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SUMMARY REPORT ON MAY ARCHIVING TEST

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SUMMARY REPORT ON MAY ARCHIVING TEST

I. Introduction

Beginning on 1 May, Data Assimilation Branch, NMC, conducted a 15-day test of the proposed system for archiving conventional and experimental data during the Data Systems Test. The archiving test was completed as planned on 15 May. With NASA approval, operations were extended for an additional 15 days. Our role in this test was to create, on a near real-time basis, Level II and Level III data tapes in standard formats and to mail these tapes to users at GISS, GFDL, NCAR, and UCLA. This test differed from a 3-day archiving test conducted in December in that we used the NOAA computer facilities at Suitland, Maryland, instead of the IBM 360/95 at Goddard Institute for Space Studies (GISS), New York. The NOAA system is the one we plan to use during the DST.

II. Detailed Operational Breakdown

A. Collection and processing of Level II data sets

The Level II data base for the DST archiving consisted of the conventional set of observations received at NMC over the Global Telecommunications System (GTS) network, operational VTPR data generated by the National Environmental Satellite Service (NESS) from NOAA-3, experimental Nimbus soundings generated by GISS, and cloud motion winds produced from ATS photos by NESS.

Conventional data were collected with a nominal cutoff time of H+10 hours.

All reports were separated into four time blocks centered at 00, 06, 12, and 18 GMT and written on Level II tapes with separate files for upper-air and surface reports. No bogus reports were included in the Level II collections or Level III analyses.

The Level II processing involved the following operations:

(1) A special data collection of conventional data using the NOAA IBM 360/40 and 360/195 computers. 06Z and 12Z data were loaded in the 360/195 at 1900L; 18Z and 00Z data were loaded at 0700L.

(2) Transmission to NESS by GISS of Nimbus data four times daily. 00Z data were received at 1500L, 06Z data at 2100L, 12Z data at 1300L, and 18Z data at 0900L (see Figure 1). Immediately after transmission over the DATAPOINT 2200 link, programs were submitted on the 195 to check the Nimbus tapes for transmission errors and correct date. When errors were detected, a retransmission from GISS was requested. A successful run of this program indicated that the Nimbus data were ready to be merged with the conventional and operational satellite data.

(3) Merging of the Nimbus data with the conventional and operational satellite data. Merging was done on the IBM 360/195. Runs were submitted 9-13 hours after scheduled Nimbus transmission times to allow for late transmission of Nimbus data. The operational procedure was to wait for a given Nimbus transmission to NMC up to 1 hour prior to the scheduled Level III run.

(4) Stacking, copying and mailing. Merged observations for each time block were stacked 1 day per tape. Copies of these Level II tapes were sent to the following organizations: GISS, GFDL, UCLA, NCAR, and GSFC. The stacking and copying programs were carried out on the IBM 360/195.

B. <u>Creation of Level III data sets</u>

Global analyses were prepared from the Level II data sets four times per day. Global forecasts to 6 hours were prepared to provide first-guess fields for the next analysis run. Analyses and forecasts were prepared over a 2.5^{o} latitude/longitude grid. The analysis program used was the spectral scheme developed by Lt. Colonel Thomas Flattery, USAF. Forecasts were produced with the 8L GLOBAL model developed by Dr. John Stackpole of NMC. The global analysis/forecast package was a very comphrensive set of programs containing the following components:

(1) A global preprocessor program that specially formatted the Level II data for the analysis program.

(2) The wind and height analysis program.

(3) The moisture and temperature analysis program.

(4) A formatting program to convert analysis data from spectral coefficient form to 2.5° latitude/longitude grid array.

(5) A tropopause "smoother" program.

(6) A diagnostic printout program to display analyses.

(7) Program to build Level III analysis tapes.

(8) Vertical data consistency check of analyses.

(9) Initializer program in preparation for forecast.

(10) Forecast program out to 6 hours.

(11) Forecast post-processor.

(12) Format program for forecast data prior to "analysis" of the forecast.

(13) Analysis of the height and wind forecasts to prepare first guess for the next analysis cycle.

(14) Analysis of the moisture and temperature forecasts to prepare first guess for the next analysis cycle.

The program package (1-14) required approximately 17 minutes CPU and 45 minutes wall time on the 195. The package required around 700K bytes of memory. Because of the core size and run time requirements, the Level III runs had to be scheduled between 1700 EDT and 0700 EDT. The package was run four times each night, producing analyses at 12, 18, 00, and 06 GMT. Only the 00 and 12 GMT analyses were written on the archive tapes.

C. Shift operations

Three two-man teams were set up to run the Level III operation and the evening Level II data collections. Each team consisted of a meteorologist and a meteorological technician. The three teams covered evening and midnight shift operations continually during the 30-day test period. The teams operated from the World Weather Building using the remote terminal facilities to the 360/195. Trips to Suitland were made once on the evening and once on the midnight shift to receive Nimbus data over the DATAPOINT link at NESS.

The Level II daytime operations were handled by two men on-site at Suitland. Their functions were to:

(1) Receive daytime Nimbus transmissions from GISS.

(2) Submit Nimbus checking and merge runs during the day.

(3) Submit Level II and Level III stack programs and copy tapes for users.

(4) Mail all Level II and III tapes to users. Level II tapes were mailed each day. Level III tapes were mailed every 3 days.

D. Operational schedule

The schedule of events for Level II and Level III operations is given in Figure 1. The schedule was designed so that Level II tapes for day n would be ready for mailing on day n+2. Level III analyses would be produced routinely with a time delay of 31 to 37 hours. Our ability to meet this timetable depended upon timely and reliable operation of programs and procedures on several hardware systems including:

(1) the GISS IBM 360/95 computer to process Nimbus data,

(2) the DATAPOINT 2200 to transmit Nimbus data,

(3) the IBM 360/195 computer at NOAA to run the Level II and III programs,

(4) the remote terminal facility at the World Weather Building to submit programs to the IBM 360/195.

A successful real-time operation required full support from each of these systems. How successful they were is addressed in a following section.

III. Chronology of Significant Events

10 January 1974. Based upon NMC plans to have the global analysis/forecast cycle functioning on the IBM 360/195 system at Suitland by 15 February, 1 March is set as target date for beginning a 15-day archiving test at NMC.

18 January 1974. Test is rescheduled to early April.

20 March 1974. Flattery analysis code runs successfully on IBM 360/195. Test date is set at 8 April.

1 April 1974. DAB begins 3-day in-house test of global analysis/forecast cycle. Test fails due to problems with moisture analysis package.

22 April 1974. Error discovered and corrected in moisture analysis code.

25 April 1974. DAB begins 3-day in-house test of Level II and Level III operations without Nimbus data as pre-test of archiving system.

1 May 1974. First Nimbus transmission received from GISS. Nimbus data included on Level II tapes. Test begins.

7 May 1974. Error corrected in the portion of the code which analyzes the forecast fields (program steps 13 and 14).

15 May 1974. Decision is made to run for another 15 days because of problems with early Nimbus retrievals, because the Northern Hemisphere analyses look good, and because it is now becoming obvious that we are developing serious problems in the Southern Hemisphere which need to be solved before the test can be considered a success.

17 May 1974. Six-hour forecast at 00 GMT 16 May fails due to stratospheric exhaustion in the Southern Hemisphere. Change introduced in the analysis code and second forecast attempt is successful.

30 May 1974. Test completed.

IV. Systems Evaluation

Earlier the various hardware/software computer systems that were involved in the archiving test were identified. This section describes how well the more important components performed to support the test.

Table 1 represents the reliability of the DATAPOINT 2200 in transmitting Nimbus data from GISS to NESS. As can be seen, Nimbus transmissions were highly reliable. Of the 117 transmissions sent, only 8 contained communication errors and each of these was successful on the second try. The three transmissions listed as never sent were the result of Goddard not sending radiance data to GISS. This occurred on the 18th (00Z data), the 22nd (18Z data), and the 30th (06Z data). The failure listed in the table resulted from a program problem at GISS on the first day of the test. Table 2 shows the timeliness of the GISS-NESS transmissions. It indicates how well GISS was able to meet their processing and transmission schedule. It should be noted that on several occasions GISS was ready to transmit to NESS ahead of schedule; however, to simplify the Level II/Level III operations, we requested that transmissions not be sent early, even if they were available.

From Table 2, it is seen that 85 percent of the transmissions were either on schedule or less than 2 hours late. These late transmissions were due to DATAPOINT 2200 downtime either at NESS or GISS or to transmission delays from Goddard to GISS. From Table 2, it can be seen that 10 percent of the Nimbus transmissions were more than 4 hours late.

Table 1. GISS Transmissions (Reliability)

Total transmissions scheduled	120
Total transmissions received	117
Total o.k. first time	108 (92%)
Total o.k. second try	8
Total failed	1

Table 2. GISS Transmissions (Timeliness)

On time or less than 2 hours late	99 (85%)
2-4 hours late	6
4-6 hours late	4
6-10 hours late	6
Greater than 10 hours late	2

Next, let's look at how successful the NOAA IBM 360/195 system was in support of Level II/Level III operations. Tables 3-5 are concerned with the smaller of the programs submitted in the operation —those with relatively small CPU and storage requirements. Tables 6 and 7 reflect the performance of the big job—the Level III analysis and forecast package described earlier.

Table 3 describes the timeliness of the program to check the Nimbus tape. Turnaround was desired on these jobs as soon as possible so that a retransmission, if necessary, could be requested from GISS as soon as possible. For the most part, these jobs were submitted over the counter at the NOAA computer site, rather than through the terminal facility at the World Weather Building. There is no reliability factor included in Table 3. All unsuccessful runs were the result of transmission errors rather than 195 system errors and were corrected after retransmission.

The timeliness of the Nimbus check (NIMCHK) runs was outstanding. Eighty-eight percent of the jobs were turned around in 1 hour or less, and 97 percent were turned around in 2 hours or less.

Table 3. NIMCHK Runs (Timeliness)

No. of runs	117
No. of turnarounds ≤ 1 hour	103 (88%)
No. of turnarounds ≤ 2 hours	113 (97%)
No. of turnarounds > 2 hours	4

Only four runs had turnaround greater than 2 hours. The maximum turnaround time was 7 hours.

Tables 4 and 5 show the timeliness and reliability of the Merge runs—those that create the Level II data tapes by combining Nimbus data with conventional and VTPR data. Most of these jobs (about 75 percent) were submitted to the 195 through the WWB terminal. Again, fast turnaround was required in order to keep an operational schedule going, but the urgency was not as high as in the case of the Nimbus check run where the threat of a retransmission was always present. Table 4 shows the results of the timeliness ratings. Only 79 percent of the Merge runs were turned around in less than 2 hours, and 9 percent had turnaround greater than 4 hours. Table 5 shows the reliability of the system in running these Merge jobs. Approximately 12 percent of the Merge runs had to be resubmitted. These were system-related problems cropping up sporadically on the 195 system. Program or programmer errors did not enter into this 12 percent figure. The three cases of wrong tapes listed in Table 5 were errors by our shift teams that required a rerun.

Table 4. Merge Runs (Timeliness)

Turnaround 0-2 hours	95 (79%)
Turnaround 2-4 hours	14
Turnaround 4-6 hours	4
Turnaround 6-8 hours	4
Turnaround 8-10 hours	2
Turnaround 10-12 hours	1

Table 5. Merge Runs (Reliability)

Total runs	120
Runs requiring resubmission	14 (12%)
Wrong tape	3

In summary, system performance for NIMCHK runs was outstanding both in reliability and timeliness. Performance for the Merge routines, although satisfactory, was definitely not as good. NIMCHK was a single tape operation. Merge runs required three tapes, and this may explain the difference in system performance.

Tables 6 and 7 show how well the system did in taking care of the big package—the Level III programs—almost exclusively a terminal operation. The timeliness summary in Table 6 is far from impressive. Only 55 percent of the Level III runs were turned around by the 195 system in 2 hours or less, only 83 percent were completed in 5 hours turnaround, and a full 11 percent had turnaround in excess of 10 hours. In general, delays were caused by conflicts with NMC or NESS operational jobs which, for one reason or another, were being run outside of their normal schedules.

Table 7 gives the reliability for the Level III runs. Out of a total of 119 runs, our DAB logs showed that 17 runs (14 percent) required restarts due to a system failure of one type or another. These were restarts where our shift teams had to reload the program card deck. Other restarts were made by the computer operators, but we do not have that data. Tables 6 and 7 do not present a favorable picture of system support to the Level III package.

Table 6. Level III Runs (Timeliness)

Total runs	119
Turnaround <2 hr	65 (55%)
Turnaround >2 hr, <5 hr	34 (83%)
Turnaround >5 hr, <10 hr	7
Turnaround >10 hr	13

Table 7. Level III Runs (Reliability)

Total runs	119
No. of restarts necessary	17

The DAB performance logs indicated that during the 30 days of the test, the 195 system was down approximately 48 hours outside of regular maintenance time and that the terminal at WWB was down about an additional 24 hours.

In summary, the system support given to the Level II/Level III operation was as follows:

the DATAPOINT 2200 Nimbus transmission--good

the 195 for NIMCHK runs—outstanding

the 195 for Merge runs--fair to good

the 195 for Level III runs—fair

V. Level II Data Counts

Table 8 summarizes the total numbers of observations of each type collected during the 30-day period. Table 9 gives the median number of observations by type and observation time.

Table 8. Total numbers of observations of each type on Level II data tapes. 00 GMT 1 May through 18 GMT 30 May

	DST MAY		
	N. HEM.	S. HEM.	TOTAL
RAOB AND PIBAL	59014	10737	69751
NIMBUS	9453	10221	19674
VTPR	11993	13940	25933
SURFACE	426205	114790	503951
AIRCRAFT WINDS	29355	2146	31501
ATS WINDS (APPROX)	7800	5800	13600
TOTAL	543820	157634	701454

Table 9. Median numbers of observations by time and observation type. Northern and Southern Hemispheres separately.

NORTHERN HEMISPHERE (MEDIAN)

TYPE REPORT	00Z	06Z	12Z	18Z	DAILY
RAOB & PIBAL	730	225	761	256	1968
VTPR	134	89	113	91	409
NIMBUS	53	85	98	88	319
AIRCRAFT	250	285	263	262	999
SURFACE (LAND & SHIP)	3559	3539	3690	3519	14313

SOUTHERN HEMISPHERE (MEDIAN)

TYPE REPORT	00Z	06Z	12Z	18Z	DAILY
RAOB & PIBAL	123	55	132	49	363
VTPR	121	134	113	123	459
NIMBUS	57	97	99	107	359
AIRCRAFT	18	18	22	16	73
SURFACE (LAND & SHIP	570	608	745	690	2625

VI. Comments on the Level III Analyses

As mentioned in Section III, there were two errors in the analysis codes which affected the quality of the Level III data sets.

The first error, corrected at 06 GMT, 6 May, involved formatting of forecast data used in determining first-guess coefficients for each global analysis. Northern and Southern Hemisphere forecasts were interchanged when written on disc. At 00 and 12 GMT, the effect of the first guess on the final analysis is relatively small, and analyses in the Northern Hemisphere appeared to be reasonable. However, all analyses from 1 May through 6 May are questionable because the first-guess fields are wrong.

Figure 2 documents the correction of this error on 6 May. The ordinate shows the global RMS vector difference between the 6-hour forecast value of the 300-mb wind and its value at time 0. Notice that the RMS difference prior to 7 May is about 50 knots—because the comparison is actually being made between forecasts and analyses in different hemispheres. From 7 May on, the difference is about 15 knots —a reasonable value for a 6-hour change in the 300-mb wind.

The second error, corrected at 06 GMT, 16 May, affected primarily the Southern Hemisphere. One of the constants in the Flattery analysis code is a parameter which is similar to an over-relaxation factor in the numerical solution of a Helmholtz equation. The value of this parameter should change very weakly with the number of observations or forecast grid points being analyzed. The number used initially was appropriate for an analysis of 5° forecast data but not for an analysis of forecasts at $2\text{-}1/2^{\circ}$ intervals. The problem, as in error one, was limited to the analysis of forecast fields. Its effect was cumulative and gradual and noticeable only (or at least primarily) in the Southern Hemisphere south of about 30°. The net effect was to cause a steady removal of mass over the South Pole (Figure 3) with an expanding and deepening polar vortex dominating the flow south of 30° to 40°.

Figure 4 shows the total number of height observations rejected by the analysis codes on each 00 and 12 GMT analysis from 13 through 22 May. On 14 and 15 May, an average of 400 to 500 height values were "tossed" on each analysis.[1] As the insert in Figure 4 shows, most of the rejections were in the Southern Hemisphere. For example, at 00 GMT, 15 May, 9.8 percent of Southern Hemisphere 300-mb heights and 0.6 percent of Northern Hemisphere heights were rejected by the analysis code. Rejections were the result of a gradual deterioration in the Southern

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[1] This number is for all 12 levels combined.

Hemisphere first guess to the point where good observations were being automatically tossed. At 06 GMT, 16 May, we changed the "over-relaxation-type" parameter in the Flattery code. And we relaxed the toss-out criteria (THROWZ) by about a factor of 5 to allow the data to correct the forecasts. From 16 to 19 May, the number of rejections is near 0. At 12 GMT, 19 May, we reduced THROWZ to its original value and about 100 to 200 height values were rejected on each analysis through the rest of the period (see percentage values in insert). The recovery of the Southern Hemisphere height fields was gradual (see Figure 3). The 1000-mb height over the South Pole appears reasonable by about 20 May; however, the analysis at this time (Figure 5) still shows an unrealistically strong south polar vortex.

We have not yet been able to try to verify the Southern Hemisphere analyses. However, subjectively, they appear to be reasonable after about 22 or 23 May.

Both of the errors were restricted to the first-guess fields and, in general, comparisons between observations and analyses show a reasonably good fit to the data throughout the period. Table 10 gives the average RMS fit of 300-mb height and wind analyses to the observations throughout the 30-day period at each analysis time and for each hemisphere. Notice that the wind observations are "drawn for" to within about 6 to 7 m sec^{-1}, heights to within 30 to 40 m. The fit in the Northern Hemisphere is best at 00 and 12 GMT—the standard radiosonde reporting times. Root-mean-square height differences are smaller in the Southern than in the Northern Hemisphere. The reverse is true for the analysis of winds. In general, we would hope that the fit would reflect the error levels in the observations. And this appears to be true in both Tables 10 and 11. Notice in Table 11 that the RMS fit is better for radiosonde than for satellite observations at all levels above about 700 mb.[2] The large height differences in the Southern Hemisphere (Table 10) reflect the fact that most of the comparisons are with satellite data. The larger wind errors in the Northern Hemisphere are related to the large number of aircraft winds (Table 9).

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[2] The RMS difference for satellite observations is necessarily 0 at 1000 mb because all VTPR and Nimbus observations are treated as thicknesses to be added to the analyzed 1000-mb height.

Table 10

RMS deviations between analysis and observations

300 mb - avg over all 30 days

	Height (m)		Wind ($msec^{-1}$)	
GMT	N. Hem.	S. Hem.	N. Hem.	S. Hem.
00	27.1	33.8	7.0	6.3
06	32.3	36.6	7.1	5.9
12	29.6	39.3	7.0	6.8
18	30.2	34.4	7.8	5.7

Table 11 shows that the satellite data were "drawn for" and that only a small percentage of satellite observations were rejected by the analysis code.

TABLE 11.

RMS FIT AND PERCENT OF HEIGHT OBSERVATIONS TOSSED

RADIOSONDE (R) AND SATELLITE (S) 20 TO 30 MAY

	RMS Fit (m)		% Observations Tossed	
	R	S	R	S
1000 mb	9.6	0.0	2.19	0.00
850 mb	10.8	10.8	1.82	0.67
700 mb	12.0	18.0	1.03	1.58
500 mb	17.4	23.4	0.71	1.82
400 mb	21.3	26.4	0.54	1.88
300 mb	26.1	30.9	0.76	1.77
250 mb	27.6	33.3	0.73	1.76
200 mb	29.7	36.0	1.30	1.76
150 mb	32.7	40.2	0.94	1.98
100 mb	38.7	43.5	1.47	3.61
70 mb	45.6	51.9	1.36	4.13
50 mb	50.7	60.0	0.95	3.41

In summary, the analysis/forecast cycle appeared to function well —except for the errors in the code which affected the first-guess fields. The 6-hour cycle works and seems to be a reasonable vehicle for assimilation of asynoptic data during the DST. Much more remains to be done in comparing DST and NMC operational analyses and in assessing the validity of the Southern Hemisphere analyses. We need to compare these fields with cloud patterns on satellite pictures and with operational analyses from Southern Hemisphere weather centers. Experiments need to be conducted to try to optimize the various parameters in the Flattery code.

Our preliminary assessment is that Northern Hemisphere analyses can be used for research after about 7 May and that Southern Hemisphere analyses are "reasonable" after about 23 May.

VII. Recommendations for 1975 DST Archiving

The May 1974 30-day DST archive was a valuable test. A number of mistakes were made and important lessons were learned.

One of the most important lessons learned is the necessity to have the analysis/forecast Level III operation run as an operational job in a regular time slot. It needs to be considered by NMC and NOAA as just as important an operational job as anything else run on the computer. Anything less than this will result in it being shunted aside or forgotten when problems, delays, or time crunches arise in the production cycle. In May, we ran the analysis/forecast package with a high priority, but in a non-operational mode. When the production cycle was running smoothly, job turnaround was satisfactory. When problems arose in production, our jobs, even with high priority, were held back from the system. On more than one occasion, computer operators held up our job for operations to run, and then neglected to free us for running after production had finished.

We also learned that an archive operation such as DST should not be set up until the analysis/forecast scheme upon which it is to operate is fully checked out. Nearly all of the programming problems and time delays we experienced were the result of the fact that NMC was trying to put together for the first time on a new computer, the new global analysis and forecast cycle upon which our archiving system was based. If this cycle had been operational prior to the archiving test, many of our errors, problems and delays would not have occurred. This is a very important lesson to learn as we approach FGGE.

The May test clearly pointed out the need for effective real-time monitoring of Level II and Level III data sets. Our display capability in May was limited strictly to grid printed maps on computer printout. Our analyst spent too much time sorting, tearing and pasting together, Xeroxing, reducing and analyzing computer printout. An automated system for map display is an absolute requirement before the next test. We plan to adapt the Varian display package currently being developed for NMC operational use for this purpose.

For the DST operation for 1975, we should expand our Level III operation to a 24-hour schedule. In May, our evening and midnight shifts left serious gaps in monitoring operations during the day. The day shift Level II staff was busily involved in stacking, copying and mailing tapes and was not able to adequately fill this void. To provide full 24-hour shift coverage will require four meteorologist/meteorological technician teams—an increase of two people over our May archiving staff.

For the extended archiving periods planned during the DST, we need to develop the NMC-GISS 360 data link either as the primary Nimbus communication network between the two agencies or as backup to the DATAPOINT GISS-NESS line.

As a final point, it must be recognized that we are staffed primarily to produce the Level II and Level III data sets and not to evaluate their quality. We will do what we can between archiving periods; however, much of this responsibility must rest with the users.

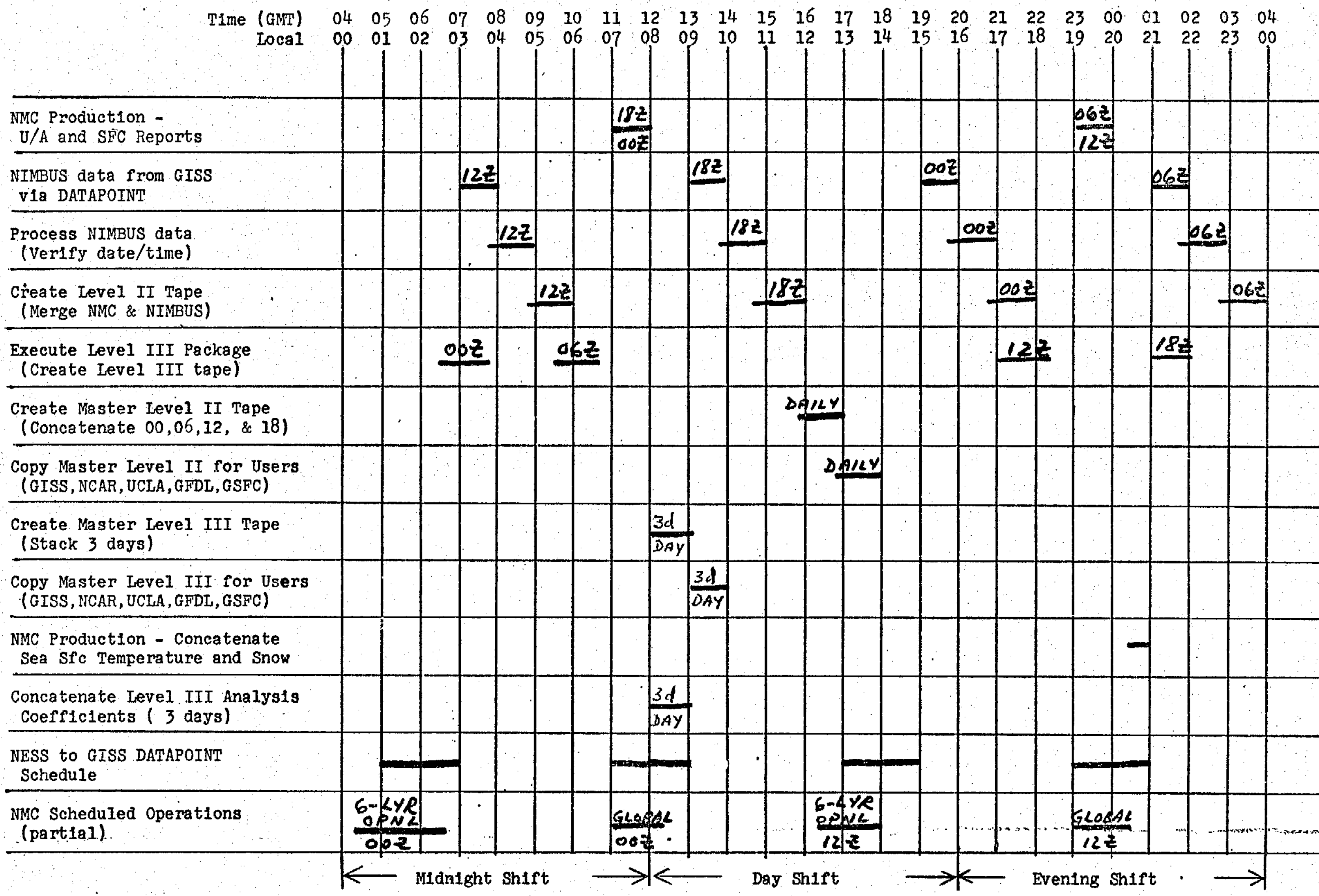


Figure 1. Scheduled Sequence of Events for Level II and Level III Operations

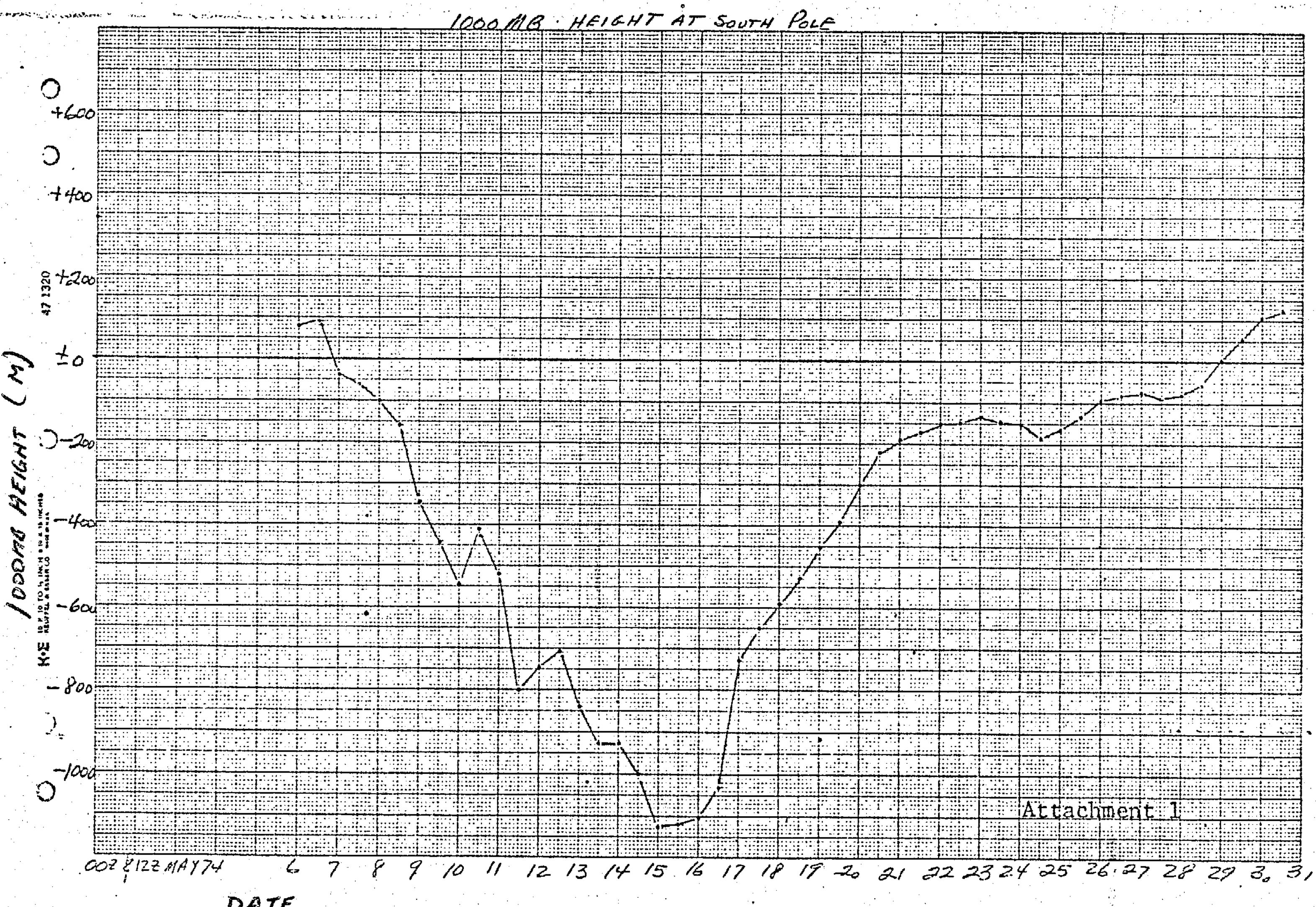
DOCUMENTATION OF ERROR IN FIRST GUESS FIELDS 1 MAY THRU 6 MAY

STATISTICS FOR ANALYSIS OF 6-HR FCST

599	154	247	99	641	320	328	286	210	192	521	0	0	0	0	0	0	

FORECAST VALUES REJECTED OUT OF 10,226. REJECTION CRITERIA 120 KNOTS.

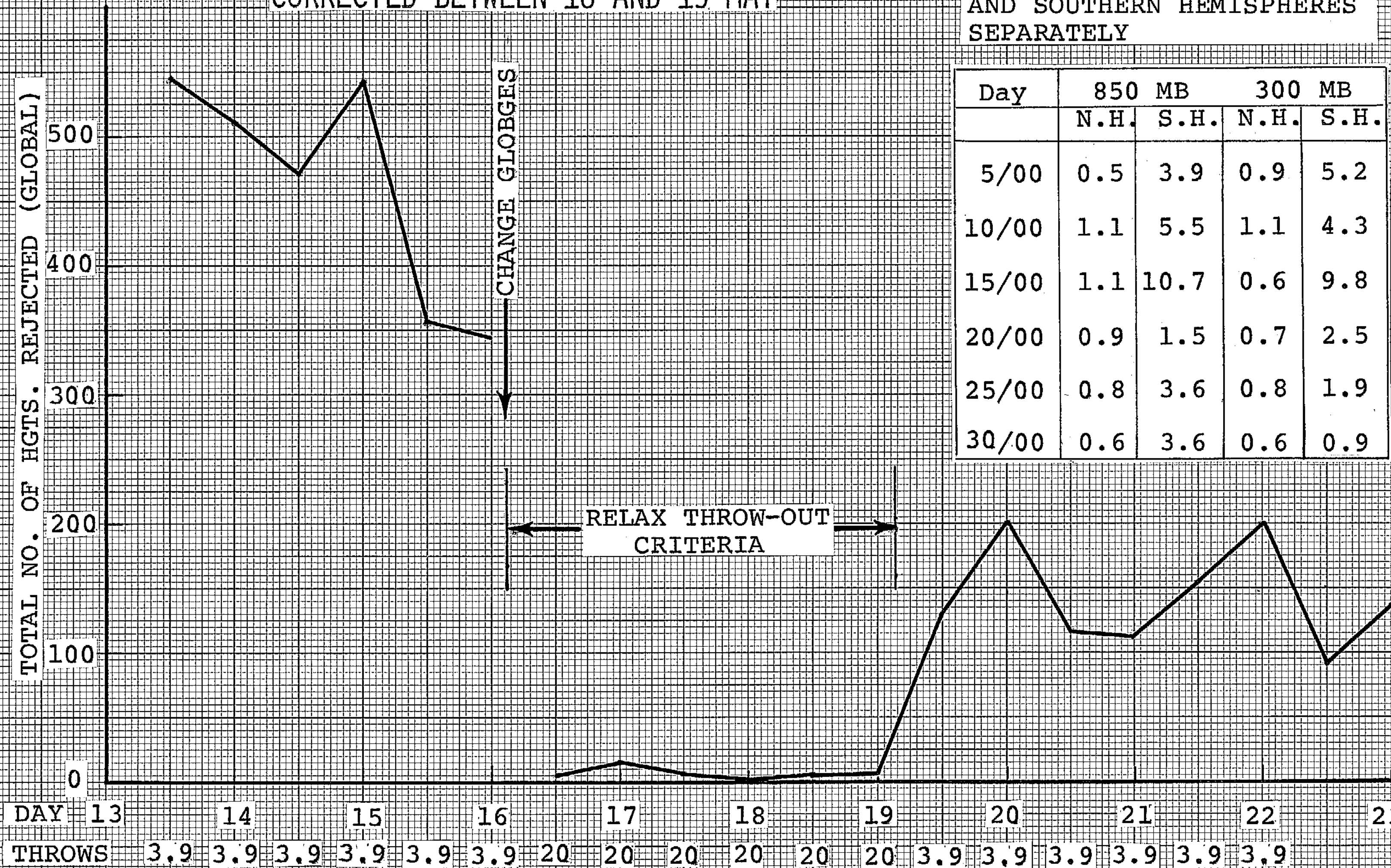
FIG. 2



1000 MB HEIGHT AT SOUTH POLE
+600
+400
+200
±0
-200
-400
-600
-800
-1000
1000MB HEIGHT (M)
00Z & 12Z MAY 74
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DATE
Attachment 1

FIG. 3

DOCUMENTATION OF SECOND [illegible]OR
CORRECTED BETWEEN 16 AND 19 MAY



% HEIGHT OBS. REJECTED
SPECIFIC LEVELS, NORTHERN
AND SOUTHERN HEMISPHERES
SEPARATELY

Day	850 MB		300 MB	
	N.H.	S.H.	N.H.	S.H.
5/00	0.5	3.9	0.9	5.2
10/00	1.1	5.5	1.1	4.3
15/00	1.1	10.7	0.6	9.8
20/00	0.9	1.5	0.7	2.5
25/00	0.8	3.6	0.8	1.9
30/00	0.6	3.6	0.6	0.9

FIG. 4

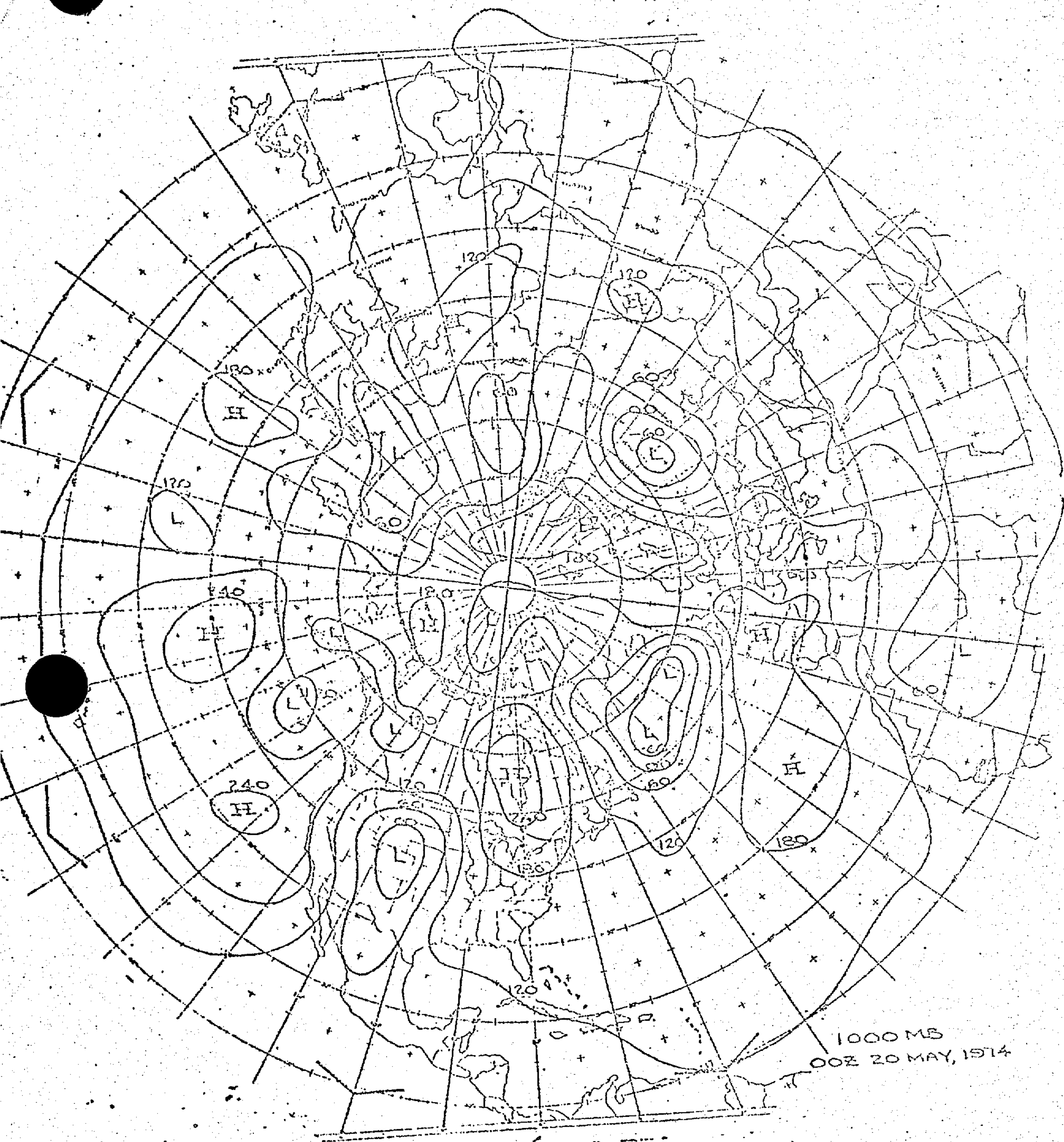


Figure 5a. DST 1000-mb analysis
Northern Hemisphere

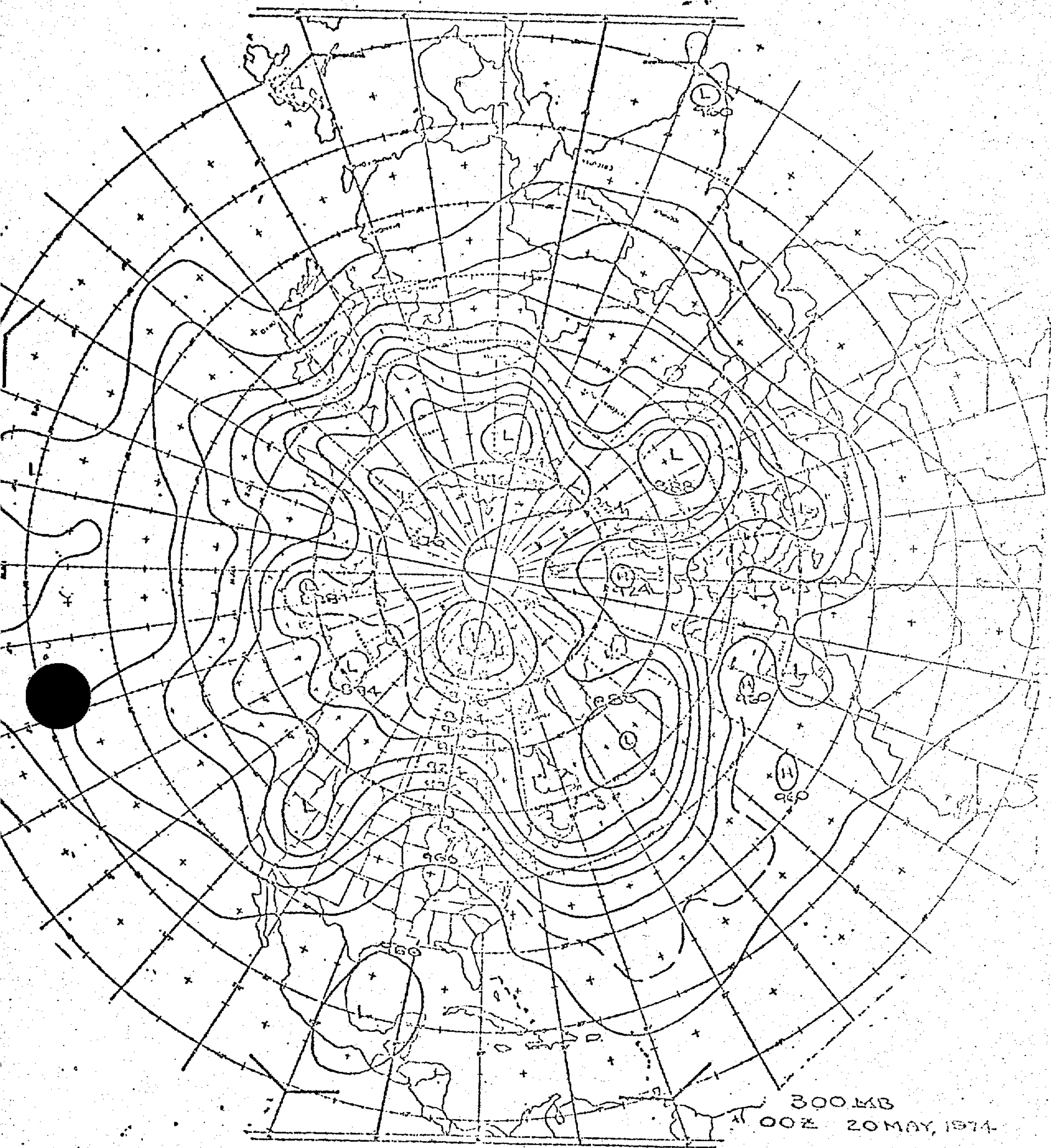


Figure 5b. DST 300-mb analysis
Northern Hemisphere

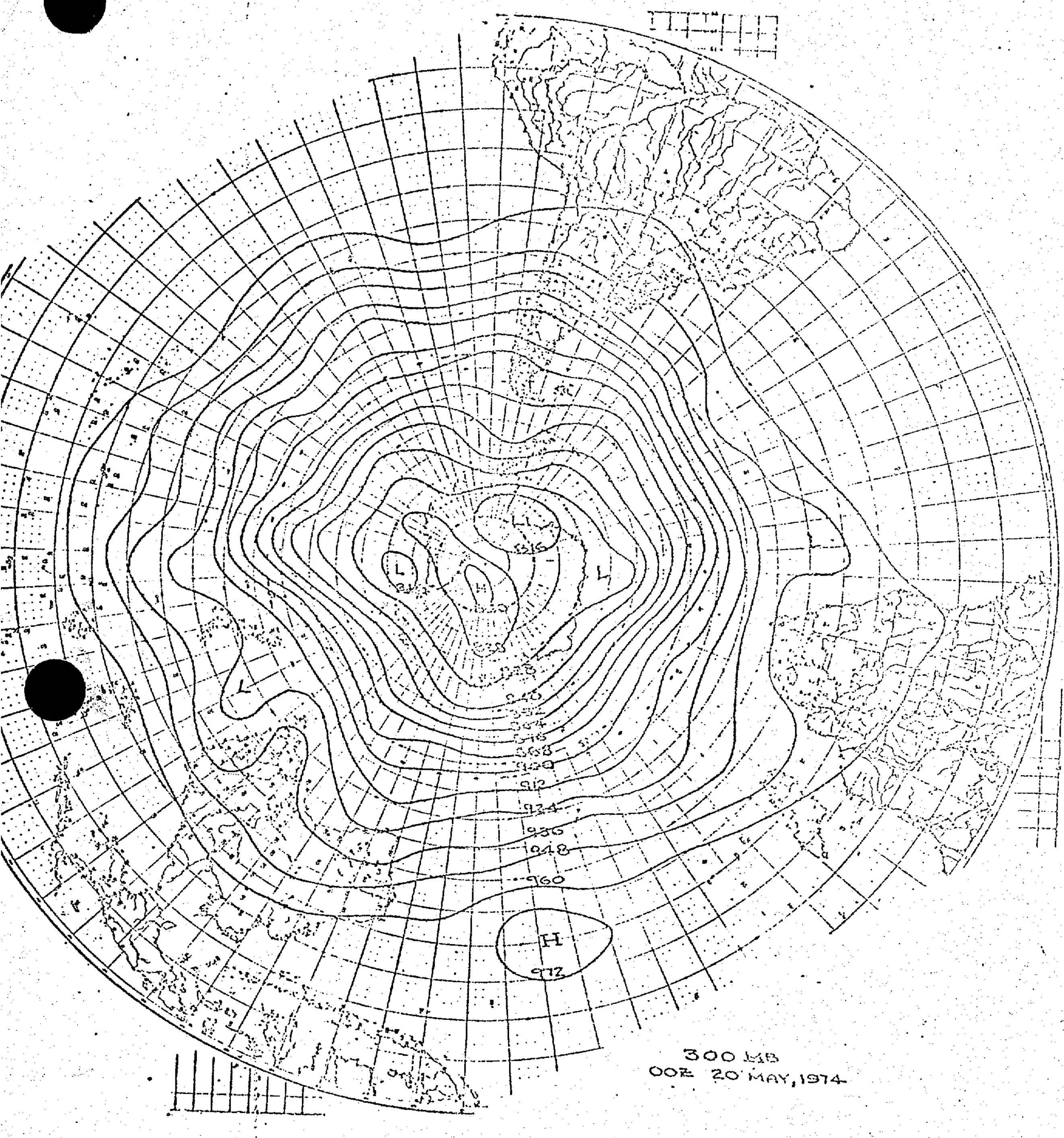


Figure 5c. DST 300-mb analysis
Southern Hemisphere

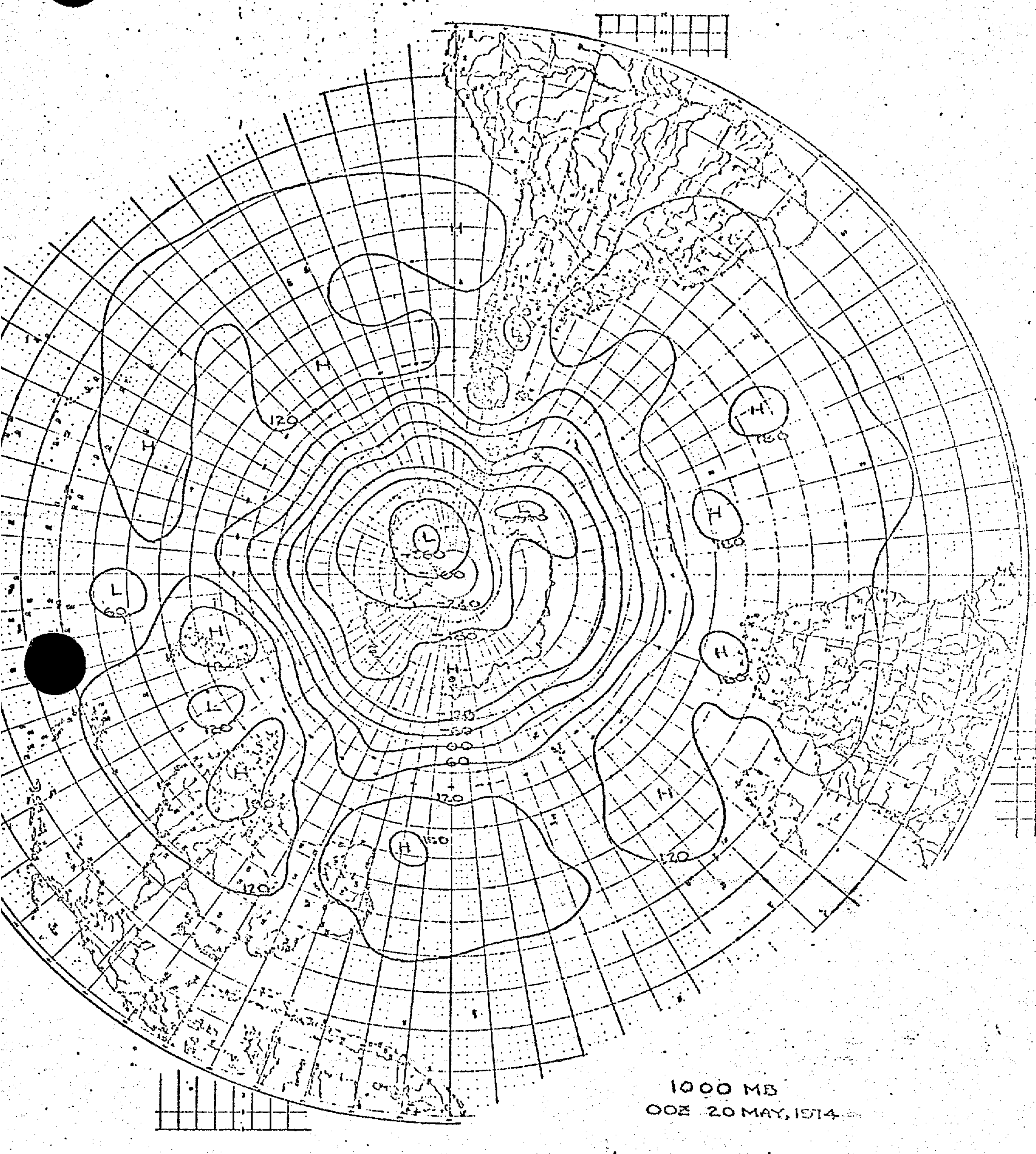


Figure 5d. DST 1000-mb analysis. Southern Hemisphere. Still shows some effect of 2nd error in area South of about 45^{0}.