The temperature trend in Sweden in three cities: a qualitative investigation using SMHI open data

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1 Introduction

The Swedish Meteorological and Hydrological institute (SMHI) regularly provides data sets open to the general public, which contain several variables which the institute monitors. One such variable is temperature, which has been regularly measured in several Swedish cities since the late 1800s.

The aim of this project is to investigate the temperature trend for three Swedish cities, specifically Lund, Falun and Karlstad using data obtained from [1] during the period 1942-2021. Furthermore, it is investigated if any major climate related events can be identified in the data. This would be visible as an outlier which does not follow the general trend.

2 Method

In order to make use of the recorded data from SMHI, different programming resources have been used. These resources include Python [2] and C++ [3] where libraries from both Numpy [4] and ROOT [5] have been used. Numpy was mainly used through Python in order to preprocess the data. The pre-processing involved cleaning the data to the relevant range and calculating mean and median values as these are the statistics of interest.

Thereon, comes the visualization of the data in the form of graphs. This was done using the root library through C++ where the data for date, mean/median temperatures and its corresponding errors obtained from the preprocessing part has been turned into separate vectors. These vectors were then plotted using the TGraph and TGraphErrors classes from ROOT, where the latter includes the errors in the plotting of the graph. Moreover, a fitting method from ROOT has been used where the graph has been fitted using a fourth degree polynomial. The data sets for the daily temperature of the cities Falun, Lund and Karlstad from 1940 to 2021 were used.

2.1 Challenges and possible improvements

During the implementation many challenges were faced, mainly related to the C++ compiler included with ROOT. This lead to the project having to undergo a major change from a completely object oriented approach to a functional one. The final code (viewable at *https://github.com/marwantaib/MNXB01-project*) is dependent on ROOT as well as Numpy. The latter could be omitted through the use of for example the Python implementation of ROOT (e.g. PyROOT) as ROOT contains the necessary functions for computing the mean and median values of datasets. As the project was done during a very limited time period, Numpy was used in place as we simply could not get PyROOT to work on our computers.

Furthermore, the resultant code is not very generalized. This leaves room for future improvements.

3 Results

The graph of the measured mean and median temperature in Lund from 1940 up to 2021 can be seen in figures 1 and 2 respectively.

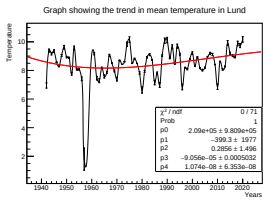

Figure 1: Measured mean temperatures in Lund from 1940 up to 2021.

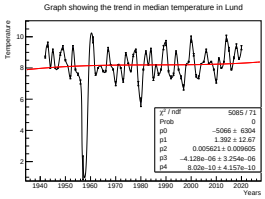

Figure 2: Measured median temperatures in Lund from 1940 up to 2021.

The graph of the measured mean and median temperature in Falun for each day from 1940 up to 2021 can be seen in figure 3 and 4 respectively.

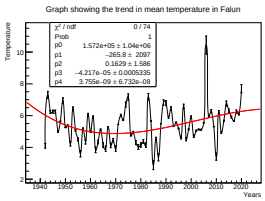

Figure 3: Measured mean temperatures in Falun from 1940 up to 2021.

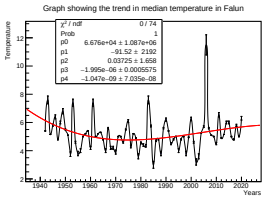

Figure 4: Measured median temperatures in Falun from 1940 up to 2021.

The graph of the measured mean and median temperature in Karlstad for each day from 1940 up to 2021 can be seen in figure 5 and 6 respectively.

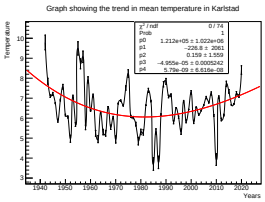

Figure 5: Measured mean temperatures in Karlstad from 1940 up to 2021.

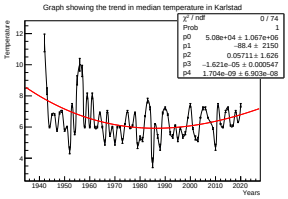

Figure 6: Measured median temperatures in Karlstad from 1940 up to 2021.

4 Discussion

As it can been seen from Figures 1 and 2 the fitted parabolas are increasing ever so slightly. It can also be seen that there a huge dip in temperature in around 1955. This can be considered an anomaly due to the summer starting with very cold and snowy weather up until June [6]. Despite that anomaly there is slight increase in overall temperature. Zooming into the two years of the pandemic 2020 and 2021, it can be seen that the mean and median temperatures have not changed by much but they are increasing ever so slightly.

Looking at Figures 3 and 4, it can also be seen that there is an overall temperature increase from the slop of the fitted polynomial. It is interesting to see that there is quite a difference from year to year. This suggests that Falun has a fluctuating climate environment. Some major events can be seen in this figures. Mainly the extreme cold winters in 1942 [7] and 2010 [8] as well as the heat wave that happened in 2007 [9]. All of these three events can be considered an anomaly, when looking at the overall trend. During the pandemic years of 2020 and 2021 it can be seen that there is an increase in mean temperature, this might be due to the hot summers experienced in both years. Nonetheless the increase seems to be within reason.

Looking at Karlstad mean and median temperatures in Figures 5 and 6, it can be seen that the temperature is much more changing compared to the Lund and Falun. This fluctuation can not be explained by events. Regardless looking at the years 2020 and 2021, it can be seen that there is an increase mean temperatures following the same trend as Falun. This can be explained due to the hot summers that occurred in these two years.

5 Conclusion

In conclusion the results are inconclusive due to the inability to describe anomalies in the figures. Despite that a clear trend in increased temperature can be seen throughout the three cities.

References

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