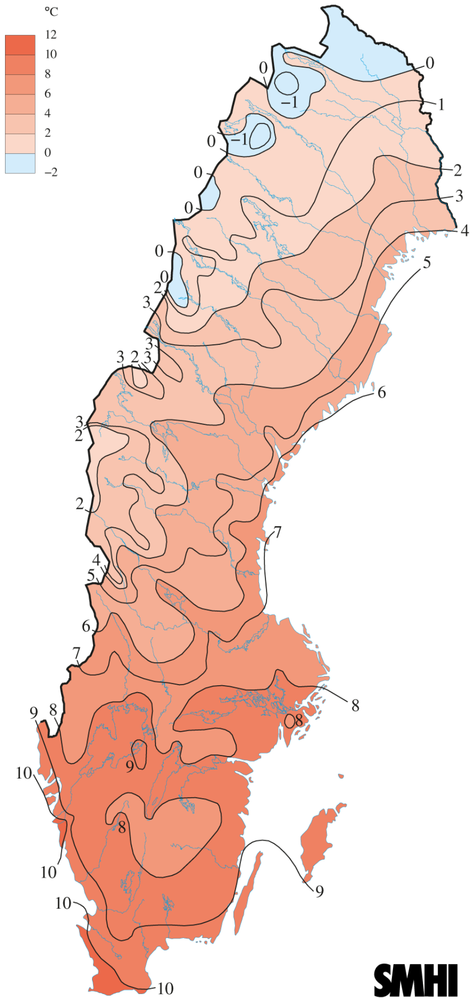
Project MNXB01

Swedish climate study



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Contents

Chapter 1

Introduction

The goal of this project is to study Swedish climate via different programs. We have access to various data from the Swedish Meteorological and Hydrological Institute (SMHI), containing the temperatures at different times, for a bunch of swedish cities. We will be focusing on Lund, Uppsala, Umea and Falsterbo. We where given some examples of what kind of programs would fit the subject and we decided to code three of the examples and make three up by ourselves. Then we have assigned one or several code to write to each of use and put it in the workplan as following :

Workplan

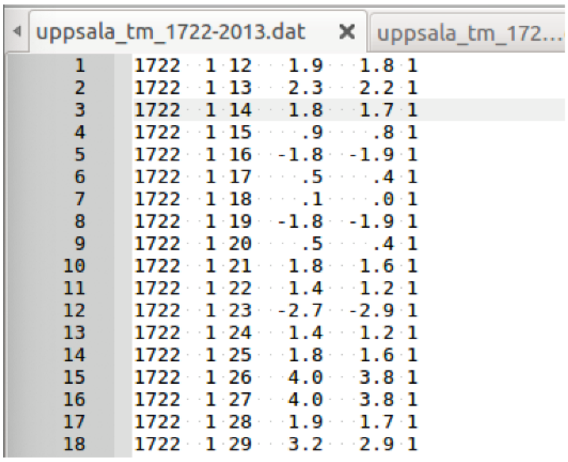
We to have select one of the available SMHI datasets and write a program that extracts information from the Swedish climate data.

- Use ROOT to make plots and eventual statistical analysis: a small code skeleton
- Section 3 contains a few examples of what kind of information you could get from the data. Decide on at least three interesting results to produce.
    - Jasmain - 3.3 example "The warmest and coldest day of each year"
    - Estelle - 3.4 example "The mean temperature of each year"
    - Philip - Personal examples: "Temperature distribution for each day during winter for each year", "Mean temperature distribution during winter for each year", "Temperature distribution for Christmas Eve every year"
    - Johan - 3.1 example "The temperature at a given day"
- At least one of them should be our own idea and should not come from Section 3
- To “clean” the input dataset we will use any of the tools we’ve learnt during the course (ROOT, C++, bash commands, bash scripts) or anything else, as long as we document the way we did and we do not modify the original data, the cleaning process is described and the cleaned up dataset must be a separate file or set of files.

Chapter 2

Uppsala's climate study

The data sheet used in this chapter consist in air temperature measurements from Uppsala in Sweden. The file format containing the data is .dat. Another file containing the description on datasets is in .txt. Figure 2.1 show a screenshot of the file associated with Uppsala temperature and figure 2.2 show a screenshot of the descritpion of the file assodiated with Uppsala data.



uppsala_tm_1722-2013.dat   uppsala_tm_172...

```
1   1722 1 12  1.9  1.8 1
2   1722 1 13  2.3  2.2 1
3   1722 1 14  1.8  1.7 1
4   1722 1 15   .9   .8 1
5   1722 1 16 -1.8 -1.9 1
6   1722 1 17   .5   .4 1
7   1722 1 18   .1   .0 1
8   1722 1 19 -1.8 -1.9 1
9   1722 1 20   .5   .4 1
10  1722 1 21  1.8  1.6 1
11  1722 1 22  1.4  1.2 1
12  1722 1 23 -2.7 -2.9 1
13  1722 1 24  1.4  1.2 1
14  1722 1 25  1.8  1.6 1
15  1722 1 26  4.0  3.8 1
16  1722 1 27  4.0  3.8 1
17  1722 1 28  1.9  1.7 1
18  1722 1 29  3.2  2.9 1
```

Figure 2.1: The raw data in Uppsala-tm-1722-2013.dat

First, I clean the file by writing a temporary code which replace the irregular space groups with a single space separating the data. This script will extract the data and save it to a new data file called tempdata_uppsala.txt. The result is shown in Figure 2.3.

uppsala_tm_1722-2013.dat | uppsala_tm_172...description.txt | ChangeLog.md | Workplan.m

```
--------------------------------------------------------------------------------
NB! Users of the file 'uppsala_tm_1722_2013.dat'
    are asked to refer to:
    Bergström, H., Moberg, A. :
    Daily air temperature and pressure series for Uppsala (1722-1998),
    Climate Change, 53:213-252.

--------------------------------------------------------------------------------
The file 'uppsala_tm_1722_2013.dat' contains:
Daily temperature data for Uppsala 1722-2013.


column      data
1-3         Year, month, day
4           Daily average temperature according to observations.
              Unit: °C
5           Daily average temperatures corrected for the urban effect.
6           Data id no. meaning data from:
              1=Uppsala, 2=Risinge, 3=Betna, 4=Linköping, 5=Stockholm, 6=Interpolated


Uppsala 2013-01-17
hans.bergstrom@met.uu.se
```

Figure 2.2: Desciption of Uppsala data file

tempdata_uppsala.txt

File Edit Search Options Help

```
1722 1 12 1.9 1.8 1
1722 1 13 2.3 2.2 1
1722 1 14 1.8 1.7 1
1722 1 15 .9 .8 1
1722 1 16 -1.8 -1.9 1
1722 1 17 .5 .4 1
1722 1 18 .1 .0 1
1722 1 19 -1.8 -1.9 1
1722 1 20 .5 .4 1
1722 1 21 1.8 1.6 1
1722 1 22 1.4 1.2 1
1722 1 23 -2.7 -2.9 1
1722 1 24 1.4 1.2 1
1722 1 25 1.8 1.6 1
1722 1 26 4.0 3.8 1
1722 1 27 4.0 3.8 1
1722 1 28 1.9 1.7 1
1722 1 29 3.2 2.9 1
1722 1 30 2.7 2.4 1
1722 1 31 1.3 1.0 1
1722 2 1 -1.3 -1.6 1
1722 2 2 1.4 1.1 1
1722 2 3 1.4 1.1 1
```

Figure 2.3: New file, tempdata_uppsala.txt

2.1 Mean temperature per year in Uppsala

I will use the year of the file (first column in figure 2.3) and daily average temperatures (corrected by the urban effect, penultimate column), in order to show a histogram plotting average values of temperatures in Uppsala each year from 1722 to 2013.

I create a function that allow us to read this file and retrieve all the temperatures per year in order to calculate the mean temperature per year. So, I extract the first 4 characters, which corresponds to the year, then the 5th field which corresponds to the temperature. I sum the values as seen below in figures 2.4 and 2.5.

project.cpp ✕ | tempTrender.cpp ✕ | tempTrender.h ✕ | rootlogon.C ✕

```cpp
#include "tempTrender.h"

#include <fstream>
#include <map>
#include <stdlib.h>
#include <TF1.h>
#include <TStyle.h>
#include <TGraph.h>
#include <TCanvas.h>
#include <TLine.h>
#include <TH1.h> // 1d histogram classes

#define NB_MAX_FILE_VALUES 200000
#define MAX_YEAR 2100 // maximum year of input data
#define MIN_TEMP_VALUE -100 // minimum value of temperature

/*
 * Constructor
 */
tempTrender::tempTrender(std::string filePath) {
        // Store file path parameter into member variable
        _filePath = filePath;
```

Figure 2.4: Extract (a) from tempTrender.cpp

project.cpp ✕ | tempTrender.cpp ✕ | tempTrender.h ✕ | rootlogon.C ✕

```cpp
}

//////////////////////////////////
// ESTELLE CODE PART
//////////////////////////////////

/* Function mean temp per year
 * @param vector of strings
 *              with following format "%s %s %s %s %s"
 *              (year, month, day, temp, temp with urban correction, city)
 * @return map of mean temp per year
 */
std::map<int, double> meanTempPerYear(std::vector<std::string> entries) {
        // we assume that values are uniformatically spread on the year

        // temp values
        std::string year_str, value_str;
        size_t pos;
        int year;
        double value;

        // storage
        int nb_values[MAX_YEAR]={0};
        double sum_values[MAX_YEAR]={0};

        // for each entry, extract year and value
        for(size_t y=0; y<entries.size(); y++) {

                std::string s = entries[y];

                // get year from 4 first characters
                year_str = s.substr(0, 4);
                year = atoi(year_str.c_str());

                // get value from 5th field
                for(size_t i=0; i<4; i++) {
                        pos = s.find(' '); // find first delimiter
                        s.substr(0, pos);
                        s.erase(0, pos + 1);
                }
```

Figure 2.5: Extract (b) from tempTrender.cpp

Then I calculate the mean temperature per year and the mean temperature for all the years. And finally I create a canvas object and draw the histogram, as you can see in extracts (d) and (e).

```cpp
        }
        pos = s.find(' ');
        value_str = s.substr(0, pos);
        value = atof(value_str.c_str());

        // add value to arrays
        nb_values[year]++;
        sum_values[year]+=value;
    }

    // return variable
    std::map<int, double> ret;
    double mean;

    // for each year, compute mean value
    for(size_t i=0; i<MAX_YEAR; i++) {
        if(nb_values[i]>0) {
            mean = sum_values[i]/nb_values[i];
            std::cerr << "year : " << i << " mean : " << mean << std::endl;
            ret.insert(std::make_pair<int, double>((int)i, (double)mean));
        }
    }

    return ret;
}

void tempTrender::tempPerYear(int yearToExtrapolate) {

    // open input file
    std::string line;
    ifstream inputfile(_filePath.c_str());

    // create array to store values
    std::vector<std::string> entries;

    // read values and store it into array, hist or something else
    if(inputfile.is_open()) {
        while(getline(inputfile, line)) {
            entries.push_back(line);
        }
```

Figure 2.6: Extract (c) from tempTrender.cpp

After compilation, we are able to plot a histogram of mean temperature each year and the mean of all years, from 1722 to 2013.

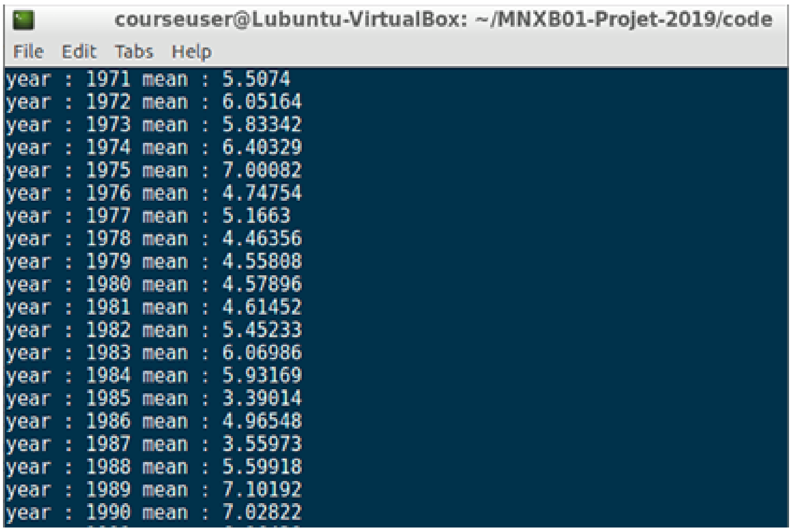
project.cpp ✕ tempTrender.cpp ✕ tempTrender.h ✕ rootlogon.C ✕

```cpp
            }
    }

    // compute mean per year
    std::map<int, double> meanPerYear = meanTempPerYear(entries);

    // compute mean for all time
    double meanAllTime = 0;
    for( std::map<int, double>::iterator it = meanPerYear.begin();
         it != meanPerYear.end();
         it++ ) {
            meanAllTime += it->second;
     }
     meanAllTime /= meanPerYear.size();

     std::cout << "meanAllTime = " << meanAllTime << endl;


    // create canvas for graph
    TCanvas *c1 = new TCanvas("Estelle", "Project : Mean Temp Per Year");

    // create new histogram object
    TH1F* hist = new TH1F("graph", "Mean Temp Per Year", meanPerYear.size(), 1722, 2100);

    // fill hist with mean temp per year values from input file
    for( std::map<int, double>::iterator it = meanPerYear.begin();
         it != meanPerYear.end();
         it++ ) {
            // fill hist with date and value from mean temp per year map
            //std::cerr << "value : " << it->second << std::endl;
            hist->Fill(it->first, it->second);
    }

    // Draw horizontal mean
    TLine *meanline = new TLine (1722,meanAllTime,2013,meanAllTime);

    // This code is given from project instruction for creating the graph
    //TGraph* graph = new TGraph();

    //for(int bin = 1; bin < hist->GetNbinsX(); ++bin) {
```

Figure 2.7: Extract (d) from tempTrender.cpp

```cpp
    //    graph->Expand(graph->GetN() + 1, 100);
    //    graph->SetPoint(graph->GetN(), hist->GetBinCenter(bin),
    //    hist->GetBinContent(bin));
    //}
    //graph->Draw("SAME C");

    // create function for extrapolation
    //TF1 *f = (TF1*)hist->GetFunction("pol7");
    //f->Eval(yearToExtrapolate);

    //Axis title
    hist->SetTitle("Mean temperature per year (Uppsala, 1722-2013)");
    hist->GetXaxis()->SetTitle("Year");
    hist->GetXaxis()->CenterTitle();
    hist->GetYaxis()->SetTitle("Mean temperature (Celcius Deg)");
    hist->GetYaxis()->CenterTitle();

    // draw hist
    hist->Draw("SAME");

    // draw mean line
    meanline->Draw();

}
```

Figure 2.8: Extract (e) from tempTrender.cpp



```
courseuser@Lubuntu-VirtualBox: ~/MNXB01-Projet-2019/code
File  Edit  Tabs  Help
year : 1971 mean : 5.5074
year : 1972 mean : 6.05164
year : 1973 mean : 5.83342
year : 1974 mean : 6.40329
year : 1975 mean : 7.00082
year : 1976 mean : 4.74754
year : 1977 mean : 5.1663
year : 1978 mean : 4.46356
year : 1979 mean : 4.55808
year : 1980 mean : 4.57896
year : 1981 mean : 4.61452
year : 1982 mean : 5.45233
year : 1983 mean : 6.06986
year : 1984 mean : 5.93169
year : 1985 mean : 3.39014
year : 1986 mean : 4.96548
year : 1987 mean : 3.55973
year : 1988 mean : 5.59918
year : 1989 mean : 7.10192
year : 1990 mean : 7.02822
```

Figure 2.9: Extract from terminal

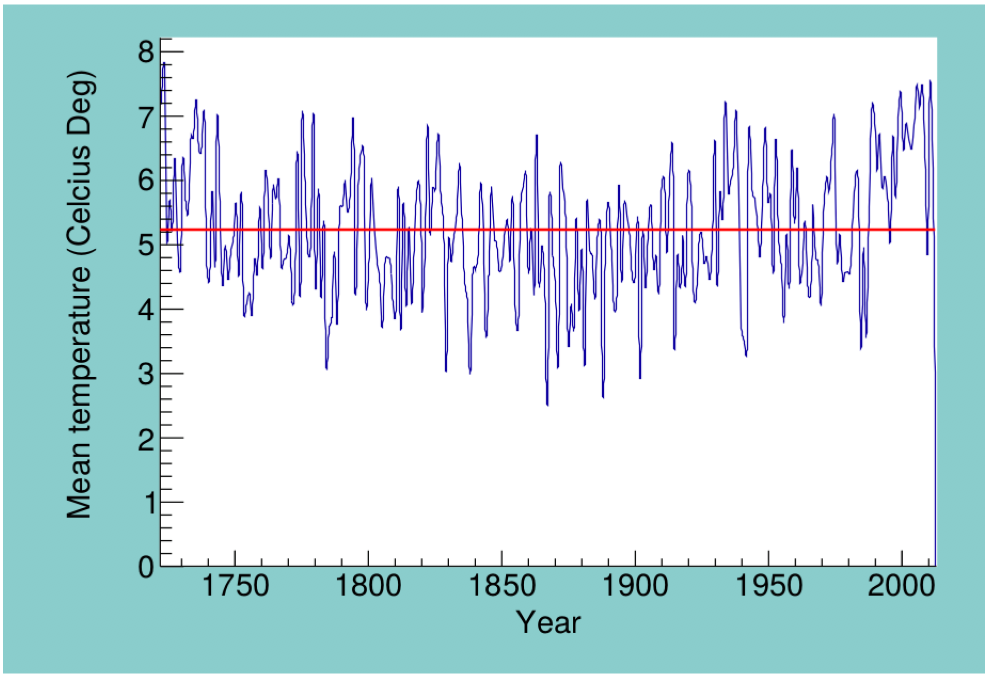


Figure 2.10: The graph shows the mean temperature of each year since 1722 in blue, and the mean of all years in red color

On the graph we can see a temperature sequence above and below the average. We notice that the temperatures are getting hotter. To improve this code we can try to extrapolate using a mathematical model to highlight global warming.

2.2 Temperature on a given day in Uppsala

In this section I'm going to study the temperature on a given day in Uppsala. For that we are going to use the tempdata_uppsala.txt file. In the exemple we are given the choice between two functions, one takes in entry the date (in form of a number contained between 1 and 365) or a date (month and day). I choose to use the second one because I already have these informations in the data file, as shown in figure 2.11 below.

```
#include "tempTrender.h"
#include <string>


void project() {
    string pathToFile = "../datasets/tempdata_uppsala.txt"; //Put the path to your data file here
    tempTrender t(pathToFile); //Instantiate your analysis object

    t.tempOnDay(8, 23); //Call some functions that you've implemented
    //t.tempOnDay(235);
    //t.tempPerDay();
    //t.hotCold(2050);
    //t.hottestTempPerYear(2050);
    //t.tempPerYear(2050);
}

```

Figure 2.11: Function Project.cpp

In this exemple I'm gonna study the climate on the 23rd of August for the past 300 years. For that I wrote a code called tempTrender.cpp that takes all the informations needed in the tempdata_uppsala.txt file and draw a plot with them. I'm now going to get through the code and explain what I did.

In the first part of the program (shown in 2.12), I'm going to declare a vector called "entries" to store every lines of the data file to have an easier access to them. Then an array for the temperatures on that day (it will be useful for the standart deviation later). And a whole bunch of variables that are going to be useful in the code.

```
/////////////////////////////////
// JOHAN CODE PART
/////////////////////////////////


void tempTrender::tempOnDay(int monthToCalculate, int dayToCalculate) {

    ifstream file(_filePath.c_str());

    //Defining all variables we need
    vector<string> entries;
    float temp[ARRAY_SIZE];

    string line, month_str, day_str, temp_str;
    int i, j=0, size, pos, month, day;
    float t, mean=0, StanDev=0;

    //Check if the file is opened
    if(file.is_open())
    {
        //Fill up the vector with the entries
        while(getline(file, line))
        {
            entries.push_back(line);
        }
    }

    size = entries.size();
```

Figure 2.12: First part of code tempTrender.cpp

In this part, we are going to create a histogram and fill it with the values we get from the vector. Basically, the idea is to store the day in the variable "day" and month in the variable "month". Check if it correspond to the day we wan't to study. If it does then we store the values of the temperature on this day in the array "temp" and fill the histogram with this value. The "atoi" part is just to convert strings to integer as the vector "entries" is filled with strings.

```
TCanvas *c1= new TCanvas("Johan","Project : Temperature on a given day");

//creating histogram
TH1D* hist = new TH1D("Hist", "Temperature on a given day", 100, -20, 40);

   //goes through all the entries
for(i=0; i<size; i++)
{
    line = entries[i];

    //get the month from 2nd field
    pos = line.find(' ');
    line.erase(0, pos + 1);
    pos = line.find(' ');
    month_str = line.substr(0, pos);
    month = atoi(month_str.c_str());

    //get the day from 3rd field
    pos = line.find(' ');
    line.erase(0, pos + 1);
    pos = line.find(' ');
    day_str = line.substr(0, pos);
    day = atoi(day_str.c_str());


    if ((month == monthToCalculate) && (day == dayToCalculate))
    {
        //get the corresponding temperature at the 4th field
        pos = line.find(' ');
        line.erase(0, pos + 1);
        pos = line.find(' ');
        temp_str = line.substr(0, pos);
        t = atof(temp_str.c_str());
        mean=mean+t;
        temp[j]=t;
        j=j+1;
        hist->Fill(t);
    }
}
```

Figure 2.13: Second part of code tempTrender.cpp

In the last part of the program (figure 2.14), I'm going to calculate the mean value of the temperature on that day and the standart deviation. To do so, I start with the mean value and then use a for-loop to get the standart deviation. After that, I will set up the X and Y axis and give them names, as well as display the mean value and the standart deviation on the terminal.

```
    //Calculate the mean value on that day
    mean=mean/j;

    //Calculate the standart deviation
    for (i=0; i<=j; i++){
        StanDev = StanDev+(temp[i]-mean)*(temp[i]-mean)/(j+1);
    }
    StanDev = sqrt(StanDev);

    cout << "The mean value on this day is : " << mean << endl;
    cout << "The standart deviation is : " << StanDev << endl;

    //Setting up X and Y axis
    hist->GetYaxis()->SetTitle("Entries");
    hist->GetXaxis()->SetTitle("Temperature in Celsius (deg)");


    //drawing histogram
    hist->SetFillColor(kGreen);
    hist->Draw("SAME");



}
```

Figure 2.14: Third part of code tempTrender.cpp

As a result, the mean temperature on the 23rd of August is 14,9003 degrees celsius and the standart deviation is 2,77906 (As shown in figure 2.15).

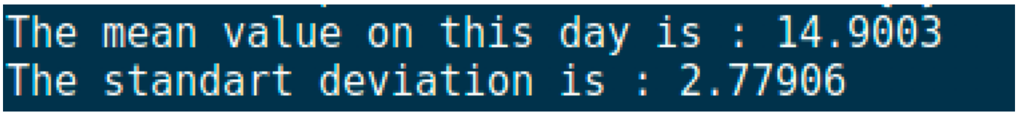


Figure 2.15: Mean value and standart deviation

By compiling the program, that is the result I get. The temperatures are pretty much contained between 10 and 20 degrees and we can see that the mean value is around 15 degrees.

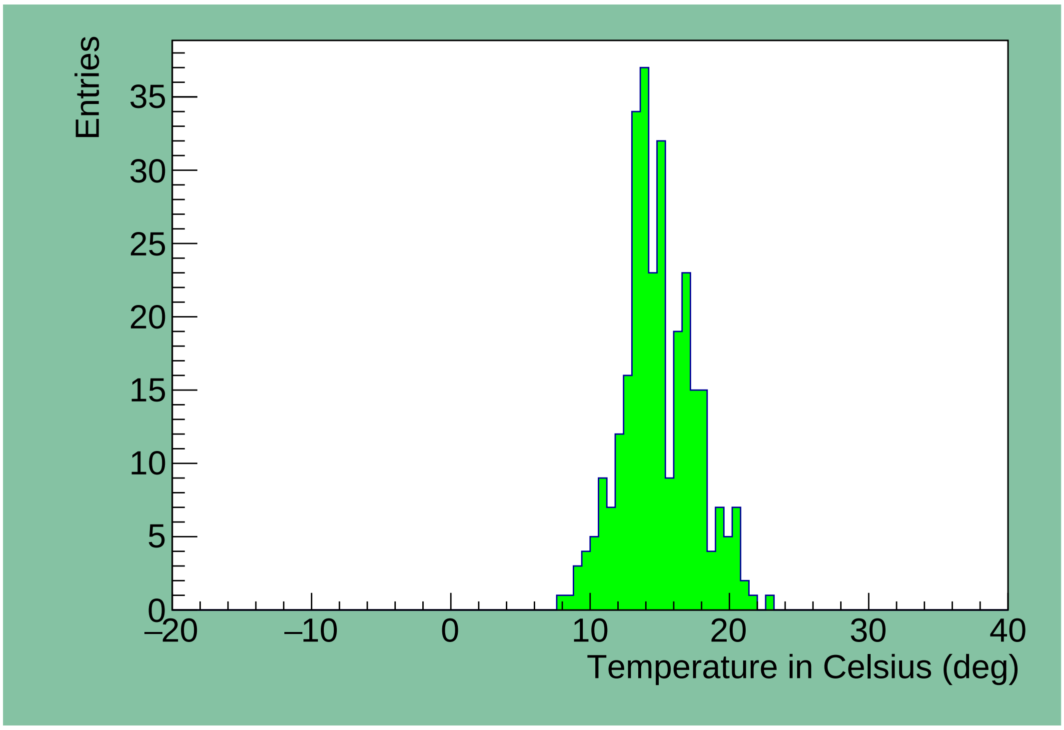


Figure 2.16: Plot of the temperature on that day

2.3 Hottest and coldest temperatures per year

In this section I'm going to study the coldest and hottest temperature for each years in Uppsala. For that we are going to use the tempdata_uppsala.txt file. In the exemple we are given the choice between two functions, one called hottestTempPerYear and the other called coldestTempPerYear. The aim is to print each hottest and coldest temperature for each year and to plot it. The two functions don't need any entries as shown in the figure 2.17 below.

```
#include "tempTrender.h"
#include <string>


void project() {
    string pathToFile = "../datasets/tempdata_uppsala.txt"; //Put the path to your data file here
    tempTrender t(pathToFile); //Instantiate your analysis object

    //t.tempOnDay(8, 23); //Call some functions that you've implemented
    //t.tempOnDay(235);
    //t.tempPerDay();
    //t.hotCold();
    t.coldestTempPerYear();
    t.hottestTempPerYear();
    //t.tempPerYear(2050);
}

```

Figure 2.17: Function Project.cpp

In these two programs I'm gonna study the hottest and coldest temperature from 1722 to 2013. For that I wrote a code called tempTrender.cpp that takes all the informations needed in the tempdata_uppsala.txt file and draw a plot with them. I'm now going to get through the code and explain what I did. In the first part of the program (shown in 2.12). Here I'm using lot of same methods as shown above: I will *create a function that allow us to read this file and retrieve all the temperatures per year in order to calculate the mean temperature per year. So I extract the first 4 characters which correspond to the year, then the 5th field which corresponds to the temperature.* I'm going to declare a vector called entries where I'm going to store every line of the data file to have an easier access to them. Then an array to store the hottest temperatures on that year and a whole bunch of variables that are going to be useful in the code.

```cpp
std::map<int, double> coldTempPerYear(std::vector<std::string> entries) {
	// temporary values
	std::string year_str, value_str;
	size_t pos;
	int year;
	double value;

	// storage
	double cold_values[MAX_YEAR]={0};

	// for each entry, extract year and value
	for(size_t y=0; y<entries.size(); y++) {
		std::string s = entries[y];
		// get year from 4 first characters
		year_str = s.substr(0, 4);
		year = atoi(year_str.c_str());

		// get value from 5th field
		for(size_t i=0; i<4; i++) {
			pos = s.find(' '); // find first delimiter
			s.substr(0, pos);
			s.erase(0, pos + 1);
		}
		pos = s.find(' ');
		value_str = s.substr(0, pos);
		value = atof(value_str.c_str());

		// add value to arrays
		if (value < cold_values[year] ) {
			cold_values[year] = value;
		}
	}
```

Figure 2.18: Coldest temperature per year

```cpp
std::map<int, double> hotTempPerYear(std::vector<std::string> entries) {
	// temporary values
	std::string year_str, value_str;
	size_t pos;
	int year;
	double value;

	// storage
	double hot_values[MAX_YEAR]={0};

	// for each entry, extract year and value
	for(size_t y=0; y<entries.size(); y++) {
		std::string s = entries[y];
		// get year from 4 first characters
		year_str = s.substr(0, 4);
		year = atoi(year_str.c_str());

		// get value from 5th field
		for(size_t i=0; i<4; i++) {
			pos = s.find(' '); // find first delimiter
			s.substr(0, pos);
			s.erase(0, pos + 1);
		}
		pos = s.find(' ');
		value_str = s.substr(0, pos);
		value = atof(value_str.c_str());

		// add value to arrays
		if (value > hot_values[year] ) {
			hot_values[year] = value;
		}
	}
```

Figure 2.19: Hottest temperature per year

So, I used “atoi” and “atof” command to convert strings to integer and to convert integer to string. Because when you are working with vectors you have to use an integer as the vector “entries”. You can also notice that I used a very simple if-loop inside the for-loop to get the extreme temperatures. In orders to replace the value inside the array by the new one of this year only if it’s a temperature hotter for the hottestTempPerYear function (colder for the coldestTempPerYear function). Finally, I will have an array that will store the hottest/coldest temperatures corresponding to specified years. In this part, we are going to create a histogram and fill it with the values we get from the vector created. Basically, the idea is to store the coldest in the variable "cold" and hottest in the variable "hot".The "atoi" part is also to convert strings to integer as the vector "entries" is filled with strings. We will see later what the “std::cear « year : “ « I « “coldest temp : “ « cold « std::endl;” is printing. (Figure ...)

```
        // return variable
        std::map<int, double> ret;
        double cold;

        // for each year, compute coldest value
        for(size_t i=0; i<MAX_YEAR; i++) {
                cold = cold_values[i];
                std::cerr << "year : " << i << " coldest temp : " << cold << std::endl;
                ret.insert(std::make_pair<int, double>((int)i, (double)cold));
        }
        return ret;
}
void tempTrender::coldestTempPerYear() {

        // open input file
        std::string line;
        ifstream inputfile(_filePath.c_str());


        // create array to store values
        std::vector<std::string> entries;


        // read values and stor it into array
        if(inputfile.is_open()) {
                while(getline(inputfile, line)) {
                        entries.push_back(line);
                }
        }

        std::map<int, double> cold = coldTempPerYear(entries);

        // create canvas for graph
        TCanvas *c1 = new TCanvas("Jasmain", "Project : COldest temperature over each year")

        // create new histogram object
        TH1D* hist = new TH1D("hist", "Coldest Temp Per Year", cold.size(), 1722, 2013);

        for( std::map<int, double>::iterator it = cold.begin();
             it != cold.end();
             it++ ) {
                // fill hist with date and value from mean temp per year map
                //std::cerr << "value : " << it->second << std::endl;
                hist->Fill(it->first, it->second);
        }
```

Figure 2.20: Main function

Then, I juste have to define and describe my histogram, with my title and the variables which constitute the x and y axis numbers. So, we can draw the histogram for both functions.

```
year : 1729 hottest temp : 19.1
year : 1730 hottest temp : 24.8
year : 1731 hottest temp : 20.8
year : 1732 hottest temp : 20.5
year : 1733 hottest temp : 22.7
year : 1734 hottest temp : 22.1
year : 1735 hottest temp : 22.5
year : 1736 hottest temp : 23.2
year : 1737 hottest temp : 21
year : 1738 hottest temp : 20.6
year : 1739 hottest temp : 21.5
year : 1740 hottest temp : 20.6
year : 1741 hottest temp : 21.9
year : 1742 hottest temp : 22.2
year : 1743 hottest temp : 22.4
year : 1744 hottest temp : 21.2
year : 1745 hottest temp : 21.6
year : 1746 hottest temp : 22
year : 1747 hottest temp : 23.6
year : 1748 hottest temp : 25.1
year : 1749 hottest temp : 21.8
year : 1750 hottest temp : 22.7
year : 1751 hottest temp : 21.8
year : 1752 hottest temp : 26.9
```

```
year : 1858 coldest temp : -16
year : 1859 coldest temp : -25.9
year : 1860 coldest temp : -20.4
year : 1861 coldest temp : -23.8
year : 1862 coldest temp : -20.4
year : 1863 coldest temp : -11.3
year : 1864 coldest temp : -13.4
year : 1865 coldest temp : -24
year : 1866 coldest temp : -15
year : 1867 coldest temp : -17.1
year : 1868 coldest temp : -21.7
year : 1869 coldest temp : -14.4
year : 1870 coldest temp : -20.1
year : 1871 coldest temp : -23.6
year : 1872 coldest temp : -12.6
year : 1873 coldest temp : -12.7
year : 1874 coldest temp : -18.6
year : 1875 coldest temp : -31.1
year : 1876 coldest temp : -22.1
year : 1877 coldest temp : -21.2
year : 1878 coldest temp : -15.9
year : 1879 coldest temp : -21.1
year : 1880 coldest temp : -15.8
year : 1881 coldest temp : -24.3
```

Figure 2.21: Output value of coldest and hottest temperature for each year

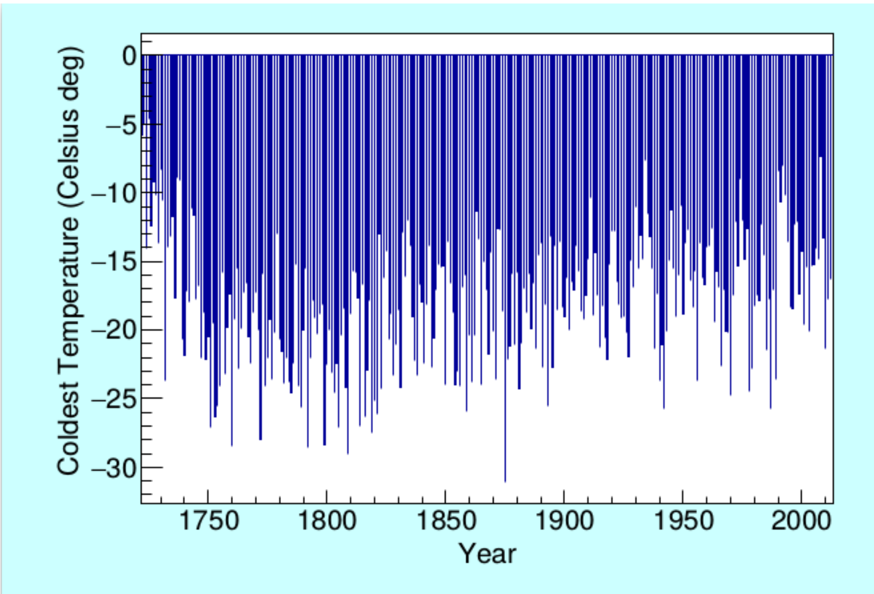


Figure 2.22: Coldest temperature

Here, above and bellow we have the different results of our program. First, (Figure 2.22) we have all the values of the hottest temperatures/coldest temperatures for each year between 1722 and 2013.
Besides, we have the 2 different histogram that show us how the hottest and coldest temperature has evolved during the last centuries. We can analyse that it's very hard to occur the hottest and coldest temperature even if we know that we have a global-warming. In one century we will probably get a much better view of the global warming on this histogram.

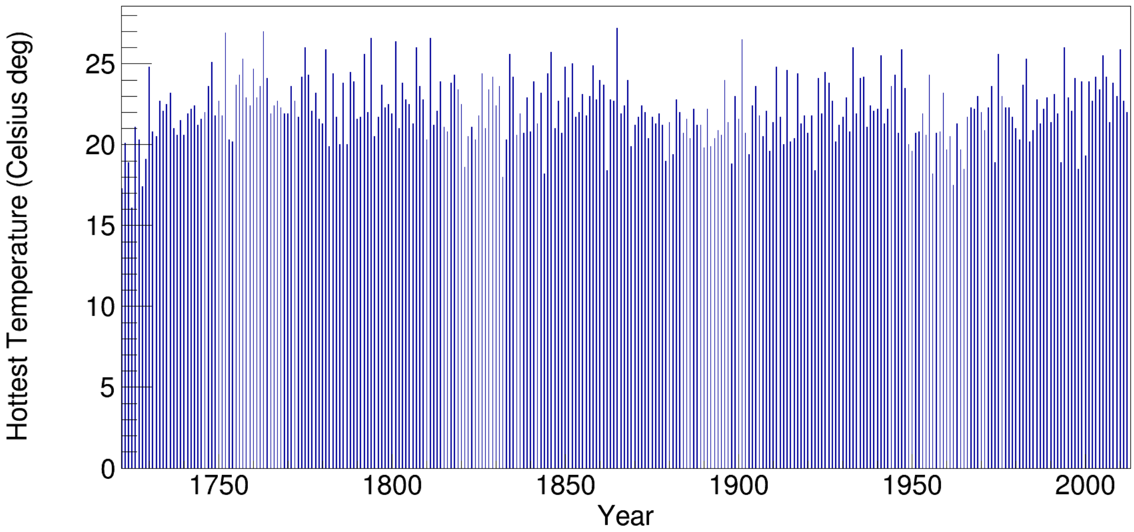
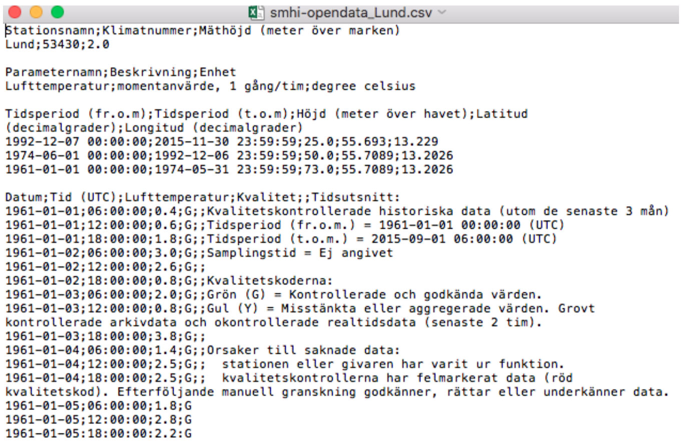


Figure 2.23: Hottest temperature

Chapter 3

Temperatures per days in Lund, Umea and Falsterbo

For this part of the project, I'm gonna use the files associated with Lund, Umea and Falsterbo, figure 3.1 shows a screenshot of the file associated with Lund.



```
smhi-opendata_Lund.csv
Stationsnamn;Klimatnummer;Mäthöjd (meter över marken)
Lund;53430;2.0

Parameternamn;Beskrivning;Enhet
Lufttemperatur;momentanvärde, 1 gång/tim;degree celsius

Tidsperiod (fr.o.m);Tidsperiod (t.o.m);Höjd (meter över havet);Latitud
(decimalgrader);Longitud (decimalgrader)
1992-12-07 00:00:00;2015-11-30 23:59:59;25.0;55.693;13.229
1974-06-01 00:00:00;1992-12-06 23:59:59;50.0;55.7089;13.2026
1961-01-01 00:00:00;1974-05-31 23:59:59;73.0;55.7089;13.2026

Datum;Tid (UTC);Lufttemperatur;Kvalitet;;Tidsutsnitt:
1961-01-01;06:00:00;0.4;G;;Kvalitetskontrollerade historiska data (utom de senaste 3 mån)
1961-01-01;12:00:00;0.6;G;;Tidsperiod (fr.o.m.) = 1961-01-01 00:00:00 (UTC)
1961-01-01;18:00:00;1.8;G;;Tidsperiod (t.o.m.) = 2015-09-01 06:00:00 (UTC)
1961-01-02;06:00:00;3.0;G;;Samplingstid = Ej angivet
1961-01-02;12:00:00;2.6;G;;
1961-01-02;18:00:00;0.8;G;;Kvalitetskoderna:
1961-01-03;06:00:00;2.0;G;;Grön (G) = Kontrollerade och godkända värden.
1961-01-03;12:00:00;0.8;G;;Gul (Y) = Misstänkta eller aggregerade värden. Grovt
kontrollerade arkivdata och okontrollerade realtidsdata (senaste 2 tim).
1961-01-03;18:00:00;3.8;G;;
1961-01-04;06:00:00;1.4;G;;Orsaker till saknade data:
1961-01-04;12:00:00;2.5;G;;  stationen eller givaren har varit ur funktion.
1961-01-04;18:00:00;2.5;G;;  kvalitetskontrollerna har felmarkerat data (röd
kvalitetskod). Efterföljande manuell granskning godkänner, rättar eller underkänner data.
1961-01-05;06:00:00;1.8;G
1961-01-05;12:00:00;2.8;G
1961-01-05:18:00:00:2.2:G
```

Figure 3.1: The raw data stored in a CSV file.

To extract only the measurements of the file, that is, all that follows after the line starting with "Datum; ..." and only the first four columns (using the field separator ";" for the definition of a column), a bash script tempdata.sh was written and executed. This script would extract the relevant data and save it to a new file data_for_town.txt. The script went through a couple of drafts, yielding different outputs as shown in figure 3.2.

data_for_Lund.txt

```
Datum Tid (UTC) Lufttemperatur Kvalitet
1961-01-01 06:00:00 0.4 G
1961-01-01 12:00:00 0.6 G
1961-01-01 18:00:00 1.8 G
1961-01-02 06:00:00 3.0 G
1961-01-02 12:00:00 2.6 G
1961-01-02 18:00:00 0.8 G
1961-01-03 06:00:00 2.0 G
1961-01-03 12:00:00 0.8 G
1961-01-03 18:00:00 3.8 G
1961-01-04 06:00:00 1.4 G
```

(a)

data_for_Lund2.txt

```
19610101 060000 0.4 G 1
19610101 120000 0.6 G 1
19610101 180000 1.8 G 1
19610102 060000 3.0 G 2
19610102 120000 2.6 G 2
19610102 180000 0.8 G 2
19610103 060000 2.0 G 3
19610103 120000 0.8 G 3
19610103 180000 3.8 G 3
19610104 060000 1.4 G 4
19610104 120000 2.5 G 4
```

(b)

data_for_Lund3.txt

```
1961 1 1 6 0.4 G 1
1961 1 1 12 0.6 G 1
1961 1 1 18 1.8 G 1
1961 1 2 6 3.0 G 2
1961 1 2 12 2.6 G 2
1961 1 2 18 0.8 G 2
1961 1 3 6 2.0 G 3
1961 1 3 12 0.8 G 3
1961 1 3 18 3.8 G 3
1961 1 4 6 1.4 G 4
1961 1 4 12 2.5 G 4
1961 1 4 18 2.5 G 4
```

(c)

Figure 3.2: Different outputs of tempdata.sh; from earlier drafts, 3.2a and 3.2b, and final draft, 3.2c.

The last column in 3.2b and 3.2c specifies the day number of the year, i.e. a number between 1 and 365/366. This was achieved by creating a UNIX timestamp in tempdata.sh, which, by the way, used the single command GNU awk to format the data (see figure 3.3).

```
#!/bin/sh
#author: Philip Siemund
#Extracts only the temperature data from SMHI datasets and saves the output in a new file data_for_${DATASET}.txt
#Requires GNU awk or mawk. Check your paths!

DATASET=$@
OUTPUTFILENAME=data_for_${DATASET}

if [[ -z "$DATASET" ]]; then
   echo "Please insert valid argument."
   exit 1
fi

awk -F';' '
    x==1 {
        gsub(/-/," ",$1)
        gsub(/:.*/,"",$2)
        gsub(/^0/,"",$2)
        tspec = sprintf("%4d %.2d %.2d 00 00 00", substr($1,1,4), substr($1,6,2), substr($1,9,2))
        t = mktime(tspec)
        gsub(" 0?", " ", $1)
        print $1, $2, $3, $4, 0 + strftime("%j", t)
    }
    /Datum/ {x=1}' ../datasets/smhi-opendata_${DATASET}.csv >> ../datasets/${OUTPUTFILENAME}.txt
```

Figure 3.3: tempdata.sh.

The purpose behind tempdata.sh was to make the data more accessible. Incuding the header fstream in a given C file, one could simply stream the different datatypes in the file data_for_town.txt onto corresponding variables in a while-loop. The data of interest could be specified by including conditional statements in the while-loop.
The file analyze_data.C exemplifies this (see figure 3.4). If one compiles the file in the data analysis tool ROOT and calls the function temPerDay(), it produces a histogram showing the temperature per day in a town at a given hour a given year. Some such histograms are shown in figure 3.5.

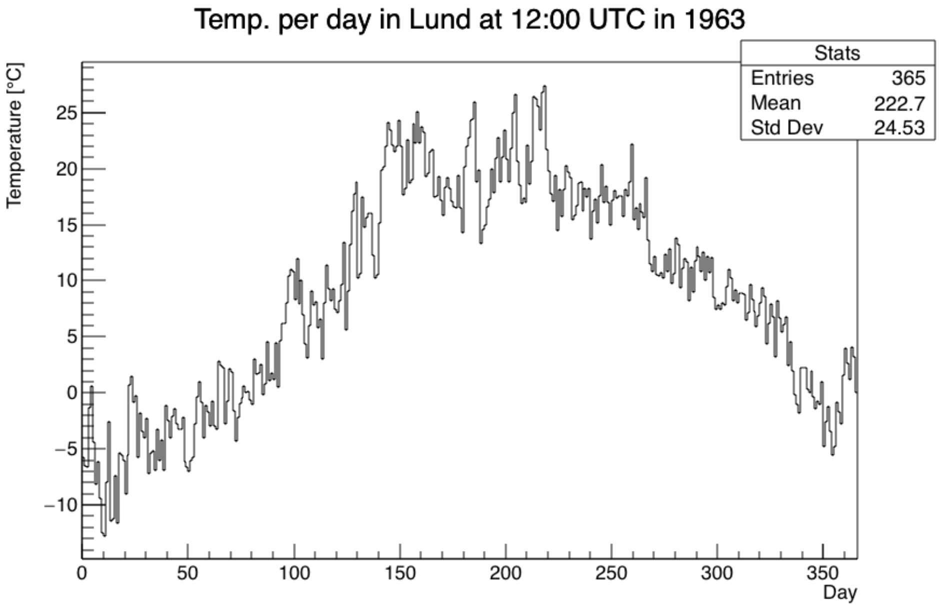
```
//author: Philip Siemund
//Draws a 1D histogram showing temp. per day at a specified time during a year. The raw data
//is extracted from the datasets using a bash script tempdata.sh. The bash script is executed once whenever
//the argument const char* town is specified for the first time for a given town. Check your paths!

#include <iostream>
#include <fstream>
#include <string>

using namespace std;

#include </Users/philipsiemund/root_v6.18.04/include/TH1.h>
#include </Users/philipsiemund/root_v6.18.04/include/TH2.h>
#include </Users/philipsiemund/root_v6.18.04/include/TCanvas.h>
#include </Users/philipsiemund/root_v6.18.04/include/TLatex.h>
#include </Users/philipsiemund/root_v6.18.04/include/TSystem.h>

void tempPerDay(Int_t year, Int_t hour, const char* town){

string fileName = Form("/Users/philipsiemund/MNXB01-Project-2019/datasets/data_for_%s.txt", town);

ifstream tempo(fileName);

if(!tempo) {
cout << "Error: could not read from file ..." << endl;
cout << "Running tempdata.sh ..." << endl;
gSystem->Exec(Form("./tempdata.sh %s", town));

}

tempo.close();
ifstream file(fileName);

TH1D* hist = new TH1D("Stats", Form("Temp. per day in %s at %d:00 UTC in %d; Day; Temperature [#circC]",town,hour,year),
            366, 0, 366);
```

(a)

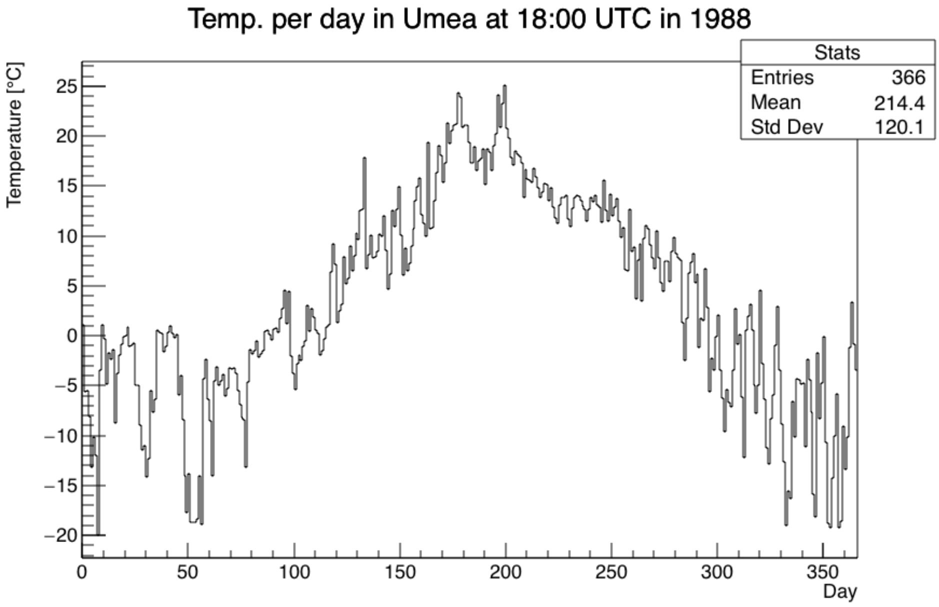
```
Int_t Year;
Int_t month;
Int_t day;
Int_t time;
Double_t temp;
string quality;
Int_t dayno;

while (file >> Year >> month >> day >> time >> temp >> quality >> dayno){

    if (Year == year && time == hour) {

    hist->SetBinContent(dayno,temp);
    }

    else {

    continue;
    }
}

file.close();

TCanvas* can = new TCanvas("can", "hist canvas", 900, 600);
hist->SetLineColor(1);
hist->Draw();

can->SaveAs("hist.png");

}
```

(b)

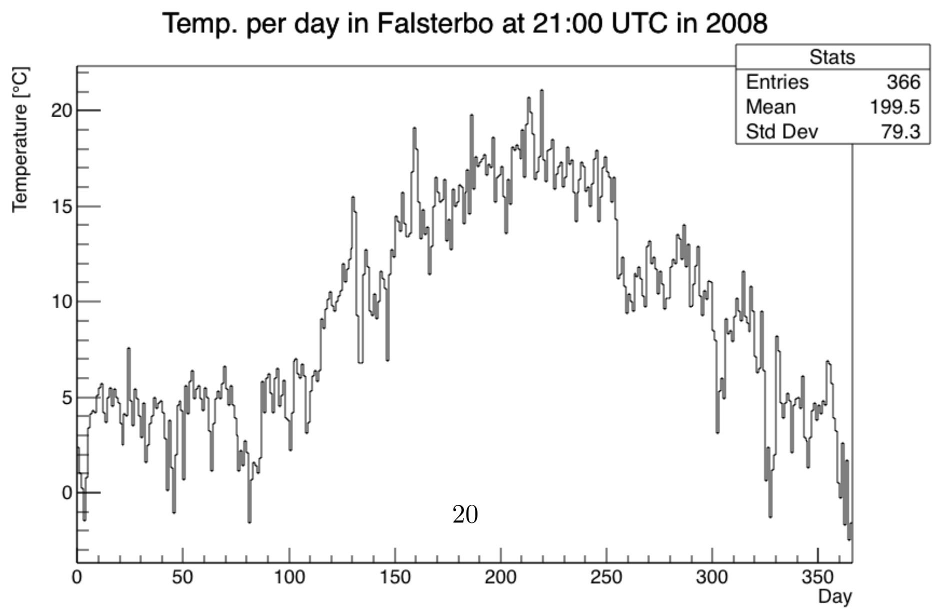
Figure 3.4: analyze_data.C.


Temp. per day in Lund at 12:00 UTC in 1963
Stats
Entries 365
Mean 222.7
Std Dev 24.53
Temperature [°C]
Day

(a)


Temp. per day in Umea at 18:00 UTC in 1988
Stats
Entries 366
Mean 214.4
Std Dev 120.1
Temperature [°C]
Day

(b)


Temp. per day in Falsterbo at 21:00 UTC in 2008
Stats
Entries 366
Mean 199.5
Std Dev 79.3
Temperature [°C]
Day

(c)