Recovery and disclosure of historical meteorological observations (Hisklim)

Theo Brandsma

Introduction

In the year 2000 KNMI started a programme on data rescue, digitising and time series homogenisation, named Hisklim1) (http://www.knmi.nl.onderzk/hisklim). The aim of the programme is to make historical land and sea climate data from Dutch sources digitally accessible, with the highest possible time resolution and quality. The data extend back into the 17th century and stem from a variety of ship and station observations (see Figure 1 for the main types of data and time periods covered by Hisklim). The resulting high-quality datasets are needed to properly assess climate change and variability. Moreover, the datasets are also required to validate climate models. The output of these models is the basis for the development of climate change policies and climate scenarios for the 21st century, which are increasingly being used in climate change impacts and adaptation studies. All historical data disclosed by Hisklim is freely available for research, engineering, and the general public from the KNMI website at http://www.knmi.nl/klimatologie.

In the first part of this chapter we present examples of the digitisation projects. Digitisation is a labour-intensive task that needs to be carried out with care. Figure 2 shows a specimen of an 18th century

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Figure 1. Types of data and time periods covered by Hisklim.

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<tr>
<th>Maritime</th>
<th>17th century</th>
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<th>19th century</th>
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<td>Light vessels</td>
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<td>Weather ships</td>
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<td>COADS</td>
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<td>Marine ships</td>
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<td>Pre-1800 ships</td>
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<tr>
<th>Land</th>
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<th>18th century</th>
<th>19th century</th>
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<td>KNMI-stations</td>
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<td>Colonial stations</td>
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<td>5-minute rainfall</td>
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Digital | Non-digital (at the start of Hisklim)

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Figure 2. Specimen from the weather diary of Jan Carel van der Muelen. The weather observations (partly in Latin) and measurements are taken partly in Utrecht and partly in Driebergen and cover the period 1759–1810.
hardcopy data source available in the archive of KNMI. This kind of data is digitised by making an electronic copy (jpeg-images), which is used to type the data into a spreadsheet. Both the images and the data are made accessible via the internet. The work is embedded internationally: from 2001-2004 the digitisation of pre-1850 ship logs got a boost from the KNMI participation in the EU-funded project CLIWOC (Climatological Database for the World’s Oceans 1750-1850; (http://www.knmi.nl/cliwoc). From March 2005 until March 2009, part of the work is being funded through the KNMI participation in the National project Climate changes Spatial Planning (http://www.klimaatvoorruimte.nl).

In the second part of the chapter, we present some examples of current work on homogenisation of climatological time series and datasets. Inhomogeneities result from e.g. changes in instrumentation, repositioning of instruments (both horizontally and vertically), changes in the surroundings like the growth of trees and the expansion of cities, and changes in measurement practices. We focus on improving homogenisation methods by studying the weather-dependence of inhomogeneities. An important goal is to obtain a homogeneous version of the so-called Zwanenburg/De Bilt subdaily temperature time series that covers the period 1706 until present. The digitisation efforts presented here are partly meant to obtain parallel time series for homogenising that series. To address deficiencies in present-day homogenisation methods, an EU COST action ES0601 (http://www.cost.esf.org/) started in 2007. KNMI participates in this action.

Digitisation

KNMI yearbooks

The 19th century KNMI yearbooks are an important source of information. The meteorological observations in these books constitute a crucial link between the pre-1850 measurements (before the founding of KNMI) and the modern post-1900 observations. The observations consist of (mostly) three measurements a day of air temperature, air pressure, humidity, wind speed and direction, cloudiness, and of daily measurements of precipitation of a varying number of stations (23 in total) distributed across the Netherlands. In the year 2006 we completed the digitisation of these data. About 0.6 million records (550 station-years) were digitised and quality controlled. About 40% of the data is now available via the KNMI website and the remainder will become available in 2007.

Amsterdam City Water Office

From about the year 1675 onwards, the Amsterdam City Water Office was responsible for the water management of the canals in the city. At that time, Amsterdam was situated along the open sea, and the canals in the city, which also served as sewer system, had to be flushed using the tide. Meteorological measurements were made by employees of the office to support this work. These measurements are unique in the sense that in the 1784-1963 period the measurements were taken hourly. In the beginning air temperature, windspeed and direction were measured. From 1824 onwards, air pressure was added. In the 1784-1963 period, the office moved three times to a new location. The handwritten observer logbooks were put on microfilms in 1984 by the Amsterdam City Archive and KNMI obtained a copy. Recently, we transformed the films into jpeg-images which were subsequently used as a basis for digitizing all 1.6 million observations. The first part of the work was finished in 200416, the second part, including Quality Control (QC), in 2006. In 2007 the data will become available.

Daily rainfall 1850-1950

KNMI measures daily rainfall since about 1850. In the 1850-1950 period, the network gradually increased to its present density of about 300 rain gauges. The measurements are taken by voluntary observers every morning. In the first decade of the 20th century a standardization of the measurements was implemented. In contrast to the post-1950 period, where all observations are digitally available, only about 10% of the observations were digitally available in the 1850-1950 period. In the years 2005 and 2006 we digitized all pre-1951 daily data, amounting to about 4.7 million observations (13500 station-years). It took two man-years of typing in the data. The data will become available in 2008 after QC and homogeneity testing.

Rainfall strip charts and paper rolls

Self-recording rain gauges (Figure 3) have been
applied for continuous rainfall measurements at a selected set of KNMI stations since the end of the 19th century. At first, rainfall was recorded on daily (Figure 4) and sometimes weekly rainfall strip charts. Thereafter, from about 1980 through 1993, paper rolls were used to register rainfall for about 10-20 days per roll. From 1994 onwards, rainfall measurements are transferred electronically and operationally stored at 10-minutes resolution (for some selected stations at 1-minute resolution). Until now, the strip charts and paper rolls have been used mainly for extracting hourly values. In infrastructural design (e.g. sewer systems, tunnel drainage) there is, however, a need for long rainfall series with much higher resolution than 1 hour. Fortunately, the charts and rolls can be used to extract rainfall with a time resolution of about 5 to 10 minutes.

We are developing a procedure that largely automates the labor-intensive extraction work for rainfall strip charts and paper rolls. Although developed for rainfall, it can be applied to other elements as well. The procedure consists of four basic steps: (1) scanning of the charts and rolls to high-resolution digital images, (2) applying automatic curve extraction software in a batch process to determine the coordinates of cumulative rainfall lines on the images, (3) visually inspecting the results of the curve extraction, (4) post-processing of the curves that were not correctly determined in step (3). Although KNMI is still perfecting the software, several tens of station-years have successfully been digitised. The time resolution is about 5 minutes. In total 321 station-years are being digitised using the stations De Bilt, Eelde, Den Helder/De Kooy, Vlissingen, Beek and Amsterdam. When the digitisation is completed, the number of station-years with digital 5-minute rainfall series will be increased by a factor of 25. The data will become available in 2009.

Homogenisation and quality control

Thermometer screen intercomparison

Thermometer screens protect thermometers against unwanted impacts like direct or indirect radiation and rainfall. On the other hand, the screens may complicate the measurement of the real air temperature by restriction of the air flow and self-heating. To obtain a homogeneous version of the Zwanenburg/De Bilt temperature series (1706 until present), it is therefore important to know and understand the effects of changes in thermometer screens. One of our activities to study this topic has been to reanalyse the results of a thermometer screen intercomparison that took place at the KNMI terrain in the period 1989-1995. The objective of the analysis was to obtain weather-dependent corrections for past changes in screen types. Ten screens (Figure 5) were compared. All were equipped with fast-responding sensors. Figure 6 presents an example of inter-screen temperature differences for the summer. For some of the screens, the figure clearly shows that the differences strongly depend on the weather. Despite the sometimes large temperature differences on specific days, the annual
mean differences for daily maximum, minimum and mean temperature rarely exceed 0.1°C. The strongly aspirated Young screen (Young.aspII) is an exception, with annual mean maximum temperatures 0.28°C below the reference. Comparison of modern-day screens with older (e.g. 19th century) screens, however, reveals annual mean differences of the order of 1.0°C. For a transition of the natural ventilated synthetic Stevenson screen to the present round-shaped multi-plate operational screen, we successfully developed transfer functions. These functions may be used for correcting inhomogeneities in times series resulting from screen changes.

Site intercomparison
Besides the effects of screen changes on temperature measurements, it is also important to know the impact of changes in the location of the screen. We therefore compared five temperature measurement sites at the KNMI terrain in De Bilt (see Figure 7), among others the current operational site (DB260), an intended future operational site (Test4) and the site that was used around 1950 (Test5). From May 2003 through June 2005, temperature and wind speed were measured simultaneously at these locations at a height of 1.5 m. Temperature differences are most evident during clear-sky night-time conditions with low windspeeds. Figure 8 shows the mean differences in minimum temperature relative to the Test4 site. Note the relatively large negative values in and around the summer months of 2003 and 2004 for the DB260, Test2 and Test3 sites. Due to a renovation of the nature area west of DB260 in October 2004, the values of these sites in 2005 are close to zero. The results are important for assessing and understanding the impact of past repositionings and for deciding upon a repositioning of the present operational temperature site.

Development of homogenisation techniques
Homogenisation of climate time series and datasets with a daily resolution is a relatively new field of research. We contributed to that research by introducing nearest-neighbour resampling for homogenizing temperature records on a daily to sub-daily level. We developed the method to obtain daily mean and sub-daily temperatures from time series subject to irregular observation frequencies and changing observation schedules. This is especially important when we connect the De Bilt series to the older parts of the Zwanenburg/De Bilt series. The method resamples diurnal temperature cycles from an observed hourly temperature sub-record at the station. Unlike other methods, the technique maintains the variance in a natural way. This is especially important for the analysis of trends and variability of extremes. Nearest-neighbour resampling can successfully be performed, even in situations were the length of the hourly sub-record is an order of magnitude smaller than the length of the series to be homogenized.
Homogenisation of climate time series and datasets with a daily resolution is a relatively new field of research

Outlook

Our digitisation efforts will continue in the next years. Besides the activities mentioned above, we are also digitising the data from the former Dutch colonies and the remaining part of the old pre-1850 measurements in the Netherlands. Furthermore, from the remainder of the ship logs at KNMI we made digital images that have been sent for digitisation to the US, where funds and labour are available for that work. To support the QC and homogenisation work, we are making digital images of the complete hardcopy metadata archive at KNMI. The images facilitate the digitisation of metadata relevant for homogenisation studies.

The work on the homogenization of the daily Zwanenburg/De Bilt temperature time series will also continue. A first release of the homogenized temperature time of the De Bilt series is available at http://www.knmi.nl/klimatologie for monthly values. As part of the homogenisation efforts, we also study the effect of urban warming on the temperature measurements in De Bilt. After an initial statistical study[8], we are now performing mobile temperature measurements in a transect containing Utrecht and De Bilt for a period of about one year. Besides temperature, we are also working on pressure observations. We recovered a 17th century series of daily air pressure readings from Leiden (1697-1698)[9]. This is one of the very few pressure series that extend back into the 17th century that may help to reconstruct the daily atmospheric circulation for Western Europe in that period. We are also working on a homogeneous daily air pressure time series for the Netherlands (1712 until present). Finally, we are contributing to the QC of the maritime US Maury collection.

Together with other international efforts similar to Hisklim, the work presented here will help to place the current climate in the right historical perspective.
4) Brandsma, T. and J.P. van der Meulen. Thermometer Screen Intercomparison in De Bilt (the Netherlands), Part II: Description and modeling of mean temperature differences and extremes. Int. J. Climatology, in press.