SHORT COMMUNICATION

Sea level pressure observations from Dutch ships 1854-1938 incorporated in COADS Release 1c climatology.

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ABSTRACT

The quality of the 5.7 million punched sea level pressure observations from Dutch ships 1854-1938 has been under debate due to ambiguities in the gravity correction. The observations were omitted from the 1985 COADS (Comprehensive Ocean-Atmosphere Data Set) Release 1 monthly summaries. We re-examined the Dutch data with the help of original meteorological ship logs. It is concluded that the Dutch procedure for pressure reduction was consistent throughout time. In the recent (2001) COADS Release 1c the Dutch data are incorporated. This increases the number of COADS pressure observations 1854-1938 by about 28%. For the 1854-1880 subperiod the increase is more than a factor two.

KEY WORDS: historical ship data; sea level pressure; data bases; COADS; marine data; Dutch ship observations.

The pre-1939 meteorological data in the Comprehensive Ocean-Atmosphere Data Set (COADS; Woodruff et al., 1987, Elms et al., 1993; recently renamed I-COADS (Diaz et al., 2002)) consists for a substantial part of observations from Dutch vessels. They are part of the Dutch contribution to historical data of COADS for that period, which is a big set of 1854-1938 data that were chiefly taken from Dutch ships. This Dutch data set is called COADS Deck 193. For the period 1854-1938, Deck 193 represents 22% of the COADS observations; for the subperiod 1854-1880 the Dutch contribution is almost 60% (Figure 1). However, in the 1985 version of COADS (known as Release 1), the 5.7 million Dutch sea level pressure (SLP) observations of Deck 193 were omitted from the $2° \times 2°$ MSTG (Monthly Summary Trimmed Groups). The reason was that only standardized pressure data were considered at the time in COADS (see Woodruff et al., 1998) whereas 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 COADS pressure grid boxes, it was considered in the late 1990s to incorporate them in the next (2001) COADS update of historical data, now known as COADS Release 1c.

By the end of 1999 it was reported (T. Basnett, pers. comm.) that the Deck-193 pressure data in the 20S-20N belt exhibited a strange behaviour 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 mean 1961-1990 pressure over the entire 20S-20N belt (1012.0 mb) 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. Figure 2, dashed line, shows that the Deck-193 offset with respect to the 1012.0-mb level is falling by a factor two between 1871 and 1890, after which it stabilizes around a value that roughly corresponds to the magnitude of the gravity correction (2.5 mb if averaged over 20S-20N).

It is well documented that the Dutch from the very start of the meteorological data acquisition in the 19th century onwards, routinely never applied the gravity correction to the SLP readings – neither for land station data nor for ship data (Onnen, 1844; KNMI, 1941). Only after the approval of the recommendations of the WMO 1929 conference in Copenhagen about standardization of SLP-data

(Secrétariat du Comité Météorologique International, 1930), did the Netherlands switch to the present system. For marine data, this occurred in the second half of 1938.

Deck 193 is the result of a big data-punching project of KNMI, which ran in the period 1935-1941. The total number of observations in Deck 193 is 6.4 million, of which 5.7 million include pressure. Although the data are of multinational origin, observations from Dutch vessels make up the vast majority: 95.3% of the Deck-193 observations are from Dutch log books, 3.4% are from Swedish logs and the remaining 1.3% is from other countries (KNMI, 1941). In the 20S-20N belt, as well as in the 19th century, the fraction of Dutch observations in Deck 193 is even larger. The anomalous behavior of the Deck-193 SLP-data (Figure 2, dashed) seemed to suggest that part of the observations, particularly in the early period, erroneously had been de-corrected for gravity prior to the punching. As the fraction of non-Dutch observations in Deck 193 is so small, it was at the same time clear that the effect could never been attributed to errors in the gravitation adjustment of the foreign observations alone.

A detailed comparison of Deck 193 with the original sources is not possible anymore. At the end of World War II almost all of the 20,000 Dutch meteorological ship logs from the period 1854-1938 were moved to Germany. At this present time they cannot be located and must be presumed lost (Wallbrink and Koek, 2000). Fortunately, there are 128 meteorological ship logs (205 worldwide ship voyages) covering the period 1851-1860 preserved at KNMI.

We first looked into the instrument descriptions of the surviving original meteorological ship logs. All logs were found to contain a detailed section at the start of each journey describing the instrumental corrections that had to be applied to the pressure readings such as the capillarity correction, the bias with respect to a standard barometer and the height of the instrument on board. 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. It appeared that in all tables of daily weather an extra pressure column was added with blue pencil, next to the original

pressure readings. Apparently this column was added during the processing of the logbooks in the 1935-1941 KNMI punching project. The values in the extra column turned out to match exactly with the values punched in Deck 193. By applying the temperature correction and the correction factors mentioned in the instrumental sections of the logs on the original pressure readings, we were able to reproduce exactly the values written in blue and hence those punched in Deck 193. No evidence was found from any of the 128 logs that gravity adjustments were ever applied to the Dutch data.

After these checks, we compared the Deck-193 data directly with the 1961-1990 standard normals of the GMSLP2.1f monthly climatology. For this, we first corrected all Deck-193 data for gravity, then calculated anomalies per 10°×10° grid box and per month and finally averaged for each calendar year the monthly anomalies over the boxes between 20S-20N. In the averaging procedure, boxes with less than 3 observations were excluded. As shown in Figure 2, solid line, we did not find 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 COADS. The only reduction that was needed for this is to apply the gravity correction throughout.

What remains to be explained is the anomalous trend in the Dutch pressures in the initial calculation (Figure 2, dashed). Its cause is the climatological SLP difference between the Indian Ocean and the Atlantic Ocean (Figure 3). Putting the border between the Indian and Pacific Oceans at 110E, the mean 1961-1990 pressures averaged over the 20S-20N belts of the Indian and Atlantic Oceans are 1011.1 mb and 1013.7 mb, respectively (Basnett and Parker, 1997). Hence the pressure over the Indian Ocean is 2.6 mb lower. The completion in 1870 of the Suez Channel resulted in a gradually increasing presence in the 20S-20N 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 3). The result is a decrease of the annual Deck-193 pressure if averaged over all observations in the Atlantic and Indian Oceans. As the vast majority of the Deck-193 observations in the 20S-20N belt originates from voyages between Europe and Indonesia, the decrease remains apparent in the averaged Deck-193 pressure over the entire (360°)

20S-20N belt (see Figure 2, dashed).

The absolute magnitude of this 'Suez Channel effect' on the Deck-193 pressures happens to be comparable with the absolute magnitudes of the standard corrections that should be applied to raw mercury barometer readings, such as the temperature correction, the cistern correction, the capillarity correction or the gravitation correction (Letestu, 1966). Putting again the border between the Indian and Pacific Oceans at 110E, then for the 1854-1875 period 57% of the annual Deck-193 SLP observations in the 20S-20N belt came from the Atlantic, 25% from the Indian Ocean, and 18% from the Pacific. For 1876-1938 these percentages are 24%, 59%, and 17%, respectively, indicating a reversal of the ratio Indian/Atlantic observations with respect to the earlier period. As the dashed line of Figure 2 indicates, this reversal leads to a lowering of the Deck-193 averaged pressure by 1.4 mb.

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 solid line in Figure 2 demonstrates that 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.

As the issue of the Dutch barometer corrections and the trend in the SLP bias is settled now, the Dutch previously untapped SLP-data were incorporated in 2001 in COADS Release 1c.

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Figure captions

Fig. 1 Annual total number of observations and annual number of Dutch observations (Deck 193) in the COADS database 1850-1940.

Fig. 2 Annual mean differences in the 20S-20N belt between the 1961-1990 pressure climatology and the Dutch pressure data 1854-1938, calculated by two different methods. Dashed line: average pressures over all Dutch observations in the 20S-20N belt (not gravity corrected) minus 1012.0 mb, the latter being the mean 1961-1990 pressure averaged over the entire (360°) 20S-20N belt. Solid line: gravity-corrected Dutch observations 1854-1938 minus mean climatological pressures 1961-1990, first averaged over 10°×10° grid boxes, and then averaged over the sea area between 20S-20N. The calculation has been done on monthly basis, and then averaged over the calendar years. The value of the gravity correction averaged over 20S-20N is indicated by a bar. The 1961-1990 climatology used is the Hadley Centre GMSLP2.1f climatology (Basnett and Parker, 1997).

Fig. 3 Mean annual pressure distribution in the 20S-20N 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 mb lower than the pressure over the Atlantic Ocean.

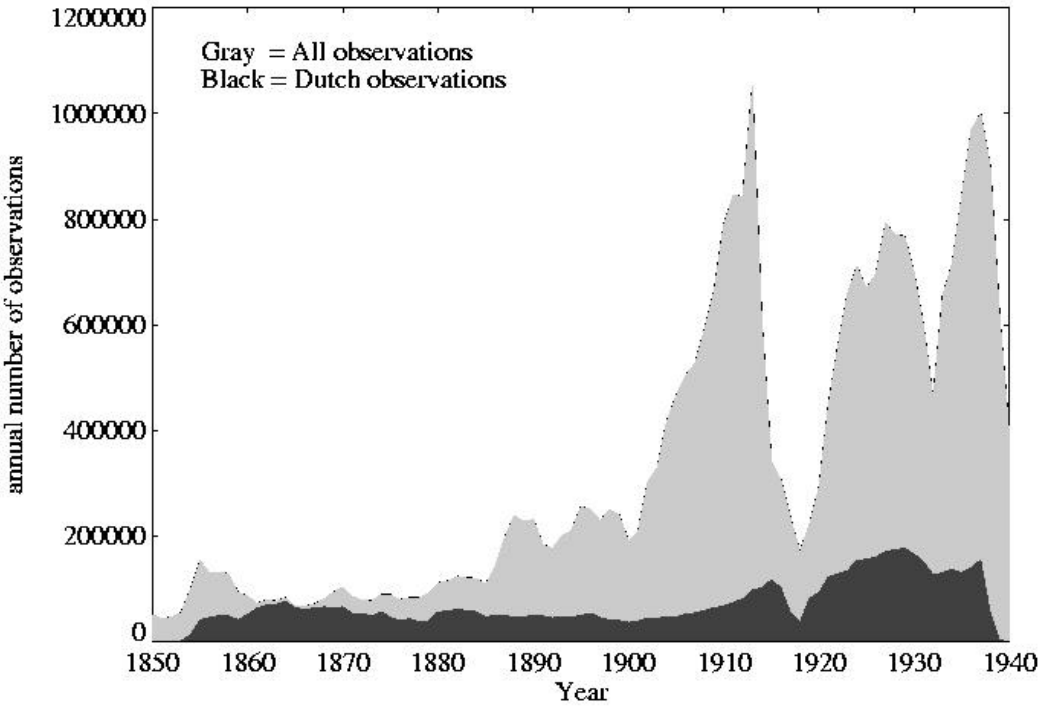
Gray = All observations
Black = Dutch observations
annual number of observations
1200000
1000000
800000
600000
400000
200000
0
1850
1860
1870
1880
1890
1900
1910
1920
1930
1940
Year

FIG 1

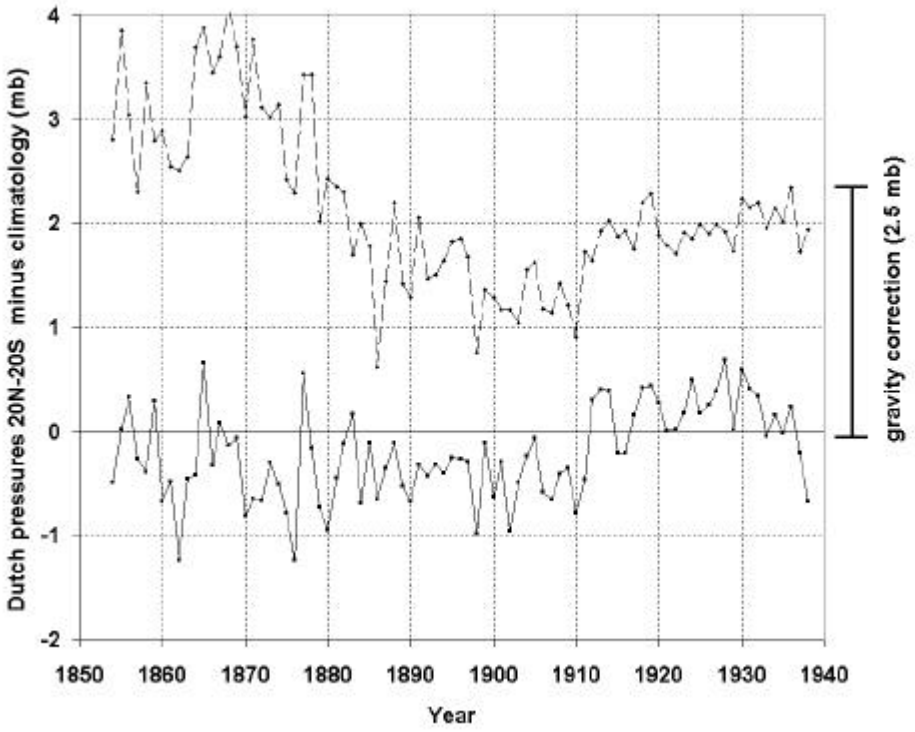
Dutch pressures 20N-20S minus climatology (mb)
4
3
2
1
0
-1
-2
1850
1860
1870
1880
1890
1900
1910
1920
1930
1940
Year
gravity correction (2.5 mb)

FIG 2

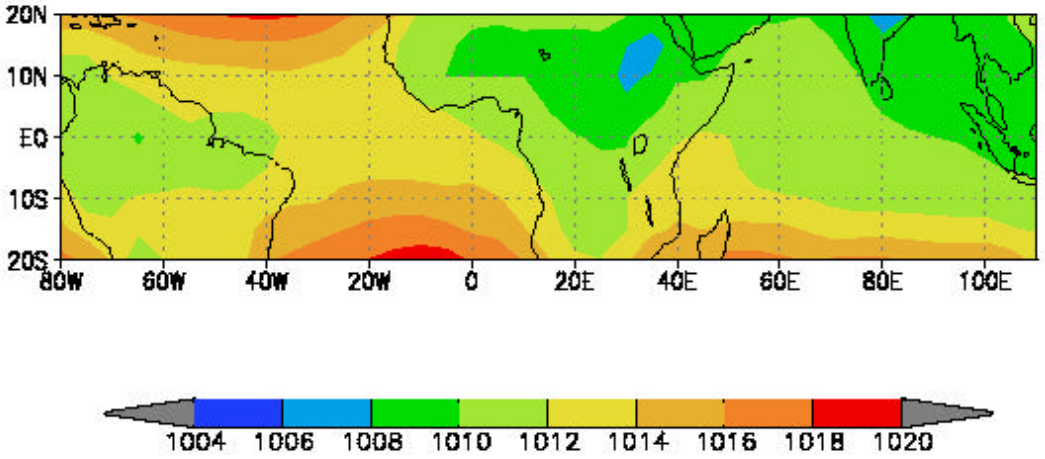
20N
10N
EQ
10S
20S
80W
60W
40W
20W
0
20E
40E
60E
80E
100E
1004
1006
1008
1010
1012
1014
1016
1018
1020

FIG 3