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"Comparison of 50 mb SIRS heights with heights from a 50 mb chart series prepared by the Stratospheric Analysis Group in the High Atmosphere Branch"

N R Watson and V Bailey

1. Introduction

During recent years, soundings of the vertical temperature profile of the atmosphere deduced from measurements made by radiometers on satellites have become available. In particular the radiances measured by the Vertical Temperature Profile Radiometers (VTPR) on board the NOAA series of spacecraft are used to produce the "SIRS" soundings which are received regularly by the Met Office (Mc Millin et al 1973).

This memorandum reports some results obtained from a comparison of the 50 mb heights obtained from SIRS soundings and the 50 mb heights from a chart series, which utilise radio sonde data alone, prepared by the Stratospheric Analysis Group in the High Atmosphere Branch.

2. Methods of comparison

Since April 1974, the Stratospheric Analysis Group have been drawing daily hemispheric 00Z charts at 50 mb using radiosonde data alone. The ascents are corrected for known differences between sonde systems and great emphasis is placed on the continuity of flow patterns to produce a series of charts which represent the best available analyses of the 50 mb level.

The radio sonde network is mainly over land with occasional island stations or weather ships in the oceanic areas. The SIRS soundings however are always made over the sea, and because the NOAA spacecraft are in sun-synchronous orbits, the soundings made over a given area occur approximately at the same time each day. Any comparison between 50 mb SIRS and "sonde" heights must be made near 00Z each day to eliminate any synoptic changes. Therefore only SIRS sounding within ± 3 hours of 00Z were used in the comparisons and this meant that the comparison areas were restricted to the Atlantic and to the western Pacific off Japan.

The SIRS soundings are received as the heights of the standard levels above 1000 mb. The 1000-50 mb thicknesses were therefore plotted on the appropriate 00Z surface chart to find the 1000 mb height and simple addition gave the SIRS 50 mb height. These were then compared with the analysed chart (or "sonde") heights.

For the 48 occasions when comparisons were made in the 12 months ending May 1975, the average number of SIRS-'sonde' differences per day was about 45 with a minimum of 8 and maximum of 85. For the period 3-10 March 1975, comparisons were made daily.

This method of comparison differs from that used by May (1975) who used "colocated" SIRS soundings and sonde ascents - the ascents being as received at Bracknell without corrections or analysis.

Results

The mean SIRS-'sonde' height difference for each of the 48 days is shown in figure 1. Of interest is the variation throughout the year especially the minima in early December 1974 and the maxima from January to March 1975. This could not be explained by any meteorological factor, but when the variability is examined in conjunction with the VTPR instrument in use at the time, (shown in the bottom of the figure) a close correlation can be seen between change in instrument and gross change in the difference. This is most marked when instrument 2 on NOAA 3 replaced instrument 1 in mid December 1974. The change is about 25 dm, which corresponds to a 3°C temperature difference in the 1000-50 mb layer.

May had found a strong latitudinal variation in his SIRS-sonde differences, so the present data were checked and a similar variation was found. A check was made to see if there was any difference in the latitude variation between comparisons made in the Atlantic or Pacific areas. No statistically significant difference was found so the comparisons from both areas were combined. The mean height differences for 10° latitude bands from 20° to 70°N are shown in table 1 (together with the number of observations and the standard error of the mean) and are also plotted in figure 2. The annual mean difference is about 10 dm at low latitudes, becomes equal to zero about 60°N and has a slope of about -0.3 dm deg^{-1}. This latitude variation could lead to erroneous conclusions regarding day to day changes in the height difference, if the mean latitude of the day's comparisons changes from one day to the next. In figure 1 the mean height differences are plotted for the 40-50°N latitude band only, and like the mean difference they vary in sympathy with the VTPR instrument in use, so confirming the reality of changes with instrument.

The latitudinal variation for the year is a mean over all the instruments used. For the 8 day period 3-10 March 1975, when instrument 2 on NOAA 3 was operational daily comparisons were carried out and a latitudinal variation of about -0.45 dm deg^{-1} was found with a difference increased to 23 dm between 20 to 30°N. (see figure 2)

The daily mean differences during the 8 days are shown in figure 3 together with the standard error of the mean. The average daily change during this limited period is about 1½ dm, although it might contain latitude variations.

Finally the 8 day mean differences were subtracted from the daily differences and the mean residual differences for each latitude band and day were plotted in figure 4. As can be seen the day to day changes in the residuals are very variable ranging from +6 to -11 dm. Also shown in figure 4 is the residual difference meaned over all latitudes. The mean day to day difference change was about 1½ dm with a maximum change of -5 dm between 3 and 4 March.

Conclusions

The results show that compared with the 50 mb heights from the chart series, the 50 mb SIRS heights show a marked variation with latitude for a given operational VTPR and that considerable differences occur when the instruments in the spacecraft are changed. The latitudinal variation is such that the SIRS sounding give greater heights at low latitudes, so that an analysis of purely SIRS data would produce a wind field with a greater westerly component at 50 mb (of order 10-15 kt at mid latitudes) than an analysed chart using radio sonde data. The height difference variation with latitude of -0.3 dm deg^{-1} is in good agreement with May (1975) who showed that for the period 2-16 October 1973, the 1000-100 mb thickness difference changed by about -0.17 dm deg^{-1} while the 1000-30 mb thickness changed by about -0.47 dm deg^{-1}.

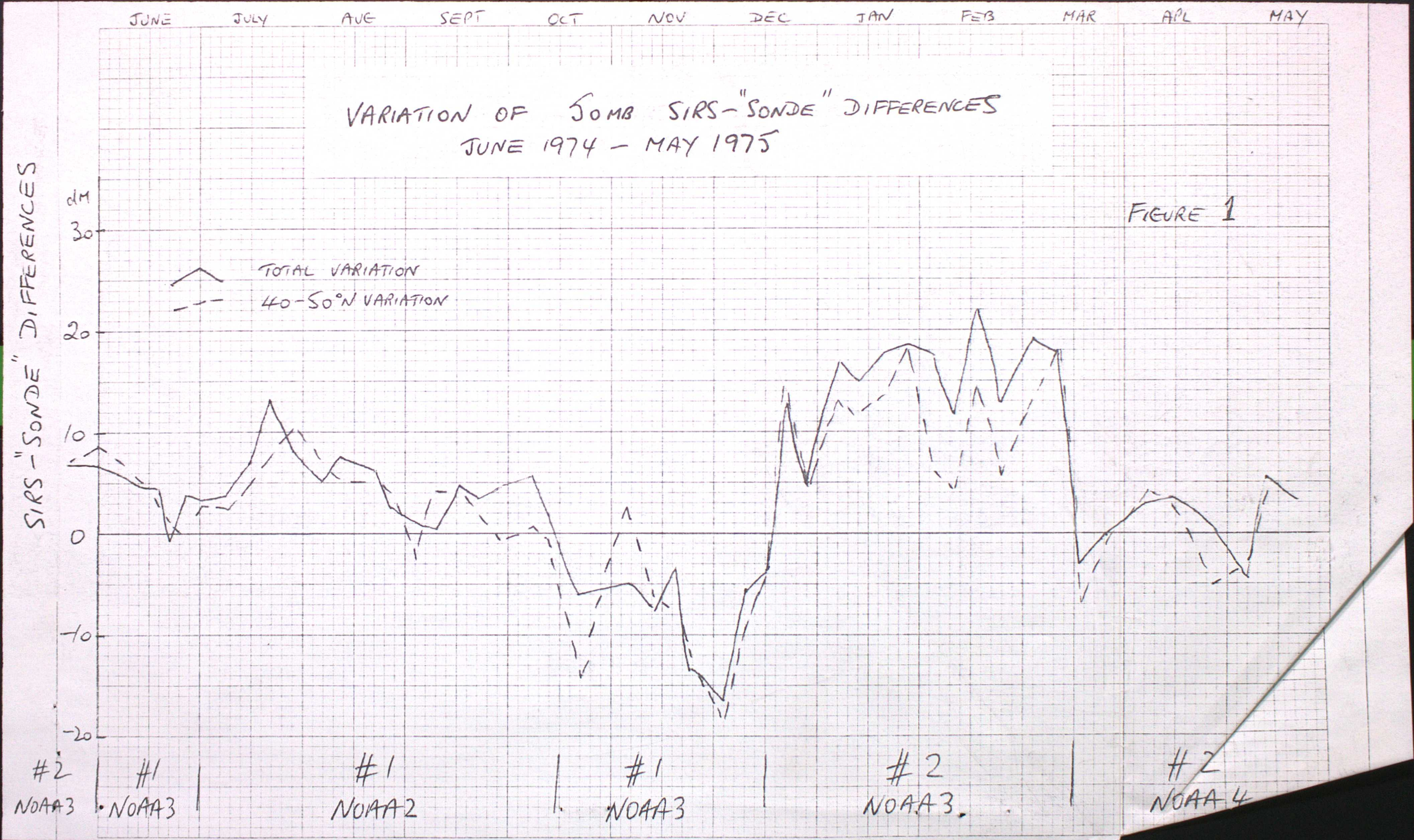
Although some variance is caused by errors in the 50 mb analysed field, the surface chart used and asynoptic data, there remains considerable variability in the day to day errors which must cause concern to anyone dealing with the operational use of SIRS. The use of a long period mean would be of little use for correction purposes and even the latest available short period mean still leaves a day to day variation with a standard deviation of about 3-4 dm within each latitude band. Further, whenever an instrument is changed in space, it is suggested that 2 to 3 weeks are required before the characteristics of the instrument are known. In that time the interpretation of 'operational' SIRS must be regarded as extremely hazardous.

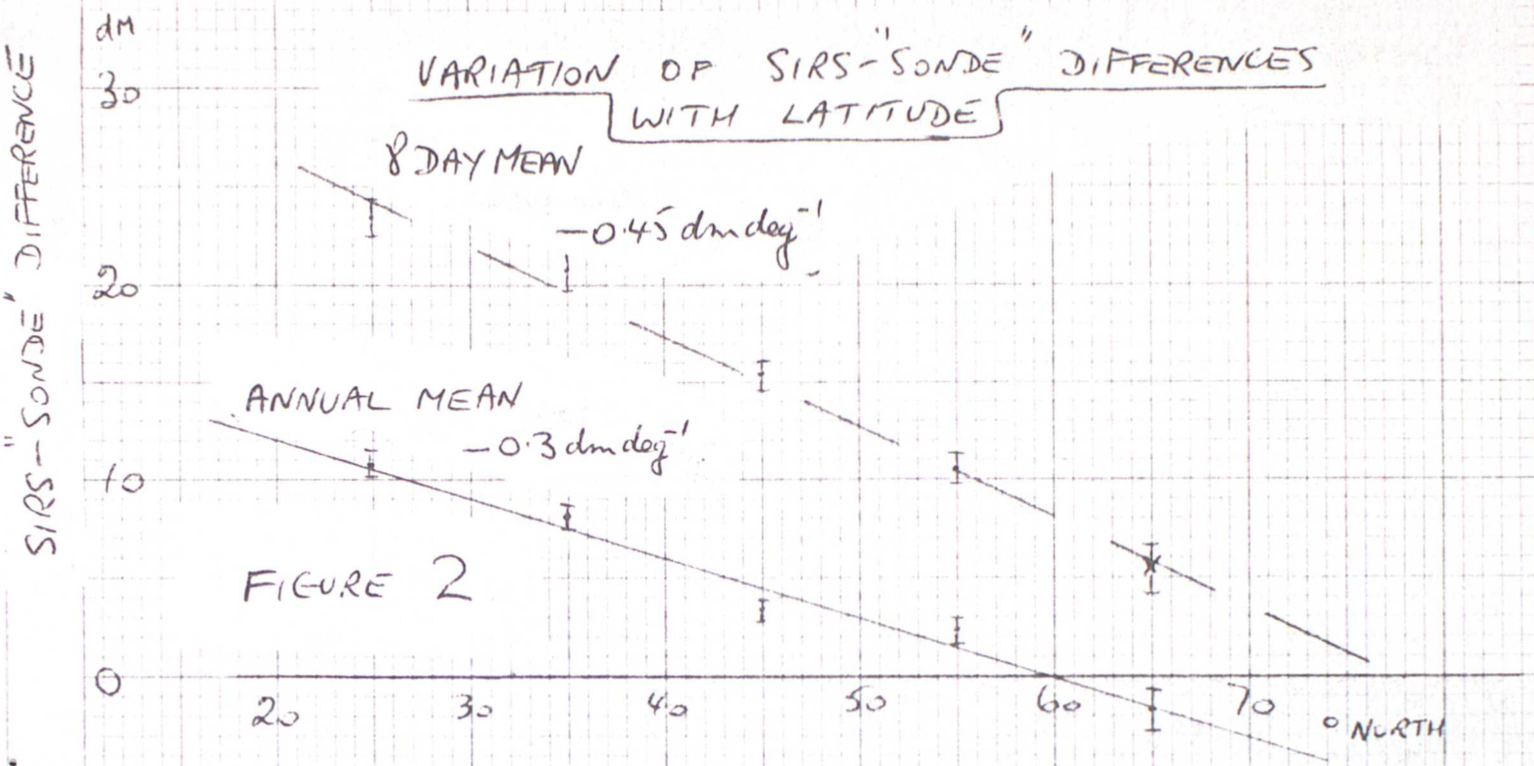
References

Mc Millin et al	1973	NOAA Tech. Report NESS 65.
May B R	1975	Met O 19 Branch Memo 16.

TABLE 1 SIRS-'SONDE' differences (dm)

Latitude (^{o}N)	Annual Mean	SE	N
60-70	-1.79	0.98	166
50-60	2.27	0.49	515
40-50	3.36	0.45	590
30-40	8.05	0.45	632
20-30	10.83	0.63	446


VARIATION OF 500MB SIRS-"SONDE" DIFFERENCES
JUNE 1974 – MAY 1975
FIGURE 1
JUNE JULY AUG SEPT OCT NOV DEC JAN FEB MAR APL MAY
SIRS-"SONDE" DIFFERENCES
dM
30
20
10
0
-10
-20
TOTAL VARIATION
40-50°N VARIATION
#2 NOAA3
#1 NOAA3
#1 NOAA2
#1 NOAA3
#2 NOAA3
#2 NOAA 4



VARIATION OF SIRS-"SONDE" DIFFERENCES WITH LATITUDE
dM
"SIRS-"SONDE" DIFFERENCE
8 DAY MEAN
−0.45 dm deg⁻¹
ANNUAL MEAN
−0.3 dm deg⁻¹
30
20
10
0
20
30
40
50
60
70
° NORTH

FIGURE 2

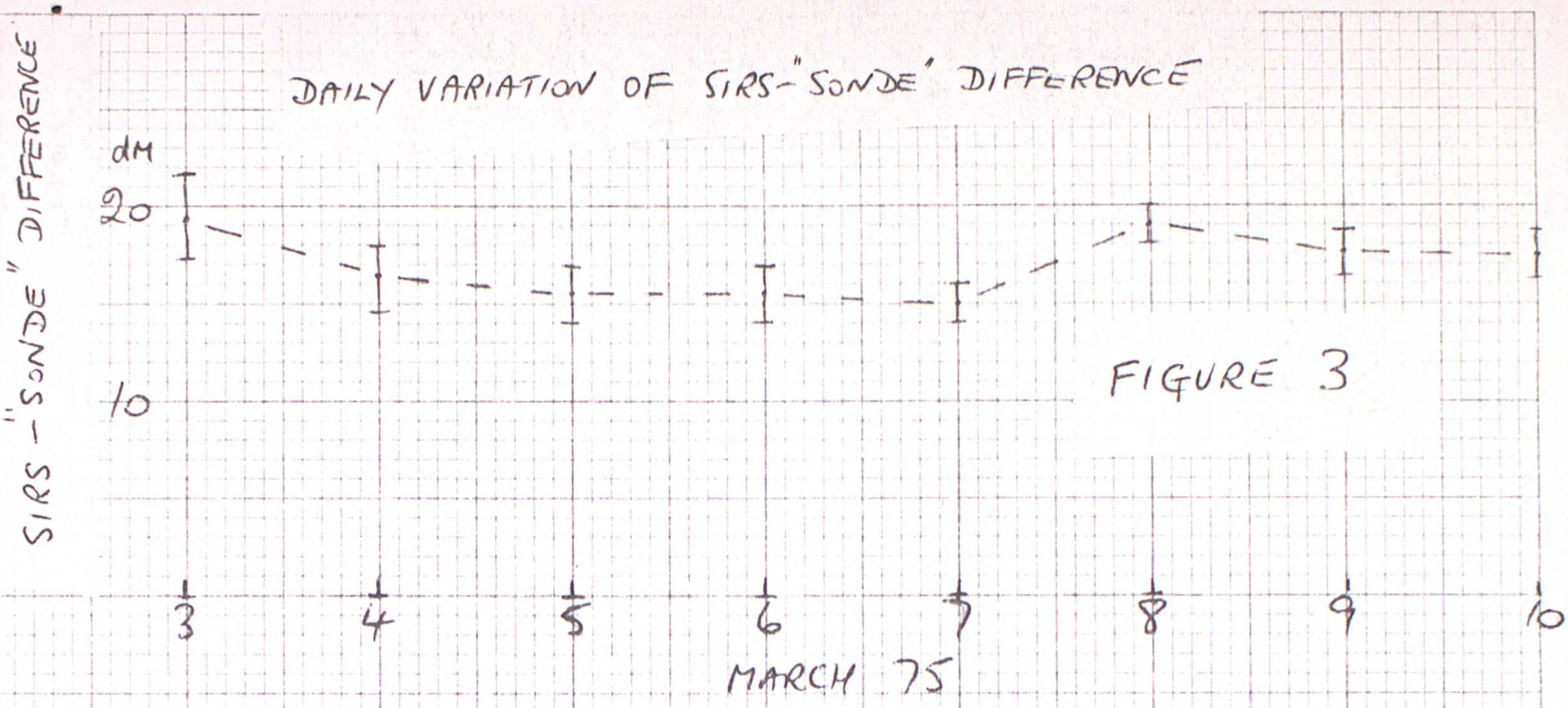


FIGURE 3

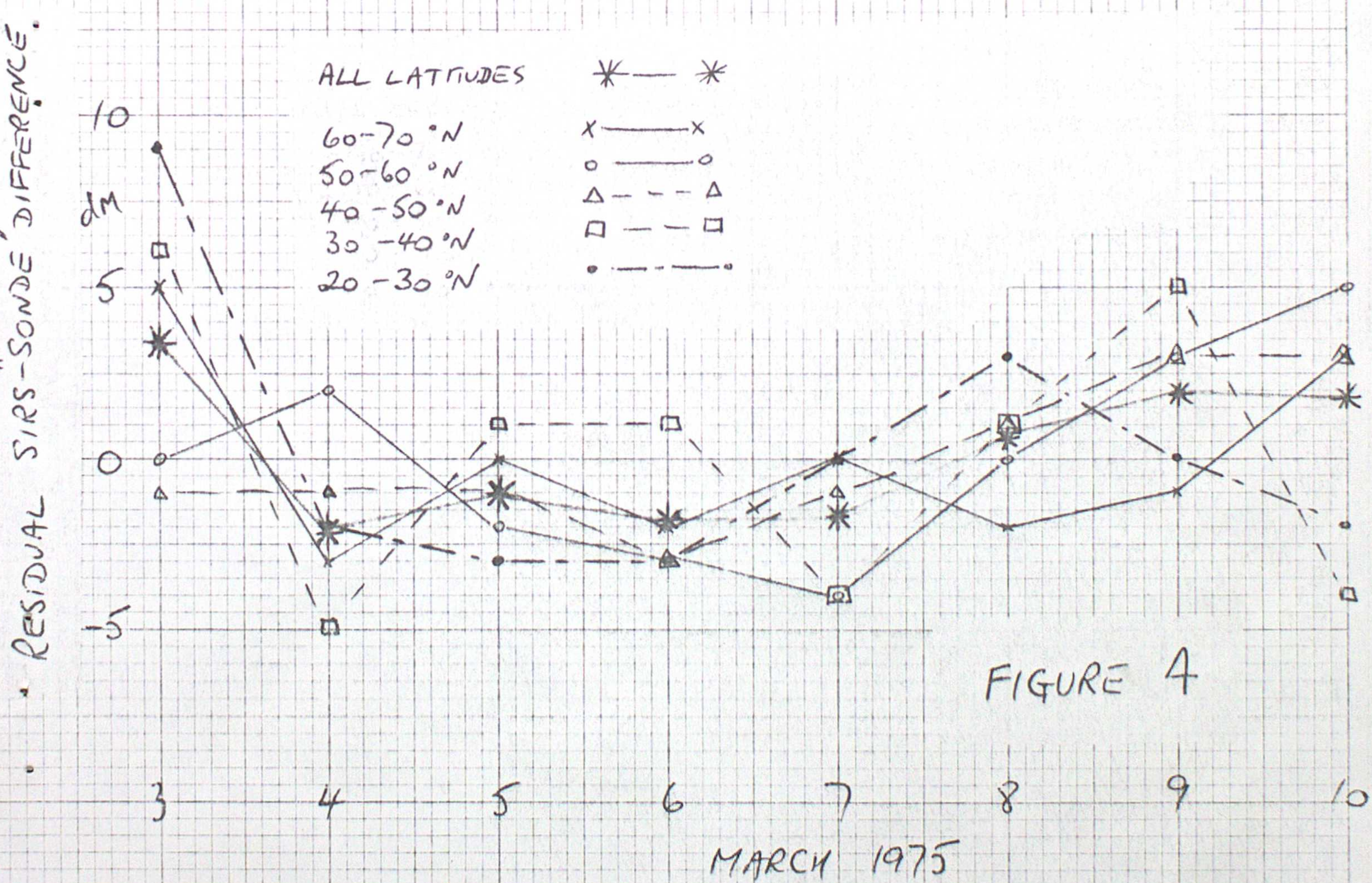


FIGURE 4