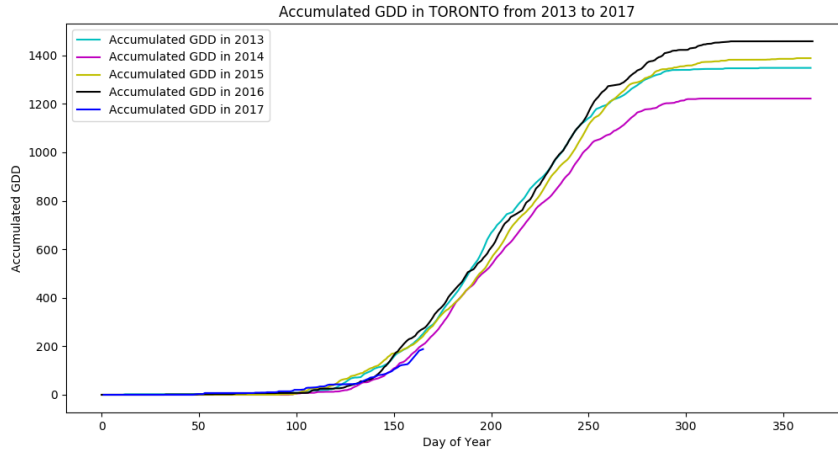


Figure 13: Accumulated GDD from 2013 to 2017 for Toronto.

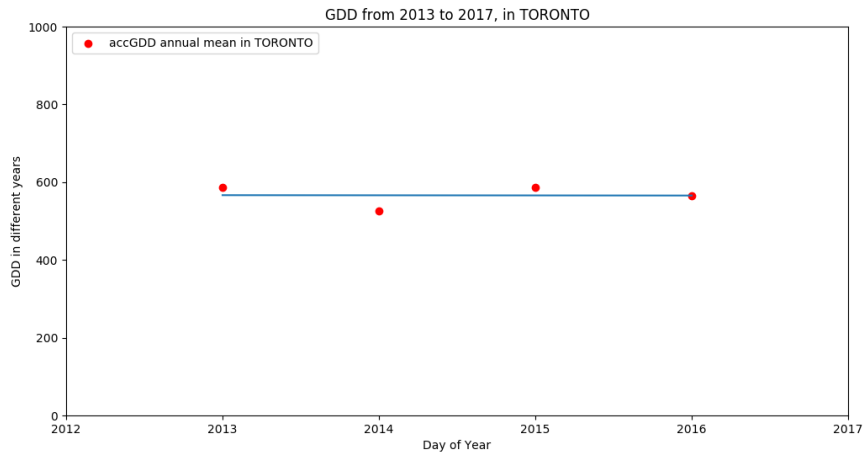


Figure 14: linear regression of accumulated GDD for Toronto in 2013.

From figure (14) we see that the linear regression of accumulated GDD of Toronto is flat, however, the accumulated GDD of Toronto in year 2014 is much lower than other years.

### 3.14 Vancouver

From figure (15), in year 2015, Vancouver has the highest accumulated GDD among year 2013 to 2016, its value is around 1400. In year 2013, the value of accumulated GDD for

Halifax is around 1100, it is the lowest value of accumulated GDD among year 2013 to 2016.

The difference of accumulated GDD between highest value to lowest value is around 300 for Vancouver among year 2013 to 2016.

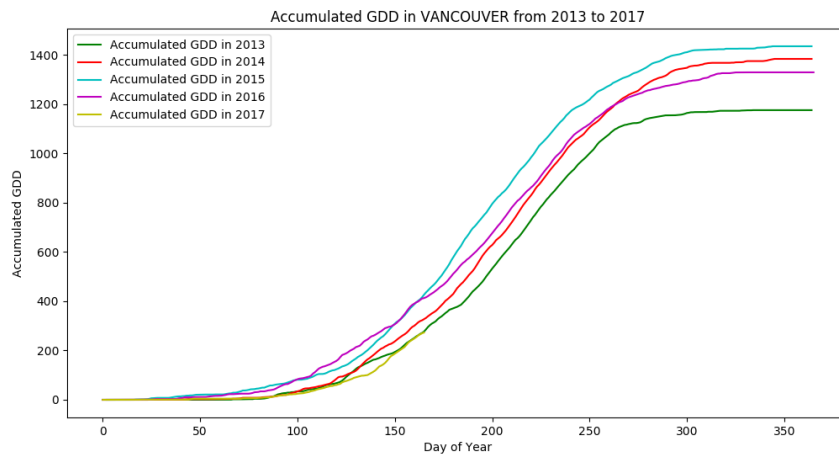


Figure 15: Accumulated GDD from 2013 to 2017 for Vancouver.

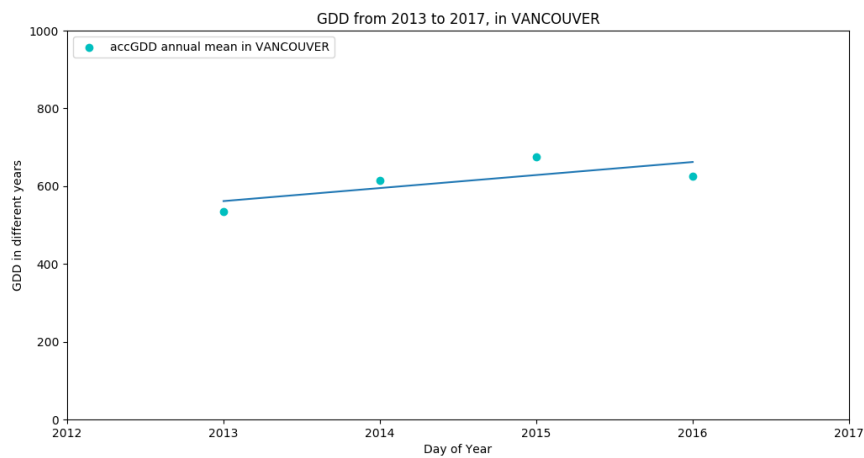


Figure 16: linear regression of accumulated GDD for Vancouver in 2013.

From figure (16) we see that the linear regression of accumulated GDD of Vancouver is increase. Moreover, the accumulated GDD of Vancouver in year 2015 is much higher than other years.

In conclusion, the biggest difference of accumulated GDD among year 2013 to 2016 belongs to Toronto which has the value 400. The smallest difference of accumulated GDD among year 2013 to 2016 belongs to Halifax which has the value 100. Moreover, city Vancouver has increased accumulated GDD value over year 2013 to 2016, city St.John's has decreased accumulated GDD value over year 2013 to 2016. City Toronto and City Halifax has almost flat changing of accumulated GDD over year 2013 to year 2016.

### 3.15 Accumulated GDD Plot with Different Base Temperature

In this section, we will explore the effect of different base temperature on calculating accumulated GDD. In our project we choose three different base temperature:  $5^{\circ}\text{C}$ ,  $10^{\circ}\text{C}$ ,  $15^{\circ}\text{C}$ .

$T_{base} = 5^{\circ}$  is normally chosen when calculate GDD for wheat or barley.  $T_{base} = 10^{\circ}$  is normally chosen when calculate GDD for rice.  $T_{base} = 15^{\circ}$  is normally chosen when calculate GDD for some flower blooming.

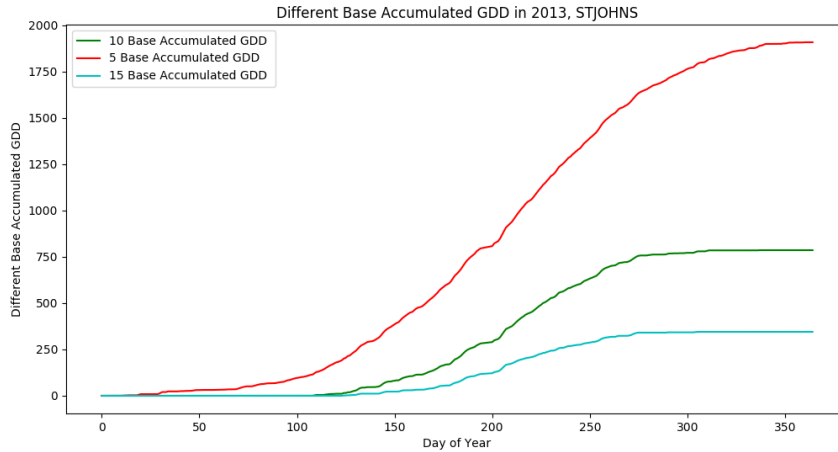


Figure 17: Accumulated GDD with different base temperature for St.John's in 2013.

From figure (17), when we chose the base temperature equal to  $5^{\circ}\text{C}$ , in year 2013, St.John's can have almost 2000 accumulated GDD. However, when we chose the base temperature equal to  $15^{\circ}\text{C}$ , the accumulated GDD decreases to 250. Therefore, we noticed that base temperature will make a big impact in calculating GDD. When we want

to analysis the condition for plant maturity we should find out which base temperature should be used for a particular plant.

## 4 Discussion

From our plots we can see that from year 2013 to year 2016, the accumulated GDDs for our selected cities are not increased year by year. Moreover, the difference of accumulated GDD for Halifax is not as big as Toronto, one reason may be that Toronto is a city in the middle of Canada, it is away from the ocean, therefore, the daily temperature may change differently from year to year. However, Halifax is near ocean, therefore, the daily temperature may remain close year to year.

For city St.John's, the accumulated GDD is relatively low compare to other selected cities. Although the difference between the highest accumulated GDD value and lowest accumulated GDD value among year 2013 to 2016 is only 250, it is still relatively a big change since the highest value of accumulated GDD is around 800. Therefore, the daily temperature of St.John's also has a relatively big change.

## 5 Conclusion

From our project, we can predict that those flowers can bloom in St.John's, it is also can blooming in Halifax, Toronto and Vancouver. However, for some agriculture plants such as wheat (need 1550-1680 GDD to maturity) can not grow well in St.John's and Halifax. Barley (need 1290-1540 GDD to maturity) can grow in Halifax but not in St.John's. Moreover, for some insect such as oats (1500-1750 GDD to maturity) can not live in Halifax and St.John's.

In our project, Xiao Wang did the most contribution on program logic and wrote most python coding. Yuan Zhi did the python coding to calculate the accumulated GDD for selected cities and added comments to other python code. Huizhong Liu did the part of test suite, and documentation work. Chen Wei did most work of creating the Latex report and web presentation, also part of documentation work. Thanjida Akhter helped with understanding the project task and added some documentations in several files. Md Kamrul Hasan and Maulik Rawal did the work of helping others understand the task and python code.

## 6 References

1. [https://en.wikipedia.org/wiki/Growing\\_degree\\_-\\_day](https://en.wikipedia.org/wiki/Growing_degree_-_day)
2. <http://climate.weather.gc.ca/>