NASA Technical Memorandum 100727

A Reduced Version of the NMC DERF II Data Set

(NASA-TM-100727) A REDUCED VERSION OF THE NMC DERF 2 DATA SET (NASA. Goddard Space Flight Center) 35 p CSCL 04B

N89-24002

Unclas
G3/47 0210314

Siegfried Schubert, Fong-Chiau Chang,
William K. M. Lau, and Robert Kistler

March 1989

NASA

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Siegfried Schubert
Goddard Space Flight Center
Greenbelt, Maryland

Fong-Chiau Chang
Applied Research Corporation
Landover, Maryland

William K. M. Lau
Goddard Space Flight Center
Greenbelt, Maryland

Robert Kistler
National Meteorological Center
Washington, DC

NASA
National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

1989

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I. Introduction

A major recommendation of the first Experimental Cimate Forecast Center (ECFC) workshop held at Goddard Space Flight Center in 1987 was to strengthen the collaboration between the ECFC and the National Meteorological Center/ Climate Analysis Center (NMC/CAC) through the joint development of a climate research data base using modern storage technology. In response to this recommendation, the ECFC at Goddard, together with NMC and the University of Maryland Center for Ocean, Land, and Atmosphere (COLA) has produced a reduced version of the second phase Dynamical Extended Range Forecast (DERF II) data. It is planned to provide this data on magnetic tape, as well as compact disc through the National Climate Data Center (NCDC).

The DERF data represents a major computational effort performed at NMC in order to better ascertain the potential for extended range forecasts and to develop a strategy for performing operational extended range forecasts using dynamical models. The data of the phase 2 experiment consists of 108 consecutive thirty-day forecasts (staring 00Z each day) beginning on 12/14/86, using the research version of the operational forecast model (NMC, 1988). A major stumbling block for using this data has been the sheer volume of data that must be processed in order to perform even the simplest of calculations. For example, the data processed for this task involved a number of steps, which included first obtaining a subset of the original 250 DERF II tapes and then reading and processing more than 50 tapes consisting of selected pressure level and surface data.

The product of the data reduction described in this document is a manageable data set which fits comfortably on 5 magnetic tapes or on one compact disc. This was accomplished through a combination of reducing the spatial resolution and choosing a subset of fields that were deemed most valuable to the immediate users. The final product represents (in addition to the authors) the efforts and support of a number of people including Max Suarez, Eugenia Kalnay, Steve Tracton, James Kinter and Larry Marx. Chapter II describes the details of the data reduction, together with samples of the original and reduced fields, while chapter III shows how the data are arranged on tape/disc and provides the formatting information needed to read it.

II. Data Reduction and Sample Fields

The fields selected from the original data for processing are the global post-processed mandatory pressure level data in the form of spherical harmonic coefficients at a resolution of rhomboidal 30 (R30). These fields consist of the ln(surface pressure) , geopotential height, $u\cos\phi$, $v\cos\phi$, temperature, vertical velocity and relative humidity. In addition, global surface data was provided on a gaussian grid with 102 points in the north-south direction and 128 points in the east-west direction. The surface gridded fields included in the reduced data base consist of surface temperature, soil moisture, snow depth, total rainfall, convective rainfall, surface sensible heat flux, surface latent heat flux, surface u-stress and surface v-stress.

The processing consisted of reducing the R30 resolution to triangular 20 (T20) and area-averaging the gridded surface data to a 4° latitude by 5° longitude grid (72 x 46). Table 1 gives the fields and the resolution of both the original and final fields. Most upper level quantities were kept at 1000, 850, 700, 500, 400, 300, 250, 200, 150, 100, and 50 mb. The exceptions are vertical velocity, which was kept up to 100mb and relative humidity which was only kept up to 300mb.

A) Spectral Data

The spectral data was truncated at T20. For the scalar fields the truncation point is at N=20 and M=20, where N is the total wave number and M is the zonal wave number. For the winds the truncation point is actually at N=21 and M=20. The higher degree in the winds is due to the relationship between the winds and the velocity potential and stream function in spectral form. For example, non-zero variance in the stream function at, say, N=20 implies non-zero values in the winds at N=21 (see Bourke, 1972). The total number of real components is then 2x252 or 504 for the winds, and 2x231or 462 for the scalar fields. For convenience we have written the scalar fields with N=21 and M=20 where all N=21 components are set to zero. This avoids problems arising from the different dimensions for the scalar and vector fields. Table 2 displays the triangular truncation and shows the order of the spectral coefficients.

As a test of our reduction programs and to assist the users of this data, we have reconstructed selected fields using both the original truncation at R30 and the truncation of the final data at T20. These fields were produced using the following formulae for the transformation routines:

$$f(\lambda, \phi) = (2 - \delta_{0m}) \sum_{m=0}^{M} \sum_{n=m}^{N+J} (a_n^m \cos m\lambda - b_n^m \sin m\lambda) P_n^m(\mu) \qquad (1)$$

where δ_{0m} is the Kronecker delta function, $\mu = \sin\phi$, and J=0 or M depending on whether the truncation is triangular or rhomboidal, respectively. The Legendre functions are defined as

$$P_n^m(\mu) = \frac{1}{2^n n!}\left[\frac{(2n+1)(n-m)!}{2(n+m)!}\right]^{1/2}(1-\mu^2)^{m/2}\frac{d^{m+n}}{d\mu^{n+m}}(\mu^2-1)^n \quad (2)$$

For convenience these functions [P(NY,NUM), NY=1,46 and NUM=1, 252] are provided on tape at the same 46 latitude points as the gridded data. See Table 2 for the ordering of the functions in terms of N and M. Figures 1- 7 show the surface pressure and upper air fields at 500 mb using both truncations for the 24-hour forecast fields verifying on Dec 15, 1987.

B) Gridded Data

As a first step the gridded data was unpacked and linearly interpolated in latitude to a regular grid with essentially the same resolution as the gaussian grid (1.875° in latitude). Some selected fields of this high-resolution data set were saved to disc for comparisons with the final low-resolution fields. The high-resolution fields were then area-averaged to reduce the resolution to 4 degrees in latitude and 5 degrees in longitude. Samples of the high-resolution (128,97) and low-resolution fields (72,46) are shown in Figures 8-16 for the 24-hour forecast verifying Dec. 15, 1987. The order of the gridded data y(i,j) is such that y(1,1) is the South Pole and the Greenwich meridian, with latitude increasing with increasing j and longitude increasing with increasing i.

The low-resolution fields were packed in INTEGER*2 format before writing to tape. Only the gridded data was packed and the unpacking routine is provided in APPENDIX A. It should be noted that the precipitation, surface fluxes of sensible and latent heat and the surface u- and v-stress components are unreliable for the 00Z fields.

III. Data Format

The records were written in the following order. For each analysis period the initial conditions (00Z) and all 30-day forecasts starting from that day were written on a daily basis. The first set of records consists of the surface (gridded fields) and the second set of records consists of the spectral data. The upper level data is organized by level, i.e., all quantities at 1000mb are written, then all quantities at 850mb are written, etc. Table 3 shows the sequence of records, and Table 4 provides information needed to read the tapes.

IV. Ordering Information

The DERF-II data is available from NCDC. For further information, please contact:

Stephen R. Doty
National Climatic Data Center
Federal Building
Asheville, North Carolina 28801
Tel: 704 - 259 - 0475

V. Appendix A

The following routine may be used to unpack the surface gridded data.

```
      SUBROUTINE  UNPAC (RMIN, RMAX, LEN, RDATA, IDATA)
C RMIN:  MINIMUM OF DATA FIELD  (FROM TAPE), REAL
C RMAX:  MAXIMUM OF DATA FIELD  (FROM TAPE),  REAL
C LEN: SIZE OF RDATA AND IDATA (72 x 46),  INTEGER
C RDATA: REAL OUTPUT ARRAY
C IDATA :  INTEGER*2 INPUT ARRAY (FROM TAPE)
      DIMENSION RDATA (LEN)
      INTEGER*2 IDATA(LEN)
      REAL*8 C1, C2
      C1= RMAX+RMIN
      C1= C1/2.0
      C2= RMAX-RMIN
      C2= 65534./C2
      DO 20 L=1,LEN
      RDATA(L)= IDATA(L) / C2 + C1
20    CONTINUE
      RETURN
      END
```

VI. References

Bourke, W., 1972: An efficient, one-level, primitive-equation spectral model. *Mon. Wea. Rev.*, 100, 683- 689.

NMC, 1988: Research Version of the NMC Medium Range Forecast Model. Documentation. Volume 1: Hydrodynamics, Physical Parameterizations and User's Guide.

Table 1. List of Quantities and the Original and New Resolution

Quantity	Original Resolution[1]	New Resolution	Units	Notes
Surface Skin Temperature	128 x 102	72 x 46	°K	
Soil Moisture	128 x 102	72 x 46	mm	maximum=150 [2].
Snow Depth	128 x 102	72 x 46	mm	maximum=50000.
Total Rainfall	128 x 102	72 x 46	mm	24-hr accumulation
Convective Rainfall	128 x 102	72 x 46	mm	24-hr accumulation
Surface Sensible Heat Flux	128 x 102	72 x 46	W/m**2	
Surface Latent Heat Flux	128 x 102	72 x 46	W/m**2	
Surface U-stress	128 x 102	72 x 46	N/m**2	
Surface V-stress	128 x 102	72 x 46	N/m**2	
Surface pressure (p*)	R30	T20	cb	actually saved as natural logarithm of p*
Height (z)	R30	T20	meters	
u cos ϕ	R30	T20	m/sec	
v cos ϕ	R30	T20	m/sec	
Temperature	R30	T20	°K	
Vertical velocity	R30	T20	mb/sec	
Relative humidity	R30	T20	percent	

[1] Gaussian Grid has 102 latitude points.

[2] Both the original and reduced data fields have some values slightly larger (eg. 150.002). This appears to be due to a combination of the packing/ unpacking and averaging routines and are at the level of the machine precision. Similarly for the snow depth.

TABLE 2. Spectral Coefficients Stored in An Array X(2,252)

Note: The order in which the sine (b(j)) and cosine (a(j)) coefficients are saved is given below. See equation in the text.

TRIANGULAR TRUNCATION (N=21, M=20)

n																					
21	22	43	63	82	100	117	133	148	162	175	187	198	208	217	225	232	238	243	247	250	252
20	21	42	62	81	99	116	132	147	161	174	186	197	207	216	224	231	237	242	246	249	251
19	20	41	61	80	98	115	131	146	160	173	185	196	206	215	223	230	236	241	245	248	
18	19	40	60	79	97	114	130	145	159	172	184	195	205	214	222	229	235	240	244		
17	18	39	59	78	96	113	129	144	158	171	183	194	204	213	221	228	234	239			
16	17	38	58	77	95	112	128	143	157	170	182	193	203	212	220	227	233				
15	16	37	57	76	94	111	127	142	156	169	181	192	202	211	219	226					
14	15	36	56	75	93	110	126	141	155	168	180	191	201	210	218						
13	14	35	55	74	92	109	125	140	154	167	179	190	200	209							
12	13	34	54	73	91	108	124	139	153	166	178	189	199								
11	12	33	53	72	90	107	123	138	152	165	177	188									
10	11	32	52	71	89	106	122	137	151	164	176										
9	10	31	51	70	88	105	121	136	150	163											
8	9	30	50	69	87	104	120	135	149												
7	8	29	49	68	86	103	119	134													
6	7	28	48	67	85	102	118														
5	6	27	47	66	84	101															
4	5	26	46	65	83																
3	4	25	45	64																	
2	3	24	44																		
1	2	23																			
0	1																				
m	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

X (1,j) = a (j), j=1, 252

X (2,j) = b (j), j=1, 252

Table 3. Order of Records

Note: The surface data is packed in INTEGER*2 format. Note that the April analyses include only the spectral data.

```
INTEGER*2  ITS(72,46),ISM(72,46),ISD(72,46),ITR(72,46),ICR(72,46),ISH(72,46),
           ILH(72,46), IUS(72,46), IVS(72,46)
DIMENSION PS(2,252), Z(2,252), UC(2,252),VC(2,252),T(2,252),W(2,252),RH(2,252)
```

FHR: forecast length 0, 24, 48, ..., 720 hrs (REAL)
IYR, IMON, IDY, IHR: year, month, day and hour of initial state (INTEGER)
RMIN: minimum of gridded data (needed for unpacking) (REAL)
RMAX: maximum of gridded data (needed for unpacking) (REAL)

a) Surface data: For each analysis period the surface fields are written first (FHR = 0, 24, 48, ... 720) in the order given below.

Record number	Data	
1	FHR,IYR,IMON,IDY,IHR	
2	RMIN,RMAX,ITS	surface temperature
3	RMIN,RMAX,ISM	soil moisture
4	RMIN,RMAX,ISD	snow depth
5	RMIN,RMAX,ITR	total rainfall
6	RMIN,RMAX,ICR	convective rainfall
7	RMIN,RMAX,ISH	sensible heat
8	RMIN,RMAX,ILH	latent heat
9	RMIN,RMAX,IUS	surface u-stress
10	RMIN,RMAX,IVS	surface v-stress
11	FHR,IYR,IMON,IDY,IHR	
12		
.		
.	etc.	
.		
310	RMIN,RMAX,IVS	surface v-stress

Table 3. Order of Records (Continued)

b) <u>Spectral data:</u> The spectral data is written next for each forecast period (FHR = 0, 24, 48, ... 720) in the order given below. Note that relative humidity extends up to 300mb and the vertical velocity extends to 100mb.

1	FHR,IYR,IMON,IDY,IHR		
2	PS	natural logrithm of surface pressure	
3	Z	1000 mb	height
4	UC		u cosϕ
5	VC		v cosϕ
6	T		temperature
7	W		vertical velocity
8	RH		relative humidity
9	Z	850 mb	
10	UC		
11	VC		
12	T		
13	W		
14	RH		
15	Z	700 mb	
16	UC		
17	VC		
18	T		
19	W		
20	RH		
21	Z	500 mb	
22	UC		
23	VC		
24	T		
25	W		
26	RH		
27	Z	400 mb	
28	UC		
29	VC		
30	T		
31	W		
32	RH		
33	Z	300 mb	
34	UC		
35	VC		
36	T		
37	W		
38	RH		

Table 3. Order of Records (Continued)

39	Z	250 mb
40	UC	
41	VC	
42	T	
43	W	
44	Z	200 mb
45	UC	
46	VC	
47	T	
48	W	
49	Z	150 mb
50	UC	
51	VC	
52	T	
53	W	
54	Z	100 mb
55	UC	
56	VC	
57	T	
58	W	
59	Z	50 mb
60	UC	
61	VC	
62	T	
63	FHR,IYR,IMON,IDY,IHR	
.		
.		
.		
1922	T	

For each analysis/forecast period there are a total of 310+1922=2232 records. Each of the first 4 tapes contain 4 files where each file consists of 6 analysis/forecast periods. For the fifth tape the first and second files are as described above and complete the set of 108 forecasts through March 31, 1987. The third and fourth files are as follows: The third file contains all the analyses for the month of April to permit verification of the forecasts made in March. This includes only the spectral data (Z, UC, VC, T, RH) and excludes the vertical velocity and surface pressure fields. The order of the records is otherwise the same as listed in Table 3. The gridded surface data was also not available. The fourth file contains the Legendre functions on a 4° latitude grid to help in the back transform of the spectral data. The format for reading the Legendre functions is given below.

```
DIMENSION  P(NY,NUM) : Legendre functions defined in equation 2. The order of the
functions                is given in Table 2.
C
C  NY:  46 latitudes with the first at the South Pole.
C  NUM:  252 spectral modes. See Table 2.

      DO 20 L=1,NUM
      READ(8) (P(J,L),J=1,NY)
20    CONTINUE
```

Table 4. Tape Information

The first 4 tapes each contain 4 files. Each file contains 6 analysis/forecast periods (initial state and 1-30 forecast). Similarly for the fifth tape for the first 2 files. The third file on the fifth tape contains the spectral data for the April analyses and the fourth file contains the Legendre functions (P(NY,NUM)). The file names are given below.

Tape	File	Name	
1		1	YBSDS.DERF.D1214.D1219
1		2	YBSDS.DERF.D1220.D1225
1		3	YBSDS.DERF.D1226.D1231
1		4	YBSDS.DERF.D0101.D0106
2		1	YBSDS.DERF.D0107.D0112
2		2	YBSDS.DERF.D0113.D0118
2		3	YBSDS.DERF.D0119.D0124
2		4	YBSDS.DERF.D0125.D0130
3		1	YBSDS.DERF.D0131.D0205
3		2	YBSDS.DERF.D0206.D0211
3		3	YBSDS.DERF.D0212.D0217
3		4	YBSDS.DERF.D0218.D0223
4		1	YBSDS.DERF.D0224.D0301
4		2	YBSDS.DERF.D0302.D0307
4		3	YBSDS.DERF.D0308.D0313
4		4	YBSDS.DERF.D0314.D0319
5		1	YBSDS.DERF.D0320.D0325
5		2	YBSDS.DERF.D0326.D0331
5		3	YBSDS.DERF.APRIL.ANLY
5		4	YBSDS.DERF.LEGR.GRD46

The tapes were written at 6250 BPI using RECFM VBS LRECL 19065 BLOCK 19069

a)

b)

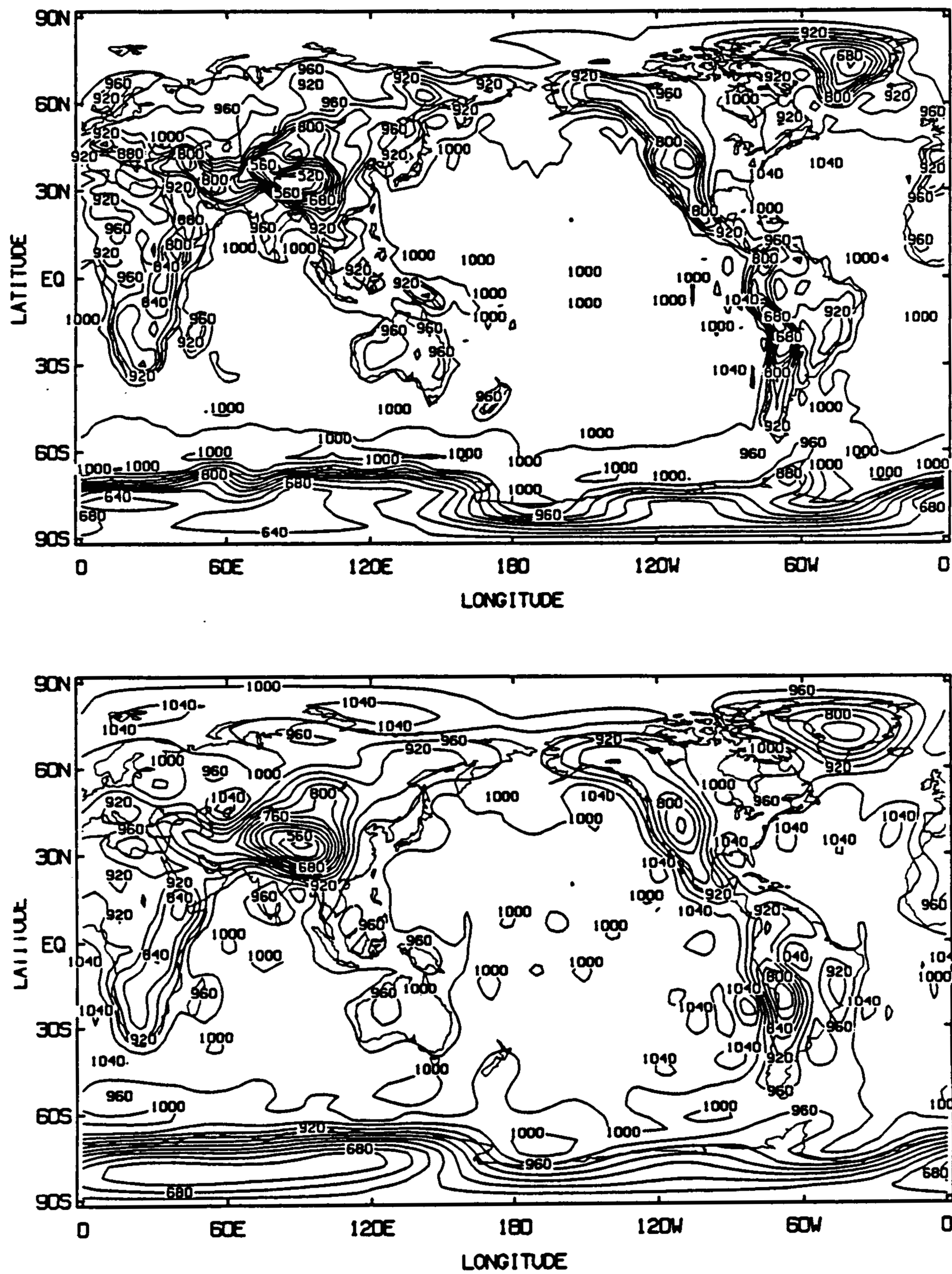


Fig. 1. Surface pressure for 24-hr forecast verifying December 15, 1987. a) R30 truncation and b) T20 truncation. Contour interval is 40 mb.

a)

b)

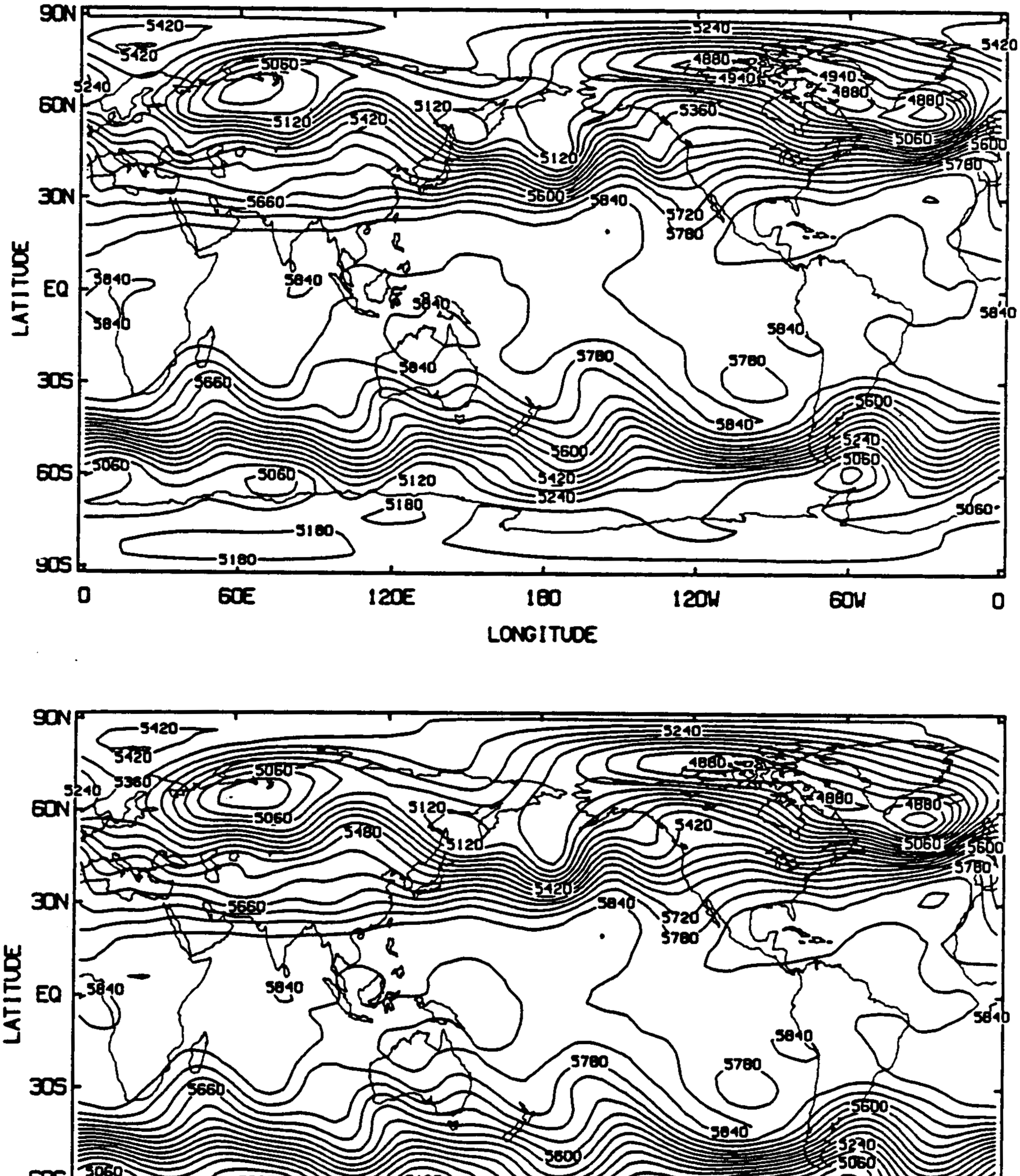


Fig. 2. Same as Fig. 1, except for 500mb height. Contour interval is 60 meters.

a)

b)

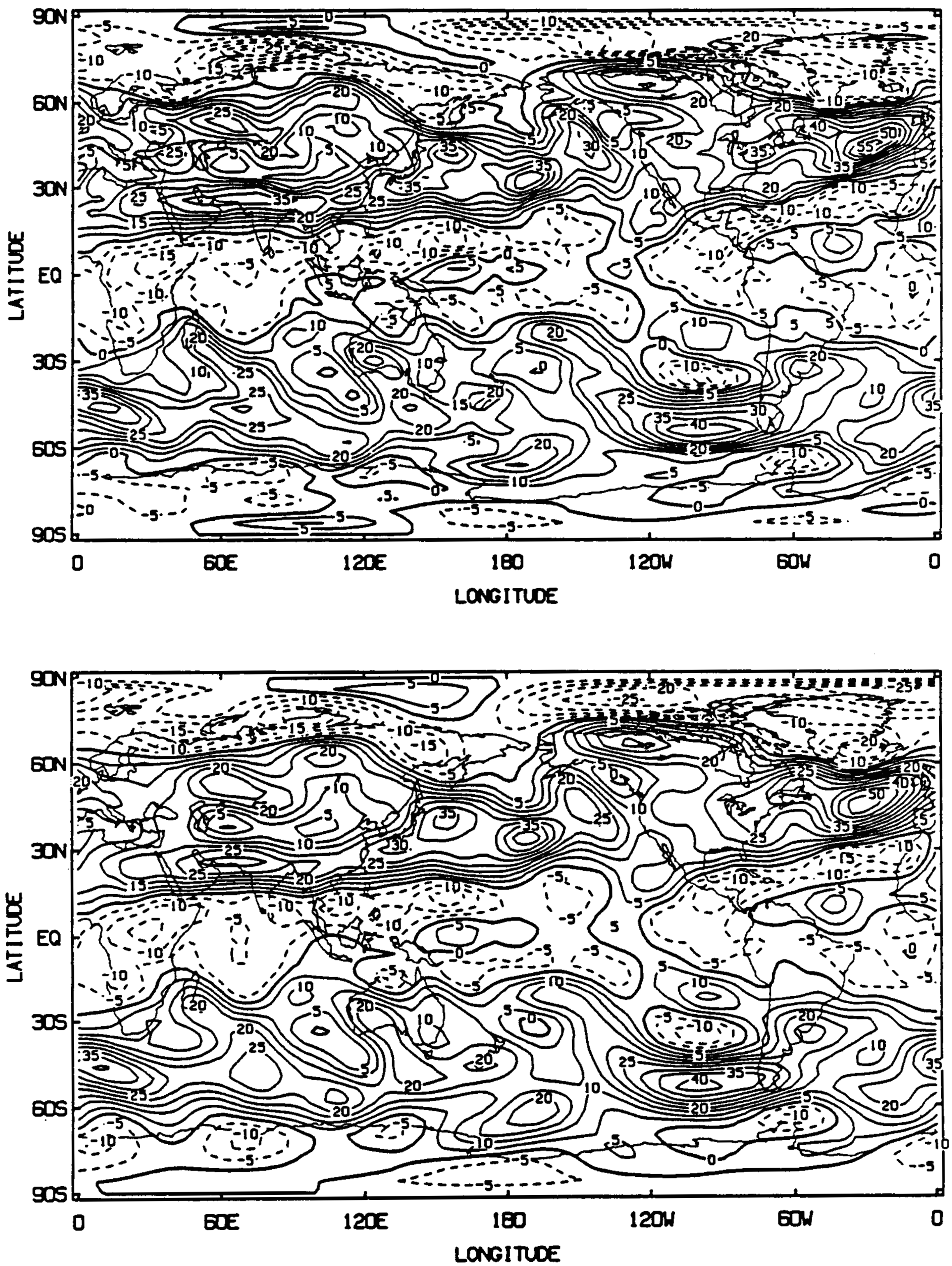
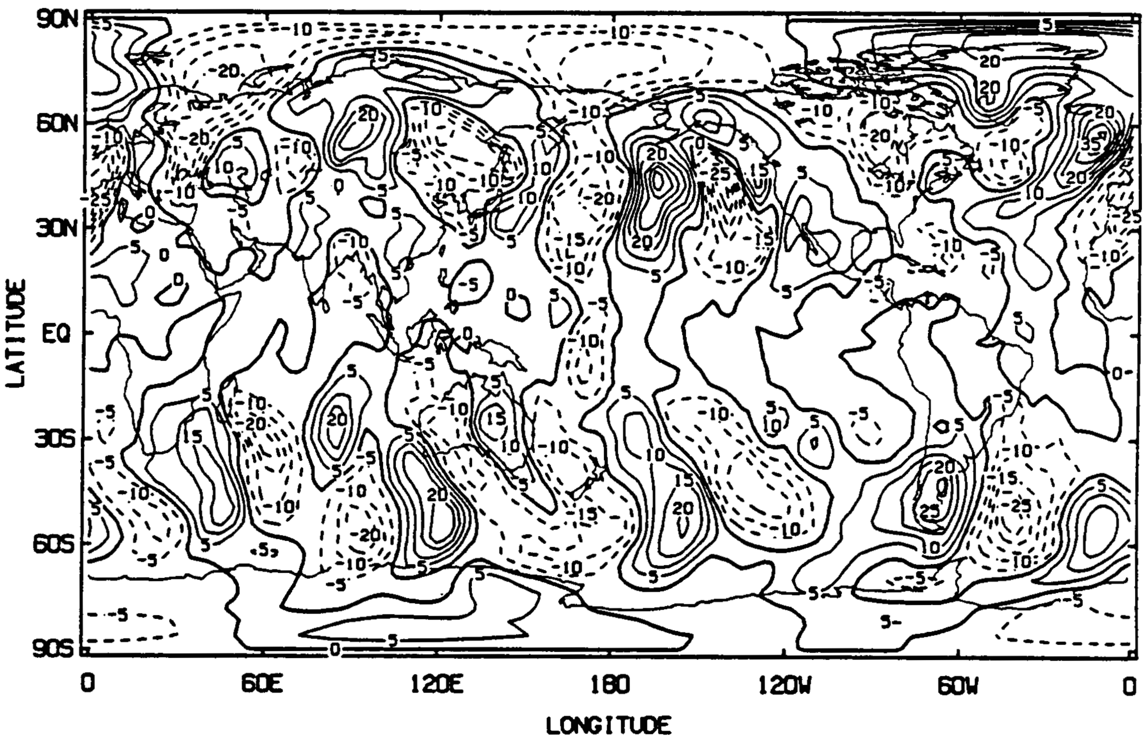


Fig. 3. Same as Fig. 1, except for u wind. Contour interval is 5 m/s.

a)



b)

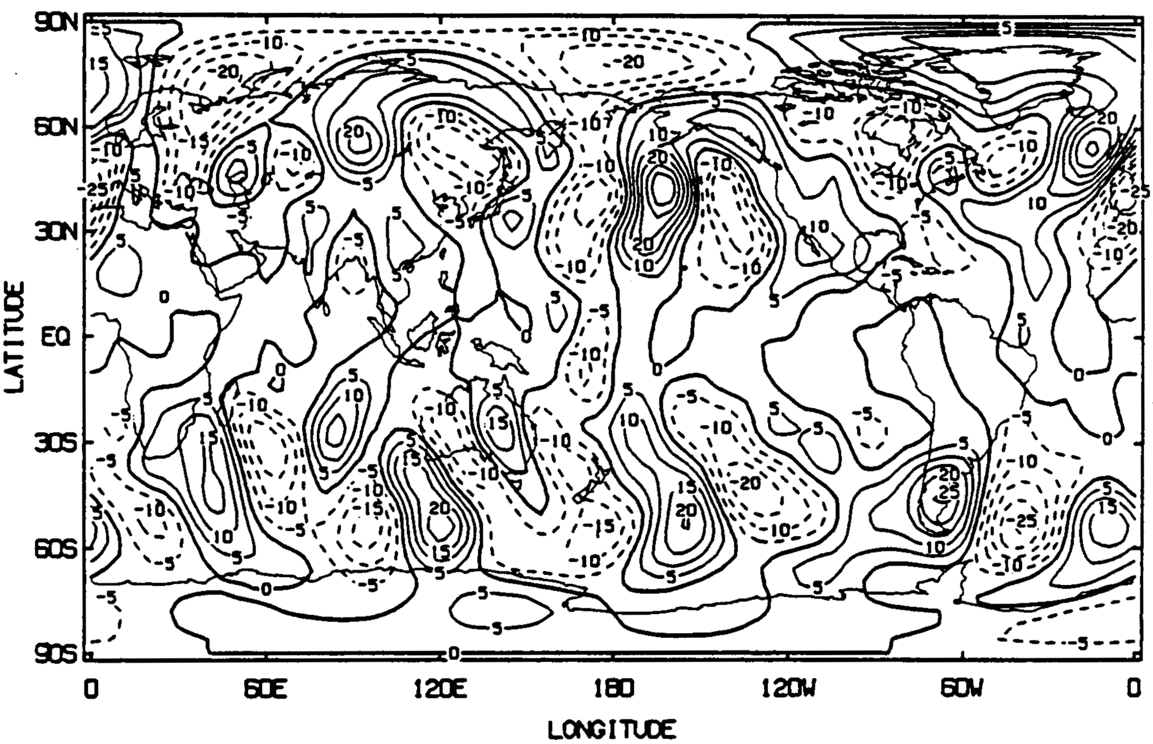


Fig. 4. Same as Fig. 1, except for v wind. Contour interval is 5 m/s.

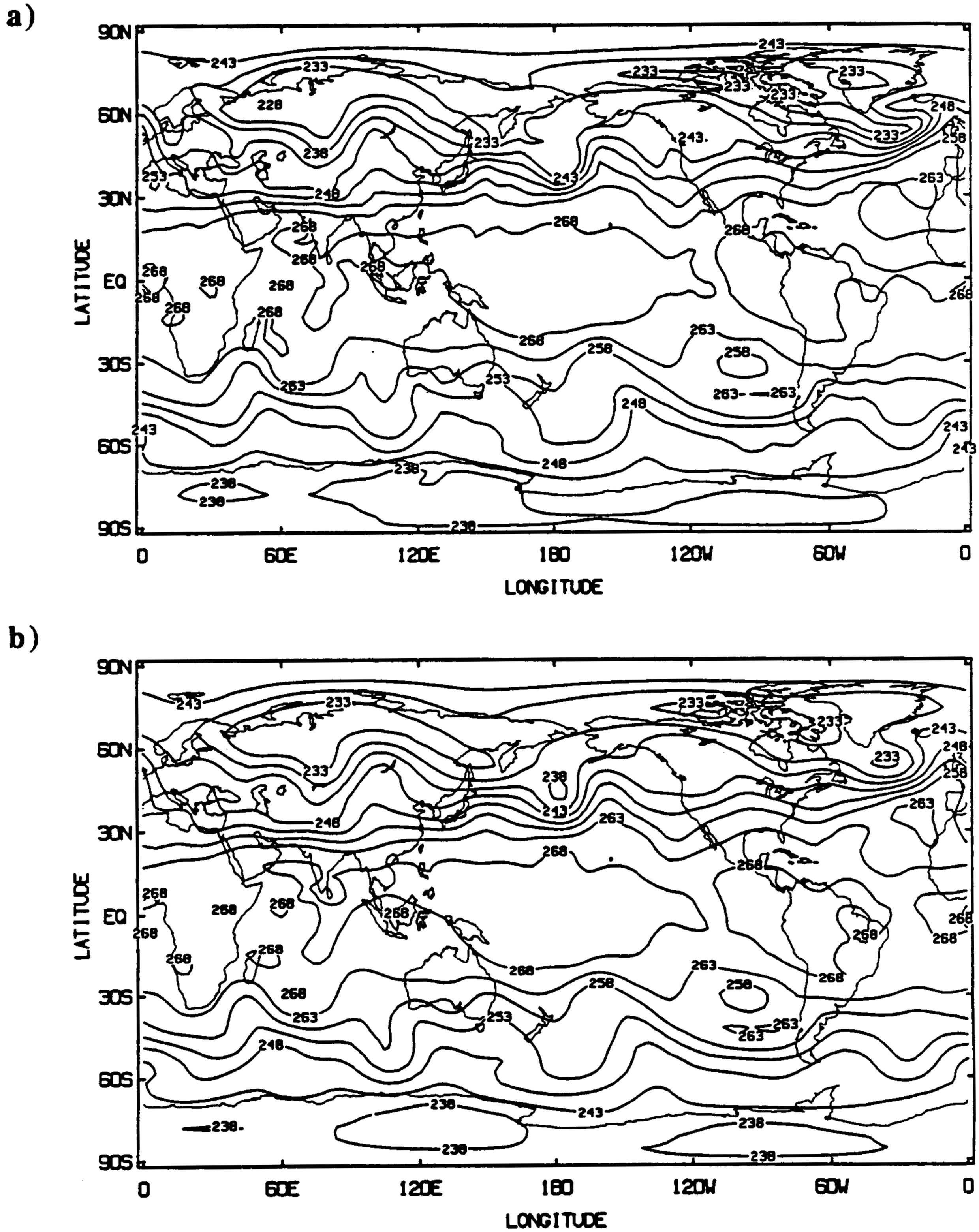


Fig. 5. Same as Fig. 1, except for temperature at 500mb. Contour interval is 5 °K.

a)

b)

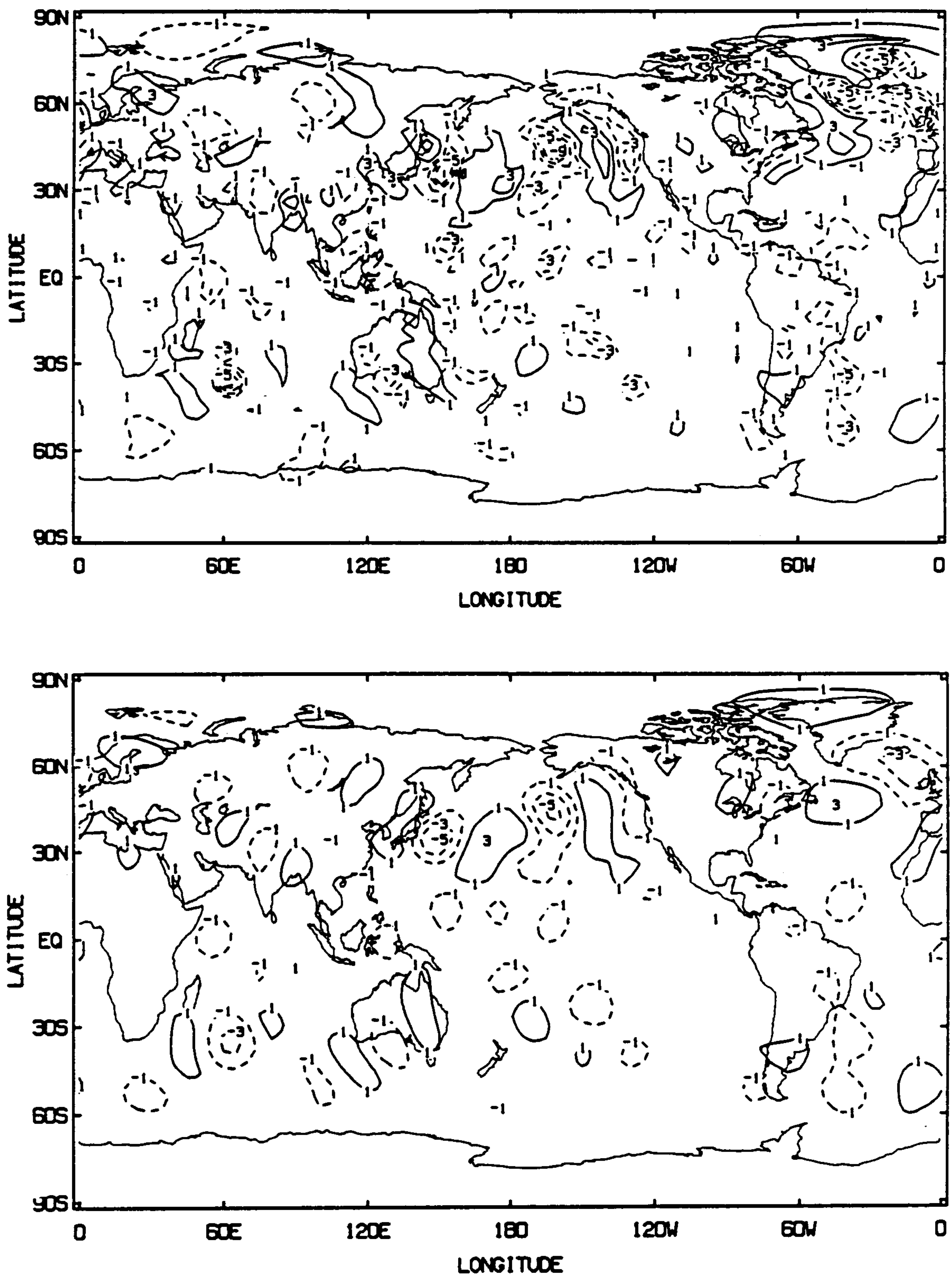


Fig. 6. Same as Fig. 1, except for vertical velocity (omega). Units are microbar/s.

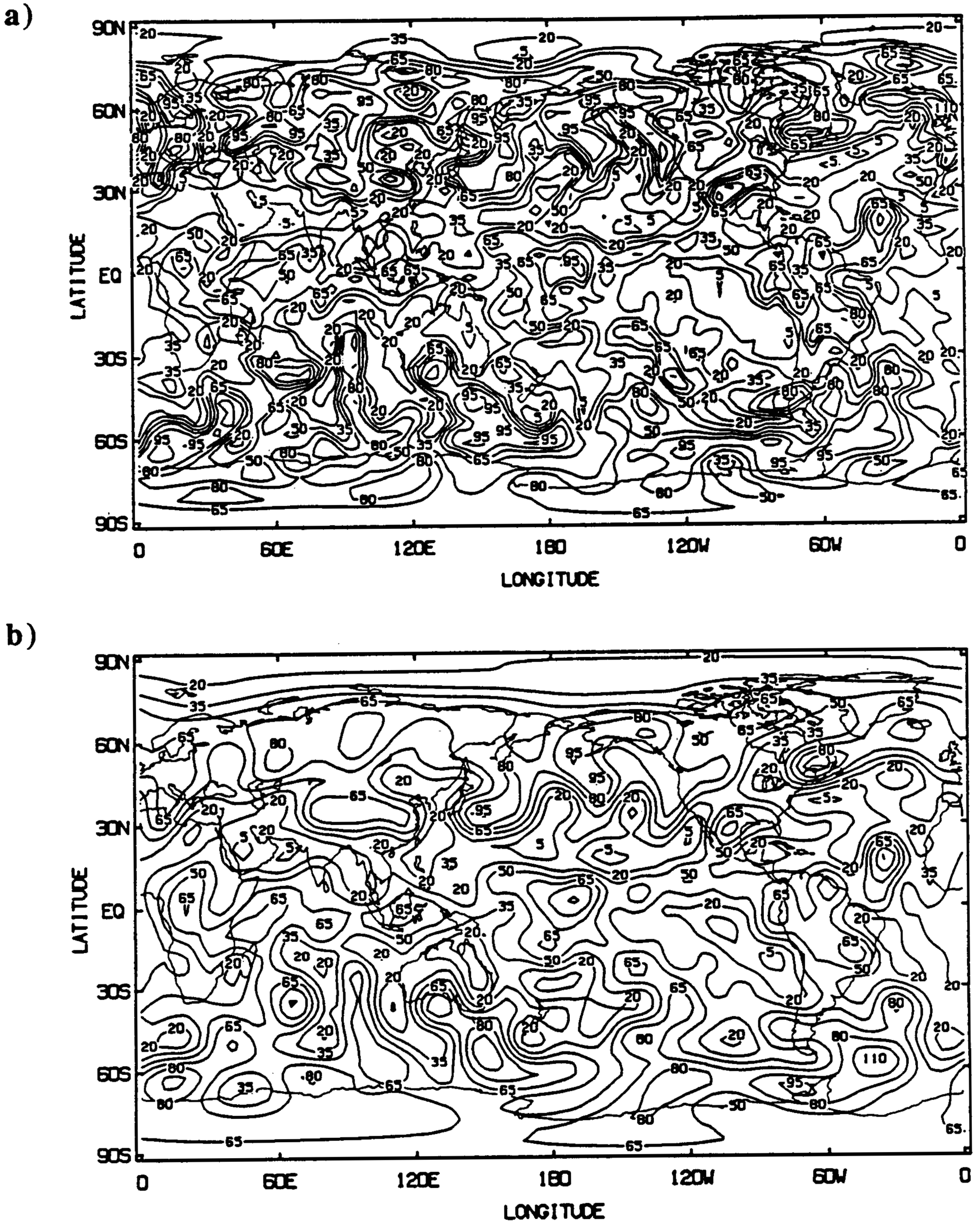


Fig. 7. Same as Fig. 1, except for relative humidity (in percent). Contour interval is 5.

a)

b)

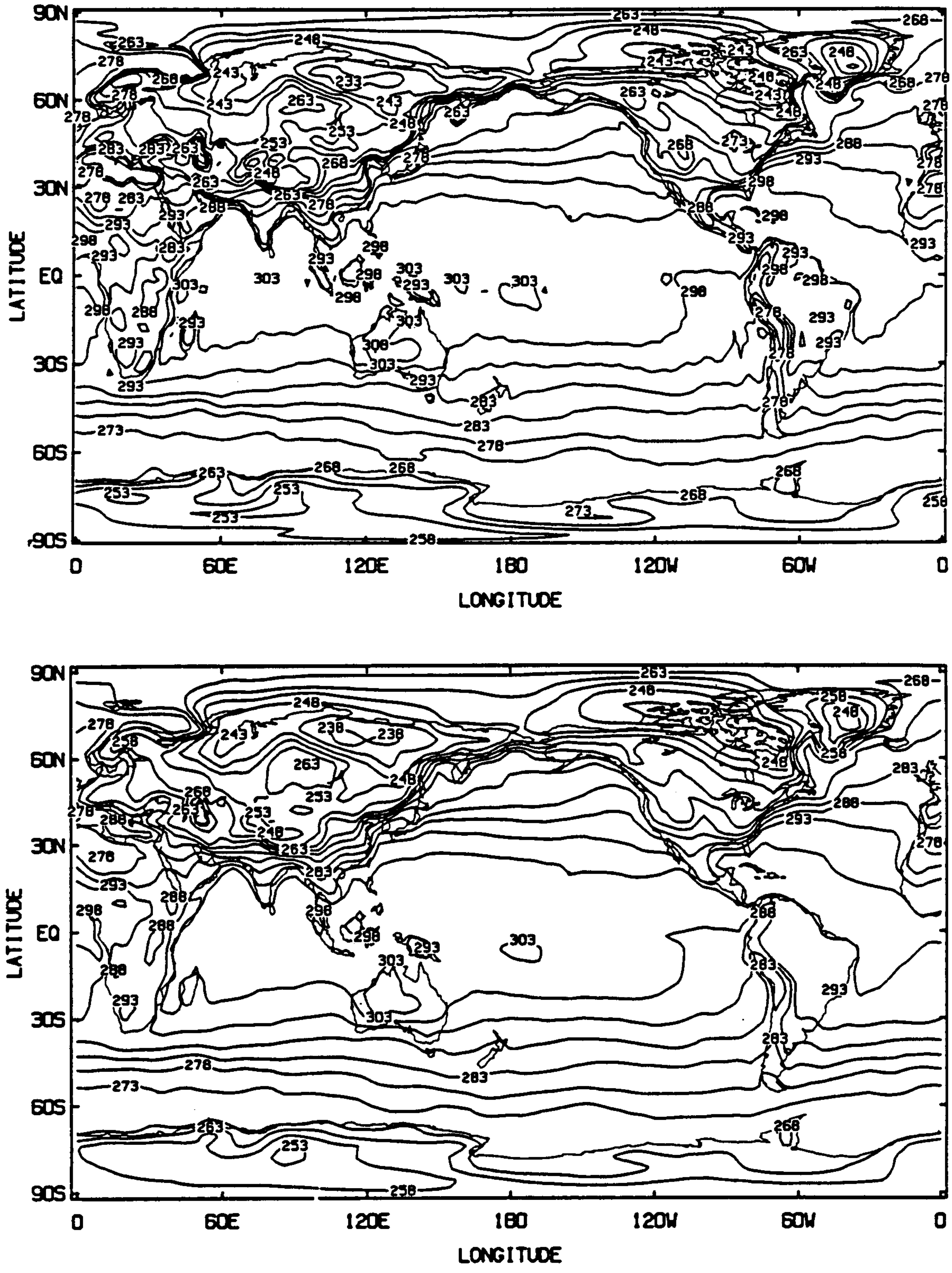
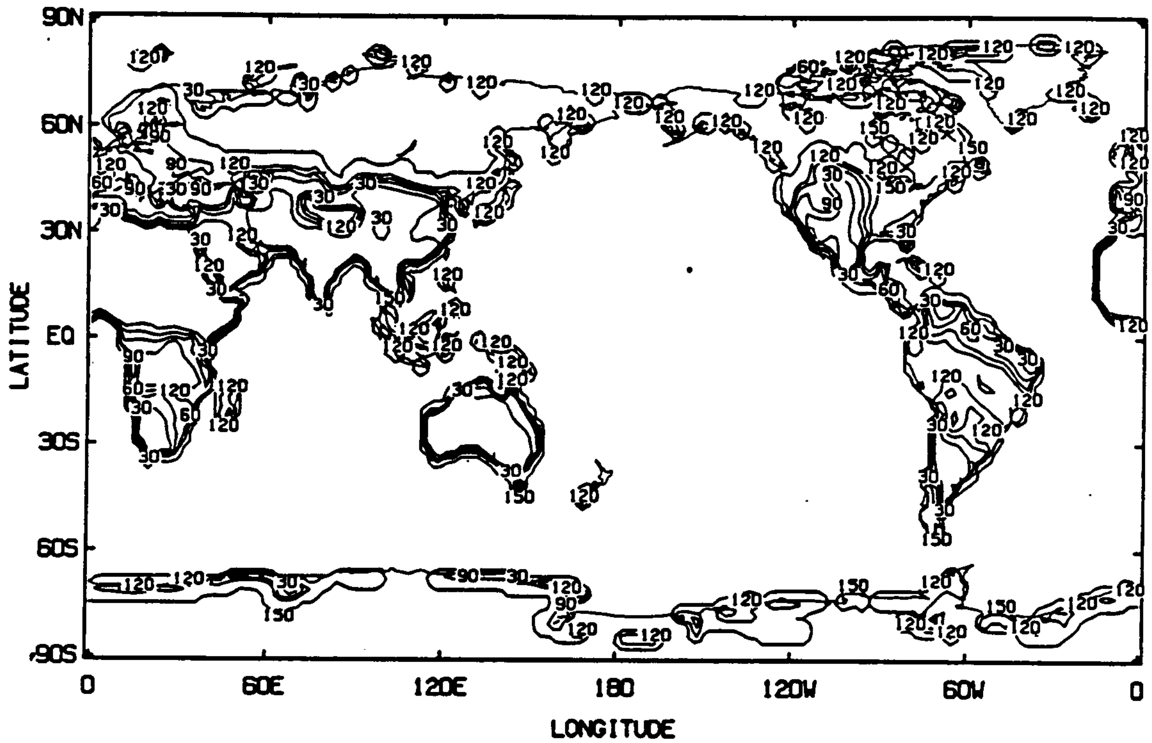


Fig. 8. Surface temperature for 24-hr forecast verifying December 15, 1987. a) High-resolution grid (128, 97) and b) low-resolution grid (72,46). Contour interval is 5° K.

a)



b)

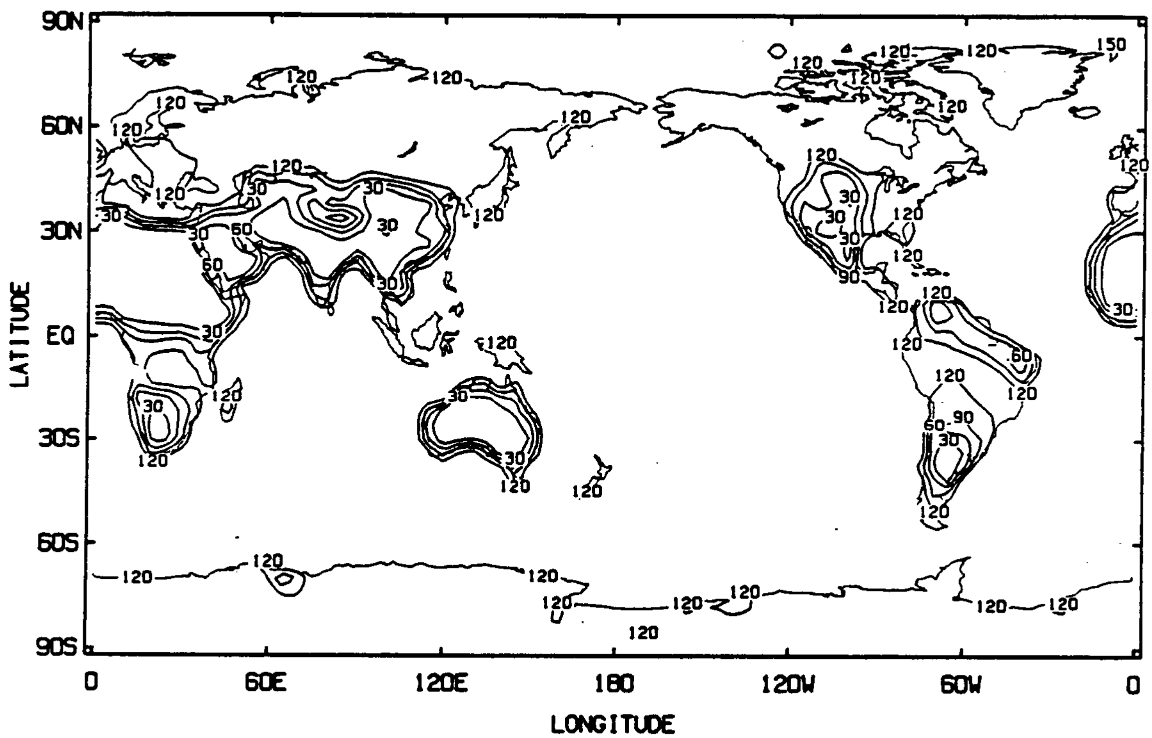


Fig. 9. Same as Fig. 8, except for soil moisture. Contour interval is 30mm. Maximum value is 150. See footnote to Table 1.

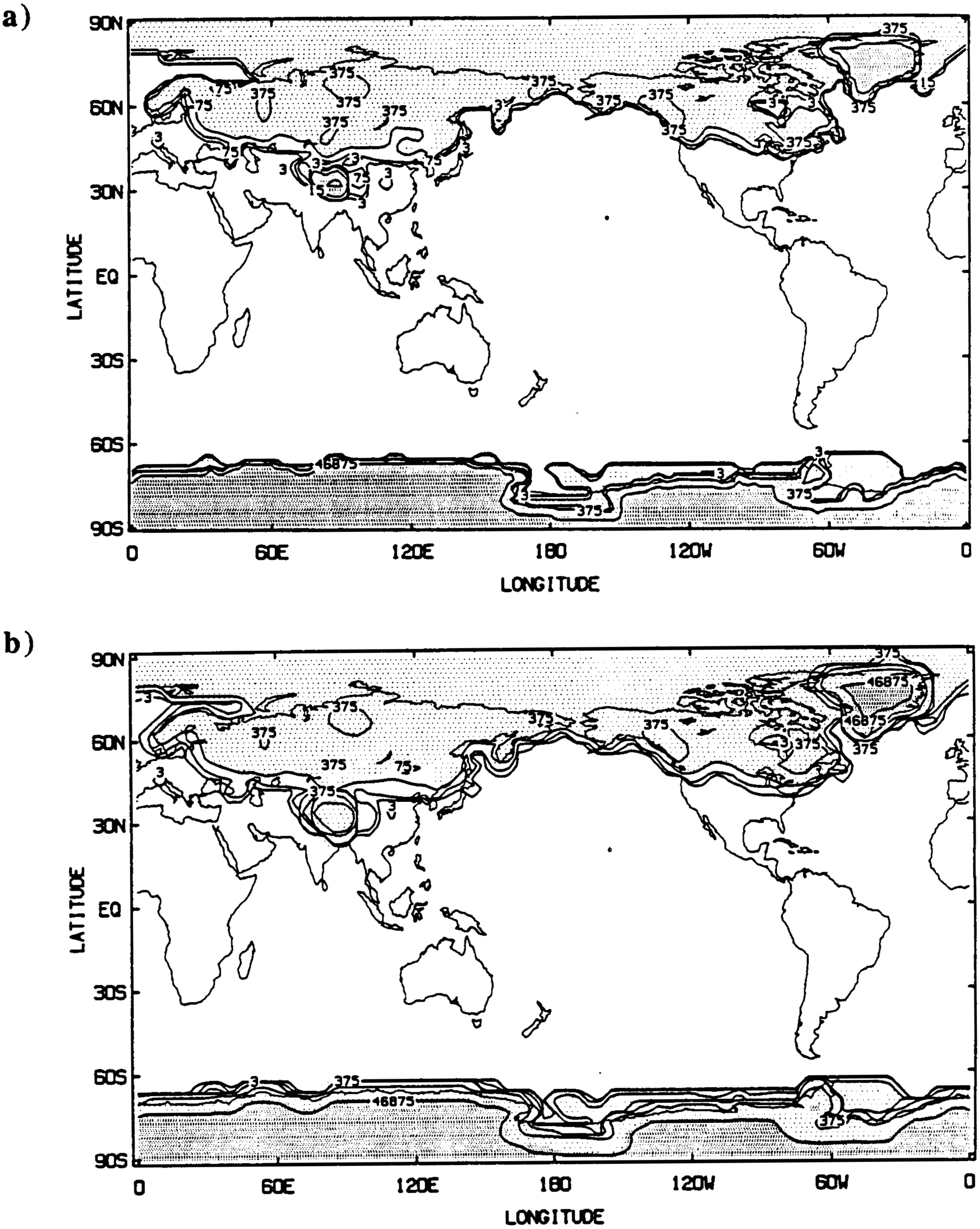


Fig. 10. Same as Fig. 8, except for snow depth. The nth contour is 3x5n . Units are mm. Values greater than 100 have light shading. Values greater than 40000 have heavy shading. Maximum value is 50000. See footnote to Table 1.

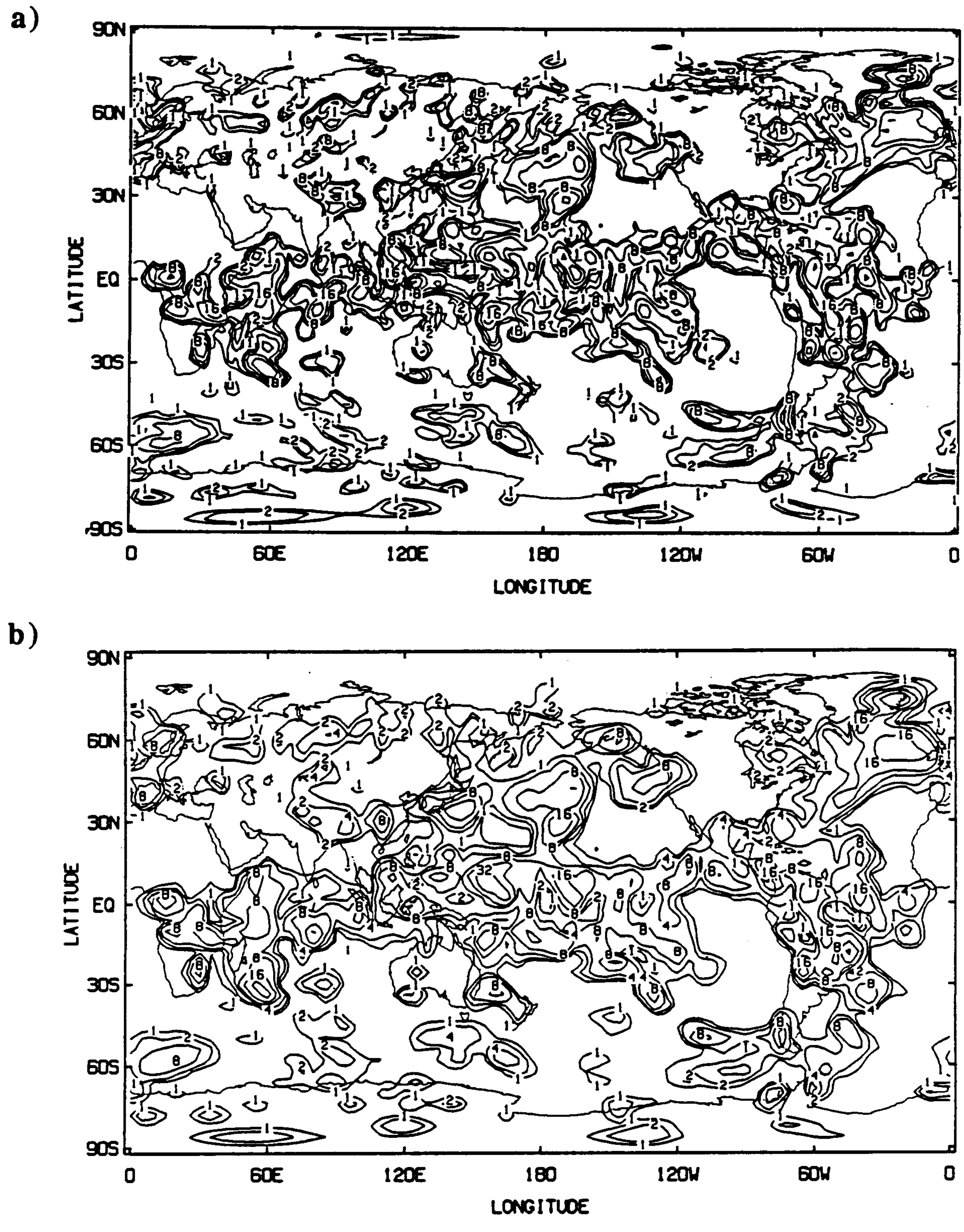
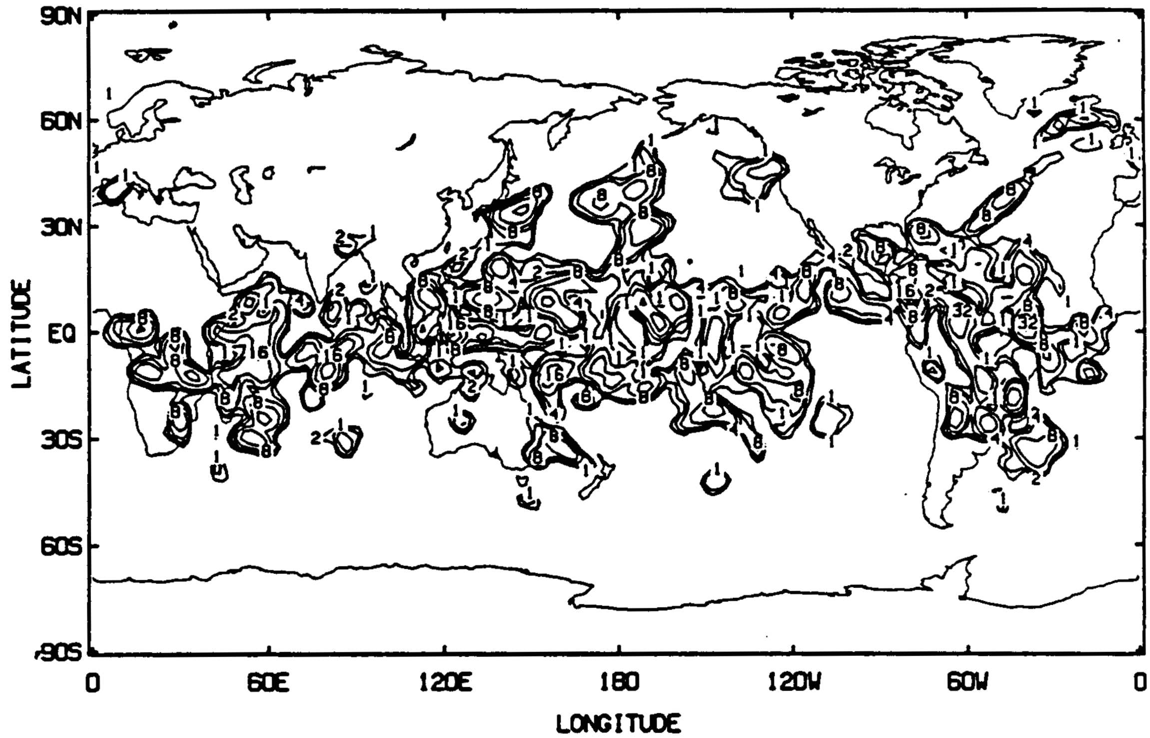


Fig. 11. Same as Fig. 8, except for total rainfall (24-hr accumulation). Contour intervals are 1,2,4,8,16,32, etc. mm .

a)



b)

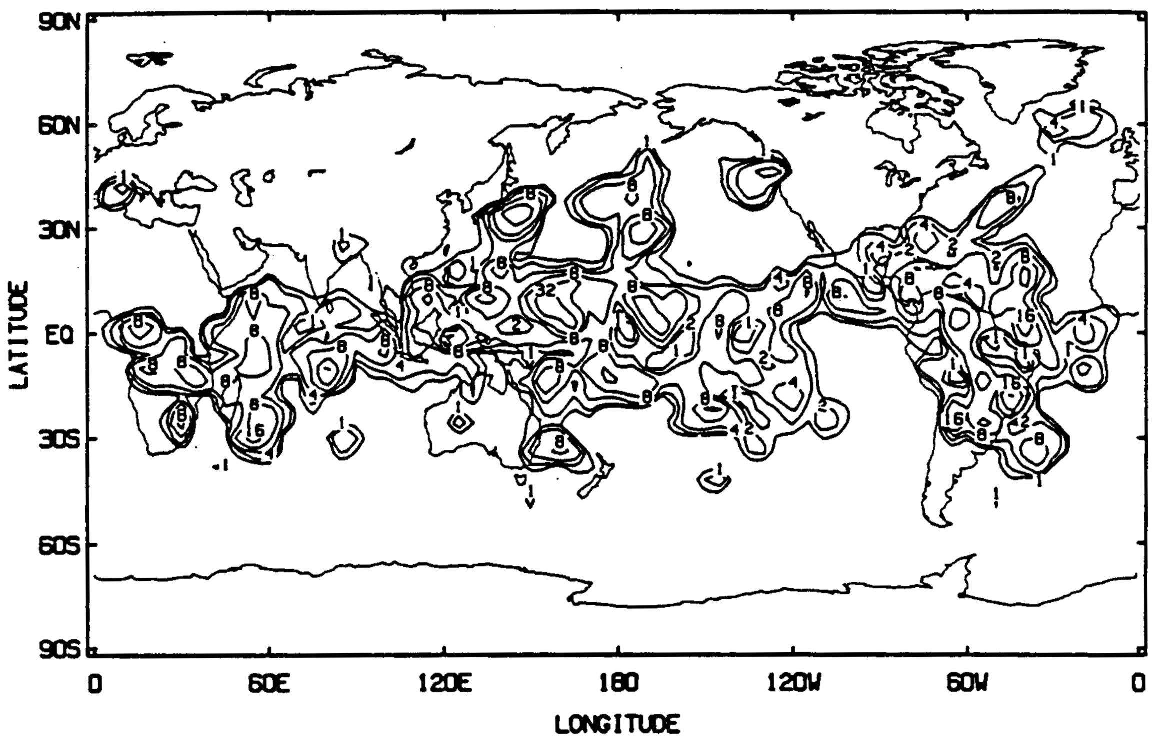


Fig. 12. Same as Fig. 8, except for convective rainfall (24-hr accumulation). Contour intervals are 1,2,4,8,16,32, etc. mm.

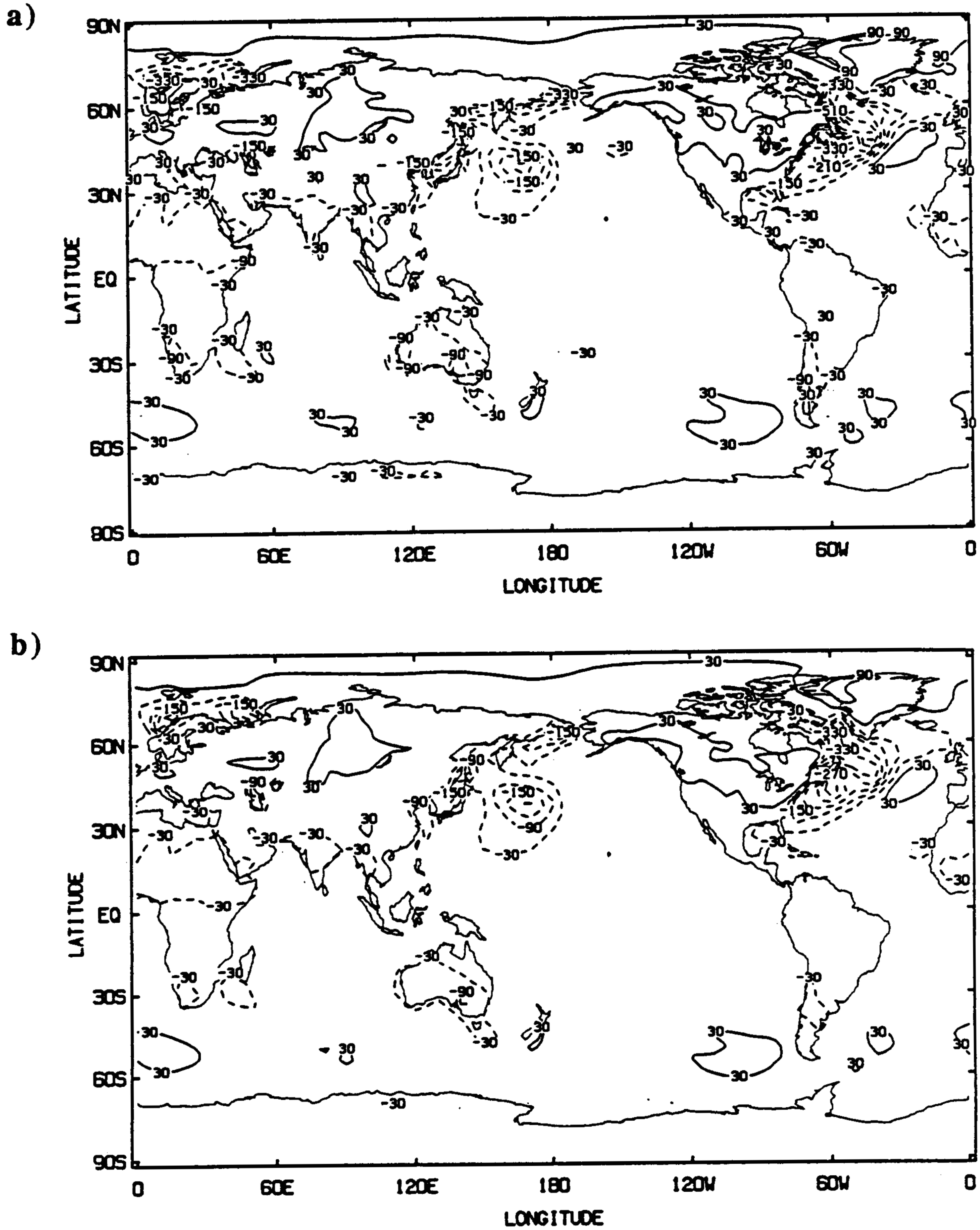


Fig. 13. as Fig. 8, except for surface sensible heat flux. Contour interval is 30 W/m^2.

a)

b)

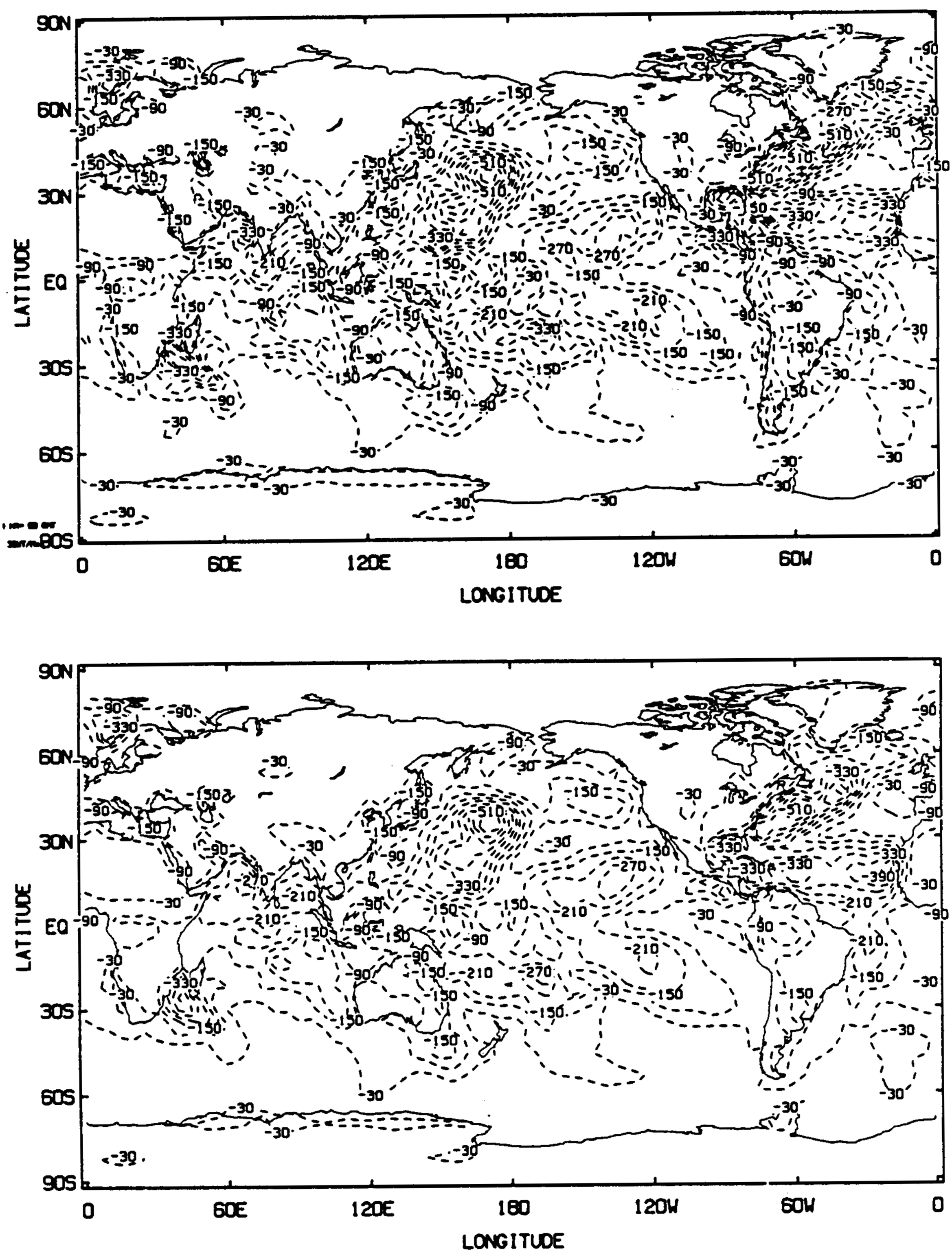
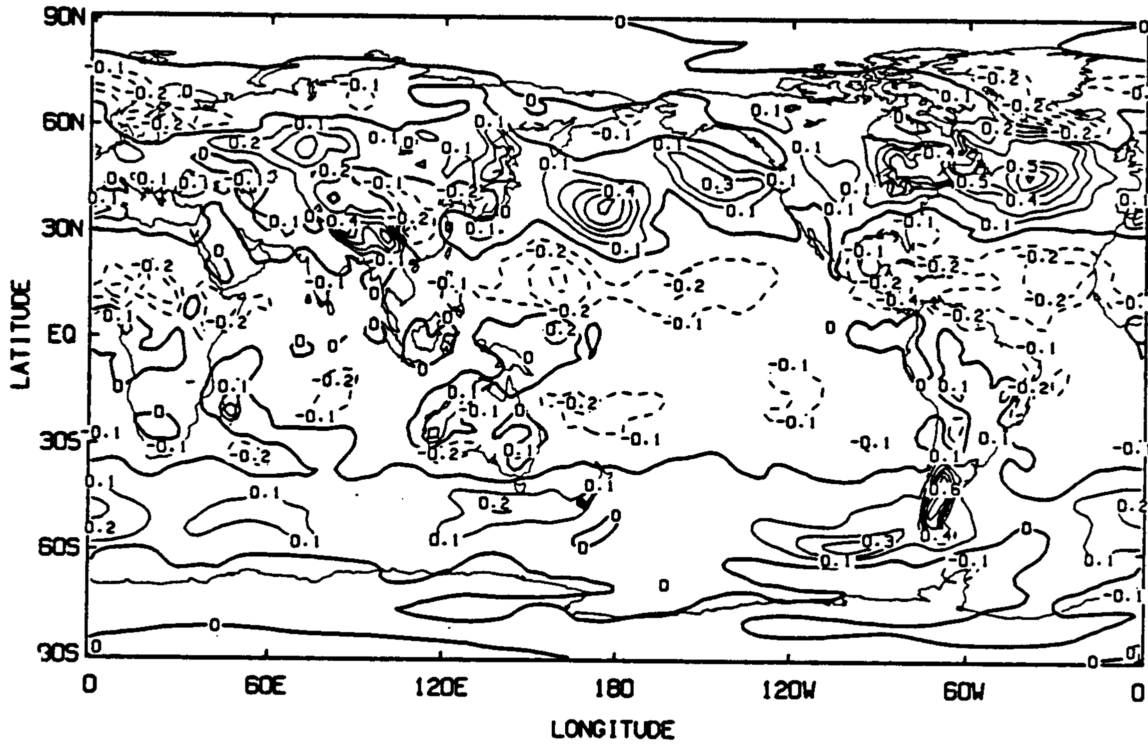


Fig. 14. Same as Fig. 8, except for surface latent heat flux. Contour interval is 30 W/m^2.

a)



b)

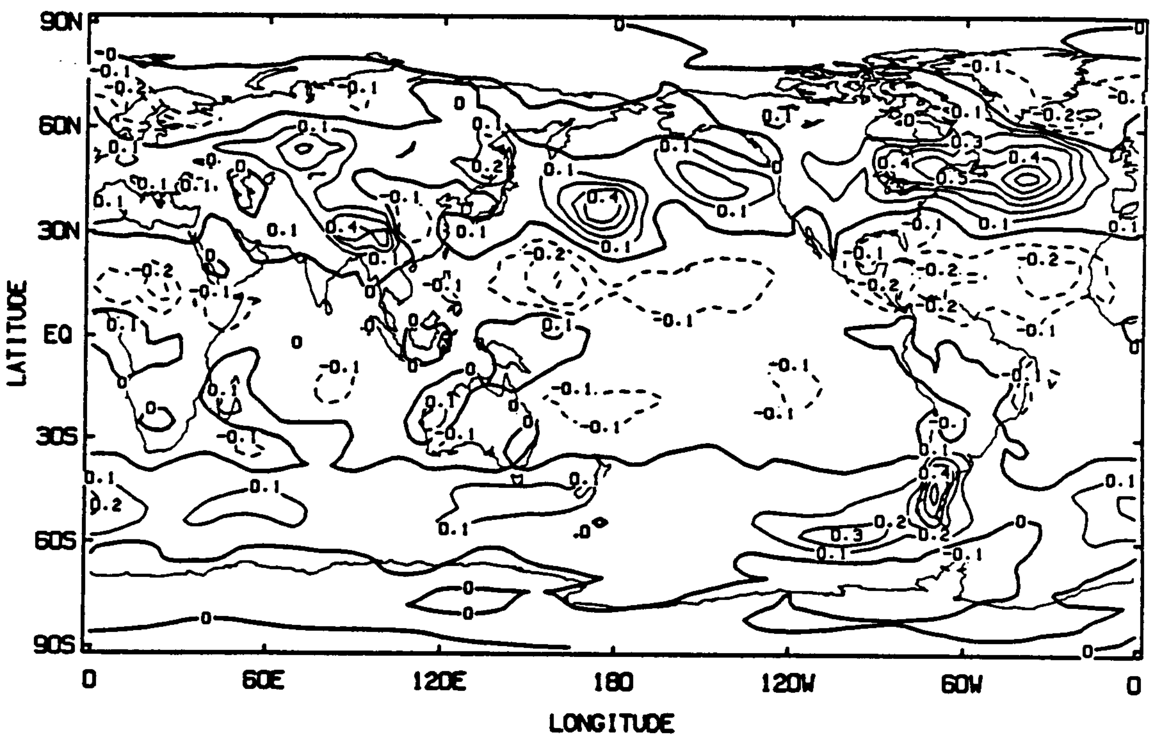


Fig. 15. Same as Fig. 8, except for surface u-stress. Contour interval is .1 N/m2.

a)

b)

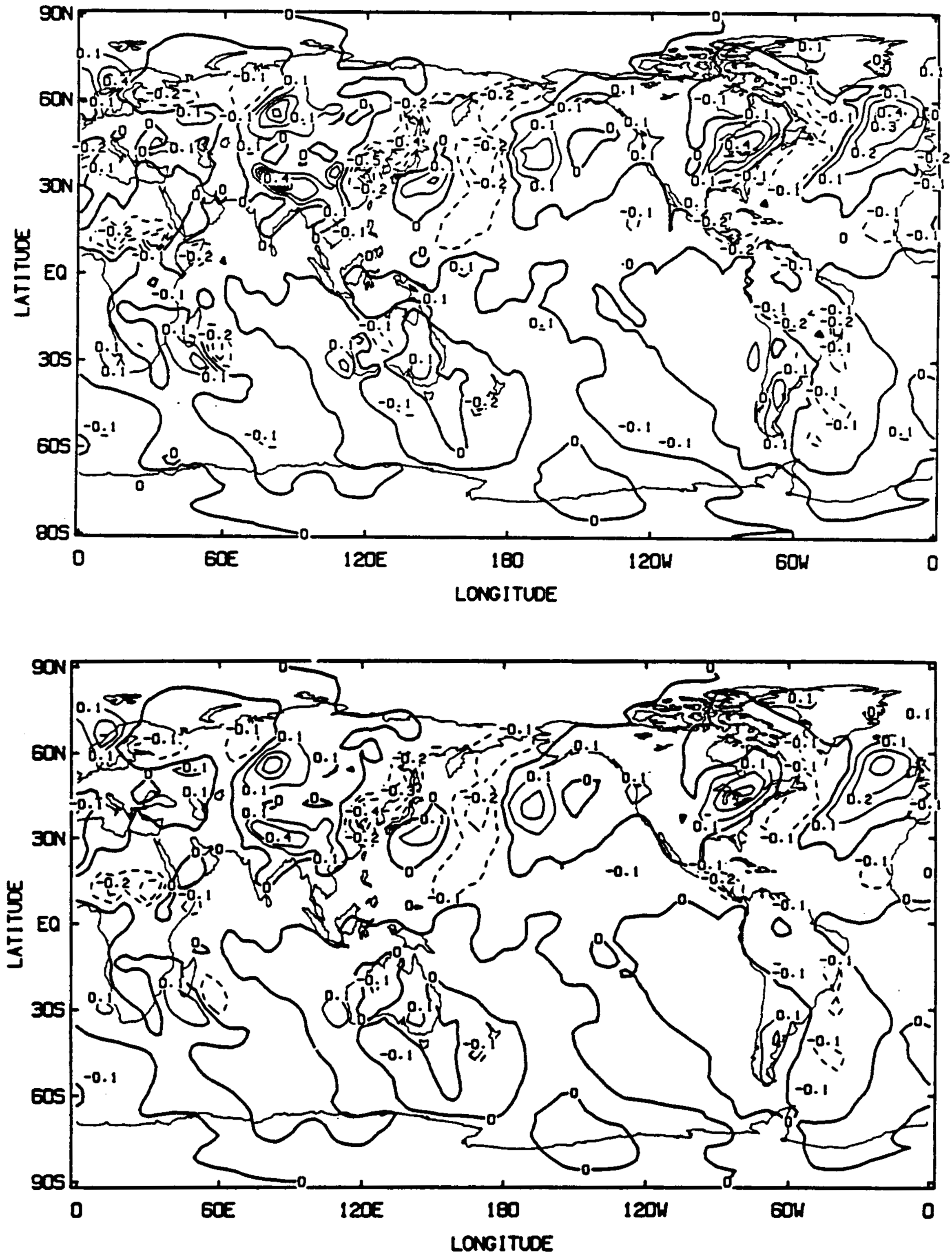


Fig. 16. Same as Fig. 8, except for surface v-stress. Contour interval is .1 N/m2.

NASA National Aeronautics and Space Administration

Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM-100727		

4. Title and Subtitle	5. Report Date
A Reduced Version of the NMC DERF II Data Set	March 1989
	6. Performing Organization Code 613
7. Author(s) Siegfried Schubert, Fong-Chiau Chang, William K. M. Lau, and Robert Kistler	8. Performing Organization Report No. 89B00097
	10. Work Unit No.
9. Performing Organization Name and Address NASA/Goddard Space Flight Center Greenbelt, Maryland 10771	11. Contract or Grant No.
	13. Type of Report and Period Covered NASA Technical Memorandum
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D. C. 20546	14. Sponsoring Agency Code

15. Supplementary Notes

S. Schubert, Goddard Space Flight Center, Greenbelt, Maryland;
F.-C. Chang, Applied Research Corporation, Landover, Maryland;
W. Lau, Goddard Space Flight Center, Greenbelt, Maryland;
R. Kistler, National Meterological Center, Washington, D. C.

16. Abstract

The NMC Dynamical Extended Range Forecast (DERF II) data represents a major computational effort to better ascertain the potential for extended range forecasts and to develop a strategy for performing operational extended range forecasts using dynamical models. A major stumbling block for using this data has been the sheer volume of data that must be processed to perform even simple calculations. The product of the data reduction described in this Technical Memorandum is a manageable data set that fits comfortably on five magnetic tapes or on one compact disc. The document outlines the data reduction process of the second phase of DERF data. It contains the description of the fields and the resolution of both the original and final fields. In order to assist the users of this data set, maps of selected fields, using both the original truncation at rhomboidal 30 and the truncation of the final data at triangular 20, are displayed.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Dynamical Extended Range Forecast NMC DERF II Data Dynamical Predictability Numerical Weather Prediction	Unclassified - Unlimited Subject Category 47

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of pages	22. Price
Unclassified	Unclassified	38	

NASA FORM 1626 OCT 86