METEOROLOGICAL OFFICE BRACKNELL

REMOTE SENSING BRANCH (RS5)
Technical Memo No 5.

OPERATIONAL EXPERIENCE OF THE VAISALA AUTOSONDE AT WATNALL JUNE – SEPTEMBER 1998

J Elms
(Meteorological Office, Bracknell, Berks RG12 2SZ)

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J Elms Met Office, RS 5

1. INTRODUCTION

A Vaisala Autosonde system was installed at Camborne in mid November 1997 where it underwent testing until March 1998. These tests included comparison ascents from the same site with operational soundings launched within 10 minutes of the Autosonde schedule. 129 Autosonde soundings were made during this period and the results were discussed in the Trial Report circulated to members of the Project Board in January 1998 . (Reference [1].)
The Autosonde was then moved to Watnall (Nottingham) in early May 1998 and has provided soundings to the Met Office forecast model and outstation display systems since 17th May 1998.
Soundings were scheduled for midnight and midday during June to allow the technical support at Met ES Watnall and the operators at the parent station at Hemsby to become familiar with the procedures. Subsequently, soundings at 6 hourly intervals were initiated on 1st July. Over 400 reported operational Autosonde soundings from Watnall have therefore been achieved since mid May.

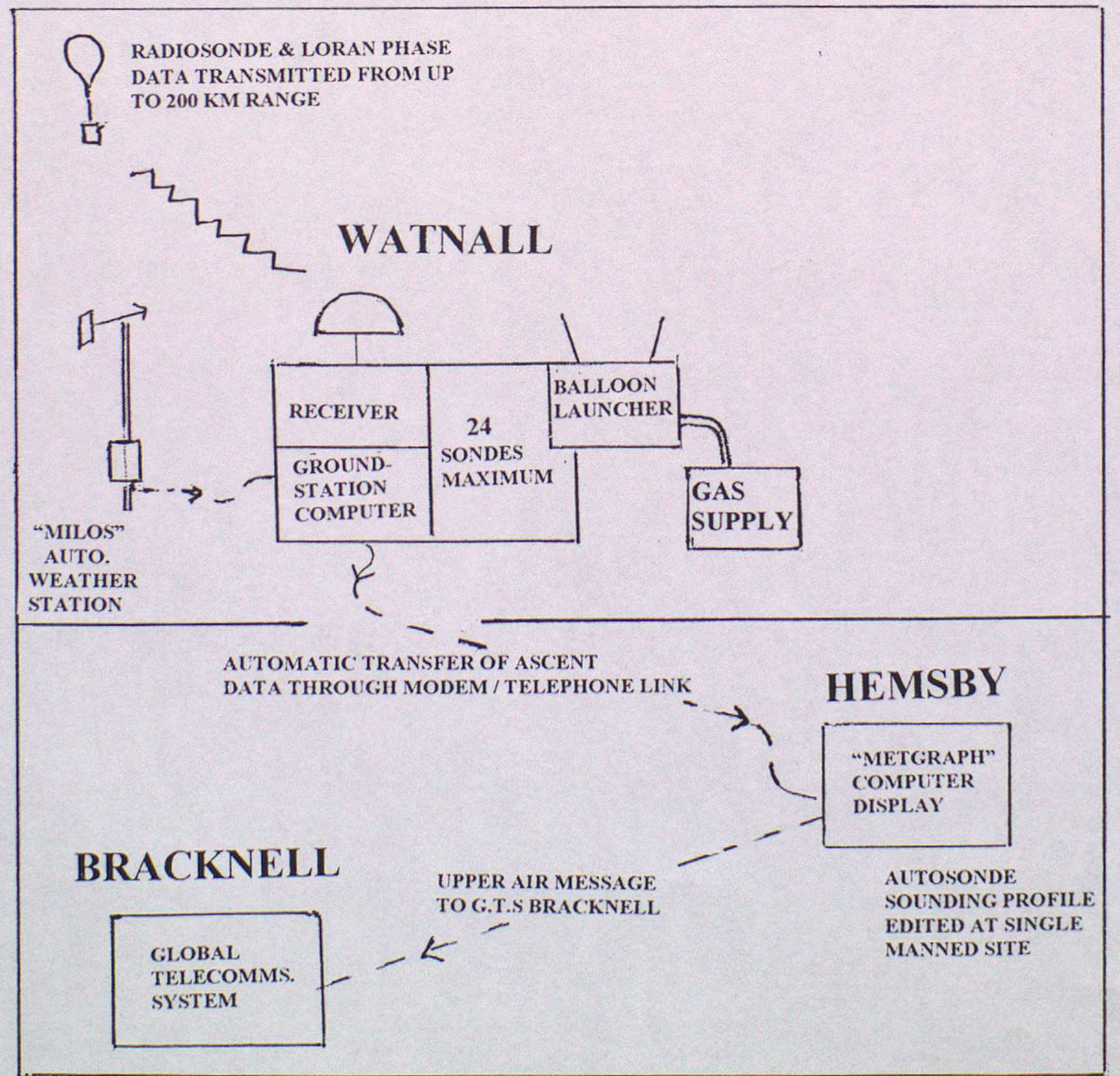
This Report summarises the Autosonde performance since its installation at Watnall and makes recommendations for future installations.

2. THE AUTOSONDE SYSTEM.

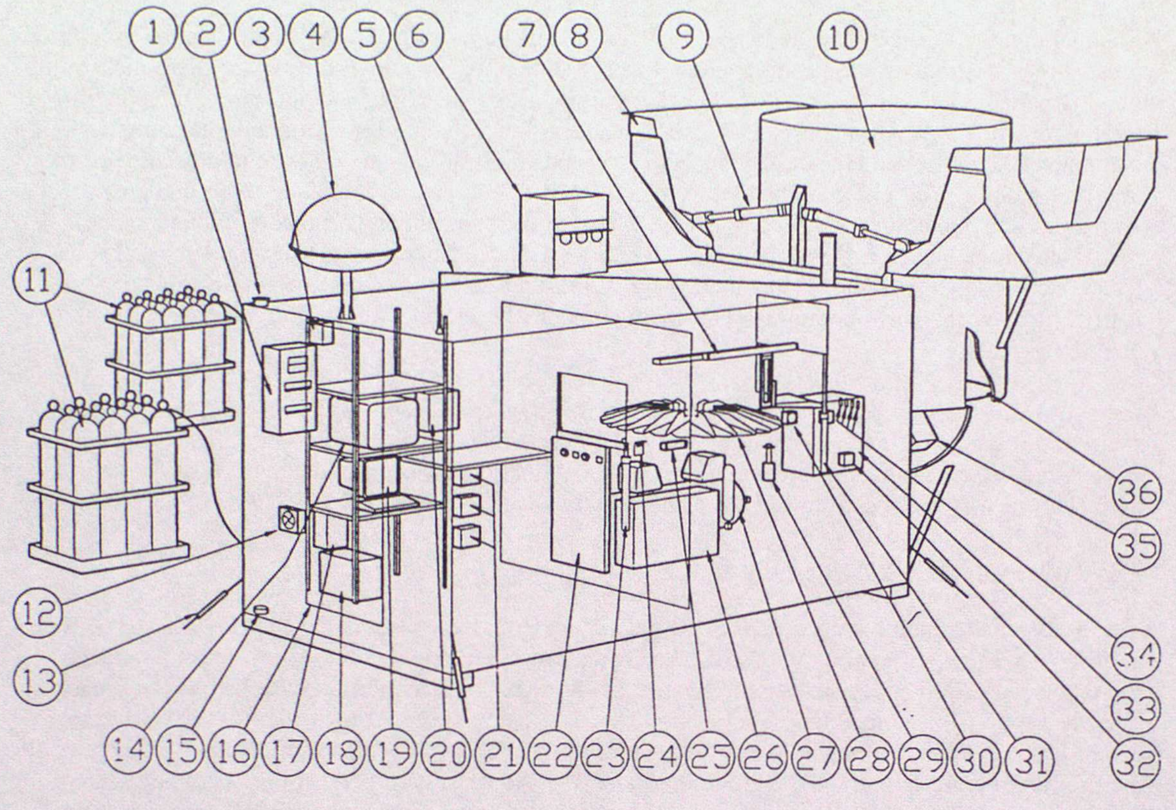
2.1 Principles of Autosonde Operation.

Figure 1 gives a simplified overview of the system hardware. Figure 2 gives a detailed 3-dimensional view of the components of the Autosonde.

FIGURE 1



VAISALA



AUTOSONDE SUB-UNITS

No.	Sub-unit	Actuator No.
1	Mains power distribution box	52, 50 (= K9)
2	Antenna cable passing through	-
3	VLF antenna amplifier	-
4	Radiosonde receiving antenna	-
5	VLF antenna	-
6	Gas measurement unit	16, 17, 26, 48
7	Tray-out control cylinder	23
8	Cover lid of the balloon launcher	-
9	Cover lid cylinder	32
10	Balloon vessel	-
11	Gas bottles (in racks)	16, 17
12	Safety fan	-
13	Shelter fixing bracket	-
14	Radiosonde receiver	39, 41
15	Cable passing through	-
16	Access door to the shelter	-
17	Junction box for surface weather station	-
18	UPS (Uninterruptible power system)	-
19	Control computer	-
20	UPS control box	13

No.	Sub-unit	Actuator No.
21	Reference sensor transmitters	41, 42, 43, 45, 46, 47
22	Logic control unit	36
23	Loading hatch cylinder	35
24	Tray site sensors	18 (= 5 pcs.), 65
25	Rotating cylinder	12
26	Battery activation system	15, 51, 53
27	Compressed air system with air dryer	49, 50
28	Radiosonde trays (max. 24 pcs.)	-
29	Battery activation cylinder	14
30	Fan for ground check	-
31	Tray-out hatch cylinder	24
32	Heater for nozzle control box	33
33	Nozzle control box	-
34	Releasing cylinders	25, 29, 30
35	Balloon detecting sensor	27
36	Launcher heater	33

Appr 951103 KCn
Check KSn
Drawn 951031 Tekno-Pic Ky

AUTOSONDE
3D-LAYOUT

VAISALA

OD30487B

FIGURE 2

z

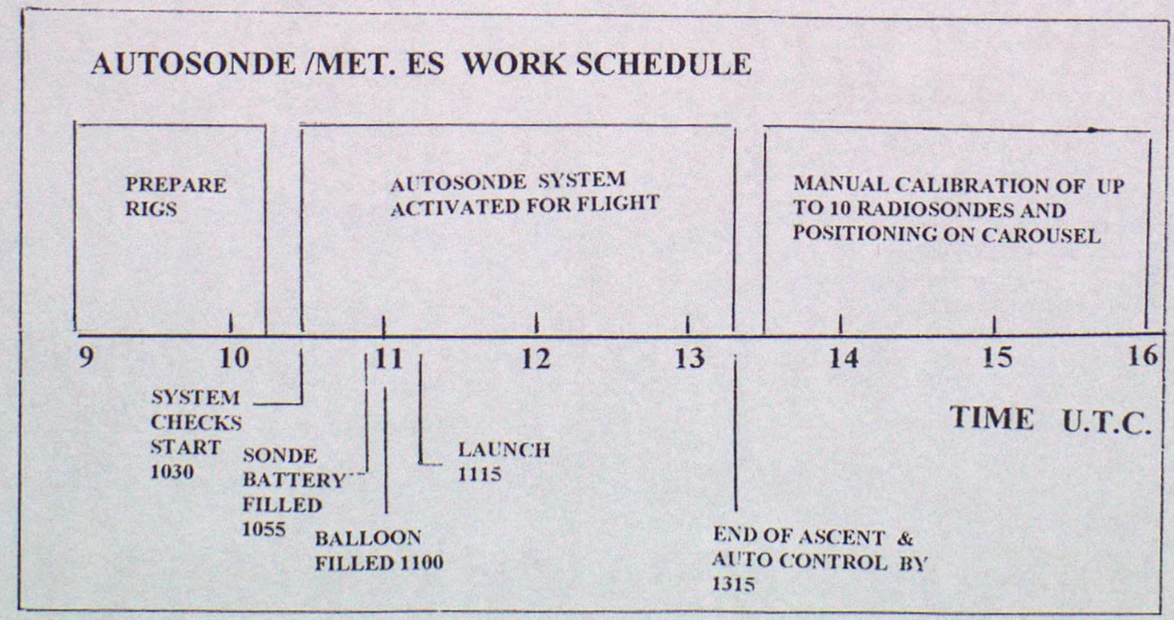
The main purpose of the Autosonde is to enable automatic launching of up to 24 Vaisala radiosondes at preset times. A groundstation computer controls a system of pneumatic pistons which drive most of the moving parts in the equipment. The radiosonde battery is activated a few minutes prior to launch and after automatic transmission checks have been made within the controlling program, the computer commands the radiosonde to be selected from a 24- position carousel and moved to the balloon launcher module. The 350 gram balloon is then filled with helium to a computer-controlled pressure. At the preset launch time, the cover flaps are deployed and the balloon is launched with attendant parachute and radiosonde. Communication links are established automatically via modems and telephone lines to a "parent" station at Hemsby. All further monitoring and upper air message creation is performed by the duty operator at Hemsby in parallel with the operational procedures for the Hemsby ascents.

Previous testing at Camborne has proved that the Autosonde is capable of maintaining a sequence of radiosonde ascents without intervention. However, operational problems do occur with such a complex system and these have been overcome with a combination of monitoring and diagnosis by the staff at both Hemsby and Watnall followed by remedial action usually by Met ES Watnall.

2.2 Technical Support From Met ES Watnall

The Autosonde contains a maximum of 24 radiosondes which are loaded by Met ES staff in between the 6-hourly standard launch times. UK Met Office procedure requires that parachutes are attached to the radiosonde rig. It is especially important that the radiosonde unwinder (attached to the parachute former) deploys on launch and experience in the UK Network has shown that this is best achieved using the method shown in Fig. A3 of the Annexe. Usually some preparation of rigs is completed in the morning before loading and calibration under Autosonde system control during the afternoon. In one afternoon about 10 radiosondes are checked against ground reference measurements and put in place on the carousel attached to 350 gram balloons and parachutes. The Met ES staff adapt these procedures according to loading requirements especially on Monday mornings when a lack of usable radiosondes on the carousel may necessitate loading a smaller number of radiosondes before the start of a midday flight. A typical Autosonde work schedule is shown in Figure 3 below:-

FIGURE 3



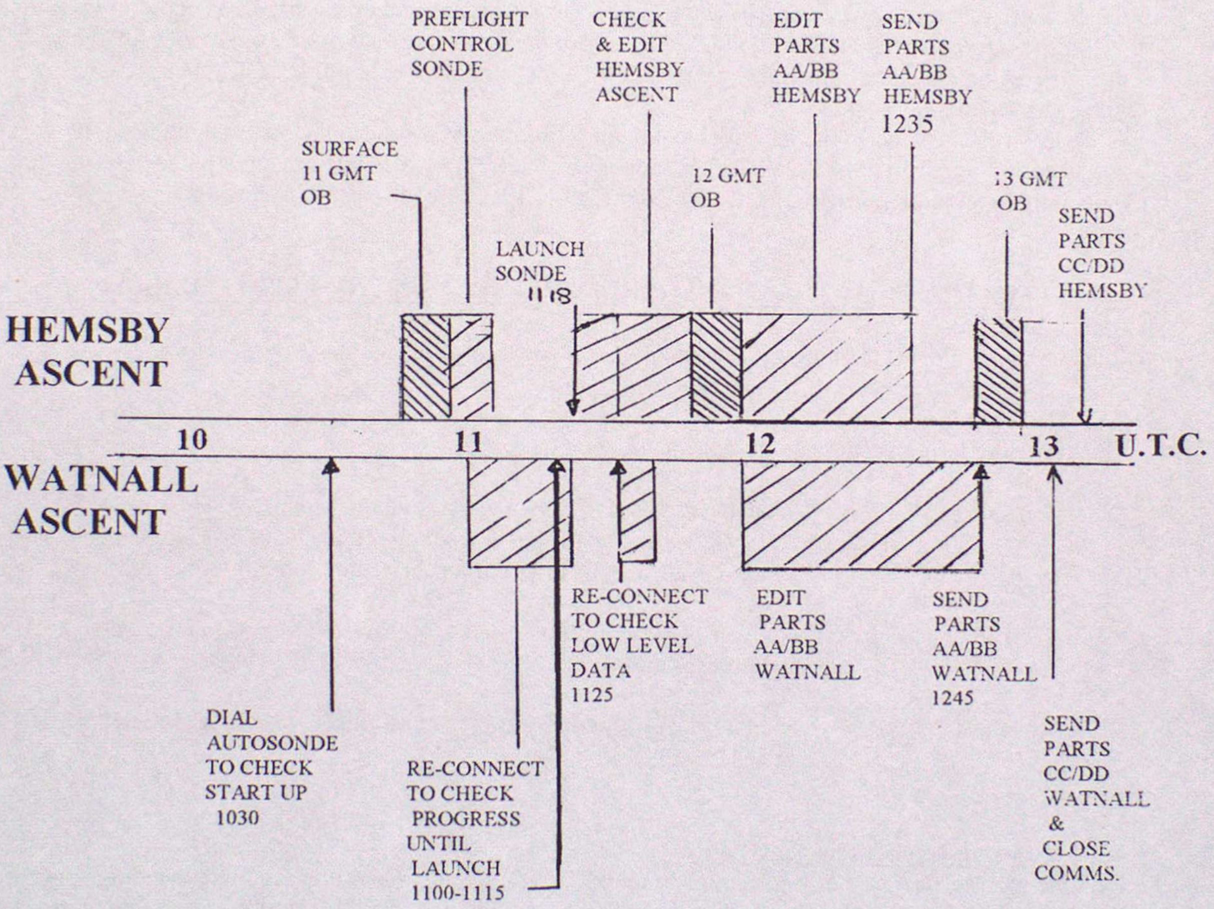
Average loading plus calibration time for radiosondes is about 20 minutes. Allowing for a possible requirement for 30 extra radiosondes per month to be loaded to overcome preflight failures (typically up to 10 radiosondes per month) and repeat ascents , the total man-hours required per month is around 70 man hours.Extra time required for servicing and correcting faults is typically another 10 man hours per month.A recent report from the Swedish Met. Institute [2] quotes 700 man hours per year required for a system which has been operating in Sweden for 4 years .

2.3 Remote Operation at Hemsby

The duty operator at Hemsby is responsible for ensuring the reliability and timeliness of both the Autosonde flight and his own manually launched ascent.
An idealised schematic of operator's interaction with the Autosonde is given in Figure 4. (In this diagram the tasks required for the Hemsby radiosonde ascent are shown above the time line and those required for the Watnall Autosonde ascent are shown below the line:-

FIGURE 4

AUTOSONDE / HEMSBY WORK SCHEDULE



Experience at Hemsby has proved that the editing and despatch of the Autosonde message to Bracknell can be achieved satisfactorily in addition to completing the work required for each 6-hourly Hemsby radiosonde ascent. Some problems were caused initially by the modem to modem data transfer from Watnall which in certain circumstances overwrote the operator's message selection with its own .These problems have now largely been overcome through experience of the system.

Further testing of the system by RS5 is still necessary to optimise the time that the Autosonde system needs to be connected via the modem link. This will be particularly important in reducing the cost of the Autosonde/parent site telephone connection which was £1202 for the first quarter.

Other initial problems were caused when anomalous ascents required aborting and repeating by the operator. RS5 have now provided instructions to Hemsby which enable operators to abort the flight in progress and instigate a repeat ascent using a specially selected radiosonde with alternative radio frequency .

2.4 On-Line Monitoring From Beaufort Park

RS5 have in October installed a remote terminal at Beaufort Park which will replicate the functions of the terminal at Hemsby. This will enable central access to the system for observing faults and giving better system support. It will also be possible to instigate occasional special tests ascents from Beaufort Park when necessary. (Met ES will be informed in advance of any test flights instigated by RS5).
This central terminal will also enable access to ascent data from the next two Autosondes to be installed in the UK in 1999.

3. AUTOSONDE FLIGHT COMPUTATION.

The radiosondes used in the Autosonde are of identical type to those used at existing manned outstations in the UK radiosonde Network. The Autosonde unit used at Watnall is a prototype system used for demonstration testing. It will be replaced by a production unit at the end of October 1998. In the current system , the receiver , PTU decoder and Loran windfinding are similar to those used in the "MW15" units currently employed at UK Met Office overseas GPS radiosonde stations , whilst most of the processing software and data archiving is a development from the PC-CORA system used operationally in the UK since 1990.
Thus, differences between the measurement quality from the Autosonde and other UK radiosonde sites ought to be small. There are however minor differences in computation and procedure relating especially to humidity measurements and windfinding. These are discussed in section 5.

4. SUMMARY OF AUTOSONDE SOUNDING RESULTS (JUNE – SEPTEMBER 1998)

The main operational statistics of the Watnall Autosonde are given in Table 1.

4.1 Terminology

The following terms are defined for clarification:-

"Soundings" = Upper Air Messages Obtained During the Month.
(It does not relate to the number of radiosondes used or launched as some repeats may be required for the same sounding)

"Reliable PTU Soundings" = Number of Soundings reported to at least 200 hPa which were not regarded as anomalous.

"Late Messages" = Number of Autosonde Messages sent from Hemsby to Bracknell after HH+50 .

4.2 Autosonde Sounding Success Rate

Reliable messages from the Autosonde were produced for about 94% of the required soundings during the 4 months of operation. This compares with a usual average of 99% to 100% of soundings from manned outstations . The reasons for the loss of messages were as follows:-

1. Gas unavailable (2 consecutive ascents in July).
2. GPS Windfinding Software/Hardware Failure .(6 ascents in July)
3. Balloon trapped in launcher vehicle during weekend (9 consecutive ascents in August).
4. Radiosonde rig tangled on filler (2 consecutive ascents in August)

Of the above problems, only the GPS Windfinding problem required advice from Vaisala Oy (Finland). The remaining problems were solved efficiently by Met-ES Watnall technicians.

TABLE 1 **WATNALL AUTOSONDE PERFORMANCE JUNE – SEPTEMBER 1998**

	JUN	JUL	AUG	SEP
SCHEDULED SOUNDINGS	62	124	124	120
ATTEMPTED SOUNDINGS	61	116	114	120
NO. MISSING	2	9	13	2
NO. ANOMALOUS NOT REPEATED	1	1	2	1
REPEATS REQUIRED	4	6	8	9
PERCENTAGE OF RELIABLE PTUASCENTS OBTAINED	**95%**	**92%**	**88%**	**98%**
NO. OF "LATE" MESSAGES (Received >HH+50)	9	13	10	17
PERCENTAGE OF RELIABLE MESSAGES TO BRACKNELL by HH+50)	**81%**	**81%**	**80%**	**83%**
NO. OF ASCENTS w SOME MISSING WINDS	6	1	3	0
PERCENTAGE WINDS MISSING	**3%**	**<1%**	**1%**	**0%**
TOTAL ANOMALOUS	2	1	5	2

Since September 1st , the Watnall Autosonde has been maintained by Met ES staff and now has an 8 hour Restoration Time with cover 24 hours/day, 365 days/year so that most problems causing consecutive 6-hourly soundings to be missed will be remedied by the On-call staff at Watnall.

4.3 Repeated Ascents

An average of 7 repeat ascents were required each month. The number of repeats required by early bursts of the balloon (about 2 per month) was higher than at manned outstations where bursts at pressures greater than 200 hPa are very rare except in severe weather.

4.4 Preflight Radiosonde Rejects

During the 4 months a total of about 40 radiosondes have been rejected prior to launch and returned to Vaisala Oy for replacement. 10 per month is about twice the normal rejection rate from the Network. A high proportion of these sondes from a particular batch were rejected in August by Met ES due to calibration problems such as temperatures measuring 10 to 15 °C too low during the ground checks. This batch of radiosondes was replaced by another batch sent specially from Met Office stores . However, some other radiosondes previously accepted during manual controls were rejected as "Bad Sondes" during the automatic preflight checks immediately prior to launch. All radiosondes returned to Vaisala are annotated with reasons for their rejection. Met ES have now also been asked to record reasons for rejecting radiosondes on a computer file . In this way Met Office RS5/OLA will continue to monitor the situation .

4.5 Late Messages.

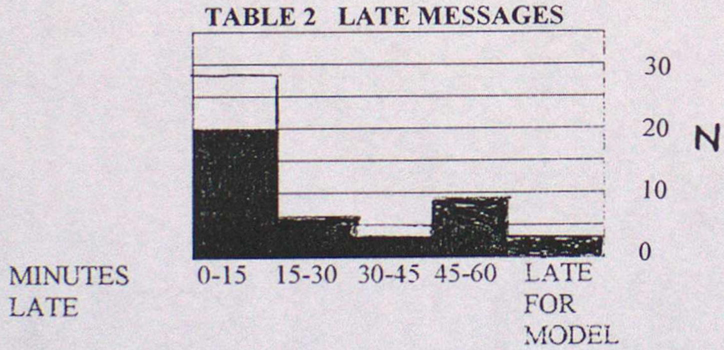
Standard operational deadlines for receipt of the operational message from the UK Network are:-

HH+50 minutes for part AA,BB messages incuding data from surface to 100 hPa (eg > 1250 for the 12 UTC ascent).

HH+110 minutes for input to the Met DB for both the Mesoscale and Unified models.

A histogram of the number of late messages (N) is given in Table 2 below:-

TABLE 2 LATE MESSAGES



Most of the late messages were sent only a few minutes after the target time. Details of the late messages and missing soundings are given in Table 1A in the Annexe.

In the long term the use of BUFR coded messages should appreciably reduce the manual intervention required by the parent station , thereby decreasing the number of late messages. Vaisala Oy are already planning to implement BUFR coding facilities within their next generation groundstation software. Met Office RS5 will ask for this facility to be additionally available on the Autosonde system.

5. AUTOSONDE RADIOSONDE AND WIND MEASUREMENTS

5.1 Geopotential Height Measurements

Figures 5(a) to 5(d) show a time series of the 100 hPa heights recorded at both Watnall and Hemsby from June to September inclusive. The Watnall heights have been plotted 100m above those from Hemsby to show good correlation between the two series. Note that the anomalies in Figure 5(c) for Hemsby (27th at 18Z) and Watnall (19th at 18Z) and in Figure 5(d) for Watnall (19th at 18Z) were caused by instability in the temperature sensors (see section 5.2)

The random errors in the radiosonde geopotential height may be assessed from the Day/Night differences from the 100 hPa geopotential height. This method relies on the fact that at 100 hPa the real atmospheric variation is relatively small compared with variation due to sonde errors.

Table 3 expresses the variability of the 100 hPa height during the 4 months of operation. This is directly related to the standard deviation of of the midnight height difference from the mean of the 2 adjacent midday heights. (Anomalous heights caused by temperature jumps have been removed from these statistics).

TABLE 3

COMPARISON OF GEOPOTENTIAL HT VARIABILITY (m)	JUNE - SEPT	
	WATNALL	HEMSBY
NO. OF DIFFS.	96	115
MEAN DAY/NIGHT DIFFERENCE	-9.5 +/- 3	-10.5 +/- 2
S.D. of DAY/NIGHT DIFFERENCE	15.0 +/- 2	10.8 +/- 1
UPPER LIMIT OF RANDOM ERROR IN RADIOSONDE MEASUREMENT	12.3	9.3

In each of the four months of operation the variability of the Watnall Autosonde heights has been slightly greater than the Hemsby height variability. A mean temperature error of 1°C in the layer from surface to 100 hPa corresponds to an integrated height error of 65m at 100 hPa . Thus the 12m random error at 100 hPa corresponds to a temperature error of about 0.2 °C from the surface to 100 hPa. (see also Table 4 in section 5.2).

Thus the Autosonde values are well within acceptable tolerances for upper air sounding statistics, but further month by month comparisons will be made to try to ascertain whether the slightly greater Autosonde variability is due to differences in operation or location

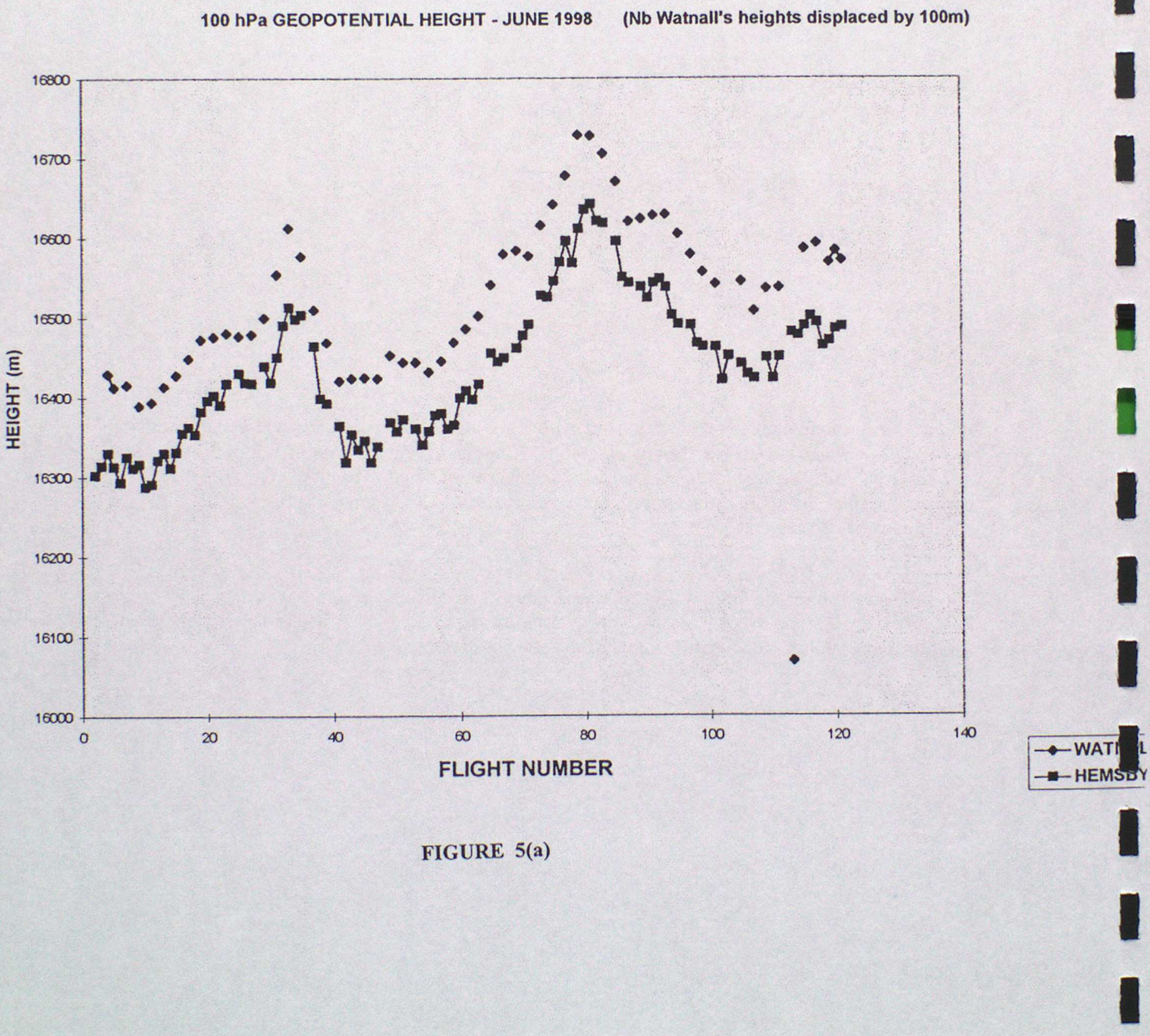

100 hPa GEOPOTENTIAL HEIGHT - JUNE 1998 (Nb Watnall's heights displaced by 100m)
HEIGHT (m)
16800
16700
16600
16500
16400
16300
16200
16100
16000
0
20
40
60
80
100
120
140
FLIGHT NUMBER
HEMSBY

FIGURE 5(a)

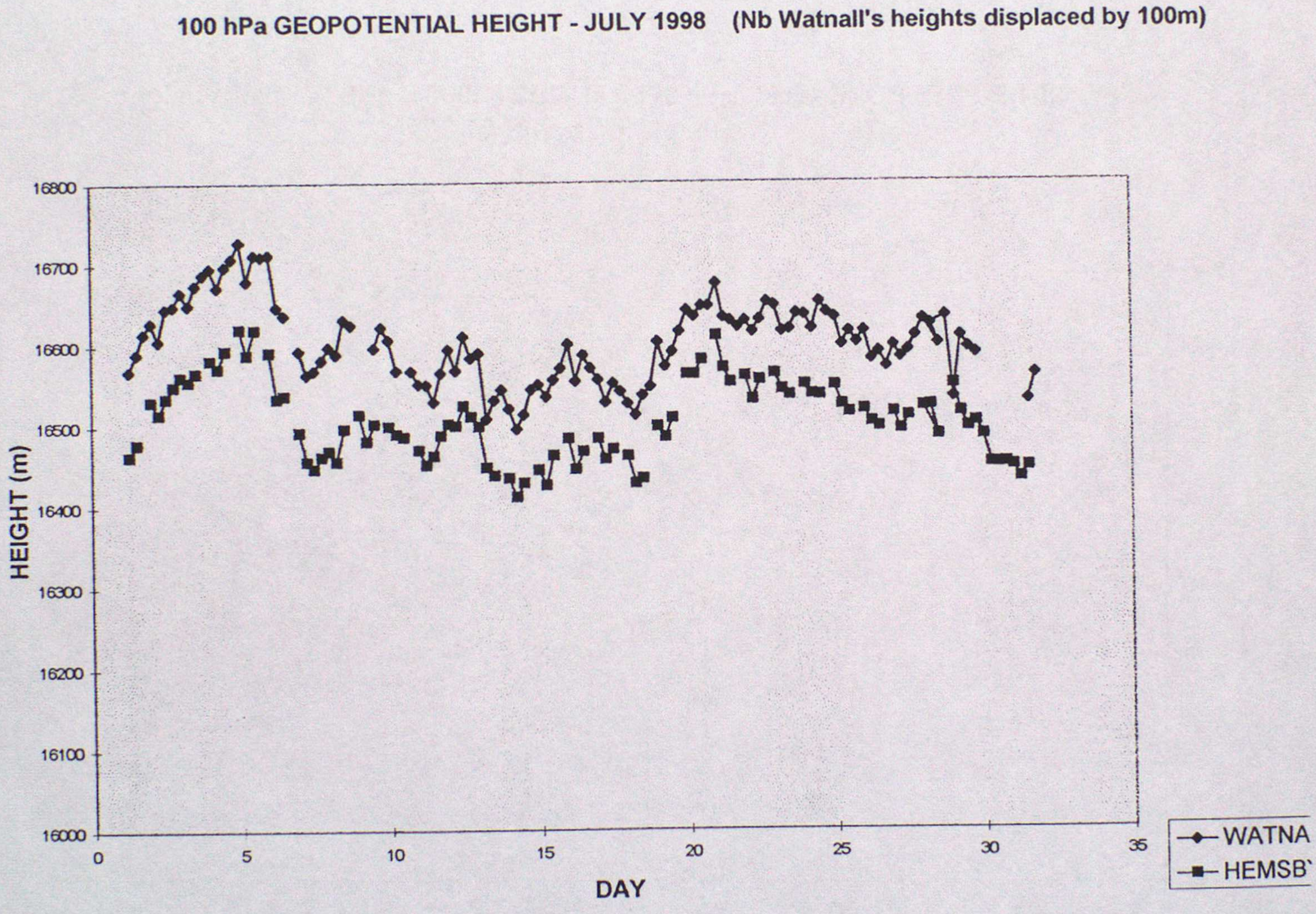

100 hPa GEOPOTENTIAL HEIGHT - JULY 1998 (Nb Watnall's heights displaced by 100m)
HEIGHT (m)
16800
16700
16600
16500
16400
16300
16200
16100
16000
0
5
10
15
20
25
30
35
DAY
WATNA
HEMSB

FIGURE 5(b)

100 hPa GEOPOTENTIAL HEIGHT - AUGUST 1998 (Nb Watnall's heights displaced by 100m)

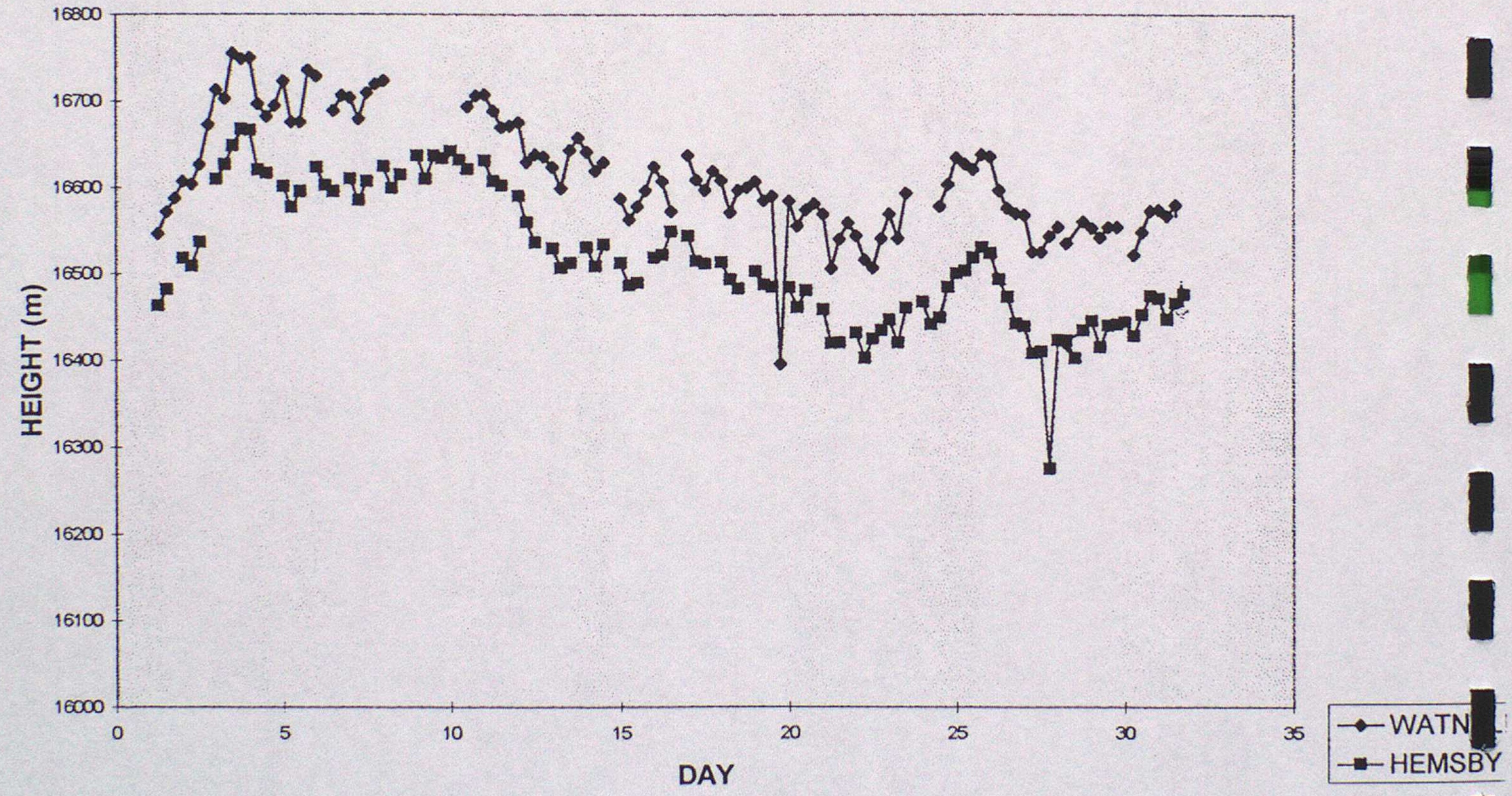


FIGURE 5(c)

100 hPa GEOPOTENTIAL HEIGHT - SEPTEMBER 1998 (Nb Watnall's heights displaced by 100m)

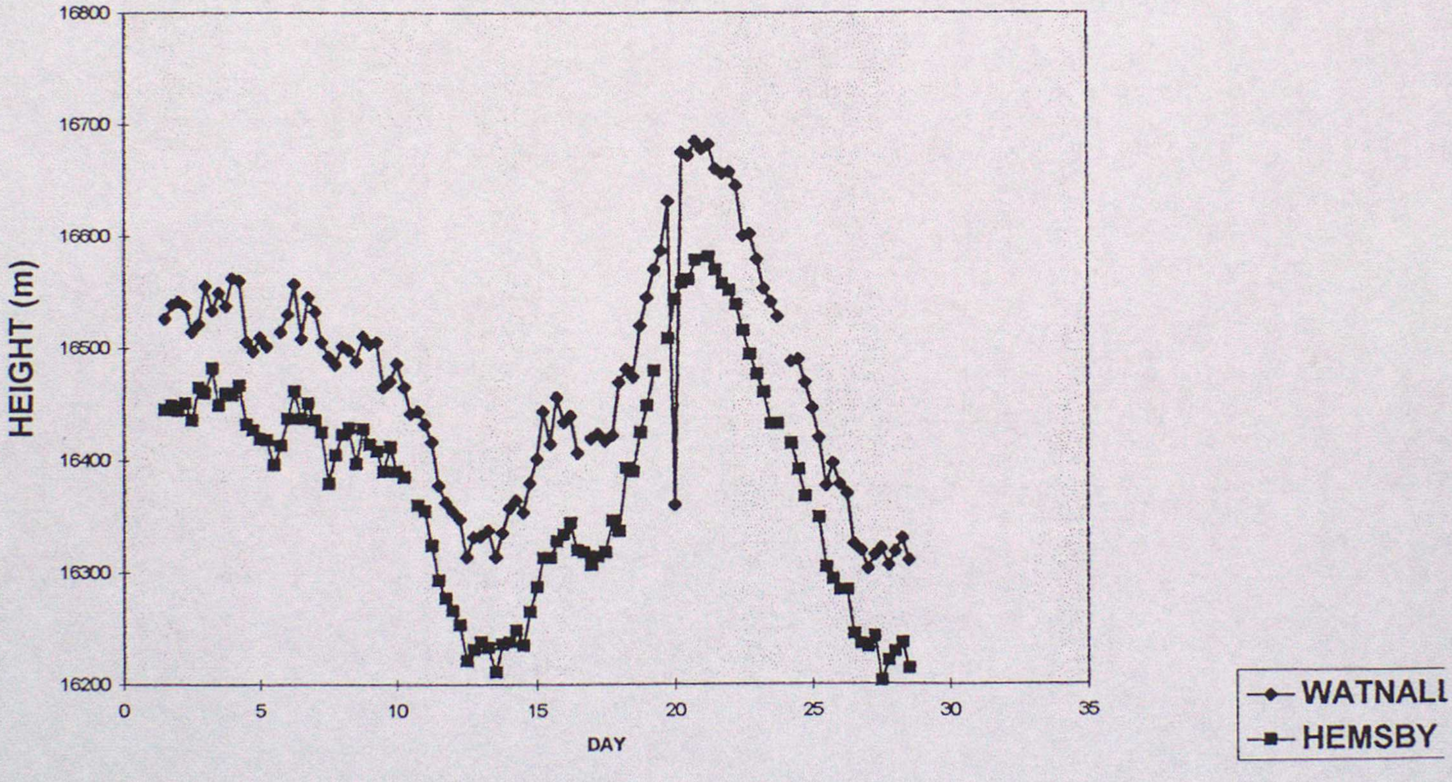


FIGURE 5(d)

5.2 Temperature

5.2 .1 Camborne Tests

Comparison tests at Camborne demonstrated good agreement in temperature between auto-launched and operational ascents launched within 10 minutes of one another. Mean differences of less than 0.1 ° C. were found at levels from the surface to 30 hPa. [1]

5.2.2 Anomalous Temperature Measurements

During the 4 months of Autosonde operations, temperature measurements throughout the UK Network have been occasionally affected by instantaneous "jumps" in calibration. Figure 6 shows an example of an in flight temperature jump at 32 minutes into flight. The raw data measurements were displaced by about 13°C (too cold) for the remainder of the ascent. The error that this introduced to the 100 hPa height can be seen in Figure 5(d).

About 2 to 3% of UK soundings have been affected and Vaisala have been informed of the problem which has necessitated repeat soundings to be made when the jumps have occurred in flight. A number of faulty radiosondes have been identified prior to launch at manned stations and these have then been set aside to return to the manufacturer. It is not practical for the parent station to monitor the preflight raw radiosonde data from the Autosonde so this problem has necessitated some repeat flights to be instigated by the Hemsby operator. (see Table 1). Vaisala have identified the cause of the problem as due to poor internal contacts within the "thermocap" sensor on certain batches of radiosondes (currently being determined) so this problem should soon be eliminated for the Autosonde system.

5.2.3 Model Statistics

A statistical analysis of the mean monthly temperature differences (OBservation – First Guess of the Global Model) at the 100 hPa and 500 hPa levels provided by NWP – Data Assimilation section of the Met Office shows similar order differences for the month of September as shown in Table 4 below:-

TABLE 4

	T °C OB-FG	RMS OB-FG
WATNALL:		
100 hPa	**-0.1**	**0.6**
500 hPa	**-0.3**	**0.8**
HEMSBY:		
100 hPa	**-0.2**	**0.5**
500 hPa	**-0.2**	**0.8**

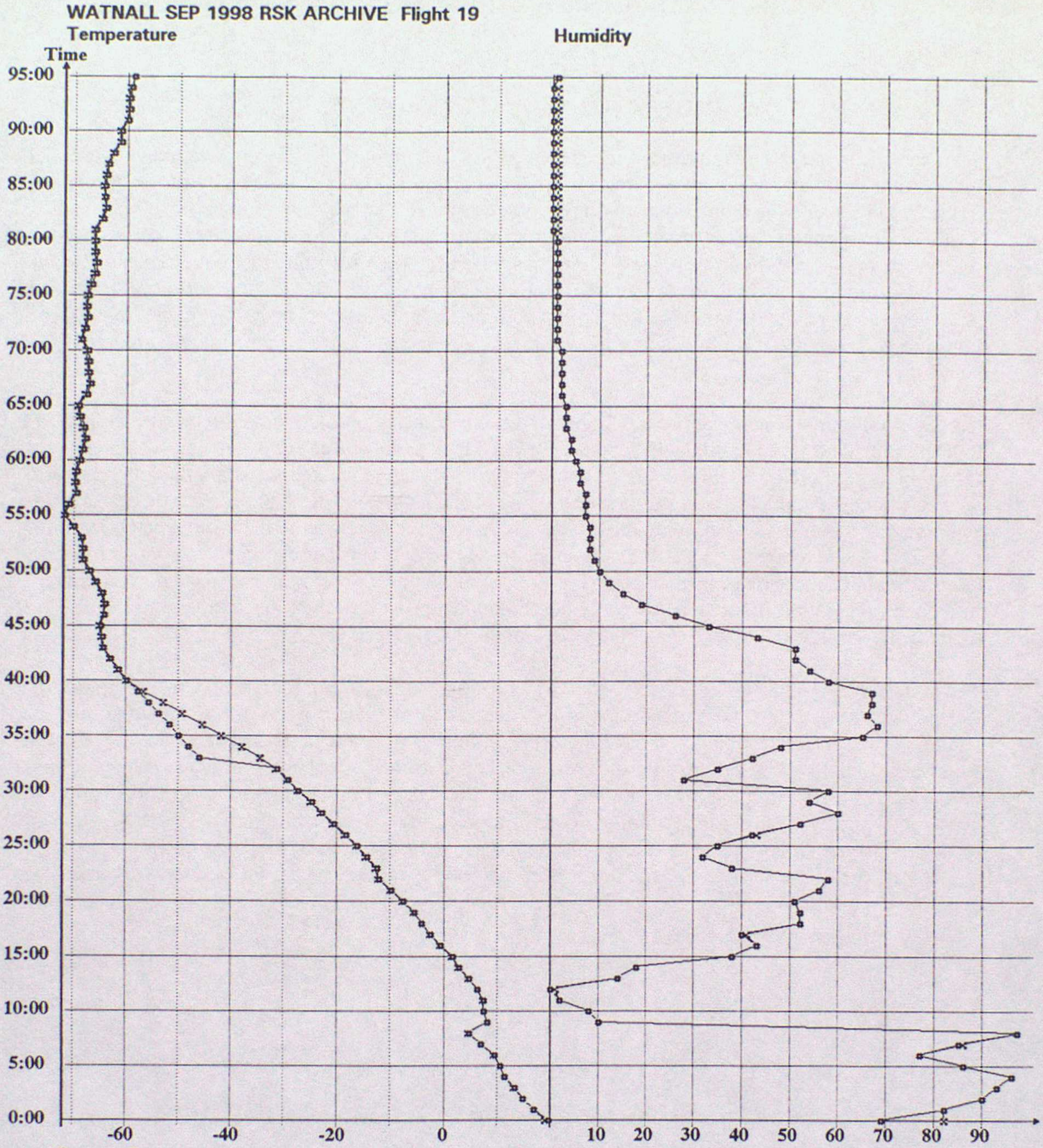


FIGURE 6

TEMPERATURE "JUMP" ON AUTOSONDE SOUNDING 19/9/98 at 18 UTC

14

5.3 Humidity

5.3.1 Analysis of Raw Data in the Stratosphere.

There are 2 regions in any radiosonde ascent which may be useful in highlighting humidity calibration errors. In the boundary layer , observation of the maximum humidity measured by the radiosonde in low cloud gives an indication of the humidity measurement errors near saturation.
Similarly ,observation of the minimum humidity measurements in the stratosphere may be used to indicate errors in calibration near to 0%. (At both extremes of the humidity range these measurements may be affected by contamination of the humidity element by water or ice particles , but such occasions of contamination may usually be eliminated from any analyses by excluding ascents launched in precipitation or displaying psychrometric cooling as the temperature sensor emerges from cloud.)

Vaisala radiosonde systems apply baseline corrections to the radiosonde humidity (and pressure and temperature) data prior to flight by comparing the radiosonde sensor measurements with reference measurements of pressure temperature and humidity. In manually operated systems , the ground checks are achieved by placing the radiosonde sensor boom inside a Ground Check Set filled with dessicant.
The humidity controls correction applied to the radiosonde measurement is the difference between the reference value (assumed 0%) and the radiosonde measurement. This correction is then applied linearly to all humidities measured in flight . However, an erroneous negative correction may be applied if the reference value is not the assumed 0% due to contamination of the dessicant or allowing insufficient time for the humidity element to acclimatise within the dessicant.

The effect of the application of erroneously large negative humidity corrections may be seen in a time series comparing "raw" minimum humidities observed in the stratosphere for each flight with the humidity controls corrections applied. Figures 7(a) and 7(b) show comparisons of the minimum stratospheric humidities and the controls corrections applied for both Hemsby and Watnall soundings during August. The negative raw humidities recorded at Watnall corresponding to the application of negative (typically –2 to –6 %) humidity control corrections suggest that either the dessicant needed replacing or alternatively that the radiosonde sensor needed to be kept in the Ground Check Set for a longer period of time (at least 10 minutes) to enable the "humicap" sensor to acclimatise to the zero humidity environment.

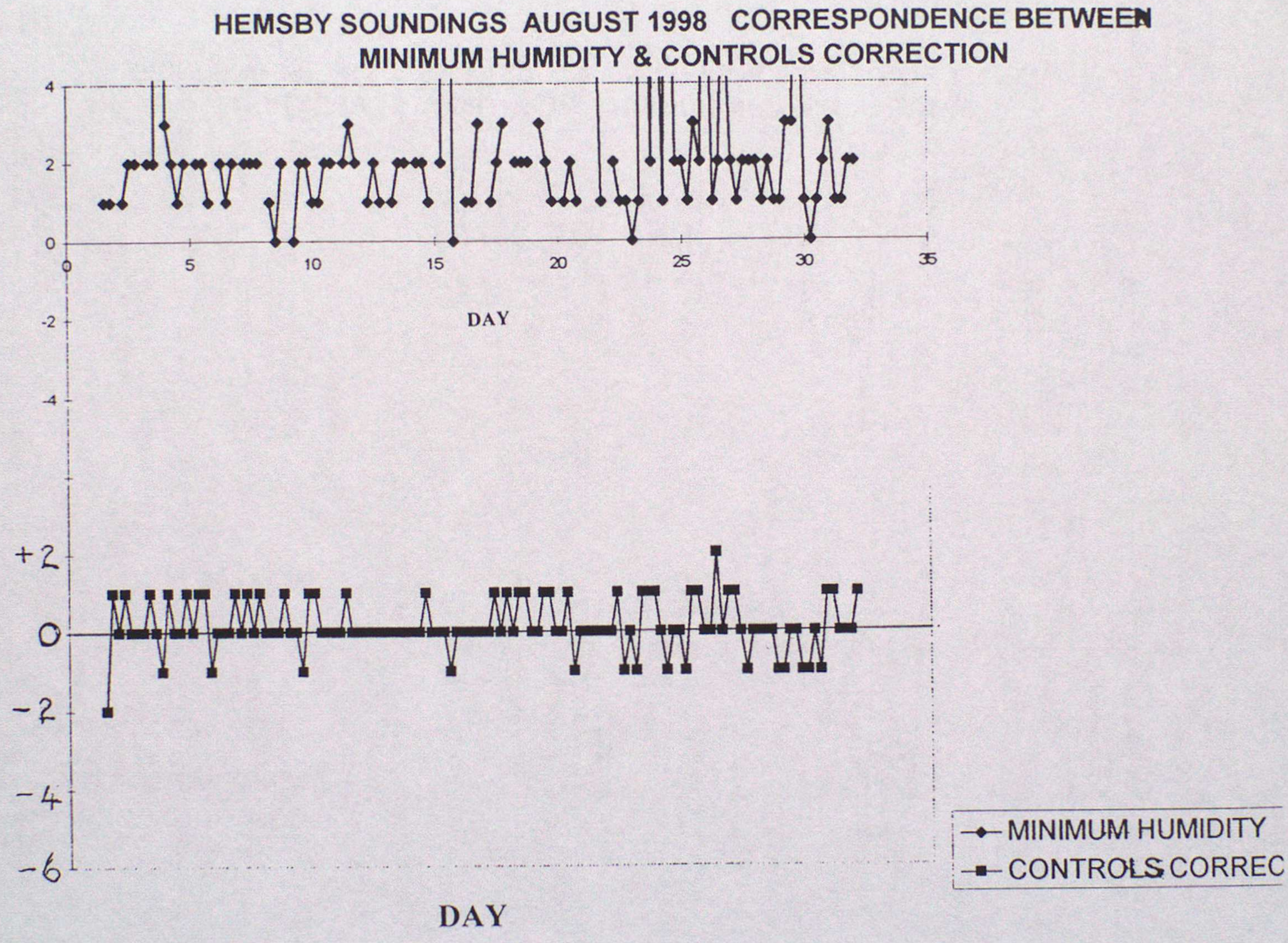

HEMSBY SOUNDINGS AUGUST 1998 CORRESPONDENCE BETWEEN
MINIMUM HUMIDITY & CONTROLS CORRECTION
4
2
0
-2
-4
0
5
10
15
20
25
30
35
DAY
+2
0
-2
-4
-6
MINIMUM HUMIDITY
CONTROLS CORREC
DAY

FIGURE 7(a)

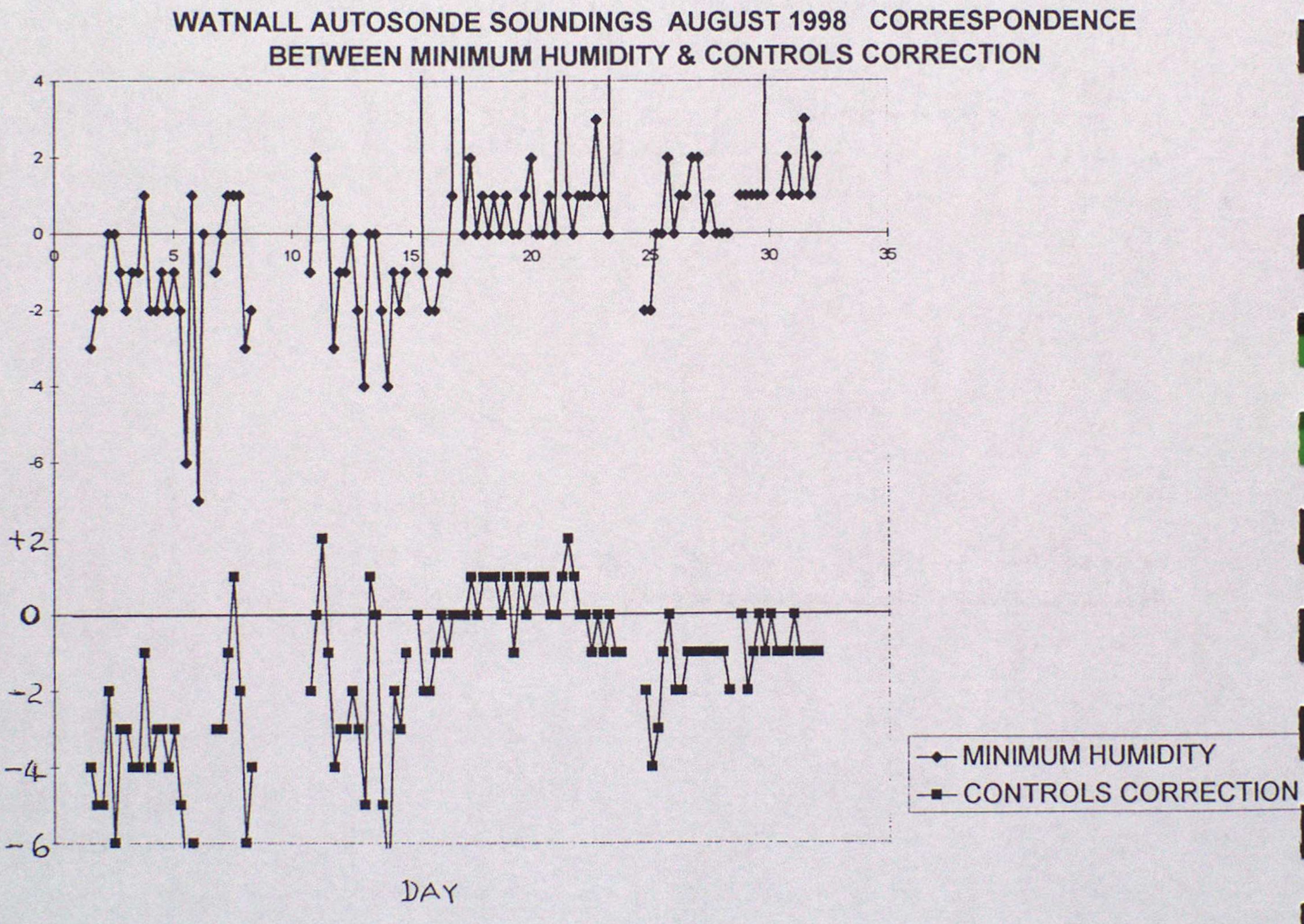

WATNALL AUTOSONDE SOUNDINGS AUGUST 1998 CORRESPONDENCE
BETWEEN MINIMUM HUMIDITY & CONTROLS CORRECTION
4
2
0
-2
-4
-6
0
5
10
15
20
25
30
35
+2
0
-2
-4
-6
MINIMUM HUMIDITY
CONTROLS CORRECTION
DAY

FIGURE 7(b)

5.3.2 Autosonde Humidity Ground Checking

The Autosonde enables both manual and automatic ground checks to be made. Tests at Camborne [1] showed that although the Autosonde software includes this option for preflight checking of the radiosonde PTU data against Vaisala's Autosonde cabin environmental sensors, a better agreement between Autosonde and operational sonde humidities was obtained when the operator used the standard (manually read) Vaisala Ground Check set employed in general radiosonde Network operations. Thus, Met ES staff at Watnall make manual checks of measurements from each radiosonde against the Ground Check readings prior to loading each radiosonde onto the carousel. The radiosonde may not be launched for a few days after this manual ground check, but immediately prior to launch , a second ground check is made , this time against automatic measurements from temperature and humidity sensors within the Autosonde cabin.
As long as this second set of comparisons is within software limits , the radiosonde is accepted for flight. These second (automatic) ground checks are used solely to accept or reject the radiosonde and the previous manual checks are used to apply the controls corrections to the in-flight measurements.

5.3.3 Humidity Measurements During the Camborne Trial.

Humidity comparisons between Autosonde soundings (using manual controls) and operational soundings made at Camborne showed mean differences generally within +/- 3% for all humidity ranges ,but with a large standard deviation in humidity zones between 10 and 80 per cent [1].
Most of the large variability in these humidity comparisons is real and caused by the fact that humidity has greater spatial and temporal variability than temperature within the lower troposphere. This is particularly apparent as a result of minor changes in the height of inversion levels which may cause very large differences in humidity measurements of compared hydrolapses

Some differences in Autosonde humidity measurements may be caused by the abrupt transition of the radiosonde from the balloon launcher to the outside atmosphere. In high humidity conditions (fog,mist or low stratus) the shorter acclimatisation period of the Autosonde (which is kept within the relatively dry and unventilated launcher until the moment of launch) may cause it to measure humidities which are too low whilst the "humicap" polymer takes a finite time to absorb the water vapour.
Figures 8(a) and 8(b) compare the the preflight and boundary layer profiles of humidity measurements made during a nighttime operational sounding and an Autosonde sounding launched 10 minutes later at Camborne in foggy conditions. There is some evidence to suggest that the Autosonde humidity sensor took more time to measure saturation than the operational radiosonde in these conditions . However, despite using radiosondes calibrated within the same week at Vaisala Oy (Helsinki) it should be noted that the operational radiosonde measured 110% humidity prior to launch, so it probably became contaminated. More ascents in fog are required to fully evaluate the Autosonde humidity measurements in saturated conditions.

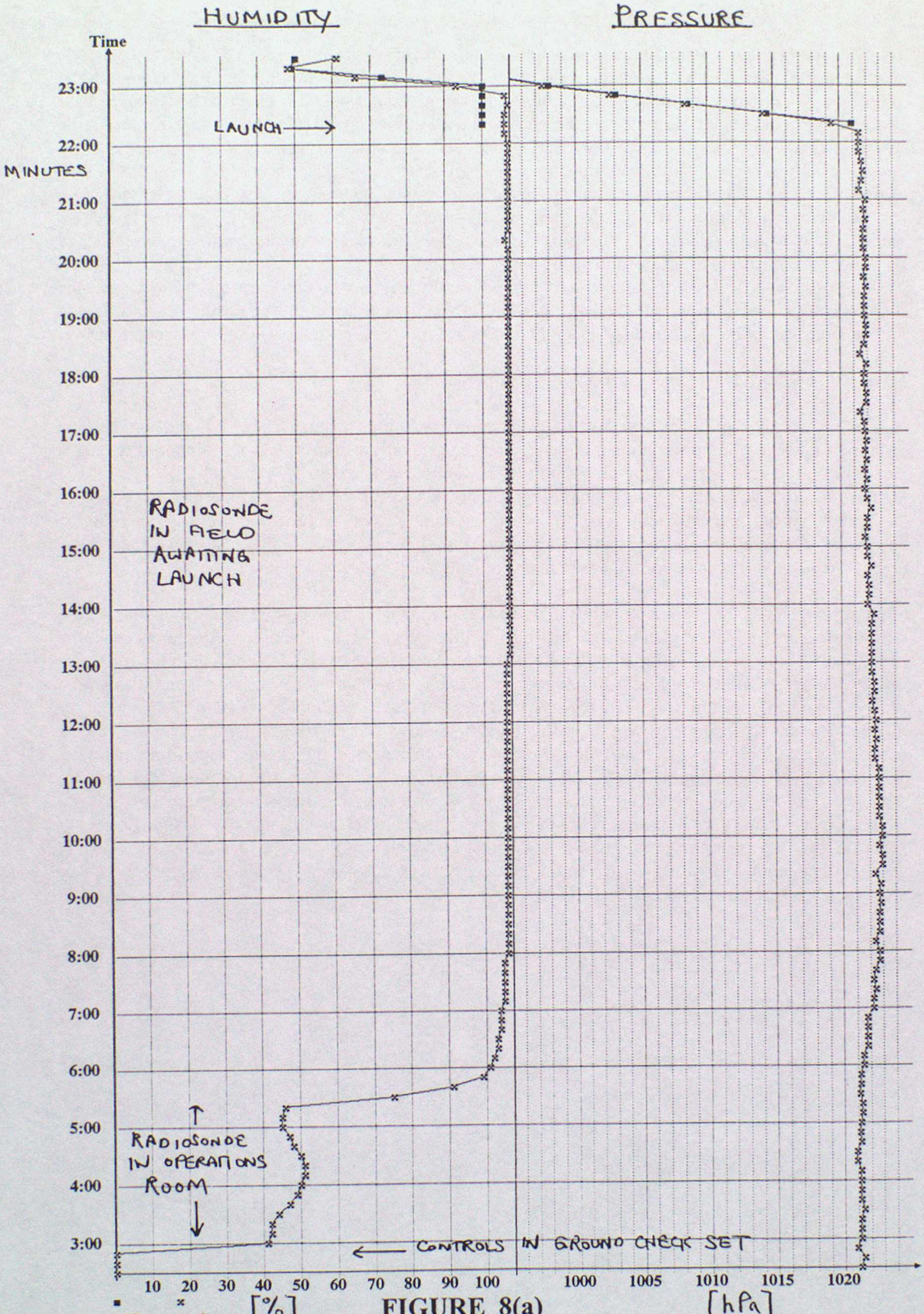


FIGURE 8(a)

CAMBORNE OPERATIONAL FLIGHT 119 LAUNCHED IN FOG 13/2/98 2320 UTC

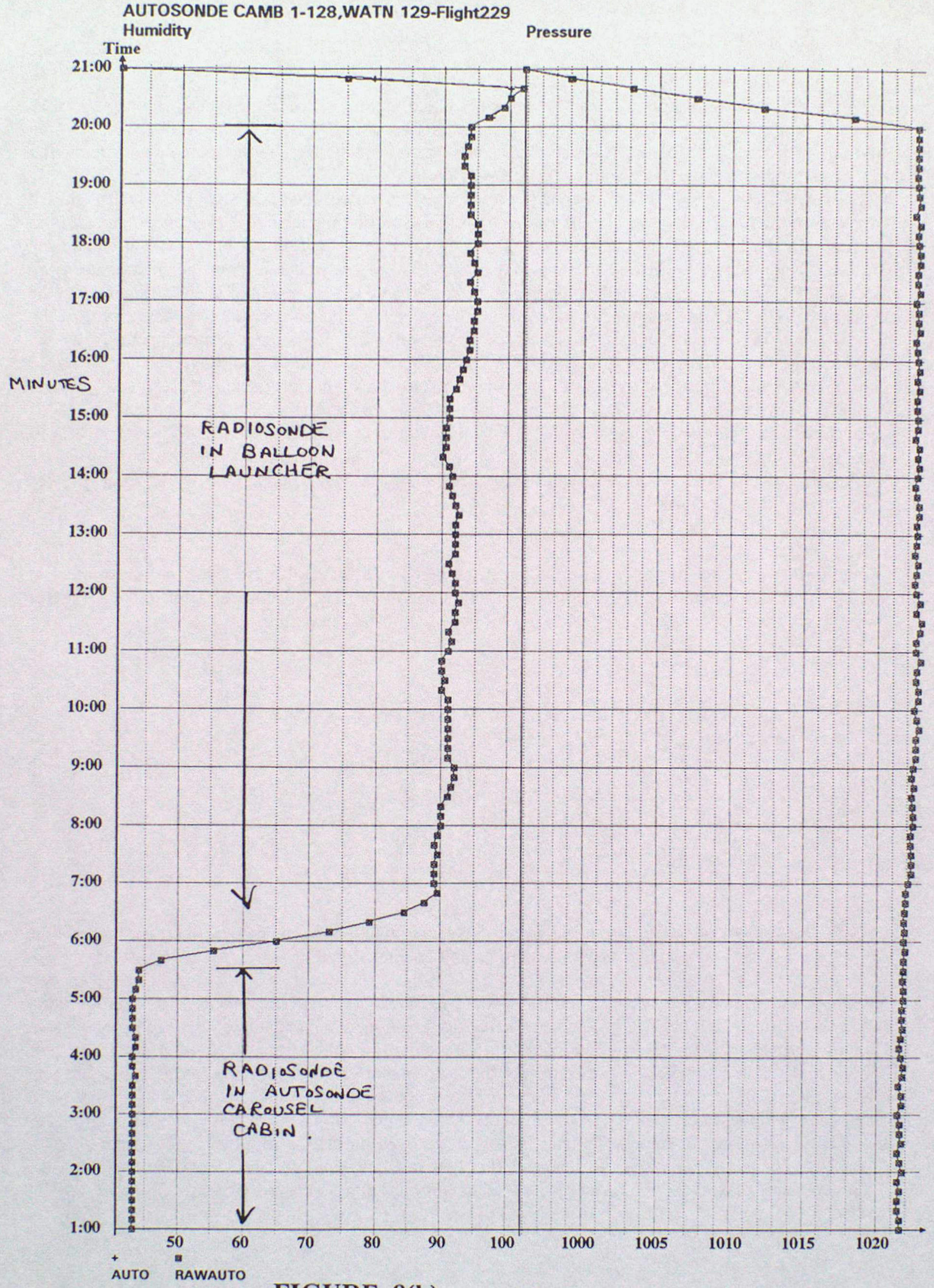


FIGURE 8(b)

CAMBORNE AUTOSONDE TRIAL FLIGHT 119 LAUNCHED IN FOG 13/2/98 2330

5. 4. Wind Measurements.

5.4.1 Trials Results

Whereas the PTU (radiosonde pressure, temperature and humidity) data processing within the MW15 is very similar to that used in the UK Radiosonde Network's PC-CORA systems, the MW15 Loran module processes twice as much Loran phase shift data and is quoted by the manufacturer as giving better windfinding detail and accuracy than PC-CORA.

Simultaneous comparisons were not made during the Autosonde Trial at Camborne which makes it difficult to quantitatively assess the Autosonde system windfinding accuracy. However, simultaneous testing of a similar MW15 against operational PC-CORA Loran wind processing at Camborne during August/September 1998 showed that the MW15 winds were less accurate than those obtained using PC-CORA . This is demonstrated in Figures 9 (a) and 9(b) which compare the mean differences of the RS80 PC-CORA Loran component winds (from the radar reference) with the mean differences of the RS90 Loran radiosonde winds (from the same radar refernce) as computed simultaneously by the MW15. The standard deviation of the MW15 system differences was significantly greater.

In case these findings resulted from radiosonde rather than wind processing differences , several soundings were made monitoring the same radiosonde with both PC-CORA and MW15 groundstations. Figure 10 compares each of simultaneous measurements of PC-CORA and MW15 computed Loran winds from the same radiosonde with the radar winds and AIR GPS winds during the AIR GPS System Trial at Camborne in September 1998. The MW15 computed winds again showed consistently bigger deviations.

5.4.2 Operational Results

Some further evidence of poorer windfinding from the MW15 system can be seen from the amount of interpolated data required to fill gaps in the reported wind data. Table 5 compares the average time of wind interpolations for Watnall and Hemsby for the 4 months of operation.

TABLE 5

MONTHLY PERCENTAGE OF WIND DATA INTERPOLATED PER FLIGHT		
	WATNALL	HEMSBY
JUNE	9.5	4.3
JULY	6.1	3.8
AUGUST	6.0	4.9
SEPTEMBER	5.5	5.0

Thus , the amount of interpolation required to evaluate winds between gaps in the measurements is also greater in the Autosonde's MW15 system than in its operational PC-CORA counterpart.

The large amount of wind interpolation for Watnall in June were largely the result of the configuration of the Autosonde's local Loran antenna. This was positioned on the top of the Autosonde cabin pointing at 45 degrees to the horizontal to preclude possible interference with launches (see photographs in the Annexe). In June , most of the interpolated winds occurred between the surface and the first level when valid winds were obtained. This first measured level was higher than normal since the Autosonde local Loran antenna was not receivimg adequate signals to enable correct Loran tracker synchronisation prior to launch.The antenna was redeployed on the top of a nearby generator shed on June 30th . Figure 11 compares the June and July times of first wind measurements demonstrating the improvement gained from this aerial redeployment . (August and September data are similar to those in July).

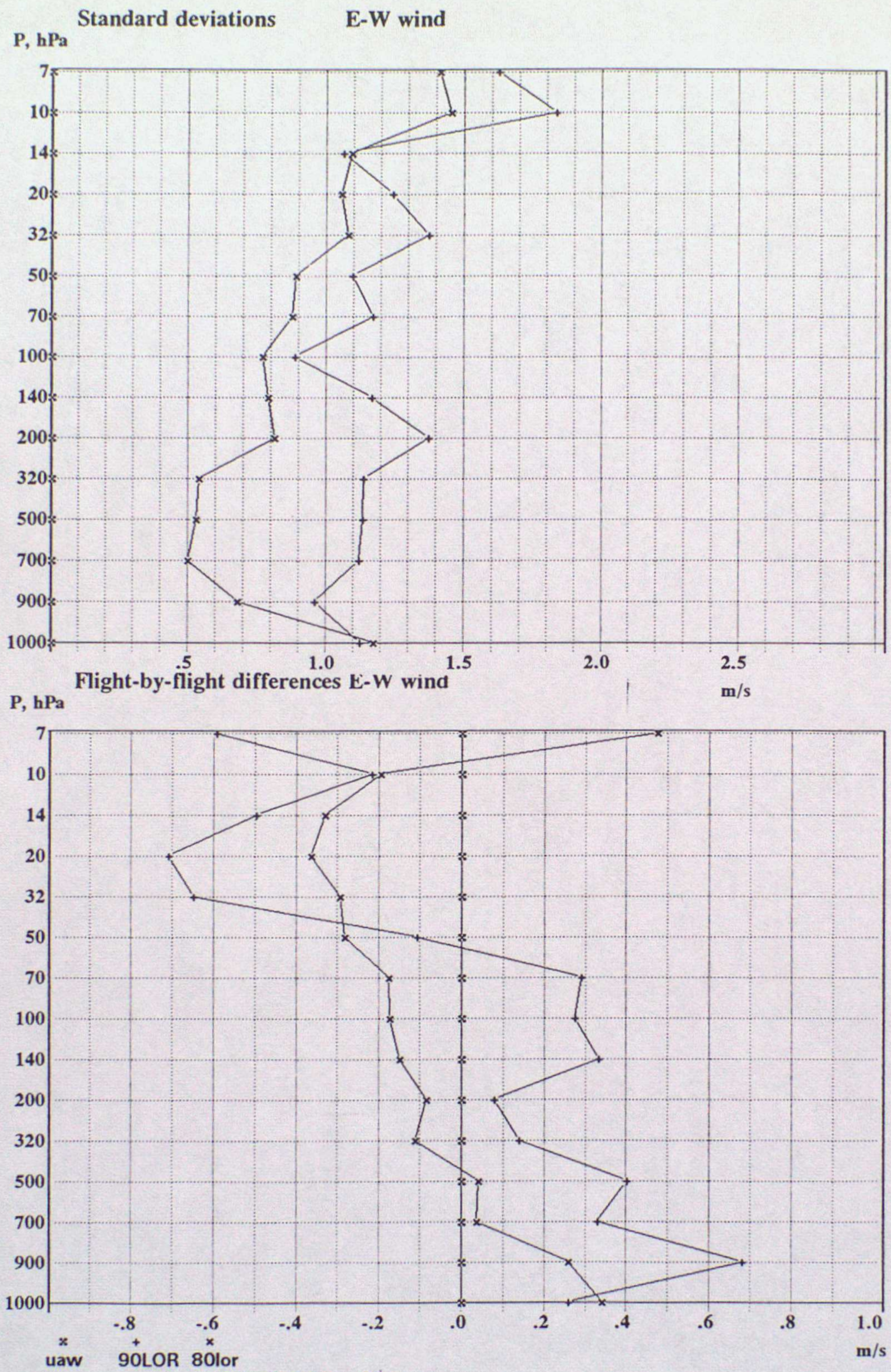


FIGURE 9(a)

RS90 TRIAL - CAMBORNE AUGUST 1998
COMPARISON OF RS80 PC-CORA & RS90 MW15 LORAN EASTERLY COMPONENT
DIFFERENCES (m.s-1) Using RADAR Reference
Flights: 2 3 4 8 9 10 11 12 14 15 16 17 18 19 21
22 23 24 25 26 28 29 30 31 32 33 34 35 36 37 38

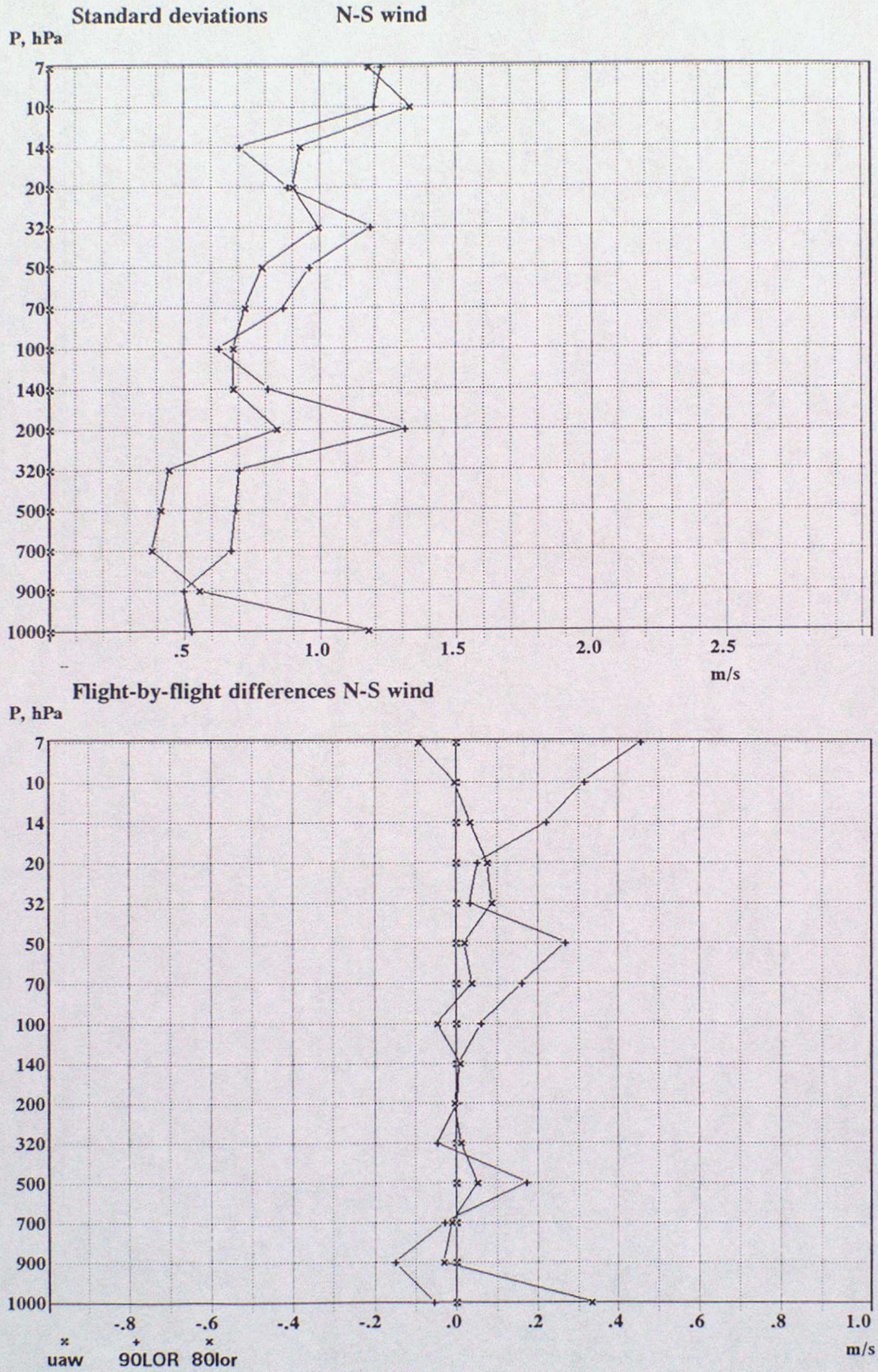


FIGURE 9(b)

RS90 TRIAL - CAMBORNE AUGUST 1998
COMPARISON OF RS80 LORAN PC-CORA SYSTEM WINDS AND RS90 MW15 WINDS

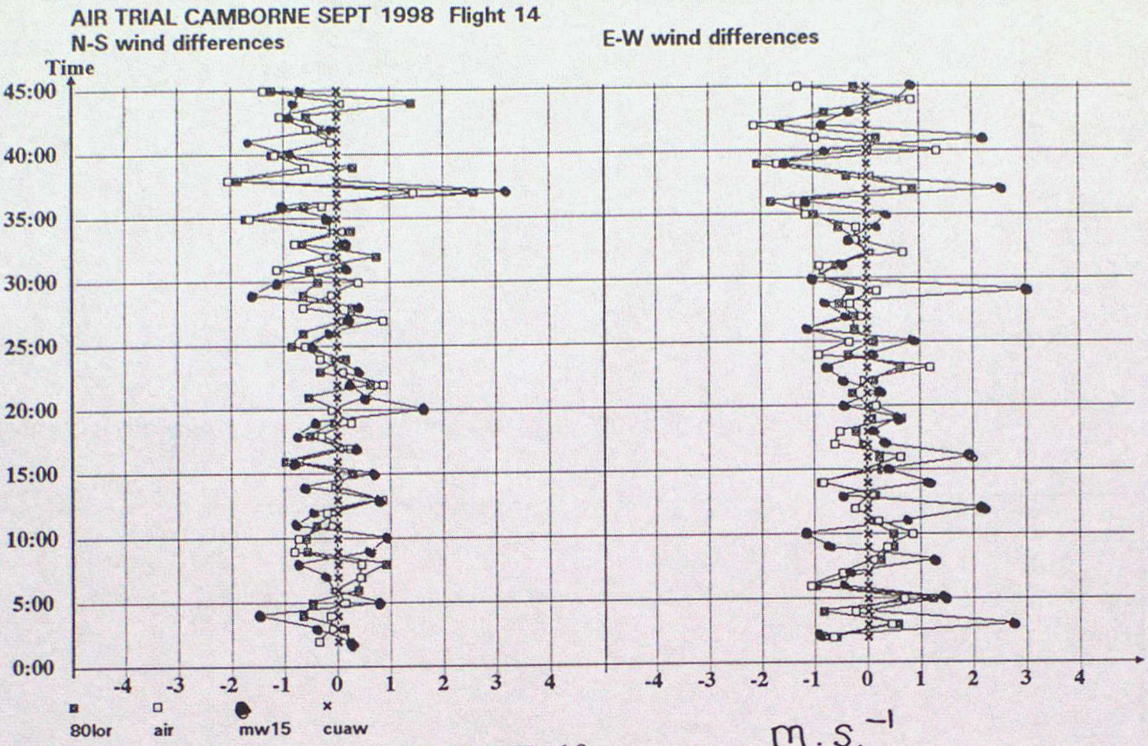
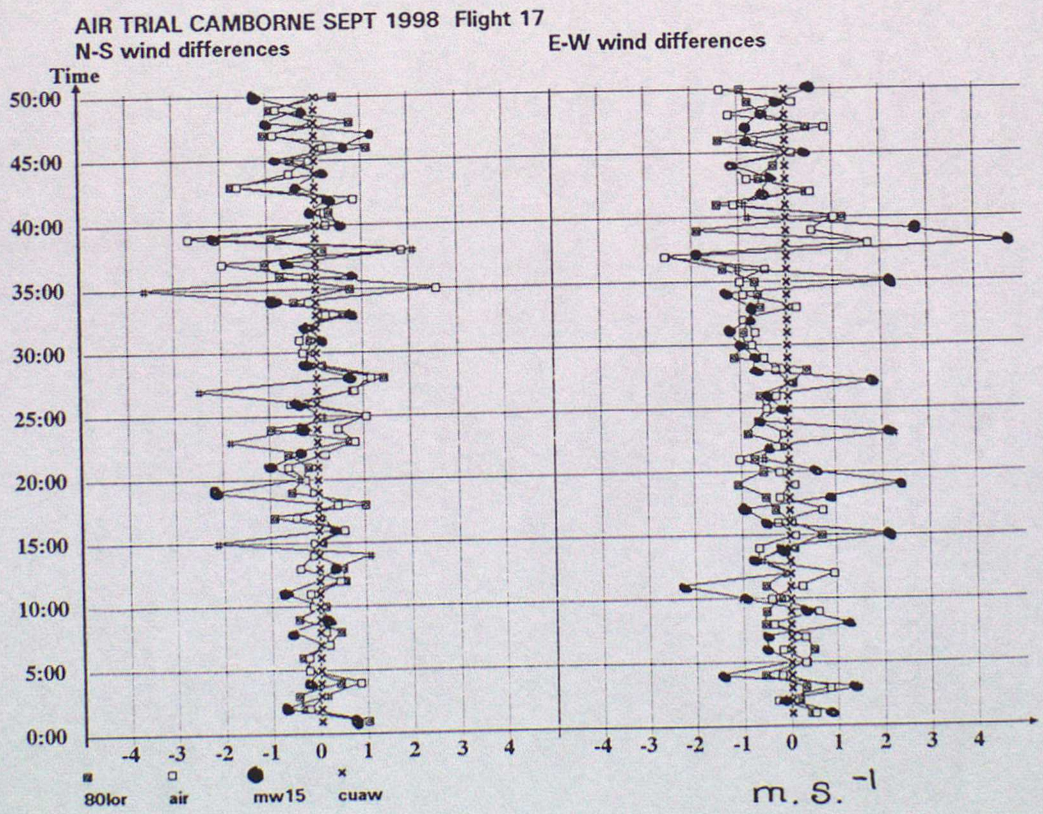


FIGURE 10

COMPARISON OF PC-CORA AND MW15 LORAN WINDS AT MINUTE INTERVALS
(During A.I.R. GPS RAdiosonde Trial , CAMBORNE September 1998)
MW15 and PC-CORA Systems Both Tracking the Same RS80 Loran Sonde
(N.B. Both Flights 14 (above) & 17 (below) show MW15 system winds deviating most from the Radar Reference Winds)



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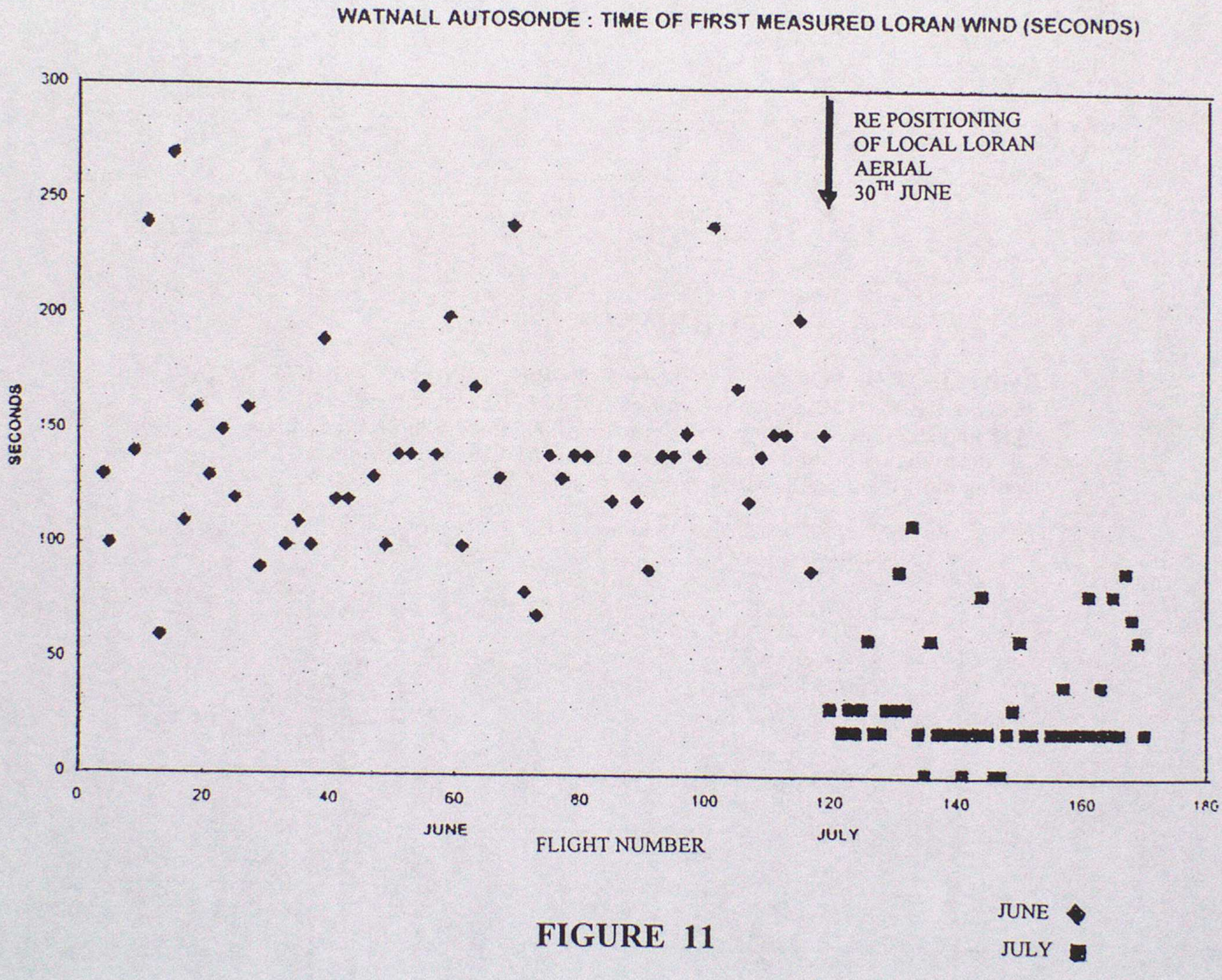


WATNALL AUTOSONDE : TIME OF FIRST MEASURED LORAN WIND (SECONDS)
RE POSITIONING
OF LOCAL LORAN
AERIAL
30TH JUNE
SECONDS
300
250
200
150
100
50
0
0
20
40
60
80
100
120
140
160
180
JUNE
FLIGHT NUMBER
JULY
JUNE
JULY

FIGURE 11

Statistics for mean differences (m/sec , OB-First Guess) of the E-W (U Component) and the N-S (V Component) from the Global Model for September are given in Table 6 below:-

TABLE 6

m/sec	U OB-FG	RMS OB-FG	V OB-FG	RMS OB-FG
WATNALL:				
100 hPa	**-0.3**	**1.4**	**0.2**	**1.6**
500 hPa	**-0.2**	**2.2**	**0.1**	**2.0**
HEMSBY:				
100 hPa	**0.3**	**1.4**	**0.3**	**1.4**
500 hPa	**-0.1**	**2.5**	**0.2**	**2.5**

5.4.3 Simultaneous Windfinding Comparisons Required.

The above results show very similar agreement between the Model statistics for Hemsby and Watnall for this month so it cannot yet be concluded that the greater variability seen in the MW15 winds monitored at Camborne ,necessarily applies to the Autosonde measurements. It is possible for example that a fault exists in the Camborne MW15 system which is not present in the Autosonde MW15 hardware/software.

Further inspection of the winds processed by the replacement Autosonde system should be made by simultaneous comparison of the same Loran radiosonde data in a PC-CORA system.

6 CONCLUSIONS.

1. **The Autosonde system produces radiosonde pressure, temperature and humidity measurements of similar quality to those from the manned operational stations in the UK Network.**

2. **There is some evidence to suggest that the Autosonde wind measurements are not yet optimised, but Model statistics do not show errors significantly different from any other UK manned station.**

3. **The remote "parenting" provided by the staff at Hemsby works well. Generally the edited message is sent to Bracknell by HH+50 . This shows that there is sufficient time to quality control and edit both radiosonde ascents when there are no problems with the Hemsby and Watnall sounding data.**

4. **The "caretaking" task of the Autosonde requires about 70 man hours per month , which is equivalent to employing 1 man on a part time basis for about half his normal monthly working hours.**

7 RECOMMENDATIONS.

7.1 Future Autosonde systems should also be coupled with an existing Upper Air station to act as "parent". Using existing facilities it would not be desirable to remotely control more than one Autosonde site from any one single-manned station.

**7.2 The amount of technical diagnosis and intervention required at Watnall has shown that it would be desirable to site Autosonde systems on or very close to Met ES sites.
This may not in practice be possible as it would depend on whether there were sufficient manual resources at these Met ES sites (eg Glasgow).**

7.3 Checks on Humidity Measurements

1. RS5 should further assess humidity measurements in foggy conditions and continue to evaluate whether the Autosonde soundings show any marked differences from the manned UK sites in evaluating maximum humidities in low cloud and fog.
2. RS5 should further investigate the use of the Autosonde's cabin sensors. Sensors on the replacement Autosonde system may allow better determination of humidity corrections.
3. Controls checking procedure by Met ES staff should ensure that the radiosonde sensor boom is allowed to acclimatise in the Ground Check Set for at least 10 minutes before ground control measurements are made.
4. Regular checks should be made of the dessicant within the Ground Check Set, especially if humidity controls corrections are regularly less than -2%.

7.4 Calibration Checks

Met ES staff should investigate the procedures necessary to calibrate the Autosonde cabin and MILOS (automatic weather station) pressure,temperature and humidity sensors.

7.5 Communications Links.

RS5 should further investigate the optimum times for the parent station to dial in to the Autosonde computer with the view to reducing costs.

7.6 Windfinding

At any future site the local Loran aerial should be removed from the Autosonde cabin and positioned to give best reception.
RS5 should further investigate the Autosonde Loran windfinding to confirm whether the system's wind measurements are less accurate than those measured simultaneously by the PC-CORA system.

7.7 Preflight Rejections.

Met ES should keep a computer record of the reasons for rejecting all Autosonde radiosondes.

7.8 Operational Requirements for Autosonde Messages

Met (OLA) /(OPR) should consider whether the target time specified for the UK Met Office upper air messages (HH+50) should apply to Autosonde messages.
Met (RS5) should request the manufacturer to include BUFR coding within the Autosonde software.This should decrease the amount of operator intervention required by the parent station and also decrease the amount of time and therefore expense of the telephone connection between Autosonde and parent site.

7.9 Future Use of Vaisala RS90 Radiosondes.

RS5 has already conducted a comparison trial of the recently developed RS90 radiosonde . (Report pending). It is likely that the Met Office Upper Air Network will begin to deploy the RS90 in 1999.
The RS90 should provide greater accuracy in its measurements of pressure,temperature and humidity ,but RS5 need to make further tests to determine the robustness of the sensors, especially on being launched from the Autosonde.

8 REFERENCES

[1] Vaisala Autosonde System Trial , Camborne November 1997 to January 1998 - J Elms,R Smout (RS5).
[2] Three Years of Operational Experience of Automatic Balloon Filling and Launching Systems in Sweden. - T. Hovberg,B Rosen, S Stahl . Swedish Met. And Hydrological Institute (SMHI),Sweden (WMO Instruments and Observing Methods , Report No. 70. TECO-98 Morocco WMO/TD No.877)

9 ACKNOWLEDGEMENTS.

The help of the station managers and all scientific and Met (ES) technical staff at Hemsby, Camborne and Watnall is very much appreciated.
Richard Smout (RS5) was responsible for most of the planning and implementation of the Autosonde installations.
Olavi Solanko (Vaisala Oy) provided the technical support during the installations at both Camborne and Watnall.
Colin Parrett (Mesoscale Data Assimilation) provided the Model statistics.

ANNEXE

ANNEXE TABLE 1A

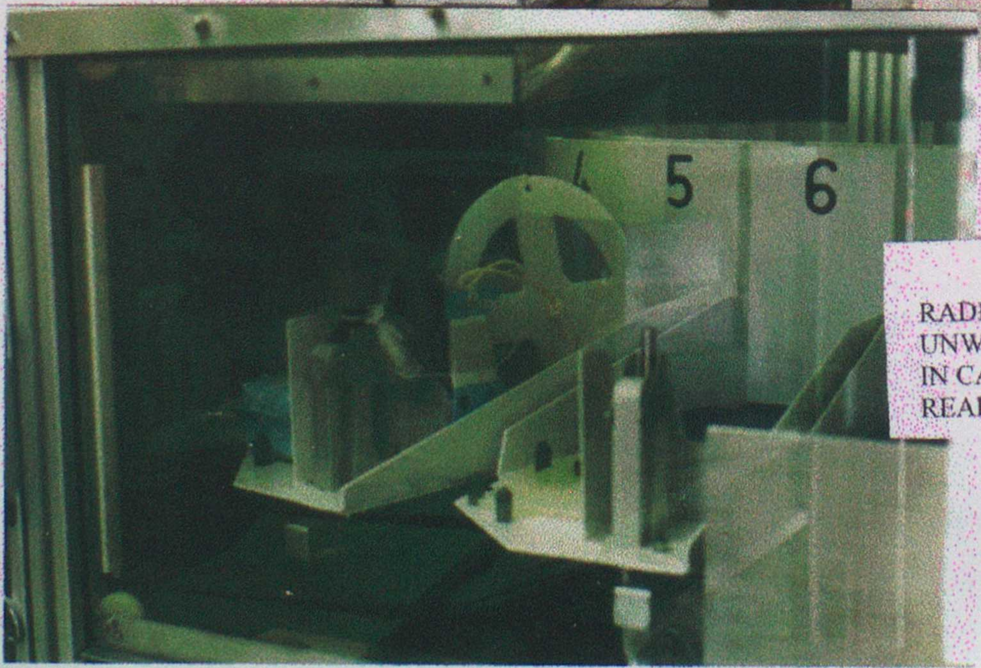
WATNALL AUTOSONDE PERFORMANCE
LATE AND REPEATED MESSAGES

	JUNE	JULY	AUGUST	SEPTEMBER
DATES MISSING	26/12 Not Scheduled (Why?)	9/00 insufficient 9/06 gas avail. 10/12 data corrupt from launch /rpt. Not successful 30/00 GPS board 30/06 failure 30/12 precluded 30/18 these 6 31/00 ascents 31/06	6/06 temp jump not reported. 8/06 launch 8/12 error . 8/18 balloon 9/00 trapped 9/06 in 9/12 launcher 9/18 during 10/00weekend 10/06 14/18 temp jump not repeated 23/18 unwinder 24/00 tangled on 24/06 filler 28/06 remote connection fail (30/00 bst 261 mb no repeat)	5/06 temp jump not reported 29/12 Software fault at Autosonde required Met ES intervention. (Computer "hung up" *(NB 16/12 Flight reported OK to bst,but Archive failed Reason unknown)*
DATES ASCENTS WITH SOME MISSING WINDS	2/12 6/00 8/12 12/00 17/00 21/12	05/06	13/00 16/18 25/00	NIL
DATES REPEATS	5/12 failed in launcher 12/00 bst 257mb 20/12 bst 628 mb 29/12 anomalous rpt 1428Z	8/00 bst 645 mb 12/12 ptu fail 17/06auto rejct/gc 22/06 launch fail 25/12 auto reject 28/12 bst 235	3/12 temp jump 10/12 GC fail spare launched 1121 11/12 GC fail spare launched 1120 12/00 temp jump rpt. 0030 13/00 bad sonde auto rpt 2323 14/00 bst 228 mb 14/12 rig parted on launch auto relaunch 17/12 manual abort bad data.	05/06 temp jump. Repeated but No pressure Decrease seen. Hence ascent "Failed." (2 sondes used) 06/06 Max interp time reached 07/00 Max interp.time reached 12/00 Manual abort temp=3500 C! 23/06 RawPTU timeout @launch 23/12 ditto 23/18 Burst 524 hPa 24/06 1st sonde failed to start. 30/06 Burst 723 hPa
DATES LATE ASCENTS	2/00 2mins late 5/12 146 6/12 1 11/12 46 12/00 55 14/00 18 20/12 46 29/12 172 30/00 21	6/18 10 mins late 8/00 25 10/06 70 12/12 43 13/12 54 (tropics) 15/00 5 21/00 5 22/00 2 22/06 8 23/00 5	3/12 56 min late 12/00 52 14/00 43 17/12 42 18/00 1 20/12 18 22/00 19 23/00 5 26/12 1 27/12 1	6/06 10 min late 6/12 5 6/18 2 7/00 10 8/00 5 9/00 8 10/06 17 12/00 15 15/12 7 15/18 5

	JUNE	JULY	AUGUST	SEPTEMBER
		24/06 3 25/12 10 28/12 50		16/00 11 18/00 5 21/12 4 23/12 45 23/18 15 25/00 1 25/06 1
DATES ANOMALOUS	29/00 (Temp. jump before launch. (REPEAT NOT REQUIRED BY CFO) 29/12 temp jump @722 hPa repeat 1428Z	29/00 (Temp jump 46 mins (200 hPa)	3/12 temp jump on launch repeat 1230 6/06 temp jump not reported 12/00 temp jump on launch repeat 0030 14/18 temp jump not reported 19/18 (Temp jump 1 min. 970 hPa) REPORTED & ARCHIVED	19/18 Temp jump 347 hPa. PTU data reported to 347mb winds to 100 mb
REMARKS	The 3% missing winds is similar to operational wind outages at both Hemsby & Camborne due to planned maintenance of NELS Loran chain.		TEMP JUMP 19/18 NOT SPOTTED BY REMOTE STATION.	

ANNEXE 2

WATNALL AUTOSONDE "PROTOTYPE" SYSTEM MAY TO OCTOBER 1998




ANNEXE A3
METHOD OF ATTACHING UNWINDER
TO PARACHUTE FORMER TO ENABLE
FULL DEPLOYMENT OF SUSPENSION

ANNEXE 4

AUTOSONDE PERFORMANCE
OCTOBER 1998 TO JANUARY 1999

The prototype Autosonde loaned from Vaisala was replaced by a new model of similar design and orientation during the period 28th October to 7th November 1998 .
2 noticeable differences are:-

(i) **A dust filter has been provided for the cabin.**
(ii) **Met –Es have observed that the metalwork of the carousel trays is already beginning to rust from radiosonde battery acid. (The previous version used stainless steel).**

Various problems were caused by automatic helium gas supply on this new system. This required a new float and then a replacement flow meter unit to be despatched from Vaisala Oy. However , gas flow warning messages were still produced and subsequently caused concern until Met Es traced the fault to a faulty electrical connection on one of the sensors.

During the winter months 1998/1999 the performance of the system measured in terms of the percentage of reliable messages transmitted to Bracknell has improved. However , due especially to problems in the communications between Hemsby and Bracknell ,the average percentage of reliable ascents obtained in time for the Model (HH+110) was still about 94% .
The average percentage of reliable messages (valid data to at least 200 hPa) produced and sent to Bracknell by HH+50 has also remained at about 82%. A full breakdown of the performance of the Autosonde over the months October 1998 to January 1999 is given in Table 7 below.

TABLE 7 WATNALL AUTOSONDE PERFORMANCE JUNE – SEPTEMBER 1998

	OCT 98	NOV 98	DEC 98	JAN 99
SCHEDULED SOUNDINGS	109	93	124	124
ATTEMPTED SOUNDINGS	108	91	122	124
NO. MISSING	2	4	4	0
REPEATS REQUIRED	3	2	4	4
PERCENTAGE OF RELIABLE PTUASCENTS OBTAINED (to at least 200 hPa)	**98%**	**95%**	**96%**	**100%**
PERCENTAGE OF RELIABLE ASCENTS IN TIME FOR MODEL (HH+110)	**97%**	**94%**	**90%**	**97%**
NO. OF "LATE" MESSAGES (Received >HH+50) (Received >HH+110)	12 1	13 1	18 7	25 3
% RELIABLE MESSAGES by HH+50	**87%**	**81%**	**82%**	**80%**
NO.ASCENTS with some MISSED WINDS	3	0	0	0
PERCENTAGE WINDS MISSING	**3%**	**0%**	**0%**	**0%**
INTERFERENCE FROM ANOTHER SONDE CAUSED TERMINATION	**3**	**1**	**5**	**5**

Arising from the last four months of operations , two further aspects now require consideration.:-

1. **The suitability of the primary frequencies used by the Autosonde and surrounding stations may need to be reassessed with the aim of reducing the number of Autosonde failures caused by mutual sonde interference.(This will become even more important when WoodVale is operating to the northwest).** N.B. from Table 7 , at least 4% soundings terminated due to mutual interference.
2. **The reasons for the (sometimes) lengthy delay between the operator sending the message and the WIZ/WIN communications system transmitting it from Hemsby to Bracknell need to be assessed.**

The variability of the 100 hPa height during the 4 months October '98 to January '99 is shown in Table 8 below which may be compared with similar Table 3 in the main Report . It shows that the variability of the Watnall Autosonde 100 hPa geopotential height remains slightly greater than that for Hemsby. However the values are not significantly different to those from other manned radiosonde stations in the Network for this period .

TABLE 8

COMPARISON OF 100 hPa HEIGHT VARIABILITY (m)	OCT 98 – JAN 99	
	WATNALL	HEMSBY
NO. OF DIFFS.	97	112
MEAN DAY/NIGHT DIFFERENCE	**-3.6** +/-5	**-1.9** +/- 3
S.D. of DAY/NIGHT DIFFERENCE	23.6 +/-3	20.3 +/- 1
UPPER LIMIT OF RANDOM ERROR IN RADIOSONDE MEASUREMENT	**19.2**	**16.6**

SERVICING TIME – JANUARY 1999

The following figures are quoted to give the most up to date statistics of required monthly technical support. Note that the total is still close to the 80 man hours per month estimated in the main Report . January was unusual ,as gas flow problems were responsible for most of the required investigations:-

TABLE 9 - JANUARY 1999 AUTOSONDE SYSTEM SUPPORT

JOB CATEGORY	**VISITS**	**MAN HOURS**
1. LOADING SONDES AND CHANGING GAS SUPPLY	10	47
2. CORRECTIVE ACTION	3	6.5
3. ROUTINE MAINTENANCE	6	5
4. TECH. INVESTIGATIONS	6 ?	20.5
TOTAL	25	79

<u>Future Developments.</u>

2 further Autosondes have been bought from Vaisala Oy. The first system has passed its acceptance test supervised by Richard Smout (RS5) at the factory in Helsinki and was delivered on 3rd February 1999. It will remain at Beaufort Park until a suitable site is found .

Autosonde system support on the 2 recently purchased systems will probably be shared between Met – Es and a "local" caretaker. The caretaker will be mainly responsible for loading the radiosondes, arranging and changing gas supply,clearing any debris from the launcher and some simple preventative maintenance (categories 1 to 3 in above Table)..Met-Es will provide technical support to resolve system failures. (category 4).

The second Autosonde is due to be delivered at the end of February 1999. Preparations are being made for its installation at RAF Wood Vale near Liverpool. (The nearest Met-Es servicing site would be at Burton Wood (Cheshire) which is about 20 miles away ,but technical support has yet to be arranged. It may be possible for Watnall Met-Es to give technical support to a caretaker near WoodVale. **Due to the more remote support it will be important for parent stations to report problems to the caretakers and/or servicing site(s) as soon as possible.** ***John Elms (3/2/99)***