10. A COMPARISON BETWEEN NOVEMBER 1969 SIRS-A AND JUNE 1970 SIRS-B DATA OVER THE SOUTHERN HEMISPHERE

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Temperatures and geopotentials at 1000, 850, 700, 500, 400, 300, 250, 200, 150 and 100 mb and at other levels to 10 mb derived from the NIMBUS 3 SIRS-A and NIMBUS 4 SIRS-B radiance measurements by the methods described by Smith *et al* (1970) were supplied to the Australian analysis team for use in the preparation of the GARP Basic Data Set analyses for November 1969 and June 1970 respectively. Each value was flagged as either A (good) or B (less reliable) quality, the quality test being: if high cloud (10% or more at pressures of or less than 500 mb) was computed for a sounding during its derivation, or if the sounding was polewards from latitude 65°S, temperatures at pressures greater than 250 mb and all geopotential heights was flagged as B quality; other values were flagged as A quality. About 55% of the November and 42% of the June soundings were flagged A.

In the Northern Hemisphere, use can be made of concurrent surface temperature analyses in the derivation of soundings; for the Southern Hemisphere, this essential parameter was not available and the climatological values of Taljaard *et al* (1969) were used. Because of this, soundings in November were confined mostly to ocean areas (and the Antarctic) to avoid the introduction of gross errors due to diurnal surface temperature variations (Woolf, 1970 personal communication) As will be shown, the restriction to non-continental areas was not strictly adhered to for the June soundings.

The SIRS data have been computer arrayed for another study as mean temperatures and heights for varying periods. The means were found over latitude/longitude blocks varying in size from 10° lat × 10° long between 10° S and 50°S to 5° lat × 40° long between 80°S and 85°S. The number of soundings used to find the mean in each block was also arrayed. From arrays of monthly means, the sounding density (expressed as their number per $(\text{km} \times 10^3)^2$) was computed for each block. The results are shown in Fig 10.1.

The November distribution (Fig 10.1(a)) shows that over most ocean regions there was a sounding density of 25 to 100 increasing to 100 to 200 over most longitudes between 50°S and the Antarctic coastline. The density decreased towards continental areas and over their interiors no soundings were recorded at all. By contrast, the June distribution (Fig 10.1(b)) shows a density of less than 50 over all regions north of about latitude 60°S. The density increased polewards from there to exceed 100 over most of the Antarctic. Although a slight decrease was apparent over parts of the continents, the only region of zero density was that south of latitude 85°S.

The number of soundings for each month in each latitudinal belt is shown in Fig 10.2 as a fraction of the total number of soundings for that month; the percentage of the total area contained within each latitude belt is also shown. Both months show disproportionate sounding concentrations in some latitudinal belts and, in spite of the facility for lateral as well as vertical sampling by SIRS-B, this disproportion was usually more pronounced in the June data. For example, the latitudinal belt 10°S to 40°S occupies almost 57% of the total area between 10°S and 85°S; 39% of the November SIRS soundings were contained within this belt but only 30% of June's were within it whilst in the polar belt, 70°S to 85°S, which contains less than 7% of the total area, less than 5% of November's soundings but more than 28% of June's were concentrated. In the intermediate belt (40°S to 70°S containing 36% of the total area) the November sounding concentration (56%) showed a greater imbalance than June's (41%).

Because of the strict time limitations imposed for the completion of each series of the Basic Data Set analyses, a full investigation of the SIRS data accuracy could not be attempted at the time they were received. However, after a preliminary evaluation of the November data by Phillpot *et al* (1971) at the main levels of interest using a small sample of pairs of SIRS and conventional soundings (SONDE) close in both time and space, it was decided that most weight would be given to good 1000-500 and

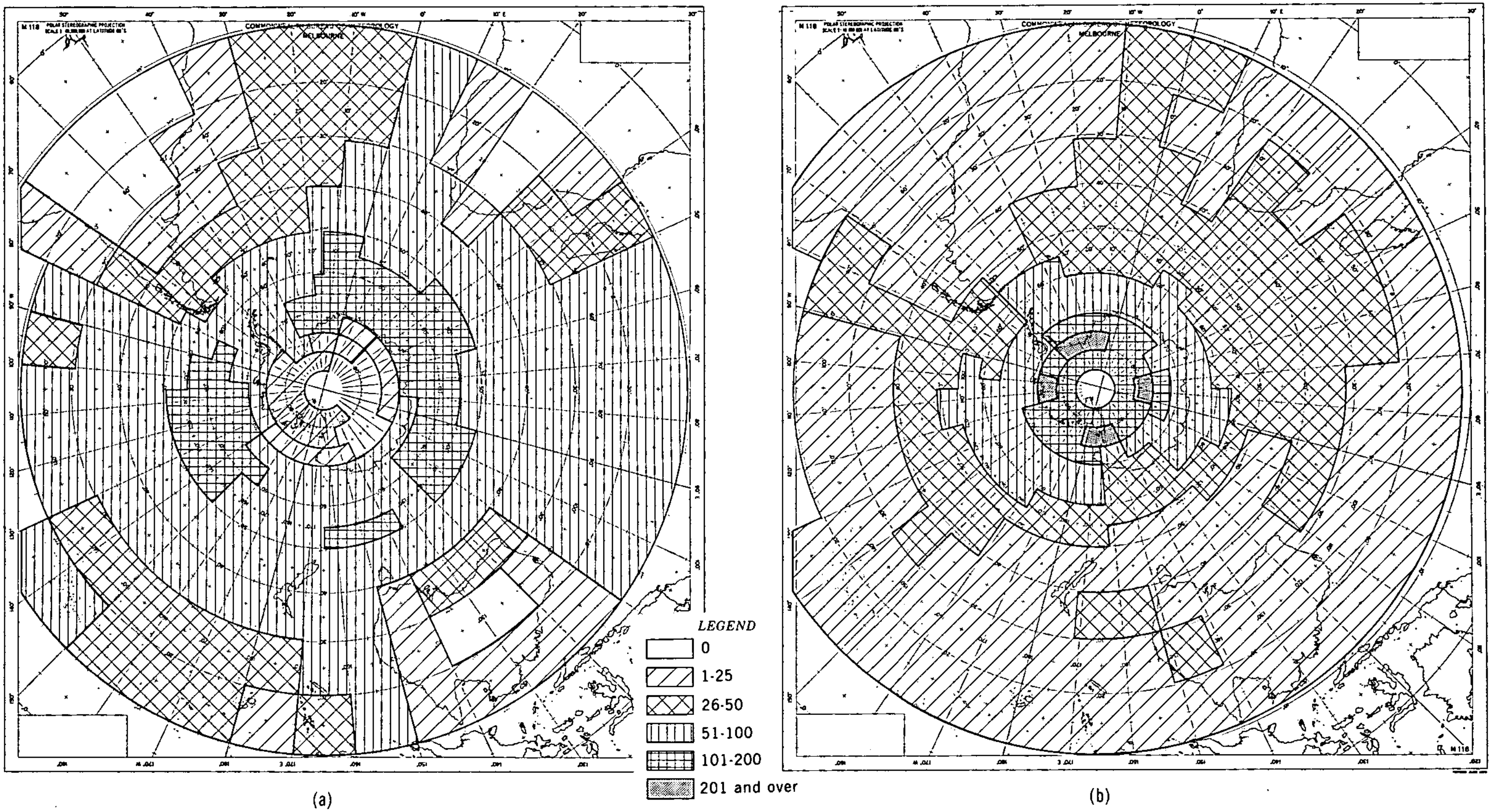

Fig 10.1 SIRS sounding densities for (a) November 1969 and (b) June 1970.
Units: number of soundings $(km \times 10^3)^{-2}$

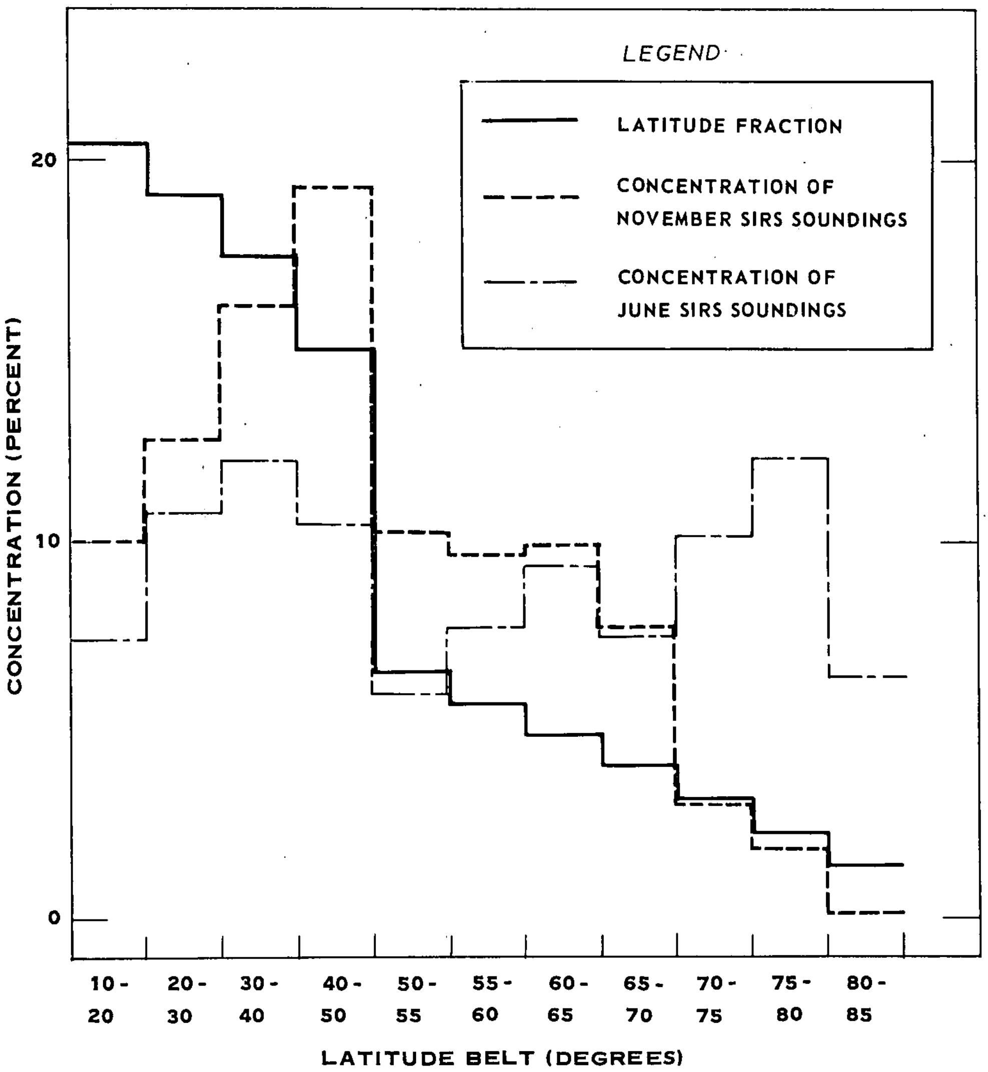

Fig 10.2 SIRS sounding concentrations within latitudinal belts for November 1969 and June 1970. The concentrations are expressed as a percentage of the total number of soundings in each month. Also shown is the percentage of the total area contained within each belt.

500-200 mb thickness values and to all 500 mb and 200 mb temperatures. In a similar assessment of the June data, Lamond *et al* (1972) concluded that, although they appeared less reliable than those for November, they would be of positive value as an analysis aid and that most reliance should be placed on the same parameters. Larger samples of comparison pairs of soundings have subsequently been selected and the differences between soundings are discussed here.

Hayden (1971) in a similar study comparing SIRS and SONDE height profiles over the Northern Hemisphere, considered a SIRS sounding eligible for verification only if at least three SONDEs with reported geopotentials *and winds* were located within 1.5 grid lengths (about 580 km at 60°N) of the SIRS report. The maximum time difference accepted between reports is not specified; however it would rarely exceed 6 hours in the Northern Hemisphere. The observed winds were then used to geostrophically extrapolate the observed heights to the SIRS location. The limited SONDE and wind observing network over most of the Southern Hemisphere precluded the use of such a sophisticated technique here; instead, it was decided to use simple time and space criteria to select sounding pairs for comparison; *ie,* if a SIRS was within a certain radius of a SONDE and the times of the two observations were within a selected interval, the two soundings would become a pair for comparison purposes.

The specification of these criteria was difficult: if they were made large, differences between comparison pairs would be inevitable in strong gradient regions; if they were reduced to minimise this possible error source however, too small a sample would result.

The SONDE data readily available for this study were the Southern Hemisphere upper air data files compiled by WMC Washington for November and WMC Melbourne for June. The SIRS data comprised about 14,000 soundings for November and 7,500 soundings for June. The number of sounding pairs between latitudes 10°S and 90°S selected from each month's data sets using various space and time criteria are shown in Table 10.1; they range from six November and four June pairs within one hour and 100 km to 1105 November and 648 June pairs within six hours and 500 km. In view of these results, criteria of three hours and 300 km were selected as the best compromise between the conflicting requirements mentioned above giving two sets of 319 November and 148 June matching pairs. These tolerances are less than satisfactory and large, non-real differences within some pairs are inevitable; but the results of this comparison should give a meaningful guide to the usefulness of the Southern Hemisphere SIRS data included in the Basic Data Set and the relative accuracies of the June and November data.

The number of pairs of temperature and geopotential values at each of the levels from 1000 to 100 mb thickness values for the layers 1000-700, 1000-500, 500-300, 500-200, 300-200, 200-150 and 150-100 mb (a thickness value was rated A quality only if the two geopotential heights used in its computation were flagged A) are shown in Table 10.2. Each pair has been labelled as A or B quality depending on the quality mark of its SIRS value. Because relatively few of the conventional data extended above 100 mb, quantitative comparisons of soundings beyond that level were not attempted for this study.

Although SONDE observations included in the upper air data files had been carefully checked during the analysis phases of the Basic Data Set project, to ensure that as high quality data as possible were used for this study, all soundings selected for comparison with SIRS data were plotted, carefully examined and as many remaining errors as possible corrected. A common error source stemmed from incorrect coding resulting in obviously positive temperatures being assigned negative values and *vice versa.* The few erroneous data which could not be corrected were excluded from subsequent comparisons. The means and standard deviation of the differences (SIRS value - SONDE value) between pair values at each level and layer were then computed. For comparison purposes, those for the thickness layers were normalised by division by the appropriate pressure thickness and expressed in cm mb^{-1}.

Table 10.1 Number of matching pairs of SIRS/SONDE soundings selected from November 1969 and June 1970 data using various time and space critera

Time	November 1969				June 1970			
difference (hr)	1	2	3	6	1	2	3	6
Radius (km)								
100	6	16	28	50	4	13	16	32
200	52	86	143	226	9	43	64	127
300	137	211	319	485	38	104	148	269
400	216	362	543	810	68	164	245	447
500	313	536	789	1105	115	253	367	648

Table 10.2 Number of temperature, geopotential and thickness SIRS/SONDE pairs selected from November 1969 and June 1970 data using criteria of 3 hr and 300 km

	1000	850	700	500	400	300	250	200	150	100	
November 1969	172	190	190	187	188	184	144	180	169	154	A quality geopotential
	110	111	111	111	98	106	95	106	95	93	B quality geopotential
	282	301	301	298	286	290	239	286	264	247	total
	158	200	198	195	193	186	245	277	275	254	A quality temperature
	73	114	111	112	106	106	0	0	0	0	B quality temperature
	231	314	309	307	299	292	245	277	275	254	total
June 1970	71	82	79	75	69	74	59	70	62	56	A quality geopotential
	51	54	53	50	48	49	45	48	41	32	B quality geopotential
	122	136	132	125	117	123	104	118	103	88	total
	66	84	80	74	71	74	104	115	106	92	A quality temperature
	31	55	54	50	50	51	0	0	0	0	B quality temperature
	97	139	134	124	121	125	104	115	106	92	total
	1000 -700	1000 -500	500 -300	500 -200	300 -200	200 -150	150 -100				
November 1969	172	169	182	175	175	169	149				A quality thickness
	105	105	106	105	105	95	88				B quality thickness
	277	274	288	280	280	264	237				total
June 1970	65	63	74	67	67	62	53				A quality thickness
	48	46	48	45	45	41	29				B quality thickness
	113	109	122	112	112	103	82				total

The various results are summarised in Table 10.3 and Fig 10.3; values in the latter are joined for clarity only, and statistics of levels and for layers intermediate to those listed in the table cannot necessarily be obtained from the figure. For example, the mean A and B quality temperature difference "profiles" for November 1969 drawn in Fig 10.3(a) imply that, on average the "mean" SIRS temperature through the layer 1000-700 mb exceeds the corresponding SONDE mean temperature. However, the mean thickness differences in Fig 10.3(c) imply a lower SIRS mean temperature on average for this layer than the SONDE mean temperature. It could be concluded from these and similar "conflicts", that the regression equations used in deriving the heights from which the thicknesses were computed tended to give a biased result. However, any biases appear to be relatively small and there is no evidence to suggest that soundings in either set were not hydrostatically consistent.

The statistics of the temperature differences are shown in Fig 10.3(a). November means were generally small and positive (*ie*, on the average, SIRS values were greater than SONDE values) for both A and B quality ranging from +1.4°C at 850 mb to -0.2°C at 300 mb; the A quality standard deviations were about 2 to 3°C and the B quality 3 to 4°C. The June mean differences were in general greater, ranging from -1.8°C at 300 mb to +2.8°C at 100 mb for A quality and from +0.3°C at 850 mb to +2.0°C at 400 mb for B quality whilst the A quality standard deviations were about 3 to 4°C below 300 mb and 4 to 5°C above and the B quality about 4°C. For both months, the least variable differences occurred around 500 mb. In spite of the use of climatological values at the surface, the RMS differences in 1000 mb temperatures were little different from those at other levels; this may be a consequence of the comparative rarity of large departures from normal of near surface temperatures over ocean areas.

The means and standard deviations of the height differences are shown in Fig 10.3(b). In both months, the A quality mean differences were negative (except at 100 mb in November) *ie*, on the average, the SIRS value was less than the SONDE value. Values range from -16 m at 1000 mb to +1 m at 100 mb in November and from -11 m at 400 mb to -59 m at 150 mb in June. Their standard deviations showed a general increase with height and were about 60 m at levels below 400 mb in both months; at lower pressures, the November values ranged up to 91 m at 100 mb but those for June were over 100 m at 200 mb and reached 124 m at 150 and 100 mb.

Suprisingly perhaps, the mean differences between B quality heights were all positive (indicating that, in the mean the SIRS values were greater than the SONDE values). Those for November were mostly less than 10 m but the June values increased rapidly from 2 m at 1000 mb to over 40 m at all levels above 400 mb except 150 mb. Their standard deviations were mostly about 20 to 40 m about the corresponding A quality values.

The statistics of the layer thickness differences are plotted in Fig 10.3(c) at the mid-point of each layer. The November means, both A and B quality were mostly negative and less than 10 cm mb^{-1}; however, the June values were often larger ranging up to 56 cm mb^{-1} for A quality and 36 cm mb^{-1} for B quality over the layer 150 to 100 mb. Standard deviations were about 10 to 20 cm mb^{-1} for both qualities and months for the layers 1000-700, 1000-500, 500-300 and 500-200 mb; they increased to around 60 cm mb^{-1} in November and 100 cm mb^{-1} in June for the 150 to 100 mb layer.

It would appear from Fig 10.3 that A quality data were superior to corresponding B quality data at many levels and layers; as well, the November data appeared overall to be better than those of the same quality for June. The levels of significance under the F test of differences between various data samples as shown in Table 10.4 confirm these impressions. Differences between November A and November B quality data were significant at the 5% level or less in 18 cases out of a total of 23; between June A and June B data in 10 cases out of 23; between November A and June A data in 18 cases out of 27 and between November B and June B in 8 cases out of 23. In each of these, the A or November variance was less than that of the B or June data respectively.

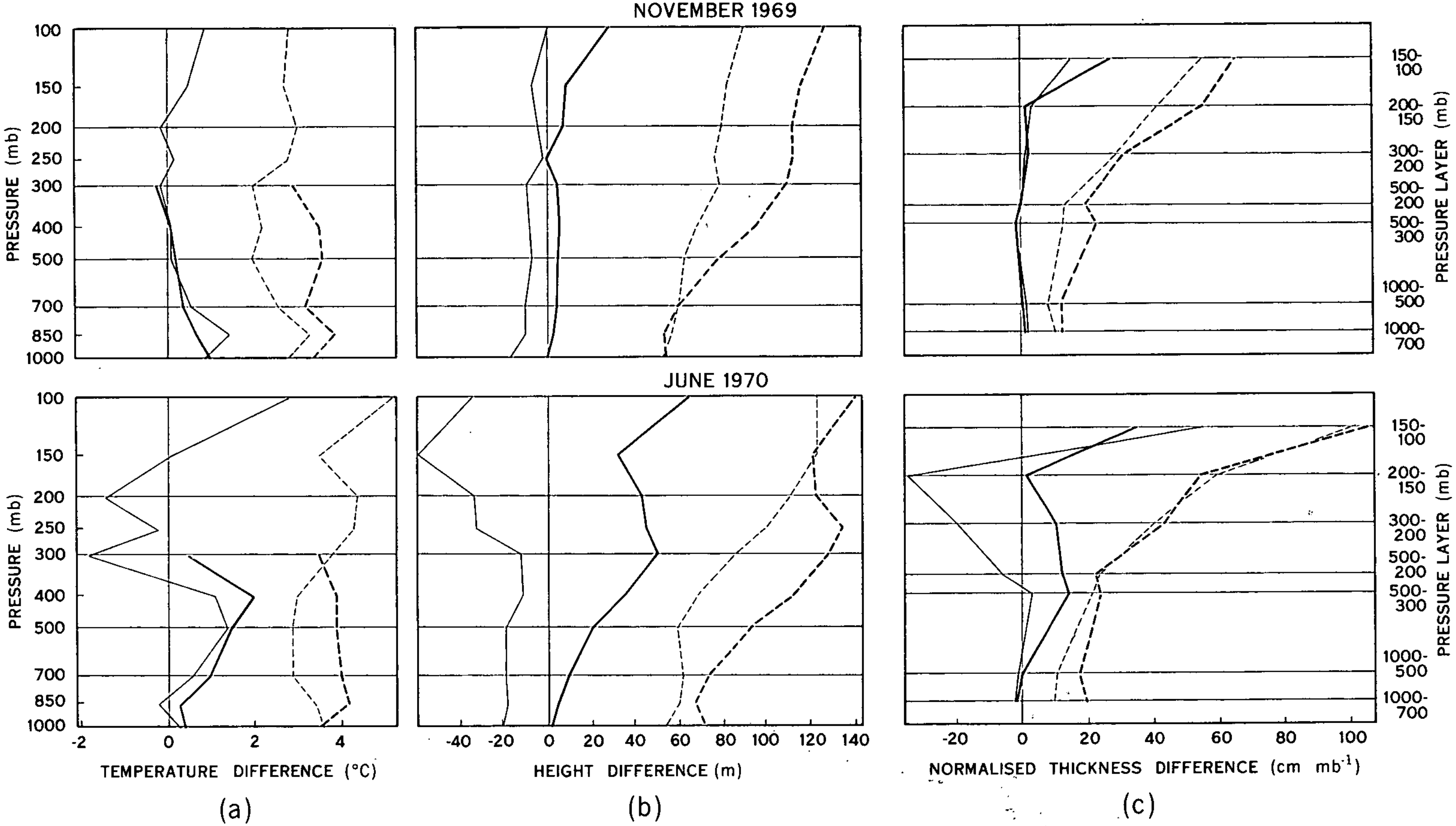

Fig 10.3 Means and standard deviations for November 1969 and June 1970. Thickness statistics have been normalised by division of the layer pressure thickness.

a) SIRS temperature - SONDE temperature
b) SIRS height - SONDE height
c) SIRS thickness - SONDE thickness

Table 10.3 Statistics of (SIRS value-SONDE value) for November 1969 and June 1970 given under each heading as MEAN/STANDARD deviation. Normalised values are shown for thicknesses

	TEMPERATURE ($^{o}C \times 10^{-1}$)				HEIGHT (m)			
	November 1969		June 1970		November 1969		June 1970	
	A	B	A	B	A	B	A	B
1000	9/28	10/34	3/36	4/35	-16/54	1/55	-20/55	2/73
850	14/33	7/39	- 2/34	3/42	- 9/57	4/55	-18/61	5/68
700	6/26	4/32	6/29	10/40	- 9/61	5/61	-19/62	10/74
500	1/20	2/36	-14/29	15/39	- 6/64	6/80	-19/60	21/94
400	1/22	1/35	11/30	20/39	- 7/70	7/97	-11/70	36/113
300	-1/20	-2/29	-18/38	5/35	- 8/80	5/111	-12/87	51/130
250	2/28		- 2/43		- 1/78	1/113	-32/101	46/136
200	-1/30		-14/44		- 3/81	8/113	-33/112	44/124
150	5/27		1/35		- 6/83	10/118	-59/124	33/123
100	9/28		28/52		+ 1/91	29/128	-34/124	65/142

	THICKNESS (cm mb^{-1})			
	November 1969		June 1970	
	A	B	A	B
1000-700	2.6/11.0	1.7/13.0	- 1.7/10.3	- 1.3/20.0
1000-500	2.2/ 8.6	1.2/13.0	- 0.2/11.2	0.2/18.0
500-300	- 0.5/13.5	- 0.5/23.5	- 3.5/22.0	15.0/24.5
500-200	0.7/14.0	0.3/20.3	- 5.0/24.0	13.0/23.0
300-200	2.0/30.0	3.0/32.0	-19.0/41.0	11.0/44.0
200-150	4.0/42.0	2.0/56.0	-34.0/60.0	2.0/55.0
150-100	16.0/56.0	28.0/66.0	+56.0/102.0	36.0/106.0

Table 10.4 Percentage level of significance under the F test of differences between A and B quality data and November and June data;
column 1: geopotential height;
column 2: temperature;
column 3: thickness;

	November A vs November B		June A vs June B		November A vs June A		November B vs June B	
	1	2	1	2	1	2	1	2
1000	*	5	2.5	*	*	2.5	2.5	*
850	*	10	*	10	*	*	5	*
700	*	5	10	2.5	*	10	10	5
500	2.5	1	1	2.5	*	1	10	*
400	1	1	1	5	*	1	10	*
300	1	1	1	*	*	1	10	5
250	1		5		1	1	10	
200	1		*		1	1	*	
150	1		*		1	1	*	
100	1		*		1	1	*	

	3	3	3	3
1000-700	5	1	*	1
1000-500	1	1	1	1
500-300	1	*	1	*
500-200	1	*	1	*
300-200	*	*	1	1
200-150	1	*	1	*
150-100	5	*	1	1

* Indicates a level greater than 10%

Table 10.5 RMS deviations of (SIRS-SONDE) heights, temperatures and thicknesses; column 1: as found by Phillpot *et al* (1971) for November 1969; columns 2 and 3: values for this study for November 1969 and June 1970 respectively

	A quality			A and B quality combined		
	1	2	3	1	2	3
Geopotential (m)						
1000 mb	65	54	55	75	55	64
500 mb	74	64	60	88	71	78
200 mb	83	81	112	102	94	123
1000-500 mb	39	43	56	51	53	72
500-200 mb	42	41	73	75	50	76
Temperature (^{o}C)						
500 mb	2.3	2.0	2.9	2.8	2.7	3.4
200 mb	4.3	3.0	4.4	4.3	3.0	4.4

The deviations computed by Phillpot *et al* (1971) using a small sample of November SIRS data are confirmed by the results presented here. The two sets of results are shown in Table 10.5 together with the June statistics from this study. The latter, as well as the more general results discussed above, support the assessment of Lamond *et al* (1972) of the relative accuracy of the November and June data.

Data coverage from future SIRS type instruments combined with reliable prognostic first guess fields will no doubt be sufficient to allow the direct analysis of constant pressure data. However the users of the data set under discussion here would wise to derive the constant pressure analyses *via* differential analysis. The decision of the Melbourne analysis team to use this approach utilising the SIRS layer thicknesses together with techniques such as those described by Zillman and Price (1972) and Lamond *et al* (1972) for the estimation of thickness values over data void ocean regions doubtless resulted in a superior final product.

In summary, the user of the Southern Hemisphere SIRS data included in the GARP Basic Data Set should

- place greater reliance on November data than those of June of the same quality;
- place greater reliance on A quality than B quality data within either period and
- if geopotential data are essential, derive the topography of constant pressure surfaces *via* differential techniques using SIRS layer thicknesses and (satellite-derived) pseudo observations in preference to the direct analysis of the geopotential data.

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