MONITORING THE QUALITY OF MARINE SURFACE OBSERVATIONS AT BRACKNELL

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1. INTRODUCTION

In 1985 the Commission for Basic Systems agreed that there was a need for GDPS/Global NWP centres to monitor the quality of observations and to exchange monthly lists of stations whose observations seemed in error. In 1988 three lead centres were nominated which would have a co-ordinating role of producing, at 6-monthly intervals, consolidated lists of suspect stations for given data types. The UK was allocated the role as lead centre for marine surface observations which is taken to include observations from ships, drifting buoys, moored buoys and other fixed marine platforms. This paper describes Bracknell's activities so far and presents monitoring results for the period from January to June 1989.

Following the CBS recommendations, three centres have been active in exchanging, monitoring information each month; the UK since August 1987, ECMWF since August 1988 and Japan since September 1988. Up to now most of the monitoring information exchanged on marine surface observations has related to pressure, and this paper will be restricted to a discussion of that parameter alone. The monthly lists of suspect stations distributed to NWP centres contain a list of observing platforms which are regarded as suspect along with values of the number of observations received at the centre, the number flagged by automatic quality-control procedures, and the mean and rms of the differences from the background values used by the numerical data assimilation system. initially each monitoring centre determined its own criteria to identify suspect observing platforms but following recent changes those used by the UK and Japan are now the same.

2. MONITORING METHODS

Errors in the observations of pressure may arise from a number of sources; the instrument may be malfunctioning, figures may be mistaken while being transferred manually, or there may be corruption of data during transmission. Some of these errors can be detected by applying checks on the code format, the internal consistency of the report, and the consistency with past reports. Checks on spatial consistency may be made if there are other nearby observations. However, such quality checks are unable to identify errors on all occasions and it is recognised that the numerical data assimilation systems in use today can provide global reference values which have a valuable application in the area of observation monitoring. The background field, or the short-term forecast from the previous numerical analysis, provides perhaps the most useful information on observation quality, as it represents an accurate and spatially consistent estimate of the observed values which is independent of the observations themselves. Observation-minus- background (O-B) differences are at the centre of all monitoring work by GDPS centres.

A histogram of O-B differences for all ship pressure reports during the period January to June 1989 is shown in Figure 1a, together with the Gaussian distribution with the same mean and standard deviation. Although almost all values fall within the range +5 to -5 hPa a small number of very large values, presumably resulting from erroneous observations, contribute to the large standard deviation of the population. The distribution for all those observations which fail the automatic quality-control checks is broad and bimodal (Figure 1b). The remaining 92 per cent of the observations which pass the quality checks show a distribution of O-B which is approximately Gaussian (Figure 1c) with mean 0.0 hPa and standard deviation 1.6 hPa. The principal component of this is probably from background errors.

Any global estimate of the background errors will conceal large variations which may occur from place to place. Background values will be more accurate in data-rich areas (eg the North Sea or Mediterranean) or where the meteorological variability is low (eg the tropics). The geographical distribution of the mean and standard deviation of the values of O-B from observations which pass the quality control checks has been calculated for 10-degree latitude-longitude boxes and plotted in Figures 2 and 3. The number of ship pressure reports within each 10-degree box and accepted by the model quality control is given in Figure 4. In almost all areas where the sample size is large the magnitude of the mean is less than 1.0 hPa; in some areas, particularly in the tropics, values lie between 0.5 and 1.0 hPa and this probably points to small systematic errors in the background field. The standard deviation in the tropics is 1.0 to 1.5 hPa, in northern latitudes 1.5 to 2.0 hPa, and in the Southern Ocean 2.0 to 3.0 hPa.

These estimates of background error provide the basis for the monitoring methods described here. Those marine observing platforms for which, in a sufficiently large sample, the observed values of pressure differ from the background by an amount significantly in excess of the estimate of background error, may be labelled as suspect with a high degree of confidence. Given a large sample the background errors appear to have a normal distribution and values of O-B which deviate from it can be identified. However, accurate statistical estimates of the likelihood of error in a sample of observations are hard to make as the background errors are correlated in time. The limits used here to identify suspect observing platforms have been set sufficiently stringent to preclude much likelihood of the background, rather than the observations, being in error.

Each monitoring centre produces a list each month of the identifiers of marine observing platforms considered suspect according to the departure from the centre's background values. Observations valid at 00, 06, 12 and 18 UT are used.

The criteria currently used by the UK and Japan are:

1. the number of observations greater than or equal to 20, and one or more of the following,
2. the absolute value of the mean of O-B greater than or equal to 4 hPa,
3. the standard deviation of O-B greater than or equal to 6 hPa,
4. the percent of gross errors is greater than or equal to 25.

A gross error is defined as a observations which departs from the background by more than 15 hPa. The mean and standard deviation of the sample are evaluated excluding gross errors and in this way occasional 'wild' values resulting from, for example, corruption during transmission, do not influence the sample characteristics.

The criteria used by ECMWF are:

1. the number of observations greater than or equal to 30, and
2. the absolute value of the mean of O-B greater than or equal to 4 hPa.

The values of the mean and standard deviation presented in their monthly monitoring report are calculated using all observations.

The monitoring results may vary from centre to centre. The reasons for this are different models used, the different selection criteria applied, and perhaps most important of all the different numbers of observations available. All centres have to apply some cut-off time after which observations received will not be used in the monitoring and it can vary between 6 and 24 hours. There are also some unexplained variations in the data receipt between the centres which may be due to problems in the GTS or in the local data handling procedures.

3. MONITORING RESULTS

Recently the UK and Japan have adopted common methods for drawing up monthly lists of identifiers producing suspect observations and results for ships over the four months March to June 1989 are summarised in Table 1.

TABLE 1. NUMBER OF SHIPS LISTED AS PRODUCING SUSPECT PRESSURE OBSERVATIONS; MARCH TO JUNE 1989

	UK list	JMA list	Total
Common to UK, JMA	165	165	165
UK list only	34		34
JMA list only		53	53
	199	218	252

Most of the differences between the two lists can be attributed to different cut-off times and processing methods at the two centres. There is very good agreement between the values of the mean and rms of O-B calculated for those identifiers common to both lists; only 12 of the 165 pairs of values differed by 1 hPa or more and none by more than 2 hPa. There are greater differences between the monthly lists from ECMWF and both the UK and JMA lists, but this can be attributed to the different selection criteria that have been used. It seems therefore that the monitoring results are almost independent of the numerical system, which lends support to the identification of suspect stations using these results.

4. THE 6-MONTH CONSOLIDATED LIST

In its role as lead centre for the monitoring of marine surface data, Bracknell has recently presented its first 6-month report to WMO. In it were listed 143 ships and 7 drifting buoys considered to have produced observations of pressure of low quality in the period January to June 1989. This consolidated list was drawn up after a careful study of all centres' monthly suspect lists and Bracknell's monthly statistics. Time series plots of O-B differences were also an invaluable aid in the identification of suspect observing platforms. A number of guiding principles were adopted:

1. As with the monthly lists, accuracy was assessed relative to background values.
2. Only those observing platforms were listed for which there was a very high degree of confidence that the observations rather than the background values were in error.

3. Appearance on one of the monthly lists was a starting point for compiling the consolidated list.

4. At least 40 reports were required over the period in which the observations were considered suspect.

5. Where the quality of the observations appeared to change over the monitoring period only the most recent performance was considered; observing platforms for which major errors appeared to have been corrected were not listed.

6. The limits set on the bias and standard deviation of O-B were slightly less stringent than those used in the monthly lists because of the larger sample size. If there was a deterioration of the observation quality over the final part of the monitoring period then the pressure observations had to meet the criteria set for the monthly lists.

No moored buoys or other fixed marine platforms met the criteria for inclusion in the consolidated list over this particular period. Many of the ships listed appeared at some time on the monthly suspect lists but a few ships never reported frequently enough in any given month to appear on any list. These ships were however identified once a larger sample of observations became available.

5. EXAMPLES OF OBSERVATIONS OF LOW QUALITY

Figure 5 shows a time series of O-B differences for a drifting buoy, which was identified as developing a major observation error during the monitoring period. in January 1989 the observations were close to background values, but after a long break in the reports received at Bracknell, a marked positive bias developed in the observed pressure, which briefly changed to a negative bias before the reports ceased. A number of other drifting buoys were identified in the Southern Oceans with persistently large rms O-B differences, but there was insufficient confidence in the quality of the background values for them to be listed in the report.

A large proportion (98 out of 143) of the ships identified in the report had a readily identifiable pressure bias with respect to the background field which in many cases remained constant over the 6-month monitoring period. Figure 6 shows a typical example of a ship with a

O-B bias of around +7 hPa and standard deviation of less than 2 hPa. A maladjustment of the instrument on board the ship is presumably the cause of the bias, which if corrected would give observations of comparable quality to those from the bulk of the global observing fleet.

In some cases the O-B bias may vary; for the ship in Figure 7 there appears to be four distinct sub-periods with different biases yet each has a small standard deviation. The example in Figure 8 shows a ship which appeared on the monthly suspect lists in May after developing a bias of around -4 hPa.

A small number of ships (7 out of 143) were listed in the report on the basis of a persistently large standard deviation of O-B differences. The ship in Figure 9 which sailed in the seas to the north of Japan during the monitoring period shows a particularly large scatter in the O-B differences (note that 15 were outside the limits of the plot). In this and all of the other examples presented in this section, the ships sailed in areas where the estimates of the background error given in Figures 2 and 3 were no larger than average.

6. SUMMARY

In its role as lead centre for the monitoring of marine surface data, Bracknell has recently presented its first report to WMO, and in it 150 observing platforms were identified as producing pressure observations of low quality over the period January to June 1989. The selection criteria were set sufficiently stringent to ensure that only those observing platforms were listed for which there was a high degree of confidence in there being large errors. The most common error identified in the pressure observations was a bias which in general remained constant for several months. A simple maladjustment of the instrument on board the ship seems the most likely explanation of this error.

FIG 1A:
DISTRIBUTION OF O-B SHIP PRESSURE INCREMENTS
PERIOD OF DATA: 1 JAN 1989 TO 30 JUN 1989 DATA USED: ALL OBSERVATIONS

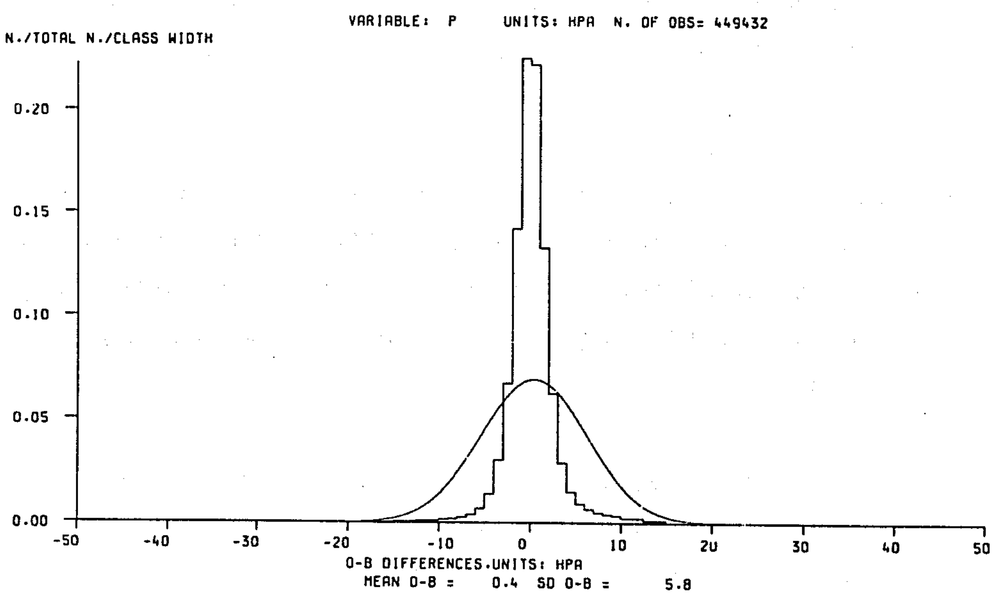


FIG 1B:
DISTRIBUTION OF O-B SHIP PRESSURE INCREMENTS
PERIOD OF DATA: 1 JAN 1989 TO 30 JUN 1989 DATA USED: FLAGGED OBSERVATIONS

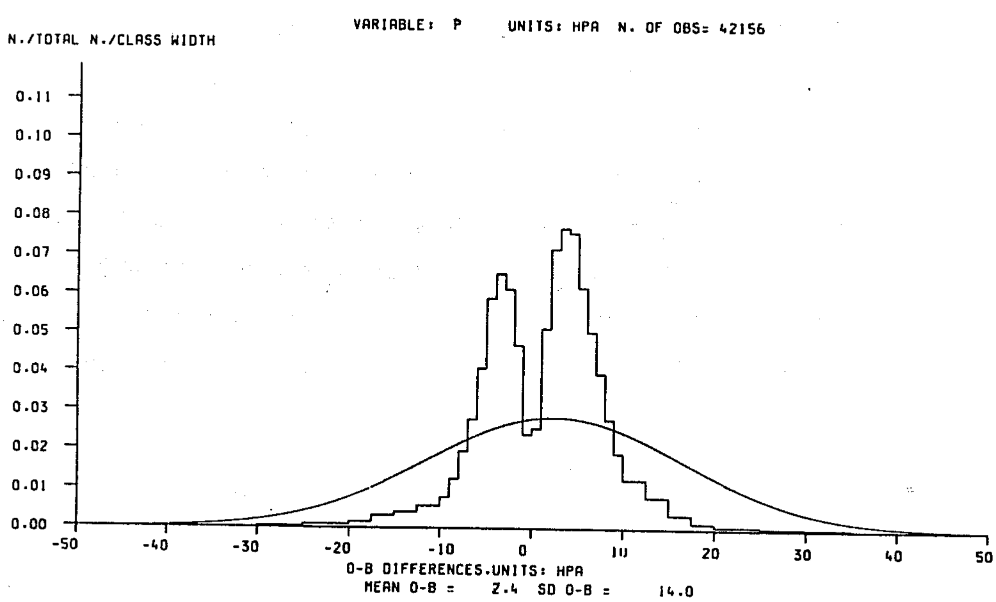


FIG 1C:
DISTRIBUTION OF O-B SHIP PRESSURE INCREMENTS
PERIOD OF DATA: 1 JAN 1989 TO 30 JUN 1989 DATA USED: UNFLAGGED OBSERVATIONS

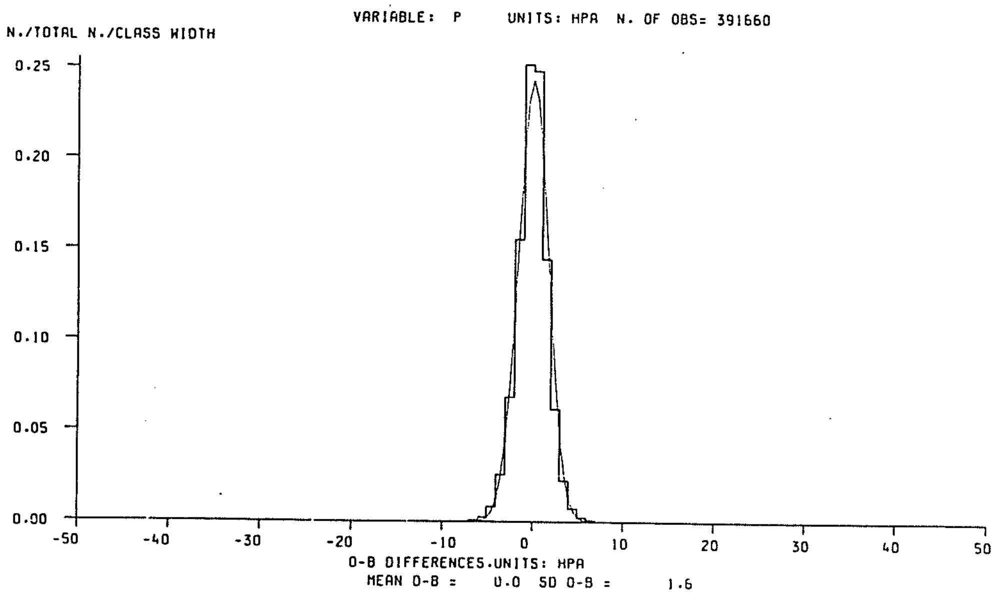


FIG 2:
BIAS OF O-B SHIP PRESSURE INCREMENTS. PERIOD: JAN TO JUN 1989
ONLY OBSERVATIONS PASSING QUALITY CONTROL USED IN STATISTICS
CONTOURS DRAWN TO 10 DEGREE BOXES IF N. OF OBS > 10

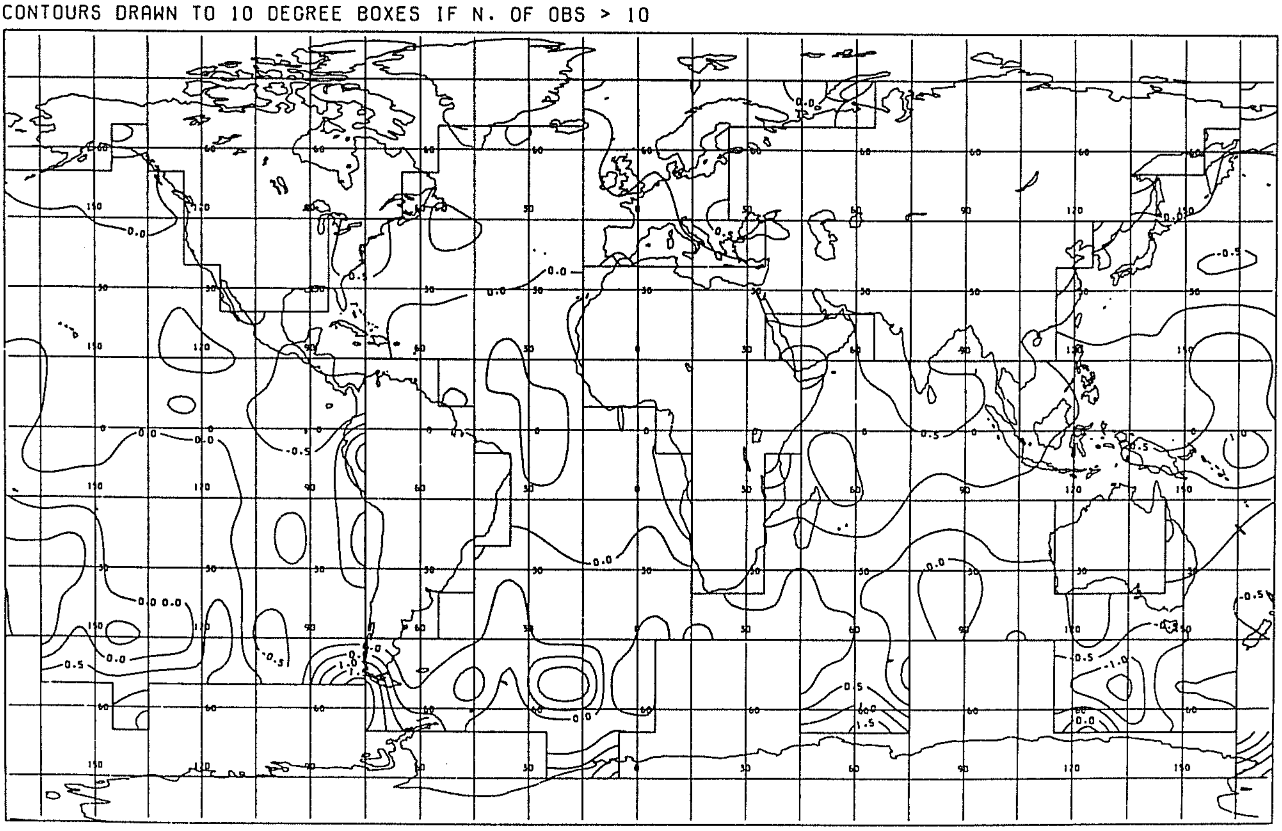


FIG 3:

S.D. OF O-B SHIP PRESSURE INCREMENTS. PERIOD: JAN TO JUN 1989

ONLY OBSERVATIONS PASSING QUALITY CONTROL USED IN STATISTICS

CONTOURS DRAWN TO 10 DEGREE BOXES IF N. OF OBS > 10

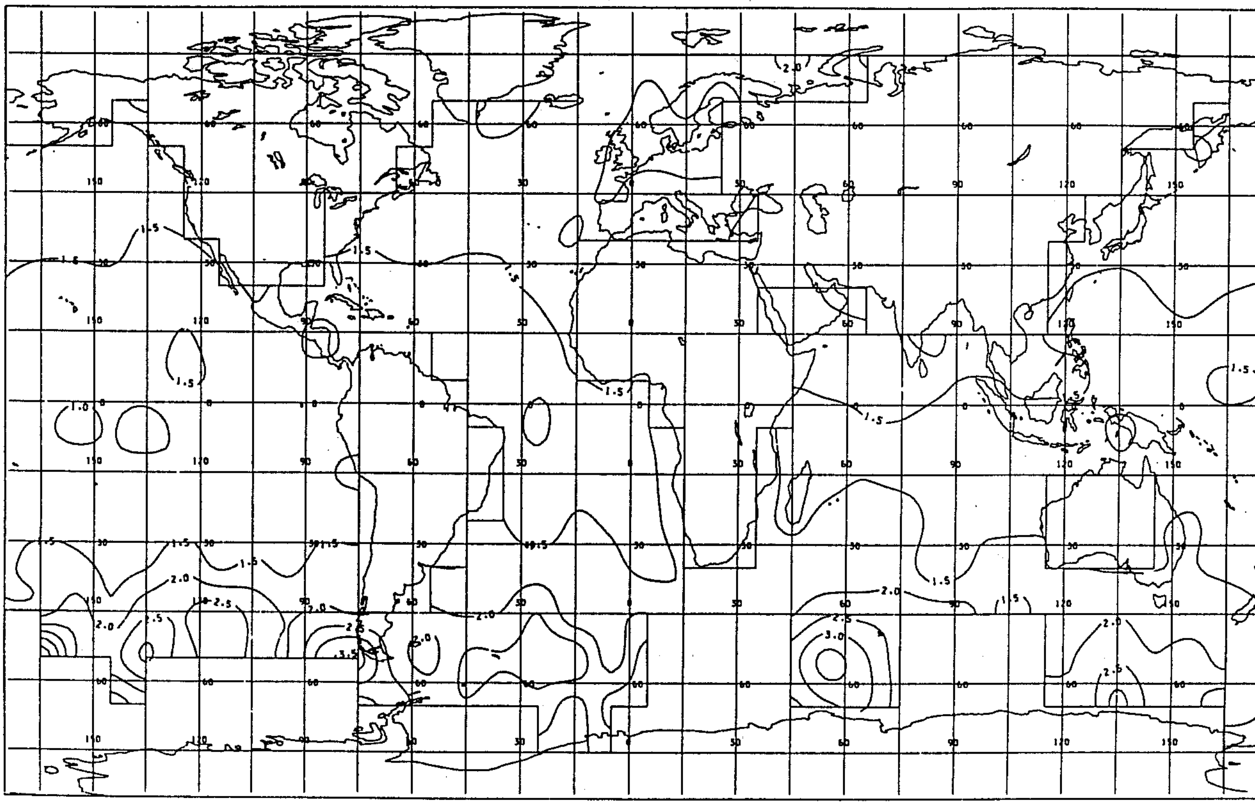


FIG 4:

PLOT OF NUMBER OF SHIP PRESSURE OBSERVATIONS.JAN TO JUN 1989

ONLY OBSERVATIONS PASSING QUALITY CONTROL COUNTED

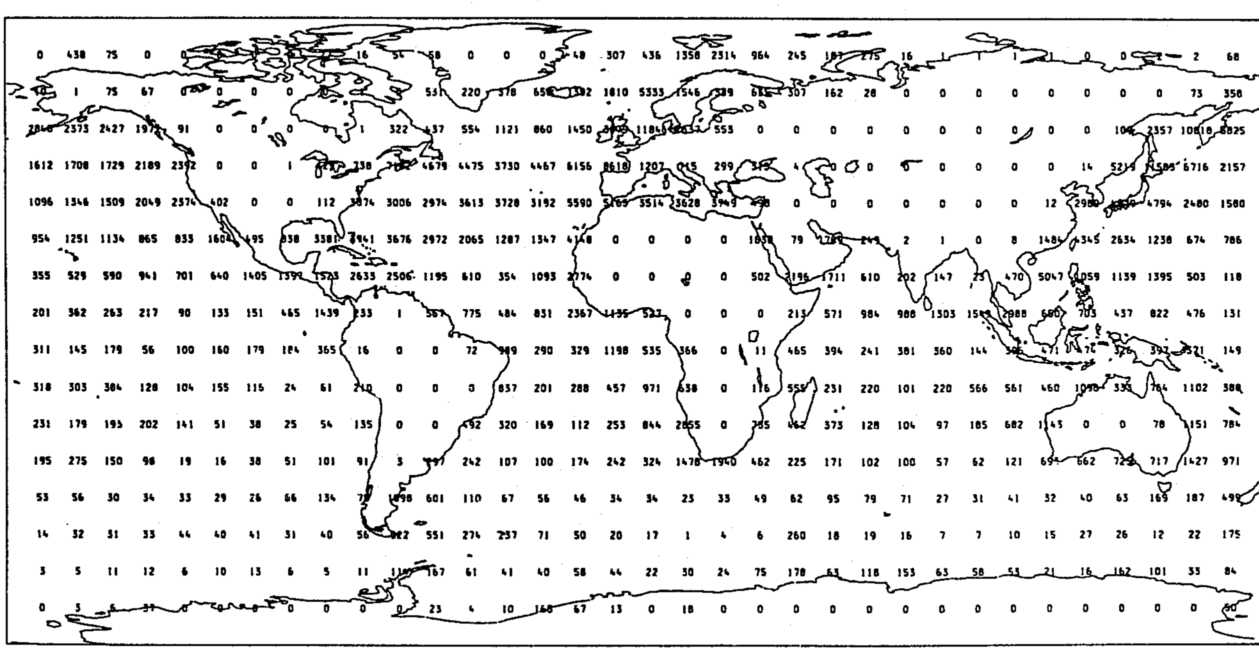


FIG 5:
BRACKNELL MONITORING INFORMATION FOR MARINE SURFACE DATA
TIME SERIES OF OBSERVATION MINUS BACKGROUND INCREMENTS(O-B) FOR DRIBU: A
VARIABLE PLOTTED: PRESSURE IN UNITS OF HPA
NUMBER OF OBSERVATIONS EXCEEDING PLOTTED LIMITS= 0

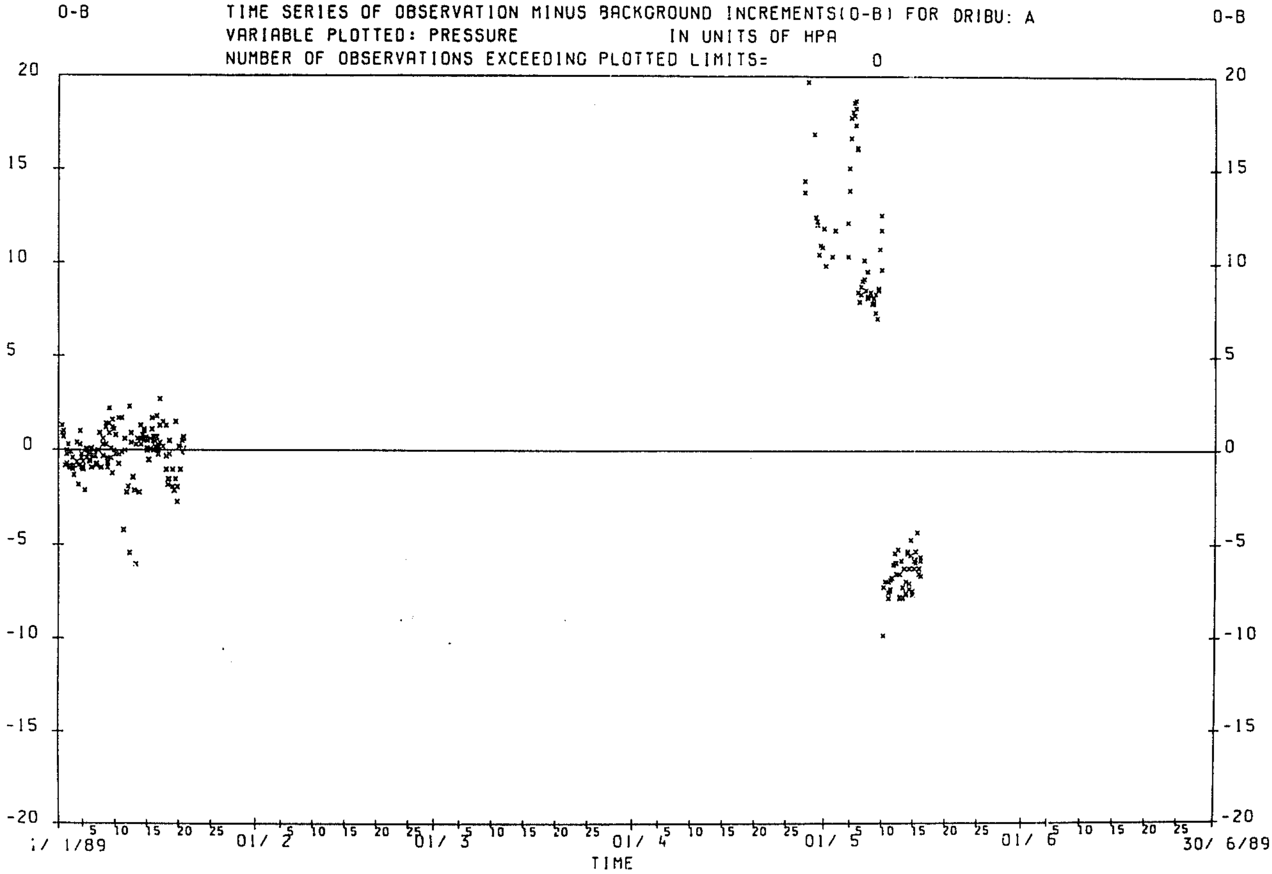


FIG 6:
BRACKNELL MONITORING INFORMATION FOR MARINE SURFACE DATA
TIME SERIES OF OBSERVATION MINUS BACKGROUND INCREMENTS(O-B) FOR SHIP : B
VARIABLE PLOTTED: PRESSURE IN UNITS OF HPA
NUMBER OF OBSERVATIONS EXCEEDING PLOTTED LIMITS= 0

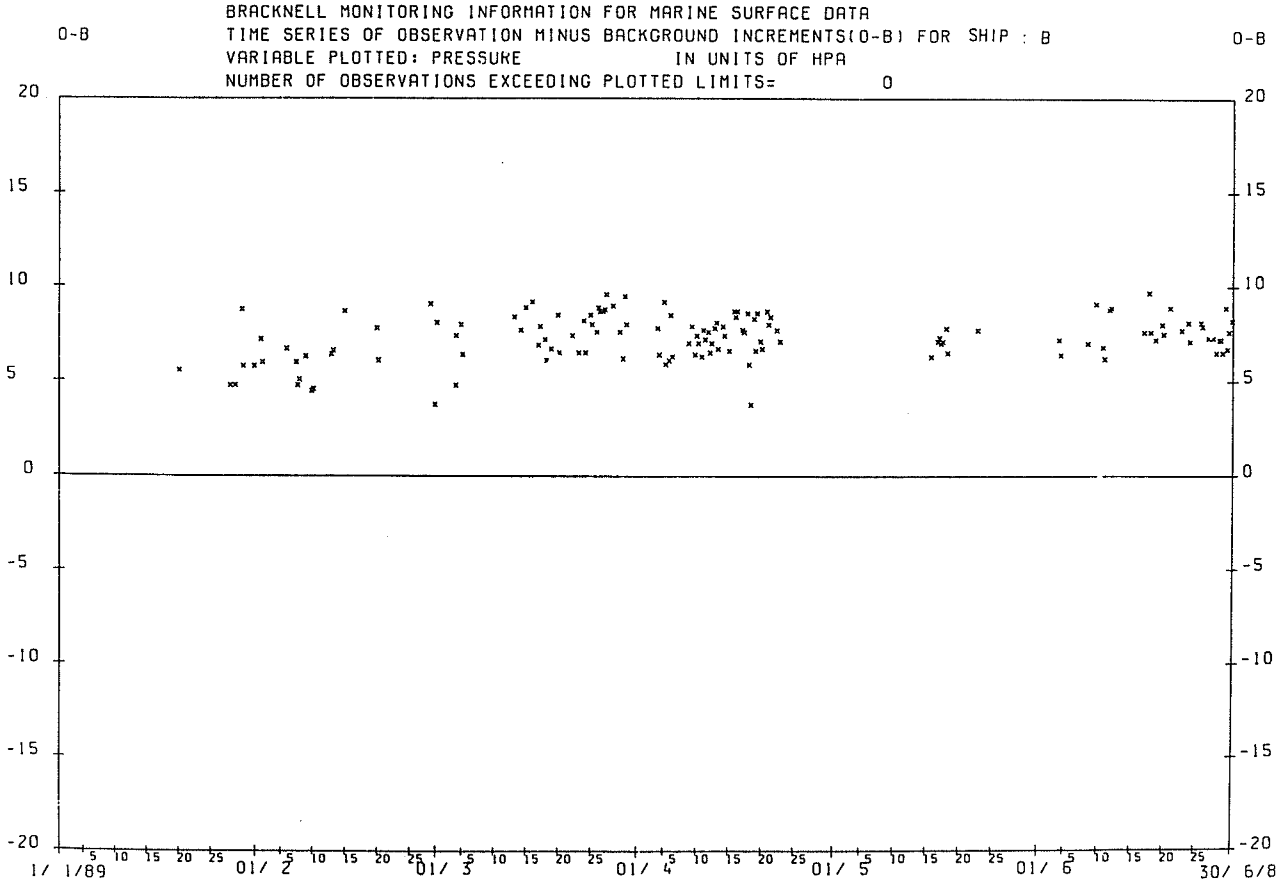


FIG 7:
BRACKNELL MONITORING INFORMATION FOR MARINE SURFACE DATA
TIME SERIES OF OBSERVATION MINUS BACKGROUND INCREMENTS(O-B) FOR SHIP : C
VARIABLE PLOTTED: PRESSURE IN UNITS OF HPA
NUMBER OF OBSERVATIONS EXCEEDING PLOTTED LIMITS= 18

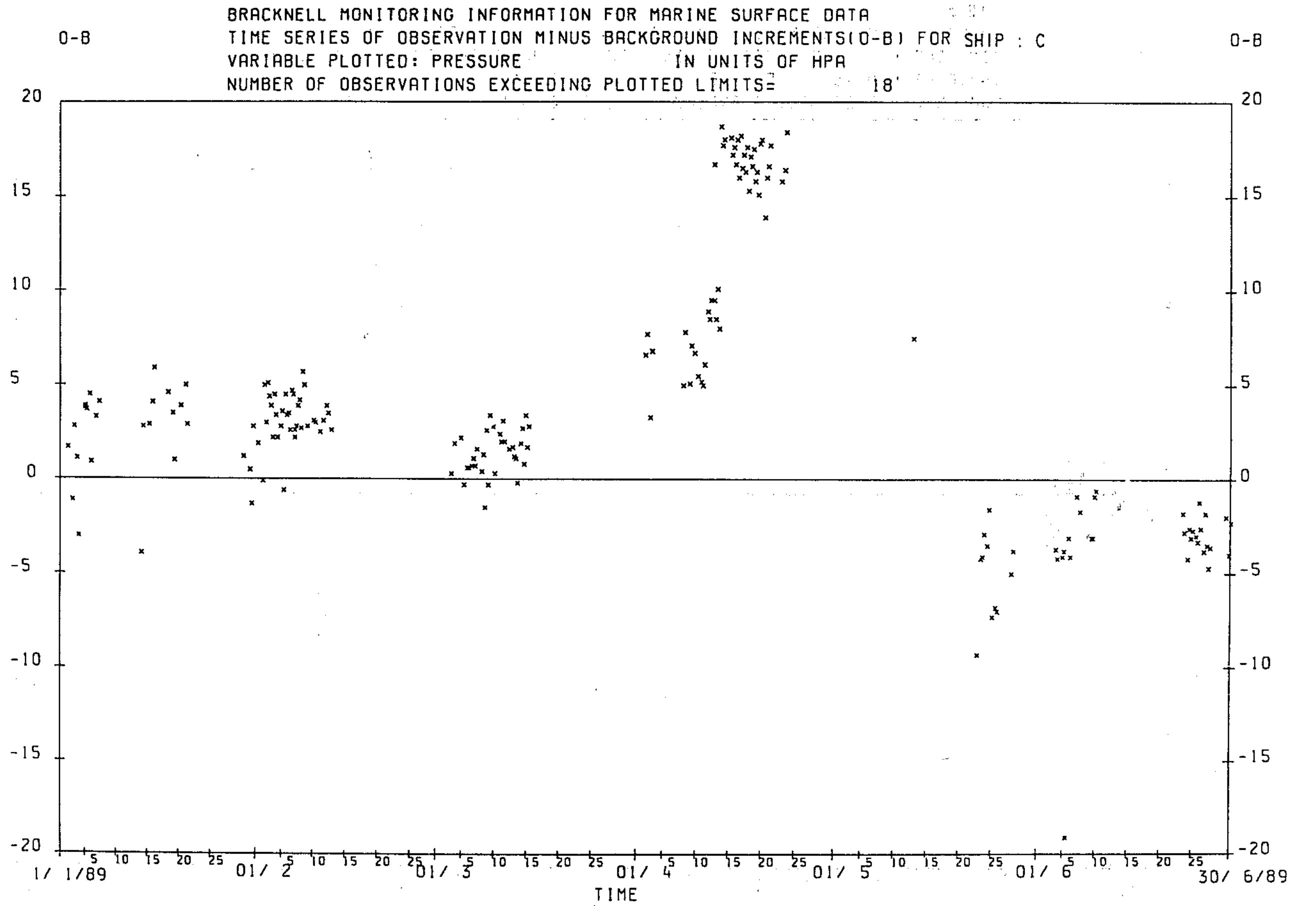
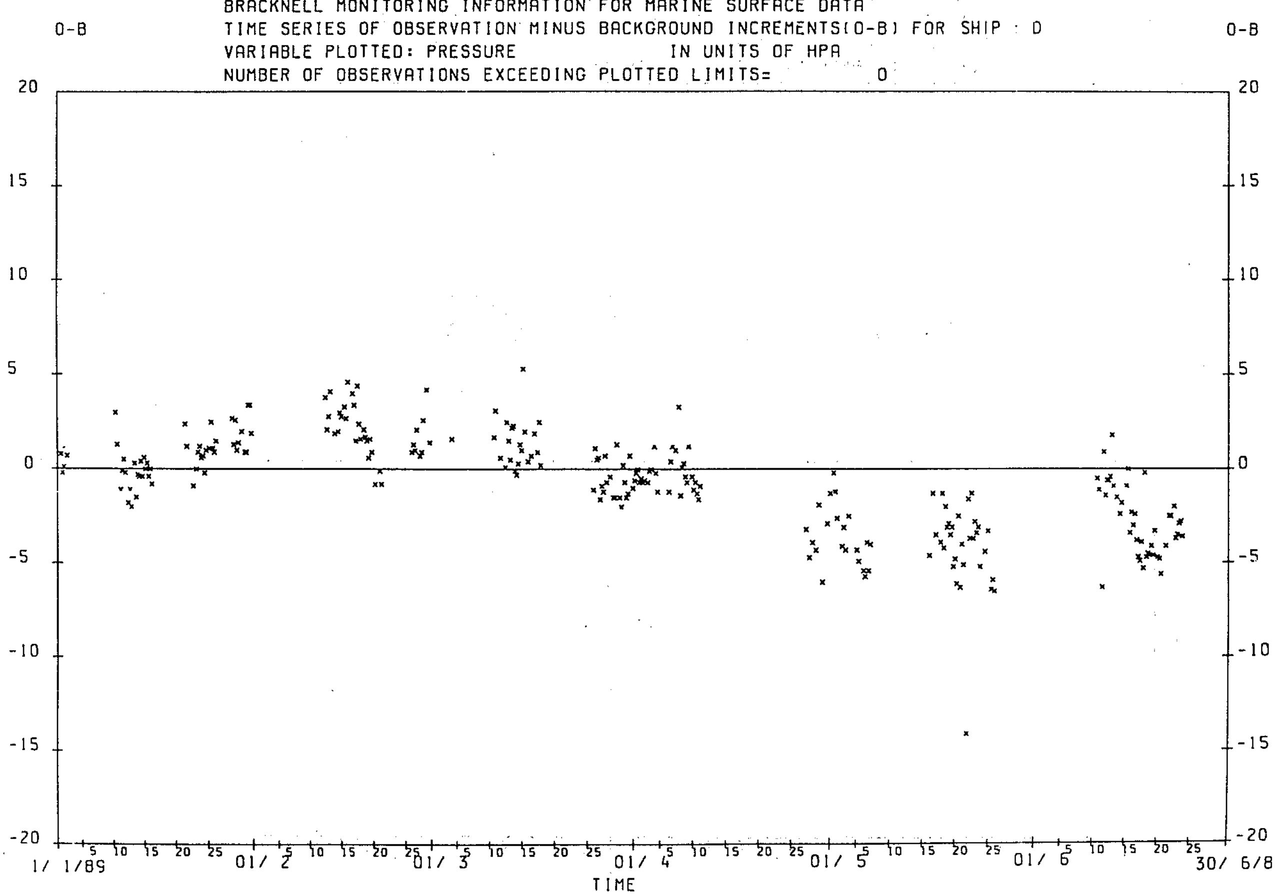


FIG 8:
BRACKNELL MONITORING INFORMATION FOR MARINE SURFACE DATA
TIME SERIES OF OBSERVATION MINUS BACKGROUND INCREMENTS(O-B) FOR SHIP : D
VARIABLE PLOTTED: PRESSURE IN UNITS OF HPA
NUMBER OF OBSERVATIONS EXCEEDING PLOTTED LIMITS= 0



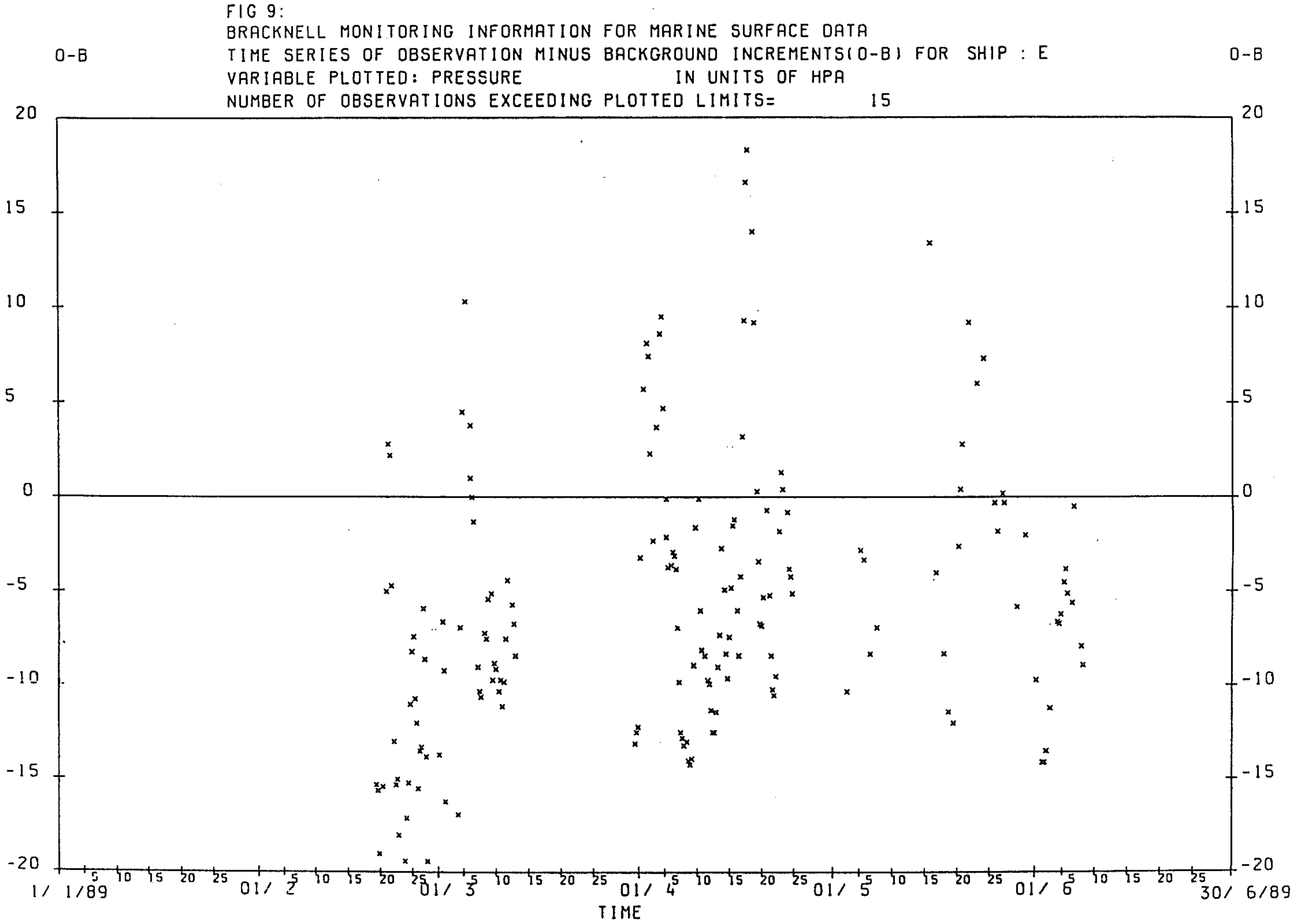


FIG 9:
BRACKNELL MONITORING INFORMATION FOR MARINE SURFACE DATA
TIME SERIES OF OBSERVATION MINUS BACKGROUND INCREMENTS(O-B) FOR SHIP : E
VARIABLE PLOTTED: PRESSURE IN UNITS OF HPA
NUMBER OF OBSERVATIONS EXCEEDING PLOTTED LIMITS= 15
O-B
1/ 1/89
01/ 2
01/ 3
01/ 4
01/ 5
01/ 6
30/ 6/89
TIME