Final project MNXB01

Andrea Grespi, Sergio David Velásquez Giraldo and Eduardo Torres Reoyo

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1 Introduction

During the last decades, the scientific community has shown the anthropogenic nature of the climate change, from which the Earth is increasingly suffering. This information is captured in the IPCC reports [1], showing how the humankind is affecting the climate and how the climate is changing in different regions of the planet. This last statement is what we want to study along this report. Particularly, we intend to show and compare how the temperatures in two different areas of Sweden are affected by the climate change, to provide a relatively general overview of the Swedish climate change, but also to identify differences and analogies between northern and southern regions. For this purposes, the two areas we have chosen are represented by Umeå, which is settled in the Northeast, and Falsterbo, in the South.

In fact, given the vast land of the Swedish country covering 450.295 km^2, we chose among the places showing a large difference in latitude (°N), principally, and longitude (°E), from the available SMHI data. Finally, in order to provide also a relatively consistent comparison between them, we selected the two regions showing the most similar local conditions such as number and timetable of the measurements, distance from the sea and height above the sea. Therefore, we chose Umeå (63.7947°N, 20.2918°E) and Falsterbo (55.3837°N, 12.8167°E), which are both by the sea at a height below 30 meters, and show a large amount of data acquired at the exact same hours from the past 60 years.

Our analysis is characterized by three different set of plots, shown in section 2. The first one (2.2) is the mean temperature per year from 1962 to 2020, the second one (2.3) shows the difference between the coldest and the mean temperature of each year, and the same for the warmest temperatures. The last plots (2.4) show the date of the coldest and warmest day of each year. Data treatment and analysis will be detailed in section 2 while section 3 presents the conclusions of our work.

2 Data treatment and analysis

2.1 Data cleaning

SMHI datasets were cleaned using 'R' with the libraries 'dplyr', 'tidyverse', 'writexl', 'lubridate', 'chron' as shown in the code.

We used the temperature data sets from **UMEÅ** and **FALSTERBO**. The dates of both data sets were filtered, we established the date range from 01/01/1962 up to 31/10/2020. The hours were also filtered, we selected the same hours for both cities, in this case, 07:00:00, 13:00:00, 20:00:00.

The data used for the two cities in case of the plots in subsection 2.4 were divided each into two further groups:

1. From day number 1 up to day number 269
2. From day number 270 up to day number 365

The division in two groups allowed us to manipulate the data for better visualizing the trend of the coldest and warmest days during the years, as explained in subsection 2.4.

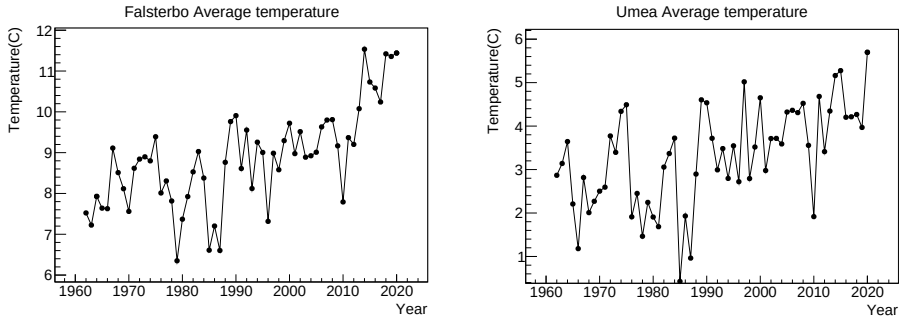
Apart from cleaning and establishing the ranges for the data, we used the potential of 'R' to change the displayed rows or columns and to summarise or to do simple mathematical operations. The data have been furhter adjusted with Excel for few features required for plots in subsections 2.3 and 2.4.

Some mathematical operations used were:

1. **Average:** Useful for obtaining the average temperature of the day with the three hours.
2. **Maximum:** Useful for obtaining the day with the highest temperature.
3. **Minimum:** Useful for obtaining the day with the lowest temperature.

2.2 Mean temperature per year

In order to compare the changes during the years between the two data sets, the mean temperature of each year has been calculated as an average of the measurements acquired at the same time in both the places.



(a) Falsterbo. (b) Umeå.

Figure 1: Mean temperature per year

The two plots have been fitted using linear, quadratic and exponential models, which yield the chi-2 parameters shown in table 1 and 2.

Model	Chi-2
Linear	45.1794
Quadratic	37
Exponential	43.5234

Table 1: Chi-2 parameters for Figure 1(a)

Model	Chi-2
Linear	53.4473
Quadratic	49.9518
Exponential	51.8294

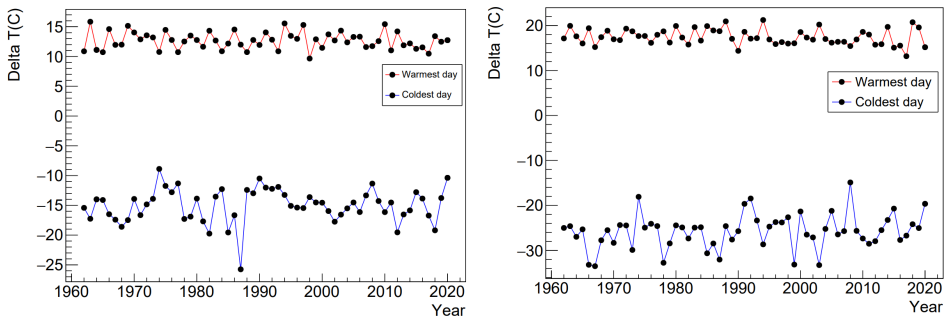
Table 2: Chi-2 parameters for Figure 1(b)

From the plots it is immediately clear the effect of the so called "Global Warming", which is indeed causing an increase of the temperatures in the whole world. The chi-2 parameters of the fitting models, with a generous approximation, even suggest there is a quadratic growth of the temperatures with the years, in both places. However, if we look at the average temperature calculated from the past 10 years, namely from 2012 to 2020, with respect to the one calculated from 1962 to 1970, we can say that the growth rate of the temperature in Falsterbo is higher (+2.5°C) than the one in Umeå (+2°C).

2.3 Coldest and warmest temperatures with respect to the mean temperature for each year

In this analysis we needed to update the filtered data by adding two new columns reporting the difference in temperature (Delta T) between the coldest (T min - T mean) or the warmest (T max - T mean) temperatures with respect to the mean ones, for each year.

From a qualitative analysis of the plot in figure 2, we can argue that there is no increase in the number of the so called "extreme conditions" during the years. The results even suggest that both in Falsterbo and Umeå the standard deviation of the temperature seems to decrease with the years, especially the warmest days are getting slightly more closer to the mean temperature with time. In both cases, the coldest temperatures are more "unstable" during the years than the warmest ones.

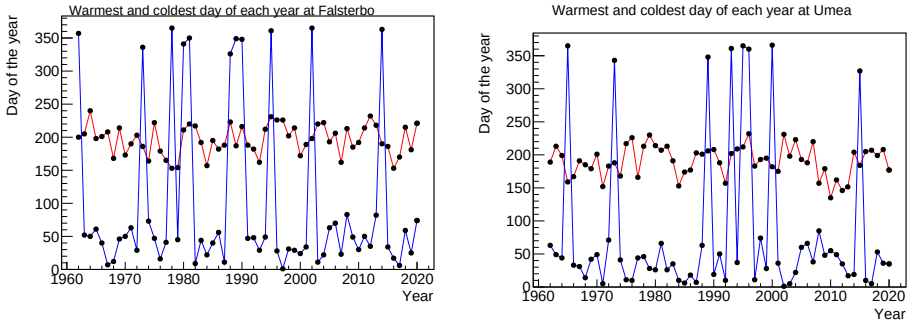


(a) Falsterbo. (b) Umeå.

Figure 2: difference with respect to the mean Temperature of warmest and coldest temperature per year

2.4 Coldest and warmest day of each year

The coldest and warmest day of the year have been selected according to the lowest or highest temperature, respectively, reached during the hours available from the cleaned data. In few cases, we have encountered years that reached the same minimum temperature in more than one day, in these cases we chose to select the day with the lower average temperature between them. To better visualize the trends of the date of the coldest and warmest days during the years, we chose to plot the days (Y-axis) starting from September, instead of January, but without losing part of the data. The reason for this choice, which may seem confusing at first sight of the plot, relies on the fact that some of the coldest days were measured in January, and others in December, hindering to visualize a possible trend of the coldest days. To modify the Y-axis order, we shifted upwards (by +95 days) all the measurements obtained from January to September, and downwards (by -270 days) the ones from September to January. This could not make complete sense and seems confusing in terms of chronological order during the single year, but does not affect the whole trend during the years and allows a better visualization of the data. We decide to call this order of the months from September to August "Academic Year", because it reminds the academic calendar. **Note: The following plot are the not shifted ones**



(a) Falsterbo. (b) Umeå.

Figure 3: difference with respect to the mean Temperature of warmest and coldest temperature per year

The plots have been fitted using linear models, which yield the chi-2 parameters shown in table **??** and **??**

...Discussion of the plots.. is there a drift? maybe we can see it with the linear fit. is there a difference between Falsterbo and Umea?

3 Conclusion

Not surprisingly, the Global Warming has been clearly demonstrated in 2.2, particularly causing a quadratic growth of the temperature during the years, according to our fitting. However, according to our calculations, it seems that the South is more affected than the North of Sweden. On the contrary, from 2.3 there is no clear distinction between the two regions in the trend of the so called "extreme conditions", both plots show that the warmest temperatures are pretty stable, and are slighlty getting closer to the mean ones. The coldest temperatures are more highly variable, still with a tendency to get slightly closer to the mean ones with time. Finally, from 2.4 we can also argue that...

References

[1] The intergovernmental panel on climate change. https://www.ipcc.ch/. (Accessed on 06/11/2022).