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NMC Participation in the GARP BDS Experiment

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1. INTRODUCTION

This note describes the results of NMC's participation in the Global Atmospheric Research Program (GARP) on numerical experimentation. Specifically, NMC's seven-layer primitive equation model (7L PE) was used to generate forecasts from global analyses for 4-9 November 1969 made by Geophysical Fluid Dynamics Laboratory (GFDL) as part of the Basic Data Set Project (Gadd, 1980). The results were then compared with those of other participating centers. Most of the discussion, tables (1 through 4), and figures are derived from Gadd's report.

2. HISTORY OF THE BDS

The BDS Project was conceived by the Working Group on Numerical Experimentation (WGNE) as a means of comparing the performance of different forecast models (Carson, 1978). The initial analyses for the project was made in early 1975 by the Dynamic Prediction Research Division (DPRD, now DRPN), which used a spectral format for global analyses for the period 4-9 November 1969.

A number of difficulties were encountered in attempting to use these analyses, and only eight of 24 participating stations were able to complete their work and submit results. NMC was one of the eight successful centers, using a 9-layer, 2.5° latitude-longitude global forecasting model (Stackpole, 1976).

Other difficulties in interpreting the results of that stage of the project arose due to the variety of initialization procedures and output formats. A partial solution was achieved by limiting intercomparison to 500 mb geopotential height forecasts, using a common projection and scale.

In April 1978 the WGNE decided to conduct a second forecast model intercomparison project, using analyses for 4-9 November 1969 prepared by GFDL. Comparisons would be made among forecasts up to 120 hours at 500 mb and 1000 mb (or sea level) geopotential heights.

3. GFDL ANALYSES

According to Gadd, the GFDL global analyses at 12 hour intervals from 00Z 4 November 1969 through 00Z 9 November 1969 uses an optimum interpolation routine and 4-D assimilation routine, in packed spectral form (Level III FGGE format). Unpacking and spectral synthesis routines were included with the data. The BDS contains fields of vorticity, divergence, temperature, mixing ratio and geopotential height at 19 levels plus sea level temperature and pressure. The 19 levels are 0.4, 2, 5, 10, 20, 30, 50, 100, 150, 200, 250, 300, 400, 500, 700, 800, 850, 900, and 1000 mb. Sea surface temperatures were not included and had to be obtained separately.

4. NMC METHODOLOGY

The operational 7L PE model (Shuman and Hovermale, 1968) was used in generating forecasts up to 120 hours from GFDL analyses at 00Z 4 November 1969, 00Z 5 November, 00Z 6 November, 00Z 7 November, and 00Z 8 November. Table 1 shows the summary of integrations carried out in NMC and other participating centers. Seventy millibar data used in generating 7L PE forecasts was not available but was interpolated (linearly with respect to log P) between 50 mb and 100 mb. However, humidity data was not used in the forecast due to incompatibility between desired and available fields; an initial default value of 40% mean relative humidity everywhere was assigned instead. The LIII FGGE grid was interpolated linearly to the NMC 381 km polar stereographic grid.

5. NMC RESULTS: COMPARISON WITH OTHER CENTERS

Table 2 gives the RMS persistence errors in meters for 500 mb height for the 00Z 4 November 1969 data. NMC's persistence errors are slightly but consistently lower than those for other centers. This result implies that the NMC version of the GFDL analyses is somewhat smoother than that for other centers, possibly as a result of the linear interpolation from Level III FGGE to NMC polar stereographic format.

Table 3 gives the 500 mb forecast errors, in meters and as a percentage of persistence, for various centers. The NMC forecasts compare quite favorably with the rest of the field, at least for this case. NMC's 24 hour forecast is average but forecasts beyond 24 hours rank among the best in the field. "Percentage of persistence" is a better indicator of relative quality since the RMS error values are affected by the smoothness of the verifying analysis, reflected by persistence values (See Table 2).

Table 4 is similar to table 3, except that 1000 mb or sea level forecasts are evaluated, and only the percentage of persistence error is given. NMC's ranking here is similar to those for the 500 mb forecasts.

Spectrally decomposed 500 mb RMS errors, which were computed at a number of other centers, were not computed here. Forecast and difference maps are shown for 120 hour (Figures 1a, 1b), but not for 72 hour. The major feature of the 120 hour forecast error for all participants was the gross underforecast of a low near Iceland. The value of the maximum difference in this region was generally about 500 m, and the NMC result is no exception.

In addition to the forecasts generated from the 00Z 4 November 1969 data, results of NMC forecasts from 00Z 5 November 1969, 00Z 6 November, 00Z 7 November, and 00Z 8 November are also given in Table 5. Here the mean forecast error is shown in addition to the RMS, and a predominantly positive bias (forecast greater than observed) is clearly evident. The mean persistence error is also positive, particularly for forecasts from 4 and 5 November.

The RMS values for 24, 48, and 72 hour forecasts respectively are fairly consistent from day to day. This consistency is more clearly seen in Table 6, where RMS errors are expressed as a percentage of persistence.

The statistics derived from NMC's 7-layer forecast model show that these forecasts compare favorably with those of other models but otherwise reveal no features of unusual interest. Statistics from forecasts generated from initial data after 4 November 1969 suggest little day to day change in RMS errors; some fluctuation does occur in mean error.

REFERENCES

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Stackpole, J. D., 1976: 'The National Meteorological Center Nine-Layer Global Forecast Model', Preprint Volume Sixth Conference on Weather Forecasting and Analysis, May 10-14, 1976, Albany, New York, Published by AMS, Boston, Mass.

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CENTRE	Run	Vertical representation	Horizontal representation	Domain	Physics	Initialisation
DRPN	1	σ , 5 levels	spectral, R29	global	dry	divergence zeroed
	2	σ , 5 levels	spectral, R29	NH	dry	divergence zeroed
	3	σ , 5 levels	spectral, R20	global	dry	divergence zeroed
	4	σ , 5 levels	spectral, R20	NH	dry	divergence zeroed
	5	σ , 10 levels	spectral, R29	NH	DRPN	divergence zeroed
	6	σ , 7 levels, finite element	spectral, R20	NH	dry	divergence zeroed
EERM		σ , 10 levels	250 km, polar stereographic	9°N	EERM	balance equation
LMD	1	σ , 11 levels	N25, sine latitude/longitude (F)	global	none	12 hour averaged fields
	2	σ , 11 levels	N25, sine latitude/longitude (F)	global	LMD	12 hour averaged fields
DW		p, 9 levels	254 km, polar stereographic	11°N	DW	balance equation
JMA		σ , 4 levels	381 km, polar stereographic	approx NH	JMA	balance equation
ECMWF	1	σ , 15 levels	N48, latitude/longitude (F)	global	ECMWF	normal mode
	2	σ , 15 levels	N32, latitude/longitude (F)	global	ECMWF	normal mode
	3	σ , 15 levels	spectral, T40	global	ECMWF	derived from N48
	4	σ , 15 levels	N48, latitude/longitude (F)	global	GFDL	normal mode
MO	1	p, 10 levels, 100(100)1000	300 km, polar stereographic	15°N	MO(i)	balance equation
	2	p, 10 levels, 100(100)1000	300 km, polar stereographic	15°N	MO(i)	none
	3	σ , 10 levels	300 km, polar stereographic	15°N	MO(ii)	balance equation
	4	p, 10 levels, 50(100)950	300 km, polar stereographic	15°N	MO(ii)	balance equation
	5	σ , 11 levels	N45, latitude/longitude (K)	NH	MO(iii)	none
	6	σ , 11 levels	N45, latitude/longitude (K)	global	MO(iii)	none
NMC		p, 7 levels	381 km, polar stereographic	NH	NMC	none

Table 1 Summary of the integrations carried out in various centres

CENTRE	day 1	day 2	day 3	day 4	day 5
DRPN	77	118	135	146	148
EERM	78	119	133	147	150
LMD	77	117	132	145	146
DW	78	119	133		
JMA	78	119	134	147	148
ECMWF	75	116	130	143	146
MO(i)	77	118	132	145	147
MO(ii)	77	118	132	146	150
NMC	75	115	129	142	142

Table 2 RMS persistence errors in metres for 500 mb height, calculated in the eight centres for the 00Z 4 Nov 1969 data.

FORECAST	RMS error in metres					% of persistence error					5 day average %
	day 1	day 2	day 3	day 4	day 5	day 1	day 2	day 3	day 4	day 5	
DRPN 1	54	87	103	125	137	70	74	77	86	93	80
DRPN 2	53	87	103	125	136	69	74	77	86	92	79
DRPN 3	52	83	96	117	131	67	70	72	80	88	76
DRPN 4	52	83	96	118	134	67	70	72	81	90	76
DRPN 5	34	61	89	107	127	44	52	67	73	86	64
DRPN 6	44	69	81	92	108	57	58	61	63	73	62
EERM	38	70	88	101	125	49	59	66	69	83	65
LMD 1	40	68	86	94	122	52	58	65	65	84	65
LMD 2	47	76	89	95	119	61	65	67	65	81	68
DW	41	72	101			53	60	76			
JMA	41	74	92	116	147	53	62	69	79	99	72
ECMWF 1	32	57	86	112	138	43	49	66	78	95	66
ECMWF 2	32	57	80	114	143	43	49	62	80	98	66
ECMWF 3	31	52	79	102	122	41	45	61	71	84	60
ECMWF 4	32	57	86	117	146	43	49	66	82	100	68
MO 1	37	63	83	101	116	48	53	63	70	79	63
MO 2	43	65	87	108	128	56	55	66	74	87	68
MO 3	37	62	80	111	126	48	52	61	76	86	65
MO 4	37	61	81	111	128	48	52	61	76	87	65
MO 5	53	74	99	111	137	69	63	75	76	91	75
MO 6	51	67	101	117	141	66	57	76	80	94	75
NMC	41	60	74	92	114	55	52	57	65	80	62

Table 3 RMS Forecast Errors, in Metres and as a Percentage of Persistence, for 500 mb Height Forecasts from 00Z Nov 1969 Data. See Table 1 for a Specification of the Forecasts.

FORECAST	% of persistence error					field	5 day average %
	day 1	day 2	day 3	day 4	day 5		
DRPN 1	79	77	78	87	99	1000 mb	84
DRPN 2	79	76	79	88	100	1000 mb	84
DRPN 3	78	74	77	83	95	1000 mb	81
DRPN 4	76	74	79	84	99	1000 mb	82
DRPN 5	63	69	81	88	99	1000 mb	80
DRPN 6	65	62	74	91	99	1000 mb	78
EERM	60	66	71	80	99	1000 mb	75
LMD 1	76	83	107	109	134	msl	102
LMD 2	73	71	87	82	93	msl	81
DW	53	60	89			msl	
JMA	63	70	83	88	104	msl	82
ECMWF 1	62	61	73	90	99	1000 mb	77
ECMWF 2	62	62	73	89	102	1000 mb	78
ECMWF 3	60	57	69	81	87	1000 mb	71
ECMWF 4	58	65	75	93	108	1000 mb	80
MO 1	63	63	65	77	89	msl	72
MO 2	77	69	68	79	92	msl	77
MO 3	72	70	71	93	113	msl	84
MO 4	63	66	71	91	107	msl	79
MO 5	81	65	84	82	91	1000 mb	81
MO 6	78	64	85	81	90	1000 mb	79
NMC		61	68	79	94	1000 mb	75

Table 4 RMS Forecast Errors, as a Percentage of Persistence, for Sea Level Forecasts from 00Z 4 Nov. 1969 Data. The Figures are Based on Mean Sea Level Pressure or 1000 mb Height as Indicated. See Table 1 for a Specification of the Forecasts.

STATISTICAL VERIFICATIONS OF GARPBDS

NMC-7 Layer Primitive Equation

Mean error (bias) and root-mean-square error of heights
(Area weighted points north of 30 N)
F: Forecast
Heights (meters)
P: Persistence

Initial Time		4 Nov. 1969		5 Nov. 1969						6 Nov. 1969				7 Nov. 1969				8 Nov. 1969			
Level (mb)		1000		500		1000		500		1000		500		1000		500		1000		500	
Statistic		Mean	RMS	Mean	RMS	Mean	RMS	Mean	RMS	Mean	RMS	Mean	RMS	Mean	RMS	Mean	RMS	Mean	RMS	Mean	RMS
Forecast Hour																					
24HR	F	13.83	37.92	5.27	40.91	8.96	32.33	0.48	38.50	5.96	35.30	1.68	35.60	9.47	37.23	5.21	40.89	6.92	32.98	-3.92	33.95
	P	15.49	53.26	11.31	74.73	8.47	59.29	4.57	76.33	-0.19	60.33	2.65	72.71	2.07	66.56	5.88	81.39	-3.83	55.26	-5.86	72.51
48HR	F	16.45	47.66	5.82	60.18	8.58	50.52	3.77	50.99	8.93	52.54	7.91	54.57	7.87	49.74	-1.58	55.07				
	P	23.96	78.51	15.89	114.87	8.28	82.59	7.23	102.50	1.07	93.80	8.53	111.50	-1.77	90.09	0.01	121.44				
72HR	F	12.80	61.01	7.74	73.74	9.67	73.82	10.24	74.31	6.11	62.14	3.72	66.64								
	P	23.77	90.07	18.54	128.89	10.35	104.15	13.10	128.52	-1.96	109.29	2.66	139.05								
96HR	F	19.23	78.50	28.65	91.75																
	P	25.84	99.12	24.42	142.02																
120HR	F	9.06	93.58	20.32	113.96																
	P	22.01	99.88	18.55	141.97																

Table 5 NMC 7L PE Forecast Statistics for GARPBDS Data.

All Initial Times are 00Z.

STATISTICAL VERIFICATION OF GARPBDS

NMC 7-Layer Primitive Equation
Forecast RMS (% of persistence)

Initial Date:		4 Nov. '69	5 Nov. '69	6 Nov. '69	7 Nov. '69	8 Nov. '69
24HR	1000 mb	71	55	59	56	60
	500 mb	55	50	49	50	47
48HR	1000 mb	61	61	56	55	
	500 mb	52	50	49	45	
72HR	1000 mb	68	71	57		
	500 mb	57	58	48		

Table 6 NMC 7L PE Forecast RMS Expressed as a Percentage of Persistence.

All Initial Times are 00Z.

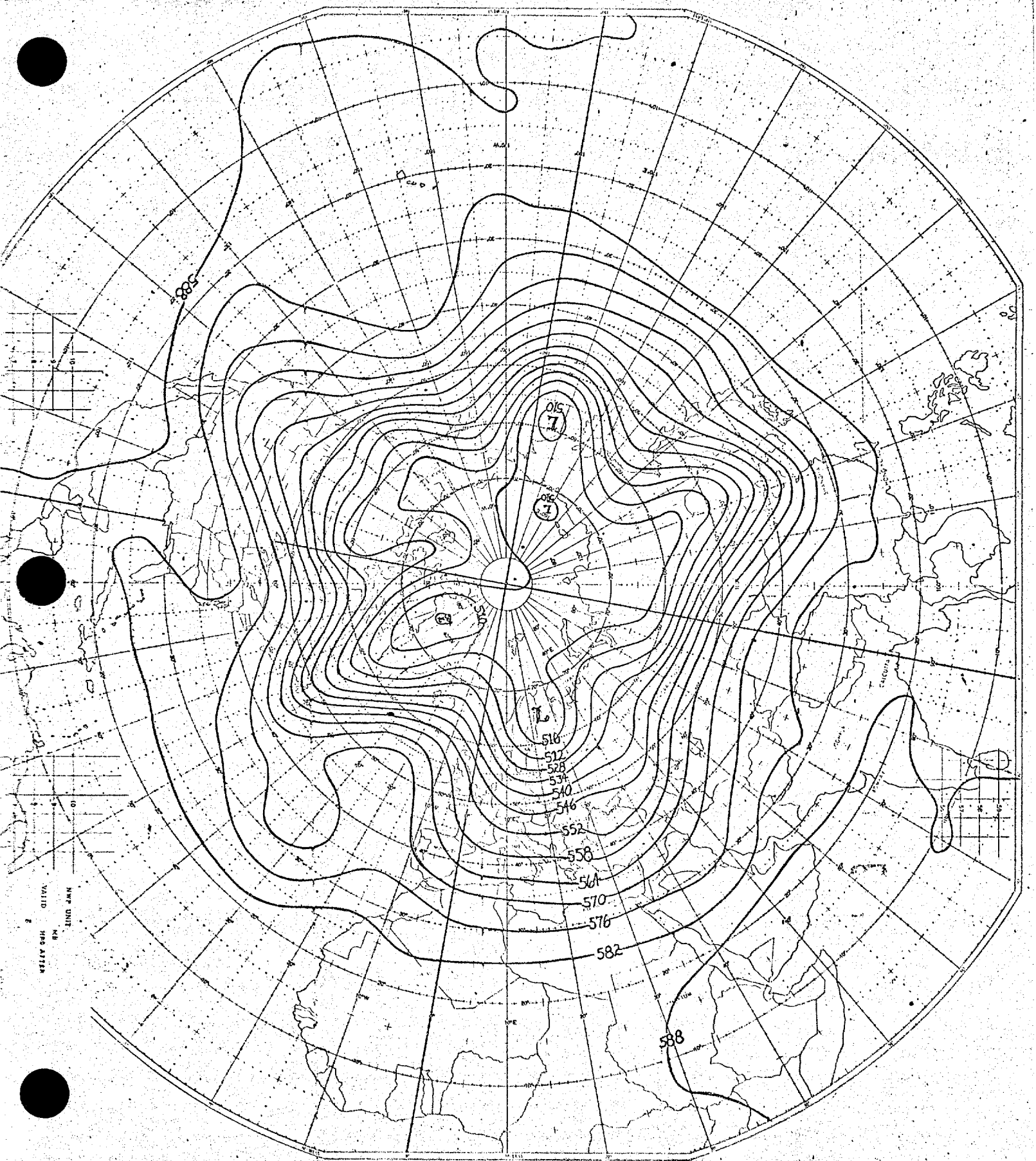

Figure 1a. NMC 120 Hour Forecast from 00Z 4 Nov 1969, 500 mb Geopotential Height (dkm)

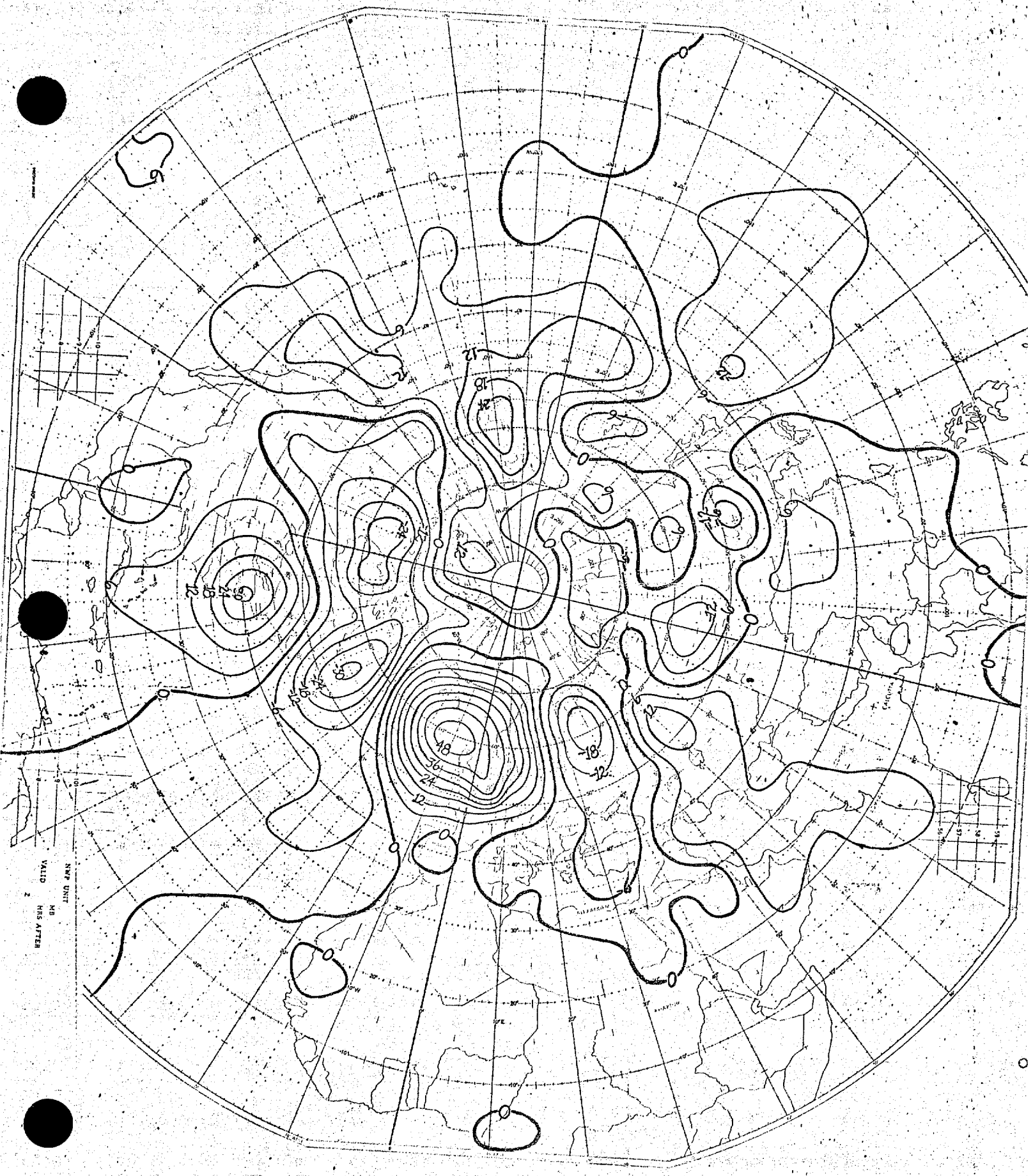

Figure 1b. NMC 120 Hour Forecast Error (Forecast-Observed) of 500 mb Heights (dkm)