Memorial University of Newfoundland

CMSC6950

Group Project

Growing Degree Days

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Abstract

The Growing Degree Day, or GDD, is a heat index that can be used to predict when a crop will reach maturity. Each day's GDD is calculated by subtracting a reference temperature, which varies with plant species, from the daily mean temperature. The reference temperature for a given plant is the temperature below which its development slows or stops. For example, cool season plants, have a reference temperature of 40 degrees fahrenheit while warm season plants, have a reference temperature of 50 degrees fahrenheit. The development of plants depends on the accumulation of heat and since cool season plants have a lower reference temperature, they accumulate GDDs faster than warm season plants.
From http://whyfiles.org

1 Introduction

From wikipedia.org: Growing degree day(s) (GDD), are a measure of heat accumulation used by horticulturists, gardeners, and farmers 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.

Growing degree days take aspects of local weather into account and allow gardeners to predict the plants pace toward maturity.

The base temperature is that temperature below which plant growth is zero. GDs are calculated each day as maximum temperature plus the minimum temperature divided by 2 (or the mean temperature), minus the base temperature. GDUs are accumulated by adding each day's GDs contribution as the season progresses.

2 List of Cities

This are the list of cities we used for this project:

1. St. John's Newfoundland.
2. Toronto, Ontario.
3. British Columbia.

2.1 Download daily historical temperature

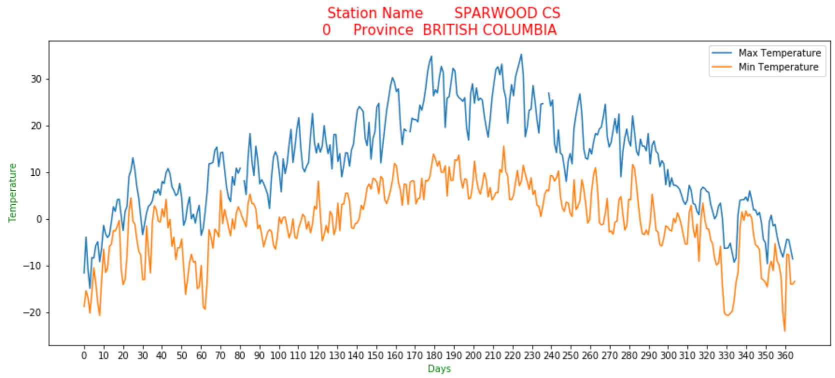
The aim of this section is to download the historical temperature of several cities from the climate.weather database of Canada. The code below extracts the weather informations for the Station Ids, which we will use for the subsequent tasks in this project.

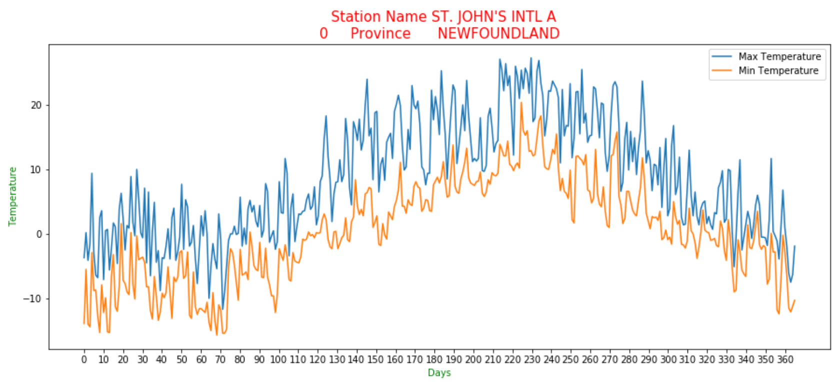
```
import numpy as np

def incmatrix(genl1,genl2):
    m = len(genl1)
    n = len(genl2)
    M = None #to become the incidence matrix
    VT = np.zeros((n*m,1), int)  #dummy variable

    #compute the bitwise xor matrix
    M1 = bitxormatrix(genl1)
    M2 = np.triu(bitxormatrix(genl2),1)

    for i in range(m-1):
        for j in range(i+1, m):
            [r,c] = np.where(M2 == M1[i,j])
            for k in range(len(r)):
                VT[(i)*n + r[k]] = 1;
                VT[(i)*n + c[k]] = 1;
                VT[(j)*n + r[k]] = 1;
                VT[(j)*n + c[k]] = 1;

                if M is None:
                    M = np.copy(VT)
                else:
                    M = np.concatenate((M, VT), 1)

                VT = np.zeros((n*m,1), int)

    return M
```

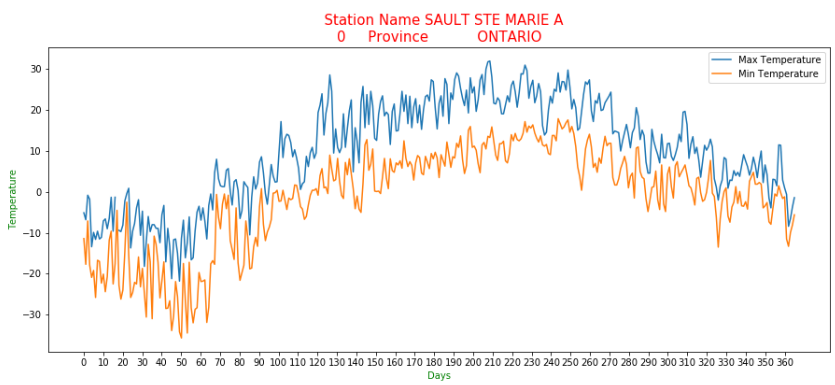
2.2 Annual Cycle of Min/Max Daily Temperatures Plots

In this subsection, we used the downloaded data from the earlier task to create a 3 plots of the selected Canadian cities showing an annual cycle of the minimum or maximum daily temperatures. The min and max temperatures will be used when calculating the GDD in the next task.
Below are the codes and min/max plots for our 3 selected cities:

```
import gdd_Cal as GD
from matplotlib import pylab as plt
import numpy as np


def plot_gdd(stationid, year):


    #for in ra

    gdd = GD.gdd_cal_accum(stationid, year)
    figure_name = "Fig_GDD_{}.png".format(stationid)


    x = np.linspace(1,13,12)
    fig= plt.figure(num=1, figsize=(10,6))
    plt.title("accumulated GDD")
    plt.plot(x,gdd, label = year)
    plt.xlabel("Year/Time")
    plt.ylabel("accumulated GDD")
    plt.legend(bbox_to_anchor=(1, 1), loc=1)

    fig.savefig(figure_name)
```


Station Name SPARWOOD CS
0 Province BRITISH COLUMBIA
Max Temperature
Min Temperature
Temperature
Days


Station Name ST. JOHN'S INTL A
0 Province NEWFOUNDLAND
Max Temperature
Min Temperature
Temperature
Days


Station Name SAULT STE MARIE A
0 Province ONTARIO
Max Temperature
Min Temperature
Temperature
Days

2.3 Calculating the GDD

To calculate the GDD, we had to use maximum temperature plus the minimum temperature divided by 2 (or the mean temperature), minus the base temperature.
GDD are calculated by taking the integral of warmth above a base temperature, $T_{\text{base}}(usually 10°C)$:
GDD can be calculated using this formulae:

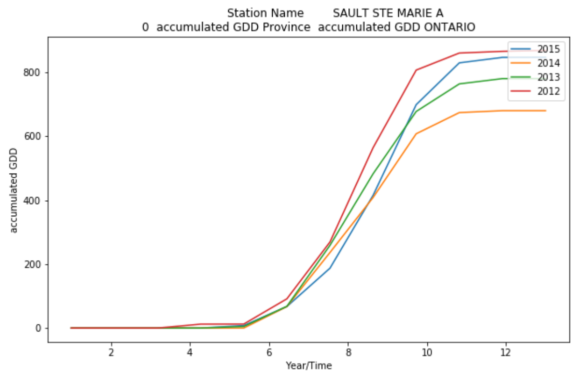
$$GDD = \frac{T_{\text{max}} + T_{\text{min}}}{2} - T_{\text{base}}.$$

The code below is for calculating GDD: –Note this is not all the code–

```
import numpy as np
import download_data as DW
import math



def gdd_tot(mean):
    temp = 0.0
    for i in mean:
        if i < 10.0:
            temp = temp + 0.0
        elif not math.isnan(i) :
            temp = temp + (i - 10.0)
    return temp
```

2.4 Plots Showing Accumulated GDD vs Time for Selected Cities

Here we use the results from our calculation above to create plots showing the accumulate GDD vs Time for selected cities.



2.5 Secondary Tasks