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NOAA Technical Memorandum NWS NMC-52

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service

Toward Developing a Quality Control System for Rawinsonde Reports

FREDERICK G. FINGER and ARTHUR R. THOMAS

National Meteorological Center

WASHINGTON, D.C.

February 1973

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TN 30 NMC 35 Saturation Thickness Tables for the Dry Adiabatic, Pseudo-adiabatic, and Standard Atmospheres. Jerrold A. LaRue and Russell J. Younkin, January 1966. (PB-169-382)

TN 37 NMC 36 Summary of Verification of Numerical Operational Tropical Cyclone Forecast Tracks for 1965. March 1966. (PB-170-410)

TN 40 NMC 37 Catalog of 5-Day Mean 700-mb. Height Anomaly Centers 1947-1963 and Suggested Applications. J. F. O'Connor, April 1966. (PB-170-376)

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WBTM NMC 38 A Summary of the First-Guess Fields Used for Operational Analyses. J. E. McDonell, February 1967. (AD-810-279)

WBTM NMC 39 Objective Numerical Prediction Out to Six Days Using the Primitive Equation Model--A Test Case. A. J. Wagner, May 1967. (PB-174-920)

WBTM NMC 40 A Snow Index. R. J. Younkin, June 1967. (PB-175-641)

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WBTM NMC 47 The National Air Pollution Potential Forecast Program. Edward Gross, May 1970. (PB-192-324)

WBTM NMC 48 Recent Studies of Computational Stability. Joseph P. Gerrity, Jr., and Ronald D. McPherson, May 1970. (PB-192-979)

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TOWARD DEVELOPING A QUALITY CONTROL SYSTEM FOR RAWINSONDE REPORTS

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National Meteorological Center

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TOWARD DEVELOPING A QUALITY CONTROL SYSTEM
FOR RAWINSONDE REPORTS

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ABSTRACT. Results of investigations indicate that many of the problems that prevent rawinsonde data from reaching the user can be rectified by proper quality control procedures. Methods have been developed to test the effectiveness of quality control, and these have resulted in significant improvements in data usage at NMC. Typically, data utilization from U.S. moving ships in the Pacific was increased from 35% to 95% in less than 3 years; from the NWS Pacific Region, data procurement and use more than doubled between 1968 and 1972; and improvements in data from conterminous U.S. stations could be projected to indicate an increase of 5,000 additional observations being processed annually at NMC.

Data quality can be improved and sustained only while active monitoring and deficiency notification programs are in operation. When such programs are terminated, data quality deteriorates to original levels. An effective program to adequately control data quality must involve integrated functions at data sources, communications centers, processing centers, and, most importantly, headquarters elements.

1. INTRODUCTION

There are a number of data quality control efforts at the National Meteorological Center (NMC) and in other organizational elements in the National Weather Service (NWS). This report primarily considers the work being carried out by the Upper Air Branch (UAB) of NMC's Development Division, which is oriented mainly toward evaluating the quantity and quality of rawinsonde data made available to NMC for daily operations. Although the approaches to the various quality control efforts are somewhat different, the overall philosophies are parallel, and they are to ensure that each NMC operation is carried out with the maximum quantity of correct data.

The UAB quality control (QC) effort was begun in June 1968, initially with the aid of funds from the Data Acquisition Division (DATAC), Office of Meteorological Operations. It was felt that NMC, as the hub of all incoming data, was a suitable location for attempting an evaluation of problems that prohibited scheduled reports from being fully utilized. Obviously, problems may arise from errors occuring at the observation site, in the communication system, or at NMC. A study of these problems with possible isolation of their causes would be helpful to DATAC, Communications, and other such units in their efforts to supply the highest quality data. The benefits to NMC from such a program are obvious. It was also hoped that rapport would be improved between personnel of NMC and the NWS Regions. This would enable the regions to gain a better understanding of the complete needs of the user and provide the regions with increased knowledge of the benefits and problems associated with computer processing of rawinsonde data.

The first major decision to be made regarded the manner in which the QC effort would be carried out. A fundamental constraint was that it would be a one-man operation, with a limited amount of technical aid from UAB personnel. Two distinctly different methods of attacking the QC problems were considered. They are:

a. "Real-time" monitoring of pertinent data the moment that they arrive at NMC via the communication lines. This scheme would entail a determination of missing reports and attempts to recover them (perhaps by telephone communication to the station) in time for insertion into the operations. In addition, corrections would be made manually to any apparent erroneous reports. Aspects of this method would complement other efforts at NMC which result in "bogus" information being added into the analysis system. However, this method would additionally entail direct communication with the stations in order to recover as much observed data as possible.

b. Determination and categorization of the reasons for missing or erroneous data by appropriate interpretation of the individual cases. One might consider this a research-oriented attack on the QC problem. The results of such studies could produce information on common types of errors. This information may then be fed back through the proper channels, hopefully allowing problems to be rectified at their source.

It was decided that the second method of attack would be followed. There were several reasons for this decision. The primary one was that this method could result in a permanent solution of continuing problems, whereas the first method would only tend to correct problems day by day. This decision did not mean that we would completely ignore the real-time monitoring method. In fact, information presented in this report shows that the real-time method was used, but only as a supplementary tool for evaluation of problems.

The primary purpose of this document is to sum up UAB QC efforts during the past three years. We will try to present some information regarding at least the main areas of concern. There are generally three aspects that may be discussed in each area. They are: (a) the discovery of a problem, (b) the gathering of information to support the contention that a problem exists, and (c) the attempt to derive a permanent solution.

2. INVESTIGATION OF OPERATIONAL RAWINSONDE DATA LOSSES

Consistent with the above stated aspects, we began our effort by trying to determine the amount of data from NWS stations which should have been--but for unknown reasons was not--available to NMC for operational usage. The primary assumption here was that all stations so noted in the "Operations of the National Weather Service" should submit timely data according to the schedule indicated. In addition, it was assumed that data from all NWS stations are necessary for NMC operations.

A cursory answer as to the magnitude of the problem was obtained by simply noting which observations were missing for a given operation. However, a full evaluation had to be based on both missing reports (defined here as reports not received in time for a given operation) and reports that could not be processed because of errors. Examples of the results of such an assessment are shown in table 1. This study was carried out a few years ago. In order to obtain stable results, operational analyses constructed for weekdays were checked for missing and unusable data over a 3-month period (January to March 1970). Results in table 1 are indicated for NWS stations within the contiguous United States; the stations considered are shown in figure 1. We should reemphasize that the values listed under "missing" include late (RTD) reports if they were not received in time for the operation for which they were intended.

There may be many reasons for data not being received by the user. To name a few: it may not have been possible to take the observation; the observation may have been terminated prematurely (in which case there is a provision for explanation in the Rawinsonde Code); the observer may not have encoded the observation properly; the communications system may have garbled or lost the report; the user's computer may have malfunctioned before the report was used. Although it may appear that finding the exact cause of a problem is a hopeless task, the unique communication facilities at NMC make in-depth investigations possible.

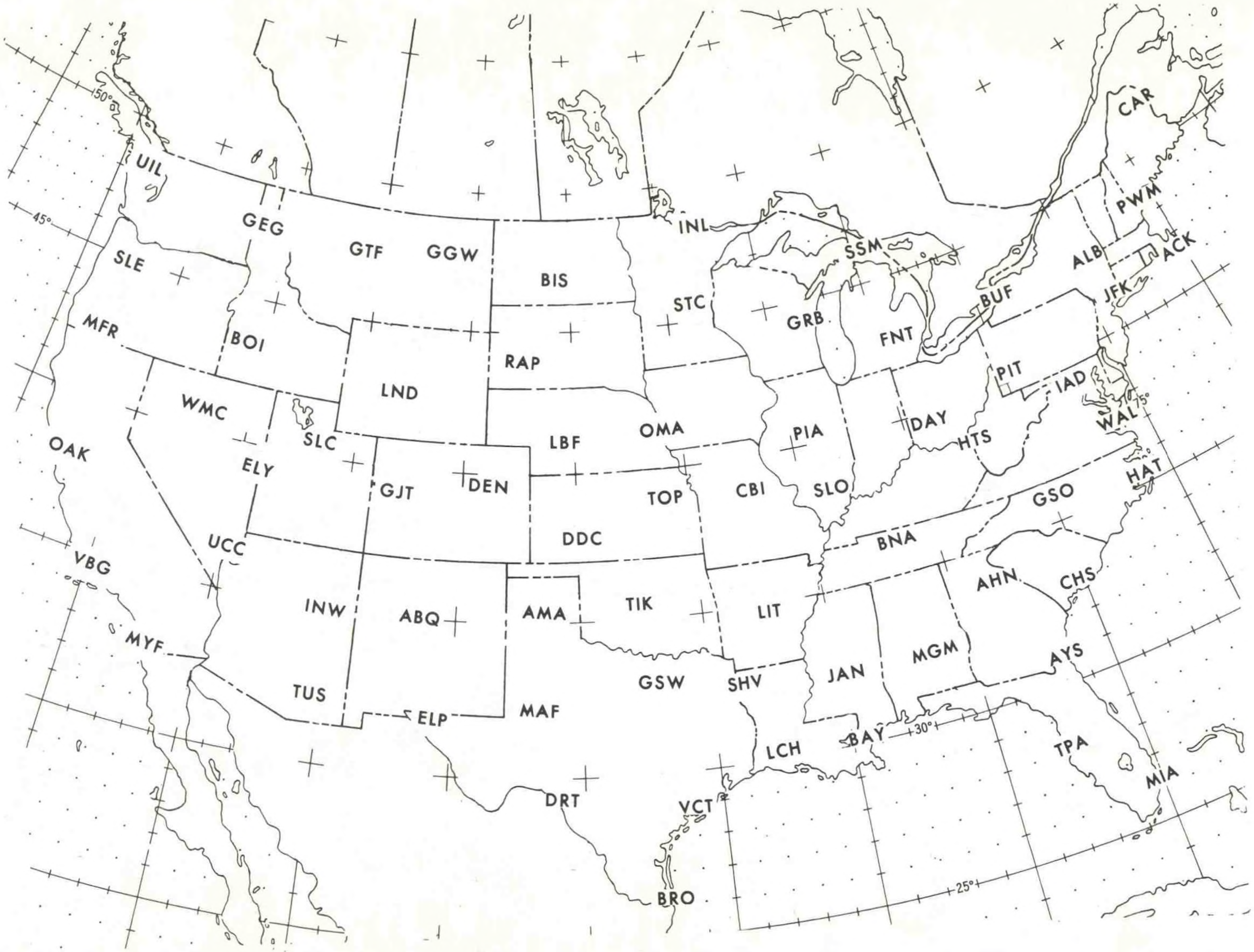


Figure 1.-- Conterminous U.S. radiosonde network - 1970

Table 1.--Missing and incomplete rawinsonde reports at NMC from January 1 to March 25, 1970 (0000 and 1200GMT). The number of reports considered in each case is shown to the right of the slash. The number on the left side represents missing or incomplete reports.

National Weather Service
(Contiguous 48 States)
(Combined-67 Stations)

	Missing	Incomplete	Total
0000Z	460/9240 (5.0%)	594/8780 (6.8%)	1054/9240 (11.4%)
1200Z	524/9131 (5.7%)	621/8607 (7.2%)	1145/9131 (12.5%)
Total	984/18371 (5.4%)	1215/17387 (7.0%)	2199/18371 (12.0%)

Explanations of the reasons for data not being received can be found by judicious investigation back through the data channel. For example, information derived from automatic map analysis and data processing can be compared with the reports as they appear on the regular communications circuits (in this case Service C). In that way, computer errors can be determined directly. A few cases of such errors were found, but these did not enter into the results shown in table 1. It should be added that our experience has shown that most of the computer errors result in the loss of blocks of data rather than single stations. Thus, the problem is generally recognizable by inspection of the analyzed maps.

The unique communications facilities at NMC make possible a determination of data which may be lost or mutilated in the communications channels. This is possible since the Center has direct access to each Service C circuit in the contiguous United States, and in effect is a station on each circuit (see fig. 2). Thus, reports from the direct circuits can be compared with similar reports which necessarily have traversed various communications circuits. The value of this capability is obvious, since a comparison of reports from both sources can definitely indicate whether data problems were initiated during communication or at a point previous to communications.

One major factor that cannot be directly determined at NMC is whether or not a station is operational for a given observation time (for example, a station might not be in operation because of

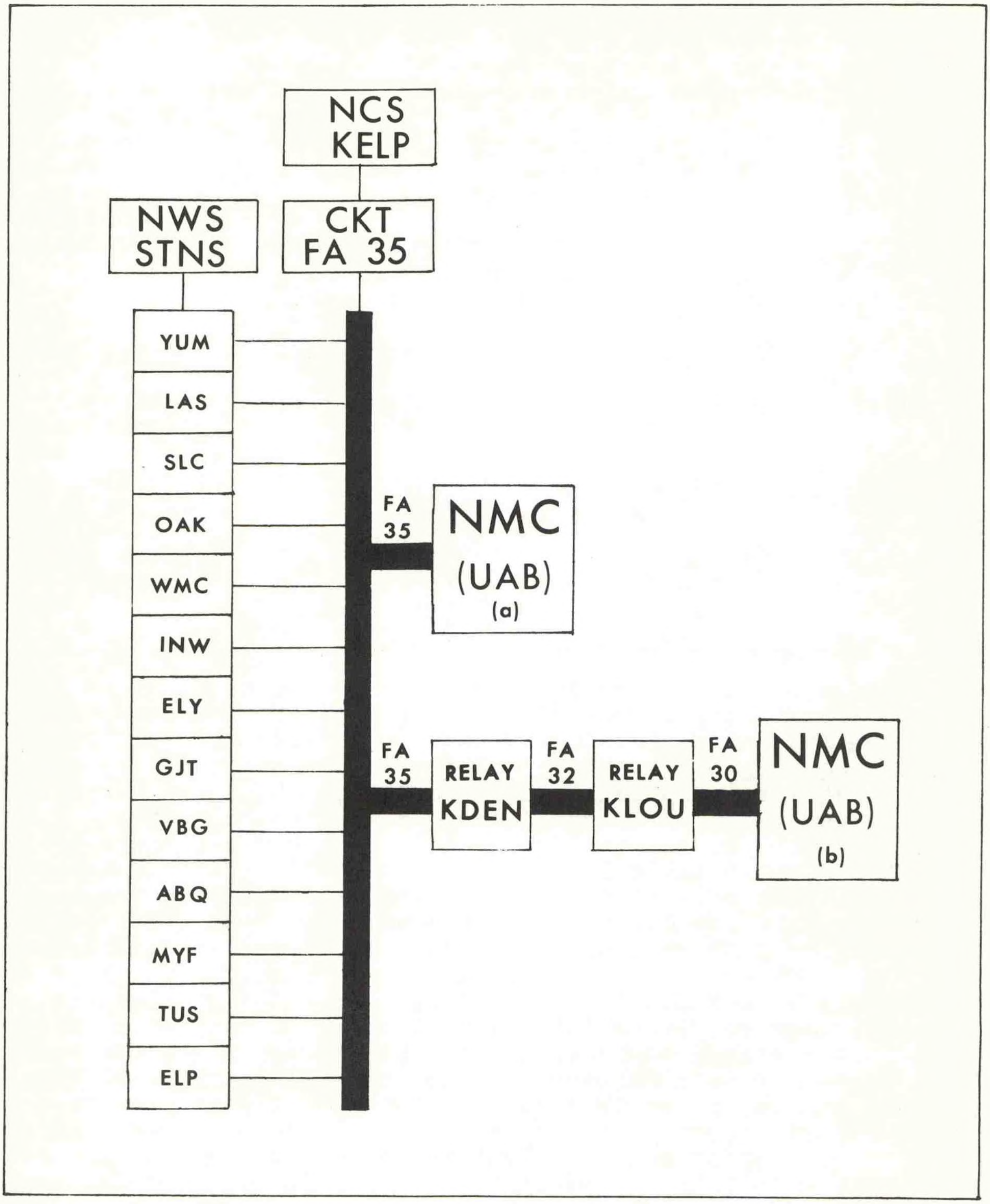


Figure 2.--Example of the two methods by which NMC's Upper Air Branch receives rawinsonde data from conterminous U.S. upper air stations. Data are received directly from the prime source circuits via NMC's IBM 360 computer. The data are also received from Service C following relays by network control stations.

equipment malfunction). However, it is assumed that these stations would transmit a general reason for non-operation as stated in the general regulations (the so-called 101 group). Such information can also be obtained on a delayed basis from the Environmental Data Service. A check of the total number of reports classified as missing in table 1 indicated that approximately 100 or 10% of the missing signals could be attributed to operational difficulties at the station.

There is no doubt that the information in table 1 indicates that a significant number of reports were either not reaching NMC in time for scheduled operations, or contained errors that prevented them from being processed properly. Since in the vast majority of cases it was known that an observation took place and that the computer was not at fault, it was assumed that the problems occurred in communications or at the observation site. Since sufficient manpower was not available to check all the Service C reports against the direct circuit reports, we could not at this point attempt to isolate the communications problems. In order to categorize the problem areas more completely, it would be mandatory to gather detailed information from the various NWS Regions as well as from the individual stations. In that way, we might obtain information on the problems which exist most frequently.

The station advisory system was initiated with the long range view of reducing errors and thereby increasing the volume of rawinsonde data processed for operational use at NMC. By this method, we could alert observers and communicators to the types of errors that occur most frequently in coded and transmitted reports. The advisories would also point out the necessity for providing the computer with coded observations in a precise form. Since the computer is only as flexible as its programs allow, it would be impossible to develop a program that could account for all possible errors and identify the corrections required for all errors.

An example of the station advisory format is shown in figure 3. As can be seen, it presents a significant amount of information to the station regarding our evaluation of the error as it appeared in the report received at NMC. It was expected that replies would be received from the stations (as suggested in the advisory), indicating that they had investigated and determined that the errors did or did not occur at the site. Some 3,000 advisories were sent out, but response was not overwhelming. Of course, replies were expected only where our evaluation of the problem appeared to be improper from the station viewpoint.

One problem with the advisory system was that the evaluations of errors would reach the stations by mail after the observation had been filed. Thus, the observer may very well have had difficulty recalling the exact circumstances. With this in mind, it

U.S. DEPARTMENT OF COMMERCE
Environmental Science Services Administration
WEATHER BUREAU
Silver Spring, Md. 20910

Date:

Reply to Attn of: W321

Subject: Missing/Incorrect Rawinsonde Reports

To: Chief, Operations

The following rawinsonde data were <u>totally</u> <u>partially</u> unprocessed by the National Meteorological Center.

Station: ______________________ Date: ___________ Time: __________Z
Type of transmission: Early (Radat) First (Raob) Second.

☐ The data were not received on schedule. A 101XX group was not received to indicate an on-station delay of this scheduled report. A PDW was not received on time for synoptic analysis.

☐ Although the report was received in time for operational use, it contained an error in the following code group:

☐ Message Identifier ☐ Date/Time

☐ Station Number ☐ Numerical Indicator

☐ __________-mb ☐ Height ☐ Temp/Depression ☐ Wind

☐ Other:

The encoded data were received as:

And should have been:

Our copy of the report is annotated and enclosed. The discrepancy is circled and subsequent data which were not corrected for ADP by NMC analysts have been lined out to show the extent of data losses due to this mistake.

This is the__________ advisory sent this month concerning losses of operational rawinsonde data from this station.

At the scheduled time for these data to be received and decoded, the communications system and processing computers appeared to be functioning normally; so it seems that this problem may have originated when the report was prepared for transmission. If you have evidence to the contrary (e.g., a letter-perfect copy of the bulletin), please advise us and we will investigate further. We hope this information will bring about a significant reduction in data losses from similar causes by serving to emphasize the importance of carefully checking reports before they are transmitted on-line.

Arthur R. Thomas
Arthur R. Thomas
Quality Control Specialist
Upper Air Branch, National
Meteorological Center

Enclosure

Figure 3.--Sample of advisory forms mailed to stations.

was decided that direct oral communication with the station as soon as possible after a problem had been found might prove more fruitful. This telephone advisory scheme was initiated with the consent of all contiguous U.S. Regional Headquarters. Since it was virtually impossible to inspect all the reports thoroughly, we carried out the telephone advisory scheme for only certain days that were selected on a random basis. A log of contact for February 1971 is shown in figure 4. It should be emphasized that these calls were not made for the purpose of recovering data for operations, but only to obtain information from the station regarding their appraisal of missing or erroneous reports. The most surprising aspect of this and logs of other months is that the stations were able to verify about two-thirds of the problems (as can be seen by inspection of the log in fig. 4). Since this phase of the effort was carried out over a 4-month period, it can be assumed that the results were representative.

In terms of increasing the amount of domestic data available for operational use, the total advisory system (combined mail and telephone) appeared successful. Success was not measured by the response, but by the results of a data availability study conducted during the period from December 1970 through February 1971. The gains in usable data (generalized in table 2) when compared to the earlier study are evident. Again, the data sample for this second period, in our opinion, was sufficiently large to be representative.

Table 2.--Percentage of rawinsonde reports from NWS conterminous Regions that were used in NMC operational analyses

Jan to Mar 1970	Dec '70 to Feb '71
88%	98%

Data gain: Approximately 5,000 reports annually
Value @ $120/observation: Approximately $600,000 annually

Form 413-50
63

NOTIFICATIONS OF DISCREPANCIES
IN RAWINSONDE REPORTS

FEBRUARY 1971

STATION-MESSAGE-DAY/TIME	MISSING-REPORT-RECEIPT	INCORRECT MESSAGE FORMAT	INCORRECT CALL LETTERS	INCORRECT MESSAGE IDENTITY	INCORRECT DATE/TIME GROUP	INCORRECT INDEX NUMBER	INCORRECT INDICATOR GROUP	INCORRECT MET. DATA	OTHER	AMTD BY FAA-UAU NO CHECK	STATION VERIFIES ERROR	STATION COPY CORRECT	STATION COPY NOT AVAILABLE	OTHER
ALB UJ 01/12Z				TT OMIT		71518					✓			
WAL UJ 01/12Z				YY(VV)							✓			
GSO UJ 01/12Z								971 MB TEMP			✓			
DDC UJ 01/12Z								1000 MB HT			✓	TRANSMITTED WRONG BY FSS		
TOP UJ1 01/12Z	✓										✓	COMMS EQUIPMENT TROUBLE AT STATION		
CAR UX 02/12Z				V(VV)							✓			
ALB UX 02/12Z		SPACE OMITTED									✓			
HTS UX 02/12Z								850 MB HEIGHT			✓			
JFK UX 02/12Z	DISCREPANCY EVIDENT AT CAR & ALB							700 MB HEIGHT		✓		JFK STATED THAT REPORT SENT TO NWS WAS OK		
ELP UX 02/12Z				0196(1046)							✓			
INW UX 02/12Z		850 TEMP GROUP									✓			
SLE UX 02/12Z												✓		
BOI-UX 02/12Z				VV MISG - NO ANSWER AFTER SEVERAL ATTEMPTS ON FTS 208-342-9272										
LND UX 02/12Z	✓	FAA HAD LND CKT ON "BLIND" POSITION												✓
AHN UJ 02/12Z					PART B						✓			
GSO UX 04/12Z					51121	VERIFIED BY REGIONAL OBS. SPEC. ON STATION AT THE TIME					✓			
CHS UX 04/12Z				VV OMIT	TRANSMITTED BY FSS BUT NOT CHECKED BY NWS OBSERVER						✓			
JFK UX 04/12Z									850 HT. GP. OMIT		✓	COR SENT ON RAWARC		
ALB UX 04/12Z					7412/						✓			
SLO UX 04/12Z	✓	STATION TD DID NOT ACTIVATE WHEN POLLED												✓
ABI UX 04/12Z									MESSAGE TERMINATED		✓			
ELY UX 05/12Z	✓	"LOCAL PROBLEM" - NO ADDITIONAL EXPLANATION GIVEN									✓			
AMA UX 05/12Z	✓	DELIVERED TO FSS ON TIME								✓				
AHN UX 05/12Z		GARBLED - STATION SENT COR IMMEDIATELY							✓		✓			
RAP UJ 08/12Z				T(TT) TRANSMITTED WRONG BY FSS							✓			
BAY UX 08/12Z	✓	LATE RELEASE - LATE REPORT									✓			
SLO UX 09/12Z									GRBLD			✓		
AMA UX 09/12Z									GRBLD			✓		
BRO UX 09/12Z									GRBLD			✓		
GEG UX 09/12Z				V(VV)							✓			
GRB UJ 09/12Z				TT OMIT	60001						✓			
ELY UX 10/12Z	✓	TELETYPE (CIRCUIT) TROUBLE												✓
WMC UX 10/12Z	✓	TELETYPE (CIRCUIT) TROUBLE												✓
JAN UX 10/12Z	✓	DELIVERED TO FSS. NOT TRANSMITTED BY FSS												✓
HAT UX 11/12Z	✓	COMMUNICATIONS OUTAGE												✓
BIS UX 11/12Z	✓	MSG. SENT OUT OF SEQUENCE AND DROPPED ON RELAY												✓
CHS UX 11/12Z				V(VV)							✓			
AHN UX 11/12Z	GARBLED AT NMC & CHS BUT OK AT AHN								✓			✓		
UCC UX 12/12Z				V(VV)					✓	✓				
ALB UX 12/12Z								700 MB HEIGHT			✓			
TOP UX 12/12Z		SPACE OMIT									✓			
LIT UJ 12/12Z					6212/						✓			
GEG UX 18/12Z		LOWER CASE									✓			
ALB UX 18/12Z		51540									✓			
CHH UX 18/12Z				19106			19106				✓			
WAL UX 18/12Z				ΦΦ(VV) ERROR CONFIRMED BY MAIN OFFICE							✓			
LIT UX 18/00Z				VV OMIT	6700/					MIC DID NOT CHECK				
LIT UX 18/12Z				VV OMIT							✓			
AMA UX 18/12Z									GRBLD			✓		
AYS UX 18/00Z	✓									COMMS TROUBLE				✓
AYS UJ 18/00Z	✓									COMMS TROUBLE				✓
ABI UJ 18/00Z					PART B 5300/						✓	MR. CREACY		
GEG UJ 18/00Z		FE SIG. LVL.									✓	MR. WALTERS		
PIA UJ 18/12Z	✓	PDW RECEIVED GRBLD. COMMS TROUBLE ALERTS									✓			
ALB UX 23/12Z				CV							✓			

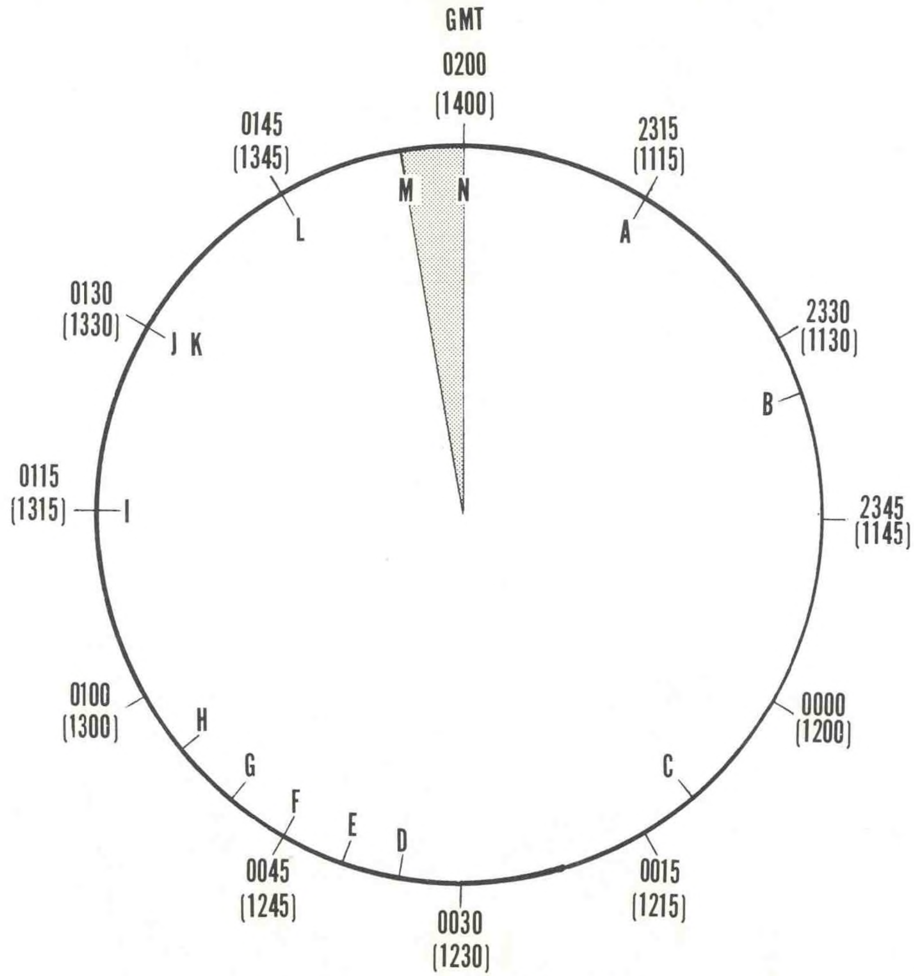
Figure 4.--Partial record of telephone calls made in investigating causes for data deficiencies. The left section identifies the data source and the reports in question. The middle section identifies the data deficiency. The right section lists the findings of the investigation.

The specific reason for the significant increase in the receipt of operational rawinsonde data was not entirely obvious. We must assume, however, that there was an increased awareness on the part of both observers and communicators as to the cause of the problems, and agreement that many of these problems could be overcome. This assumption appears logical, since, in addition to the advisories, we (we, meaning many more interested parties than only the UAB QC organization) had taken every opportunity through the various internal news media to speak of the necessity of inserting "correct" data into the computer operations.

3. TESTING A REAL-TIME DATA DEFICIENCY NOTIFICATION SCHEME

At the beginning of the QC effort we were not at all certain that our program would be the best approach to the QC problem. Some colleagues suggested that a real-time monitoring effort would accomplish more. They reasoned that a real-time effort would allow recovery of at least a portion of the missing and erroneous reports and would also enable field personnel to be made aware of deficiencies while their observations were still fresh in their minds. In order to test the feasibility of a real-time program, a monitoring and discrepancy notification program was planned and carried out for a short time period. Unfortunately, manpower limitations forced curtailment of our other apparently successful schemes and in addition allowed us to consider only the 1200 GMT rawinsonde observations during regular workdays.

To accomplish the real-time monitoring and data recovery scheme, it is necessary to scan the teletype sequences as they are received. It soon became evident there is only a very limited time period (in some cases only a few minutes) in which missing and erroneous data can be recovered in time for operations. Our method depended on telephone communication to recover the data, followed by manual insertion of the information into the computer. However, it is obvious from the time limitations between the observations and NMC operations as shown in figure 5 that significant impracticalities exist in the development of a real-time monitoring system unless high speed communication links are available between the monitoring point and all stations. For example, although the U.S. rawinsonde observations begin (point A in fig. 5), about 2 hours and 45 minutes prior to NMC's Limited Fine Mesh (LFM) analysis deadlines, the data needed to produce the charts are not received (point M in fig. 5) until 5 minutes before these automated analyses must commence (point N in fig. 5). Obviously, it is impossible within such a short time frame (the shaded wedge in fig. 5) to examine each report, detect every discrepancy, notify the responsible stations, obtain corrected data and meet these stringent LFM analysis deadlines.



EVENTS

A	Balloon release
B	Balloon 500 mbs
C	Balloon 100 mbs
D	Early transmission prepared
E	Normal termination of RAOB
F	Balloon 10 mbs
G	Early transmissions communicated
H	Early transmissions received at NMC
I	Balloon 5 mbs
J	NMC initial deadline for using early transmissions
K	Stations prepare RAOB PART A
L	RAOBS PART A transmitted
M	RAOBS PART A available at NMC
N	NMC's initial deadline for using RAOB PART A

Figure 5.--A 3-hour clock showing the time available to obtain and communicate Part A radiosonde data and the time available (shaded area) for NMC to correct erroneous reports prior to initiating operations.

In carrying out the real-time test, we found that our telephone calls often reached the stations at inopportune times (e.g., during peak workload periods when the radiosonde observation was still being processed). Thus, the decision was made that only under special circumstances could this system be carried out and then only within the contiguous United States. Even so, operational time limitations at NMC made success highly dependent on rapid telephone communication.

4. COMPUTER AIDS FOR QUALITY CONTROL PROGRAMS

The workload associated with the total (real-time and post operational) advisory system was such that it required the full-time efforts of more than one person to be carried out properly. With the pressure of other tasks it was impossible to continue this entire program and pursue other areas of activity. However, the computer could aid substantially in generating valuable information regarding data availability and usage. Thus, much of the manual work, such as was necessary to derive table 1, could be circumvented. Furthermore, this could be accomplished with only a modest amount of programming. For example, since all (worldwide) incoming rawinsonde data are computer-processed operationally, it is a relatively easy task to generate information regarding the availability and usability of any given report. This can be done for each parameter reported at mandatory pressure surfaces, and in addition, for the various portions of the rawinsonde messages which are utilized for each phase of the operations. The output can take the form of daily tabulations as well as summaries for given time periods.

A portion of our monthly summary of computer statistics is shown in table 3. The monthly results list the 0000 and 1200 GMT observations separately. Within each set, the percentages are associated first with the number of reports actually received at NMC and then with the number that could be fully processed, both keyed to the total number of expected reports. A report is considered fully usable if all parameters contained within two of the three groups for the 700-, 400-, and 200-mb standard pressure surfaces can be processed automatically. This does not mean that these levels constitute rejection criteria for the use of a report at NMC. It means only that they were the criteria used to determine the completeness of reports for the purpose of making certain statistical inferences.

Problems brought out by the monthly summaries, for example low percentages, can be delineated further by inspection of the daily listings. An example of such a listing is shown in table 4. Unfortunately, it must be assumed that all included stations were scheduled to make daily observations. This assumption can be verified for stations in the United States, but there is a

Table 3.--Monthly summary of the percentage of radiosonde data processed by NMC within 3 1/2 hours after 0000 and 1200 GMT observation times - October 1971.

	PER CENT RECEIVED				PER CENT RECEIVED		
IDENT	00	12	TYPE	IDENT	00	12	TYPE
72340	93.55	90.32	RB	72349	87.10	93.55	RB
72354	93.55	93.55	RB	72355	0.00	41.94	RB
72363	100.00	100.00	RB	72365	100.00	100.00	RB
72374	96.77	96.77	RB	72385	100.00	90.32	RB
72391	3.23	6.45	RB	72393	87.10	90.32	RB
72402	96.77	90.32	RB	72403	90.32	80.65	RB
72425	93.55	96.77	RB	72429	100.00	100.00	RB
72433	96.77	100.00	RB	72451	96.77	96.77	RB
72456	100.00	96.77	RB	72469	96.77	93.55	RB
72476	96.77	100.00	RB	72486	93.55	90.32	RB
72493	100.00	93.55	RB	72497	0.00	9.68	RB
72518	87.10	83.87	RB	72520	93.55	90.32	RB
72528	93.55	96.77	RB	72532	100.00	100.00	RB
72553	100.00	96.77	RB	72562	96.77	93.55	RB
72572	100.00	96.77	RB	72576	96.77	93.55	RB
72583	90.32	87.10	RB	72597	96.77	96.77	RB
72600	80.65	74.19	RB	72606	100.00	93.55	RB
72637	93.55	96.77	RB	72645	93.55	100.00	RB
72655	96.77	96.77	RB	72662	96.77	100.00	RB
72681	100.00	96.77	RB	72694	100.00	96.77	RB
72712	100.00	100.00	RB	72722	93.55	90.32	RB
72734	100.00	100.00	RB	72747	100.00	100.00	RB
72764	96.77	100.00	RB	72768	96.77	100.00	RB
72775	100.00	93.55	RB	72785	93.55	100.00	RB
72797	100.00	100.00	RB	72811	90.32	90.32	RB
72815	93.55	93.55	RB	72816	93.55	93.55	RB
72826	80.65	87.10	RB	72836	87.10	90.32	RB
72848	90.32	80.65	RB	72867	93.55	87.10	RB
72896	96.77	90.32	RB	72906	93.55	77.42	RB
72907	90.32	74.19	RB	72909	80.65	90.32	RB
72913	93.55	90.32	RB	72915	90.32	87.10	RB
72917	93.55	83.87	RB	72924	87.10	87.10	RB
72925	87.10	87.10	RB	72926	90.32	70.97	RB
72934	93.55	93.55	RB	72945	93.55	93.55	RB
72957	90.32	77.42	RB	72964	93.55	100.00	RB
74043	93.55	96.77	RB	74051	93.55	83.87	RB
74072	90.32	80.65	RB	74074	77.42	87.10	RB
74081	83.87	77.42	RB	74082	90.32	83.87	RB
74109	96.77	87.10	RB	74119	90.32	93.55	RB
74486	87.10	87.10	RB	74494	83.87	64.52	RB
74794	0.00	58.06	RB	76151	61.29	35.48	RB
76225	70.97	58.06	RB	76256	61.29	64.52	RB
76394	80.65	48.39	RB	76458	70.97	0.00	RB
76644	70.97	54.84	RB	76679	61.29	25.81	RB
76692	35.48	0.00	RB	78016	77.42	77.42	RB
78118	0.00	38.71	RB	78384	74.19	64.52	RB
78397	74.19	61.29	RB	78486	74.19	12.90	RB
78501	77.42	77.42	RB	78526	90.32	87.10	RB
78806	100.00	96.77	RB	78861	0.00	45.16	RB
78866	0.00	22.58	RB	78897	29.03	22.58	RB
78954	0.00	54.84	RB	78970	25.81	6.45	RB
78988	61.29	58.06	RB	80001	51.61	70.97	RB
80222	61.29	51.61	RB	80413	0.00	16.13	RB
81405	0.00	6.45	RB	82193	0.00	6.45	RB
82280	0.00	6.45	RB	82332	0.00	3.23	RB

Table 4.--Portion of daily computer listing of data processed at NMC. Station identification is at left. Various mandatory levels are shown at top. The "M" notation indicates height (H), temperature (T) or wind (W) not processed for that level.

TIME OF RUN 0Z YEAR 72 MONTH 3 DAY 24

IDENT	TIME	1000MB H	1000MB T	1000MB W	850MB H	850MB T	850MB W	700MB H	700MB T	700MB W	500MB H	500MB T	500MB W	400MB H	400MB T	400MB W	300MB H	300MB T	300MB W	250MB H	250MB T	250MB W	200MB H	200MB T	200MB W	150MB H	150MB T	150MB W	100MB H	100MB T	100MB W	70MB H	70MB T	70MB W	50MB H	50MB T	50MB W	30MB H	30MB T	30MB W	20MB H	20MB T	20MB W	10MB H	10MB T	10MB W
72213	0																															M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72221	0																															M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72226	0																															M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72232	0																															M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72235	0																															M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72240	0	M	M	M										M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72248	0																															M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72250	0																															M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72255	0																															M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72259	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72261	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72265	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72266	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72270	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72274	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72290	0																															M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72304	0																															M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72317	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72327	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72340	0																															M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72349	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72354	0	M	M	M										M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72363	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72365	0		M	M	M	M																										M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72374	0		M	M	M	M																										M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72385	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72393	0																															M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72402	0																															M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72403	0	M	M	M										M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72425	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72429	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72433	0		M	M																							M			M			M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72451	0		M	M				M	M	M																						M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72456	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72469	0		M	M	M	M																										M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72476	0		M	M	M	M																										M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72486	0		M	M	M	M																M			M			M			M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72493	0																															M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72518	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72520	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72528	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72532	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72553	0	M	M	M										M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72562	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72572	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72576	0		M	M	M	M																										M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72597	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72600	0																																					M	M	M	M	M	M	M	M	M
72606	0			M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
72637	0		M	M																												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M

question of its validity for other stations throughout the world. This may account for some of the variation in the percentages for the foreign stations as shown in the lower one-fourth of table 3. It is unlikely though that most losses of data from foreign stations are a result of observations not being taken. Much of the total loss is due to nonreceipt of existing data and discrepancies that exist in reports that are received. However, the situation is improving as specific problem areas are identified and reported. Nonetheless, these figures point out the need for expanded quality control programs on an international scale that are commensurate with the growth in the meteorological data gathering and dissemination system.

Forms containing the monthly summaries for U.S. stations have been distributed to all regional headquarters and other intersted users on a regular basis. Although this computer information is valuable, it must be admitted that it does not appear to have the same success as did the station advisories. Perhaps one reason for this is that the listing cannot supply the stations with all of the information that the advisories did; that is, information tending to pinpoint the reason for a missing or erroneous report.

We wish to emphasize that during the advisory stage, a sharp increase occurred in total data processed on schedule at NMC. Also, that when the advisory system was discontinued, the volume of processed data began to slowly diminish. This points out that a high standard with regard to quality control can be maintained with a significant effort at NMC. However, the effort expended on a test basis cannot be carried out on a regular schedule with available manpower. On the other hand, much of the work can be done at the local station level, and simpler methods of checking the reports at all stages can be derived. The final stage would be to ensure that the checked reports entered the communication circuits properly. At that point, it would appear that the responsibility of the station is ended.

5. PROBLEMS WITH DATA FROM THE PACIFIC AREA

In responding to requests to evaluate data receipt from the NWS Pacific Region, we found that:

a. On the average, more than half of the reports from that Region needed within 3 1/2 hours after observation time for prescribed operations at NMC were either missing or unusable (table 5),

b. we could not use most of our methods developed for the contiguous United States to gain the information needed for a complete definition of the problems, and

Table 5.--Summation of rawinsonde reports from NWS Pacific Region stations processed by NMC within 3 1/2 hours after observation time--March 1970. Number of reports considered are to the right of the slash.

	Missing	Incomplete	Total
Early Transmissions	407/638 (63.9%)	16/231 (6.9%)	423/638 (66.3%)
First Transmissions	250/902 (27.7%)	133/652 (20.4%)	383/902 (42.5%)
Total	657/1540 (42.6%)	149/883 (16.9%)	806/1540 (52.3%)

c. it would be mandatory that a cooperative effort be established with Pacific Region Headquarters (PRH) personnel if any of the problems were to be solved.

Independent evaluations of the situation were begun at PRH and NMC. Our results indicated that most of the observations were taken on time but that communications channels were mainly responsible for delays that were preventing data from reaching the user when they were needed. The results of PRH substantiated ours, since it was found that many reports were not even reaching the Hawaiian area in time for Regional operations. The results did not preclude the possibility that problems might exist at individual stations.

Two approaches were begun; one was oriented toward determining communications problems, and the other toward lessening problems at the stations. The station advisory program formed the nucleus for the second investigation. That this program was successful is apparent from figure 6, which shows that at one stage 91% of the data were usable for operations. An inspection of the graph reveals trends that were obvious to us throughout the history of our quality control program. After a problem is uncovered through studies such as those illustrated earlier, and the advisory or some other process is initiated, an increase (sometimes a sharp increase) occurs in the number of usable reports NMC receives on schedule. When we are reasonably certain that our efforts have been successful, the notification program is terminated. At this point, the volume of available data will usually begin to diminish slowly.

Another major problem of the Pacific area was related to the Moving Ship Radiosonde Program (MSRP). Joint efforts to improve the receipt of data from these ships in time for NMC operations

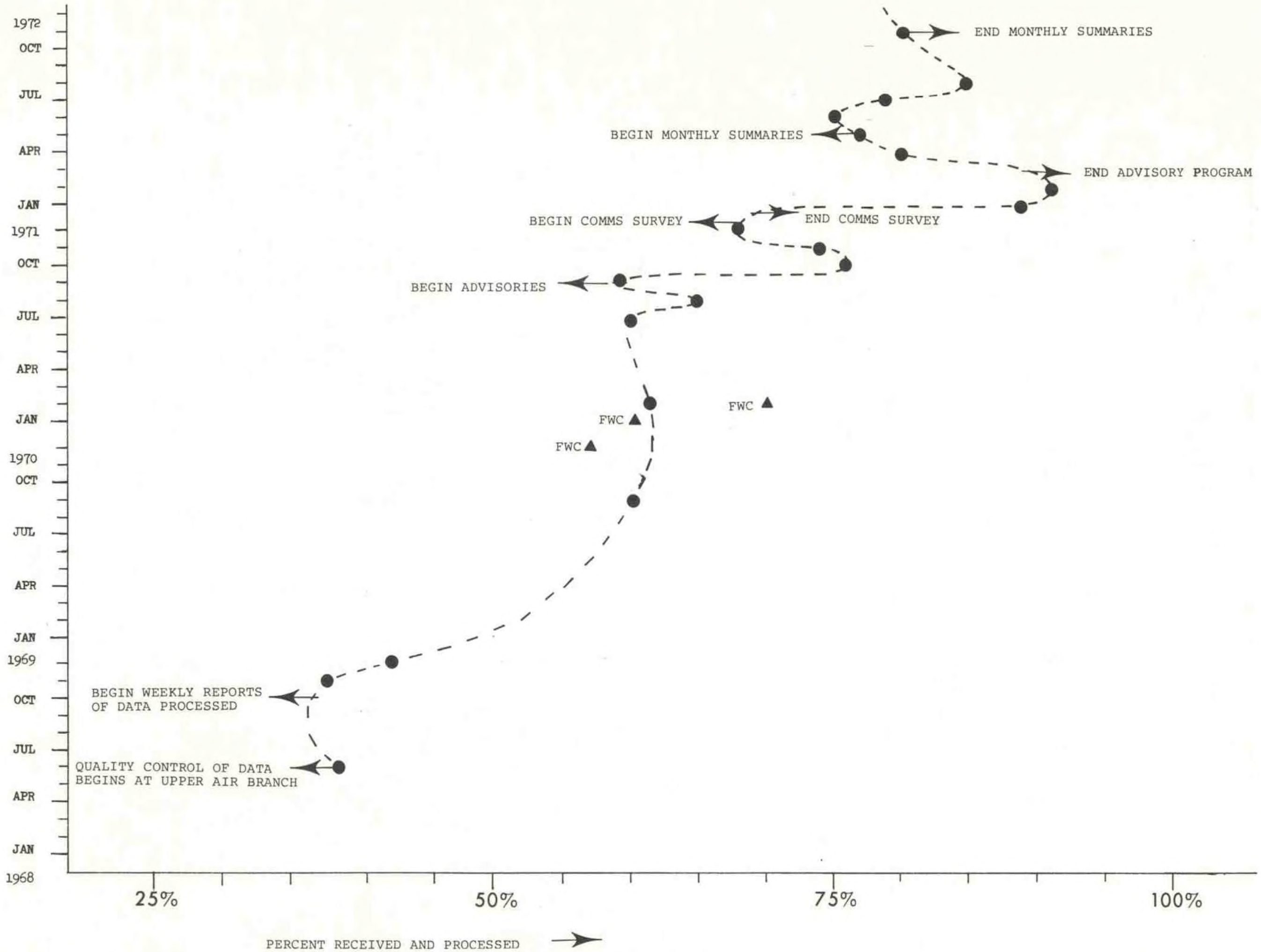


Figure 6.--Percentage of NWS Pacific Region radiosonde observations automatically processed at NMC in time for a specific operation (3+25). Dots indicate times when various data studies were performed at NMC. Arrows show when actions were taken to test problem-solving techniques or discontinued when desirable progress was noted--usually outlined by the studies. Triangles represent times of independent studies conducted by Fleet Weather Central.

were carried out with the Overseas Operations Division and the Communications Division of the Office of Meteorological Operations (OMO) as well as the Marine Supervisor in San Francisco.

The data problems associated with the ships had been termed critical for their operations by NMC personnel in early 1969. In order to verify the problem, a count of the number of usable MSRP reports was made for one week. The results, segmented for the various transmissions, are shown in table 6. Many of the reports received were of such poor quality that they could not be automatically processed. Manual correction recovered some of the data, but this was a tedious process. Although the number of messages received was inordinately small, we still had to determine how many observations were actually taken.

The complete check on the MSRPs was even more complicated and time-consuming than that for the Pacific land stations since there are no direct communications links, and sailings and observation schedules are variable. The Marine Supervisor in San Francisco provided the information regarding which ships were active. Also included in his reports was information on the observations taken as well as the radio station to which they were sent for release to the collecting point at Redwood City. Thus, a preliminary conclusion was that many reports were being delayed unduly at the various coastal relay points and were not reaching NMC in time for use.

Further investigation suggested that messages other than weather reports were causing congestion at many of the government coastal radio stations used for relay points. Delays of ships' observations were common. In order to circumvent this, and break the communications bottleneck, commercial radio stations were used. Additionally, the communications center at Redwood City exerted an increased effort to relay the reports to NMC as expeditiously as possible.

A parallel effort was initiated to increase the accuracy of the MSRP reports. As with the domestic stations, an attempt was made to feed information regarding errors back to the source of the errors, whether the source was at the observing location or at a particular location in the communications channel. This appeared to be a successful mechanism. As can be seen in table 7, receipt of accurate reports from MSRPs increased dramatically. By the end of 1971, the on-time data receipt and usage at NMC had increased to 90%.

The Marine Supervisor in San Francisco successfully assumed the burden of maintaining the quality control effort after the initial phase was completed. The success makes us feel more strongly that the quality control effort at NMC should primarily define the data

Table 6.--Results of NMC survey (Jan. 25-31, 1969) of rawinsonde data received from moving chips (MSRP). The number of reports under "Reception Time" at NMC and located above and to the right of the solid line were received too late for use in scheduled operations.

Type of Report	Total Sent	Reports Used by NMC		Reception Time at NMC			
		Number	Percent	1200-1330	1330-1450	1450-1525	1525-2200
Early Transmissions	26	5	19	1	3	1	0
First Transmissions	65	38	58	0	12	11	15
Second Transmissions	65	25	38	0	4	12	9

Table 7.--Results of various data surveys for moving ships (MSRP). Percentage indicates raobs received at NMC in time for operational use. Note: Surveys of early transmissions were terminated in March 1970.

By:	Early Transmissions (Radats)	First Transmissions (Raobs)
Early 1969	4%	35%
Mid 1969	13%	41%
Late 1969	23%	49%
Early 1970	30%	48%
Mid 1970	48%	62%
Late 1970		73%
Early 1971		81%
Mid 1971		86%
Late 1971		90%

problems and derive possible solutions. Due to stringent operational deadlines, however, it appears that others closer to the actual observation points would have to carry out operational quality control procedures.

6. INVOLVEMENTS WITH DATA FROM OTHER AGENCIES AND COUNTRIES

Although our quality control efforts are keyed primarily to data received from the NWS stations, we have also satisfied a number of requests to investigate problems associated with rawinsonde information supplied by foreign countries as well as U.S. military stations. Indeed, some of the non-NWS stations involved in our efforts were in critical areas with respect to domestic NWS operations.

As noted previously, a real-time notification system becomes quite improbable when considering areas beyond the contiguous United States. It is in fact a problem of some magnitude to establish an easily accessible communication channel with foreign countries to solve problems that may have been delineated through various checks of the incoming data. In general, this can be accomplished through the World Meteorological Organization. However, there have been requests to evaluate certain problems and we have had direct communication with foreign representatives. It may be most appropriate to handle simple day-to-day data problems by direct communication with appointed representatives in WMO member countries and deal directly with WMO Headquarters regarding major system deficiencies.

In one example of foreign cooperation, our efforts with authorities of a nearby country, through the Technical Representative to that country brought about a significant correction to a chronic problem with data. Quality control monitoring had discovered apparently erroneous geopotential heights in reported data. After investigation by the local government authorities, they resolved the problem by correcting the station elevation height.

The computer assessment of data usage, on both a daily and a monthly summary basis, includes information on all known stations within the worldwide rawinsonde network. Table 8 shows the percentage of data received from all sources, with respect to schedules published by the World Meteorological Organization. If no data were available for the entire month from a given station and time, we assumed that the station was not scheduled to take observations. However, we had no way of knowing whether a station was operating only part time. Thus, some values, especially in the right hand columns of the table, may be in doubt.

Table 8 shows that overall there were generally no large differences between the number of 0000 GMT and 1200 GMT observations processed during August 1972 at NMC's 3 1/2-hour analysis deadline. However, this was not necessarily true on a regional basis: since, for example, more observations may be taken during the day than during the night in certain countries. In total though, for this particular month, approximately 61% of the data supposedly available had been received and automatically processed by NMC 3 1/2 hours after synoptic observation times. Other monthly summaries provided similar results.

One of the more important quality control tasks having a direct bearing on NMCs ability to process data is the updating of the upper air dictionaries. A concerted effort was completed in time for use in the pre-GARP exercises. The dictionaries, vital to the identification and positioning of each report received, had to be revised substantially. This included hundreds of additions and deletions. The task was not straightforward, since information had to be obtained from many different sources over a period of several weeks. Both the station elevation and the coordinates had to be known. This updating appeared to be successful and the techniques applied are now being used on a continuing basis.

7. NMC QUALITY CONTROL OF RAWINSONDE DATA

If we assume that weather observing networks are reasonably dense, effectively spaced, and that the frequency of synoptic observations is sufficient, then the inclusion of accurate data in operational weather analyses depends on three things:

a. Timely availability of data from scheduled rawinsonde observations:

Table 8.--Number of complete rawinsonde reports from the world-wide network that were automatically processed for NMC's operational analyses during August 1972.

COUNTRY	NUMBER OF STATIONS OPERATING 1		REPORTS EXPECTED 2		REPORTS PROCESSED 3,4		PERCENT PROCESSED 3,4	
	00Z	12Z	00Z	12Z	00Z	12Z	00Z	12Z
Norway	6	6.	186	186	85	80	45.6	43.0
Sweden	6	6	186	186	126	113	67.8	60.8
Finland	3	3	93	93	88	85	94.6	91.4
United Kingdom & No. Ireland	5	5	155	155	150	149	96.7	96.1
Ireland	4	5	124	155	84	113	67.5	72.9
Iceland	1	1	31	31	29	30	93.5	96.7
Greenland	7	7	217	217	113	129	51.9	59.4
Denmark	2	2	62	62	55	47	88.4	75.8
Netherlands	1	1	31	31	13	22	43.3	71.0
Belgium	2	2	62	62	20	31	63.4	50.0
Switzerland	1	1	31	31	27	30	86.7	96.8
France	5	7	155	217	87	145	56.0	66.8
Spain	5	5	155	155	63	60	40.8	38.4
Gibraltar	1	1	31	31	18	24	56.7	77.4
Portugal	2	4	62	124	32	58	51.7	46.8
Germany	9	11	279	341	224	226	80.4	66.2
Austria	1	2	31	62	29	62	93.3	100.0
Czechoslovakia	2	2	62	62	47	40	75.0	64.5
Poland	3	4	93	124	63	66	67.8	53.2
Hungary	2	2	62	62	22	23	35.0	37.1
Yugoslavia	2	2	62	62	16	16	25.0	24.2
Romania	3	3	93	93	77	55	83.3	59.2
Bulgaria	1	2	31	62	16	6	50.0	17.8
Italy	5	5	155	155	144	125	92.7	80.6
Malta	1	1	31	31	7	17	23.3	54.8
Greece	2	2	62	62	22	42	35.5	67.8
Turkey	6	6	186	186	19	49	10.2	26.4
Cyprus	1	1	31	31	24	24	76.7	77.4
Soviet Union	184	184	5704	5704	3423	3204	60.0	56.1
(Block 20)	10	10	310	310	162	179	52.3	57.6
(Block 21)	9	9	279	279	192	207	68.8	74.2
(Block 22)	5	5	155	155	22	27	14.2	17.4
(Block 23)	13	13	403	403	203	202	50.3	50.0
(Block 24)	14	14	434	434	260	252	60.0	58.0
(Block 25)	13	13	403	403	298	258	73.9	64.0
(Block 26)	11	11	341	341	197	173	57.9	50.7
(Block 27)	8	8	248	248	166	148	66.9	59.7
(Block 28)	7	7	217	217	107	111	49.5	51.2
(Block 29)	9	9	279	279	229	202	82.2	72.4
(Block 30)	13	13	403	403	350	306	86.9	75.9
(Block 31)	15	15	465	465	342	357	73.6	76.8
(Block 32)	10	10	310	310	244	222	78.7	71.6
(Block 33)	11	11	341	341	213	152	62.4	44.6
(Block 34)	9	9	279	279	138	129	49.6	46.2
(Block 35)	7	7	217	217	116	98	53.5	45.3
(Block 36)	3	3	93	93	68	67	73.3	72.1
(Block 37)	6	6	186	186	46	40	24.5	26.5
(Block 38)	11	11	341	341	70	74	20.6	21.7
Syria	1	1	31	31	0	1	.00.0	03.2
Lebanon	1	1	31	31	9	7	30.0	22.6
Israel	1	1	31	31	28	18	90.0	58.1
Jordan	1	1	31	31	3	1	10.0	03.2
Arabia	4	4	124	214	17	16	13.6	12.9
Iraq	1	0	31	0	7	0	23.3	00.0
Iran	3	8	93	248	5	6	05.6	02.3
Afghanistan	1	1	31	31	0	0	00.0	00.0
Maldive	0	1	0	31	0	1	00.0	03.2
Pakistan	5	0	155	0	0	0	00.0	00.0
India	16	16	496	496	108	110	21.7	22.2
Monogolia	5	5	155	155	1	0	00.7	00.0
Hong Kong	1	1	31	31	25	28	80.0	90.3
Taiwan	4	4	124	124	84	81	67.7	65.3
No. Korea	1	1	31	31	0	2	00.0	06.5
So. Korea	3	3	93	93	72	76	77.8	81.7
Japan	23	22	713	682	622	590	87.3	86.5
Burma	2	2	62	62	0	0	00.0	00.0
Thailand	5	5	155	155	150	139	96.0	89.7
Malaysia	1	1	31	31	27	27	86.7	87.1
Singapore	1	1	31	31	22	1	70.0	03.2
Viet Nam	3	3	93	93	22	12	23.3	12.9
China 5	120	112	3719	3472	3507	3255	93.4	93.8
(Block 50)	4	4	124	124	121	122	97.5	98.3
(Block 51)	12	11	372	341	350	307	94.0	90.0
(Block 52)	15	14	465	434	403	370	86.6	85.2
(Block 53)	10	10	310	310	307	304	99.0	98.3
(Block 54)	13	11	403	341	401	333	99.5	97.7
(Block 55)	3	2	93	62	87	59	93.5	95.2
(Block 56)	18	18	558	558	517	536	92.7	96.1
(Block 57)	18	17	558	527	550	523	98.6	99.2
(Block 58)	14	14	434	434	400	401	92.2	92.4
(Block 59)	13	11	403	341	371	300	92.1	88.0
Canary Is.	1	1	31	31	11	9	36.7	29.0
Morocco 6	1	2	31	62	4	0	13.3	00.0
Algeria 6	1	5	31	155	24	20	76.6	12.9
Tunisia	1	1	31	31	17	13	53.3	41.9
Niger	1	0	31	0	1	0	03.3	00.0
Mali	1	0	31	0	1	0	03.3	00.0
Mauritania	0	1	0	31	0	2	00.0	06.5
Senegal	1	1	31	31	4	5	13.3	19.4

COUNTRY	NUMBER OF STATIONS OPERATING 1		REPORTS EXPECTED 2		REPORTS PROCESSED 3,4		PERCENT PROCESSED 3,4	
	00Z	12Z	00Z	12Z	00Z	12Z	00Z	12Z
Ocean Islands (Block 61) 6	5	1	155	31	1	19	00.7	61.3
Libya	0	3	0	93	0	16	00.0	17.2
United Arab Republic	3	3	93	93	0	0	00.0	00.0
Sudan	0	3	0	93	0	9	00.0	09.7
Ethiopia	1	1	31	31	0	0	00.0	00.0
Uganda	1	1	31	31	0	0	00.0	00.0
Kenya	1	1	31	31	0	0	00.0	00.0
Tanzania	1	1	31	31	0	0	00.0	00.0
Zaire	0	3	0	93	0	0	00.0	00.0
Central African Republic	1	0	31	0	0	0	00.0	00.0
Chad	1	0	31	0	0	0	00.0	00.0
Cameroon	1	0	31	0	0	0	00.0	00.0
Nigeria	0	2	0	62	0	0	00.0	00.0
Ivory Coast	1	0	31	0	2	0	06.7	00.0
Angola	0	3	0	93	0	0	00.0	00.0
Malagasay Republic	1	0	31	0	0	0	00.0	00.0
Mozambique	1	2	31	62	1	6	03.3	09.7
South Africa	6	10	186	310	5	33	02.7	10.7
United States (Excl. Alaska and Hawaii)	69	69	2139	2139	2090	2045	97.7	95.6
Alaska	16	14	496	434	474	407	95.6	93.7
Canada	32	32	992	992	935	865	94.3	87.2
Mexico	8	8	248	248	167	154	67.5	62.0
Bermuda	1	1	31	31	28	27	90.0	87.1
Bahamas	0	1	0	31	0	16	00.0	51.6
Cuba	1	1	31	31	0	3	00.0	09.7
Guantanamo	1	1	31	31	24	21	76.7	67.7
Cayman	1	1	31	31	23	25	73.3	80.6
Jamaica	1	1	31	31	30	22	96.7	71.0
Dominican Republic	1	1	31	31	19	16	60.0	51.6
Swan Islands	1	1	31	31	16	24	50.0	77.4
Puerto Rico	1	1	31	31	31	28	100.0	90.3
Panama C.Z.	1	1	31	31	31	31	100.0	100.0
Antigua	0	1	0	31	0	18	00.0	58.1
St. Maarten	0	1	0	31	0	29	00.0	93.5
Guadeloupe	1	1	31	31	23	23	73.3	74.2
Barbados	1	1	31	31	22	26	70.0	83.9
Trinidad	1	1	31	31	11	13	36.7	41.9
Curacao	1	1	31	31	17	19	53.3	61.3
Colombia	2	2	62	62	23	33	36.7	53.2
Venezuela	1	2	31	62	0	0	00.0	00.0
Fr. Guiana 6	0	1	0	31	5	10	16.7	32.3
Brazil	1	17	31	527	3	90	10.0	17.0
Ecuador	0	2	0	62	0	0	00.0	00.0
Peru	1	0	31	0	2	0	06.7	00.0
Bolivia	0	1	0	31	0	0	00.0	00.0
Chile	4	4	124	124	5	22	04.1	17.7
Argentina	9	10	279	310	49	52	17.4	16.7
Antarctica	14	8	434	248	29	4	06.6	01.6
No. Pacific	12	11	372	341	298	275	80.0	80.6
Malaysia	2	1	62	31	49	27	78.3	87.1
Solomon Island	1	0	31	0	1	0	03.3	00.0
New Hebrides	1	0	31	0	0	0	00.0	00.0
New Caledonia	1	0	31	0	0	0	00.0	00.0
Fiji Island	1	0	31	0	1	0	03.3	00.0
Canton Island	1	1	31	31	21	16	66.7	51.6
Samoa	1	1	31	31	30	23	96.7	74.2
Marquesas Island	1	0	31	0	22	0	70.0	00.0
Society Island	1	0	31	0	23	0	73.3	00.0
Tuamotu & Gambier Island	2	0	62	0	24	0	38.4	00.0
Austral Island	1	0	31	0	21	0	66.7	00.0
Lord Howe Island	1	0	31	0	0	0	00.0	00.0
Norfolk Island	1	0	31	0	0	0	00.0	00.0
New Zealand	7	3	217	93	6	2	02.8	02.1
New Guinea	1	0	31	0	0	0	00.0	00.0
Australia	26	4	806	124	12	1	06.5	00.8
Sarawak 6	1	0	31	0	27	19	86.7	61.3
Djawa	1	0	31	0	1	0	03.3	00.0
Cocos Island	1	0	31	0	0	0	00.0	00.0
Philippines (Clark AB)	1	1	31	31	6	0	20.0	00.0
Ocean Stations								
4YA	1	1	31	31	9	10	30.0	32.3
4YB	1	1	31	31	10	11	33.3	35.5
4YC	1	1	31	31	23	20	73.3	64.5
4YD	1	1	31	31	26	23	83.3	74.2
4YE	1	1	31	31	19	20	60.0	64.5
4YH	1	1	31	31	28	29	90.0	93.5
4YI	1	1	31	31	30	24	96.7	77.4
4YJ	1	1	31	31	27	26	86.7	83.9
4YK	1	1	31	31	27	23	86.7	74.2
4YM	1	1	31	31	7	10	23.3	32.3
4YN	1	1	31	31	27	24	86.7	77.4
4YP	1	1	31	31	27	24	86.7	77.4
4YT	1	1	31	31	8	5	26.7	16.1
TOTALS	939	927	29109	28737	17841	17459		
AVERAGES							61.3	60.8

1. According to WMO OMM No.9 TP.4-May 1972 (Except China-see footnote 5).

2. Rawinsonde Part A

3. Received within 3 1/2 hours after observation time and decodeable by computer.

4. Based on the observing schedule published by the WMO in May 1972 and assuming 100% success in obtaining and communicating observations as scheduled.

5. Information on the operations' schedules at Chinese stations was obtained from sources other than the WMO. Also, no time limits were imposed (e.g. 3 1/2 hours) for the reports to be available.

6. Based on availability of data at NMC, stations appear to be operating at times other than is indicated in WMO OMM No.9 TP.4.

b. Quality of the data when received by users, and

c. Users capabilities for screening out deficient data without sacrificing accurate information.

As an operational data user, NMC becomes involved in data quality control in each of the preceding areas. Programs are carried out at NMC for handling data deficiencies through identification, correction and prevention.

The primary responsibility for each of these aspects of data quality control is assumed by separate NMC divisions. At the same time, there is considerable interdivisional coordination and cooperation to guarantee that the distinct functions complement rather than conflict with one another. For example, the Automation Division accepts basic responsibility for identifying data deficiencies. The Forecast Division, while also identifying data deficiencies during manual operations, is solely responsible for correcting deficient data for manual as well as automated analyses. The Development Division is responsible for the prevention of future deficiencies in data.

Divisional Quality Control Responsibilities

The Automation Division maintains all automatic data processing programs. To ensure comprehensive and uninterrupted automatic processing of data, the computer programs, reference directories, processing dictionaries, and decoders must be kept current at all times. This effort requires continual attention because global observing and reporting procedures are constantly changing. These changes involve deletions, additions, and modifications, not only in data, but also in the sources and routes from which data are obtained. The computer programs must efficiently direct the system in identifying, sorting, merging, and compiling all types of data according to class, origin, synopticity, and acceptability. In addition, this must be done with respect to both standard and nonstandard national, regional, and international code formats. Special programs, tailored for data quality control, have been developed, and output from these programs is directed to the other two involved divisions to enable them to perform their quality control functions.

The Forecast Division assumes most of the responsibility for correcting erroneous reports in order that these data can be included in operational analyses. This responsibility involves both manual and automated efforts--essentially, the man-machine mix. Conspicuous errors are identified and rectified in various ways. For example, subjective methods have always been effective in correcting errors in identity groups that might cause data to be misplotted. The rectification of coding discrepancies and garbling that could otherwise render data unusable is also possible by subjectively scanning the reports. Further checks and corrections can be made with reasonable confidence during subjective analysis procedures. In some instances when time allows and the situation warrants it, telephone contact can be made with domestic data sources for confirmation or correction of reports received. In addition, reports which the computer cannot decode are diverted to and displayed on a cathode ray tube (CRT) - a TV-type display. The report can be examined and if necessary corrected and reprocessed. This phase of data quality control deals exclusively with data that the computer cannot decode without human assistance. It is becoming one of the key factors in the progressive real-time programs NMC is developing in order to correct erroneous data in time for operational use.

The Development Division (Upper Air Branch) assumes responsibility for:

a. Identifying and categorizing data discrepancies and losses.

b. Performing analytical studies to determine the specific causes for data deficiencies.

c. Deriving statistical summaries to validate major sources of data deficiencies.

d. Preparing conclusive documentary evidence to identify problem areas, thereby enabling national, regional, and local levels to implement remedial actions.

e. Developing procedures, methods, and techniques to improve the internal quality control functions of NMC.

This form of quality control serves to improve the data where they are produced and distributed. Thus, the effort is oriented toward the entire NWS, as well as NMC.

8. CONCLUSIONS

Principally, we have attempted to outline the philosophy of the UAB QC program for rawinsonde data and some of the milestones in its 4-year history. These major projects have been supplemented by numerous small-scale efforts which were accomplished either at the request of interested authorities or on our own initiative.

It would be presumptuous to try to dictate operational aspects of field stations, communications centers, or even national meteorological centers. Still, we feel that our continual data review has revealed one inescapable fact, namely, that a significant percentage of the data destined for operations cannot be used.

Although we have oriented our investigations toward NWS facilities, similar types of problems also occur on the international scene. We further feel that a properly integrated quality control program can minimize the problems. NMC, in cooperation with the Office of Meteorological Operations (especially the Data Acquisition Division) has undertaken a program to promote QC of operational data.

A basic conclusion from our efforts to date is that a centralized unit, whether it be at the user's end of the data channel, or somewhere else, cannot singularly maintain a continuously effective QC program; that is, a QC program that can operate indefinitely on a real-time basis. Any program must include efforts from the moment an observation has begun to the time the data are archived. Thus, on-station programs should be designed which adequately control the quality of operational data through their proper entry into communications channels. There is an equally important responsibility to maintain QC of the communications system to protect the data while they are enroute to the users. This would involve monitoring at points along the communications lines as well as at terminals. Unless such monitoring is performed routinely and systematically, data losses cannot be effectively identified, documented, or corrected. Data processing centers should be involved in QC by performing final checks to ensure that as much information as possible can be considered in analyses. They should also provide headquarters and field elements with routine information on data deficiencies in order to allow persistent problem areas to be identified and corrected. A flow chart of typical points along the data channel where QC could be implemented is shown in figure 7.

More importantly, figure 7 illustrates how the volume of rawinsonde data from U.S. stations that use the Service C communications network increases downstream during each synoptic cycle. Had figure 7 included international data, the volume at the last two points along the abscissa would be increased by more than an order of magnitude. This points to the need for strict quality control of the data before they reach users. Otherwise, every data recipient will be faced with the inevitable choice of either committing scarce resources to correct erroneous data before use or, worse, to attempt to produce accurate analyses without a full array of the potentially available data. Usually, a combination of the two alternatives is implemented.

Improved quality control of operational data might be accomplished with existing resources by modifying certain management procedures. For example, by shifting some of the emphasis from the quality of recorded data to the quality of communicated data, the integrity of much of the recorded data should be automatically protected. The opposite is not true. Moreover, UAB studies show

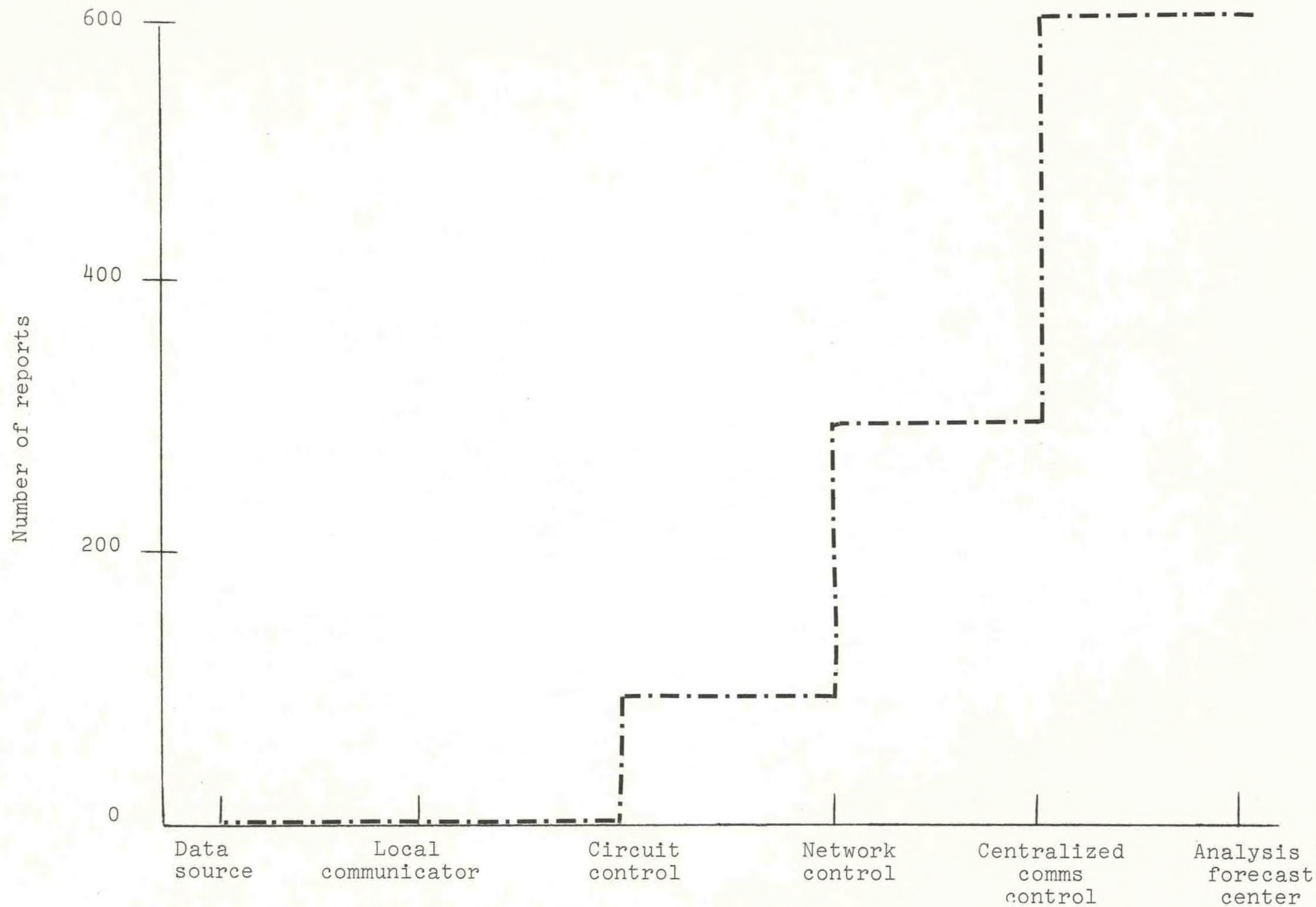


Figure 7.--Cumulative number of rawinsonde reports that pass through each distribution, relay or processing point on the Service C Communications System during a typical 12-hour cycle.

conclusively that the vast majority of deficiencies in operational data can either be avoided or acted on at the data source. Other so-called data deficiencies (which actually pertain more to communications such as message headings, formats, and so on) could easily be interpreted and rectified at key points along the circuits before bulletins enter users' computers. Lastly, the few remaining residual deficiencies that do slip through could be handled by the data recipients.

We conclude by saying that any quality control system, to be of maximum effectiveness, must include systematic procedures for routinely categorizing and reporting data deficiencies, their frequencies, and probable causes. No such methods currently exist for operational meteorological data.

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