



DMI

Ministry of Transport and Energy

Technical Report 06-13

Temperature measurements in Copenhagen from 1767 to 1860

Ane Marie Closter, Rikke Margrethe Closter, John Cappelen, Jens Hesselbjerg Christensen, Kirsten Christoffersen (FBL) and Claus Kern-Hansen





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Serial title:

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Title:

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Responsible institution:

Danish Meteorological Institute

Language:

English

Keywords:

Air temperature measurements, Copenhagen, Rundetårn, Old Botanical Garden

Url:

www.dmi.dk/dmi/tr06-13

ISSN:

1399-1388

Version:**Website:**

www.dmi.dk

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Front cover:

King Christian the 4th constructed the Trinitatis complex (which Rundetårn is a part of) as a combined church, library and observatory connected to the University. This picture showing Rundetårn is from a book published by Peder Horrebow in 1741.

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Content:

Abstract	4
Resumé.....	4
1. Introduction.....	5
1. Indledning	5
2. Temperature measurements from Copenhagen before 1767	6
3. Temperature measurements from Copenhagen 1767 – 1860.....	9
3.1. Timeline of meteorological observations.....	9
3.2. Period 1767 – 1776 (RdtMdr_1767_1776).....	9
3.3. Period 1767 – 1779 (RdtDay_1767_1779).....	10
3.4. Period 1780 – 1781	11
3.5. Period 1782 – 1788 (RdtMdr1782_1788).....	11
3.6. Period 1789 – 1797	11
3.7. Period 1798 – 1799 (Rdt3Day_1798_1799).....	11
3.8. Period 1800 (RdtDay_1800)	11
3.9. Period 1801 – 1819 (Rdt3Day_1801_1819).....	12
3.10. Period 1818 – 1860 (GIBoT_1818_1860).....	12
4. Missing temperature data	12
5. The quality of the data	13
6. Data files	14
References.....	15
Previous reports.....	15
Appendix 1. Specific note about the data in Excel	16



Abstract

In this report temperature measurements Copenhagen from 1767 to 1860, as found in different documents, are published.

Resumé

Formålet med denne rapport er at publicere temperaturmålinger foretaget i København i perioden 1767 til 1860.



1. Introduction

The objective with this report is to publish temperature measurements from Copenhagen from 1767 to 1860 as found in different documents. The number of long temperature time series is very limited internationally, so the processing of the old weather data has a general interest. The present processing of old weather data was done to compare them with climate signals in sediment cores from the Danish lake Frederiksborg Slotssø. The report is part of a larger project, which is focusing on developing a fundamental scientific understanding of the interactions between climate and the aquatic environment in and around Denmark (<http://www.conwoy.ku.dk>).

The report and the data files can be found on the DMI Web pages.

1. Indledning

Formålet med denne rapport er at publicere temperaturmålinger foretaget i København i perioden 1767 til 1860. Antallet af lange temperaturtidsserier er meget begrænsede på verdensplan og oparbejdelsen af de gamle vejrdato har derfor en generel interesse. Den aktuelle oparbejdelse er foretaget for at sammenligne lufttemperaturmålingerne med klimasignaler i sedimentkerner fra i Frederiksborg Slotssø. Rapporten er led i et større projekt, der fokuserer på at udvikle en fundamental videnskabelig forståelse af interaktioner mellem klimaet og det akvatiske miljø i og omkring Danmark (<http://www.conwoy.ku.dk>).

Rapporten og tilhørende data kan hentes på DMI's Internetsider.



2. Temperature measurements from Copenhagen before 1767

The first known meteorological observations in Copenhagen are from the year 1671, where Thomas Bartholin, Senior (1616-1680) measured air temperature four times daily. These observations can be found in “Animadversia Meteorologica” from 1671. However, these data can be questioned, since the accuracy of the thermometer is unknown.

The Royal Library in Copenhagen is in possession of an original temperature curve of the Danish astronomer Ole Rømer (1644-1710) (or one of his students) from 1708/09, which can be found as an attachment to Rømer’s notebook (<http://www.rundetaarn.dk/dansk/observatorium/term.htm>).

In 1751 P. Horrebow (1679-1764) initiated meteorological observations three times daily in the astronomical tower Rundetårn in Copenhagen (Willaume-Jantzen, 1896). However, from 1751 to 1766 the thermometer was situated inside a room in the little observatory on the top of the tower and for that reason these measurements cannot be used as outside temperatures. But the quality of the temperature measurements from Rundetårn from 1751-1766 should be reliable, and can be used as an indication of the air temperature in that period.

From 1767 the thermometer was situated outside the observatory facing north, and the data presented in this report therefore starts from this year.



Figure 1. Old map of Copenhagen 1784. The locations of Rundetårn and The Old Botanical Garden are shown. In 1784 the first steps were taken in the construction of the The Old Botanical garden.

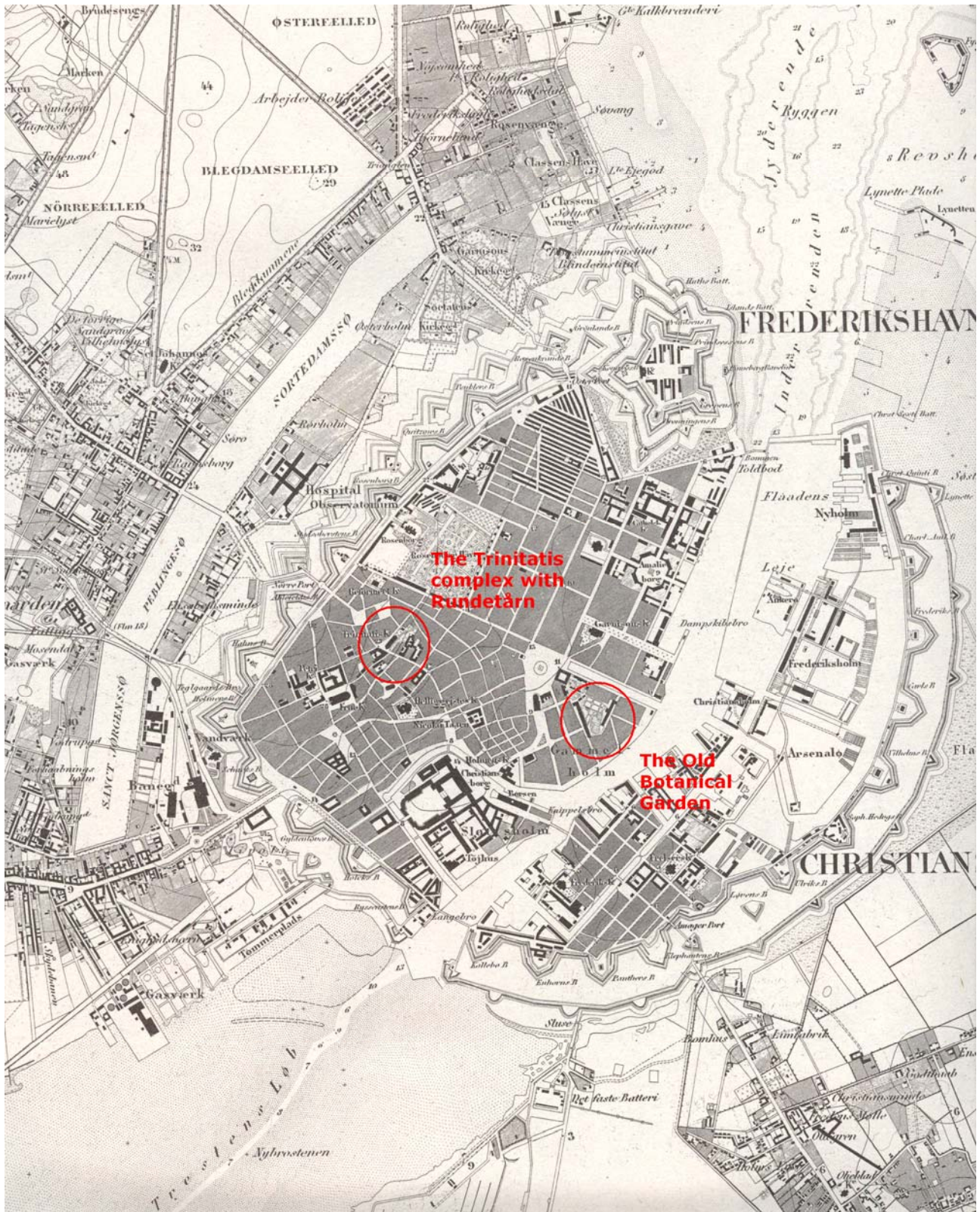


Figure 2. Map of Copenhagen from 1852 (corrections 1865). The locations of Rundetårn and The Old Botanical Garden (Charlottenborg Haven) are shown. It can be seen that compared to the older map from 1784 the old botanical garden in 1852 are now developed to maximum extent. The space in the garden was at that time very narrow and a new location was needed. 9 October 1874 the present Botanical Garden in Copenhagen was started a few kilometres northwest of the old botanical garden near the Hospital and Observatorium just nearby "Sortedamssø".

3. Temperature measurements from Copenhagen 1767 – 1860

The Danish National Archives are in possession of the meteorological observations from Rundetårn from the period 1767 – 1819. From 1818 meteorological observations from The Old Botanical Garden “Gamle Botaniske Have” (Charlottenborg Haven) in Copenhagen also are available.

The location of the Trinitatis complex with the astronomical tower Rundetårn and the location of The Old Botanical Garden (between Charlottenborg and the harbour Gammelholm, also known as Charlottenborg Haven) are shown at two old maps of Copenhagen, one from 1784 and one from 1852 (see figure 1 and 2).

Furthermore, The Danish National Archives are in possession of different processed data material, which is the mean temperature from three to five daily observations.

In the following the different material digitised in connection to the project are described.

From 1 June 1860 observations of temperature was also started at The Royal Veterinary and Agricultural University in Copenhagen and it is still the case today. Monthly average temperatures from 1768 – 1893 was processed and homogenized in 1896 by Willaume-Jantzen (Willaume-Jantzen, 1896). In DMI technical Report 06-09: DMI monthly Climate Data Collection 1768-2005, Denmark, The Faroe Islands and Greenland (Cappelen et al., 2006) a monthly time series of temperature 1768 – 2005 from The Royal Veterinary and Agricultural University in Copenhagen can be found.

3.1. Timeline of meteorological observations

The data presented in this report can be found in a summoned spread sheet called “cph_temp_data_1767_1860.xls”. The different folders in this spread sheet represents different periods with data. The names of the folders are given in brackets below.

The different data can also be found in a number of specific spread sheets called “Therm-LAE_<period>.xls” (ThermLAE = Therm. libero aéri expo (thermometer in free air)), where data furthermore are plotted for visual check.

Finally all the data are plotted in one graph, see “dataplot_all.pdf” (see also figure 3)

3.2. Period 1767 – 1776 (RdtMdr_1767_1776)

In this period (January 1767 to December 1776) the meteorological observations was taken outside the Observatory on top of the tower Rundetårn (appr. 43 m above sea level), in Copenhagen.

The data are from two documents with monthly mean temperatures. The first document contains monthly mean temperature in Réaumur without corrections. The other document contains monthly mean temperature in Réaumur with corrections for the night, because there were only observations during the day. The “true” mean temperatures, representing all 24 hours the clock around, are therefore calculated using corrections. However, there are no further explanations concerning these corrections.

The monthly mean temperature have been converted into Celsius by following equation: $5/4 * \text{Réaumur}$.

The data can also be found in a specific spread sheet called “ThermLAE_1767_1776.xls”, where data furthermore are plotted for visual check.

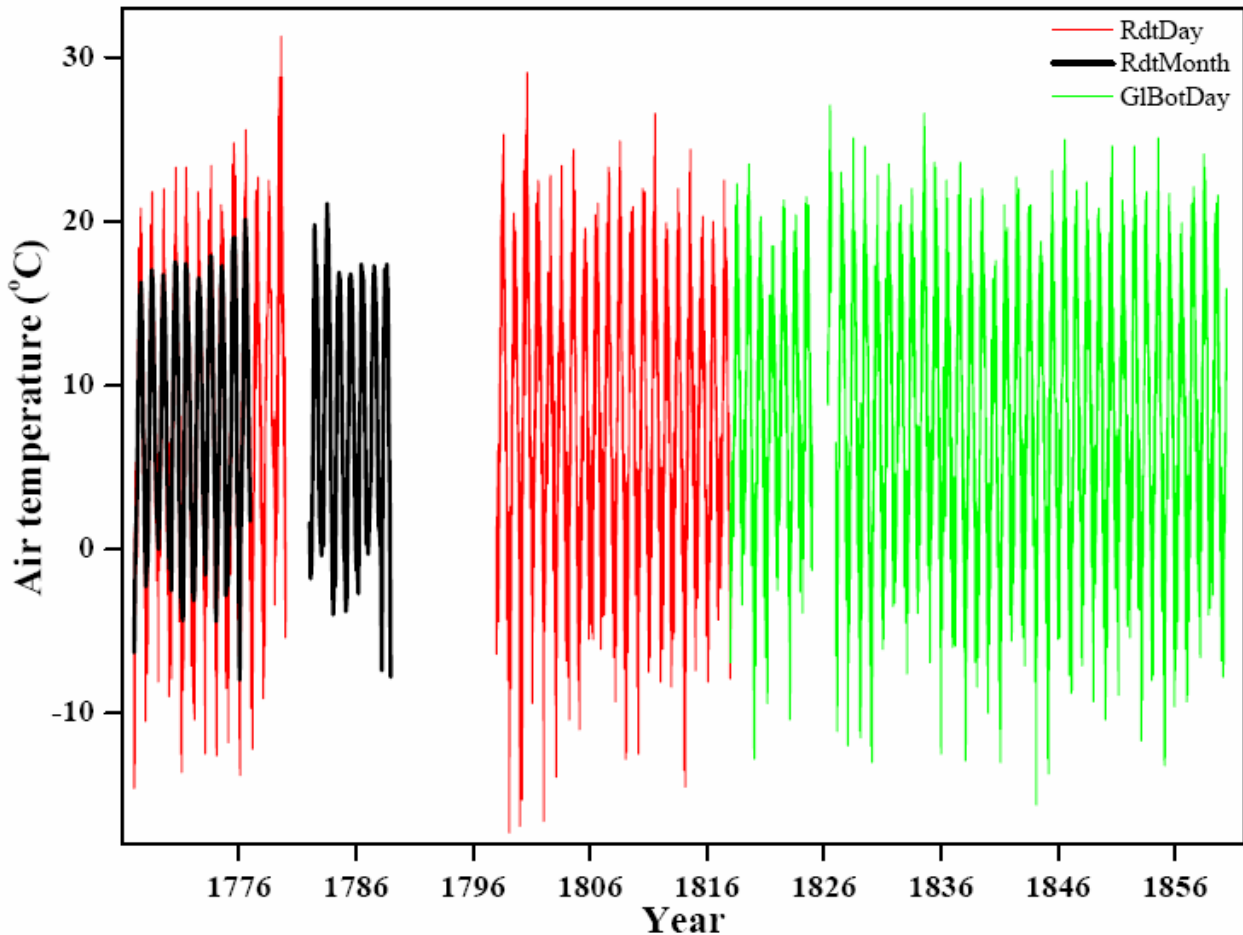


Figure 3. Daily and monthly average temperatures from Copenhagen. The observations are from Rundetårn 1767-1817 and Gl. Botaniske Have 1818-1860.

3.3. Period 1767 – 1779 (RdtDay_1767_1779)

In this period (January 1767 to December 1779) the meteorological observations was taken outside the Observatory on top of the tower Rundetårn, Copenhagen.

The data are from one document with daily mean temperatures in Réaumur.

The daily mean temperature have been converted into Celsius by following equation: $5/4 * \text{Réaumur}$. A comparison of the “RdtMdr_1767til1776” and “RdtDay_1767til1779” were performed, and can be seen at the bottom of the schemes in RdtDay_1767til1779.

NB. The time of the reading of the observations is varying for the years 1777 – 1779. This might also count for the year 1767 – 1776, but the time of the observation is not indicated for these years.

The data can also be found in 13 specific spread sheets called “ThermLAE_1767.xls” “ThermLAE_1779.xls”, where data furthermore are plotted for visual check.



3.4. Period 1780 – 1781

There are either no temperature measurements from these two years or the data is missing from the original documents.

3.5. Period 1782 – 1788 (RdtMdr1782_1788)

In this period (January 1782 to December 1788) the meteorological observations was taken from the Observatory on top of the tower Rundetårn, Copenhagen.

The data are from two documents with monthly mean temperatures. The first document contains monthly mean temperature in Réaumur without corrections. The other document contains monthly mean temperature in Réaumur with corrections for the night, because there were only observations during the day. The “true” mean temperatures, representing all 24 hours the clock around, are therefore calculated using corrections. However, there are no further explanations concerning these corrections.

The monthly mean temperature have been converted into Celsius by following equation: $5/4 * \text{Réaumur}$.

The data can also be found in a specific spread sheet called “ThermLAE_1782_1788”, where data furthermore are plotted for visual check.

3.6. Period 1789 – 1797

There are either no temperature measurements from these years or the data is missing from the original documents.

3.7. Period 1798 – 1799 (Rdt3Day_1798_1799)

In this period (January 1798 to December 1799) the meteorological observations was taken from the Observatory on top of the tower Rundetårn, Copenhagen.

The data are from a document with three daily temperature measurements in Réaumur. The three daily temperatures were converted into Celsius by following equation: $5/4 * \text{Réaumur}$, and daily mean temperature have been calculated from the converted temperatures.

Furthermore, calculated daily mean temperatures in Celsius from the same period exist in another document. There is generally a good agreement between the read and the calculated mean temperatures.

The data can also be found in 2 specific spread sheets called “ThermLAE_1798.xls” and “ThermLAE_1799.xls”, where data furthermore are plotted for visual check.

3.8. Period 1800 (RdtDay_1800)

In this year (1800) the meteorological observations was taken from the Observatory on top of the tower Rundetårn, Copenhagen.

The data are from a document with daily temperature measurements in Réaumur. The daily mean temperature have been converted into Celsius by following equation: $5/4 * \text{Réaumur}$.

The data can also be found in a specific spread sheet called “ThermLAE_1800.xls”, where data furthermore are plotted for visual check.

3.9. Period 1801 – 1819 (Rdt3Day_1801_1819)

In this period (January 1801 to December 1819) the meteorological observations was taken from the Observatory on top of the tower Rundetårn, Copenhagen.

The data are from a document with three daily temperature measurements in Réaumur. The three daily temperatures were converted into Celsius by following equation: $5/4 * \text{Réaumur}$, and daily mean temperature have been calculated from the converted temperatures.

Furthermore, calculated daily mean temperatures in Celsius from the same period exist in another document; 1801 – 1817 from Rundetårn, Copenhagen and 1818 – 1819 from Gl. Botanisk Have, Copenhagen. There is generally a good agreement between the read and the calculated mean temperatures.

The data can also be found in 19 specific spread sheets called “ThermLAE_1801.xls”.....
“ThermLAE_1819.xls”, where data furthermore are plotted for visual check.

3.10. Period 1818 – 1860 (GIBot_1818_1860)

In this period (January 1818 to December 1860) meteorological observations was taken from The Old Botanical garden, Gl. Botaniske Have (Charlottenborg Haven), Copenhagen in shadow conditions. The location can be seen at figure 1 and 2.

The data are from a document with daily mean temperatures in Celsius. The mean temperature was calculated from three to five daily temperature observations.

For the years 1829, 1830, 1853 and 1855 also mean temperature data in Réaumur were found. Generally there is agreement between the two temperature units.

The data can also be found in 42 specific spread sheets called “ThermLAE_1818.xls”.....
“ThermLAE_1860.xls”, where data furthermore are plotted for visual check.

4. Missing temperature data

Following data is missing from the original documents from Rundetårn, Copenhagen:

- 1780 – 1781.
- July 1788.
- 1789 – 1797.
- 15 – 21 December 1800.
- Many missing observations in March, April, June and July 1802.
- 3 – 6 September 1807: The daily temperature readings are missing these four days because Copenhagen was bombed by the English navy. The following remark was found in the document: *”3–6 Septbr. I disse 4re Dage kunde ingen meteorologiske Observasjoner anstilles fordi Bÿen blev bombarderet af den fjendtlige Engelske Belejningsarmé”*. English modern translation: *3 – 6 September. During these 4 days no meteorological observations were*

taken, because the city was bombed by the hostile English siege army". However, daily mean temperatures were found for these four days. It is not known which original measurements they are calculated from.

- February 1816: The original temperature data measured three times daily and the daily mean temperatures are missing.
- January – July 1818: The original temperature data measured three times daily and the daily mean temperatures are missing.

Following data is missing from the original documents from Gl. Botanisk Have, Copenhagen:

- 1825: The full year is missing
- 1826: January – April and September – December are missing
- 1860: From 1 July the observation site was moved to the Royal Veterinary and Agricultural University, Copenhagen.

5. The quality of the data

All the observations have been notified in tables, and the readability from the original documents was fairly clear. In the cases where the documents contain three daily observations (Rdt3Day_1798til1799 and Rdt3Day_1801til1819) a generally good agreement between the read and calculated daily mean temperatures was found.

The daily mean temperature is based on three to five observations every day. These observations are most common in the periods 7 – 8 am, 12 am – 1 pm and 8 – 11 pm. There were at that time no observations performed during night. To get the “true” daily mean temperatures it was necessary to correct for the missing night observations. For that reason care should be taken when comparing daily mean temperatures without corrections and daily mean temperatures with corrections.

The accuracy of the thermometer is not known, but a note on an original document from Rundetårn, Copenhagen 30 September 1813, gives some indications that the observations were taken with care:

”Om Morgenen bemærkeder at et Stykke af Qvægsölv Colonnen i Röret af det store Thermometer i fri Luft havde skilt sig fra den övrige Qvægsölvcollone, som viste +3,2°, og sad fast omtrent ved 14°. Bemeldte fraskilte Stykke var omtrent 1° i Störrelse, hvilket först idag Morgen blev bemærket. Heraf følger at alle det udvendige Thermometer Höjder ere formodentlig omtrent fra d. 21 Septbr. henved 1° for smaae. Den fölgende Dag d. 1 Octbr. om Morgen förend Observationen blev denne Fejl afhjulpen ved at opvarme Thermometrets Kugle indtil Qvægsölvvet steeg op til det fraskilte Stykke og foreenede sig dermed.”

English modern translation: ”In the morning we noticed that a piece of the mercury column in the large thermometer was separated from the rest of the mercury column, the latter indicated a temperature of +3,2°. The little piece was fixed at 14° and was 1° in size. It was first time noticed this morning. As a consequence of that all thermometer readings from 21 September probably are 1° to small. The following day 1 October in the morning before the observation this defect was taken care of by warming up the circular container of the thermometer until the mercury rise to the separated piece and joined it.”

For the years 1767 – 1776 was there both a monthly mean temperature without correction and an average monthly temperature. These two temperature data were compared to each other (see the single sheets for each year). General was there a good agreement between the data, except for the three months February 1767, October 1769 and December 1769 which is in discrepancies.



6. Data files

The data following this report can be found in:

- 1) A summoned spread sheet: **cph_temp_data_1767_1860.xls**, where the different folders in this spread sheet represents different periods with data.
- 2) 77 Specific spread sheets with data from the individual years: **ThermLAE_<period>.xls** (ThermLAE = Therm. libero aéri expo (thermometer in free air)).
- 3) One graph: **dataplot_all.pdf**, where all the data are plotted.



References

Willaume-Jantzen V.: Meteorologiske observationer i Kjøbenhavn. Det Danske Meteorologiske Institut, Kjøbenhavn 1896.

Cappelen J., Laursen E. V. Jørgensen P. V. and Kern-Hansen C.: DMI monthly Climate Data Collection 1768-2005, Denmark, The Faroe Islands and Greenland. DMI Technical Report No. 06-09, Copenhagen 2006.

Previous reports

Previous reports from the Danish Meteorological Institute can be found on:

<http://www.dmi.dk/dmi/dmi-publikationer.htm>



Appendix 1. Specific note about the data in Excel

In Excel the date is given as a number of days from 1 January 1900. When working with dates prior to year 1900 Excel automatically adds 1900 to the date. For example is the 1 January 1767 not written as 01-01-1767 but as 01-01-3667. This problem can be solved by installing the program “Extended Date Functions add-in (XDate)”:

1. Download “Extended Date Functions add-in (XDate)” from:
www.j-walk.com/ss/excel/files/xdate.htm
2. Run xdate.exe
3. Start Excel
4. Select Add-Ins from the Tools menus. This menu won't be available if a workbook is not displayed.
5. In the Add-ins dialog box, click Browse
6. Locate the xdate.xla file, and click OK to close the Browse dialog box. By default, this file is located in: c:\program files\xdate
7. Mark the “Extended Date Functions” and click OK to close the Add-Ins dialog box.