NOAA Technical Memorandum NWS NMC 64

THE USE OF DRIFTING BUOY DATA AT NMC

Washington, D.C.
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U.S. DEPARTMENT OF COMMERCE / National Oceanic and Atmospheric Administration / National Weather Service

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THE USE OF DRIFTING BUOY DATA AT NMC

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ABSTRACT.--The value to NMC surface pressure analyses of data from the Drifting Buoy System over the Southern Hemisphere oceans during the Special Observing Periods SOP - 1 and SOP - 2 in 1978-79 is evaluated. Buoy locations and numbers of observations are shown.

1. INTRODUCTION

During the last several years, increased and improved observing systems in space have provided substantial wind and temperature data over the otherwise data sparse reaches of the globe, especially the Southern Hemisphere oceans. However, the utility of these new data has been severely limited by the lack of adequate specification of the surface pressure patterns, an essential factor in defining the initial state of the atmospheric mass field.

The few widely scattered island stations are almost totally inadequate for specifying the surface pressure field over the vast ocean areas of the Southern Hemisphere. The Drifting Buoy System as designed and implemented by the Global Weather Experiment (GWEx, formerly FGGE) was designed to fill the gaps. During 1978 and 1979 buoys were deployed according to a strategy designed to provide maximum coverage over data sparse areas. At this writing, nearly 300 drifting buoys have been deployed in the Southern Hemisphere, and of this number about 200 continue to report useful meteorological information.

In addition, more than 30 platforms have been located in middle and high latitudes of the Northern Hemisphere and about 30 in equatorial regions. In early July 1979, about 75 percent of these buoys were reporting useful meteorological data.

2. DISTRIBUTION OF DRIFTING BUOYS

The spatial distribution of drifting buoys during the first Special Observing Period (SOP-1), particularly in the first few weeks of January, was inadequate. Figure 1, giving the locations of buoys as of January 15, 1979, shows large gaps in the coverage in the South Atlantic and Western Indian Oceans, and less than satisfactory coverage in the far South Pacific.

Table 1.-- Status of the FGGE Southern Hemisphere drifting buoy system

Date	Total number deployed	Number with good pressure	Number on GTS	% of area within 500 km of good buoy
5 June 1979	296	206	209	81
11 June 1979	297	200	203	80
18 June 1979	297	191	209	78
25 June 1979	301	195	207	77
2 July 1979	301	192	208	--

By mid-May, early in SOP-2, further buoy deployment had considerably improved the data coverage in the South Atlantic (fig. 2), but in the Pacific and Indian Oceans, areas in excess of 1000 km^2 were still devoid of buoy data.

Continuing deployment of buoys helped close some of the remaining data gaps and by late in SOP-2 a reasonably satisfactory coverage had been achieved over all but the tropical Atlantic and the southern reaches of the Pacific Ocean. Figure 3, which displays the location of buoys towards the end of September, shows the excellent coverage afforded by the buoys. The buoys at some of these locations may have been reporting incorrect pressure data.

A better measure of the effectiveness of drifting buoys may be found in table 1 which indicates the percentage of Southern Hemisphere area that is enclosed by circles of 500 km radius around buoys reporting good data. During SOP-2 an average of 80 percent of the Southern Hemisphere was adequately covered by drifting buoy data.

3. TIMELINESS OF DATA

In discussing the timeliness of receipt of drifting buoys data it is relevant to consider the scheduling of NMC's analysis operations, particularly its Optimum Interpolation (OI) global analyses. The schedule allows for data input to (nominally) 10 hours after the synoptic hour for the major analysis (0000 GMT and 1200 GMT) but only up to 4 hours for the off-time (0600 GMT and 1800 GMT) cycles.

Figures 4, 5, and 6 display the average number of drifting buoy reports received within specified times of the synoptic hours on selected

Table 2.--Average number of drifting buoy reports used by OI analyses at each cycle

	0000 GMT Cycle	0600 GMT Cycle	1200 GMT Cycle	1800 GMT Cycle
SOP-1	62.9	25.3	44.8	31.5
SOP-2	106.9	31.2	96.6	65.3

Table 3.--Percentage of cases in which no drifting buoy data were available at data cutoff time

	0000 GMT Cycle	0600 GMT Cycle	1200 GMT Cycle	1800 GMT Cycle
SOP-1	16.7	64.3	40.5	45.2
SOP-2	8.8	63.2	15.5	37.5

days during SOP-1 and SOP-2. The figures show that the number of reports received at the scheduled cutoff time for the 0000 GMT and 1200 GMT analyses were far in excess of those received at the cutoff for the off-time cycles. During SOP-1 an average of 76 reports were received for the 0000 GMT analysis and 58 for 1200 GMT at the scheduled H+10-hour cutoff, while for 0600 GMT the average number was 29 and for 1800 GMT, 39. During SOP-2 the major hour analyses (0000 and 1200 GMT) averaged 143 and 132 buoy reports at nominal cutoff time, while the off-time analyses (0600 and 1800 GMT) averaged only 62 and 96 reports, respectively. Although there was significant improvement by the time of SOP-2, the amount of data available for the off-time analyses was still less than desired.

More important was the count of data actually used in the analyses. Table 2 shows the average number of buoy data used by the four analysis cycles during the two SOPs. The significantly lower numbers in table 2 as compared with figures 4, 5, and 6 are attributable to the cutoff and the rejection of a number of bad buoy reports. Table 3 shows the number of instances in which no buoy data were available at cutoff. About half the off-time analyses did not benefit from buoy data during either SOP.

Table 4.--List of drifting buoys reporting bad data

as of September 26, 1979

17619A	17622A	17626A	17638A	17644A	17633A	17605A
17752B	17755B					
56613C	56617C	56623C	56631C	56641C		
74611D	74614D	74634D				
14625E						
54621F	54623F	54627F	54616F	32607F		
55607G						
16608H						
32651I	32654I					

4. BUOY DATA MONITORING

There has been no real-time monitoring of drifting buoy data at NMC. The only checking of the data are the Gross Error and Buddy Check used in the OI analysis cycle and listing of buoys that regularly report incorrect data.

The Gross Error check is a preanalysis check in which data that do not fall within liberal, specified limits are eliminated prior to analysis. The Buddy Check is one in which data are compared with neighboring reports and are tossed out if they are incompatible.

The Gross Error check has only limited value as a means of ensuring that bad data do not contaminate the analyses, as the very liberal toss-out limits cause only the grossly incorrect data to be discarded. The Buddy Check also has only limited value as a means of editing buoy data, since, by design, buoys are generally located in regions in which other data are unavailable or, at best, sparse. The Buddy Check, therefore, in most instances checks a buoy action against other buoy data, hardly a satisfactory means of assessing the integrity of a buoy report.

The delayed mode monitoring of drifting buoy data involves examination of these reports about twice a week and the creation of lists of buoys identified as frequently reporting incorrect data. The lists (example at table 4) are provided to the Aviation Weather Branch which institutes action to ensure that reports from buoys on the list are purged from the data base of the NMC analysis system. Prior to June 1979, the action involved keying in of the list at each analysis cycle. Since that time the list resides on a direct access data set against which all incoming buoy reports are checked.

The limited editing procedures adopted to date achieve little more than the removal of either patently incorrect data or reports from buoys previously recognized as providing bad data. The procedures do not provide for removal of the occasionally incorrect report that would be readily recognized by a meteorologist. This type of report has caused numerous instances of incorrect NMC analyses in the Southern Hemisphere.

To overcome adverse effects of incorrect buoy data on the analyses it would be necessary to either apply more stringent automated quality checks or provide real-time manual monitoring of the data. The first option is likely to lead to the rejection of some good data--not an appropriate solution for the Southern Hemisphere. The second option, probably the sounder one, involves substantial manual effort.

5. ACCURACY, UTILITY AND IMPACT OF BUOY DATA

A. Data Accuracy

Except in some isolated instances, buoys were located in regions where the 'ground truth' as defined by island, coastal station, or ship reports were not available. Thus it was nearly impossible to assess the accuracy of a buoy report by direct comparison with conventional data. By default, assessment of the accuracy of buoy reports was limited to subjective methods which include the following:

- comparison with first guess fields generated by NMC's global analysis-prediction system
- comparison with pressure fields estimated from cloud imagery
- comparison with other drifting buoy reports
- infrequent comparison with nearby conventional data.

The comparison of buoy data with the first guess surface pressure fields generated by NMC's Global analysis-prediction system indicated that the buoy data in the 30° to 90° latitude region were more at variance with predicted field than were station and ship data; (see table 5). However, most of the buoys were located at higher latitudes in regions with greater pressure variability than most of the land and ship reports. Therefore, it is likely that the error of the first guess would be greater in the areas in which the buoys were deployed. Thus the higher error level of the buoy data may be partially attributable to the errors of the first guess field.

The use of satellite imagery was limited to comparing pressure fields analyzed from buoy data with those estimated from cloud imagery, based on

Table 5.--Six-day mean rms differences between first-guess surface pressure field and data from various sources. latitude 30° S to 90° S.

Land station	3.60	3.49	3.57	3.76	3.45	4.09	4.34	3.58	3.56	3.93
Ship reports	4.59	4.75	4.38	4.36	4.37	4.26	4.06	3.54	3.92	4.28
Drifting buoys	5.21	5.29	4.92	4.89	5.31	5.34	5.92	5.59	5.55	5.84
	20-25 Jan.	25-31 Jan.	1-6 Feb.	7-12 Feb.	13-18 Feb.	22-27 May	28 May-2 Jun.	3-8 Jun.	9-14 Jun.	15-20 Jun.
	SOP-1					SOP-2				

methods described by Lanford (1970), Guymer (1978), and others. In most instances the flow patterns implied by the buoy data were consistent with those derived from interpretation of cloud imagery; however, on numerous occasions the buoys indicated more intense pressure systems than were estimated from the cloud imagery. This tendency was generally confirmed by subsequent reports from other buoys or island and ship reports.

B. Utility of Buoy Data

Although the accuracy of drifting buoy data was difficult to determine, the utility of these reports was beyond question. Buoys were deployed mainly in the data-sparse oceans of Southern Hemisphere--regions in which the specification of the surface pressure pattern had previously been limited to qualitative methods based on satellite cloud imagery. Buoy data provided information that helped define the pressure patterns over otherwise data-sparse regions with reasonable accuracy. The pressure fields obtained from analysis of buoy data displayed temporal coherence and were consistent with the atmospheric thermal structure defined by satellite borne sounders, and with pressure fields interpreted from cloud imagery.

C. Impact of Buoy Data

It was fortuitous that during the first few months of 1979 there were numerous occasions, some extending over several days, in which drifting buoy data were not available to NMC's Global analysis system

Table 6.--Six-day mean rms differences between OI analysis surface pressure and data from various sources. latitude 30° S to 90° S.

Land stations	2.21	1.76	1.86	1.95	1.77	1.92	1.99	1.84	1.97	1.95
Ship stations	2.94	2.28	1.87	2.00	2.37	2.21	1.98	1.60	1.67	1.82
Drifting buoys	2.05	2.21	1.89	1.97	1.92	2.47	2.31	2.22	2.16	2.19
	20-25 Jan.	26-31 Jan.	1-6 Feb.	7-12 Feb.	13-18 Feb.	22-27 May	28 May-2 Jun.	3-8 Jun.	9-14 Jun.	15-20 Jun.
	SOP-1					SOP-2				

(fig. 7). The alternation between 'with buoy' and 'without buoy' analyses permitted the impact of buoys to be measured. However, particularly during SOP-1, the deteriorating quality of VTPR data, and eventually the temporary loss of remote sounding data early in March, restricted the validity of these comparisons.

During SOP-2, when buoy data were received more regularly and TIROS-N data were available, the analyses were of significantly better quality -- i.e., more temporally coherent and vertically consistent -- than during SOP-1.

Comparison of tables 5 and 6 indicates that buoy data fitted the final OI analyses significantly better than they fitted the first guess fields. Also note that the improvement in the fit of the data between the first guess and analysis fields was substantially larger in the case of the buoys than for either land station or ship reports. If this improvement can be considered to reflect the effect of the particular data type on the analysis, then buoy data may be considered to have had a greater impact than either land or ship data.

Indications of a possible positive impact of drifting buoy data on the performance of numerical prediction models has been provided by Guymer (1979) who showed (table 7) that the margin of skill of a prediction model over persistence was nearly 2 S1 skill score points better in January 1979 (with buoy data) than on January 1978 (without buoy data). However, Guymer suggests that further evaluation is necessary to confirm this result.

Table 7.--S_1 skill scores (mean for month)

	Pers.	Spec. Prog.*	Diff.	Average skill for whole of 1978
Jan. 1978	64.8	59.3	5.5	58.

*Hemisphere Spectral Model Prognosis produced operationally at the National Meteorological Analysis Center, Melbourne.

6. CONCLUSION

The drifting buoy program implemented for the GWEx has proven to be of significant benefit to NMC and other meteorological centers in their analyses of Southern Hemisphere pressure patterns. The buoys have provided data which, by SOP-2, fell only marginally short of meeting adequate spatial distribution requirements. With a few notable exceptions, the accuracy of the buoy data has appeared to be adequate.

The buoy data have enabled the specification of surface pressure fields with reasonable accuracy in previously data-void regions. The ability to specify the surface pressure patterns with reasonable confidence and accuracy significantly augmented the value of wind and temperature data provided by remote sensing from satellites.

The number of buoys which either report incorrect data or fail to report is increasing. It is probable that over the next several months more buoys will malfunction and thereby reduce the availability of useful meteorological data over the southern oceans. It is desirable that the drifting buoy program be continued to ensure the deployment of buoys to replace expected failures. In the absence of such a program, a return to substandard specification of surface pressure patterns could result, significantly reducing the value of the space-based observing system and probably causing a deterioration in the quality of analyses at all levels of the atmosphere.

ACKNOWLEDGMENTS

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Guymer, Leon B., 1979. Personal communication.

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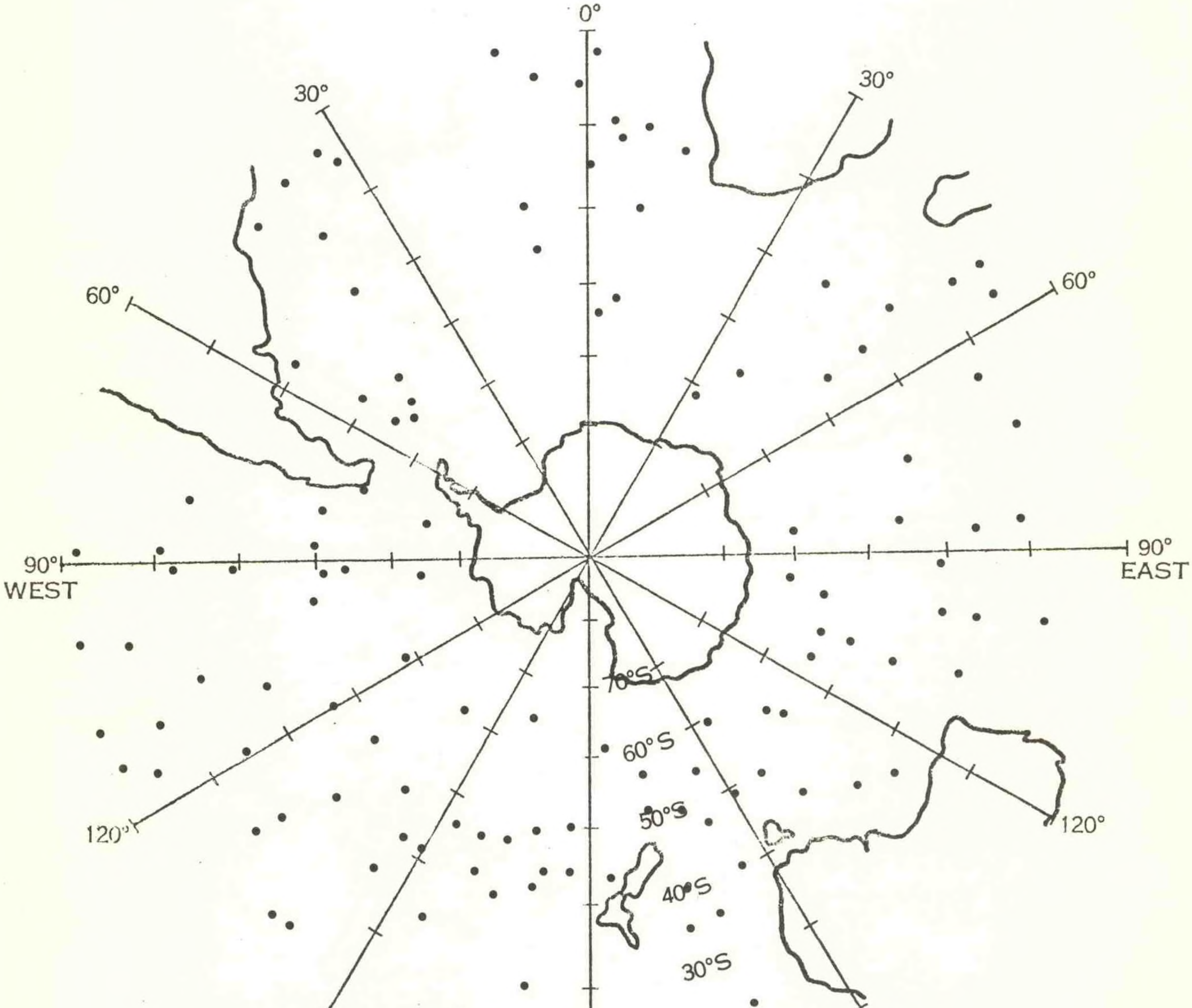


Figure 1.--Drifting buoy distribution during early January 1979.

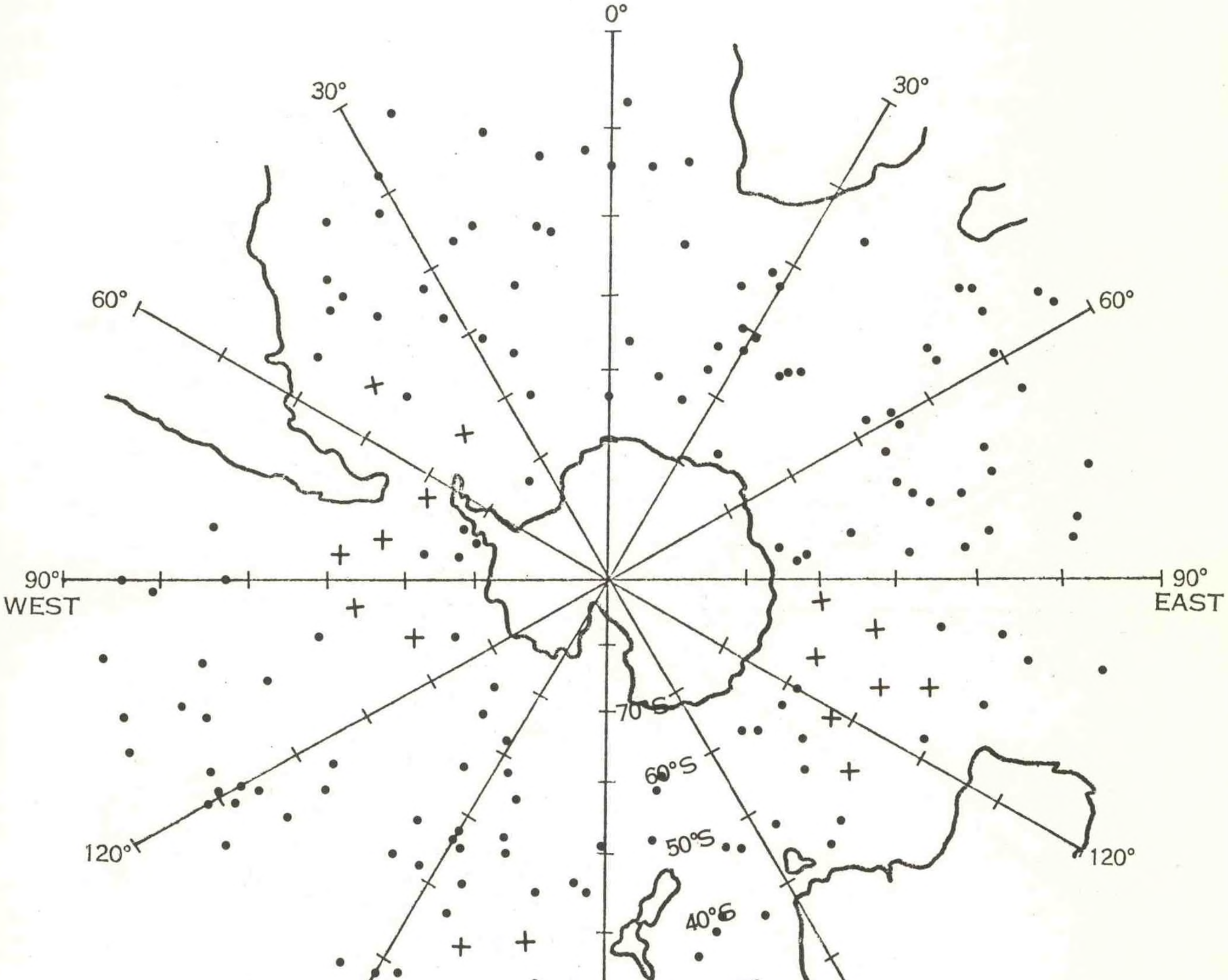


Figure 2.--Distribution of the operational GWE Southern Hemisphere drifting buoys as of May 10, 1979, in the area south of 20°S latitude Crosses indicate buoys deployed by air-drop during May 1979.

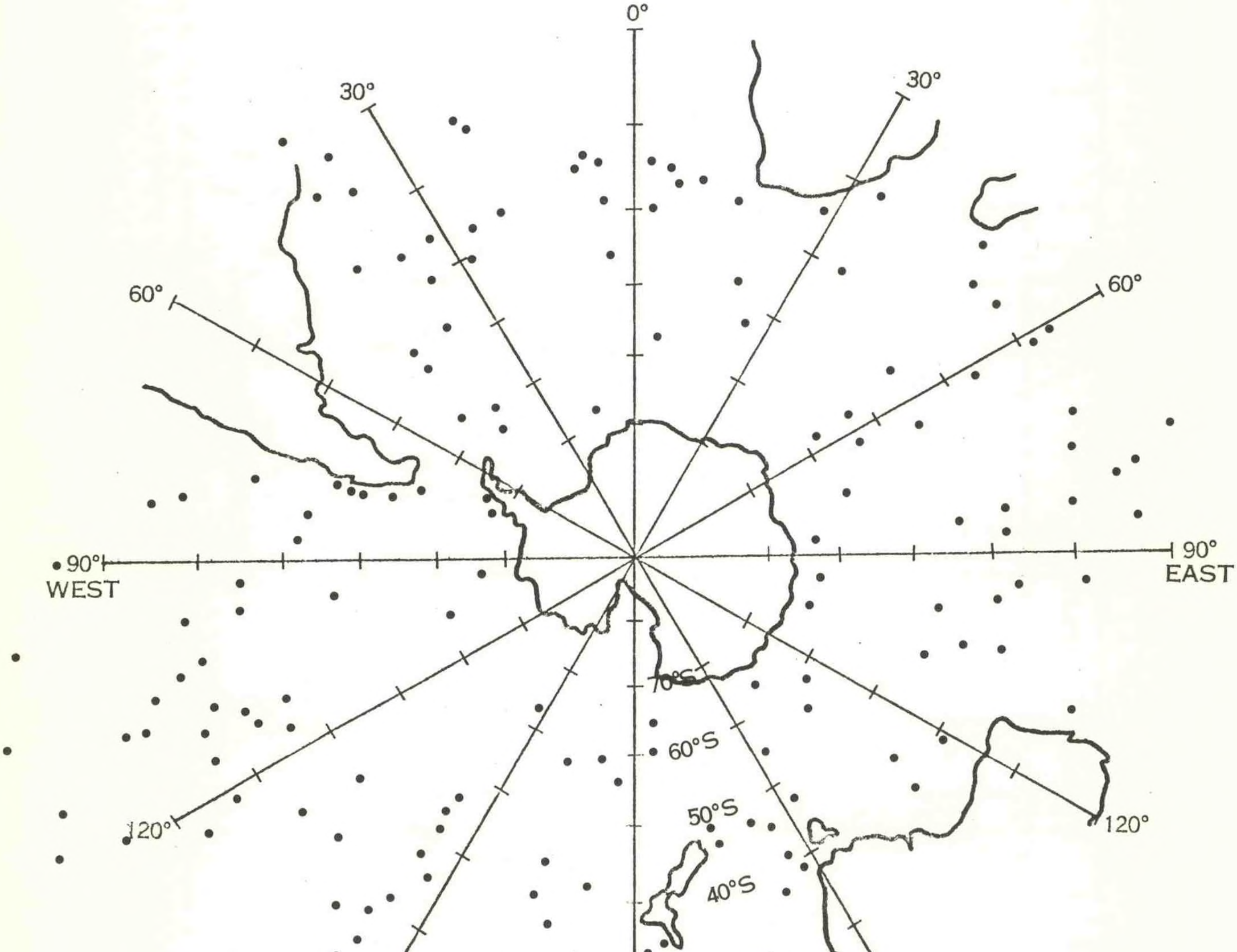
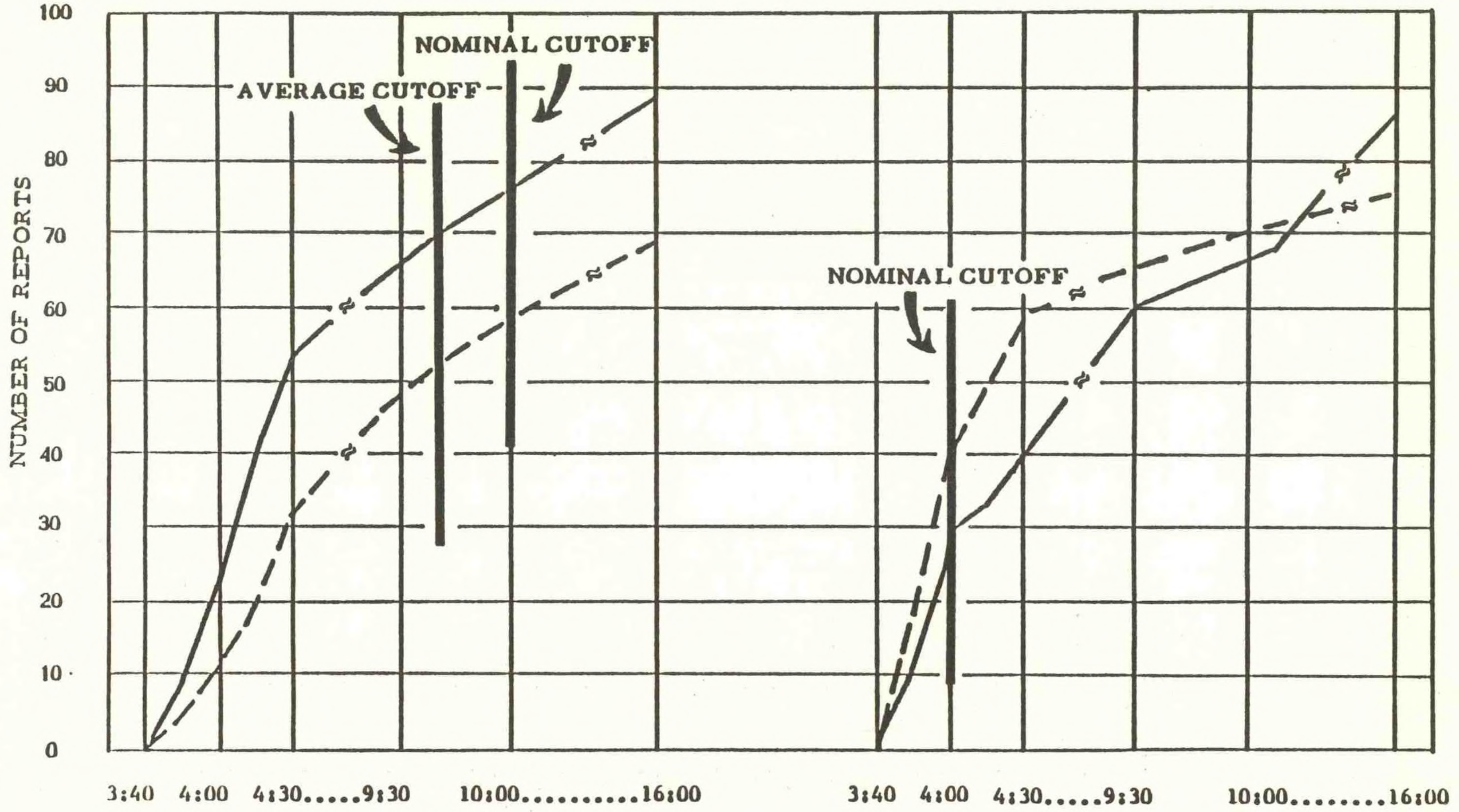


Figure 3.--Drifting buoy distribution, late September 1979.



RECEIPT TIME H+ hrs.

Figure 4(a)--DRIBU data receipt at NMC, First SOP.

——— 00Z data
– – – 12Z data

Figure 4(b).--Average for 25 days picked at random

——— 06Z data
– – – 18Z data

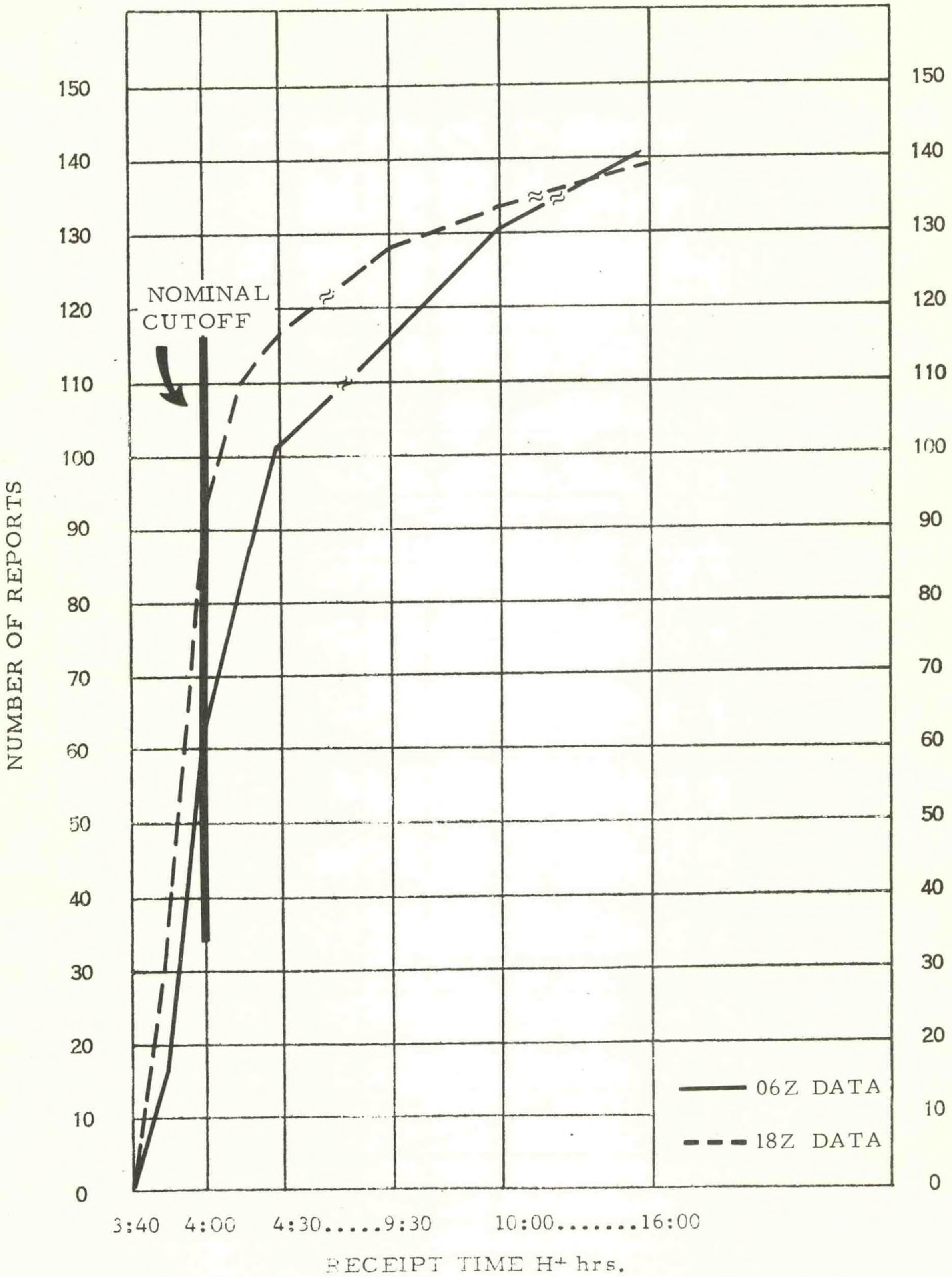


Figure 5.--DRIBU data receipt at NMC, second SOP. Average of 20 days receipt.

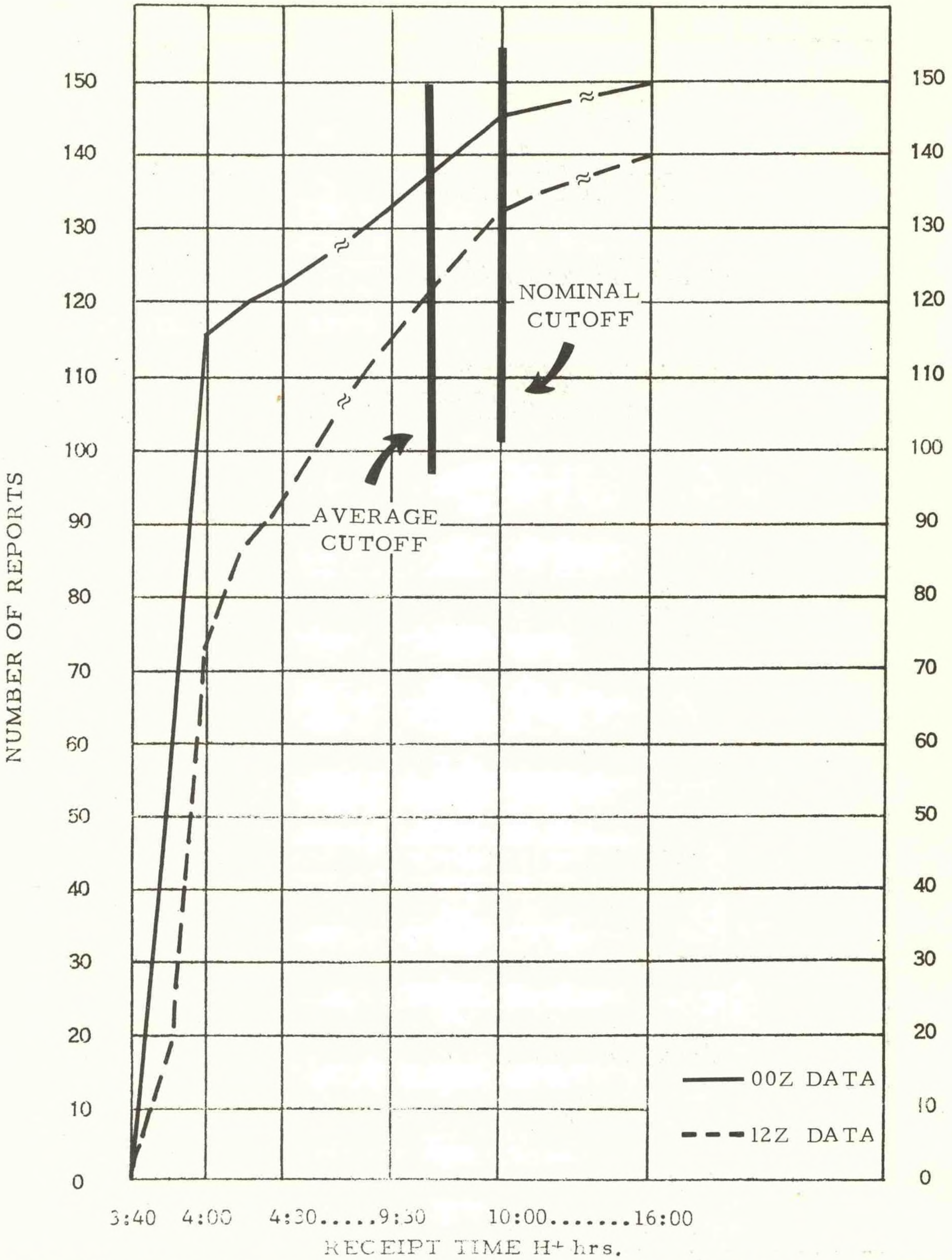


Figure 6.--DRIBU data receipt at NMC, second SOP. Average of 20 days receipt.

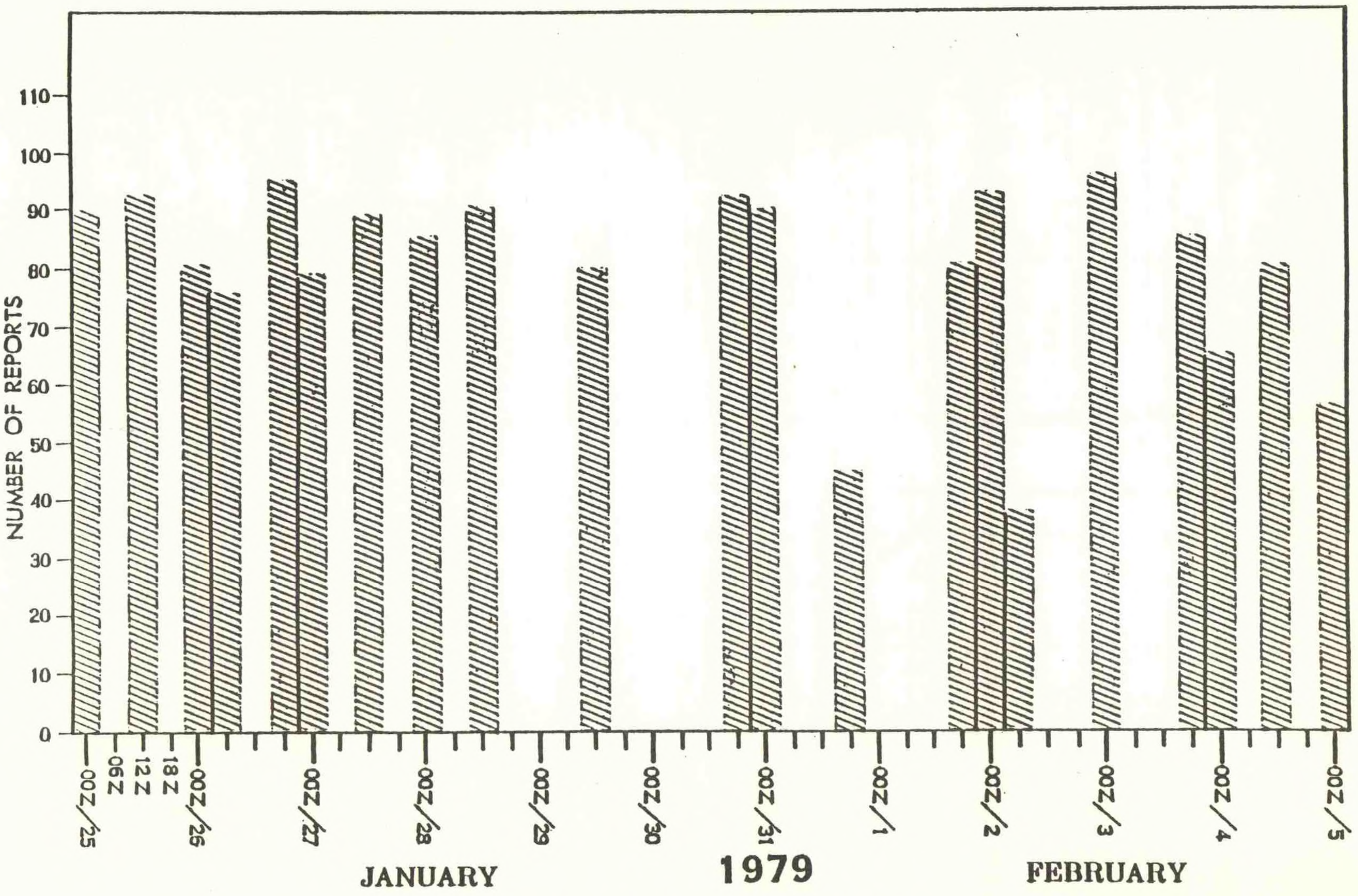


Figure 7.--Number of DRIBU reports used in final analysis.

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