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HISKLIM-8

HISKLIM-COADS

Final report

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The KNMI-program HISKLIM aims at making historical land and sea climate data from Dutch sources physically accessible, with the highest possible time resolution and quality. The program started in 2000 and will run 5 to 10 years.

HISKLIM-1	Het KNMI-programma HISKLIM (HIStorisch KLIMaat). T. Brandsma, F.B. Koek, H. Wallbrink en G.P. Können. (also KNMI-publication 191)
HISKLIM-2	Gang van zaken 1940-48 rond de 20.000 zoekgeraakte scheepsjournalen. H. Wallbrink en F.B. Koek. (also KNMI-publication 192)
HISKLIM-3	Historische maritieme winsdschalen tot 1947. H. Wallbrink en F.B. Koek. (Memorandum)
HISKLIM-4	Onbekende weersymbolen in oude Extract-Journalen (1826-1865). H. Wallbrink en F.B. Koek. (Memorandum)
HISKLIM-5	CLIWOC, Multilingual Meteorological Dictionary; an English-Spanish-Dutch-French dictionary of wind force terms used by mariners from 1750-1850 (also KNMI-publication 205)
HISKLIM-6	DIGISTAD (DIGitaliseren STADswaterkantoor). H.W. Riepma. (Memorandum)
HISKLIM-7	Parallel air temperature measurements at the KNMI-terrain in De Bilt (The Netherlands) May 2003-April 2005. T. Brandsma (Interim report)

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Contents

Abstract

The availability of a – though limited – number of Dutch meteorological ship logbooks from the period 1854-1938 and the accessibility of several archived documents and manuals gave the opportunity to investigate the methods of measuring sea level pressure on board ships and describe the practice of processing the recorded data afterwards. In Wallbrink et al. (2003), we showed that from the very start of the marine meteorological data acquisition, from 1854 onwards, the Dutch procedure for pressure reduction was consistent throughout. This cleared up the doubts that were attributed to the Dutch marine sea level pressure observations covering the period 1854-1938. As a result 5.7 million Dutch marine sea level pressure observations are now incorporated in ICOADS release 1c climatology. We present more background information about the used barometer corrections and the quality of the Dutch marine sea level pressure data, used in ICOADS. Unfortunately we determined that the Dutch ship logbooks, containing additional meta data, are presumed to be lost forever.

Introduction

Acquisition of marine meteorological and oceanographical observations from Dutch ships took place since the establishment of the Royal Netherlands Meteorological Institute (KNMI) on 31 January 1854. During the period 1854-1938 meteorological observations were recorded 6 times per day in meteorological ship logbooks. In the period 1924-1943 about 6.6 million Dutch meteorological observations, including about 5.7 million marine sea level pressure observations covering this period, were digitized i.e. key-punched on punch cards. Towards the end of the 20th century the quality of the punched marine sea level pressure observations from this period came under debate. This was a major problem for the internationally used marine climatological database COADS (Comprehensive Ocean Atmosphere Data Set (Woodruff et al., 1987, Elms et al., 1993; recently renamed I-COADS (Diaz et al., 2002) and subsequently ICOADS (Parker et al., 2004), the 'I' standing for International). Due to ambiguities in the gravity correction, the 5.7 million Dutch marine sea level pressure observations were kept out of the 1985 COADS release 1 monthly summaries. If we would succeed resolving the ambiguity the sea level pressure observations could be added to the statistics of these summaries and enhance their accuracy dramatically. Since the important meta information was only available in the original meteorological ships' logbooks, it was necessary to find either these logbooks or come with another solution. However, at the end of WW II almost all of the KNMI meteorological ship logbooks were confiscated by the German occupier and never returned. The confiscation of the ship logbooks and a description of the search for these books after the war could be reconstructed by the discovery of 85 originally letters, correspondence and official copies about this matter in a KNMI archive (Wallbrink and Koek, 2000). In addition some selected correspondence with foreign museums and institutes on the matter of the lost Dutch ship logbooks is attached in Annex A.

Reconstruction confiscation KNMI ships' logbooks

At the end of WW II, during the period December 1944 - January 1945, the German 'Oberkommando der Kriegsmarine' at Berlin gave the order to confiscate all of the 20,000 KNMI marine meteorological and oceanographical ships logbooks. The 'Kriegsmarine' i.e.

the German Navy who was in control during that time at KNMI, transported the logbooks by train to Greifswald, situated in northeast Germany (see Figure 1).

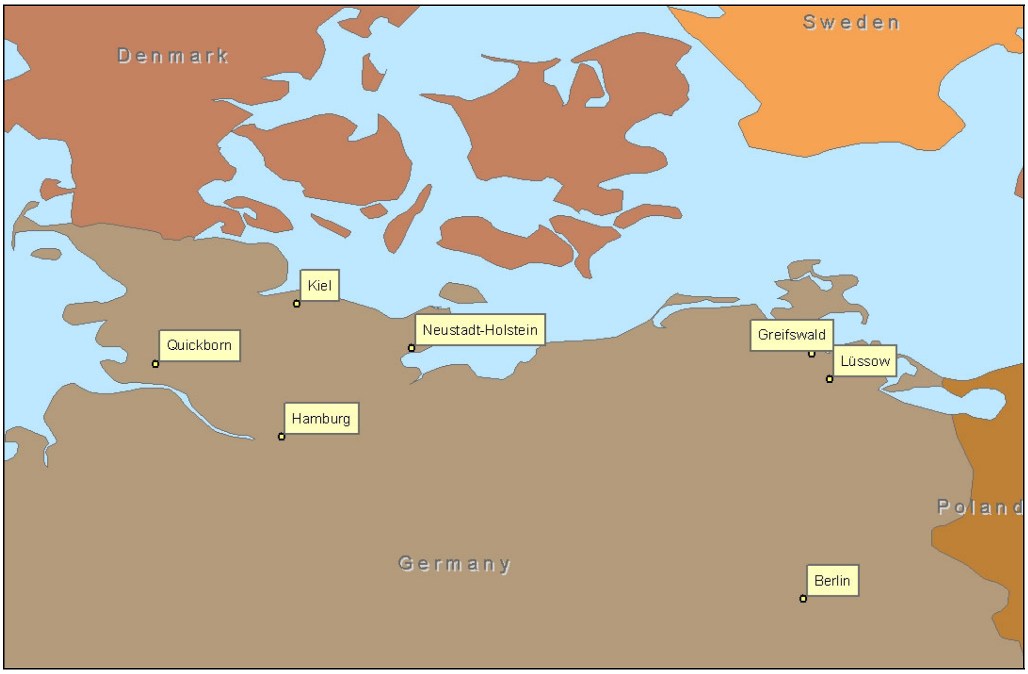

Figure 1. Northern Germany

Also 8 million punch cards with ships' meteorological observations and associated equipment like key-punching machines were moved from KNMI to Greifswald where they were stored in the 'Marine Observatorium'. The ship logbooks were separately stored, about 20 km southeast of Greifswald, in the castle Lüssow. The reason for this was that the Germans would like to store valuable climatological data in a safe place away from possible hostilities, like air attacks. Two days before the Russians took over Greifswald on 29 April 1945, the 'Marine Observatorium' was moved to West Germany. The Germans transported the Dutch punch cards and 5 key-punching machines by ship, the 'Boergen' and 'Martha Gneis', to a small town, Neustadt-Holstein, in the vicinity of Kiel were the 'Marine Observatorium' owned some storage rooms in a submarine school. Because the Germans were not able to arrange transport between Lüssow and Greifswald on short notice, the Dutch ship logbooks were left behind in the Russian zone. After the German capitulation the Dutch punch cards and key-punching machines were discovered by the meteorological service of the British Royal Air Force, and were moved to the British meteorological radio station Quickborn, about 10 km north of Hamburg. During November 1946 the punch cards and the key-punching machines were returned to the Netherlands again. The ship logbooks however, could not be located and are presumed to have disappeared somewhere in the former Soviet Union (Wallbrink and Koek, 2000).

Quest for the ship's logbooks

Soon after WW II, several attempts were made to retrieve the valuable KNMI logbooks. A thorough search at a politically high level during some years after the capitulation took place. Recent intensive email correspondence, including Russian marine climatological scientists, also did not lead to the lost logbooks. However, a small number of meteorological ship logbooks (128 covering the period 1851-1860) were safely hidden during the WW II and not transported to Germany. According to archived correspondence (KNMI, 1947), 138 severely damaged logbook pages of the approximately 20,000 complete meteorological ship logbooks were returned on 16 June 1947 (Wallbrink and Koek, 2000). Unfortunately these pages could not be located.

Due to the absence of the majority of the original logbooks the interpretation of the data found on the punch cards is very difficult. Not all meta information that was available in the original logbooks was transferred onto the punch cards. Meta data concerning the type of the ship, use of instruments, applied corrections, etc. is merely unavailable.

Data and Meta data

Although the key-punching of the meteorological ship logbook observations at KNMI started in 1924, almost the entire number of ship's observations, covering the period 1854-1938, was key-punched on 45 columns punch cards between 1936 and 1943. For the punching special KNMI punch codes (KNMI, 1941) were used (code 2 and 7), that prescribed that sea level pressure was to be punched in tens, units, and tenths of millimeters omitting the initial 7 (thus 568 represents 756.8 mm). According to the punch codes, the punched sea level pressure was corrected for temperature and was reduced to sea level but not corrected for gravity.

Dutch ICOADS ships'observational data

The 45 columns punch card deck was reproduced during the years 1951-1953 onto 80 columns punch cards, IBM#A11831 (see Figure 2), and transferred to the USA in 1954 for use in the marine climatological database COADS. The card deck was added to the COADS database under the name 'Deck-193' and contained nearly 6.6 million world wide Dutch ship's observations, including 5.7 million sea level pressure observations. According to the American reference manual of Deck-193 (Reference manual, 1954), the make-over in the USA was accomplished on a slightly revised 80 columns card, IBM#809691. Deck-193 still forms the largest source of data prior to 1900 within the ICOADS database.

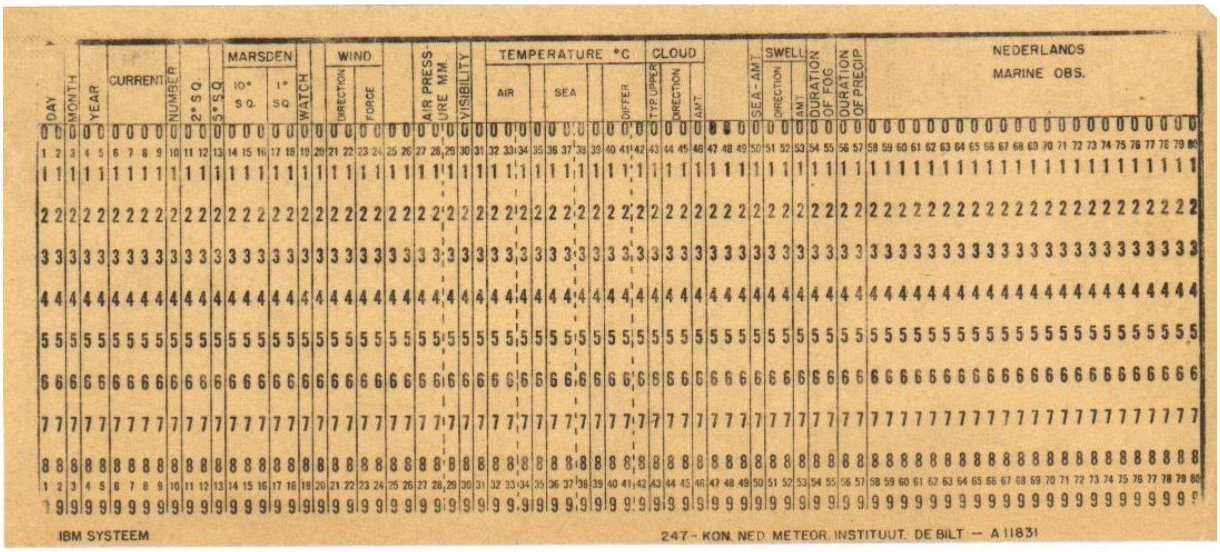

Figure 2. Punch card, IBM #A11831, used for reproduction of Dutch marine meteorological data for COADS. Only the first 57 characters were used

KNMI ship's data

At present the ship's data preserved at KNMI covering the period 1854-1938, the so-called 120-character format code 28 data, are probably less reliable than the American Deck-193 data. Between 1961 and 1963 all original 45 columns punch cards were reproduced onto 80 columns punch cards according KNMI punch code 28 and subsequently destroyed. Due to dust and many of the same repeating punch holes, the rollers of the key-punching machines locally burnt in and introduced many errors. Later, in 1968, the data were reproduced onto magnetic tape at the *Rijks Computer Centrum*. KNMI was not able to pay sufficient attention to the procedures due to lack of manpower. Later it was found that errors occurred in about 10% of all observations (Broersma, 1981). During the period 1980-1981 all the KNMI code 28 ship data were re-examined and cleaned. However, some new errors, e.g. in date-time and the sign of the gravity correction, were introduced. These errors are still not corrected in the KNMI database. We therefore recommend using the original Dutch ship data of the ICOADS database for climatological purposes, rather than the KNMI 120-character format code 28 data. A copy of the Deck-193 data set is kept at KNMI.

Metadata

Uncertainties and differences in the data can only be explained and solved with the help of the original ship's logbooks. With the help of the rescued logbooks it was possible to confidently reconstruct in what way the original logbooks were prepared for key-punching and which corrections were applied. Most logbooks, including the rescued logbooks, were key-punched between 1936 and 1941 by the same people, mostly unemployed captains and deck-officers. Therefore it is assumed that the punching of all the logbooks was done consistently with the same criteria for the logbooks from the period 1854-1938.

The mercury barometer

Prior to 1939 the Dutch marine mercury barometers were equipped with a scale, graduated in millimeters or inches of mercury (Hg). Both readings of the barometer and of the attached thermometer (Celsius or Fahrenheit) were recorded in their original units into the meteorological ship logbooks. The International Meteorological Conference of Copenhagen in 1929 (Secrétariat du Comité Météorologique International, 1930) introduced the unit millibar instead of inches or millimeters Hg. As one of the last countries in Europe, the Netherlands switched over from millimeters Hg to millibars in October 1938 (Keyser, 1939). From that time on KNMI supplied ships with a 'standard' marine mercury barometer, equipped with a scale graduated in millibars.

Before 1938 the design and construction of the ships' mercury barometers was left completely to the manufacturer. Shipping companies and captains mentioned no particular requirements on the capacity and diameter of the capillary glass tube at the purchase of a mercury barometer. Basically the only demands were a constricted glass tube, to avoid 'pumping' of the mercury by the ship's movements, and an accompanying reasonable lagging time of the barometer.

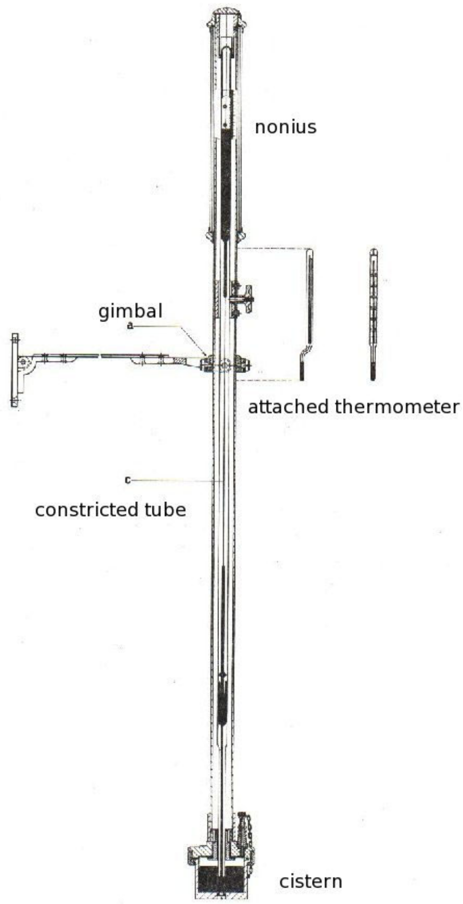

Figure 3. Marine mercury barometer used on board Dutch ships

Several brands of mercury barometers with different barometer capacities were found on board of the Dutch merchant fleet. The most common brands were: *H. Olland*, *W.C. Olland*, *L.J. Harri* and *G. de Koningh*. Due to accidents during the voyage, e.g. breaking of the glass tube in stormy weather, also English Kew Pattern marine mercury barometers, acquired abroad, were found on Dutch ships.

The aneroid barometer

KNMI did not allow aneroid barometer readings for regular ship observations until 1955 (KNMI, 1958). Even if the mercury barometer was out of order or broken it was not allowed to use the aneroid barometer instead. If the reported sea level pressure was measured with an aneroid barometer the observations dating from before 1955 were not key-punched at KNMI. The ship aneroid barometers were considered unreliable because they showed an erratic behavior due to temperature changes that affected the levers and springs inside the instruments. An exception was made for instruments constructed in the factory of Naudet (former Vidi) in Paris. Buys Ballot treated these aneroids as more reliable than the common aneroid barometers because of their higher quality (Buys Ballot, 1889).

Regulations how to handle ship's mercury barometers

The following instructions were found (KNMI, 1853)

- The barometer should be gimbaled.
- The glass tube should be vacuous.
- The mercury should be clear of any air bubbles.
- The glass tube should be constricted.
- The barometer should not be exposed to direct sunlight or draught.

Barometric corrections for the ship's mercury barometer

While aneroid barometer observations should only be corrected for index and height above sea level, mercury barometer readings prior to 1938 had to be corrected for various reasons (Keyser, 1940):

a. **Temperature correction (mm)**

The commonly used formula for calculating the pressure *p* corrected to 0°C is:

$$p = (1 - f)p^*$$

where

$$f = \frac{(\alpha - \beta)t}{1 + \alpha t}$$

and,

α = cubic expansion coefficient: 182 * 10^{-6} [$°C^{-1}$]

β = linear expansion coefficient: $19 * 10^{-6}$ [°C^{-1}]

t = temperature of the mercury and the graduation scale [°C]

p^* = barometer reading [mm Hg] at temperature t

p = barometer reading [mm Hg] corrected to 0°C

During the second part of the 19th century the temperature correction was calculated in two parts, one for the expansion of the scale and one for the expansion of the mercury. The temperature correction table used in the first half of the 20th century, before 1938, was calculated by using the formula for estimation (Keyser, 1940). For mercury barometers with reduced graduation, i.e. all Dutch ships' mercury barometers, the formula is not exactly correct. In 1939 it was decided that an extra correction of 4% on average, had to be applied to the existing temperature corrections. For temperatures in the tropics this meant a rise of a few tenths of a millibar.

b. Capacity or cistern correction (mm)

The relation between the diameter of the mercury in the cistern around the tube and the diameter of the mercury in the tube at the top of the mercury column is called the capacity. Barometers of the brand *H. Olland, W.C. Olland and L.J. Harri* all had a capacity of 24. G. *de Koningh's* barometer had a capacity of 45. The neutral point of the barometer is the reading at a temperature of 0° Celsius, where point zero of the graduation is equal to the mercury level in the cistern. The sign of the correction determines how the correction is to be applied.

Capacity correction = (reading - neutral point) / capacity

Both capacity and neutral point were noted at the first pages of the ship's logbook. For barometers of the Fortin type, normally not in use on Dutch ships, this correction is not necessary.

c. Capillarity correction (mm)

The fine capillary glass tube of the barometer causes a depression of the mercury level in the tube, resulting in a reading of the barometer that is too low. The size of the error depends on the diameter of the glass tube (see Table I). Glass tubes with a diameter less than 6mm were not allowed on Dutch ships.

Diameter (mm)	Correction (mm)
10.0	+0.42
9.5	+0.47
9.0	+0.53
8.5	+0.60
8.0	+0.68
7.5	+0.77
7.0	+0.88
6.5	+1.00
6.0	+1.14

Table 1. Capillarity correction

In the 20th century, the correction became more or less constant for barometers with a diameter of the glass tube of more than 6mm (1922) or 8mm (1940) and allowance could be made for them in the construction process. If the capillarity is considered constant it is included in the index correction. The index correction was recorded on the first pages of the ships' logbooks.

The metal protected mercury barometers of the brand *H. Olland*, in use at the Dutch Navy, do not need to be corrected for capacity and capillarity. The capacity and capillarity correction have already been taken care of in the graduation on the scale.

d. Height correction (mm)

In the lower part of the atmosphere, the specific gravity of mercury is approximately 10,500 times bigger than the specific gravity of air. The height correction amounts therefore *1 mm Hg for each 10,500 mm above sea level*. For each meter above sea level this means an addition to the observed pressure of approximately 0.09 mm Hg (equal to 0.12 hPa). The correction is not constant due to the changing draft of the ship and was recorded on the first pages of the meteorological logbook, preferably at the beginning and end of a voyage.

e. Index correction (mm)

The index correction is introduced to correct instrumental errors, that are mostly related to the positioning of point zero on the graduation. To determine the errors, the barometer is compared to a standard barometer of which the errors are accurately known. This was always done at KNMI or at one of its branch offices. The difference between the two barometers is called the index error. Inexperienced use or negligent treatment of the barometer may change the index correction; therefore additional inspectional observations are necessary. Inspectional observations against reliable instruments were done in the Netherlands at Amsterdam, Rotterdam, Den Helder and Vlissingen, and in Indonesia at Batavia (Nautical Institute of the KPM) and Surabaja (Naval yard). It was not allowed to determine a new index correction, based upon inspectional observations made by the ship itself. Re-verification of the index correction was only possible at the fore mentioned locations. Index corrections established in foreign (English) ports sometimes already include height and gravity corrections (adjusted fiducial temperature). These adjustments were usually accepted.

f. Gravity or latitude correction (mm)

Before to the introduction of the millibar graduation scale in October 1938, the gravity correction was not applied on board or at KNMI. Before punching, the barometer readings (expressed in millimeters or inches) were corrected to 'Adjusted Pressure', which is the reading of the mercury barometer, corrected for index (including capacity and capillarity), temperature (0° C) and height above sea level.

In those days the mariners were only interested in the deviation from the mean sea level pressure in certain, hurricane sensitive, areas. In meteorological atlases, issued by KNMI (Atlantic and Indian Ocean), the mean sea level pressure was not corrected for gravity. Consequently, to be able to compare the values properly, the sailors did not have to apply a gravity correction. For that reason inaccurate navigation (e.g. dead reckoning) did not bother them in determining the actual barometer's deviation (KNMI, 1937).

The unit conversion from millimeters to millibars was done at KNMI between 1950 and 1968 during the reproduction of the 45 columns punch cards to 80 columns punch cards according to KNMI key-punch code 28. During this reproduction the gravity correction was also applied (KNMI, 1955).

Reconstruction findings by Hadley Centre

As described in Wallbrink et al. (2003), the pre-1939 meteorological data in ICOADS consists for a substantial part of observations from Dutch vessels. They are part of the Dutch contribution to historical data of ICOADS for that period, which is a large set of 1854-1938 data that were mainly taken from Dutch ships. This Dutch data set is called ICOADS Deck-193. For the period 1854-1938, Deck-193 represents 22% of the ICOADS observations; for the sub-period 1854-1880 the Dutch contribution is nearly 60% (see Figure 4).

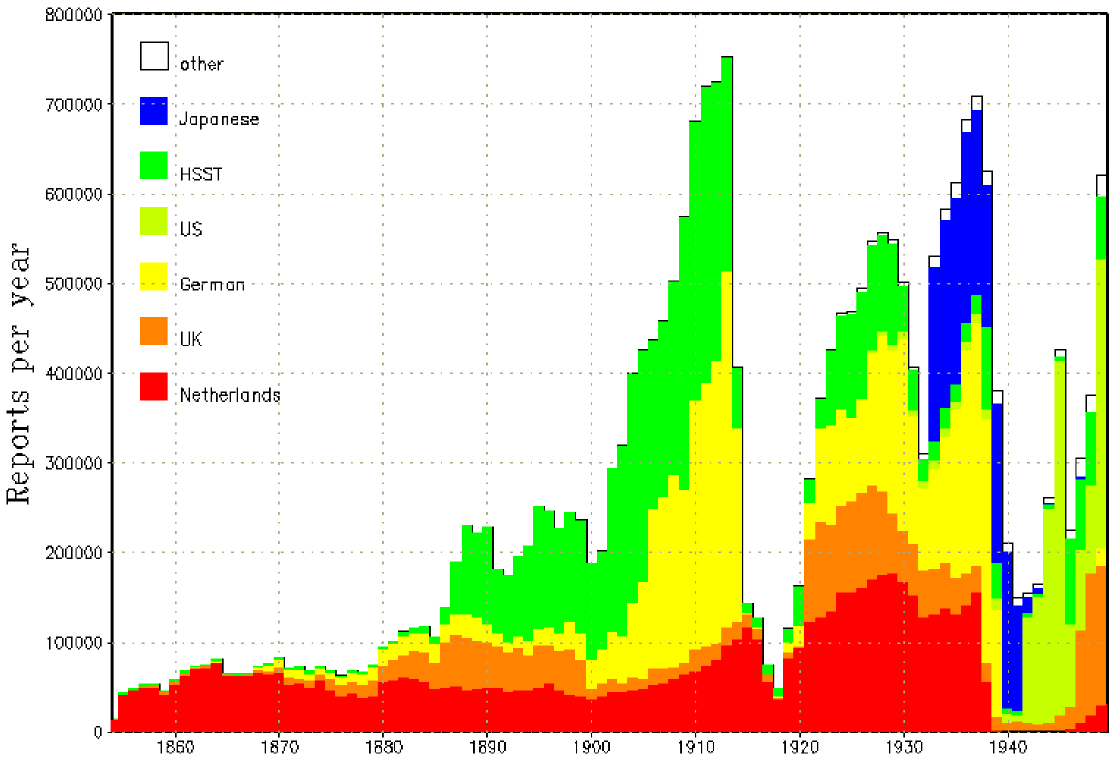

Figure 4. Annual number of observations per country of origin including the Historical Sea Surface Temperature (HSST) project data in the COADS Release 1 database 1854-1949 (Woodruff et al., 1998).

However, in the 1985 version of COADS (known as Release 1), the 5.7 million Dutch sea level pressure observations of Deck-193 were omitted from the 2°×2° MSTG (Monthly Summary Trimmed Groups). The reason was that at the time, only standardized sea level pressure data were considered in COADS (Woodruff et al., 1998), and the Dutch data of Deck-193 were not corrected for gravity. As the inclusion of the Deck-193 data would significantly improve the temporal and spatial density in the ICOADS sea level pressure grid boxes, it was considered in the late 1990's to incorporate them in the next (2001) update of historical data, now known as COADS Release 1c. A thorough study of this pressure problem was needed to underpin the reliability of the quality of these data. This study was carried out under the umbrella of HISKLIM at KNMI and is described in Wallbrink et al. (2003).

The steps that were taken were primarily aimed at reconstructing the behavior of the Deck-193 sea level pressure data that Basnett described to us in a personal communication at the end of 1999. She reported that the sea level pressure data in the area between 20°N-20°S exhibited a strange behavior with respect to the 1961-1990 climatology of the Hadley Centre Global Mean Sea Level Pressure Data Set (version GMSLP2.1f, Basnett and Parker, 1997). The bias of the Deck-193 data with respect to the climatology was reported to be time dependent. This roused suspicion about the consistency over time of the correction procedures applied to the raw logbook data, particularly with regard to the gravity correction. An irreparable offset would seriously degrade the value of the Deck-193 data. A check by us with the raw Deck-193 data confirmed the time dependency of the bias.

Solutions and releasing the sea level pressure data from Deck-193

A detailed comparison of Deck-193 with the original sources is not possible anymore, because virtually all 20,000 Dutch meteorological ship logbooks from the period 1854-1938 were transported to Germany and are presumed to be lost. Fortunately, 128 meteorological ship logbooks (205 worldwide ship voyages) covering the period 1851-1860 are preserved at KNMI.

First we looked into the instrument descriptions that were reported in the surviving original meteorological ship logbooks. With no exception, the instrumental sections indicate the use of a mercury barometer. This is in accordance with the formal regulations of KNMI, which forbade including readings from aneroid barometers in weather reports (KNMI, 1937). Then we compared the pressure data of the logbooks with the Deck-193 data, but no evidence was found from any of the 128 logbooks that gravity adjustments were ever applied to the Dutch data.

After these checks, we compared the Deck-193 data directly with the 1961-1990 mean values of the GMSLP2 monthly climatology. As explained in the paper (Wallbrink et al., 2003), we did not find any evidence for a bias in the Dutch data with respect to the 1961-1990 climatology. From this, together with our checks of the metadata described above, we concluded that the Deck-193 data are suitable for incorporation in ICOADS. The only correction that was needed for this data set is to apply the gravity correction throughout.

What remains to be explained is the anomalous trend in the Dutch sea level pressures in the initial calculation. Its cause appeared to be the climatological sea level pressure difference between the Indian Ocean and the Atlantic Ocean (see Figure 5).

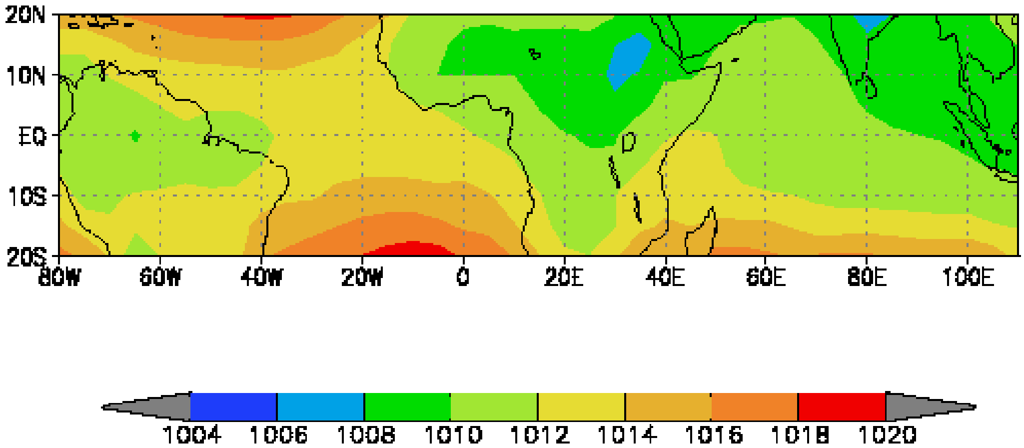

Figure 5. Mean annual pressure distribution in the 20°N-20°S belt, according to the 1961 1990 Hadley Centre GMSLP2 pressure climatology (Basnett and Parker, 1997). The pressure over the Indian Ocean is on average 2.6 hPa lower than the pressure over the Atlantic Ocean.

The mean 1961-1990 sea level pressures averaged over the 20°N-20°S belts of the Indian and Atlantic Oceans are 1011.1 hPa and 1013.7 hPa, respectively (Basnett and Parker, 1997). Hence the pressure over the Indian Ocean is 2.6 hPa lower than over the Atlantic Ocean area. The completion in 1870 of the Suez Canal resulted in a gradually increasing presence in the 20°N-20°S belt of Indonesia-bound Dutch ships in the Indian Ocean relative to the Atlantic, and hence in more observations from the oceanic regions of lower pressure. This is enhanced by the accompanying shift in the Indian-Ocean shipping lanes toward more northern regions, where the pressure is lower (see Figure 5). The result is a decrease of the annual Deck-193 mean sea level pressure if averaged over all observations in the Atlantic and Indian Oceans. As the vast majority of the Deck-193 observations in the 20°N-20°S belt originates from voyages between Europe and Indonesia, the decrease remains apparent in the averaged Deck-193 sea level pressure over the entire (360°) 20°N-20°S belt.

The magnitude of this 'Suez Canal effect' on the Deck-193 pressures is comparable with the magnitudes of standard barometer corrections, such as the temperature correction (Können et al., 2003) or the gravity correction.

The conclusion of this analysis is that comparison of Deck-193 with single-value climatology is not an appropriate procedure to assess the quality of the Deck-193 data. The reported time dependent offset in the Deck-193 data disappears if in the comparison with the 1961-1990 climatology the spatial distribution in the climatological pressure fields is properly taken into account.

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Annex A

A few responses on the quest for the missing ship logbooks

31 January 2000, Main Geophysical Observatory, Russia:

"Trying to find at least some traces of these logbooks I have talked with several former officers (now retired) of the Navy Hydrography Administration. Participating long ago in compiling of comprehensive ship observations data sets, they deny categorically even the probability of these logbooks to be here. So, I think the opportunity to find them in Russia is zero."

22 May 2000, All-Russian Research Institute of Hydrometeorological Information:

"Our institute have a big Historical Archive where is contain there are many hydrometeorological observations receiving from other country. But at present time I do not know about your logbooks and meteorological observations wich was made on boards Dutch merchant ships.

As well as I do not think that your observations between 1857-1937 was included in the our archive 'Mormet'. During the many years we can not to treat and digitize own historical marine meteorological observations. Unfortunately, now it is very difficult to define all updating contributions wich was made during creation archive 'Mormet'. There are many callsings is wrong and missing.

I will have been trying help you with logbooks, and let you know about my steps and new informations wich I will be getting. At the first I have must look for in our Historical Archive-library."

Some open ends

3 December 2001, no reply from:

Museum of the World Ocean
Naberezhnaya Petra Velikogo, 1
236006 Kaliningrad, Russia

10 December 2001, no reply from:

Department of Media Studies (Archives and Information Studies) University of Amsterdam