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Central Forecasting Technical Note No. 16

Monitoring Wind Observations From The Capel Dewi MST Radar

by

A M Radford

February 1994

**Headquarters, Bracknell**

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## 1. Introduction

The Science and Environmental Research Council (SERC) MST radar is sited at Capel Dewi, Wales, and is operated by the University College of Wales at Aberystwyth. Although it is primarily a research facility, vertical profiles of wind up to the lower stratosphere at six-hourly intervals are produced regularly. These are converted to the standard PILOT code format for direct input into the UK Met Office (UKMO) computer system. The data have been stored and processed since May 14th 1992, when the station number 03501 was added to the station list of the Synoptic Data Bank (SDB).

During the early stages of operations (May and June 1992) there were some teething problems affecting both data reception and quality. This report provides an assessment of the availability and quality of the wind observations during the period from July 1992 to March 1993. However due to an error in the SDB between 3 October and 2 November 1992, when the location of station number 03501 was erroneously moved to a point in Scotland, the statistics relating to data quality do not include this 31-day period.

In order to evaluate the quality of the observations we have used the short-period forecast, or background, fields of the UKMO Limited Area Model (LAM) as a basis for comparison. It is generally accepted that this method can provide valuable information for monitoring a wide range of observational parameters, e.g. see Hollingsworth *et al* (1986), and Hall *et al* (1991). The basis of the method is the comparison of observations with the background field interpolated to the observation points - otherwise known as O-B differences.

Contributions to the O-B values come from the measurement error, the background error and the representativeness error (Hall (1992)). In order to minimise the effect of the background error we have compared results with nearby operational radiosonde stations, particularly at Aberporth (station number 03502), which is only 45km away.

Wind data from the Capel Dewi radar are reported at 300m vertical intervals between 2100m and 22100m. In order that they may be processed by the quality control and data assimilation scheme, the heights must be converted to pressure values. This conversion is carried out assuming the model's standard temperature profile which is based on the ICAO standard atmosphere - for details see Dumelow (1991). It is recognised that this conversion process can introduce unwanted errors in the height assignment of wind observations - a change has since been made to use the model background temperature profile. Vertical averaging is then carried out in order to obtain winds on model levels. Full details of this procedure may be found in Ingleby and Parrett (1991).

## 2. Data Availability

The observed data map onto 12 model levels between approximately 792 hPa (level 5) and 55 hPa (level 16). The number of observations available at each of these levels is given in Table 1.

Only 192 observations were received at the lowest level (792 hPa), and at the highest level (55 hPa) there were fewer observations than at the remaining intermediate levels. These levels roughly correspond with the instrument limits, 2100m to 22100m. The distribution of observations between the four data hours is fairly even.



Approximate pressure at model level	Hour (UTC)				All
	00	06	12	18	
55 hPa	167	199	184	171	721
98 hPa	239	244	236	240	959
149 hPa	240	243	236	240	959
199 hPa	240	243	235	240	958
249 hPa	240	243	235	240	958
299 hPa	240	242	235	240	957
354 hPa	240	243	235	240	958
421 hPa	240	243	236	240	959
504 hPa	240	243	236	240	959
599 hPa	239	243	237	240	959
699 hPa	239	242	236	240	957
792 hPa	43	49	47	53	192
Total	2607	2677	2588	2624	10496

Table 1: Number of observations received for each model level by datum hour.

*Note: Another 5 reports were received at some intermediate hours during this period; they have not been included in this table.*

Figure 1 displays the time sequence of availability on a daily basis during the period. Each vertical column represents one day and each row a datum hour. The character plotted represents the number of model levels derived from the report at that time, where A=1, B=2 etc. Most of the time 11 levels ('K') were available. When no report was received no character has been plotted. Apart from a 10-day period between 22 February and 3 March 1993 it can be seen that any 'outages' of data were short-lived.

Table 2 shows the average delay in receiving the data in the SDB during the 9-month period, together with the maximum and minimum times achieved. The data cut-off time for the Limited Area Model (LAM) analysis is 1h 55m after the main synoptic hour. On average the reports were received 36 minutes inside this deadline although there were occasions at 06, 12 and 18 UTC when they arrived too late to be used in the main run of the LAM.



Hour (UTC)	Minutes after observation time		
	Minimum	Mean	Maximum
00	64	75	96
06	63	81	341
12	68	82	147
18	63	78	242
All	63	79	341

Table 2: The delay in receiving Capel Dewi PILOT data.

### 3. Data Quality

The assessment of data quality covers the period between 1 July 1992 and 31 March 1993, but excluding a 31-day interval between 3 October and 2 November 1992 for reasons already noted in the introduction. During this period a total of 846 observations were received.

#### (i) Quality control decisions

The automatic quality control carried out by the data assimilation system assigns a 'probability of gross error' value to each observation used; if this value is above a certain threshold then the observation will be 'flagged' and not used in the analysis. Only one report during the study period was flagged. This was on 24 November at 0600 UTC when the wind speed assigned to model level 11 (299 hPa) was approximately  $26 \text{ ms}^{-1}$  compared with a model background value of  $46 \text{ ms}^{-1}$ . The most likely cause of the flagging was an error in the background field since the radiosonde observation from Aughton (03322) was consistent with the profiler. Unfortunately there were no wind observations for comparison from Aberporth on that day.

#### (ii) Vertical profiles

Mean and root mean square (rms) values of O-B (observation minus background) and O-A (observation minus analysis) differences on model levels have been calculated for all reports received during the period. The one observation that was flagged by the assimilation has been excluded from the statistics.

Figures 2(a) and 2(b) show vertical profiles of the mean and rms differences for wind speed and wind direction; the solid and dashed lines indicate the O-B and O-A profiles respectively; the numbers on the right-hand side of each graph indicate the sample size and the number of flagged data which have been excluded. It is apparent that there is a negative mean O-B speed difference (bias) in the troposphere of 1 to  $2 \text{ ms}^{-1}$ , decreasing slightly in the stratosphere; the



corresponding profile for Aberporth (03502) for the same period (see figure 3(a)) shows a small, positive tropospheric bias but a similar stratospheric pattern. Although the sample size for Aberporth is smaller, because ascents are only made in the morning, the same difference is seen when comparing with the two main radiosonde stations at Camborne and Aughton (not shown). The rms speed difference (figure 2(b)) is comparable with that at Aberporth (figure 3(b)) except at the top and bottom of the profile - the limits of the instrument - and around the jet stream the values for the profiler are up to  $1 \text{ ms}^{-1}$  less than those for the Aberporth radiosonde.

The direction bias (figure 2(a)) is small (less than the precision of 5 degrees available in a PILOT report) throughout most of the profile and is similar to that at Aberporth (figure 3(a)) and Camborne and Aughton (not shown). All four stations show a small positive bias around 700-850 hPa - this is a characteristic found at most land stations and is probably due to inadequacies in the model's boundary layer parameterisation. However the increased mean and rms direction differences at the very top of the Capel Dewi profile are not reflected (to the same extent) at the other stations indicating, as with the speed, a rather poorer quality here. In general though, the rms direction differences are around the same level as those at the nearby radiosonde stations.

### *(iii) Wind speed errors*

Taking a more detailed look at the wind speed statistics, Figure 4 shows the mean O-B differences (for Capel Dewi and Aberporth) stratified into wind speed classes, or bins. The appropriate bin is calculated by averaging the observed and the background wind speeds. The bias in the profiler observations compared with the background tends to increase as the wind speed increases, but even at relatively low wind speeds the negative bias is still greater than  $1 \text{ ms}^{-1}$ . On the other hand the radiosonde observations show very little bias at  $50 \text{ ms}^{-1}$  and below. At higher speeds there is a positive bias of around  $3-4 \text{ ms}^{-1}$ , probably indicating an underestimation in the background field. This would imply that the 'true' negative speed bias of the profiler data at high wind speeds is even larger than that shown by the O-B statistics.

Figure 5 shows the same information but presented in a different form. This time the mean O-B wind speed percentage differences have been plotted, i.e. each O-B value has been expressed as a percentage of the background wind speed and put in the appropriate speed bin. The profiler observations of wind speed are on average around 5% lower than the background field and are worse at lower wind speeds. The radiosonde observations show an increase over the background. Figure 6 separates the percentage O-B speed differences for the profiler and radiosonde into different vertical layers - below 700 hPa, 700-500 hPa, 500-300 hPa, 300-100 hPa and above 100 hPa. Now it is clear that most of the differences between the stations are occurring below 100 hPa. In fact the profiler observations become worse with respect to the background field lower in the atmosphere. The fact that both observing systems show a negative bias of around 4% above 100 hPa suggests that the model background fields at these levels are too strong.

## 4. Summary

Over the 9-month period from 1 July 1992 to 31 March 1993, 846 PILOT reports were received from the Capel Dewi MST radar. Data reception was good apart from a 10-day period between 22 February and 3 March 1993. Excepting observations received during the time when the station location was incorrectly assigned, only one report was flagged by the



automatic quality control system and this was probably due to an error in the background field.

There was little or no bias in the observations of wind direction, and the rms O-B direction differences were around the same level as those at surrounding radiosonde stations. However, the mean O-B wind speed differences showed a negative bias (under-forecasting) of around  $1-2 \text{ ms}^{-1}$  in the troposphere, decreasing slightly in the stratosphere. Comparison with surrounding stations suggests that this was due to errors in the observations rather than the background field. The percentage speed error was around -5% overall, but became worse lower in the atmosphere and at lower wind speeds. Errors above 100 hPa were difficult to assess because of a possible problem with the background fields. The rms O-B speed differences were comparable with nearby stations in the troposphere, but were worse in the stratosphere and the lowest layer.

The problems reported here are known by the operators of the MST radar at Capel Dewi and action is being taken to correct the negative speed bias (Nash, *pers. comm.*). In particular, increasing the pulse beam angle from  $6^\circ$  to  $9^\circ$  or  $12^\circ$  may have a positive effect, although the return signal strength tends to be reduced.

#### 5. Acknowledgements:

Most of the data extraction was done by S.R. Waters (CF).

Figure 1 was produced using the SAS statistical package.

#### References:

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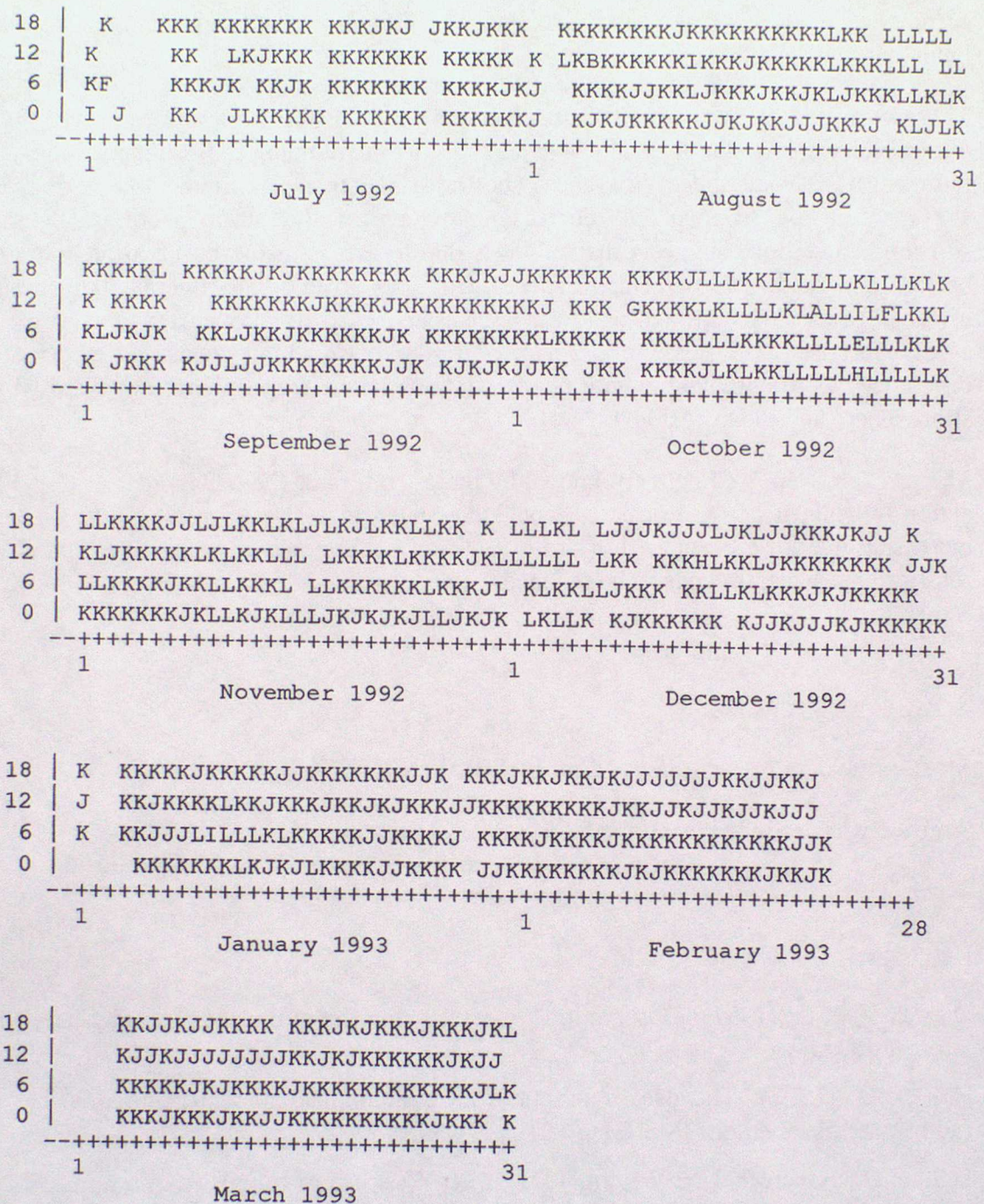


Figure 1: Availability of ascents from Capel Dewi. Plot of observation hour v date. Legend: A = 1 level, B = 2 levels, etc..., K = 11 levels.



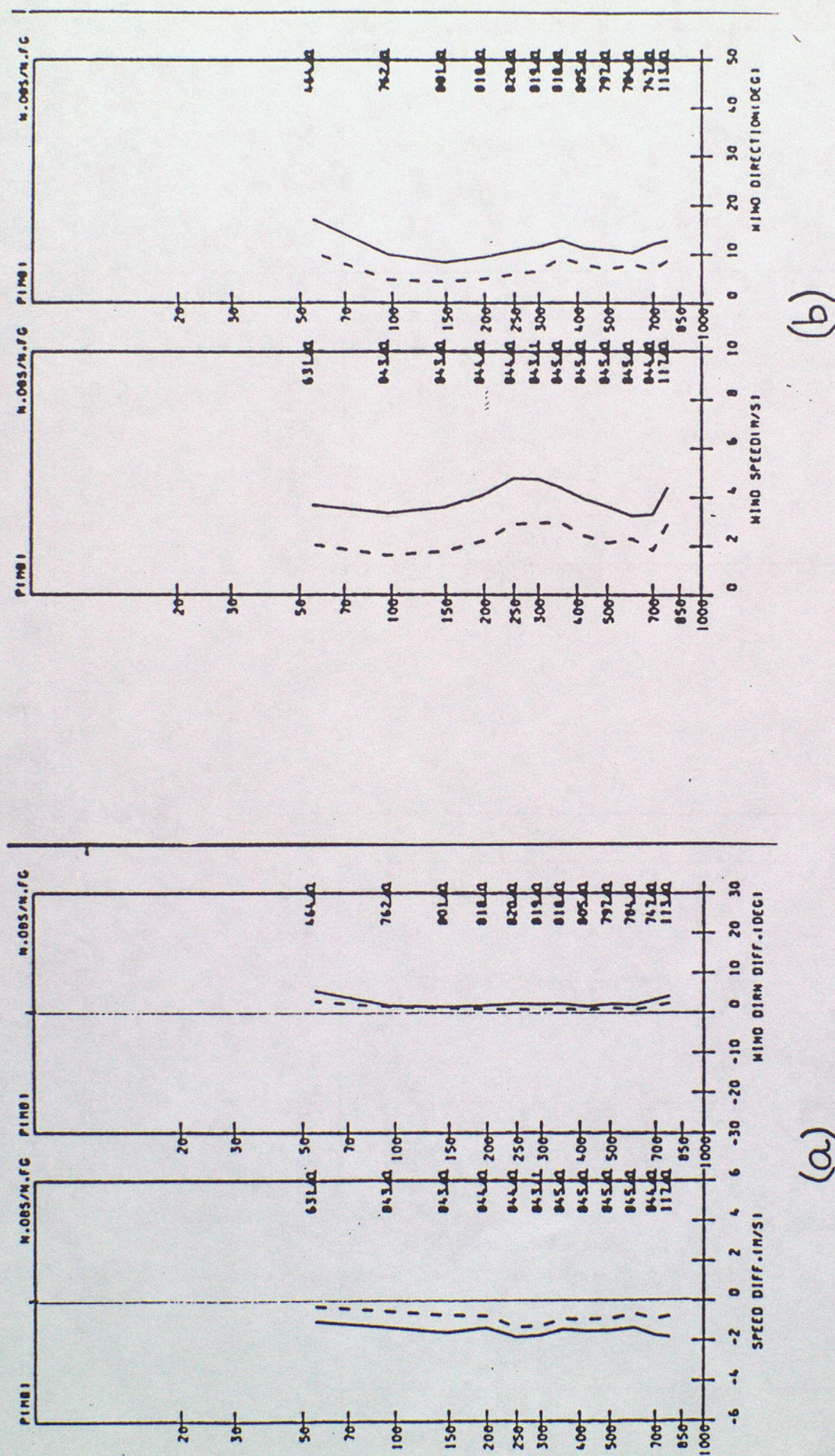


Figure 2: Vertical profiles of (a) mean, and (b) rms observed-background (solid line) & observed-analysis (dashed line) values of wind speed and direction at Capel Dewi (03501) for all analysis hours. Period is 1 July 1992 to 31 March 1993, excluding 3 October to 2 November.



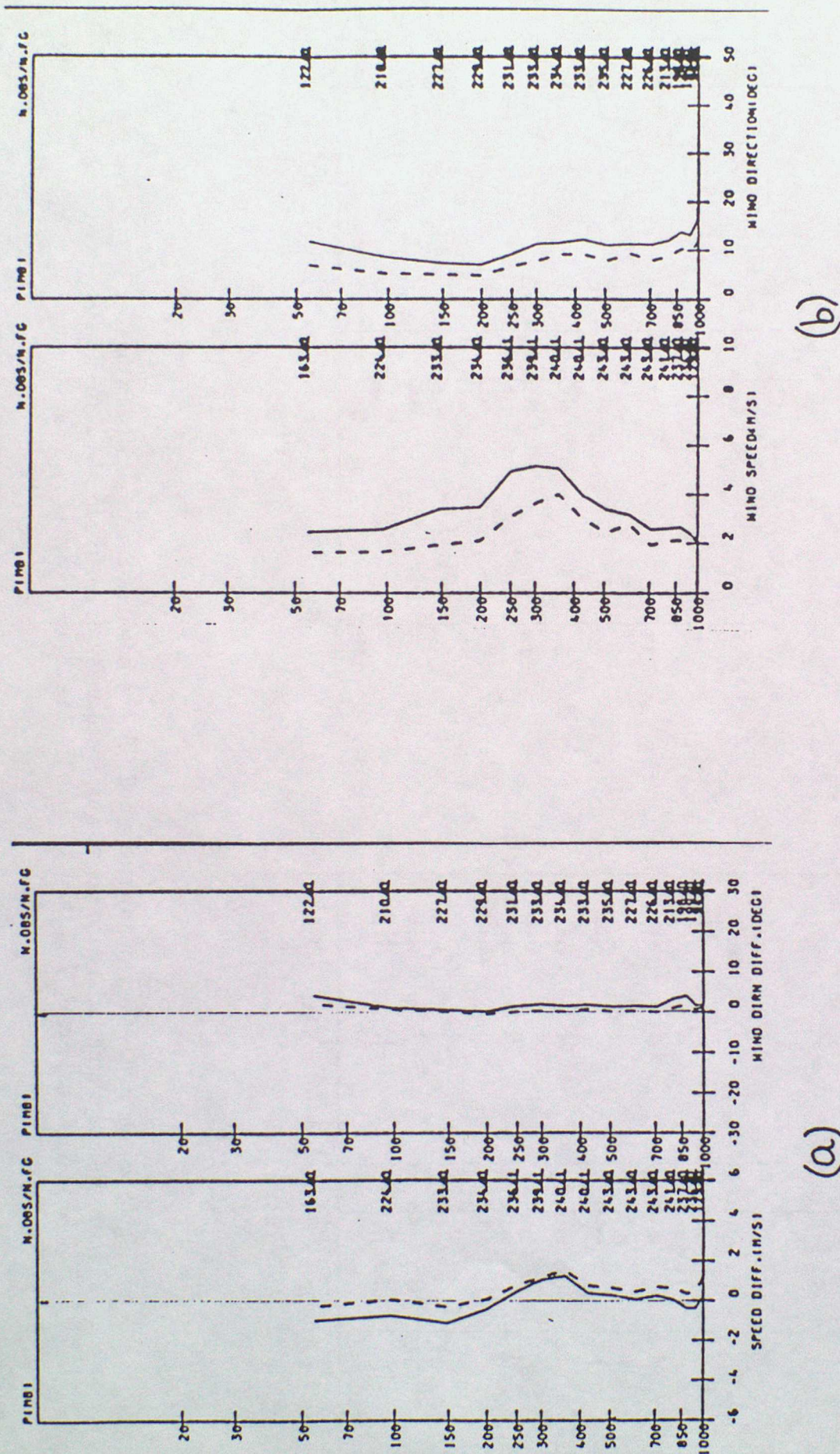


Figure 3: Vertical profiles of (a) mean, and (b) rms observed-background (solid line) & observed-analysis (dashed line) values of wind speed and direction at Aberporth (03502) for all analysis hours. Period is 1 July 1992 to 31 March 1993, excluding 3 October to 2 November.



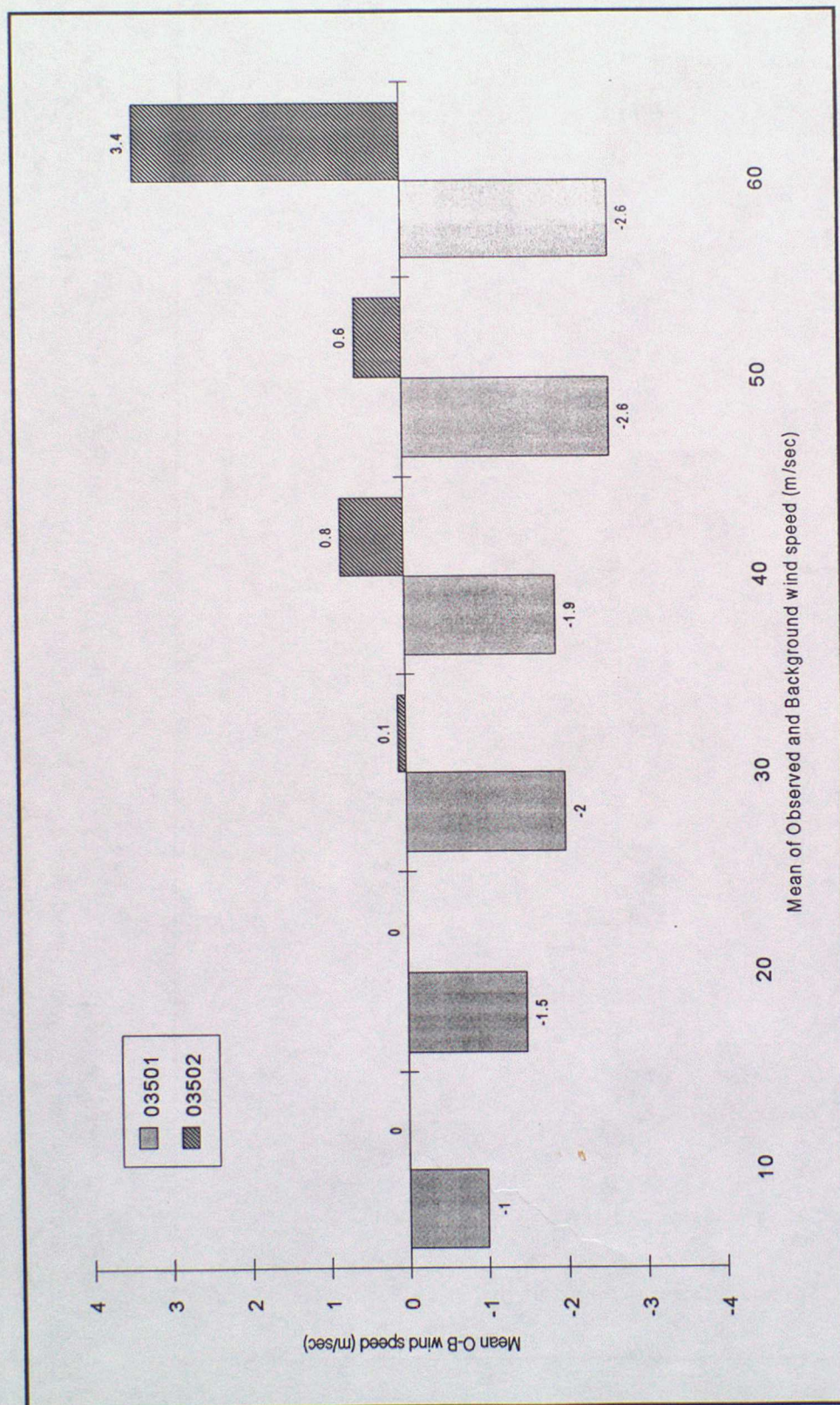


Figure 4: Mean O-B wind speed differences for the Capel Dewi profiler (03501) and the Aberporth radiosonde (03502). Data have been stratified into wind speed classes of  $10 \text{ ms}^{-1}$  centred on the values shown, i.e.  $5\text{--}15 \text{ ms}^{-1}$ ,  $15\text{--}25 \text{ ms}^{-1}$ , etc. The sample sizes for wind speed classes above  $60 \text{ ms}^{-1}$  are too small to be considered.



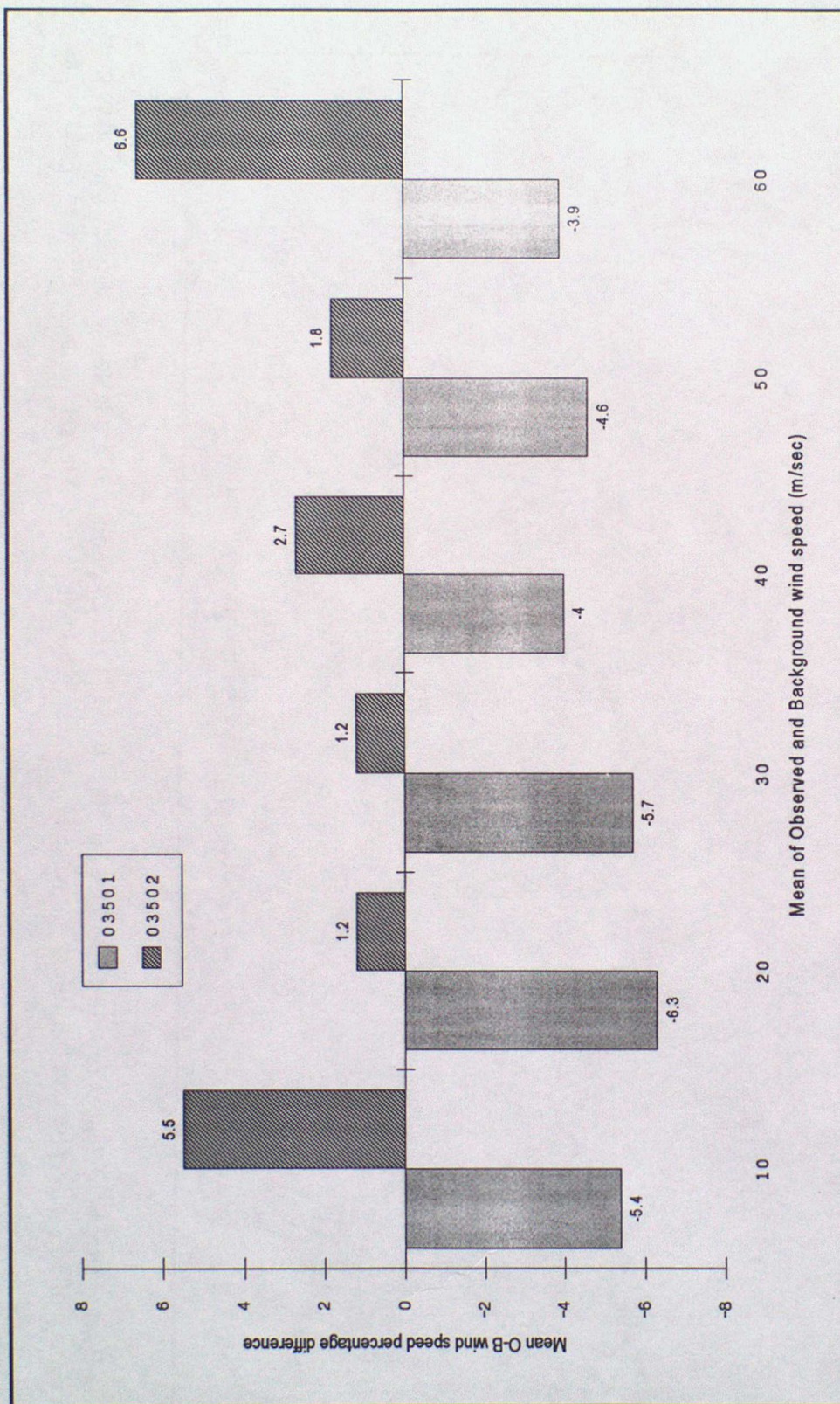


Figure 5: Mean O-B wind speed percentage differences ( $100 \times (O-B)/B$ ) for the Capel Dewi profiler (03501) and the Aberporth radiosonde (03502). Data have been stratified into wind speed classes of  $10 \text{ ms}^{-1}$  centred on the values shown, i.e.  $5\text{-}15 \text{ ms}^{-1}$ ,  $15\text{-}25 \text{ ms}^{-1}$ , etc. The sample sizes for wind speed classes above  $60 \text{ ms}^{-1}$  are too small to be considered.



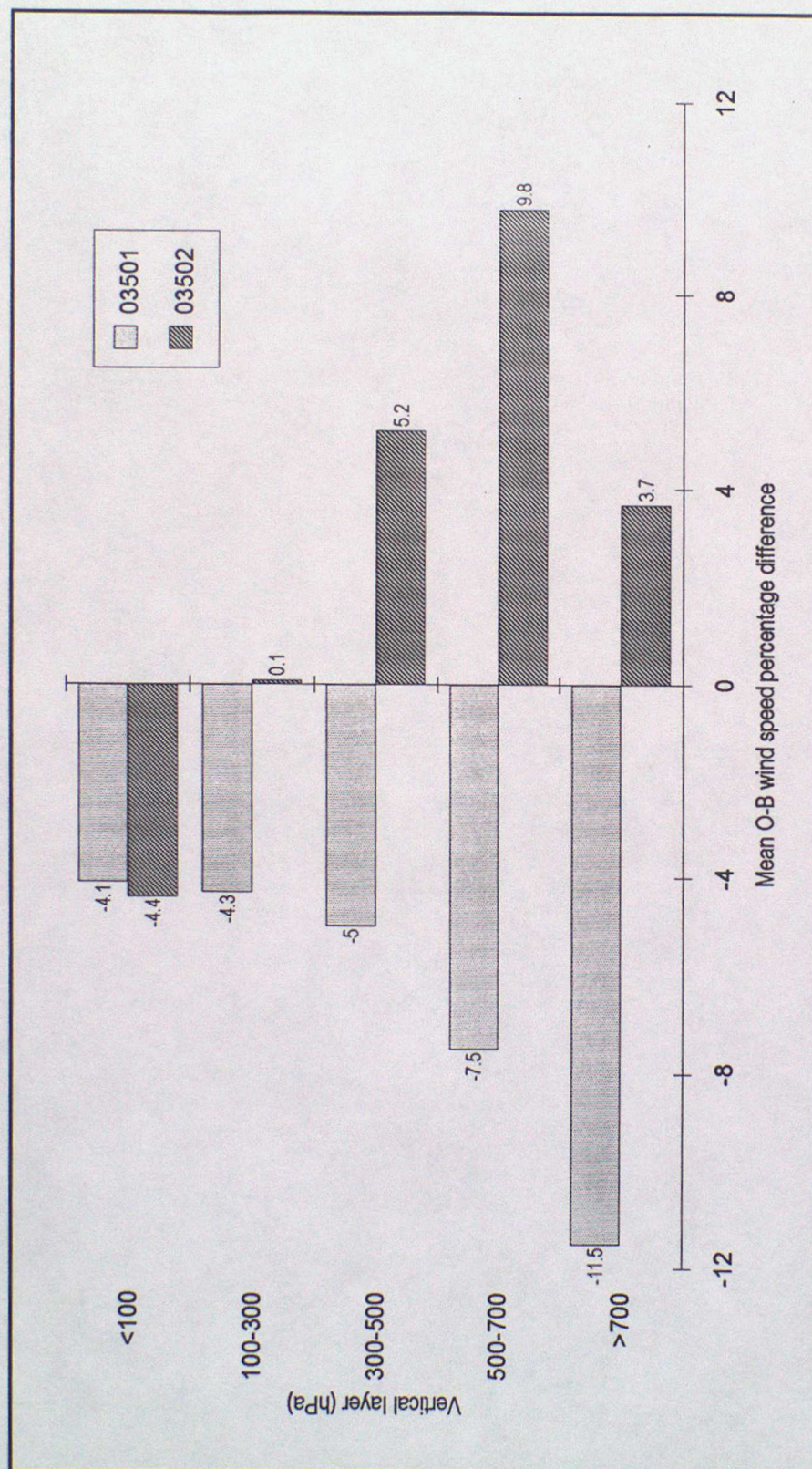


Figure 6: Mean O-B wind speed percentage differences ( $100 \times (O-B)/B$ ) for the Capel Dewi profiler (03501) and the Aberporth radiosonde (03502). Data have been stratified into vertical layers.