MONITORING OF MARINE SURFACE DATA

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1. INTRODUCTION

Following recommendations by the CBS there has been increased activity in the monitoring of the quality of observations at major numerical weather prediction centres. It is recognised that the numerical data assimilation systems in use today provide fields of high quality against which observations may be compared. At Bracknell a database has been in use since January 1987 containing much model information relating to observation quality; in addition to the observation itself, the values archived include the flags raised by the various quality-control procedures, and the background and analysis values at the observation position. The values of the model background field provide perhaps the most valuable information on observation quality as they represent a spatially consistent estimate of the observed value which is of high quality and independent of the observation itself. Observation-minus-background differences are at the centre of the monitoring work performed at Bracknell.

In 1988 it was agreed by the CBS that Bracknell should become the lead centre for monitoring the quality of marine surface data. Some preliminary results are presented in the following sections mostly relating to the observations of surface pressure from ships.

2. MONITORING AT BRACKNELL

2.1 Quality-control tests

Before being used by a numerical data assimilation system all observations are subject to various quality-control tests. The flags raised provide useful information on observation quality. The tests performed fall in different categories:

1. Checks on code format, etc.

2. Internal consistency checks on the data within one observation.

3. Temporal consistency checks on data from one source.

4. Checks that the observation is reasonably close to the model background (a forecast from the previous analysis).

5. Checks on the spatial consistency with other observations (buddy checks).

6. Manual checks.

Checks under item 1, where unintelligible code is identified, are usually performed as the data are received over the GTS. Internal consistency checks (2) include, in the case of marine data, tests to ensure that the latitude, longitude, wind direction and observation time fall within possible limits, and the identification of dew points which are greater than the reported air temperature. Temporal consistency checks (3) ensure, for instance, that the reported pressure and tendency are consistent with the earlier observation from the station, or, in the case of moving stations such as ships or drifting buoys, that the position is consistent with the position reported at an earlier time.

Checks under items 4 and 5 make use of the extra information contained in the model fields. New methods of performing background and buddy checks based on probability theory have been developed at Bracknell and these have been in use operationally since March 1988. The probability of gross error in an observation is estimated at various stages (a priori, after the background check, after comparison with each buddy) and evidence on the accuracy of the observation is gradually accumulated as the tests are performed. A flag, determining whether the observation is suitable for use in numerical data assimilation, is set at the end of the quality-control process if the final probability of error is greater than some limit, usually 50 percent.

Manual checks (6) are also performed in real time by forecasters at some centres, but they are assuming a less important role as automatic quality-control procedures become more reliable.

2.2 Differences from background

A histogram of observation-minus-background differences for all ship reports during January 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 hPa a small number of very large values, presumably from erroneous observations, contribute to the large standard deviation of the population. Suspect observations identified by the quality-control tests described in the previous section have a broad bimodal distribution (figure 1b). The remaining population (figure 1c) is approximately Gaussian with standard deviation around 2-3 hPa and the principal component of this is probably the errors of the background fields.

An example of a time sequence of observation-minus-background differences for each report from a ship over the 6-month period March to August 1988 is shown in figure 2. The pressure observations are regularly flagged and indeed there seems to be a consistent large negative bias relative to background. It is worth noting that the bias is not stationary with time; it seems to take at least 3 distinct values over the period. In addition there seem to be a number of outliers which deviate significantly from the rest of the sample and to evaluate meaningful values of the mean and standard deviation of the population as a whole they should probably not be used. There are periods with no observations at all and these probably coincide with the times the ship is in port or out of service.

2.3 Monthly results

Almost all marine platforms providing meteorological observations give a unique identifier. Over a typical month reports are received over the GTS from some 5000 different ships, 80 automatic marine stations including fixed buoys and platforms , and 130 drifting buoys. The number of reports received at Bracknell from individual ships over a month (November 1988) and a whole year (1988) is shown in table 1 as a frequency distribution. Apparently, a very large number of ships only report once. The reason for this is unclear but may be a result of transmission errors in the part of the message giving the ship identifier. In a month some 900 ships each provide at least 30 reports and in a year some 2000 each provide at least 100 reports.

The CBS has recommended that the normal monitoring period should be one month and Bracknell along with some other numerical weather prediction centres has been producing monthly lists of ships with suspect pressure observations. The criteria chosen to identify such ships are:

1. the number of reports during the month is greater or equal to 30, and,

2. the percent pressure observations flagged is greater than or equal to 50, and,

3. the rms observation-minus-background difference is greater than or equal to 4 hPa.

Between January and December 1988, 175 different ships were identified as producing suspect pressure reports in at least one month (table 2). 103 of these were identified as suspect in only one of the 12 months which raised the question of what was happening at other times. Several examples of a 2-year time series of monthly values of mean and standard deviation of the observation-minus-background differences for pressure reports from suspect ships are shown in figures 3-6. From these and other cases several characteristics of ship reporting practice and observation errors become apparent.

1. Some ships stop reporting for periods of many months.

2. Shorter periods without reports (presumably due to being in port) lead to monthly totals being very variable and often falling below 30.

3. In most cases suspect observations seem to be due to a persistent bias rather than frequent random errors.

4. The bias is often constant over a period of a few months, but on longer time scales it usually changes.

TABLE 1. THE NUMBER OF REPORTS OF PRESSURE FROM SHIPS RECEIVED OVER THE GTS AT BRACKNELL BY SHIP IDENTIFIER.

No. of reports	No. of ships Nov 1988	No. of ships Jan-Dec 1988
1	1445	9511
2-10	1283	4315
11-20	855	590
21-30	565	345
31-100	860	1500
100-200	21	1302
200-500	0	1476
500-1000	0	290
	5029	19329

TABLE 2. MONTHLY MONITORING OF SHIP PRESSURE OBSERVATIONS: UK SUSPECT LISTS. SUMMARY OF THE 12 MONTHS JAN-DEC 1988.

No. of times listed	No. of ships
1	103
2	28
3	21
4	12
5	4
6	2
7	2
8	1
9	1
10	1
11	0
12	0
	175

3. RESULTS FROM OTHER CENTRES

At present lists of suspect ships are regularly produced by the UK Meteorological Office, ECMWF and the Japanese Meteorological Agency (JMA) and distributed to other centres. The criteria chosen to identify suspect reports differ considerably from centre to centre and are listed in table 3. As a result of the different selection criteria and no doubt other factors (model cut-off, data availability on the GTS), only 11 out of the 46 ships identified as suspect in December 1988 were common to all 3 lists (table 4). However, amongst these 11 ships the mean and rms differences from background from the 3 centres were very similar (table 5) showing and encouraging independence from the numerical model. The few cases where the there is a substantial difference between the values of rms calculated at each centre are probably due to different methods of handling observations with exceptionally large (gross) errors.

TABLE 3. CRITERIA FOR IDENTIFYING SUSPECT PRESSURE OBSERVATIONS FROM SHIPS AT DIFFERENT CENTRES.

	UK		ECMWF	JMA	
Period (months)	1		1	1	
Observation times (GMT)	0,6,12,18		0,6,12,18	0,12	
Minimum no. of observations	30		30	15	
Mean (O-B) limit (hPa)	*		4	4	or
Rms (O-B) limit (hPa)	4	and	*	6	or
Percent flagged	50		*	50	

TABLE 4. NUMBER OF SHIPS IDENTIFIED AS PRODUCING SUSPECT PRESSURE OBSERVATIONS IN DECEMBER 1988.

	UK list	ECMWF list	JMA list	total
Common to UK,ECMWF,JMA	11	11	11	11
Common to UK,ECMWF	4	4		4
Common to UK,JMA	1		1	1
Common to ECMWF,JMA		6	6	6
UK list only	5			5
ECMWF list only		14		14
JMA list only			5	5
	21	35	23	46

TABLE 5. MEAN AND RMS DIFFERENCES FROM BACKGROUND (HPA) OF PRESSURE OBSERVATIONS FROM SHIPS IDENTIFIED AS SUSPECT IN DECEMBER 1988.

	UK	ECMWF	JMA
CBVM	6.2/6.8	7.8/8.3	8.4/8.5
ERNM	3.1/5.5	4.2/4.6	3.7/5.2
ESIW	-5.4/6.0	-5.7/6.0	-5.0/5.4
EVPY	8.5/9.5	9.4/9.5	9.8/10.0
EWJS	7.9/8.8	8.1/9.0	7.5/7.9
EWWL	6.8/7.2	6.4/13.1	8.5/8.7
UFAO	3.7/4.2	5.2/5.6	4.5/5.0
UFGQ	6.0/6.6	8.4/13.7	7.5/8.1
URPK	9.8/10.0	10.4/10.7	10.0/10.2
UUIY	13.7/13.8	14.0/14.1	14.0/14.0
Y5EJ	5.7/6.0	5.8/5.9	6.1/6.2

4. CONCLUSIONS AND RECOMMENDATIONS

Background fields from a numerical data assimilation system are a very powerful tool for monitoring the quality of pressure observations from ships. They are of high accuracy, typically showing mean errors in mean-sea-level pressure no larger than 1-2 hPa and standard deviations of the error in the range 2-3 hPa when verified against reliable observations. In contrast a small number of ships produce observations regularly with errors which are considerably larger than this. At present 3 major numerical weather prediction centres (UK Meteorological Office, ECMWF and Japanese Meteorological Agency) perform a regular monthly monitoring of ship pressure observations and distribute lists of suspect ships. The criteria for identifying suspect ships at each centre are different, nevertheless, observation-minus-background differences from the models are in good agreement.

Ships spend time in port and out of service and do not provide a regular number of reports over a period of one month. Although the calendar month is a natural period over which to calculate deviations from model background fields, it seems appropriate to allow for a longer overall monitoring period. It is recommended that each centre, when compiling its monthly suspect list, continues to provide for any ship listed as suspect in at least one of the previous 12 months the departure of the observed pressure from the model background values irrespective of the current observation quality or the reporting frequency. In this way a history of the quality of the observations of the ship can be seen. It is recommended also that some agreement is reached on the criteria used to identify suspect ships.

As the lead centre for marine surface data, Bracknell intends to draw up lists of ships which have produced suspect observations of pressure at some time during the past 12 months. These lists will be updated every month and will be distributed to all interested centres at working level. Each list will contain details of the perceived observation quality over the whole 12-month period. Comparison of results from different centres will be an important part of the monitoring process and every 6 months a consolidated list will be prepared as recommended by the CBS. Further development work is still necessary, in particular in the methods of monitoring ship wind observations.

Under CBS arrangements the WMO Secretariat, on receiving the consolidated lists from the lead centres, will initiate follow-up action with the WMO member or other resposible agency for observations which appear regularly to be of low quality. CMM, at its recent meeting in Paris, also discussed follow-up action with regard to marine surface data.

Figure 1 MONTHLY MONITORING OF SHIP PRESSURE OBSERVATIONS: OBSERVATION-BACKGROUND DIFFERENCES. JAN 1989

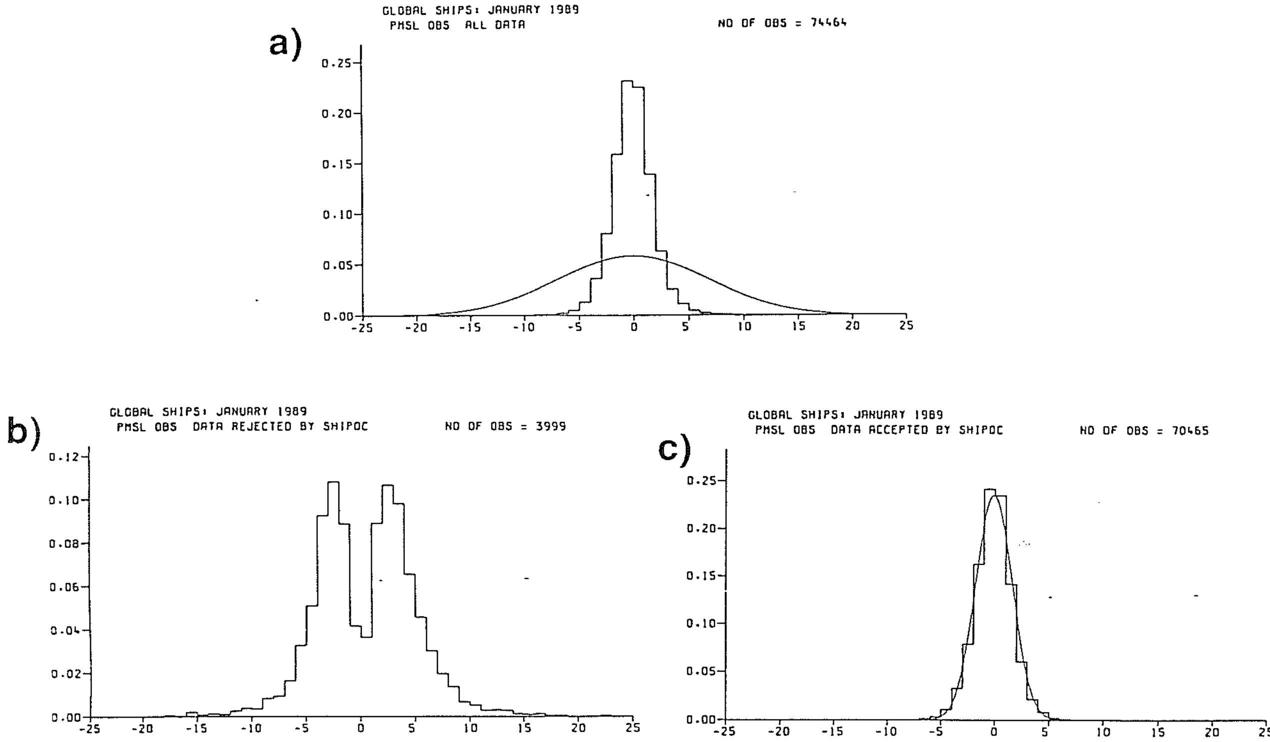


Figure 2

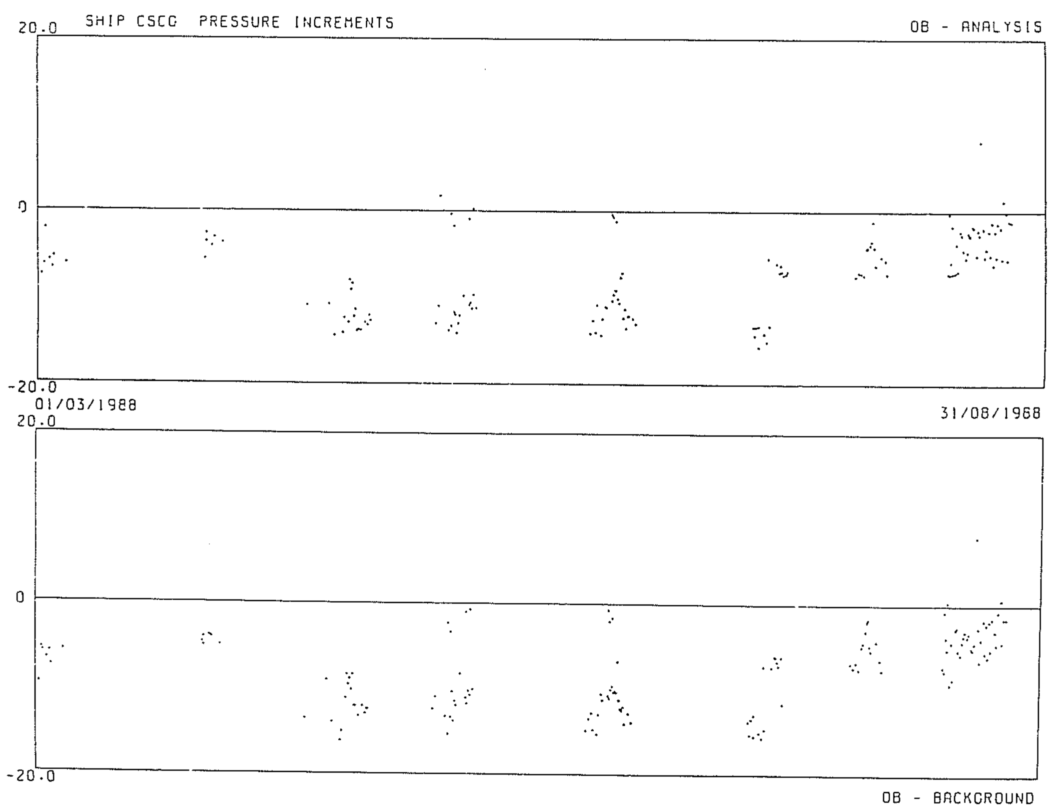


Figure 3 MONTHLY MONITORING OF SHIP PRESSURE OBSERVATIONS:
1987-1988

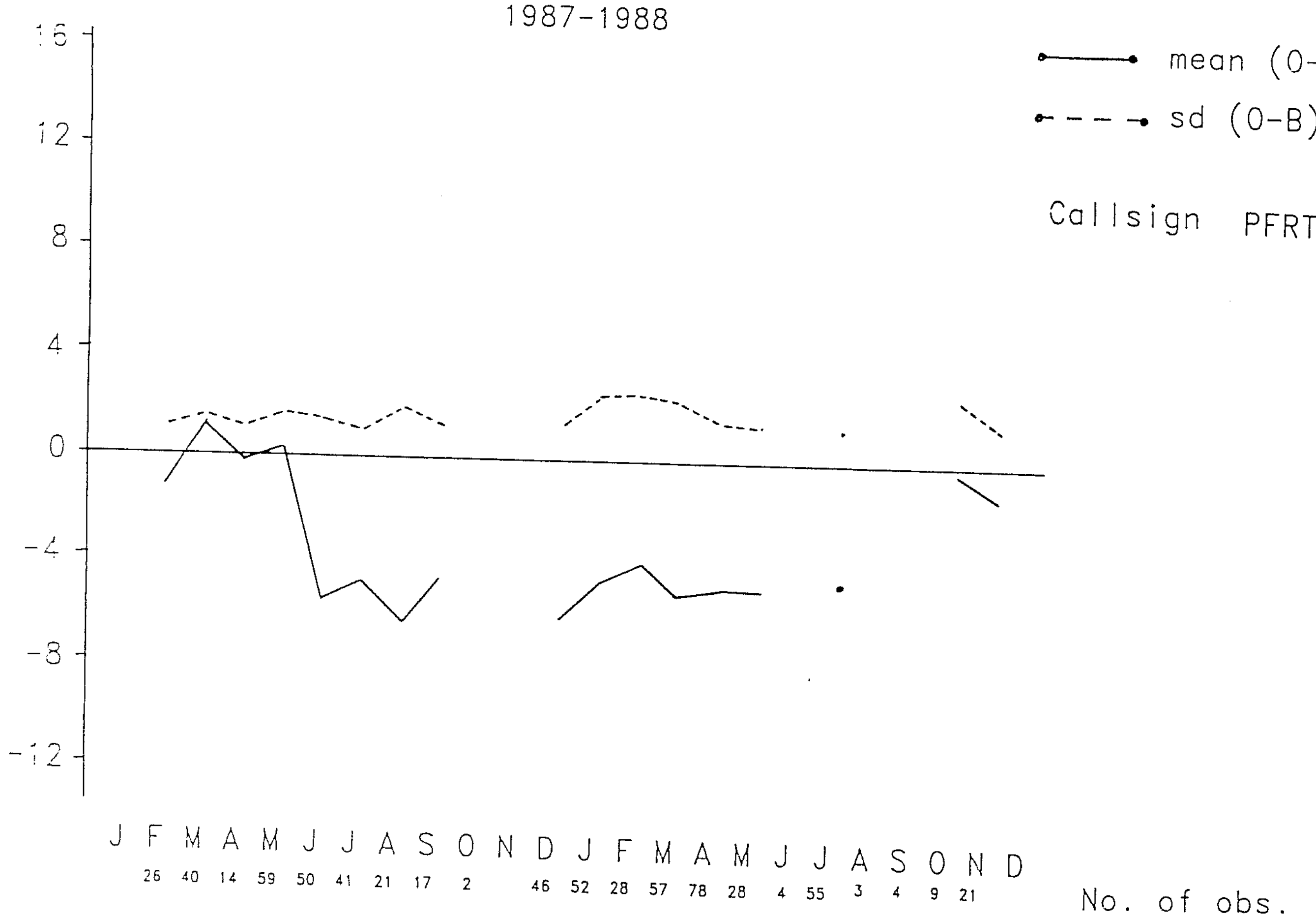
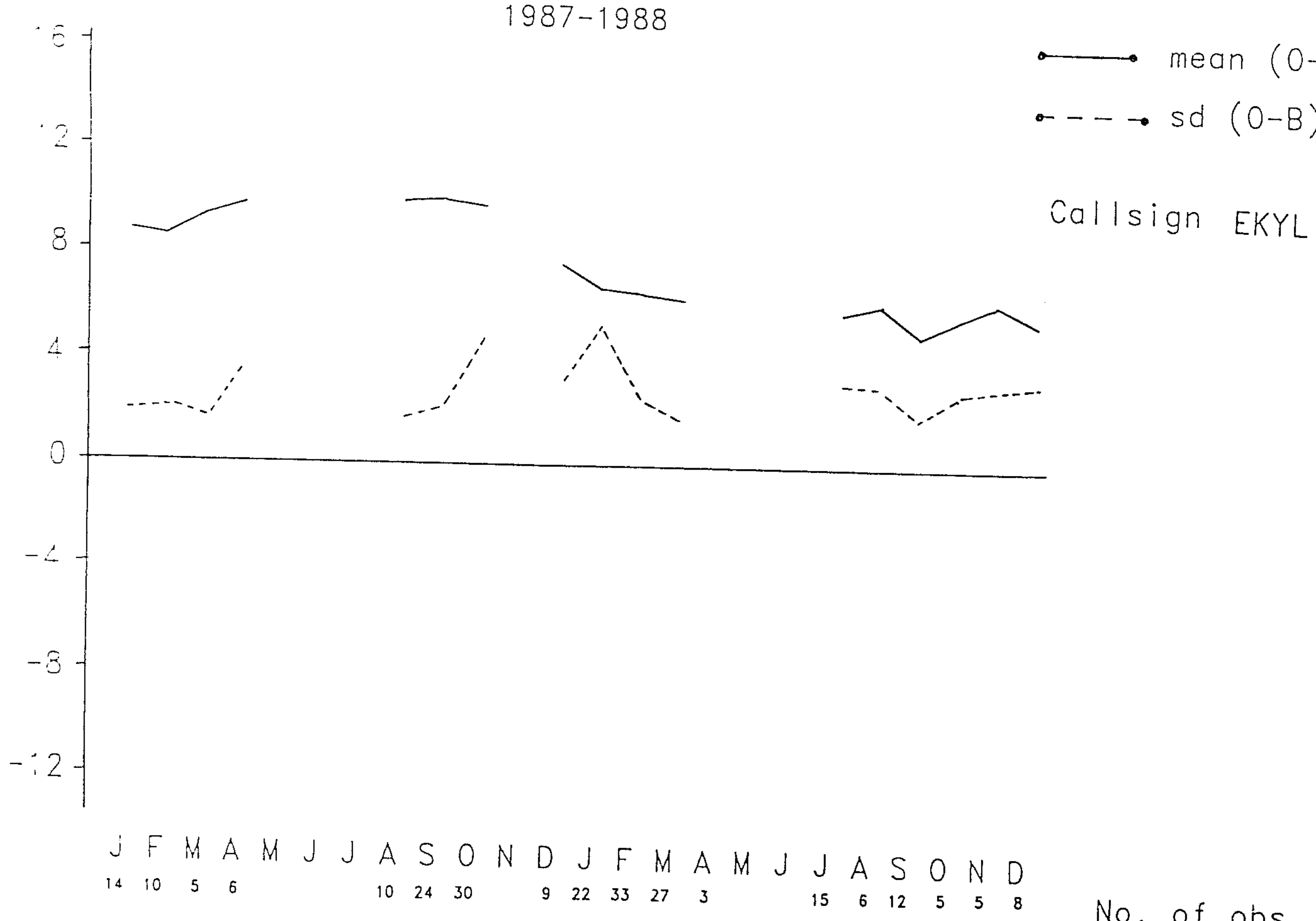
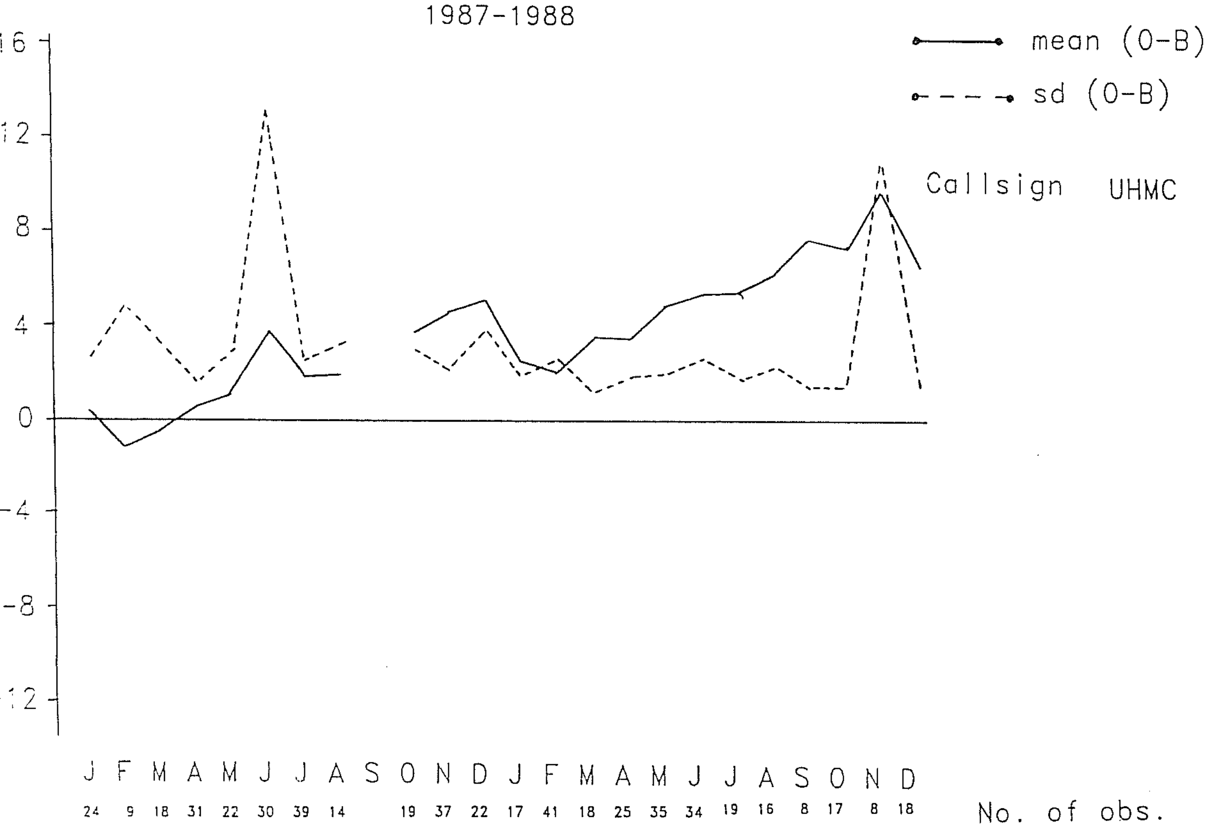


Figure 4 MONTHLY MONITORING OF SHIP PRESSURE OBSERVATIONS:
1987-1988



re 5 MONTHLY MONITORING OF SHIP PRESSURE OBSERVATIONS:
1987-1988



re 6 MONTHLY MONITORING OF SHIP PRESSURE OBSERVATIONS:
1987-1988