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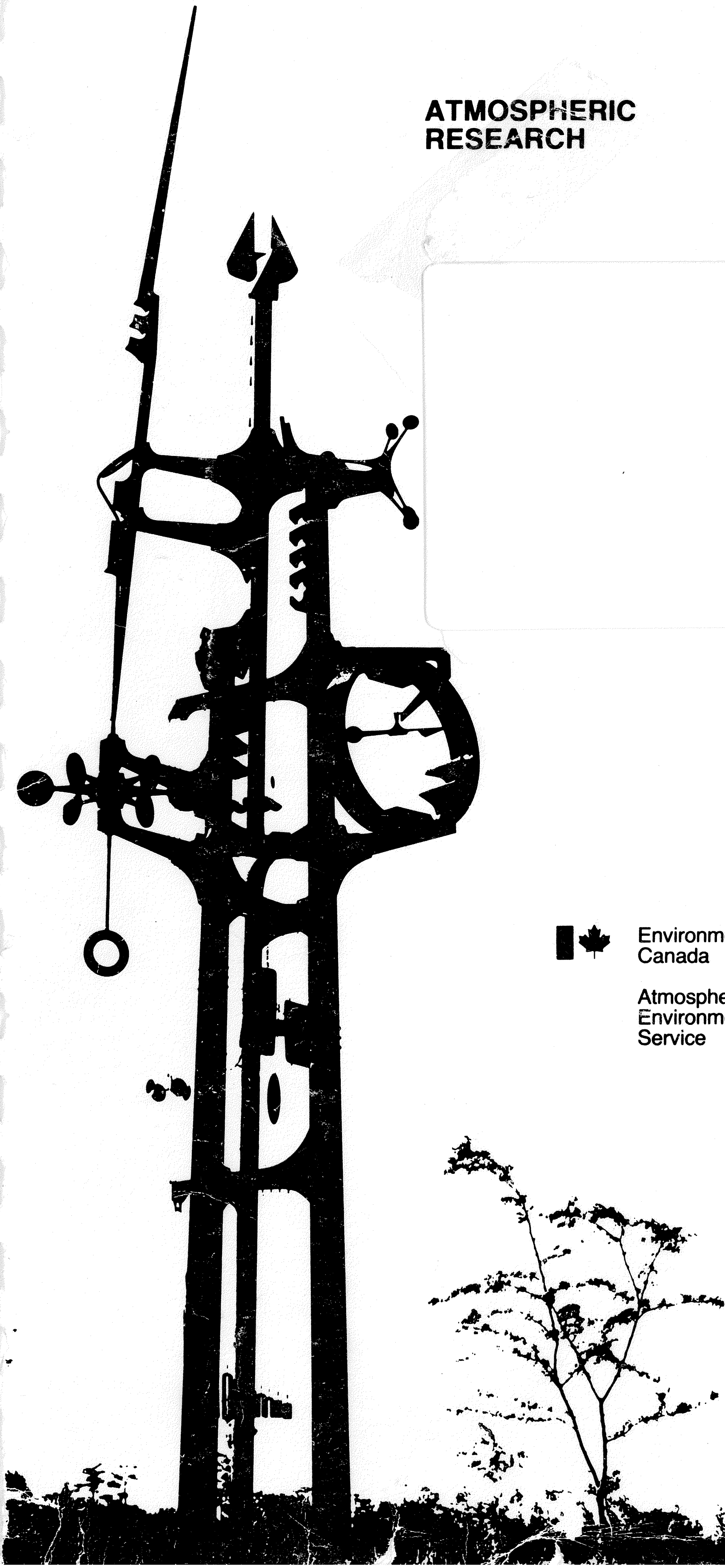

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The Askervein Hill Project: Report on the Sept./Oct. 1983, Main Field Experiment

by

P.A. Taylor and H.W. Teunissen

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ABSTRACT

Askervein '83 was the main field experiment of a collaborative study of boundary layer flow over low hills carried out under the auspices of the International Energy Agency Programme of R&D on Wind Energy Conversion Systems. The experiment was conducted during September/October 1983 on and around Askervein, a 116m high hill on the west coast of South Uist.

During the experiment approximately 50 towers were deployed and instrumented for wind measurements. The majority were simple 10m posts bearing cup anemometers but two 50m towers, a 30m tower, a 16m tower and thirteen 10m towers were instrumented for 3-component turbulence measurement.

The present report includes data from the towers as well as background siting and meteorological data and wind speed profile data from TALA kites. The data are being used for detailed comparison with numerical and wind-tunnel model studies. They provide a valuable record of wind speed and turbulence modifications in the flow over a low hill which is typical of many potential WECS sites.

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1. INTRODUCTION

Askervein is a 116m high (126m above sea level) hill on the west coast of South Uist, one of the islands of the Outer-Hebrides (Scotland). As discussed by Taylor and Teunissen (1983), hereafter referred to as ASK82, it was selected as the site for the field experiments which form the major component of Task VI of the IEA Programme of R&D on Wind Energy Conversion Systems (WECS). A preliminary study (Askervein '82) was conducted in September/October 1982 and reported on in ASK82. The present report covers the main field experiment conducted during September/October 1983 which will be referred to as Askervein '83.

Groups participating in the experiment were from the Atmospheric Environment Service (AES), Canada, the Riso National Laboratory (RISO), Denmark, the University of Hannover (U. of H.), Germany, the University of Canterbury, New Zealand and from both the Building Research Establishment (BRE) and ERA Technology Ltd. (ERA) in the United Kingdom. The abbreviations given above will be used throughout the report.

The basic objective of the Askervein study is to further our understanding of boundary-layer flow over relatively low hills, especially as it relates to WECS siting. Factors of particular significance include the mean wind 'speed-up' and the modifications to the turbulence which occur as air flows over a hill. As indicated in ASK82, data from the Askervein field experiments are being used to evaluate and refine physical (wind tunnel) and mathematical modelling techniques.

The original 'detailed programme of work' for IEA, R&D WECS, Task VI (see ASK82, Appendix A) set the goals of Askervein '83 as:

a) detailed resolution of mean wind and turbulence fields in several vertical cross-sections through the hill using 10m towers and tethersonde profiling systems;

b) a detailed study of the characteristics of turbulence above the hilltop to heights of at least 50m.

In our revised plans, drawn up in May '83, we amended the original instrumentation lists to replace tethersonde systems by TALA kite systems. With this minor change we were able to meet the goals stated above, although most of the data give wind and turbulence variations along lines at a fixed height (usually 10m) above ground level plus one or two vertical profiles rather than throughout well-defined vertical cross-sections.

2. ASKERVEIN '83, OVERVIEW

To avoid undue repetition the reader is referred to ASK82 for much of the background material on the site and its climatology. In summary, however, it is noted that Askervein (Figs. 2.1, 2.2) is a 126m high hill of essentially elliptical plan form with a 1 km minor axis and a 2 km major axis. The major axis is aligned approximately NW - SE while the predominant winds during the period of the experiment were expected to be from the SW - that is, roughly along the minor axis of the hill. For this direction the upstream terrain is flat and uniform to the coast, which is about 3 km away from the hilltop. An upstream reference site (RS) was established approximately 3 km to the SSW of the hill near Daliburgh to make detailed measurements of the undisturbed upstream flow. Also a base station (BS) for support of operations on the hill was located in flat terrain immediately SW of the hill (see Fig. 2.1). Hill locations have been identified relative to the summit (HT) which lies towards the NW 'end' of the hill. In particular towers were deployed along lines through HT and CP (the approximate centre point of the hill) which were designated as lines A, AA and B (see Fig. 2.6a). Locations along these lines are denoted by a code which includes the line identifier (e.g. A), the direction along the line (e.g. SW) and the approximate distance from HT (or, for line AA only, from CP) in tens of metres. Thus ASW85 is a location approximately 850m SW of HT along line A. Exact locations of HT and all towers were determined by theodolite survey and are given in section 2.2.

The basic timetable for Askervein '83 was:

Sept.14 - Sept.24	:	set-up and testing of instruments;
Sept.25 - Oct. 10	:	main observing period;
Oct. 11 - Oct. 18	:	dismantling and removal of equipment.

Times will be given throughout in British Summer Time (BST) unless stated otherwise. BST=GMT + 1 hr.

2.1 BACKGROUND METEOROLOGICAL DATA

2.1.1 Daily Weather Maps and Other Records

Daily weather maps for the main observing period 25 Sept. to 10 Oct. 1983 are shown in Fig.2.3, while Table 2.1 is a summary of weather conditions. The weather was generally unsettled during the main observing period after an anti-cyclone tracked to the south-east across the British Isles and gave way to a series of depressions passing eastwards to the north of Scotland. The strongest winds we experienced at the site occurred during our setting-up period (on 18 September) as an intense depression (96.8 KPa) tracked just to the north of Scotland. The anemometer at the reference site recorded winds gusting to $25 ms^{-1}$ that afternoon while those of us on the hilltop experienced real difficulty in merely standing up and estimated local winds to be about $40 ms^{-1}$. Pressures recorded at BS dropped to 97.4 KPa as the storm passed.

Continuous, on-site recording of basic meteorological data included 10m windspeed and direction at RS and HT and pressure, temperature and humidity at BS. Stripchart outputs from the sensors concerned have been analyzed and hourly averages from RS and BS are plotted for the main observing period in Fig. 2.4. Periods of rain are also indicated based on stripchart records from a tipping-bucket rain-gauge located at RS.

Comparisons of Figs. 2.3 and 2.4 identify such features as a period of reasonably steady SW winds on 25, 26 September and the passage of a weak front in light winds on the afternoon of 27 September. This was followed by three days of, from our point of view, rather undesirable easterly winds. The approach of a depression on 30 September, 1 October can also be seen. This feature provided us with two days of generally S to SW winds on 2 and 3 October giving way to unsettled conditions on 4 October as a complex system of fronts passed through the area. Moderate-to-strong ($\sim 10 ms^{-1}$) W to NW winds gave good conditions for observations on 5 October while on 6 October frontal passages and persistent rain gave highly variable conditions. The afternoon of 7 October had moderate-to-strong ($\sim 10 ms^{-1}$) westerly winds. These were not as steady as we would have wished but the period has nevertheless provided useful data.

Fig. 2.4 also identifies the times at which AIRsonde flights were made at BS, periods identified as mean flow runs and the main periods during which turbulence data were collected.

2.1.2 Estimates of Geostrophic Wind and Baroclinicity

Atmospheric boundary layer flow is driven by the horizontal pressure gradient. It is often assumed that the relevant pressure gradient does not change with height. However, if the flow depth to be considered exceeds something like a hundred meters the height dependence of the pressure forcing should be accounted for. The results obtained by Estoque (1973) demonstrate this very clearly.

The data available to do this here are rather limited. They comprise published weather maps (Europaischer Wetterbericht, 1983 and Berliner Wetterkarte, 1983) as well as the basic weather charts used operationally by the German weather bureau (Deutscher Wetterdienst). From this material the horizontal surface pressure gradient $\nabla_h p$ at 00z was deduced. Using the geostrophic wind relation (equation 1) a geostrophic wind vector $\underline{V}_g$ at the surface was estimated as

$$\underline{V}_g = \frac{1}{\rho . f} . \underline{k} \times \nabla p \quad . \tag{1}$$

Here ρ stands for air density and f for the Coriolis-parameter. The results in terms of speed in ms^{-1} and wind direction of this geostrophic wind are summarized in Table 2.2.

To get an idea of the vertical changes of the geostrophic wind the concept of the thermal wind was applied. The thermal wind only occurs in a baroclinic atmosphere. The changes of $\underline{V}_g$ with height, z, may basically be described according to the equation

$$\frac{\partial \underline{V}_g}{\partial z} = - \frac{g}{f . T} . \nabla T \times \underline{k} . \tag{2}$$

Here g denotes gravity and T the air temperature.

To investigate the baroclinicity, data from the surface and the standard isobaric levels of 85 kPa and 70 kPa were used as available from the appropriate maps. As the accuracy of the data taken from the maps is not particularly high the baroclinicity is given in three classes. The first class includes all cases with (according to this preliminary analysis) geostrophic wind speed changes between the surface and the 85 kPa-level (roughly 1500m above the ground) less than 4 ms^{-1}. In these cases no direction of the thermal wind between these two levels is given. When the thermal wind (surface - 85kPa) was moderate, (4-7 ms^{-1}) its direction is listed in Table 2.2. This applies as well in strongly baroclinic conditions, when the thermal wind speed exceeds 7 ms^{-1}. In these cases the estimated speed is given in brackets.

As can be seen from Table 2.2, strong baroclinicity is closely linked to synoptic-scale disturbances, and in particular to their frontal systems. On days with frontal passages the estimated time and the type of the fronts are listed in Table 2.2. Note that all data in Table 2.2 should be treated as estimates only.

2.1.3 AIRsonde Profiles

In order to investigate the structure of the boundary layer to 2 km, AIRsondes were released at times appropriate to the mean flow and turbulence runs. The sondes, borne aloft on 100 gm balloons, transmitted back (403.5 MHz) to a micro-computer-based ground station (ADAS) sequential samples every 5 seconds from a thermistor (time constant, τ, ~ 1 sec), carbon hygristor (± 2% accuracy) and capacitance barometer (± 0.2 mb). The expendable sondes were also tracked with an encoded theodolite to determine depth-averaged wind speed and direction every 15 seconds during the ascent. Plots of ambient temperature (Ta±0.1°C), relative humidity (RH±3%), potential temperature (Pot T±0.2°K), wind speed (U±0.5 m/s), and direction (Drn ± 2° Mag) were routinely plotted (Figure 2.5) on-line using an IBM PC-XT computer. Wind speed and direction data are missing, or available only over a limited height range, for many of the runs due to tracking problems. On 2 Oct. we had problems with data recording and only the original field plots are available for display. Note that these are for a height range 0-2500m. The lowest 500m of selected profiles have been used to determine static stability with the results given in Table 2.3.

2.1.4 Richardson Numbers

The temperature differences, ΔT, on the 17m RS tower (see Section 3.1.3) were combined with velocity differences, ΔU, to provide a gradient Richardson number between the 4.9 and 16.9m levels. This was calculated as

$$Ri = g\, \Delta^{*}z\, \Delta\theta / T(\Delta U)^2 \qquad (3)$$

where $\Delta\theta$ is the difference in potential temperature and $\Delta^{*}z$ is the height difference (12m). The values will be interpreted as appropriate to a 10m height above ground and are tabulated for the MF, TK and TU runs in the relevant tables (3.1, 3.2 and 4.7). From our reading of the literature there is not a clearly-defined Ri range corresponding to 'near-neutral' conditions. Golder's (1972) figures of 1/L values (where L is the surface Monin-Obukhov length) corresponding to Pasquill and Turner neutral stability classes gives approximate ranges of $-0.12<z/L<0.11$ for Pasquill's D category and $-0.17<z/L<0.06$ for Turner's '4' category with z=10m and z_0=0.03m. Using the approximate relationships

$$Ri = z/L \quad \text{for } L<0 \text{ (unstable)}$$

and

$$Ri = (z/L)/(1+5\, z/L) \quad \text{for } L>0 \text{ (stable)}$$

this gives $-0.12<Ri_{10}<0.07$ and $-0.17<Ri_{10}<0.046$ as the corresponding gradient Richardson number ranges. On either basis all but one of the MF, TK and TU runs correspond to near-neutral conditions. The exception is run TU 05-D for which the run average Ri_{10}=0.0461 and a half hour value of 0.067 was recorded. Even this would satisfy the Pasquill class D, Ri_{10} conditions. The ranges $-0.1<Ri<0.1$ or $-0.1<z/L<0.1$ are often used to denote 'near-neutral' conditions. Once again all of the data satisfy these criteria at height Δz=10m.

In order to identify those runs which were slightly less neutral than others we will flag runs with $|Ri_{10}|\geq 0.015$, but it should be remembered that they are still 'near-neutral' according to generally accepted criteria.

2.2 DETAILS OF TOWER DEPLOYMENT AND INSTRUMENTATION

Fig. 2.6 shows the locations of all towers used during the 1983 experiment while Table 2.4 lists their coordinates in Ordinance Survey (OS) grid reference values ('Eastings' and 'Northings', in metres, on OS Survey Sheet NF 72/82). The detailed theodolite survey carried out during Askervein '83 to produce these values resulted in some minor discrepancies relative to the positions determined during the 1982 experiment and reported in ASK82. In particular, the revised estimates for the locations of HT, CP and the 50m tower at RS [(075383, 823737), (075678, 823465) and (074300, 820980), respectively] differ by several metres from the original values in ASK82 [(075380, 823732), (075672, 823458) and (074312, 820982), respectively]. It is our view that the 1983 survey was the more accurate of the two and is therefore the one which should be accepted. Note also in Table 2.4 that 'Cemetery BM', 'Milestone', 'Pacman Lake', etc., are reference points used to define baselines for the survey.

As in Askervein '82, towers were generally located along the lines A, AA and B shown in Figs. 2.1 and 2.6(a). These lines are oriented at 043°-223° and 133°-313° grid. Fig. 2.6(a) shows the exact locations used and identifies the towers by their nominal location code (e.g. AANE10) and, where necessary, an extra identifier to distinguish separate 'turbulence' ('t') and 'mean flow' ('mf') towers collocated at the same nominal position. Note that several of the towers are not precisely on the lines shown due either to minor discrepancies in the initial survey or to the absence of suitable anchoring points on the lines; nevertheless, the relative positions shown in Fig. 2.6(a) are the correct ones. Horizontal distances of the towers from HT or CP are listed in Table 2.5. These were measured independently of the tower locations listed in Table 2.4 and minor (2-3m) discrepancies occasionally present due to resolution problems are considered insignificant.

Instrumentation details for the towers along the lines in Fig. 2.6(a) are as follows:

(i) Line A: ANE40 to ASW85 - 10m towers with 'vertical' (i.e., w-component arm oriented vertically) Gill UVW propeller anemometers at the top (CAN); 'UK 30m' - a 30m telescopic mast (BRE) located at approximately ASW60. This mast was mounted on a small trailer (Fig. 2.7) and was deployed as close to the base of the hill as was practicable in order to make measurements in the partially-blocked flow (for SW winds) upstream of the hill. It was instrumented with four 'vertical' Gill UVW propeller anemometers at the 6m, 10m, 20m and 31m levels;

(ii) Line AA: AANE10 to 60 - 10m posts with cup anemometers (CAN); AASW10t, 30t and 50t - 10m towers with 'vertical' Gill UVW anemometers atop them (FRG); AASW10mf, 20, 30mf and 40 - 10m posts with cup anemometers (FRG); AASW15 and AASW50mf to 90 - 10m posts with cup anemometers (UK-ERA); and

(iii) Line B: BNW10, BNW20 and BSE10 to 170 - 10m posts with cup anemometers (CAN).

Figs. 2.6(b) and (c) give additional details of tower positions near HT and CP, respectively. The towers near HT were:

(i) A '50m tower' (which was in fact actually 48m high and is described in detail in ASK82) installed by the Danish group and instrumented with three sonic anemometers (DK), four 'tilted' (i.e., mounted with the w-component at 45° to the horizontal) Gill UVW propeller anemometers (AES), and four cup anemometers (AES). Locations of these instruments are shown in Fig. 2.9;

(ii) A 10m climbable tower (10m t) located somewhat closer to the exact hilltop position than the 50m tower and in an area with fewer local surface irregularities. This tower was used to obtain the lower portions of the HT mean velocity and turbulence profiles. It was (nominally) instrumented with three cup anemometers (CAN), one sonic anemometer (DK) and one 'vertical' Gill UVW anemometer (CAN) mounted as shown in Fig. 2.9;

(iii) A 10m mean flow post (10m mf) with a cup anemometer at the top (CAN);

(iv) A 10m tower with an R.M. Young model 05102 Wind Monitor ('WM') mounted at its top (CAN).

At CP, five towers were deployed initially, with some being moved at various times during the experiment. Three of these towers were 10m mean flow posts with cup anemometers (CAN, UK-ERA) and a cup-and-vane (FRG) atop them, one was a 10m tower instrumented with two gust anemometers (UK-ERA) and the other was a 16m tower (FRG) with 3 'vertical' Gill UVW anemometers,(at 5m, 10m, and 16m), and three cup anemometers, (at 1.6, 3.0 and 7.4m).

Fig. 2.8 is a photo showing some of the towers at HT, while Fig. 2.10 shows the towers at CP.

Tower locations used at the reference station (RS) are shown in Fig. 2.6d. Although the figure shows the positions of all the towers used at any time during the experiment, it should be noted that many of these towers and/or the instruments on them were moved to other locations at various times during the experiment. The towers shown are:

(i) A '50m tower' similar to that erected near HT, instrumented with four 'tilted' Gill UVW anemometers (CAN), four cup anemometers (CAN) and one sonic anemometer (CAN). The heights of these instruments on the tower are identical to those shown in Fig. 2.9 for the HT tower from the 10m level to the top;

(ii) A 10m tower ('AES Gill') with a 'vertical' Gill UVW anemometer (CAN) at the top and three cup anemometers (CAN) at the 3m, 5m and 8m levels;

(iii) Two 10m towers ('BRE Gill' and 'FRG Gill') with a 'vertical' Gill UVW anemometer (UK-BRE, FRG) at the top of each;

(iv) A 10m tower ('ERA Gust') with the ERA gust anemometer (UK-ERA) at its top;

(v) Two 10m towers ('AES Sonic' and 'DK Sonic') with a sonic anemometer (CAN, DK) at the top of each;

(vi) Two 10m mean flow posts ('AES P1' and 'AES P2') with a cup anemometer at the top of each (CAN);

(vii) A 10m tower ('AES WM') with a R.M. Young Wind Monitor (CAN) at its top; and

(viii) A 17m mean flow tower ('FRG PROFILE TWR') with cups at 4.9, 10 and 16.9m, a vane at 10m and temperature sensors at 4.9 and 16.9m (FRG).

Fig. 2.11 is a photograph showing most of the 10m towers at RS and some of the instruments located on them.

3. MEAN FLOW MEASUREMENTS

In this section we will discuss data obtained from the 10m mean flow (mf) posts and the TALA kites and mean flow data from the systems deployed primarily for turbulence measurement. The latter include Gill UVW anemometers at 10m along the A line through HT, Gill UVW anemometers on various other towers and cup anemometers on the 50m towers at RS and HT. Details of these systems will be discussed in Section 4. Periods during which good data have been obtained from the 10m mf posts will be referred to as 'MF' runs while 'TK' runs and profiles will refer to TALA kite data and 'TU' runs will designate periods during which good turbulence measurements were obtained. All runs are indicated in Fig. 2.4. MF runs are listed in Table 3.1, TK runs in Table 3.2 and TU runs in Table 4.7.

3.1 ANEMOMETER SYSTEMS, INTERCOMPARISONS AND DEPLOYMENT (MF POSTS)

Three types of anemometer system were employed for the mean flow measurements during the Askervein '83 experiments. One each of these systems was provided by Canada (AES), United Kingdom (ERA) and Germany (U of H). The systems were employed in two linear arrays - along lines AASW-AANE and BNW-BSE. The data from all systems were handled similarly and were eventually incorporated into one large mean-flow data base.

In this section, each system will be described separately and then some anemometer intercomparisons will be presented. Finally the temporal and geographical details of anemometer deployment will be given.

3.1.1 Canadian Mean Flow Measurement System

This system consisted of up to 27 cup anemometers, 10m portable posts and data loggers along with a portable microcomputer which was used to poll the data loggers for the previous day's data. Anemometers, post and data loggers, as well as the data-collecting microcomputer, are shown in Figure 3.1 for a rather unusual case where four anemometers were mounted on the same post for profile measurements.

The anemometers and posts were identical to those used in the Askervein '82 experiment (see ASK82, section 5.1.1) while the data loggers were an improvement over the previous system. They were designed (see Kobelka, 1984) around an Intel 8748 microcomputer which counted the pulses from the anemometer for a ten-minute period and then stored this number in memory. Total counts for up to 341 ten-minute logging cycles (~56 hours) could be stored in the device. The data logger and anemometer were powered by a common 8V Gates sealed lead acid battery. During the experiment, there were problems with the capacity of the batteries and with our arrangements for recharging them. Some loss of data from the Canadian mean flow system is due to battery failure.

The data logger could be interrogated at any time via an active interface and RS232C link by an Epson HX-20 portable microcomputer. The data were checked for continuity as they were read by the HX-20 and then stored on the built-in microcassette. The Epson HX-20 was then used to examine the data files and process the pulse count totals into engineering units while creating hard copy back-up data files. Upon return to Canada, the microcassette files were read onto disk storage on a DEC PDP 11/44 minicomputer, "cleaned up" and further processed into a mean-flow data base with the British and German data.

The anemometers were calibrated in the AES boundary-layer wind tunnel before and after the experiment and showed calibration changes of 0.0 to 1.8% between the two calibrations.

3.1.2 U.K. (ERA) Mean Flow Measurement System

The ERA system was very similar to the one used by the AES team except for the anemometers and towers. The anemometers were Vector Instruments A100R's (3-cup, reed switch pulse type, 1 pulse per revolution). They were mounted on 10m telescopic Clark's towers. The loggers and polling system were identical to those of the AES group and data were processed (as described above) using the AES microcomputer system. An ERA anemometer and tower can be seen at CP in Fig. 2.10b.

The ERA system benefitted from a much lower current drain by the anemometer and therefore encountered no battery failures during the experiment.

The anemometers were calibrated by the manufacturer before and after the experiment and showed a maximum of 0.4% change between the two calibrations.

3.1.3 German Mean Flow Measurement System

The mean flow measurement system included three different stand alone units:

(1) Reference Station (17m tower). This was instrumented with

- three Gill cup anemometers (Model 12102) at 4.9m, 10m and 16.9m
- one wind vane (Thies) at 10m
- two thermometers for ΔT between 4.9m and 16.9m

(2) Line CP - AASW40: (10m posts, similar to Fig. 3.2)

- one Gill-cup and one wind vane (Friedrichs) per post (5 posts)

(3) CP', nearly 30m NE of CP (16m tower)

- three Friedrichs Model 4011 cup anemometers at 1.6m, 3.0m and 7.4m

The anemometer and wind vane output is a d.c. voltage proportional to wind speed and direction respectively. All of the cup generator signals were low pass filtered with a time constant of 2 min.

Each unit was equipped with a battery powered Data Logger (Micro-data M 200) for signal digitizing and storing on C90 cassettes with a sampling rate of 2 min. Back in Hannover the cassettes were read on a special reading unit. The calibrations of the instruments were conducted in the institute's wind tunnel before and after the experiment. With one exception (RS, 16.9m which failed from October 6th) all instrument's calibration coefficients could be reproduced.

3.1.4 Cup Overspeeding and Cosine Response

As with our analysis of data from Askervein '82, the cup anemometer data to be presented in this report have not been corrected for possible overspeeding or cosine response. Coppin (1982) gives estimates of percentage overspeeding by Gill and Friedrichs cup anemometers at various heights over flat terrain with various roughness lengths. For z_o=0.03m we can interpolate between his values and obtain estimates of 1.3% overspeeding at 10m for the Friedrichs model 4011 cup anemometer and 0.4% for the Gill cup (Model 12102 with aluminum cups (part 12170A)). At locations on the hill where U is increased relative to RS we generally find that σ_u/U is lower than the upstream, flat terrain values (which are ~0.14 - 0.16) and thus the overspeeding at Δz = 10m should be even less than the values given above. There may be slight increases near the upstream base of the hill but the greatest effects will be in the lee of the hill. Here (see section 4.3.2) we have found very high turbulence levels, (σ_u/U ~ 0.4 to 0.7) from Gill UVW data for some wind directions. These could lead to moderately large windspeed errors (~ 10% for the Gill cups) since the overspeeding depends upon $(\sigma_u/U)^2$ (see Coppin (1982)). No attempt will be made to apply corrections to the MF post data, however, since local σ_u values are not available.

For the wind speed profiles to be presented for reference site (RS) and hilltop (HT and CP) locations, the cup overspeeding errors can be estimated for different anemometer types and heights. Values are given in Table 3.3. They are based on interpolations between Coppin's (1982, Table 3) values for flat terrain with somewhat subjectively-estimated reductions at hilltop locations to account for reduced σ_u/U levels. The Gill cup anemometers on the 50m towers were fitted with type 12170B polyproplene cups. These had slightly different characteristics compared with the aluminum cups tested by Coppin but we expect the overspeeding errors to be reasonably similar. We consider the overspeeding errors estimated in the table to sufficiently small, even at Δz=1m, for us to neglect in our initial analyses of the profile data.

Cosine response corrections due to the tilt of the cup anemometers relative to the wind on the sloping hillside were discussed in some detail in ASK82 and the same conclusions apply to the present data. Maximum discrepancies between true total wind speed and the wind measured by the cup anemometers should be of order 4% and corrections could be applied by assuming the flow to be parallel to the terrain. This has not been done with the data presented here but could be attempted on a run-by-run basis in later work.

3.1.5 Intercomparisons

Intercomparisons among the three anemometer systems used by AES, ERA and U. of H. on their MF posts were carried out at the CP and RS locations during the period 25 Sept. to 5 Oct. The anemometers were mounted at the 10m level with the horizontal dispositions shown in Figures 2.6c and 2.6d. The average wind speeds, U, measured by each anemometer during several MF runs are tabulated in Tables 3.4 (CP) and 3.5 (RS). These averages were calculated by averaging the 10-minute run-of-wind values during the MF run period. The standard deviations, s, of the averages are also tabulated. Table 3.4 shows that the ERA anemometer gave results which were consistently ~2% higher than those of the AES anemometer while U. of H. anemometer was ~3% lower. In Table 3.5, there is generally good agreement between the two AES anemometers and the U. of H. anemometer although occasional anomalies are present. Close scrutiny of Tables 3.4 and 3.5, ignoring cases with possible interference by upstream towers, suggests that a field intercomparison of the sort described here shows a scatter of about ±2% in the compared mean velocities and therefore cannot be expected to detect calibration discrepancies smaller than this amount. On this basis the U. of H. anemometer at CP (#36) was the only one which showed a calibration which was distinguishable from the AES standard anemometers (#15 and #2) at CP and RS. It was not however deemed appropriate at this time to modify the calibration of this anemometer (nor of any of the other U. of H. anemometers) and the data presented in Section 3.2 have not been adjusted.

3.1.6 Mean Flow Tower Deployment

For purposes of identification the mean flow anemometers were assigned permanent numbers from 1 to 40 (AES, #1-#27; ERA, #30-#35; U.of H., #28, #36-#40). The posts or towers were not themselves numbered but the locations where they stood were named as described in previous sections (and ASK82). The anemometer numbers can be matched with the post locations using Table 3.6. The mean flow posts were deployed in two linear arrays, along BSE-BNW and along AASW-AANE (see Figure 2.6a), during the experiment. There were also two AES posts and one U. of H. tower (with mean flow anemometer, #28) at the 10m level at RS. Initially all anemometers were placed at the 10m level. There were few relocations of posts and/or anemometers during the experiment until 6 October when the majority of the anemometers were moved to 3.0, 1.0 or 0.5m levels on selected posts. Table 3.6 gives a detailed history of anemometer locations and indicates where an anemometer was deployed at any given time. This does not necessarily mean that data are available for that time since there were occasional anemometer or logger failures and some battery failures. Not all the anemometers were actually in place at 00:00 on Sept. 15. The posts and anemometers were deployed over a period of days beginning on Sept. 15 with the system fully operational by approximately 18:00 on 26 Sept. However, whenever data became available for a particular anemometer, its proper location is indicated in the table.

The first configuration provided good coverage of three quarters of the hill with two linear arrays (BNW-BSE and AASW-AANE) at right angles. CP was a common point. The north west end of the hill did not have complete coverage. All anemometers were mounted at the 10m level. On Oct. 6, the anemometers were re-deployed to give reduced areal coverage (the SE end of the hill was stripped) but with anemometers at different heights - usually the 10m and/or 3m levels. Two of the posts (at BSE10 and BSE40 = CP) were instrumented at four levels (10m, 3m, 1m, 0.5m) to provide profile measurements.

3.2 MEAN FLOW RUNS, DATA FROM 10m POSTS

Because the anemometers were being logged continuously throughout the experiment, there are far more data available than could be conveniently tabulated in this report. The data, in the form of ten-minute run-of-wind means[1] are archived on magnetic tape in the form described in Appendix B. There are data available from a maximum of 33 anemometers and 30 post locations. The data archive starts Sept. 16 (JD259[2]) at 10:00 with data from the two AES reference anemometers (#1 and #2) at RS. It ends Oct. 10 (JD283) at 18:40 with data from these same two anemometers. There are ~43,000 pieces of data in the archive for the period from the beginning of MF25 to the end of MF10-B, compared with a theoretical maximum of ~64,600 for complete data coverage.

The periods designated as Mean Flow or MF runs are listed in Table 3.1(a). They were selected on the basis of steadiness of the upstream wind speed and, especially, direction and on the availability of reliable data. The table lists mean wind speed and direction at the reference site, based on the wind monitor data, and the average Richardson number, based on data from the 17m FRG tower at RS.

Grouping of the runs is possible on the basis of wind direction and this is done in Table 3.1(b). This lists twelve direction groups, five of which include four or more runs.

Data from the runs are presented chronologically in Figs. 3.3 and 3.4. In these plots the upper figure shows winds from towers along the ridge line, B while the lower figure shows winds along the AA line through CP. Data for runs up to 6 Oct. are for Δz=10m and are shown in Figs. 3.3 while from 07 Oct. onwards Figs. 3.4 are for Δz=3m. The wind speeds were normalized with the average of the two wind speeds measured at the reference site (P1 and P2). The data points are averages, over the duration of the run, of the normalized wind speed for each ten-minute interval. The error bars represent plus and minus one standard deviation for these averages. There are often multiple

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[1]The U.of H. data were produced by averaging five two-minute wind speeds over the ten minute period.

[2]Julian Day

points at CP, representing data from the AES, ERA and U. of H. systems. Discrepancies between the different values are small compared to the signal (c.f. Table 3.4). Some mean wind data from the FRG turbulence towers along the AA line are also included and give multiple points, e.g. Run MF01-D. Turbulence data from the FRG towers are shown in Fig. 4.4 and will be discussed in section 4.3.2.

All of the runs clearly show the influence of the hill on the near-surface wind speeds and will provide an excellent basis for comparisons with numerical and wind-tunnel model simulations. Typical runs yield fractional speed-up ratios (ΔS = Normalized Speed-1) of 0.6-0.9 at HT depending on wind direction. Wind speed reductions upstream of the hill and in the lee are also clearly evident.

To illustrate the data we will consider a few typical runs:

MF28-A to -D

These are cases with winds from nearly due E, outside the range in which we are primarily interested and with other hills upstream. In run 28-A there is a well-resolved speed-up (i.e. fractional speed-up ratio) over the hill of about 40% and a slight (~10%) reduction in wind speed on the lee side (AASW40), while in runs 28-B,-C the hilltop speed-up is greater. The pattern of variation in normalized windspeed with position is however very similar in all three runs and the differences are probably due to anomalies in the reference site wind for these directions. Run 28-D is slightly stable but gives a similar pattern of wind speed variation.

MF26-A, MF01-D,-E, MF04-A

These cases are for wind directions of approximately 180°. Hilltop wind speeds are 50-80% higher than those at RS with slight (10-20%) reductions in wind speed upstream and in the lee of the hill. Normalized wind speeds on the hilltop ridge are slightly higher for run MF01-E than for the other three cases, possibly as a result of the 5° difference in incident wind directions.

MF26-C,-D

These two runs have incident winds approximately normal to the ridge. Data from HT were not available for these runs but near HT the wind speeds show an increase of about 85% relative to upstream. There are also large reductions upstream and in the lee of the hill where the wind speed is reduced to 50% of the RS value. Flow separation is difficult to define or observe unambiguously in flow over 3D hills but we would suggest that it may have occurred in the lee of the hill in these cases.

MF07-B,-C

These two runs were conducted under rather unsteady, squally conditions and show rather larger standard deviations in ΔS than other cases. They are for Δz=3m and the ΔS values are somewhat higher than runs for the same incident wind direction at Δz=10m (c.f. runs MF07-B and MF27-A,-B for ϕ_{RS}~240°).

More detailed analyses and comparisons with numerical and wind-tunnel models will be presented in later publications.

Some limited near-surface profiles are available from the MF posts at RS and HT (3m and 10m) and at CP and BSE10 (0.5m, 1m, 3m and 10m) during the period Oct. 7-10. Data from eight MF runs with $260° < \phi_{RS} < 285°$ are plotted in Fig. 3.5. No corrections have been made for possible cup overspeeding error. Most of the data are consistent with approximately-logarithmic profiles at all of the tower positions, although for run MF09A (Fig. 3.5d) there is an indication that dU/d(ln z) could be increasing slightly with height. The profiles for $0.5m < \Delta z < 3m$ at CP and BSE10 can, perhaps inadvisedly, be used to provide z_0 and u_* values at these locations. These are listed in Table 3.7. The z_0 values are substantially lower than we would expect (near 0.03m, see Table 4.7) and the u_* values are also low relative to RS values (c.f. Table 4.7(a)) when the speed-up caused by the hill is taken into consideration. Our inference from this is that the profiles for $\Delta z < 3m$ are not in local equilibrium, even though they may appear to be approximately logarithmic, and that these profile-derived values are misleading. They are included as a warning rather than for use.

3.3 MEAN FLOW DATA FROM 10m GILL UVW ANEMOMETERS

Data were obtained during the turbulence (TU) runs (Table 4.7) from fourteen Gill UVW anemometers mounted at the 10m level. One was at RS, one at CP', three along Line AA and the other nine along Line A, as described in Section 2.2. Details of the data analysis are presented in Sections 4.1.3 and 4.1.5 and the turbulence data are discussed in Section 4.3.2. The wind speed data along the A and AA lines respectively are presented as amplification factors (=Normalized Speed, $1+\Delta S$) in Figs. 4.3 and as fractional speed-up ratios, ΔS, in Figs. 4.4. The latter plots include data from some of the MF posts along the AA line (marked as a 'o') as well as those from the Gill UVW anemometers. There is good consistency between the Δz=10m results from the two systems for the period up to and including Oct. 5. For Runs TU06 and TU07 (Figs. 4.4(l) to (o)), the MF post data are for Δz=3m and ΔS values are slightly higher than for Δz=10m. The normalized wind speed data along the A line provide additional information on the spatial variation of wind speed over the hill during Askervein '83 and also provide confirmation of the results obtained with MF posts during Askervein '82. For example Runs TU01-A,-B,-C (Figs. 4.3 (c), (d), (e)) with ϕ=180° ± 10° show similar variations in normalized wind speed (amplification factor) to those obtained in Runs 1.22 and 2.28 during Askervein '82. Runs TU03-A,-B (Figs. 4.3 (j), (k)) for ϕ=210° show similar behaviour to the Askervein '82 Run 2.02 (ϕ=200°) but do not extend as far down the rear slope of the hill.

Wind direction data for the TU runs are also plotted in Figs. 4.3 and 4.4. The Gill UVW direction at HT often appears anomalous (e.g. Run TU25, Fig. 4.3(g)) and we strongly suspect an alignment error for that anemometer. Because of this, Figs. 4.3 include direction data extracted from the HT Windmonitor stripchart (represented by an asterisk). Differences between the two directions are 13.7° ± 1.3° and it is highly unlikely that this could be due to differences in location (c.f. Fig. 2.6 (b)).

The pattern of variation of direction over the hill is well illustrated by data from runs TU01-A,-B,-C (Figs. 4.3 (c), (d), (e)) and corresponding results in Figs. 4.4. These have $\phi_{RS} \simeq 180°$, about 45° to the major axis of the hill, and show the greatest effect. On the upstream side of the hill the flow is deflected away from the normal to the ridge with the maximum deflection (about -10° to -15°) occurring near the upstream base of the hill, about 500m from the ridge. Near the hilltop, as the flow accelerates over the ridge the wind turns towards the normal with deflections relative to RS of +10° to +20°, while in the lee of the hill the data from the A line again show deflections away from the normal as the flow decelerates. We found no evidence in any of the data of mean flow reversal in the lee of the hill of the type one would associate with recirculating flow in steady 2D separation. However we did observe some very high turbulence levels and suspect that there may have been intermittent weak reversed flow on some occasions, especially at levels below Δz=10m.

For runs with the upstream flow more closely aligned with the normal to the ridge (e.g., Run TU26 in Figs. 4.3(h) and 4.4(h) and Run TU06-B in Figs. 4.3(m) and 4.4(m)), the variations in wind direction are generally smaller, especially along Line AA through CP. Note again that for Runs TU06 and TU07, the wind directions from the MF posts along Line AA are for Δz = 3m while the Gill UVW values are for Δz = 10m.

Mean wind 'upwash' results (i.e., upward deflection relative to the horizontal plane) are also shown in Figs. 4.3 (as 'UPWASH' angle, in degrees) and 4.4 (as mean vertical velocity component $\overline{W}$, in ms^{-1}). As anticipated, maximum upward deflection of the wind occurs on the front face of the hill when the wind is nearly perpendicular to the major axis (e.g. Figs. 4.3 and 4.4, (g) to o)). Taking Run TU03-B as an example, we see that along Line A (Fig. 4.3(k)), a maximum upward angle of about 16° is reached about 200m upwind of HT, this angle decreasing to nearly zero at HT and becoming correspondingly negative on the leeward face of the hill, as expected. Along Line AA (Fig. 4.4(k)), the maximum vertical soeed of ~ 2.3 ms^{-1} corresponds to upwash angles of about 10° at AASW10 and 15° at AASW30 (using the mean speed data in Table A1.5), in good agreement with the values along Line A. (Note that the $\overline{W}$ values at CP' are suspected to be somewhat high due to a tilt error for the aneometer located there). For increasing off-normal wind directions, of course, we would expect decreasing values of mean wind upwash along Lines AA and A, and the results of Figs. 4.3 and 4.4 show that this is indeed the case.

3.4 VELOCITY PROFILES FROM 50m and 17m TOWERS

Data from the cup anemometers on the 50m and 10m towers at RS and HT during the TU runs are plotted in Figs.4.1 and provide profiles from 1m (3m at RS) to 49m. Also shown are mean speed data from the vertical Gill UVW anemometers at RS and HT and from the tilted Gill UVW anemometers on the 50m tower at RS.

The mean velocity profiles at RS are well-defined and show good consistency between different measurement systems. The upper levels indicate some curvature in the profile relative to a simple log-law but in general the lower portions of the profile are nearly logarithmic and z_0 and u_* values can easily be extracted from them. This was done graphically and the values have been included in Table 4.7. At HT, despite some anemometer problems, the velocity profiles were reasonably well-defined and were used to provide vertical profiles of fractional speed-up ratio for a range of incident wind directions. These will be discussed in more detail in Section 4.3.1, together with additional data from the FRG 17m tower at RS and the FRG 16m tower at CP'.

3.5 TALA KITE PROFILES

3.5.1 TALA Kite Systems and Data Acquisition

The basic Tethered Aerodynamic Lifting Anemometer or TALA kite system is manufactured by TALA Inc. It is essentially a sled kite, with a stabilizing tail, which is flown on a non-stretch Kevlar line. The tension in this line is primarily due to the aerodynamic forces on the kite and, when measured, can provide data on the wind speed at the kite position. There is a small contribution to the measured tension due to the tangential aerodynamic forces on the line itself. For moderate line lengths (~200m), however, this can be neglected while for longer line lengths, a small correction (6% at 1000m line length) should be applied.

Kite altitude is determined from elevation angle, measured with an inclinometer, and line length, which is related to a reel count. An observation of horizontal direction towards the kite provides wind direction data. In the simple versions of the TALA system the line tension is measured with a spring balance inside a calibrated measurement tube and the data are recorded manually. This works quite well provided a suitable procedure for selecting and processing tension data is adhered to (as in the Askervein '82 experiment).

For Askervein '83, both the BRE and AES groups developed automated data acquisition systems for kite profiling. In the AES system we replaced the spring balance by a load cell (Kyowa, LU-10KA) and manual recording by an electronic system. These are shown in Fig. 3.6(a). The data acquisition system controls the input to the load cell and conditions the output for recording on a Sea Data logger (Model 1250). Provision was also made for the input of line count, elevation and azimuth data to the data logger, which recorded the information on digital cassettes. Details of the data acquisition system are given by Austerberry (1983).

During Askervein '83, the AES group used two TALA systems to profile from heights (Δz, above local ground) of about 20m to 200m above locations near the hilltop ridge and near the base station, at ASW85. For ASW85, which is in flat terrain, the kite could be flown from a fixed position since small changes in horizontal position would not appreciably affect the results. On the hill, however, we sometimes had to move upwind as the kite's elevation increased in order to maintain the kite's horizontal position above the ridge. Corrections have been made to Δz in cases where the elevation of the kite-tethering position differed from that of the point on the ridge above which it was being flown. Profiles were flown with fixed elevations (line counts) being maintained for approximately 15 mins, the data then being normalized against surface tower data for the same periods to separate the spatial (in Δz) and temporal variations in windspeed.

The BRE system comprised six standard kites, six line-tension transducers and a six-channel microprocessor, data logging and printing system.

The kites were flown simultaneously at six different heights. Six individual lines of different lengths were pre-measured and wound onto a TALA powered-winch with a modified spool (Figure 3.6(b), bottom left). The kites were launched individually from a position just downwind of the measurement line, starting with the lowest (shortest line) and proceeding in order of increasing height. When each kite line was fully extended, the line was detached from the winch spool and the kite was 'walked' to the corresponding transducer.

The transducer (Figure 3.6(b), bottom right) was contained in a tube pushed vertically into the ground. The end of the kite line was attached to a flexible wire. This wire passed over a jockey pulley in the top of the tube, twice around a transducer pulley and was attached to a linear spring at the bottom of the tube. The jockey pulley was able to castor to follow changes in wind direction. Application of tension to the wire caused the spring to expand up the tube and the transducer pulley to rotate. The range was adjusted so that the spring reached a stop near the top of the tube and the transducer pulley rotated 350° when a force of 50N (5 kg) was applied. The rotation of the transducer pulley was sensed by a 100k ohm potentiometer. A spacing of 30m cross-wind between each transducer was adopted after initial attempts at 20m resulted in some tangled lines.

The data logger (Figure 3.6(b), top) consisted of an Acorn microprocessor with an 8-channel, 8-bit analogue-to-digital converter (ADC), 1-channel digital-to-analogue converter (DAC) driving an analogue voltmeter, control switch panel, 12-column printer, random access memory (RAM) and read-only memory (ROM). The operating program was developed and tested at BRE on a larger Acorn system and impressed on the ROM. The ADC ran at 10 Hz per channel and acquired the signal from each kite transducer, the supply battery voltage and the stabilized 10V supply voltage. The supply battery was an ordinary 12V car battery which served also to power the winch. A stabilized DC voltage of 10V was supplied across each kite transducer potentiometer and the wiper voltage was returned to the ADC. A warning message was printed if the battery voltage fell below the level required to maintain the 10V stabilized voltage.

The microprocessor program ran in two modes. In 'calibrate' mode any given kite channel could be selected by a switch. The transducer signal for that channel was passed to the DAC and displayed on the meter. When tension was removed from the line and a 'zero' switch pressed, the microprocessor read and remembered the corresponding zero signal voltage. When a 5 kg weight was hung on the line and a 'calibrate' switch pressed, the microprocessor read and remembered the corresponding calibration signal voltage. Default zero and calibration voltages were impressed in the ROM and it was only necessary to set the zero in the field. Switching from 'calibrate' to 'run' mode caused the calibration values for each channel to be printed. This calibration process was performed before each run.

In 'run' mode the microprocessor proceeded to analyze the six kite signals. The program was optimized for minimum analysis error and real-time running. Samples from each channel were first corrected for zero and gain using the calibration values, then converted from proportional-to-line-tension to proportional-to-wind-speed through a look-up table of values. Wind speed samples from each channel were then summed in blocks of 25, to give 2.5-second averages. Any one channel, selected by switch, was used to drive the DAC, displaying the linearized wind speed on the meter. In each period of ten minutes duration the mean value was accumulated and maximum 2.5-second value retained for each channel, and these values were printed at the end of each period.

Both AES and BRE systems were calibrated against the cup anemometer at 48m on the RS 50m tower. The results are given in Table 3.8, and correction factors based on these comparisons have been applied to the data presented in the remainder of this section. For the AES system all kites were individually calibrated, while for the BRE system all six kites were flown at the same height (110m) to give relative calibration values and a reference kite was then flown at 48m next to the 48m cup anemometer at RS to give absolute values. The reference-kite calibration data are given in Table 3.8(b) and indicate that an RMS error near 4% is typical for the ten-minute mean values.

It can be seen from Table 3.2, which lists the TK runs, that there is only partial overlap between the timing of the BRE TALA kite profile runs and those conducted by AES. This arose because AES personnel were busy with other aspects of the experiment during the early part of the main observing period and BRE had intermittent printer problems which prevented them obtaining profiles at some times. In general the BRE system provided the best data since they flew up to six kites simultaneously at the same site.

Basic data for the TALA kite runs are given in Tables 3.9 and 3.10. These tabulated data include calibration corrections (U_{TALA}^{ADJ}), but <u>do not include corrections for the effects of line drag</u>, which was originally thought to be negligible. Following the experiment, Taylor and Cook (1985, personal communication) re-evaluated these effects and suggest the approximate correction factor

$$U_{TRUE} = U_{TALA}^{ADJ} \times (1 - 0.6 \times 10^{-4} L)$$

where L is the line length in metres. Profiles plotted in Figs. 3.7, 3.9, 3.10 and 3.11 include this line drag correction with an additional minor adjustment to account for this error during the calibration runs at Δz = 48m.

3.5.2 Upstream Profiles Near RS

Profiles derived from the BRE data from the coastal or 'Coastal Machair' site (CM - see Fig. 2.1) along with data from the anemometers on the various towers at RS, are shown in Fig. 3.7. In most of the cases there is a well-defined profile with an excellent match between the TALA kite profile and the tower data. The only slightly anomalous value is the 30m wind speed during run TK03 which is high compared to the rest of the profile. All profiles show that there are significant departures from a simple log-law above $\Delta z \approx 30$m. This confirms the tendency already noted for the upper portions of the tower profiles (Section 3.4).

We can see from Table 3.2 that $|Ri_{10}|$ values for all these runs were ≤ 0.015, implying near-surface conditions with close to neutral thermal stability. AIRsonde profiles (see Fig. 2.5) flown during or at times close to these profile runs show near-neutral to slightly stable thermal stratification over the lowest 1 km for all of these runs. The potential temperature profile at 13.08 on 02 October shows a moderately sharp inversion layer at $\Delta z \approx 400$m coupled with a drop in relative humidity, probably associated with a disturbance which produced heavy rain in the area later that afternoon. No significant low-level features were apparent in the AIRsonde profiles for other runs in this series. Table 2.2 indicates weak baroclinicity on 01, 02, 03 October but a moderate thermal wind on 07 October. This may explain the tendency for the TALA/Tower profile on 07 October to be rather closer to logarithmic than the other profiles since, in this case, the thermal wind is in exactly the opposite direction to the surface geostrophic wind.

In general these profiles from the surface to heights of order 400m are qualitatively consistent with models of the planetary boundary-layer over homogeneous terrain for slightly stable, near neutral conditions - see Fig. 3.8. The Askervein profiles are for slightly higher wind speeds and surface roughness than Jensen et al's. (1984) calculations but the roughness Rossby numbers,

$$Ro = G/fz_o$$

where G is the geostrophic wind speed and f is the coriolis parameter ($= 1.22 \times 10^{-4} s^{-1}$ at Askervein) are close to the values used in the calculations (5×10^6).

Since we are working at a coastal site we might expect to see evidence of the coastal roughness change in these upstream profiles, especially for the 3 Oct. and 7 Oct. profiles where the flow had an on-shore component. For wind speeds of $O(10ms^{-1})$ the surface roughness over water is ~ 2×10^{-4}m compared to a value of ~ 2×10^{-2}m on land while for a fetch of 1 km, appropriate at RS for a wind direction of ≈205°, the internal boundary-layer depth, based on Elliott's (1958) simplest form, would be approximately 90m. The TALA kite data were from the Coastal Machair site near the shoreline and here we might have expected to see essentially marine wind profiles above the 50m level for on-shore winds. Our preliminary conclusion is that these upstream profiles show no clear evidence of modification by the roughness change at the coast and appear to be qualitatively compatible with theoretically predicted profiles for homogeneous terrain under barotropic conditions with slightly stable stratification. There is a distinct change in the slope of the profile at heights, Δz, between 30m and 50m and attempts to extract z_0 values from the upper portion of the profiles would lead to anomalously high values (~ 1-3m). This contrasts with the upstream TALA kite profiles obtained during Askervein '82 which generally, but not always, gave z_0 values consistent with those obtained from the tower profiles.

3.5.3 Upstream and Hilltop Profiles

A number of runs were successfully completed for which TALA kite data were available from both upstream sites, either the CM site or ASW85, and hilltop locations. In order to avoid possible entanglement of the kite with the 50m tower at HT most of the "hilltop" kite data are for a location about midway between HT and CP. Data from three of these runs are presented in Figs. 3.9 (a-c) which also include cup anemometer data from the RS and HT towers. All windspeeds are normalized by the value obtained for the 10m Gill UVW anemometer at RS. In the case of TALA kite data from the AES system the normalization is in two stages and the value plotted is

$$\frac{U_{TRUE}\ (15\ \text{min})}{U_{10m}^{LOCAL}(15\ \text{min})} \times \frac{U_{10}^{LOCAL}\ (\text{run})}{U_{10}^{RS}\ (\text{run})}$$

where the (run) values are averages over the complete run.

Figs. 3.9(a),(b) provide good pairs of profiles from the RS/CM and hilltop areas and can be used to illustrate the decay of ΔS with height. Run TK07-B shown in Fig. 3.9(c) has rather different behaviour, probably due to a combination of the different incident flow direction and the fact that the upper portion of the upstream profile was measured at ASW85 and could be showing some partial upstream blockage effects. A profile measured at the Coastal Machair site earlier that afternoon (Run TK07-A) is shown in Fig. 3.7(e) and is more closely logarithmic. There was however a 20° wind direction change between the profiles and the period was rather unsteady with squalls and heavy rainshowers.

Fig. 3.10 shows velocity profiles at ASW85 and on the hilltop on two occasions when suitable local 10m wind data were not available for the normalization procedure. The profiles are derived from pairs of approximately synchronous, 15-min average wind speeds with the same line length being used for each kite. For Run TK05 this gives a pair of reasonably-matched profiles with the exception of the hilltop speed at $\Delta z \simeq 145$m (which has been bracketed). This data point is believed bad as the kite was observed to loop and recover several times during the 15 min period. For this wind direction (ϕ=305°) the flow is approximately parallel to the major axis of the hill. As a result wind speeds above ASW85 could be increased due to flow around the hill which could partially explain the shape of the profiles and the apparently low ΔS values. We should however stress that these profiles include a mix of temporal and spatial variations and cannot be relied upon to give good information on $U(\Delta z)$. Run TK10 was carried out at the very end of the experiment to try to increase the amount of profile data. The ΔS values corresponding to these profiles (0.25 at $\Delta z \sim 50$m, 0.15 at $\Delta z \sim 100$m) are similar to the values for Run TK01-B but the lack of other background information makes more detailed interpretation unsound. In Fig. 3.11 we have plotted normalized wind speed profiles for Run TK03. The hill profile in this case was flown from a location on the lee side of the hill, about 150m from the ridge line, in an attempt to investigate flow separation. There certainly was flow separation near the ground and the kite had to be launched on the hilltop and then moved to the lee side position in order to keep it in the air. We started the profile at about Δz=125m ending at a height Δz=30m. Below that level the kite fell to the ground indicating very light winds below, we estimate, Δz=25m. Between Δz=25m and 125m the hillside winds were slightly higher than those at the coastal machair site but the quality of these data is not really good enough to warrant quantitative interpretation.

4. TURBULENCE MEASUREMENTS

4.1 MEASUREMENT SYSTEMS AND DEPLOYMENT

Turbulence data were obtained at various periods during the experiment using a total of eight distinct instrumentation systems, each operated by one of the participating groups. Generally speaking, most of these systems were the same as, or similar to, those used during the 1982 experiment and described in detail in ASK82. For this reason, we give details here of only the new systems or of significant changes in the old systems and refer the reader to ASK82 for additional information.

4.1.1 AES (Canada) Sonic Anemometer

The Kaijo-Denki Model DAT-300 Ultrasonic Anemometer-Thermometer used by AES during Askervein '83 is the same as that used for the 1982 experiment, including the data collection and storage system. The anemometer was mounted on a 10m tower at RS (Fig. 2.11) until Thursday, September 29, when it was moved to the 47m level on the RS 50m tower where it stayed for the remainder of the experiment. A sampling rate of 20 Hz with anti-aliasing filtering at 10 Hz was used for most of the data collected.

4.1.2 DK (Denmark) Sonic Anemometers

As in the 1982 experiment, five Risϕ (DK) Kaijo-Denki Model PAT-311 Ultrasonic Anemometers were operated during Askervein '83, four by Risϕ personnel at HT and one by AES personnel, with Risϕ assistance, at RS. Three of the hilltop units were mounted on the 50m tower at the heights shown in Fig. 2.8 and the fourth was on the nearby 10m tower at a height of 1.91m. Signals from these units were analog-recorded on-site and subsequently replayed in the laboratory at Risϕ for analysis (see ASK82). The RS unit was mounted atop a 10m tower at RS (Fig. 2.11) throughout the experiment. Data from this anemometer were collected along with those from the AES unit using the AES collection/storage system described in ASK82.

4.1.3 AES (Canada) 'Vertical' Gill UVW Anemometers

Ten Gill UVW 3-component propeller anemometers (Model 27004) with polypropylene propellers (Model 8234) were operated by AES during Askervein '83. One of these was located atop a 10m tower at RS (Fig. 2.11) and the other nine were on 10m towers along the line ASW-ANE, as described in Section 2.2 and shown in Fig. 2.6(a). All of these units were oriented 'vertically', in the sense that the vertical component arm was aligned to be geopotentially vertical and pointing up. The horizontal arms were aligned with the u-component arm pointing toward 270° grid and the v-arm toward 180° and were not changed during the experiment. Thus the anemometer coordinate system was defined by a positive u-axis pointing toward 90° and a positive v-axis pointing toward 0°. This basic alignment was chosen for all vertical Gill UVW anemometer systems during the experiment for consistency. Rotation of the raw components into the standard streamline coordinate system was subsequently performed during data analysis prior to calculation of the final statistics.

Data collection and storage were performed using digital cassette data loggers as described in ASK82. Non-cosine response corrections were applied as in ASK82, but using a new (and only slightly different) set of correction coefficients, the details of which can be found in Bowen and Teunissen (1983).

4.1.4 BRE (UK) Gill UVW Anemometers

As in the 1982 experiment, four 'vertical' Gill UVW anemometers with polyproplene propellers were operated by BRE during Askervein '83. At the start of the experiment, one unit was mounted at 10m at RS in the reference line and data were acquired in each of the intercomparison runs I1 through I7 (see Table 4.2). For the main experiment, the four units were mounted at 6m, 10m, 20m and 31m on a 30m telescopic mast mounted on a trailer and located as near ASW60 as possible (Figs. 2.6(a) and 2.7).

The signal acquisition and analysis electronics were housed in a 4-wheel-drive Bedford CF van. During data acquisition this was parked alongside and downwind of the mast to avoid affecting the anemometers. As no mains power was available at ASW60, 240V/50Hz AC was provided by a 1500W Honda generator which ran for about eight hours between refuelling. The acquisition equipment comprised 32-channels of Barr and Stroud EF16 low-pass filters and a Plessey System 3 computer system. The computer system was based on a DEC PDP 11/23 with 256 kbytes memory, 10.8 Mbyte Winchester disk, 500 kbyte 8-inch floppy disk, EPSON FX80 printer and two 16-channel Data Translation analogue-to-digital converters (ADC). As only 12 signals required to be recorded, only one

ADC was used. Signals from the anemometers were low-pass filtered at 1 Hz, digitized at 2 Hz and stored without further processing on the Winchester disk.

Each evening, after the last TU run, the signal cables were disconnected and the van was driven from ASW60 across the road to the base station, where the electronics were powered from the mains supply. The data files were checked for over-ranging and a preliminary field analysis was made of the data overnight. Each morning, the van was driven back to ASW60 and the signal cables were reconnected.

When the analysis system was calibrated after the experiment one channel of the Barr and Stroud filters was found to be faulty, with a gain of 1.24. (Pre-calibration was not possible as the filters arrived from the manufacturer one day before departure.) The faulty channel corresponded to a horizontal axis on the 20m anemometer. Corrections were applied to this channel assuming that the fault existed for the whole experiment. The final analysis of the data given in this report used the AES set of non-cosine response corrections for 'vertical' Gill anemometers which were adopted as standard for this experiment.

4.1.5 FRG (Germany) Gill UVW Anemometers

A total of 6 Gill UVW 3-component propeller anemometers were operated by the University of Hannover (FRG). Three of these were mounted (vertically) at 5m, 10m and 16m on the 16m tower at CP' (Figs. 2.6(c) and 2.10(a)) and the other three were located atop 10m towers at AASW 10t, 30t and 50t (Fig. 2.6(a)). At each position the horizontal orientation of the instruments was the same: the u-sensor was directed towards west and the v-sensor towards south. For the period 21/09-22/09, one unit was mounted atop a 10m tower at RS (Fig. 2.11) to obtain intercomparison results with other sensors.

The voltages of the 18 generators were low-pass filtered with a time constant of 0.5 s. Scanning and digitizing of signals was done by an ORION-data-logger (Solartron, Schlumberger) with a sampling rate of 2 Hz. This logger was situated at the point AASW 17 to obtain the minimum length of the cabling. After digitization values were given to a serial transmission line driven by special amplifiers. In the computer van of the FRG group (located near BS) the data were received, reduced and stored on a 9-track-magtape. All these procedures - collection and storage - were organized and initiated by the Digital-PDP 11/23 computer located in that van. As was the case for the BRE Gill anemometers, the FRG anemometers were similar to those used by AES and hence the same non-cosine response correction factors were applied during data processing.

4.1.6 AES (Canada) 'Tilted' Gill UVW Anemometers

One of the main shortcomings of Gill propeller anemometers as sensors of atmospheric turbulence occurs when the mean wind vector is normal to the axis of rotation of the propeller [see Bowen and Teunissen (1983) or Hicks (1972), for example]. This is because the instantaneous wind vector repeatedly passes through the propeller stall region and the propeller must continually stop and reverse direction. Frictional and inertia effects are therefore considerably more severe than if the propeller is merely increasing or decreasing a uni-directional rotational speed in response to changes in the instantaneous wind vector. Thus for 'vertically' mounted Gill UVW anemometers in flat terrain, where the vertical-component arm is nearly always perpendicular to the mean wind vector, the dynamic response of the anemometer to vertical fluctuations will be significantly poorer than its response to horizontal-component fluctuations (except of course, for wind directions for which the mean wind vector is also perpendicular to one of the horizontal arms). Bowen and Teunissen (1983) have reported losses of 40-50% in σ_w^2 for a 'vertical' Gill UVW anemometer with 15 cm diameter orange polystyrene propellers (Model 21283), compared to only 5-10% for the horizontal components, after correcting for non-perfect-cosine response to off-axis winds.

The usual way to alleviate the above problems for the horizontal components is to try to ensure that the mean wind vector always bisects the u- and v-component arms. Continual adjustment of the 10 widely dispersed anemometers used for Askervein '83 was not feasible, however, and hence the permanent alignment chosen for the horizontal arms was such that the prevailing (and most desirable) wind direction would bisect the arms. For the vertical component, the usual solution is to 'tilt' the anemometer in the upwind direction so that the vertical-component arm forms an angle of 30°-45° with the (usually horizontal) mean wind vector and hence the vertical-component propeller does not normally change direction for reasonably steady winds. The main drawback of this approach is that it makes the results unacceptable for winds from the 'back' side, due to aerodynamic interference from the supporting body. In addition, it makes the mounting of the anemometer atop a tower considerably more difficult. Because of this, and because for many of the 10m towers along line ASW-ANE the mean wind vector was <u>not</u> horizontal and hence was not perpendicular to the geopotential vertical, a 'vertical' alignment was accepted for all AES Gill UVW anemometers on 10m towers and also, for consistency, for the BRE and FRG Gill UVW anemometers. For the 50m towers at RS and HT, however, mounting booms with a 45° 'tilt' were readily available. Thus the four AES Gill UVW anemometers on each of these towers (Section 2.2 and Fig. 2.9) were mounted in a 'tilted' configuration throughout the entire experiment. The exact configuration was such that the w-component arm pointed 45° <u>below</u> the horizontal plane and lay in the vertical plane containing the mounting boom and the bisector of the u- and v-arms. The mounting booms pointed toward 226° grid at RS and 212° grid at HT. Data collection and storage procedures were identical to those used for the other AES Gill UVW anemometers as described in ASK82. Black, 18 cm polypropylene propellers (Model 8234) were used for some of these anemometers while orange, 15 cm polystyrene propellers (Model 21283) were used for others (due to limited availability of each model), and non-cosine correction coefficients appropriate to each type were used during data processing.

During the Askervein '83 experiment, the tilted Gill anemometer system at RS performed reliably throughout the entire measurement period. Unfortunately, the same cannot be said for the system at HT. For example, the mean wind speeds from the tilted Gill anemometers at HT were always inconsistent with the cup data and were, on occasion, also internally inconsistent. This anomalous behaviour was in fact noticed during the experiment and many attempts were made to identify and correct the apparent problems. Thorough checks of the data acquisition system revealed water in a filter box as a likely cause of some problems, but corrective action failed to produce acceptable results. In spite of all other attempts to salvage useable data both during and after the experiment, only a few of the results from the HT tilted Gill system were considered acceptably reliable and hence no results from this system have been presented here.

4.1.7 <u>AES (Canada) Cup Anemometers</u>

The AES cup anemometers used for obtaining mean speed profiles at RS and HT (see Section 2.2) also provided an estimate of the longitudinal (u) component turbulence velocity. As discussed in ASK82, these anemometers respond to the total wind vector, V_h, in the horizontal plane, rather than only one or the other horizontal component, but it can easily be shown that to first order the variance σ_h^2 obtained from this signal is approximately (i.e. within one percent) equal to that of the longitudinal component alone (i.e., σ_u^2).

During Askervein '83 we had unexpected difficulties with some of the cup anemometers mounted at upper levels on the HT 50m tower. They were a new version of the Gill Model 12102 anemometer and had occasional problems with slippage between the cups and the tachometer/generator at high wind speeds. As a result we lost a considerable amount of data from the 49m level at HT and have some doubts about some of the 34m level winds, which appear slightly lower than we would expect. Suspect values are bracketed in the data tables (Table A1.7) and on the profile plots (Figs. 4.1).

4.1.8 ERA (UK) Gust Anemometers

The ERA Gust Anemometers used during Askervein '83 are the same as those used during the 1982 experiment and are described in ASK82. Data collection and analysis procedures are also similar. The anemometers were mounted on a 10m tower at RS until 01/10 when they were moved to a position near CP ('UK TURB' in Fig. 2.6(c)).

4.2 SYSTEM INTERCOMPARISONS

In order to calibrate the various turbulence measurement systems against one another, several intercomparison runs were carried out at RS prior to the start of the main observation period. A typical anemometer from each system was mounted atop a 10m tower at RS along the line shown in Figs. 2.6(d) and 2.11. Data were then collected from all operational systems whenever the mean wind was roughly perpendicular to the line so that no mutual interference of the anemometers would be encountered. No runs were obtained during which every type of anemometer was operating. However, the AES sonic anemometer was in operation during all but two runs so that all instruments could be referred to its results and hence could ultimately be compared with one another.

Usable intercomparison runs were obtained on five different days. The exact time periods and the instruments in operation at the time of each run are listed in Table 4.1.

4.2.1 Sonic/Gill UVW Anemometers

Table 4.1 shows that there were five runs (I1, I3, I4, I6 and I7) during which the reference (AES) sonic anemometer and at least two Gill UVW anemometers were in operation, representing a total measurement period of eight hours and three distinct mean wind directions (245°, 230° and ~ 180°). The data from each anemometer were analyzed in 1/2-hour blocks for which mean velocities and turbulence statistics were calculated. For each data block, ratios of the values obtained from the Gill units to those from the sonic anemometer were determined for each parameter by simple division. The data blocks were then grouped according to the three mean wind directions and block-averaged values of the ratios were obtained by averaging over all the blocks in each group. These block-averaged ratios are presented in Table 4.2 as a function of θ, defined as the angle between the mean wind vector and the nearest horizontal-component arm (i.e., u- or v-) of the 'vertical' Gill anemometer. This angle is a relevant parameter since, for vertical Gills, when θ ~ 0°, the v-component arm, like the w-component arm, is roughly perpendicular to the mean flow and hence should exhibit poorer response than the u-component arm. At θ ~ 45°, both the u- and v-component arms should respond similarly.

The most reliable results in Table 4.2, in a statistical sense, are those for θ ~ 0° since they are derived from the largest number of data blocks. The mean velocity values for the Gill units are seen to be in excellent agreement (± 2%) with each other and with the sonic anemometer for this direction, while being rather more scattered (up to 10% for the 'tilted' Gills) for the other angles. The vertical Gill response to turbulence at θ ~ 0° is roughly as expected [see Bowen and Teunissen (1983), for example], with the u-arm responding best (it is nearly always parallel to the instantaneous wind vector), followed by the v-arm (usually perpendicular) and the w-arm (nearly always perpendicular). For θ ~ 25° and 40°, the u-component and v-component responses are more similar to each other, while the w-component response (for the straight Gills, at least) is not significantly changed, as expected. Note also the significant improvement in w-component response for the tilted Gill in comparison with the straight Gills for all directions, the expected result of tilting the vertical arm out of the plane perpendicular to the mean wind vector.

Table 4.2 shows that, in general, the three straight Gill UVW anemometer systems produce similar results, although there can be differences of up to 10 - 15% among them for any particular turbulence parameter. In comparison with the sonic anemometer, they tend to underestimate σ_u by ~5%, σ_v by ~20%, σ_w by ~40% and u_* by ~15%. When the Gill unit is tilted, these underestimates become ~5% for σ_u (i.e., roughly unchanged), ~10% for σ_v, ~20% for σ_w and ~5% for u_*. There are, of course, individual exceptions to these generalities, most notably the overestimation of σ_v by 8.7% for the tilted Gill at θ ~ 25°. However, most of these exceptions occur for θ ~ 25° or 40°, where the mean wind speeds are rather low (~3 - 4 ms^{-1}) and hence where the results are understandably more scattered. In the present report, no corrections or adjustments have been made to any of the data from the Gill systems to try to account for their response characteristics. Rather, the general response characteristics summarized above should be kept in mind when interpreting the relative changes in turbulence produced by the hill as indicated by the Gill measurements (Sections 4.3.1 and 4.3.2). In effect, we are assuming that, to first order, we are aided by 'compensating errors' in that any unique response characteristic on the hill should be matched by comparable response at the reference site and hence the change in the relevant parameter will be roughly correct. Note that the major weakness in this assumption can be expected to be felt on the upwind and downwind face of the hill where the vertically-oriented Gills are in effect 'tilted' by up to 10 - 15° to the incident flow due to the upwash and downwash produced by the hill, and hence where an increase of up to ~10% in the observed σ_w may be the result simply of improved sensor response rather than a true effect of the hill on the flow. Additional studies of the response of the Gill UVW anemometer to various orientation angles and a more complicated correction scheme would be required to attempt to correct for this effect.

4.2.2 AES/DK Sonic Anemometers

It is seen from Table 4.1 that there were three runs (I8, I9, I10) on two days during which direct comparisons could be made between the AES and the DK sonic anemometer systems. The data from these runs were divided into ten 15-minute blocks and analyzed in a manner similar to that described above for the Gill systems. Table 4.3 presents the DK/AES anemometer ratios for each data block along with the averaged values for all 10 blocks. It is seen that, on average, the two anemometers agreed to within 8% for all dimensional quantities, with the DK instrument being consistently higher than the AES unit. The normalized parameters (T_u, T_v, T_w and u_*/U) are all within about 3% of each other except for T_u, which is about 6% lower for the DK unit. Although this relative performance is not unreasonable, it is not as good as originally anticipated. In particular, the 6.7% overestimate in U by the DK anemometer (the AES unit is assumed to be 'correct' because of the absence of systematic corrections needed for it and its good agreement with the vertical Gill systems as demonstrated in Table 4.2) is unexpectedly high. Part of this overestimation (perhaps about 1%) is attributed to temperature and humidity effects, which have not been corrected for in the DK unit (corrections are not needed for the AES unit). With the exception of the tabulated data in Table A1.1, all DK sonic data presented and discussed in this report (Figs. 4.5, Table A1.2 and Section 4.3.3) have been adjusted using the ratios given in Table 4.3 to remove potential systematic differences between them and the data from the other anemometer systems.

4.2.3 Sonic/ERA Gust Anemometers

Table 4.1 shows that direct comparisons between the ERA Gust Anemometers and the AES sonic anemometer were available for 23/09/83 and between the ERA Gust Anemometer and the BRE and FRG Gill anemometers for 22/09/83. Table 4.4 presents the appropriate ratios of parameters for the total of 7 blocks of data available. Note that the ERA data were available only in 18-24 minute blocks which did not always fully overlap the reference anemometer results, and that not all parameters were available from the ERA unit for all blocks. Note also that the AES and BRE anemometers are considered to be 'correct' for the runs in question in view of their good agreement with each other and with the other anemometers in the other intercomparison tests (see Table 4.2, for example).

Table 4.4 shows that there is considerable variability in the degree of agreement between the ERA Gust Anemometer and the other instruments. This anomalous behaviour of the ERA unit is attributed to undesirable noise in the data signals obtained in the field. No results from this unit have been presented in this report for any of the experimental runs carried out during Askervein '83.

4.2.4 Sonic /AES Cup Anemometers

Two runs (I1, I4) were obtained during which direct comparison of the AES cup anemometer and the AES sonic anemometer could be made. Table 4.5 presents the relevant ratios of parameters for each of these runs together with the weighted average. The cup anemometer tends to produce values of U and σ_h which are about 5% high, thus yielding a T_u value very similar to the sonic anemometer. The high U and σ_h estimates could be due in part (~1%) to classical 'overspeeding' of the cupwheel of the cup anemometer (see Section 3.1.4), with the remaining difference presumably being caused by an overestimate in the cup anemometer calibration constant or similar factors.

4.3 TURBULENCE RESULTS

Tables 4.6(a) to (g) summarize the complete periods of usable data obtained during the main observation period of ASKERVEIN '83 by each of the turbulence measurement systems described in Section 4.1. In Table 4.7, we have defined the 'turbulence' (TU) runs referred to in Section 3, based on periods of reasonably steady and strong winds at the RS wind monitor location and the availability of usable data from a reasonable number of measurement systems. This is similar to the approach taken to define the mean flow (MF) runs listed in Table 3.1 and, indeed, many of the runs overlap, as is desirable. Results obtained from the various systems during these runs are plotted and discussed in the following sections. The actual averaged quantities for each system and each run which were used to obtain the plots are tabulated in Appendix A (Tables A1.1 to A1.7).

4.3.1 Vertical Profiles at RS, HT and CP'

Figures 4.1(a) to (s) present vertical profiles of mean speed ($\bar{U}$) and longitudinal-component turbulence (σ_h or σ_u for cup or Gill UVW anemometers, respectively) at RS and HT for each of the 19 TU runs defined in Table 4.7, along with the ΔS profile obtained from subjectively-drawn smooth-curve fits to the speed profiles for each run. The data themselves were obtained from the AES cup anemometers, the AES tilted Gill anemometers (RS only, due to system failures for the tilted Gills at HT), the AES vertical Gill anemometers and the AES MF posts, and most of them can be found in Tables A1.3, A1.6 and A1.7. For ease of discussion, the order of presentation of the runs follows the directional grouping of Table 4.7(b), rather than the chronological order of Table 4.7(a). Thus the correlation between figure number, direction and run number is as follows:

Figures	Nominal Direction	Run Numbers
4.1 (a), (b)	135°	TU30-A, 30-B
4.1 (c) to (f)	175°	TU01-A, -B,-C, 02
4.1 (g) to (m)	215°	TU15,26,01-D,03-A,-B,06-A,-B
4.1 (n), (o)	250°	TU07-A, -B
4.1 (p) to (s)	300°	TU05-A, -B, -C, -D

Mean Speed and ΔS Profiles at RS and HT

Generally speaking, the mean speed profiles at RS and HT and the corresponding ΔS profiles in Figs. 4.1 are similar in shape to the lower sections of the corresponding TALA kite profiles, as already pointed out in Section 3.5.2 and Figures 3.7 and 3.9 and as one would of course expect. The lower portions of the RS speed-profiles $\Delta z \lesssim$ 20-30 m) follow a well-defined logarithmic relationship with height from which reliable estimates of u_* and z_0 could easily be obtained. These estimates are tabulated in Table 4.7 and the consistent values of 2 - 4 cm for z_0 agree very well with expected values for terrain of this type (see ESDU (1974), for example) and with most of the values obtained during ASK '82 (see also Section 4.3.3 re sonic anemometer estimates of z_0). On the other hand, the upper portions of these profiles usually depart from the simple log-law relationship, displaying an increase in $d(\bar{U})/d(\ell n\ z)$ for heights above about 20 - 30 m. As discussed in Section 3.5.2 for the combined TALA kite/tower profiles, we believe this curvature to be the result of the combined effects of slightly stable thermal stratification and baroclinicity rather than local terrain inhomogeneities (i.e., the change-of-roughness from water to land). It has, however, not been possible to correlate the degree of curvature shown by the profiles with our measurements of stability. For example, the profiles for Runs TU01-C (Fig. 4 .1(e)) and TU03-A (Fig. 4.1(j)) display roughly the same degree of curvature. But for Run TU01-C, the near-surface Ri of +0.0103 (Table 4.7(a)) and the value of $(\partial\theta/\partial z)_{5-500m}$ of 5.17°K/km (Table 2.3) indicate a moderately-stable situation in the context of this experiment, while for Run TU03-A, the corresponding values of -0.0038 for Ri and 2.01°K/km for $\partial\theta/\partial z$

indicate weak stable stratification through the PBL as a whole and slight instability at the surface. Thermal winds (Table 2.2) were weak on both days. Thus our only conclusion in this regard can be to state that 'what was measured is what has been presented' and to add the observation that accurate upstream profile measurements to greater heights (say 500 m) would be desirable for all runs in future experiments of this type.

An interesting feature of the RS profiles for Runs TU05-A, -B, -C and -D (Figs. 4.1(p) to (s)) is their characteristic departure from a simple logarithmic form in the height range from 10 m to about 30 m. We suspect that this is a wake effect from a group of farm buildings located about 200 m upstream of RS for this range (~285° -305°) of incident flow directions (see Fig. 2.1) and that this effect is also responsible for the local maxima in the corresponding σ profiles around $\Delta z \sim 10$m. RS Wind Monitor and Gill UVW speeds were also somewhat anomalous for most of these runs, a not surprising result when wake effects are present in view of the different location of these instruments in the horizontal (Fig. 2.6(d)). Caution is advised when interpreting the data for these runs.

Turning to the HT wind speed profiles, we find significant variability in some of the data, especially in the range $1 \text{ m} < \Delta z < 10$ m. This, we believe is primarily due to the different horizontal positioning of the various anemometers. That is, the cups at the 1, 3 and 5 m levels were on one tower (10m t, see Fig. 2.6(b)), together with a Gill UVW anemometer at 10 m, while the cups at 8 m and above were on the 50m tower, located about 10 m away and farther behind the true summit of the hill (which is marked 'HT' in Fig. 2.6(b)). For some runs, we have plotted wind speed values from the 10m mf post, which was about 10 m away from the 10m t tower in roughly the opposite direction to the 50m tower. Several of these wind speeds display significant (~ 5%) differences from the other comparable results. Note also that at the $\Delta z = 3$ m level at HT for Runs TU06-B, TU07-A and TU07-B (Figs. 4.1 (m) to (o) respectively), the mf post values are ~ 12% higher than the 10m t tower values are are assumed to reflect the larger local variations to be expected very close to the surface.

Given the variabilities discussed above, it is clear that the smooth curves drawn through the HT wind speed data in Figs. 4.1 are often quite subjective, especially at the lower levels. In some cases (e.g. Runs TU30-A, TU07-A) it is possible to distinguish different profile segments for different towers. These different segments are indicated by dashed lines in Figs. 4.1, while the solid lines are taken as 'the' hilltop profile for ΔS calculations. In most cases, we believe the HT speed profiles to be correct to within about 2 - 3% (relative error between levels) and the RS profiles to within 1 - 2%, thereby estimating ΔS to be correct to about ± 0.05.

As was discussed in Section 3.5.3 for the combined TALA kite/tower profiles (Figs. 3.9), the ΔS profiles of Figs. 4.1 generally display a steady increase in speed-up with decreasing height. In many cases (e.g. Runs TU06-A, -B, Figs. 4.1(l) and (m), ΔS appears still to be increasing at $\Delta z \sim 1$ m, suggesting that its maximum occurs at the surface. In others (e.g. Runs TU30-A and TU01-D, Figs. 4.1(a) and (i)), it has become fairly constant around $\Delta z \sim 1$ m and has likely already reached its maximum value.

As expected, there are significant differences in the behaviour of the ΔS profiles for different wind directions. Runs in the ϕ = 215° group (i.e., nearly normal to the hill major axis) have the highest near-surface values ($\Delta S \sim 1.3$ -1.4 at $\Delta z = 1$ m, in good agreement with Jackson and Hunt's (1975) rule-of-thumb prediction of $\Delta S_{max} \sim 2h/L \sim 1.2$ for this direction), while those in the 135° and 300° groups (i.e., nearly parallel to the major axis) have the lowest near-surface values ($\Delta S \sim 0.5$ at $\Delta z = 1$ m) and decrease more slowly with height. Results for the other directional groups tend to fall between these values and are consistent with expected behaviour, given the general shape and orientation of the hill.

Turbulence (σ) Profiles at RS and HT

The lower half of each of Figs. 4.1 displays the longitudinal-component turbulence profile data at RS and HT for each TU run. For the Gill UVW anemometers, it is the RMS of the true u-component of turbulence that is plotted (σ_u), while for the cup anemometers, it is the RMS (σ_h) of the total wind vector, V_h. As mentioned in Section 4.1.7, however, these differ by less than 1% in turbulence of the type encountered here.

Generally speaking, the individual data points for σ show substantially more variability than do the corresponding mean speed values. We can find no systematic explanation for this in the sense of possible experimental error, since both the mean values and the σ's were obtained from the same raw signals and we would expect their experimental accuracy to be similar. In spite of the scatter, we have subjectively fitted smoothed curves to the data for each run in order to obtain at least a qualitative estimate of the changes in σ induced by the hill. Profiles of $\Delta\sigma_u$ have not been calculated, however.

Considering the σ profiles by directional grouping (see list above or Table 4.7 (b)), we see that for $\phi \sim 135°$, 175° and 215° (Figs. 4.1 (a) to (m)), the general pattern of the profiles at RS show σ roughly constant or decreasing slowly with height above the surface. This is the type of behaviour to be expected in idealized surface-layer flow over flat terrain. The RS profiles in Runs TU07-A and TU07-B for $\phi \sim 250°$ are similar, although they show that σ has a tendency to increase slightly with height, rather than decreasing. The most unusual profiles of σ at RS are those for $\phi \sim 300°$ (Runs TU05-A to -D, Figs. 4.1 (p) to (s)), which clearly display a local maximum at $\Delta z \simeq 10 - 15$ m. As discussed above, we attribute this maximum to likely wake effects from upstream farm buildings for this direction.

As for the HT profiles, there is clearly considerable variability in their shapes, both within and across directional groupings. Nevertheless, a few general observations can be made:

(i) For $\phi \sim 135°$, the HT profiles are similar to those at RS in both shape and magnitude and indicate that σ does not change substantially as the flow passes over the hill, except perhaps very close to the surface;

(ii) For $\phi \sim 175°$ and $\sim 215°$, there tend to be local minima in the HT profiles at $\Delta z \sim 10 - 15$ m. This results in a 'three-layer' pattern insofar as turbulence changes are concerned, typified by the profiles of Figs. 4.1 (k) and (m): a layer below $\Delta z \sim 4 - 5$ m where σ increases relative to upstream, a mid-layer between about 5 and 25 m where σ decreases and an upper layer above $\Delta z \sim 25$ m where σ remains unchanged. There are obviously individual exceptions to these generalities, most notably the profiles of Runs TU02 (Fig. 4.1 (f)) and TU01-D (Fig. 4.2 (i)). In the latter case, the HT profile has a shape consistent with that for the other runs in this grouping, but its magnitude is anomalously large relative to the RS results. The reason for this is unknown, although it may be related to the fact that this was a nighttime run with a value of Ri indicating slight stability near the surface (see Table 4.7 (a)).

(iii) For $\phi \sim 250°$ (Runs TU07-A and -B, Figs. 4.1 (n) and (o)), the HT profiles are such that there appears to be only a 'two-layer' pattern for $\Delta\sigma$ or, alternatively, a three-layer pattern where the bottom layer (which has substantial increases in σ) is much thicker than in (ii) above (up to $\Delta z \sim 25 - 30$ m) and the top of the mid-layer is above our range of measurement. Note that this pattern is similar to that for Run TU02 (Fig. 4.1(f), $\phi = 165°$), although there is no obvious commonality between the three runs in either direction or thermal stability (see Table 4.7 (a)).

(iv) For $\phi \sim 300°$ (Runs TU05-A to -D, Figs. 4.1 (p) to (s)), the considerable variability in the σ profile at HT, together with the aforementioned probable wake effects on the RS profile, result in no clear pattern emerging for $\Delta\sigma$.

<u>Profiles at RS and CP'</u>

Figures 4.2 present mean velocity and turbulence profiles obtained from the FRG 17 m tower at RS and the FRG 16 m tower at CP' during the designated TU runs. These results are presented in the same directional-grouping order as those of Figs. 4.1. In the case of the tower at CP', both cup anemometers (at Δz = 1.6, 3.0 and 7.4 m) and Gill UVW anemometers (at Δz =5.0, 10.0 and 16.0 m) provided mean speed profiles, parts of which overlap each other. It is obvious from the figures that the agreement between the two sets of results in the areas where they overlap is not good - in fact, as noted in the caption for Figs. 4.2, the cup anemometers produce mean speeds ~9.8% higher than those from the Gill anemometers. It is interesting that in the intercomparison tests between the AES cup and sonic anemometers (Sec. 4.2.4 and Table 4.5),

the cup anemometers also produced high mean speed values, in this case by about 5%. As mentioned earlier, we feel that cup overspeeding could account for no more than about 1% of such overestimation and that the similarity in cup response in the two cases is probably coincidental. No explanation for the 9.8% differences in Figs. 4.2 has yet been found, however.

Generally speaking, the mean speed and ΔS profiles in Figs. 4.2 are similar to the corresponding portions of the RS/HT results in Figs. 4.1, as we would of course expect. The magnitude of the ΔS values at CP' in Figs. 4.1 is on the whole slightly smaller than that of the HT values, a result consistent with the lower elevation of CP' relative to HT. As for turbulence results, data for all three components of σ were obtained, although only at CP'. In virtually all cases, the relative magnitude of the component values (σ_u largest, σ_w smallest) is the same as one would expect in idealized flow over flat terrain. In their regions of overlap, the σ_u profiles of Figs. 4.2 and 4.1 are fairly similar, with the former usually being slightly smaller in magnitude than the latter.

4.3.2 Horizontal Profiles along Lines A and AA

Figures 4.3 display the mean wind and turbulence results obtained from the AES Gill UVW anemometers at Δz = 10m along Line A (through HT), while Figs. 4.4 show the corresponding results from the FRG Gill UVW anemometers along Line AA (through CP). In both instances, the runs have been grouped according to wind direction rather than chronologically, as was done for Figs. 4.1 and 4.2. The mean wind speed and direction data for both sets of results have already been discussed in Section 3.3, so we will consider only the turbulence results in this section. Note that there are some estimates of turbulence parameters which are suspect due to their apparently anomalous values (e.g. Figs. 4.3(a), (n)). These values have been bracketed in the figures, rather than totally eliminated, because we could not identify any errors in the basic data or the equipment which would justify our rejecting them outright.

The variations of σ_u, σ_v, σ_w and $\overline{uw}$ along Line A for wind directions nearly-perpendicular to the major axis of the hill are typified by the results in Figs. 4.3(g) to (m). In these figures, the value of the turbulence parameter obtained at RS is plotted on the left axis of each graph to permit relative hill effects to be estimated. For σ_u, it is seen that no major changes occur on the upwind side of the hill, although it would appear that, at this height at least (Δz = 10m), there is a slight increase in σ_u in the region around ASW50 and a slight decrease at HT. The major impact of the hill on σ_u is obviously on the downwind side, where the large increase in σ_u is a reflection of the highly-turbulent, intermittently-separated flow usually observed in this region near the surface for this range of wind directions (see Sections 3.3 and 3.5.3). For σ_v, σ_w and shear stress ($\Xi - \overline{uw}$), the general pattern is not too different from that for σ_u - that is, only moderate changes from RS on the upwind face of the hill and at the summit, but very large increases in the lee. Note that σ_v appears to increase continuously toward the summit as the flow passes over the hill, while $-\overline{uw}$ (note that it is $+\overline{uw}$ that is plotted in the figures) varies in a manner rather similar to σ_u. At HT $\sigma_u \simeq \sigma_v$ for wind directions in the 215° and 250° groups.

For wind directions nearly parallel to the hill major axis, the effects of the hill on the 10m turbulence quantities presented are smaller, as is to be expected. In Runs TU30-A (Fig. 4.3(a)) and TU05-B (Fig. 4.3(q)), for example, the values of the turbulence parameters at the 'back' of the hill (ANE10 to 40) are similar to the upwind (RS) values, as are most of the other values on the hill. For wind directions between the normal and parallel to the major axis, the effects of the hill are typically intermediate to those observed for normal and parallel flow.

The turbulence results in Figs. 4.4 are for the southwest face of the hill only, along Line AA. Generally speaking, they display trends which are similar to the corresponding sections of the profiles along Line A in Figs. 4.3. That is, we observe only minor changes in the various turbulence quantities in this region as the flow passes over the hill.

4.3.3 Sonic Anemometer Data (RS and HT)

The sonic anemometer systems mounted on the 50m towers at RS and HT permitted us to measure vertical profiles of σ_v, σ_w and u_* at these two locations, in addition to the $\bar{U}$ and σ_u profiles which could also be obtained from some of the other anemometer systems. A total of eight runs were obtained during which both sets of sonic anemometers were operating successfully (see Table 4.6(a)). Although HT results from only one of these runs (1430-1700 L.S.T., October 3, 1983, a nearly-complete subset of Run TU03-B defined in Table 4.7) were available at the time of writing this report, these results provide very good insight into the changes induced by the hill on the vertical profiles of turbulence as the flow passes over it. The relevant profiles are displayed in Figs. 4.5, based on data taken from Tables A1.1 and A1..2. Note that in these figures, all DK sonic data have been adjusted using the intercomparison ratios of Table 4.3 to remove potential systematic differences between them and the other anemometer systems (see Section 4.2.2). Note also that in Table A1.1, the estimates of roughness length, z_0, at RS are in general substantially higher than the corresponding values obtained from the cup/Gill UVW anemometer mean speed profiles (Figs. 4.1 and Section 4.3.1) which are tabulated in Table 4.7. This difference is attributed to the fact that the sonic anemometer estimates are based on only a single-point (Δz = 10m) measurement of $\overline{uw}$ ($=-u_*^2$) at RS and the log-law assumption. They can therefore not be considered to be as reliable as the estimates from the complete profiles and are included in Table A1.1 general guidance only. The largest anomalies are for Runs TU05-B and TU05-C when, as noted earlier, the measurements are probably influenced by the wakes of upstream farm buildings.

In Fig. 4.5(a), the mean speed results obtained from the sonic anemometers are plotted together with those from the cup anemometers (for the same time period). The latter values are of course virtually the same as those plotted in Fig. 4.1(k) for the complete TU03-B run. It is seen in the figure that the sonic results agree quite well with the cup data, except (perhaps) for the 1.9m level at HT. We have no reason to suspect the reliability of the 1.9 m sonic value nor, in fact, the 1m cup value at HT. In addition, we note that the 1, 3 and 5m cups and the 1.9m sonic were all mounted on the same 10m tower at HT (see Fig. 2.9), so we would expect no anomalous 'local' effects which might result from differing horizontal locations of the anemometers. In view of the slight differences between cup and sonic data we have subjectively drawn two possible curves in Fig. 4.5(a). Curve (a) is similar to the HT profiles plotted in Figs. 4.1 where no sonic data were available to define the intermediate points while for curve (b) more weight has been given to the sonic data, especially the 1.9m wind speed.

It is clear that more measurements very close to the surface will be needed in future experiments of this type in order to assess the exact nature of the 'inner layer' flow. The observation that this 'inner layer' region is much thinner than previously thought is in fact one of the more important findings of the Askervein experiment as a whole.

Figure 4.5(b) shows the turbulence profiles obtained during this Run. The RS profiles for all parameters are based on measurements at only two heights but are assumed nearly constant with height, as was observed previously for σ_u (Section 4.3.1) and as we would expect in an idealized surface layer. For σ_u, σ_w and u_* (= $(-\overline{u'w'})^{1/2}$), the combined RS/HT results clearly reiterate the 'three-layer' pattern discussed in Section 4.3.1 for the σ_u profiles from the cup and Gill UVW anemometers for this wind direction (i.e., nearly-normal to the ridge); that is, a thin lower layer with large increases, a mid-layer with substantial decreases and an upper layer with only small changes, if any, in the turbulence parameters. The results for σ_v are clearly quite different, with σ_v increasing above the hill at all heights, although the increase is probably no longer significant above 40 - 50m. Note that some liberty has been taken in drawing the curve for σ_u at HT above $\Delta z \sim 6$m, but this is felt to be justifiable in view of the shape of the corresponding profiles in Figs. 4.1 (especially (j) and (k), for example).

5. CONCLUDING REMARKS

The Askervein experiments have produced what we feel is an excellent set of full-scale data on the nature of atmospheric boundary-layer flow over an isolated, moderately low hill in essentially neutrally-stable conditions. Changes in the mean wind and turbulence characteristics induced by the hill have been identified for a number of basic wind directions and, while the spatial extent of the data sets is often not as large as we would have liked (an almost foregone conclusion in experiments of this type!), we believe that the results obtained will be extremely useful for validating and improving the physical and mathematical models and techniques which are currently being developed for flows of this type.

During ASKERVEIN '83, a total of 44 mean flow ('MF') runs and 19 turbulence ('TU') runs were obtained, bringing the total for the two main field experiments to 56 MF runs, ranging in length from 1/2 to 14 hours each and representing nearly 150 hours of data, and 19 TU runs, ranging from 1/2 to 2 hours each and totalling 33 hours. A total of 15 TALA kite runs of 1-2 hours' duration each were also obtained. In the present report, we have presented the basic data for ASKERVEIN '83 in the form of tables and graphs and have provided general observations and discussion for many of them, just as was done for the ASKERVEIN '82 results in ASK82. More detailed discussion of these results and intercomparisons with various model predictions will be undertaken in separate publications, several of which are in progress and some preliminary versions of which have already appeared (e.g. Taylor et al. (1985), Teunissen and Taylor (1985) and Teunissen and Shokr (1985a and b)). In the meantime, we hope that the data in this report will prove as useful to other researchers in the field of wind flow over hills as they are to the group of scientists who obtained them.

6. ACKNOWLEDGEMENTS

The Askervein '83 experiment, like its predecesser in 1982, involved a major collaborative effort by scientists and technical support staff from the six participating institutes. Fig. 6.1 is a photograph showing most of the participants in the field phase of the work and listing the others. We are most grateful for their enthusiastic involvement. As in the 1982 experiment we should single out Mrs. Elizabeth Moughton of ERA Technology Ltd. for thanks in respect of her work on the local organization and logistical support. Other personnel involved in data analysis included R. Surkow and R. Dybizbansky of U of Hannover, Arent Hansen from Risφ Laboratories and Steve Derco of AES to whom we owe thanks for their work. The manuscript has been typed with great patience and her usual proficiency by Evonna Mathis with additional valuable help from Bea McKay and June Hawkins, while John Strecansky, Gord Young, Tom Chivers and Brian Taylor were responsible for most of the drafting.

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APPENDIX A

Run-averaged data from various turbulence systems for designated turbulence (TU) runs. Values tabulated are averages of all 1/2-hour-block values during each run.

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TABLE A1.1 AVERAGED DATA FROM SONIC ANEMOMETERS AT RS FOR DESIGNATED TURBULENCE RUNS

RUN	TIME	ΔZ (m)	$\overline{U}$ (ms^{-1})	DIR (deg)	UPW (deg)	σ_u (ms^{-1})	σ_v (ms^{-1})	σ_w (ms^{-1})	$\overline{uv}$ (m^2s^{-2})	$\overline{uw}$ (m^2s^{-2})	$\overline{vw}$ (m^2s^{-2})	T_u	T_v	T_w	ΔZ/L (3)	Z_o (4) (cm)	E/u_*^2
TU25	1600 -1700	10 (1)	5.51	208	1.3	0.931	0.609	0.495	+.020	-.158	-.002	0.168	0.110	0.089	-.029	4.05	4.69
TU30-A	1130 -1300	10	8.06	133	2.8	1.421	0.938	0.746	-.110	-.385	-.016	0.176	0.116	0.092	-.005	5.50	4.49
		47	9.87	131	0.3	1.221	0.829	0.649	+.003	-.283	-.016	0.124	0.085	0.066	-.064	-	
TU30-B	1600 -1700	10	13.06	-	2.5	2.098	1.562	1.140	-	-	-	0.160	0.120	0.087	-	-	
		47	16.61	125	0.4	1.641	1.312	1.000	-.048	-.558	-.002	0.098	0.079	0.060	-.052	-	
TU01-A	1300 (2) -1400	10	9.44	174	2.7	1.562	1.191	0.909	-.341	-.489	+.055	0.165	0.126	0.096	-.030	4.54	4.79
		47	11.71	177	0.2	1.408	1.060	0.909	-.037	-.534	-.016	0.121	0.090	0.078	-.165	-	
TU01-B	1400 -1600	10	9.25	180	2.8	1.511	1.003	0.843	-.082	-.433	+.010	0.163	0.108	0.092	-.026	3.64	4.62
		47	11.42	183	0	1.272	0.891	0.823	-.027	-.425	+.037	0.111	0.078	0.072	-.108	-	
TU01-C	1700 -1830	10	7.81	185	2.7	1.322	0.892	0.727	-.119	-.285	+.014	0.171	0.114	0.093	+.001	3.34	5.39
		47	10.34	189	0.2	1.191	0.837	0.697	-.101	-.247	+.027	0.116	0.081	0.067	+.021	-	
TU01-D	1930 -2000	10	7.70	203	2.5	1.144	0.922	0.737	-.058	-.267	+.013	0.149	0.120	0.096	+.008	2.59	5.06
		47	10.57	206	0.9	1.103	0.859	0.665	-.083	-.218	+.025	0.104	0.081	0.063	+.074	-	
TU03-A	1200 -1300	10	9.90	210	2.0	1.500	1.037	0.907	-.111	-.458	+.045	0.152	0.105	0.092	-.015	2.88	4.53
		47	13.08	208	0.1	1.254	0.878	0.779	-.110	-.377	+.011	0.096	0.067	0.060	-.068	-	
TU03-B	1400 -1700	10	9.11	211	2.2	1.409	0.965	0.826	-.090	-.375	+.036	0.154	0.106	0.090	-.004	2.70	4.80
		47	11.66	209	0.1	1.166	0.796	0.710	-.027	-.307	+.017	0.100	0.068	0.060	-.096	-	
TU05-A	1030 -1130	10	10.19	285	1.5	1.655	1.246	0.974	+.229	-.484	+.006	0.163	0.122	0.095	-.016	2.88	5.41
		47	13.20	281	+.3	1.236	0.922	0.563	+.047	-.208	-.013	0.094	0.070	0.043	-.110	-	
TU05-B	1330 -1530	10	8.69	303	0.4	1.630	1.153	0.948	-.229	-.573	+.026	0.187	0.133	0.109	-.012	10.07	4.26
		47	11.97	303	-.6	1.277	0.835	0.613	-.032	-.259	+.018	0.106	0.070	0.051	-.150	-	
TU05-C	1530 -1700	10	8.15	298	0	1.477	1.103	0.871	+.033	-.470	+.031	0.181	0.135	0.107	-.016	8.73	4.42
		47	11.11	300	-.9	1.067	0.761	0.560	-.055	-.202	-.004	0.096	0.069	0.050	-.165	-	
TU07-B	1530 -1700	10	10.27	256	+.4	1.600	1.546	0.822	+.326	-.321	-.015	0.155	0.145	0.080	-.008	7.24	(5.76)
		47	12.56	258	+.3	1.722	1.606	0.648	-.559	-.270	+.032	0.137	0.119	0.052	-.122	-	

Notes:
1. 10 m values for Run TU25 and 47 m values for all runs are from AES sonic anemometers; 10 m values for all other runs are from DK sonic anemometer and have not been adjusted for intercomparison differences (see Section 4.2.2).
2. Sonic anemometer data available for only part of Run TU01-A.
3. ΔZ/L based on height of anemometer (10 m or 47 m) and Monin-Obukhov length (L) determined from local $\overline{uw}$ and $\overline{wT}$ measurements.
4. Z_o determined from $\overline{uw}$ ($=-u_*^2$) and $\overline{U}$ at ΔZ = 10 m, assuming log-law velocity profile.

TABLE A1.2 AVERAGED DATA FROM DK SONIC ANEMOMETERS AT HT DURING RUN TU03-B

Height, m	U	σ_u	σ_v	σ_w	u_*	ε
47	15.9	1.20	0.88	0.83	0.56	3.0
6	15.8	1.41	1.11	0.68	0.33	1.2
4	16.0	1.60	1.22	0.65	0.41	-0.6
2	15.7	1.99	1.35	0.83	0.63	1.2

Notes:

1. Data are averages of five 1/2-hour (nominal) blocks from 1435 to 1700 h, 03/10/83. First block is actually 25 minutes in length.
2. These data have been adjusted for DK/AES sonic anemometer differences using the intercomparison ratios given in Table 4.3.
3. All speeds are in m s^{-1}; ε is upwash angle in degrees.
4. Remaining data from these anemometers (see Table 4.6(a)) undergoing analysis at time of printing.

TABLE A1.3

AVERAGED DATA FROM AES VERTICAL GILL UVW ANEMOMETERS FOR DESIGNATED TURBULENCE RUNS

Legend

UPWASH	: upwash angle relative to u-v (horizontal) plane
SIGMu,v,w	: RMS values, $\sigma_{u,v,w}$
INTu,v,w	: turbulence intensities
uv, uw, vw	: covariances ($\overline{uv}$, $\overline{uw}$, $\overline{vw}$)

RUN NO: TU25 DATE: 25/09/83 TIME: 1600-1700

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S	210.3	1.8	5.5	0.992	0.179	0.552	0.100	0.255	0.046	0.152	-0.114	-0.006
ASW85	201.7	3.1	4.8	0.742	0.153	0.469	0.097	0.244	0.050	0.047	-0.057	0.005
ASW50	198.7	2.8	4.0	0.883	0.221	0.522	0.131	0.317	0.079	-0.003	-0.129	0.012
ASW35	201.2	10.5	4.1	0.831	0.204	0.671	0.165	0.299	0.073	0.036	-0.158	-0.010
ASW20	205.7	16.9	6.8	0.711	0.105	0.662	0.098	0.367	0.054	0.023	-0.107	0.000
ASW10	211.8	16.0	8.3	0.678	0.082	0.747	0.090	0.417	0.050	-0.002	-0.087	0.015
H/T	206.2	2.3	9.9	0.728	0.073	0.627	0.063	0.333	0.034	0.025	-0.043	0.011
ANE10	211.6	-10.5	7.4	1.109	0.149	0.660	0.089	0.340	0.046	-0.055	-0.116	-0.008
ANE20	207.7	-18.4	3.8	1.380	0.361	0.825	0.215	0.477	0.125	-0.269	-0.136	0.103
ANE40												

RUN NO: TU26 DATE: 26/09/83 TIME: 1000-1400

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S	213.9	2.0	7.1	0.915	0.129	0.592	0.083	0.320	0.045	0.124	-0.139	-0.011
ASW85	208.8	3.0	6.1	0.893	0.145	0.590	0.096	0.308	0.050	-0.029	-0.125	0.008
ASW50	204.5	3.2	4.6	1.033	0.228	0.677	0.149	0.406	0.089	-0.061	-0.204	0.020
ASW35	205.0	10.6	5.0	0.947	0.190	0.785	0.157	0.415	0.083	0.001	-0.230	0.016
ASW20	208.3	17.0	8.5	0.836	0.099	0.849	0.100	0.496	0.059	-0.003	-0.179	0.022
ASW10	214.6	15.7	11.0	0.769	0.070	0.913	0.083	0.552	0.050	-0.026	-0.190	0.031
H/T	209.6	2.7	13.3	0.763	0.058	0.754	0.057	0.492	0.037	0.012	-0.121	0.026
ANE10	213.0	-9.8	9.9	1.573	0.159	0.833	0.084	0.459	0.047	-0.165	-0.253	0.003
ANE20	207.6	-15.3	4.5	2.038	0.460	1.209	0.273	0.703	0.159	-0.735	-0.336	0.189
ANE40												

RUN NO: TU30-A DATE: 30/09/83 TIME: 1130-1300

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S	137.8	0.0	7.5	1.263	0.169	0.732	0.098			-0.084		
ASW85	135.9	2.2	8.3	1.263	0.151	0.793	0.095	0.369	0.044	-0.052	-0.224	-0.049
ASW50												
ASW35	130.8	1.3	8.3	1.383	0.167	0.954	0.115	0.282	0.034	-0.285	-0.154	-0.077
ASW20	138.4	7.8	8.8	1.533	0.176	1.038	0.119	0.594	0.068	-0.360	-0.503	-0.183
ASW10	140.9	3.2	9.8	1.400	0.143	0.934	0.095	0.368	0.037	-0.070	-0.197	-0.163
H/T	137.4	1.5	10.7	1.363	0.127	0.957	0.090	0.313	0.029	0.064	-0.171	-0.062
ANE10	134.7	-1.6	9.2	1.363	0.149	0.573	0.096	0.369	0.040	-0.241	-0.261	0.056
ANE20	138.7	0.9	9.3	1.347	0.145	0.903	0.097	0.397	0.043	-0.115	-0.259	0.098
ANE40	136.7	0.1	9.3	1.330	0.143	0.861	0.093	0.374	0.040	-0.019	-0.236	0.027

RUN NO: TU30-B DATE: 30/09/83 TIME: 1600-1700

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S	129.4	1.5	12.1	1.880	0.155	1.195	0.099	0.530	0.044	-0.171	-0.512	-0.095
ASW85	122.7	2.0	11.9	1.805	0.151	1.420	0.118	0.511	0.043	-0.118	-0.461	-0.101
ASW50												
ASW35	115.8	-0.4	11.7	1.950	0.165	1.205	0.102	0.371	0.032	0.381	-0.394	-0.132
ASW20	125.1	3.5	12.6	1.850	0.147	1.380	0.109	0.780	0.062	0.151	-0.767	-0.479
ASW10	122.6	-0.4	14.2	1.910	0.134	1.410	0.099	0.589	0.041	0.355	-0.468	-0.369
H/T	117.4	1.6	14.8	2.155	0.146	1.520	0.103	0.501	0.034	0.227	-0.510	-0.066
ANE10	116.7	1.1	13.4	1.930	0.143	1.225	0.091	0.520	0.039	0.282	-0.388	0.131
ANE20	125.5	5.5	13.1	1.845	0.141	1.055	0.081	0.758	0.058	-0.277	-0.634	0.254
ANE40	123.3	1.8	12.7	2.010	0.159	1.265	0.099	0.550	0.043	-0.254	-0.520	0.051

RUN NO: TU01-A DATE: 01/10/83 TIME: 1200-1400

TWR LOCN	DIRECTION	UPWASH	Norm Spd	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S	171.5	2.6		9.4	1.485	0.158	0.845	0.090	0.475	0.051	-0.082	-0.321	-0.020
ASW85	165.7	3.1	1.06	10.0	1.545	0.154	0.981	0.098	0.490	0.049	-0.167	-0.361	-0.001
ASW50	157.2	1.2	1.05	9.9	1.503	0.151	1.006	0.101	0.461	0.046	-0.142	-0.265	0.002
ASW35	157.4	6.7	1.06	10.0	1.478	0.148	1.100	0.110	0.548	0.055	-0.078	-0.383	-0.078
ASW20	166.7	14.0	1.34	12.6	1.405	0.112	1.197	0.095	0.579	0.046	0.001	-0.429	-0.075
ASW10	175.8	10.3	1.53	14.4	1.300	0.090	1.202	0.083	0.437	0.030	0.257	-0.296	-0.143
H/T	176.2	1.8	1.87	17.6	1.340	0.076	1.100	0.063	0.366	0.021	0.288	-0.087	0.021
ANE10	176.7	-7.7	1.50	14.1	1.658	0.118	0.983	0.070	0.435	0.031	0.063	-0.192	0.023
ANE20	166.0	-4.8	0.86	8.1	2.263	0.281	1.363	0.169	0.765	0.095	-1.244	-0.919	0.324
ANE40	156.8	-3.0	0.96	9.0	1.750	0.194	1.202	0.133	0.687	0.076	-0.198	-0.430	0.242

RUN NO: TU01-B DATE: 01/10/83 TIME: 1400-1600

TWR LOCN	DIRECTION	UPWASH	Norm Spd	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S	177.6	2.7		9.0	1.408	0.156	0.786	0.087	0.473	0.052	0.057	-0.289	-0.009
ASW85	171.7	3.5	1.06	9.5	1.298	0.137	0.854	0.091	0.455	0.048	-0.090	-0.235	-0.007
ASW50	161.7	1.3	.97	8.7	1.387	0.159	1.056	0.121	0.443	0.051	-0.188	-0.221	0.032
ASW35	162.3	7.4	.98	8.8	1.370	0.155	1.140	0.129	0.494	0.056	-0.142	-0.309	-0.044
ASW20	172.4	14.8	1.27	11.4	1.233	0.108	1.064	0.093	0.570	0.050	0.087	-0.328	-0.075
ASW10	182.0	11.9	1.49	13.4	1.240	0.093	1.188	0.089	0.431	0.032	0.209	-0.216	-0.113
H/T	182.1	1.8	1.81	16.3	1.260	0.077	1.070	0.066	0.385	0.024	0.147	-0.027	-0.018
ANE10	182.9	-8.3	1.39	12.5	1.587	0.127	0.898	0.072	0.401	0.032	-0.050	-0.193	0.050
ANE20	170.8	-6.8	.79	7.1	2.255	0.316	1.370	0.192	0.754	0.105	-1.434	-0.749	0.303
ANE40	159.0	-2.4	.82	7.4	1.565	0.211	1.188	0.161	0.673	0.091	-0.161	-0.338	0.256

RUN NO: TU01-C　　DATE: 01/10/83　　TIME: 1700-1830

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S	181.9	2.7	7.4	1.200	0.164	0.658	0.089	0.396	0.054	-0.090	-0.184	0.005
ASW85	173.4	3.9	7.4	1.213	0.164	0.608	0.082	0.374	0.051	-0.201	-0.149	-0.001
ASW50	160.7	1.0	6.8	1.142	0.167	0.797	0.117	0.331	0.048	-0.333	-0.107	0.021
ASW35	161.7	6.9	7.2	1.167	0.162	0.842	0.117	0.403	0.056	-0.209	-0.195	0.002
ASW20	174.8	14.2	9.9	1.123	0.114	0.772	0.078	0.468	0.047	-0.068	-0.232	-0.008
ASW10	185.8	12.5	12.0	1.113	0.093	0.945	0.079	0.415	0.034	0.086	-0.182	-0.062
H/T	186.0	1.3	15.0	1.140	0.076	0.723	0.048	0.209	0.014	0.047	-0.034	0.008
ANE10	186.9	-8.5	11.2	1.497	0.134	0.682	0.061	0.362	0.032	-0.063	-0.138	0.045
ANE20	167.6	-9.0	5.4	1.993	0.371	1.407	0.264	0.759	0.142	-1.362	-0.549	0.216
ANE40	154.9	-2.1	6.0	1.280	0.212	1.160	0.193	0.690	0.114	-0.162	-0.199	0.298

RUN NO: TU01-D　　DATE: 01/10/83　　TIME: 1930-2000

TWR LOCN	DIRECTION	UPWASH		SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S	198.7	2.1		7.7	1.140	0.148	0.688	0.089	0.342	0.044	-0.049	-0.146	-0.003
ASW85	192.1	3.3		7.4	1.200	0.162	0.731	0.099	0.388	0.053	-0.123	-0.177	0.020
ASW50	182.4	2.4		5.5	1.170	0.212	0.837	0.152	0.431	0.078	-0.241	-0.173	0.001
ASW35	185.0	8.9		6.1	1.210	0.197	0.839	0.137	0.419	0.068	-0.131	-0.228	-0.002
ASW20	193.2	16.1		9.2	1.140	0.123	0.990	0.107	0.516	0.056	-0.067	-0.265	-0.046
ASW10	201.7	14.5		11.6	1.100	0.095	1.090	0.094	0.492	0.042	-0.108	-0.088	-0.077
H/T	197.5	2.6	1.57	14.4	1.340	0.093	0.994	0.069	0.462	0.032	-0.046	-0.152	-0.025
ANE10	199.7	-9.6		10.0	1.880	0.188	0.973	0.097	0.499	0.050	-0.202	-0.214	0.076
ANE20	178.8	-13.3		3.5	2.090	0.589	1.590	0.448	0.866	0.244	-1.695	-0.402	0.284
ANE40	156.6	-3.4		3.7	1.620	0.438	1.460	0.395	1.040	0.281	0.086	0.051	0.564

RUN NO: TU02　　DATE: 02/10/83　　TIME: 1400-1600

TWR LOCN	DIRECTION	UPWASH	Norm Spd	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S	164.3	2.2		9.8	1.553	0.160	0.839	0.086	0.438	0.045	-0.161	-0.299	-0.010
ASW85	159.5	3.1	1.06	10.4	1.605	0.154	1.034	0.099	0.534	0.051	-0.130	-0.355	-0.032
ASW50	152.1	0.8	1.11	10.9	1.617	0.148	0.932	0.086	0.430	0.040	-0.260	-0.236	0.008
ASW35	150.6	5.1	1.11	10.9	1.690	0.155	1.085	0.100	0.524	0.048	-0.221	-0.342	-0.117
ASW20	160.0	12.5	1.34	13.1	1.618	0.123	1.253	0.096	0.593	0.045	-0.008	-0.419	-0.196
ASW10	168.4	10.7	1.52	14.9	1.582	0.106	1.295	0.087	0.574	0.038	0.154	-0.329	-0.250
H/T	169.3	1.9	1.79	17.5	1.625	0.093	1.175	0.067	0.357	0.020	-0.075	-0.119	0.003
ANE10	168.1	-6.7	1.43	14.0	1.750	0.125	1.153	0.082	0.504	0.036	-0.272	-0.284	0.061
ANE20	158.1	-2.9	0.91	8.9	1.975	0.229	1.178	0.136	0.689	0.080	-0.671	-0.707	0.283
ANE40	152.5	-2.4	1.05	10.3	1.872	0.183	1.093	0.107	0.603	0.059	-0.317	-0.436	0.167

RUN NO: TU03-A DATE: 03/10/83 TIME: 1200-1300

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S	205.9	2.7	9.3	1.325	0.142	0.665	0.071	0.432	0.046	0.307	-0.255	-0.023
ASW85	202.1	3.7	8.6	1.250	0.145	0.867	0.101	0.491	0.057	-0.012	-0.263	0.047
ASW50	192.4	2.9	7.4	1.440	0.194	0.706	0.095	0.516	0.070	0.067	-0.353	0.002
ASW35	195.0	11.2	7.9	1.465	0.185	1.080	0.137	0.637	0.081	0.283	-0.442	-0.037
ASW20	199.6	15.9	11.5	1.290	0.112	1.205	0.105	0.623	0.054	0.066	-0.373	0.013
ASW10	207.4	14.9	14.7	1.155	0.079	1.360	0.093	0.669	0.046	0.031	-0.296	-0.056
H/T	203.0	2.9	17.9	1.120	0.062	1.115	0.062	0.615	0.034	0.182	-0.145	0.032
ANE10	206.0	-10.7	13.3	1.790	0.135	1.110	0.084	0.575	0.043	0.080	-0.271	0.078
ANE20	194.0	-12.4	5.9	2.820	0.479	1.800	0.306	0.975	0.166	-1.847	-0.623	0.267
ANE40	184.6	-7.3	3.1	2.260	0.740	2.095	0.692	1.335	0.440	-0.412	-0.800	0.342

RUN NO: TU03-B DATE: 03/10/83 TIME: 1400-1700

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S	207.3	2.5	8.6	1.223	0.143	0.704	0.082	0.413	0.048	0.135	-0.247	-0.013
ASW85	201.6	3.9	7.8	1.200	0.153	0.762	0.097	0.463	0.059	0.007	-0.239	0.002
ASW50	192.9	2.8	6.7	1.350	0.202	0.683	0.102	0.475	0.071	0.099	-0.272	0.015
ASW35	196.0	11.5	7.2	1.243	0.174	1.038	0.145	0.580	0.081	0.042	-0.351	-0.033
ASW20	200.6	16.0	10.5	1.115	0.107	1.126	0.107	0.565	0.054	0.032	-0.287	-0.004
ASW10	207.9	14.5	13.2	1.059	0.080	1.232	0.093	0.577	0.044	0.098	-0.243	-0.049
H/T	203.4	2.7	16.2	1.100	0.068	1.034	0.064	0.577	0.036	0.189	-0.153	0.031
ANE10	206.5	-11.1	12.0	1.758	0.146	1.012	0.084	0.531	0.044	-0.004	-0.241	0.056
ANE20	195.9	-13.0	5.6	2.560	0.458	1.502	0.269	0.881	0.158	-1.431	-0.560	0.206
ANE40	188.1	-5.7	3.0	1.983	0.668	1.798	0.606	1.192	0.402	-0.275	-0.694	0.459

RUN NO: TU05-A DATE: 05/10/83 TIME: 1030-1130

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S	285.3	1.2	9.2	1.275	0.138	0.967	0.105	0.426	0.046	-0.028	-0.242	0.016
ASW85	286.3	-0.3	9.5	1.305	0.138	0.907	0.095	0.321	0.034	0.067	-0.080	0.097
ASW50	289.0	2.9	9.6	1.280	0.133	1.005	0.105	0.456	0.048	0.003	-0.232	0.011
ASW35	287.1	4.3	9.6	1.475	0.154	1.061	0.111	0.508	0.053	0.234	-0.282	0.129
ASW20												
ASW10	282.1	4.6	12.9	1.620	0.126	1.230	0.095	0.319	0.025	0.195	-0.154	0.210
H/T	274.6	1.4	14.3	1.445	0.101	1.389	0.097	0.268	0.019	0.266	-0.066	0.042
ANE10	282.0	-3.7	11.6	1.680	0.145	1.164	0.100	0.374	0.032	0.310	-0.207	-0.115
ANE20	291.5	-8.5	11.1	1.690	0.152	0.865	0.077	0.526	0.047	-0.049	-0.080	-0.226
ANE40	291.3	-1.7	10.1	1.585	0.157	0.955	0.094	0.365	0.036	-0.070	-0.195	[illegible]

RUN NO: TU05-B   DATE: 05/10/83   TIME: 1330-1530

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S	306.1	0.7	8.2	1.313	0.161	0.842	0.103	0.422	0.052	-0.172	-0.255	0.023
ASW85	305.0	0.0	8.9	1.275	0.143	0.894	0.099	0.216	0.024	-0.068	-0.082	0.000
ASW50	305.3	2.5	9.3	1.215	0.131	0.820	0.087	0.403	0.043	-0.038	-0.213	0.043
ASW35	303.6	1.4	9.2	1.473	0.161	0.816	0.089	0.401	0.044	-0.087	-0.271	0.099
ASW20												
ASW10	305.9	0.8	11.4	1.472	0.130	0.909	0.080	0.364	0.032	-0.042	-0.150	0.185
H/T	303.5	1.1	11.6	1.345	0.116	1.038	0.089	0.253	0.022	-0.002	-0.098	0.014
ANE10	307.5	-0.2	10.9	1.490	0.137	0.943	0.086	0.270	0.025	0.021	-0.074	-0.116
ANE20	313.2	-3.4	10.7	1.482	0.139	0.849	0.079	0.387	0.036	-0.053	-0.073	-0.162
ANE40												

RUN NO: TU05-C   DATE: 05/10/83   TIME: 1530-1700

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S	303.2	0.9	7.7	1.183	0.155	0.799	0.104	0.405	0.053	-0.003	-0.223	0.018
ASW85	302.5	0.4	8.6	1.177	0.137	0.742	0.086	0.232	0.027	0.069	-0.089	-0.004
ASW50	303.4	2.7	8.6	1.079	0.126	0.676	0.079	0.382	0.045	-0.081	-0.169	0.043
ASW35	300.4	1.8	8.6	1.293	0.151	0.799	0.093	0.385	0.045	0.030	-0.211	0.094
ASW20												
ASW10	304.2	0.9	10.4	1.190	0.115	0.754	0.073	0.315	0.030	0.045	-0.105	0.102
H/T	301.1	1.1	11.0	1.150	0.105	0.772	0.071	0.217	0.020	0.013	-0.058	0.011
ANE10	304.5	-1.0	10.4	1.273	0.123	0.792	0.077	0.264	0.026	-0.047	-0.039	-0.086
ANE20	311.2	-4.4	9.6	1.270	0.133	0.764	0.081	0.368	0.039	0.036	-0.104	-0.114
ANE40												

RUN NO: TU05-D   DATE: 05/10/83   TIME: 1800-2100

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S	301.0	0.7	5.0	0.787	0.155	0.504	0.099	0.211	0.041	0.021	-0.069	0.011
ASW85	303.2	0.4	5.2	0.789	0.151	0.435	0.084	0.111	0.021	0.054	-0.026	0.001
ASW50	304.3	2.5	4.9	0.697	0.142	0.454	0.094	0.188	0.037	0.030	-0.035	0.013
ASW35	306.4	0.7	5.2	0.713	0.135	0.488	0.094	0.167	0.032	0.077	-0.037	0.024
ASW20												
ASW10	300.5	1.4	6.7	0.840	0.123	0.559	0.082	0.164	0.024	0.059	-0.019	0.053
H/T	296.1	0.9	6.9	0.820	0.117	0.609	0.088	0.134	0.019	-0.031	-0.018	0.011
ANE10	303.0	-2.5	6.3	0.873	0.139	0.498	0.080	0.184	0.030	-0.052	0.004	-0.035
ANE20	311.3	-7.7	5.9	0.783	0.132	0.433	0.074	0.258	0.044	-0.020	0.021	-0.046
ANE40												

RUN NO: TU06-A DATE: 06/10/83 TIME: 1430-1600

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S	209.1	2.7	10.9	1.423	0.130	0.777	0.071	0.482	0.044	0.386	-0.294	-0.040
ASW85	205.2	2.0	10.1	1.423	0.141	0.923	0.091	0.311	0.031	-0.025	-0.180	0.004
ASW50	197.7	3.2	8.0	1.650	0.207	0.938	0.117	0.587	0.073	0.160	-0.442	0.015
ASW35	200.6	10.5	9.0	1.557	0.172	1.207	0.134	0.602	0.067	0.043	-0.524	-0.002
ASW20	203.6	18.2	13.4	1.440	0.108	1.283	0.096	0.753	0.056	-0.003	-0.509	0.013
ASW10	210.9	15.7	17.2	1.277	0.074	1.443	0.084	0.802	0.047	-0.092	-0.367	0.057
H/T	205.4	1.8	20.8	1.287	0.062	1.143	0.055	0.411	0.020	0.144	-0.161	0.019
ANE10	209.6	-10.3	15.4	2.230	0.145	1.230	0.080	0.666	0.043	-0.184	-0.385	0.020
ANE20	197.2	-12.4	7.3	3.280	0.451	1.957	0.269	1.177	0.162	-2.394	-1.121	0.350
ANE40												

RUN NO: TU06-B DATE: 06/10/83 TIME: 1700-1800

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S	224.4	2.5	9.3	1.105	0.119	0.674	0.073	0.396	0.043	0.125	-0.194	-0.013
ASW85	223.3	2.5	8.2	1.210	0.148	0.790	0.097	0.310	0.038	-0.104	-0.169	0.012
ASW50	220.6	4.3	6.2	1.330	0.216	0.889	0.144	0.582	0.094	-0.006	-0.354	-0.055
ASW35	220.4	11.0	7.4	1.305	0.177	1.165	0.158	0.558	0.076	-0.155	-0.404	0.044
ASW20	217.5	17.6	11.2	1.185	0.106	1.220	0.109	0.641	0.057	-0.109	-0.301	0.130
ASW10	222.3	13.7	14.4	1.085	0.075	1.250	0.087	0.598	0.041	-0.054	-0.244	0.079
H/T	215.3	1.7	17.1	1.048	0.061	1.060	0.062	0.294	0.017	-0.126	-0.104	0.030
ANE10	220.9	-11.2	13.1	1.715	0.131	1.020	0.078	0.575	0.044	-0.043	-0.227	-0.028
ANE20	216.7	-17.3	7.3	2.010	0.277	1.230	0.169	0.798	0.110	-0.086	-0.505	0.110

RUN NO: TU07-A DATE: 07/10/83 TIME: 1200-1400

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S	240.4	2.1	9.2	1.748	0.189	1.350	0.147	0.370	0.040	-0.098	-0.216	0.020
ASW85	241.1	2.2	8.2	1.550	0.191	1.164	0.142	0.297	0.036	0.025	-0.140	0.032
ASW50	243.5	4.6	6.2	1.548	0.249	1.132	0.182	0.539	0.087	-0.118	-0.312	-0.046
ASW35	243.0	10.9	7.0	1.553	0.223	1.403	0.199	0.578	0.083	-0.016	-0.352	0.074
ASW20	234.6	17.1	10.1	1.528	0.153	1.590	0.158	0.601	0.060	0.236	-0.203	0.198
ASW10	237.1	14.8	12.7	1.692	0.135	1.715	0.135	0.594	0.047	0.149	-0.126	0.206
H/T	230.5	1.4	15.3	2.000	0.131	2.003	0.131	0.389	0.026	0.808	-0.359	-0.043
ANE10	238.3	-12.4	11.1	1.865	0.170	1.385	0.125	0.542	0.049	-0.102	-0.045	-0.161
ANE20	243.9	-18.4	7.0	2.075	0.296	1.447	0.206	0.577	0.082	0.310	-0.096	-0.113
ANE40												

RUN NO: TU07-B DATE: 07/10/83 TIME: 1530-1700

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S	257.2	1.9	9.8	1.533	0.156	1.395	0.141	0.376	0.038	-0.268	-0.235	0.058
ASW85												
ASW50	258.1	4.4	6.8	1.333	0.195	1.319	0.192	0.519	0.076	-0.191	-0.262	-0.049
ASW35	259.1	9.0	7.9	1.600	0.201	1.333	0.167	0.601	0.076	-0.584	-0.460	0.189
ASW20	250.1	15.0	10.5	1.433	0.137	1.850	0.176	0.598	0.057	0.170	-0.269	0.435
ASW10	249.4	13.4	13.1	1.477	0.113	1.960	0.148	0.602	0.046	-0.482	-0.249	0.569
H/T	239.2	0.8	15.4	1.607	0.104	1.757	0.113	0.188	0.012	-0.758	-0.181	0.048
ANE10	248.9	-9.9	12.0	1.567	0.129	1.568	0.129	0.521	0.043	-0.445	0.021	-0.470
ANE20	260.7	-17.3	7.6	1.917	0.252	1.400	0.183	0.567	0.075	-0.421	-0.092	-0.222
ANE40												

TABLE A1.4 AVERAGED DATA FROM BRE GILL UVW ANEMOMETERS (ASW60) FOR DESIGNATED TURBULENCE RUNS.

Note: "incid deg" refers to upwash angle relative to u-v (horizontal) plane.

ASKERVEIN-84 TURBULENCE RUN DATA AT ASW60
BRE Gill UVW Anemometer Data
Corrected for cosine response using standard coefficients

RUN TU25

Date: 25/ 9/83 Start time: 16:00:00 Stop time: 17:00:00

height m	dir deg g	incid deg	$\bar{U}$ m/s	σ_u m/s	σ_v m/s	σ_w m/s	$\overline{uv}$ (m/s) 2	$\overline{uw}$ (m/s) 2	$\overline{vw}$ (m/s) 2
6	205.339	1.837	4.133	0.842	0.524	0.225	0.034	-0.077	-0.012
10	206.019	0.301	4.733	0.867	0.550	0.240	0.049	-0.084	-0.011
20	210.267	0.562	5.088	0.839	0.529	0.289	0.058	-0.098	-0.017
31	205.073	-0.553	5.995	0.806	0.541	0.301	0.050	-0.103	-0.022

RUN TU26 (first 3 hours of 4)

Date: 26/ 9/83 Start time: 10:00:07 Stop time: 13:00:07

height m	dir deg g	incid deg	$\bar{U}$ m/s	σ_u m/s	σ_v m/s	σ_w m/s	$\overline{uv}$ (m/s) 2	$\overline{uw}$ (m/s) 2	$\overline{vw}$ (m/s) 2
6	207.787	2.163	4.859	1.085	0.676	0.294	0.089	-0.136	-0.015
10	212.031	1.009	5.016	0.996	0.634	0.341	0.145	-0.145	-0.008
20	210.028	1.531	6.702	1.096	0.681	0.381	0.045	-0.183	-0.013
31	208.822	-0.851	7.241	1.032	0.688	0.407	0.051	-0.207	-0.019

RUN TU30-A

Date: 30/ 9/83   Start time: 11:30:01   Stop time: 13:00:01

height m	dir deg g	incid deg	$\bar{U}$ m/s	σ_u m/s	σ_v m/s	σ_w m/s	$\overline{uv}$ (m/s) 2	$\overline{uw}$ (m/s) 2	$\overline{vw}$ (m/s) 2
6	137.692	1.563	8.680	1.390	0.896	0.358	-0.087	-0.108	0.034
10	132.073	0.238	8.532	1.229	0.834	0.373	0.028	-0.188	0.032
20	136.139	1.447	10.230	1.291	0.944	0.440	-0.092	-0.237	0.057
31	132.940	-1.166	10.932	1.328	0.933	0.464	-0.144	-0.353	0.034

RUN TU30-B

Date: 30/ 9/83   Start time: 16:00:02   Stop time: 17:00:02

height m	dir deg g	incid deg	$\bar{U}$ m/s	σ_u m/s	σ_v m/s	σ_w m/s	$\overline{uv}$ (m/s) 2	$\overline{uw}$ (m/s) 2	$\overline{vw}$ (m/s) 2
6	124.893	2.117	12.047	1.864	1.342	0.535	-0.471	-0.432	0.058
10	117.347	1.213	11.741	1.768	1.079	0.590	-0.966	-0.403	0.101
20	122.941	2.805	14.171	1.658	1.338	0.687	-0.041	-0.436	0.037
31	120.682	-1.811	15.424	1.777	1.390	0.766	-0.319	-0.839	0.132

RUN TU01-A (15mins early)

Date: 1/10/83   Start time: 11:44:52   Stop time: 13:44:52

height m	dir deg g	incid deg	$\bar{U}$ m/s	σ_u m/s	σ_v m/s	σ_w m/s	$\overline{uv}$ (m/s) 2	$\overline{uw}$ (m/s) 2	$\overline{vw}$ (m/s) 2
6	163.162	1.848	9.872	1.589	1.029	0.446	0.095	-0.256	0.015
10	160.523	1.025	9.395	1.453	0.983	0.526	0.016	-0.294	0.022
20	162.846	1.974	11.694	1.628	1.035	0.626	0.188	-0.369	-0.012
31	161.181	-3.983	12.088	1.592	0.998	0.831	0.071	-0.757	-0.048

RUN TU01-B (15mins early)

Date: 1/10/83 Start time: 13:44:52 Stop time: 15:44:52

height m	dir deg g	incid deg	$\overline{U}$ m/s	σ_u m/s	σ_v m/s	σ_w m/s	$\overline{uv}$ (m/s) 2	$\overline{uw}$ (m/s) 2	$\overline{vw}$ (m/s) 2
6	168.226	1.584	8.710	1.443	0.979	0.410	0.165	-0.210	0.008
10	165.979	0.747	8.099	1.287	0.948	0.486	0.083	-0.241	0.002
20	168.643	1.663	10.289	1.471	0.996	0.579	0.238	-0.303	-0.037
31	167.189	-3.011	10.598	1.385	0.984	0.715	0.162	-0.492	-0.076

RUN TU01-C

Date: 1/10/83 Start time: 16:59:57 Stop time: 18:29:27

height m	dir deg g	incid deg	$\overline{U}$ m/s	σ_u m/s	σ_v m/s	σ_w m/s	$\overline{uv}$ (m/s) 2	$\overline{uw}$ (m/s) 2	$\overline{vw}$ (m/s) 2
6	167.736	1.184	6.687	1.094	0.708	0.285	0.152	-0.108	-0.004
10	166.792	0.467	6.352	0.961	0.706	0.370	0.101	-0.126	-0.003
20	170.050	1.204	8.143	1.144	0.759	0.415	0.261	-0.163	-0.022
31	169.657	-1.578	8.646	1.146	0.746	0.464	0.193	-0.263	-0.062

RUN TU01-D

Date: 1/10/83 Start time: 19:29:57 Stop time: 19:59:27

height m	dir deg g	incid deg	$\overline{U}$ m/s	σ_u m/s	σ_v m/s	σ_w m/s	$\overline{uv}$ (m/s) 2	$\overline{uw}$ (m/s) 2	$\overline{vw}$ (m/s) 2
6	187.951	1.127	6.267	1.289	0.731	0.323	0.143	-0.113	-0.012
10	190.632	0.768	6.047	1.109	0.817	0.372	0.222	-0.130	-0.011
20	190.620	1.710	8.199	1.314	0.895	0.443	0.316	-0.192	-0.018
31	190.310	-1.571	8.772	1.265	0.890	0.506	0.331	-0.290	-0.055

RUN TU02

Date: 2/10/83 Start time: 14:00:11 Stop time 16:00:11

height m	dir deg g	incid deg	$\overline{U}$ m/s	σ_u m/s	σ_v m/s	σ_w m/s	$\overline{uv}$ (m/s) 2	$\overline{uw}$ (m/s) 2	$\overline{vw}$ (m/s) 2
6	157.007	1.629	10.312	1.641	1.012	0.445	0.069	-0.198	0.006
10	154.331	0.683	10.389	1.586	1.016	0.500	-0.111	-0.215	-0.029
20	156.466	1.966	12.150	1.678	1.088	0.609	0.090	-0.274	-0.054
31	154.818	-3.201	12.755	1.634	1.031	0.778	-0.017	-0.694	-0.071

RUN TU03-A

Date: 3/10/83 Start time: 12:00:00 Stop time: 13:00:00

height m	dir deg g	incid deg	$\overline{U}$ m/s	σ_u m/s	σ_v m/s	σ_w m/s	$\overline{uv}$ (m/s) 2	$\overline{uw}$ (m/s) 2	$\overline{vw}$ (m/s) 2
6	198.653	1.627	7.867	1.351	0.931	0.394	0.084	-0.197	-0.021
10	199.698	1.221	8.424	1.350	0.955	0.453	0.118	-0.233	-0.011
20	202.792	2.417	8.834	1.276	0.947	0.547	0.183	-0.235	-0.036
31	199.424	-2.180	10.340	1.280	0.947	0.588	0.121	-0.332	-0.053

RUN TU03-B

Date: 3/10/83 Start time: 13:59:58 Stop time: 16:59:58

height m	dir deg g	incid deg	$\overline{U}$ m/s	σ_u m/s	σ_v m/s	σ_w m/s	$\overline{uv}$ (m/s) 2	$\overline{uw}$ (m/s) 2	$\overline{vw}$ (m/s) 2
6	199.461	1.358	7.060	1.378	0.889	0.363	0.084	-0.168	-0.005
10	200.608	0.927	7.754	1.379	0.893	0.421	0.154	-0.218	-0.006
20	203.288	2.108	8.089	1.285	0.839	0.497	0.154	-0.229	-0.007
31	199.579	-1.821	9.422	1.280	0.841	0.556	0.089	-0.342	-0.039

RUN TU05-A

Date: 5/10/83 Start time: 10:29:59 Stop time : 11:29:59

height m	dir deg g	incid deg	$\bar{U}$ m/s	σ_u m/s	σ_v m/s	σ_w m/s	$\overline{uv}$ (m/s) 2	$\overline{uw}$ (m/s) 2	$\overline{vw}$ (m/s) 2
6	291.439	1.189	8.744	1.509	0.919	0.380	-0.186	-0.219	0.007
10	281.507	2.866	8.924	1.522	0.681	0.478	-0.321	-0.293	0.047
20	289.882	3.516	10.588	1.562	1.036	0.524	-0.174	-0.274	-0.001
31	291.875	1.218	11.400	1.617	0.989	0.606	-0.127	-0.552	-0.010

RUN TU05-B

Date: 5/10/83 Start time: 13:30:09 Stop time: 15:30:09

height m	dir deg g	incid deg	$\bar{U}$ m/s	σ_u m/s	σ_v m/s	σ_w m/s	$\overline{uv}$ (m/s) 2	$\overline{uw}$ (m/s) 2	$\overline{vw}$ (m/s) 2
6	309.124	1.423	9.302	1.538	0.986	0.359	0.350	-0.170	0.018
10	303.284	4.031	8.941	1.414	1.065	0.415	0.538	-0.150	0.051
20	309.379	4.226	10.766	1.385	0.978	0.472	0.316	-0.160	0.049
31	311.416	0.325	11.302	1.230	0.938	0.575	0.129	-0.339	0.028

RUN TU05-C

Date: 5/10/83 Start time: 15:30:09 Stop time: 17:00:09

height m	dir deg g	incid deg	$\bar{U}$ m/s	σ_u m/s	σ_v m/s	σ_w m/s	$\overline{uv}$ (m/s) 2	$\overline{uw}$ (m/s) 2	$\overline{vw}$ (m/s) 2
6	306.282	1.371	8.670	1.361	0.892	0.370	0.208	-0.210	0.028
10	298.457	4.054	8.127	1.181	0.847	0.432	0.072	-0.191	0.056
20	306.634	4.139	10.101	1.194	0.886	0.457	0.164	-0.192	0.037
31	308.606	0.502	10.611	1.067	0.820	0.547	0.063	-0.305	0.015

RUN TU05-D

Date: 5/10/83 Start time: 17:59:59 Stop time: 20:59:59

height m	dir deg g	incid deg	$\overline{U}$ m/s	σ_u m/s	σ_v m/s	σ_w m/s	$\overline{uv}$ (m/s) 2	$\overline{uw}$ (m/s) 2	$\overline{vw}$ (m/s) 2
6	306.746	0.054	4.650	0.820	0.481	0.160	0.034	-0.017	0.009
10	295.821	3.039	4.356	0.734	0.472	0.205	-0.006	-0.028	0.027
20	306.911	2.986	6.076	0.826	0.561	0.218	-0.058	-0.027	0.024
31	308.750	1.433	6.789	0.827	0.585	0.238	-0.075	-0.063	0.018

RUN TU06-A

Date: 6/10/83 Start time: 14:30:00 Stop time: 16:00:00

height m	dir deg g	incid deg	$\overline{U}$ m/s	σ_u m/s	σ_v m/s	σ_w m/s	$\overline{uv}$ (m/s) 2	$\overline{uw}$ (m/s) 2	$\overline{vw}$ (m/s) 2
6	205.026	1.665	8.522	1.682	1.077	0.448	0.258	-0.247	-0.015
10	208.852	1.235	8.848	1.566	1.050	0.512	0.436	-0.276	-0.017
20	207.535	2.698	11.415	1.730	1.070	0.625	0.252	-0.360	-0.006
31	206.647	-0.158	12.088	1.606	1.087	0.704	0.278	-0.568	-0.038

RUN TU07-B

Date: 7/10/83 Start time: 15:30:01 Stop time: 17:00:01

height m	dir deg g	incid deg	$\overline{U}$ m/s	σ_u m/s	σ_v m/s	σ_w m/s	$\overline{uv}$ (m/s) 2	$\overline{uw}$ (m/s) 2	$\overline{vw}$ (m/s) 2
6	260.949	0.804	7.431	1.723	0.998	0.357	0.140	-0.162	0.001
10	265.525	2.073	8.688	1.725	0.573	0.409	0.308	-0.173	0.020
20	258.859	3.189	9.860	1.880	1.079	0.453	0.245	-0.078	0.053
31	261.375	1.000	10.665	1.859	1.107	0.516	0.404	-0.439	-0.006

(Intentionally blank)

TABLE A1.5 AVERAGED DATA FROM FRG CUP AND GILL UVW ANEMOMETERS FOR DESIGNATED TURBULENCE RUNS.

Legend

LOC	:	location specifier
DZ	:	height of instrument above ground
DIR	:	wind direction in the grid system
DIF	:	hill wind directions minus reference direction
SPEED	:	wind speed
UPWSH	:	mean vertical component
FSPUP	:	fractional speed up
SIGMU, -V, -W	:	RMS-values σ_{u}, v, w
INTU, -V, -W	:	turbulence intensities
U'V',.....,	:	Reynolds stresses (covariances)

Notes

1. MF data (cup anemometers) at heights 1.6, 3.0 and 7.4 m at CP' are ~9.8% higher than corresponding Gill anemometer data (5.0 m, 10.0 m and 16.0 m) in areas where they overlap (see Figs. 4.2). No explanation for these differences has been found and no attempted corrections have been made.

2. Cup anemometers (MF) at CP and AASW10, 20, 30 and 40 were lowered from DZ=10 m to DZ = 3 m for Runs TU06 and TU07, as indicated on appropriate tables.

RUN NO : TU25

TIME : 1600 - 1700

MEAN GRADIENT RICHARDSON NUMBER : -0.0083

LOC		DZ (M)	DIR (DEG)	DIF (DEG)	SPEED (M/S)	UPWSH (M/S)	FSPUP	SIGMU (M/S)	INTU	SIGMV (M/S)	INTV	SIGMW (M/S)	INTW	U'V' (M/S)^2	U'W' (M/S)^2	V'W' (M/S)^2
RS	MF	4.9			4.84											
RS	MF	10.0	210		5.57											
RS	MF	16.9			6.26											
CP'	MF	1.6			*******											
CP'	MF	3.0			*******											
CP'	TU	5.0	220	10	8.94	0.47		0.859	0.0961	0.612	0.0685	0.232	0.0259	0.023	-0.069	0.015
CP'	MF	7.4			*******											
CP'	TU	10.0	***		**********	0.79	*****	*****	******	*****	******	*****	******	******	******	******
CP'	TU	16.0	217	7	9.54	0.42		0.701	0.0735	0.556	0.0583	0.375	0.0393	0.007	-0.067	0.024
CP	MF	10.0	223	13	8.79		0.578									
AASW10	MF	10.0	219	9	8.15		0.463									
AASW10	TU	10.0	217	7	8.44	1.41	0.514	0.734	0.0871	0.687	0.0815	0.385	0.0456	0.072	-0.060	0.022
AASW20	MF	10.0	220	10	6.70		0.203									
AASW30	MF	10.0	215	5	5.49		-0.015									
AASW30	TU	10.0	212	2	5.31	1.38	-0.047	0.748	0.1409	0.732	0.1377	0.437	0.0824	0.003	-0.150	0.027
AASW40	MF	10.0	214	4	4.43		-0.205									
AASW50	TU	10.0	210	0	3.88	-0.23	-0.303	0.969	0.2494	0.581	0.1497	0.204	0.0527	-0.059	0.013	-0.002

RUN NO : TU26 (PARTIAL)

TIME : 1330 - 1400

MEAN GRADIENT RICHARDSON NUMBER : -0.0116

LOC		DZ (M)	DIR (DEG)	DIF (DEG)	SPEED (M/S)	UPWSH (M/S)	FSPUP	SIGMU (M/S)	INTU	SIGMV (M/S)	INTV	SIGMW (M/S)	INTW	U'V' (M/S)^2	U'W' (M/S)^2	V'W' (M/S)^2
RS	MF	4.9			6.99											
RS	MF	10.0	216		7.91											
RS	MF	16.9			8.77											
CP'	MF	1.6			*******											
CP'	MF	3.0			*******											
CP'	TU	5.0	***		**********	0.92		*****	******	*****	******	*****	******	******	******	******
CP'	MF	7.4			*******											
CP'	TU	10.0	224	8	13.36	1.21	0.689	0.826	0.0618	0.773	0.0579	0.425	0.0318	0.053	-0.121	-0.017
CP'	TU	16.0	222	6	13.72	0.65		0.800	0.0583	0.732	0.0534	0.526	0.0383	0.058	-0.198	-0.020
CP	MF	10.0	227	11	12.67		0.602									
AASW10	MF	10.0	228	12	11.71		0.480									
AASW10	TU	10.0	223	7	12.21	2.00	0.544	0.832	0.0681	0.903	0.0740	0.506	0.0414	0.045	-0.147	0.033
AASW20	MF	10.0	228	12	9.50		0.201									
AASW30	MF	10.0	230	14	7.70		-0.027									
AASW30	TU	10.0	223	7	7.57	1.92	-0.043	0.960	0.1268	0.953	0.1259	0.602	0.0795	-0.093	-0.266	0.074
AASW40	MF	10.0	233	17	6.06		-0.234									
AASW50	TU	10.0	221	5	5.13	0.28	-0.351	1.361	0.2653	0.765	0.1491	0.479	0.0934	-0.151	-0.233	-0.007

RUN NO : TU30-A

TIME : 1130 - 1300

MEAN GRADIENT RICHARDSON NUMBER : 0.0005

LOC		DZ (M)	DIR (DEG)	DIF (DEG)	SPEED (M/S)	UPWSH (M/S)	FSPUP	SIGMU (M/S)	INTU	SIGMV (M/S)	INTV	SIGMW (M/S)	INTW	U`V` (M/S)^2	U`W` (M/S)^2	V`W` (M/S)^2
RS	MF	4.9			6.83											
RS	MF	10.0	131		7.96											
RS	MF	16.9			8.72											
CP`	MF	1.6			8.04											
CP`	MF	3.0			9.23											
CP`	TU	5.0	***	***	8.80	0.71		1.250	0.1427	1.414	0.1649	0.323	0.0368	0.591	-0.181	-0.034
CP`	MF	7.4			10.95											
CP`	TU	10.0	137	6	10.39	0.83	0.306	1.228	0.1183	0.850	0.0819	0.343	0.0330	-0.019	-0.137	-0.034
CP`	TU	16.0	137	6	11.18	0.89		1.174	0.1051	0.850	0.0760	0.383	0.0343	-0.051	-0.125	-0.031
CP	MF	10.0	138	7	10.21		0.284									
AASW10	MF	10.0	133	2	10.29		0.293									
AASW10	TU	10.0	137	6	10.26	0.61	0.290	1.327	0.1294	0.820	0.0799	0.358	0.0349	-0.036	-0.164	-0.104
AASW20	MF	10.0	141	10	9.97		0.253									
AASW30	MF	10.0	133	2	9.61		0.208									
AASW30	TU	10.0	136	5	9.40	0.53	0.181	1.235	0.1316	0.843	0.0897	0.422	0.0449	-0.068	-0.212	-0.144
AASW40	MF	10.0	139	8	8.86		0.113									
AASW50	TU	10.0	134	3	8.95	0.22	0.125	1.333	0.1491	0.748	0.0836	0.367	0.0410	-0.025	-0.247	-0.048

RUN NO : TU30-B   MBA Fig 12a

TIME : 1600 - 1700

MEAN GRADIENT RICHARDSON NUMBER : 0.0051

LOC		DZ (M)	DIR (DEG)	DIF (DEG)	SPEED (M/S)	UPWSH (M/S)	FSPUP	SIGMU (M/S)	INTU	SIGMV (M/S)	INTV	SIGMW (M/S)	INTW	U`V` (M/S)^2	U`W` (M/S)^2	V`W` (M/S)^2
RS	MF	4.9			11.23											
RS	MF	10.0	124		12.90											
RS	MF	16.9			14.14											
CP`	MF	1.6			12.08											
CP`	MF	3.0			13.75											
CP`	TU	5.0	***	***	13.41	1.12		1.964	0.1462	1.237	0.0918	0.416	0.0311	0.644	-0.299	-0.040
CP`	MF	7.4			16.80											
CP`	TU	10.0	119	-5	15.10	1.18	0.170	1.924	0.1273	1.292	0.0851	0.494	0.0327	0.663	-0.391	-0.123
CP`	TU	16.0	120	-4	16.16	1.41		1.868	0.1154	1.318	0.0811	0.563	0.0349	0.681	-0.446	-0.111
CP	MF	10.0	118	-6	15.25		0.182									
AASW10	MF	10.0	115	-9	15.04		0.166									
AASW10	TU	10.0	121	-3	15.02	0.36	0.164	1.999	0.1321	1.365	0.0902	0.481	0.0320	0.517	-0.489	-0.255
AASW20	MF	10.0	128	4	14.72		0.141									
AASW30	MF	10.0	121	-3	14.11		0.093									
AASW30	TU	10.0	123	-1	13.87	0.09	0.075	1.901	0.1365	1.276	0.0912	0.894	0.0626	0.744	-0.614	-0.362
AASW40	MF	10.0	124	0	12.51		-0.030									
AASW50	TU	10.0	123	-1	12.55	0.12	-0.028	1.908	0.1521	1.143	0.0905	0.494	0.0395	0.190	-0.520	-0.116

RUN NO : TU01-A (PARTIAL)

TIME : 1230 - 1400

MEAN GRADIENT RICHARDSON NUMBER : -0.0228

LOC	DZ (M)	DIR (DEG)	DIF (DEG)	SPEED (M/S)	UPWSH (M/S)	FSPUP	SIGMU (M/S)	INTU	SIGMV (M/S)	INTV	SIGMW (M/S)	INTW	U`V` (M/S)^2	U`W` (M/S)^2	V`W` (M/S)^2
RS MF	4.9			8.38											
RS MF	10.0	170		9.60											
RS MF	16.9			10.45											
CP` MF	1.6			12.32											
CP` MF	3.0			13.80											
CP` TU	5.0	186	16	14.12	1.05		1.426	0.1010	1.023	0.0725	0.323	0.0229	0.202	-0.160	-0.035
CP` MF	7.4			16.11											
CP` TU	10.0	180	10	14.96	1.54	0.559	1.280	0.0856	1.036	0.0693	0.439	0.0294	0.223	-0.170	-0.024
CP` TU	16.0	179	9	15.60	1.13		1.217	0.0781	1.075	0.0690	0.561	0.0360	0.209	-0.187	0.028
CP MF	10.0	187	17	14.36		0.496									
AASW10 MF	10.0	178	8	13.76		0.433									
AASW10 TU	10.0	177	7	14.05	2.02	0.464	1.341	0.0954	1.158	0.0825	0.495	0.0353	0.261	-0.221	-0.114
AASW20 MF	10.0	177	7	12.40		0.292									
AASW30 MF	10.0	169	-1	11.37		0.185									
AASW30 TU	10.0	166	-4	11.50	2.11	0.199	1.382	0.1201	0.965	0.0840	0.574	0.0499	0.105	-0.368	-0.101
AASW40 MF	10.0	167	-3	9.69		0.010									
AASW50 TU	10.0	160	-10	9.22	0.57	-0.040	1.505	0.1633	0.958	0.1040	0.551	0.0598	-0.052	-0.423	-0.020

RUN NO : TU01-B

TIME : 1400 - 1600

MEAN GRADIENT RICHARDSON NUMBER : -0.0205

LOC	DZ (M)	DIR (DEG)	DIF (DEG)	SPEED (M/S)	UPWSH (M/S)	FSPUP	SIGMU (M/S)	INTU	SIGMV (M/S)	INTV	SIGMW (M/S)	INTW	U`V` (M/S)^2	U`W` (M/S)^2	V`W` (M/S)^2
RS MF	4.9			7.94											
RS MF	10.0	177		9.12											
RS MF	16.9			9.99											
CP` MF	1.6			11.32											
CP` MF	3.0			12.74											
CP` TU	5.0	192	15	13.11	0.97		1.290	0.0982	0.964	0.0736	0.321	0.0245	0.228	-0.156	-0.013
CP` MF	7.4			14.57											
CP` TU	10.0	186	9	13.81	1.41	0.514	1.150	0.0832	0.985	0.0714	0.433	0.0314	0.216	-0.132	0.005
CP` TU	16.0	185	8	14.37	0.98		1.090	0.0757	0.954	0.0665	0.546	0.0381	0.160	-0.126	0.057
CP MF	10.0	192	15	13.24		0.451									
AASW10 MF	10.0	184	7	12.43		0.362									
AASW10 TU	10.0	183	6	12.73	1.95	0.396	1.182	0.0928	1.041	0.0819	0.473	0.0371	0.154	-0.193	-0.056
AASW20 MF	10.0	181	4	10.97		0.202									
AASW30 MF	10.0	173	-4	9.79		0.073									
AASW30 TU	10.0	171	-6	9.86	1.95	0.081	1.200	0.1218	1.000	0.1012	0.555	0.0563	0.008	-0.289	-0.096
AASW40 MF	10.0	175	-2	8.49		-0.069									
AASW50 TU	10.0	165	-12	7.96	0.50	-0.128	1.410	0.1780	0.907	0.1142	0.486	0.0614	-0.077	-0.344	0.001

RUN NO : TU01-C

TIME : 1700 - 1830

MEAN GRADIENT RICHARDSON NUMBER : 0.0103

LOC		DZ (M)	DIR (DEG)	DIF (DEG)	SPEED (M/S)	UPWSH (M/S)	FSPUP	SIGMU (M/S)	INTU	SIGMV (M/S)	INTV	SIGMW (M/S)	INTW	U`V` (M/S)^2	U`W` (M/S)^2	V`W` (M/S)^2
RS	MF	4.9			6.47											
RS	MF	10.0	181		7.55											
RS	MF	16.9			8.38											
CP`	MF	1.6			10.62											
CP`	MF	3.0			11.96											
CP`	TU	5.0	197	16	12.14	0.86		1.182	0.0974	0.741	0.0610	0.280	0.0231	0.118	-0.119	-0.015
CP`	MF	7.4			13.80											
CP`	TU	10.0	192	11	12.80	1.26	0.696	1.071	0.0836	0.759	0.0591	0.380	0.0297	0.094	-0.093	0.020
CP`	TU	16.0	191	10	13.40	0.85		1.049	0.0783	0.701	0.0522	0.470	0.0350	0.039	-0.098	0.039
CP	MF	10.0	198	17	12.24		0.621									
AASW10	MF	10.0	191	10	11.32		0.500									
AASW10	TU	10.0	189	8	11.63	1.82	0.541	1.065	0.0918	0.796	0.0684	0.442	0.0380	0.043	-0.130	-0.032
AASW20	MF	10.0	186	5	9.62		0.275									
AASW30	MF	10.0	177	-4	8.23		0.091									
AASW30	TU	10.0	174	-7	8.30	1.67	0.099	1.042	0.1252	0.799	0.0960	0.468	0.0562	-0.050	-0.184	-0.014
AASW40	MF	10.0	175	-6	7.02		-0.071									
AASW50	TU	10.0	166	-15	6.34	0.39	-0.160	1.110	0.1748	0.722	0.1138	0.433	0.0682	-0.073	-0.207	0.024

RUN NO : TU01-D

TIME : 1930 - 2000

MEAN GRADIENT RICHARDSON NUMBER : 0.0205

LOC		DZ (M)	DIR (DEG)	DIF (DEG)	SPEED (M/S)	UPWSH (M/S)	FSPUP	SIGMU (M/S)	INTU	SIGMV (M/S)	INTV	SIGMW (M/S)	INTW	U`V` (M/S)^2	U`W` (M/S)^2	V`W` (M/S)^2
RS	MF	4.9			6.46											
RS	MF	10.0	197		7.56											
RS	MF	16.9			8.44											
CP`	MF	1.6			10.85											
CP`	MF	3.0			11.89											
CP`	TU	5.0	211	14	12.02	0.82		1.602	0.1333	0.890	0.0740	0.295	0.0245	-0.322	-0.120	0.000
CP`	MF	7.4			13.63											
CP`	TU	10.0	207	10	12.40	1.16	0.640	1.559	0.1257	0.895	0.0722	0.458	0.0369	-0.364	-0.133	0.011
CP`	TU	16.0	205	8	12.90	0.72		1.602	0.1242	0.853	0.0661	0.575	0.0446	-0.384	-0.188	0.050
CP	MF	10.0	213	16	11.88		0.571									
AASW10	MF	10.0	208	11	10.85		0.435									
AASW10	TU	10.0	206	9	11.15	1.83	0.475	1.462	0.1311	0.913	0.0819	0.501	0.0449	-0.294	-0.116	0.000
AASW20	MF	10.0	207	10	8.77		0.160									
AASW30	MF	10.0	197	0	7.14		-0.056									
AASW30	TU	10.0	194	-3	6.90	1.66	-0.087	1.178	0.1707	0.903	0.1309	0.553	0.0801	-0.182	-0.185	-0.019
AASW40	MF	10.0	195	-2	5.58		-0.262									
AASW50	TU	10.0	187	-10	4.75	0.35	-0.372	1.259	0.2651	0.820	0.1726	0.446	0.0939	-0.134	-0.184	0.011

RUN NO : TU02

TIME : 1400 - 1600

MEAN GRADIENT RICHARDSON NUMBER : 0.0026

LOC		DZ	DIR	DIF	SPEED	UPWSH	FSPUP	SIGMU	INTU	SIGMV	INTV	SIGMW	INTW	U`V`	U`W`	V`W`
		(M)	(DEG)	(DEG)	(M/S)	(M/S)		(M/S)		(M/S)		(M/S)		(M/S)^2	(M/S)^2	(M/S)^2
RS	MF	4.9			8.56											
RS	MF	10.0	160		9.88											
RS	MF	16.9			10.86											
CP`	MF	1.6			11.92											
CP`	MF	3.0			13.34											
CP`	TU	5.0	177	17	13.68	1.00		1.567	0.1144	1.094	0.0801	0.360	0.0263	0.118	-0.193	-0.062
CP`	MF	7.4			15.96											
CP`	TU	10.0	170	10	14.99	1.51	0.517	1.463	0.0975	1.151	0.0771	0.427	0.0286	0.254	-0.183	-0.067
CP`	TU	16.0	169	9	15.86	1.21		1.389	0.0878	1.186	0.0754	0.523	0.0332	0.276	-0.182	-0.025
CP	MF	10.0	177	17	14.42		0.459									
AASW10	MF	10.0	170	10	13.86		0.403									
AASW10	TU	10.0	168	8	14.20	1.85	0.437	1.554	0.1095	1.204	0.0849	0.491	0.0347	0.155	-0.247	-0.161
AASW20	MF	10.0	169	9	12.84		0.300									
AASW30	MF	10.0	157	-3	12.17		0.231									
AASW30	TU	10.0	158	-2	12.28	1.89	0.242	1.517	0.1238	1.092	0.0888	0.559	0.0456	0.068	-0.357	-0.180
AASW40	MF	10.0	161	1	10.44		0.056									
AASW50	TU	10.0	153	-7	10.17	0.50	0.029	1.656	0.1634	1.025	0.1015	0.521	0.0515	-0.169	-0.392	-0.009

RUN NO : TU03-A

TIME : 1200 - 1300

MEAN GRADIENT RICHARDSON NUMBER : -0.0038

LOC		DZ	DIR	DIF	SPEED	UPWSH	FSPUP	SIGMU	INTU	SIGMV	INTV	SIGMW	INTW	U`V`	U`W`	V`W`
		(M)	(DEG)	(DEG)	(M/S)	(M/S)		(M/S)		(M/S)		(M/S)		(M/S)^2	(M/S)^2	(M/S)^2
RS	MF	4.9			8.73											
RS	MF	10.0	206		10.01											
RS	MF	16.9			10.95											
CP`	MF	1.6			14.63											
CP`	MF	3.0			15.80											
CP`	TU	5.0	217	11	15.99	1.08		1.357	0.0849	1.064	0.0664	0.363	0.0227	0.061	-0.177	0.033
CP`	MF	7.4			18.17											
CP`	TU	10.0	213	7	16.45	1.49	0.644	1.119	0.0680	1.057	0.0641	0.557	0.0338	0.125	-0.161	0.056
CP`	TU	16.0	211	5	16.92	0.85		1.119	0.0661	1.007	0.0594	0.685	0.0405	0.140	-0.199	0.058
CP	MF	10.0	220	14	15.59		0.557									
AASW10	MF	10.0	213	7	14.48		0.447									
AASW10	TU	10.0	212	6	14.88	2.57	0.486	1.141	0.0766	1.180	0.0792	0.631	0.0424	0.088	-0.204	0.034
AASW20	MF	10.0	214	8	11.81		0.179									
AASW30	MF	10.0	207	1	9.68		-0.033									
AASW30	TU	10.0	206	0	9.68	2.49	-0.033	1.254	0.1295	1.208	0.1247	0.684	0.0706	-0.056	-0.412	0.029
AASW40	MF	10.0	209	3	7.70		-0.231									
AASW50	TU	10.0	201	-5	6.65	0.57	-0.336	1.525	0.2298	1.011	0.1520	0.593	0.0894	-0.243	-0.463	0.055

RUN NO : TU03-B (PARTIAL)

TIME : 1425 - 1700

MEAN GRADIENT RICHARDSON NUMBER : -0.0074

LOC		DZ	DIR	DIF	SPEED	UPWSH	FSPUP	SIGMU	INTU	SIGMV	INTV	SIGMW	INTW	U`V`	U`W`	V`W`
		(M)	(DEG)	(DEG)	(M/S)	(M/S)		(M/S)		(M/S)		(M/S)		(M/S)^2	(M/S)^2	(M/S)^2
RS	MF	4.9			7.88											
RS	MF	10.0	207		9.03											
RS	MF	16.9			9.81											
CP`	MF	1.6			13.01											
CP`	MF	3.0			14.27											
CP`	TU	5.0	217	10	14.57	1.00		1.287	0.0884	0.986	0.0677	0.330	0.0226	0.174	-0.161	0.020
CP`	MF	7.4			16.35											
CP`	TU	10.0	213	6	15.05	1.37	0.666	1.093	0.0727	0.947	0.0630	0.483	0.0321	0.157	-0.159	0.047
CP`	TU	16.0	212	5	15.49	0.80		1.061	0.0687	0.910	0.0588	0.616	0.0397	0.128	-0.190	0.068
CP	MF	10.0	218	11	14.17		0.569									
AASW10	MF	10.0	211	4	13.15		0.456									
AASW10	TU	10.0	212	5	13.62	2.35	0.507	1.133	0.0834	1.061	0.0779	0.584	0.0429	0.100	-0.226	0.080
AASW20	MF	10.0	214	7	10.69		0.184									
AASW30	MF	10.0	208	1	8.86		-0.019									
AASW30	TU	10.0	205	-2	8.91	2.30	-0.013	1.143	0.1289	1.139	0.1285	0.619	0.0698	0.012	-0.285	0.026
AASW40	MF	10.0	210	3	7.06		-0.218									
AASW50	TU	10.0	202	-5	6.14	0.53	-0.321	1.387	0.2260	1.022	0.1664	0.563	0.0917	-0.123	-0.395	0.042

RUN NO : TU05-A

TIME : 1030 - 1130

MEAN GRADIENT RICHARDSON NUMBER : -0.0011

LOC		DZ	DIR	DIF	SPEED	UPWSH	FSPUP	SIGMU	INTU	SIGMV	INTV	SIGMW	INTW	U`V`	U`W`	V`W`
		(M)	(DEG)	(DEG)	(M/S)	(M/S)		(M/S)		(M/S)		(M/S)		(M/S)^2	(M/S)^2	(M/S)^2
RS	MF	4.9			8.71											
RS	MF	10.0	283		9.78											
RS	MF	16.9			11.03											
CP`	MF	1.6			10.33											
CP`	MF	3.0			11.80											
CP`	TU	5.0	279	-4	11.56	0.14		1.346	0.1165	1.036	0.0894	0.246	0.0213	0.219	-0.089	0.065
CP`	MF	7.4			13.84											
CP`	TU	10.0	279	-4	12.78	0.16	0.308	1.357	0.1061	1.133	0.0883	0.305	0.0238	0.104	-0.082	0.107
CP`	TU	16.0	279	-4	13.31	-0.03		1.318	0.0991	1.166	0.0872	0.361	0.0271	0.039	-0.117	0.061
CP	MF	10.0	285	2	12.82		0.311									
AASW10	MF	10.0	284	1	12.63		0.292									
AASW10	TU	10.0	280	-3	12.63	1.13	0.292	1.388	0.1099	1.151	0.0909	0.416	0.0329	0.155	-0.147	0.194
AASW20	MF	10.0	282	-1	11.76		0.203									
AASW30	MF	10.0	289	6	10.89		0.114									
AASW30	TU	10.0	286	3	11.02	1.09	0.127	1.355	0.1228	0.981	0.0888	0.496	0.0451	0.163	-0.232	0.134
AASW40	MF	10.0	298	15	9.87		0.010									
AASW50	TU	10.0	289	6	9.42	0.25	-0.036	1.501	0.1593	0.890	0.0942	0.446	0.0473	0.062	-0.333	0.008

RUN NO : TU05-B

TIME : 1330 - 1530

MEAN GRADIENT RICHARDSON NUMBER : -0.0073

LOC		DZ (M)	DIR (DEG)	DIF (DEG)	SPEED (M/S)	UPWSH (M/S)	FSPUP	SIGMU (M/S)	INTU	SIGMV (M/S)	INTV	SIGMW (M/S)	INTW	U`V` (M/S)^2	U`W` (M/S)^2	V`W` (M/S)^2
RS	MF	4.9			7.21											
RS	MF	10.0	303		8.28											
RS	MF	16.9			9.54											
CP`	MF	1.6			8.33											
CP`	MF	3.0			9.51											
CP`	TU	5.0	305	2	9.23	-0.06		1.182	0.1283	0.873	0.0937	0.271	0.0293	0.019	-0.112	0.036
CP`	MF	7.4			11.33											
CP`	TU	10.0	304	1	10.37	-0.14	0.253	1.211	0.1170	0.946	0.0902	0.329	0.0316	-0.010	-0.139	0.038
CP`	TU	16.0	305	2	11.10	-0.15		1.227	0.1106	0.999	0.0891	0.380	0.0342	-0.055	-0.159	-0.007
CP	MF	10.0	310	7	10.04		0.213									
AASW10	MF	10.0	307	4	10.61		0.282									
AASW10	TU	10.0	303	0	10.97	0.29	0.325	1.232	0.1122	0.906	0.0821	0.398	0.0363	-0.040	-0.164	0.117
AASW20	MF	10.0	303	0	10.16		0.228									
AASW30	MF	10.0	307	4	10.38		0.254									
AASW30	TU	10.0	304	1	10.29	0.19	0.244	1.298	0.1264	0.810	0.0784	0.385	0.0374	0.082	-0.158	0.105
AASW40	MF	10.0	310	7	9.61		0.161									
AASW50	TU	10.0	305	2	9.43	0.07	0.139	1.234	0.1312	0.826	0.0869	0.367	0.0389	-0.032	-0.213	0.022

RUN NO : TU05-C

TIME : 1530 - 1700

MEAN GRADIENT RICHARDSON NUMBER : -0.0118

LOC		DZ (M)	DIR (DEG)	DIF (DEG)	SPEED (M/S)	UPWSH (M/S)	FSPUP	SIGMU (M/S)	INTU	SIGMV (M/S)	INTV	SIGMW (M/S)	INTW	U`V` (M/S)^2	U`W` (M/S)^2	V`W` (M/S)^2
RS	MF	4.9			6.86											
RS	MF	10.0	299		7.85											
RS	MF	16.9			8.92											
CP`	MF	1.6			7.97											
CP`	MF	3.0			9.20											
CP`	TU	5.0	301	2	8.94	-0.05		1.125	0.1256	0.787	0.0881	0.255	0.0285	0.013	-0.113	0.028
CP`	MF	7.4			10.85											
CP`	TU	10.0	300	1	10.07	-0.13	0.283	1.117	0.1107	0.802	0.0795	0.304	0.0301	0.060	-0.114	0.040
CP`	TU	16.0	301	2	10.72	-0.19		1.113	0.1036	0.841	0.0783	0.344	0.0321	0.055	-0.125	0.016
CP	MF	10.0	308	9	9.57		0.220									
AASW10	MF	10.0	304	5	9.84		0.254									
AASW10	TU	10.0	299	0	10.24	0.39	0.305	1.156	0.1130	0.868	0.0848	0.387	0.0378	0.082	-0.134	0.118
AASW20	MF	10.0	299	0	9.59		0.222									
AASW30	MF	10.0	304	5	9.87		0.258									
AASW30	TU	10.0	301	2	9.80	0.31	0.249	1.218	0.1245	0.732	0.0749	0.368	0.0376	0.167	-0.094	0.087
AASW40	MF	10.0	305	6	8.99		0.146									
AASW50	TU	10.0	302	3	9.07	0.09	0.156	1.166	0.1288	0.738	0.0817	0.361	0.0399	0.016	-0.202	0.013

RUN NO : TU05-D

TIME : 1800 - 2100

MEAN GRADIENT RICHARDSON NUMBER : 0.0461

LOC		DZ	DIR	DIF	SPEED	UPWSH	FSPUP	SIGMU	INTU	SIGMV	INTV	SIGMW	INTW	U`V`	U`W`	V`W`
		(M)	(DEG)	(DEG)	(M/S)	(M/S)		(M/S)		(M/S)		(M/S)		(M/S)^2	(M/S)^2	(M/S)^2
RS	MF	4.9			4.42											
RS	MF	10.0	298		5.20											
RS	MF	16.9			6.21											
CP`	MF	1.6			5.02											
CP`	MF	3.0			5.98											
CP`	TU	5.0	300	2	5.75	-0.05		0.706	0.1218	0.491	0.0848	0.132	0.0228	0.034	-0.030	0.010
CP`	MF	7.4			7.09											
CP`	TU	10.0	298	0	6.64	-0.10	0.275	0.753	0.1115	0.594	0.0877	0.147	0.0219	-0.062	-0.022	0.015
CP`	TU	16.0	298	0	7.24	-0.15		0.700	0.0953	0.535	0.0735	0.191	0.0258	0.053	-0.019	0.014
CP	MF	10.0	304	6	6.42		0.234									
AASW10	MF	10.0	303	5	6.34		0.218									
AASW10	TU	10.0	300	2	6.62	0.22	0.272	0.727	0.1083	0.566	0.0854	0.212	0.0318	0.020	-0.034	0.041
AASW20	MF	10.0	300	2	6.19		0.190									
AASW30	MF	10.0	308	10	5.97		0.147									
AASW30	TU	10.0	305	7	5.83	0.08	0.120	0.654	0.1097	0.469	0.0808	0.528	0.0791	0.060	-0.011	0.043
AASW40	MF	10.0	309	11	5.12		-0.015									
AASW50	TU	10.0	304	6	4.85	0.05	-0.069	0.807	0.1668	0.461	0.0966	0.170	0.0340	0.039	-0.044	0.008

RUN NO : TU06-A

TIME : 1430 - 1600

MEAN GRADIENT RICHARDSON NUMBER : 0.0002

LOC		DZ	DIR	DIF	SPEED	UPWSH	FSPUP	SIGMU	INTU	SIGMV	INTV	SIGMW	INTW	U`V`	U`W`	V`W`
		(M)	(DEG)	(DEG)	(M/S)	(M/S)		(M/S)		(M/S)		(M/S)		(M/S)^2	(M/S)^2	(M/S)^2
RS	MF	4.9			10.16											
RS	MF	10.0	210		11.65											
RS	MF	16.9			*******											
CP`	MF	1.6			17.28											
CP`	MF	3.0			18.99											
CP`	TU	5.0	220	10	18.82	1.33		1.522	0.0809	1.123	0.0598	0.366	0.0195	0.109	-0.201	0.025
CP`	MF	7.4			21.69											
CP`	TU	10.0	215	5	19.42	1.81	0.667	1.271	0.0654	1.128	0.0582	0.564	0.0291	0.155	-0.214	0.051
CP`	TU	16.0	214	4	19.97	1.02		1.224	0.0613	1.042	0.0522	0.722	0.0362	0.150	-0.284	0.049
CP	MF	3.0	217	7	16.22		0.775									
AASW10	MF	3.0	216	6	15.53		0.699									
AASW10	TU	10.0	215	5	17.56	3.02	0.508	1.319	0.0752	1.231	0.0701	0.681	0.0388	0.156	-0.290	0.054
AASW20	MF	3.0	218	8	11.55		0.264									
AASW30	MF	3.0	209	-1	10.23		0.119									
AASW30	TU	10.0	210	0	11.19	2.93	-0.039	1.484	0.1330	1.364	0.1220	0.777	0.0695	0.069	-0.542	0.023
AASW40	MF	3.0	211	1	7.24		-0.208									
AASW50	TU	10.0	208	-2	7.44	0.66	-0.362	1.748	0.2354	1.165	0.1568	0.675	0.0909	-0.238	-0.611	0.014

RUN NO : TU06-B

TIME : 1700 - 1800

MEAN GRADIENT RICHARDSON NUMBER : 0.0011

LOC		DZ	DIR	DIF	SPEED	UPWSH	FSPUP	SIGMU	INTU	SIGMV	INTV	SIGMW	INTW	U`V`	U`W`	V`W`
		(M)	(DEG)	(DEG)	(M/S)	(M/S)		(M/S)		(M/S)		(M/S)		(M/S)^2	(M/S)^2	(M/S)^2
RS	MF	4.9			8.69											
RS	MF	10.0	223		9.91											
RS	MF	16.9			*******											
CP`	MF	1.6			13.99											
CP`	MF	3.0			15.47											
CP`	TU	5.0	231	8	15.19	0.95		1.340	0.0882	0.984	0.0647	0.324	0.0213	0.090	-0.147	0.013
CP`	MF	7.4			17.66											
CP`	TU	10.0	227	4	15.78	1.30	0.593	1.128	0.0714	0.948	0.0600	0.460	0.0291	0.085	-0.164	-0.001
CP`	TU	16.0	226	3	16.25	0.70		1.097	0.0674	0.882	0.0542	0.576	0.0355	0.071	-0.244	-0.016
CP	MF	3.0	227	4	13.31		0.695									
AASW10	MF	3.0	227	4	12.98		0.653									
AASW10	TU	10.0	227	4	14.51	2.48	0.464	1.104	0.0760	0.978	0.0674	0.567	0.0391	0.083	-0.236	-0.023
AASW20	MF	3.0	233	10	9.64		0.228									
AASW30	MF	3.0	225	2	8.49		0.081									
AASW30	TU	10.0	229	6	9.22	2.38	-0.070	1.220	0.1323	1.012	0.1097	0.680	0.0737	-0.048	-0.395	0.024
AASW40	MF	3.0	235	12	6.23		-0.206									
AASW50	TU	10.0	228	5	6.43	0.51	-0.351	1.464	0.2273	0.900	0.1399	0.554	0.0861	0.072	-0.409	-0.029

RUN NO : TU07-A

TIME : 1200 - 1400

MEAN GRADIENT RICHARDSON NUMBER : 0.0004

LOC		DZ	DIR	DIF	SPEED	UPWSH	FSPUP	SIGMU	INTU	SIGMV	INTV	SIGMW	INTW	U`V`	U`W`	V`W`
		(M)	(DEG)	(DEG)	(M/S)	(M/S)		(M/S)		(M/S)		(M/S)		(M/S)^2	(M/S)^2	(M/S)^2
RS	MF	4.9			8.36											
RS	MF	10.0	237		9.58											
RS	MF	16.9			*******											
CP`	MF	1.6			11.33											
CP`	MF	3.0			13.18											
CP`	TU	5.0	240	3	13.41	0.72		1.838	0.1399	1.300	0.0958	0.300	0.0224	-0.368	-0.105	0.068
CP`	MF	7.4			14.83											
CP`	TU	10.0	238	1	14.03	0.99	0.464	1.779	0.1300	1.412	0.0997	0.408	0.0292	-0.424	-0.078	0.091
CP`	TU	16.0	237	0	14.35	0.46		1.785	0.1279	1.392	0.0962	0.493	0.0343	-0.329	-0.139	0.042
CP	MF	3.0	237	0	11.90		0.584									
AASW10	MF	3.0	237	0	11.59		0.542									
AASW10	TU	10.0	238	1	13.14	2.14	0.371	1.702	0.1321	1.482	0.1123	0.494	0.0376	-0.230	-0.127	0.081
AASW20	MF	3.0	245	8	9.19		0.223									
AASW30	MF	3.0	241	4	8.52		0.134									
AASW30	TU	10.0	244	7	9.28	2.17	-0.032	1.607	0.1744	1.396	0.1503	0.570	0.0613	-0.350	-0.292	0.163
AASW40	MF	3.0	253	16	6.61		-0.121									
AASW50	TU	10.0	246	9	6.81	0.55	-0.289	1.709	0.2514	1.188	0.1740	0.512	0.0751	-0.211	-0.399	0.035

RUN NO : TU07-B

TIME : 1530 - 1700

MEAN GRADIENT RICHARDSON NUMBER : 0.0009

LOC		DZ	DIR	DIF	SPEED	UPWSH	FSPUP	SIGMU	INTU	SIGMV	INTV	SIGMW	INTW	U`V`	U`W`	V`W`
		(M)	(DEG)	(DEG)	(M/S)	(M/S)		(M/S)		(M/S)		(M/S)		(M/S)^2	(M/S)^2	(M/S)^2
RS	MF	4.9			8.79											
RS	MF	10.0	256		10.15											
RS	MF	16.9			*******											
CP`	MF	1.6			11.56											
CP`	MF	3.0			13.52											
CP`	TU	5.0	250	-6	13.45	0.56		1.700	0.1258	1.268	0.0935	0.295	0.0219	-0.139	-0.106	0.118
CP`	MF	7.4			15.14											
CP`	TU	10.0	249	-7	14.22	0.77	0.402	1.608	0.1126	1.464	0.1020	0.390	0.0273	-0.144	-0.093	0.151
CP`	TU	16.0	248	-8	14.55	0.28		1.581	0.1084	1.491	0.1014	0.432	0.0296	-0.064	-0.138	0.076
CP	MF	3.0	246	-10	12.04		0.533									
AASW10	MF	3.0	248	-8	11.78		0.500									
AASW10	TU	10.0	250	-6	13.38	1.94	0.319	1.425	0.1059	1.516	0.1124	0.441	0.0329	-0.199	-0.142	0.203
AASW20	MF	3.0	262	6	9.66		0.230									
AASW30	MF	3.0	258	2	8.95		0.140									
AASW30	TU	10.0	259	3	10.05	1.95	-0.009	1.603	0.1586	1.401	0.1384	0.571	0.0567	-0.484	-0.427	0.289
AASW40	MF	3.0	272	16	7.02		-0.105									
AASW50	TU	10.0	262	6	7.64	0.49	-0.247	1.569	0.2046	1.242	0.1618	0.489	0.0640	-0.242	-0.381	0.063

(Intentionally blank)

TABLE A1.6

AVERAGED DATA FROM AES TILTED GILL UVW ANEMOMETERS AT RS AND HT FOR DESIGNATED TURBULENCE RUNS

RUN NO: TU21-A DATE: 21/09/83 TIME: 1200-1230

R/S

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
10	242.4	-2.3	5.8	0.774	0.133	0.585	0.100	0.361	0.062	-0.041	-0.144	0.042
20	217.0	-1.6	4.8	0.041	0.008	0.022	0.005	0.024	0.005	0.000	0.000	0.000
30	219.5	0.7	7.9	0.228	0.029	0.026	0.003	0.189	0.024	-0.003	-0.042	0.002
40	219.2	-1.1	8.3	0.015	0.002	0.006	0.001	0.005	0.001	0.000	0.000	0.000

RUN NO: TU21-B DATE: 21/09/83 TIME: 1530-1630

R/S

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
10	239.4	-2.0	6.7	1.530	0.230	1.090	0.166	0.386	0.058	-0.251	-0.182	0.054
20	218.3	-2.2	4.7	0.005	0.001	0.006	0.001	0.004	0.001	0.000	0.000	0.000
30	218.3	-3.9	8.6	0.009	0.001	0.006	0.001	0.012	0.001	0.000	0.000	0.000
40	219.2	-1.1	7.9	0.017	0.002	0.007	0.001	0.006	0.001	0.000	0.000	0.000

RUN NO: TU22-A DATE: 22/09/83 TIME: 1000-1030

R/S

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
10	243.9	-2.3	3.8	0.507	0.134	0.552	0.146	0.267	0.070	0.003	-0.057	0.027
20	56.0	1.0	0.9	0.689	0.801	0.219	0.255	0.086	0.100	-0.142	0.000	0.001
30	219.1	57.0	5.0	0.208	0.042	0.129	0.026	0.746	0.150	-0.013	0.153	-0.049
40	219.1	-1.1	8.5	0.031	0.004	0.008	0.001	0.008	0.001	0.000	0.000	0.000

RUN NO: TU22-B DATE: 22/09/83 TIME: 1130-1300

R/S

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
10	226.2	-2.5	3.7	0.591	0.161	0.628	0.171	0.308	0.084	-0.009	-0.063	0.006
20	217.1	-1.8	4.6	0.042	0.009	0.025	0.006	0.014	0.003	0.002	-0.001	-0.001
30	219.4	1.6	7.5	0.232	0.032	0.036	0.005	0.173	0.024	0.003	-0.043	-0.001
40	219.1	-1.1	8.0	0.017	0.002	0.006	0.001	0.007	0.001	0.000	0.000	0.000

RUN NO: TU22-C DATE: 22/09/83 TIME: 1430-1700

R/S TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
10	174.1	-0.3	4.7	0.565	0.126	0.495	0.110	0.266	0.059	0.003	-0.067	-0.015
20	177.2	4.4	4.4	0.819	0.193	0.463	0.110	0.476	0.113	-0.092	-0.425	0.040
30	212.3	40.1	39.7	1.540	0.039	0.577	0.015	0.533	0.013	0.306	0.120	0.178
40	179.9	19.1	61.4	2.082	0.034	6.426	0.105	3.248	0.053	-8.377	7.286	-23.242

RUN NO: TU23 DATE: 23/09/83 TIME: 1400-1630

R/S TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
10	182.6	-1.2	10.0	1.550	0.155	0.987	0.099	0.735	0.074	0.056	-0.394	0.027
20	181.7	-0.8	11.2	1.470	0.132	0.905	0.081	0.724	0.065	-0.017	-0.455	0.072
30	185.0	0.7	11.7	1.388	0.118	0.861	0.073	0.793	0.068	-0.055	-0.410	0.105
40	182.9	-0.4	12.4	1.378	0.111	0.820	0.066	0.730	0.059	-0.070	-0.432	0.110

RUN NO: TU25 DATE: 25/09/83 TIME: 1600-1700

R/S TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
10	210.1	-2.0	5.6	0.845	0.151	0.587	0.105	0.437	0.078	-0.043	-0.130	0.001
20	209.0	-1.7	6.4	0.806	0.127	0.516	0.081	0.395	0.062	-0.053	-0.137	-0.004
30	212.8	-0.2	7.0	0.810	0.116	0.524	0.075	0.428	0.061	-0.054	-0.149	0.009
40	211.3	-1.0	7.1	0.778	0.109	0.511	0.072	0.394	0.055	-0.019	-0.133	-0.022

RUN NO: TU26 DATE: 26/09/83 TIME: 1000-1400

R/S TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
10	214.7	-1.9	7.3	1.030	0.142	0.681	0.094	0.534	0.074	-0.035	-0.205	0.008
20	214.1	-2.0	8.3	0.959	0.115	0.643	0.077	0.505	0.061	-0.019	-0.229	-0.012
30	217.0	-0.1	9.0	0.880	0.098	0.623	0.069	0.514	0.057	-0.069	-0.181	0.020
40	216.7	-1.3	9.5	0.858	0.090	0.594	0.062	0.459	0.048	-0.004	-0.184	-0.022

RUN NO: TU30-A DATE: 30/09/83 TIME: 1130-1300

R/S TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
10	133.6	-0.2	7.8	1.343	0.172	0.886	0.113	0.517	0.066	-0.050	-0.274	0.029
20	133.6	0.7	8.8	1.267	0.145	0.835	0.095	0.491	0.056	-0.089	-0.261	-0.090
30	137.3	1.5	9.3	1.247	0.134	0.890	0.095	0.587	0.063	-0.105	-0.342	0.111
40	133.8	0.1	9.9	1.220	0.124	0.862	0.087	0.521	0.053	-0.072	-0.309	-0.054

RUN NO: TU30-B DATE: 30/09/83 TIME: 1600-1700

R/S TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
10	127.0	0.0	12.7	1.950	0.153	1.330	0.105	0.778	0.061	-0.141	-0.648	-0.081
20	125.0	2.0	14.4	1.905	0.132	1.295	0.090	0.763	0.053	-0.352	-0.595	-0.282
30	129.3	1.1	15.3	1.795	0.117	1.220	0.080	0.788	0.051	-0.184	-0.639	-0.160
40	126.2	0.7	16.8	1.790	0.106	1.340	0.080	0.783	0.046	-0.345	-0.518	-0.373

RUN NO: TU01-A DATE: 01/10/83 TIME: 1200-1400

R/S TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
10	170.6	-0.9	9.5	1.508	0.159	1.077	0.114	0.704	0.074	0.097	-0.460	-0.084
20	170.2	-0.5	10.6	1.442	0.136	0.934	0.088	0.674	0.063	-0.007	-0.450	0.007
30	172.6	1.5	11.0	1.352	0.123	1.016	0.092	0.825	0.075	0.007	-0.486	-0.013
40	170.3	-0.1	11.7	1.413	0.120	0.925	0.079	0.735	0.063	-0.029	-0.486	0.004

RUN NO: TU01-B DATE: 01/10/83 TIME: 1400-1600

R/S TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
10	177.2	-1.5	9.0	1.358	0.151	0.863	0.096	0.648	0.072	-0.014	-0.356	-0.011
20	176.7	-0.9	10.1	1.313	0.130	0.771	0.076	0.631	0.062	-0.139	-0.362	0.060
30	180.0	1.0	10.5	1.223	0.116	0.890	0.084	0.760	0.072	-0.013	-0.376	-0.027
40	177.4	-0.5	11.1	1.243	0.111	0.761	0.068	0.669	0.060	-0.058	-0.405	0.021

RUN NO: TU01-C DATE: 01/10/83 TIME: 1700-1830

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S												
10	180.8	-1.3	7.4	1.150	0.155	0.727	0.098	0.552	0.074	0.094	-0.200	0.016
20	181.0	-1.1	8.6	1.157	0.136	0.675	0.079	0.530	0.062	0.076	-0.211	0.041
30	184.7	1.1	9.2	1.137	0.124	0.822	0.090	0.632	0.069	0.093	-0.231	-0.052
40	182.4	-0.4	9.7	1.157	0.119	0.721	0.074	0.559	0.057	0.051	-0.218	0.030

RUN NO: TU01-D DATE: 01/10/83 TIME: 1930-2000

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S												
10	198.6	-1.7	7.6	1.200	0.158	0.868	0.114	0.598	0.079	0.123	-0.224	-0.062
20	198.8	-1.3	8.8	1.200	0.136	0.812	0.092	0.574	0.065	0.115	-0.278	-0.031
30	202.6	0.4	9.6	1.200	0.125	0.852	0.089	0.632	0.066	0.088	-0.316	-0.051
40	200.5	-0.8	10.2	1.100	0.107	0.825	0.081	0.577	0.056	0.103	-0.271	-0.040

RUN NO: TU02 DATE: 02/10/83 TIME: 1400-1600

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S												
10	161.7	-0.4	10.1	1.528	0.152	1.038	0.103	0.687	0.068	0.096	-0.376	-0.028
20	161.9	-0.4	11.4	1.510	0.133	0.915	0.081	0.636	0.056	0.005	-0.388	0.005
30	164.3	1.3	11.9	1.423	0.120	0.955	0.080	0.757	0.064	0.035	-0.447	-0.051
40	162.4	-0.2	12.8	1.468	0.116	0.934	0.073	0.707	0.056	0.007	-0.441	-0.015

RUN NO: TU03-A DATE: 03/10/83 TIME: 1200-1300

TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S												
10	207.8	-2.0	9.8	1.455	0.149	0.957	0.098	0.722	0.074	-0.017	-0.383	0.005
20	206.4	-2.0	11.3	1.095	0.097	0.732	0.065	0.574	0.051	0.278	-0.133	-0.152
30	210.6	-0.6	12.0	1.260	0.105	0.873	0.073	0.717	0.060	-0.041	-0.387	0.029
40	208.7	-1.2	12.5	1.230	0.099	0.854	0.068	0.654	0.052	0.036	-0.378	-0.018

RUN NO: TU03-B DATE: 03/10/83 TIME: 1400-1700

R/S TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
10	207.9	-2.0	8.9	1.327	0.149	0.859	0.096	0.643	0.072	-0.014	-0.291	0.009
20	207.1	-1.8	10.1	1.212	0.121	0.764	0.076	0.597	0.059	-0.011	-0.289	-0.005
30	210.5	-0.1	10.6	1.167	0.111	0.810	0.077	0.650	0.061	-0.047	-0.310	0.008
40	208.9	-1.3	11.2	1.123	0.101	0.776	0.069	0.593	0.053	-0.003	-0.296	-0.027

RUN NO: TU05-A DATE: 05/10/83 TIME: 1030-1130

R/S TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
10	286.5	-0.4	9.7	1.635	0.169	1.095	0.114	0.778	0.080	0.122	-0.518	-0.061
20	283.0	-3.6	11.8	1.595	0.135	0.913	0.077	0.557	0.047	0.106	-0.386	-0.018
30	286.0	-0.7	12.3	1.360	0.111	0.935	0.076	0.595	0.049	0.033	-0.306	-0.082
40	286.9	-1.6	13.2	1.280	0.097	0.914	0.069	0.493	0.037	-0.006	-0.240	-0.004

RUN NO: TU05-B DATE: 05/10/83 TIME: 1330-1530

R/S TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
10	307.2	-1.5	8.6	1.553	0.181	0.971	0.114	0.824	0.096	-0.059	-0.485	-0.116
20	303.7	-3.6	10.5	1.428	0.135	0.814	0.077	0.600	0.057	-0.006	-0.328	0.108
30	307.3	-1.5	11.0	1.276	0.116	0.718	0.065	0.599	0.054	0.005	-0.208	0.028
40	307.9	-1.5	12.0	1.254	0.104	0.724	0.061	0.581	0.049	-0.053	-0.264	0.041

RUN NO: TU05-C DATE: 05/10/83 TIME: 1530-1700

R/S TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
10	304.0	-1.2	8.0	1.363	0.170	0.945	0.118	0.709	0.089	-0.028	-0.380	-0.088
20	300.6	-3.7	9.7	1.307	0.134	0.805	0.083	0.567	0.058	-0.003	-0.286	0.077
30	304.8	-1.2	10.2	1.142	0.112	0.738	0.072	0.580	0.057	0.016	-0.199	-0.030
40	304.9	-1.2	11.2	1.078	0.096	0.695	0.062	0.530	0.047	-0.060	-0.212	0.022

RUN NO: TU05-D DATE: 05/10/83 TIME: 1800-2100

R/S TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
10	302.6	-1.4	5.2	0.928	0.176	0.613	0.117	0.469	0.089	-0.060	-0.156	-0.024
20	298.8	-3.6	6.7	0.847	0.125	0.551	0.082	0.327	0.048	-0.066	-0.099	0.039
30	302.4	-0.6	7.3	0.734	0.100	0.573	0.079	0.340	0.047	-0.076	-0.055	-0.031
40	302.3	-1.1	7.9	0.689	0.086	0.511	0.064	0.277	0.035	-0.079	-0.054	0.013

RUN NO: TU06-A DATE: 06/10/83 TIME: 1430-1600

R/S TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
10	211.9	-1.8	11.5	1.633	0.142	1.037	0.090	0.792	0.069	-0.088	-0.487	0.060
20	211.2	-1.8	13.3	1.560	0.117	0.951	0.071	0.747	0.056	-0.052	-0.539	0.005
30	214.5	-0.1	13.9	1.430	0.103	0.977	0.070	0.777	0.056	-0.091	-0.445	0.032
40	213.1	-1.4	14.7	1.367	0.093	0.974	0.066	0.747	0.051	0.059	-0.453	-0.042

RUN NO: TU06-B DATE: 06/10/83 TIME: 1700-1800

R/S TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
10	226.3	-2.1	9.6	1.390	0.145	0.920	0.096	0.642	0.067	0.122	-0.300	-0.040
20	225.8	-2.5	11.3	1.255	0.111	0.899	0.079	0.622	0.055	0.113	-0.337	-0.060
30	228.4	-0.6	11.9	1.210	0.101	0.869	0.073	0.646	0.054	0.155	-0.313	-0.089
40	227.8	-1.6	12.6	1.165	0.092	0.840	0.067	0.586	0.047	0.143	-0.287	-0.067

RUN NO: TU07-A DATE: 07/10/83 TIME: 1200-1400

R/S TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
10	240.6	-1.8	9.2	1.748	0.190	1.480	0.162	0.635	0.069	0.272	-0.247	0.079
20	240.4	-2.7	10.5	1.810	0.172	1.548	0.148	0.585	0.056	0.329	-0.286	-0.093
30	242.5	-0.1	11.0	1.813	0.164	1.548	0.140	0.605	0.055	0.276	-0.254	-0.001
40	242.3	-1.5	11.6	1.883	0.163	1.577	0.136	0.559	0.048	0.194	-0.244	-0.033

RUN NO: TU07-B   DATE: 07/10/83   TIME: 1530-1700

	TWR LOCN	DIRECTION	UPWASH	SPEED	SIGMu	INT u	SIGMv	INT v	SIGMw	INT w	uv	uw	vw
R/S													
	10	258.0	-1.4	9.8	1.607	0.165	1.500	0.152	0.674	0.069	0.274	-0.333	0.003
	20	257.7	-3.3	11.4	1.670	0.148	1.463	0.127	0.575	0.051	0.735	-0.356	-0.174
	30	259.6	0.1	11.6	1.570	0.137	1.535	0.130	0.631	0.055	0.692	-0.317	-0.081
	40	259.8	-1.4	12.4	1.703	0.139	1.509	0.120	0.567	0.046	0.976	-0.342	-0.106

TABLE A1.7 AVERAGED DATA FROM AES CUP ANEMOMETERS AT RS AND HT FOR DESIGNATED TURBULENCE RUNS

Run Details	Parameters	Levels (m)							
		1	3	5	8	15	24	34	49
TU25									
25 Sept.	RS U	-	4.43	4.98	5.39	5.68	6.18	-	7.47
16.00-17.00	RS σ_u	-	0.94	0.93	0.95	0.80	0.84	-	0.79
1 hour	HT U	8.20	9.91	10.29	10.28	10.12	-	-	-
ϕ_{RS}=210°	HT σ_u	1.00	0.93	0.94	0.78	0.79	-	-	-
TU26									
26 Sept.	RS U	-	5.78	6.47	7.00	7.72	8.54	-	10.41
10.00-14.00	RS σ_u	-	1.11	1.09	1.11	1.02	0.97	-	0.87
4 hours	HT U	-	-	13.82	13.85	13.74	13.60	13.73	-
ϕ_{RS}=220°	HT σ_u	-	-	1.07	0.87	0.90	0.96	0.97	-
TU30-A									
30 Sept.	RS U	-	6.24	6.96	7.64	8.42	9.15	9.58	10.00
11.30-13.00	RS σ_u	-	1.30	1.37	1.43	1.30	1.31	1.26	1.24
1-1/2 hours	HT U	7.41	9.59	10.18	10.80	11.65	12.25	12.23	-
ϕ_{RS}=135°	HT σ_u	1.30	1.35	1.41	1.40	1.36	1.28	1.15	-
TU30-B									
30 Sept.	RS U	-	9.94	10.95	12.00	13.63	14.93	15.77	16.72
16.00-17.00	RS σ_u	-	1.88	1.93	2.00	1.88	1.83	1.73	1.60
1 hour	HT U	10.94	13.36	14.34	15.11	16.61	17.65	17.62	17.74
ϕ_{RS}=130°	HT σ_u	1.97	2.10	2.26	2.11	2.15	1.99	1.78	1.68
TU01-A									
01 Oct.	RS U	-	7.69	8.54	9.23	10.07	10.94	11.41	12.19
12.00-14.00	RS σ_u	-	1.50	1.53	1.57	1.49	1.41	1.44	1.43
2 hours	HT U	12.48	15.18	16.33	16.73	17.19	17.07	(16.58)	16.88
ϕ_{RS}=170°	HT σ_u	1.76	1.60	1.62	1.37	1.12	1.25	(1.20)	1.26
TU01-B									
01 Oct.	RS U	-	7.43	8.25	8.86	9.62	10.43	10.90	11.73
14.00-16.00	RS σ_u	-	1.42	1.44	1.49	1.38	1.29	1.29	1.31
2 hours	HT U	11.57	14.13	15.20	15.51	15.79	15.62	(15.19)	15.45
ϕ_{RS}=180°	HT σ_u	1.59	1.55	1.53	1.30	1.15	1.24	(1.24)	1.32
	ΔS	(1.92)	1.90	1.84	1.75	1.64	1.50	1.39	1.32
TU01-C									
01 Oct.	RS U	-	6.01	6.68	7.20	8.00	9.25	9.46	10.45
17.00-18.30	RS σ_u	-	1.16	1.20	1.28	1.15	1.05	1.19	1.22
1-1/2 hours	HT U	10.71	13.19	14.12	14.25	14.35	14.59	(14.41)	14.82
ϕ_{RS}=185°	HT σ_u	1.44	1.33	1.32	1.12	1.11	1.15	(1.12)	1.05
	ΔS		2.19	2.11	1.98	1.79			

( ) Suspect values, see text, Sec. 4.1.7

TABLE A1.7 (continued)

Run Details	Parameters	Levels (m) 1	3	5	8	15	24	34	49
TU01-D									
01 Oct.	RS U	-	6.33	6.97	7.54	8.11	9.52	9.85	11.04
19.30-20.00	RS σ_u	-	1.15	1.17	1.26	1.19	1.07	1.18	1.16
1/2 hour	HT U	11.12	13.57	14.34	14.31	14.30	14.46	14.37	14.67
ϕ_{RS}=200°	HT σ_u	1.56	1.56	1.53	1.38	1.41	1.51	1.48	1.43
TU02									
02 Oct.	RS U	-	8.00	8.88	9.71	10.75	12.03	12.24	13.12
14.00-16.00	RS σ_u	-	1.57	1.59	1.66	1.52	1.33	1.47	1.49
2 hours	HT U	12.30	15.13	16.30	16.43	17.16	17.58	17.14	-
ϕ_{RS}=165°	HT σ_u	1.76	1.75	1.82	1.67	1.54	1.45	1.36	-
TU03-A									
03 Oct.	RS U	-	7.78	8.65	9.28	10.26	11.27	12.11	13.39
12.00-13.00	RS σ_u	-	1.45	1.45	1.55	1.40	1.35	1.28	1.24
1 hour	HT U	14.31	17.34	18.12	18.01	18.29	17.95	17.54	-
ϕ_{RS}=210°	HT σ_u	1.72	1.52	1.52	1.23	1.14	1.28	1.18	-
TU03-B									
03 Oct.	RS U	-	7.10	7.86	8.44	9.35	10.19	10.84	11.96
14.00-17.00	RS σ_u	-	1.42	1.37	1.42	1.27	1.23	1.16	1.16
3 hours	HT U	12.99	15.71	16.38	16.30	16.63	16.15	15.77	-
ϕ_{RS}=210°	HT σ_u	1.57	1.45	1.38	1.17	1.04	1.19	1.17	-
TU05-A									
05 Oct.	RS U	-	8.11	8.84	9.45	10.70	12.06	12.57	13.22
10.30-11.30	RS σ_u	-	1.46	1.47	1.60	1.64	1.49	1.33	1.23
1 hour	HT U	9.88	12.14	13.34	13.70	-	14.83	14.64	-
ϕ_{RS}=285°	HT σ_u	1.54	1.66	1.71	1.42	-	1.39	1.00	-
TU05-B									
05 Oct.	RS U	-	6.98	7.63	8.21	9.57	10.81	11.28	12.00
13.30-15.30	RS σ_u	-	1.39	1.44	1.56	1.54	1.39	1.32	1.26
2 hours	HT U	7.39	9.41	10.51	11.36	-	12.78	13.31	-
ϕ_{RS}=305°	HT σ_u	1.35	1.46	1.60	1.46	-	1.18	1.07	-
TU05-C									
05 Oct.	RS U	-	6.64	7.26	7.79	8.84	10.03	10.50	11.15
15.30-17.00	RS σ_u	-	1.26	1.31	1.43	1.36	1.24	1.14	1.19
1-1/2 hours	HT U	-	-	-	-	-	-	-	-
ϕ_{RS}=300°	HT σ_u	-	-	-	-	-	-	-	-
TU05-D									
05 Oct.	RS U	-	4.18	4.62	5.10	6.00	7.03	7.41	7.85
18.00-21.00	RS σ_u	-	0.80	0.82	0.88	0.89	0.79	0.72	0.68
3 hours	HT U	4.47	5.74	6.43	6.82	-	8.08	9.16	-
ϕ_{RS}=300°	HT σ_u	0.82	0.87	0.94	0.87	-	0.74	0.66	-

TABLE A1.7 (continued)

Run Details	Parameters	Levels (m) 1	3	5	8	15	24	34	49
TU06-A									
06 Oct.	RS U	-	9.27	10.33	11.10	12.25	13.48	14.19	15.64
14.30-16.00	RS σ_u	-	1.74	1.74	1.83	1.62	1.56	1.45	1.41
1-1/2 hours	HT U	17.04	19.34	21.36	21.14	(21.42)	20.96	20.90	-
ϕ_{RS}=215°	HT σ_u	1.94	1.73	1.63	1.35	(0.98)	1.42	1.40	-
TU06-B									
06 Oct.	RS U	-	7.75	8.65	9.35	10.30	11.40	12.16	13.30
17.00-18.00	RS σ_u	-	1.42	1.44	1.48	1.33	1.24	1.22	1.18
1 hour	HT U	14.18	16.04	17.75	17.57	-	17.35	17.38	-
ϕ_{RS}=230°	HT σ_u	1.63	1.46	1.38	1.15	-	1.23	1.22	-
TU07-A									
07 Oct.	RS U	-	7.42	8.29	8.98	9.94	10.79	11.30	12.03
12.00-14.00	RS σ_u	-	1.64	1.74	1.84	1.81	1.86	1.87	1.91
2 hours	HT U	11.85	13.60	15.28	15.09	(15.40)	15.26	14.83	-
ϕ_{RS}=240°	HT σ_u	1.92	2.03	2.14	1.95	(1.79)	1.93	1.81	-
TU07-B									
07 Oct.	RS U	-	8.05	8.95	9.66	10.71	11.62	12.10	12.64
15.30-17.00	RS σ_u	-	1.56	1.63	1.71	1.67	1.69	1.70	1.69
1-1/2 hours	HT U	11.91	13.49	15.43	15.23	15.37	15.63	15.31	15.21
ϕ_{RS}=260°	HT σ_u	1.72	1.74	1.84	1.69	1.76	1.71	1.60	1.52

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APPENDIX B

Description of the Mean Flow Data Archive

The mean flow data are archived on magnetic tape. This includes the AES data (anemometers #1 to #27), the ERA data (anemometers #30 to #35) and the U of H data (anemometers #36 to #40). The first record of the archive is for Julian Day 261 (JD261) 16 Sept. 1983 at 10:00 BST and the last is for JD283, 10 Oct. 1983 at 18:40. These are 8084, 80-character records in the file, which is referred to as A3MF.DAT for convenience.

Figure B.1(a) is a sample of the file (which is in ASCII code). Reading from left to right, the first figure is the Julian day, the second is the hour and third is the minute. The minute will always be one of 0,10,20,30,40 or 50 (since the data are 10-minute run-of-wind means) and signifies the beginning of a 10-minute run-of-wind averaging period. The fourth figure is the number of pieces of data (grouped in pairs, see below) to follow. All of the data need not be contained within this record and can be written on subsequent records. If there are seven or less pieces of data, then one record will suffice to describe a single 10-minute run-of-wind period. Seven to 14 pieces will require an additional record, 14 to 21 will require two additional records, etc. The next figures in the record are grouped in pairs. The first of the pair is the anemometer number while the second of the pair is the wind speed (m/s) measured by that anemometer for the 10-minute run-of-wind period described by the first three figures. Table 3.6 can be used to match up anemometer numbers with post locations.

Note that if there is more than one record to describe the data from a single 10-minute run-of-wind period, that the succeeding records repeat the Julian day and time but not the number of data pairs. It is also important to note that, while the data are in strict chronological order, if there are no data at all for a particular 10-minute period then this period is skipped entirely. There is no record inserted to "hold the place" in the time series. Users should beware, especially when accessing the file for time-series purposes.

Figure B.1(b) is FORTRAN IV code which can be used to read the data for a single 10-minute period. Note that these data can consist of one to six records of the file. The format of the data can easily be inferred from Figure B.1(a) and is given in FORTRAN statements 5060 and 5070 in the (b) part of that figure.

The technical specifications of the magnetic tape are as follows:

- 9-track
- 1600 bpi phase encoded
- ASCII code
- odd parity
- no label
- fixed record length (=80 characters)
- blocked (block length=50 records=4000 characters;
  last block padded with blanks)
- double tape mark at end of data (EOF)

TABLES

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Table 2.1 Weather conditions during the main observation period

Sunday, 25 Sept.	High cloud with SW winds. Cloud level dropped to 100 m in late afternoon.
Monday, 26	Very low cloud with visibility often less than 1 km. Light SW winds. Clouds lifted temporarily on several occasions.
Tuesday, 27	Very foggy in morning with light SW winds. The fog cleared at about 1300 hrs and the afternoon was relatively warm and sunny with the cloud level at about 300 m with occasional clear patches.
Wednesday, 28	Cool E winds which steadily increased during the afternoon. 9/10 middle cloud with low cloud over the higher hill tops.
Thursday, 29	Cool E to SE winds with showers. High 10/10 middle cloud with low cloud over the higher hill tops. Cloud level lifted during day.
Friday, 30 Sept.	9/10 middle cloud and low cloud over hill tops. SE winds gradually strengthened to gale force in evening. Occasional sunny periods.
Saturday, 1 Oct.	Winds slowly decreased during the morning and backed to the south. Low cloud and showers continued in morning. More westerly winds in afternoon with 9/10 middle cloud and low cloud over hill tops. Showers became infrequent in afternoon.
Sunday, 2	SW winds and scattered cloud at about 1000 m with patches of sunshine. A front came through at about 16.30 bringing continual rain and poor visibility.
Monday, 3	9/10 low cloud at 300 m but lower near high ground. Moderate SW winds strengthened during the middle of the day and then decreased in afternoon. A long heavy shower occurred between 10 and 11.00 hrs followed by occasional sunny intervals.
Tuesday, 4	Dense low cloud down to 200 m with long periods of heavy rain. Light S winds reduced to near calm conditions in late afternoon. Westerly wind change at about 17.00 hrs.
Wednesday, 5	9/10 low cloud at 300 m with periodic heavy showers from cumulus clouds. Strong winds from NNW gradually decreased during the afternoon and became fine and calm by evening.

Table 2.1 (cont'd)

Thursday, 6	Persistent heavy rain and strong SW winds with low cloud level at about 100 m.
Friday, 7	Westerly winds with broken cloud and periodic high cumulus clouds brought short but heavy showers with periods of sunshine. Cooler temperatures.
Saturday, 8	Showers in morning with heavy cloud and light NNW winds but cleared in afternoon with calm, sunny conditions.
Sunday, 9	Cloudy with light winds in morning but light winds and mist from the south set in during the afternoon.
Monday, 10	SW to W winds and cumulus clouds brought heavy showers and sunny periods.

Table 2.2 Estimates of surface geostrophic wind and the thermal wind between the surface and the 85 kPa-level at 00z (weak 0-3 m/s, moderate 4-7 m/s, strong > 8 m/s)

Date	Surface Geostrophic Wind u_g in m/s	Surface Geostrophic Wind Direction	Thermal Wind (Surface-85 kPA) Speed (m/s)	Thermal Wind (Surface-85 kPA) Direction	Fronts
18.9.83	27	210	moderate	120	occlusion 01z
19.9.83	34	240	weak	-	-
20.9.83	20	340	weak	-	-
21.9.83	15	350	weak	-	-
22.9.83	11	270	weak	-	-
23.9.83	13	160	moderate	340	warm front 10z cold front 15z
24.9.83	11	290	strong (19)	190	occlusion 00z
25.9.83	7	260	weak	-	-
26.9.83	11	230	strong (11)	310	cold front 12z
27.9.83	23	260	weak	-	-
28.9.83	6	120	moderate	260	
29.9.83	6	180	moderate	070	stationary warm
30.9.83	15	160	moderate	030	front close to experimental area
01.10.83	15	180	weak	-	old occlusion 10z
02.10.83	20	220	weak	-	old occlusion 22z
03.10.83	22	220	weak	-	-
04.10.83	9	200	weak	-	warm front 06z
05.10.83	22	300	weak	-	cold front 12z
06.10.83	6	240	moderate	020	warm front 11z cold front 18z
07.10.83	20	290	moderate	110	-
08.10.83	18	310	moderate	240	-
09.10.83	5	180	moderate	340	occlusion 18z
10.10.83	20	270	weak	-	-

Table 2.3 Potential and virtual potential temperature gradients derived from AIRsonde profiles

Date	Time	$\frac{\partial\theta}{\partial z}$ (50-500m)	$\frac{\partial\theta_v}{\partial z}$ (50-500m)	Comments
27/09	0922	5.68*	5.45*	
	1501	3.21	2.86	More stable above 350m.
28/09	0959	9.14	9.29	
30/09	1038	1.01	0.68	
	1458	1.30	1.19	
01/10	1052	5.15	4.86	
	1302	5.87	5.76	
	1621	5.17	4.81	Less stable below 200m
	2037	2.74	2.34	
02/10	1014	3.24	2.87	
03/10	0923	2.52	2.18	
	1302	2.01	1.54	
	1643	1.91	1.53	
	1716	1.72	1.34	
	2201	5.29	5.04	
04/10	1028	4.40	4.02	Embedded stable layer at 200m
05/10	0923	1.20	0.89	
	1232	2.93	2.63	
	1604	0.94	0.62	
	2045	0.98	0.64	
06/10	1526	4.86	4.60	
	1734	3.60	3.15	
	2108	1.79	1.54	
07/10	1318	1.83	1.51	
	1734	0.44	0.34	
08/10	1017	0.35	0.20	
	1156	0.03	0.01	

*°K/km

Table 2.4 ASKERVEIN HILL TOWER LOCATIONS 1983

TOWER (or SITE)	GRID REFERENCE *
RS 50 m tower	074300 820980
Cemetary BM	073380 821940
Milestone	075284 821714
TV tower	073590 821711
Base station	074846 823306
Pacman lake	076207 823587
Askernish House	073654 823845
HT Hill Top	075383 823737
10 m mf	075387 823735
10 m t	075381 823745
50 m tower	075381 823753
WM	075360 823763
CP Centre Point	075678 823465
UK mf	075686 823457
BSE 40	075680 823464
FRG mf	075676 823466
FRG 17 m tower	075688 823493
BNW 10	075313 823810
20	075243 823875
BSE 10	075458 823671
20	075528 823603
30	075606 823535
40	075680 823465
50	075754 823397
60	075833 823324
70	075905 823260
80	075982 823193
90	076046 823130
100	076120 823063
110	076195 822997
130	076338 822860
150	076490 822723
170	076636 822585

TOWER	GRID REFERENCE
ANE 10	075454 823812
20	075523 823884
40	075661 824017
ASW 10	075319 823667
20	075257 823604
35	075162 823498
50	075050 823378
UK 30 m tower	074970 823295
85	074813 823122
AANE 10	075746 823540
20	075807 823610
30	075871 823675
40	075938 823745
50	076006 823813
60	076073 823886
AASW 10 mf	075613 823396
10 t	075623 823388
20	075553 823320
30 mf	075483 823253
30 t	075493 823244
40	075417 823174
50 mf	075341 823107
50 t	075352 823100
60	075274 823038
70	075208 822968
80	075140 822895
90	075069 822820

mf - mean flow anemometers
t - turbulence anemometers
WM - wind monitor
BM - bench mark
RS - reference site

* Eastings and Northings, in metres, on OS Survey Sheet NF 72/82

Table 2.5 Horizontal distances from HT or CP to towers along lines A, AA and B.

Distances were measured directly from the survey plot.

Line A

Tower	ASW85	60	50	35	20	10	ANE10	20	40
Distance from HT(m)	841	608	492	327	186	96	100	198	393

Line AA

Tower	AASW90	80	70	60	50t	50mf	40	30t	30mf
Distance from CP(m)	887	787	685	588	489	491	390	287	289

Tower	AASW20	15	10t	10mf	AANE10	20	30	40	50	60
Distance from CP(m)	192	141	93	94	100	193	284	382	477	575

Line B

Tower	BNW20	10	BSE10	20	30	40*	50	60
Distance from HT(m)	196	100	101	199	303	405	505	613

Tower	BSE70	80	90	100	110	130	150	170
Distance from HT(m)	709	811	903	1002	1101	1301	1504	1703

*CAN MF post. See Figs. 2.6b,c for details of HT and CP tower positions.

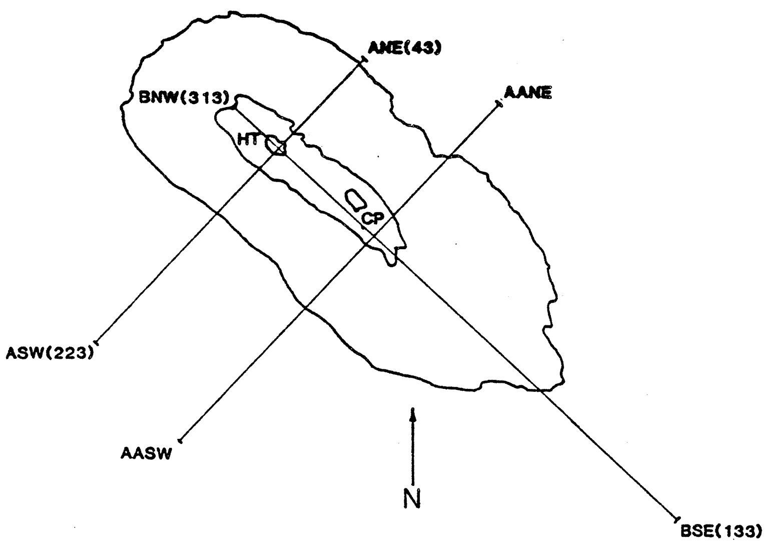
Table 3.1 Designated mean flow (MF) runs during Askervein '83 and directional grouping.

(a) Run Details

Date	Run Number	Time BST	Mean* Velocity, ms^{-1}	Mean* Direction °Grid ±5°	Ri^+	Duration, Hours
Sept.'83						
Sun 25	MF25	(1600-2130)	5.0	210	0.0098[3]	5.5
Mon 26	MF26-A	(0000-0500)	6.0	180	0.0161	5.0
	MF26-B	(0900-1000)	8.0	210	0.0043	1.0
	MF26-C	(1900-2100)	7.8	220	0.0097	2.0
	MF26-D	(2100-0200)	7.1	225	0.0110	5.0
Tue 27	MF27-A	(0300-0430)	6.1	235	0.0126	1.5
	MF27-B	(0430-0700)	5.9	245	0.0134	2.5
Wed 28	MF28-A	(0400-0600)	6.8	090	0.0078	2.0
	MF28-B	(0600-0800)	6.5	095	0.0109	2.0
	MF28-C	(0800-1000)	7.2	100	0.0133	2.0
	MF28-D	(2000-1000)	6.0	105	0.0167	14.0
Fri 30	MF30-A	(1600-1900)[1]	12.0	130	0.0084	3.0
	MF30-B	(1900-0200)	12.5	135	0.0103	7.0
Oct.'83						
Sat 01	MF01-A	(0200-0500)	13.0	140	0.0091	3.0
	MF01-B	(0500-0900)	14.8	145	0.0059	4.0
	MF01-C	(1030-1200)	10.2	170	0.0028[3]	1.5
	MF01-D	(1400-1600)	9.0	180	-0.0205[3]	2.0
	MF01-E	(1700-1830)	7.5	185	0.0103	1.5
	MF01-F	(2100-2400)	8.0	210	0.0141	3.0
Sun 02	MF02-A	(0200-0700)	6.8	210	0.0166	5.0
	MF02-B	(1400-1600)	10.0	165	0.0026	2.0
	MF02-C	(1600-2000)	11.0	165	0.0074	4.0
Mon 03	MF03-A	(0200-0600)	10.5	205	0.0131	4.0
	MF03-B	(0700-1000)	10.0	210	0.0116	3.0
	MF03-C	(1130-1300)	10.0	210	-0.0017	1.5
	MF03-D	(1400-1700)	8.9	210	-0.0110	3.0
Tue 04	MF03-A	(1000-1300)	7.0	180	0.0090	3.0
	MF03-B	(1830-1930)	11.0	285	0.0067	1.0
	MF03-C	(2300-2400)	10.0	270	0.0132	1.0
Wed 05	MF05-A	(0000-0200)	10.0	258	0.0133	2.0
	MF05-B	(0300-0700)	10.0	263	0.0123	4.0
	MF05-C	(0800-0900)	12.0	268	0.0079	1.0
	MF05-D	(1030-1130)	9.5	285	-0.0011	1.0
	MF05-E	(1330-1700)	7.8	305	-0.0092	3.5

Table 3.1 (Continued)

Date	Run Number	Time BST	Mean* Velocity, ms^{-1}	Mean* Direction °Grid ±5°	Ri^+	Duration, Hours
Fri 07	MF07-A	(0230-0500)	8.5	260	0.0046	2.5
	MF07-B	(1200-1400)[2]	9.0	240[4]	0.0004	2.0
	MF07-C	(1400-1600)	10.0	255[4]	0.0005	2.0
	MF07-D	(2200-2300)	11.0	270	0.0029	1.0
Sat 08	MF08	(0200-0400)	9.0	280	0.0045	2.0
Sun 09	MF09-A	(1800-1900)	11.0	275	0.0025	1.0
	MF09-B	(1930-2030)	10.2	283	0.0038	1.0
	MF09-C	(2130-2230)	9.1	268	0.0034	1.0
Mon 10	MF10-A	(0030-0200)	9.0	263	0.0045	1.5
	MF10-B	(0230-0330)	8.8	265	0.0040	1.5



* based on run-averaged wind monitor data from RS
\+ Based on temperature and velocity differences (4.9m-16.9m) on RS 17m post
[1] Anemometer #30 moved during run
[2] Reference data available only 1300-1400
[3] Quite variable during these runs
[4] Direction somewhat unsteady

Table 3.1 (Continued)

(b) Directional grouping

Nominal Direction	No. of Runs	No. of Hours	Run Numbers
100	4	20	MF28-A, 28-B, 28-C, 28-D^{S}
135	3	13	MF30-A, 30-B, 01-A
145	1	4	MF01-B
165	2	6	MF02-B, 02-C
170	1	1.5	MF01-C
180	4	11.5	MF26-A^{S}, 01-D^{U}, 01-E, 04-A
210	8	26	MF25, 26-B, 01-F, 02-A^{S}, 03-A, 03-B, 03-C, 03-D
220	2	7	MF26-C, 26-D
240	3	6	MF27-A, 27-B, 07-B
265	10	17	MF04-C, 05-A, 05-B, 05-C, 07-A, 07-C, 07-D, 09-C, 10-A, 10-B
280	5	6	MF04-B, 05-D, 08, 09-A, 09-B
305	1	3.5	MF05-E
Totals	44	121.5	

$( )^{U} \Rightarrow Ri < -0.015$ (Slightly Unstable)

$( )^{S} \Rightarrow Ri > 0.015$ (Slightly Stable)

Table 3.2 ASKERVEIN '83 - TALA Kite Profile Runs (BRE and AES)

Date	Run No.	Duration	ϕRS^+	Ri_{10}	Locations	Comments
01 Oct.	a) TK01-A	15:00-16:00	180°	-0.0142	Coastal Site*	6 Standard Kites (BRE)
	b) TK01-B	16:30-17:30	180°	+0.0104	Coastal Site*	6 Standard Kites (BRE) - data from 4 kites avail. 14:20-18:10
		16:30-18:00	180°		Approx. midway between HT & CP	Single kite (CAN) with data normalized wrt 10m winds at HT
02 Oct.	a) TK02-A	12:30-14:00		-0.0128	Near HT	Single Kite (CAN).
	b) TK02-B	13:30-15:30	165°	-0.0017	Coastal Site*	6 Standard Kites (BRE), Data available 13:00-15:50
03 Oct.	TK03	15:00-17:00	205°	-0.0040	Coastal Site*	6 Standard Kites (BRE)
		15:15-17:15	205°		On downwind hillside	Single Kite (CAN)
05 Oct.	TK05	14:45-16:45	305°	-0.0105	ASW85	Single Kite (CAN)
		15:15-16:45	305°		Between HT & CP	Single Kite (CAN)
07 Oct.	a) TK07-A	13:00-14:00	240°	+0.0013	Coastal Site*	4 Standard Kites (BRE) - variable winds. Data also available 14:00-14:30
	b) TK07-B	16:15-17:30	260°	+0.0011	ASW85	Single Kite (CAN)
		16:15-17:30	260°		Between HT & CP	Single Kite (CAN)
10 Oct.	TK10	10:15-11:45	260°	+0.0003	ASW85	Single Kite (CAN)
		10:15-11:45	260°		Between HT & CP	Single Kite (CAN) - no HT normalizing data.

+Based on Windmonitor strip chart.
*Coastal Site kite profiles combined with RS tower data to give single upstream profile.

Table 3.3 Estimates of Cup Anemometer Percentage Overspeeding for Profile Data at RS, CP and HT

50m towers - Gill anemometers (Model 12102 with 12170B Polypropylene cup)

	Height (m)							
	1	3	5	8	15	25	35	48
RS	3.7+	1.3	0.7	0.5	0.3	0.2	0.1	0.1
HT	1.8	0.5	0.2	0.2	0.1	0.1	0.1	0.1

16/17m towers - Friedrichs Model 4011 cup anemometers

	Height (m)					
	1.6	3.0	4.9	7.4	10.0	16.9
RS	5.4+	2.8+	2.2	1.7+	1.2	0.9
CP	2.0	1.2	-	0.6	-	-

+ No Anemometers in these Positions

Table 3.4 Anemometer intercomparisons between mean flow anemometers #15 (AES Gill), #30 (ERA Vector Instruments) and #36 (U. of H. Gill). All anemometers were mounted at the 10m level near the CP location. The towers (or posts) were all within 15m of each other (see Figure 2.6c). Each of the velocities being compared is an average of the 10 min run-of-wind values taken over the time period indicated. All velocities ($\bar{U}$) and standard deviations of the 10 min values (s) are given in ms^{-1}. The % values in brackets are percent deviation from the AES (anemometer #15) average speed.

Mean-Flow Run #	Date (1983)	Time	Wind Dir. from RS Wind Monitor	$\bar{U}_{\#15}/s_{U_{\#15}}$ (AES)	$\bar{U}_{\#30}/s_{U_{\#30}}$ (ERA)	$\bar{U}_{\#36}/s_{U_{\#36}}$ (U. of H.)
MF25	25 Sept.	15:00-21:30	210°	9.20/0.69	9.30/0.76 (1.1%)	8.76/0.65 (-4.8%)
*MF26-A	26 Sept.	00:00-05:00	180°	9.57/0.82	9.70/0.95 (1.3%)	9.15/0.87 (-4.4%)
MF26-B	26 Sept.	09.00-10:00	210°	13.68/0.71	14.04/0.78 (2.6%)	13.17/0.70 (-3.7%)
MF26-C	26 Sept.	19:00-21:00	220°	13.03/0.49	13.37/0.50 (2.6%)	12.56/0.44 (-3.6%)
MF26-D	26 Sept.	21:00-02:00	225°	12.51/0.48	12.75/0.52 (2.0%)	12.01/0.44 (-4.0%)
MF27-A	27 Sept.	03:00-04:30	235°	10.77/0.44	10.94/0.51 (1.6%)	10.34/0.38 (-3.9%)
MF27-B	27 Sept.	04:30-07:00	245°	9.34/0.51	9.42/0.55 (0.1%)	8.99/0.51 (-3.7%)
MF28-A	28 Sept.	04:00-06:00	090°	9.41/0.53	9.59/0.58 (1.9%)	9.24/0.47 (-1.8%)
MF28-B	28 Sept.	06:00-08:00	095°	11.08/0.73	11.37/0.73 (2.5%)	10.96/0.69 (-1.0%)
MF28-C	28 Sept.	08:00-10:00	100°	11.83/0.30	12.04/0.32 (1.7%)	11.65/0.31 (-1.5%)
MF28-D	28 Sept.	20:00-10:00	105°	11.04/1.19	11.20/1.27 (1.4%)	10.82/1.19 (-2.0%)
*MF30-A	30 Sept.	16:00-19:00	130°	14.63/1.27		14.11/1.30 (-3.6%)
*MF30-B	30 Sept.	19:00-02:00	135°	15.91/1.32		15.30/1.26 (-4.0%)
MF01-A	01 Oct.	02:00-05:00	140°	15.01/0.67		14.59/0.57 (-2.8%)
MF01-B	01 Oct.	05:00-09:00	145°	16.59/0.59		16.19/0.59 (-2.4%)
MF01-C	01 Oct.	10:30-12:00	170°	15.25/0.47		14.86/0.43 (-2.6%)
*MF01-D	01 Oct.	14:00-16:00	180°	13.67/0.63		13.24/0.56 (-3.1%)

*Possible interference due to alignment of towers or wake effects from other equipment.

Table 3.4 (Continued)

Mean-Flow Run #	Date (1983)	Time	Wind Dir. from RS Wind Monitor	$\bar{U}_{\#15}/s_{U_{\#15}}$ (AES)	$\bar{U}_{\#30}/s_{U_{\#30}}$ (ERA)	$\bar{U}_{\#36}/s_{U_{\#36}}$ (U. of H.)
*MF01-E	01 Oct.	17:00-18:30	185°	12.61/0.97		12.24/1.61 (-2.9%)
MF01-F	01 Oct.	21:00-24:00	210°	13.86/0.67		12.85/0.63 (-3.8%)
MF02-A	02 Oct.	02:00-07:00	210°	11.58/0.70		11.09/0.67 (-4.2%)
MF02-B	02 Oct.	14:00-16:00	165°	14.88/1.46		14.42/1.35 (-3.1%)
MF02-C	02 Oct.	16:00-20:00	165°	16.66/0.85		16.22/0.74 (-2.6%)
MF03-A	03 Oct.	02:00-06:00	205°	17.07/0.74		16.40/0.69 (-3.9%)
MF03-B	03 Oct.	07:00-10:00	210°	16.24/0.65		15.58/0.49 (-4.1%)
MF03-D	03 Oct.	14:00-17:00	210°	14.73/0.88		14.17/0.82 (-3.8%)
MF04-B	04 Oct.	18:30-19:30	285°	15.16/0.38		14.68/0.34 (-3.2%)
MF04-C	04 Oct.	23:00-24:00	270°	14.56/0.50		14.11/0.44 (-3.1%)
MF05-A	05 Oct.	00:00-02:00	258°	14.21/0.51		13.77/0.42 (-3.1%)
MF05-B	05 Oct.	03:00-07:00	263°	15.27/1.00		14.78/0.94 (-3.2%)
MF05-C	05 Oct.	08:00-09:00	268°	16.76/0.48		16.28/0.55 (-2.9%)
*MF05-E	05 Oct.	13:30-17:00	305°	10.61/0.73		9.84/0.66 (-7.2%)

*Possible interference due to alignment of towers or wake effects from other equipment.

Table 3.5 Anemometer intercomparisons between mean flow anemometers #15 (AES Gill), #30 (ERA Vector Instruments) and #36 (U. of H. Gill). All anemometers were mounted at the 10m level at the RS location. The towers (or posts) were all within 46m of each other (see Figure 2.6d). Each of the velocities being compared is an average of the 10 min run-of-wind values taken over the time period indicated. All velocities ($\overline{U}$) and standard deviations of the 10 min values (s) are given in ms^{-1}. The % values in brackets are percent deviation from the AES (anemometer #15) average speed.

Mean-Flow Run #	Date (1983)	Time	Wind Dir. from RS Wind Monitor	$\overline{U}_{\#2}/s_{U_{\#2}}$ (AES)	$\overline{U}_{\#26}/s_{U_{\#26}}$ (ERA)	$\overline{U}_{\#28}/s_{U_{\#28}}$ (U. of H.)
MF26-A	26 Sept.	00:00-05:00	180°	6.29/0.78	6.24/0.84 (-0.1%)	6.10/0.75 (-3.2%)
MF26-B	26 Sept.	09.00-10:00	210°	8.10/0.47	8.12/0.58 (0.0%)	8.11/0.54 (0.0%)
MF26-C	26 Sept.	19:00-21:00	220°	7.94/0.42	7.82/0.35 (-1.5%)	8.01/0.48 (0.1%)
MF27-A	27 Sept.	03:00-04:30	235°	6.79/0.34	6.78/0.31 (0.0%)	6.80/0.33 (0.0%)
MF27-B	27 Sept.	04:30-07:00	245°	6.04/0.45	6.06/0.49 (0.0%)	6.02/0.43 (0.0%)
MF28-D	28 Sept.	20:00-10:00	105°	7.04/0.87	7.02/0.91 (0.0%)	6.91/0.08 (-1.8%)
*MF30-A	30 Sept.	16:00-19:00	130°	11.91/1.06	12.17/1.10 (2.2%)	12.09/1.12 (1.5%)
*MF30-B	30 Sept.	19:00-02:00	135°	12.49/0.96	12.82/1.01 (2.6%)	12.54/0.97 (0.0%)
MF01-A	01 Oct.	02:00-05:00	140°	13.08/0.76	13.49/0.78 (3.1%)	12.90/0.74 (-1.4%)
MF01-B	01 Oct.	05:00-09:00	145°	14.83/0.88	15.24/0.90 (2.8%)	14.69/0.96 (-0.1%)
MF01-C	01 Oct.	10:30-12:00	170°	10.56/0.44	10.68/0.39 (1.1%)	10.35/0.42 (-2.0%)
MF01-D	01 Oct.	14:00-16:00	180°	9.28/0.50	9.38/0.53 (1.1%)	9.12/0.46 (-1.7%)

*Possible interference from upwind towers.

Table 3.5 (Continued)

Mean-Flow Run #	Date (1983)	Time	Wind Dir. from RS Wind Monitor	$\bar{U}_{\#2}/s_{U_{\#2}}$ (AES)	$\bar{U}_{\#26}/s_{U_{\#26}}$ (ERA)	$\bar{U}_{\#28}/s_{U_{\#28}}$ (U. of H.)
MF01-E	01 Oct.	17:00-18:30	185°	7.62/0.93	7.68/0.85 (0.1%)	7.55/0.90 (-0.1%)
MF01-F	01 Oct.	21:00-24:00	210°	7.97/0.50	8.01/0.50 (0.1%)	7.96/0.61 (0.0%)
MF02-A	02 Oct.	02:00-07:00	210°	6.95/0.45	7.03/0.54 (1.2%)	6.86/0.42 (-1.3%)
MF02-B	02 Oct.	14:00-16:00	165°	9.96/1.16	10.40/1.20 (4.4%)	9.88/1.05 (-0.1%)
MF03-A	03 Oct.	02:00-06:00	205°	10.74/0.54	10.90/0.60 (1.5%)	10.59/0.51 (-1.4%)
MF03-B	03 Oct.	07:00-10:00	210°	10.09/0.44	10.26/0.52 (1.7%)	10.07/0.37 (0.0%)
MF03-C	03 Oct.	11:30-13:00	210°	10.24/0.42	10.12/0.34 (-1.2%)	10.14/0.35 (-0.1%)
MF03-D	03 Oct.	14:00-17:00	210°	9.01/0.62	9.09/0.69 (0.1%)	9.03/0.61 (0.0%)
MF04-A	04 Oct.	10:00-13:00	180°	7.35/0.56	7.48/0.67 (1.8%)	7.19/0.56 (-2.2%)
*MF04-B	04 Oct.	18:30-19:30	285°	11.49/0.76	11.26/0.72 (-2.0%)	11.15/0.52 (-3.0%)
*MF04-C	04 Oct.	23:00-24:00	270°	10.64/0.50	10.56/0.57 (-0.1%)	10.28/0.56 (-3.4%)
*MF05-A	05 Oct.	00:00-02:00	258°	10.31/0.46	10.39/0.55 (0.1%)	10.19/0.42 (1.2%)
*MF05-D	05 Oct.	10:30-11:30	285°	10.07/0.49	9.97/0.44 (-0.1%)	9.77/0.44 (-3.0%)
MF05-E	05 Oct.	13:30-17:00	305°	8.33/0.64	8.45/0.68 (1.4%)	8.09/0.60 (-2.9%)

*Possible interference from upwind towers.

Table 3.6 History of mean flow anemometer locations during the experiment. "OS" indicates that the anemometer was out of service. After the initial deployment on Sept. 15, 00:00 the date and time entries indicate changes to the system which were made at that time. "Height" indicates the vertical distance of the anemometer above the base of its tower.

Date & Time													
Sept. 15	00:00	1[1]	RS[2]	10.[3]	11	HT	10.	21	BSE100	10.	31	AASW50	10.
		2	RS	10.	12	BSE10	10.	22	BSE110	10.	32	AASW60	10.
		3	AANE60	10.	13	BSE20	10.	23	BSE130	10.	33	AASW70	10.
		4	AANE50	10.	14	BSE30	10.	24	BSE150	10.	34	AASW80	10.
		5	AANE40	10.	15	BSE40*	10.	25	BSE170	10.	35	AASW90	10.
		6	AANE30	10.	16	BSE50	10.	26	OS		36	BSE40	10.
		7	AANE20	10.	17	BSE60	10.	27	OS		37	AASW10	10.
		8	AANE10	10.	18	BSE70	10.	28	RS	10.	38	AASW20	10.
		9	BNW20	10.	19	BSE80	10.	29	CPP*	3.	39	AASW30	10.
		10	BNW10	10.	20	BSE90	10.	30	BSE40	10.	40	AASW40	10.
Sept. 23	09:00	1	OS										
		26	RS	10.									
Sept. 27	15:00	13	OS										
		27	BSE20	10.									
Sept. 30	17:40	30	AASW15	10.									
Oct. 1	12:00	3	OS										
		13	BSE20	10.									
		27	AANE60	10.									
Oct. 5	18:20	1	RS	10.									
		26	OS										
Oct. 6	12:00	4	AANE50	3.0	19	BSE10	3.0	32	AASW60	3.0			
		5	AANE40	3.0	20	BSE20	3.0	33	AASW70	3.0			
		6	AANE30	3.0	21	BSE30	3.0	34	AASW80	3.0			
		7	AANE20	3.0	22	BSE40	0.5	35	AASW90	3.0			
		8	AANE10	3.0	23	OS		36	BSE40	3.0			
		9	BSE10	0.5	24	BSE40	1.0	37	AASW10	3.0			
		10	BSE10	1.0	25	BSE40	3.0	38	AASW20	3.0			
		16	BSE50	3.0	27	AANE60	3.0	39	AASW30	3.0			
		17	BSE60	3.0	30	AASW15	3.0	40	AASW40	3.0			
		18	HT	3.0	31	AASW50	3.0						
Oct. 7	09:30	2	RS	3.0									
Oct. 9	11:30	26	AANE60	3.0									
		27	OS										

Anemometers #1 -#27 AES (Canada)
#30-#35 ERA (Great Britain)
#28,#29,#36-#40 U. of H. (F.R.G.)

*BSE40 is CP
CPP is CP'

[1]Anemometer Number [2]Location [3]Height (m)

Table 3.7: Profile-derived z_0 and u_* values at CP and BSE10 during selected MF runs, Oct. 7-10, 1983.*

Run	CP		BSE 10	
	z_o(m)	$u_*(ms^{-1})$	z_o(m)	$u_*(ms^{-1})$
MF07-A	0.0003	0.43	.0011	0.55
MF07-D	-	-	.0010	0.68
MF08	-	-	.0009	0.53
MF09-A	0.0012	0.64	.0006	0.58
MF09-B	0.0017	0.65	.0013	0.60
MF09-C	0.0007	0.56	.0009	0.59
MF10-A	0.0006	0.54	.0011	0.62
MF10-B	0.0007	0.53	.0008	0.56

Based on winds measured at 0.5m and 3m levels.

*see discussion in text with regard to the interpretation of these values

Table 3.8a AES TALA kite and 48m cup anemometer comparisons during Askervein '83.

Date (1983)	Time Period	Kite Data			50m Cup Anemometer	Ratio
		Kite No.	Δz(m)	$\bar{U}$(ms^{-1})	$\bar{U}$(ms^{-1})	$\bar{U}_{TALA}/\bar{U}_{cup}$
28 Sept.	15.00.13-15.12.45	A1	51	9.26	8.92	1.038
29 Sept.	15.52.49-16.30.52	B1	49	9.96	9.49	1.050
	16.40.56-17.17.43	JD2	48	9.23	8.79	1.050
30 Sept.	10.29.25-11.02.00	JD2	50	11.45	10.56	1.084
	11.23.40-12.01.10	A1	51	11.31	10.67	1.060

Ratios Kite/50m Cup

	Values	Time-Weighted Average
Kite A1	1.038, 1.060	1.055
B1	1.050	1.050
JD2	1.050, 1.084	1.066

Table 3.8b BRE TALA kite and 48m cup anemometer comparisons during Askervein '83

Location: Reference Site   Date: 28-Sep-83

Start Time (hrs.min)	Gill Cup Speed (m/s)	TALA Kite Speed (m/s)	Calibration Factor
10.21	9.87	9.1	1.085
10.31	9.90	9.0	1.100
10.41	9.22	8.3	1.111
10.51	10.62	10.1	1.051
11.01	10.03	9.6	1.045
11.11	10.48	10.0	1.048
11.21	10.34	9.7	1.066
11.31	9.57	8.6	1.113
11.41	9.50	8.9	1.067
11.51	9.65	9.0	1.072
12.01	9.96	9.1	1.095
12.11	9.96	9.1	1.095
12.21	9.53	8.4	1.135
12.31	9.39	8.3	1.131
12.41	8.57	7.3	1.174
12.51	7.81	6.5	1.202
Means :	9.65	8.81	1.099
Stnd devs:	.68	.91	.043

Table 3.9 BRE TALA Kite Data

BRE Standard TALA Array : 10-minute Mean Wind Speed Data

Title : ASKERVEIN 83 Location : Coastal Machair
Date : 1-Oct-83

Details of Kite Array :

Channel	1	2	3	4	5	6
Kite	1	3	2	4	5	6
Gain	1.03	1.03	1.00	1.03	1.00	1.01
Calibn	1.098	1.098	1.098	1.098	1.098	1.098
Elev (deg)	55	50	47	43	33	25
Line (yd)	65	110	190	330	580	1000
Height (m)	49	69	114	185	260	348

Start Time :: Calibrated 10-minute mean wind speed (m/s) ....

Run	Start Time						
	14.10	12.3	13.3	15.2	16.8		
	14.20	11.0	12.3	14.5	16.9	20.4	
	14.30	12.0	13.2	14.7	16.6	20.0	
	14.40	11.3	12.5	14.4	16.6	19.9	20.1
	14.50	11.8	13.3	15.3	17.2	19.9	20.7
RUN TK01-A	15.00			15.3	17.7	19.9	20.7
RUN TK01-A	15.10	11.8	13.2	15.3	18.0	20.4	21.0
RUN TK01-A	15.20	11.4	13.2	15.5	17.5	19.5	20.5
RUN TK01-A	15.30	11.1	12.6	14.3	16.6	18.9	20.1
RUN TK01-A	15.40	11.3	12.8	14.8	16.8	19.2	20.5
RUN TK01-A	15.50	11.7	13.6	15.6	17.3	19.7	21.2
	16.00	11.4	12.9	15.5	17.5	20.0	21.3
	16.10	11.1	13.2	15.5	17.6	19.9	21.0
	16.20	10.7	12.8	15.0	16.9	19.0	20.5
RUN TK01-B	16.30	10.4	12.3	14.5	15.9	17.7	18.6
RUN TK01-B	16.40	10.4	12.2	14.4	15.7	17.8	19.0
RUN TK01-B	16.50	11.4	13.3	14.8	15.1	17.1	18.4
RUN TK01-B	17.00	12.0	14.0	15.0	15.7	17.5	18.8
RUN TK01-B	17.10	11.7	13.3	14.4	15.0	17.1	18.3
RUN TK01-B	17.20	11.7	13.5	14.5	15.8	18.8	19.8
	17.30	12.6	14.3	15.0	15.9	18.8	20.5
	17.40	11.0	12.8	14.1	15.4	18.0	
	17.50	9.9	11.4	13.0	15.1		
	18.00	10.0	11.4	12.2	14.7		
	Height (m)	49	69	114	185	260	348

Table 3.9 (continued)

BRE Standard TALA Array : 10-minute Mean Wind Speed Data

Title : ASKERVEIN 83 Location : Coastal Machair
Date : 2-Oct-83

Details of Kite Array :

Channel	1	2	3	4	5	6
Kite	1	2	3	4	5	6
Gain	1.03	1.00	1.03	1.03	1.00	1.01
Calibn	1.098	1.098	1.098	1.098	1.098	1.098
Elev (deg)	51	49	47	43	35	26
Line (yd)	65	110	190	330	580	1000

Height (m)	46	68	114	185	274	361
Start Time :: Calibrated 10-minute mean wind speed (m/s)						
13.00	12.2	13.3	15.4	17.7	21.4	
13.10	12.3	13.2	14.6	16.6	20.3	21.4
13.20	11.0	12.4	14.0	15.9	18.8	21.0
13.30	12.9	14.1	15.8	17.9	21.2	21.7
13.40	11.4	12.4	13.6	15.9	20.3	22.4
13.50	11.4	12.4	13.9	15.5	19.7	21.7
14.00	10.4	11.4	13.1	15.5	20.1	21.6
14.10	10.7	11.7	13.5	15.8	20.3	21.4
14.20	10.7	11.6	13.3	15.1	19.5	22.4
14.30	10.7	11.7	13.6	15.8	20.8	22.7
14.40	11.3	12.5	14.4	16.9	21.1	23.5
14.50	13.6	15.2	17.2	19.3	22.9	23.9
15.00	13.9	15.5	18.0	20.8	22.4	23.9
15.10	15.4	17.0	19.4	21.2	24.5	25.4
15.20	15.1	16.9	18.8	21.0	24.2	26.1
15.30	15.0	16.7	18.7	21.2	24.8	27.0
15.40	15.9	17.8	19.7	22.0	25.4	27.6
Height (m)	46	68	114	185	274	361

RUN TK02-B (13.30 – 15.20)

Table 3.9 (continued)

BRE Standard TALA Array : 10-minute Mean Wind Speed Data

Title : ASKERVEIN 83 Location : Coastal Machair
Date : 3-Oct-83

Details of Kite Array :

Channel	1	2	3	4	5	6
Kite	7	1	2	3	4	5
Gain	1.00	1.03	1.00	1.03	1.03	1.00
Calibn	1.098	1.098	1.098	1.098	1.098	1.098
Elev (deg)	55	54	51	48	41	34
Line (yd)	40	65	110	190	330	580

Start Time :: Calibrated 10-minute mean wind speed (m/s) ....

	Height (m)	30	48	70	116	178	267
	12.11		13.6	14.8	17.3	19.1	
	12.21		13.6	15.0	17.5	19.3	
	12.31		13.5	14.5	16.9	19.3	
	12.41		12.9	14.1	16.4	18.8	
	12.51		13.1	14.4	16.6	18.8	
	13.01		13.2	14.5	16.6	18.4	
	13.11		13.3	14.5	16.6	18.8	
	13.21		12.9	14.1	16.2	18.4	
	13.31		13.1	14.3	16.5	18.7	
	13.41		12.9	14.1	16.5	18.8	
	13.51		12.5	13.7	16.1	18.4	
	14.01		12.0	13.3	15.7	18.0	
	14.11		13.1	14.4	17.2	19.4	
	14.21		12.8	14.1	16.4	18.2	
	14.31		12.8	14.1	16.5	19.0	
	14.41		12.0	13.3	15.5	17.9	20.1
	14.51		11.8	13.2	15.8	18.2	20.1
	15.01	12.8	12.9	14.1	16.4	18.4	20.4
	15.11	13.0	13.1	14.3	16.4	18.0	19.7
	15.21	13.3	13.3	14.4	16.2	17.6	19.2
	15.31	11.7	12.0	13.2	15.5	17.3	18.9
	15.41	12.6	12.8	13.9	16.1	17.7	18.9
	15.51	11.6	11.8	12.8	15.0	16.6	18.1
RUN TK03	16.01	10.7	10.8	11.9	14.4	15.9	17.5
	16.11	10.7	10.8	11.9	14.4	16.2	17.8
	16.21	12.6	12.8	13.6	15.4	16.6	17.8
	16.31	11.9	12.0	12.8	14.6	15.9	16.9
	16.41	11.3	11.5	12.5	14.4	15.4	16.6
	16.51	10.5	10.8	11.7	13.9	15.0	16.3
	17.01	11.0	10.8	11.7	13.9	15.1	16.9
	17.11	12.1	12.3	13.2	15.1	16.2	17.3
	17.21	11.6	11.8	13.0	14.8	16.4	17.7
	Height (m)	30	48	70	116	178	267

Table 3.9 (continued)

BRE Standard TALA Array : 10-minute Mean Wind Speed Data

Title : ASKERVEIN 83 Location : Coastal Machair
Date : 7-Oct-83

Details of Kite Array :

Channel	1	2	3	4	5	6
Kite		1	2	3	4	5
Gain	1.00	1.03	1.00	1.03	1.03	1.00
Calibn	1.098	1.098	1.098	1.098	1.098	1.098
Elev (deg)		55	53	45	40	32
Line (yd)		65	110	190	330	580

	Start Time :: Calibrated 10-minute mean wind speed (m/s)					
	Height (m)	49	72	111	175	253
RUN TK07-A	13.00	14.4	15.2	15.9	17.2	18.8
RUN TK07-A	13.10	13.3	13.7	14.6	16.4	18.2
RUN TK07-A	13.20	13.5	14.1	14.7	16.1	18.4
RUN TK07-A	13.30	12.5	13.0	snap	14.3	15.5
RUN TK07-A	13.40	10.4	11.3		13.2	15.5
RUN TK07-A	13.50	8.4	8.8		10.8	13.7
	14.00	10.7	11.6		13.1	15.2
	14.10	19.1	19.7		20.1	21.5
	14.20	18.3	19.2		20.3	21.6
	14.30	snap	snap		snap	snap
	Height (m)	49	72	111	175	253

TABLE 3.10: ASKERVEIN '83 - TALA KITE DATA RUN TK01-B

Date 01 October 1983 ; Duration of Profile 16.30-18.00

Ident No. 201 Kite No. B1 $\langle U_{10} \rangle / \langle U_{10}^{REF} \rangle$ = 2.03

Location: Near hilltop, 30m SW of BSE27, Kite midway between HT and CP. HT Gill UVW anemometer used for normalization. Δz adjustment, - 6m for all heights.

Nominal Period (BST)	U_{10}^{LOCAL} (ms^{-1})	Basic Kite Data			Adjusted Data+			Comments
		Δz (m)	U_{TALA} (ms^{-1})	Azimuth (^{o}mag)*	Δz^{ADJ} (m)	U_{TALA}^{ADJ} (ms^{-1})	$U_{TALA}^{ADJ} / U_{10}^{REF}$	
16.30-16.45	15.3	44.8	15.0	211	39	14.3	1.89	Kite appeared to veer
16.45-17.00	15.6	64.4	15.9	211	58	15.1	1.97	to right of wind on
17.00-17.15	15.1	89.8	16.5	218	84	15.7	2.11	some occasions.
17.15-17.30	15.6	106.2	16.8	222	100	16.0	2.08	
17.30-17.45	16.5	132.6	17.6	217	127	16.7	2.06	
17.45-18.00	15.3	154.8	16.9	218	149	16.1	2.13	
								$\phi_{10}^{REF} \cong 185^o$
								$\phi_{10}^{HT} \cong 200^o$

*^{o}grid = ^{o}mag -6^o +see text to describe adjustments

TABLE 3.10: ASKERVEIN '83 - TALA KITE DATA RUN TK02-A

Date 02 October 1983 ; Duration of Profile 12.30-14.00

Ident No. 202 Kite No. B1 $<U_{10}>/<U_{10}^{REF}> = 1.81$

Location: Near HT, 30m SW of BSE 17, between HT and CP. HT 10m Gill UVW used for normalization. Δz adjustment - 4m, all levels.

Nominal Period (BST)	U_{10}^{LOCAL} (ms^{-1})	Basic Kite Data			Adjusted Data+			Comments
		Δz (m)	U_{TALA} (ms^{-1})	Azimuth (^{o}mag)*	Δz^{ADJ} (m)	U_{TALA}^{ADJ} (ms^{-1})	$U_{TALA}^{ADJ}/U_{10}^{REF}$	
12.30-12.45	16.3	44.7	16.1	203	41	15.3	1.70	Kite tending to fly to
12.45-13.00	16.5	62.1	17.4	195	58	16.5	1.81	right of wind direction.
13.00-13.15	15.9	85.6	16.5	189	82	15.7	1.78	
13.15-13.30	17.1	110.6	19.0	195	107	18.1	1.91	$\phi_{RS}^{10} \cong 165^o$ - variable
13.30-13.45	17.2	135.3	18.4	193	131	17.5	1.84	
13.45-14.00	18.4	156.3	20.9	201	152	19.9	1.95	

*^{o}grid = ^{o}mag -6^o +see text to describe adjustments

TABLE 3.10: ASKERVEIN '83 - TALA KITE DATA RUN TK03

Date 03 October 1983 ; Duration of Profile 15.15-17.15

Ident No. (302)* Kite No. B1 $<U_{10}>/<U_{10}^{REF}>$ = 1.88

Location: Kite flown from location in lee of hill at approx. 230m N of CP

No Δz corrections applied, HT Gill UVW anemometer at 10m used for normalization.

Nominal Period (BST)	U_{10}^{LOCAL} (ms^{-1})	Basic Kite Data			Adjusted Data+			Comments
		Δz (m)	U_{TALA} (ms^{-1})	Azimuth (^{o}mag)*	Δz^{ADJ} (m)	U_{TALA}^{ADJ} (ms^{-1})	$\frac{U_{TALA}^{ADJ}}{U_{10}^{REF}}$	
15.15-15.30	16.7	125.3	17.0	189				Kite flown in lee of
15.30-15.45	16.0	120.5	16.3	196				hill in attempt to
15.45-16.00	16.1	99.2	16.0	194				identify separation
16.00-16.15	15.0	87.3	14.3	200				zone.
16.15-16.30	15.5	70.2	13.4	195				
16.30-16.45	15.8	53.9	13.8	195				
16.45-17.00	15.1	37.7	13.2	199				
17.00-17.15	14.9	29.6	12.6	200				LC 150
								No wind at LC 100 -
								flow separated below
								about 25m above local
								ground.

*^{o}grid = ^{o}mag -6^o +see text to describe adjustments

*should have been 203 but logger set incorrectly

TABLE 3.10: ASKERVEIN '83 - TALA KITE DATA RUN TK05

Date 05 October 1983 ; Duration of Profile 14.45-16.45

Ident No. 305 Kite No. A1 $<U_{10}>/<U_{10}^{REF}> = 1.14$

Location: ASW85 - ASW85 10m Gill used for normalization. No Δz adjustments.

Nominal Period (BST)	U_{10}^{LOCAL} (ms^{-1})	Basic Kite Data			Adjusted Data+			Comments
		Δz (m)	U_{TALA} (ms^{-1})	Azimuth (^{o}mag)*	Δz^{ADJ} (m)	U_{TALA}^{ADJ} (ms^{-1})	$U_{TALA}^{ADJ}/U_{10}^{REF}$	
14.45-15.00	9.4	)						
15.00-15.15	9.2	) 43.8	11.6	312	44	11.0	1.39	$\phi_{10}^{REF} \cong 305^o$
15.15-15.30	8.4	)						
15.30-15.45	8.9	64.4	12.1	311	64	11.5	1.47	
15.45-16.00	9.1	90.9	13.0	307	91	12.3	1.54	
16.00-16.15	8.9	115.8	13.1	300	116	12.4	1.59	
16.15-16.30	8.3	147.2	12.0	304	147	11.4	1.56	
16.30-16.45	8.7	178.4	12.2	300	178	11.6	1.52	

*^{o}grid = ^{o}mag -6^o

+see text to describe adjustments

TABLE 3.10: ASKERVEIN '83 - TALA KITE DATA

RUN TK05

Date 5 October 1983 ; Duration of Profile 15.09-16.46

Ident No. 205 Kite No. B1 $\langle U_{10} \rangle / \langle U_{10}^{REF} \rangle = 1.46$

Location: Kite flown from location approx. 20m SE of HT with NW winds.

Kite flying along ridge, downwind of HT.

Nominal Period (BST)	U_{10}^{LOCAL} (ms^{-1})	Basic Kite Data			Adjusted Data[+]			Comments
		Δz (m)	U_{TALA} (ms^{-1})	Azimuth (^{o}mag)*	Δz^{ADJ} (m)	U_{TALA}^{ADJ} (ms^{-1})	$\frac{U_{TALA}^{ADJ}}{U_{10}^{REF}}$	
15.00-15.15		43.4	12.4	291	Not Used			Short TALA block
15.15-15.30	11.8	42.3	12.7	297	44	12.1	1.50	15.09-15.14. Heights
15.30-15.45	11.6	61.6	12.8	297	64	12.2	1.53	adjusted relative to
15.45-16.00	- *	90.1	13.0	289	94	12.4	- *	ridge.
16.00-16.15	- *	109.8	12.9	292	115	12.3	- *	
16.15-16.30	10.9	134.8	13.2	295	145	12.6	1.68	Dove and looped during this block - not plotted
16.30-16.45	10.4	165.3	11.8	295	176	11.2	1.58	
								$\phi_{10}^{REF} \cong 305^o$
	* Data	Not Available						

*^{o}grid = ^{o}mag -6^o

+see text to describe adjustments

TABLE 3.10: ASKERVEIN '83 - TALA KITE DATA RUN TK07-B

Date 07 October 1983 ; Duration of Profile 16.09-17.30

Ident No. 307 Kite No. A1 $\langle U_{10} \rangle / \langle U_{10}^{REF} \rangle$ = 0.96

Location: ASW85 - No Δz adjustments.

Nominal Period (BST)	U_{10}^{LOCAL} (ms^{-1})	Basic Kite Data			Adjusted Data+			Comments
		Δz (m)	U_{TALA} (ms^{-1})	Azimuth (°mag)*	Δz^{ADJ} (m)	U_{TALA}^{ADJ} (ms^{-1})	$U_{TALA}^{ADJ} / U_{10}^{REF}$	
16.15-16.30	9.6	41.6	12.0	266	42	11.4	1.14	
16.30-16.45	9.1	64.0	12.9	265	64	12.2	1.29	$\phi_{RS}^{10} \cong 260^{o}$, somewhat
16.45-17.00	10.0	92.8	14.0	275	93	13.3	1.27	variable
17.00-17.15	10.8	116.8	15.3	284	117	14.5	1.29	
17.15-17.30	10.8	141.9	15.3	267	142	14.5	1.29	

*°grid = °mag -6°

+see text to describe adjustments

TABLE 3.10: ASKERVEIN '83 - TALA KITE DATA RUN TK07-B

Date 07 October 1983 ; Duration of Profile 16.06-17.30

Ident No. 207 Kite No. B1 $\langle U_{10}\rangle / \langle U_{10}^{REF}\rangle$ = 1.54

Location: Kite flown above 'KO', ≅ 20m NE of BSE20. HT 10m Gill UVW used for normalization. Kite flying location moved along line to SW of KO.

Nominal Period (BST)	U_{10}^{LOCAL} (ms^{-1})	Basic Kite Data			Adjusted Data+			Comments
		Δz (m)	U_{TALA} (ms^{-1})	Azimuth (^{o}mag)*	Δz^{ADJ} (m)	U_{TALA}^{ADJ} (ms^{-1})	$U_{TALA}^{ADJ}/U_{10}^{REF}$	
16.00-16.15	14.1	44.6	13.7	247	44	13.1	1.43	TALA data 16.06-16.15
16.15-16.30	14.4	44.6	15.3	249	44	14.6	1.56	
16.30-16.45	15.5	64.0	15.7	250	58	15.0	1.49	ϕ_{RS}^{10} ≅ 260^o - somewhat
16.45-17.00	15.6	91.3	16.0	264	82	15.2	1.50	variable
17.00-17.15	16.6	115.0	17.7	270	106	16.9	1.56	
17.15-17.30	17.1	140.1	17.4	253	130	16.6	1.49	

*^{o}grid = ^{o}mag -6^o +see text to describe adjustments

TABLE 3.10: ASKERVEIN '83 - TALA KITE DATA RUN TK10

Date 10 October 1983 ; Duration of Profile 10.15-11.45

Ident No. 110 Kite No. A1 $<U_{10}>/<U_{10}^{REF}>$ =

Location: ASW85

Nominal Period (BST)	U_{10}^{LOCAL} (ms^{-1})	Basic Kite Data			Adjusted Data+			Comments
		Δz (m)	U_{TALA} (ms^{-1})	Azimuth (°mag)*	Δz^{ADJ} (m)	U_{TALA}^{ADJ} (ms^{-1})	$U_{TALA}^{ADJ}/U_{10}^{REF}$	
10.15-10.30		43.6	11.1	269	44	10.5		$\phi_{RS}^{10} \cong 260^o$
10.30-10.45		63.6	11.3	264	64	10.7		
10.45-11.00		91.6	11.1	267	92	10.5		
11.00-11.15		115.0	11.4	267	115	10.8		
11.15-11.30		148.1	12.5	258	148	11.9		
11.30-11.45		178.7	12.5	263	179	11.9		

*^{o}grid = ^{o}mag -6^o

+see text to describe adjustments

TABLE 3.10: ASKERVEIN '83 - TALA KITE DATA   RUN TK10

Date 10 October 1983 ;   Duration of Profile 10.15-11.45

Ident No. 210   Kite No. B1 $<U_{10}>/<U_{10}^{REF}>$ =

Location: Kite flown above ridge, about midway between HT and CP, base moved down side of hill in two stages.

Nominal Period (BST)	U_{10}^{LOCAL} (ms^{-1})	Basic Kite Data			Adjusted Data+			Comments
		Δz (m)	U_{TALA} (ms^{-1})	Azimuth (^{o}mag)*	Δz^{ADJ} (m)	U_{TALA}^{ADJ} (ms^{-1})	$\frac{U_{TALA}^{ADJ}}{U_{10}^{REF}}$	
10.15-10.30		44.3	13.7	264	40	13.1		$\phi_{RS}^{10} \cong 260^o$
10.30-10.45		63.8	14.0	272	60	13.3		line slipping?
10.45-11.00		94.1	12.8	272	76	12.2		
11.00-11.15		114.6	13.1	275	97	12.5		
11.15-11.30		142.0	14.4	274	124	13.7		Kite moving downwind
11.30-11.45		164.2	14.4	267	146	13.7		of ridge

*^{o}grid = ^{o}mag -6^o +see text to describe adjustments

TABLE 4.1: TURBULENCE SYSTEM INTERCOMPARISON RUNS

					TURBULENCE SYSTEMS OPERATING AT RS							
DATE	RUN NO.	TIME	DURATION (HRS)	RS* WIND	AES SONIC	DK SONIC	AES GILL	BRE GILL	FRG GILL	AES 'TILTED' GILL	AES CUPS	ERA GUST
21/09	I1	1200-1230	0.5	245/5.4	✓	-	✓	✓	✓	✓	✓	-
	I2	1530-1630	1.0	240/6.0	-	-	✓	✓	-	✓	✓	-
22/09	I3	1000-1030	0.5	245/3.5	✓	-	-	✓	✓	✓	-	-
	I4	1130-1300	1.5	230/3.3	✓	-	✓	✓	✓	✓	✓	-
	I5	1430-1700	2.5	180/4.6	-	-	-	✓	✓	**	-	1451-1510 1628-1648
23/09	I6	1000-1300	3.0	180/10.5	✓	-	✓	✓	-	-	-	1036-1054 1222-1240
	I7	1400-1630	2.5	185/10.0	✓	-	✓	✓	-	✓	-	1402-1426 1450-1514 1540-1604
26/09	I8	1528-1558	0.5	220/7.0	✓	✓	**	-	-	**	-	-
28/09	I9	1026-1126	1.0	110/7.0	✓	✓	-	-	-	**	-	-
	I10	1132-1232	1.0	110/6.8	✓	✓	-	-	-	**	-	-

* MEAN WIND FROM AES WIND MONITOR AT RS FOR TIME PERIOD SHOWN ($^{\circ}$GRID/MS^{-1})

** PARTIAL DATA AVAILABLE

TABLE 4.2 BLOCK-AVERAGED VALUES OF RATIOS OF MEAN WIND AND TURBULENCE PARAMETERS MEASURED BY VARIOUS SENSORS TO THOSE MEASURED BY AES (CAN) SONIC ANEMOMETER

	$\theta \approx 0°$ (1)				$\theta \approx 25°$ (2)				$\theta \approx 40°$ (3)			
	AES GILL	BRE GILL	FRG GILL	AES TLT GILL	AES GILL	BRE GILL	FRG GILL	AES TLT GILL	AES GILL	BRE GILL	FRG GILL	AES TLT GILL
$\overline{U}$	1.017	.995	-	.993 (4)	.951 (5)	1.016	1.004	1.092	1.005	1.010	1.036	1.105
σ_u	.968	.935	-	.967	.928	.948	1.004	.958	1.017	.933	.897	1.000
σ_v	.805	.774	-	.911	.811	.978	.908	1.087	.959	.946	.967	.922
σ_w	.595	.606	-	.842	.656	.678	.657	.781	.647	.732	.703	.840
$\overline{uw}$	.704	.712	-	.839	.863	.781	.899	.928	.729	.914	.725	.966
u_*	.838	.843	-	.915	.929	.880	.948	.957	.853	.954	.838	.970
T_u	.951	.938	-	.975	.986	.935	1.004	.879	1.014	.923	.866	.897
T_v	.792	.780	-	.920	.852	.962	.903	.992	.955	.936	.934	.829
T_w	.584	.610	-	.852	.693	.666	.653	.711	.649	.725	.679	.758
$u_*/\overline{U}$	.824	.847	-	.922	.976	.866	.943	.877	.851	.944	.812	.879

(1) AVERAGES OF 11 1/2-HOUR BLOCKS FROM RUNS I6, I7; $\overline{U} \sim 10$ ms^{-1}, $\phi \sim 180°$.

(2) AVERAGES OF 2 1/2-HOUR BLOCKS FROM RUNS I1, I3; $\overline{U} \sim 4$ ms^{-1}, $\phi \sim 245°$.

(3) AVERAGES OF 3 1/2-HOUR BLOCKS FROM RUN I4; $\overline{U} \sim 3$ ms^{-1}, $\phi \sim 230°$.

(4) AVERAGES OF ONLY 5 1/2-HOUR BLOCKS (FROM RUN I7) FOR AES TILTED GILL ONLY.

(5) RESULTS OF ONLY 1 1/2-HOUR BLOCK (FROM RUN I1) FOR AES GILL ONLY.

TABLE 4.3 RATIOS OF MEAN WIND AND TURBULENCE PARAMETERS FOR DK/AES SONIC ANEMOMETER INTERCOMPARISON RUNS

RUN	I8(220°/7.0)		I9 (110°/7.0)				I10 (110°/6.8)					
BLOCK START TIME	1528	1543	1026	1041	1056	1111	1132	1147	1202	1217	AVG.	STD. DEV.
$\overline{U}$	1.079	1.090	1.044	1.039	1.045	1.056	1.065	1.080	1.084	1.086	1.067	.019
σ_u	.986	1.108	1.011	.989	.933	.951	1.007	1.027	1.011	.992	1.002	.047
σ_v	1.038	1.046	1.031	1.047	1.064	1.089	1.020	1.066	1.003	1.064	1.047	.025
σ_w	1.036	1.045	1.071	1.105	1.117	1.087	1.089	1.091	1.083	1.081	1.080	.025
$\overline{uw}$	.870	1.127	1.113	1.034	.974	.922	1.160	1.224	1.237	1.035	1.070	.124
u_*	.933	1.062	1.055	1.019	.987	.959	1.077	1.108	1.113	1.018	1.033	.061
T_u	.917	1.013	.971	.954	.991	.903	.945	.952	.933	.917	0.939	.036
T_v	.960	.956	.983	1.008	1.018	1.000	.955	.991	.931	.972	0.977	.027
T_w	.954	.956	1.022	1.054	1.067	1.037	1.022	1.011	1.000	1.000	1.012	.037
$u_*/\overline{U}$	.865	.974	1.011	.980	.944	.908	1.012	1.026	1.027	.937	0.968	.054

All values are ratios of value produced by DK Sonic Anemometer to that produced by AES Sonic Anemometer.

TABLE 4.4 RATIOS OF MEAN WIND AND TURBULENCE PARAMETERS FOR ERA GUST ANEMOMETER TO AES SONIC ANEMOMETER OR BRE GILL ANEMOMETER (MARKED BY ASTERISK)

RUN BLOCK NO.	I5* 1	I5* 5	I6 2	I6 5	I7 1	I7 3	I7 4
SONIC OR GILL BLOCK TIME	1430-1500	1630-1700	1030-1100	1200-1230	1400-1430	1500-1530	1530-1600
SONIC OR GILL $\overline{U}$, ms^{-1}	5.00	4.01	10.83	10.38	10.31	10.65	9.87
SONIC OR GILL ϕ	181°	173°	181°	182°	183°	187°	184°
ERA BLOCK TIME	1451-1510	1628-1648	1036-1054	1222-1240	1402-1426	1450-1514	1540-1604
ERA ϕ	-	-	177°	164°	166°	175°	162°
T_u RATIO	0.918	1.000	1.084	1.030	1.141	1.163	1.051
T_v RATIO	0.967	1.182	1.416	-	-	1.739	-

TABLE 4.5 RATIOS OF MEAN WIND AND TURBULENCE PARAMETERS FOR AES CUP/SONIC ANEMOMETERS

RUN	I1	I4	WEIGHTED AVERAGE
NO. OF BLOCKS	1	3	
$\overline{U}$	1.030	1.058	1.051
σ_u*	0.936	1.092	1.053
T_u	0.912	1.029	1.000

* ratio of σ_h ($\approx \sigma_u$) for the cup anemometer to σ_u for the sonic anemometer (similarly for T_u) .

TABLE 4.6 SUMMARY OF AVAILABLE TURBULENCE DATA COLLECTED FROM VARIOUS SYSTEMS

(a) SONIC ANEMOMETER DATA

	AES (RS)			DK (RS)		DK (HT)	
DATE	TIME	HEIGHT(m)	RS* WIND	TIME	HEIGHT(m)	TIME	HEIGHTS(m)
21/09	1030-1230	10	250/5.6	-	-	-	-
	1400-1500	10	270/6.8	-	-	-	-
	1515-1645	10	245/6.0	-	-	-	-
22/09	1000-1030	10	250/3.5	-	-	-	-
	1045-1300	10	230/3.6	-	-	-	-
23/09	1000-1300	10	180/10.5	-	-	-	-
	1400-1700	10	185/10.0	-	-	-	-
	1703-1733	10	185/8.0	-	-	-	-
25/09	1400-1600	10	225/5.5	-	-	-	-
	1600-1700	10	212/5.5	-	-	-	-
26/09	1528-1558	10	220/7.0	1528-1558	10	-	-
28/09	1026-1126	10	110/7.0	1026-1126	10	-	-
	1132-1232	10	110/6.8	1132-1232	10	-	-
30/09	1130-1300	47	135/7.8	1130-1300	10	-	-
	1400-1700	47	130/12.5	1400-1700	10	-	-
01/10	1300-1400	47	175/9.5	1300-1400	10	1345-1400	4,6,47
	1400-1600	47	180/9.0	1400-1600	10	1400-1600	"
	1700-1830	47	185/7.5	1700-1830	10	1700-1830	"
	1930-2000	47	200/7.5	1930-2000	10	1930-2000	"
03/10	1130-1300	47	210/10.0	1130-1300	10	-	-
	1400-1700	47	210/8.9	1400-1700	10	1430-1700	2,4,6,47
05/10	1030-1130	47	285/9.5	1000-1300	10	-	-
	1335-1705	47	305/7.8	1335-1705	10	1530-1705	2,4,6,47
07/10	1030-1130	47	255/9.0	1030-1130	10	-	-
08/10	-	-	-	-	-	1130-1245	2,4,6,47
	1400-1530	47	325/4.2	1400-1530	10	1315-1430	"

* MEAN WIND FROM AES WIND MONITOR AT RS FOR TIME PERIOD SHOWN (°GRID/MS^{-1})

TABLE 4.6 (Continued)

(b) AES VERTICAL GILL UVW ANEMOMETER DATA

DATE	MAIN* PERIOD	LOCATIONS (All heights 10 m)
21/09	1000-1730	RS
	1130-1330	RS
22/09	1600-1700	RS
23/09	0930-1700	RS
25/09	1400-1700	RS, ASW85, ASW50, ASW35, ASW20, ASW10, HT, ANE10, ANE20
26/09	1000-1730	"
27/09	1000-1700	"
30/09	1000-1700	RS, ASW85, ASW35, ASW20, ASW10, HT, ANE10, ANE20, ANE40
01/10	1200-2000	RS, ASW85, ASW50, ASW35, ASW20, ASW10, HT, ANE10, ANE20, ANE40
02/10	1200-1700	"
03/10	1130-2130	"
05/10	1000-2100	RS, ASW85, ASW50, ASW35, ASW20, ASW10, HT, ANE10, ANE20
06/10	1400-2200	"
07/10	1030-1730	"

* Main time period during most of which anemometers at the locations shown produced usable data.

TABLE 4.6 (Continued)

(c) UK (BRE) GILL UVW DATA

DATE	TIME	DURATION (HRS)	LOCATION	HEIGHT(s),m	APPROXIMATE WIND (10m)*
21/09	1000-1230	2.5	RS	10	250/5
	1400-1700	3	RS	10	250/5
22/09	1000-1300	3	RS	10	230/3
	1400-1700	3	RS	10	175/5
23/09	1000-1300	3	RS	10	180/10
	1400-1700	3	RS	10	182/10
25/09	1400-1700	3	ASW60	6, 10, 20, 31	215/5
26/09	1000-1300	3	ASW60	6, 10, 20, 31	210/5
	1355-1655	3	ASW60	6, 10, 20, 31	220/5
30/09	1000-1300	3	ASW60	6, 10, 20, 31	130/9
	1400-1700	3	ASW60	6, 10, 20, 31	120/10
01/10	1145-1545	4	ASW60	6, 10, 20, 31	165/9
01/10	1615-2015	4	ASW60	6, 10, 20, 31	175/7
02/10	1100-1300	2	ASW60	6, 10, 20, 31	160/8
	1400-1700	3	ASW60	6, 10, 20, 31	155/11
03/10	1000-1300	3	ASW60	6, 10, 20, 31	205/9
	1400-1700	3	ASW60	6, 10, 20, 31	205/8
	1800-2100	3	ASW60	6, 10, 20, 31	200/5
05/10	1000-1300	3	ASW60	6, 10, 20, 31	290/8
	1315-1700	3.75	ASW60	6, 10, 20, 31	300/9
	1800-2100	3	ASW60	6, 10, 20, 31	290/5
06/10	1330-1715	3.75	ASW60	6, 10, 20, 31	210/9
	1800-2100	3	ASW60	6, 10, 20, 31	275/6
07/10	1000-1300	3	ASW60	6, 10, 20, 31	265/7
	1345-1715	3.5	ASW60	6, 10, 20, 31	250/9
08/10	1000-1300	3	ASW60	6, 10, 20, 31	270/3
	1400-1700	3	ASW60	6, 10, 20, 31	310/4

* Approximate Mean Wind for Time Period shown from BRE Gill UVW Anemometer at 10m (°Grid/ms^{-1})

TABLE 4.6 (Continued)

(d) FRG GILL UVW DATA

DATE	TIME	DURATION (HRS)	ANEMOMETER LOCATIONS	APPROXIMATE WIND*
21/09	1040/1425 1625-2025	3.75 4.0	RS (10m) RS (10m)	255/6 250/5
22/09	1000-1400 1410-1810	4.0 4.0	RS (10m) RS (10m)	225/4 170/4
25/09	1415-1815	4.0	CP', AASW 10, 30, 50	225/9
26/09	1330-1730 2000-2400	4.0 4.0	CP', AASW 10, 30, 50 CP', AASW 10, 30, 50	220/12 225/13
27/09	0930-1330 1433-1833	4.0 4.0	CP', AASW 10, 30, 50 CP', AASW 10, 30, 50	260/5 310/2
30/09	0955-1355 1400-1800	4.0 4.0	CP', AASW 10, 30, 50 CP', AASW 10, 30, 50	130/10 125/13
01/10	1230-1630 1645-2045	4.0 4.0	CP', AASW 10, 30, 50 CP', AASW 10, 30, 50	195/14 200/13
02/10	0945-1345 1350-1750	4.0 4.0	CP', AASW 10, 30, 50 CP', AASW 10, 30, 50	185/13 180/16
03/10	0950-1350 1425-1818	4.0 3.88	CP', AASW 10, 30, 50 CP', AASW 10, 30, 50	215/16 210/14
04/10	1830-2230	4.0	CP', AASW 10, 30, 50	270/14
05/10	0120-0520 1002-1402 1404-1733 1740-2140	4.0 4.0 3.5 4.0	CP', AASW 10, 30, 50 CP', AASW 10, 30, 50 CP', AASW 10, 30, 50 CP', AASW 10, 30, 50	255/14 290/10 300/10 300/7
06/10	1400-1800 1802-2202	4.0 4.0	CP', AASW 10, 30, 50 CP', AASW 10, 30, 50	220/18 270/12
07/10	0912-1312 1320-1720	4.0 4.0	CP', AASW 10, 30, 50 CP', AASW 10, 30, 50	245/13 250/15
08/10	1404-1754	3.83	CP', AASW 10, 30, 50	330/5

* Average Wind Direction (°GRID/ms^{-1}) from FRG Cup at ΔZ=10m at RS (21/09 and 22/9) or CP' (all other dates).

TABLE 4.6 (Continued)

(e) AES TILTED GILL UVW ANEMOMETER DATA

DATE	MAIN* PERIOD	HEIGHTS AT RS, m	HEIGHTS AT HT, m
21/09	1000 - 1800	10	-
22/09	1000 - 1400 1530 - 1730	10 10	- -
23/09	1330 - 1730	10,20,30,40	-
25/09	1100 - 1700	"	-
26/09	0930-1730	"	-
27/09	0930 - 1700	"	-
28/09	1030 - 1630	"	-
29/09	1600 - 1730	"	-
30/09	1000 - 1500 1600 - 1700	" "	- -
01/10	1130 - 2000	"	-
02/10	1000 - 1700	"	-
03/10	1000 - 2330	"	-
05/10	1000 - 2130	"	-
06/10	1300 - 2230	"	-
07/10	1000 - 1800	"	-

* Main time period during most of which anemometers at the locations shown produced usable data.

TABLE 4.6 (Continued)

(f) AES CUP ANEMOMETER DATA

DATE	RS		HT	
	MAIN* PERIOD	HEIGHTS, m	MAIN* PERIOD	HEIGHTS, m
21/09	1000-1730	5,8,10	-	-
22/09	1130-1400	10	-	-
23/09	0930-1730	3,15,25	-	-
25/09	1100-1700	3,5,8,15,25,48	1400-1700	1,3,5,8,15
26/09	0930-1700	"	1000-1800	1,3,5,8,15,25,35,48
27/09	0930-1630	"	1000-1630	1,3,5,8,15,25,35
28/09	1000-1630	3,5,8,15,25,35,48	-	-
29/09	1600-1730	"	-	-
30/09	0930-1700	"	1000-1700	1,3,5,8,15,25,35
01/10	1100-1930	"	1130-2000	1,3,5,8,15,25,35,48
02/10	1000-1700	"	1130-1630	1,3,5,8,15,25,35
03/10	0930-2300	"	1200-2100	"
05/10	1000-2130	"	1030-2100	"
06/10	1300-2200	"	1400-2130	"
07/10	0930-1730	"	1030-1700	1,3,5,8,15,25,35,48

* Main time period during most of which anemometers at the heights shown produced usable data.

TABLE 4.6 (Continued)

(g) ERA (UK) GUST ANEMOMETER DATA

Date	Time	Duration (min)	Location	$\overline{U}$, ms^{-1}	ϕ	$\sigma_u/\overline{U}$	$\sigma_v/\overline{U}$	$\sigma_w/\overline{U}$
22/09	1451-1510	19	RS (10 m)	-	-	0.15	0.12	-
	1628-1648	20	"	-	-	0.18	0.13	-
23/09	1036-1054	18	"	-	183	0.18	0.16	-
	1222-1240	18	"	-	170	0.17	-	-
	1402-1426	24	"	-	172	0.17	-	-
	1450-1514	24	"	-	181	0.2	0.2	-
	1540-1604	24	"	-	168	0.17	-	-
01/10	1802-1826	24	CP (10 m)	-	187	0.072	0.062	-
	1850-1902	12	"	-	202	0.13	0.14	-
	1902-1914	12	"	-	222	0.075	0.060	-
02/10	1359-1423	24	"	-	172	0.1	-	-
	1447-1511	24	"	-	168	0.1	-	-
	1536-1600	24	"	-	181	0.11	-	-
	1622-1646	24	"	-	184	0.12	-	-
03/10	1403-1415	12	"	-	206	0.11	0.078	-
	1415-1427	12	"	-	206	0.074	0.077	-
	1451-1503	12	"	-	206	0.092	0.076	-
	1503-1515	12	"	-	206	0.079	0.074	-

TABLE 4.7 DESIGNATED 'TURBULENCE' (TU) RUNS OBTAINED DURING ASKERVEIN '83 AND DIRECTIONAL GROUPING

(a) Run Details

DATE	RUN NUMBER	TIME (BST)	DURATION (HRS)	MEAN WIND AT RS (1)	RS PROFILE DATA (2)		(3) Ri	(4) Z/L
					u_*, ms^{-1}	Z_o, m		
Sept.'83								
Sun 25	TU25	1600-1700	1.0	210/5.5	0.37	0.024	-0.0083	-0.029
Mon 26	TU26	1000-1400	4.0	220/7.0	0.49	0.026	-0.0116	-
Fri 30	TU30-A	1130-1300	1.5	135/7.8	0.54	0.030	+0.0005	-0.005
	-B	1600-1700	1.0	130/13.0	0.85	0.028	+0.0051	-
Oct. '83								
Sat 01	TU01-A	1200-1400	2.0	170/9.2	0.63	0.023	-0.0228	-0.030
	-B	1400-1600	2.0	180/9.0	0.55	0.013	-0.0205	-0.026
	-C	1700-1830	1.5	185/7.5	0.49	0.022	+0.0103	+0.001
	-D	1930-2000	0.5	200/7.5	0.49	0.017	+0.0205	+0.008
Sun 02	TU02	1400-1600	2.0	165/10.0	0.69	0.029	-0.0026	-
Mon 03	TU03-A	1200-1300	1.0	210/9.8	0.63	0.022	-0.0038	-0.015
	-B	1400-1700	3.0	210/8.9	0.57	0.020	-0.0074	-0.004
Wed 05	TU05-A	1030-1130	1.0	285/9.5	0.64	0.020	-0.0011	-0.016
	-B	1330-1530	2.0	305/7.8	0.51	0.014	-0.0073	-0.012
	-C	1530-1700	1.5	300/7.5	0.45	0.009	-0.0118	-0.016
	-D	1800-2100	3.0	300/5.0	0.38	0.039	+0.0461	-
Thu 06	TU06-A	1430-1600	1.5	212/11.0	0.75	0.021	+0.0002	-
	-B	1700-1800	1.0	228/9.2	0.64	0.024	+0.0011	-
Fri 07	TU07-A	1200-1400	2.0	240/9.0	0.63	0.027	+0.0004	-
	-B	1530-1700	1.5	260/10.0	0.66	0.022	+0.0009	-0.008

(1) From AES Wind Monitor at ΔZ = 10 m (°Grid/ms^{-1})

(2) From Lowest~10 m of Profiles Plotted in Figs. 4.1

(3) Based on temperature and velocity differences (4.9 m - 16.9 m) on RS 17 m tower

(4) Ratio of height (10 m) to Monin-Obukhov length (L) from sonic anemometer at ΔZ = 10 m at RS.

TABLE 4.7 (continued)

(b) Directional Grouping

Nominal Dir'n (± 10° or less)	No. of Runs	No. of Hours	Run Numbers
135	2	2.5	TU30-A, 30-B
175	4	7.5	TU01-A, 01-B, 01-C, 02
215	7	12.0	TU25, 26, 01-D, 03-A, 03-B, 06-A, 06-B
250	2	3.5	TU07-A, 07-B
300	4	7.5	TU05-A, 05-B, 05-C, 05-D
TOTALS	19	33.0	

FIGURES

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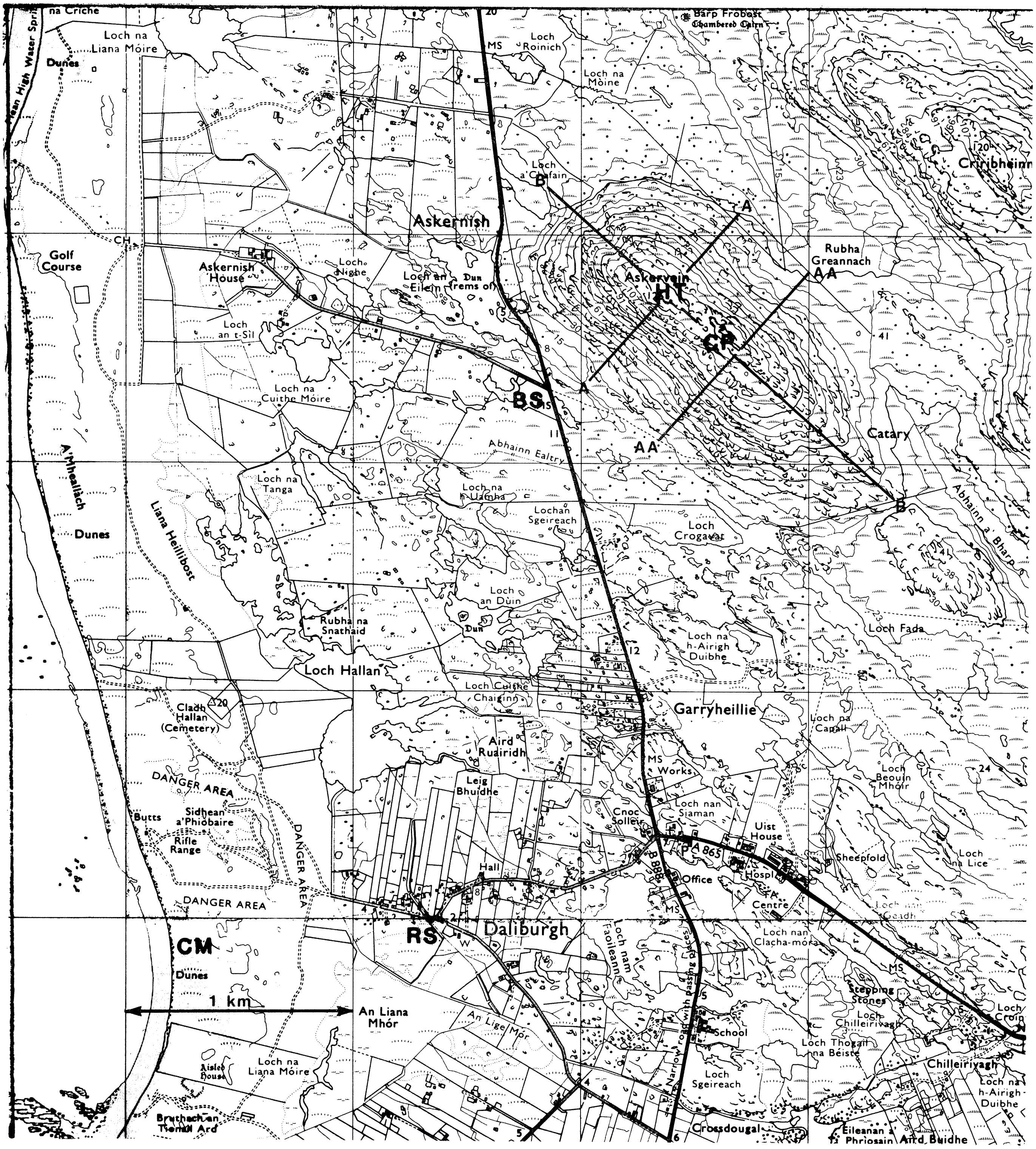


Fig. 2.1 Contour map of Askervein Hill

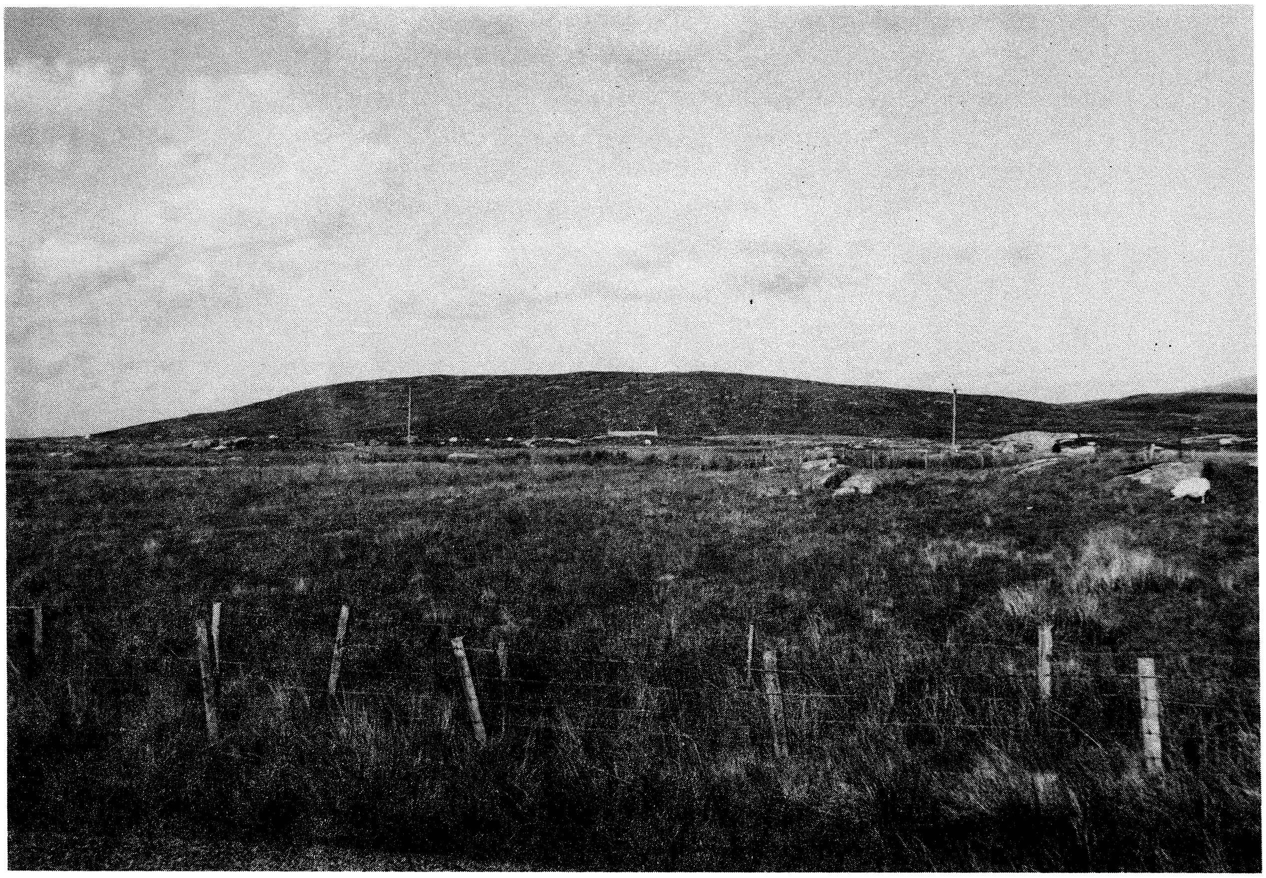


Fig. 2.2 Askervein Hill from the south southwest

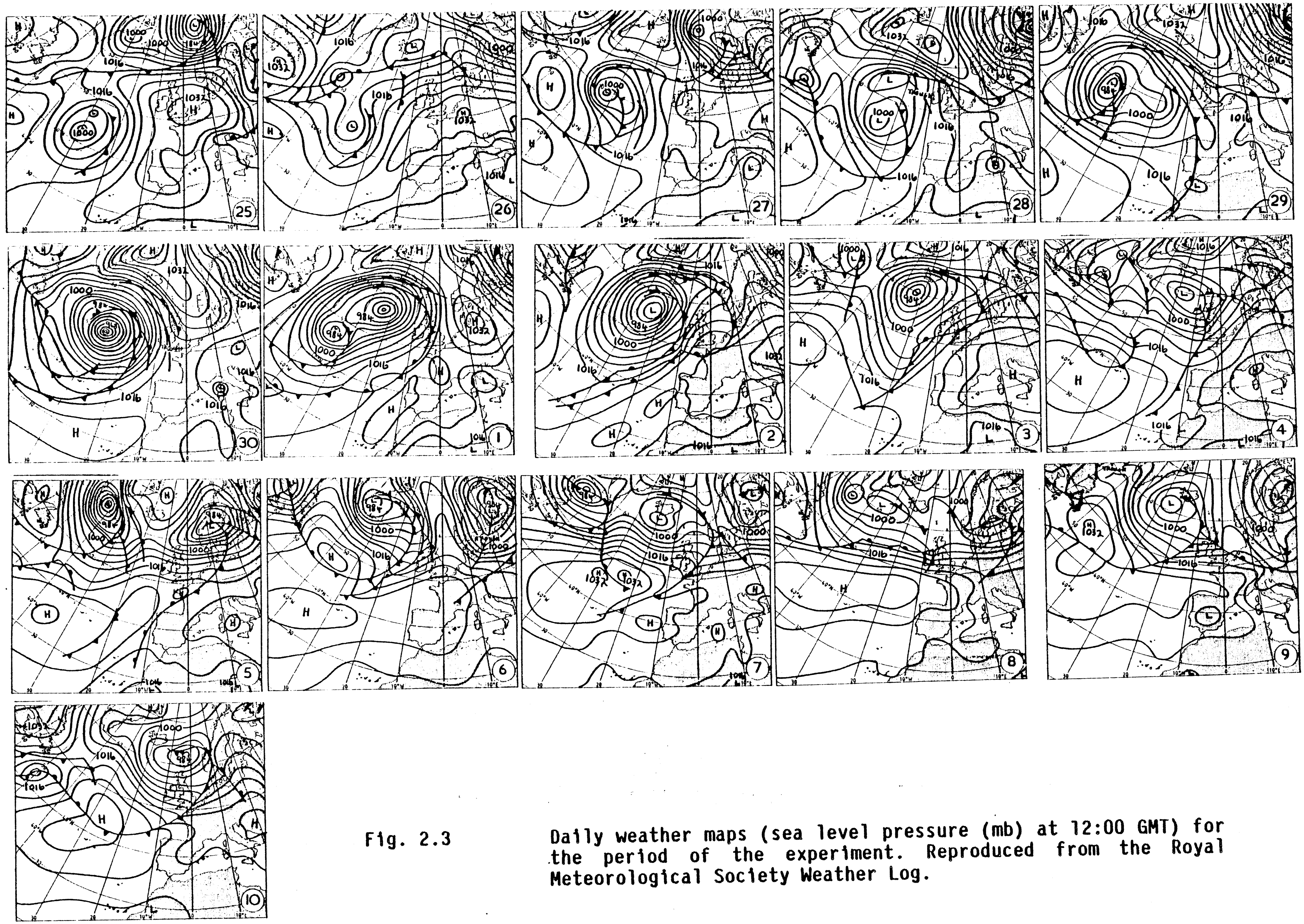


Fig. 2.3 Daily weather maps (sea level pressure (mb) at 12:00 GMT) for the period of the experiment. Reproduced from the Royal Meteorological Society Weather Log.

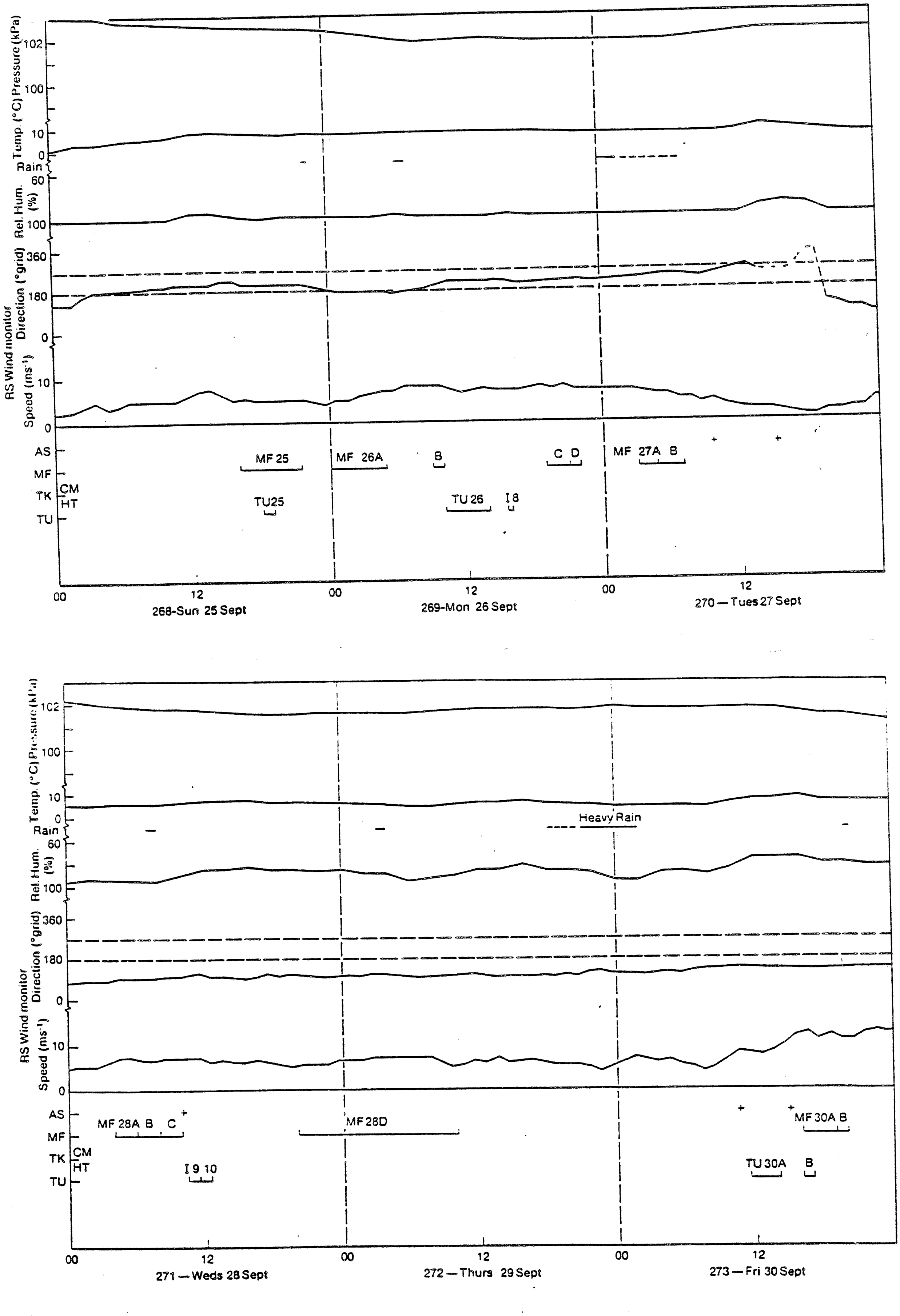
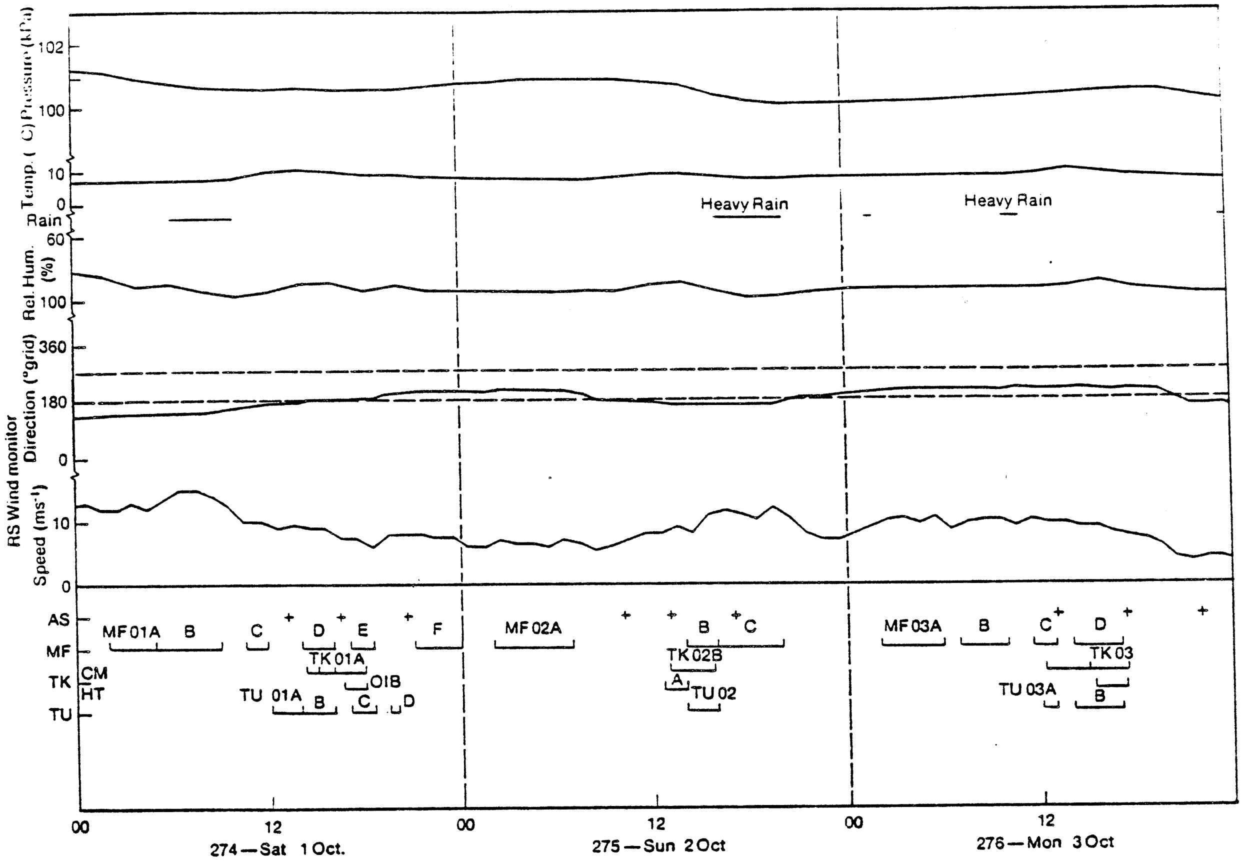
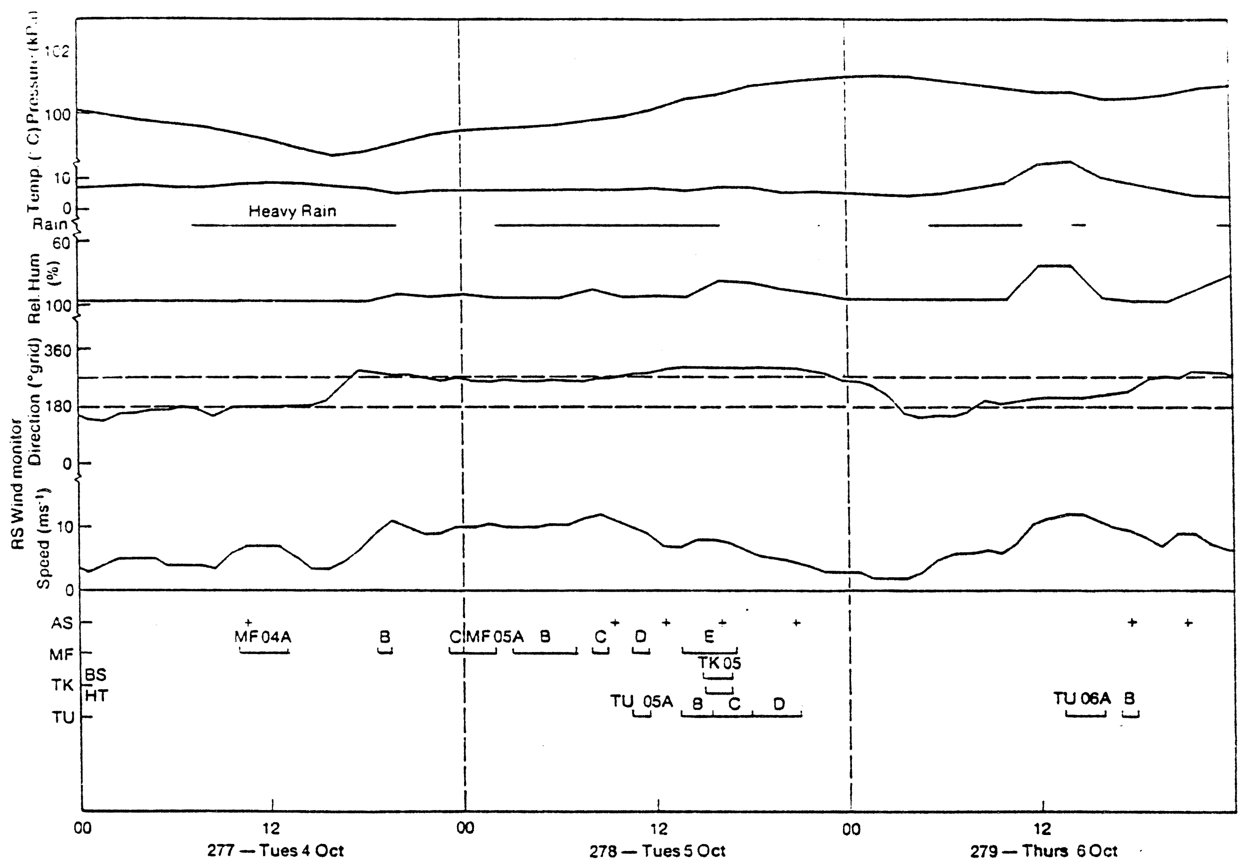


Fig. 2.4 Wind speed and direction (10m, RS), surface pressure, temperature and humidity (2m, BS) during the main observing period. Main data collection and analysis periods are indicated. AS - AIRsonde flights, MF - mean flow run, TK - TALA kite profile, TU - Turbulence run, (I = intercomparison). (Note that 'Rel. Hum.' scale is inverted).

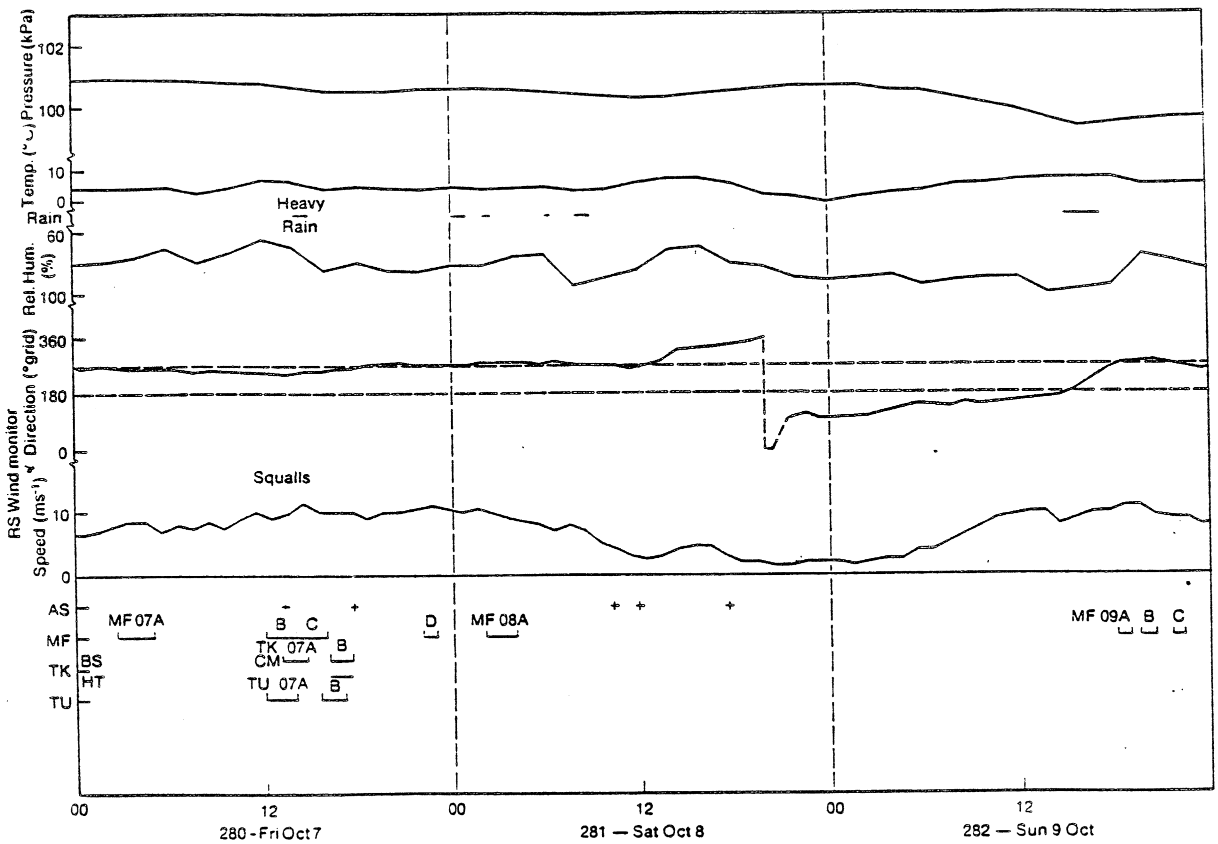


Pressure (kPa)
Temp. (°C)
Rain
Rel. Hum. (%)
RS Wind monitor
Direction (°grid)
Speed (ms⁻¹)
Heavy Rain
Heavy Rain
AS
MF
TK
TU
MF01A
B
C
D
E
F
MF02A
B
C
MF03A
B
C
D
TK01A
OIB
TK02B
TK03
CM
HT
TU 01A
B
C
D
A
TU 02
TU 03A
B
274—Sat 1 Oct.
275—Sun 2 Oct
276—Mon 3 Oct



Pressure (kPa)
Temp. (°C)
Rain
Rel. Hum. (%)
RS Wind monitor
Direction (°grid)
Speed (ms⁻¹)
Heavy Rain
AS
MF
TK
TU
MF04A
B
C
MF05A
B
C
D
E
TK05
BS
HT
TU 05A
B
C
D
TU 06A
B
277—Tues 4 Oct
278—Tues 5 Oct
279—Thurs 6 Oct

Fig. 2.4 (cont.)


Pressure (kPa)
Temp. (°C)
Rain
Rel. Hum. (%)
RS Wind monitor
Direction (°grid)
Speed (ms⁻¹)
Heavy Rain
Squalls
AS
MF
TK
TU
MF 07A
B C
TK 07A
CM
B
BS
HT
TU 07A
B
D
MF 08A
MF 09A B C
00
12
280 - Fri Oct 7
281 — Sat Oct 8
282 — Sun 9 Oct

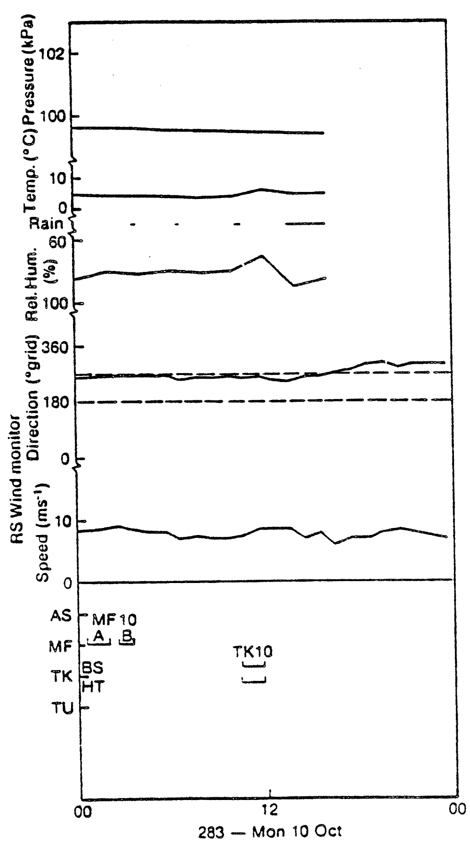
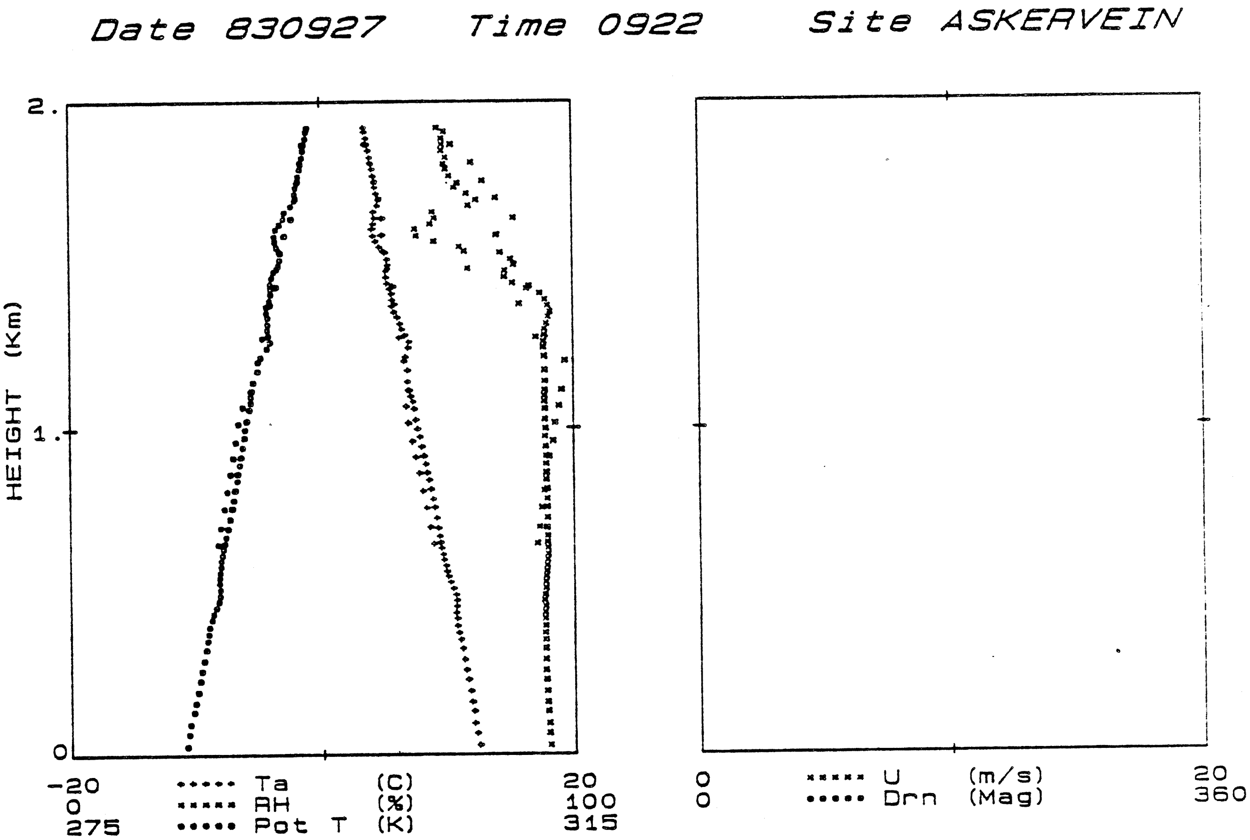

Pressure (kPa)
Temp. (°C)
Rain
Rel. Hum. (%)
RS Wind monitor
Direction (°grid)
Speed (ms⁻¹)
AS
MF
TK
TU
MF 10
A B
BS
HT
TK10
00
12
283 — Mon 10 Oct

Fig. 2.4 (cont.)



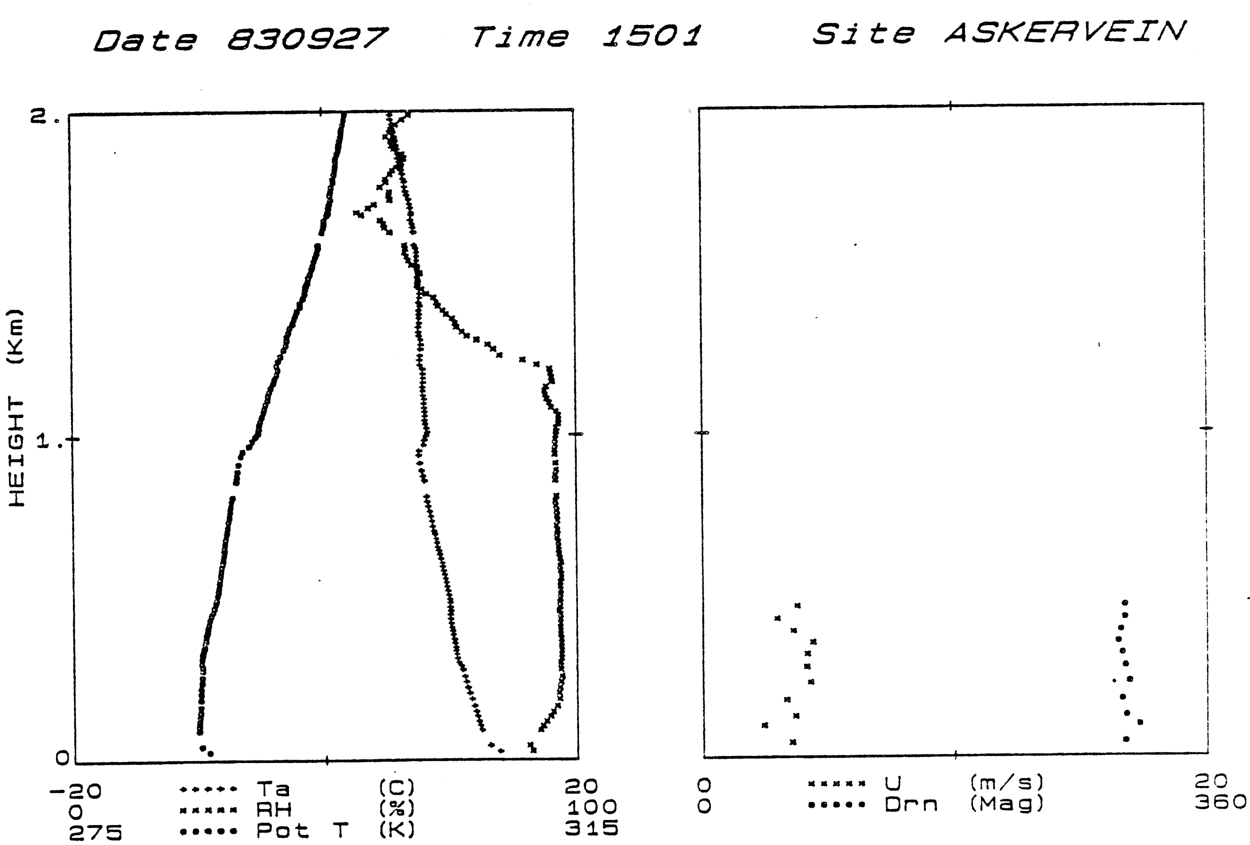


Fig. 2.5 AIRsonde profiles.

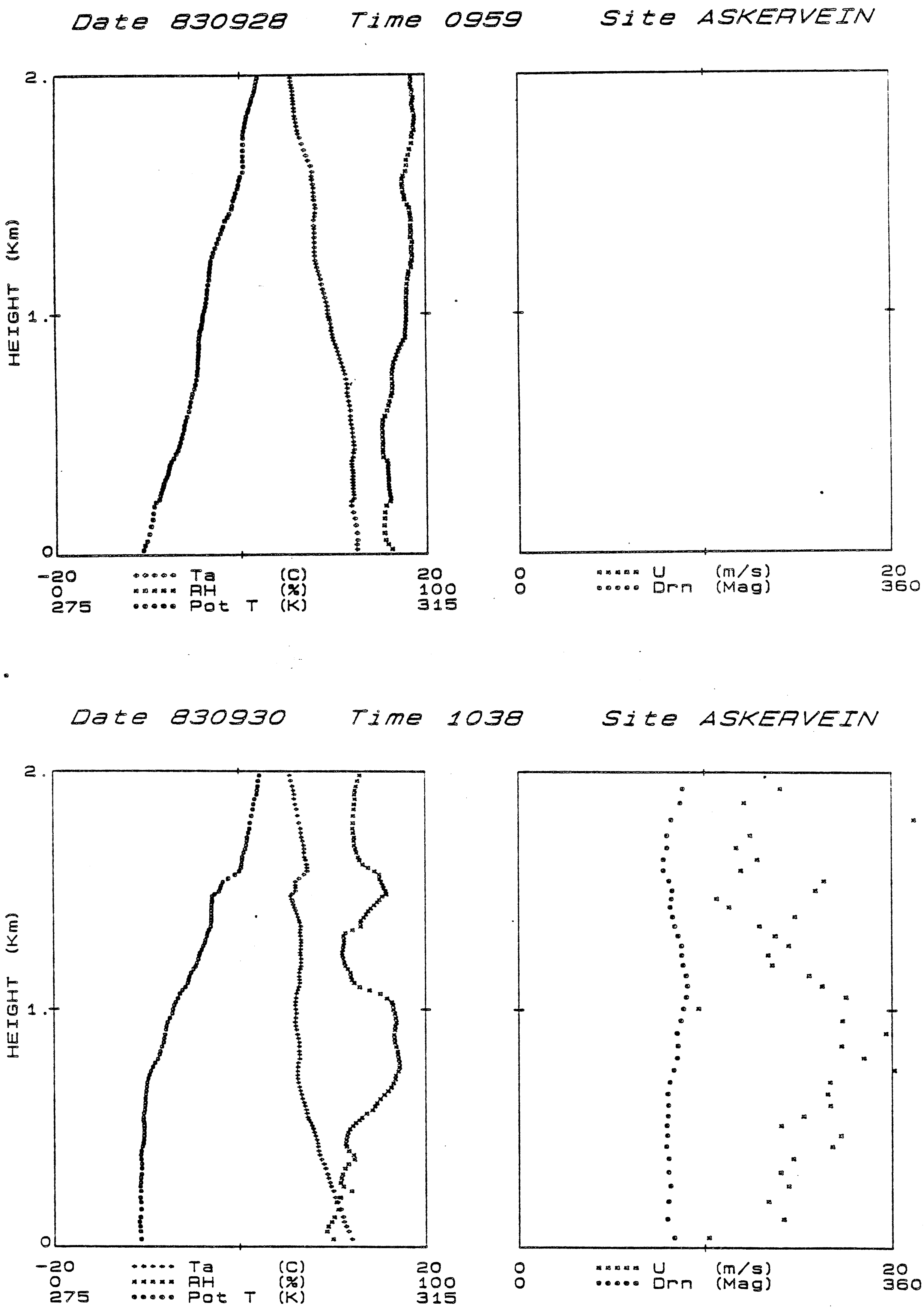

Date 830928 Time 0959 Site ASKERVEIN
HEIGHT (Km)
2.
1.
0
-20
0
275
Ta (C)
RH (%)
Pot T (K)
20
100
315
0
0
U (m/s)
Drn (Mag)
20
360
Date 830930 Time 1038 Site ASKERVEIN
HEIGHT (Km)
2.
1.
0
-20
0
275
Ta (C)
RH (%)
Pot T (K)
20
100
315
0
0
U (m/s)
Drn (Mag)
20
360

Fig. 2.5 (cont.)

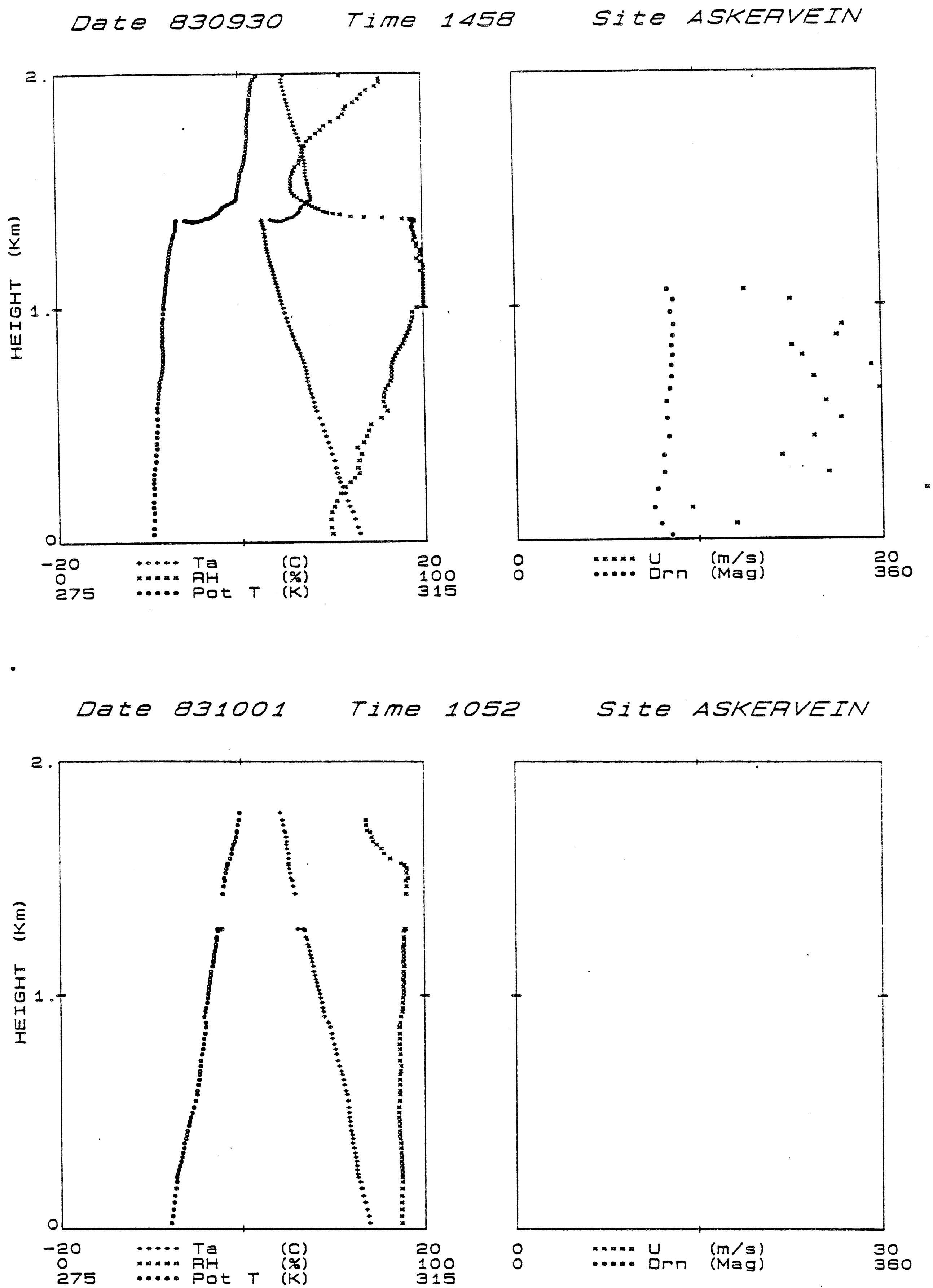
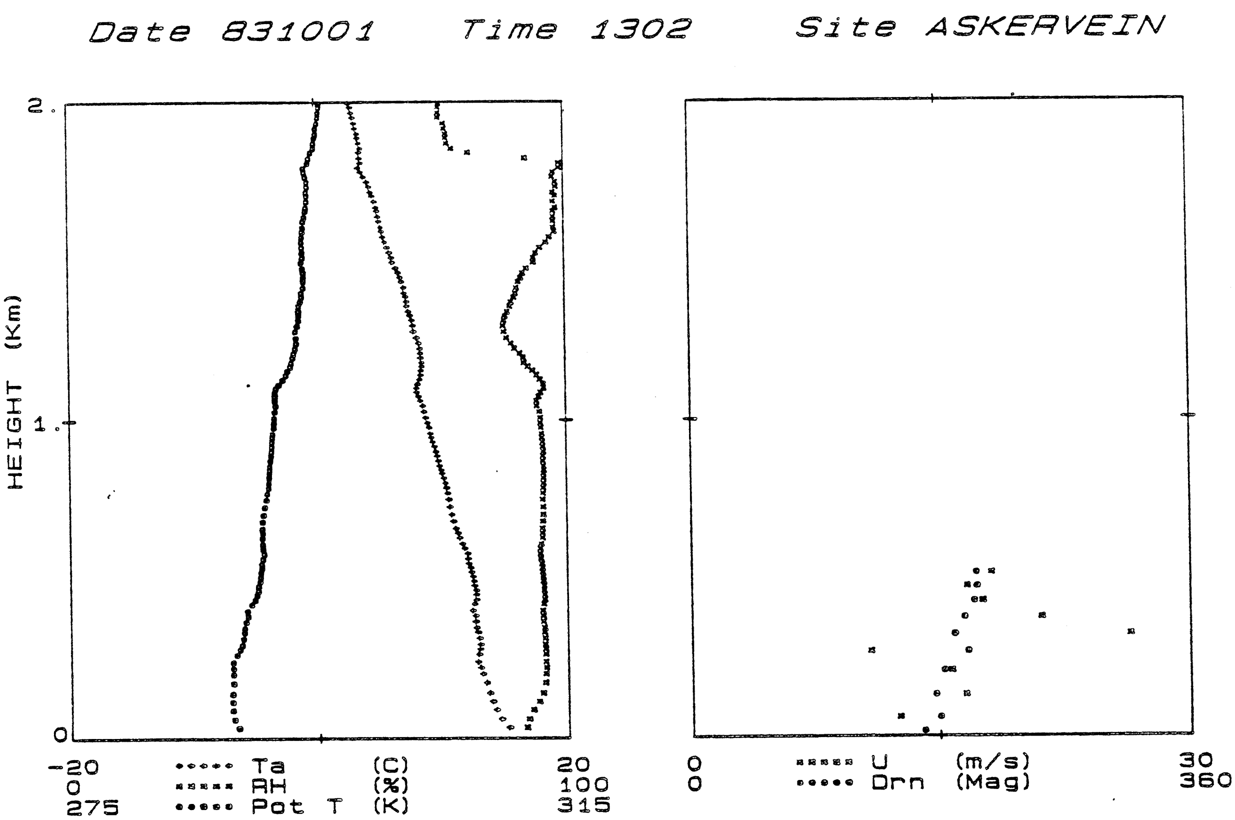

Date 830930 Time 1458 Site ASKERVEIN
HEIGHT (Km)
2.
1.
0
-20 ····· Ta (C) 20
0 ····· RH (%) 100
275 ····· Pot T (K) 315
0 ····· U (m/s) 20
0 ····· Drn (Mag) 360
Date 831001 Time 1052 Site ASKERVEIN
HEIGHT (Km)
2.
1.
0
-20 ····· Ta (C) 20
0 ····· RH (%) 100
275 ····· Pot T (K) 315
0 ····· U (m/s) 30
0 ····· Drn (Mag) 360

Fig. 2.5 (cont.)


Date 831001 Time 1302 Site ASKERVEIN
HEIGHT (Km)
2.
1.
0
-20 ••••• Ta (C) 20
0 ••••• RH (%) 100
275 ••••• Pot T (K) 315
0 ••••• U (m/s) 30
0 ••••• Drn (Mag) 360

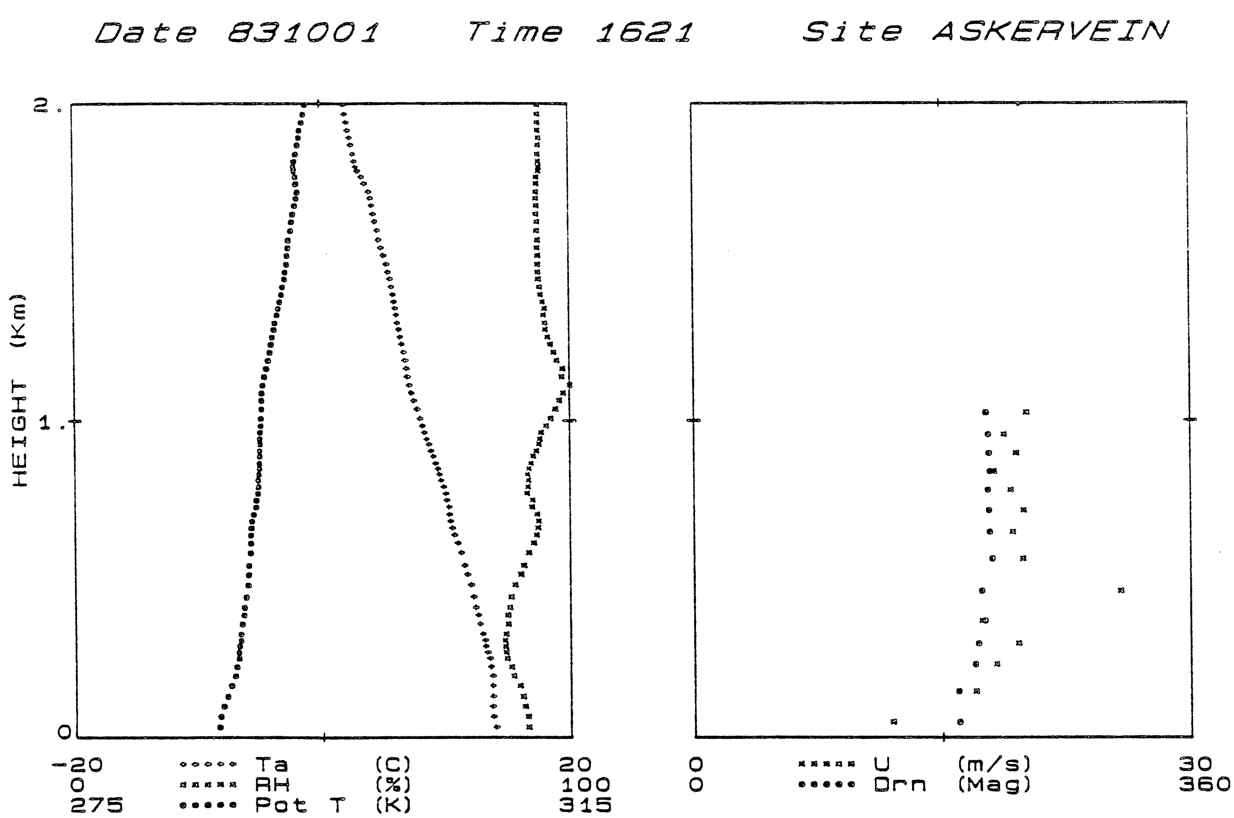

Date 831001 Time 1621 Site ASKERVEIN
HEIGHT (Km)
2.
1.
0
-20 ••••• Ta (C) 20
0 ••••• RH (%) 100
275 ••••• Pot T (K) 315
0 ••••• U (m/s) 30
0 ••••• Drn (Mag) 360

Fig. 2.5 (cont.)

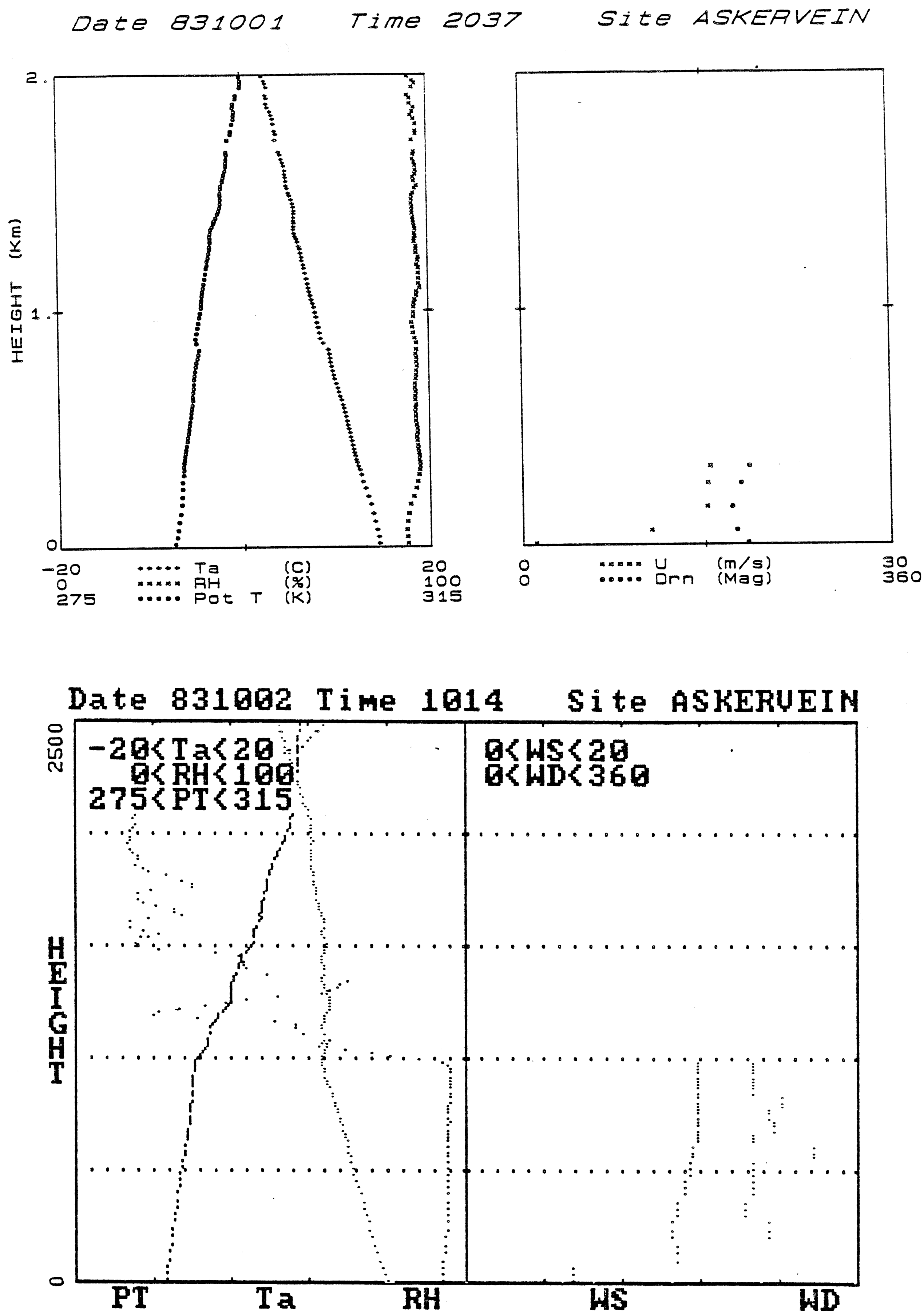
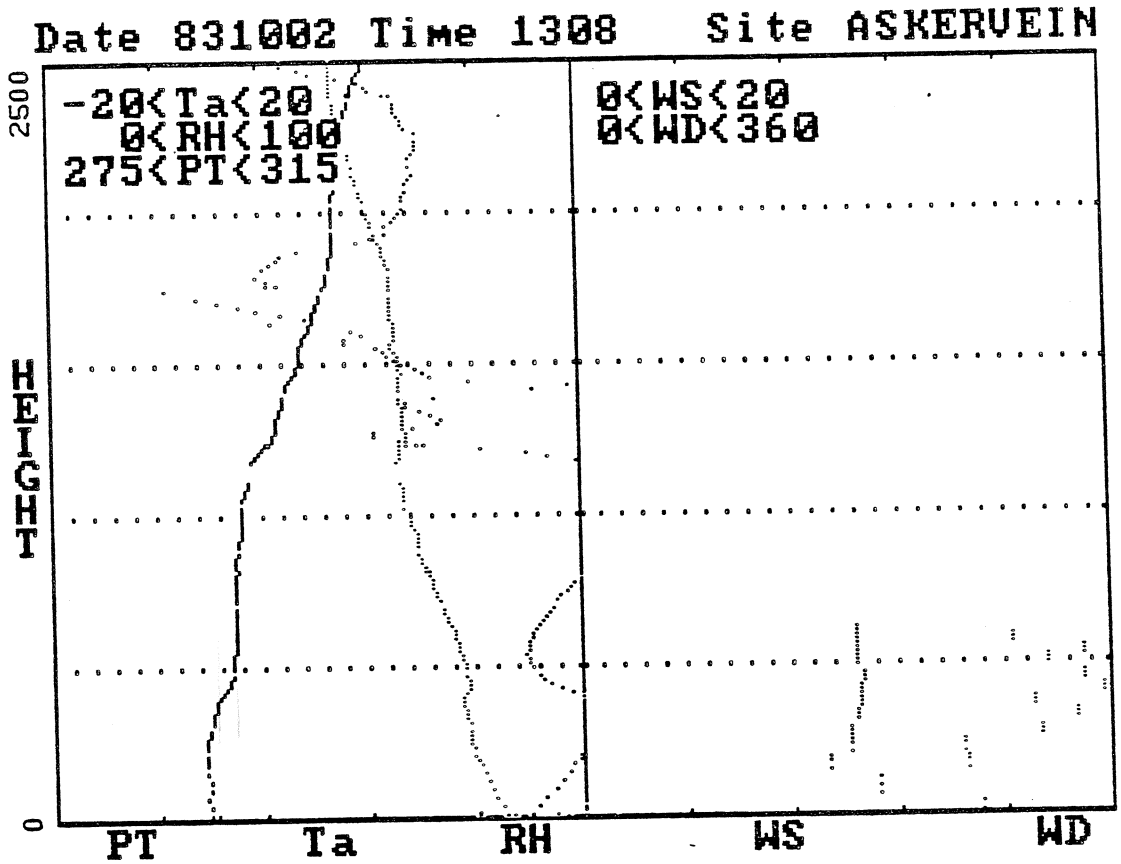

Date 831001 Time 2037 Site ASKERVEIN
HEIGHT (Km)
2.
1.
0
-20
0
275
Ta (C)
RH (%)
Pot T (K)
20
100
315
0
0
U (m/s)
Drn (Mag)
30
360
Date 831002 Time 1014 Site ASKERVEIN
-20<Ta<20
0<RH<100
275<PT<315
0<WS<20
0<WD<360
2500
HEIGHT
0
PT
Ta
RH
WS
WD

Fig. 2.5 (cont.)


Date 831002 Time 1308 Site ASKERVEIN
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0<RH<100
275<PT<315
0<WS<20
0<WD<360
2500
0
HEIGHT
PT
Ta
RH
WS
WD

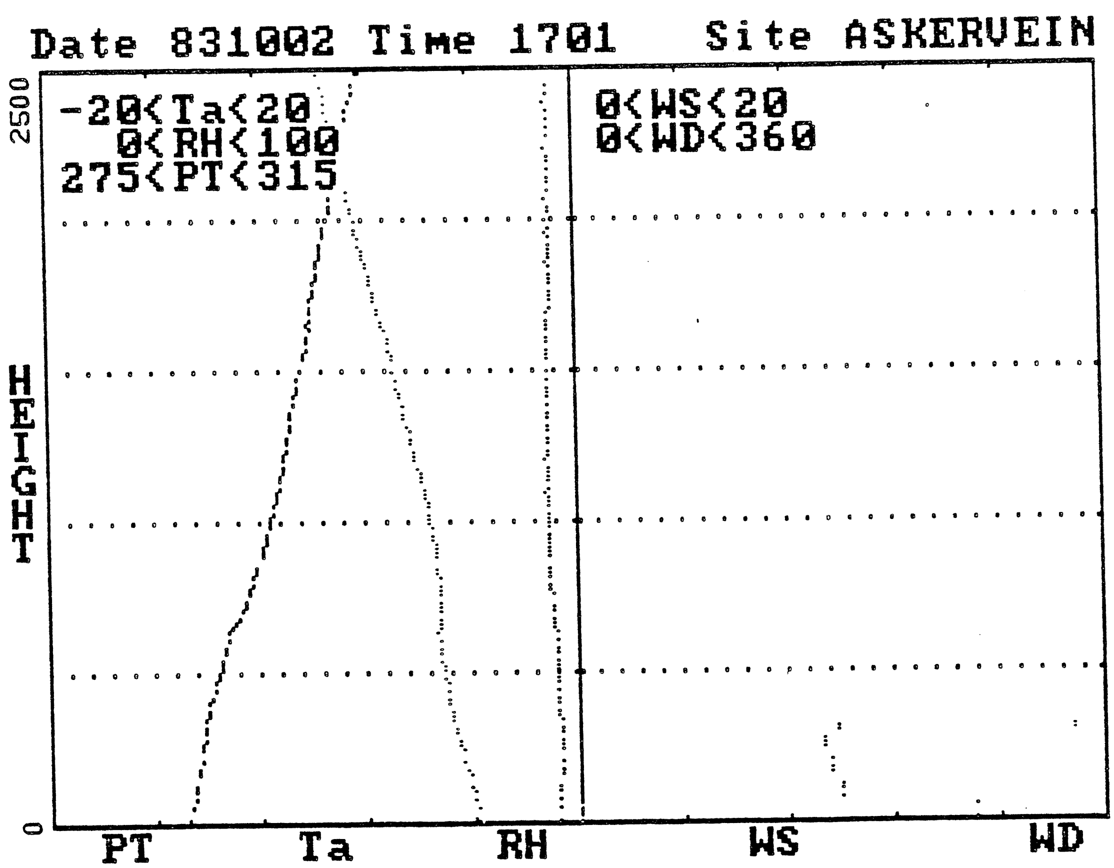
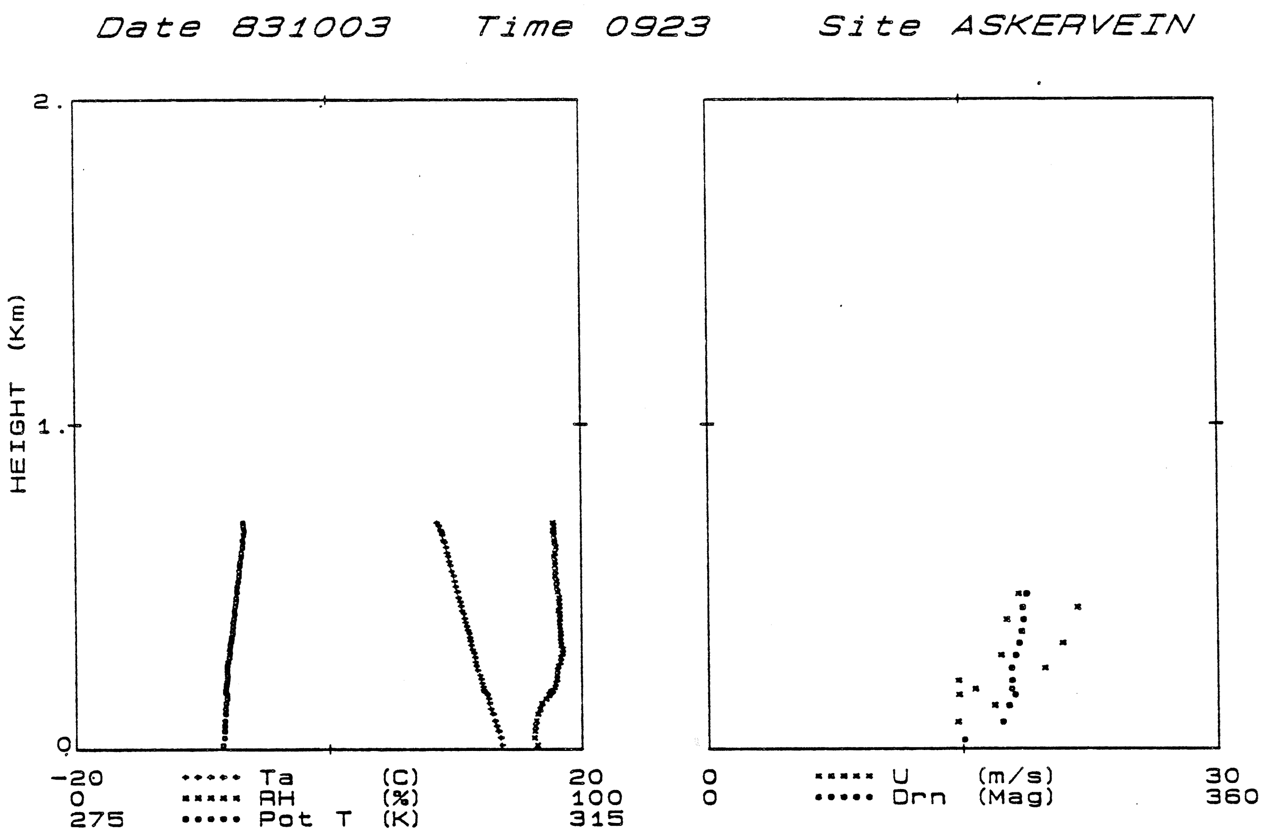
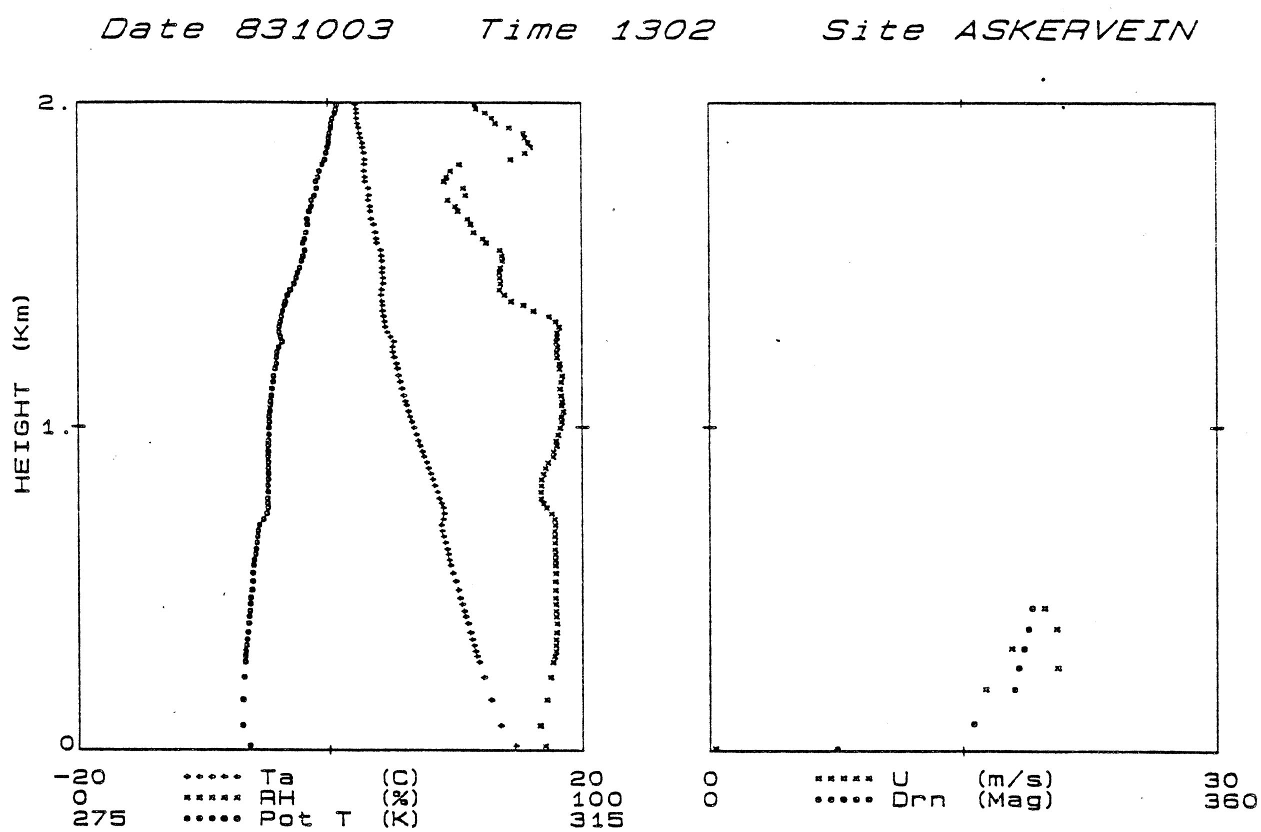

Date 831002 Time 1701 Site ASKERVEIN
-20<Ta<20
0<RH<100
275<PT<315
0<WS<20
0<WD<360
2500
0
HEIGHT
PT
Ta
RH
WS
WD

Fig. 2.5 (cont.)



Date 831003 Time 0923 Site ASKERVEIN
HEIGHT (Km)
2.
1.
0
-20 0 275
Ta (C)
RH (%)
Pot T (K)
20 100 315
0 0
U (m/s)
Drn (Mag)
30 360



Date 831003 Time 1302 Site ASKERVEIN
HEIGHT (Km)
2.
1.
0
-20 0 275
Ta (C)
RH (%)
Pot T (K)
20 100 315
0 0
U (m/s)
Drn (Mag)
30 360

Fig. 2.5 (cont.)

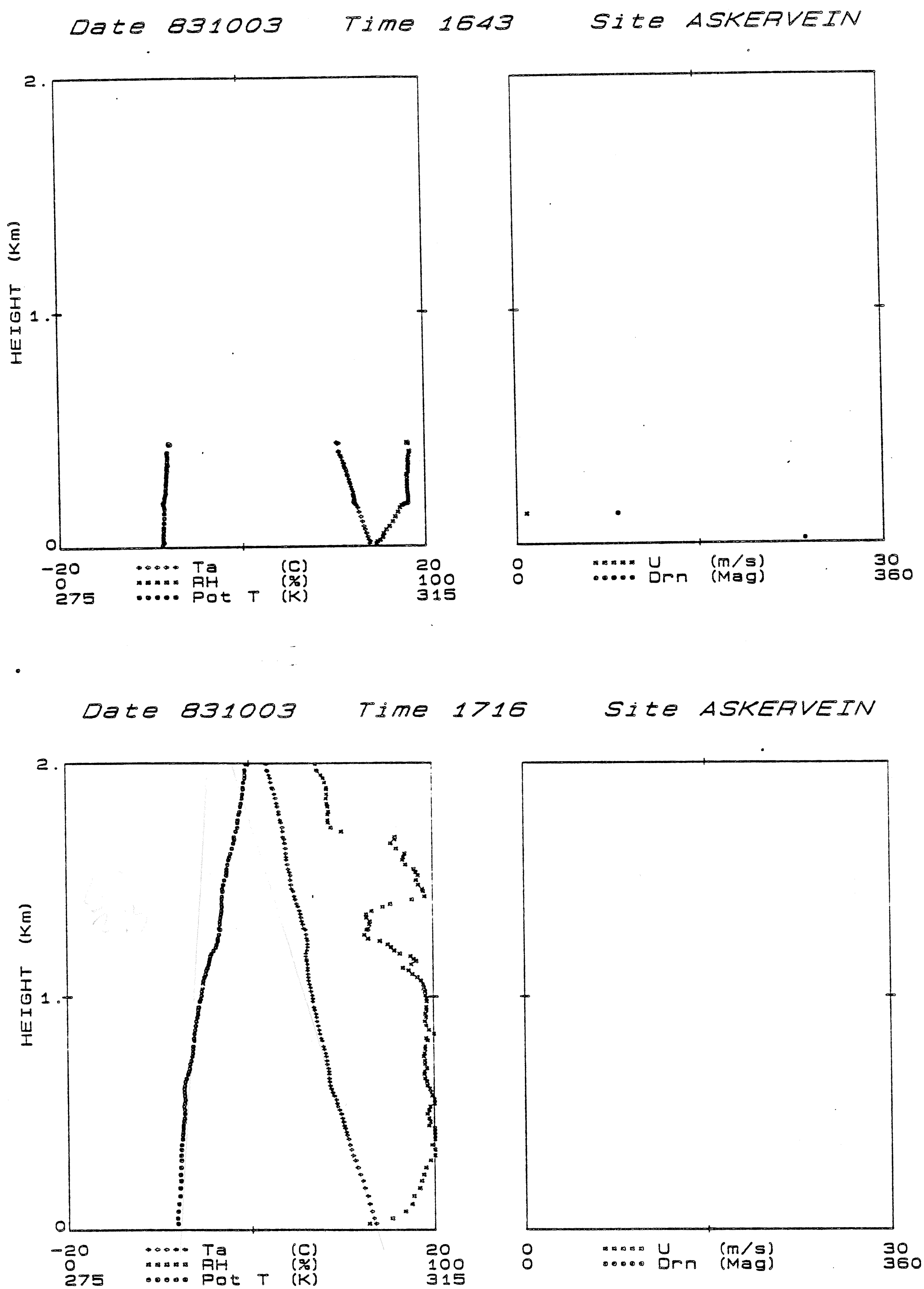
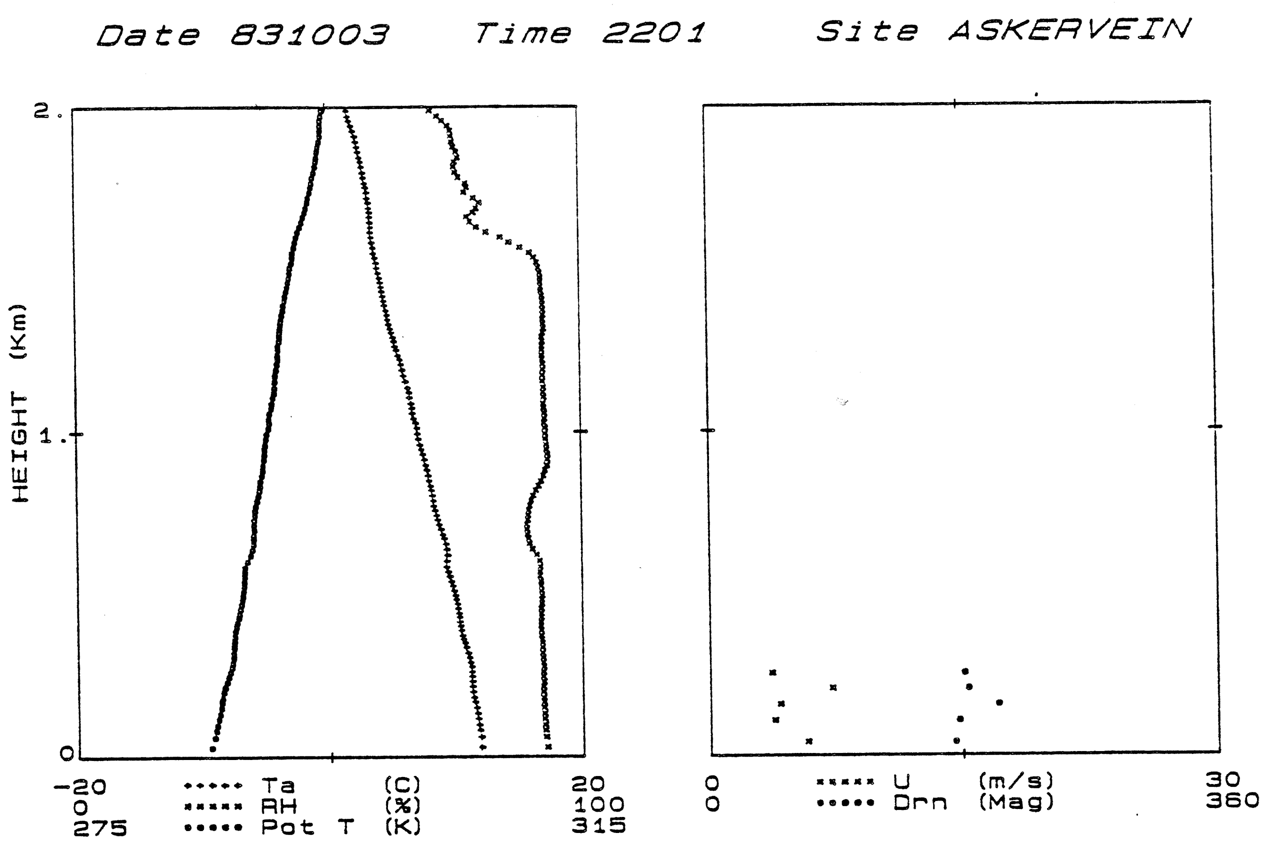

Date 831003 Time 1643 Site ASKERVEIN
2.
1.
0
HEIGHT (Km)
-20 Ta (C) 20
0 RH (%) 100
275 Pot T (K) 315
0 U (m/s) 30
0 Drn (Mag) 360
Date 831003 Time 1716 Site ASKERVEIN
2.
1.
0
HEIGHT (Km)
-20 Ta (C) 20
0 RH (%) 100
275 Pot T (K) 315
0 U (m/s) 30
0 Drn (Mag) 360

Fig. 2.5 (cont.)


Date 831003 Time 2201 Site ASKERVEIN
HEIGHT (Km)
2.
1.
0
-20 ····· Ta (C) 20
0 ××××× RH (%) 100
275 ····· Pot T (K) 315
0 ××××× U (m/s) 30
0 ····· Drn (Mag) 360

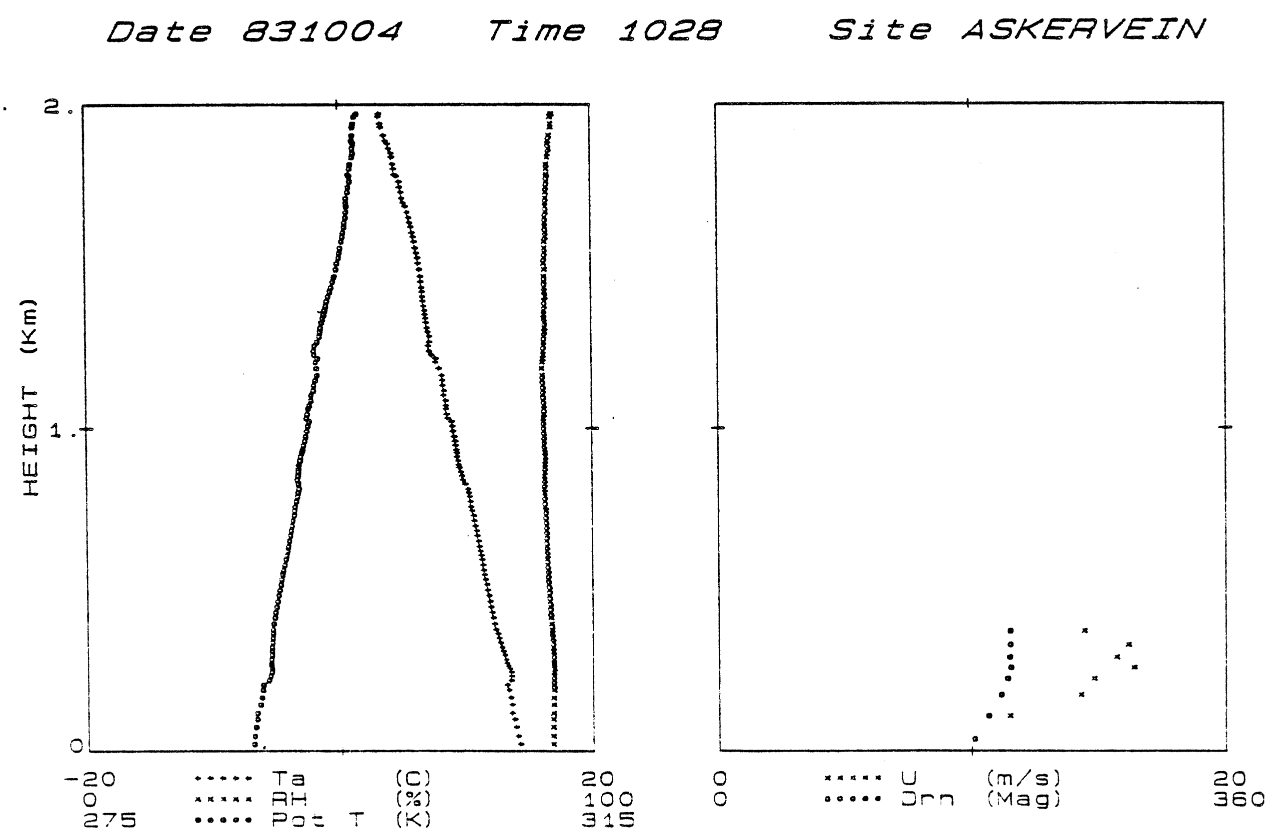
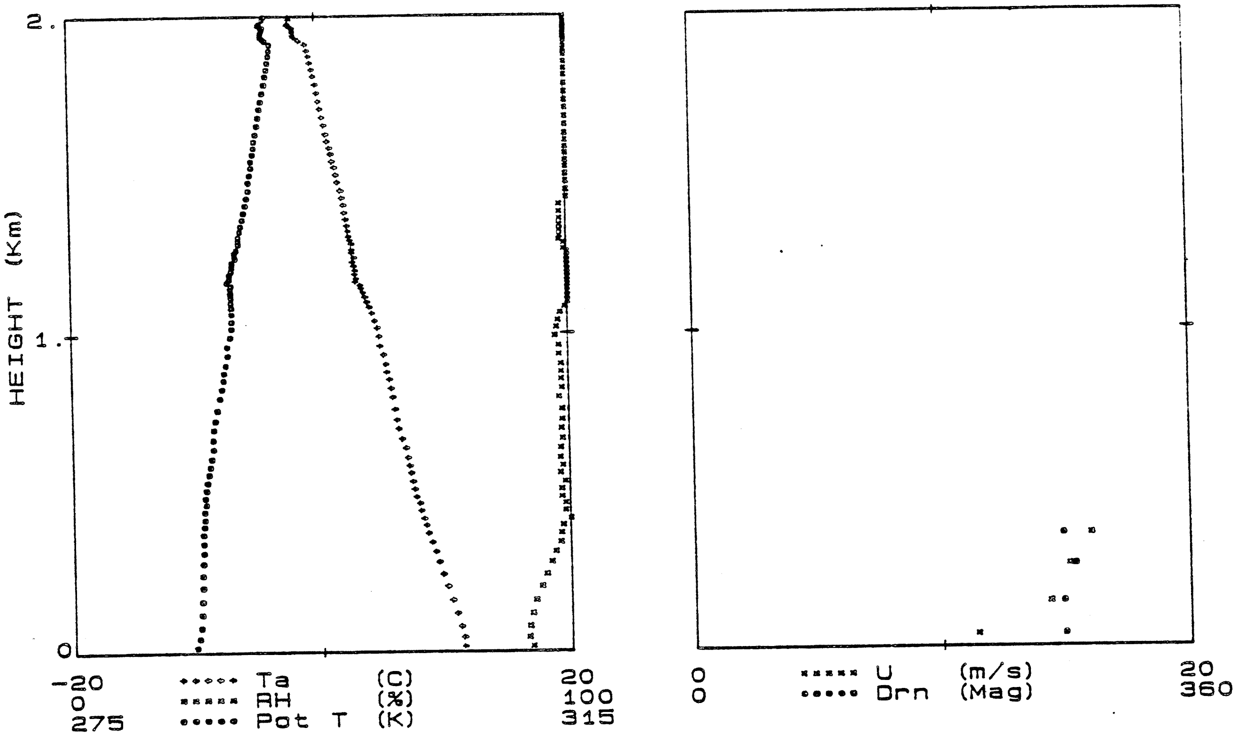

Date 831004 Time 1028 Site ASKERVEIN
HEIGHT (Km)
2.
1.
0
-20 ····· Ta (C) 20
0 ××××× RH (%) 100
275 ····· Pot T (K) 315
0 ××××× U (m/s) 20
0 ····· Drn (Mag) 360

Fig. 2.5 (cont.)

Date 831005 Time 0923 Site ASKERVEIN



Date 831005 Time 1232 Site ASKERVEIN

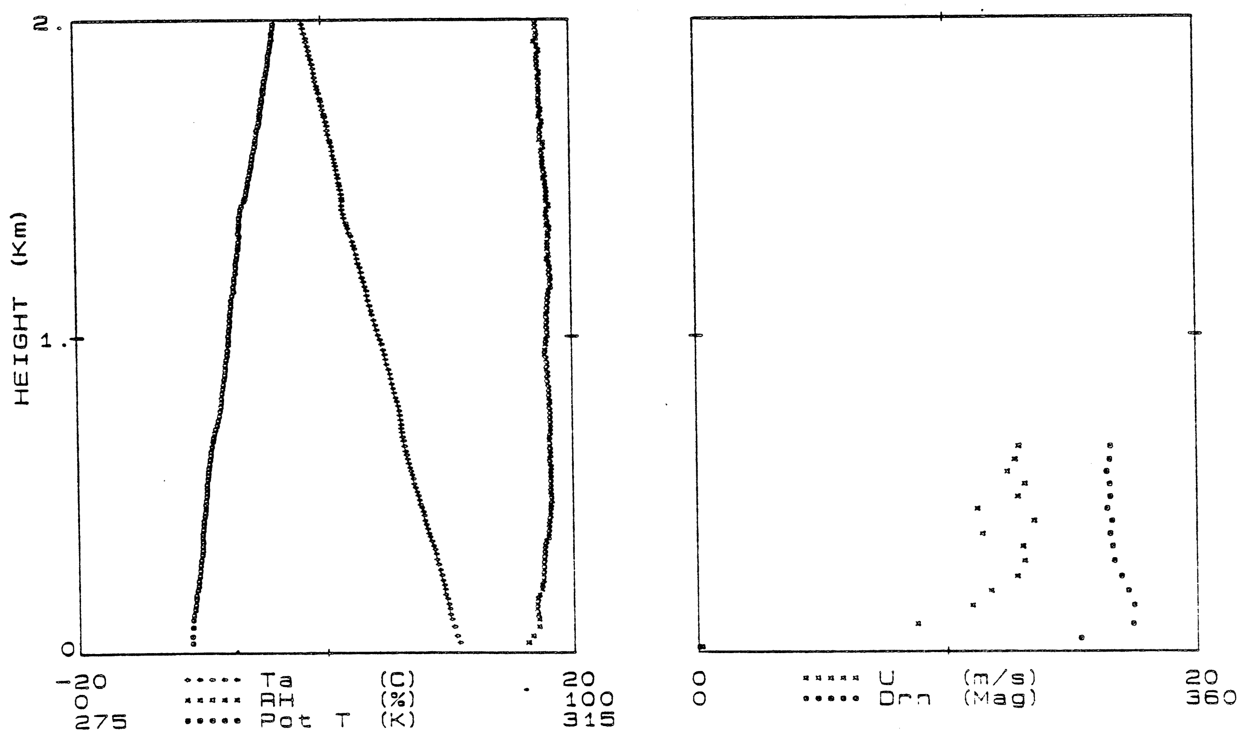
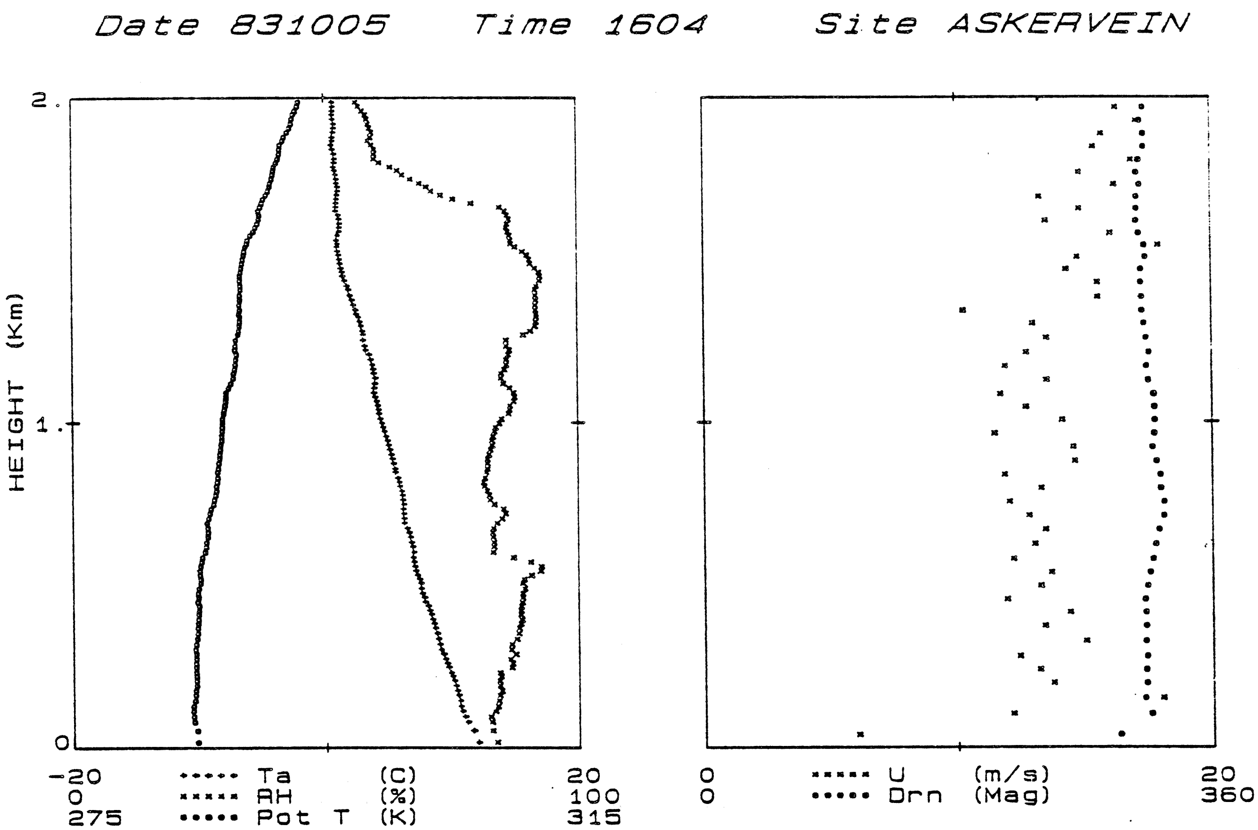


Fig. 2.5 (cont.)


Date 831005 Time 1604 Site ASKERVEIN
HEIGHT (Km)
2.
1.
0
-20 0 275
••••• Ta (C)
××××× RH (%)
••••• Pot T (K)
20 100 315
0 0
××××× U (m/s)
••••• Drn (Mag)
20 360

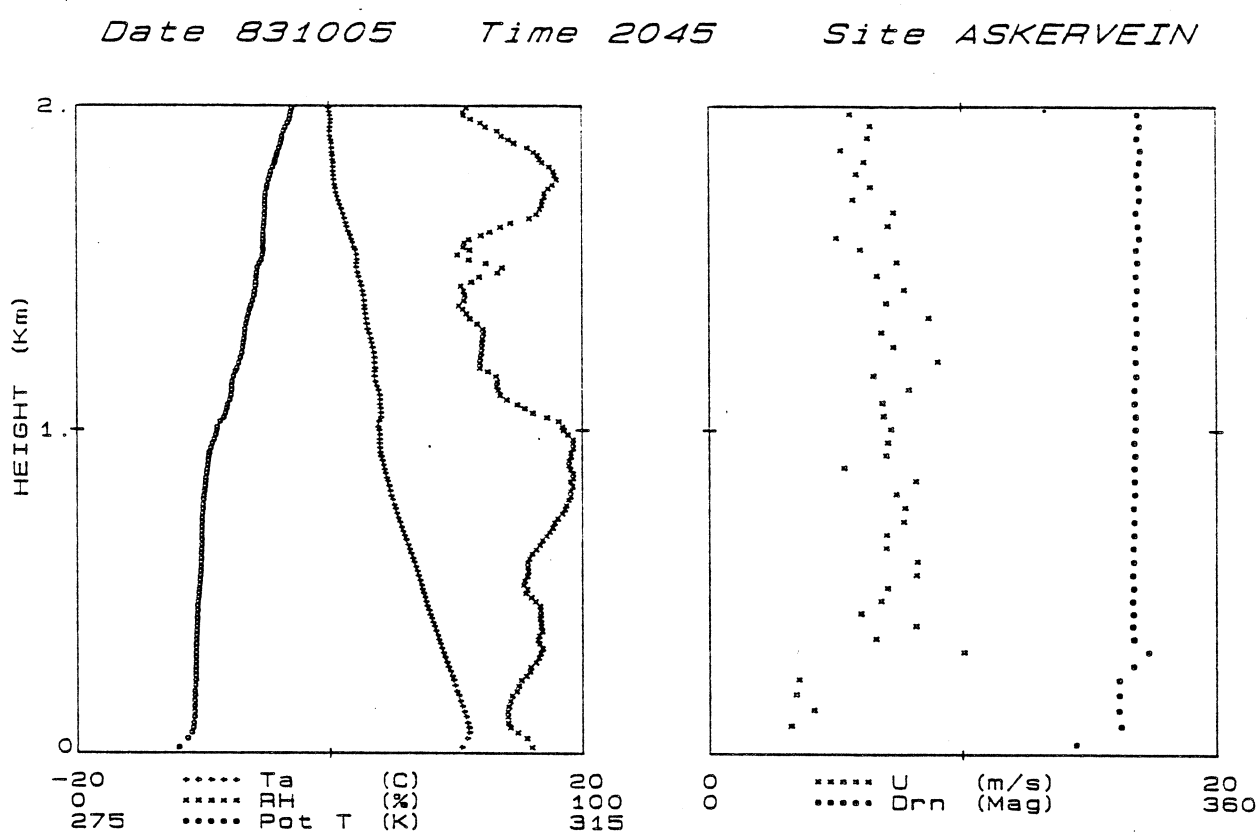
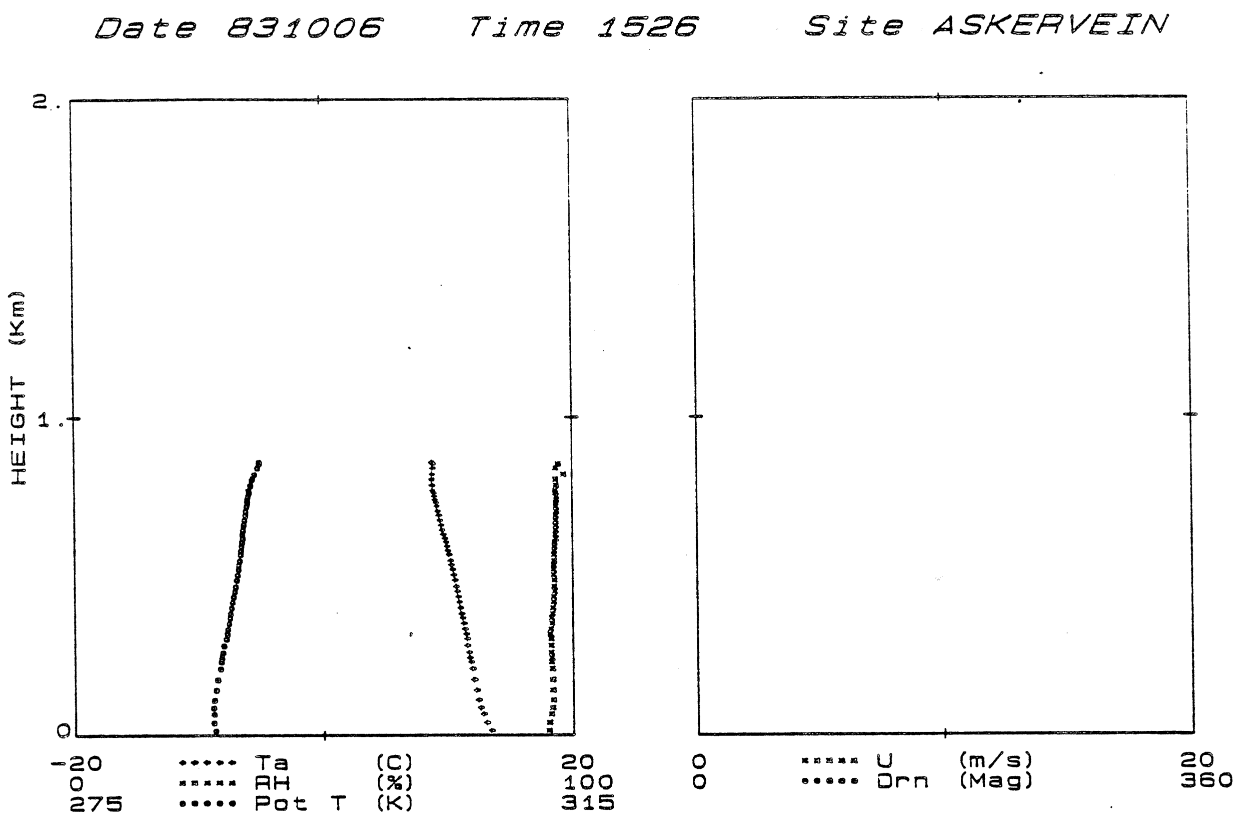

Date 831005 Time 2045 Site ASKERVEIN
HEIGHT (Km)
2.
1.
0
-20 0 275
••••• Ta (C)
××××× RH (%)
••••• Pot T (K)
20 100 315
0 0
××××× U (m/s)
••••• Drn (Mag)
20 360

Fig. 2.5 (cont.)


Date 831006 Time 1526 Site ASKERVEIN
HEIGHT (Km)
2.
1.
0
-20
0
275
Ta (C)
RH (%)
Pot T (K)
20
100
315
0
0
U (m/s)
Drn (Mag)
20
360

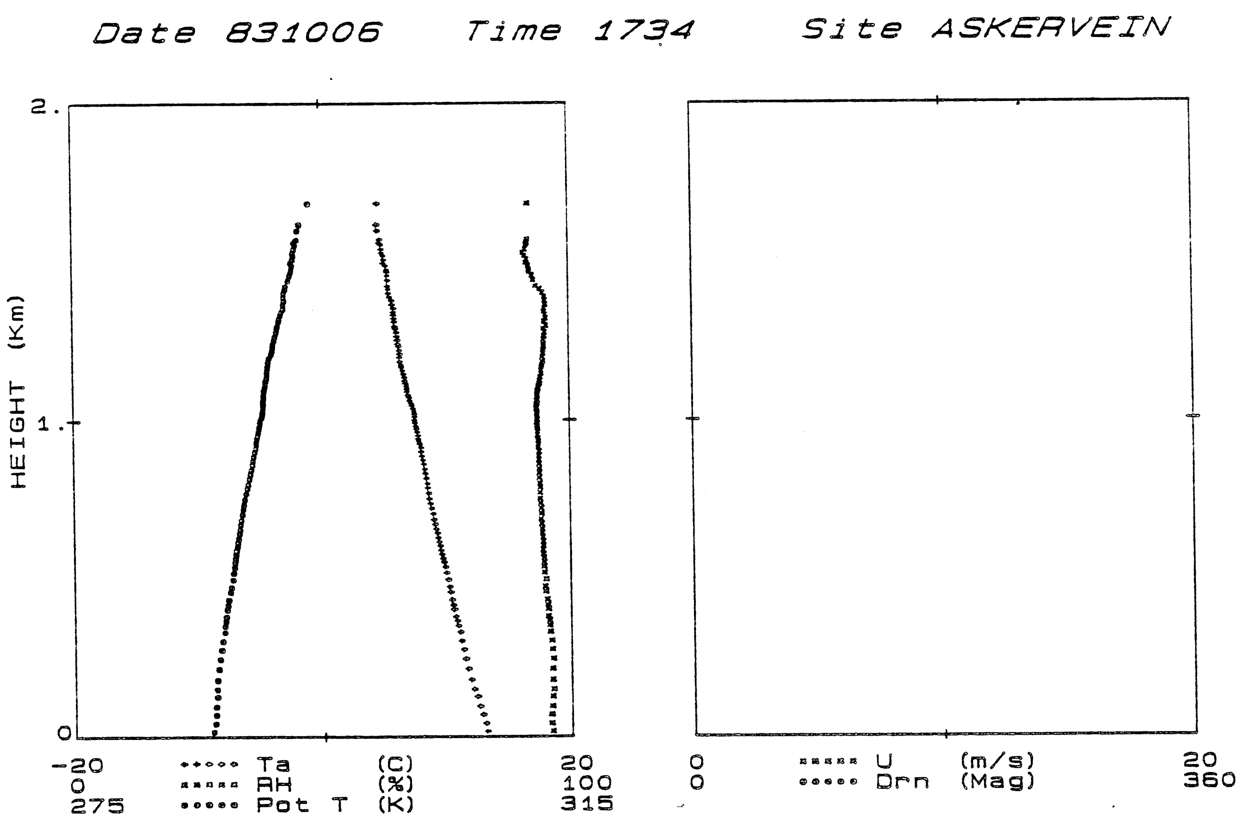
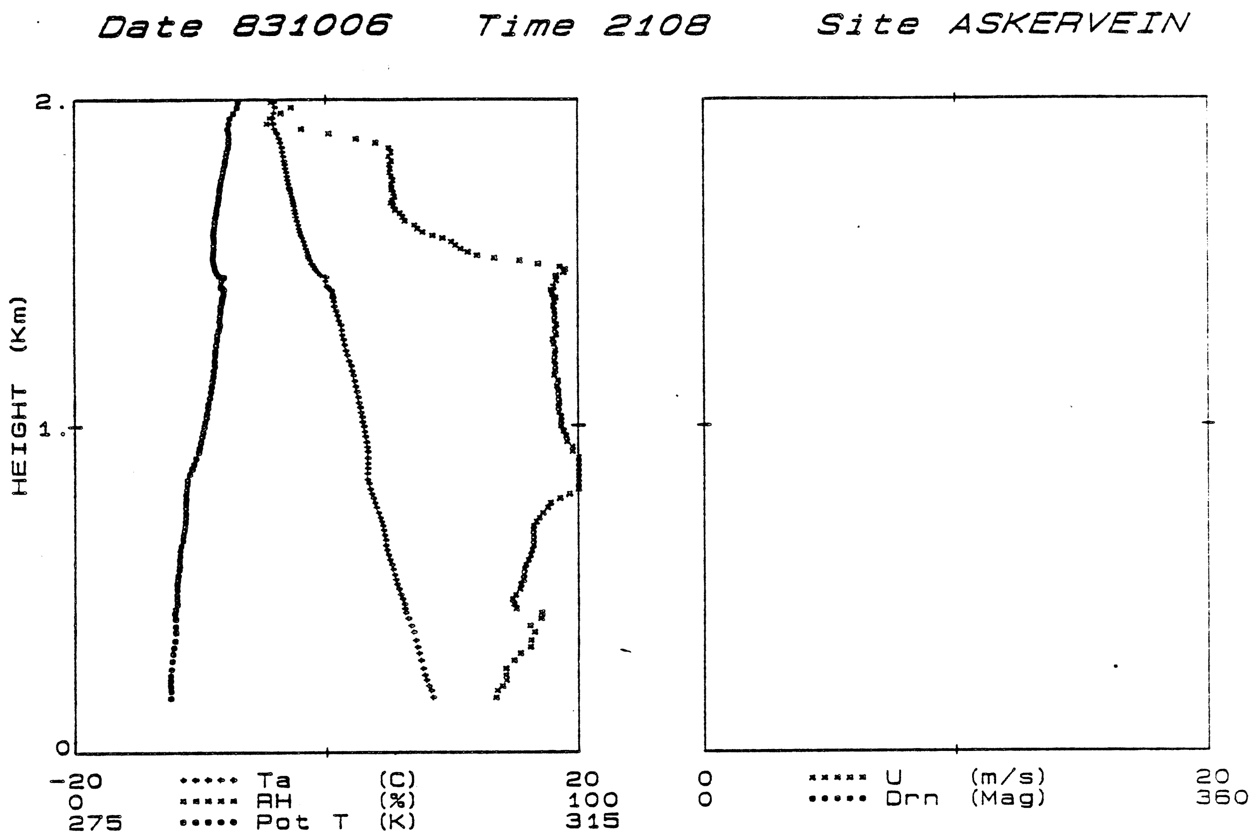

Date 831006 Time 1734 Site ASKERVEIN
HEIGHT (Km)
2.
1.
0
-20
0
275
Ta (C)
RH (%)
Pot T (K)
20
100
315
0
0
U (m/s)
Drn (Mag)
20
360

Fig. 2.5 (cont.)


Date 831006 Time 2108 Site ASKERVEIN
HEIGHT (Km)
2.
1.
0
-20 0 275
20 100 315
Ta (C)
RH (%)
Pot T (K)
0 0
20 360
U (m/s)
Drn (Mag)

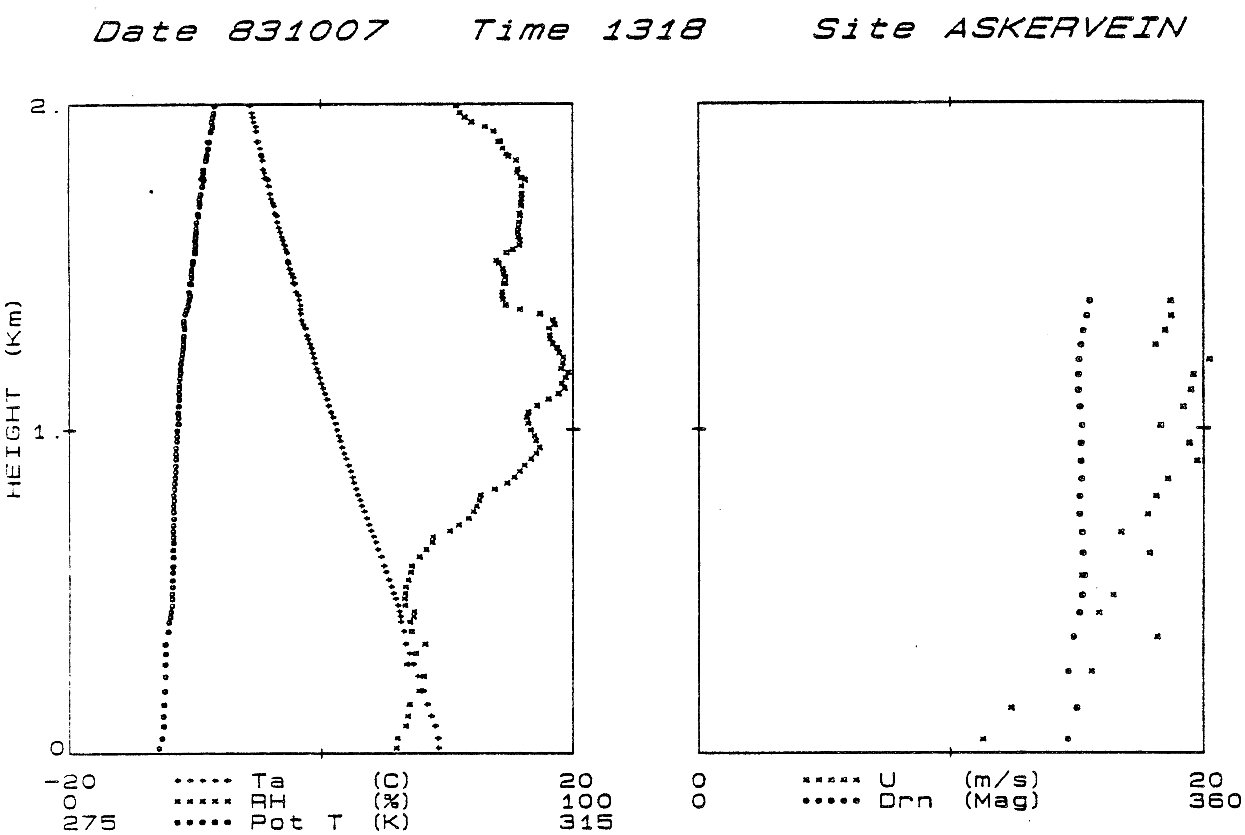
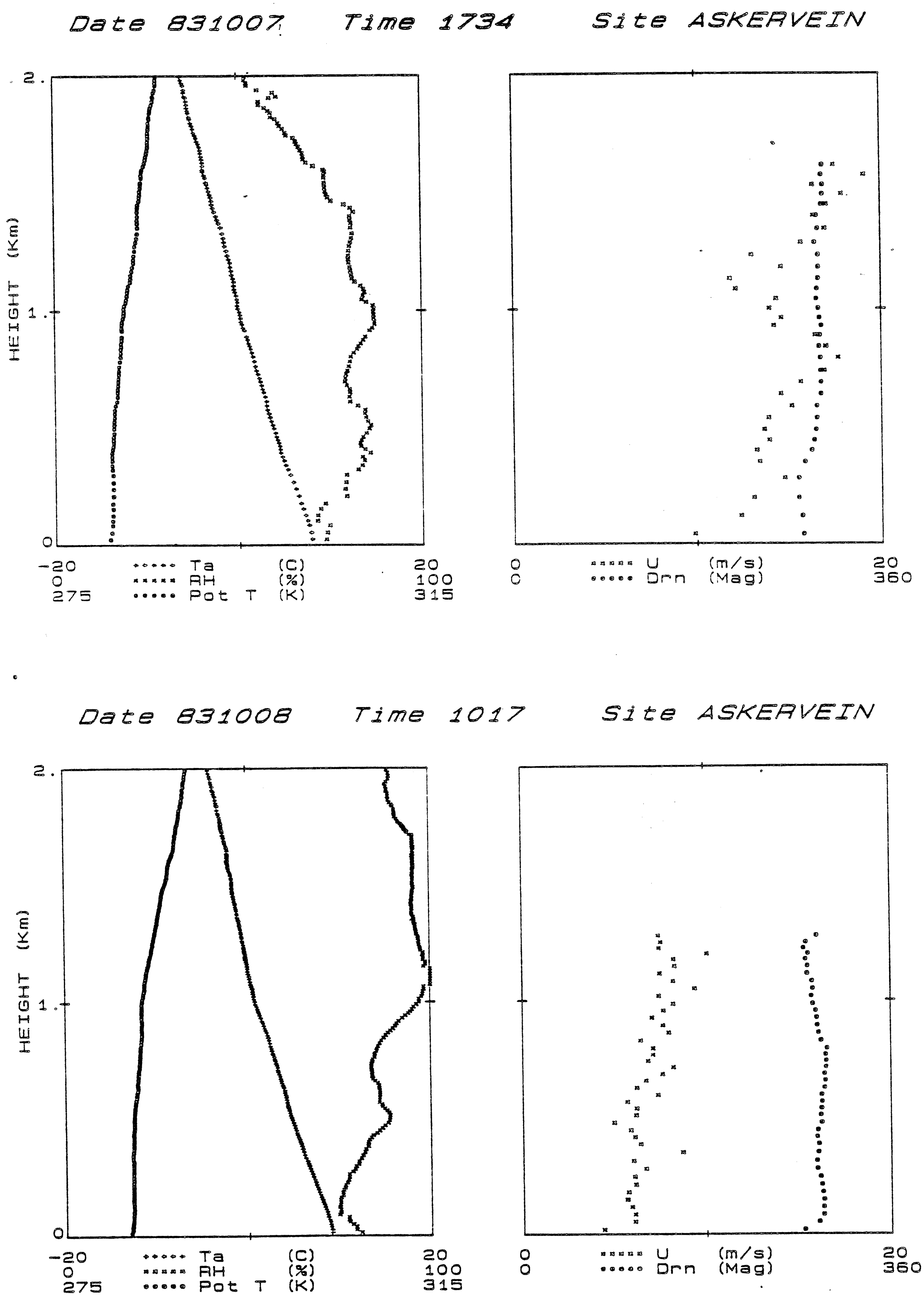
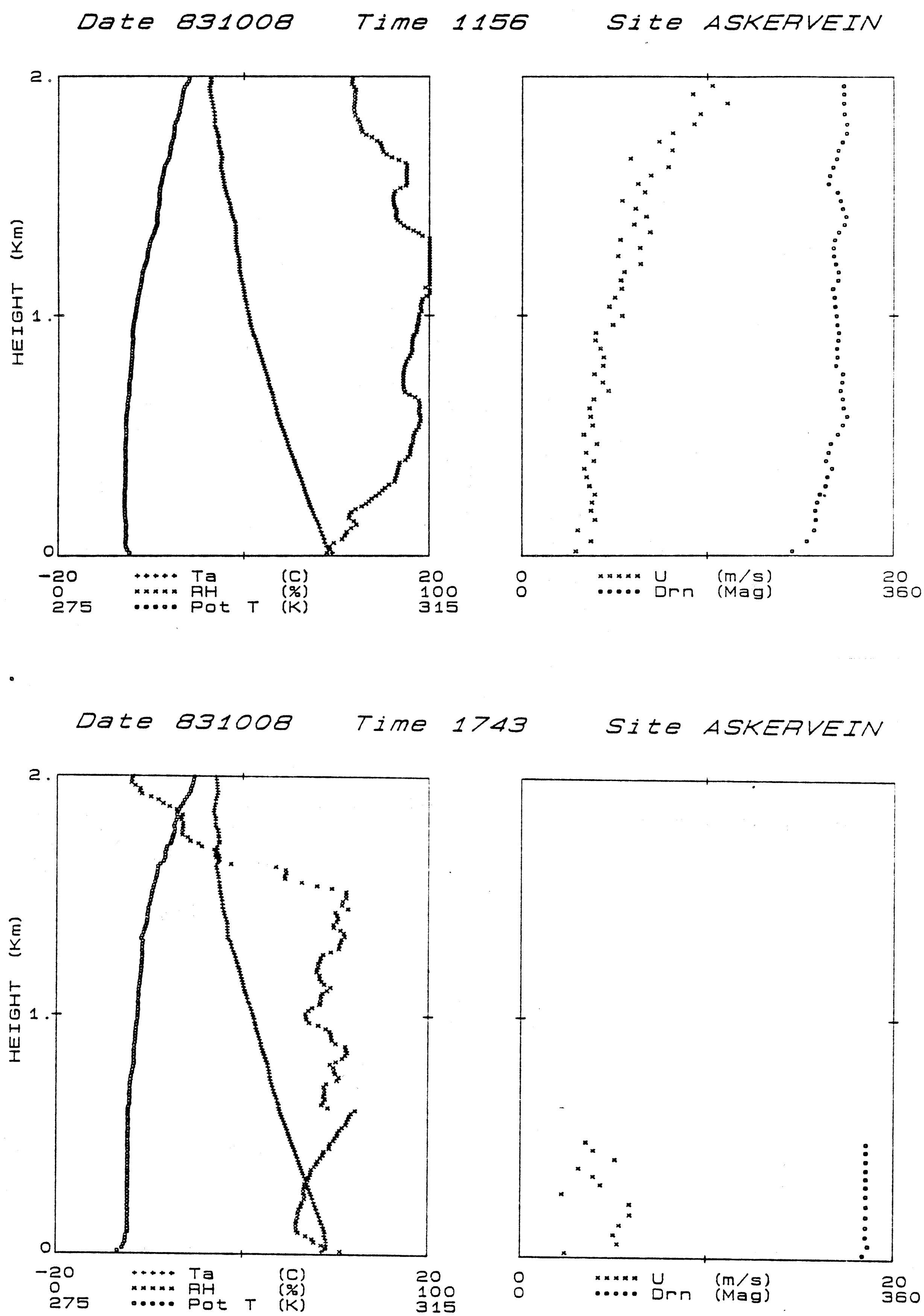

Date 831007 Time 1318 Site ASKERVEIN
HEIGHT (Km)
2.
1.
0
-20 0 275
20 100 315
Ta (C)
RH (%)
Pot T (K)
0 0
20 360
U (m/s)
Drn (Mag)

Fig. 2.5 (cont.)



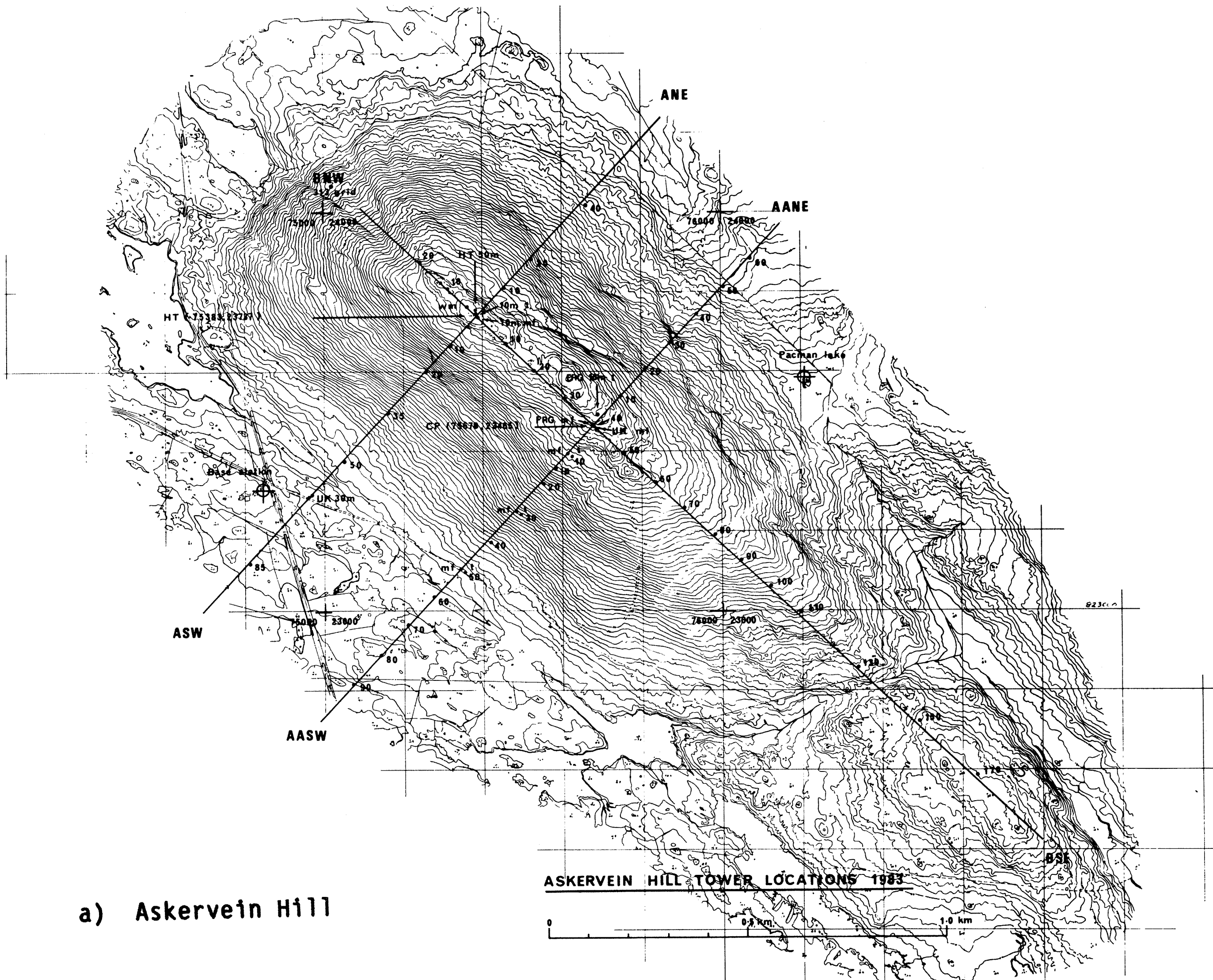
Date 831007 Time 1734 Site ASKERVEIN
HEIGHT (Km)
2.
1.
0
-20 Ta (C) 20
0 RH (%) 100
275 Pot T (K) 315
0 U (m/s) 20
0 Drn (Mag) 360
Date 831008 Time 1017 Site ASKERVEIN
HEIGHT (Km)
2.
1.
0
-20 Ta (C) 20
0 RH (%) 100
275 Pot T (K) 315
0 U (m/s) 20
0 Drn (Mag) 360

Fig. 2.5 (cont.)

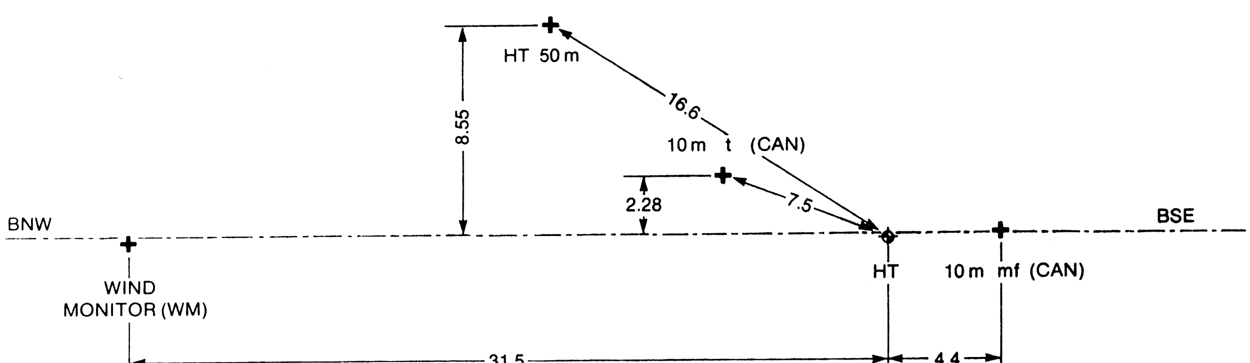


Date 831008 Time 1156 Site ASKERVEIN
HEIGHT (Km)
2.
1.
0
-20 ····· Ta (C) 20
0 ××××× RH (%) 100
275 ····· Pot T (K) 315
0 ××××× U (m/s) 20
0 ····· Drn (Mag) 360
Date 831008 Time 1743 Site ASKERVEIN
HEIGHT (Km)
2.
1.
0
-20 ····· Ta (C) 20
0 ××××× RH (%) 100
275 ····· Pot T (K) 315
0 ××××× U (m/s) 20
0 ····· Drn (Mag) 360

Fig. 2.5 (cont.)

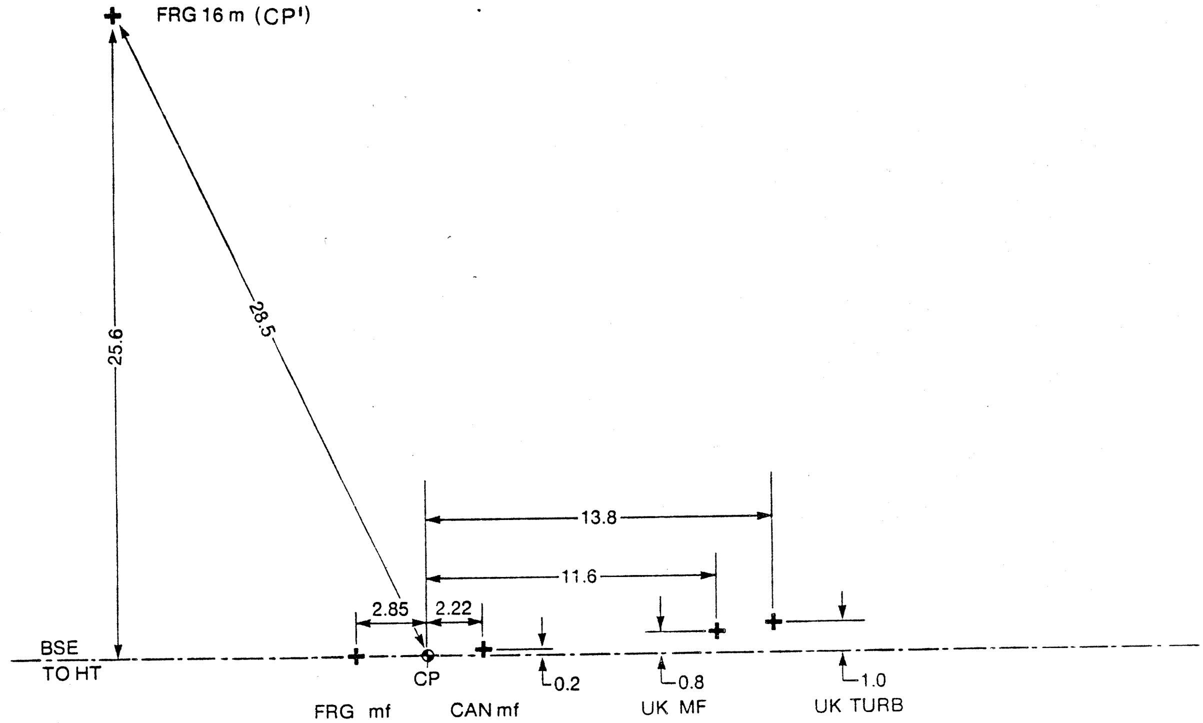


a) Askervein Hill

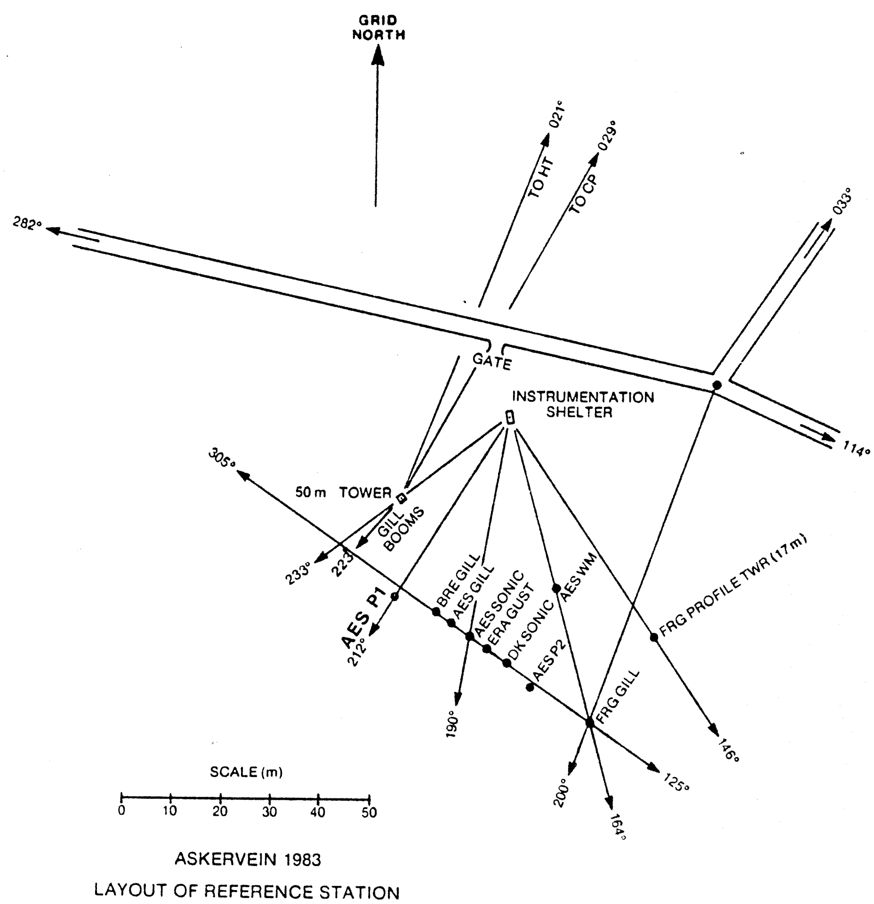


b) HT Locations

Fig. 2.6 Tower Locations, 1983



c) CP Locations



d) RS Area

Fig. 2.6 (cont.)

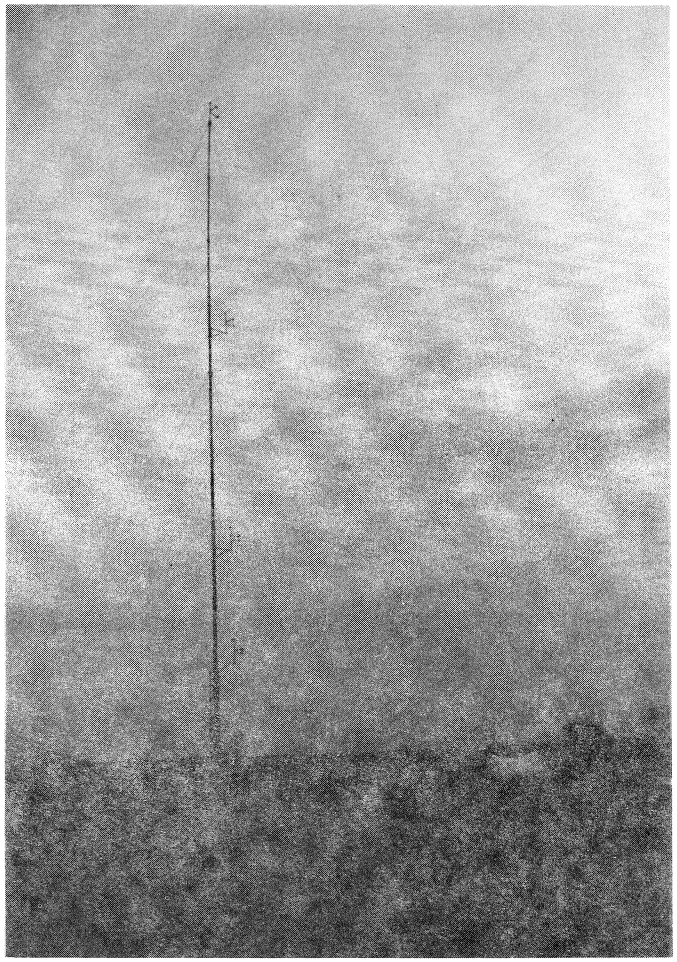


Fig. 2.7

Photograph of UK (BRE) telescopic 30m tower at ASW60.

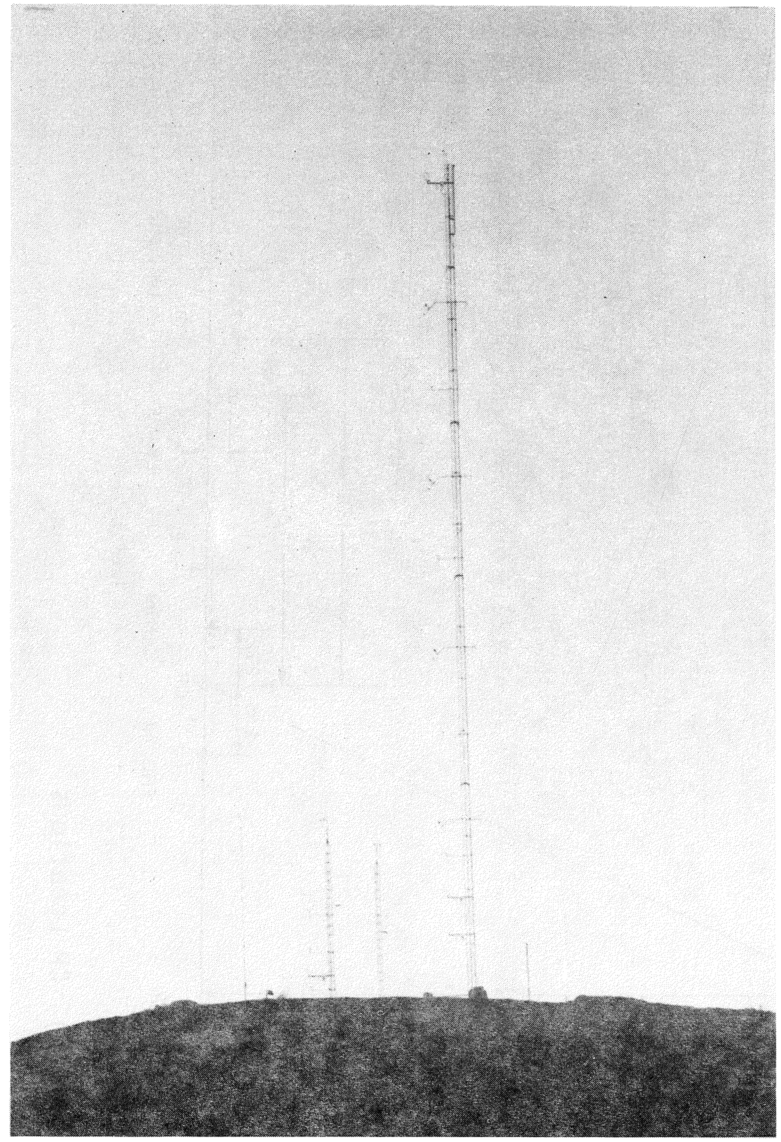


Fig. 2.8

Photograph of towers at HT (looking west northwest).

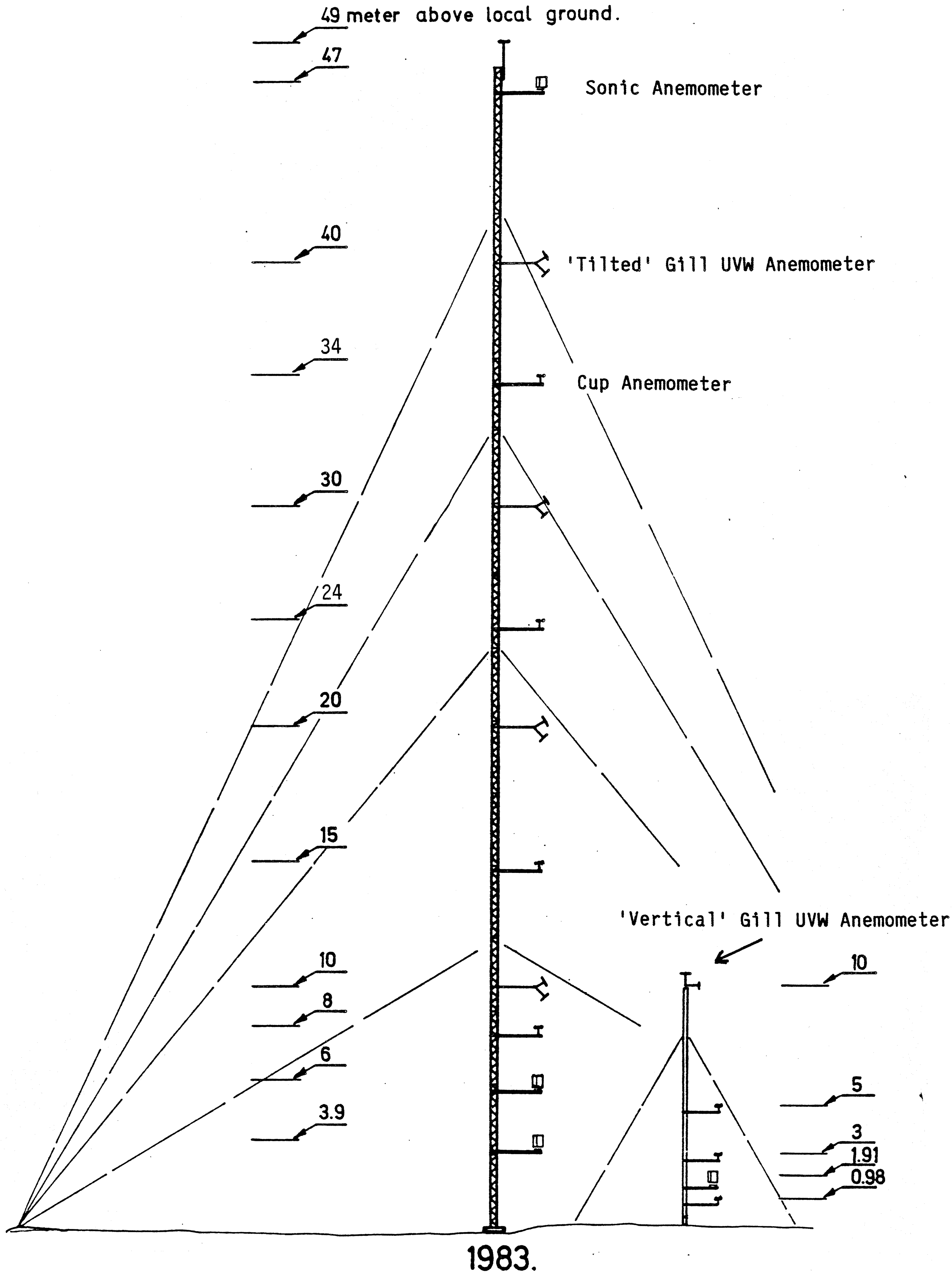
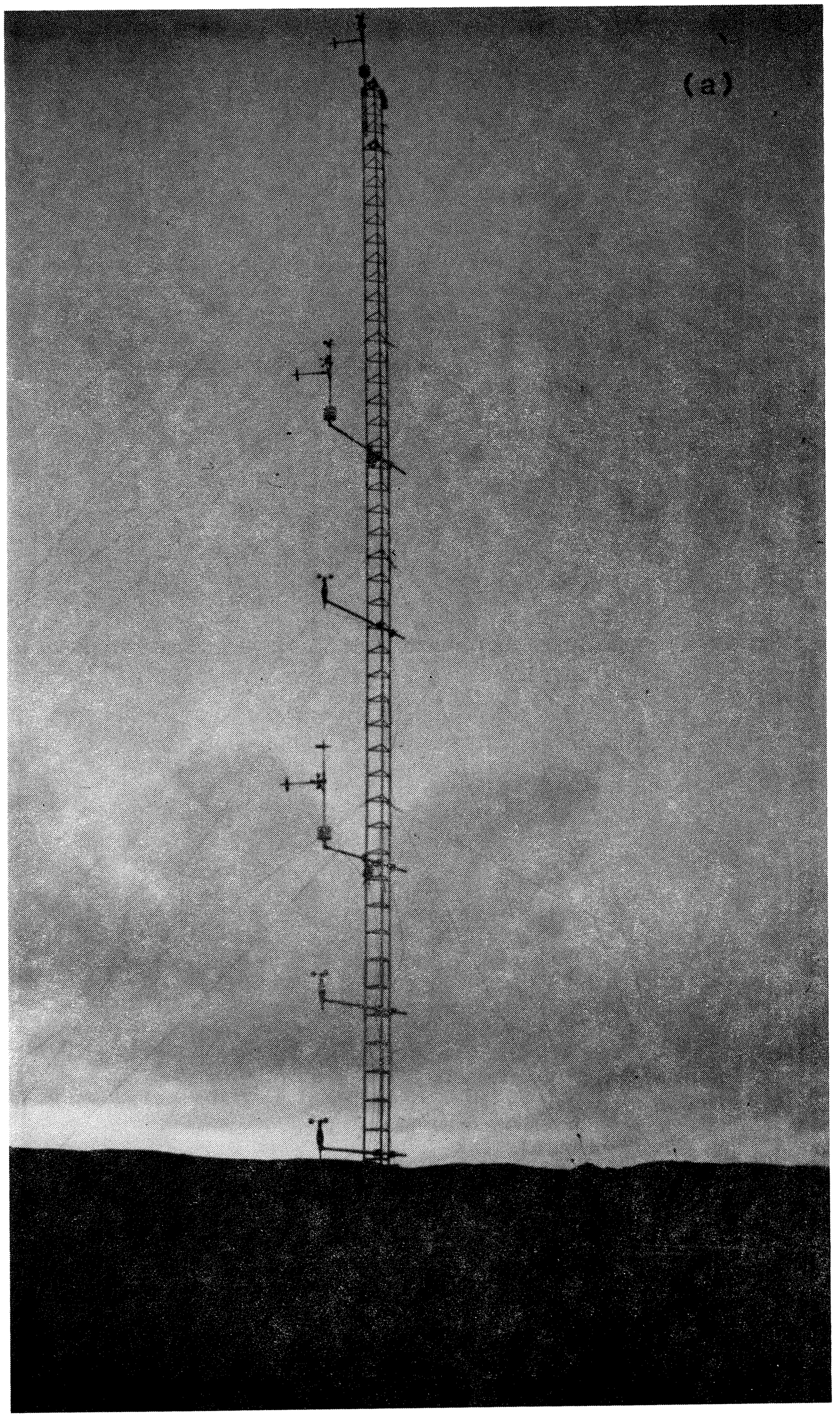


Fig. 2.9 HT tower instrumentation levels (50m & 10m towers).



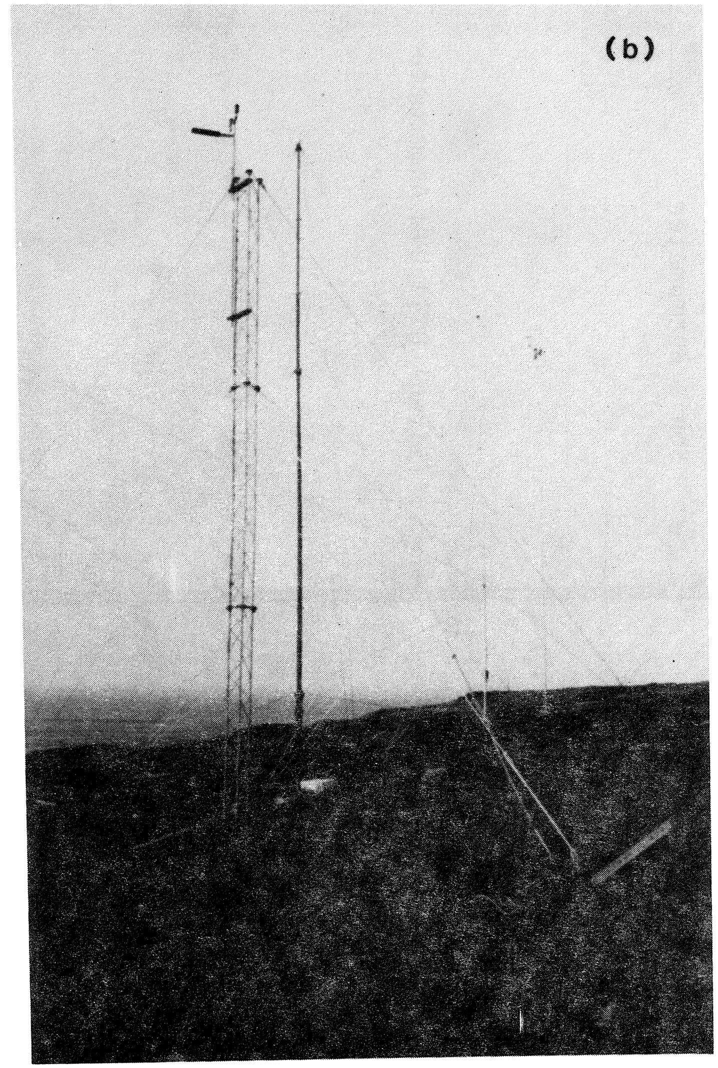


Fig. 2.10 Photographs of CP and CP' Towers
a) FRG 16m tower at CP'
b) 10m towers at CP (looking west northwest)

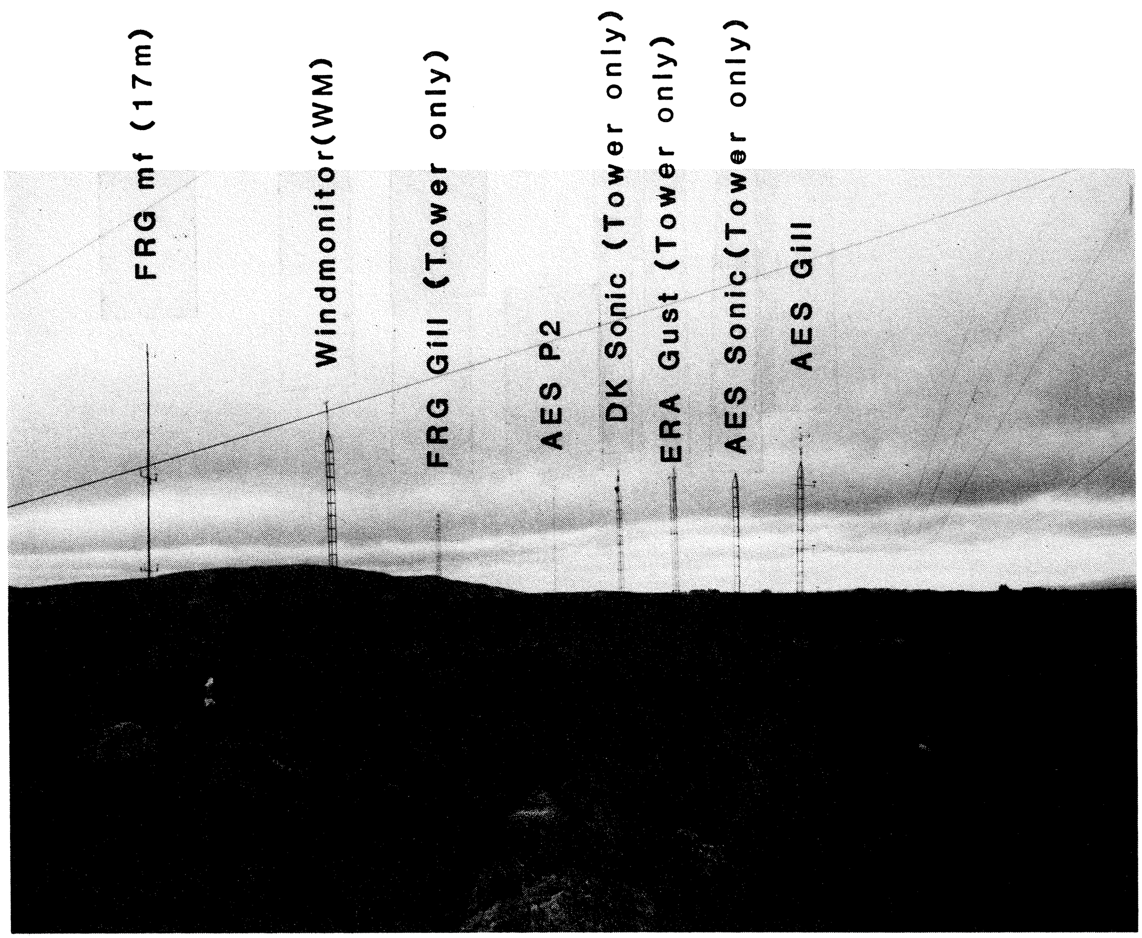


Fig. 2.11 Photograph of RS Towers (looking southwest)

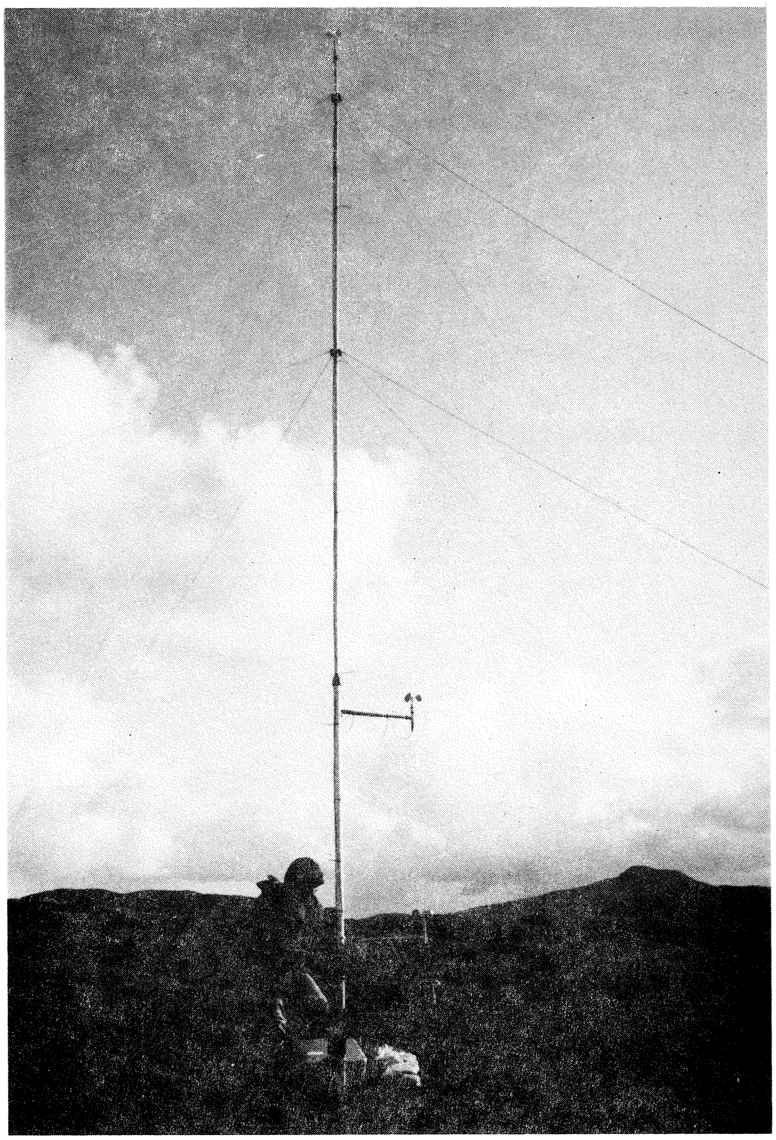


Fig. 3.1 An example of a Canadian mean flow measurement post. Cup anemometers are shown at the 10m, 3m, 1.5m and 0.5m levels. The black boxes strapped to the post are the data loggers. Power supply batteries are at the base of the post. The operator is polling the logger via the cable to the instrument case on the ground which contains an active interface (and battery power supply) linking the data logger to a portable microcomputer. The microcomputer checks the data as they are read from the logger and then stores them onto microcassette.

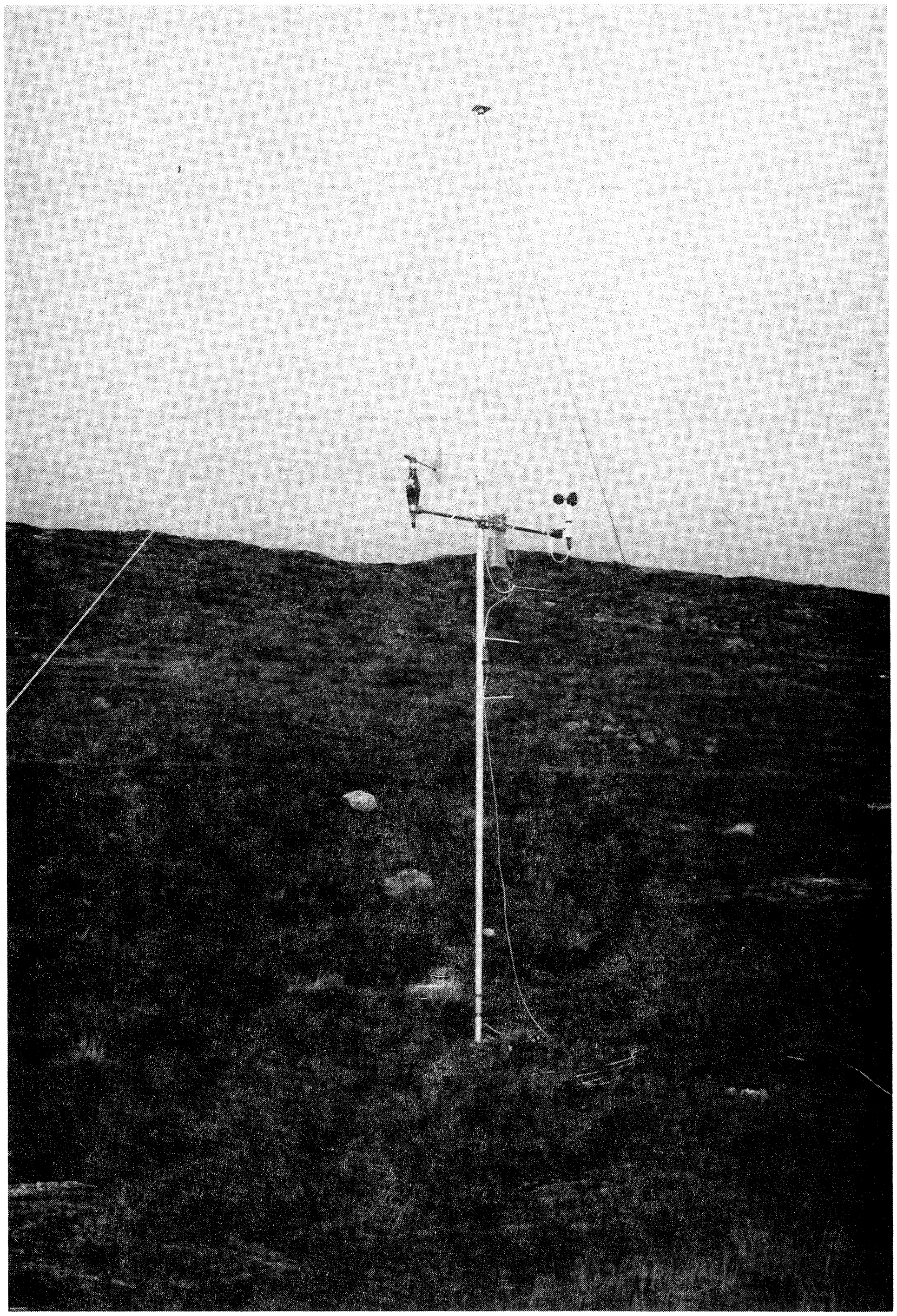
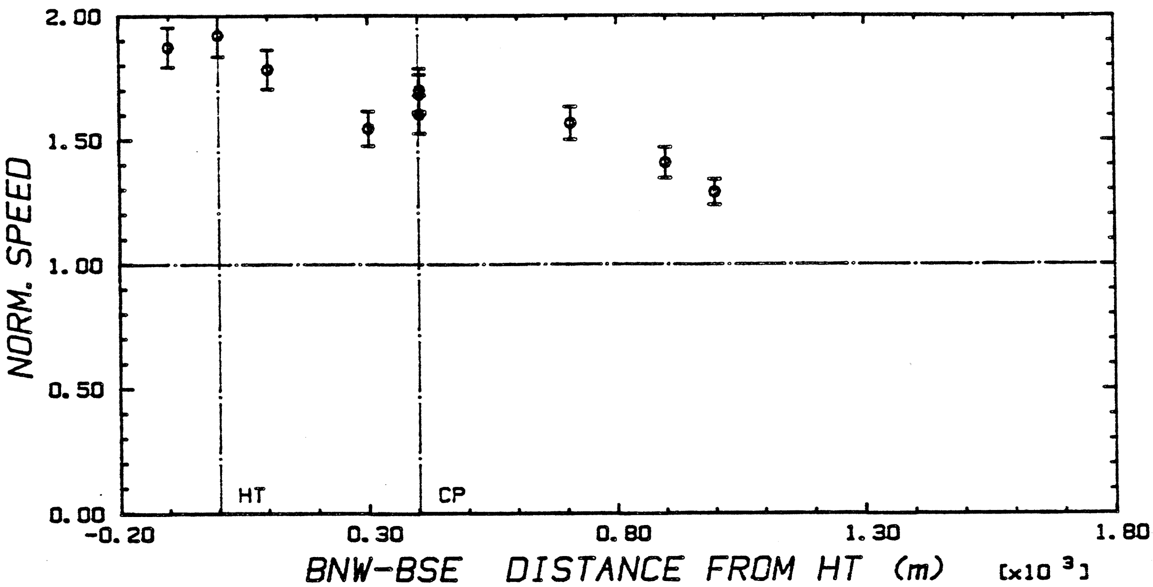
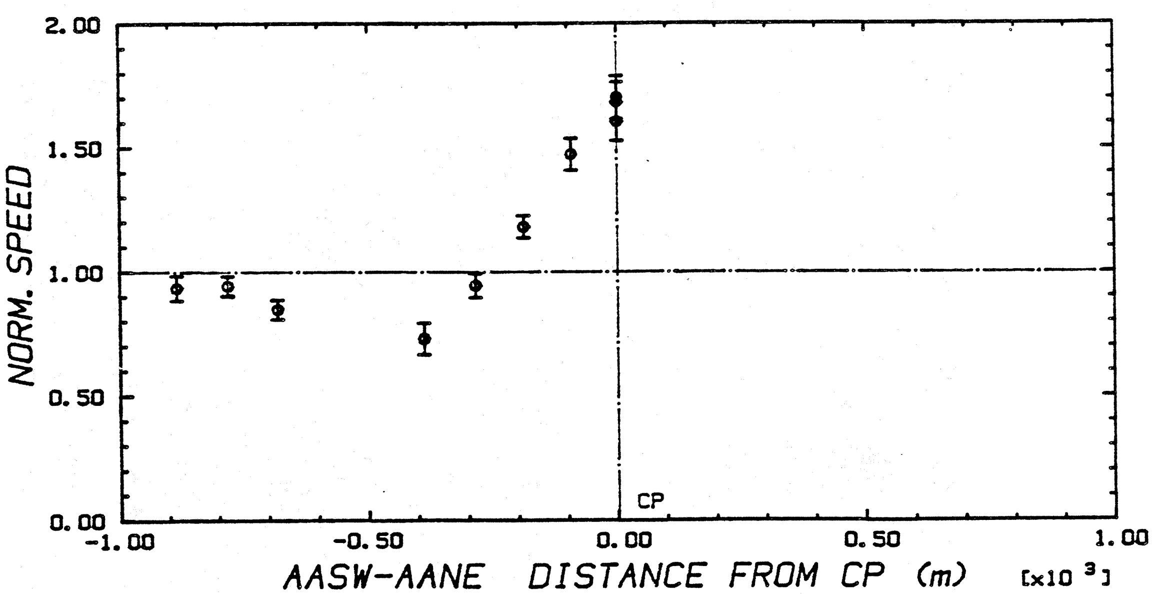


Fig. 3.2 FRG Mean Flow Measurement Post with anemometer and vane lowered to the 3m level

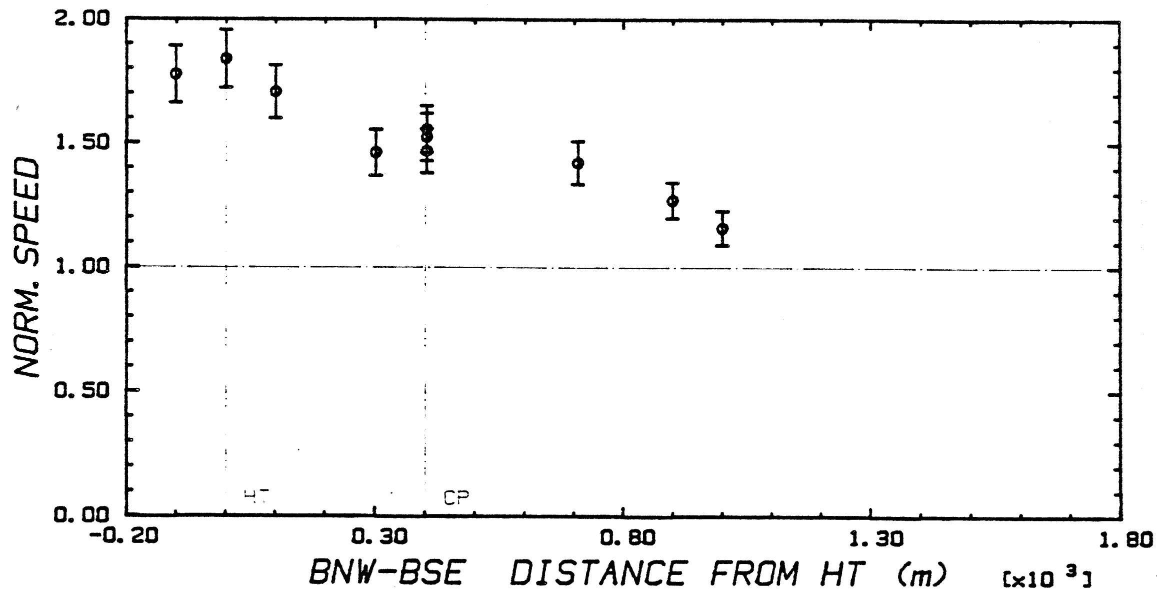


A3MF MF25 Sept. 25 (JD268) 16:00-21:30 5.0m/s 210deg 10.m

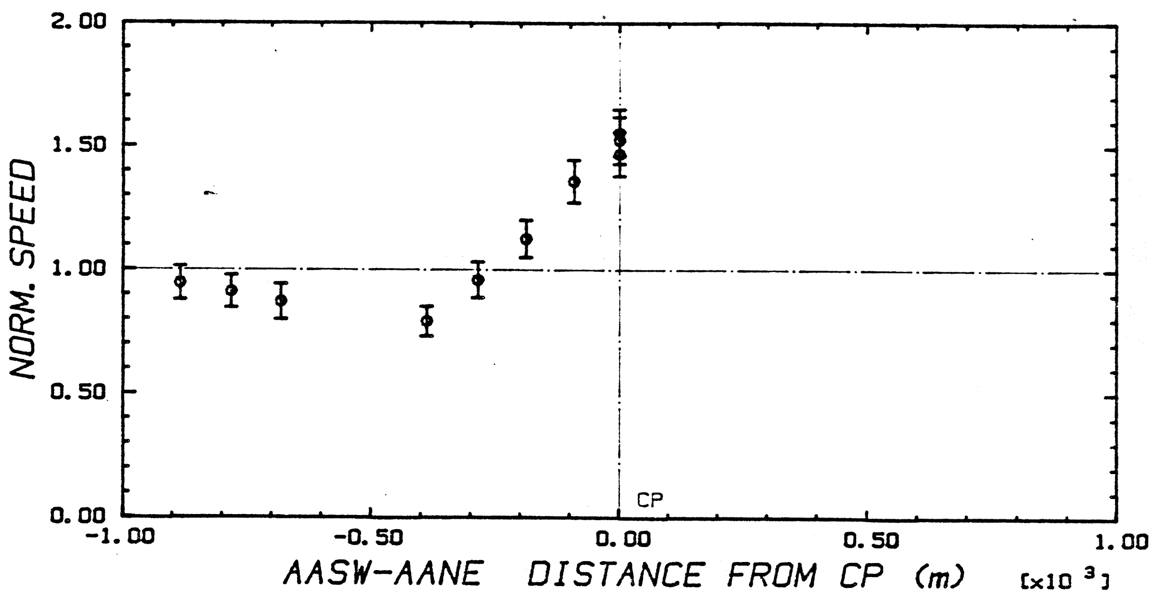


A3MF MF25 Sept. 25 (JD268) 16:00-21:30 5.0m/s 210deg 10.m

Fig. 3.3 Normalized wind speeds at 10m during MF runs.

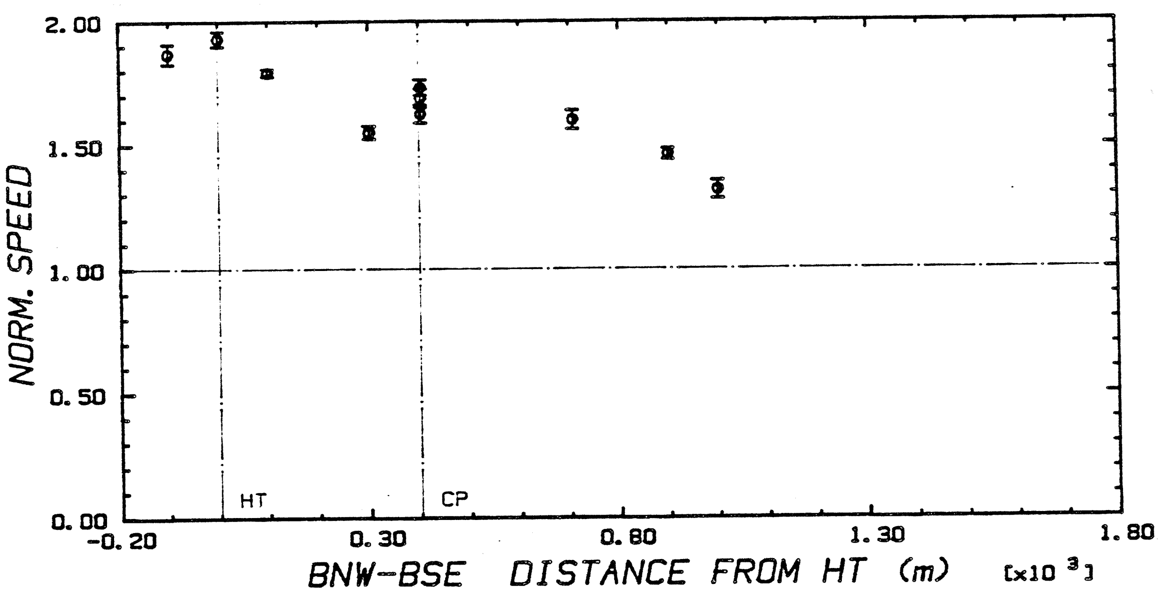


A3MF MF26-A Sept. 26 (JD269) 00:00-05:00 6.0m/s 180deg 10.m

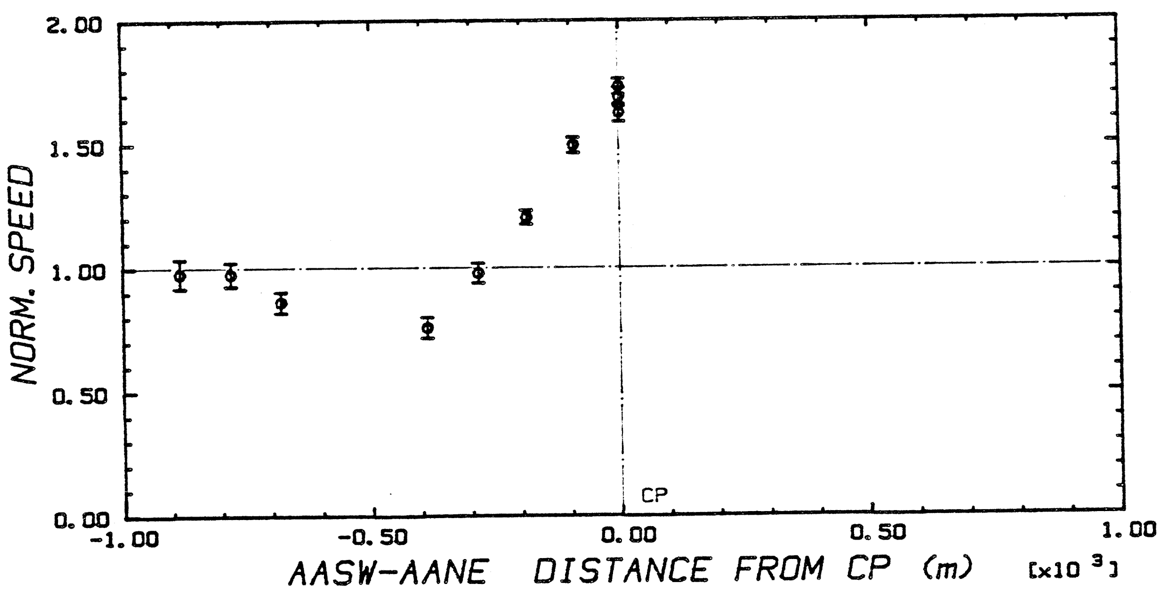


A3MF MF26-A Sept. 26 (JD269) 00:00-05:00 6.0m/s 180deg 10.m

Fig. 3.3 (cont.)

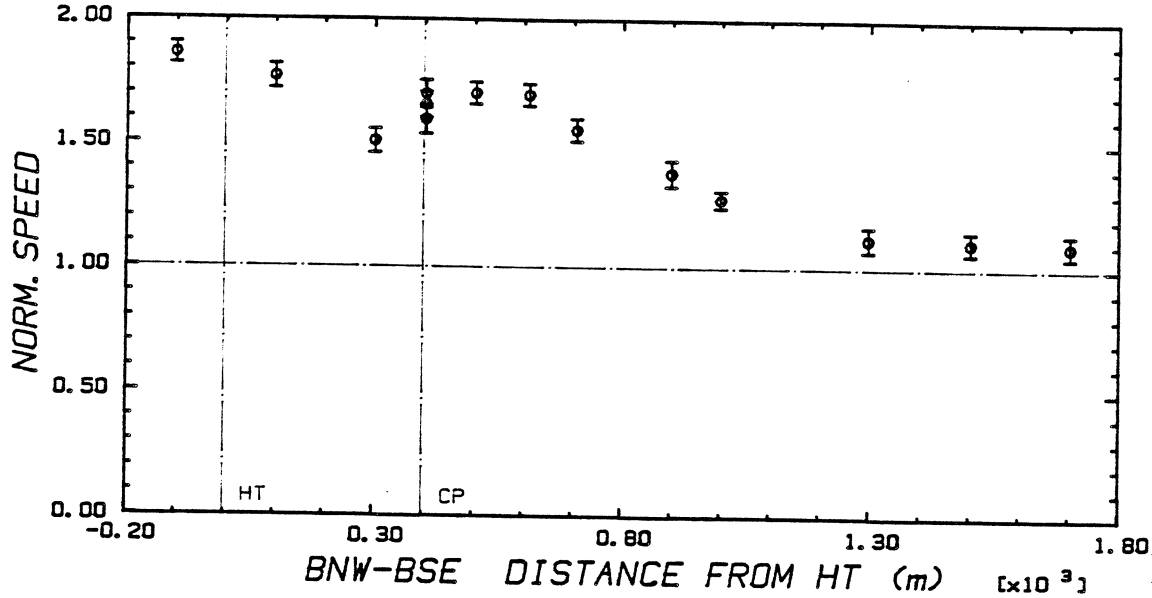


A3MF MF26-8 Sept. 26 (JD269) 09:00-10:00 8.0m/s 210deg 10. m

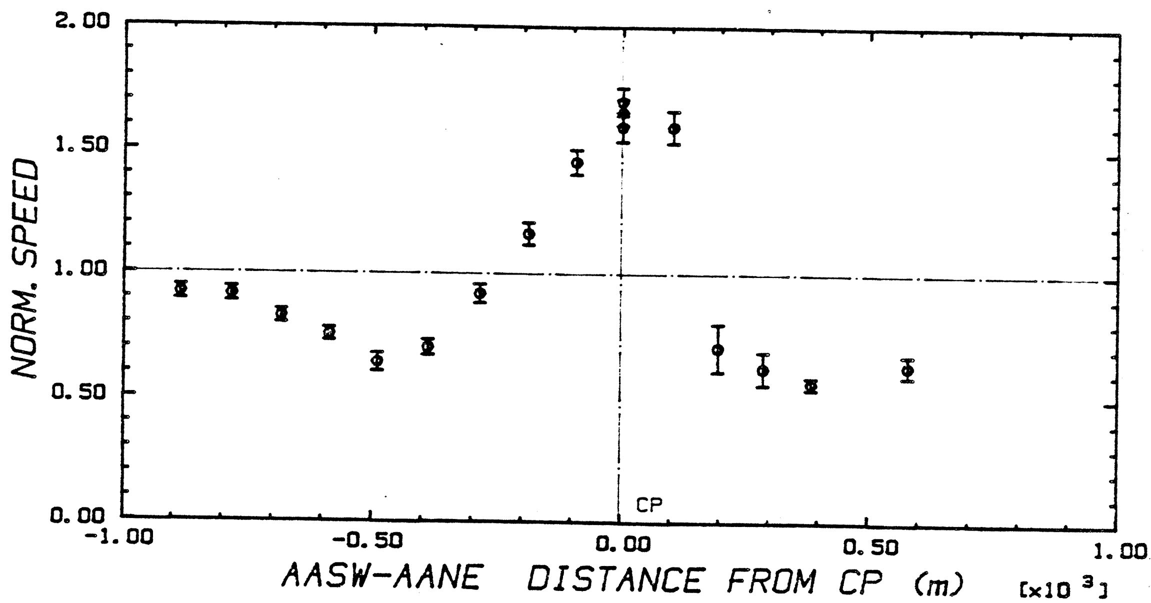


A3MF MF26-8 Sept. 26 (JD269) 09:00-10:00 8.0m/s 210deg 10. m

Fig. 3.3 (cont.)

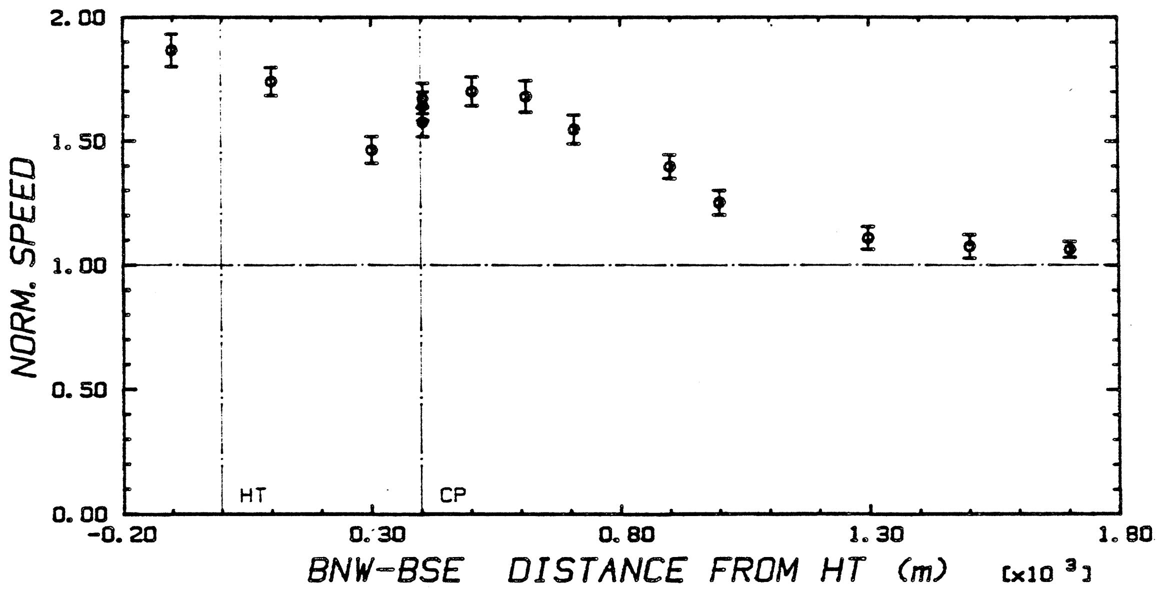


A3MF MF26-C Sept. 26 (JD269) 19:00-21:00 7.8m/s 220deg 10. m

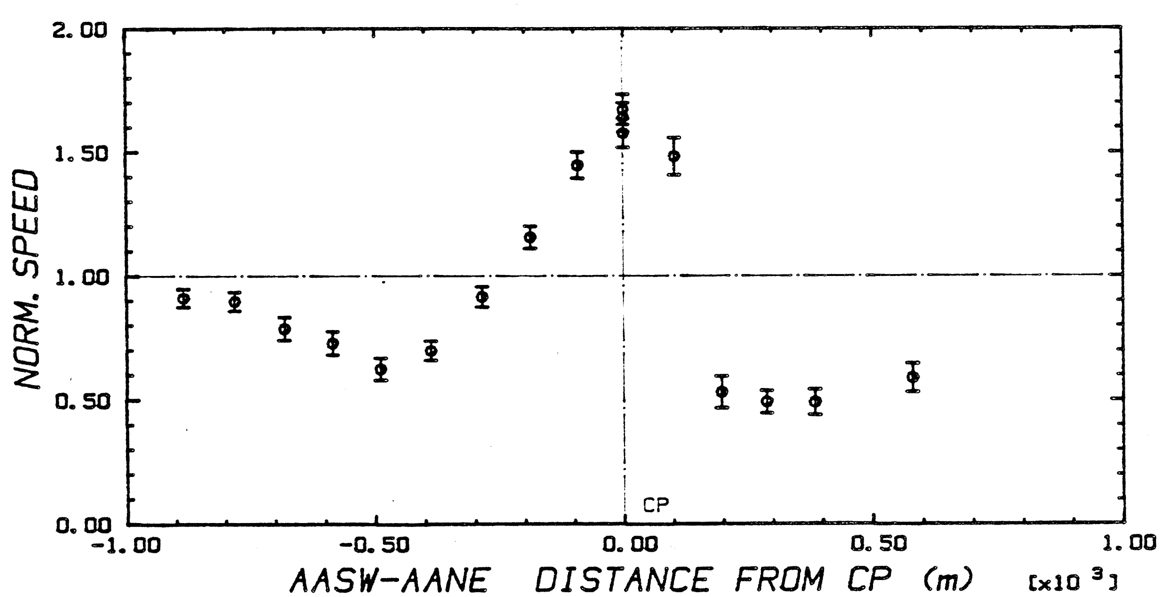


A3MF MF26-C Sept. 26 (JD269) 19:00-21:00 7.8m/s 220deg 10. m

Fig. 3.3 (cont.)

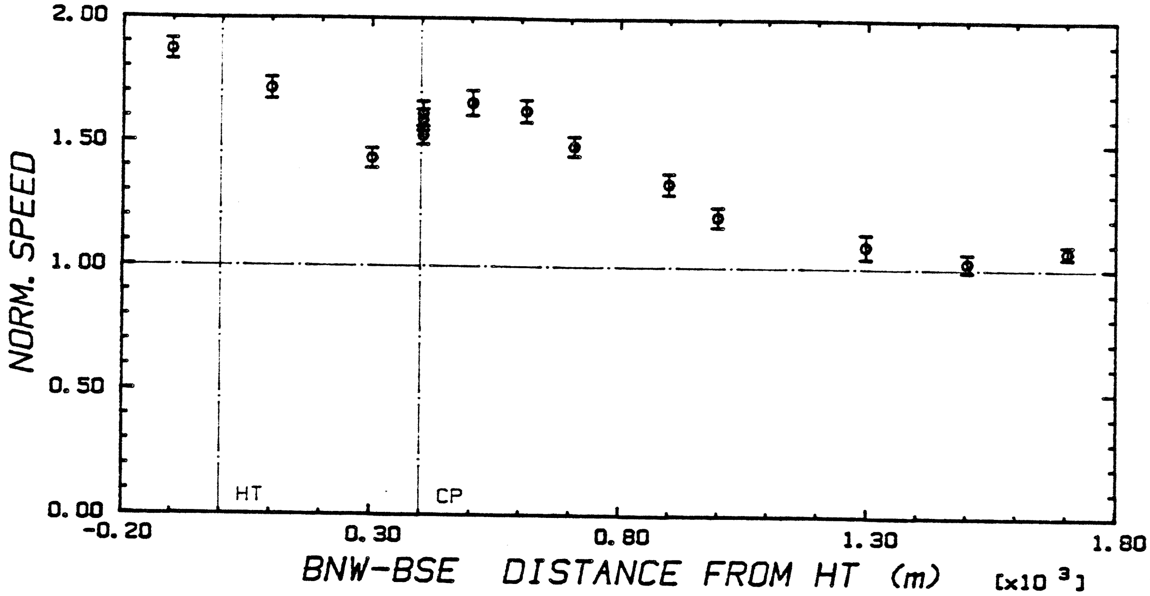


A3MF MF26-D Sept. 26 (JD269) 21:00-02:00 7.1m/s 225deg 10.m

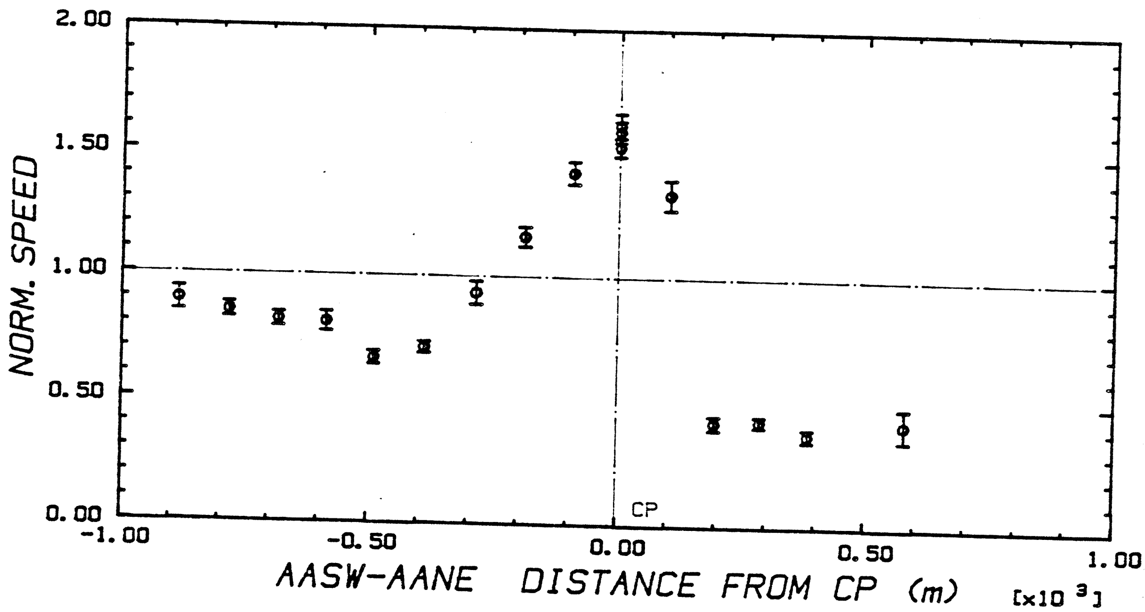


A3MF MF26-D Sept. 26 (JD269) 21:00-02:00 7.1m/s 225deg 10.m

Fig. 3.3 (cont.)

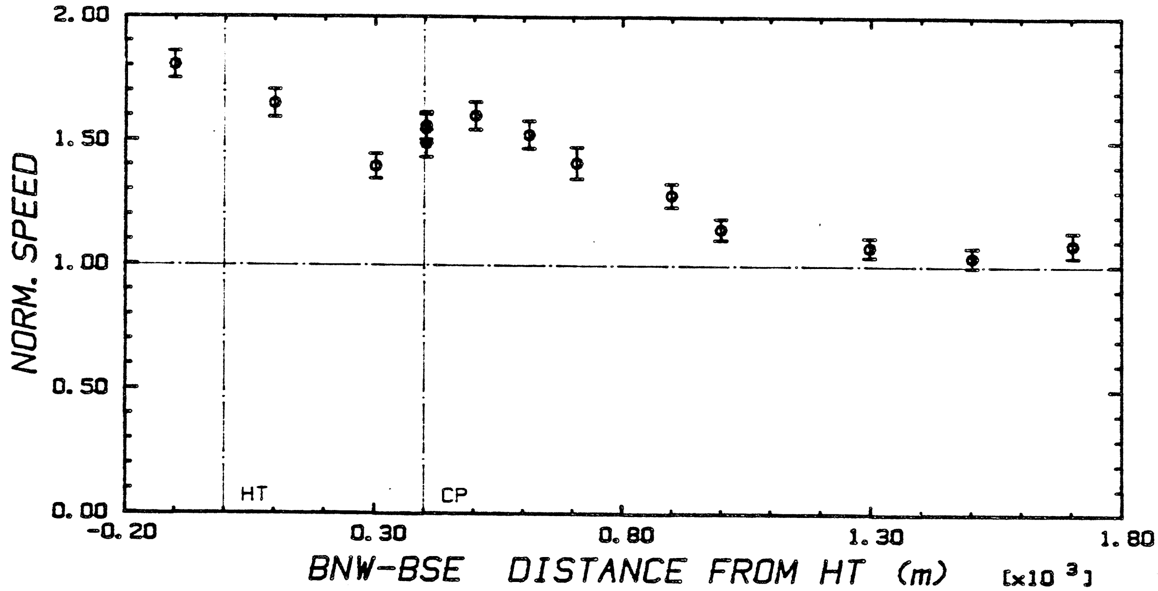


A3MF MF27-A Sept. 27 (JD270) 03:00-04:30 6.1m/s 235deg 10.m

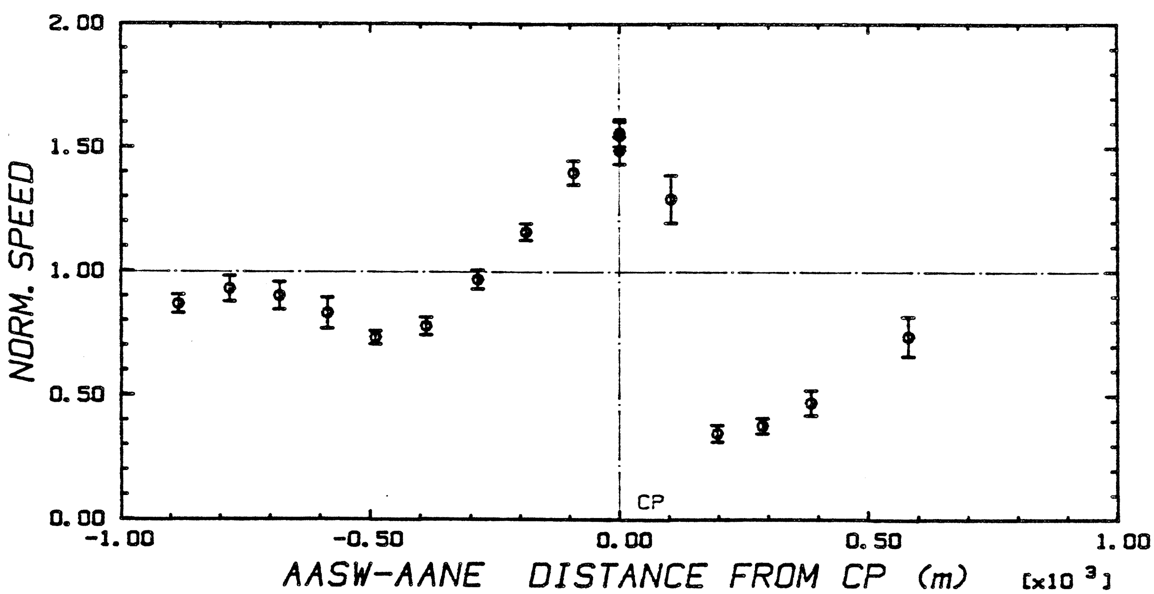


A3MF MF27-A Sept. 27 (JD270) 03:00-04:30 6.1m/s 235deg 10.m

Fig. 3.3 (cont.)

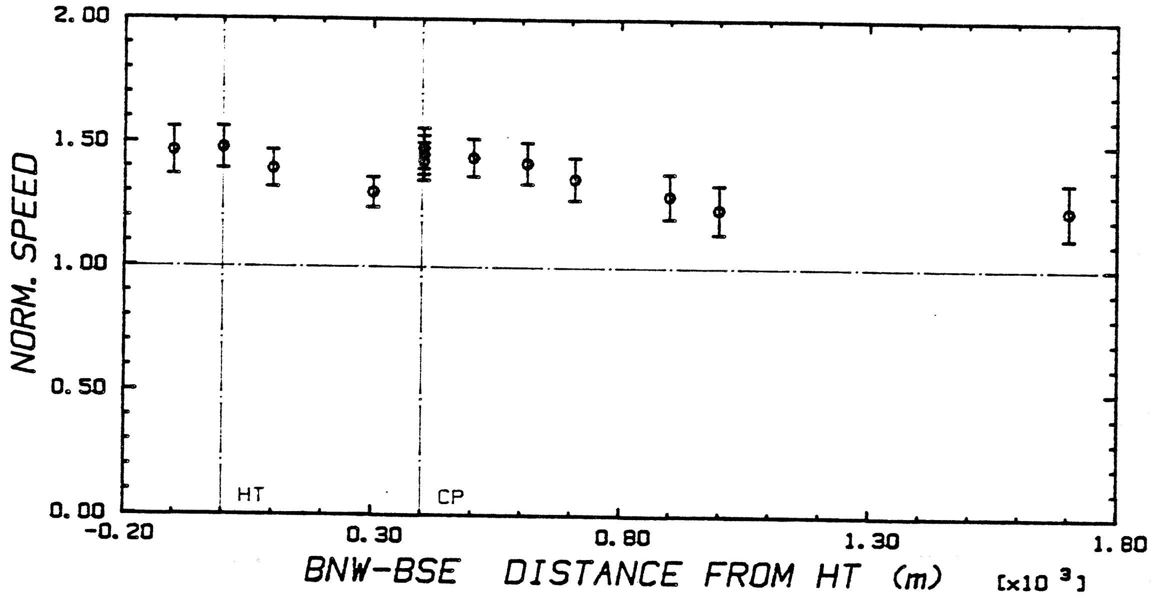


A3MF MF27-B Sept. 27 (JD270) 04:30-07:00 5.9m/s 245deg 10.m

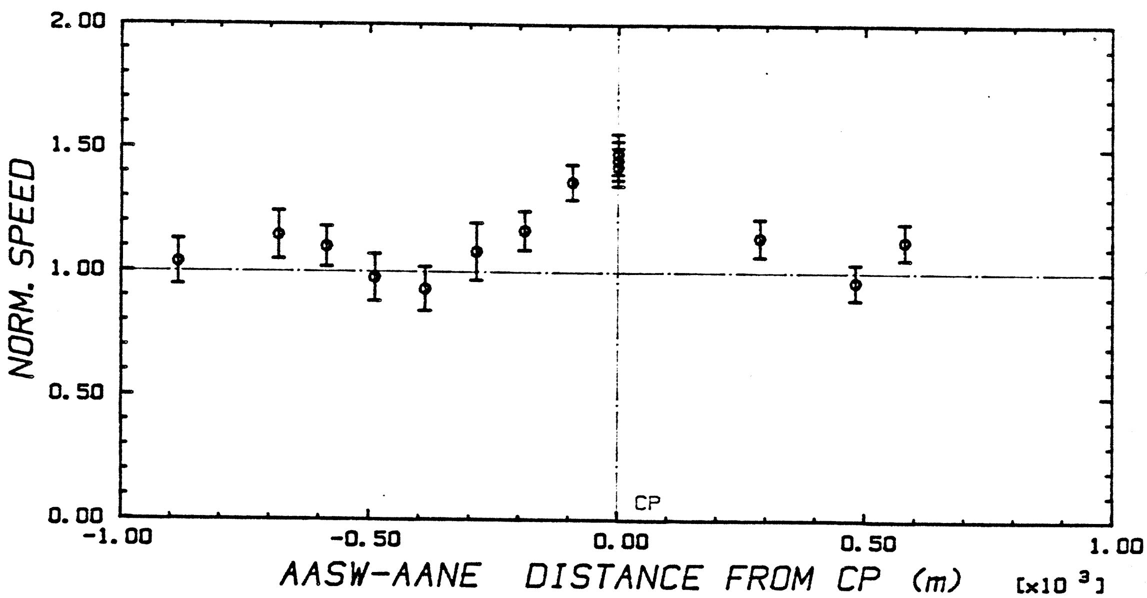


A3MF MF27-B Sept. 27 (JD270) 04:30-07:00 5.9m/s 245deg 10.m

Fig. 3.3 (cont.)

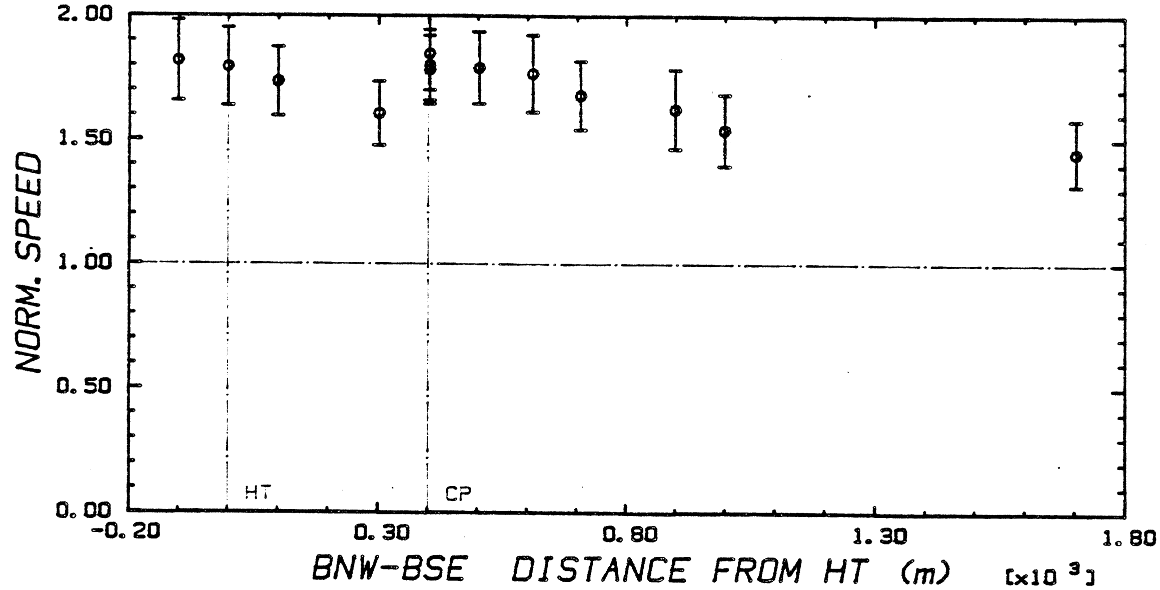


A3MF MF28-A Sept.28(JD271) 04:00-06:00 6.8m/s 090deg 10.m

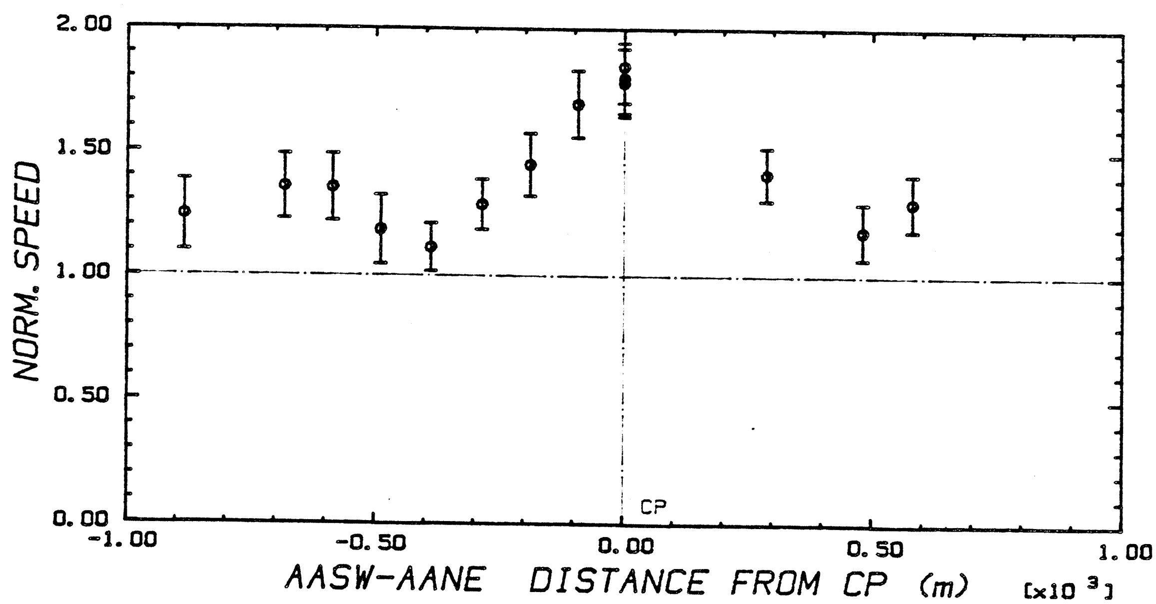


A3MF MF28-A Sept.28(JD271) 04:00-06:00 6.8m/s 090deg 10.m

Fig. 3.3 (cont.)

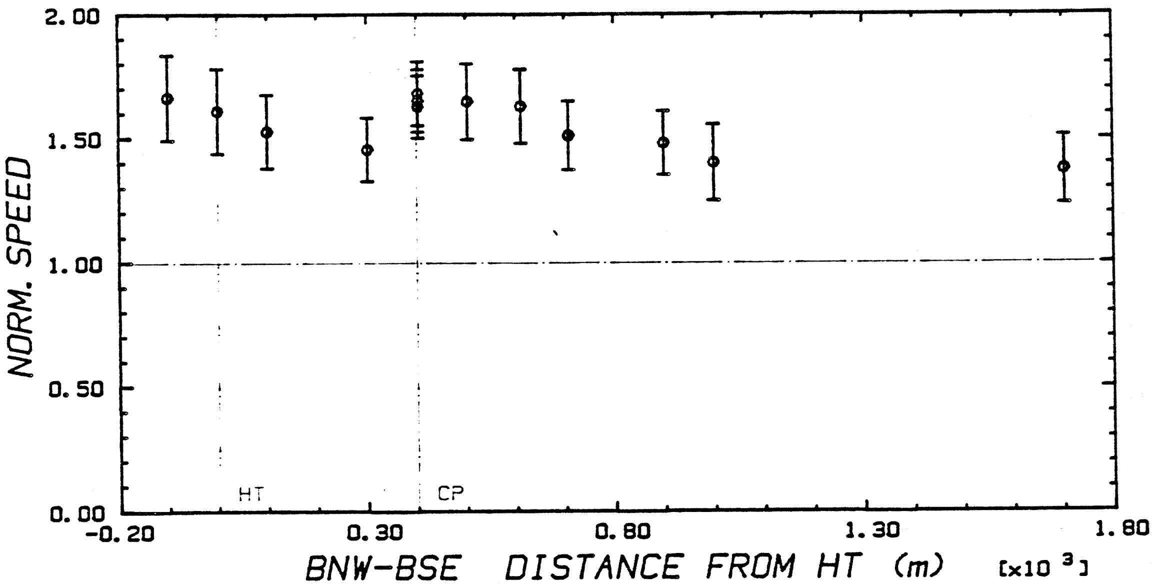


A3MF MF28-8 Sept. 28 (JD271) 06:00-08:00 6.5m/s 095deg 10.m

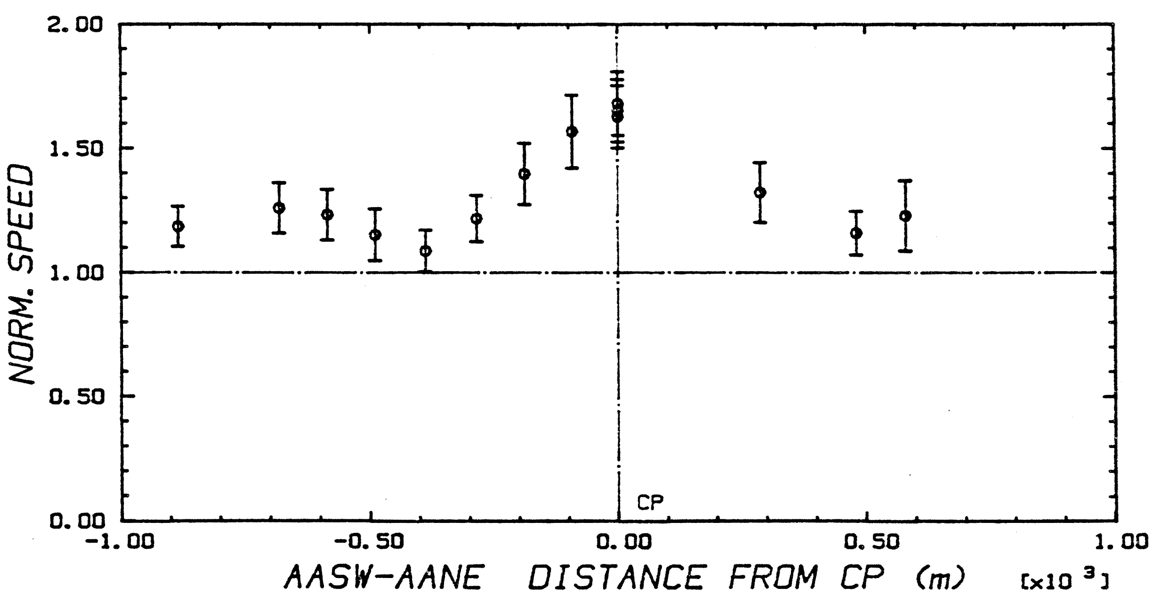


A3MF MF28-8 Sept. 28 (JD271) 06:00-08:00 6.5m/s 095deg 10.m

Fig. 3.3 (cont.)

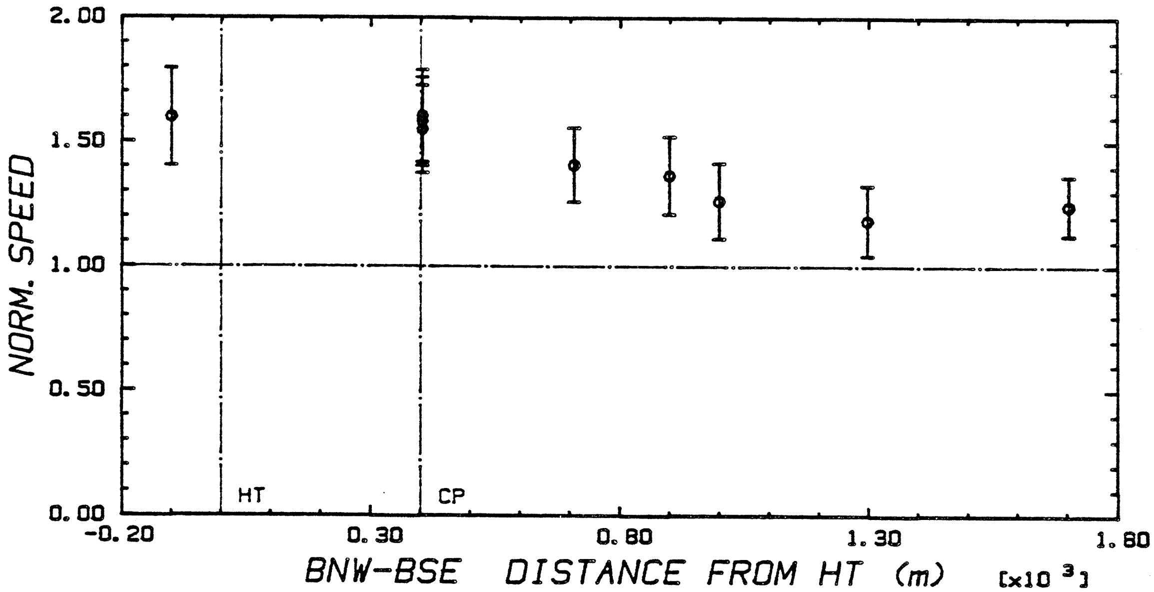


A3MF MF28-C Sept.28(JD271) 08:00-10:00 7.2m/s 100deg 10.m

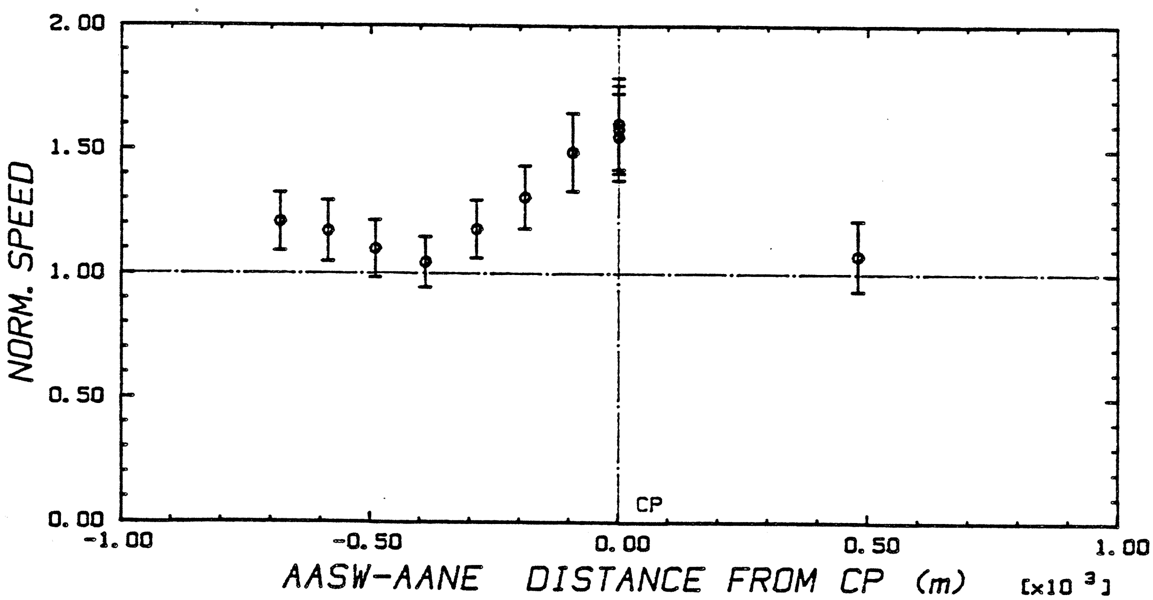


A3MF MF28-C Sept.28(JD271) 08:00-10:00 7.2m/s 100deg 10.m

Fig. 3.3 (cont.)

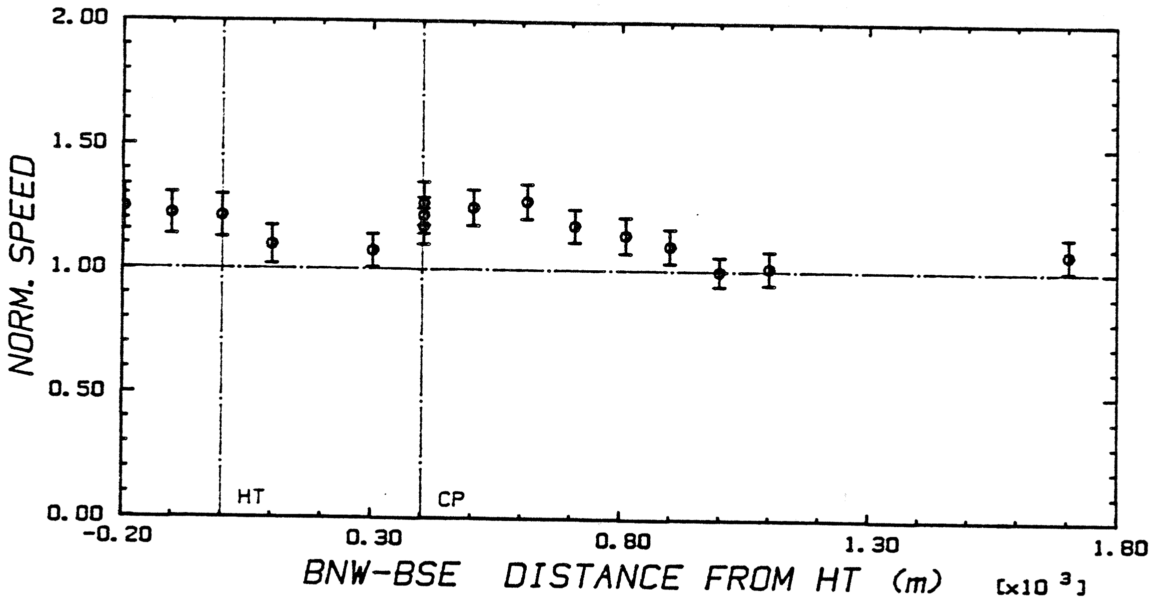


A3MF MF28-D Sept.28(JD271) 20:00-10:00 6.0m/s 105deg 10.m

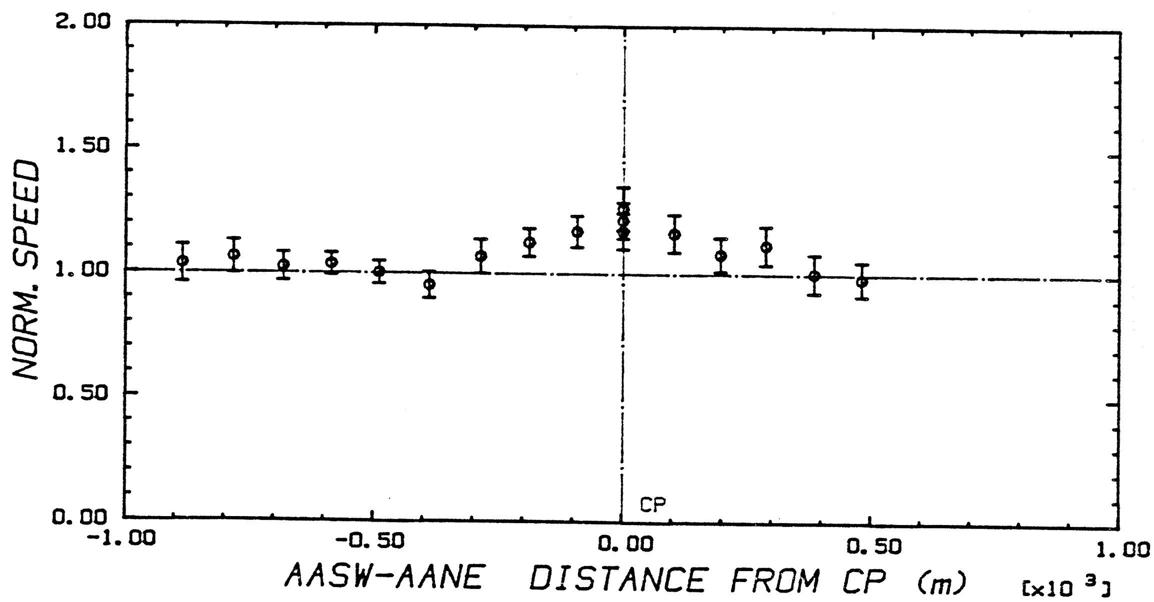


A3MF MF28-D Sept.28(JD271) 20:00-10:00 6.0m/s 105deg 10.m

Fig. 3.3 (cont.)

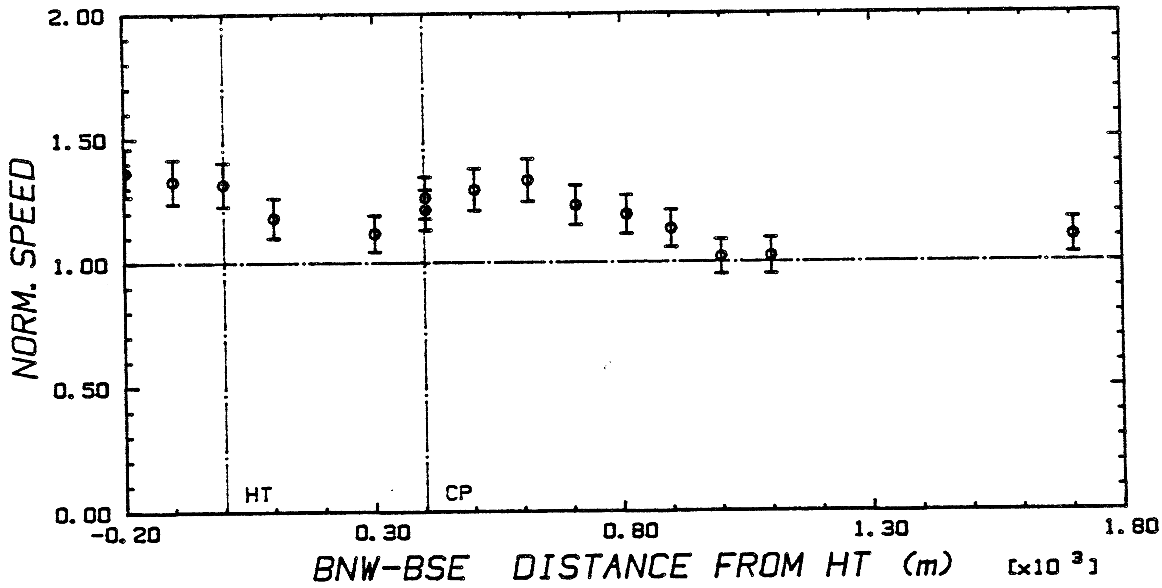


A3MF MF30-A Sept.30(JD273) 16:00-19:00 12.0m/s 130deg 10.m

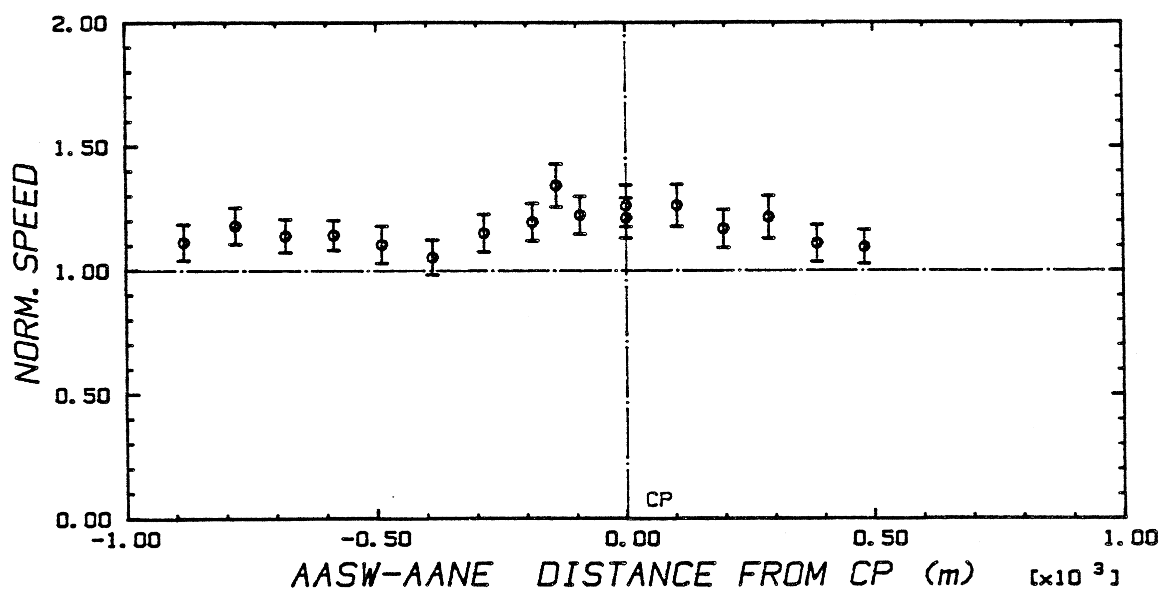


A3MF MF30-A Sept.30(JD273) 16:00-19:00 12.0m/s 130deg 10.m

Fig. 3.3 (cont.)

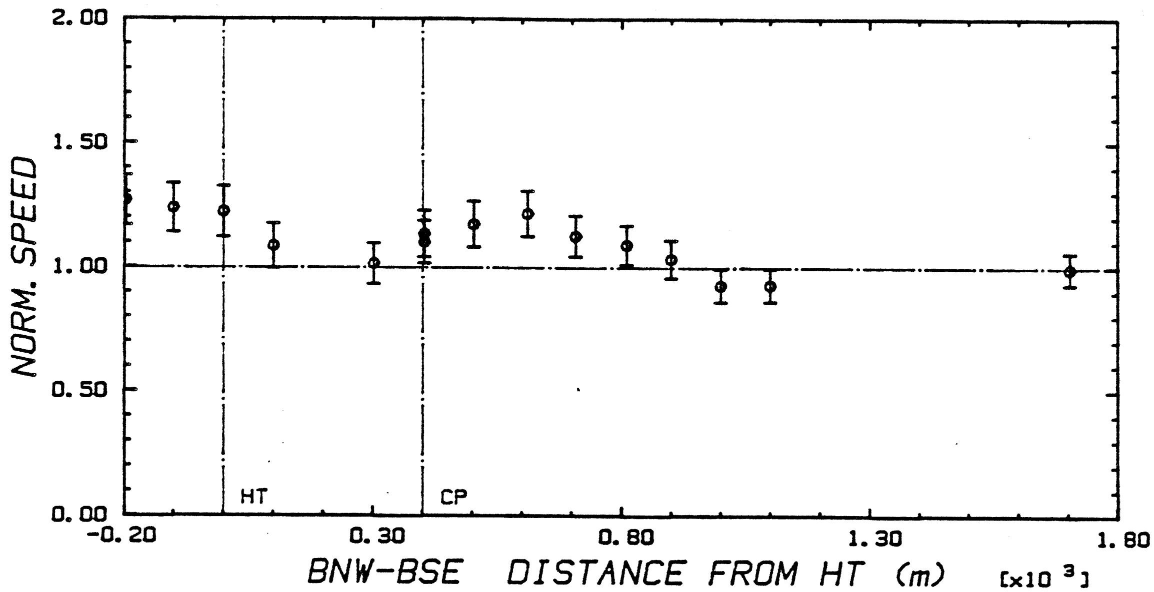


A3MF MF30-B Sept. 30 (JD273) 19:00-02:00 12.5m/s 135deg 10.m

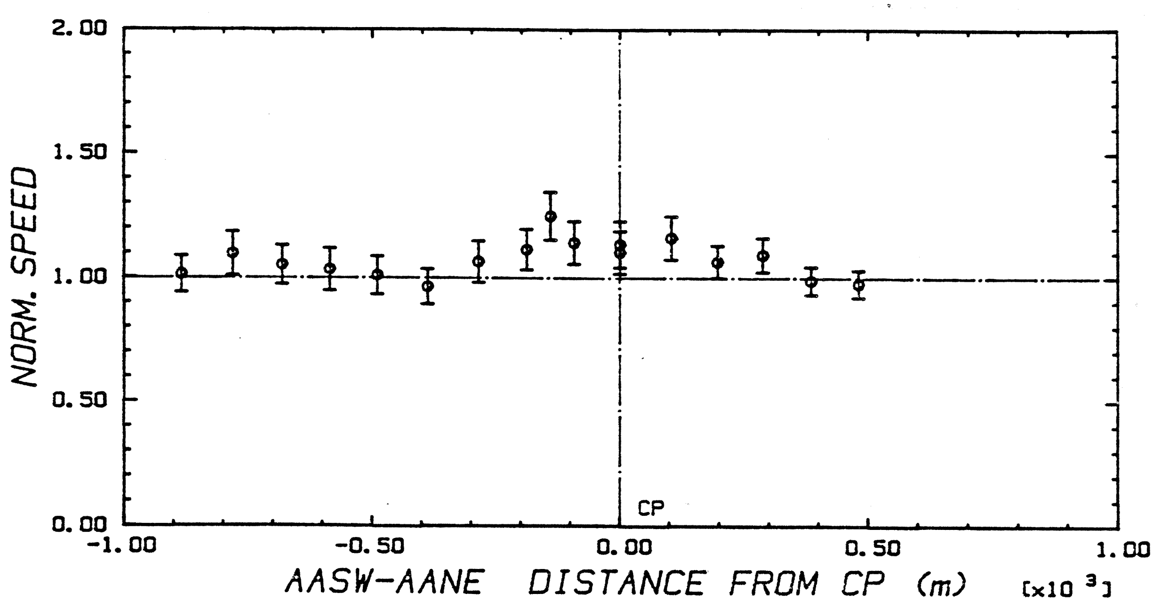


A3MF MF30-B Sept. 30 (JD273) 19:00-02:00 12.5m/s 135deg 10.m

Fig. 3.3 (cont.)

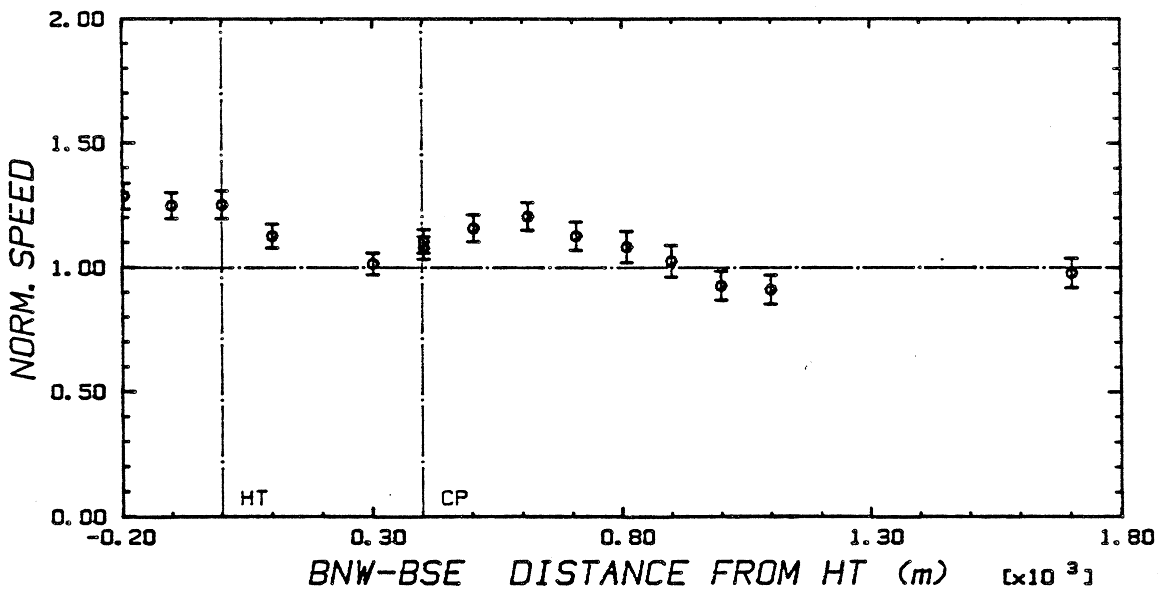


A3MF MF01-A Oct.1(JD274) 02:00-05:00 13.0m/s 140deg 10.m

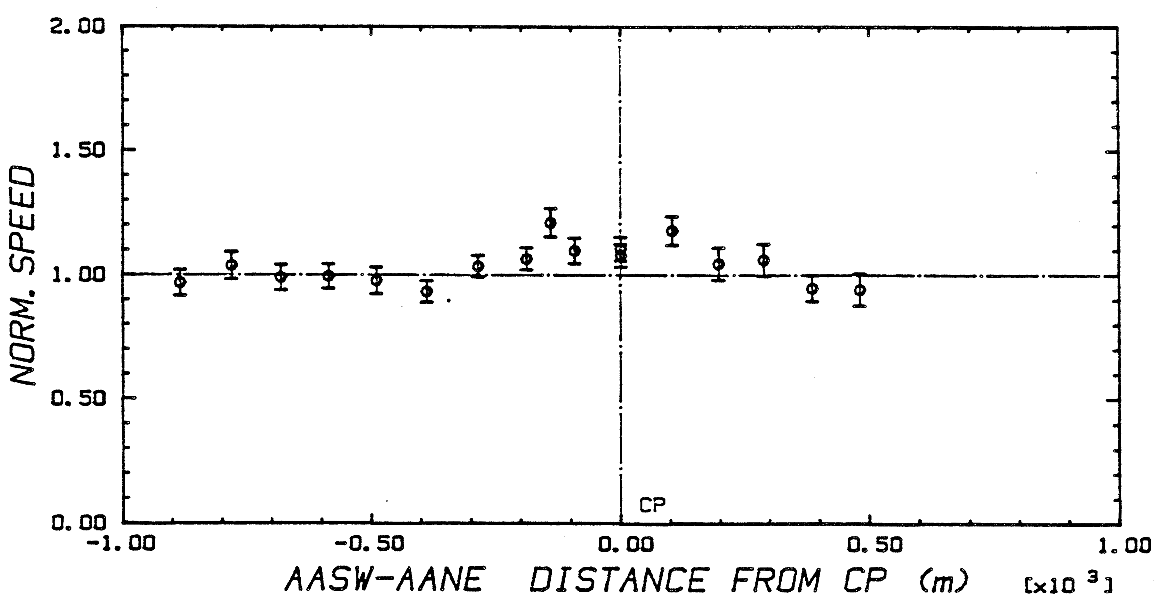


A3MF MF01-A Oct.1(JD274) 02:00-05:00 13.0m/s 140deg 10.m

Fig. 3.3 (cont.)

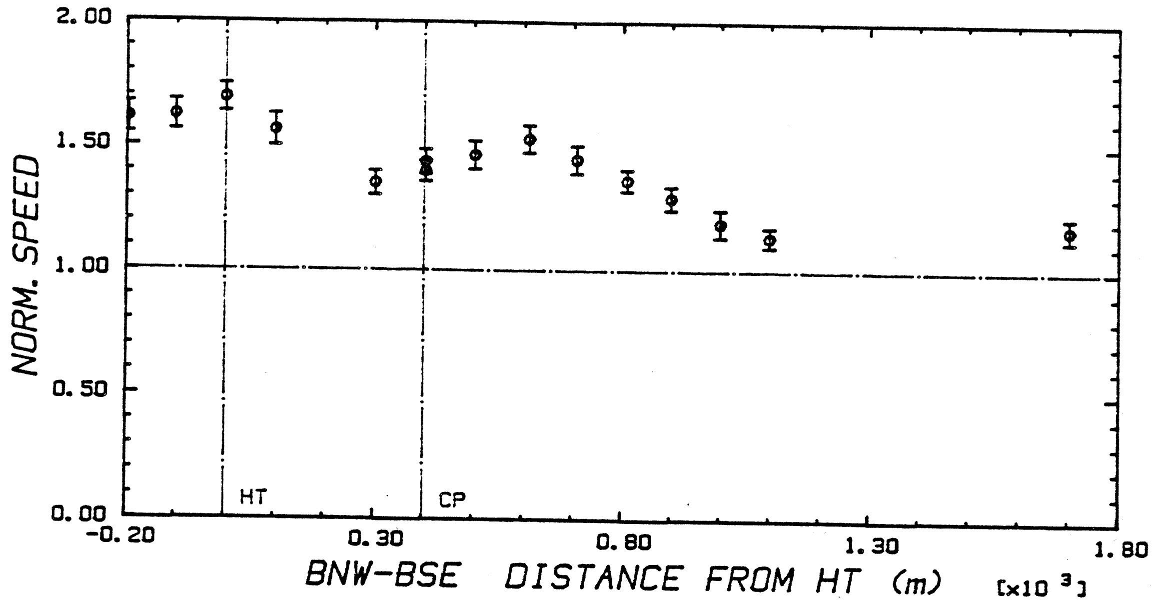


A3MF MF01-B Oct. 1 (JD274) 05:00-09:00 14.8m/s 145deg 10.m

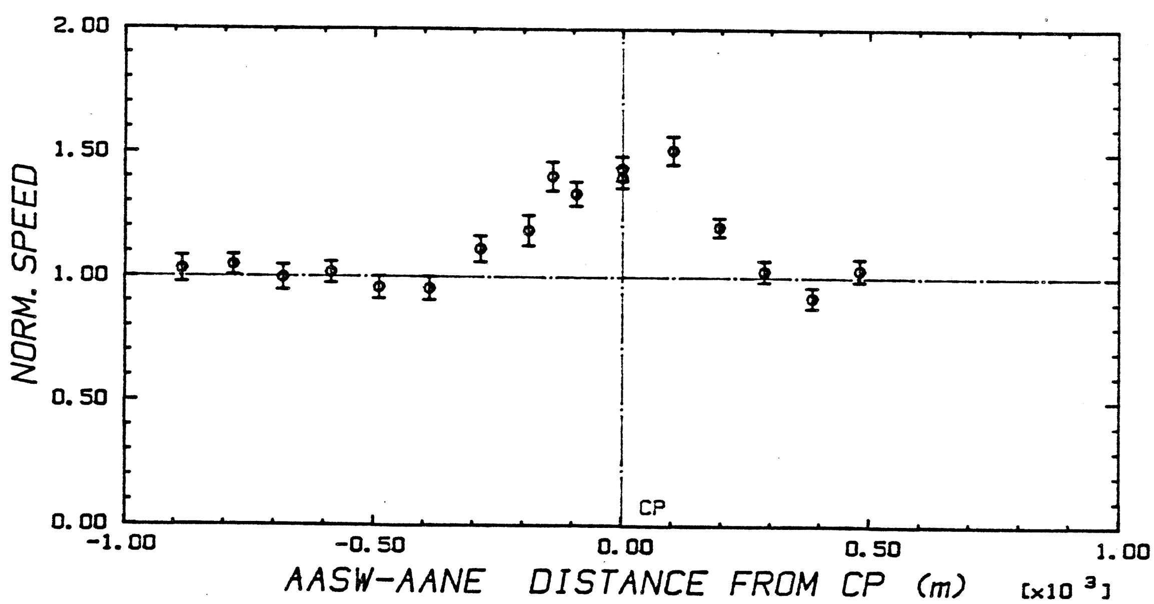


A3MF MF01-B Oct. 1 (JD274) 05:00-09:00 14.8m/s 145deg 10.m

Fig. 3.3 (cont.)

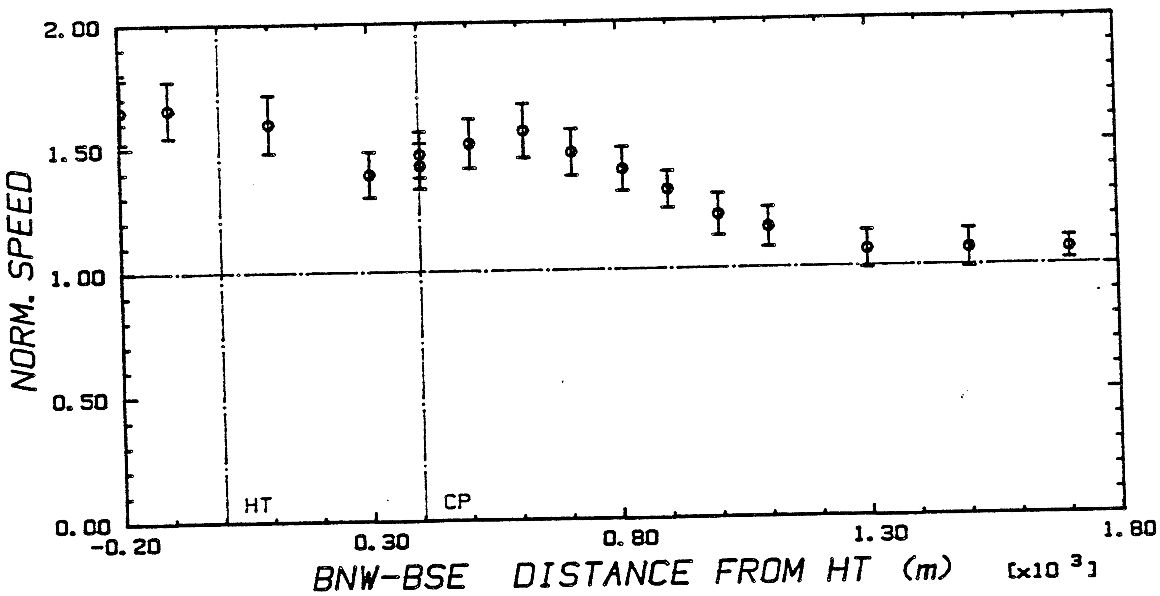


A3MF MF01-C Oct.1 (JD274) 10:30-12:00 10.2m/s 170deg 10.m

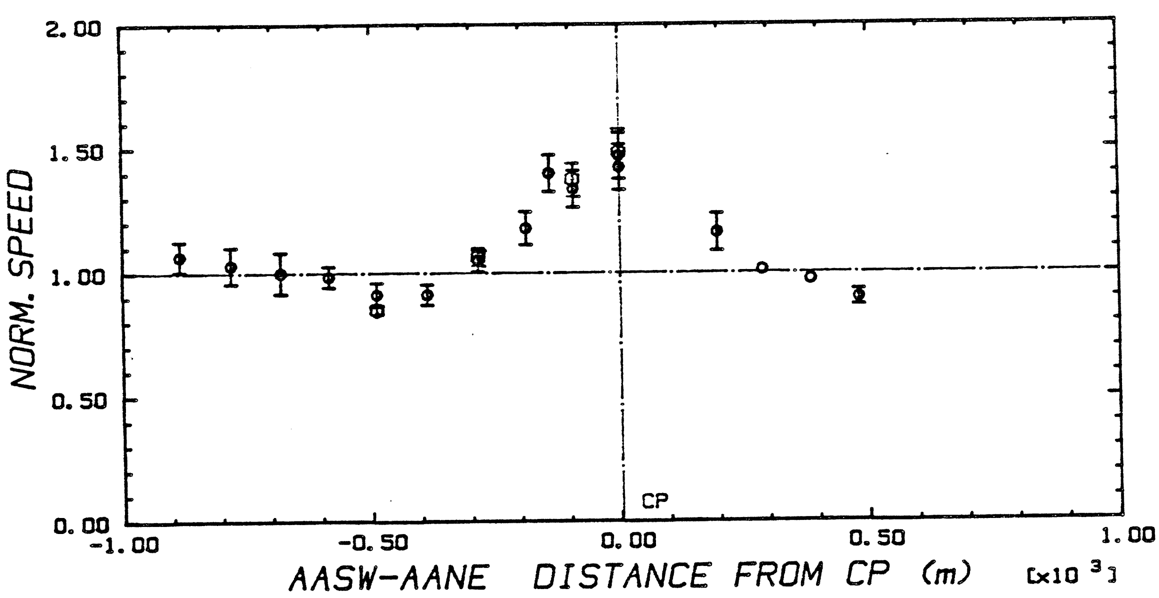


A3MF MF01-C Oct.1 (JD274) 10:30-12:00 10.2m/s 170deg 10.m

Fig. 3.3 (cont.)

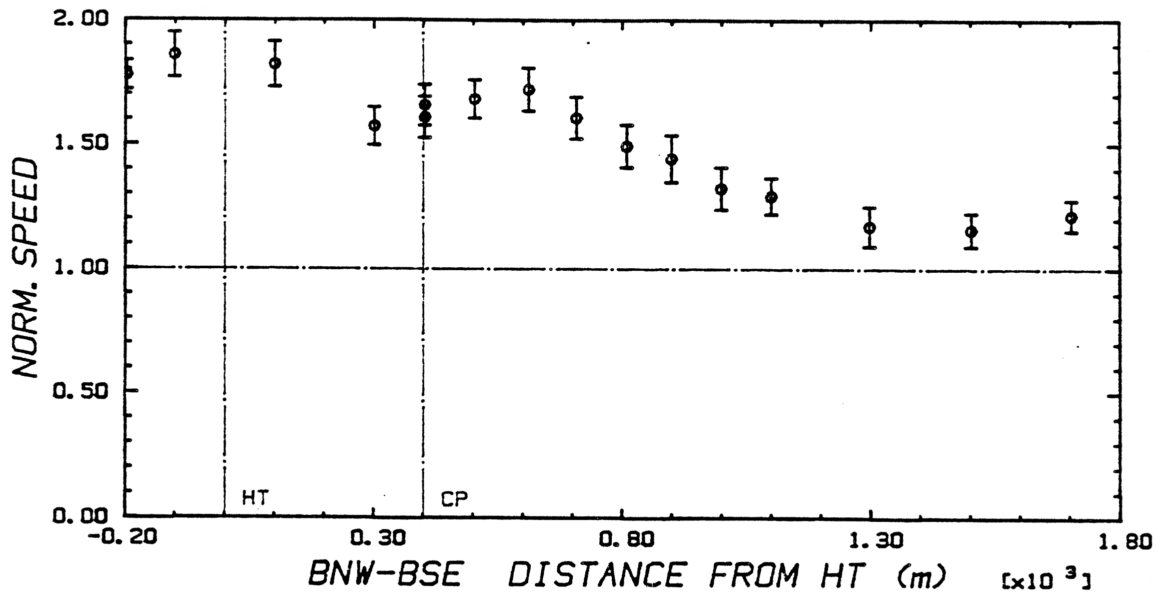


A3MF MF01-D Oct. 1 (JD274) 14:00-16:00 9.0m/s 180deg 10.m

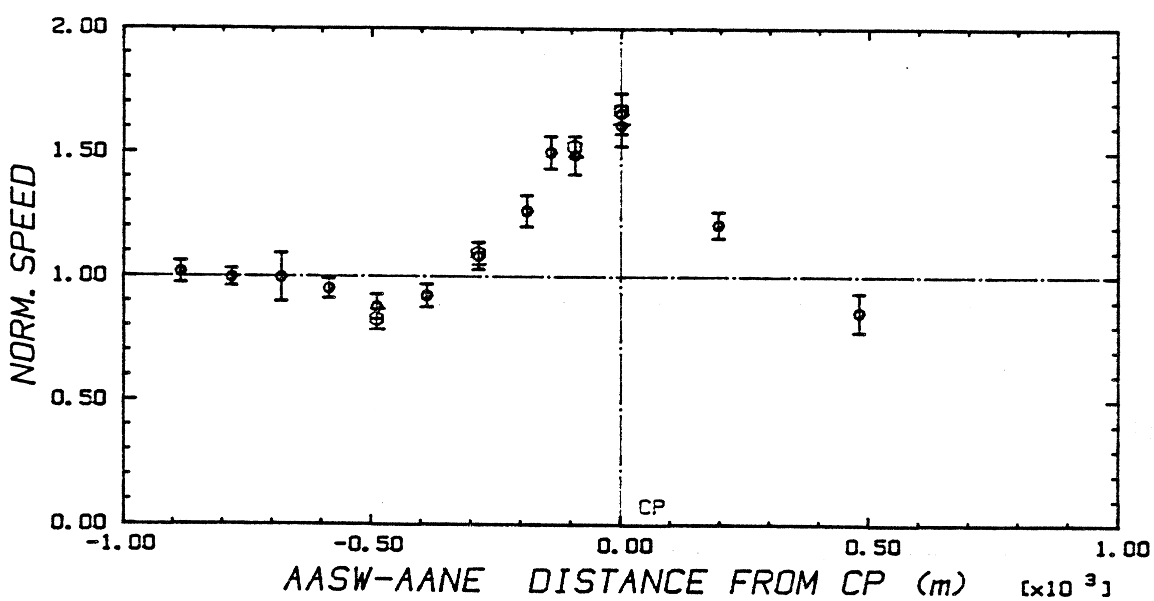


A3MF MF01-D Oct. 1 (JD274) 14:00-16:00 9.0m/s 180deg 10.m

Fig. 3.3 (cont.)

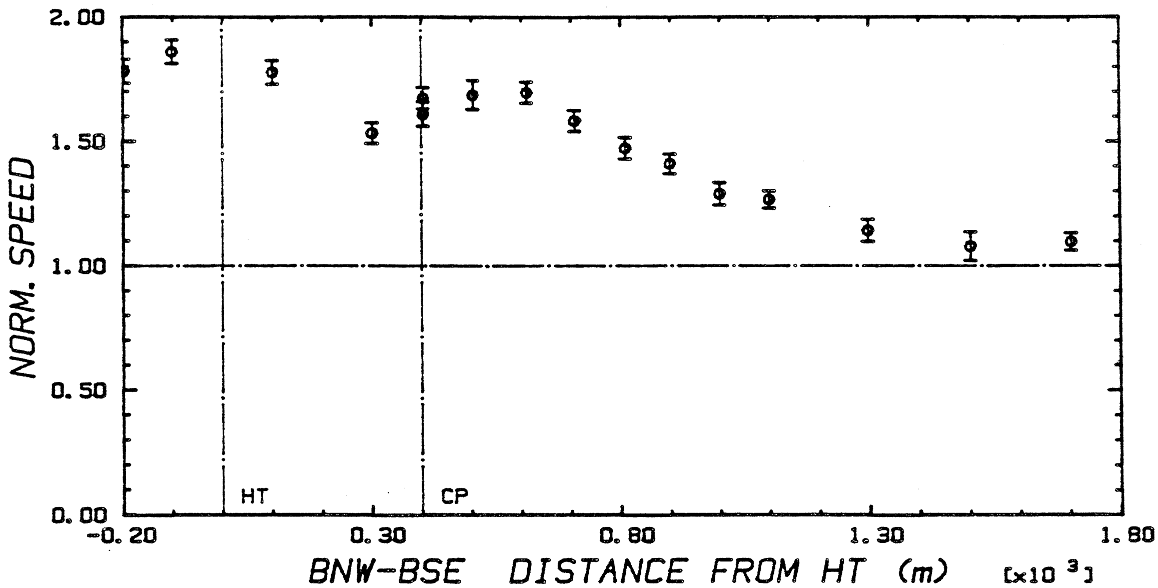


A3MF MF01-E Oct.1(JD274) 17:00-18:30 7.5m/s 185deg 10.m

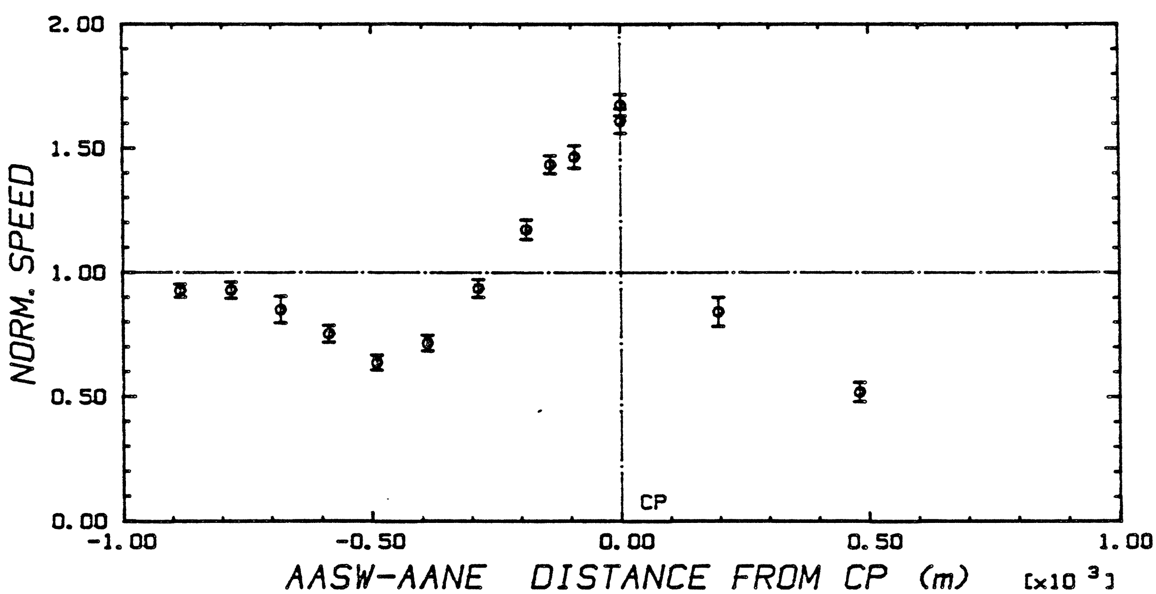


A3MF MF01-E Oct.1(JD274) 17:00-18:30 7.5m/s 185deg 10.m

Fig. 3.3 (cont.)

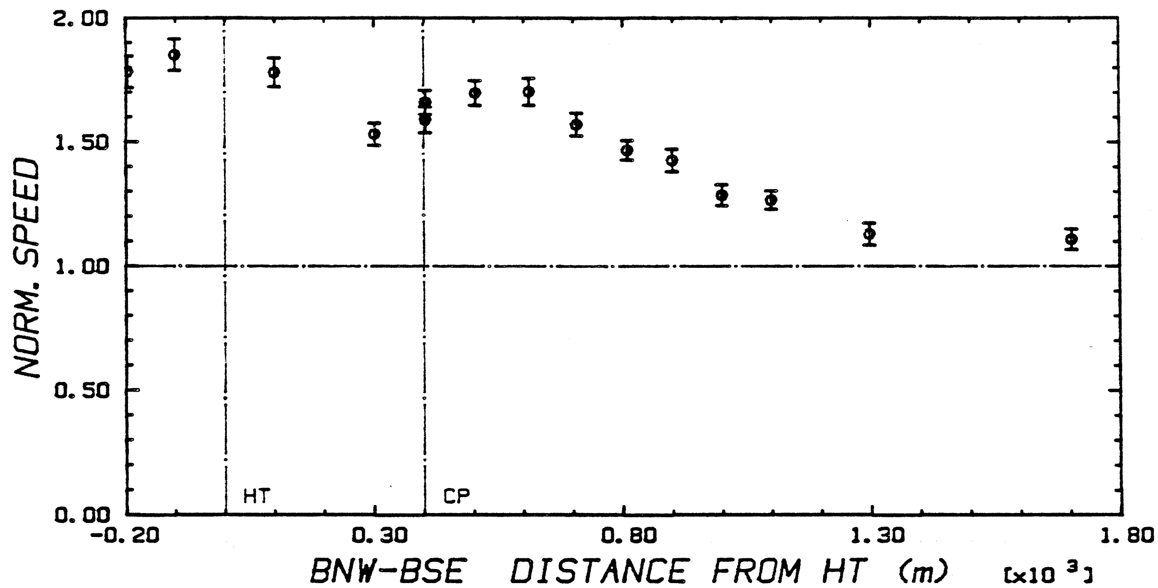


A3MF MF01-F Oct.1(JD274) 21:00-24:00 8.0m/s 210deg 10.m

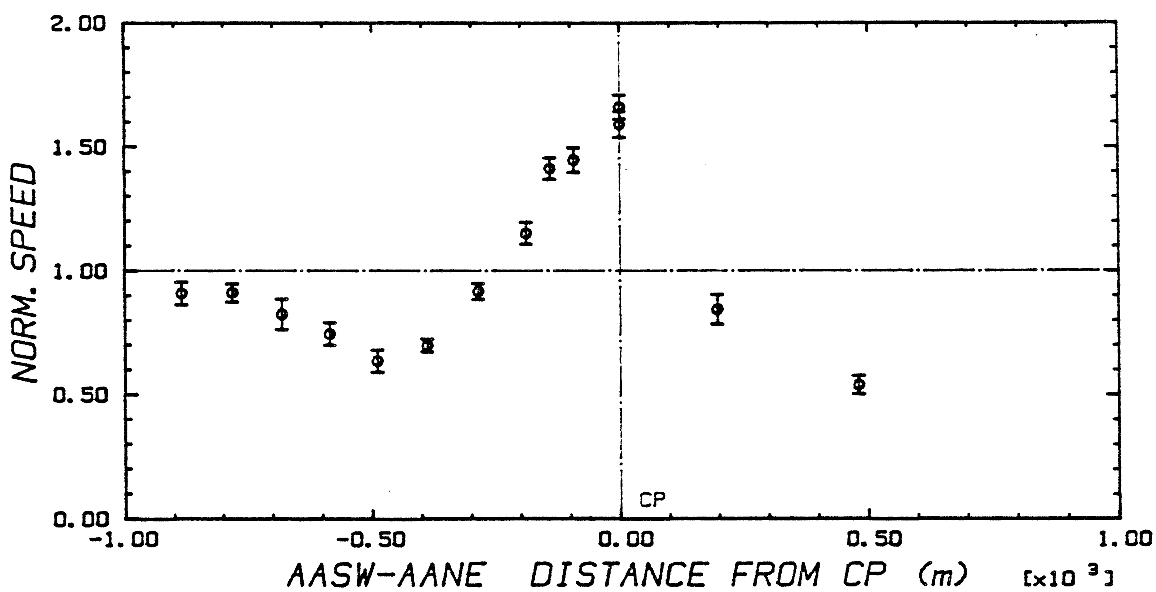


A3MF MF01-F Oct.1(JD274) 21:00-24:00 8.0m/s 210deg 10.m

Fig. 3.3 (cont.)

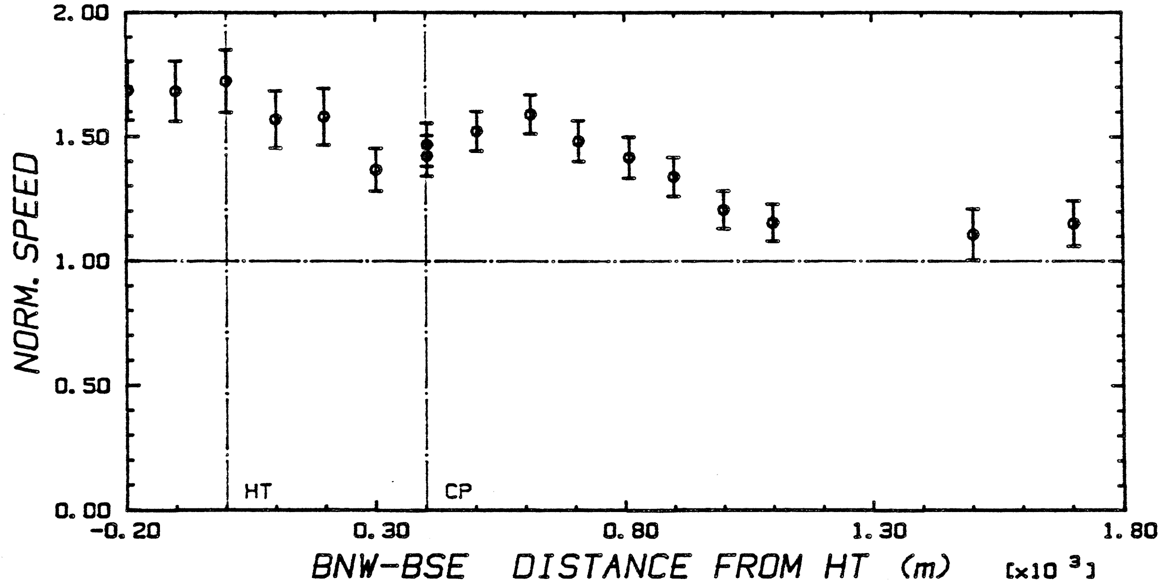


A3MF MF02-A Oct.2(JD275) 02:00-07:00 6.8m/s 210deg 10.m

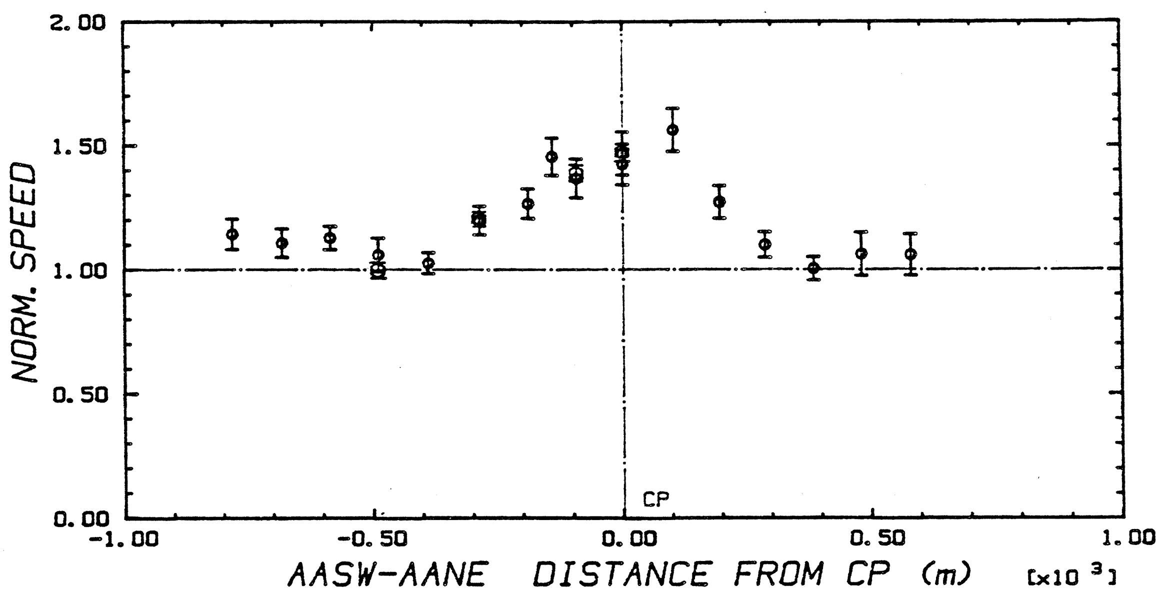


A3MF MF02-A Oct.2(JD275) 02:00-07:00 6.8m/s 210deg 10.m

Fig. 3.3 (cont.)

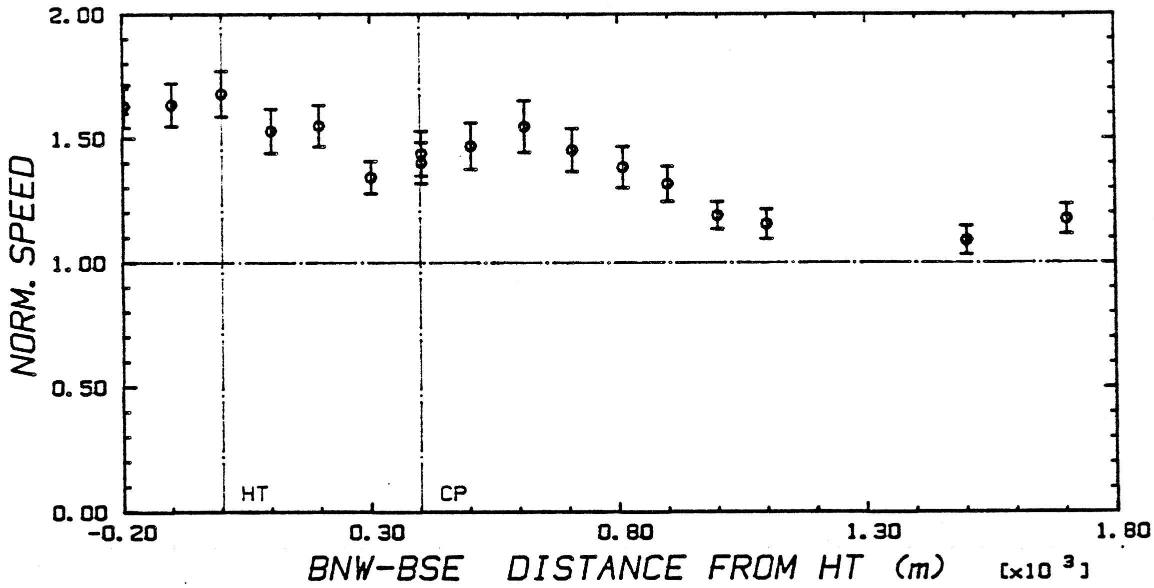


A3MF MF02-8 Oct.2(JD275) 14:00-16:00 10.0m/s 165deg 10.m

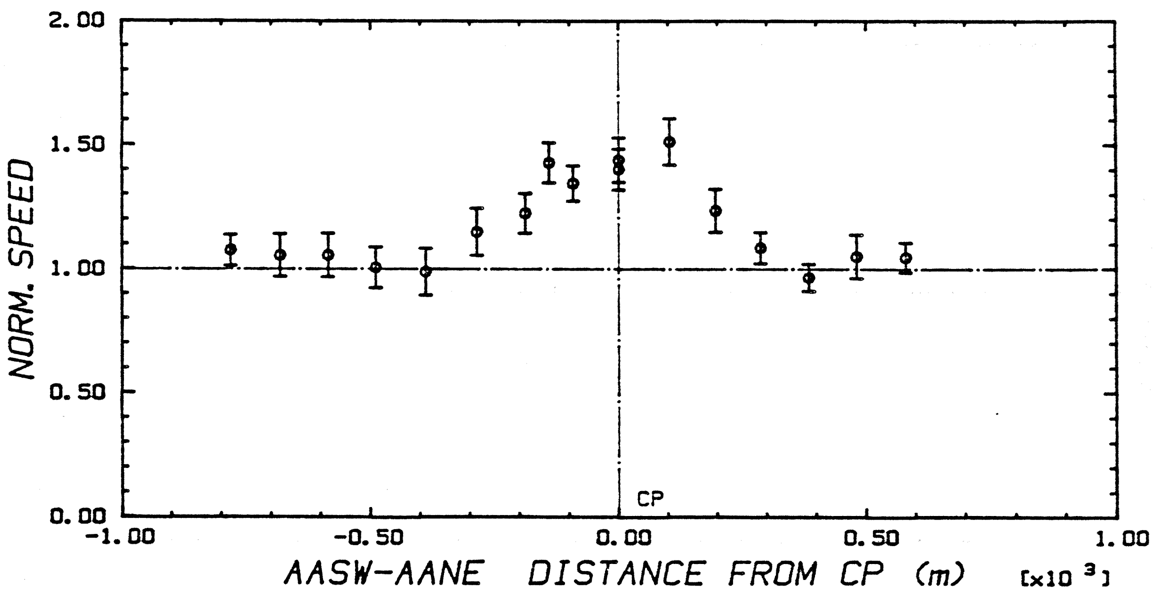


A3MF MF02-8 Oct.2(JD275) 14:00-16:00 10.0m/s 165deg 10.m

Fig. 3.3 (cont.)

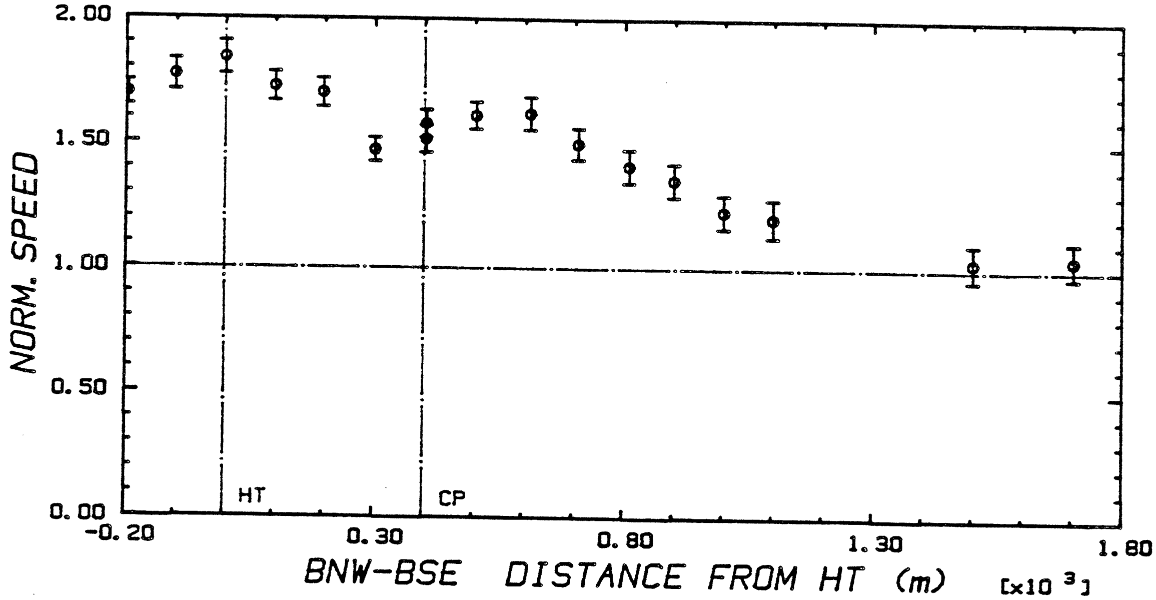


A3MF MF02-C Oct. 2 (JD275) 16:00-20:00 11.0m/s 165deg 10.m

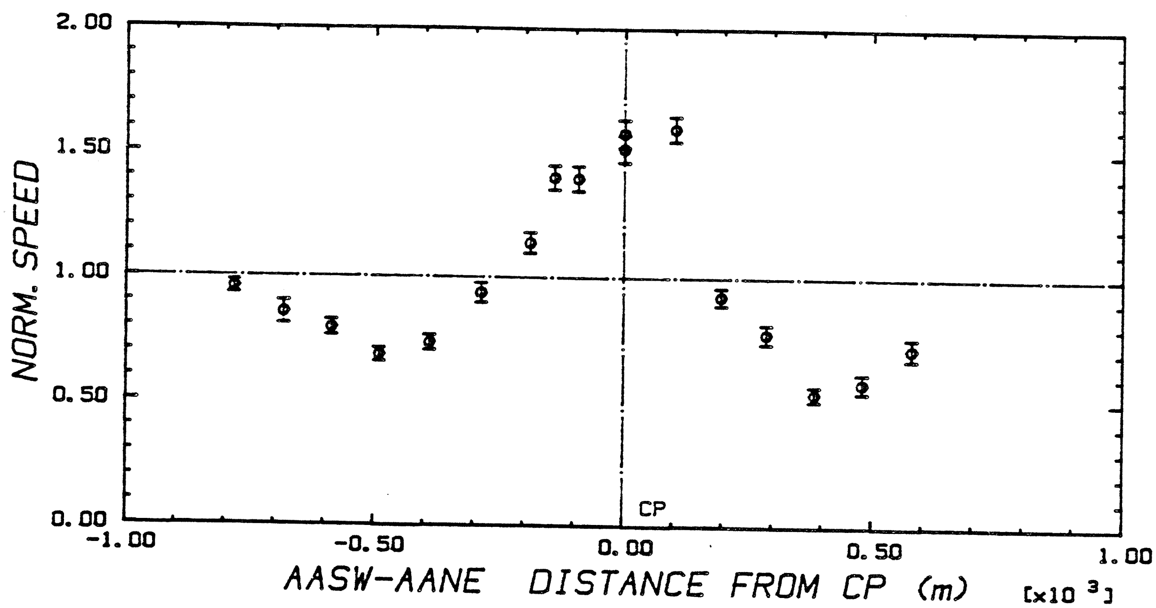


A3MF MF02-C Oct. 2 (JD275) 16:00-20:00 11.0m/s 165deg 10.m

Fig. 3.3 (cont.)

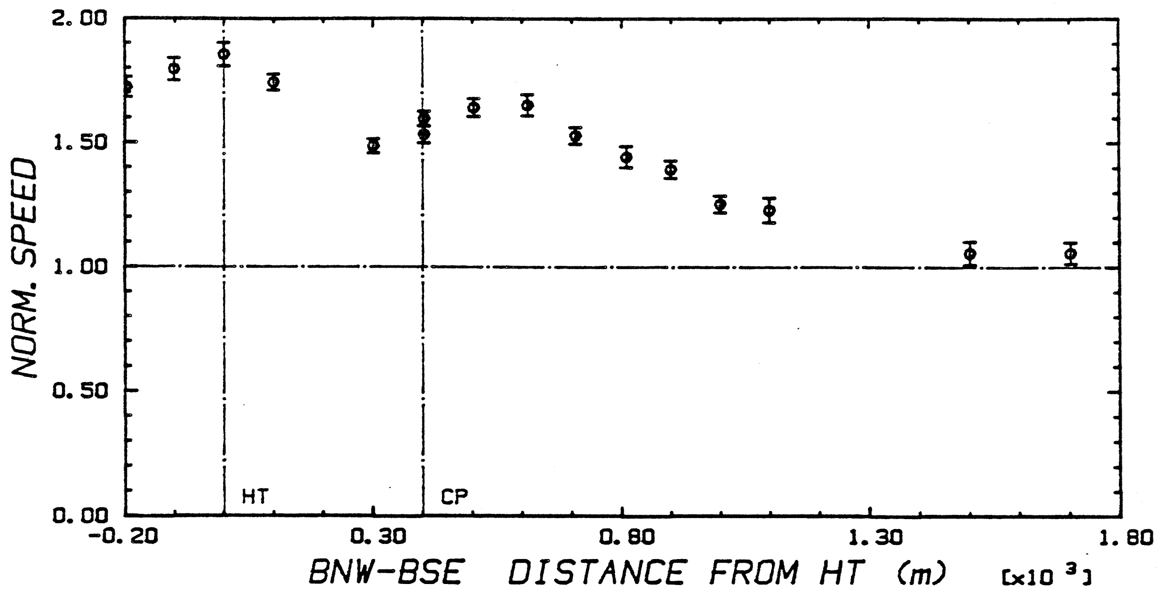


A3MF MF03-A Oct. 3 (JD276) 02:00-06:00 10.5m/s 205deg 10. m

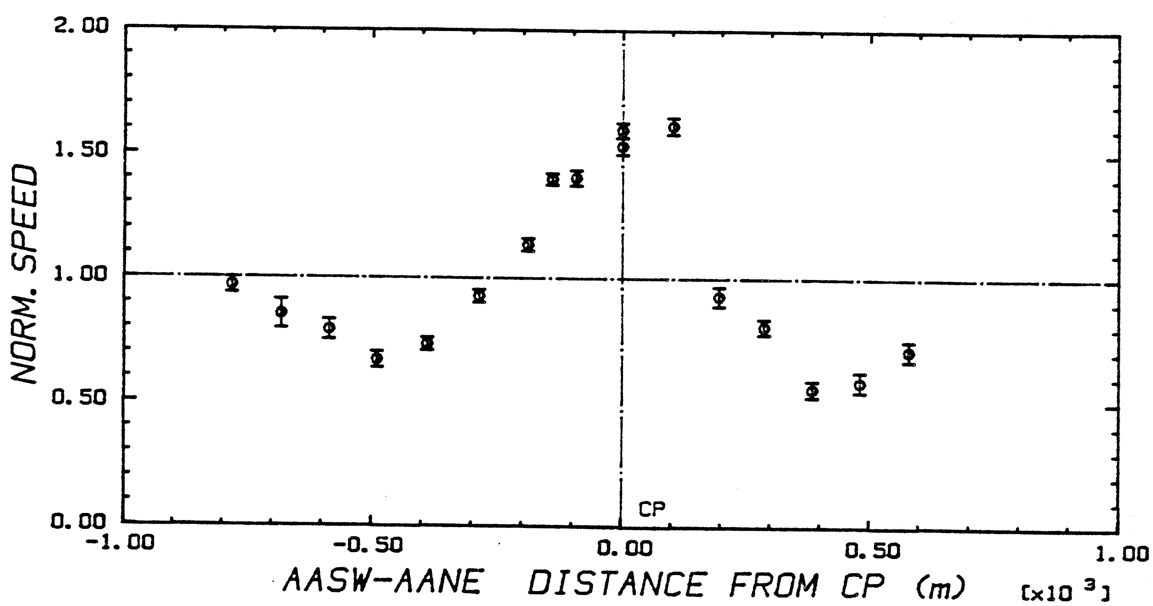


A3MF MF03-A Oct. 3 (JD276) 02:00-06:00 10.5m/s 205deg 10. m

Fig. 3.3 (cont.)

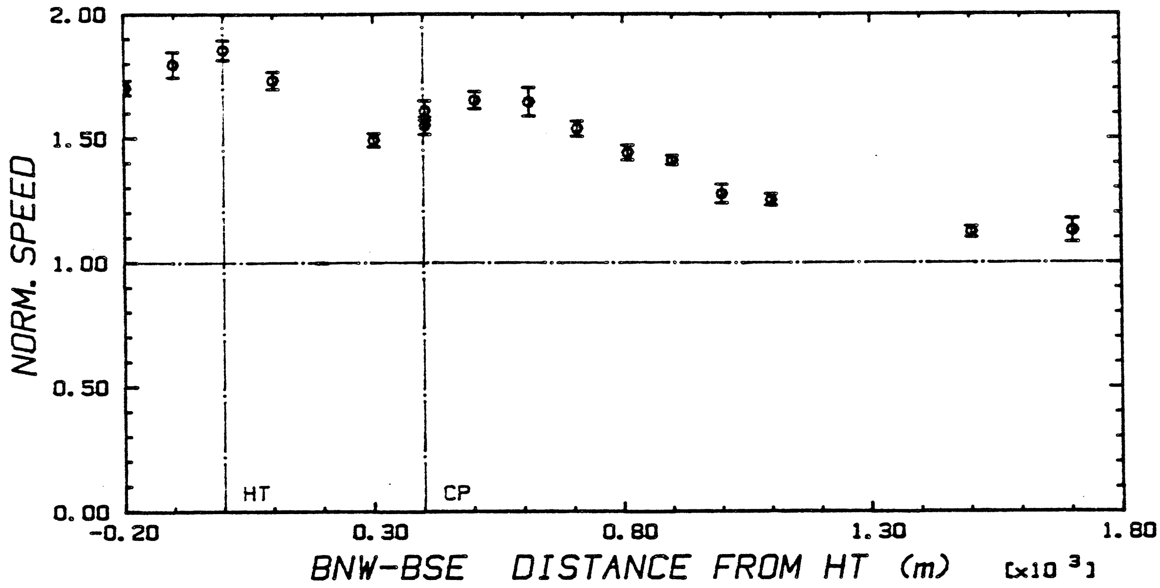


A3MF MF03-B Oct.3(JD276) 07:00-10:00 10.0m/s 210deg 10.m

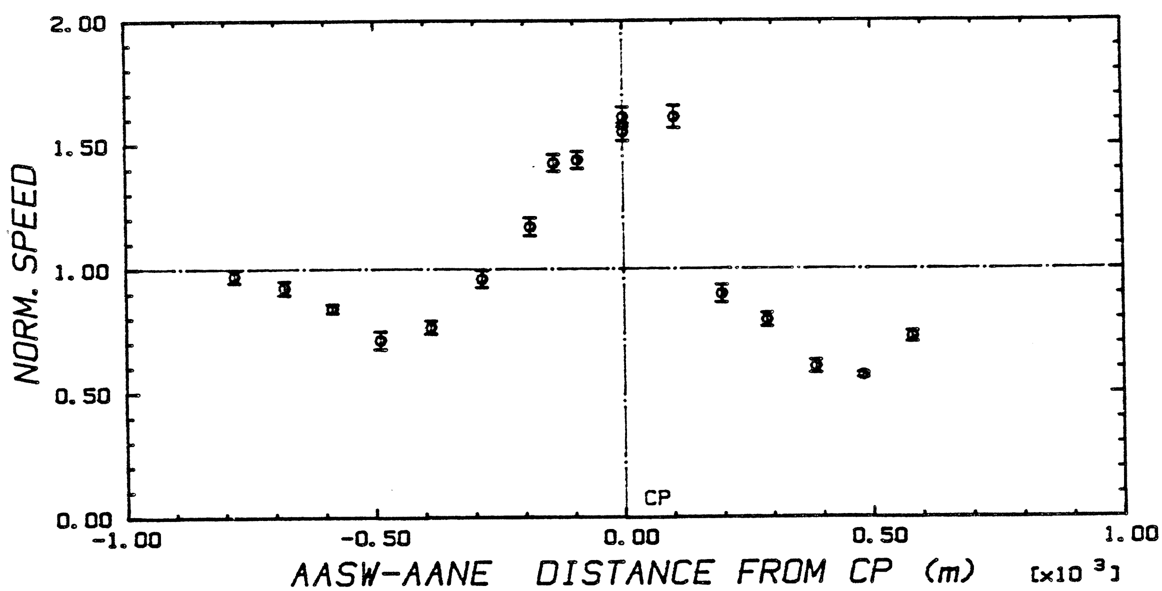


A3MF MF03-B Oct.3(JD276) 07:00-10:00 10.0m/s 210deg 10.m

Fig. 3.3 (cont.)

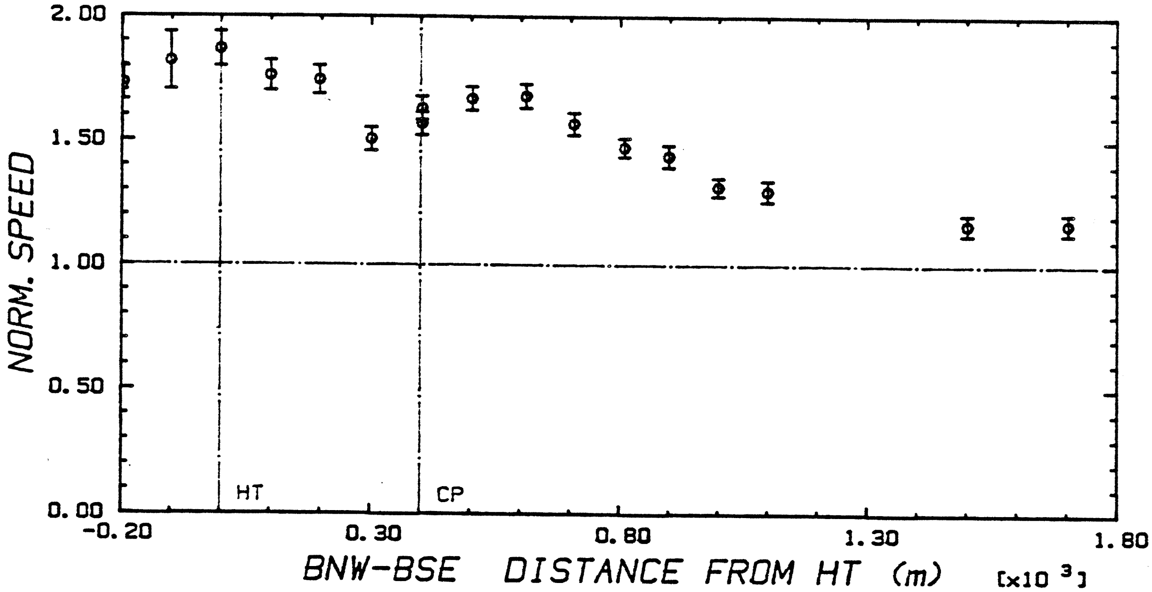


A3MF MF03-C Oct. 3(JD276) 11:30-13:00 10.0m/s 210deg 10.m

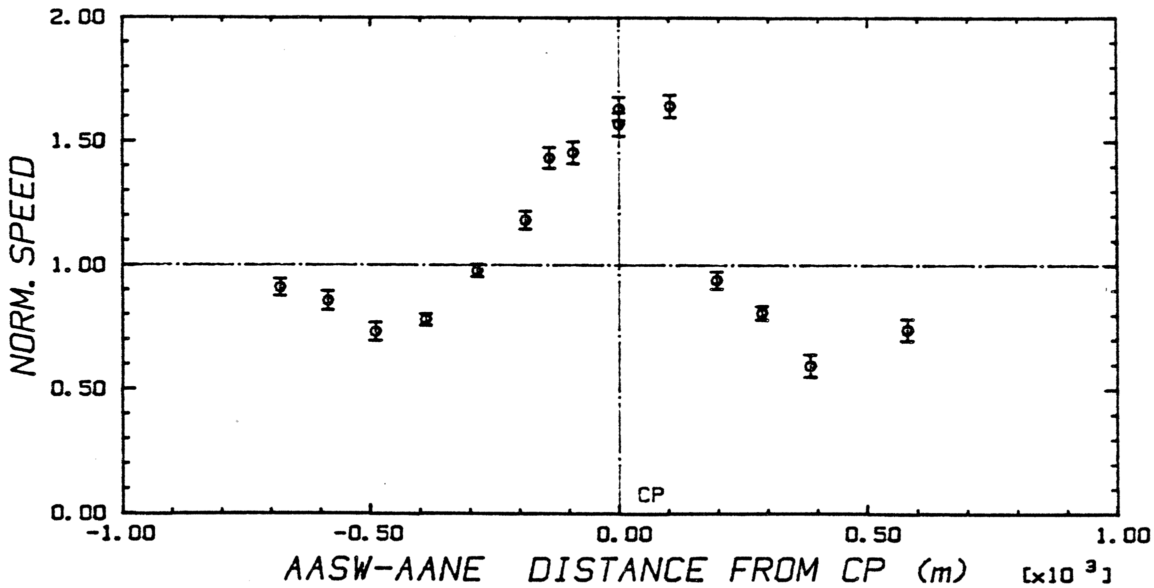


A3MF MF03-C Oct. 3(JD276) 11:30-13:00 10.0m/s 210deg 10.m

Fig. 3.3 (cont.)

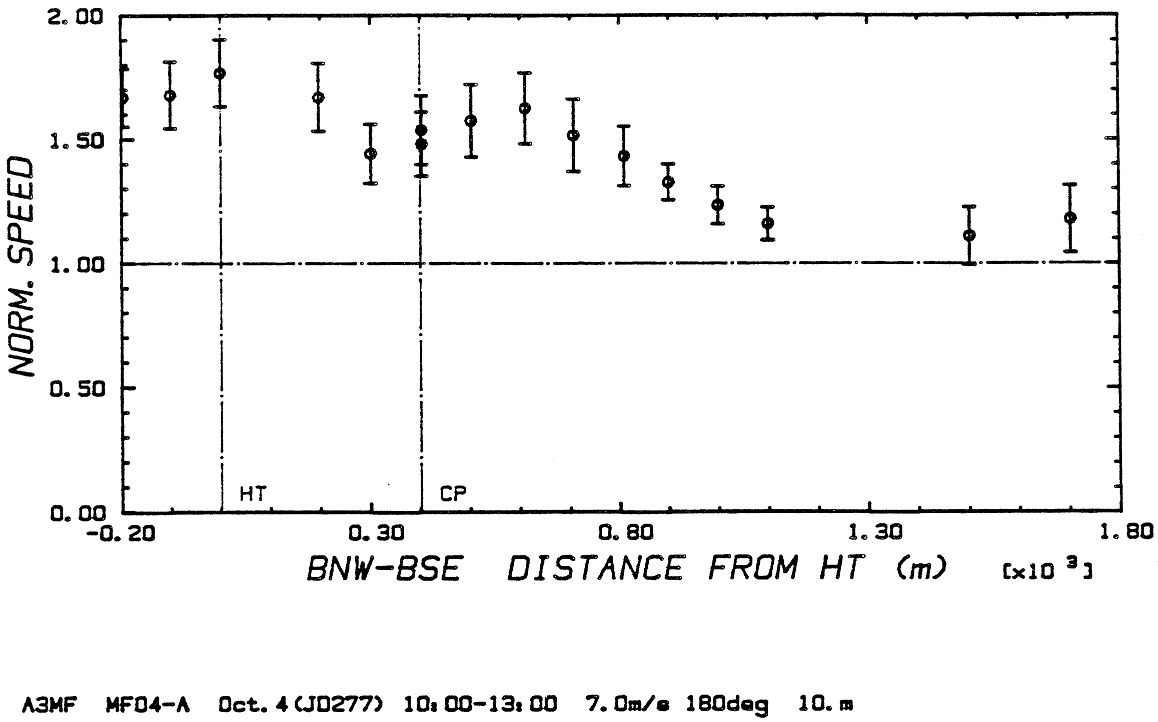


A3MF MF03-D Oct.3(JD276) 14:00-17:00 8.9m/s 210deg 10.m



A3MF MF03-D Oct.3(JD276) 14:00-17:00 8.9m/s 210deg 10.m

Fig. 3.3 (cont.)


2.00
1.50
1.00
0.50
0.00
NORM. SPEED
HT
CP
-0.20
0.30
0.80
1.30
1.80
BNW-BSE DISTANCE FROM HT (m)
[x10 3]
A3MF MF04-A Oct.4(JD277) 10:00-13:00 7.0m/s 180deg 10.m

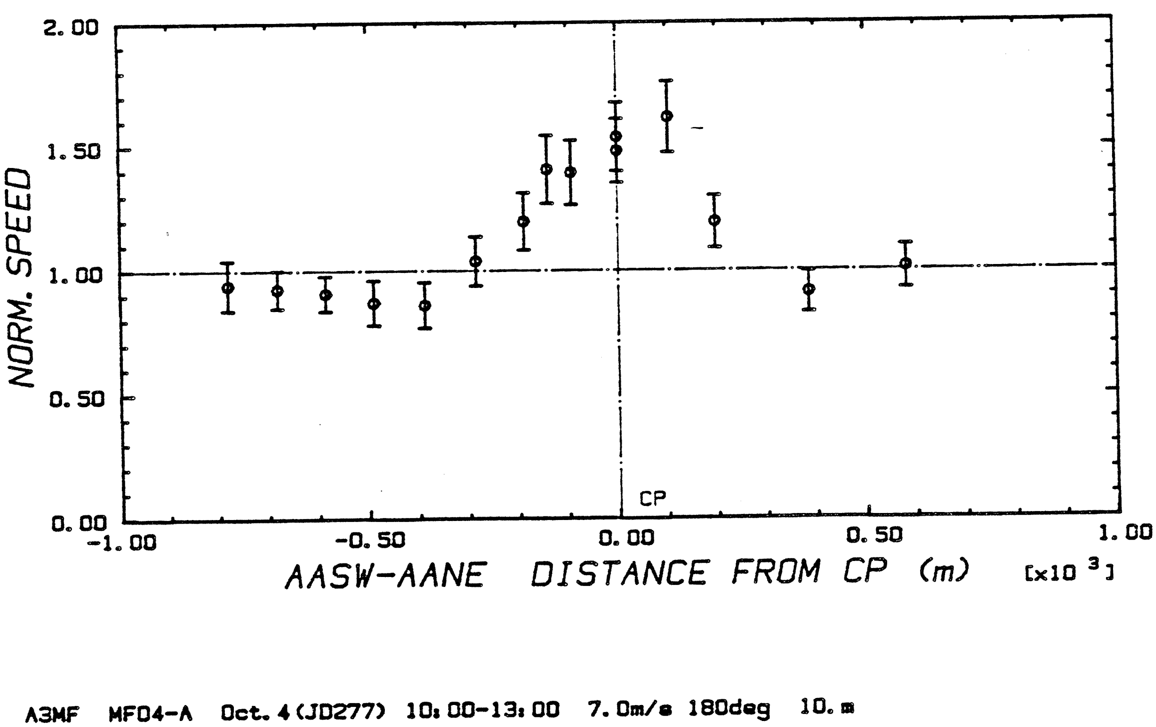
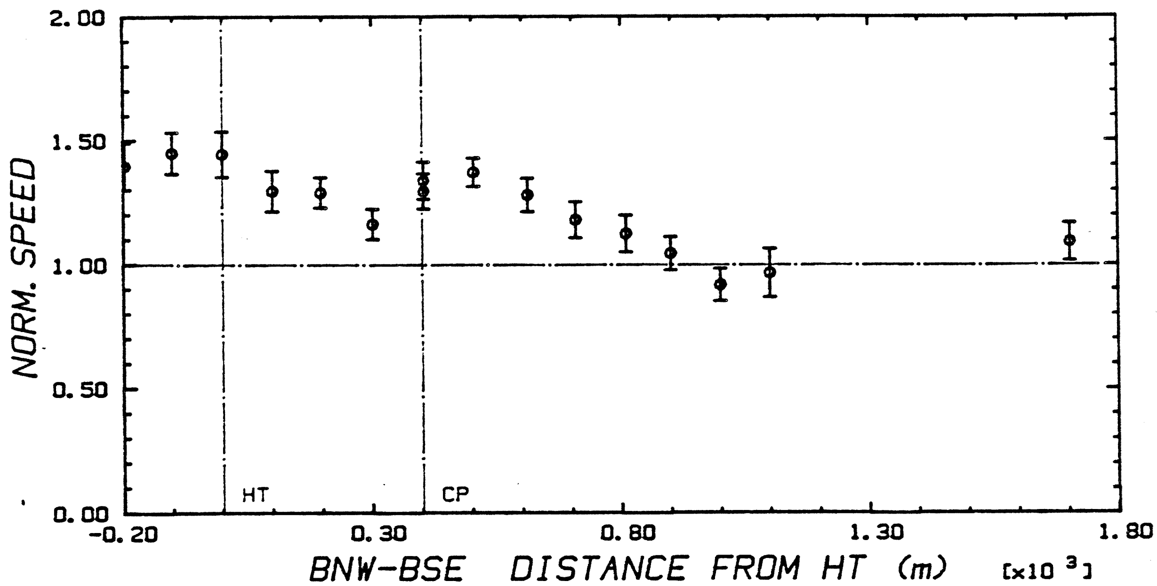
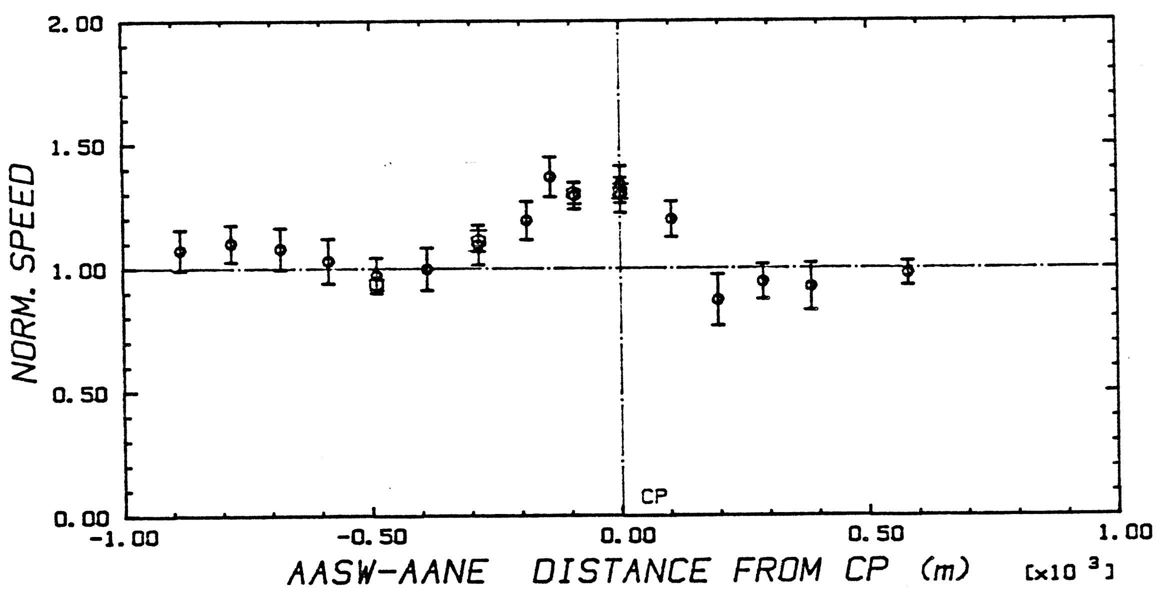

2.00
1.50
1.00
0.50
0.00
NORM. SPEED
CP
-1.00
-0.50
0.00
0.50
1.00
AASW-AANE DISTANCE FROM CP (m)
[x10 3]
A3MF MF04-A Oct.4(JD277) 10:00-13:00 7.0m/s 180deg 10.m

Fig. 3.3 (cont.)

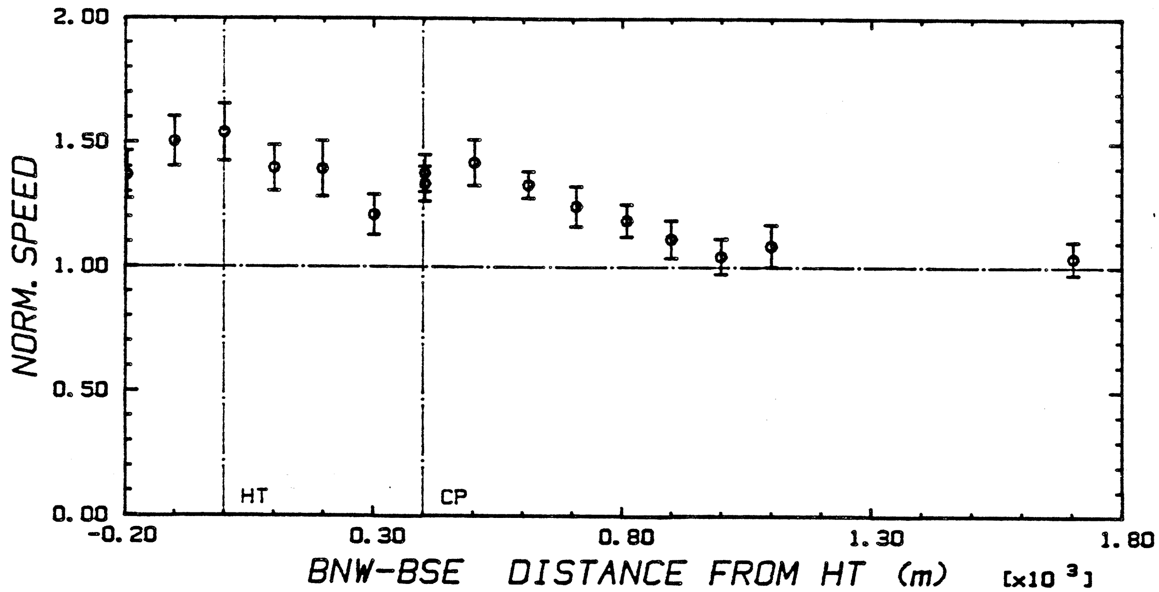


A3MF MF04-B Oct. 4 (JD277) 18:30-19:30 11.0m/s 285deg 10.m

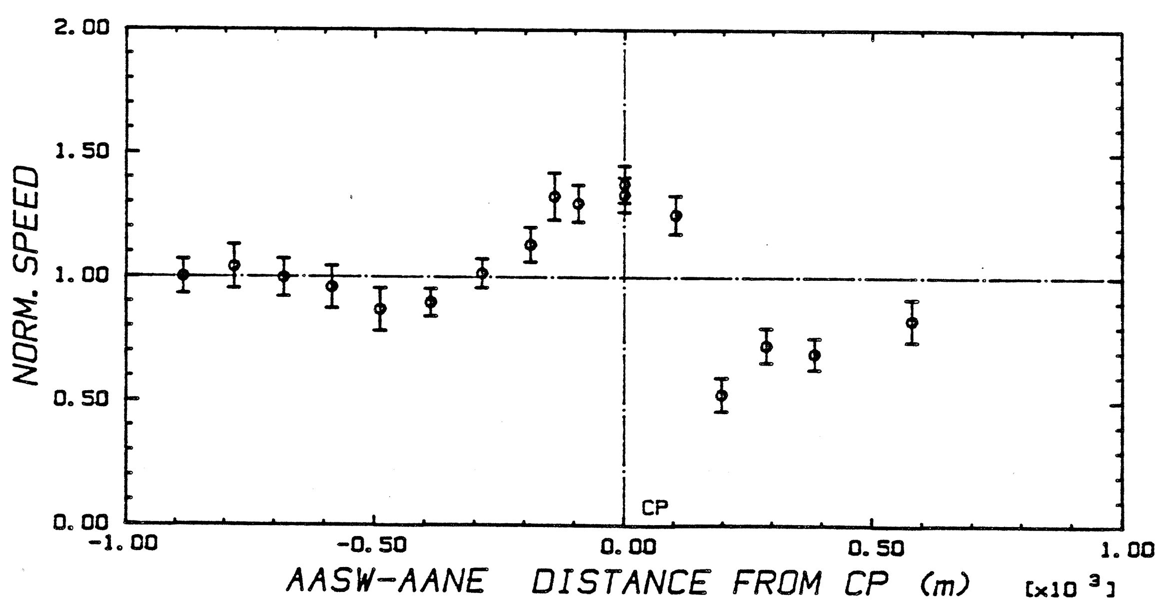


A3MF MF04-B Oct. 4 (JD277) 18:30-19:30 11.0m/s 285deg 10.m

Fig. 3.3 (cont.)

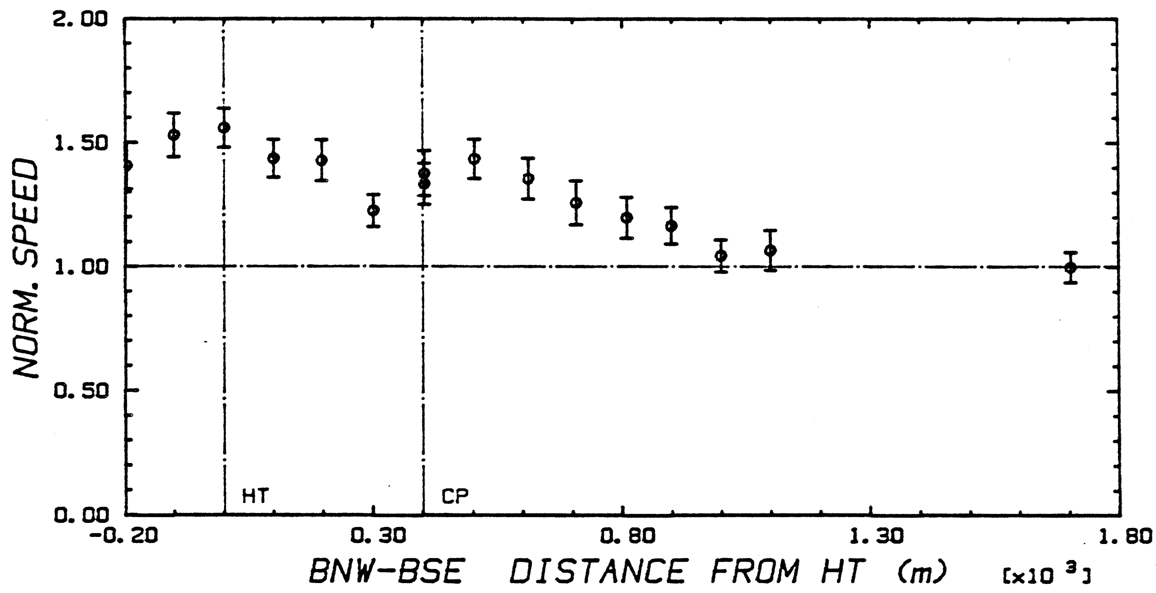


A3MF MF04-C Oct.4(JD277) 23:00-24:00 10.0m/s 270deg 10.m

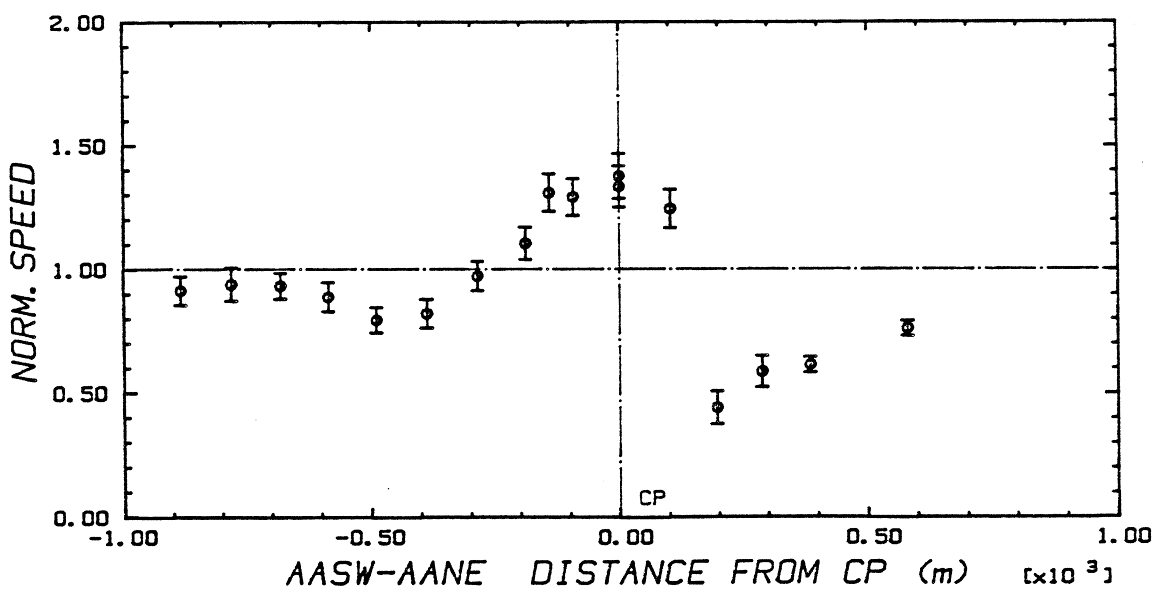


A3MF MF04-C Oct.4(JD277) 23:00-24:00 10.0m/s 270deg 10.m

Fig. 3.3 (cont.)

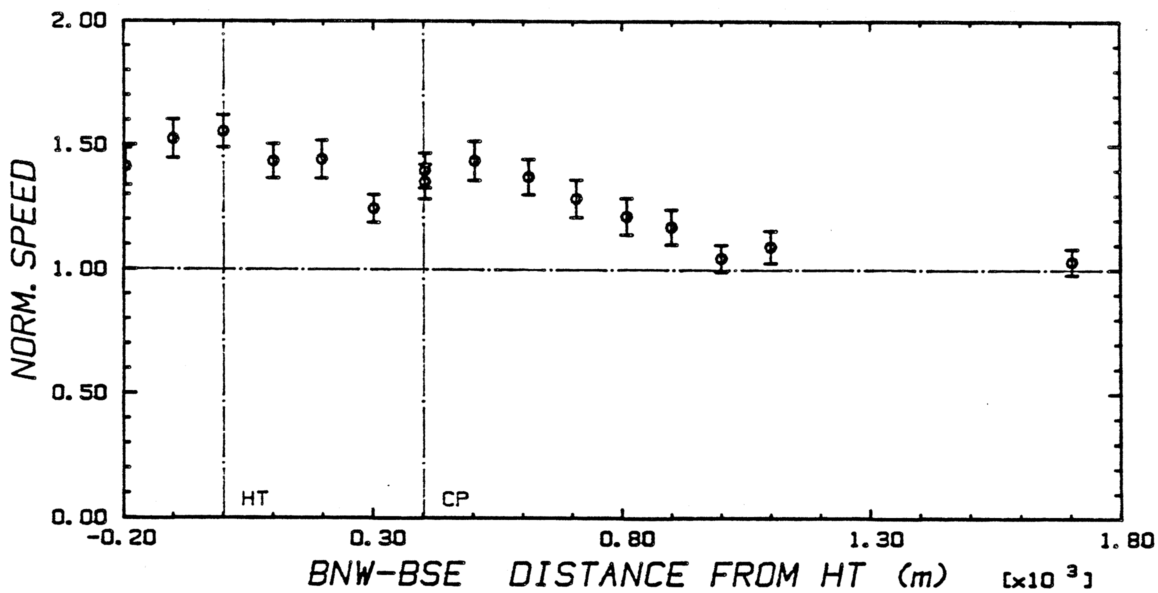


A3MF MF05-A Oct.5(JD278) 00:00-02:00 10.0m/s 258deg 10.m

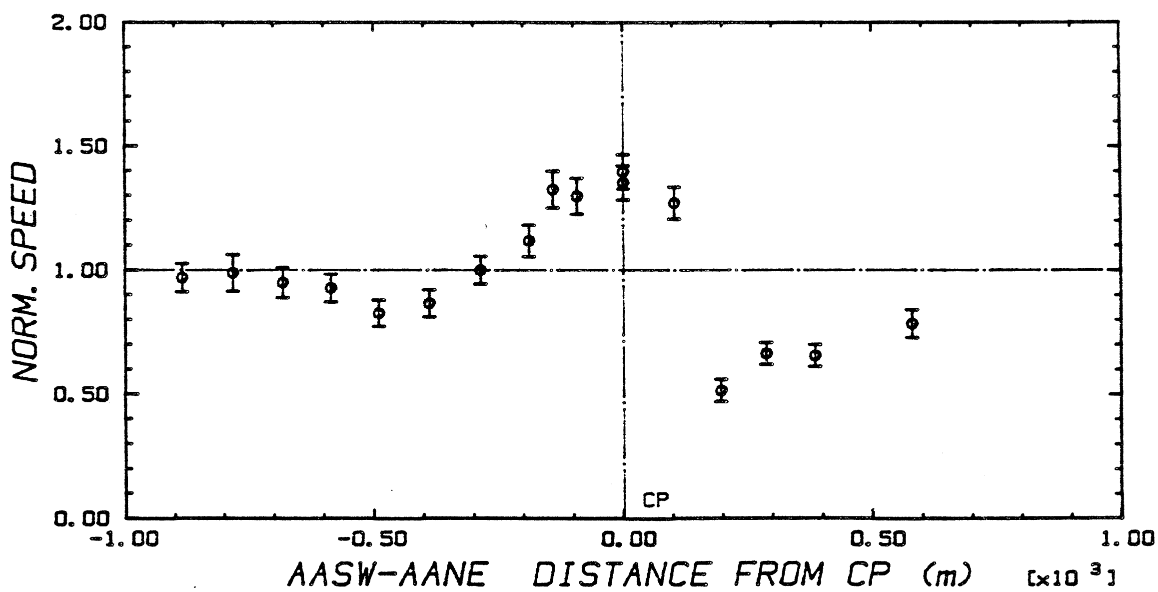


A3MF MF05-A Oct.5(JD278) 00:00-02:00 10.0m/s 258deg 10.m

Fig. 3.3 (cont.)

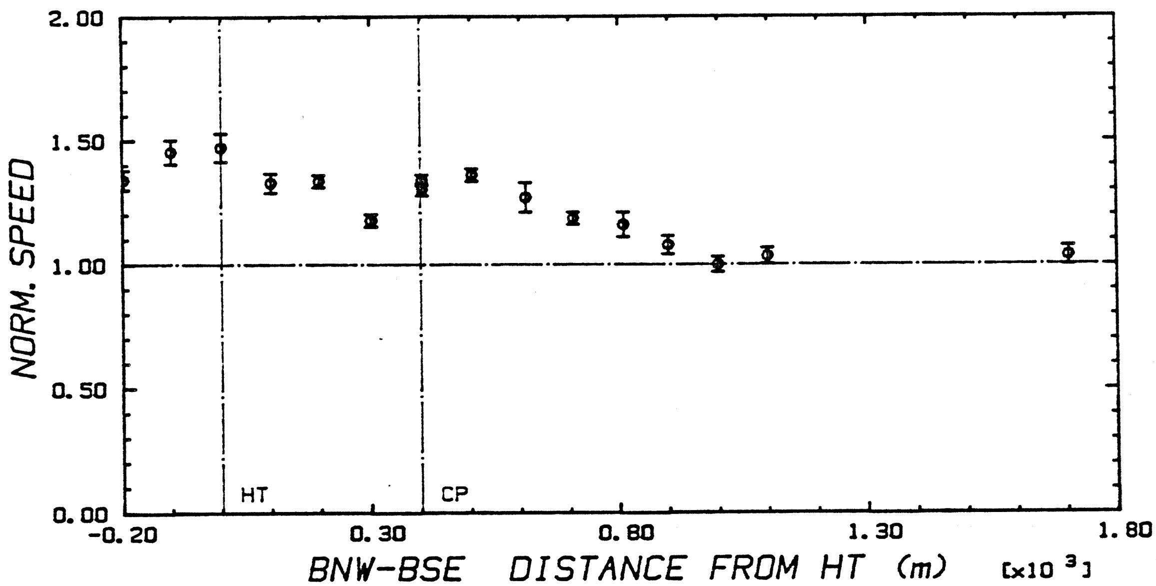


A3MF MF05-B Oct. 5 (JD278) 03:00-07:00 10.0m/s 263deg 10. m

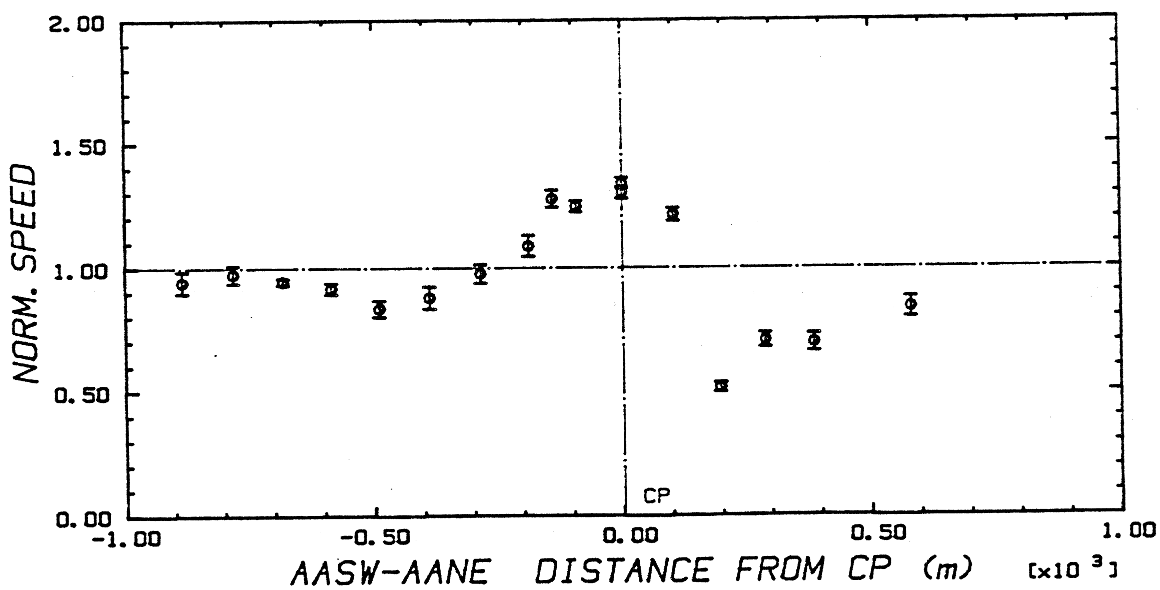


A3MF MF05-B Oct. 5 (JD278) 03:00-07:00 10.0m/s 263deg 10. m

Fig. 3.3 (cont.)

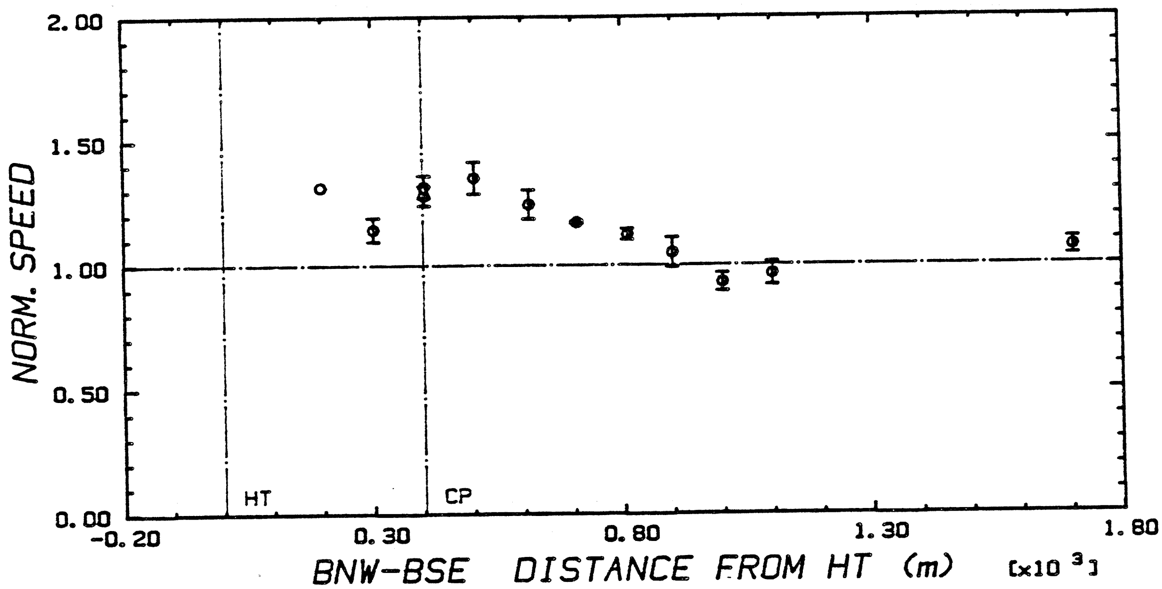


A3MF MF05-C Oct.5(JD278) 08:00-09:00 12.0m/s 268deg 10.m

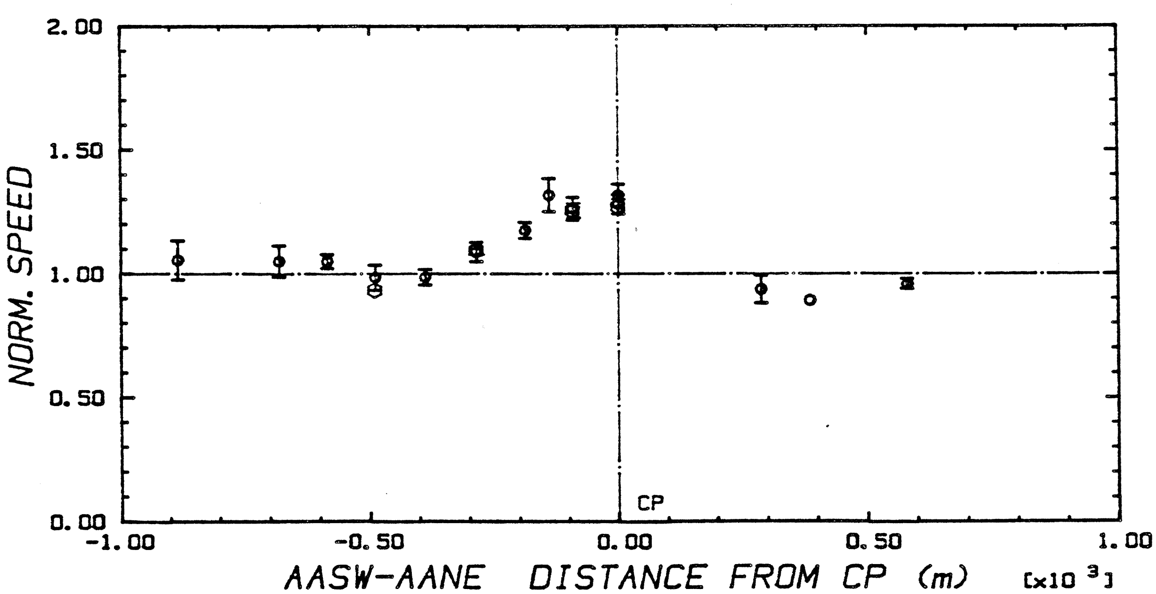


A3MF MF05-C Oct.5(JD278) 08:00-09:00 12.0m/s 268deg 10.m

Fig. 3.3 (cont.)

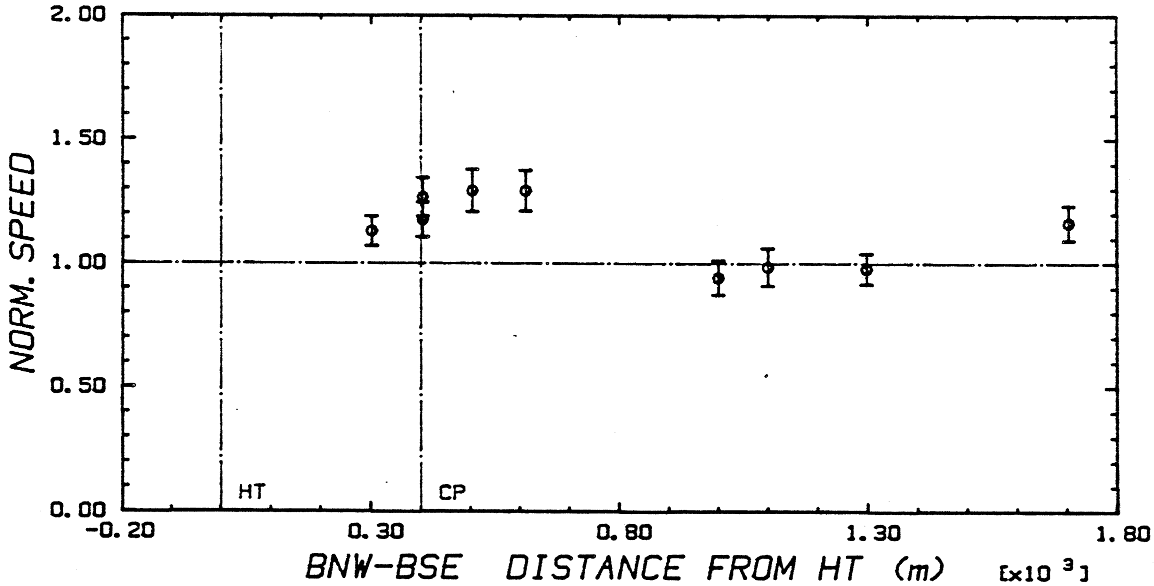


A3MF MF05-D Oct.5(JD278) 10:30-11:30 9.5m/s 285deg 10.m

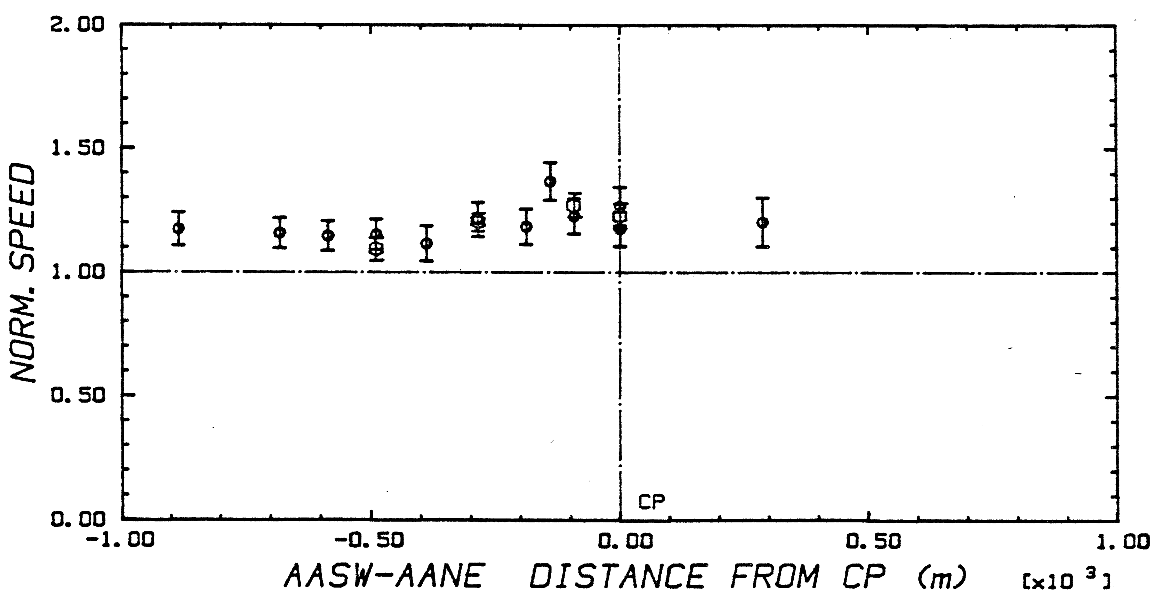


A3MF MF05-D Oct.5(JD278) 10:30-11:30 9.5m/s 285deg 10.m

Fig. 3.3 (cont.)

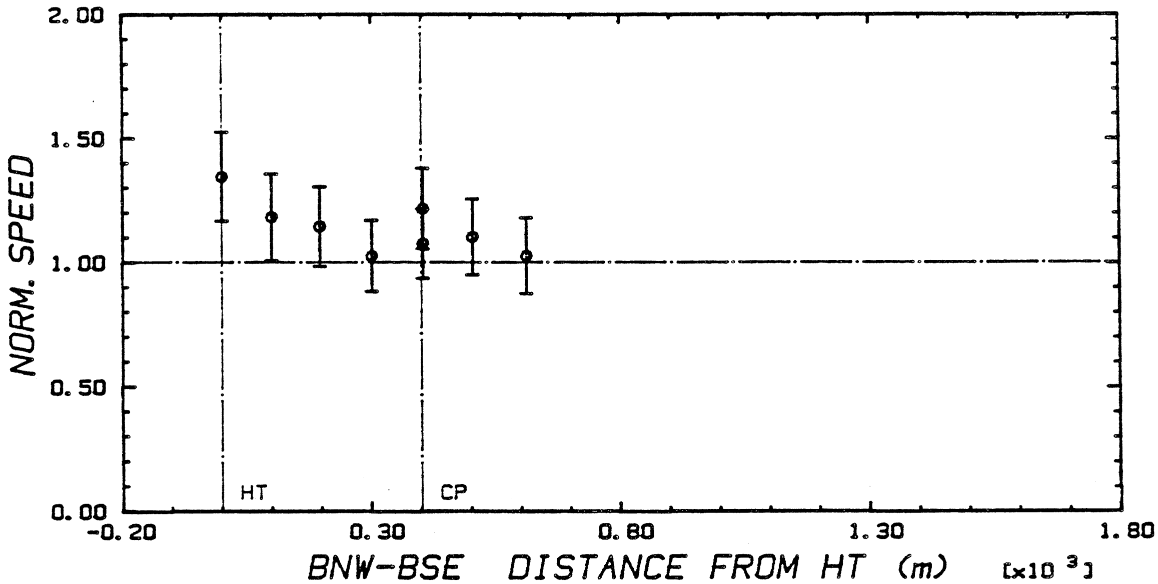


A3MF MF05-E Oct. 5 (JD278) 13:30-17:00 7.8m/s 305deg 10.m

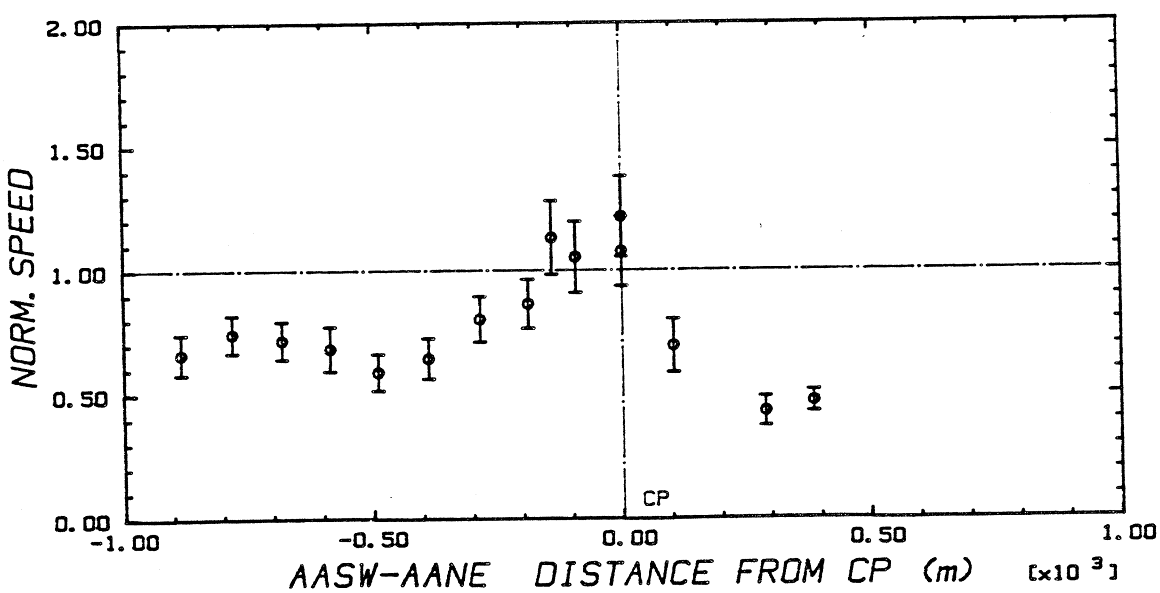


A3MF MF05-E Oct. 5 (JD278) 13:30-17:00 7.8m/s 305deg 10.m

Fig. 3.3 (cont.)

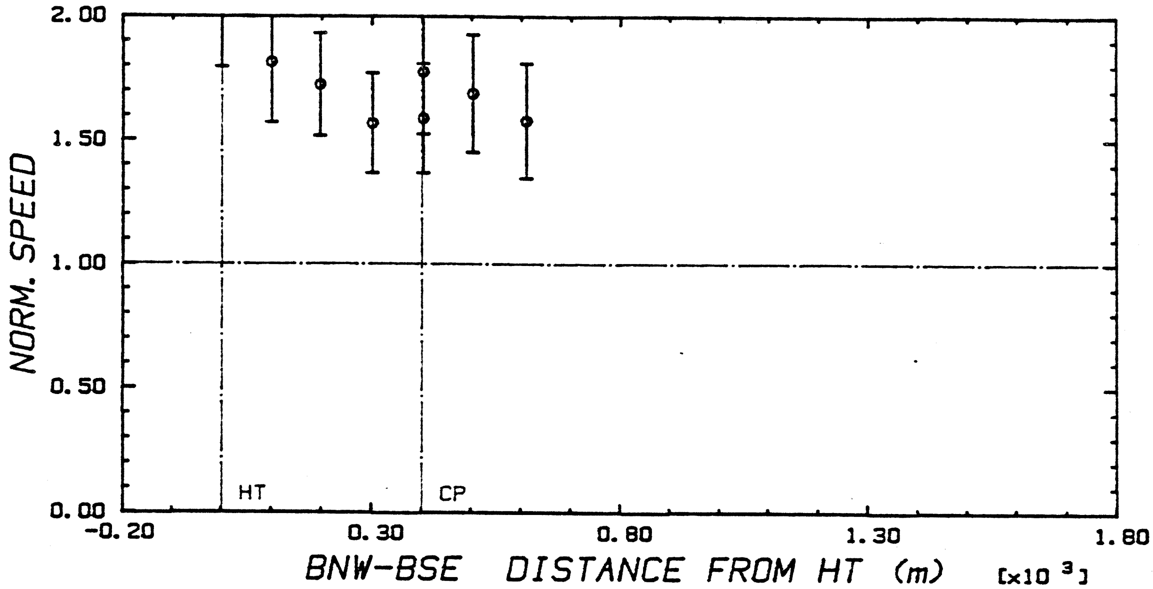


A3MF MF07-A Oct.7(JD280) 02:30-05:00 8.5m/s 260deg 3.m

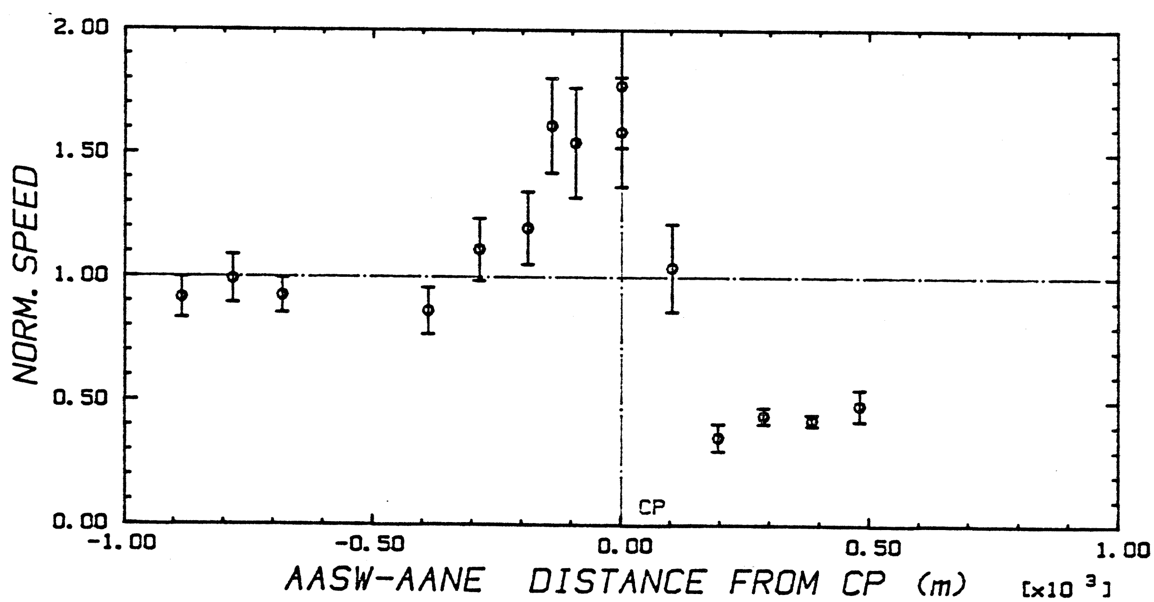


A3MF MF07-A Oct.7(JD280) 02:30-05:00 8.5m/s 260deg 3.m

Fig. 3.4 Normalized wind speeds at 3m during MF runs.

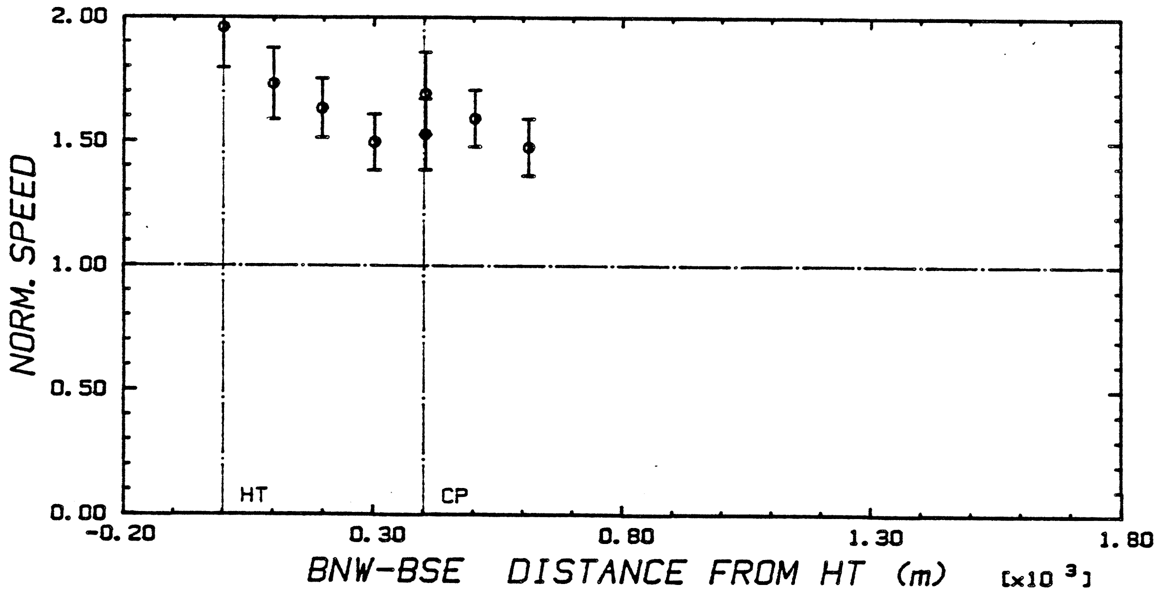


A3MF MF07-B Oct.7(JD280) 12:00-14:00 9.0m/s 240deg 3.m

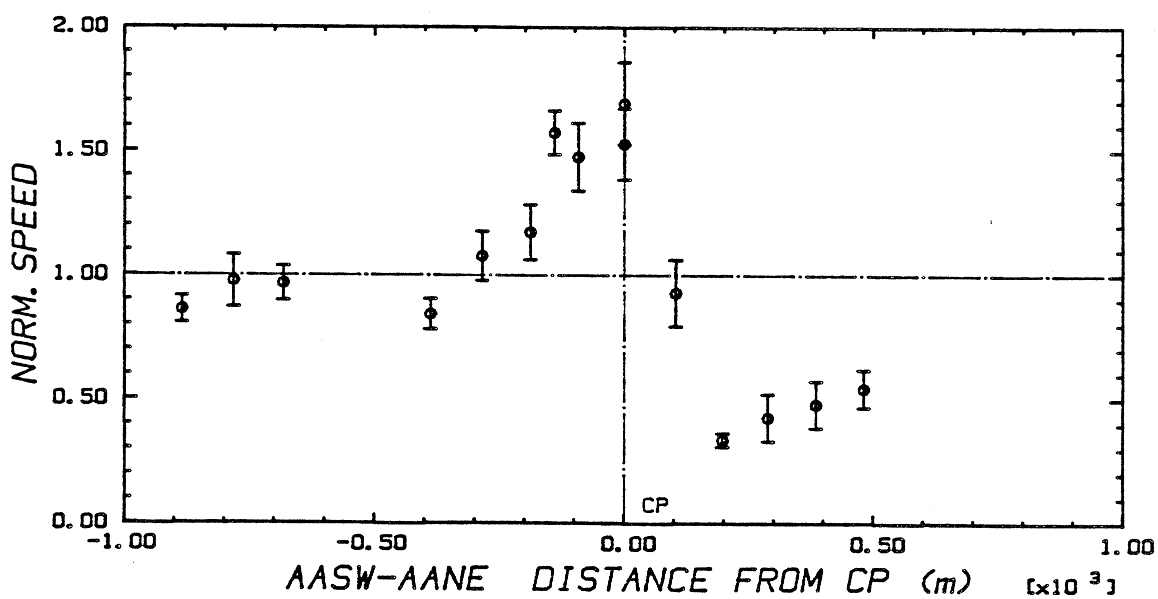


A3MF MF07-B Oct.7(JD280) 12:00-14:00 9.0m/s 240deg 3.m

Fig. 3.4 (cont.)

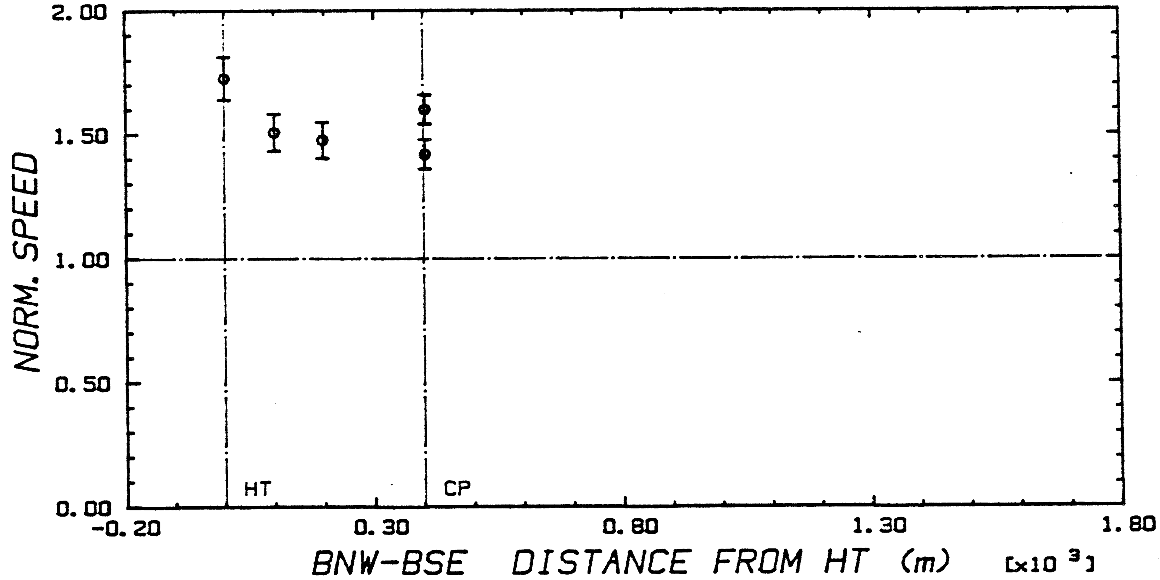


A3MF MF07-C Oct.7(JD280) 14:00-16:00 10.0m/s 255deg 3.m

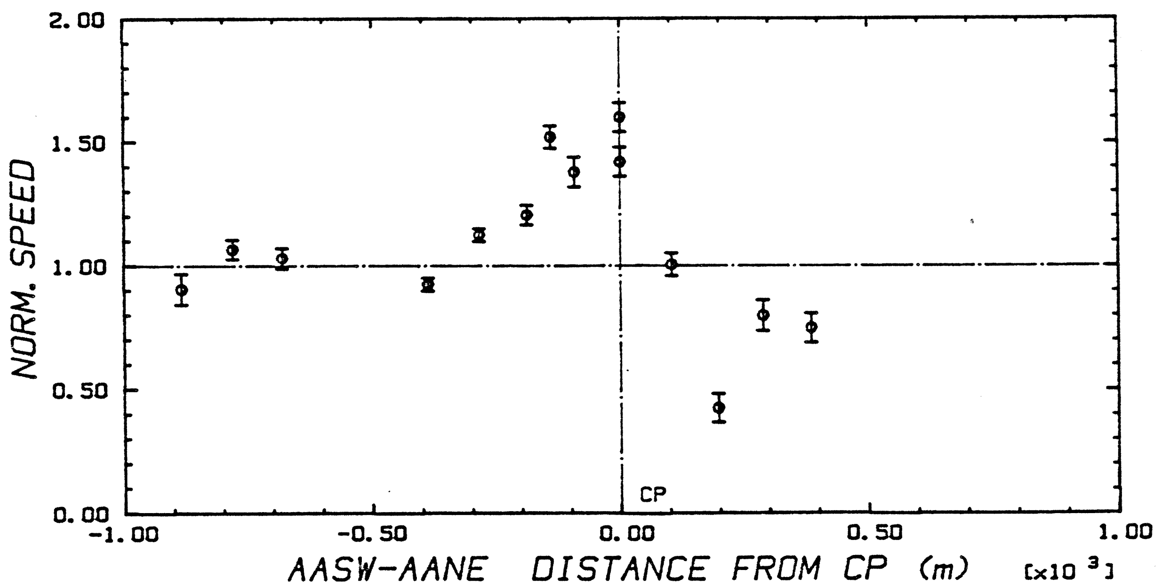


A3MF MF07-C Oct.7(JD280) 14:00-16:00 10.0m/s 255deg 3.m

Fig. 3.4 (cont.)

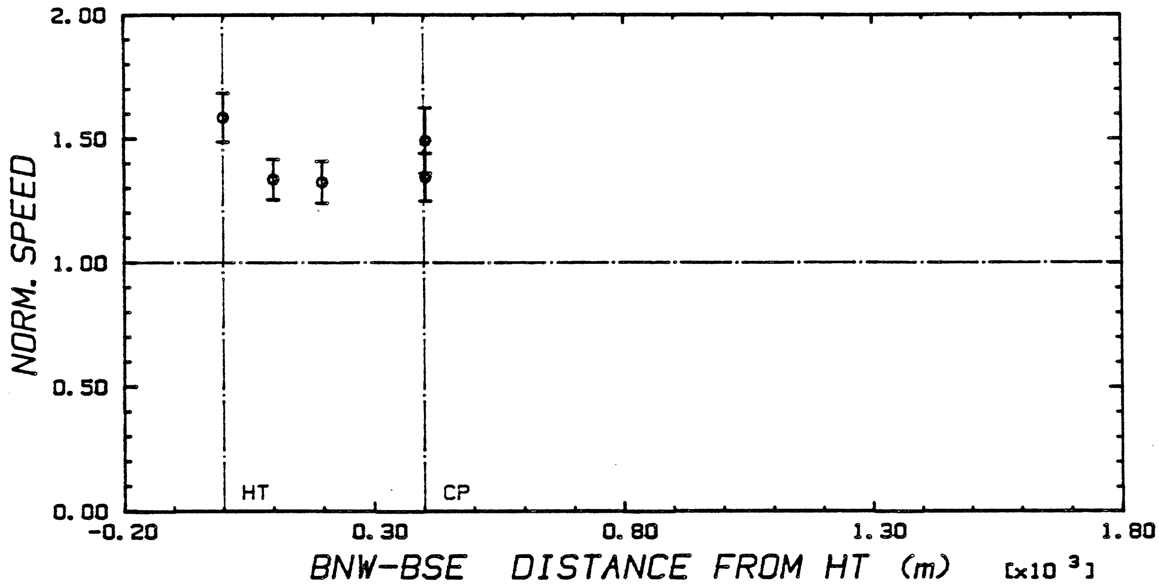


A3MF MF07-D Oct.7(JD280) 22:00-23:00 11.0m/s 270deg 3.m

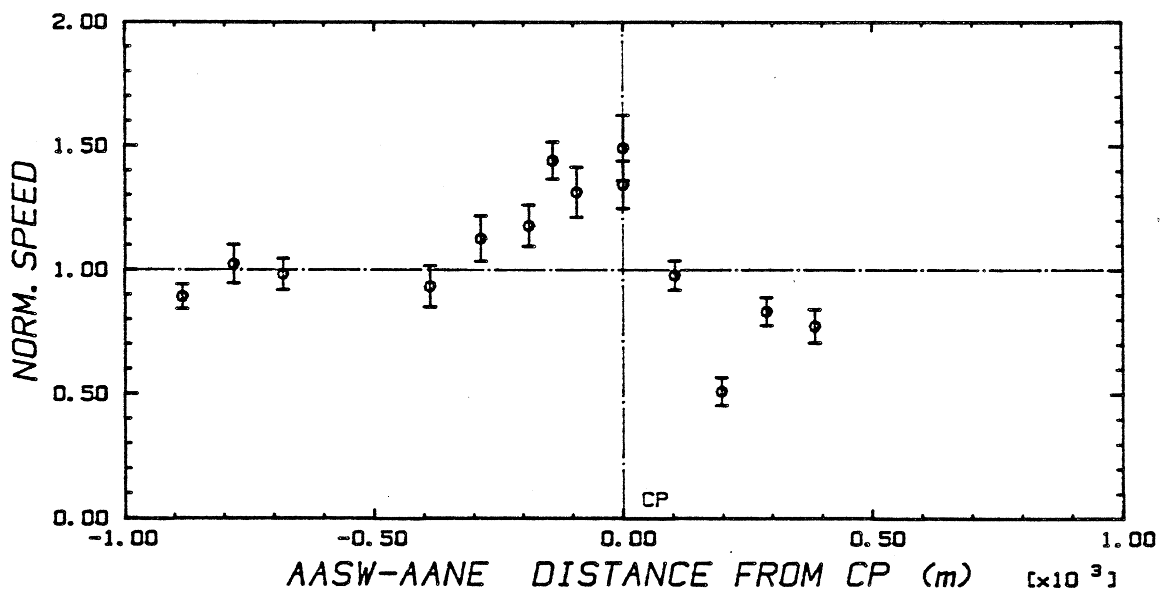


A3MF MF07-D Oct.7(JD280) 22:00-23:00 11.0m/s 270deg 3.m

Fig. 3.4 (cont.)

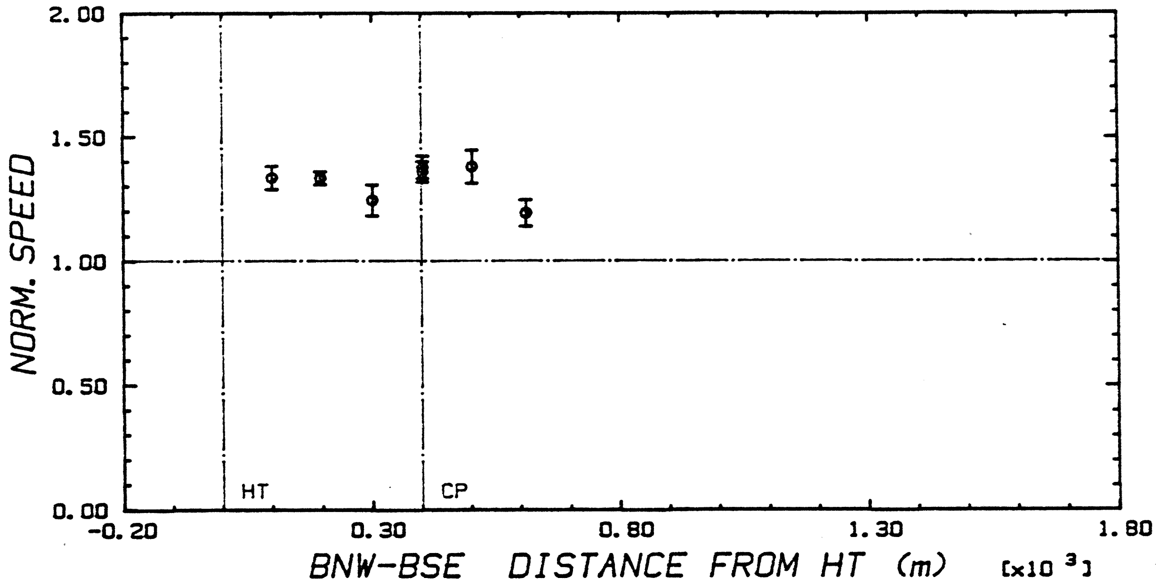


A3MF MF08 Oct.8(JD281) 02:00-04:00 9.0m/s 280deg 3.m

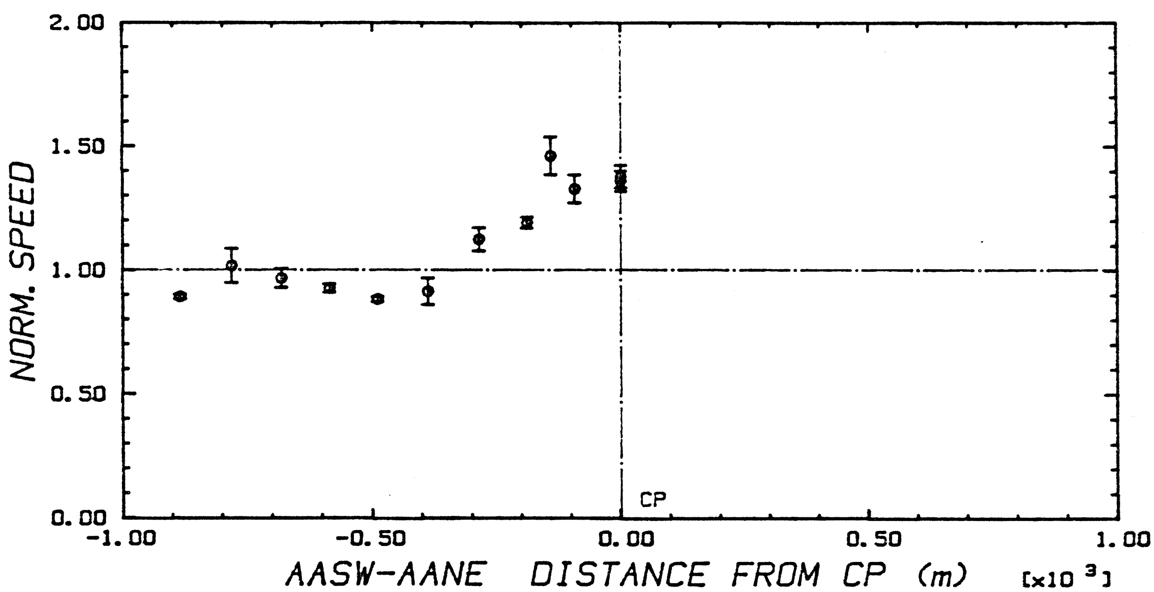


A3MF MF08 Oct.8(JD281) 02:00-04:00 9.0m/s 280deg 3.m

Fig. 3.4 (cont.)

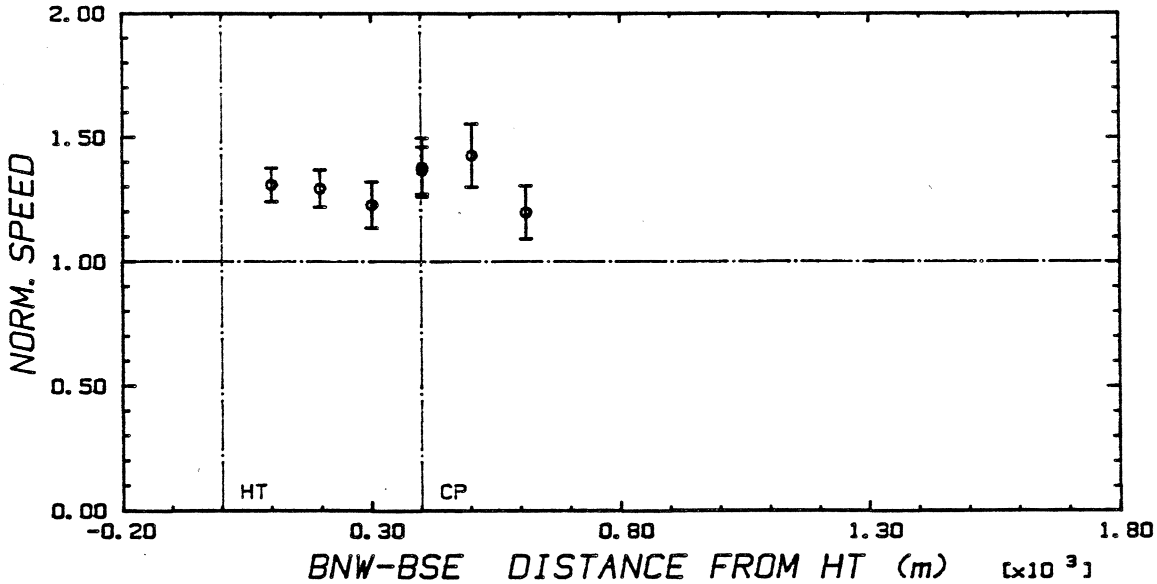


A3MF MF09-A Oct.9(JD282) 18:00-19:00 11.0m/s 275deg 3.m

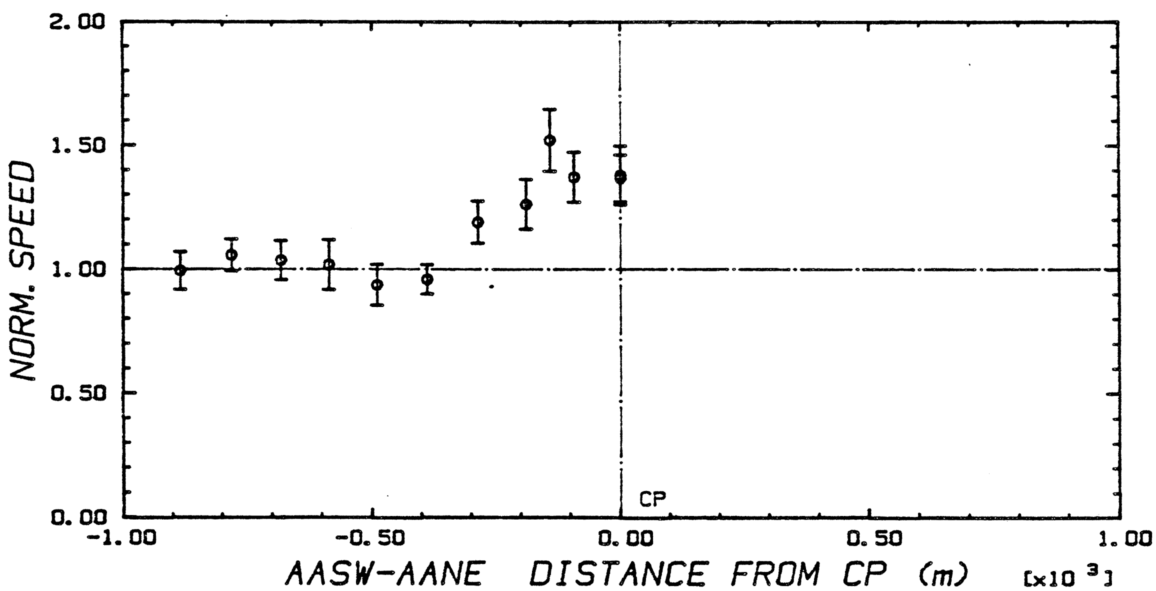


A3MF MF09-A Oct.9(JD282) 18:00-19:00 11.0m/s 275deg 3.m

Fig. 3.4 (cont.)

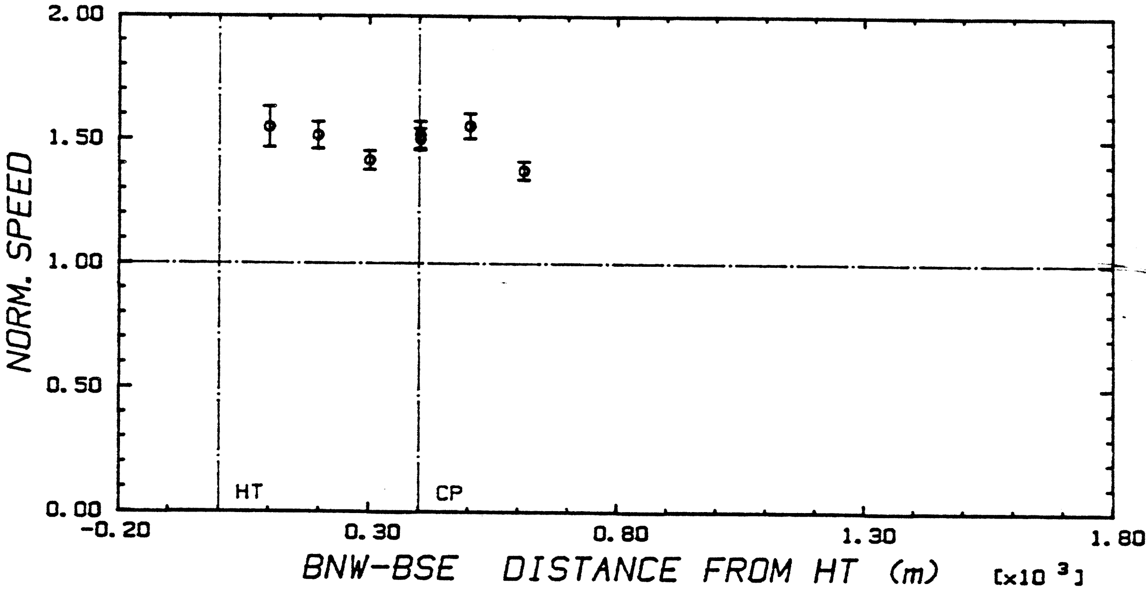


A3MF MF09-B Oct. 9 (JD282) 19:30-20:30 10.2m/s 283deg 3.m

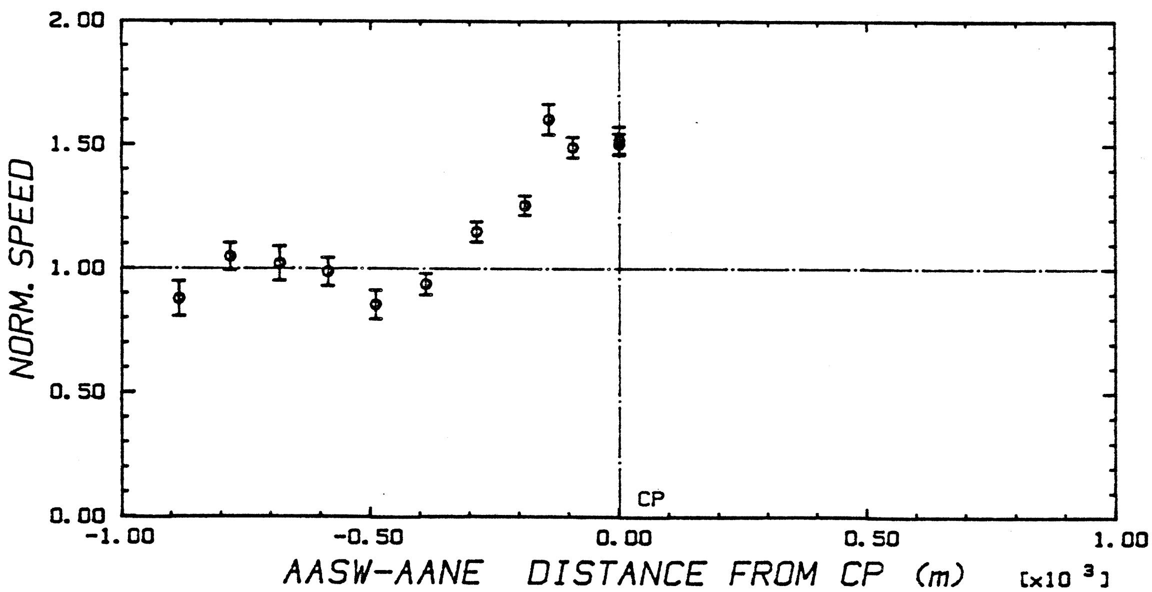


A3MF MF09-B Oct. 9 (JD282) 19:30-20:30 10.2m/s 283deg 3.m

Fig. 3.4 (cont.)

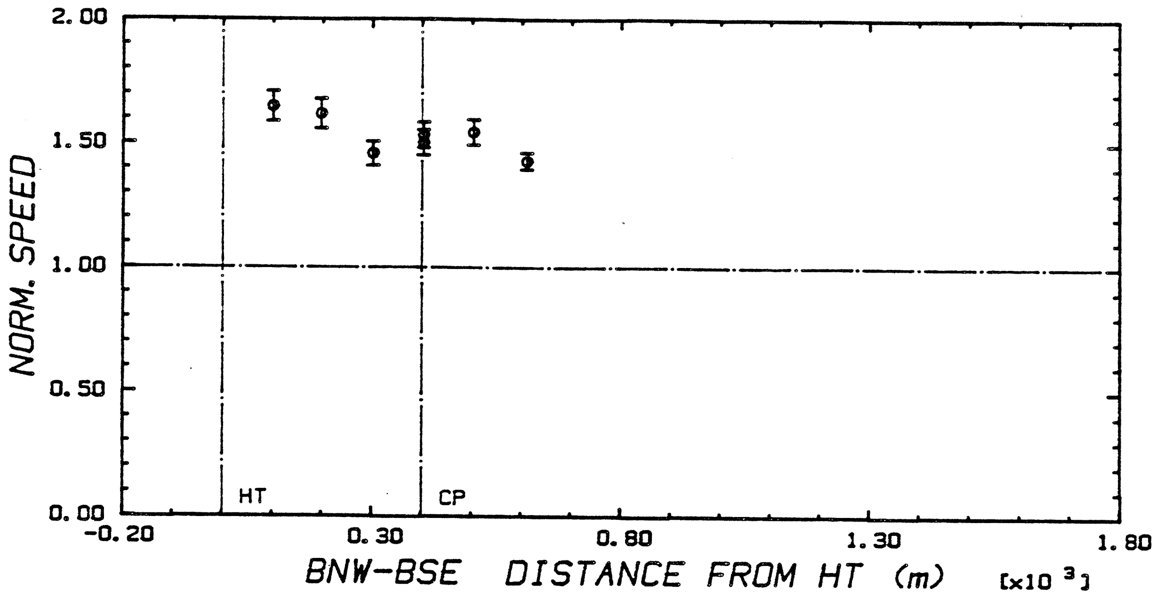


A3MF MF09-C Oct.9(JD282) 21:30-22:30 9.1m/s 268deg 3.m

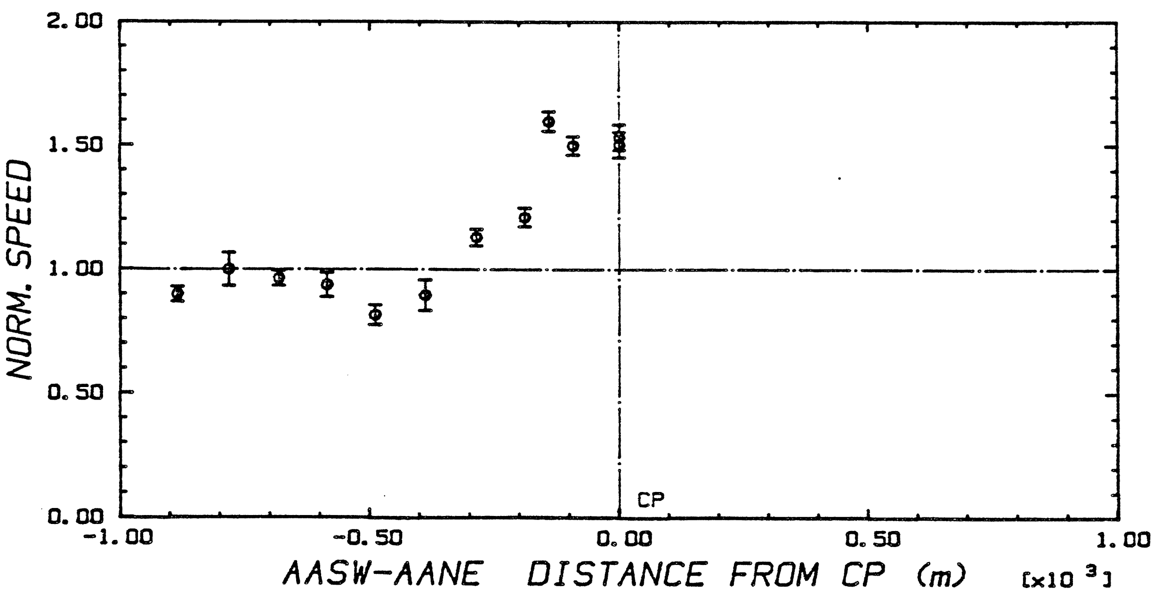


A3MF MF09-C Oct.9(JD282) 21:30-22:30 9.1m/s 268deg 3.m

Fig. 3.4 (cont.)

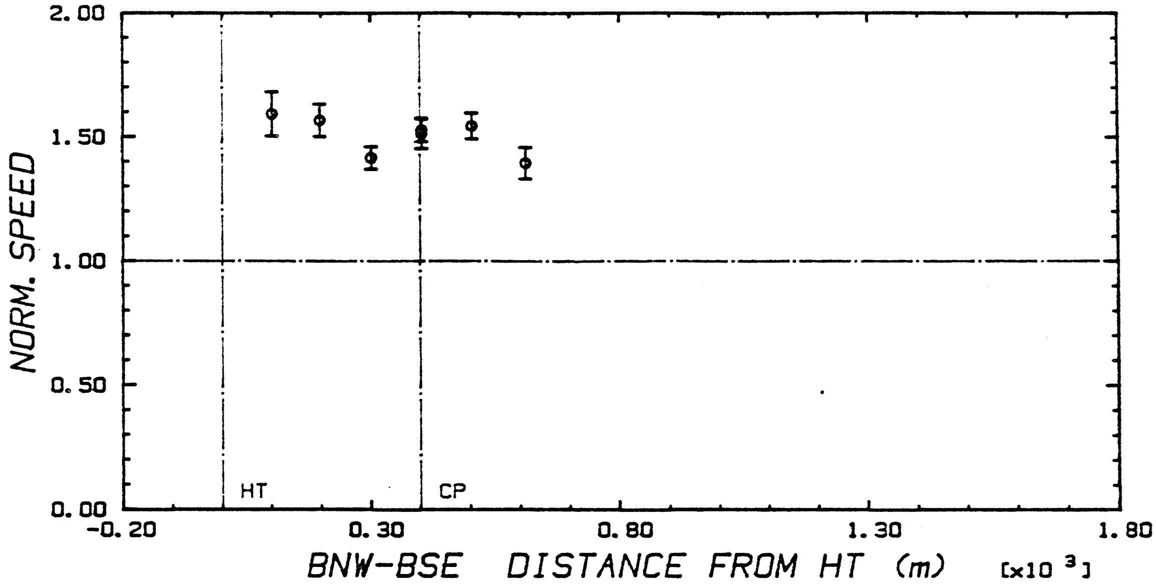


A3MF MF10-A Oct. 10 (JD283) 00:30-02:00 9.0m/s 263deg 3.m

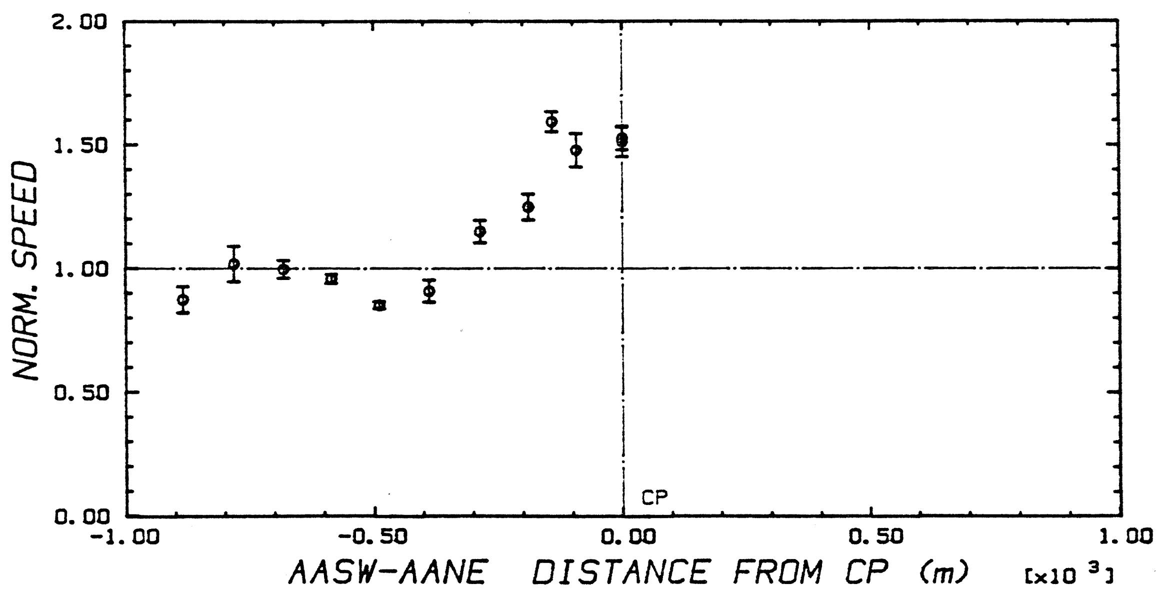


A3MF MF10-A Oct. 10 (JD283) 00:30-02:00 9.0m/s 263deg 3.m

Fig. 3.4 (cont.)



A3MF MF10-B Oct.10(JD283) 02:30-03:30 8.8m/s 265deg 3.m



A3MF MF10-B Oct.10(JD283) 02:30-03:30 8.8m/s 265deg 3.m

Fig. 3.4 (cont.)

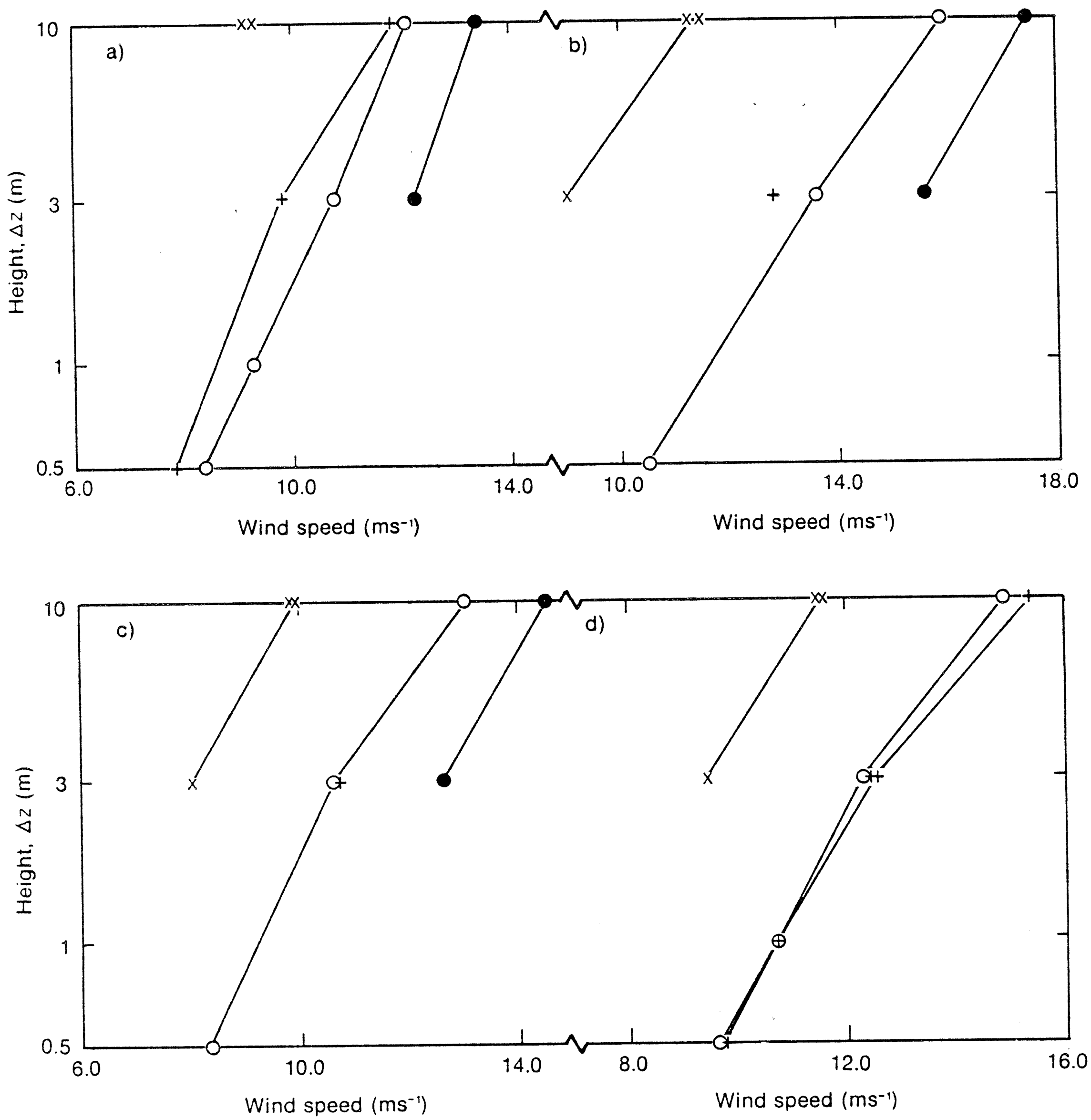


Fig. 3.5 Wind Speed Profiles from MF Posts for Selected Runs

a) MF07A, ϕ_{RS} = 260° b) MF07D, ϕ_{RS} = 270°
c) MF08, ϕ_{RS} = 280° d) MF09A, ϕ_{RS} = 275°
e) MF09B, ϕ_{RS} = 283° f) MF09C, ϕ_{RS} = 268°
g) MF10A, ϕ_{RS} = 263° h) MF10B, ϕ_{RS} = 265°

x RS
○ BSE10
+ CP (=BSE40)
● HT

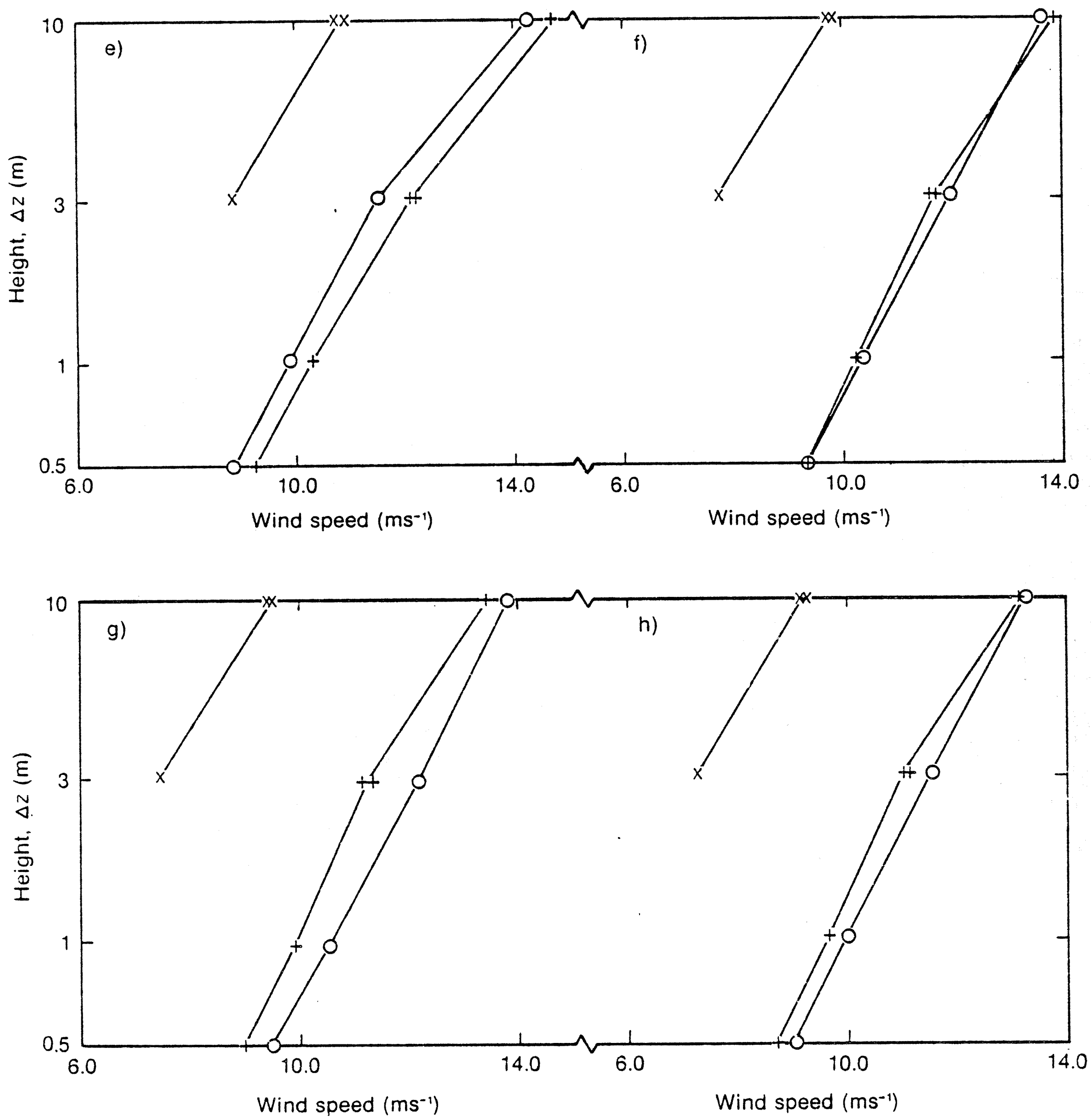


Fig. 3.5 (continued)

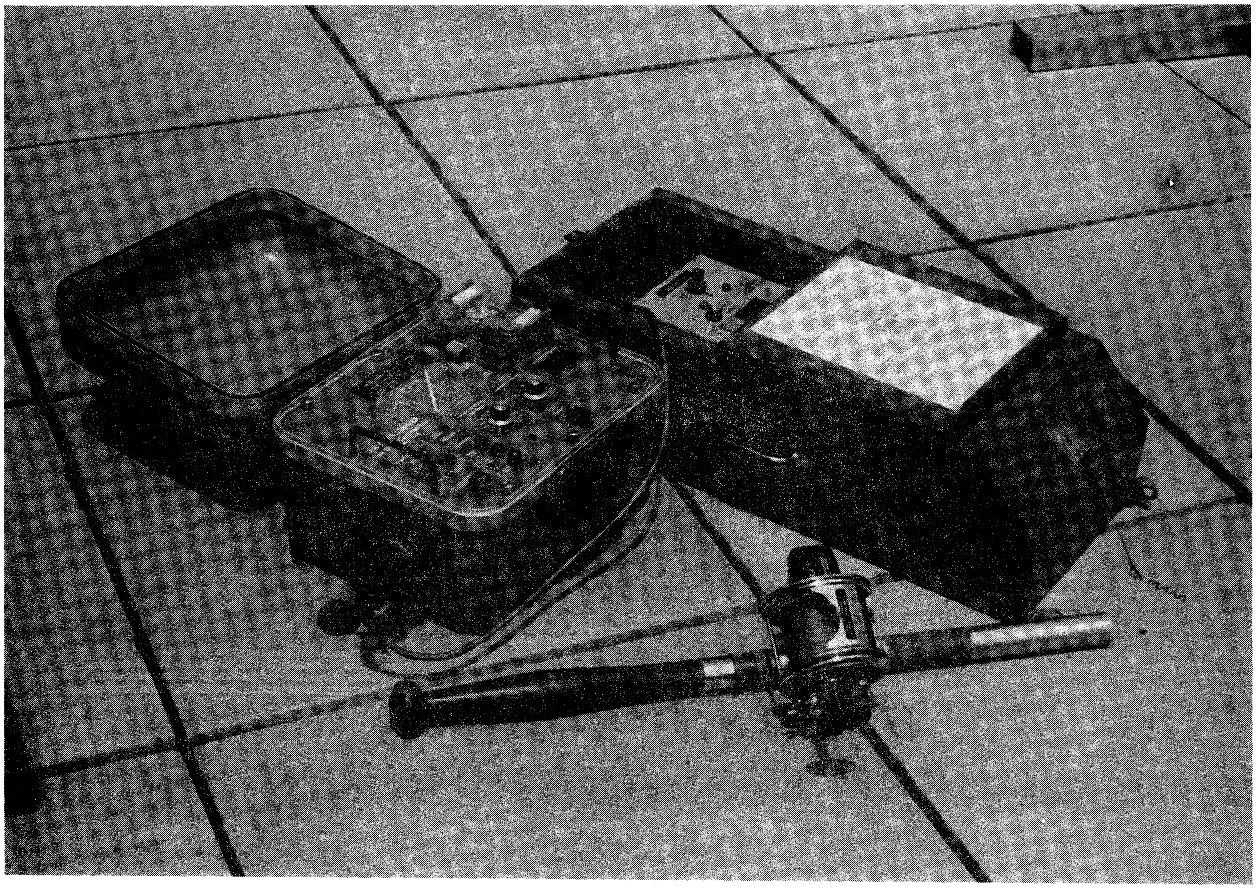


Fig. 3.6(a) AES TALA Kite Data Acquisition System

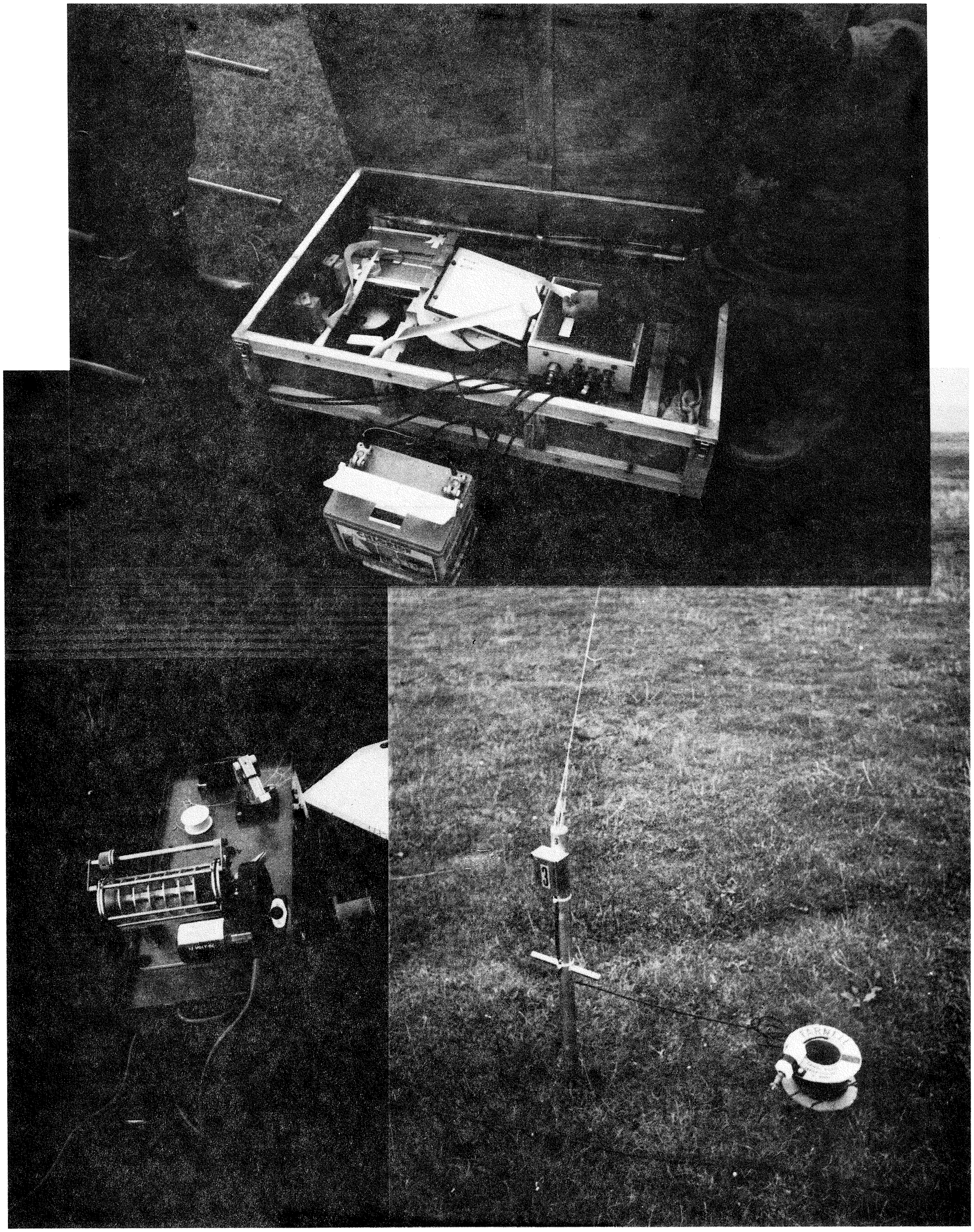
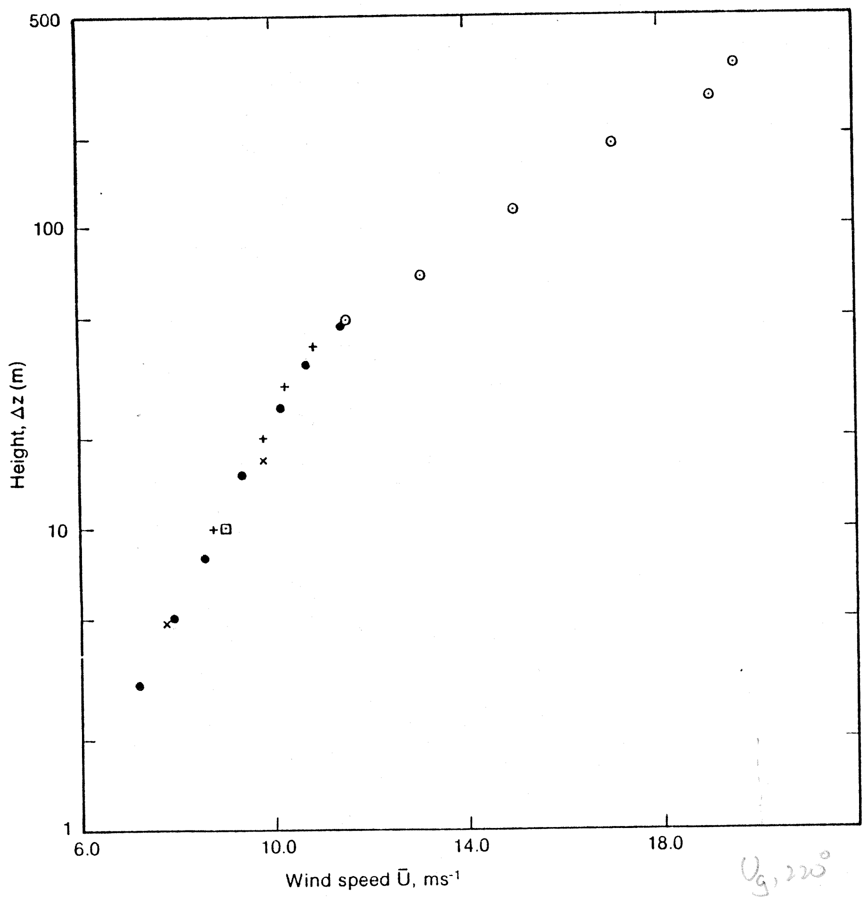
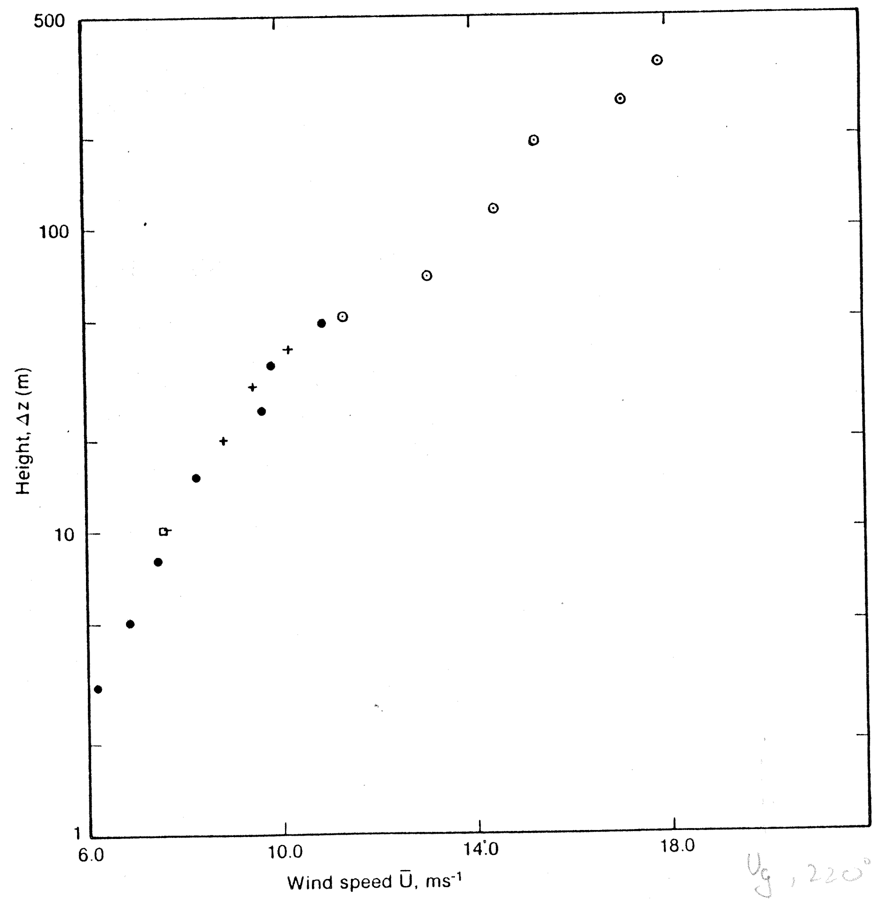


Fig. 3.6(b) BRE TALA Kite System - see text for details



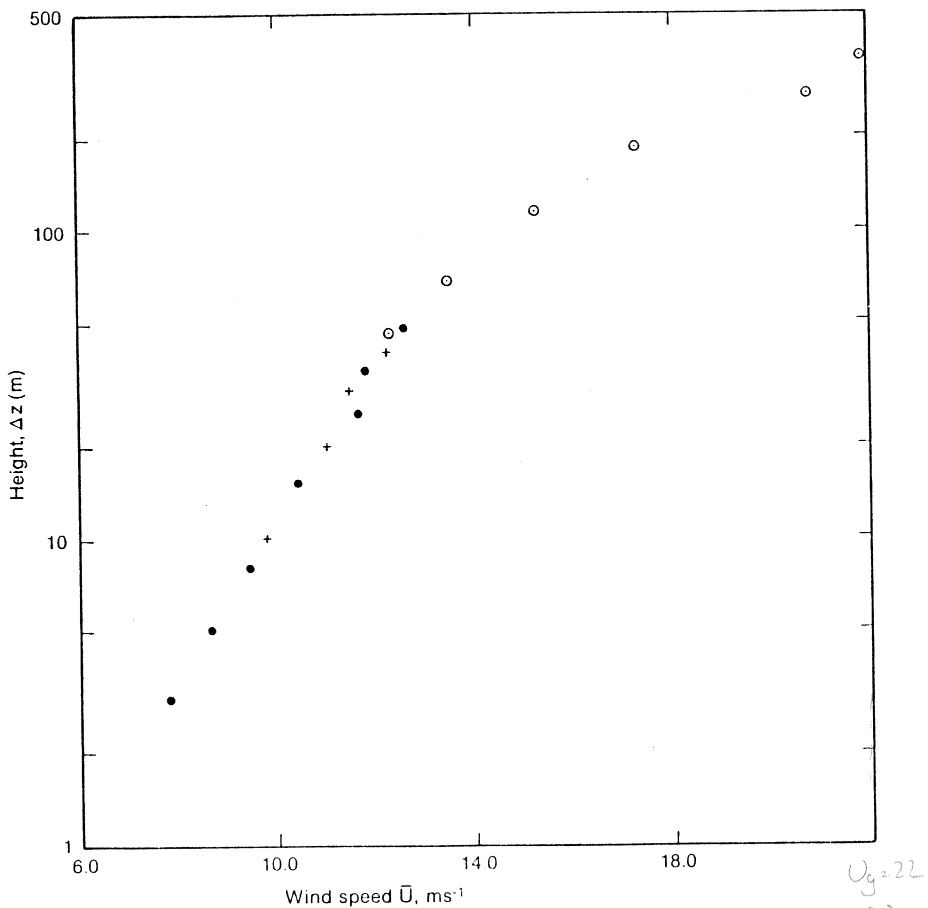
a) TK01a, ϕ_{RS} = 180°, z_o = 0.021m
15.00 - 16.00



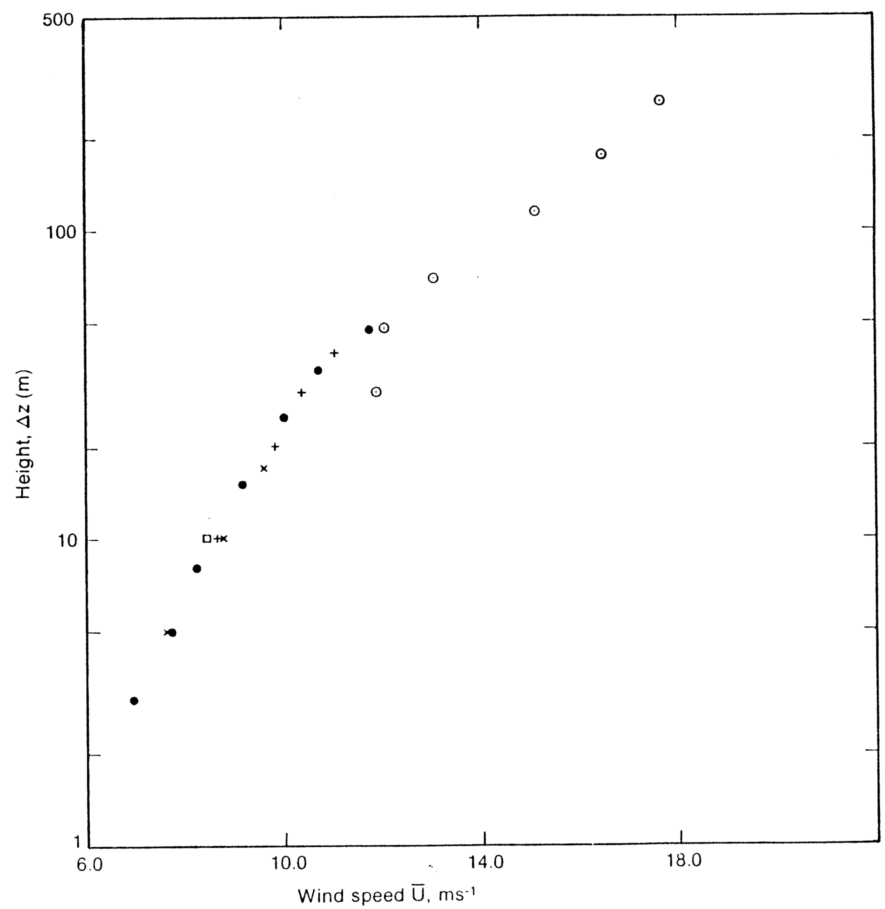
b) TK01b, ϕ_{RS} = 180°, z_o = 0.030m
16.30 - 17.30

Fig. 3.7 Upstream velocity profiles from the BRE TALA Kite System and Towers at RS. Run Numbers, RS Wind Directions (Δz=10m) and z_o values estimated from the lowest 50m of the profile are given below each graph.

- o BRE TALA Kite Data - with line drag correction
- • Cup anemometer data from the 50m and 10m towers
- + Tilted Gill Data from 50m Tower
- □ 10m Gill Data at RS
- x FRG 17m Tower, Cup Anemometer Data

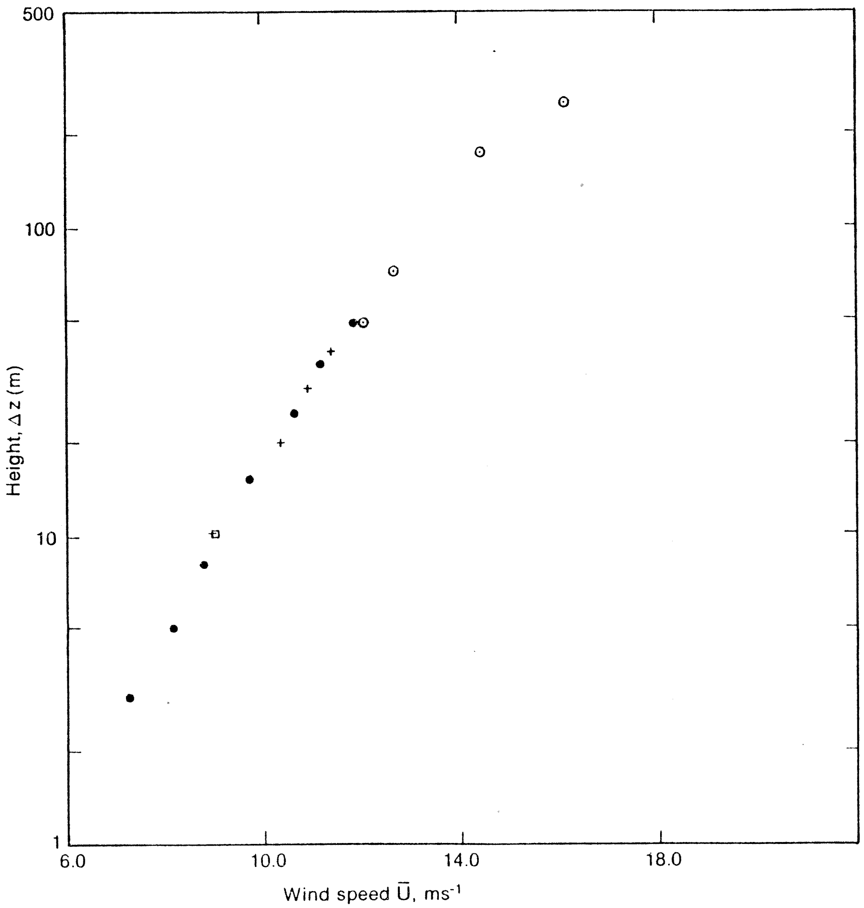


c) TK02b, ϕ_{RS} = 164°, z_o = 0.026m



d) TK03, ϕ_{RS} = 206°, z_o = 0.022m

Fig. 3.7 (cont.)



e) TK07a, Φ_{RS} = 238°, z_0 = 0.024m

Fig. 3.7 (cont.)

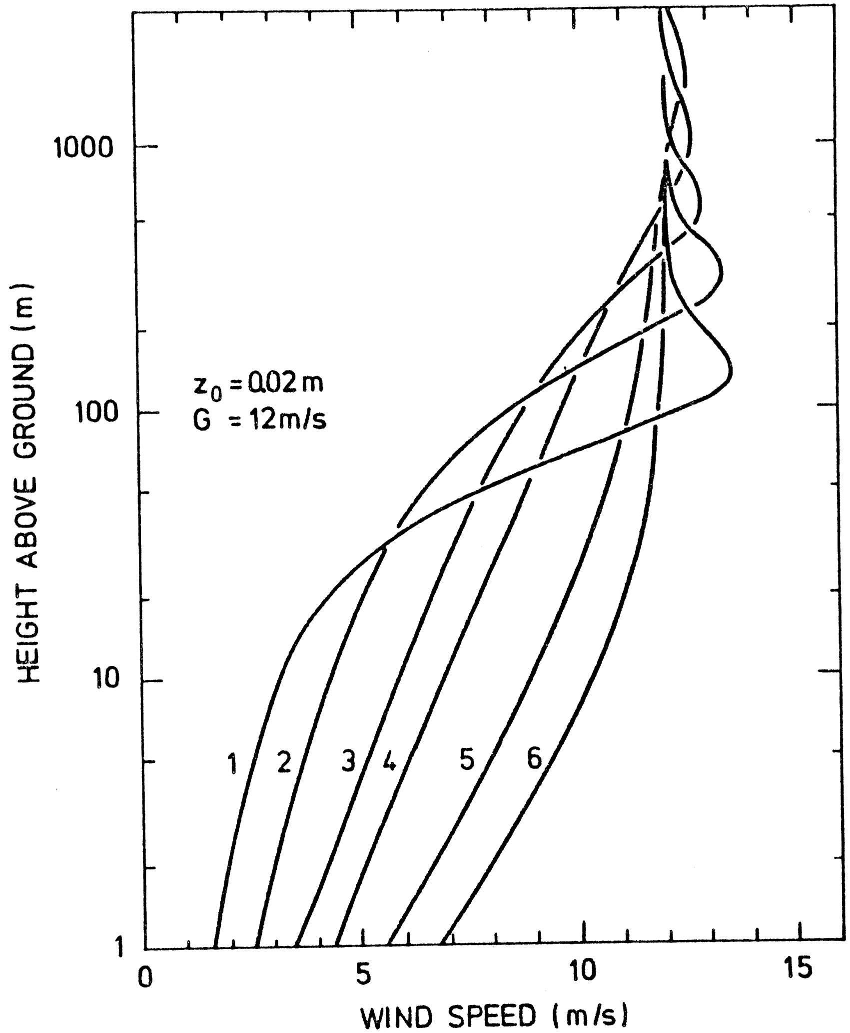
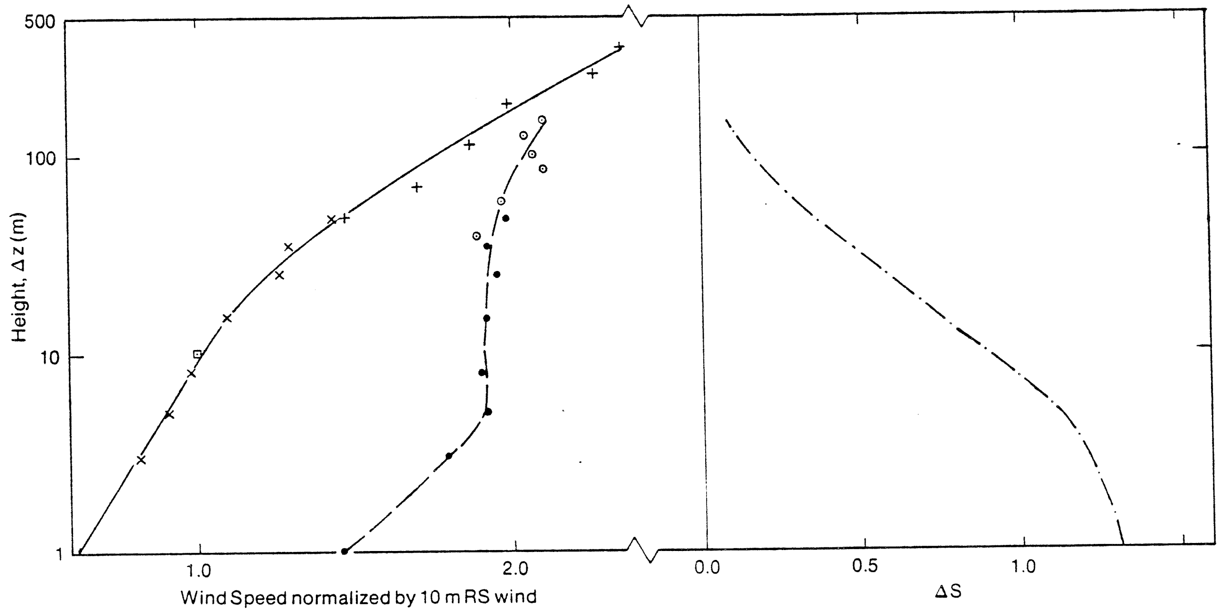
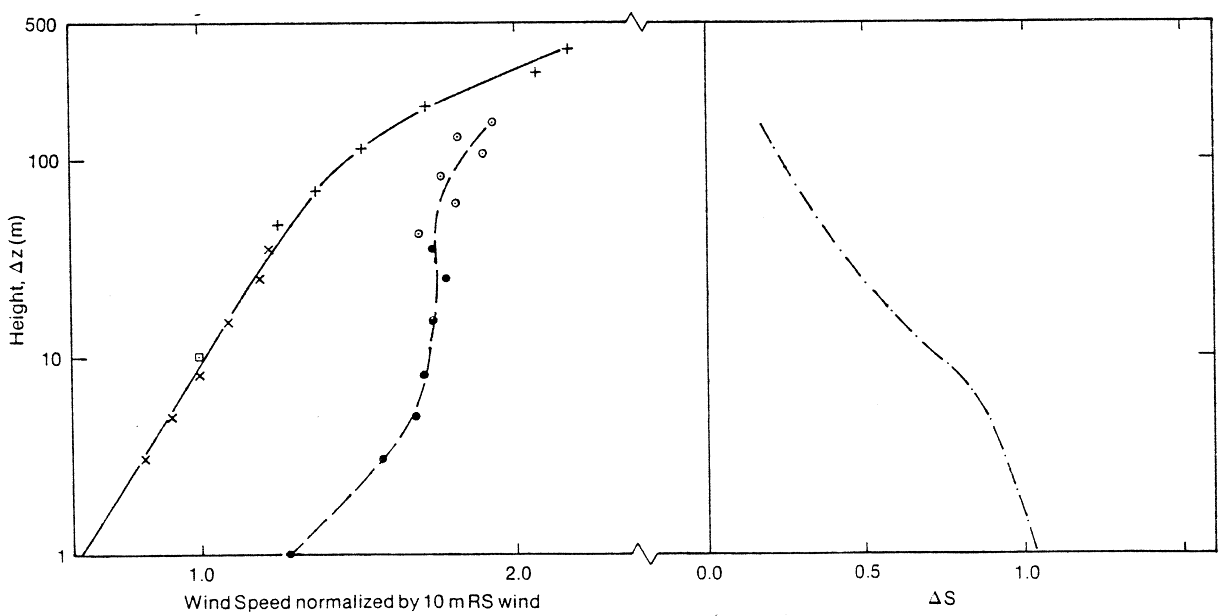


Fig. 3.8

Theoretical Wind Speed Profiles from a PBL Model for a range of stabilities (Strongly Stable(1)→Neutral(4)→Strongly Unstable(6)), after Jensen et al. (1984).



a) TK01b, ϕ_{RS} = 180°, U_{RS}(10m) = 7.7 ms^{-1}



b) TK02a, ϕ_{RS} = 165°, U_{RS}(10m) = 9.4 ms^{-1}
(Upstream Kite Data 13.00-14.00 only)

Fig. 3.9 TALA and Tower Normalized Velocity Data for Upstream and Hilltop Locations.

- \+ Upstream TALA Kite
- o Hilltop TALA Kite
- x Upstream Tower, Cup Anemometers
- • Hilltop Tower, Cup Anemometers
- □ Gill UVW Anemometer at RS

ΔS values based on subjectively-drawn velocity profiles.

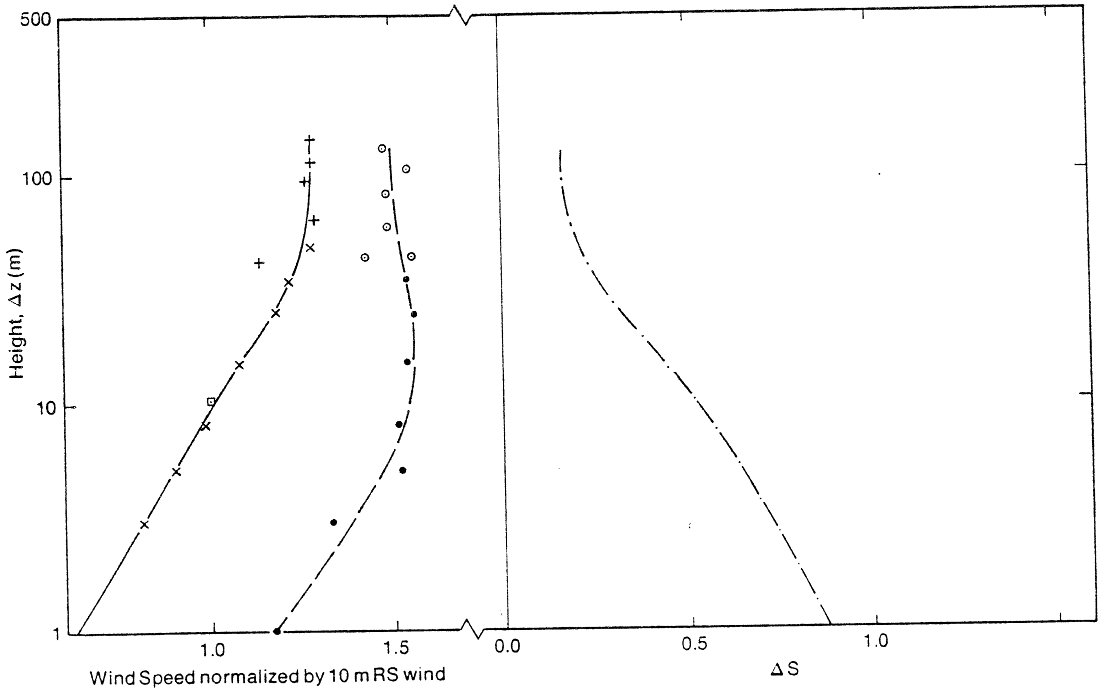
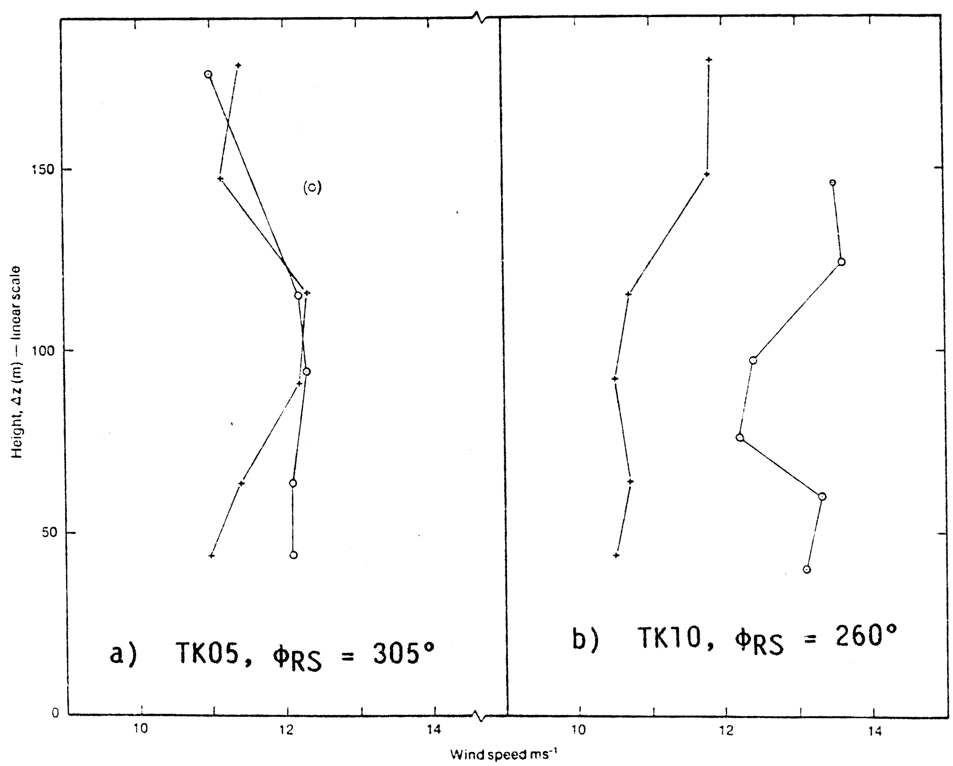


Fig. 3.9 (cont.) c) TK07b, ϕ_{RS} = 260°, $U_{RS}(10m)$ =10.1 ms^{-1}



+ Speeds at ASW85
o Speeds near Hilltop

Fig. 3.10 TALA kite profiles for runs without suitable surface normalization data - based on synchronous 15 min averages at each level.

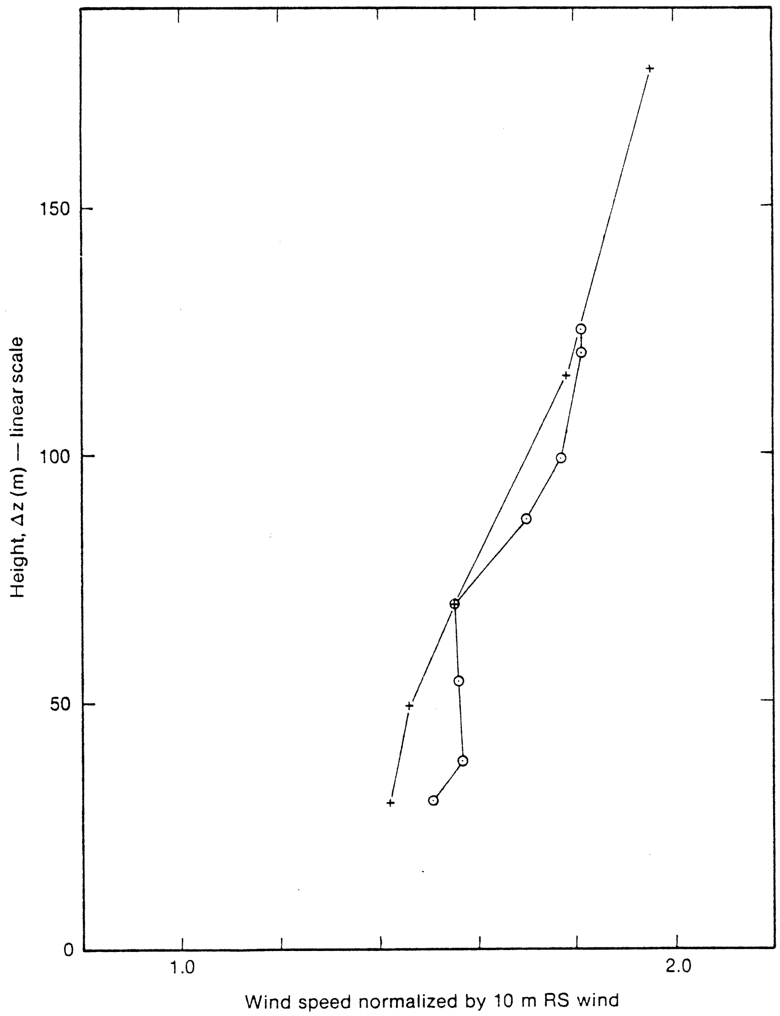


Fig. 3.11 Normalized TALA kite profiles for run TK03, ϕ = 205°, $U_{RS}(10m)$ = 8.4 ms^{-1}

- \+ BRE multi kite profile at Coastal Machair Site (2 hr average)
- o Single kite profile at location approx 230m N of CP on downwind face of hill - normalized against 10m windspeeds at HT. (15 min averages at each level)

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Figs. 4.1 Vertical mean velocity and turbulence profiles at RS and HT during turbulence runs

Legend

	RS	HT
AES CUP ANEMOMETERS	○	●
AES TILTED GILLS	×	
AES VERTICAL GILLS (10 m)	□	■
MF POSTS (10 m)	△	▲

Notes

1) Data for these plots are tabulated in Tables A1.3, A1.6 and A1.7.

2) $\sigma \Rightarrow \sigma_u$ for Gills, σ_h for cups.

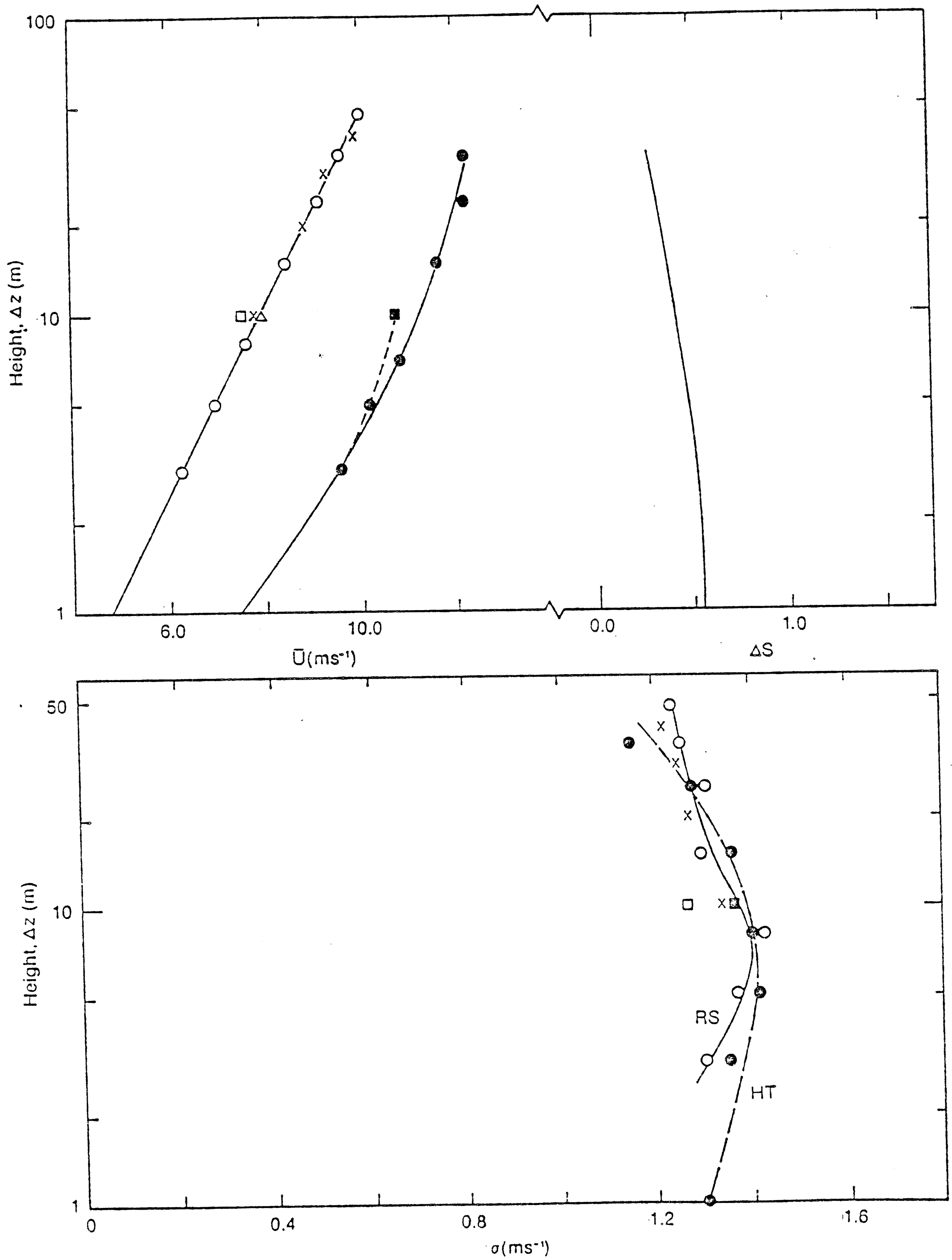


Fig. 4.1 (a) Run TU30-A: 30/09/83, 1130-1300 h, $135^{0}/7.8\ m\ s^{-1}$

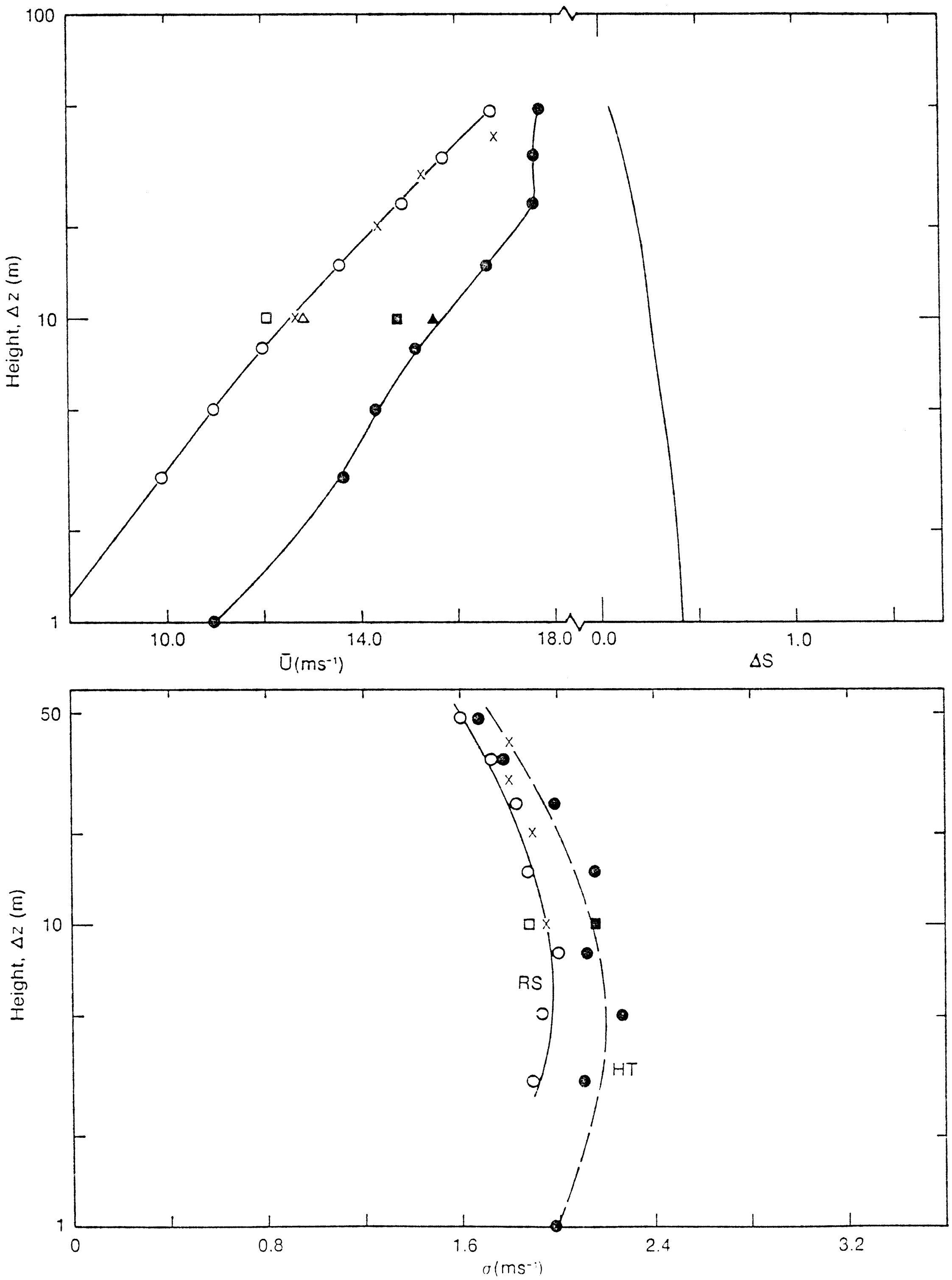


Fig. 4.1 (b) Run TU30-B: 30/09/83, 1600-1700 h, $130^{0}/13.0\ m\ s^{-1}$

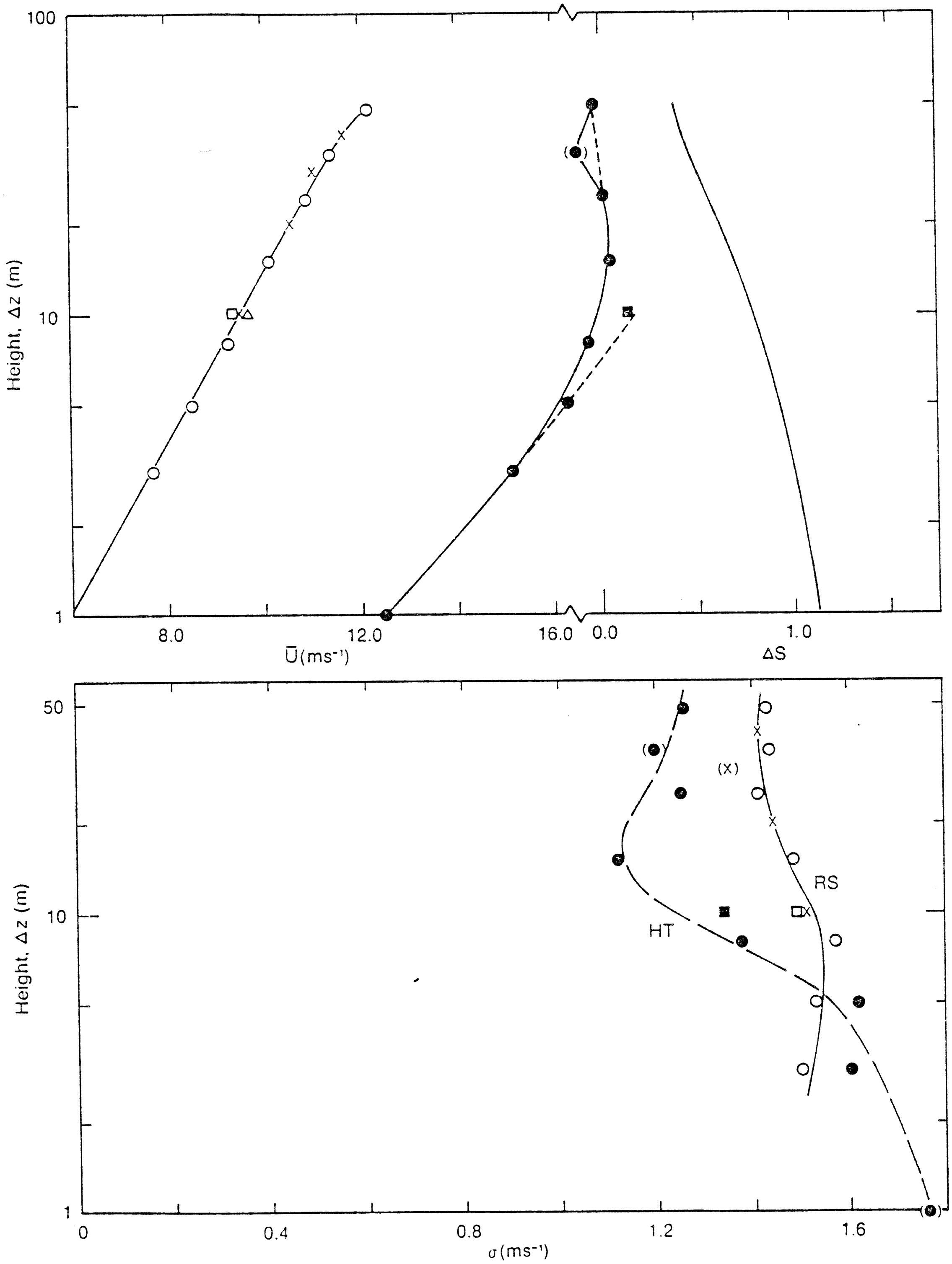


Fig. 4.1 (c) Run TU01-A: 01/10/83, 1200-1400 h, $170^{o}/9.2$ m s^{-1}

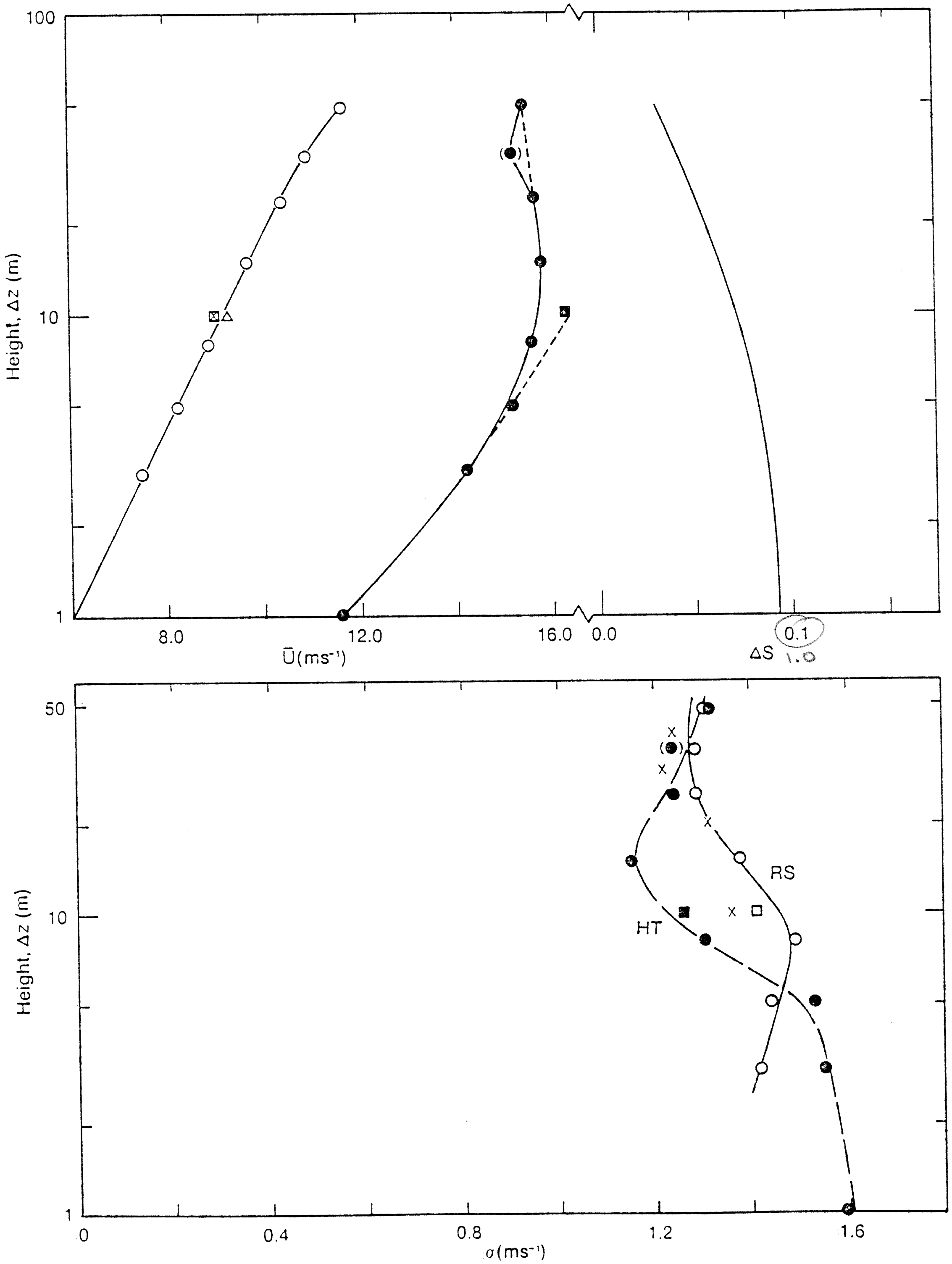


Fig. 4.1 (d) Run TU01-B: 01/10/83, 1400-1600 h, $180^{o}/9.0\ m\ s^{-1}$

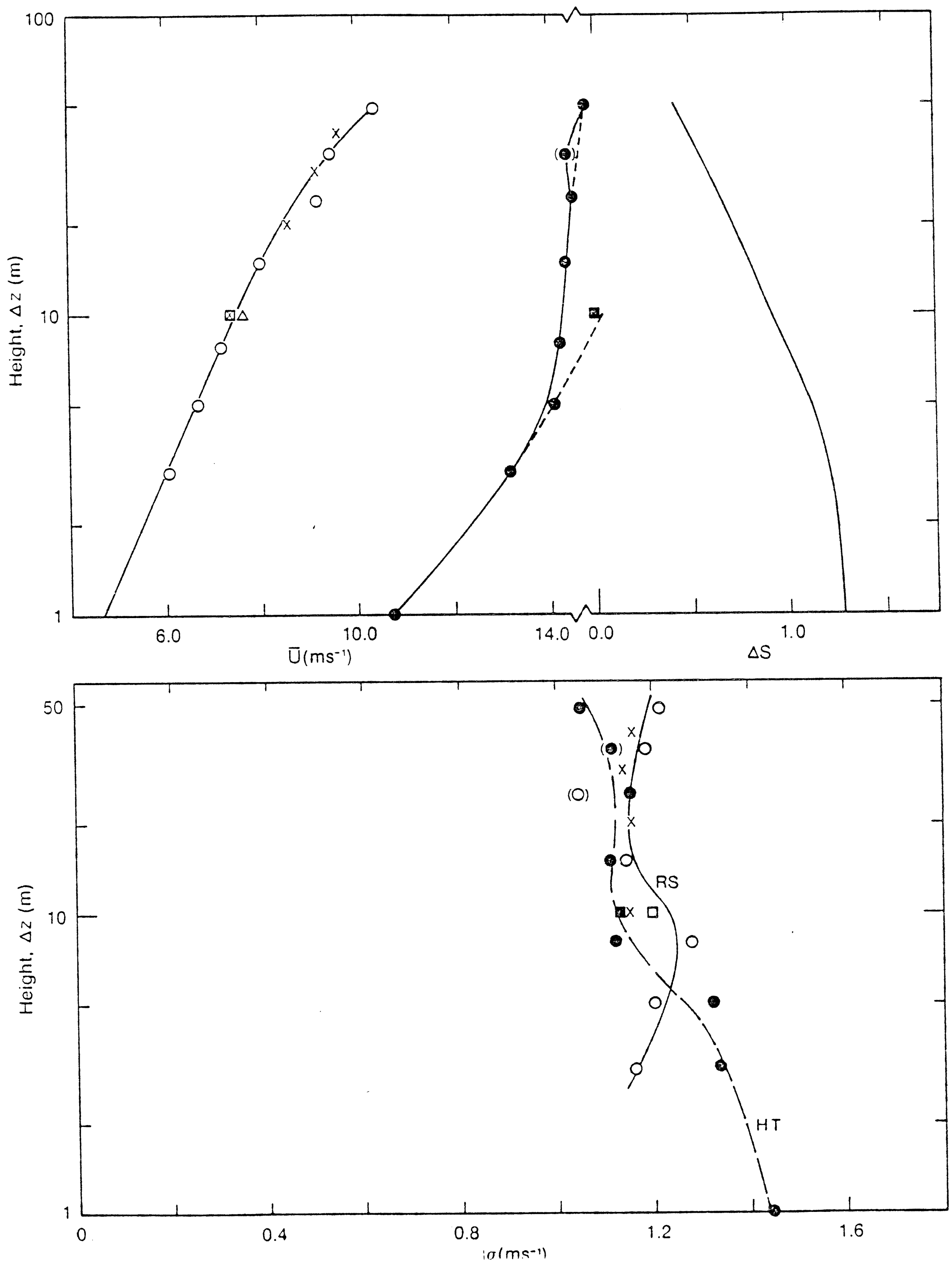


Fig. 4.1 (e) Run TU01-C: 01/10/83, 1700-1830, $185^{o}/7.5\ m\ s^{-1}$

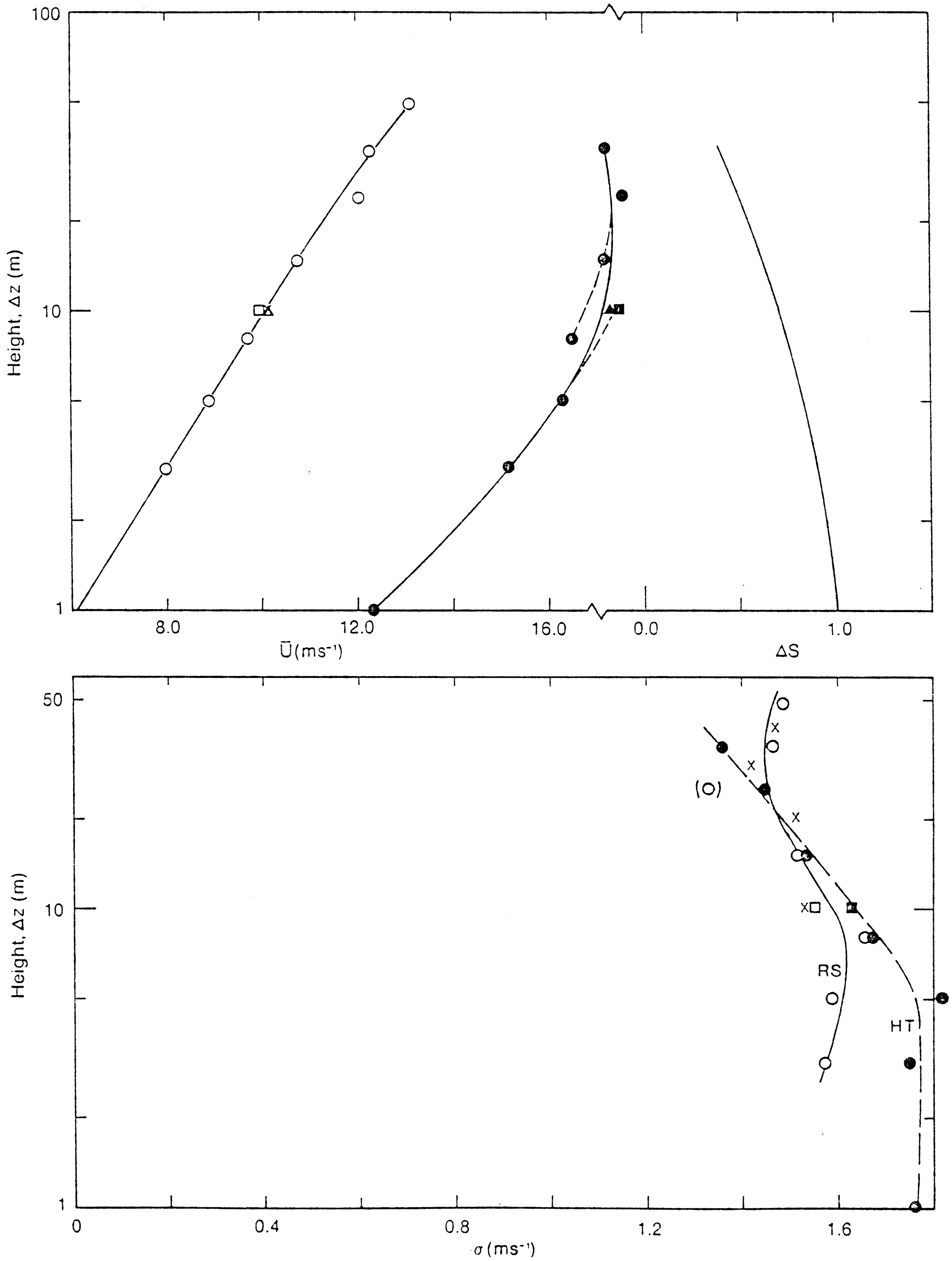


Fig. 4.1 (f) Run TU02: 02/10/83, 1400-1600 h, $165^{0}/10.0$ m s^{-1}

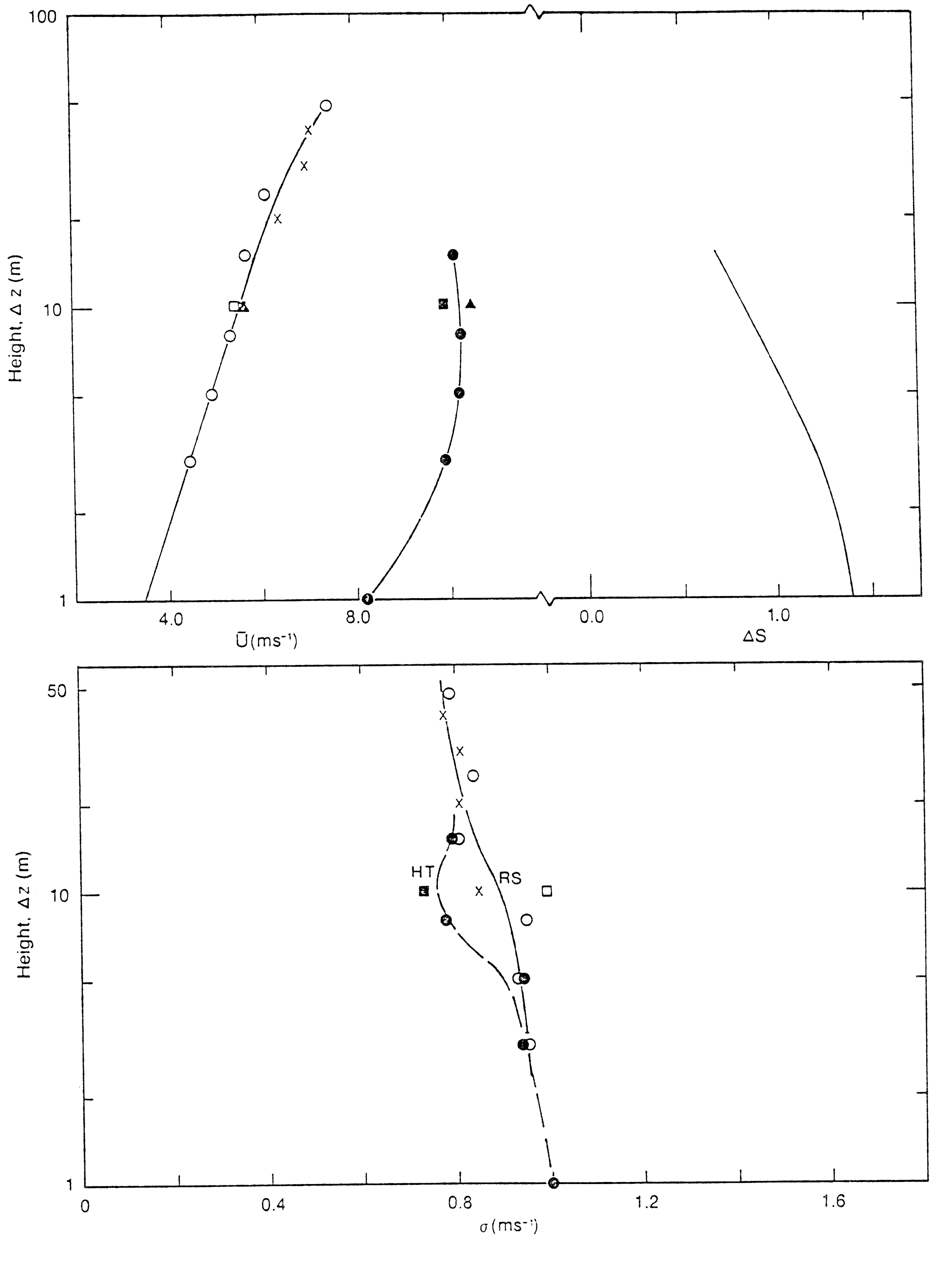
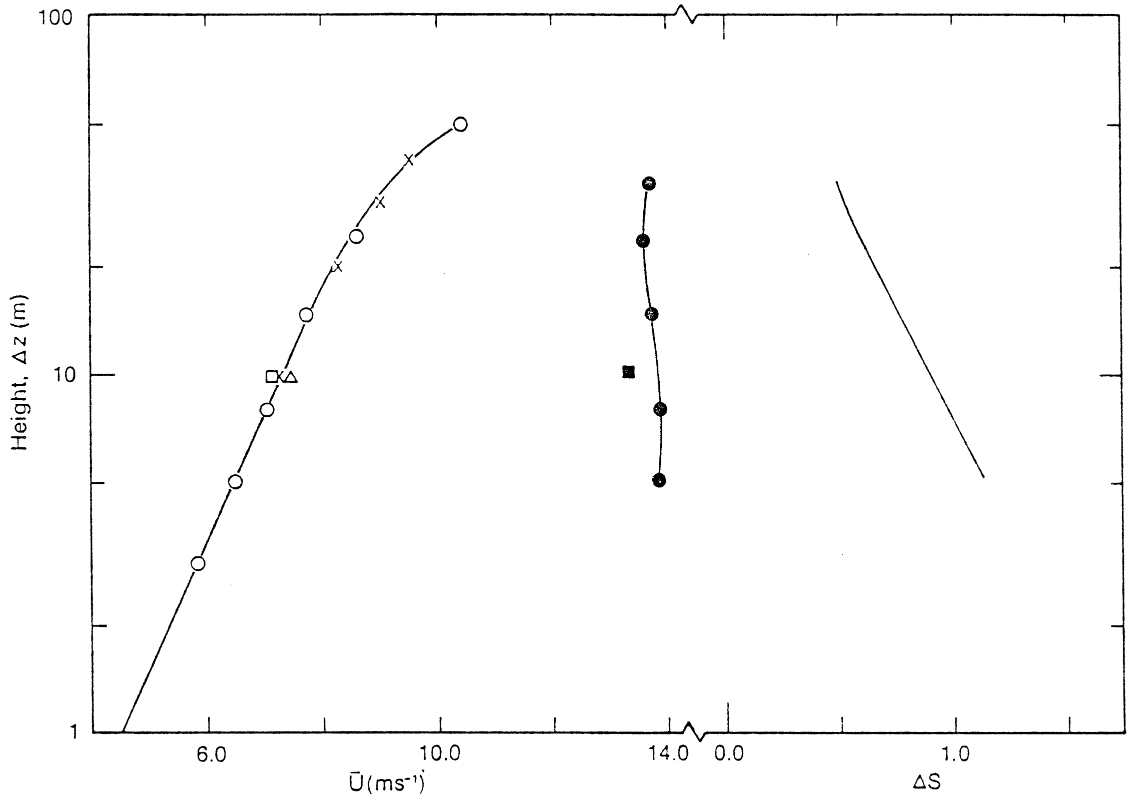


Fig. 4.1 (g) Run TU25: 25/09/83, 1600-1700 h, $210^{0}/5.5\ m\ s^{-1}$



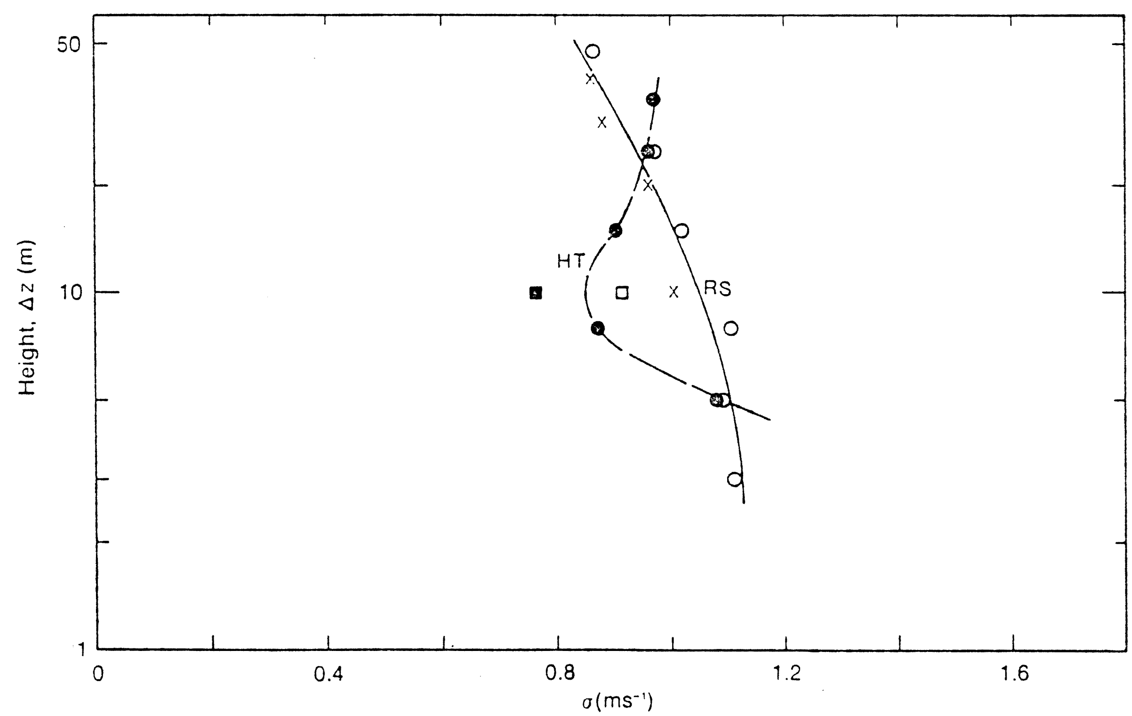


Fig. 4.1 (h) Run TU26: 26/09/83, 1000-1400 h, 220^0/7.0 m s^{-1}

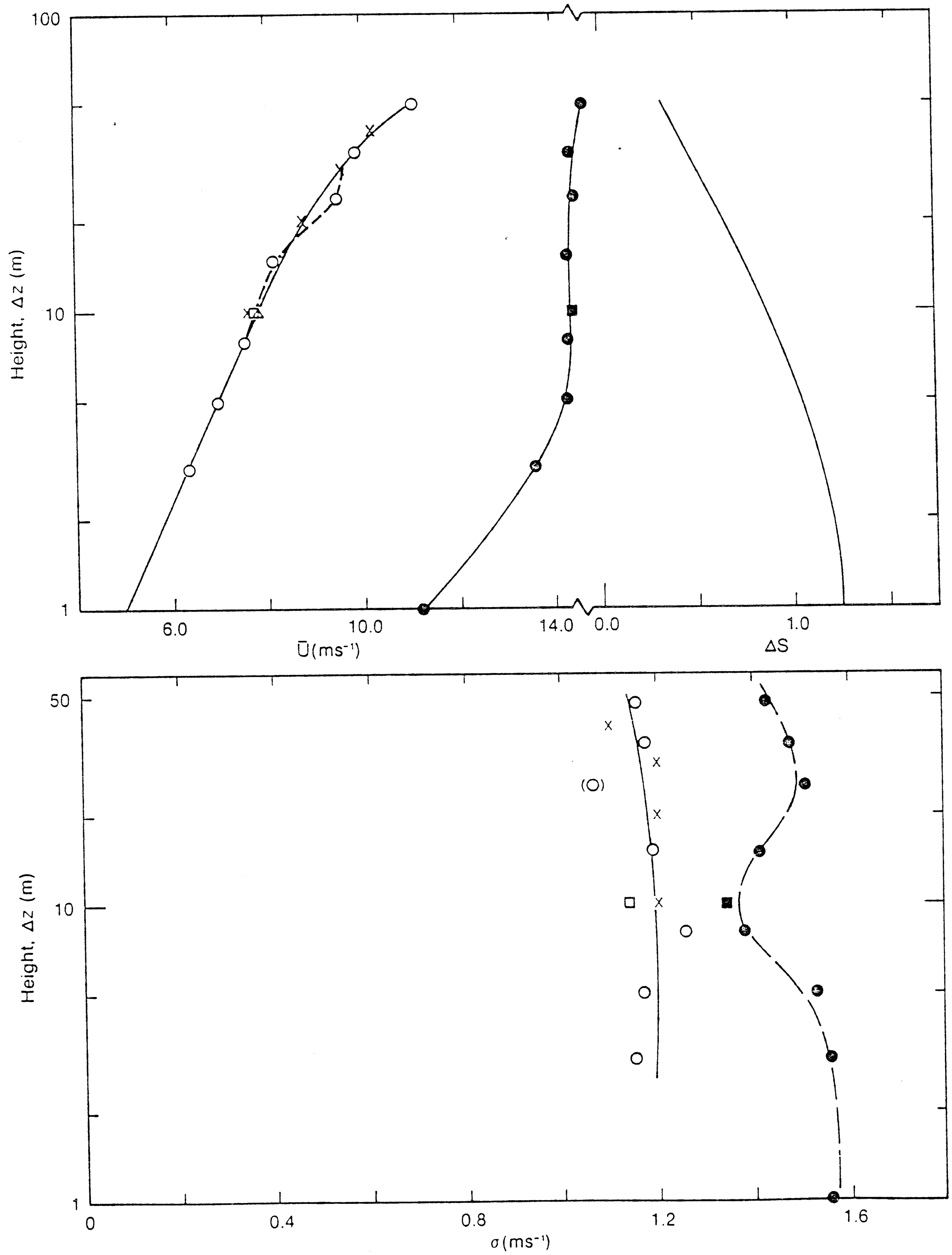
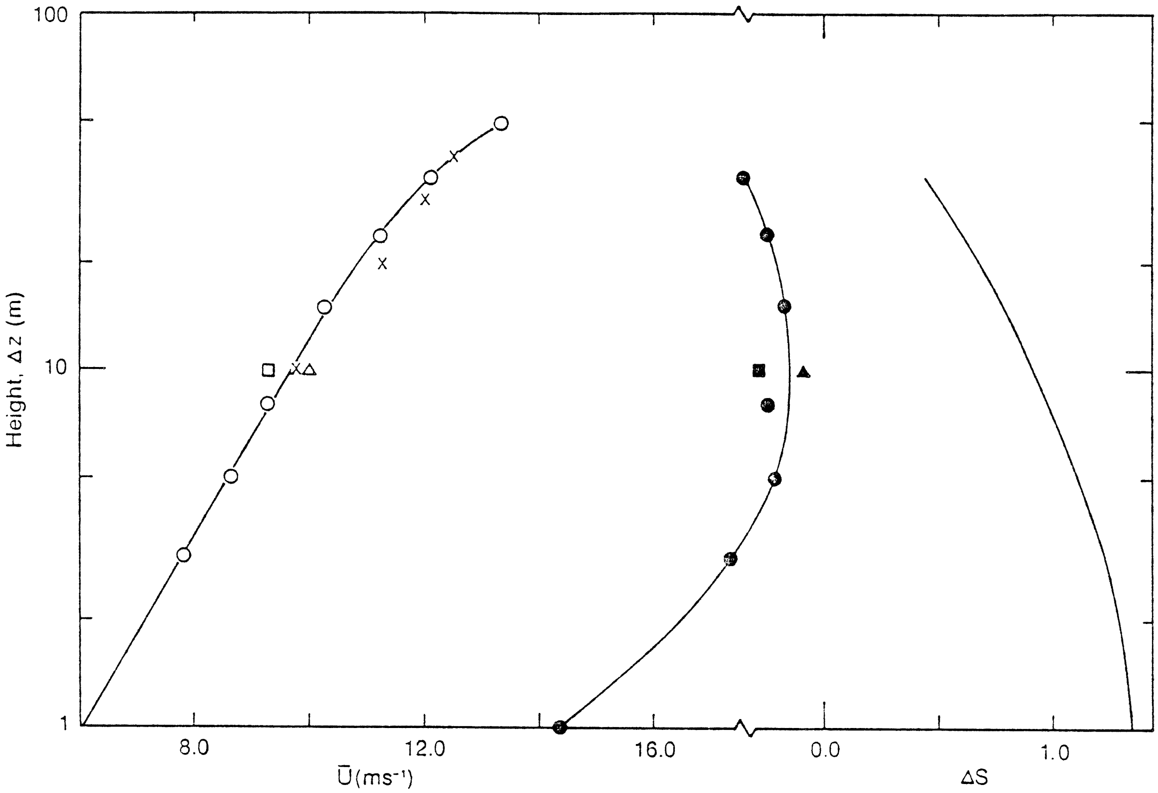


Fig. 4.1 (i) Run TU01-D: 01/10/83, 1930-2000 h, $200^{0}/7.5\ m\ s^{-1}$



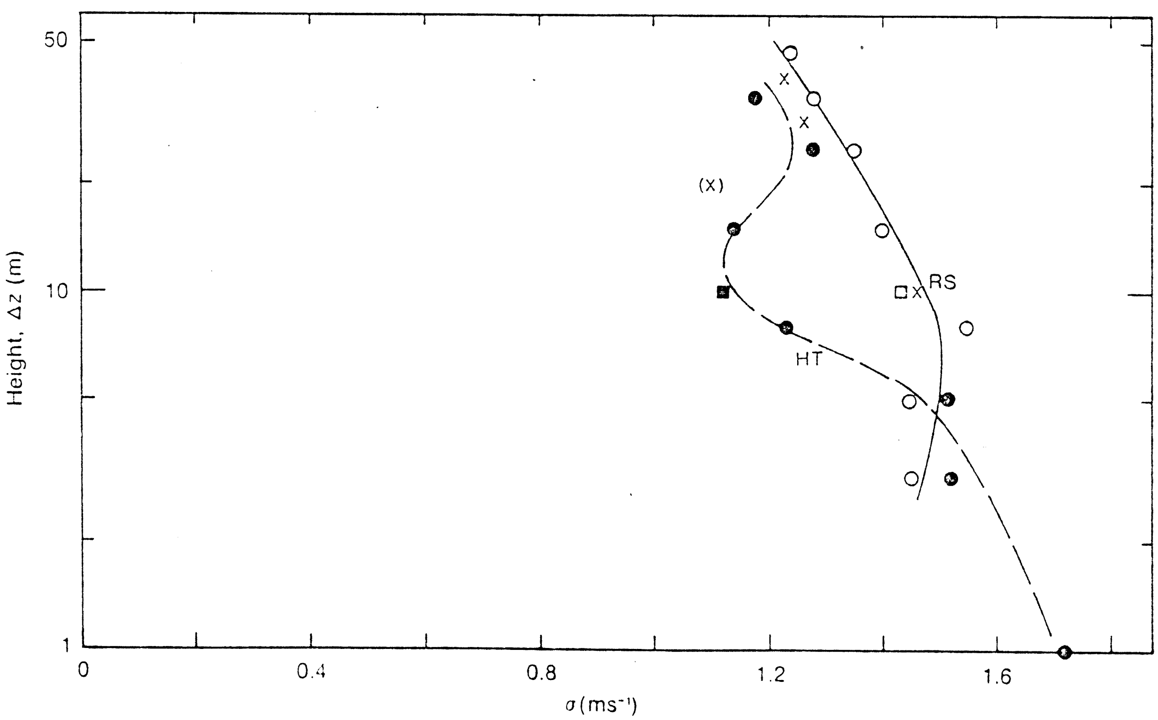


Fig. 4.1 (j) Run TU03-A: 03/10/83, 1200-1300 h, $210^{0}/9.8\ m\ s^{-1}$

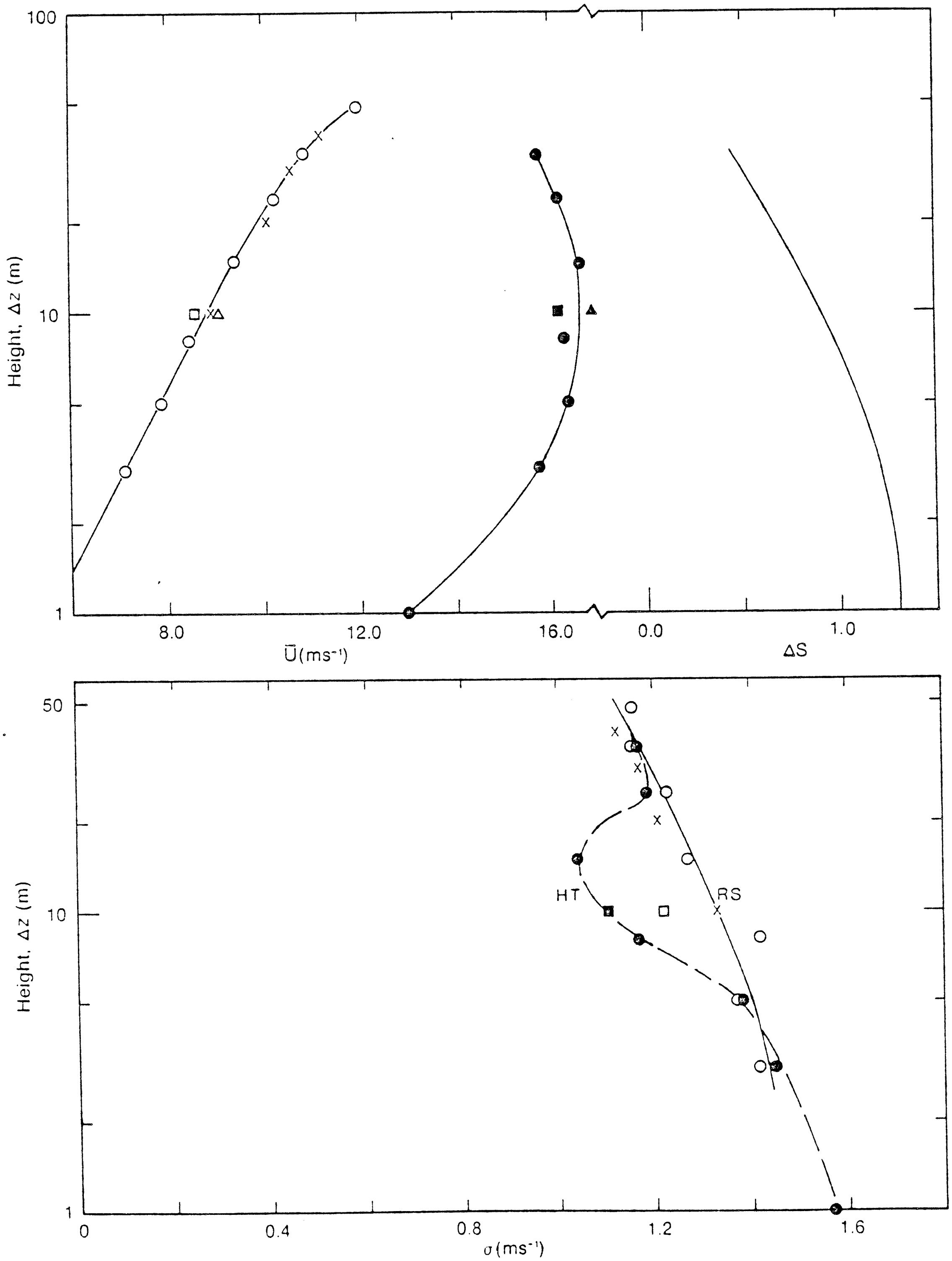


Fig. 4.1 (k) Run TU03-B: 03/10/83, 1400-1700 h, $210^0/8.9$ m s^{-1}

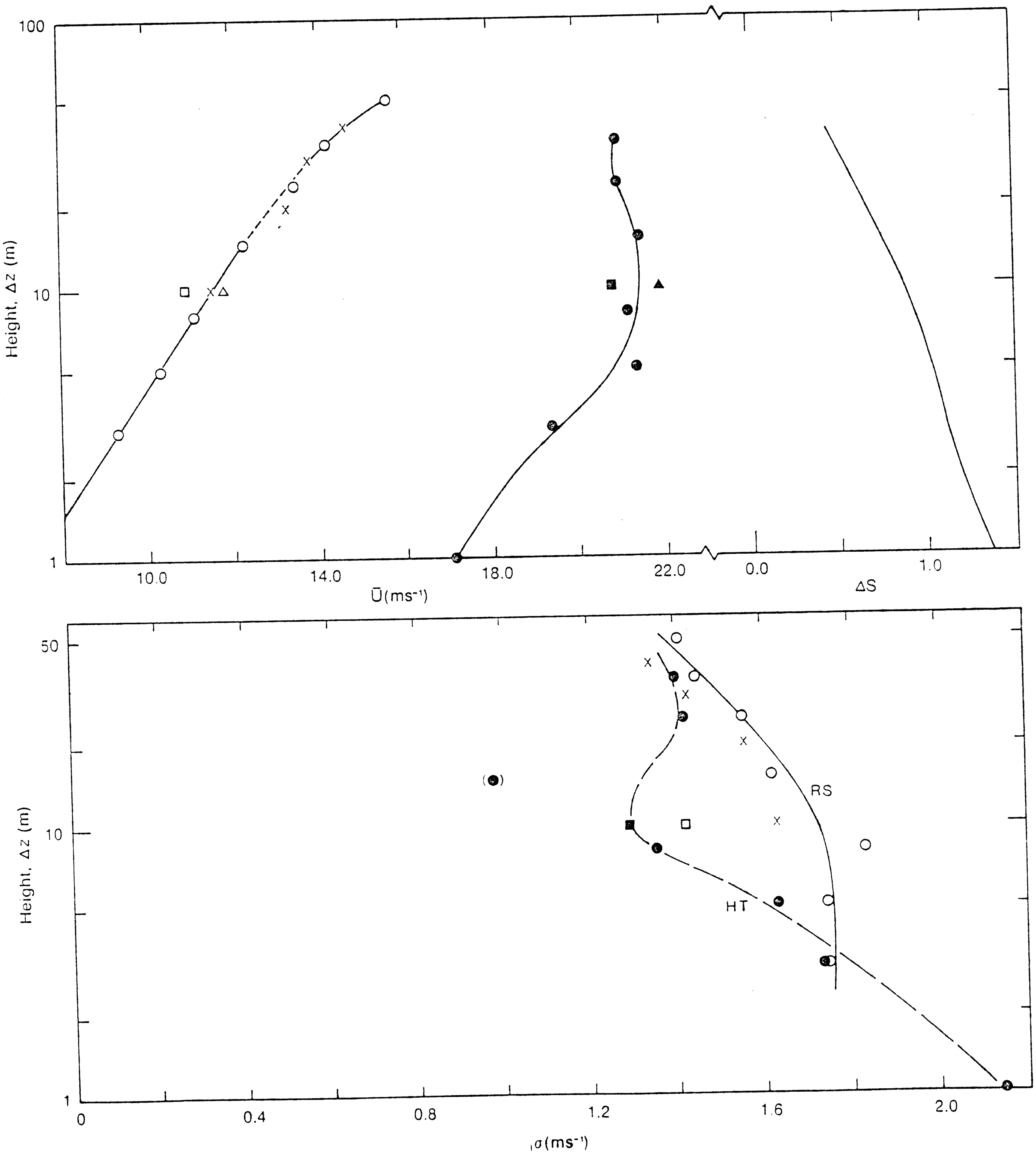


Fig. 4.1 (ℓ) Run TU06-A: 06/10/83, 1430-1600 h, 212°/11.0 m s $^{-1}$

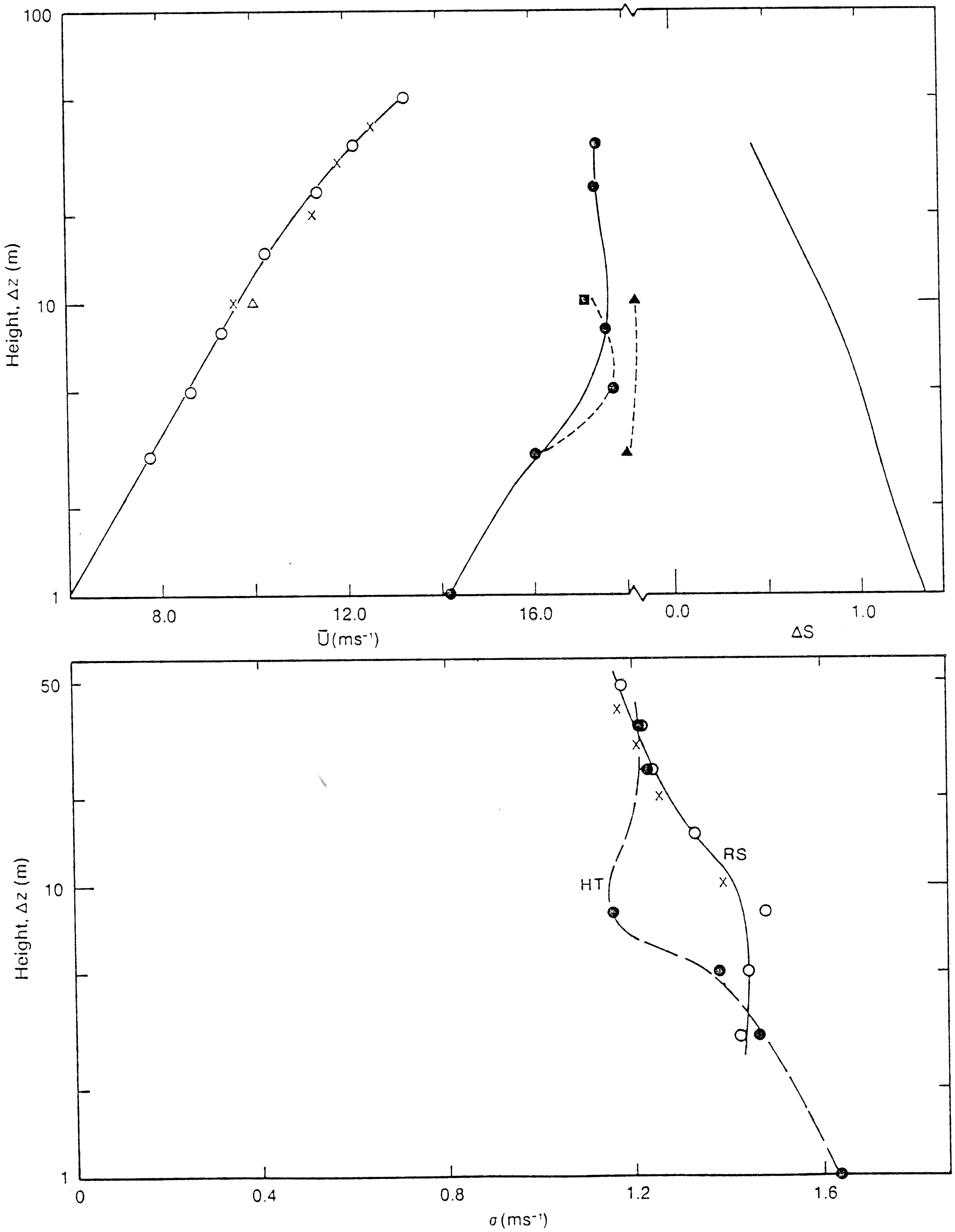


Fig. 4.1 (m) Run TU06-B: 06/10/83, 1700-1800 h, 228°/9.2 m s^{-1}

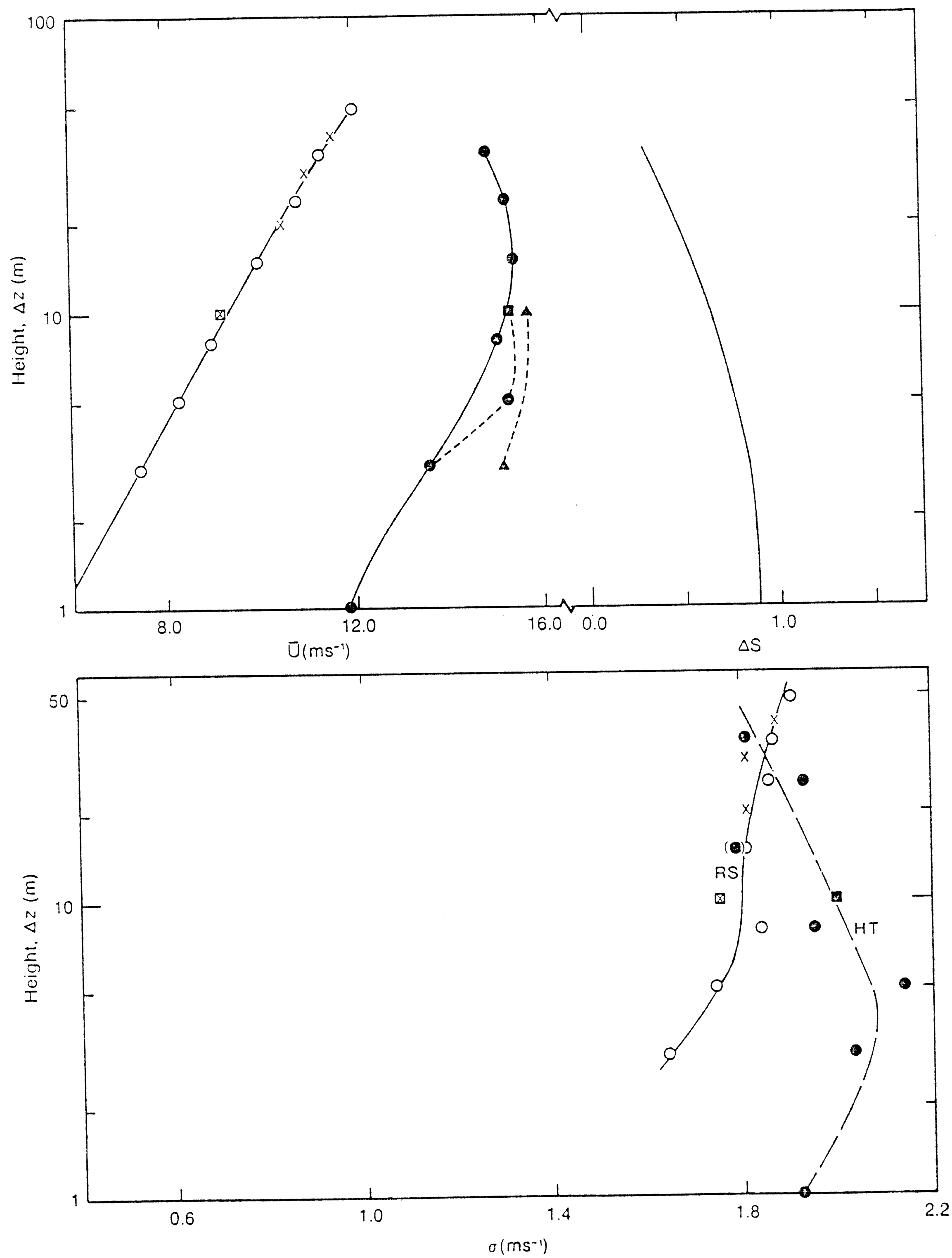


Fig. 4.1 (n) Run TU07-A: 07/10/83, 1200-1400 h, $240^{0}/9.0 \text{ m s}^{-1}$

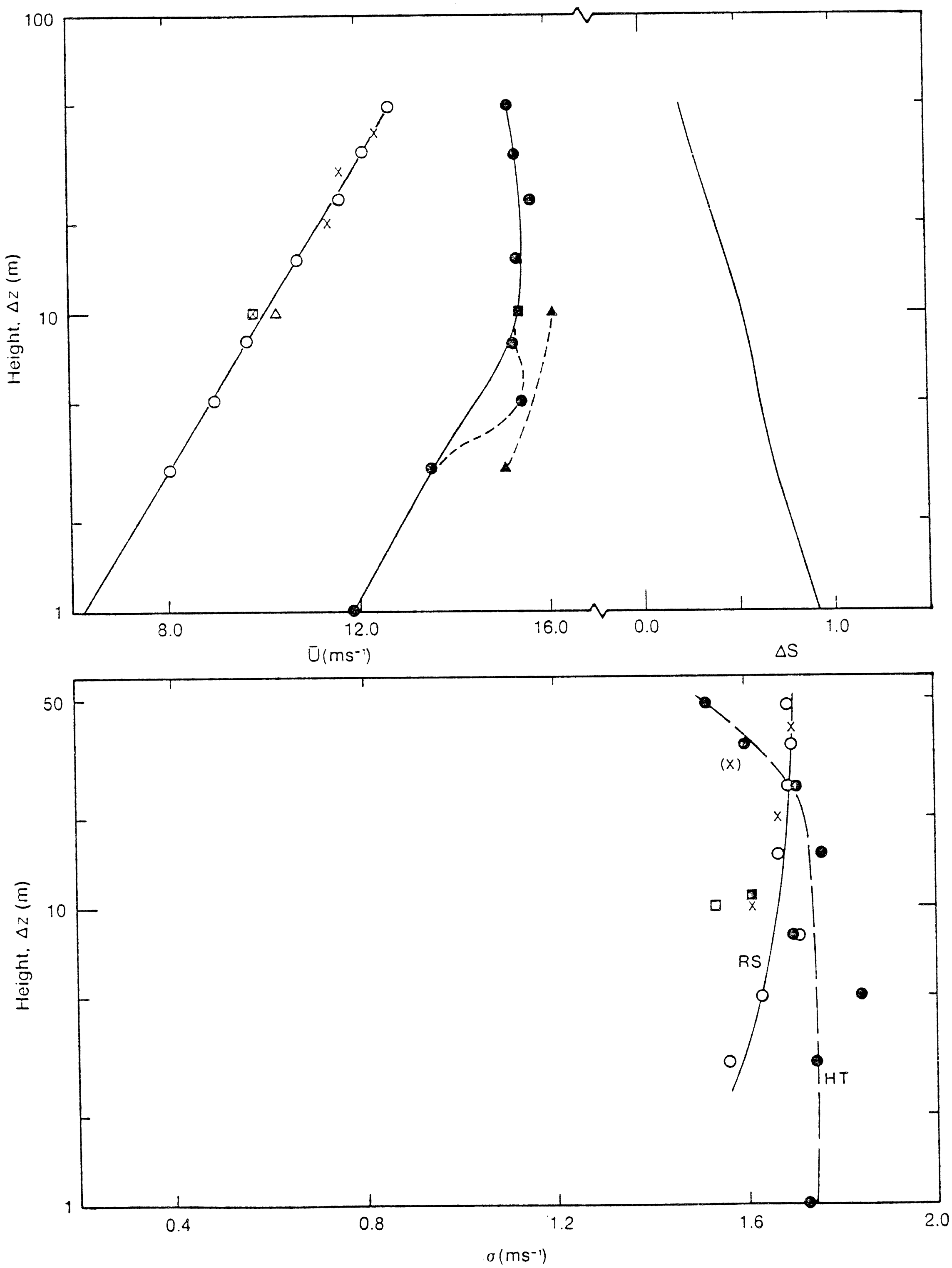


Fig. 4.1 (o) Run TU07-B: 07/10/83, 1530-1700 h, $260^{0}/10.0$ m s^{-1}

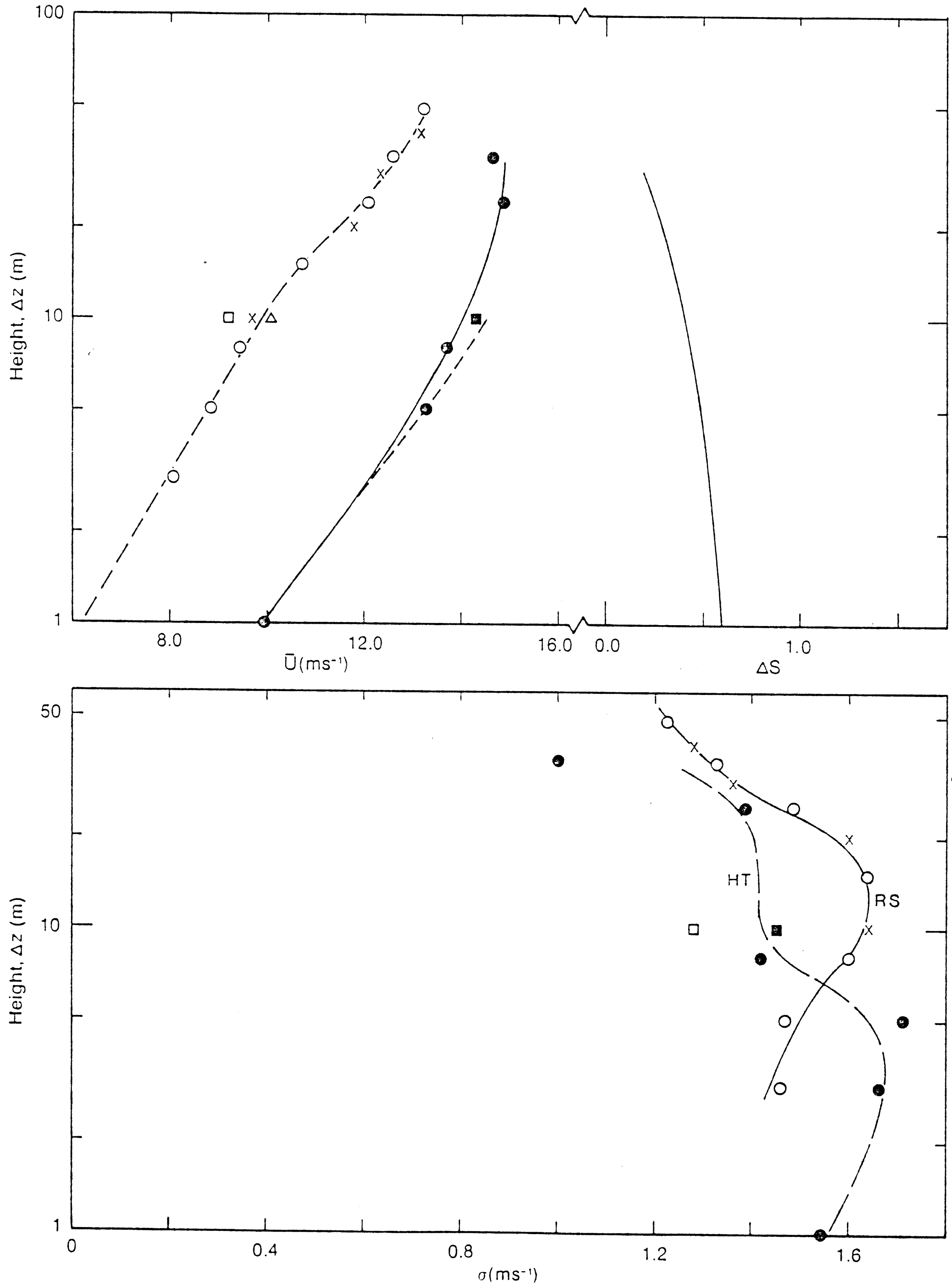


Fig. 4.1 (p) Run TU05-A: 05/10/83, 1030-1130 h, 285^{o}/9.5 m s^{-1}

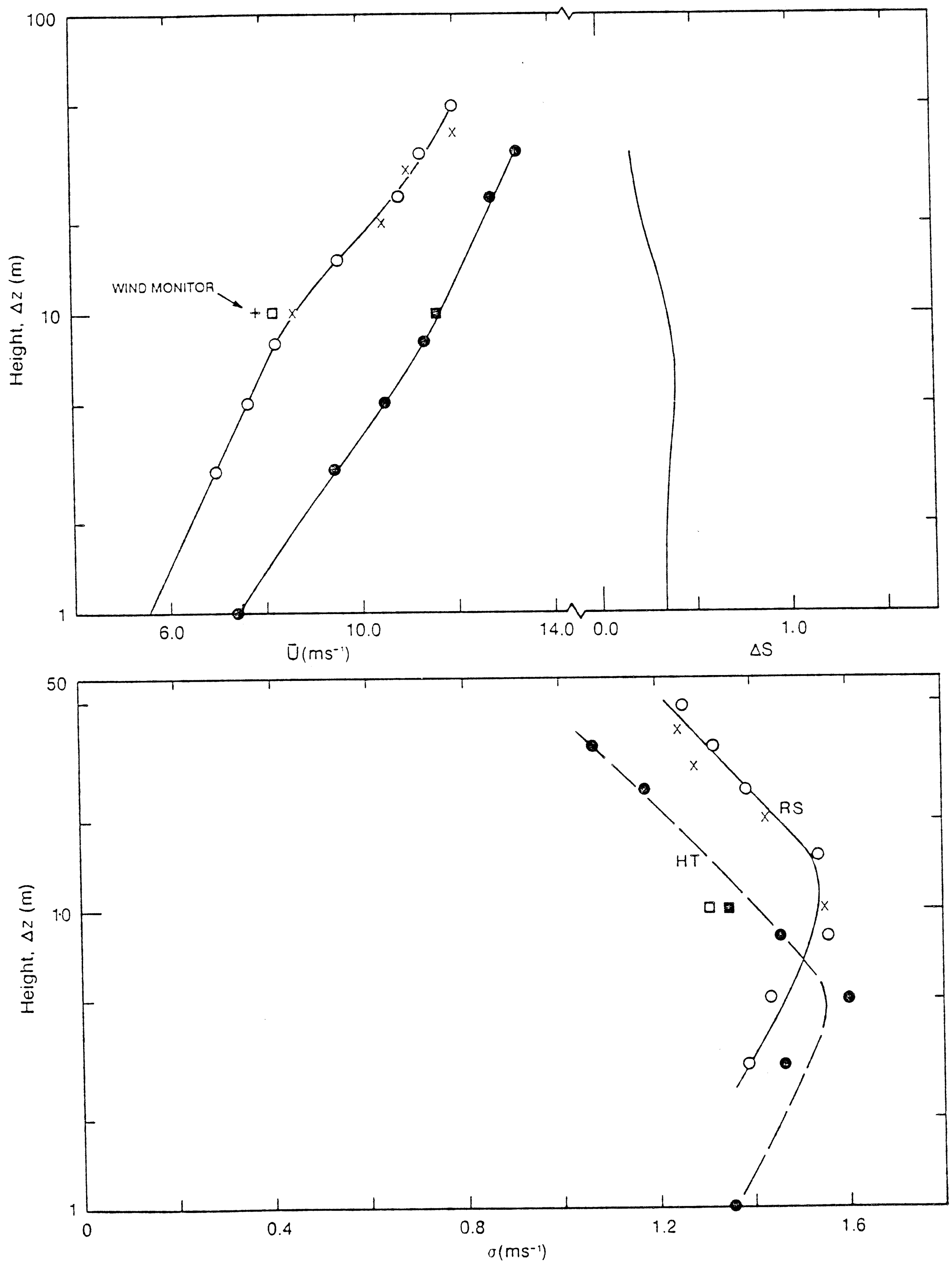


Fig. 4.1 (q) Run TU05-B: 05/10/83, 1330-1530 h, 305°/7.8 m s^{-1}

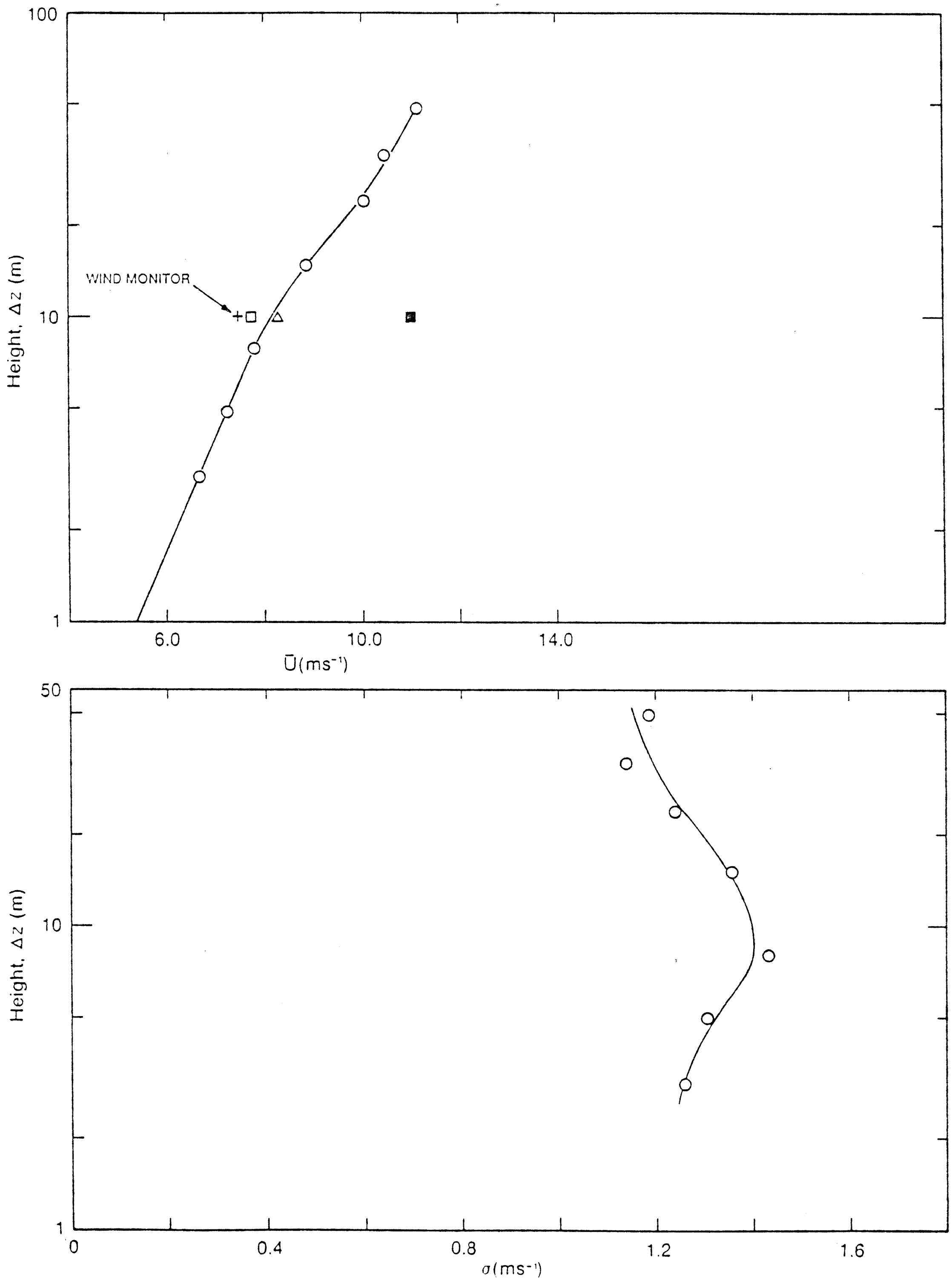


Fig. 4.1 (r) Run TU05-C: 05/10/83, 1530-1700 h, 300°/7.5 m s^{-1}

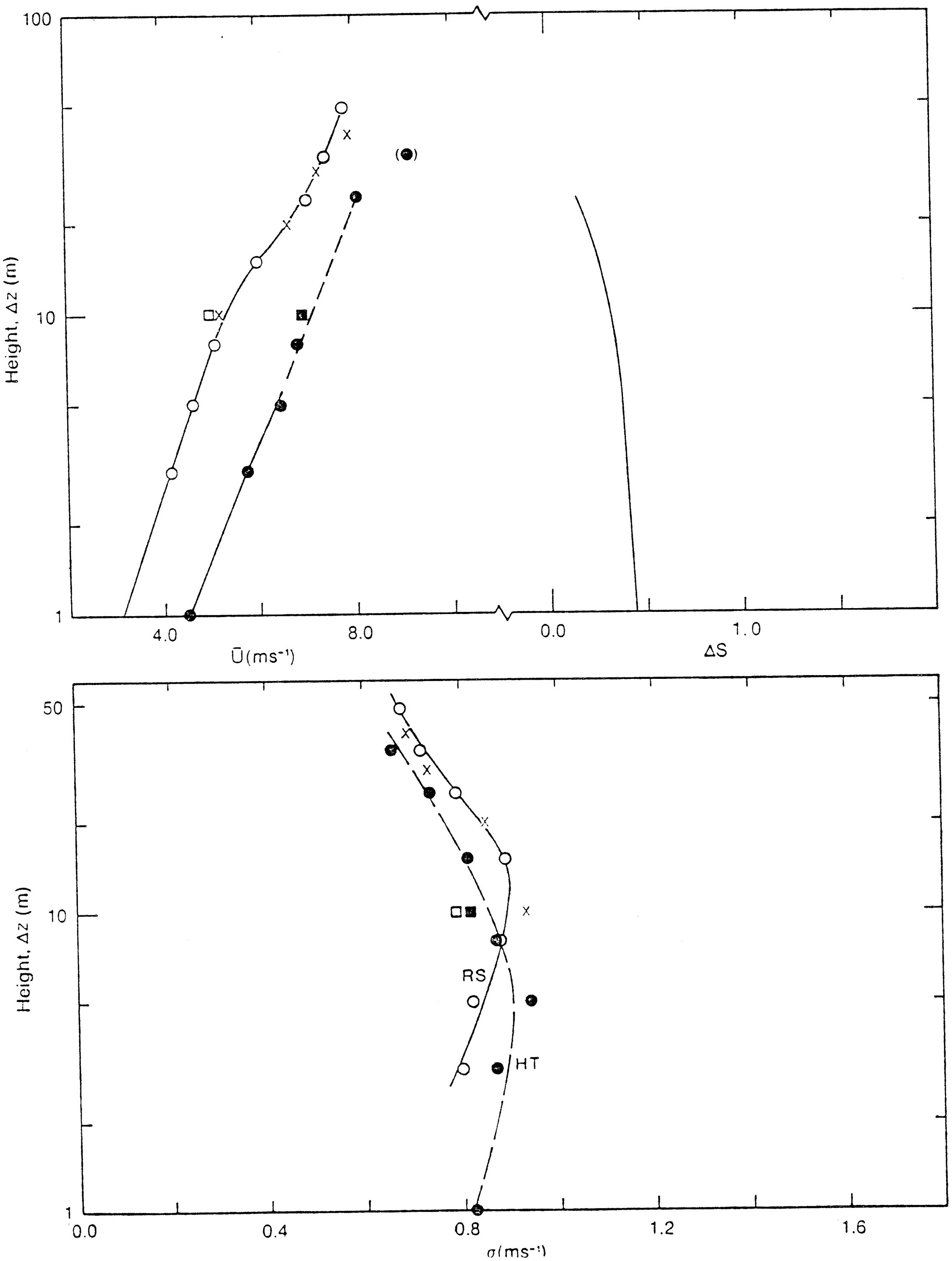


Fig. 4.1 (s) Run TU05-D: 05/10/83, 1800-2100 h, 300°/5.0 m s^{-1}

Figs. 4.2 Vertical profiles at RS and CP' from FRG anemometers

Legend

(i) Upper half of each figure:

⊙———⊙ :	U at RS	}	from cup anemometer
⊙– – – –⊙ :	U at CP'		
●··········● :	ΔS at CP'		
△– – – –△ :	U at CP'	}	from Gill UVW anemometer
▲··········▲ :	ΔS at CP'		

(ii) Lower half of each figure:

△– – – –△ :	σ_u at CP'	}	from Gill UVW anemometers
▽– – – –▽ :	σ_v at CP'		
⊡– – – –⊡ :	σ_w at CP'		

Notes

1) Data for these plots are tabulated in Tables A1.5.

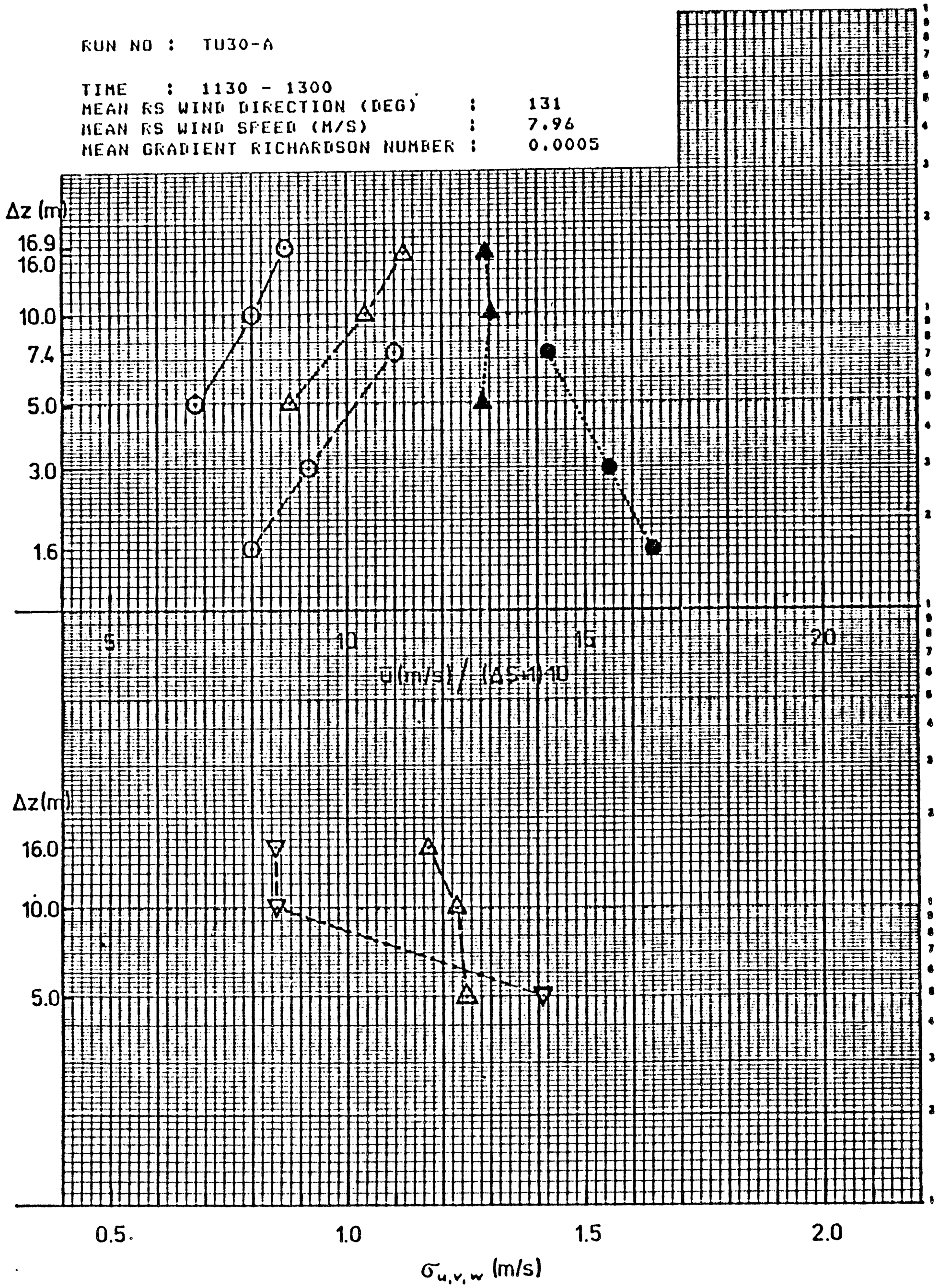
2) Cup anemometers (MF) at CP' (1.6 m, 3.0 m and 7.4 m) produce mean speeds ~9.8% higher than corresponding Gill anemometers (5.0 m, 10.0 and 16.0 m) in areas where they overlap. No explanation for these differences has been found and no attempted corrections have been made.

3) Values given in each figure for mean wind speed and direction at RS are from the 20m cup anemometer on the FRG tower, rather than the AES wind monitor. Thus the values are similar to, although not identical with, the RS reference speeds in Tables 3.1 and 4.7.

4) Results for runs TU26, TU01-A and TU03-B are for partial subsets of the 'standard' run periods defined in Table 4.7.

Fig. 4.2 (continued)

(a)



(b)

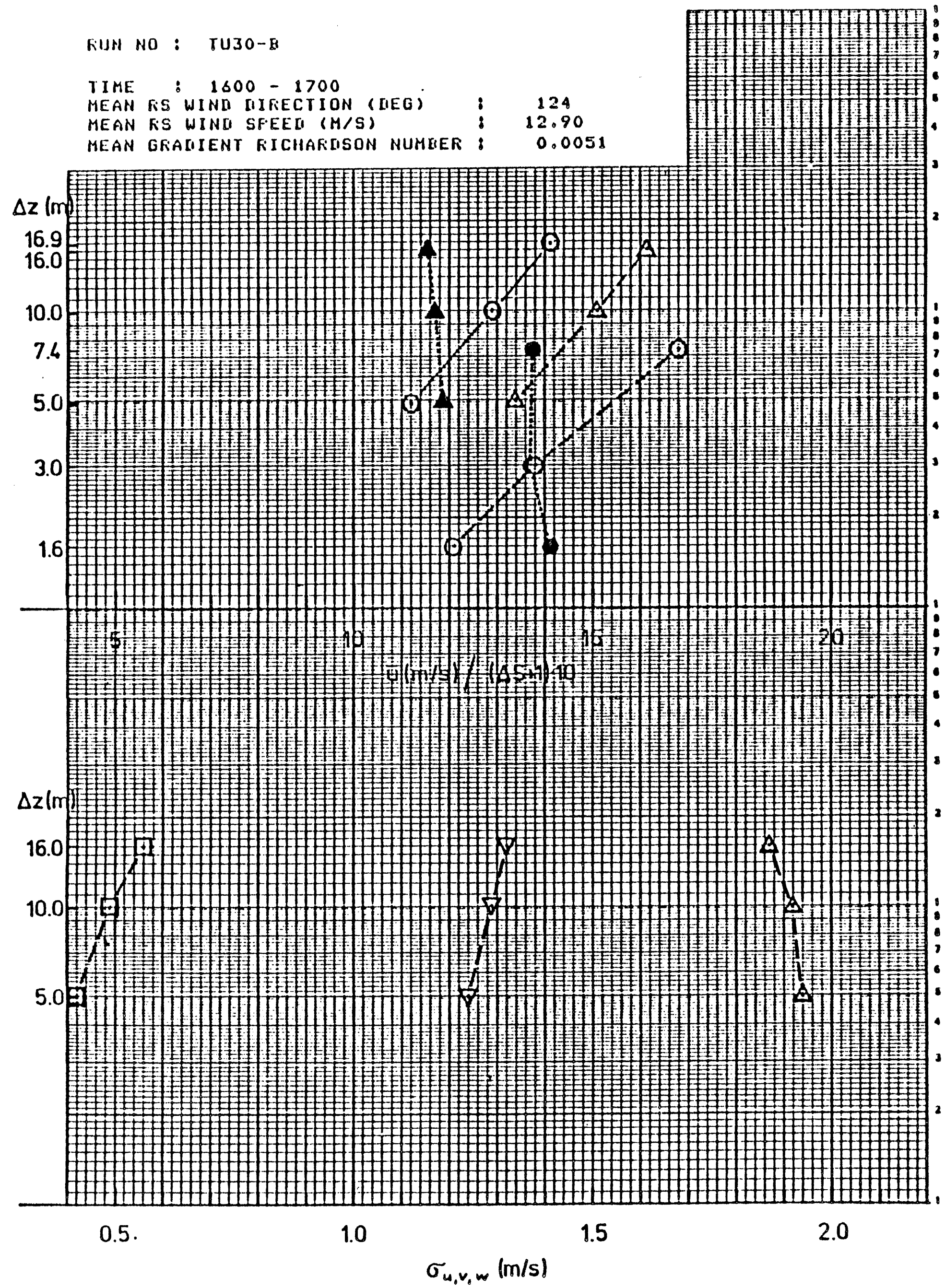


Fig. 4.2 (continued)

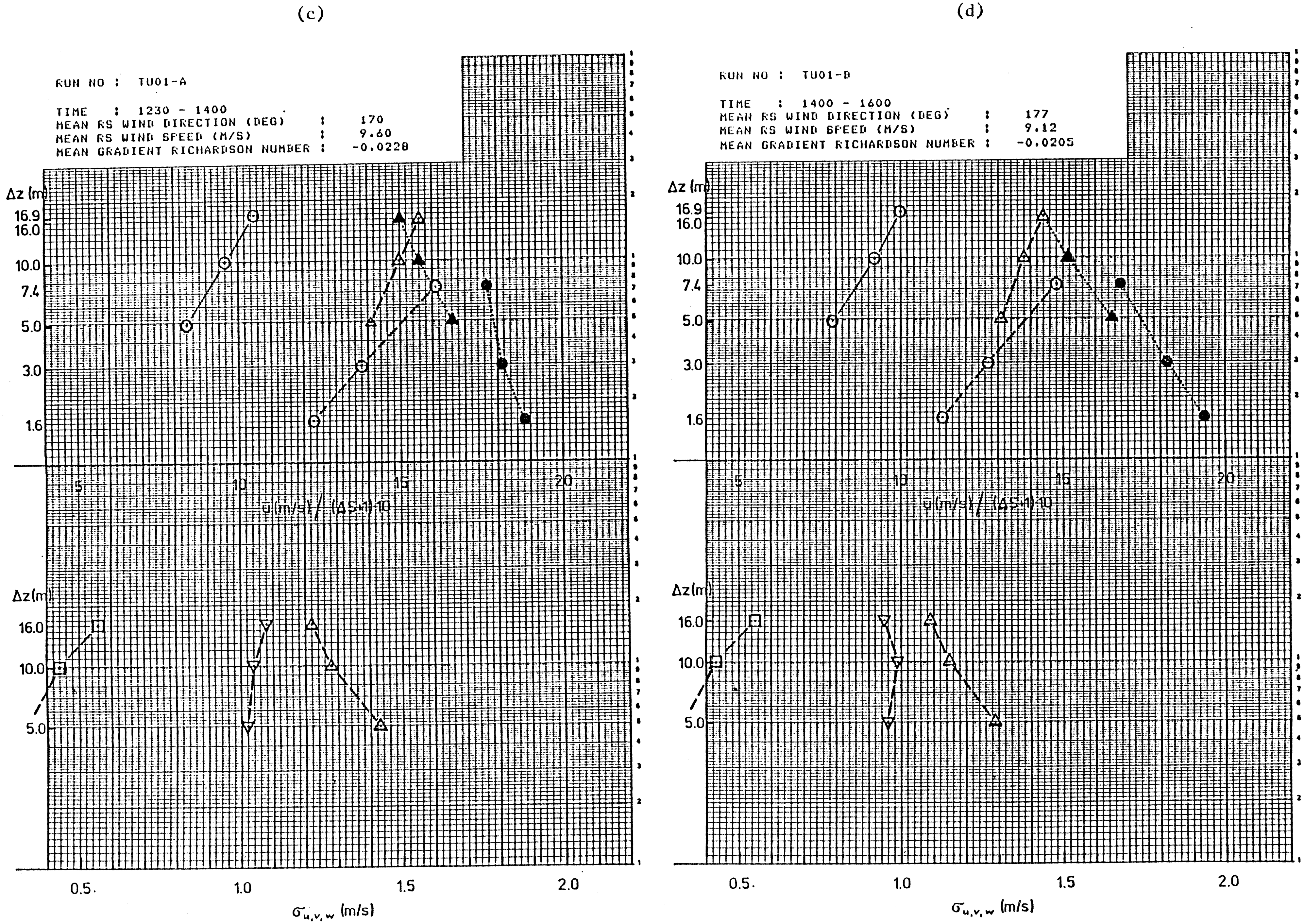
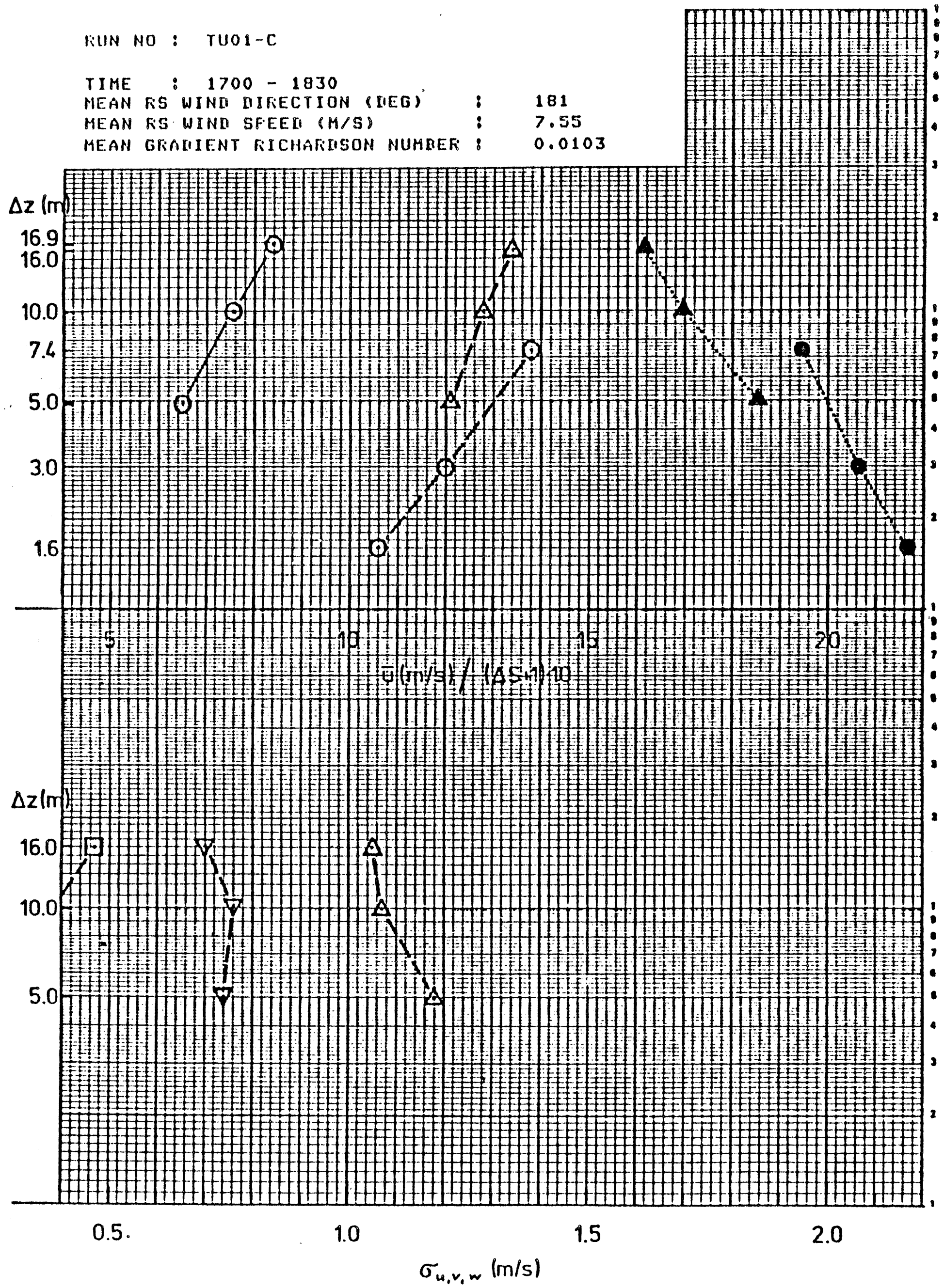


Fig. 4.2 (continued)

(e)



(f)

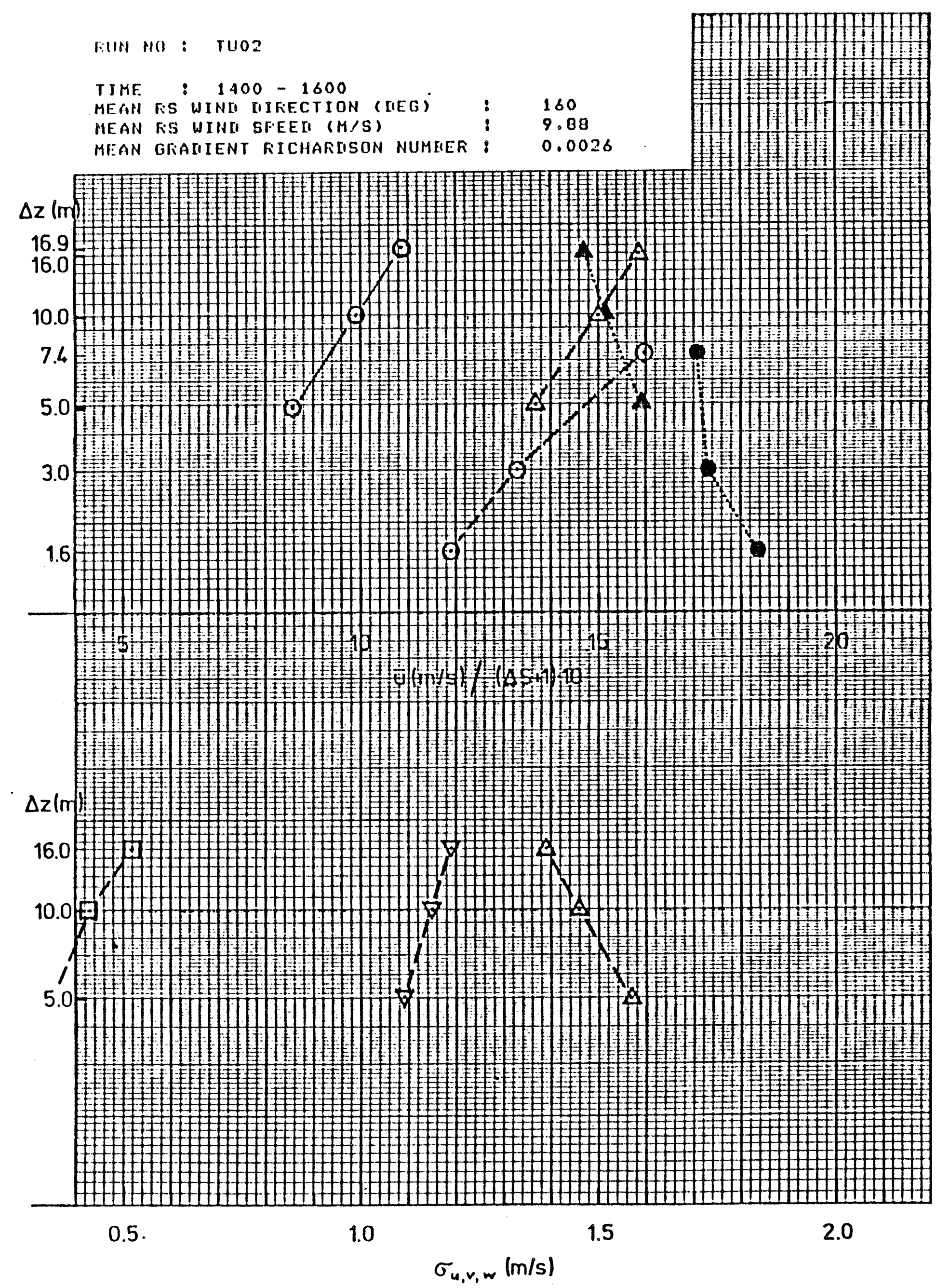
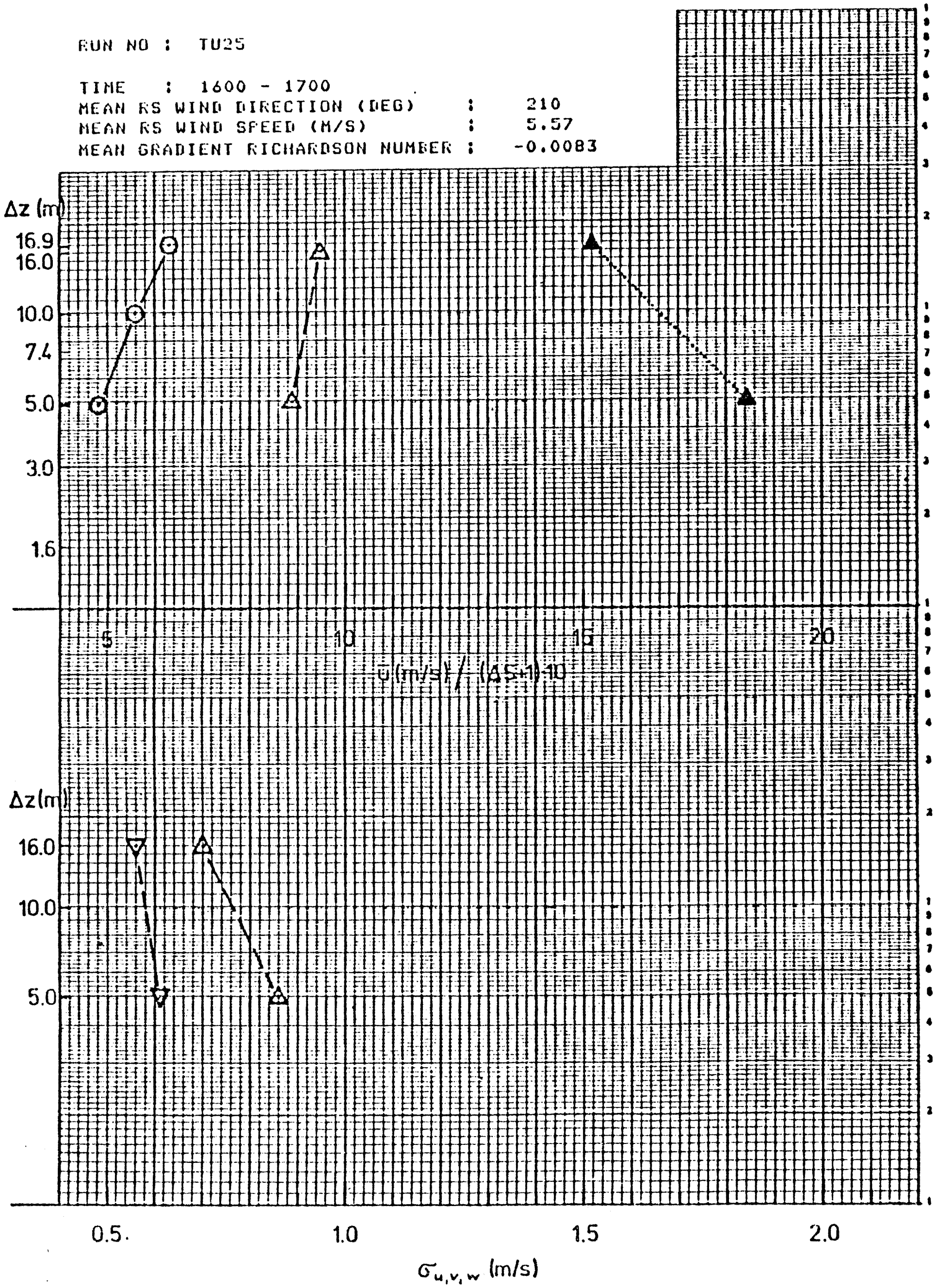


Fig. 4.2 (continued)

(g)



(h)

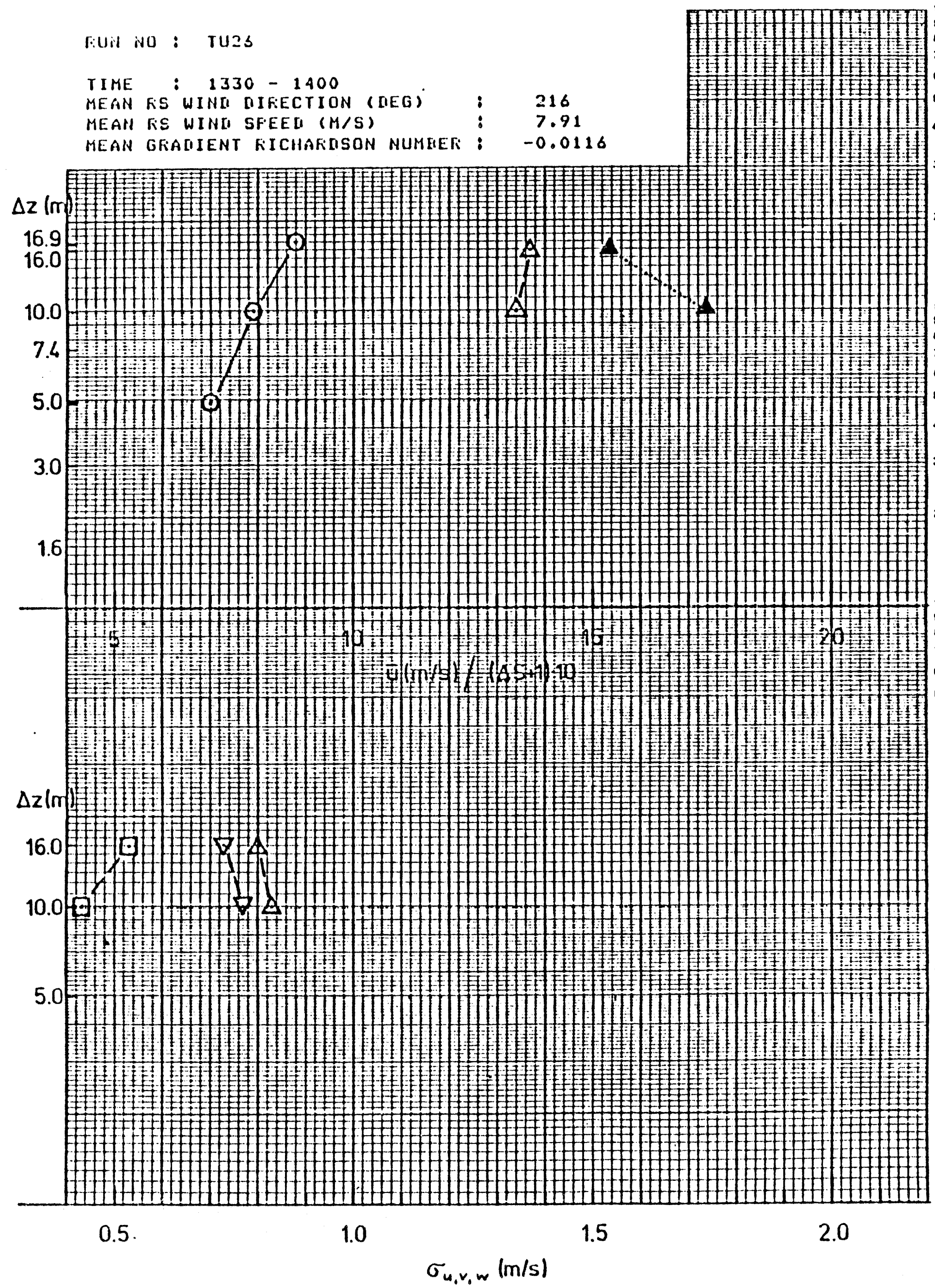


Fig. 4.2 (continued)

(i)

RUN NO : TU01-D

TIME : 1930 - 2000
MEAN RS WIND DIRECTION (DEG) : 197
MEAN RS WIND SPEED (M/S) : 7.56
MEAN GRADIENT RICHARDSON NUMBER : 0.0205

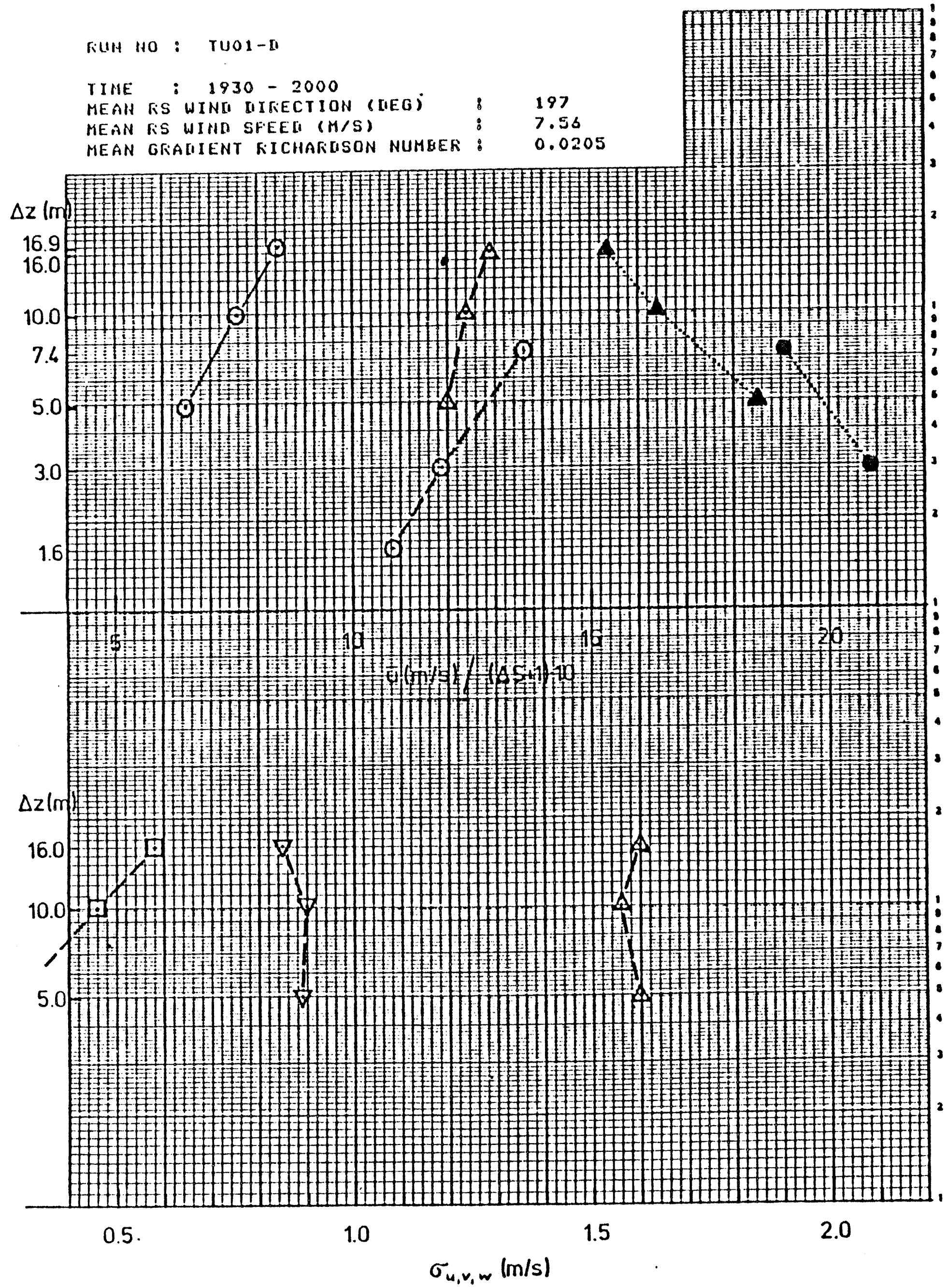
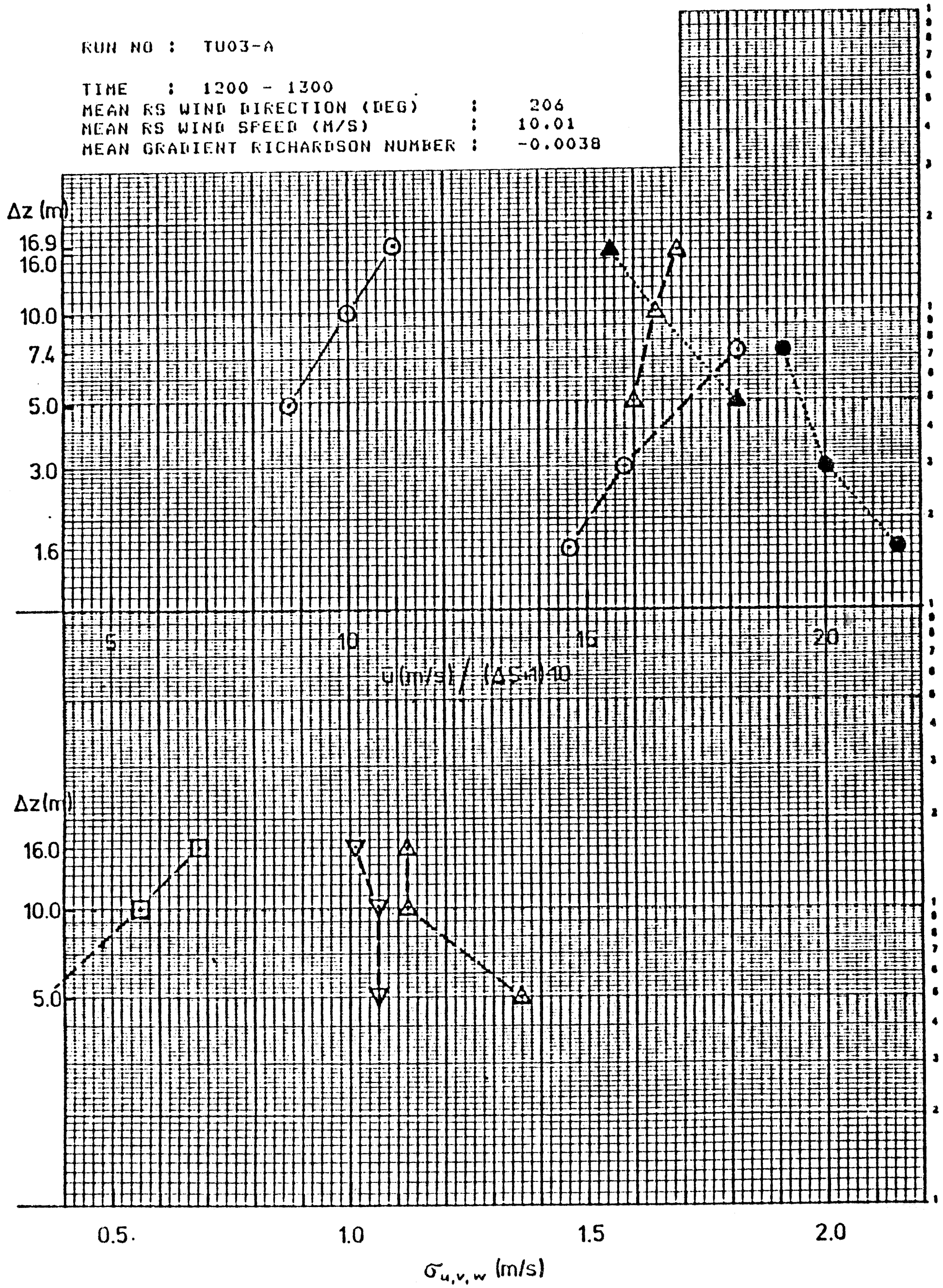


Fig. 4.2 (continued)

(j)



(k)

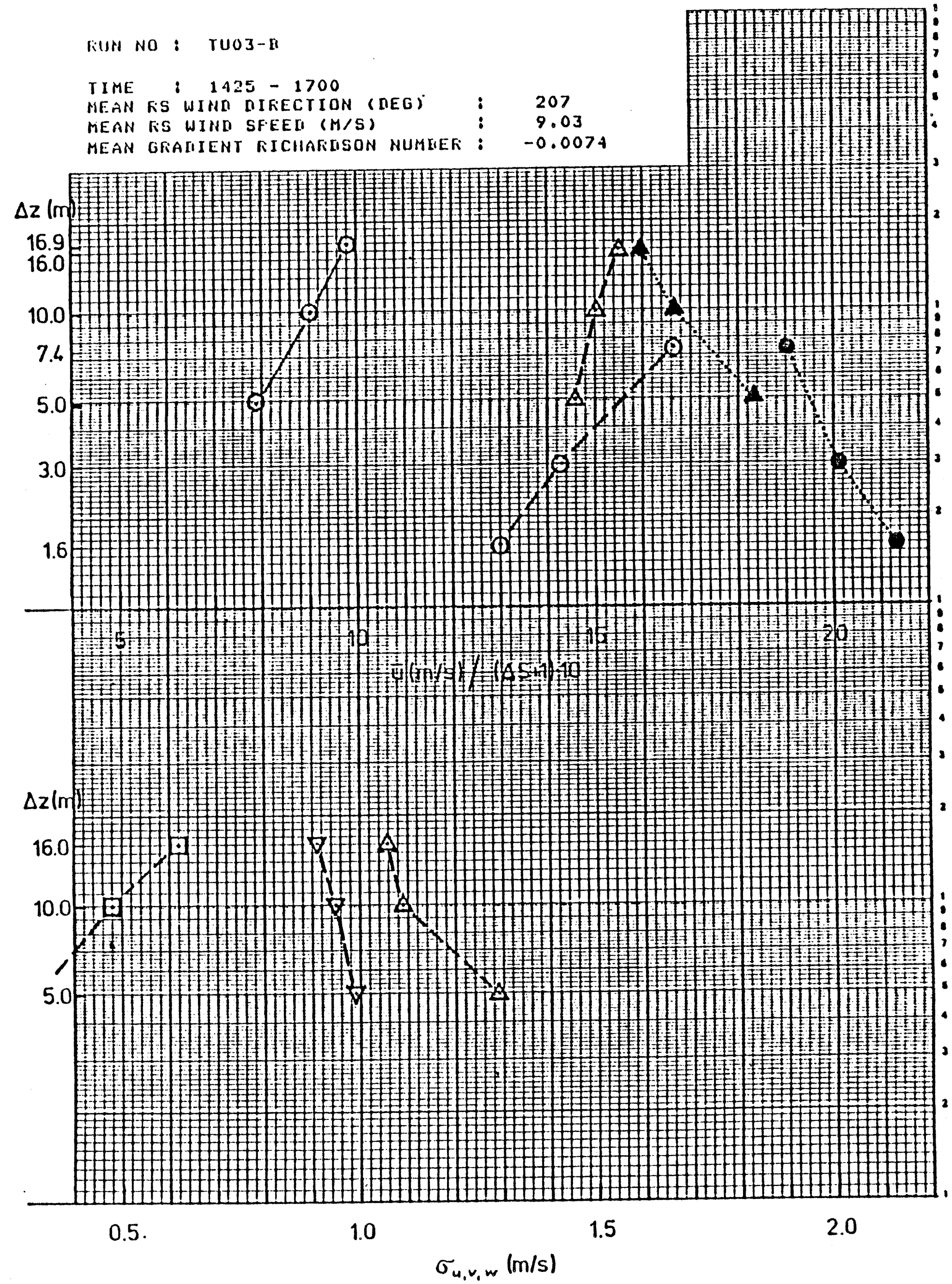
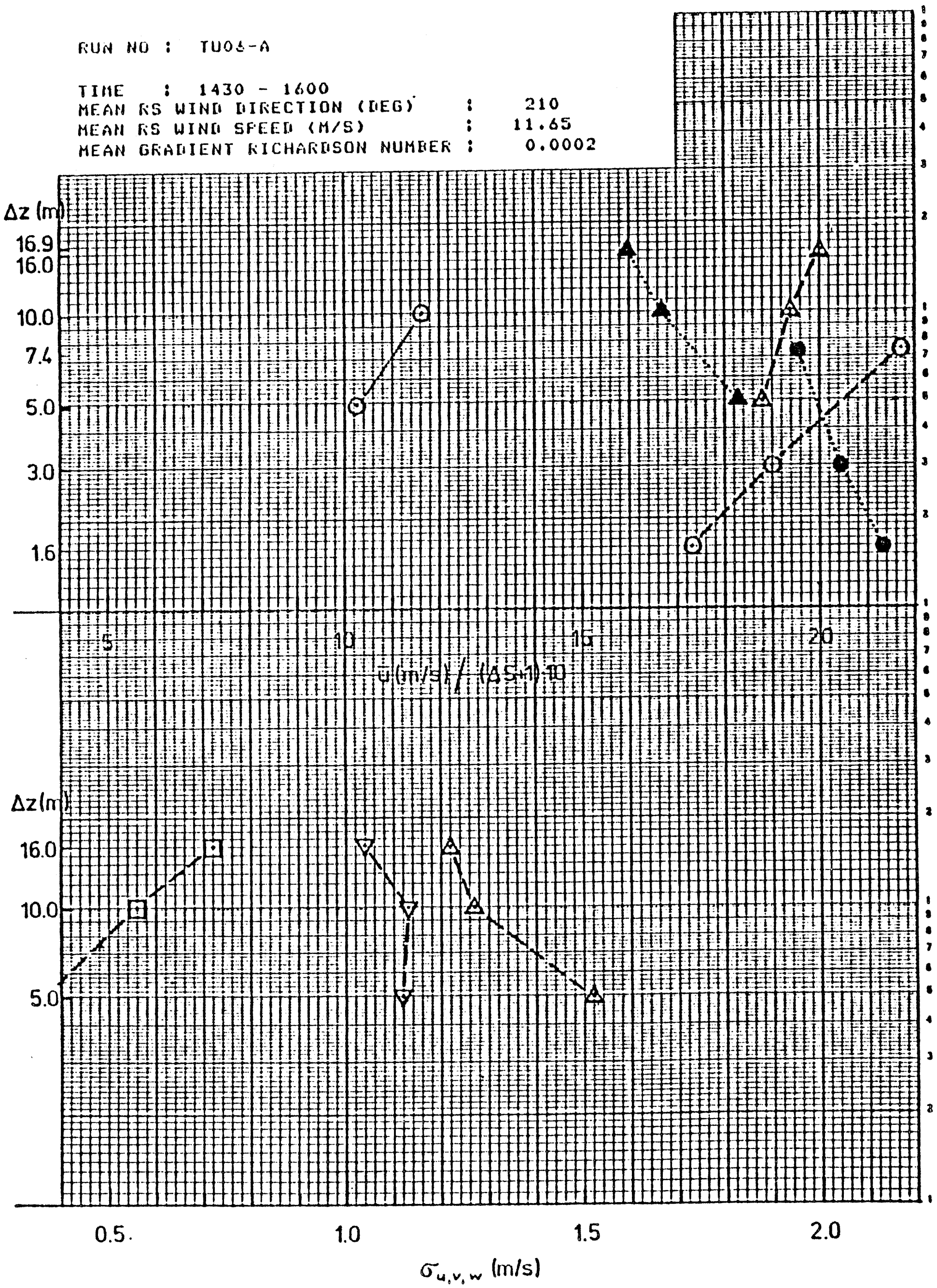


Fig. 4.2 (continued)

(l)



(m)

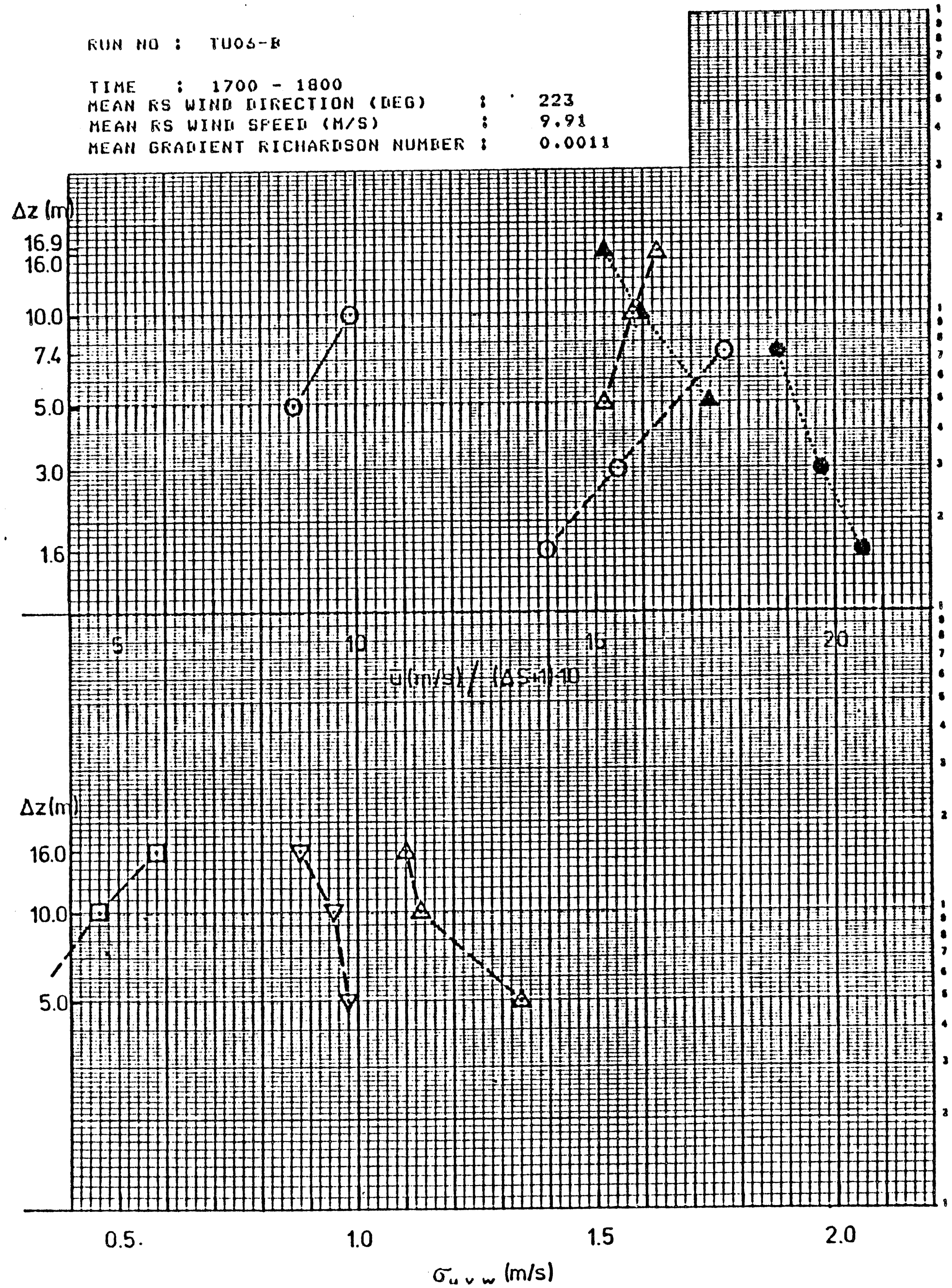


Fig. 4.2 (continued)

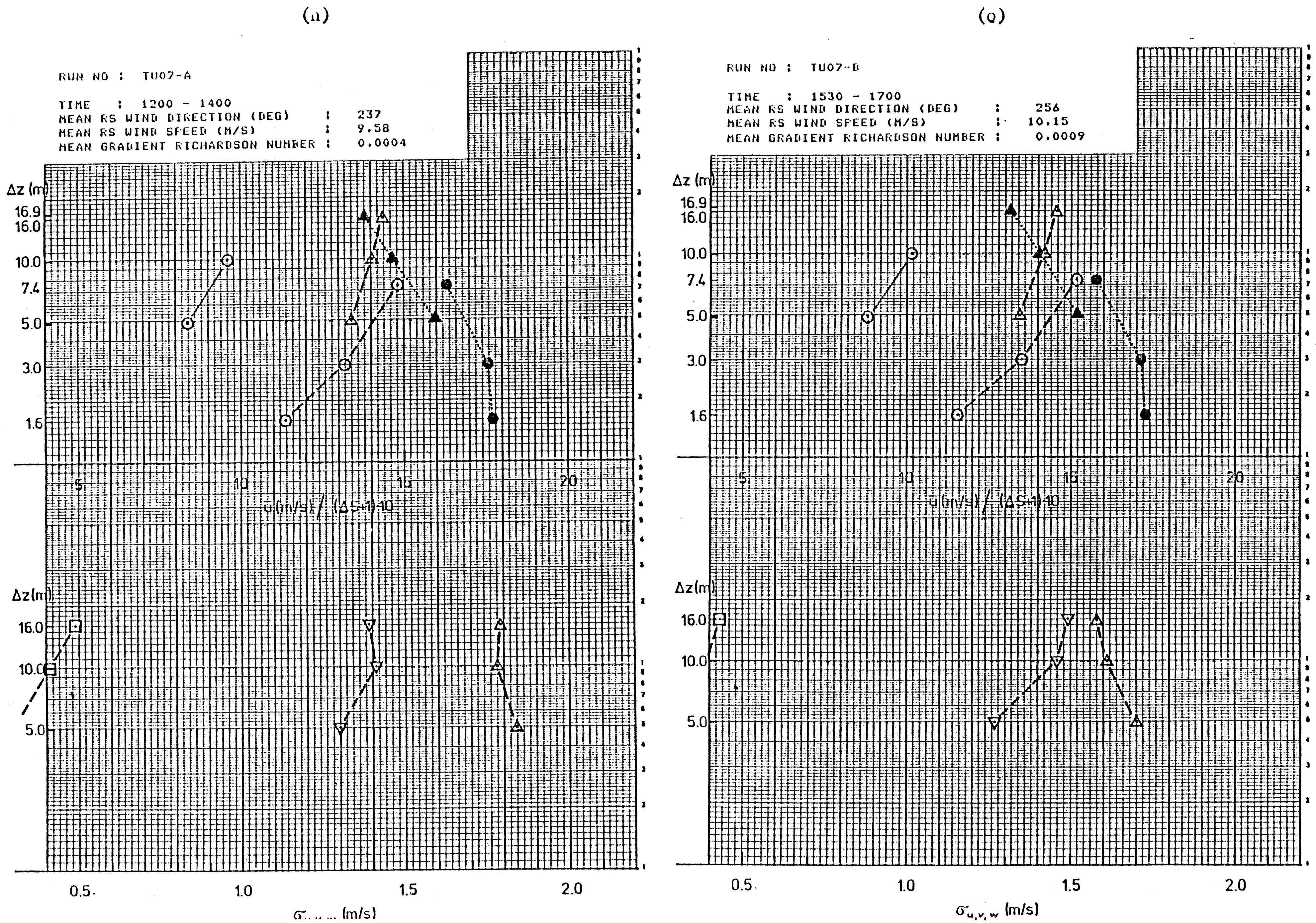
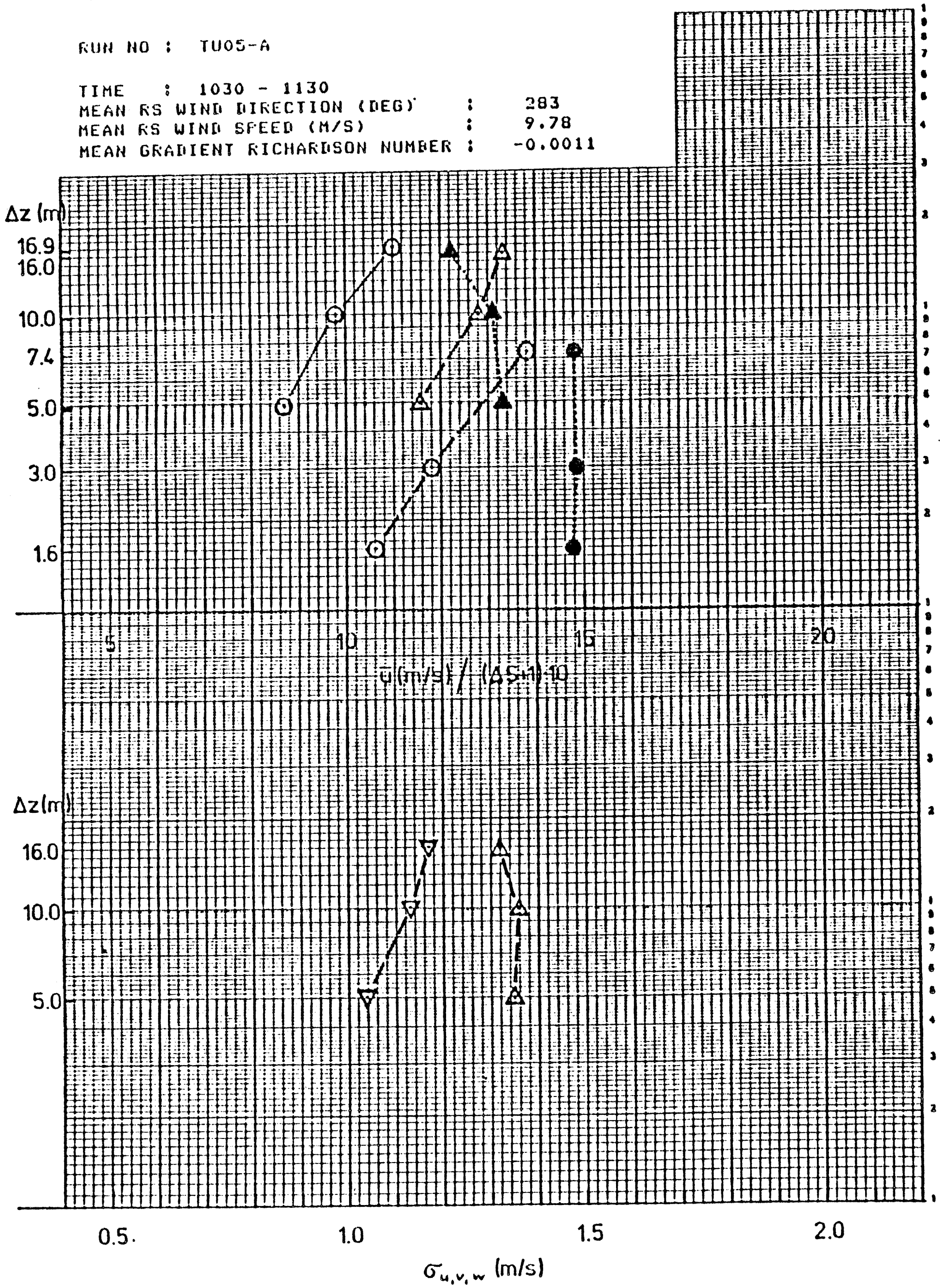


Fig. 4.2 (continued)

(p)



(q)

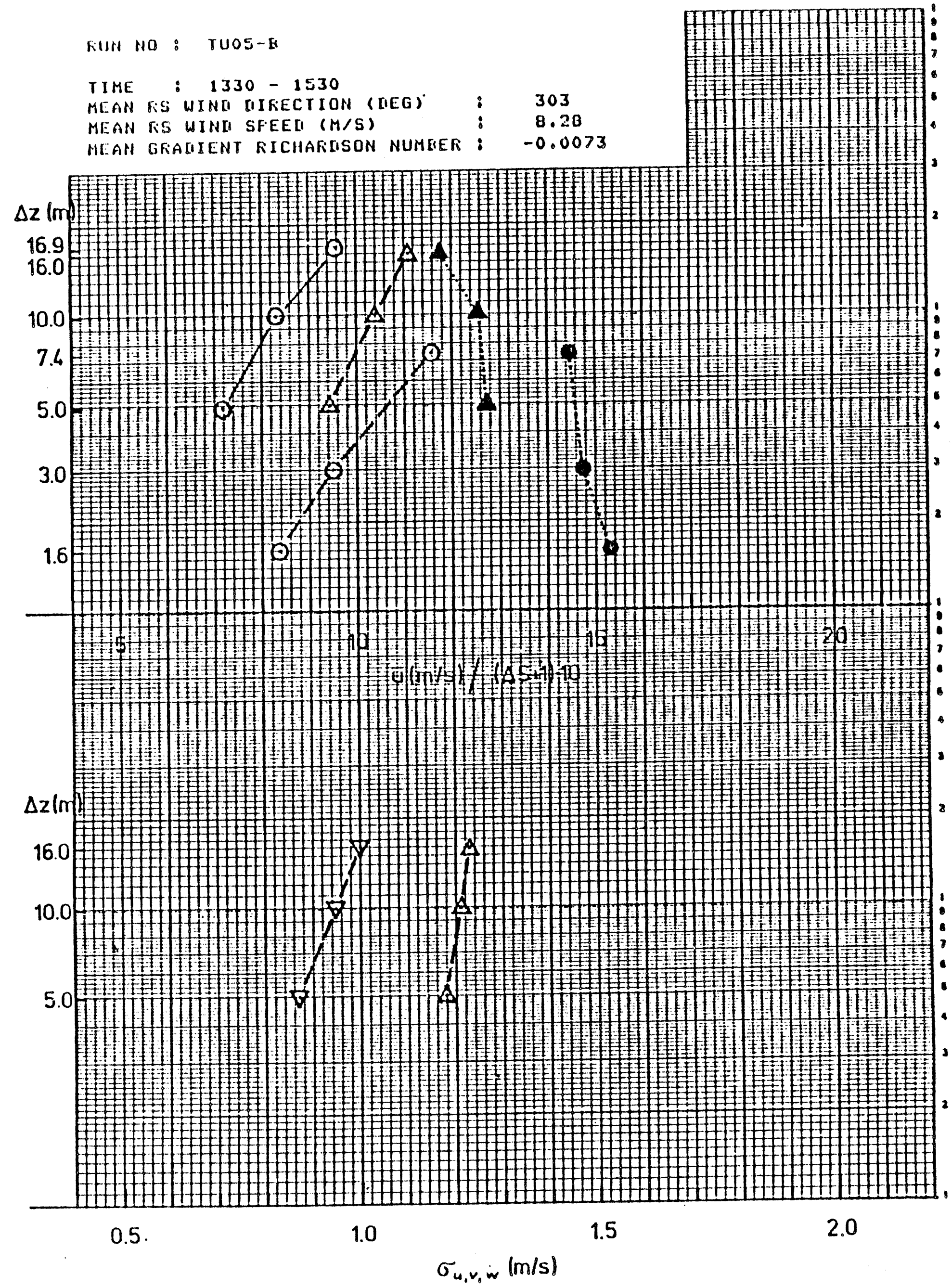
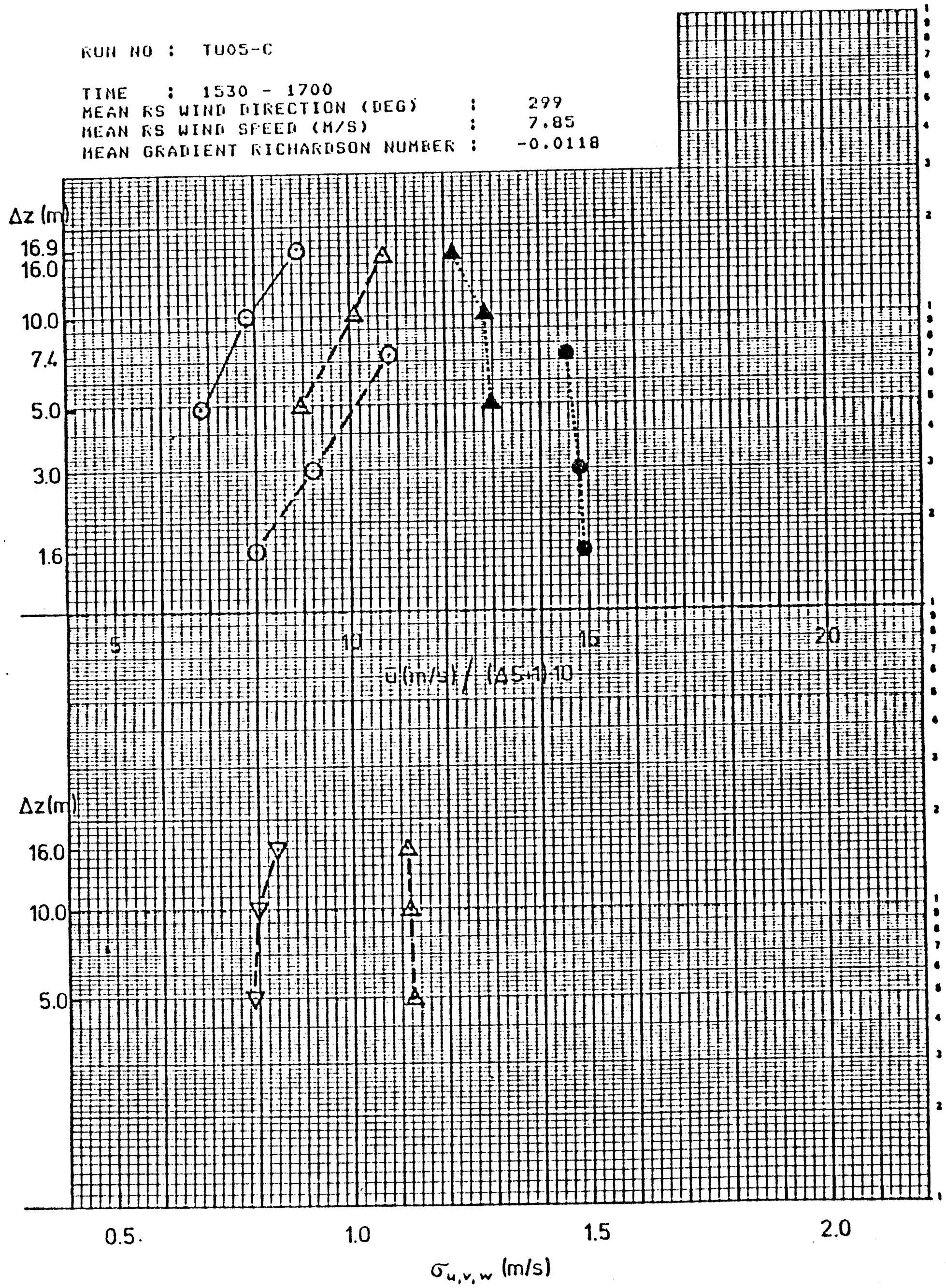
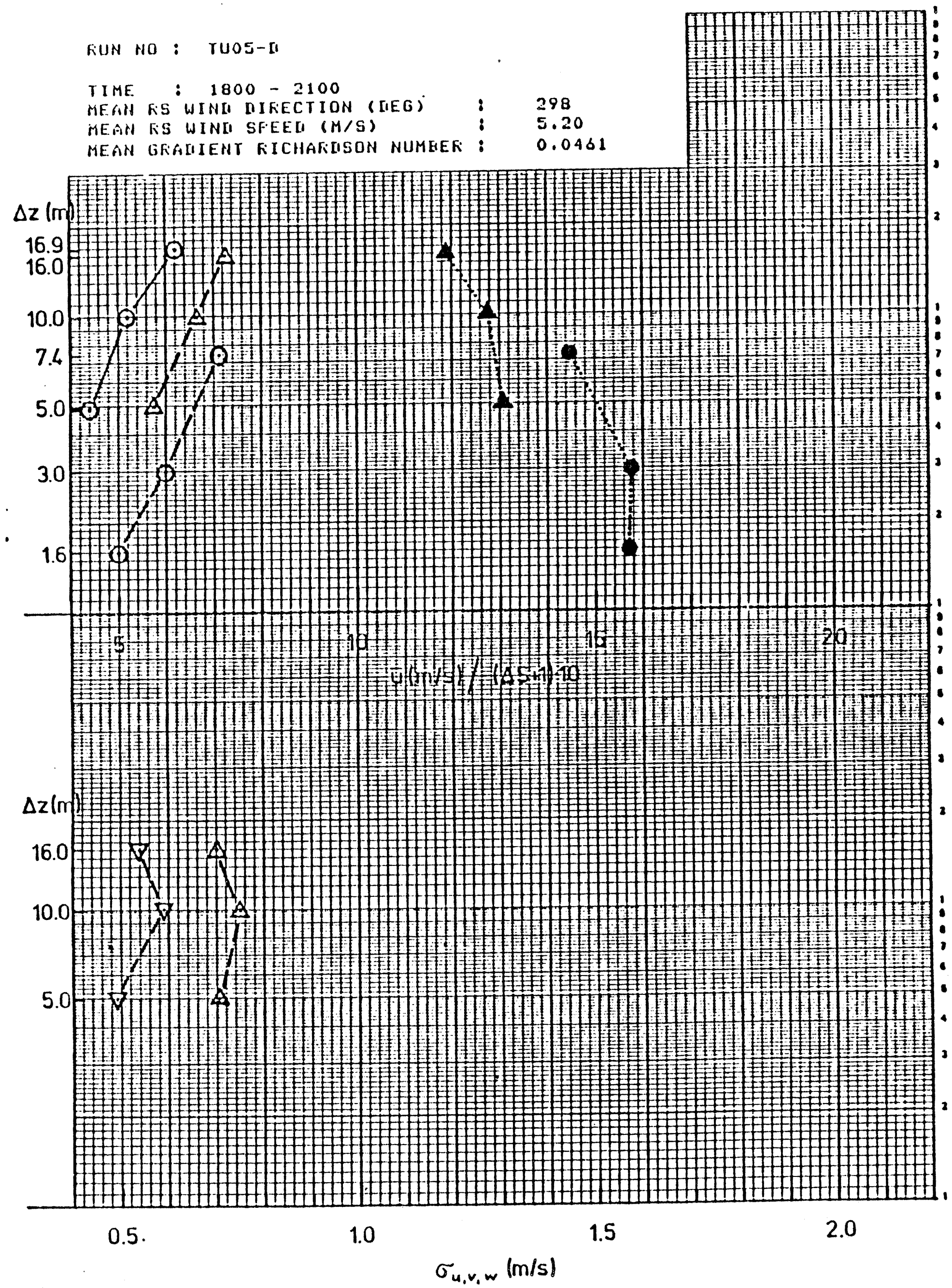


Fig. 4.2 (continued)

(r)



(s)



(Intentionally blank)

Figs. 4.3 Horizontal profiles (at 10 m) along line A for designated turbulence runs.

Notes:

1. Values at ASW60 (-60 on abscissa of plots) are from Gill UVW anemometer at ΔZ = 10 m on BRE 30 m tower.
2. Extra value of direction at HT (*) is from AES Wind Monitor located there (see Fig. 2.6(b)).
3. Values at RS are plotted at X=-100 for reference.
4. $u'w' \equiv \overline{uw} \equiv$ covariance.
5. Data for these plots are tabulated in Table A1.3.
6. Suspect data points are enclosed in brackets.

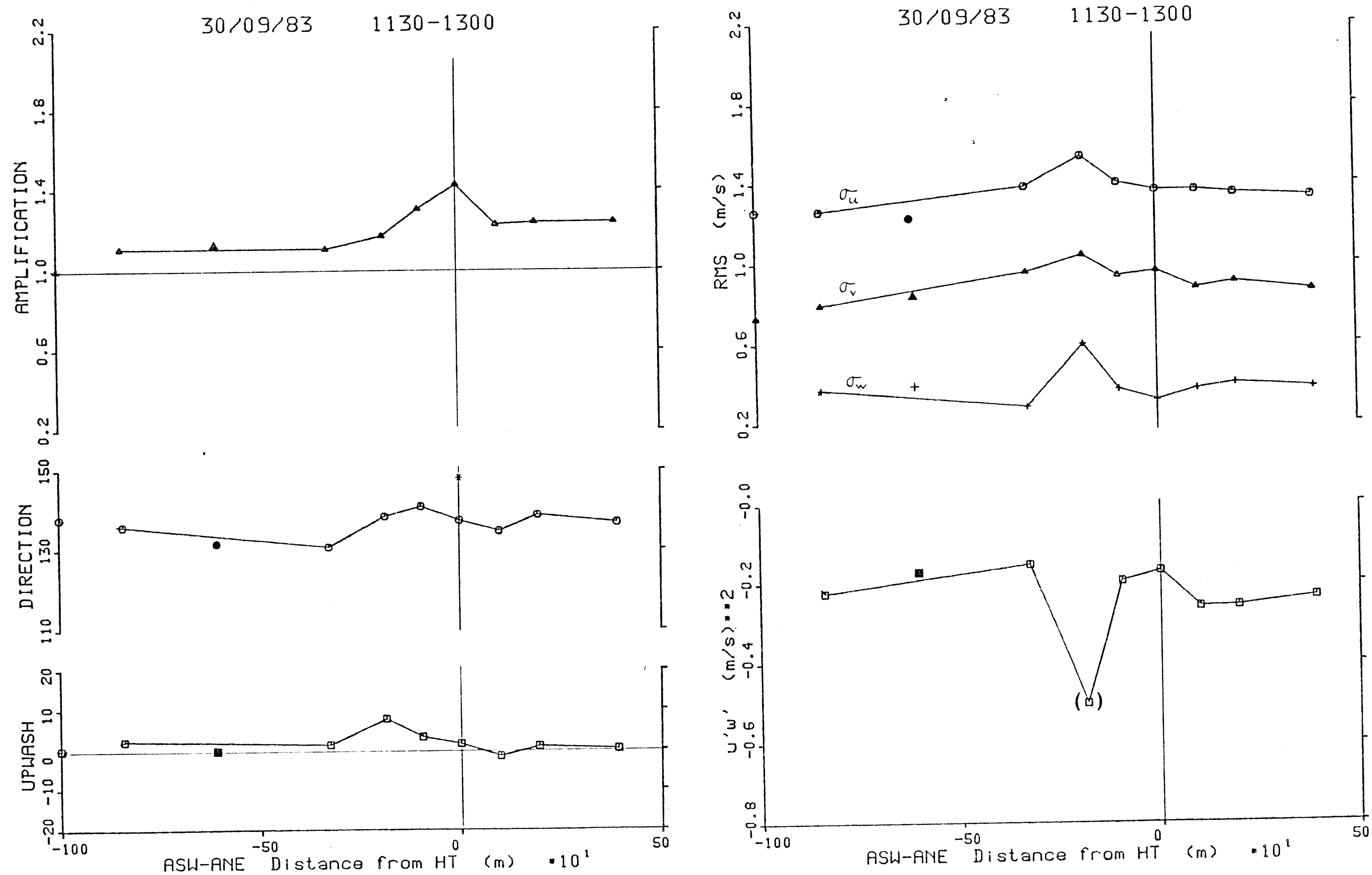


Fig. 4.3 (a) TU30A, $\phi_{RS}=135^o$, $U_{RS}(10m)=7.8\ ms^{-1}$

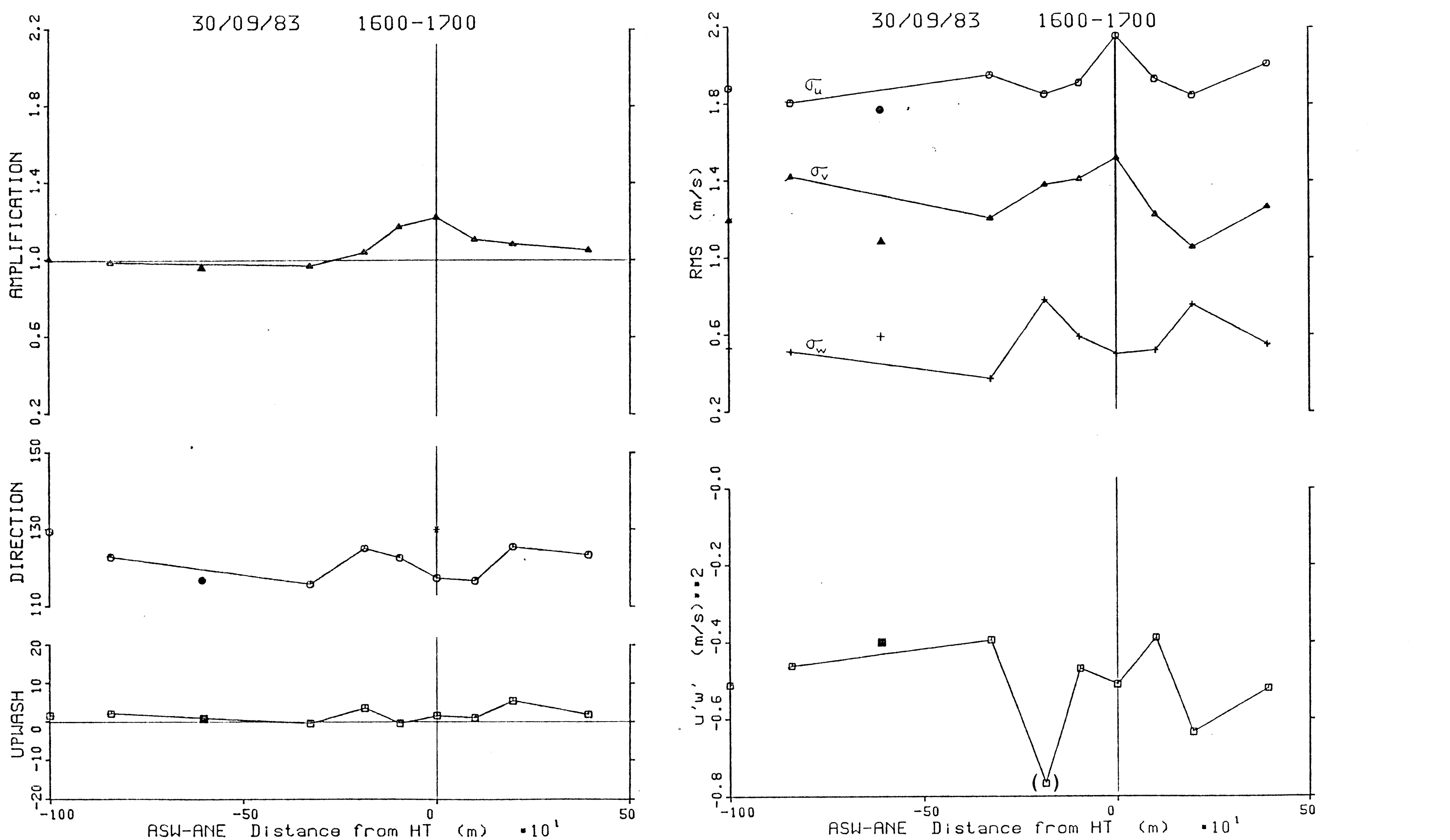


Fig. 4.3 (b) TU30B, $\phi_{RS}=130^o$, $U_{RS}(10m)=13.0\ ms^{-1}$

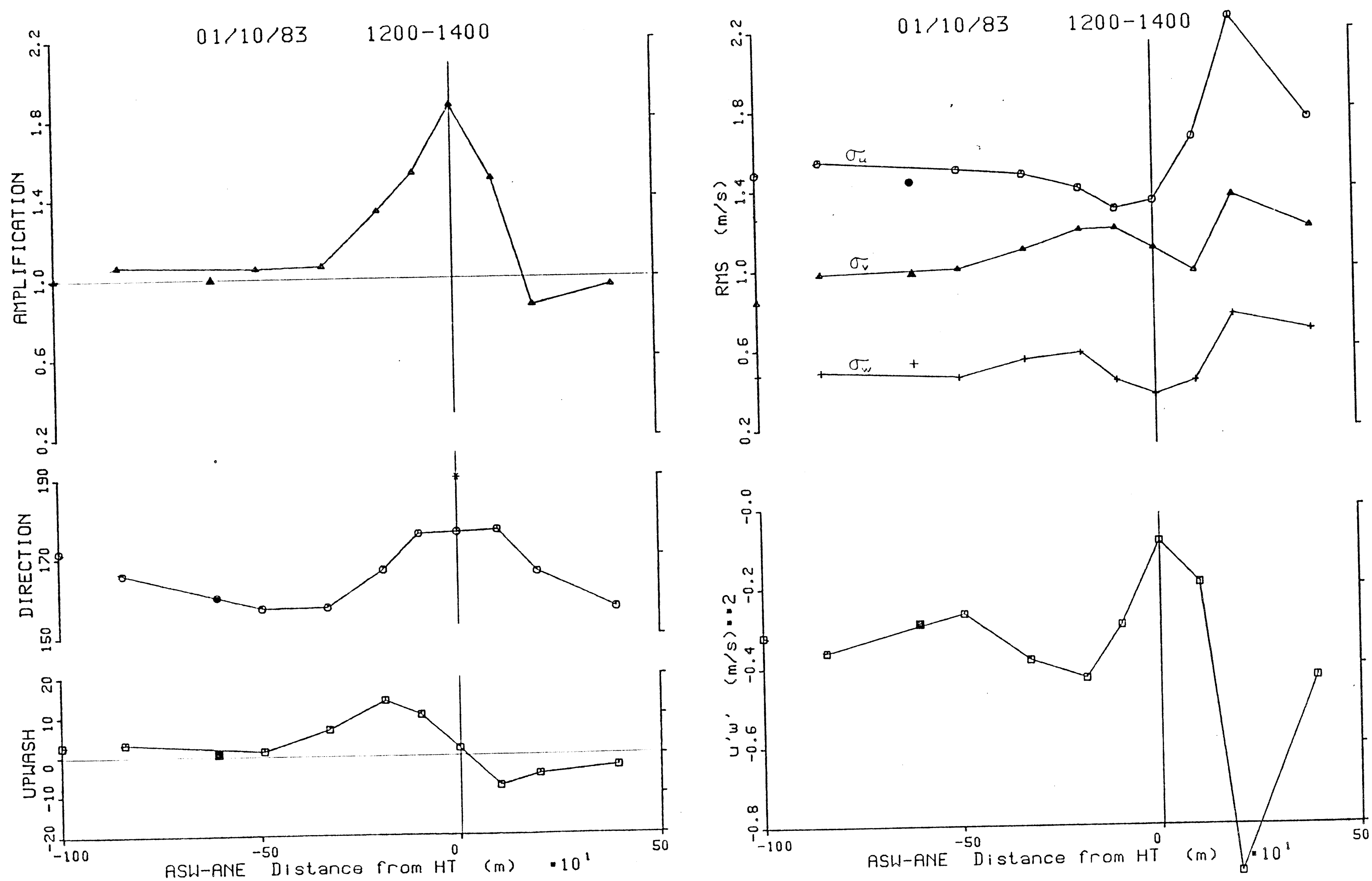


Fig. 4.3 (c) TU01A, ϕ_{RS}=170^{o}m U_{RS}(10m)=9.2 ms^{-1}

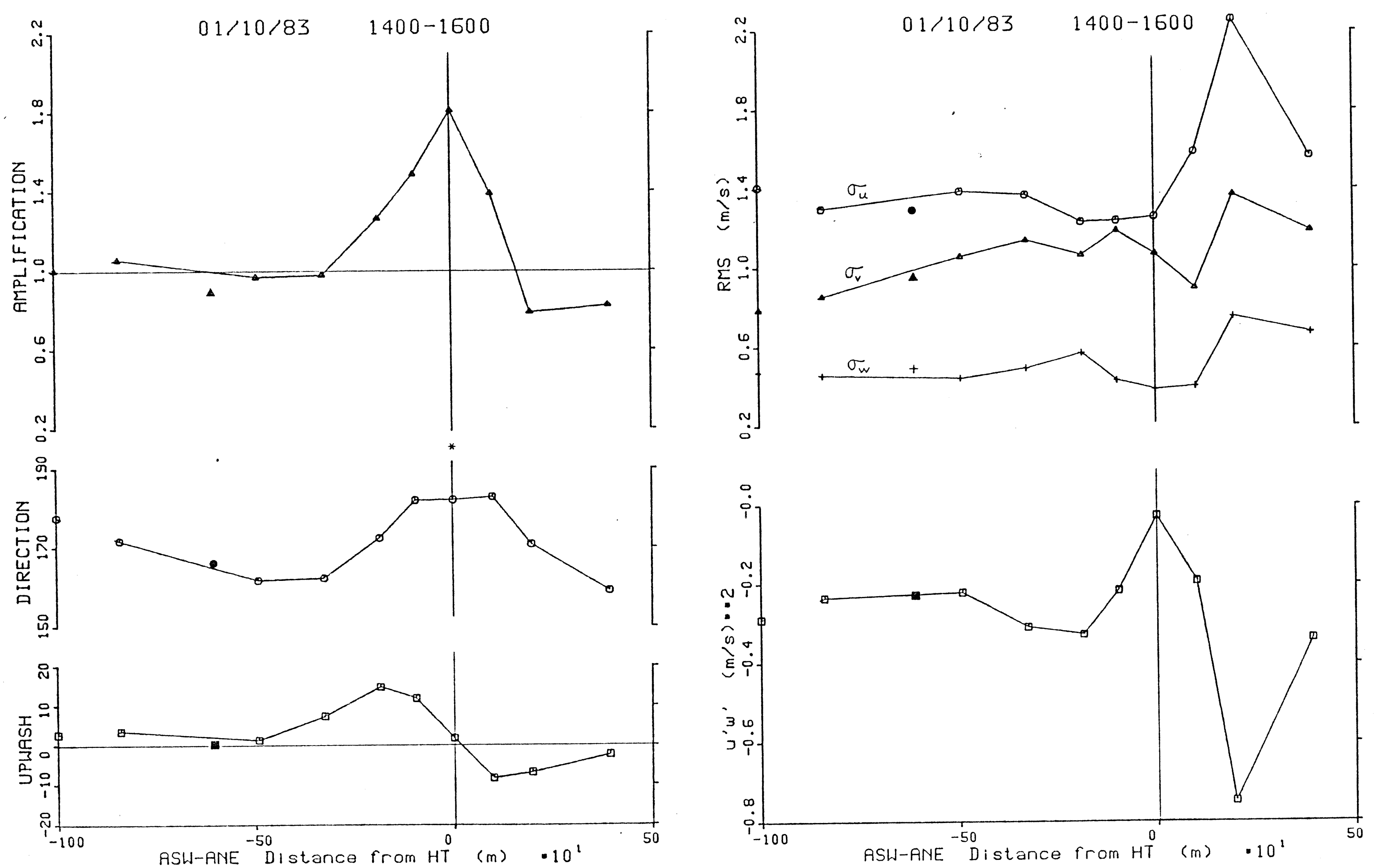


Fig. 4.3 (d) TU01B, $\phi_{RS}=180^0$, $U_{RS}(10m)=9.0\ ms^{-1}$

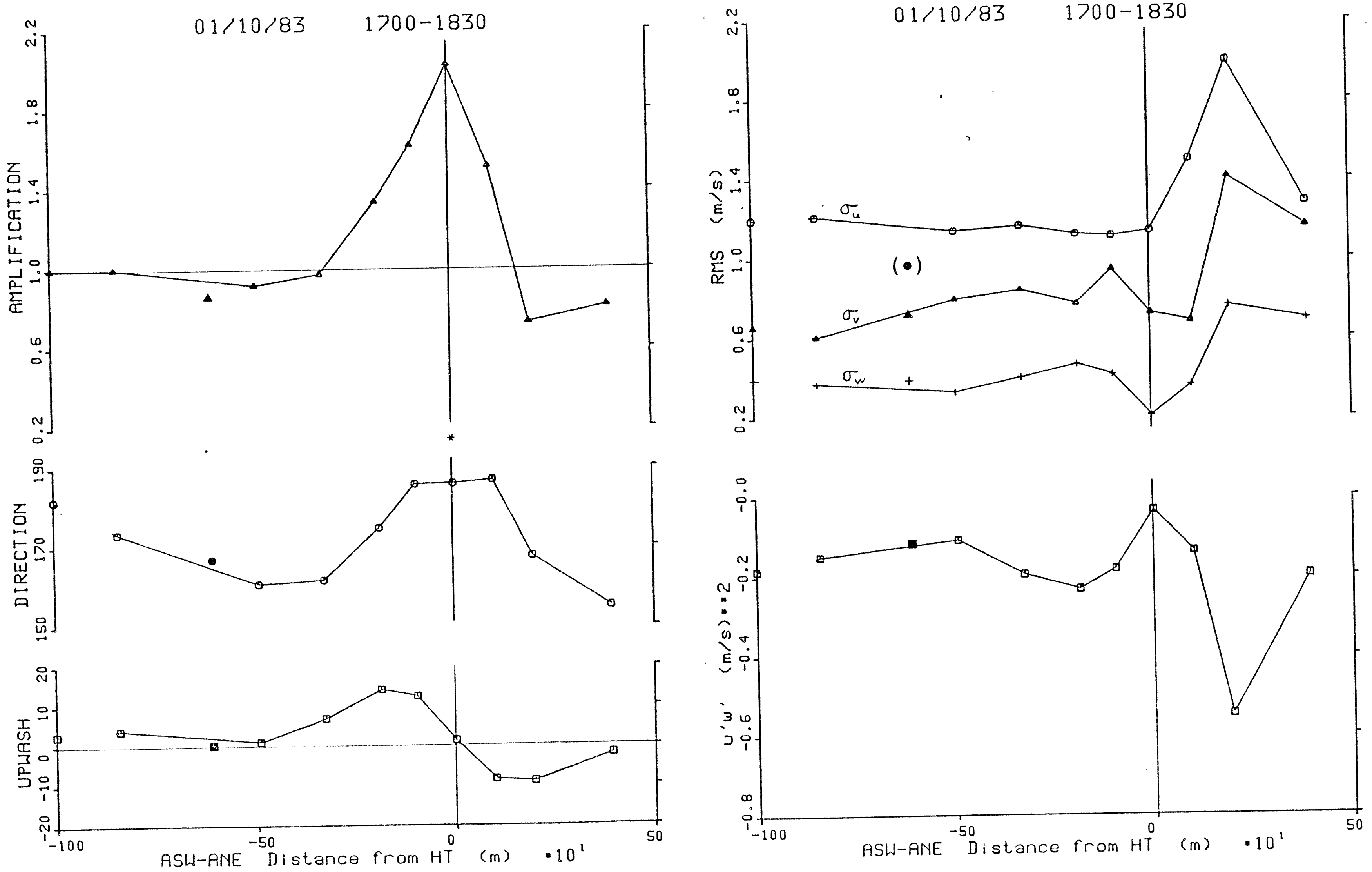


Fig. 4.3 (e) TU01C, $\phi_{RS}=185^o$, $U_{RS}(10m)=7.5$ ms-1

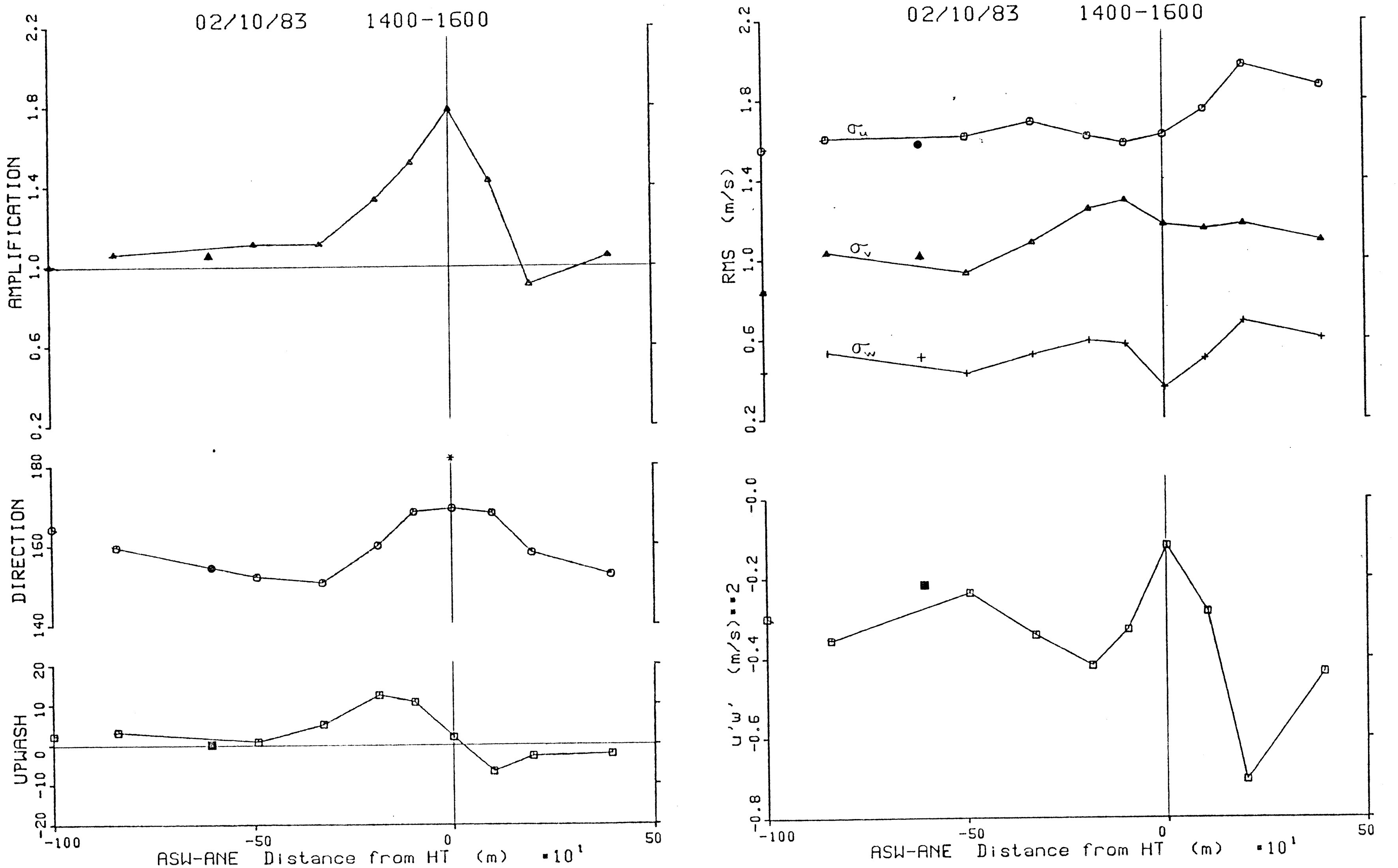


Fig. 4.3 (f) TU02, ϕ_{RS}=165°, U_{RS}(10m)=10.0 ms^{-1}

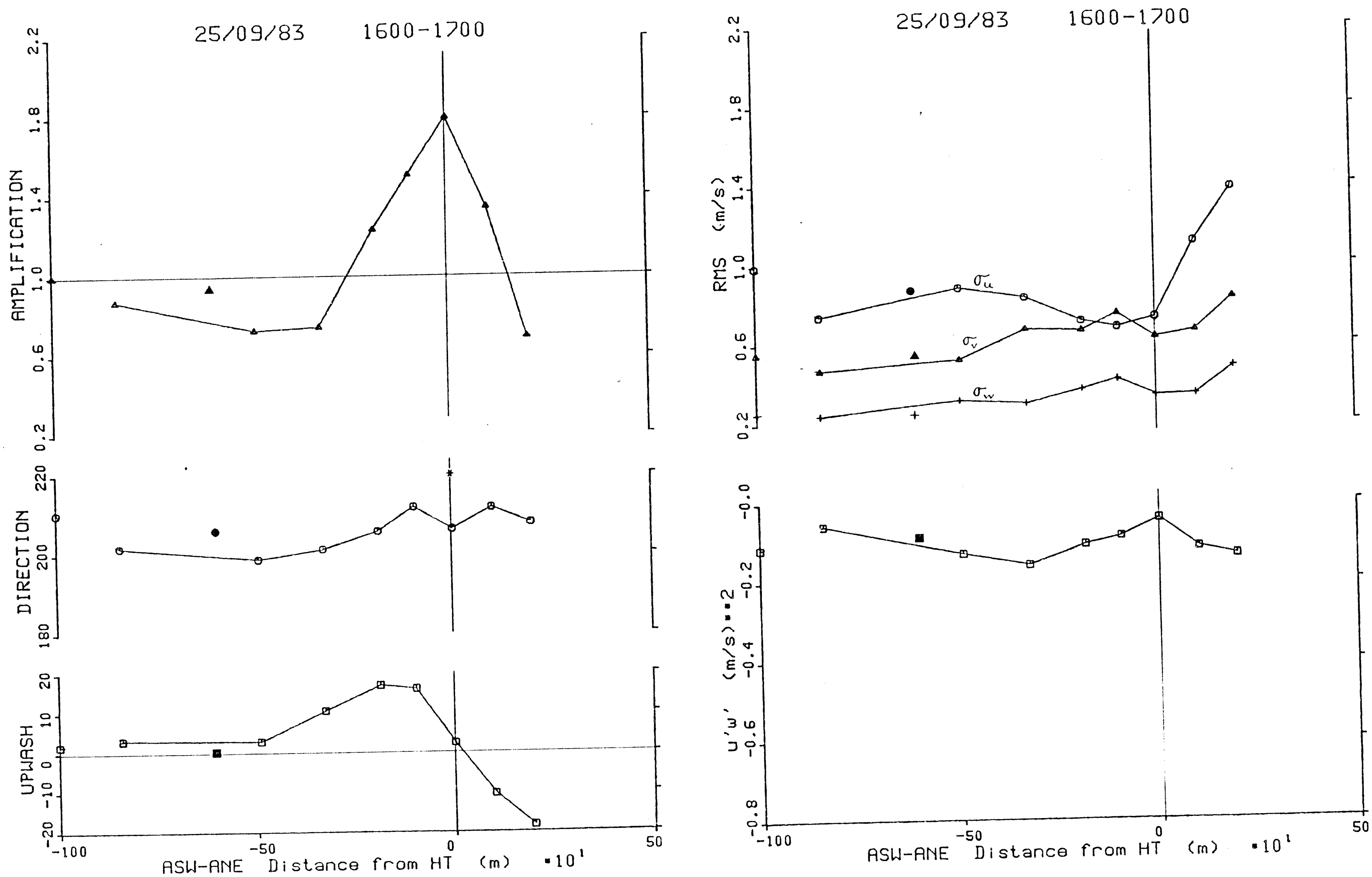


Fig. 4.3 (g) TU25, $\phi_{RS}=210^{o}$, $U_{RS}(10m)=5.5\ ms^{-1}$

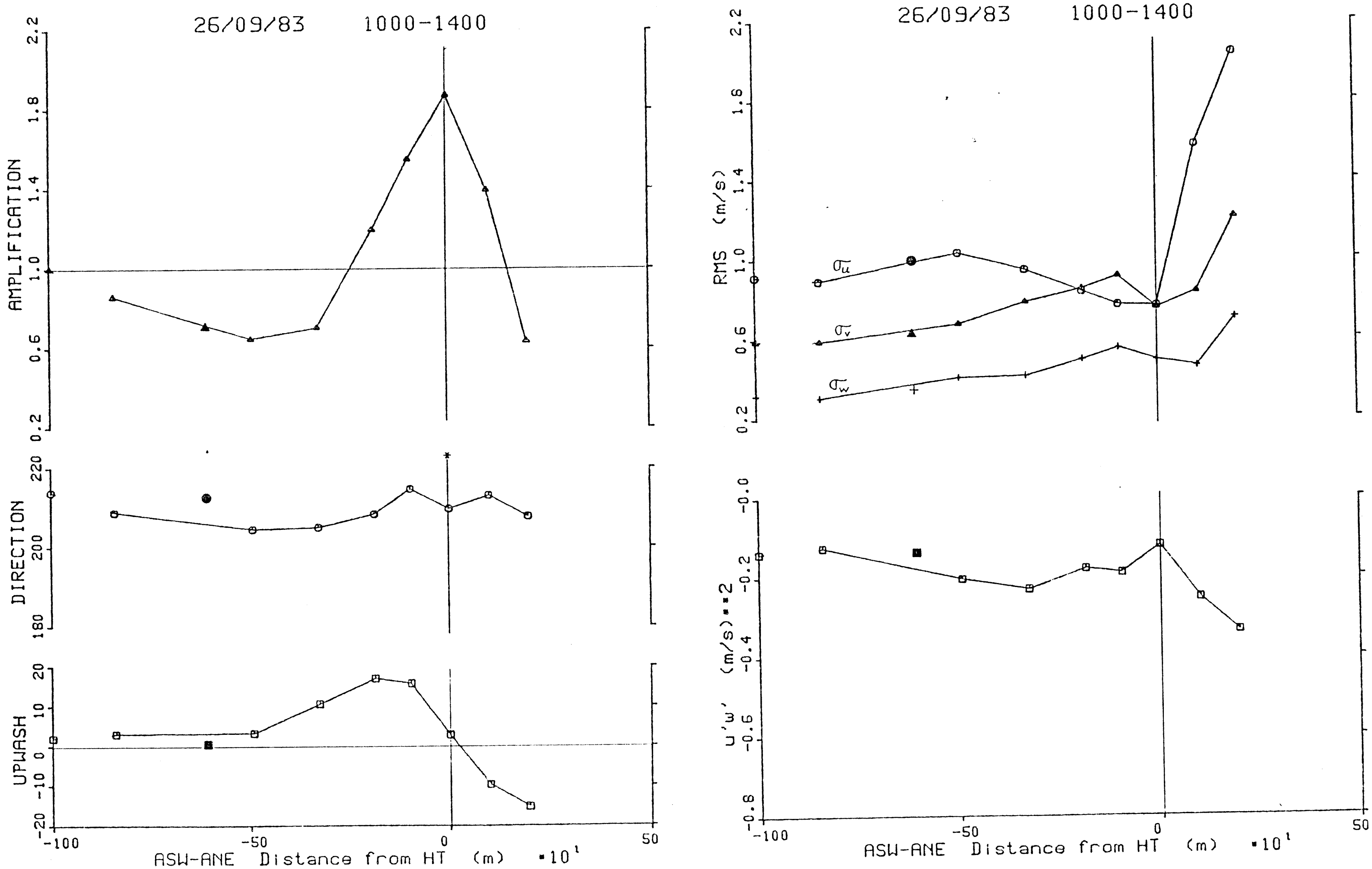


Fig. 4.3 (h) TU26, ϕ_{RS}=220°m U_{RS}(10m)=7.0 ms^{-1}

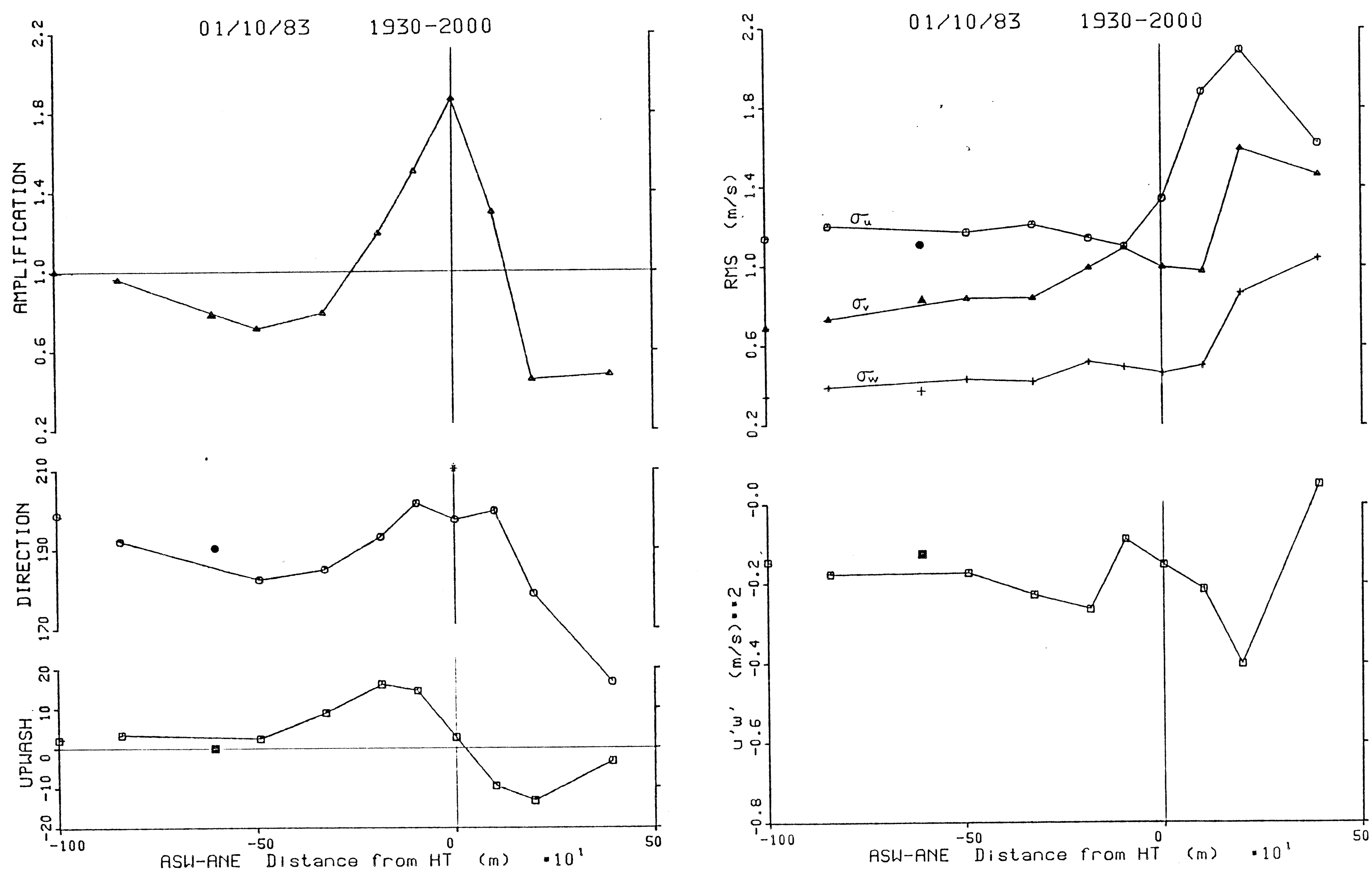


Fig. 4.3 (i) TUO1D, $\phi_{RS}=200^{o}$, $U_{RS}(10m)=7.5\ ms^{-1}$

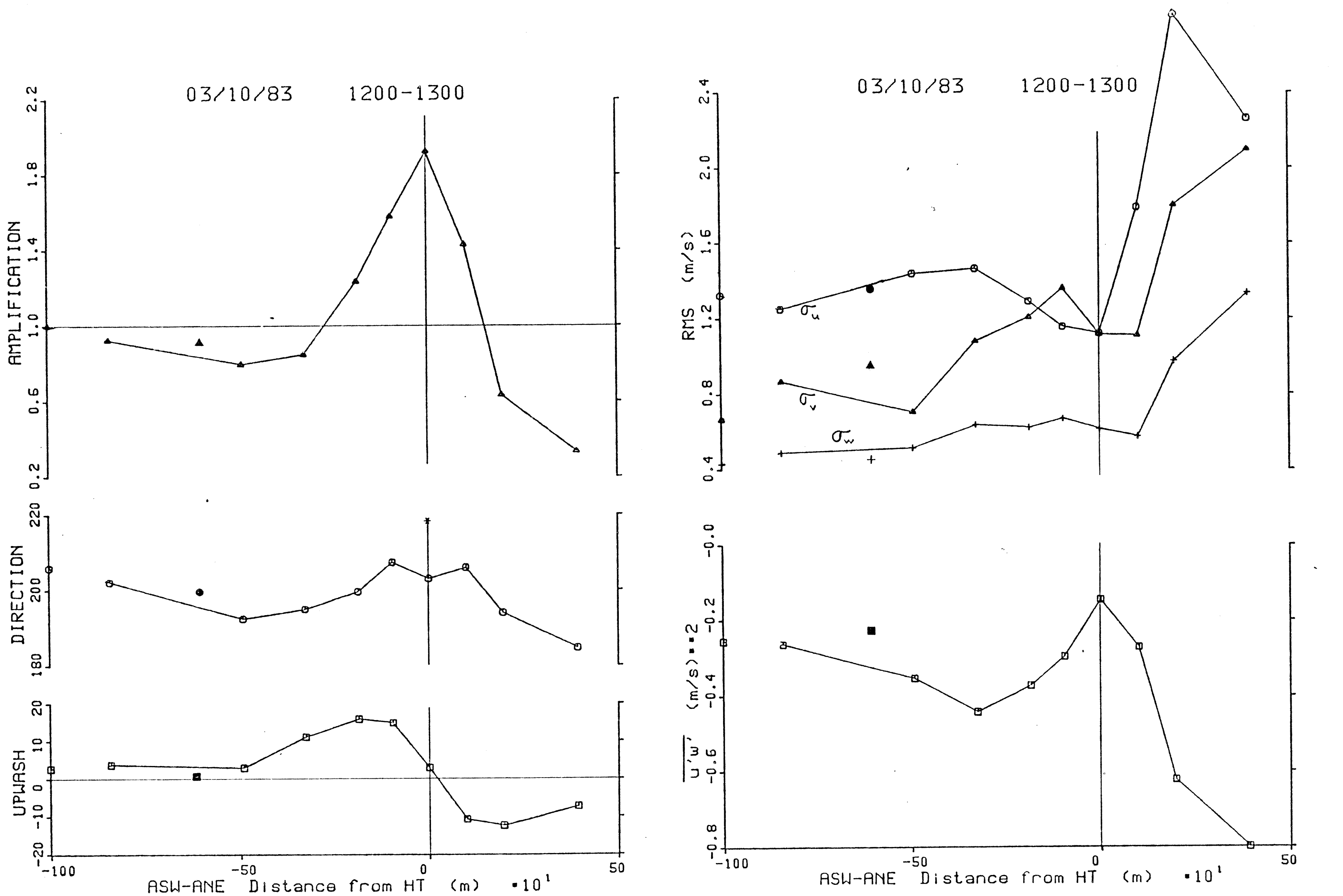


Fig. 4.3 (j) TU03A, $\phi_{RS}=210^{o}$, $U_{RS}(10m)=9.8\ ms^{-1}$

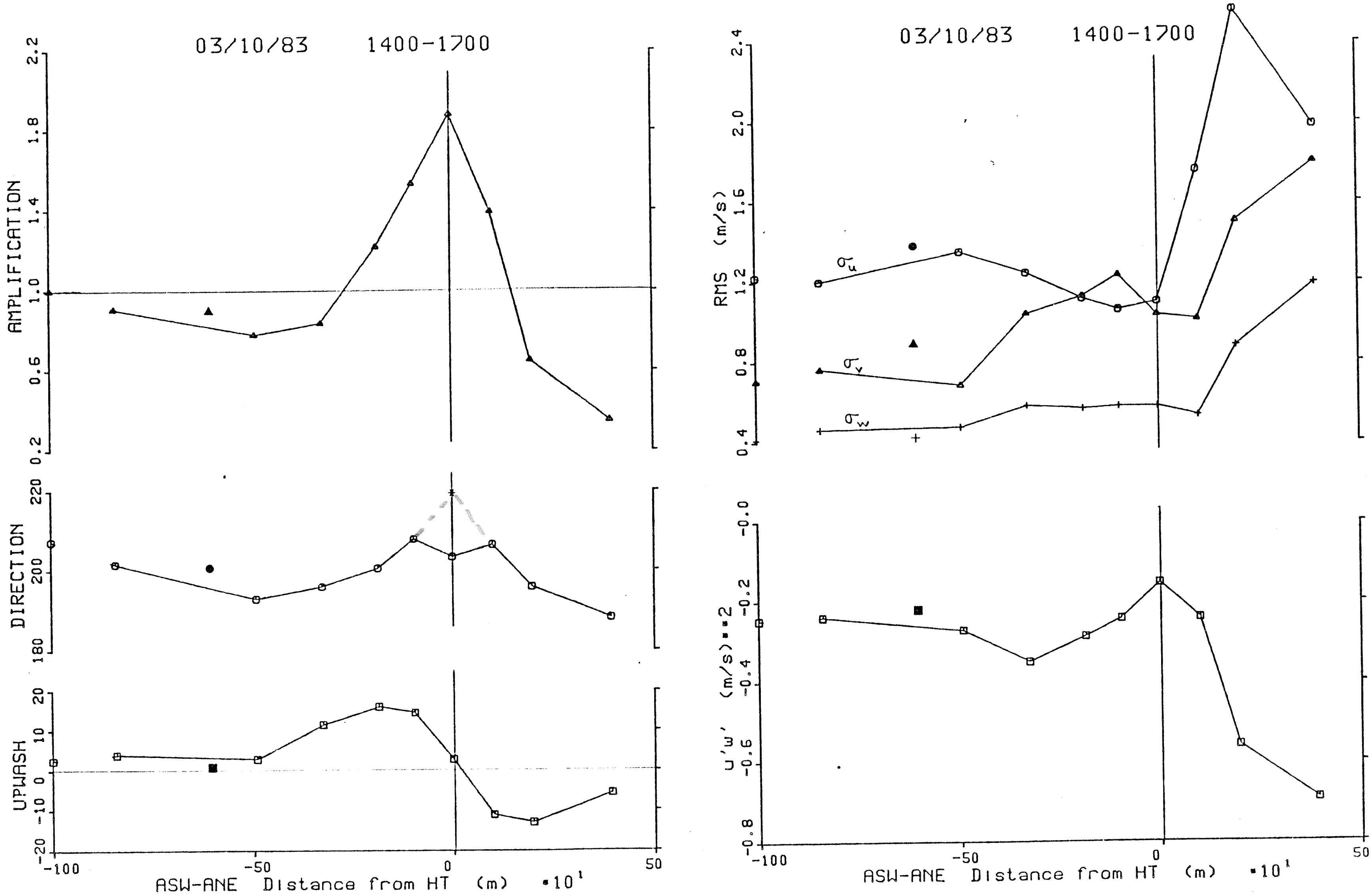


Fig. 4.3 (k) TU03B, $\phi_{RS}=210^o$, $U_{RS}(10m)=8.9\ ms^{-1}$

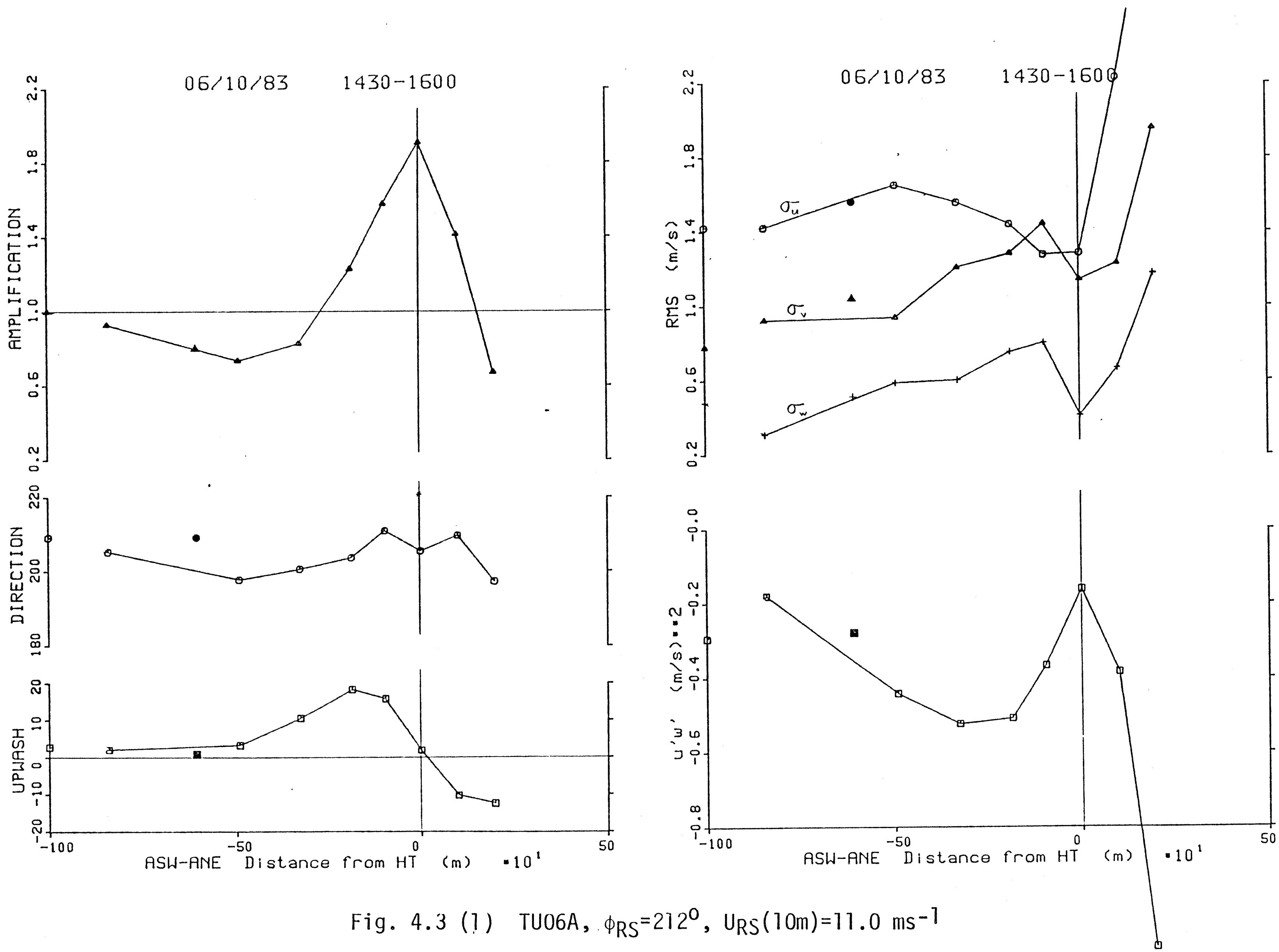


Fig. 4.3 (1) TU06A, $\phi_{RS}=212^{o}$, $U_{RS}(10m)=11.0\ ms^{-1}$

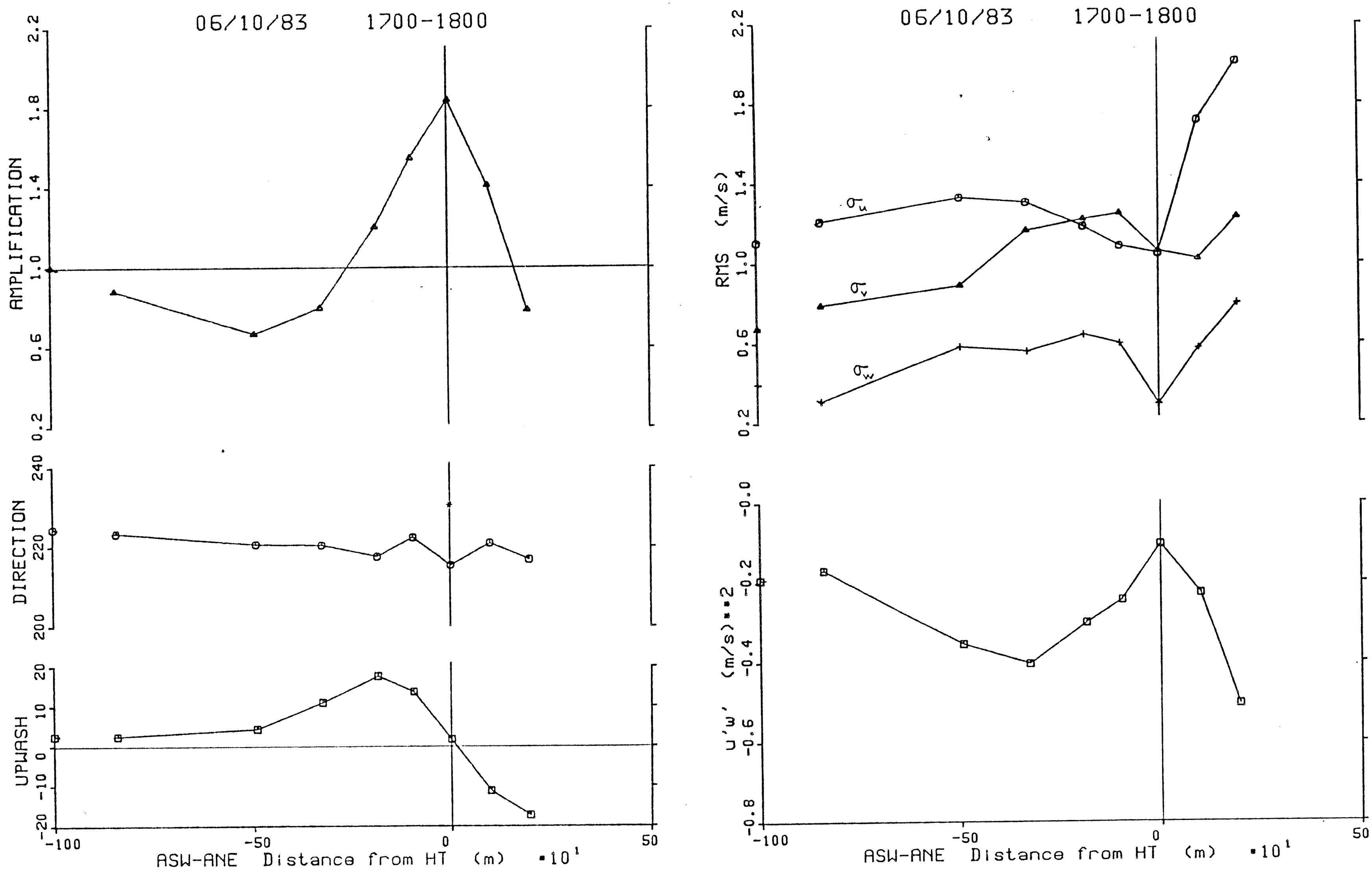


Fig. 4.3 (m) TU06B, $\phi_{RS}=228^{o}$, $U_{RS}(10m)=9.2\ ms^{-1}$

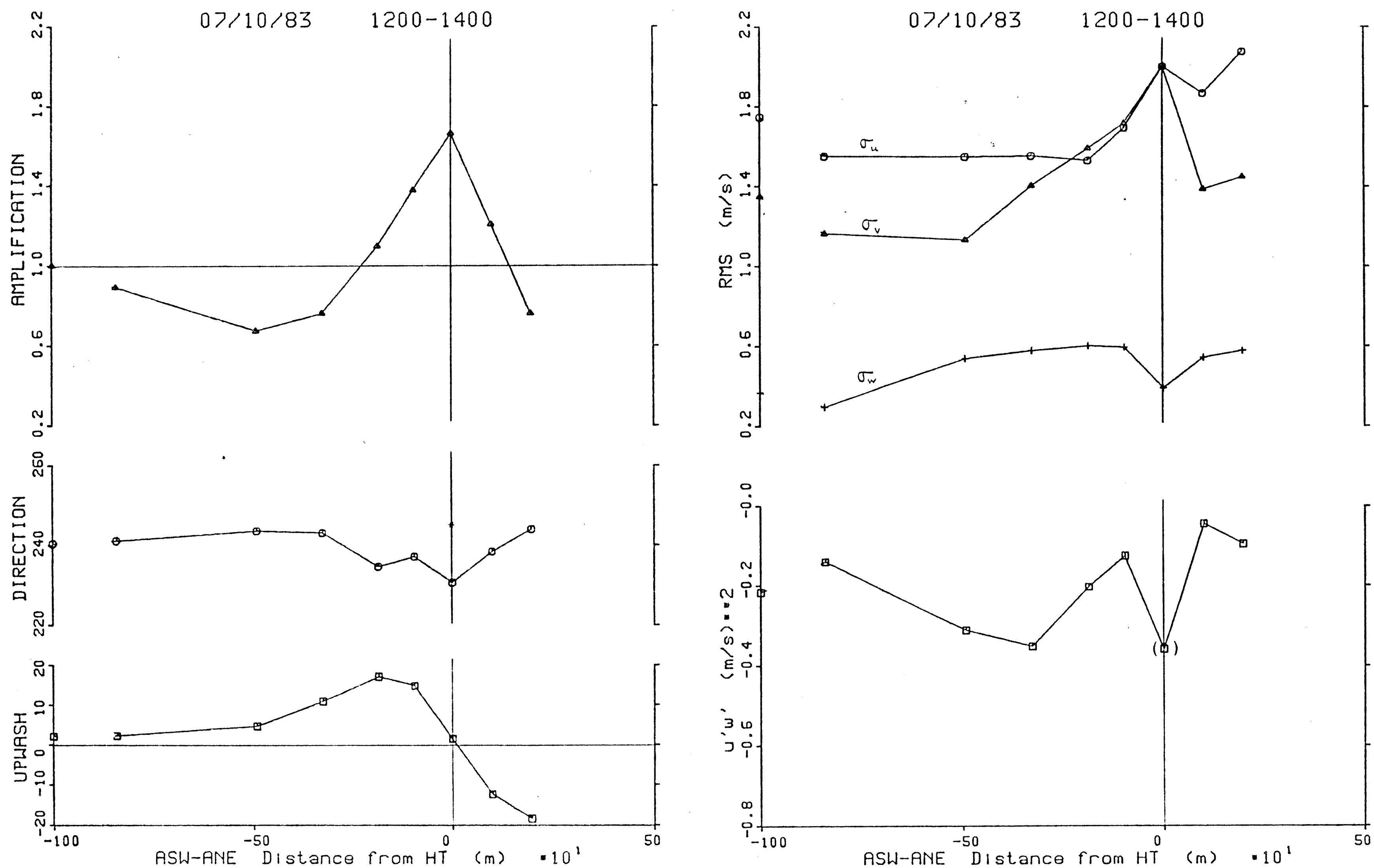


Fig. 4.3 (n) TU07A, $\phi_{RS}=240^0$, $U_{RS}(10m)=9.0\ ms^{-1}$

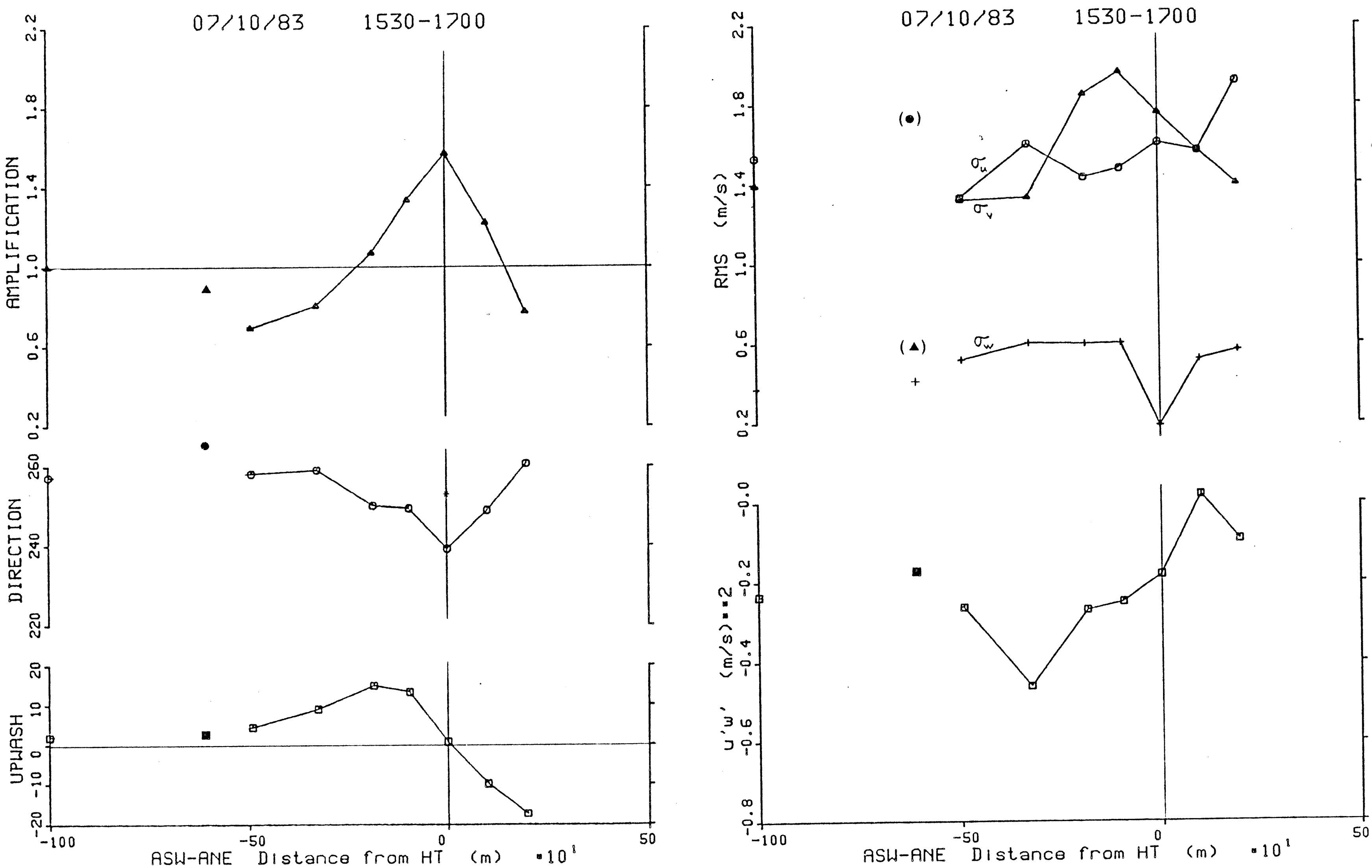


Fig. 4.3 (Q) TU07B, $\phi_{RS}=260^{0}$, $U_{RS}(10m)=10.0\ ms^{-1}$

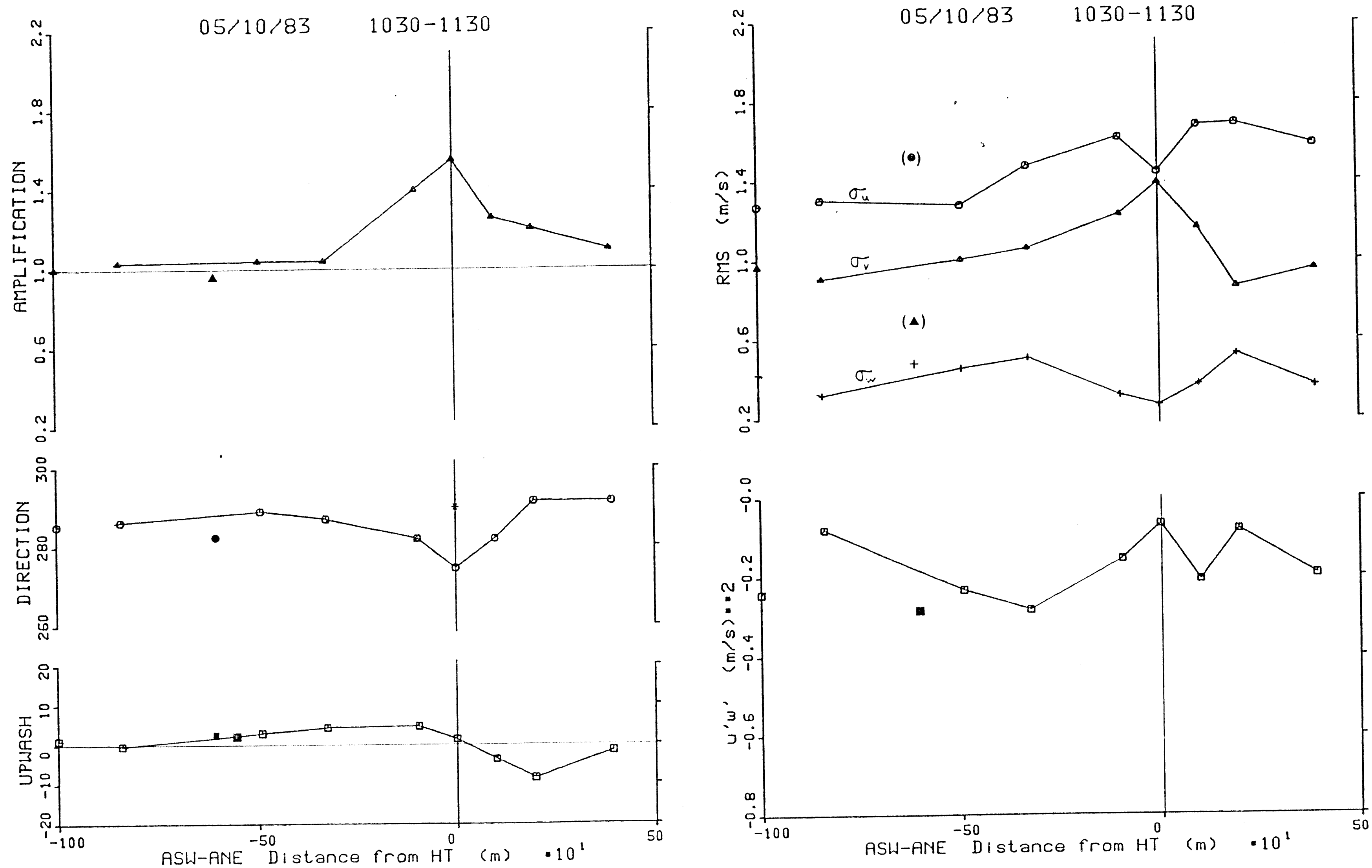


Fig. 4.3 (p) TU05A, $\phi_{RS}=285^{o}$, $U_{RS}(10m)=9.5\ ms^{-1}$

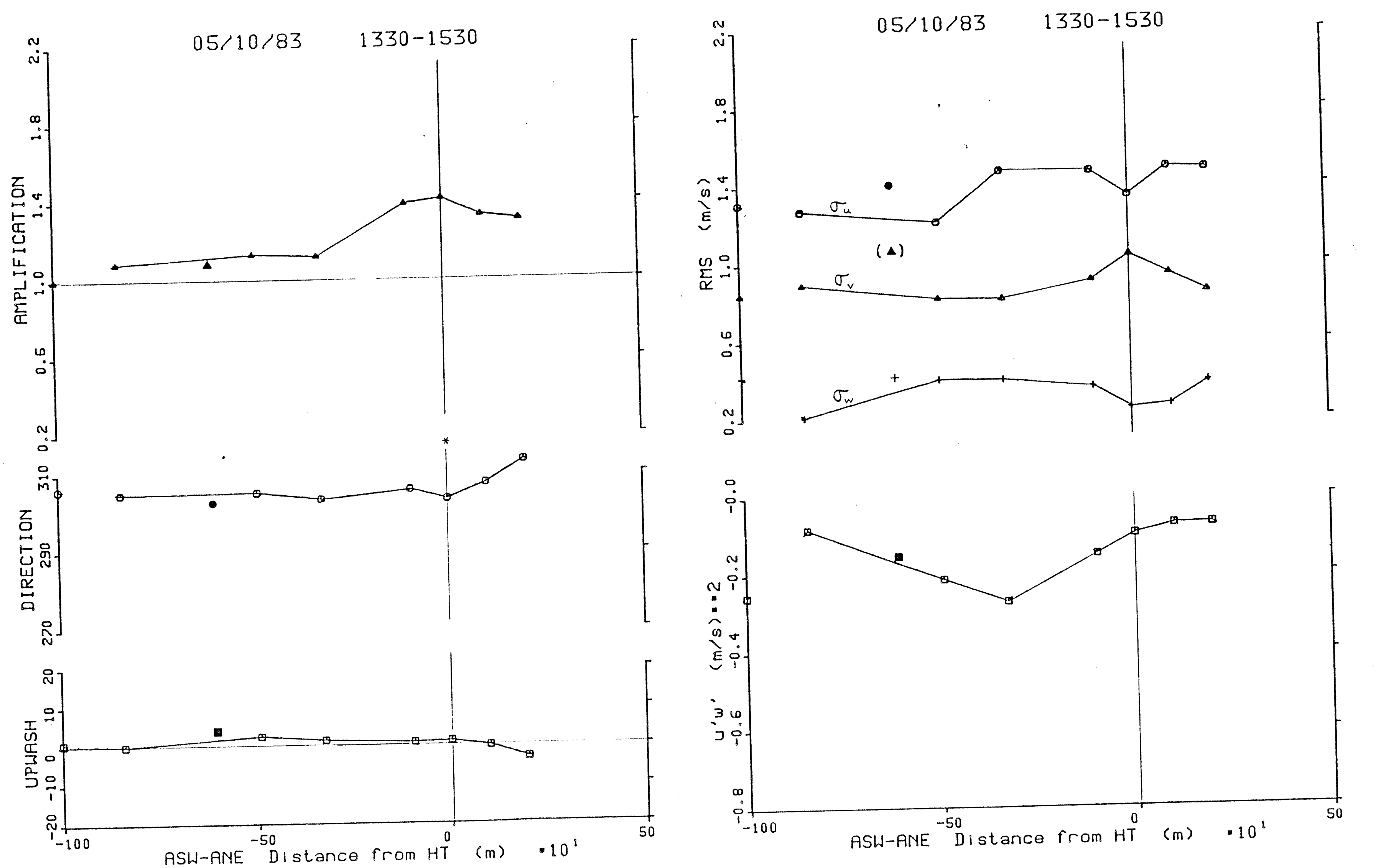


Fig. 4.3 (q) TU05B, $\phi_{RS}=305^{o}$, $U_{RS}(10m)=7.8\ ms^{-1}$

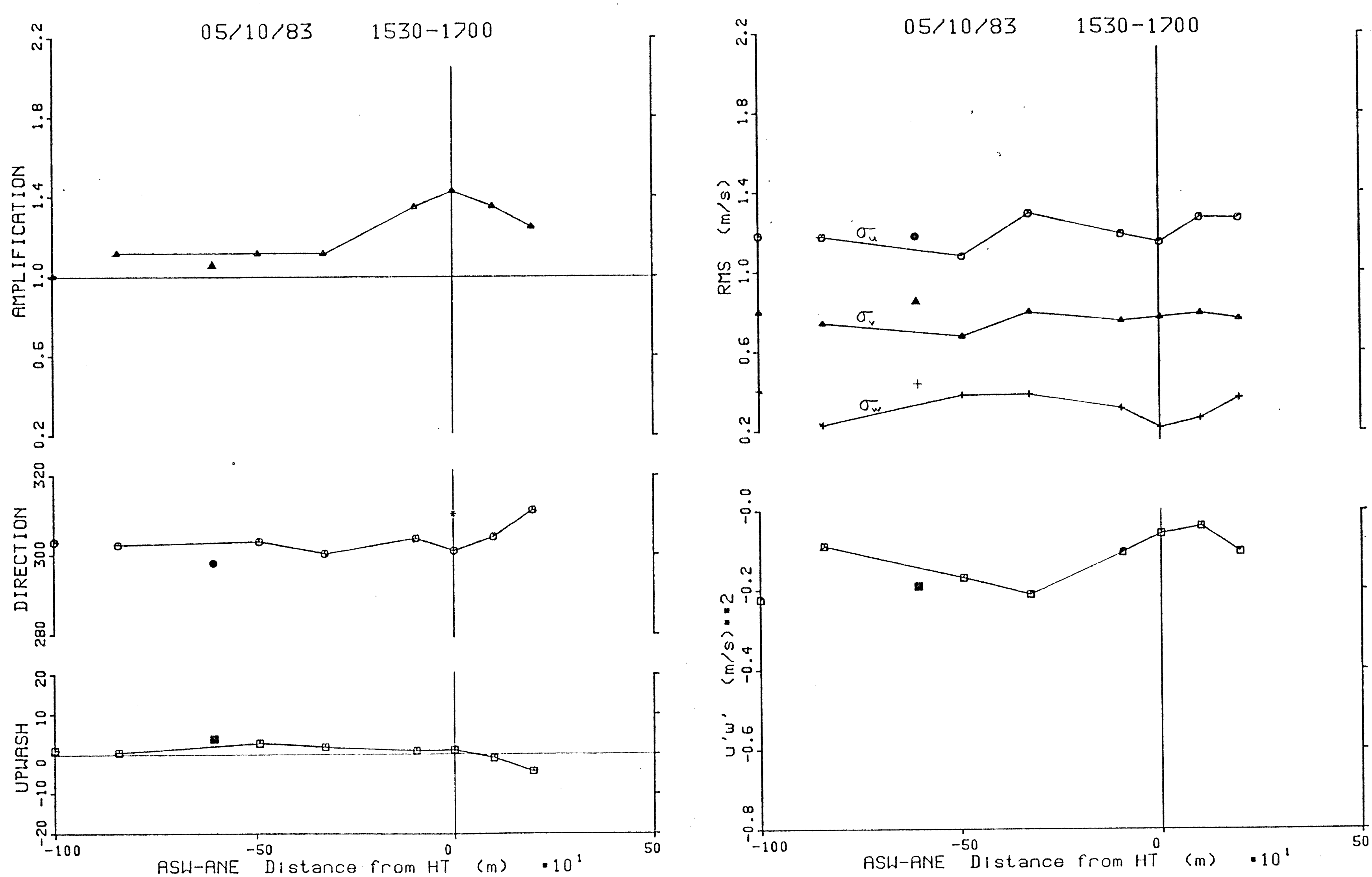


Fig. 4.3 (r) TU05C, $\phi_{RS}=300^{o}$, $U_{RS}(10m)=7.5\ ms^{-1}$

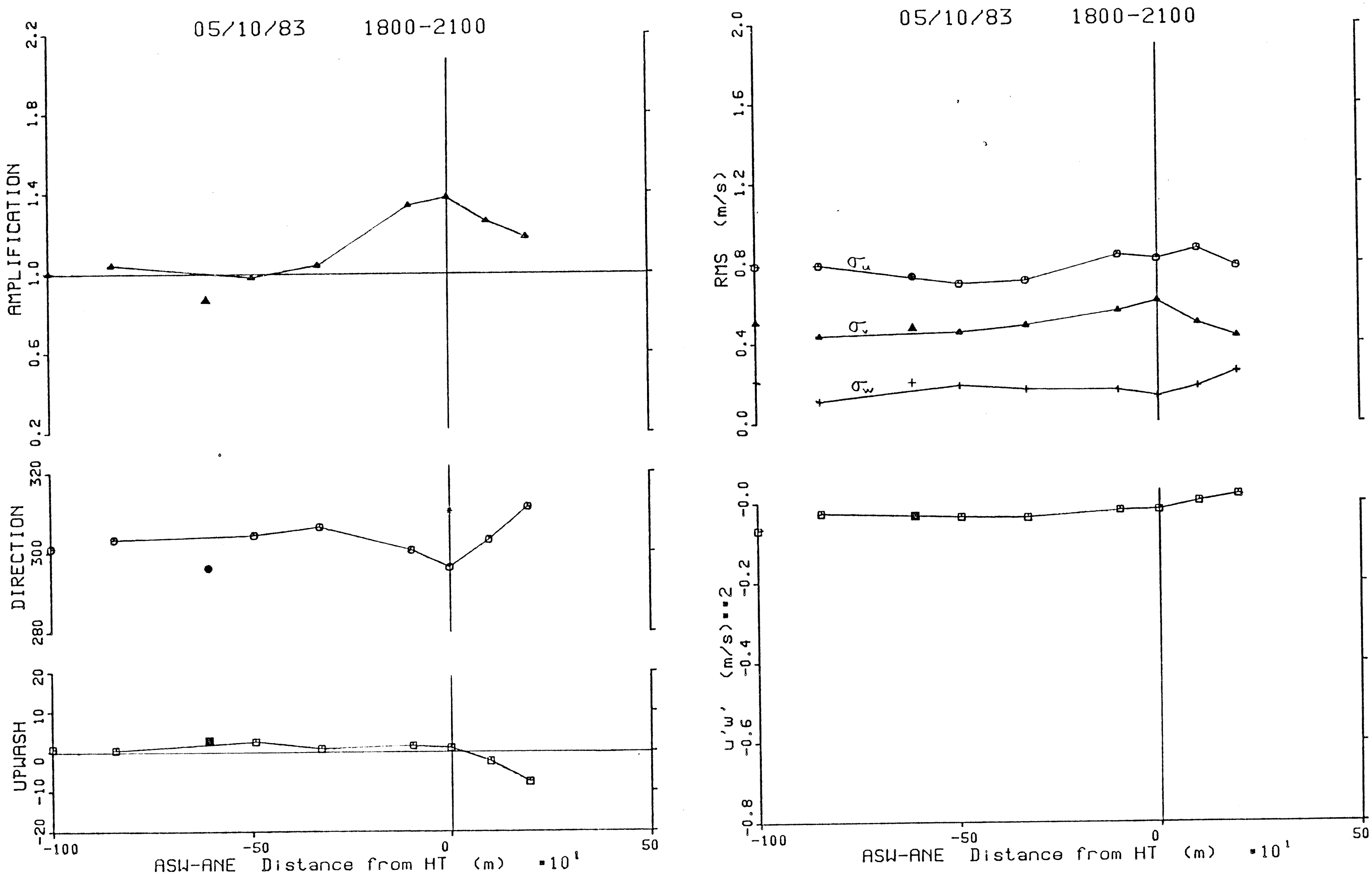


Fig. 4.3 (s) TU05D, ϕ_{RS}=300^0, U_{RS}(10m)=5.0 ms^{-1}

Figs. 4.4 <u>Horizontal profiles along Line AA for designated turbulence runs</u>

<u>Legend</u>

⊙: ΔS, $\Delta\phi$ from cup anemometers and wind vanes

△: Gill UVW anemometer values of $\Delta\phi$, $\overline{W}$ and $\overline{uw}$ (covariance)

$\left\{\begin{matrix} \triangle \\ \nabla \\ \boxdot \end{matrix}\right\}$: Gill UVW anemometer RMS values of $\left\{\begin{matrix} \sigma_u \\ \sigma_v \\ \sigma_w \end{matrix}\right\}$

Notes: 1. ΔZ = 10m for all results except cup values of ΔS and $\Delta\phi$ in Runs TU06 and TU07, for which ΔZ = 3m.

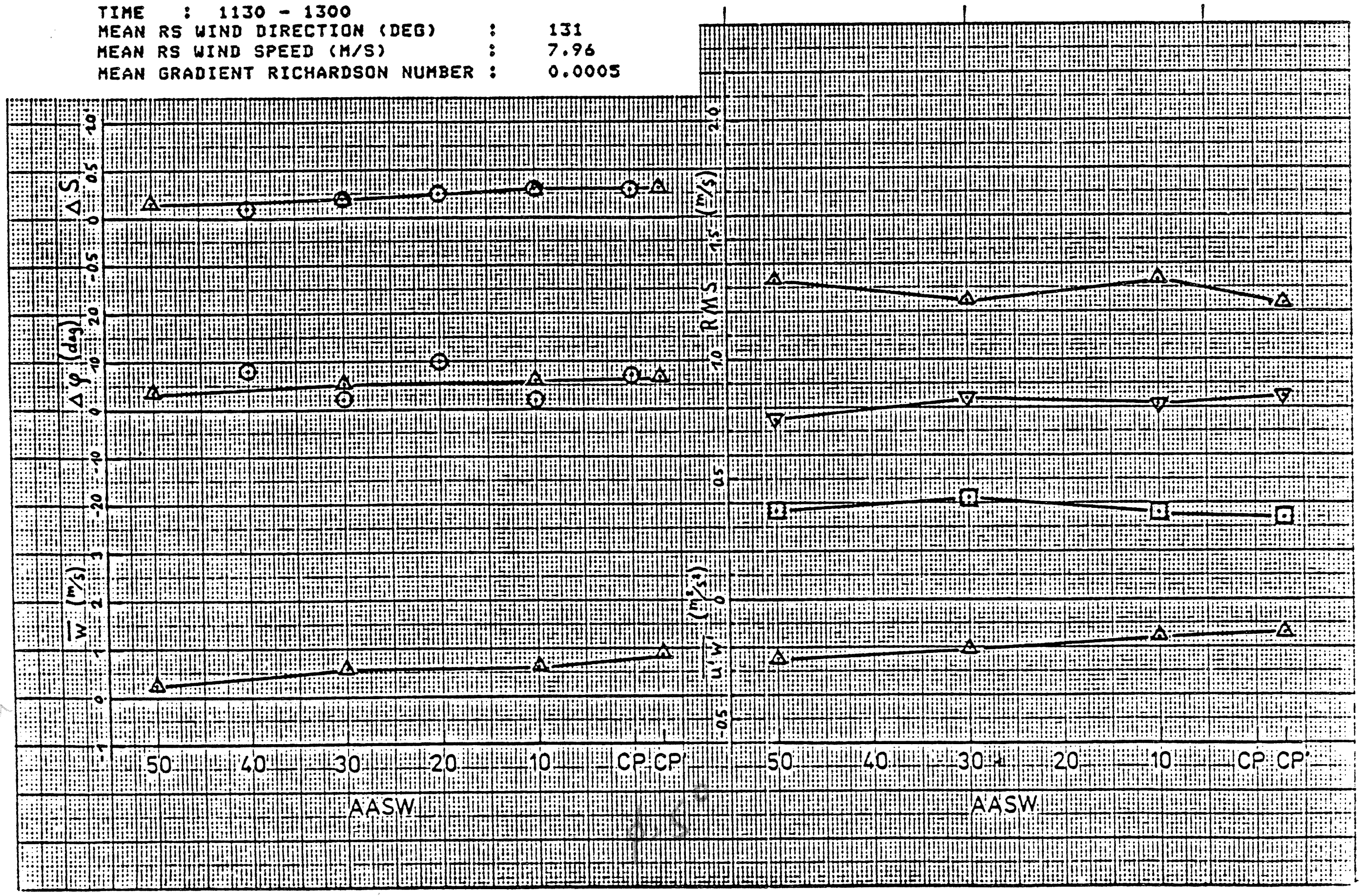
2. Data for these plots are tabulated in Table A1.5 ('DIF' in tables ≡ $\Delta\phi$ in figures).

Fig.4.4 (continued)

(a)

RUN NO : TU30-A

TIME	:	1130 - 1300
MEAN RS WIND DIRECTION (DEG)	:	131
MEAN RS WIND SPEED (M/S)	:	7.96
MEAN GRADIENT RICHARDSON NUMBER	:	0.0005



(b)

RUN NO : TU30-B

TIME	:	1600 - 1700
MEAN RS WIND DIRECTION (DEG)	:	124
MEAN RS WIND SPEED (M/S)	:	12.90
MEAN GRADIENT RICHARDSON NUMBER	:	0.0051

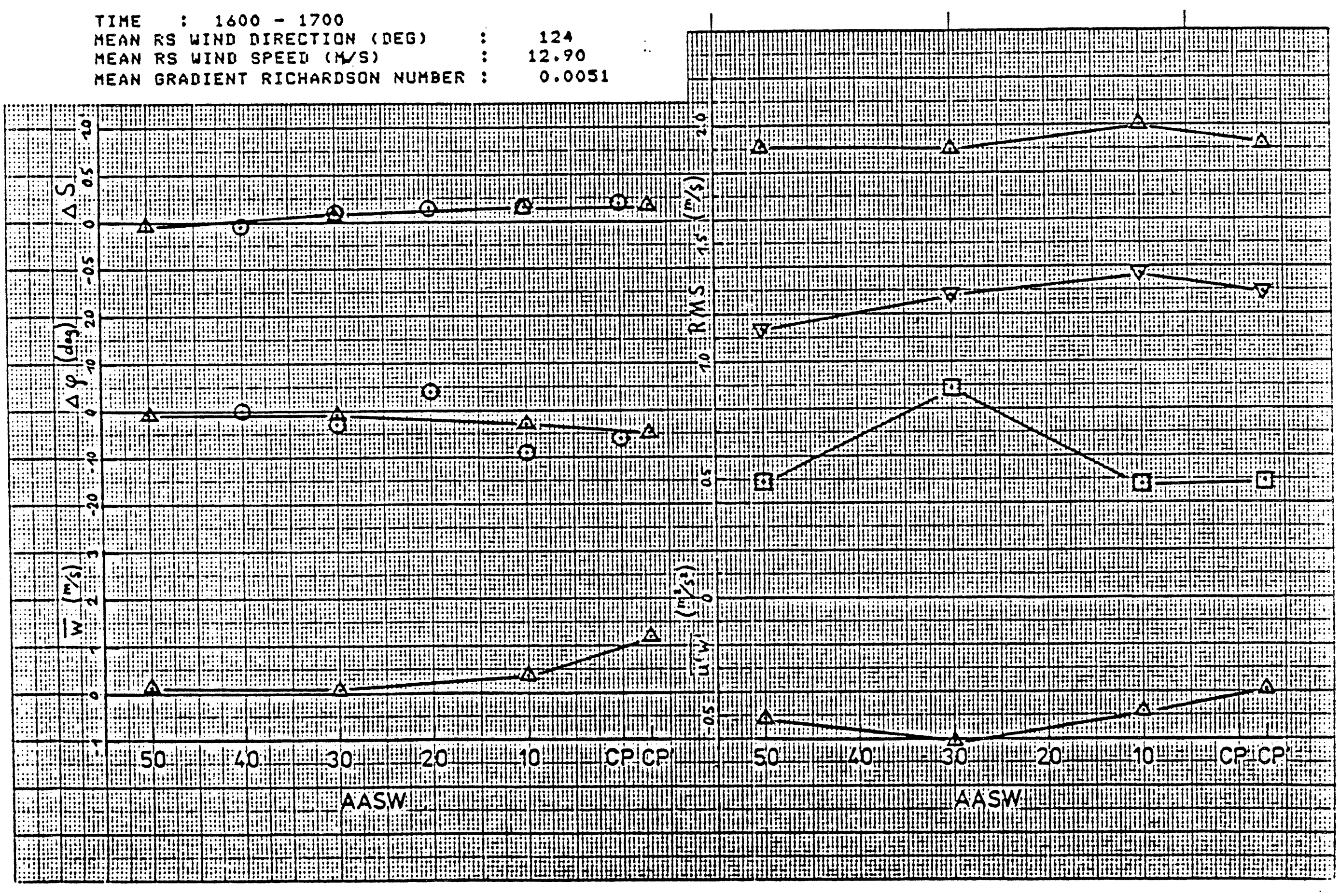
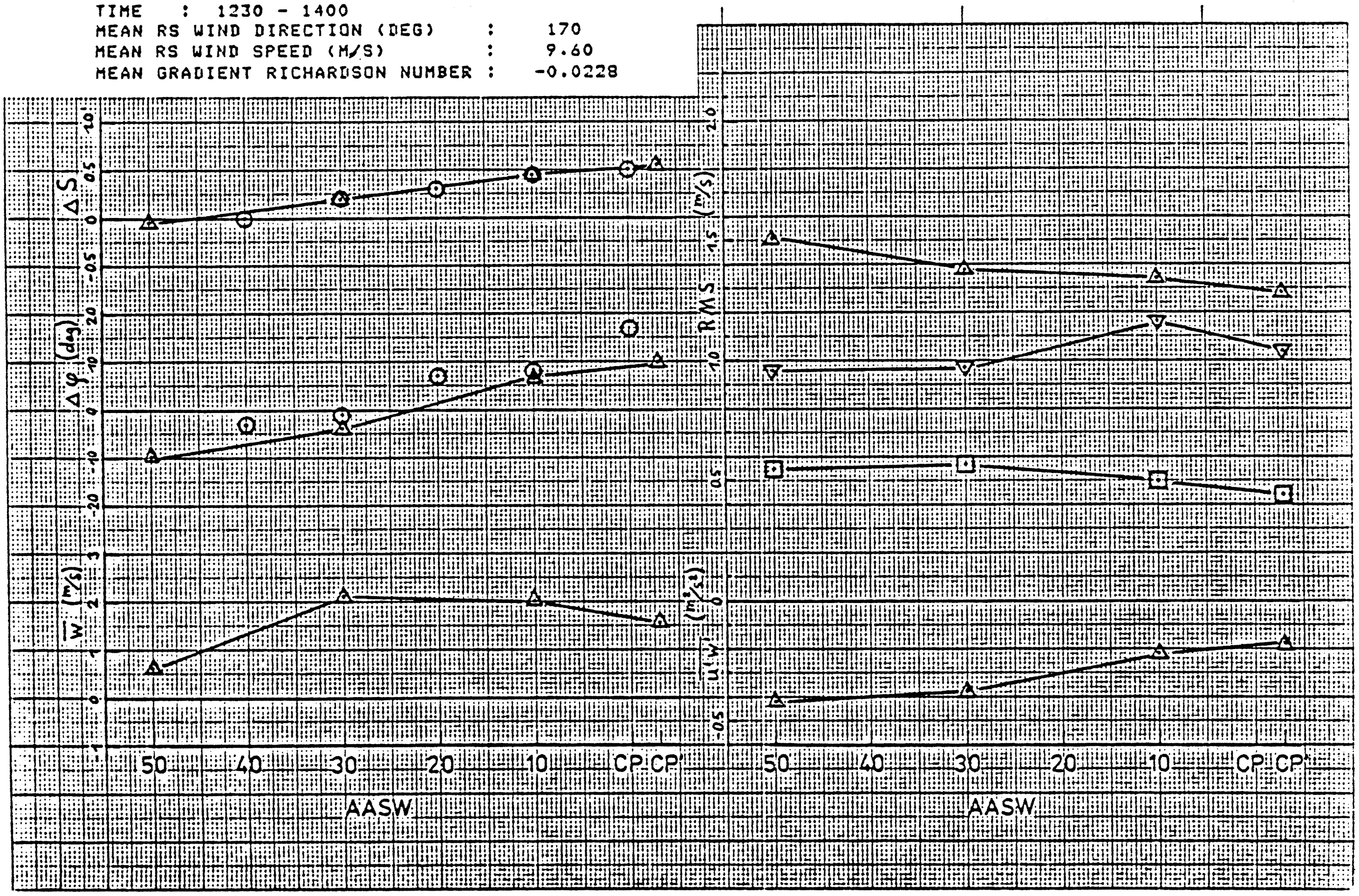


Fig. 4.4 (continued)

(c)

RUN NO : TU01-A

TIME : 1230 - 1400
MEAN RS WIND DIRECTION (DEG) : 170
MEAN RS WIND SPEED (M/S) : 9.60
MEAN GRADIENT RICHARDSON NUMBER : -0.0228



(d)

RUN NO : TU01-B

TIME : 1400 - 1600
MEAN RS WIND DIRECTION (DEG) : 177
MEAN RS WIND SPEED (M/S) : 9.12
MEAN GRADIENT RICHARDSON NUMBER : -0.0205

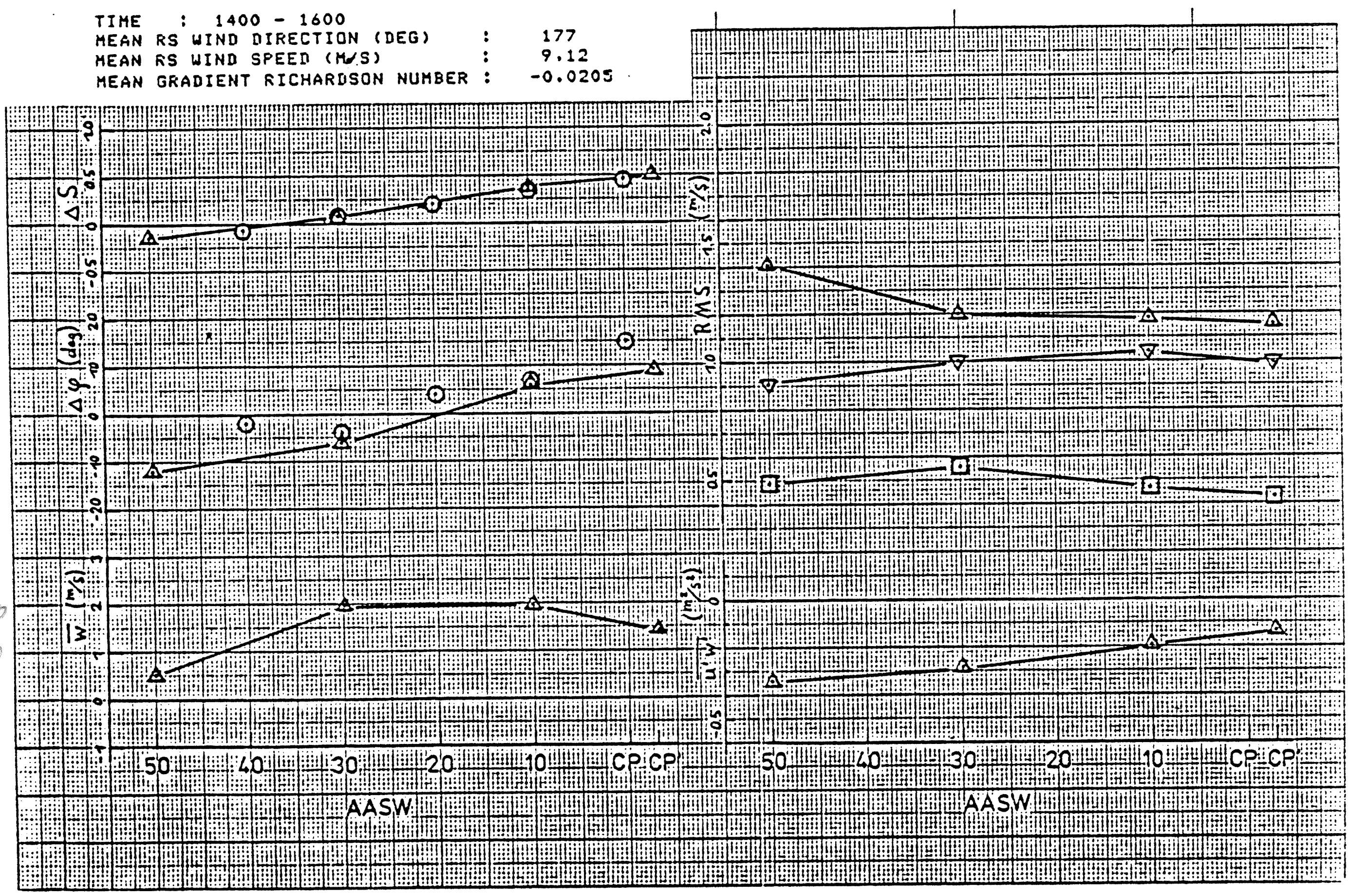
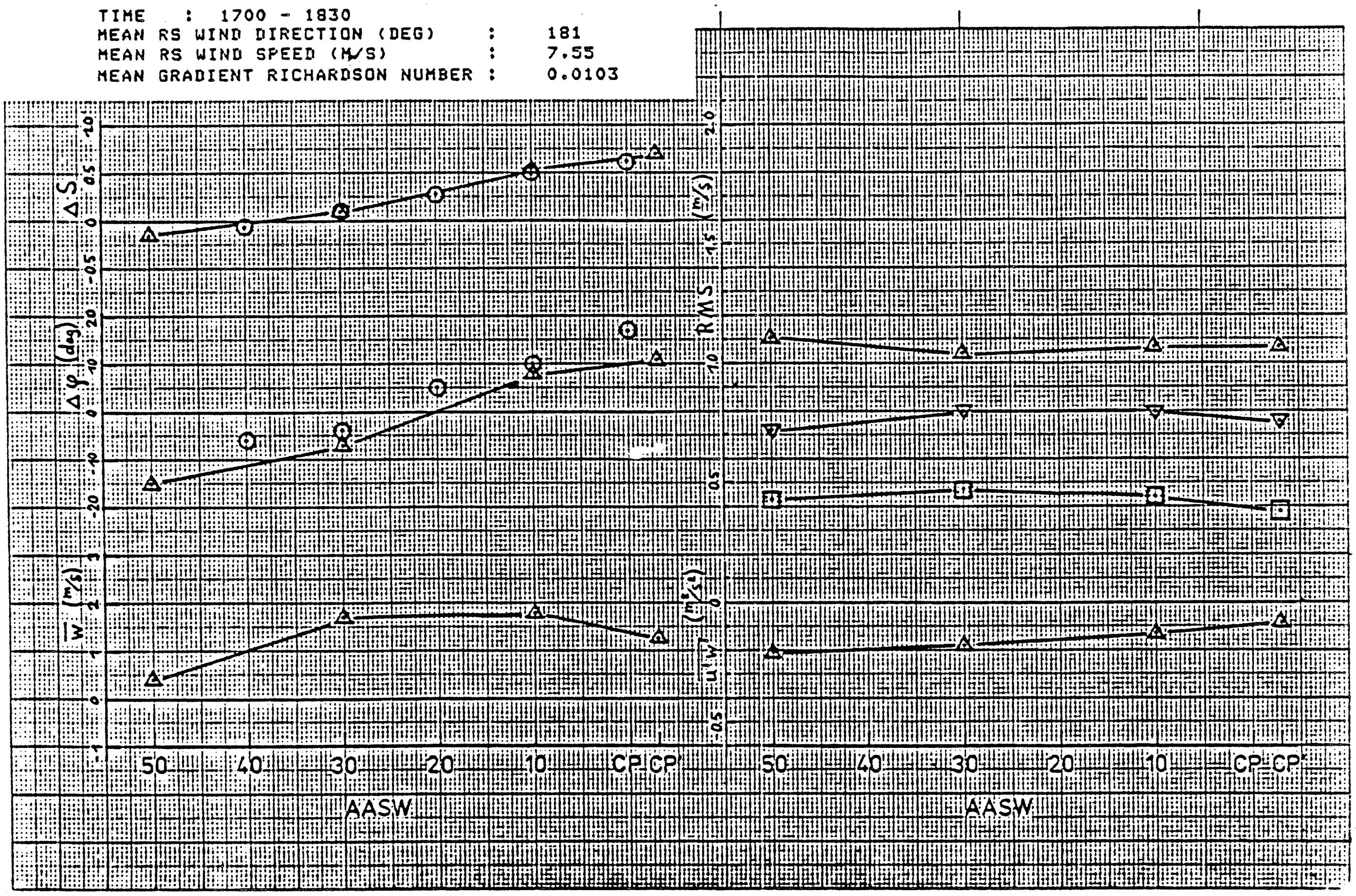


Fig. 4.4 (continued)

RUN NO : TU01-C

(e)

TIME : 1700 - 1830
MEAN RS WIND DIRECTION (DEG) : 181
MEAN RS WIND SPEED (M/S) : 7.55
MEAN GRADIENT RICHARDSON NUMBER : 0.0103



RUN NO : TU02

(f)

TIME : 1400 - 1600
MEAN RS WIND DIRECTION (DEG) : 160
MEAN RS WIND SPEED (M/S) : 9.88
MEAN GRADIENT RICHARDSON NUMBER : 0.0026

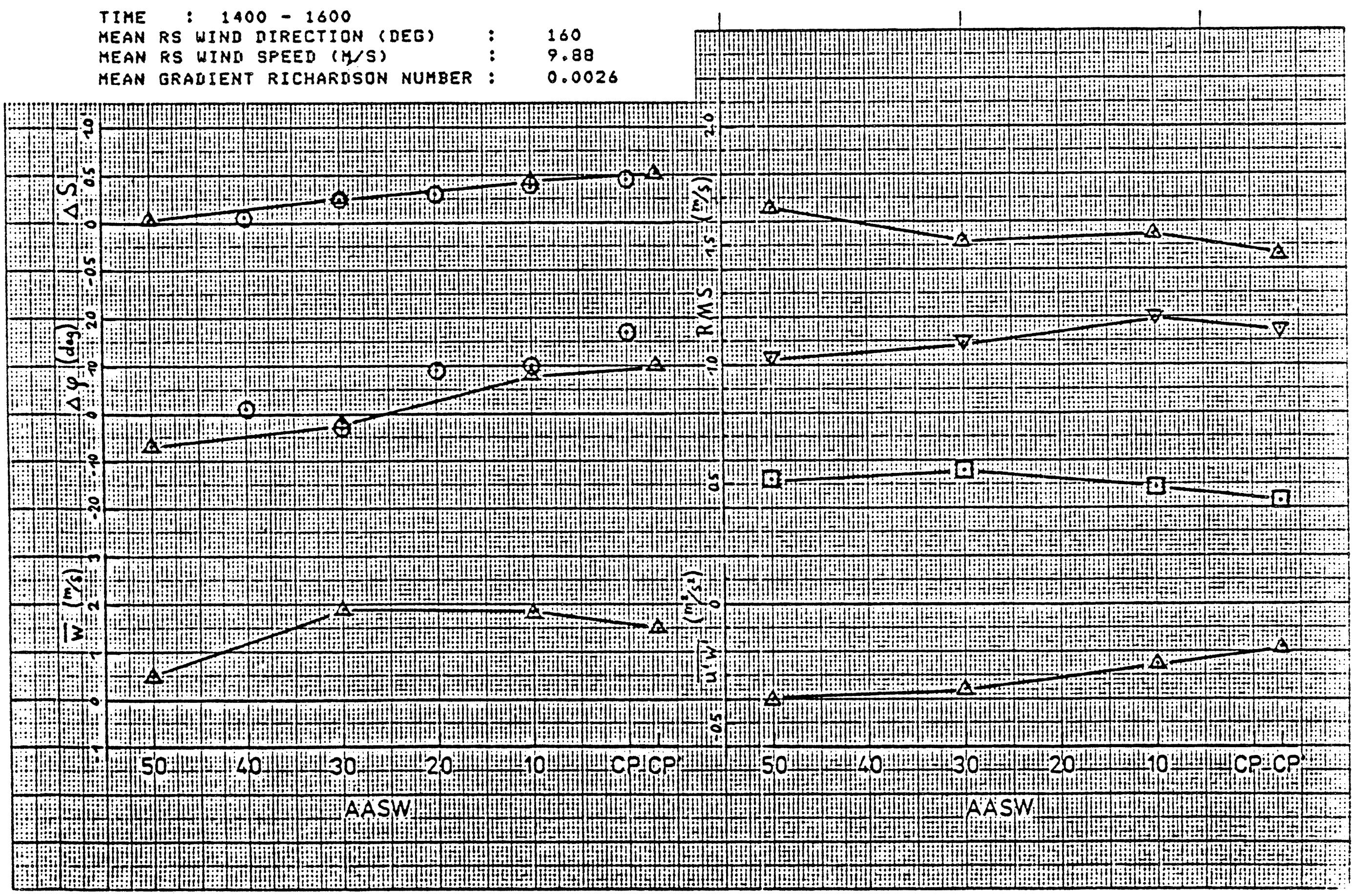
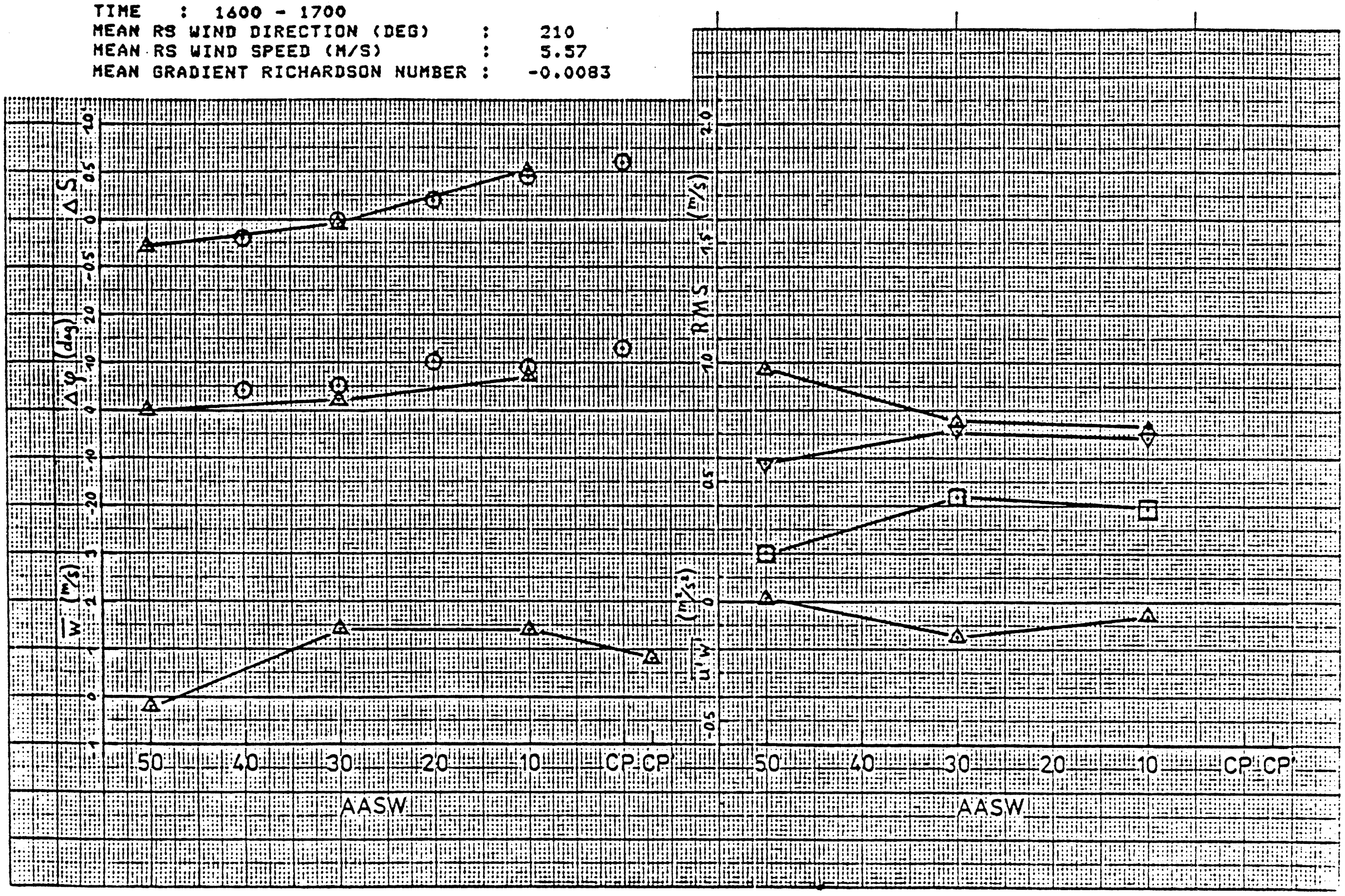


Fig. 4.4 (continued)

RUN NO : TU25

(g)

TIME : 1600 - 1700
MEAN RS WIND DIRECTION (DEG) : 210
MEAN RS WIND SPEED (M/S) : 5.57
MEAN GRADIENT RICHARDSON NUMBER : -0.0083



RUN NO : TU26

(h)

TIME : 1330 - 1400
MEAN RS WIND DIRECTION (DEG) : 216
MEAN RS WIND SPEED (M/S) : 7.91
MEAN GRADIENT RICHARDSON NUMBER : -0.0116

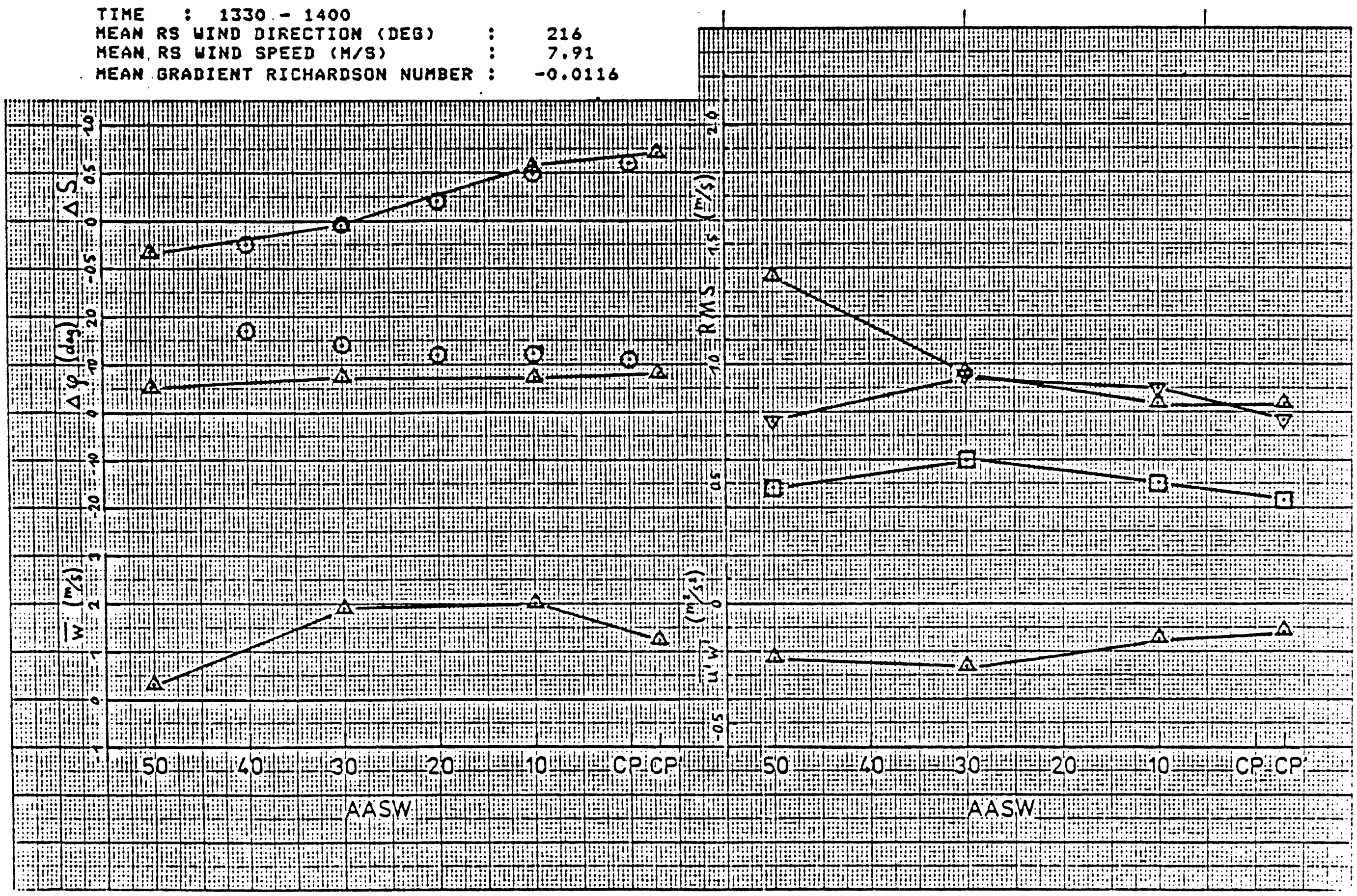


Fig. 4.4 (continued)

(i)

RUN NO : TU01-D

TIME : 1930 - 2000
MEAN RS WIND DIRECTION (DEG) : 197
MEAN RS WIND SPEED (M/S) : 7.56
MEAN GRADIENT RICHARDSON NUMBER : 0.0205

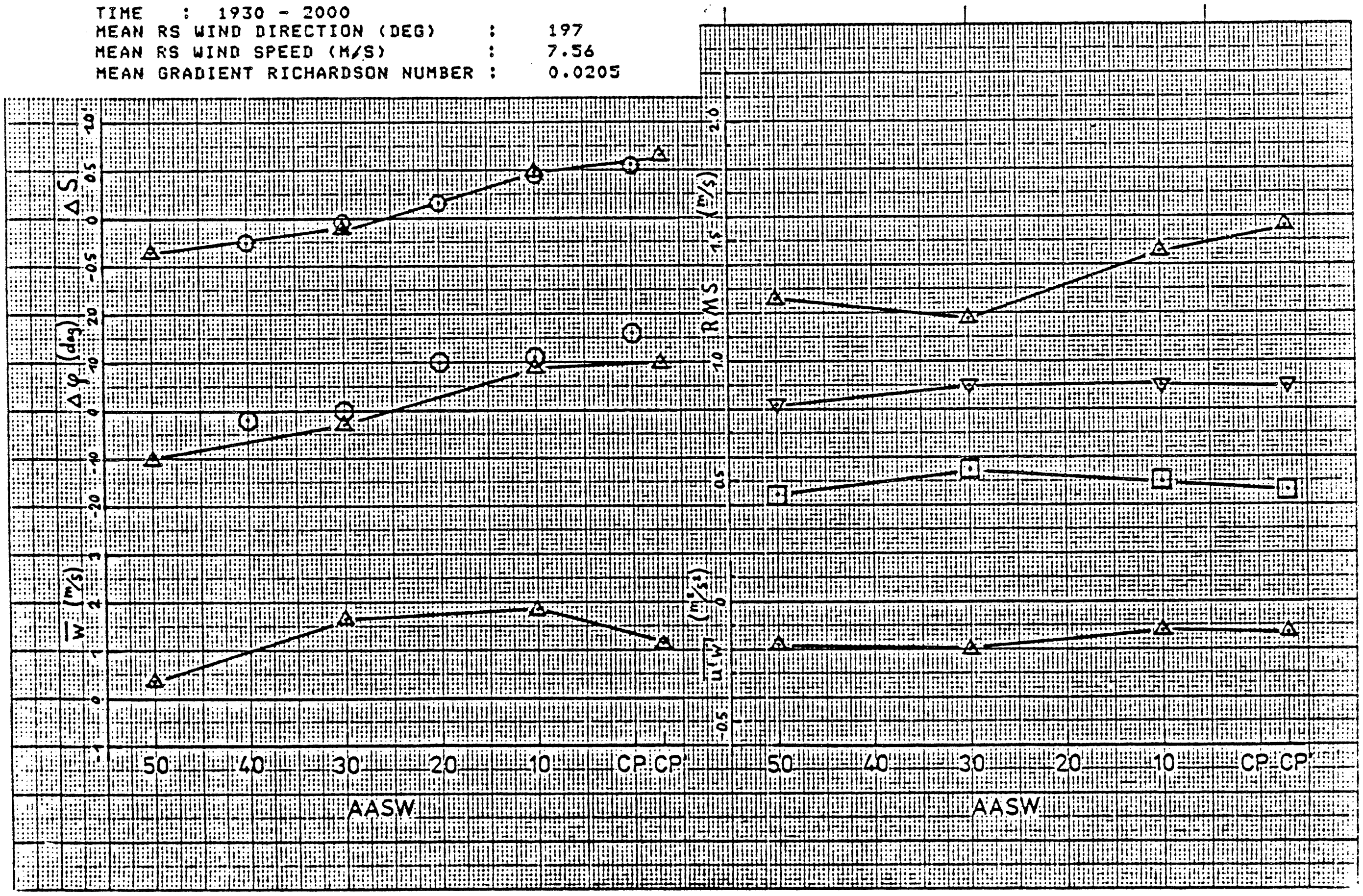
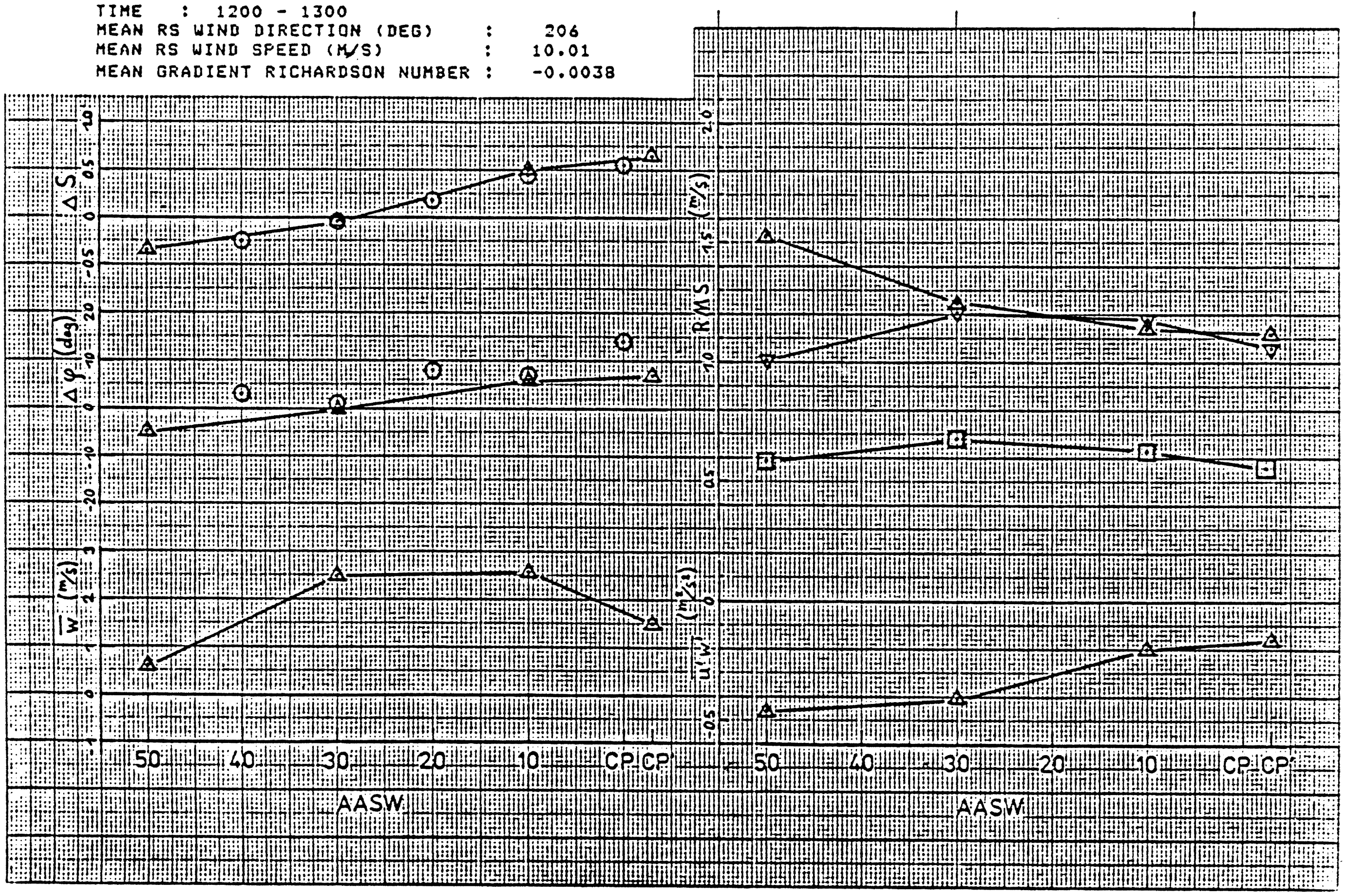


Fig. 4.4 (continued)

(j)

RUN NO : TU03-A

TIME : 1200 - 1300
MEAN RS WIND DIRECTION (DEG) : 206
MEAN RS WIND SPEED (M/S) : 10.01
MEAN GRADIENT RICHARDSON NUMBER : -0.0038



(k)

RUN NO : TU03-B

TIME : 1425 - 1700
MEAN RS WIND DIRECTION (DEG) : 207
MEAN RS WIND SPEED (M/S) : 9.03
MEAN GRADIENT RICHARDSON NUMBER : -0.0074

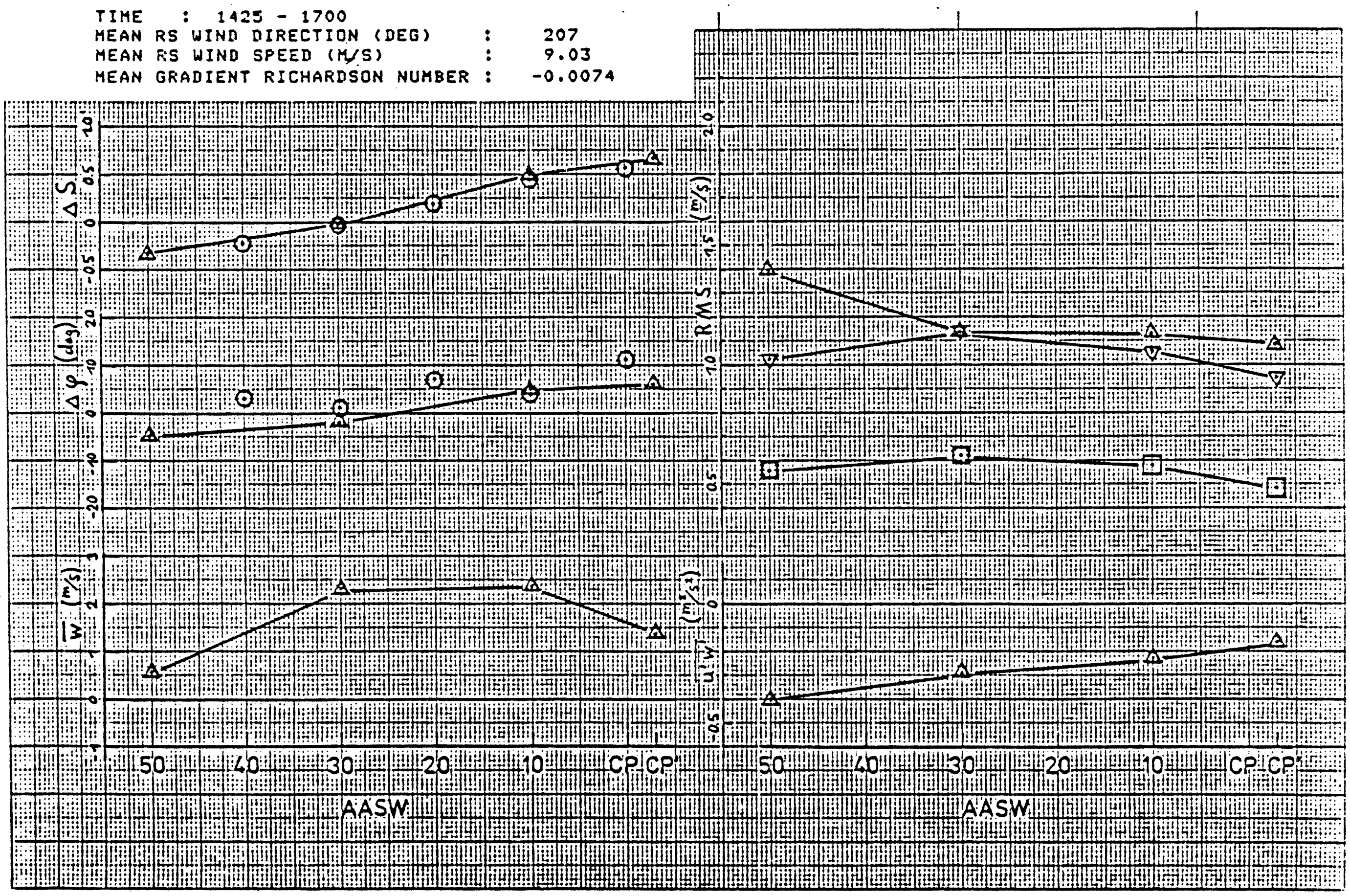
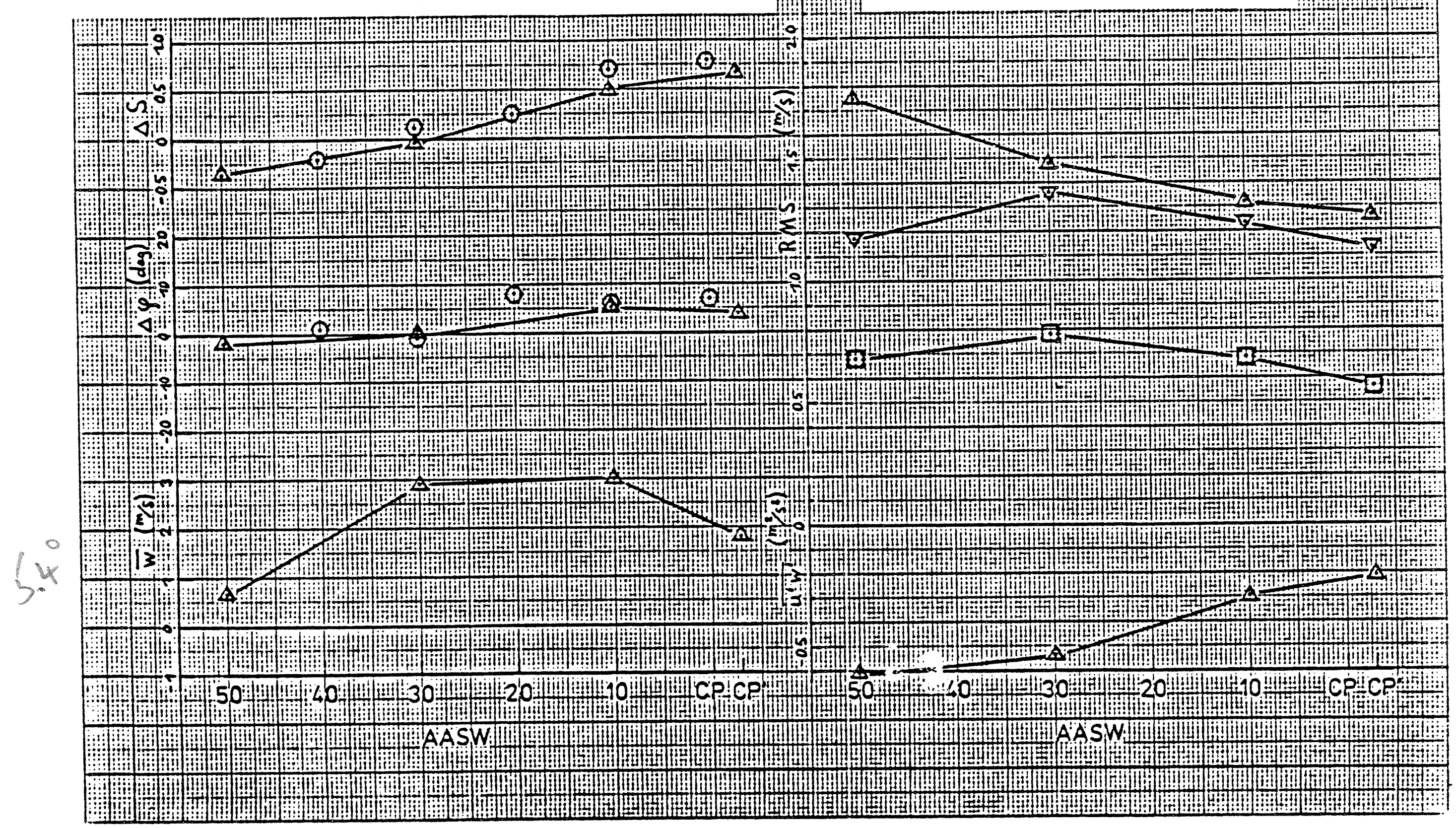


Fig. 4.4 (continued)

(l)

RUN NO : TU06-A

TIME : 1430 - 1600
MEAN RS WIND DIRECTION (DEG) : 210
MEAN RS WIND SPEED (M/S) : 11.65
MEAN GRADIENT RICHARDSON NUMBER : 0.0002



(m)

RUN NO : TU06-B

TIME : 1700 - 1800
MEAN RS WIND DIRECTION (DEG) : 223
MEAN RS WIND SPEED (M/S) : 9.91
MEAN GRADIENT RICHARDSON NUMBER : 0.0011

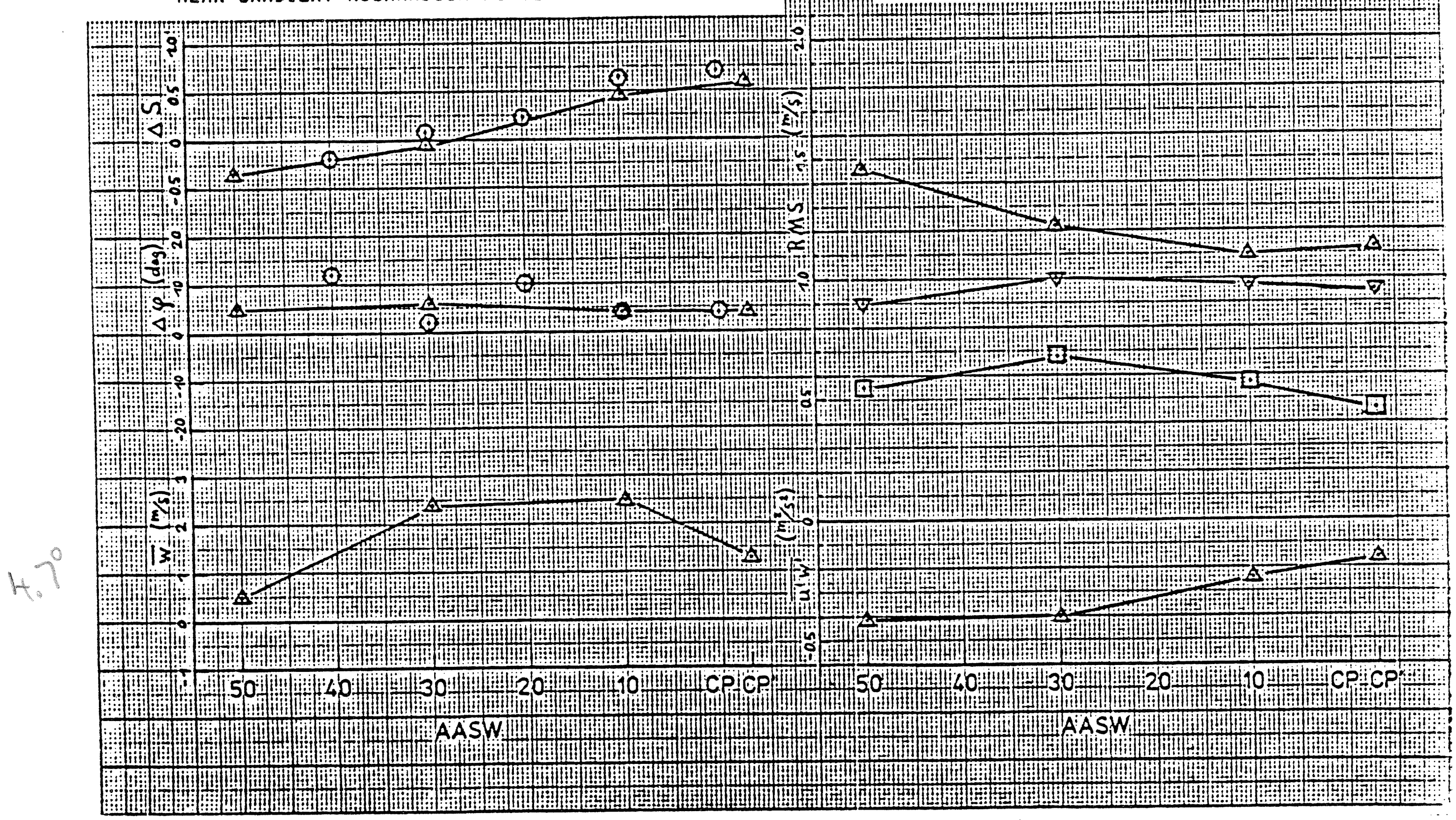
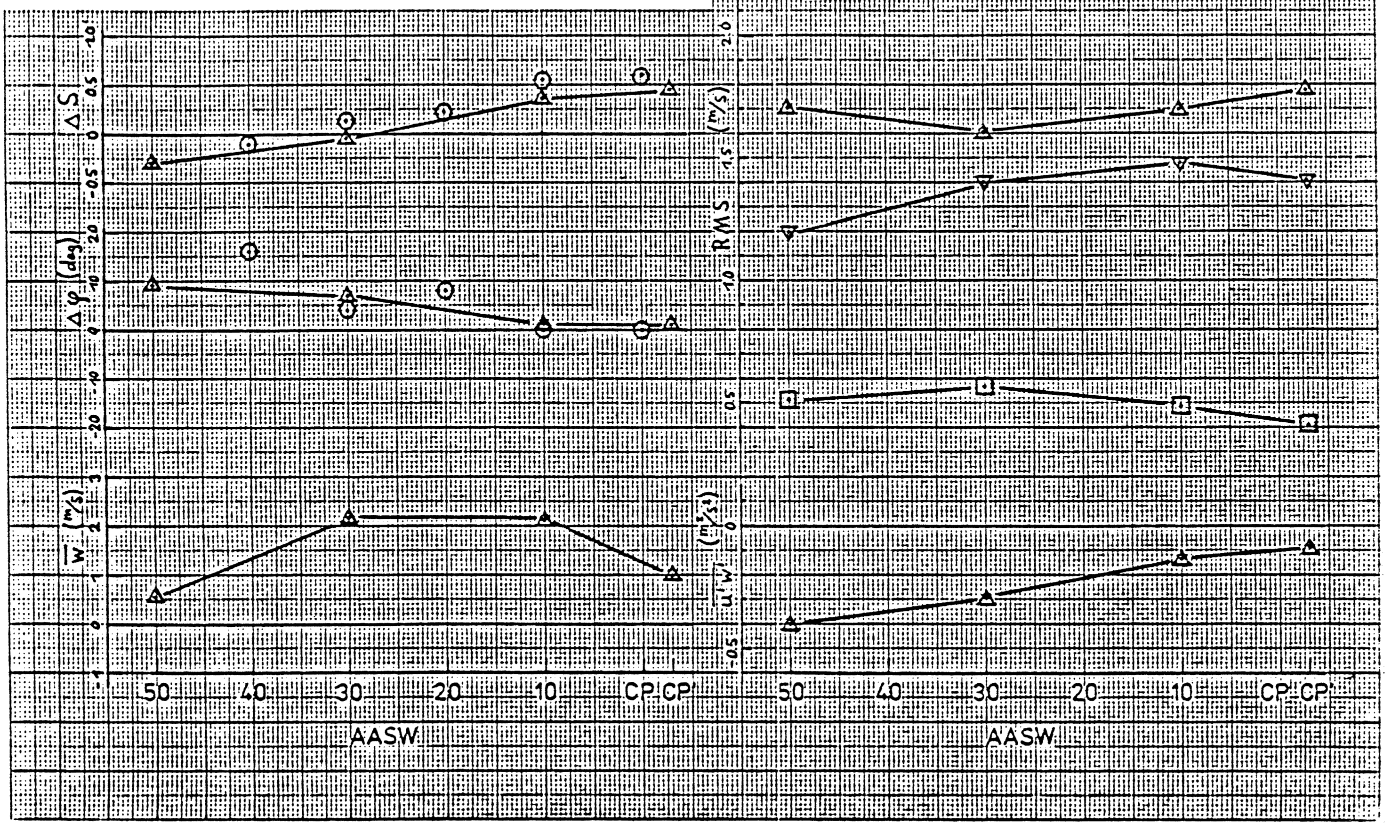


Fig. 4.4 (continued)

(n)

RUN NO : TU07-A

TIME : 1200 - 1400
MEAN RS WIND DIRECTION (DEG) : 237
MEAN RS WIND SPEED (M/S) : 9.58
MEAN GRADIENT RICHARDSON NUMBER : 0.0004



(o)

RUN NO : TU07-B

TIME : 1530 - 1700
MEAN RS WIND DIRECTION (DEG) : 256
MEAN RS WIND SPEED (M/S) : 10.15
MEAN GRADIENT RICHARDSON NUMBER : 0.0009

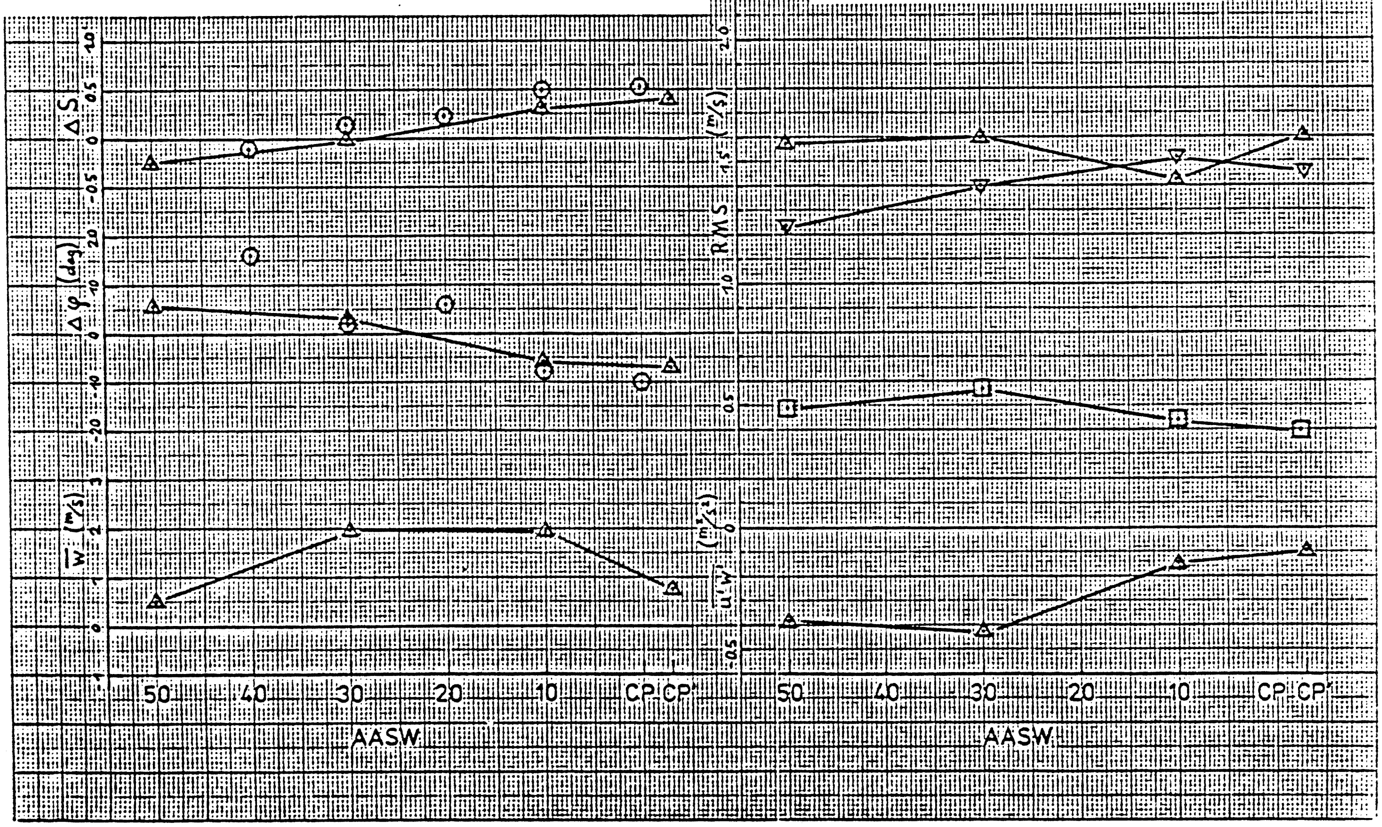
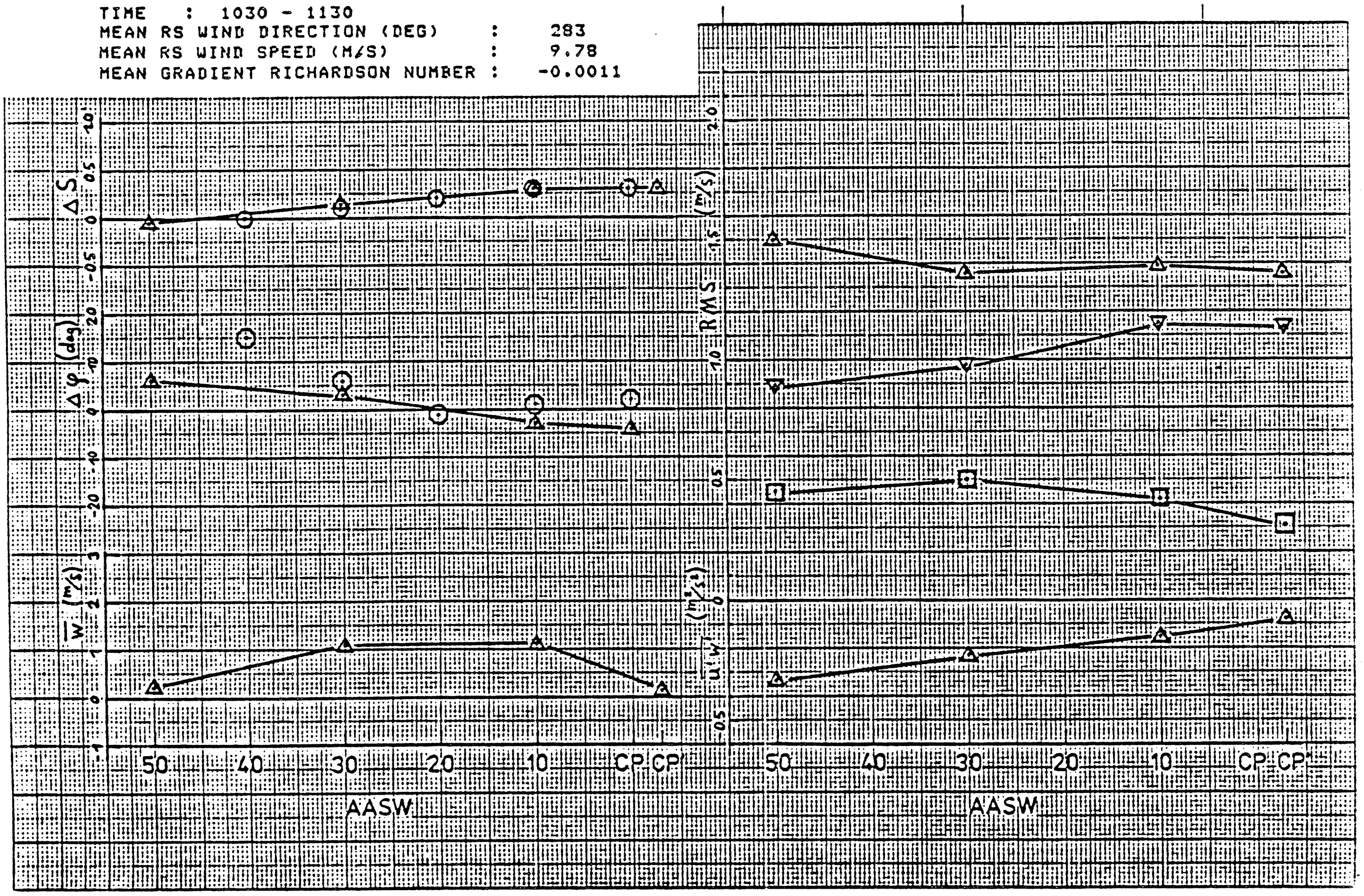


Fig. 4.4 (continued)

(p)

RUN NO : TU05-A

TIME : 1030 - 1130
MEAN RS WIND DIRECTION (DEG) : 283
MEAN RS WIND SPEED (M/S) : 9.78
MEAN GRADIENT RICHARDSON NUMBER : -0.0011



(q)

RUN NO : TU05-B

TIME : 1330 - 1530
MEAN RS WIND DIRECTION (DEG) : 303
MEAN RS WIND SPEED (M/S) : 8.28
MEAN GRADIENT RICHARDSON NUMBER : -0.0073

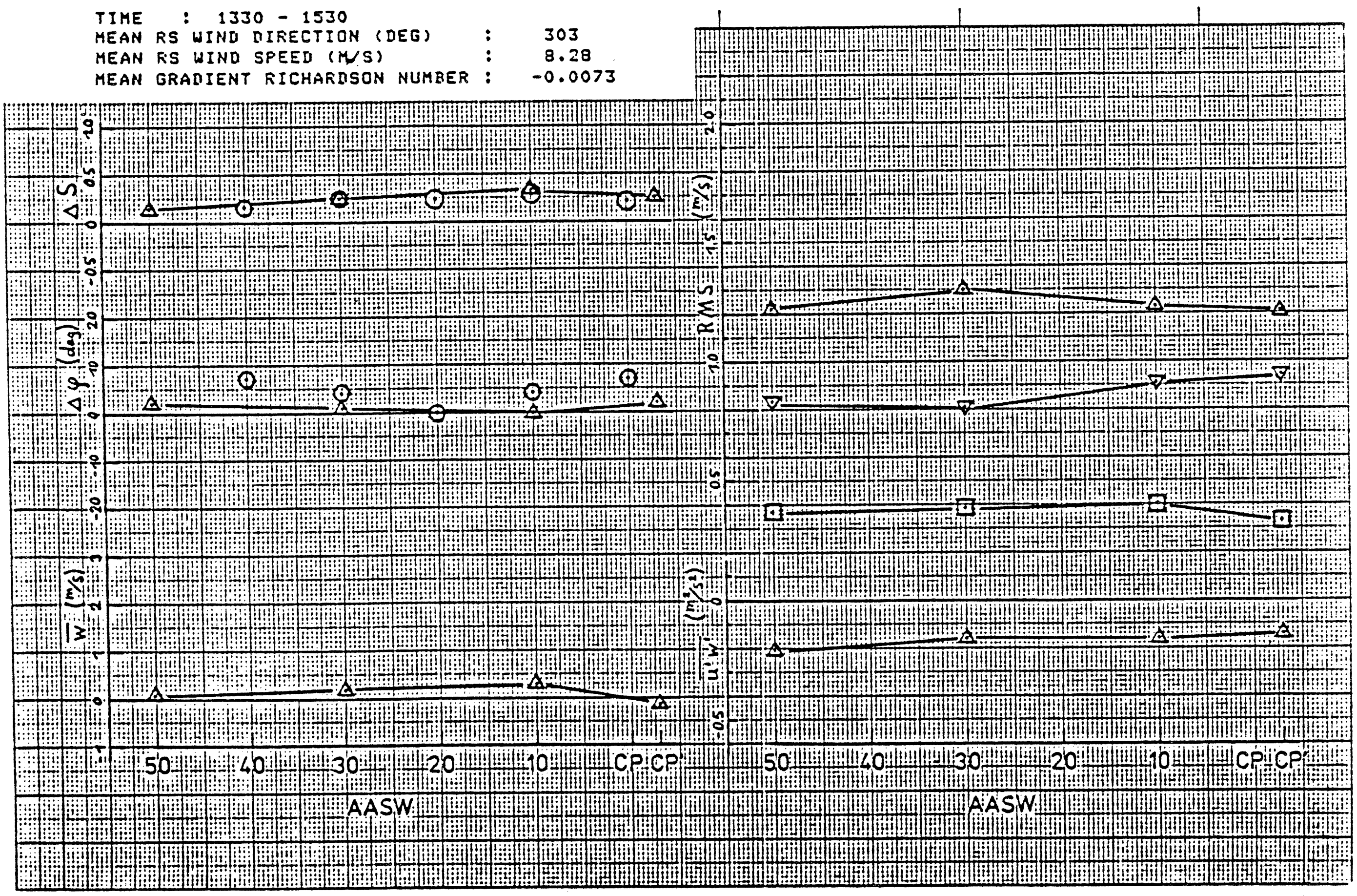
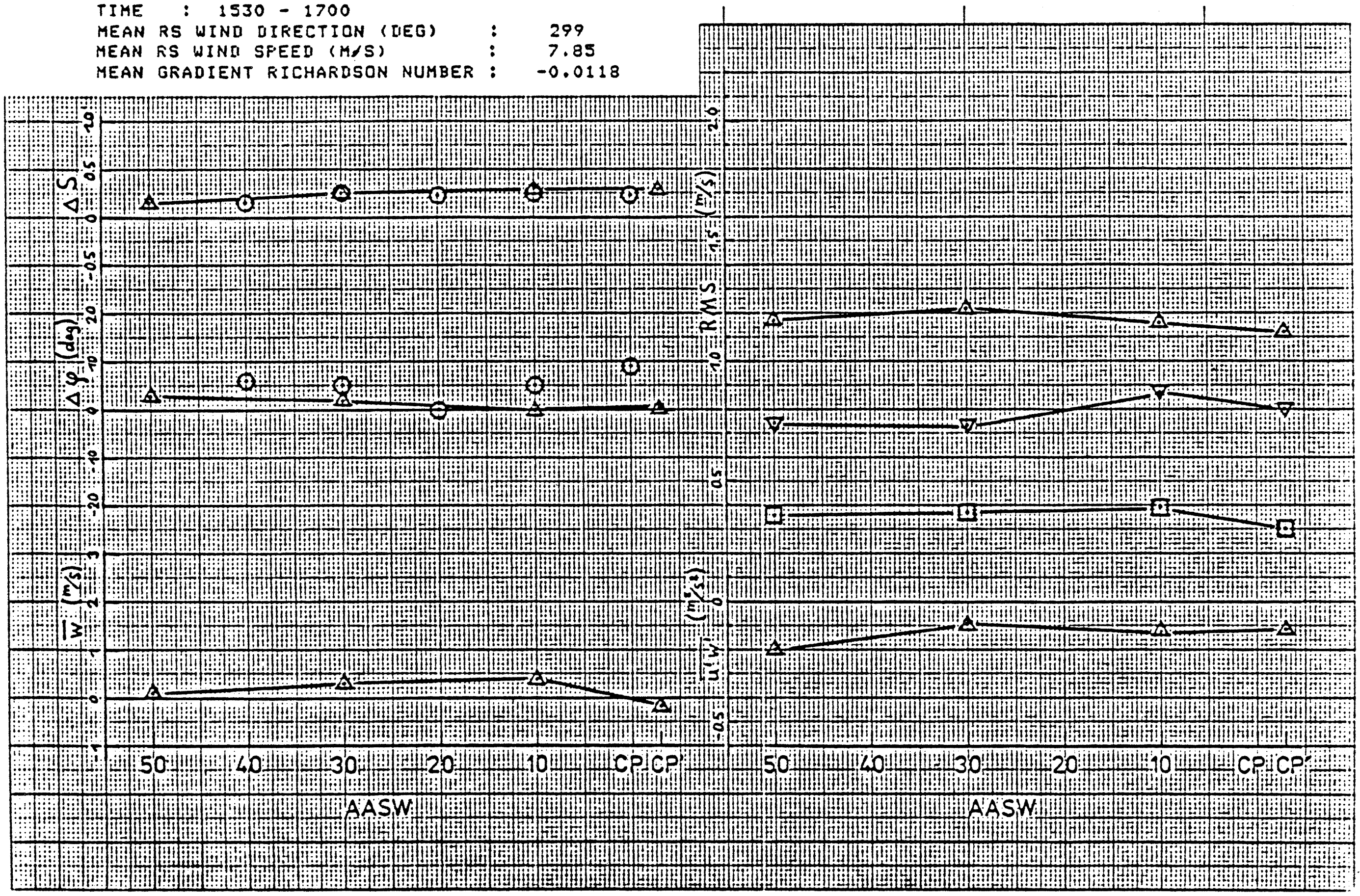


Fig. 4.4 (continued)

(r)

RUN NO : TU05-C

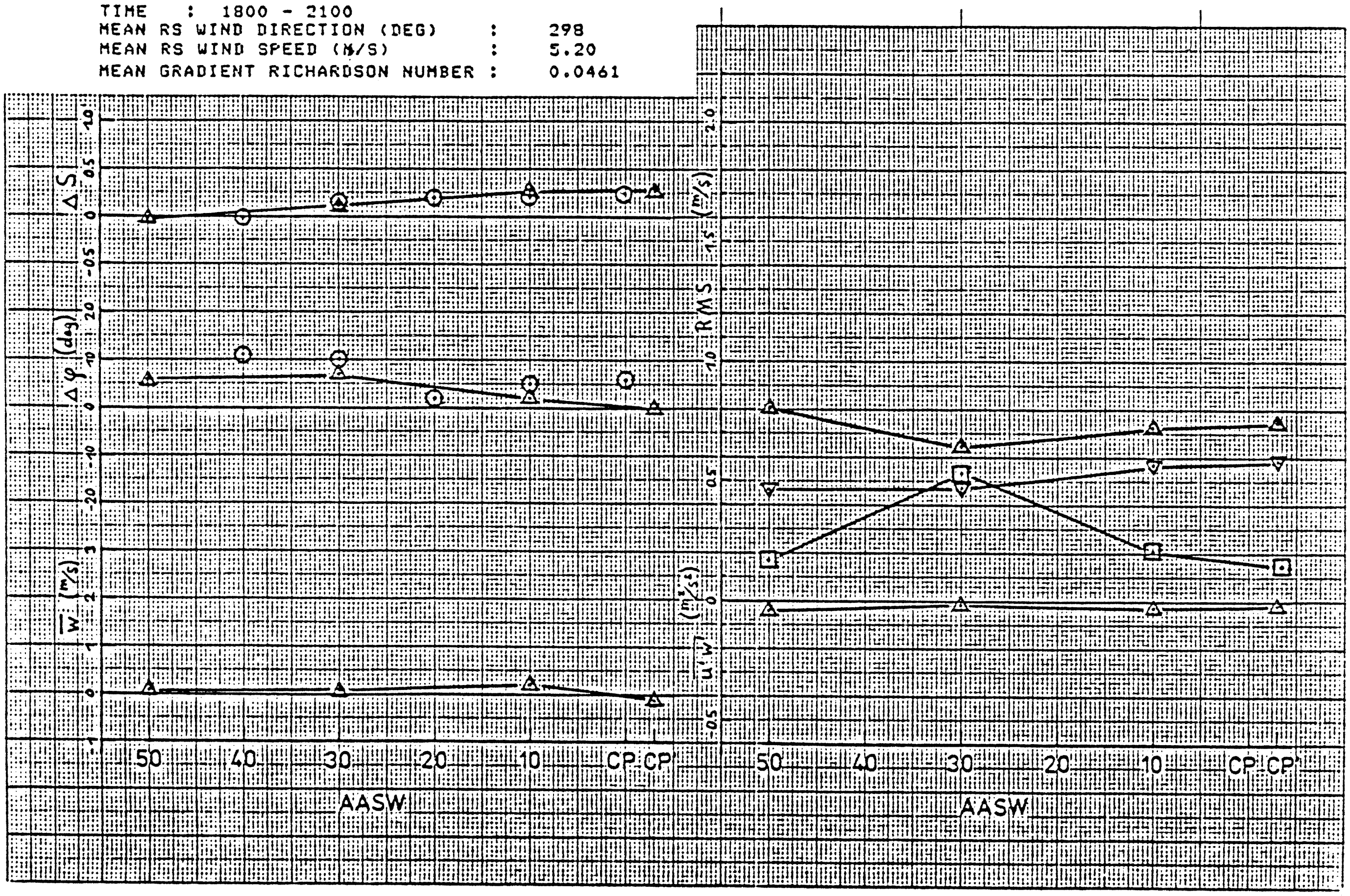
TIME : 1530 - 1700
MEAN RS WIND DIRECTION (DEG) : 299
MEAN RS WIND SPEED (M/S) : 7.85
MEAN GRADIENT RICHARDSON NUMBER : -0.0118



(s)

RUN NO : TU05-D

TIME : 1800 - 2100
MEAN RS WIND DIRECTION (DEG) : 298
MEAN RS WIND SPEED (M/S) : 5.20
MEAN GRADIENT RICHARDSON NUMBER : 0.0461



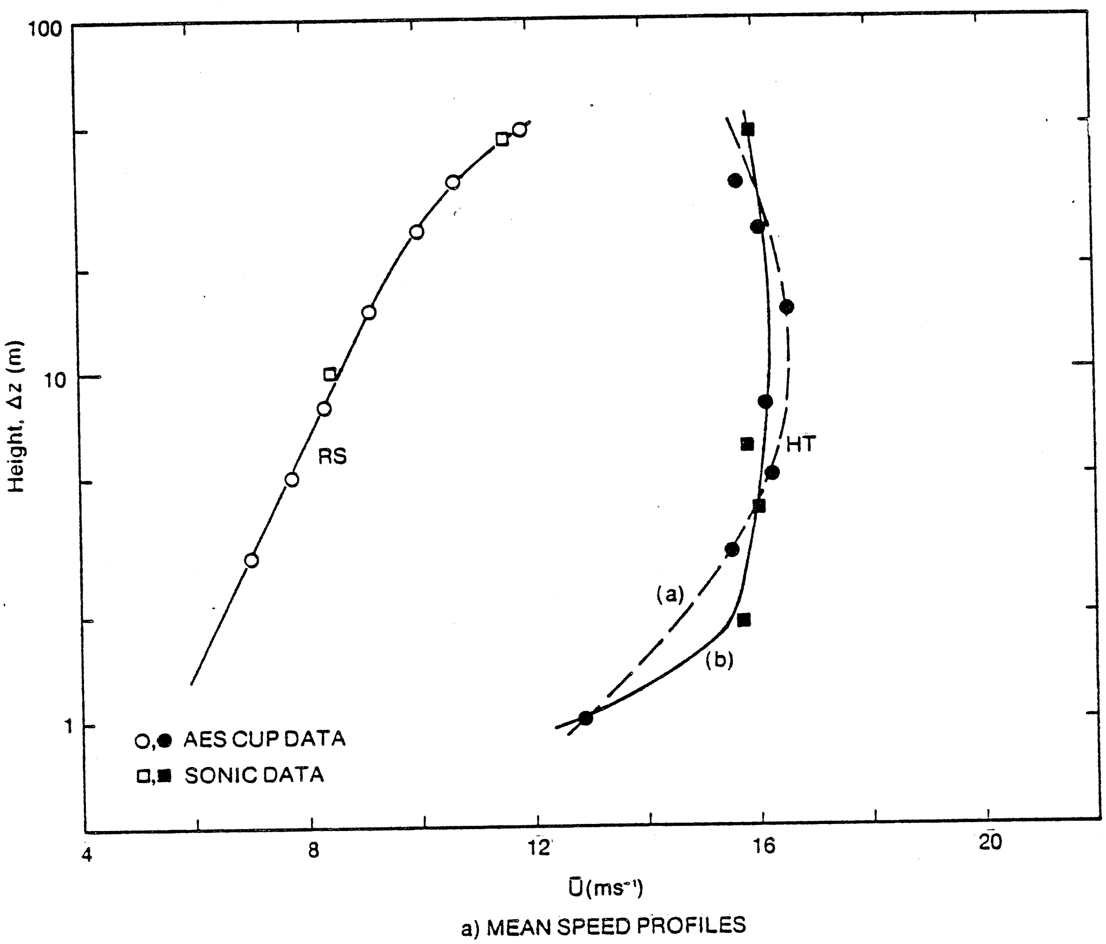
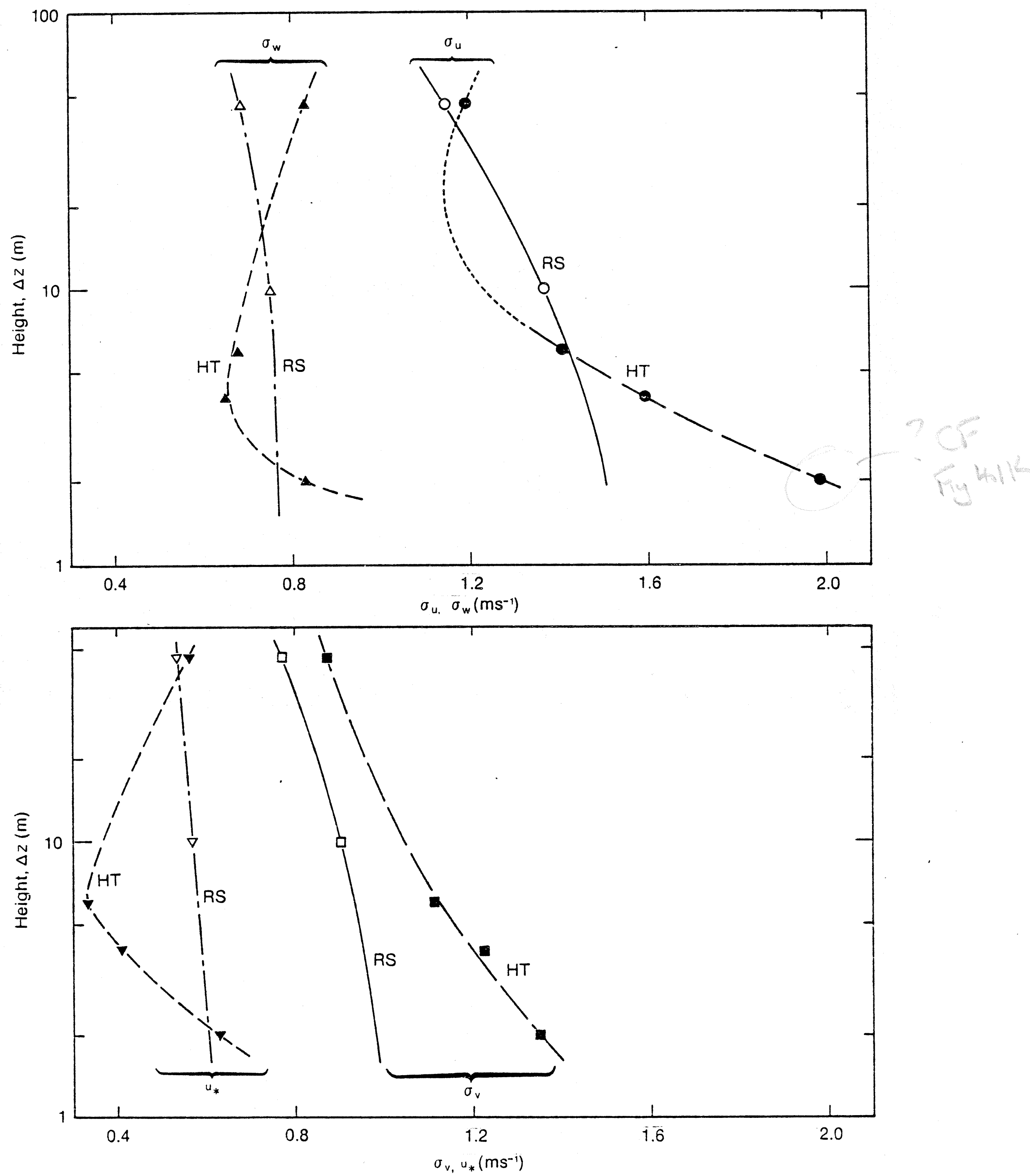


Fig. 4.5 Vertical profiles at RS and HT from sonic anemometers on 50m towers during Run TU03-B (partial: 1430-1700 LST). Note that all DK sonic data (HT and 10m RS values) have been 'adjusted' using results of inter-comparison tests (Table 4.3). Data are obtained from Tables A1.1 and A1.2. Reference wind direction at RS was 210°.



b) TURBULENCE PROFILES

— Sonic data only.

Fig. 4.5 (continued)

Fig. 6.1 Participants in the experiment relaxing at the Lochboisdale Hotel. Back row left to right: Elizabeth Moughton (ERA), Peter Taylor (AES), David Redfern (BRE), Tony Bowen (U. of Calgary), Nick Cook (BRE), Rob Johnson (ERA), Jim Arnold (AES), Finn Hansen (Risø), Mogens Nielsen (Risø), Bob Mickle (AES), Thomas Burger (U. of Hannover). Seated: Karl Vanek (AES), Hans Teunissen (AES), Kurt Pengel (U. of Hannover), Jim Salmon (CAN.), Masood Nourshargh (ERA), Niels Otto Jensen (Risø). Seated on floor: Wes Kobelka (AES), Gunnar Dalsgaard (Risø), John Deary (AES). Not in photo: Bob Delnon (ERA), Doug Warne (ERA), Martin Shaw (BRE)

(a)

```
269  4 40 14  2   6.73 10 11.79 11 11.92 12 11.07 14   9.58 15   9.84 18   9.40
269  4 40     20  8.34 21  7.53 26  6.69 30 10.02 33   5.93 34   6.66 35   6.58
269  4 50 14  2   7.21 10 11.72 11 12.29 12 11.34 14   9.80 15  10.15 18   9.54
269  4 50     20  8.69 21  8.16 26  7.14 30 10.36 33   5.81 34   6.53 35   6.93
269  5  0 14  2   7.35 10 11.59 11 12.12 12 11.24 14   9.88 15  10.26 18  10.16
269  5  0     20  8.87 21  8.34 26  7.34 30 10.55 33   5.83 34   6.19 35   6.41
269  5 10 14  2   7.59 10 12.16 11 12.40 12 11.85 14   9.97 15  10.82 18  10.82
269  5 10     20  9.41 21  9.12 26  7.40 30 11.13 33   6.01 34   6.34 35   6.51
269  5 20 14  2   8.14 10 12.60 11 13.28 12 12.37 14  10.78 15  11.22 18  10.86
269  5 20     20  9.84 21  9.04 26  8.10 30 11.54 33   6.84 34   6.76 35   7.23
269  5 30 14  2   7.28 10 13.44 11 13.85 12 12.75 14  10.95 15  11.42 18  10.90
269  5 30     20  9.86 21  9.37 26  7.51 30 11.77 33   6.65 34   7.26 35   7.41
269  5 40 14  2   6.94 10 13.46 11 13.84 12 12.63 14  10.87 15  11.54 18  11.70
269  5 40     20 10.47 21  9.87 26  6.97 30 11.83 33   7.44 34   7.74 35   9.28
269  5 50 14  2   7.90 10 14.23 11 14.39 12 13.40 14  11.46 15  12.52 18  12.23
269  5 50     20 10.58 21 10.12 26  7.52 30 12.76 33   7.85 34   7.81 35   8.74
269  6  0 14  2   7.38 10 14.11 11 14.33 12 13.36 14  11.33 15  11.96 18  12.14
269  6  0     20 10.54 21  9.66 26  7.07 30 12.29 33   7.56 34   7.73 35   8.28
269  6 10 14  2   6.71 10 13.83 11 14.10 12 13.29 14  11.40 15  11.85 18  11.75
269  6 10     20 10.61 21  9.37 26  6.74 30 12.20 33   7.10 34   7.50 35   7.43
```

(b)

```
C          JDAY2 - JULIAN DAY
C          IHOUR2 - HOUR
C          IMIN2 - MINUTE
C          ICT - NUMBER OF DATA PAIRS TO FOLLOW (N.B. THEY MAY
C                CONTINUE ON TO SUBSEQUENT RECORDS)
C          IWS(K),WS(K) - THE K'TH DATA PAIR CONSISTING OF THE
C                         ANEMOMETER NUMBER (IWS(K)) AND THE
C                         10-MINUTE RUN-OF-WIND MEAN (WS(K))
C                         MEASURED BY THAT ANEMOMETER
C
      KL=1
      KU=7
      READ (1,5060) JDAY2,IHOUR2,IMIN2,ICT,(IWS(K),WS(K),
     $     K=1,IMINO(ICT,7))
 5060 FORMAT (1X,4I3,7(I3,F6.2))
      IF (ICT.LE.7) GOTO 2130
 2140 KL=KL+7
      KU=KU+7
      READ (1,5070) JDAY2,IHOUR2,IMIN2,(IWS(K),WS(K),
     $     K=KL,IMINO(ICT,KU))
 5070 FORMAT (1X,3I3,3X,7(I3,F6.2))
      IF (ICT.LE.KU) GOTO 2130
      GOTO 2140
 2130 CONTINUE
```

Fig. B.l: (a) Sample records from mean-flow data archive A3MF.DAT

(b) FORTRAN IV computer code used to read the wind speeds for a single 10-minute run-of-wind period. Multiple periods can be read by looping through this code.

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Three Dark Figures
Making the Weather
In Folk, in Myth, in Legend,
A threefold test.
Shiva, Vishnu, Brahmin.
Father, Son, Holy Ghost.
Body, Mind, Spirit.
Triune, Triumvirate, Tribunal.
One is Isolate
Two is divisive
Three is Peace.
Three is Torment.
Three is Potent.
Power, Power, Power.
Air, Fire, Water.
Three Dark Figures,
Making the Weather.

Ron Baird, Sculptor