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ATLANTIS II (CRUISE 102) MOORED AND SHIPBOARD SURFACE METEOROLOG--ETC(U)

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→ A PET computer, hardwired to sensors positioned on the ship, displayed data that were logged during both legs of the cruise. Manual data were gathered by the science watches.

→ This report describes the PET system, and displays and compares all the data. VAWR hourly meteorological data are listed for the 38 day period.

→ Scientific interpretation of these data, such as calculations of heat fluxes, will be published separately.

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ATLANTIS-II (CRUISE 102) MOORED AND SHIPBOARD
SURFACE METEOROLOGICAL MEASUREMENTS DURING JASIN 1978

by

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WOODS HOLE OCEANOGRAPHIC INSTITUTION
Woods Hole, Massachusetts 02543

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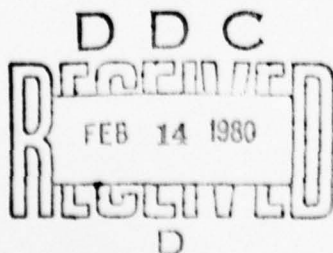
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ABSTRACT

During cruise 102 of the R/V Atlantis-II in the Joint Air-Sea Interaction Project (JASIN), surface meteorological data were gathered by Woods Hole Oceanographic Institution personnel from two moored buoys and from the ship.

One buoy (JASIN W2/WHOI 651) carried a Vector Averaging Wind Recorder (VAWR) and a Vector Measuring Wind Recorder (VMWR); these instruments provided 18 days of intercomparison data and 38 days of meteorological data from 30 July to 6 September 1978. The other buoy (JASIN H2) carried a VMWR and gave 25 total days of data from 16 July to 10 August, and from 26 August to 1 September.

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This report describes the PET system, and displays and compares all the data. VAWR hourly meteorological data are listed for the 38 day period.

Scientific interpretation of these data, such as calculations of heat fluxes, will be published separately.

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INTRODUCTION

The Joint Air-Sea Interaction Project (JASIN; see Pollard, 1978) was an international study of the atmospheric and oceanic boundary layers, of the fluxes within and between them, and of their interaction on the process scale. Nine countries, fourteen ships, and four aircraft participated in the main field experiment from mid-July to mid-September 1978 in an area northwest of Scotland about half-way to Iceland (see Figure I-1).

The R/V Atlantis-II participated as its Cruise 102 with two legs:

Leg 1: Glasgow - Glasgow, 25 July - 16 August

Leg 2: Glasgow - Woods Hole, 21 August - 21 September

The latter part of Leg 1 and the early part of Leg 2 were spent in CTD work at Anton Dohrn Seamount, and the last two weeks of Leg 2 were spent in passage across the North Atlantic. The actual working periods in the central JASIN area, i.e. the vicinity of the Fixed Intensive Array (FIA) near 59°N, 12°30'W, were: 0600Z/27 July to 2400Z/13 August, and 0700Z/24 August to 1400Z/7 September.

During these periods near the FIA, surface meteorological observations were made from the Atlantis-II using a mix of automatic and manually-operated sensors. The automatic system, called PET here because a small PET computer was used as a data acquisition device, are described in Part II of this report. The PET data were logged approximately hourly by the science watch since the 5-minute automatic recording system was not working. The science watch also took certain observations manually, called MANUAL here, on an hourly or 4-hourly (Leg 1) or 3-hourly (Leg 2) basis, depending on the observation. Figure I-2 locates the observations on the ship.

The PET and MANUAL observations from the ship were meant primarily as backup data in case the meteorological data being recorded on buoy W2 (see Figures I-1 and I-3, and Table I-1) were faulty. The meteorological package (Payne, 1974) was a Vector Averaging Wind Recorder. Only the PET Dew Point and the MANUAL Dew Point and Relative Humidity (calculated from wet and dry bulb temperatures; see PSYCHROMETRY section below) were unique observations from the ship; all the other shipborne meteorological data were redundant to buoy data, called BUOY here. Additional data on wind measurements only were obtained from a Vector Measuring Wind Recorder on buoy H2 and supplement the W2 data by starting earlier.

We expect all the buoy data, but especially wind speed and air pressure and temperature, to be of higher quality than the same data from the ship because of the derogatory influence the ship has on its environment. Also, the motivation for these measurements is as supporting data for the array of current meters and thermistors deployed on the moorings in the FIA, so observations from mooring W2 are in any case preferable to those from a roving ship or from mooring H2. Figure I-4 and Table I-2 give the range and bearing from the Atlantis-II to buoy W2 (nominally 59°01.5'N, 12°33.0'W) during Legs 1 and 2; only during the Leg 1 periods 1600Z/2 August to 0500Z/3 August, 1600Z/8 August to 0400Z/9 August, and 1100-2400Z/9 August was the ship consistently within 10 km of the buoy and were there meteorological measurements being made on the ship. These are the periods used for the ship-to-buoy "10 km" scatterplots (see Table III-4, and figures III-35 to 38).

We present here the BUOY data in some detail, including hourly listings, spectra, statistics, etc. The PET and MANUAL dew point estimates from Leg 2 are compared in Figure III-12 and III-33; there seems to be no reason to choose one as preferable to the other except that the PET estimates are probably less subject to the change of the watch.

No derived data, for example wind stress or surface heat flux, are presented in this report. See also Tarbell, Briscoe, and Weller (1979) for the current meter data from the moorings, and Pennington and Briscoe (1979) for the hydrographic (CTD profiles) data.

OBSERVATIONS

The VAWR and VMWR data were handled as normal current-meter data (see Tarbell, et al., 1979) since both instruments are based on the original VACM and VMCM instruments. Figure I-3 shows buoy W2 on which the VAWR and one of the VMWR instruments were mounted; the H2 VMWR instruments were on a different kind of tower structure but were equally exposed and at about the same height. The W2 VAWR and VMWR were mounted 1 m apart at 3.5 m height above the water line. The vane on the buoy kept the two wind recorders on the upwind side of the buoy; there was free exposure of the wind sensors to the wind. Except for the air pressure sensor, the VAWR was as described in Payne (1974). A Digiquartz pressure sensor provided 0.1 mbar accuracy pressures averaged over the 15 minute recording interval of the VAWR. The VMWR was simply a VMCM turned upside down.

The PET data are described in Part II; see also Peal (1979).

The MANUAL data were taken with a variety of instruments. The winds used the ship's anemometer which was mounted on the port forward yardarm. It yielded (relative to the PET measurements) a diminished wind speed when the winds were from 090° relative, i.e. when the winds had to pass the mast to get to the anemometer. More surprisingly, the measurements were biased high when the winds were from between 070 - 085° and 095 - 110°, apparently because of a funneling effect past the mast. The winds were read on an analog dial (one minute visual average) in the wet lab. Ship speed was from the single-axis Sperry doppler log, which was the same instrument the PET was reading; only time of reading and the variability of visual averaging should produce differences between the PET and MANUAL ship speed. Similarly, the ship's gyro repeater provided ship heading. The MANUAL measurements of sea surface temperature came from a standard bucket thermometer. During Leg 1 the bucket was stored in the main lab and consequently was biased high; for most of Leg 2 the bucket was stored on deck. Air pressure came from an aneroid barometer on the bridge; it was of unknown calibration, but presumably would have only an offset. (It proved to be reading 8.5 mbar high, by correlation comparison with the pressure sensor on the buoy.)

The wet and dry bulb air temperatures were obtained with a Bendix 566-3 Psychron, which is a motor aspirated pair of mercury thermometers, one with a wetted wick, one without. It was used on the exposed side of the bridge wing

or the flying bridge, depending on the severity of the weather. The calculations of dew point and relative humidity were made using algorithms described below, under PSYCHROMETRY. All MANUAL data were logged by hand on an hourly (wind, sea temperature) or four-hourly (Leg 1: wet and dry bulb temperatures, clouds, air pressure, visual wave observations) or three-hourly (Leg 2) basis. The cloud and wave observations are not reported here: they are subjective visual estimates for the JASIN meteorological reporting forms only.

Editing of all three data sets (MANUAL, PET, BUOY) was done by hand; values clearly in error were replaced by a linear interpolation of adjacent points.

Calibrations

None of the ship's sensors were specially calibrated: the ship speed and direction, wind speed and direction, and bridge barometer were simply used as provided. The sea temperature (bucket with integral mercury thermometer) and wet and dry bulb temperatures used precision thermometers but no additional checks were made.

The PET sensors were calibrated as described in Part II of this report.

The VAWR sensors were calibrated as described in Payne (1974) except for the new pressure sensor, which was checked ashore against a mercury barometer. The cups and vane used the existing calibrations, and the temperature sensors were checked before and after the cruise in the WHOI calibration facility.

Note that the solar radiation values are presented in cal cm^{-2} ; in fact, these are values integrated over the 15 minute recording interval of the VAWR and normalized to 1 minute values, so the units should be interpreted as $\text{cal cm}^{-2} \text{ min}^{-1}$, which is the old (prior to 1947) definition of a langley. For reference,

$$\begin{aligned}
 1 \text{ cal cm}^{-2} \text{ (units on plots)} &= 1 \text{ cal cm}^{-2} \text{ min}^{-1} \\
 &= 1 \text{ langley (old)} \\
 &= 1 \text{ langley min}^{-1} \text{ (new)} \\
 &= 697.6 \text{ watts m}^{-2}
 \end{aligned}$$

CALCULATIONS

All calculations and displays were made on a Xerox Sigma-7 computer. In general, the data displayed here were analyzed with standard programs used for current meter data; see Tarbell, et al. (1979) for detail of the procedures. Brief descriptions follow.

Time Series

All the measured variables as well as some derived quantities (true wind, dew point, relative humidity) are presented versus time in Part III. In addition, the buoy winds (Fig. III-7) are presented as stick plots, i.e. 4-hour average vectors whose length is proportional to the wind speed and whose angle shows the wind direction as the direction to which the wind is blowing. Note that 6520SB and 6520WD are on the same buoy (JASIN W2), but that H2S1B and H2S2B are on JASIN H2, 44 km to the north of W2.

Histograms

Each of the variables from the VAWR are shown as frequency of occurrence versus amplitude; the means over the entire record are marked.

Statistics

Various moments (mean, variance and standard deviation, skewness, kurtosis) and extreme values are given for the entirety of each record (Table III-1) and for consecutive 5-day periods (Table III-2) commencing with 0000Z on 30 July; the final "5-day period" is only 4 days and 7 hours long.

Spectra

The spectra are calculated by breaking the record into one or two equal length segments (as long as possible to fit into the record length), and then frequency - band averaging over 3 bands to give a little more statistical reliability to the estimates. The plotting program additionally averages increasing larger groups of estimates together at the higher frequencies. The spectra therefore have a minimum of 6 degrees of freedom at the lowest frequencies, and as many as several hundred degrees of freedom at the highest frequencies. There was no data windowing or prewhitening prior to the Fourier transformation. The integral under the spectrum equals the variance of the record.

Progressive Vectors

The wind displacement vectors (one hour averages) are placed head-to-tail to show the path a perfect particle would have taken if the fluid were perfectly homogeneous with no spatial gradients. The same data are plotted as North versus East scatter plots with a regression line that denotes the principal axis of the cluster of points.

PSYCHROMETRY

Calculations of dew point and relative humidity were made using formulae from the Smithsonian Meteorological Tables (List, 1951). The lithium chloride cell used in the PET measurements (see Part II) read out directly in dew point; the wet and dry bulb temperatures of the Bendix psychrometer used in the MANUAL observations were therefore converted to dew point, for comparison with the lithium chloride cell, and to relative humidity, for general use.

The algorithm for calculation was:

1. Input T_w , T_d , p , where T_w = wet bulb temperature in degrees Celsius, T_d = dry bulb, and p = observed barometric pressure in millibars.
2. Calculate the saturation vapor pressure e_{sw} in mbar for the wet-bulb temperature:

$$e_{sw} = 1013.25 \times 10^{f(T_w + 273.16)} \quad (1)$$

$$\text{where } f(T) = a_1 \left(\frac{T_s}{T} - 1 \right) + a_2 \log_{10} \left(\frac{T_s}{T} \right) \quad (2)$$

$$+ a_3 \left(10^b \left(1 - \frac{T}{T_s} \right) - 1 \right)$$

$$+ a_4 \left(10^c \left(\frac{T_s}{T} - 1 \right) - 1 \right)$$

$$\text{and } T_s = 373.16, a_1 = -7.90298, a_2 = 5.02808,$$

$$a_3 = -1.3816 \times 10^{-7}, a_4 = 8.1328 \times 10^{-3}, b = 11.344,$$

$$\text{and } c = 3.49149.$$

3. Calculate the saturation vapor pressure for the dry-bulb temperature:

$$e_{sd} = 1013.25 \times 10^3 \frac{f(T_d + 273.16)}{p} \quad (3)$$

4. Calculate the mixing ratios for saturated air for the wet and dry-bulb temperatures:

$$r_{sw} = \mathcal{E} \frac{e_{sw}}{p - e_{sw}}; \quad r_{sd} = \mathcal{E} \frac{e_{sd}}{p - e_{sd}} \quad (4)$$

where $\mathcal{E} = 0.622$ is the ratio of the molecular weight of water to that of dry air; calculate the mixing ratio for the unsaturated air:

$$r = \frac{r_{sw} L - C_p (T_d - T_w)}{L + C_{pv} (T_d - T_w)} \quad (5)$$

where $L = 597.3 \text{ cal/gm}$ is the latent heat of evaporation, $C_p = 0.240 \text{ cal/(gm}^\circ\text{K)}$ is the specific heat of air at constant pressure, and $C_{pv} = 0.432 \text{ cal/(gm}^\circ\text{K)}$ is the specific heat of water vapor.

5. Calculate the relative humidity:

$$U = \frac{r}{r_{sd}} \times 100 \quad (6)$$

6. Calculate the vapor pressure for the unsaturated air:

$$e = \frac{r p}{\mathcal{E} + r} \quad (7)$$

7. Using equation (1), iterate on the value of T_w until an e_{sw} is found that is equal to e from equation (7); this value of T_w is the dew point temperature.

8. For reference, because it is needed in the bulk aerodynamic flux formulae, the specific humidity is related to the mixing ratios by

$$q = \frac{r}{1+r}$$

so the specific humidity of the moist air is

$$q = \frac{r}{1+r} \quad (8)$$

where r comes from equation (5), and the specific humidity of the saturated air at the sea surface is

$$q_o = \frac{r_{so}}{1+r_{so}} \quad (9)$$

where the r_{so} comes from equation (4) based on e_{so} from equation (1) evaluated at the sea surface temperature T_o .

These calculations were checked against examples in the Smithsonian Meteorological Tables and (for relative humidity) against tables in the Instruction Manual (No. 509942, revised March 1968) for the Bendix Psychron.

RESULTS

The purpose of these meteorological measurements was to provide the background information needed for calculations of air-sea fluxes, especially of heat and momentum. The observations are of a kind that is appropriate for the use of bulk aerodynamic formulae (e.g., Bunker, 1976) for which the crucial variables are wind speed, sea and air temperatures, and the specific humidities for the moist air and for the saturated air at the sea surface.

The buoy measurements provide our best estimates of wind speed, sea and air temperatures, and the specific humidity at the sea surface. Since the buoy provides no moist air measurement, we have to use the shipborne measurement of dew point (PET) or wet bulb temperature (MANUAL) to supplement the data set.

The MANUAL measurements in general are noisy, only on a 4 or 3-hourly basis, and are more subjective than the other measurements. The uncalibrated aneroid barometer on the bridge was read by the mates on watch and reported verbally to the science watch. The bucket sea-surface temperatures have all the traditional problems with biases introduced by the storing temperature of the bucket, warming by the ship of the water around it when the ship is on station, and evaporative cooling of the water in the bucket while it is being read.

The PET measurements, except for dew point and incidentally ship speed and heading, provide no information that is unavailable from the buoy. For interest, the PET dew point temperature (Figures III-3 and 4) and the calculated MANUAL dew point temperature (Figures III-1b and 2b) are plotted together (Figure III-12) for Leg II of the cruise, and are given as a scatter plot (Figure III-33) that shows the regression line (MANUAL regressed on PET; Table III-4):

$$T_{\text{MANUAL}} = 0.581^{\circ}\text{C} + 0.945 \times T_{\text{PET}}$$

The standard error of the regression is only 0.50°C , hence it appears that the dew point temperature estimates from the ship are useful to something better than 1°C .

The scatter plots (Figures III-13 to 38) and regressions (Table III-4) display interesting comparisons between the various measurements of the same variable. Some of the comparisons are extraordinarily good, such as the pressure, dew point, and ship speed measurements (Figures III-32 to 34), whereas some are terrible, like BUOY versus MANUAL water temperature (Figure III-26) which is badly biased by the distance between the ship and the buoy (c.f., Figure I-4b). PET versus MANUAL water temperature (Figure III-27), both being made on the ship, compare better with only 0.22°C standard error.

The effect of separation between the buoy and the ship (PET) is minimized in the last four scatter plots, which are restricted to only the periods when the separation is less than 10 km. Unfortunately, these 10 km - plots cannot be directly compared to the other scatter plots because the 10 km - plots are for Leg 1, whereas all the other PET plots are for Leg 2.

A useful number is obtainable from the overall statistics of the BUOY record in Table III-1a. The mean solar radiation is given as $2783 \text{ watt-h m}^{-2}$; it has been normalized to one 24-hour day. In more usual units (divide by 24) the mean insolation during our measurements was

$$116 \text{ watts m}^{-2} = 0.17 \text{ langleys (old)} = 0.17 \text{ langleys (new) min}^{-1}.$$

For comparison, Bunker (1976) gives about 50 watts m^{-2} for this location for the net average annual radiational flux to the ocean, and a sensible heat flux

and latent heat flux from the ocean of about 30 watts m^{-2} and 135 watts m^{-2} respectively, for a net loss over the year of about 85 watts m^{-2} ; the imbalance in this budget is due to the averaging and contouring used by Bunker (1976), plus the necessity to obtain the numbers by reading small graphs.

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We wish to thank Joe Poirier and Nancy Pennington for instrumental and data processing aspects of the VAWR data on W2, Bob Weller for providing the VMWR data from W2 and H2, and all those watchstanders who acquired the MANUAL and logged the PET data on the Atlantis-II. Sue Slagle is particularly thanked for her continuing, realtime assessment of the quality of the wind data. Nancy Pennington also was responsible for transmission of all the MANUAL and PET data into the computer, and did most of the editing.

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TABLE I-1

Summary of Mooring Locations and Dates

Mooring	Location (°N) (°W)	Cruise A-II-102 Date Set (1978)	Cruise A-II-102 Date Recovered (1978)	Purpose of Mooring	Comment
B1	59°00.4' 12°33.1'	1 Aug.	6 Sept.	meteorology thermistor chain	NOTE 1
B2	59°00.2' 12°27.5'	29 July	6 Sept.	thermistor chain	NOTE 1
B3	59°01.6' 12°27.4'	28 July	6 Sept.	thermistor chain	NOTE 1
B4	59°10.7' 12°31.0'	28 July	3 Sept.	thermistor chain	NOTE 1
W1	59°01.1' 12°32.0'	29 July	7 Sept.	subsurface currents	NOTE 2
W2	59°01.5' 12°33.0'	30 July	6 Sept.	meteorology surface currents	NOTE 2
W3	59°01.1' 12°34.3'	30 July	6 Sept.	spar buoy for surface currents	NOTE 2
K1	58°59.8' 12°30.6'	9 July	6 Sept.	subsurface currents	NOTE 3
H2	59°25.0' 12°30.0'	16 July	3 Sept.	meteorology and and surface currents	NOTE 4

- Notes: 1. Oregon State University buoys (W. Burt) deployed and recovered by the A-II.
 2. Woods Hole Oceanographic Institution buoys.
 3. Institut für Meereskunde, Kiel, F. R. Germany, buoy deployed by Meteor, recovered by Planet.
 4. NOAA/PMEL, Seattle, buoy (D. Halpern) deployed by Shackleton, recovered by A-II.

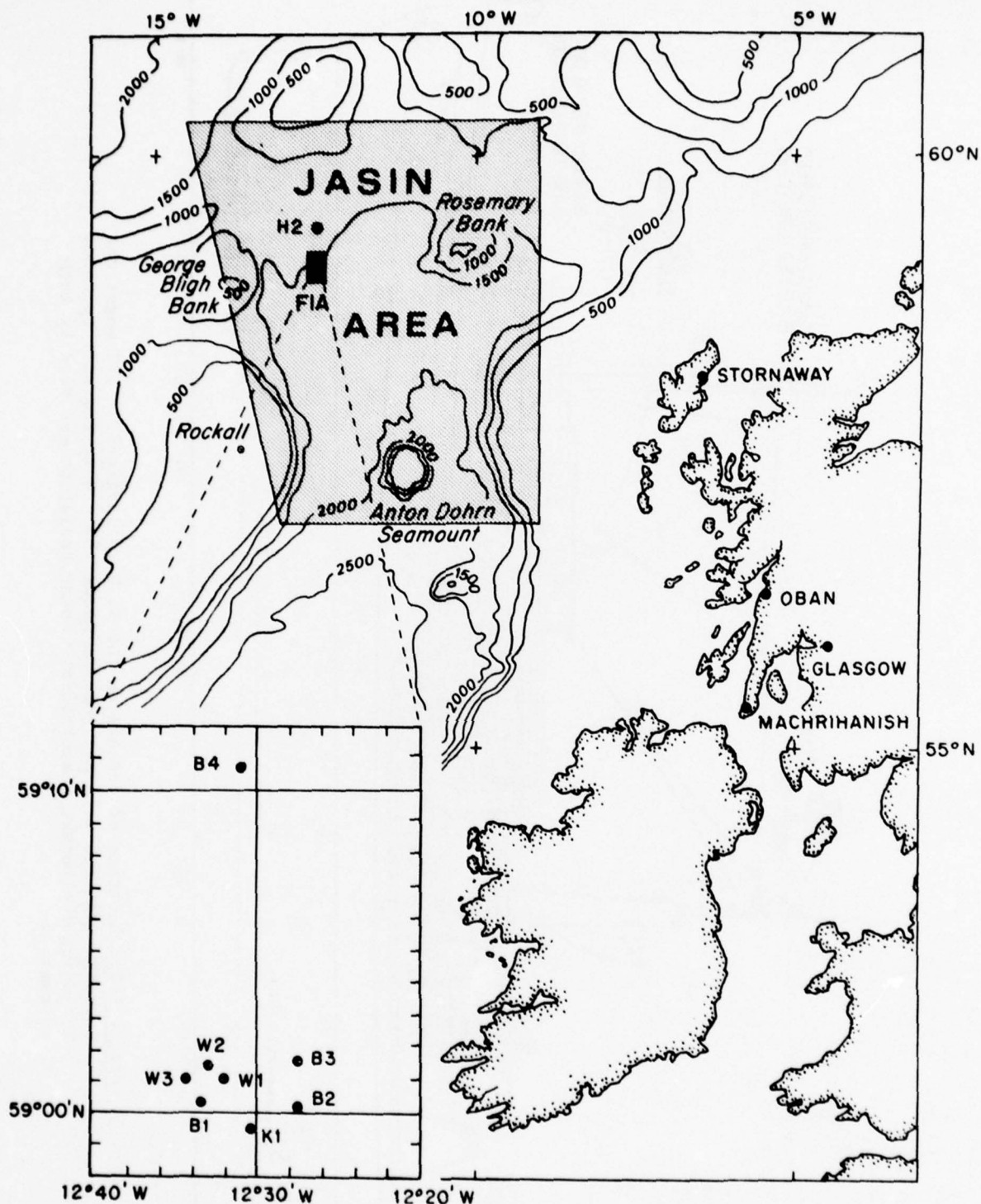


Figure I-1: Chart of the JASIN area. FIA means fixed intensive array, shown in detail at lower left. Glasgow was the main ship port, although Stornaway was also used. Oban was the communications center, and Machrihanish the airfield.

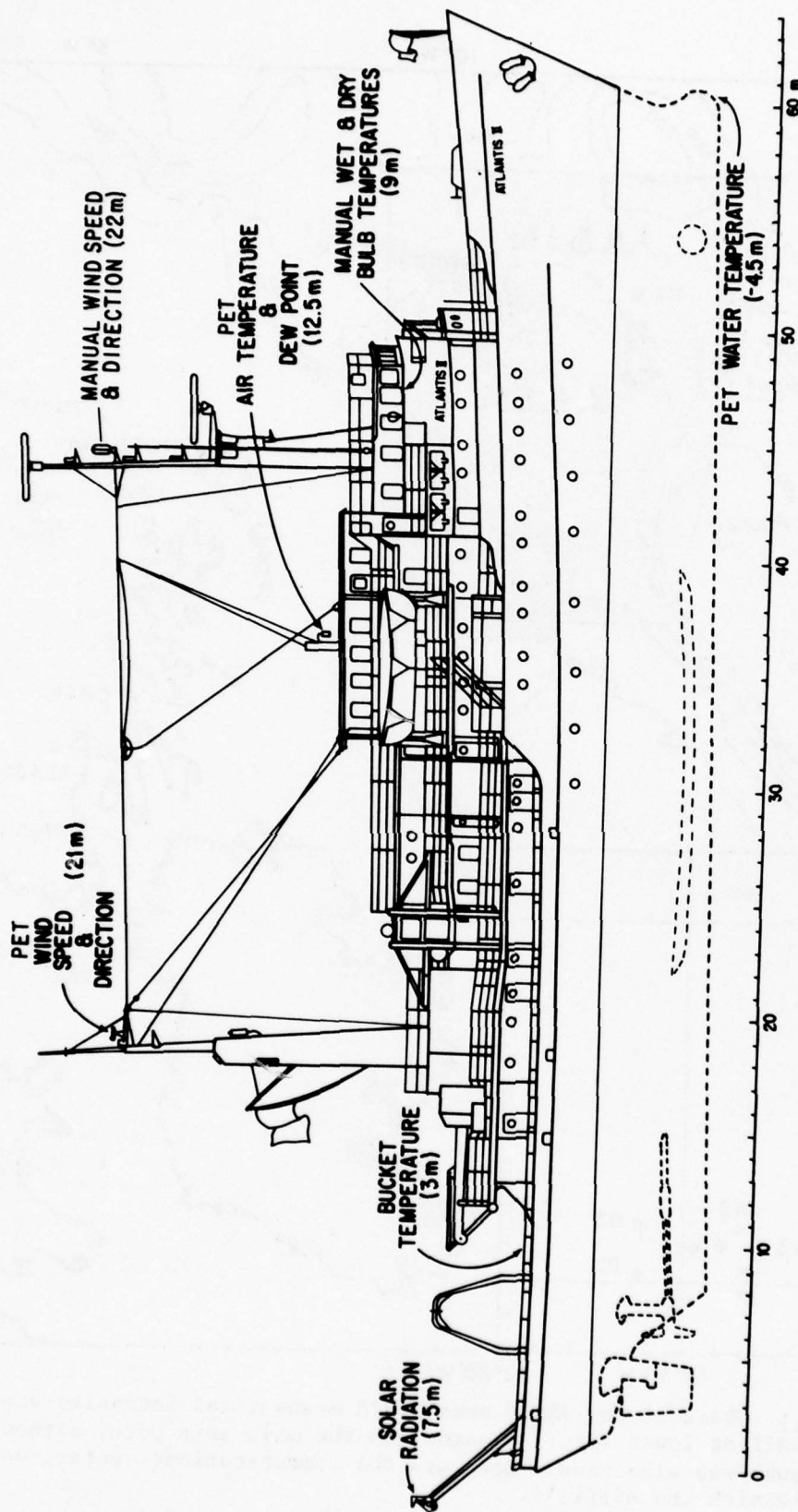


Figure I-2: Location of sensors on the R. V. Atlantis-II. PET means the computer-acquired data set, MANUAL means those data acquired by hand, including the bucket temperature. Solar radiation was read by both systems.

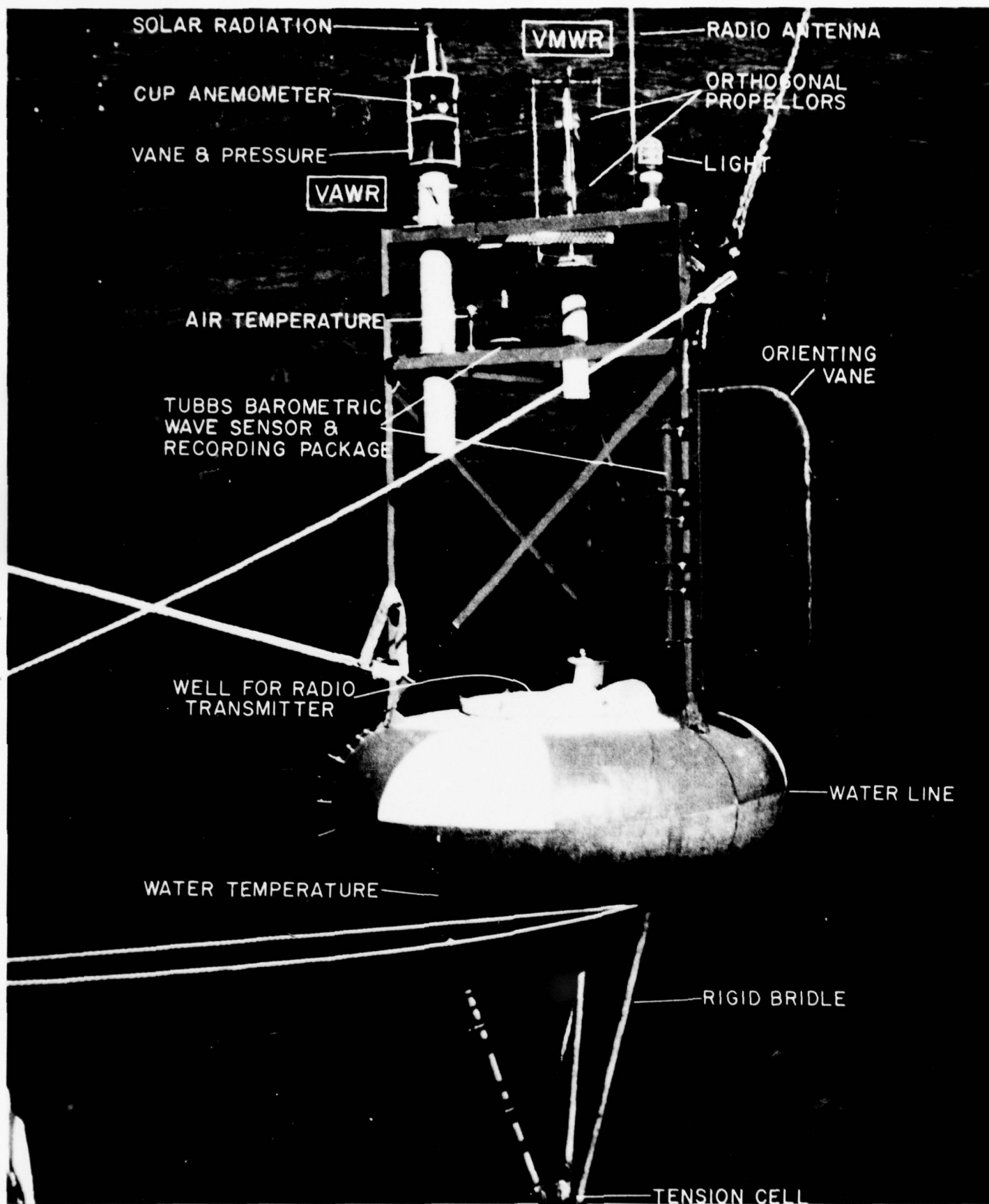


Figure I-3: Detail of buoy W2 and its meteorological sensors. The buoy is 2.4 m in horizontal diameter at its waterline; the wind sensors are at 3.5 m height, and the water temperature sensor is at 60 cm depth.

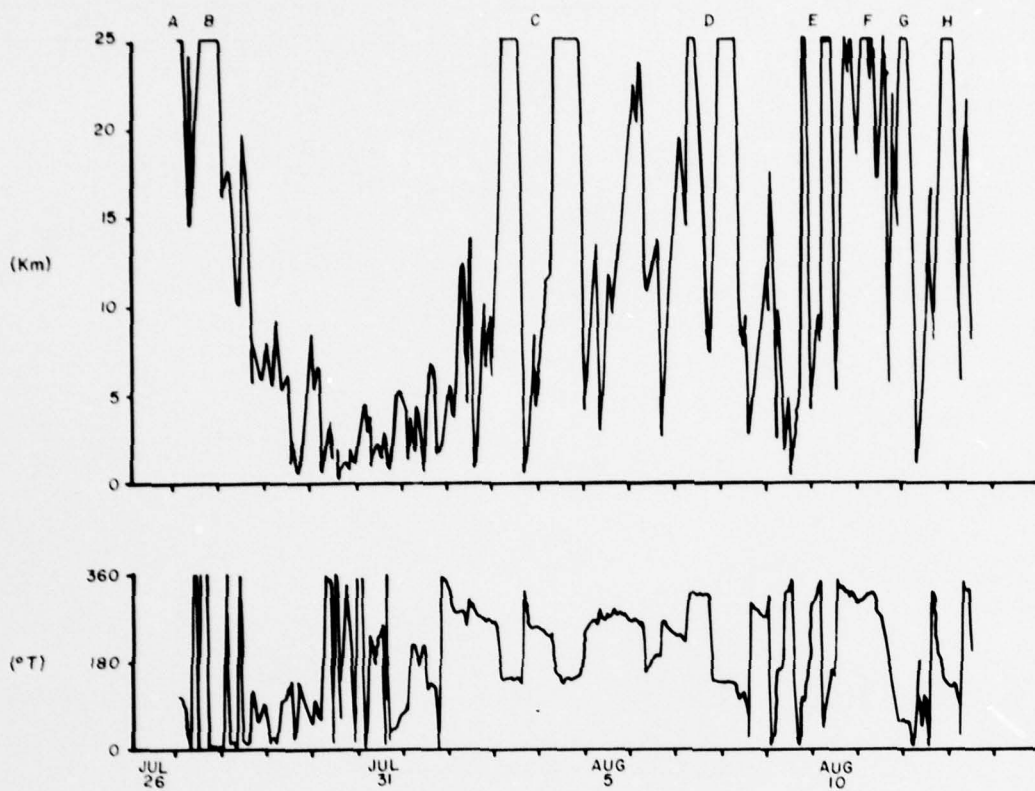


Figure I-4a: Range and bearing from ship to buoy W2.

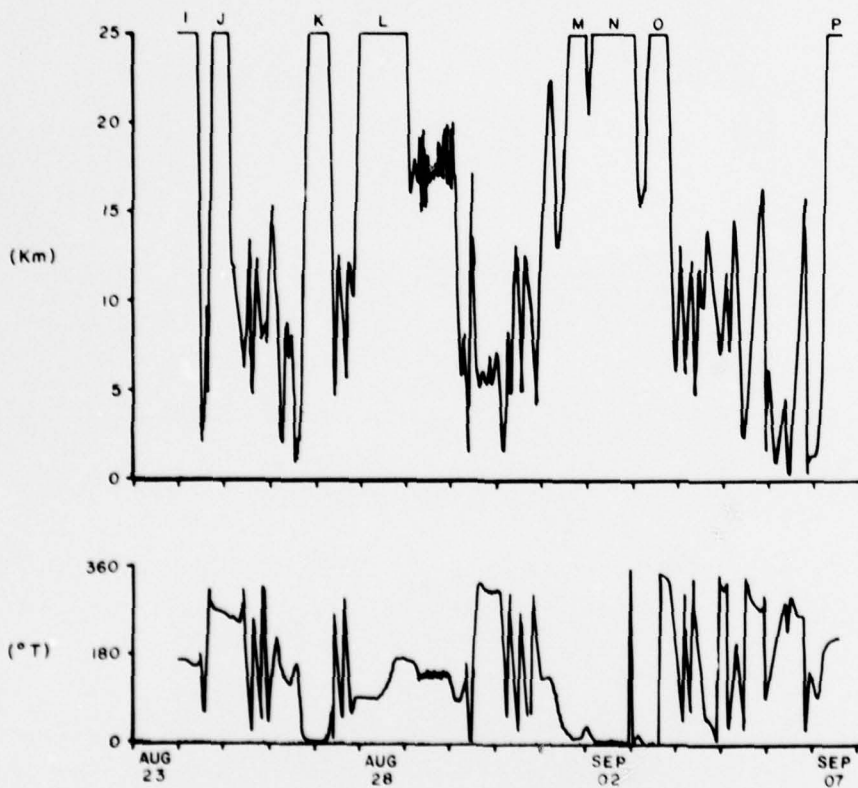


Figure I-4b: Range and bearing from ship to buoy W2.

Table I-2

Range and Bearing from Ship to Buoy W2

(Refers to Figure I-4a,b)

Leg 1

78-VII-26 to 78-VIII-15

- A Glasgow to JASIN site
- B B4 Deployment
- C VCM/3 tracking
- D CTD section (NW→SE)
- E XBT section (S→SE)
- F CTD section (SW of FIA*)
- G B4 area
- H CTD section (SE of FIA)

Leg 2

78-VIII-23 to 78-IX-08

- I Glasgow to JASIN site
- J CTD section (W of FIA)
- k CTD section (heading North)
- L CTD section (59°N W→E)
- M H2 area
- N Multiship experiment (N of FIA)
- O B4 recovery
- P Returning to Woods Hole

* Fixed Intensive Array

PART II
PET SYSTEM

INTRODUCTION

The system provides continuous display and a digital record of several parameters relating to shipboard meteorology. It was designed for the Joint Air-Sea Interaction (JASIN) experiment and was used aboard the Atlantis II to supplement buoy-based recording systems. This report describes the sensors used and data collected during the JASIN cruise. However, the design of the system is such that it can support different sensors and other additional sources of data input in future applications.

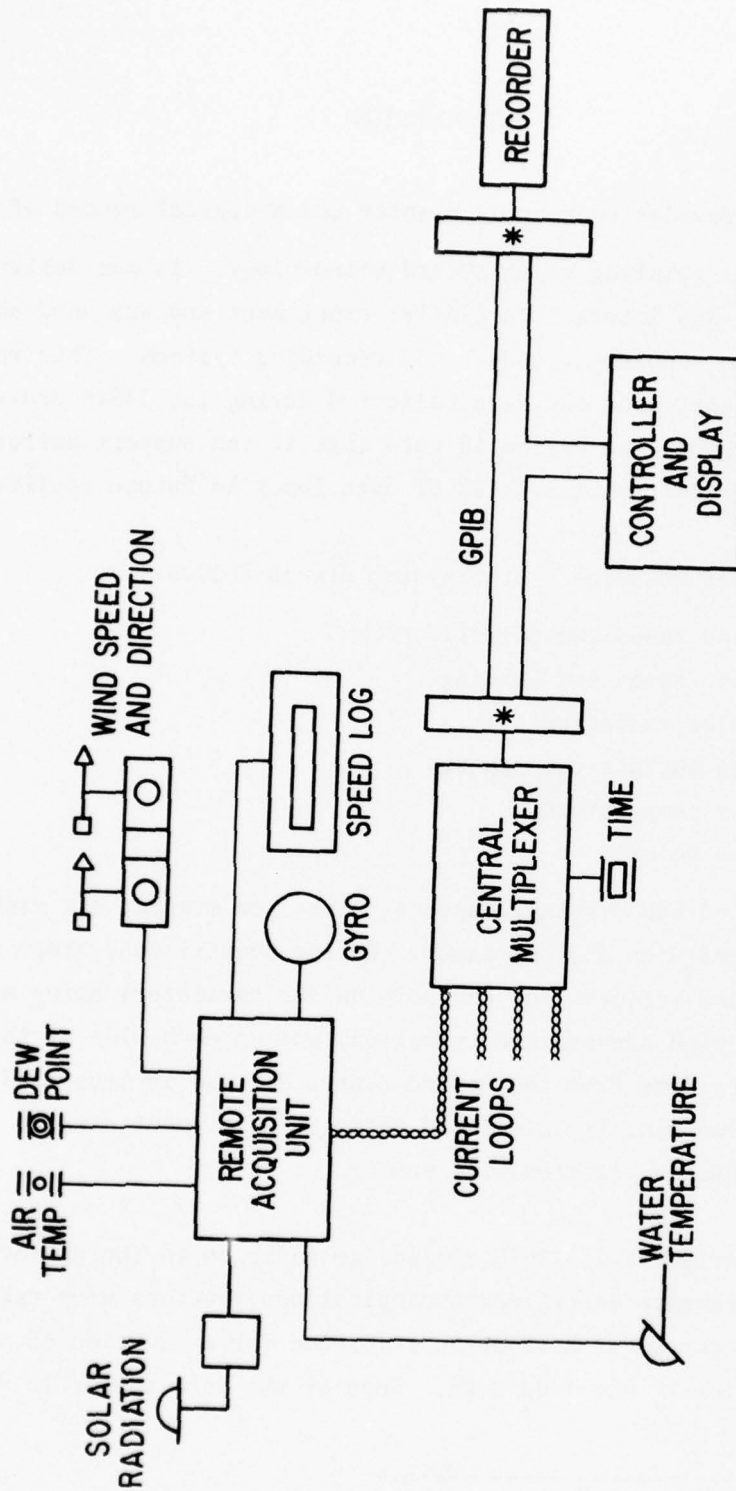
The parameters measured by the system are as follows:

1. wind speed and direction
2. ship speed and heading
3. solar radiation
4. sea surface temperature
5. air temperature
6. dew point

Sensors are sampled and displayed several times per minute; six minute averages are recorded on digital tape*. During acquisition, steps are taken to remove the influence of the ship on the parameters being measured. For example, two wind sensors are installed, one on each side of the ship. The system selects data from the upwind sensor for use in true wind calculations. True wind is calculated using ship movement data in conjunction with the data from the selected wind sensor.

During the Atlantis II JASIN cruise, in addition to the nearby buoy measurements, extensive manual meteorological observations were taken on the ship. These served as a valuable reference for evaluation of and comparison with the automatically acquired data. Some of the data appear in Part III of this report.

* The recording system did not function during this test cruise of the prototype system.



* GPIB TO RS-232 CONVERTER

Figure II-1: Block diagram of meteorological data system.

SYSTEM SPECIFICATIONS

The system design described in Peal and Bradley (1978) is based on four main modules as follows (see Figure II-1):

- The remote acquisition unit converts the sensor outputs to digital values and sends the raw numbers to a central location.
- The central multiplexer performs the digital data transmission.
- The controller and display unit controls the data acquisition and recording, and converts the raw data to engineering units for display at the central location and for recording.
- The recorder stores the data for later analysis.

An important feature is the continuously updated display of the measured values converted to engineering units. The display (Figure II-2) is readily understood providing instant access to the data being recorded and verification of system operation.

Another important feature of the system is the ease with which it can transmit data to external devices. Thus, although this system has display and bulk storage capabilities, it can serve as a source of pre-processed real-time data for other systems aboard ship.

The system accuracy for DC inputs is determined by the analog-to-digital conversion in the remote acquisition unit. The conversion is performed by an Analog Devices 7507 multiplexer, a 581 J voltage reference,



Figure 11-2: Live data display in main laboratory. Data being recorded are continuously updated.

and a 7550 converter at a clock rate of 614.4 KHz. Figure II-3 shows a calibration of this portion of the system.

This calibration does not apply to devices which are inherently digital since they are read into the system as digits. The ship speed log and gyrocompass are two such devices.

The system is capable of sampling all sensors as frequently as once per second. In this case, the following sample scheme is used:

- | | |
|------------------|---|
| every 30 seconds | - wind speed (both sensors) |
| | - wind direction (both sensors) |
| | - ship speed |
| | - ship heading |
| | - solar radiation (buffered raw output) |
| every 6 minutes | - sea surface temperature |
| | - air temperature |
| | - dew point. |

A tape record is written every 6 minutes and consists of:

- sequential record number
- time of day
- sea surface temperature
- air temperature
- dew point
- ship speed north and east (average of 12 values)
- wind speed relative to ship, forward and starboard beam vectors (average of 12 values)
- true wind speed north and east (average of 12 values)
- solar radiation (average of 12 values).

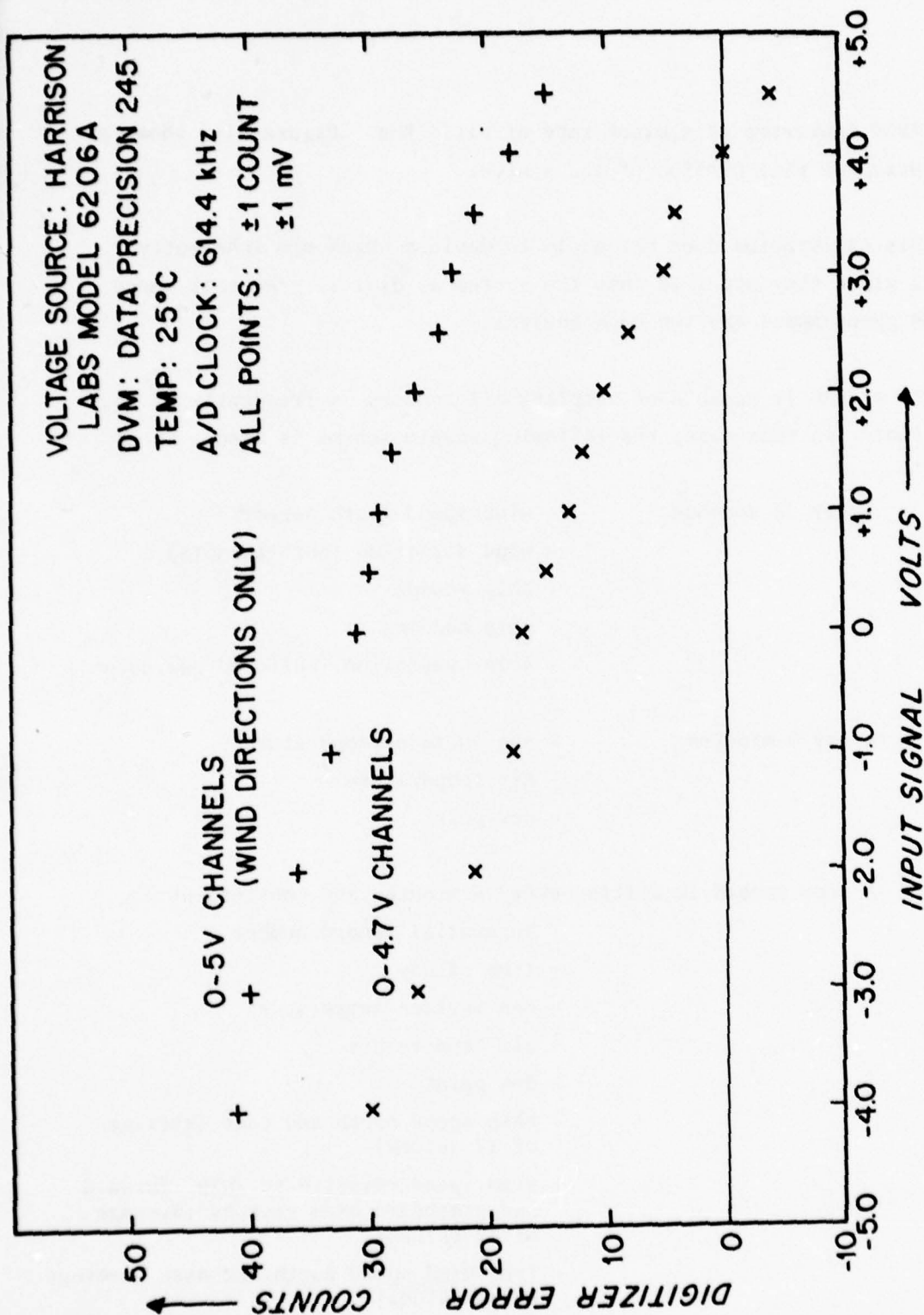


Figure II-3: Calibration of digitizer portion of system.

The data are recorded in a standard code on tape cartridges. In this case, each cartridge holds 468,800 bytes of data, requiring a new cartridge about every 12 days.

SYSTEM OPERATION

Prior to performing data acquisition, it is necessary to initialize the various modules of the system. This process is performed automatically by the control and display unit as a separate program under operator control. Once initialized, the remote acquisition units access all active sensors on a continuous basis. This ensures that current valid data is available for transmission to the central display location at all times.

To perform acquisition, the control and display unit continuously checks the current time of day against a pre-defined sensor acquisition schedule. When a given sensor is to be accessed, a command is sent to the remote acquisition unit which replies with its most recent value. The control display unit performs appropriate conversion and averaging calculations, then displays and records the value in engineering units.

SENSOR SPECIFICATIONS

This section provides specifications for each sensor as used in this system including conversion factors, ranges, accuracy, and response time. A summary is shown in Table II-1.

Wind speed and direction

The anemometer is a vortex counting speed sensor mounted in the tail of a vane which is free to rotate about a vertical axis. Two units are mounted, one on each side of the after mast catwalk approximately 21 meters above the ocean surface. The units are mounted well outboard on each side to minimize the effect of the ship on the wind measurement - see Figure II-4. In the calculation of true wind, the computer uses the data from the upwind anemometer.



Figure II-4: One of two anemometers mounted on after mast catwalk.

Table II-1

Summary of measurements made

Parameter	Range	Units	Accuracy	Response	Sensor	Sample period	Data recorded every 6 minutes
Wind speed	0 to 60	m/sec	0.6 m/sec	0.33 cm	J-tec VA 320 sonic	30 sec.	average of 12 rel. vectors
Wind direction	0 to 358	degrees rel. to ship	±2 degrees	10 m.	J-tec VA 320 vane	30 sec.	and average of 12 true vectors (m/sec)
Ship speed	0 to 20	knots	10% (est)	20 sec., integration	Sperry SRD 101	30 sec.	average of 12 true vectors.
Ship heading	0 to 359	degree true	1 degree	limited by ship	Sperry Mk37 gyrocompass	30 sec.	(m/sec)
Solar radiation	0 to 5	volts	10% (est)	5 sec. (est)	Eppley/WHOI	30 sec.	average of 12 values
Sea surface temperature	-10 to +40	°C	±0.05 °C	2 min. (est)	RdF platinum	6 mins.	value
Air temperature	-40 to +50	°C	±1 °C	2 min.	General Eastern platinum	6 mins.	value
Dew point	-17.78 to 93.3	°C	±1 °C	3 to 5 mins.	General Eastern LiCl with platinum	6 mins.	value

The unit is a model VA-320, manufactured by J-Tec. The speed sensing unit utilizes the linear relationship between the frequency of vortex formation in the wake of a stationary rod and the speed of the air moving around it. The speed data from the unit is available as a frequency proportional to the rate of vortex shedding and as a voltage which is an analog of the frequency; the voltage is used in this case. The direction output is a linear voltage obtained from a precision, low torque, 358° potentiometer: 0° is wind from dead ahead, 90° is wind from starboard beam, etc.

The speed range is from a threshold of 1 m/sec to 65 m/sec with an accuracy of 0.6 m/sec. The direction range is 0 to 358 degrees with an accuracy of ± 2 degrees for speeds above 5 m/sec. The speed distance constant is 0.33 cm; the direction constant is 10 m.

The conversion factors used by the program are as follows:

- speed = 12 x (volts) m/sec
 = 0.01379012 x (counts) m/sec

- direction = 72 x (volts) degrees
 = 1.256637062 x (volts) radians
 = 0.08802207194 x (counts) degrees
 = 0.00153627497 x (counts) radians

Ship speed

Ship speed is measured with a single-axis acoustic doppler log, model SRD101, manufactured by Sperry Marine Systems. A direct interface to the system's data lines reads the speed into the remote acquisition unit.

Speed readings from 0 to ± 19.9 knots are possible. These are converted to m/sec in the program by multiplying by 0.508. Using speed and heading information, ship's velocity is determined as north and east vectors. Values in the range 0 to 10.16 m/sec are recorded; other values are recorded as 99.99 m/sec.

Ship heading

The ship uses a Sperry Mark 37 gyrocompass with step-by-step repeaters. The remote acquisition unit monitors the pulses on the three lines going to these repeaters. From these pulses it tracks the ship's heading from an initial heading entered by an operator.

The ship's heading data are thus available directly in degrees true. This is used in determining the ship's north and east velocity and subsequently in determining true wind.

True wind

This is actually a derived parameter but since it is displayed and recorded in real time, the method is described here.

For both anemometers, the apparent wind (i.e., relative to ship) is resolved into along-ship and athwart-ship vectors. For a given observation the sum of the athwart-ship vectors from the two anemometers is computed. If the sum is negative, data from the port anemometer is



Figure II-5: Sea surface temperature detector mounted in transducer adapter ring in bow chamber.

selected; if it is zero or positive, data from the starboard anemometer is selected. Using ship heading, the selected apparent wind vectors are then resolved to north and east vectors. Finally, the ship's north and east velocities are subtracted leaving true wind.

Note that ship vectors indicate the direction the ship is moving to whereas wind vectors indicate the direction the wind is blowing from.

Solar radiation

The radiation sensor is an Eppley differential thermopile mounted on the top of the stern A-frame about 8 meters above the water surface. The unit is connected to a W.H.O.I.-manufactured device which provides a buffer amplifier with an analog integrator and chart recorder. The 0 to 5 VDC output of the buffer amplifier is digitized and recorded by the computer as a voltage reading. The conversion used for the digitizer output is

$$0.00114918 \times (\text{counts}) \text{ volts.}$$

When the stern frame was tilted from its rest position, the science watch noted the times for later annotation of the solar radiation data series.

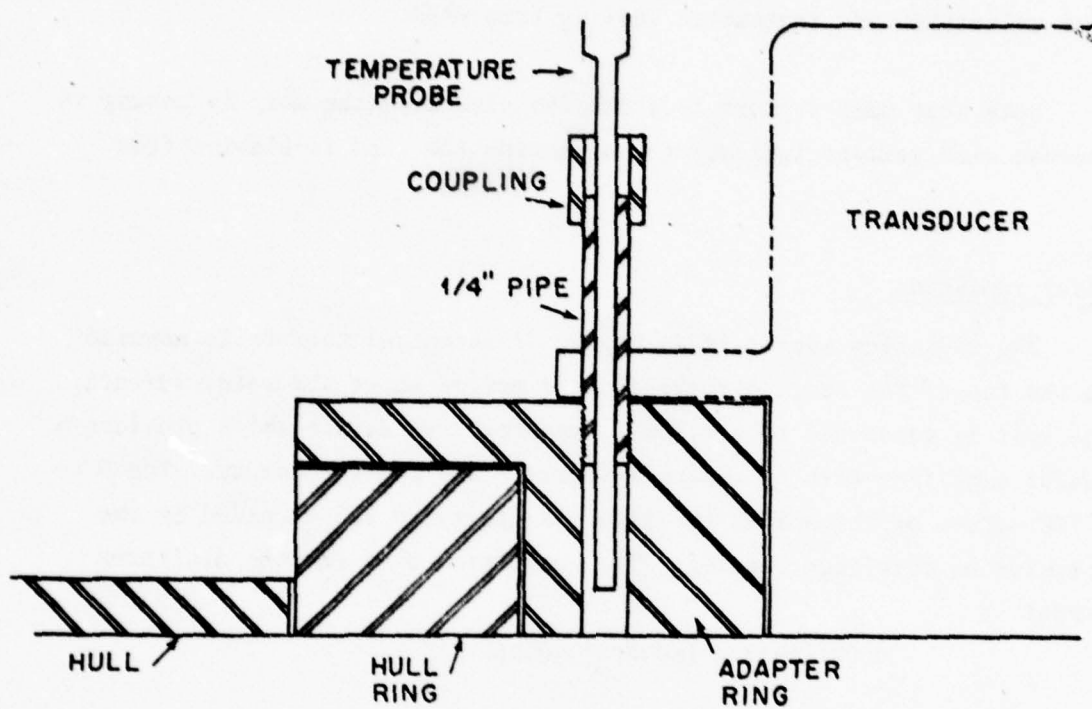


Figure II-6: Detail of mounting arrangement for sea surface temperature detector.

Sea surface temperature

The water temperature sensor is a 100 ohm platinum resistance temperature detector installed in the forward transducer adapter ring in the A-II bow chamber - Figure II-5. The ring is drilled through and tapped for a $\frac{1}{4}$ " pipe; the sensor is mounted in the pipe with its tip flush with the outside surface of the hull as shown in Figure II-6. The measurement is made at about 4.5 meters depth.

The sensor is a 3-wire type 21 connected to a 2-wire transmitter type 2600, both manufactured by RdF Corporation and calibrated for linear output within $\pm 0.05^{\circ}\text{C}$ over a span of -10° to $+40^{\circ}\text{C}$. The transmitter output is a direct current between 4 and 20 milliamperes which is proportional to the water temperature. The current output is passed through a Vishay 250 ohm resistor, type S102, tolerance 0.5%, to generate a voltage which is measured by the remote acquisition unit.

The temperature sensor and transmitter were calibrated before and after the JASIN cruise at the W.H.O.I. temperature calibration facility. This was to verify the quoted accuracy and to allow corrections to be applied to the recorded data if additional accuracy is desired. The calibration results are shown in Figure II-7. Additional accuracy can be obtained by applying a correction as shown in Figure II-8 to the recorded data. A further improvement could be obtained by performing a more accurate digitizer calibration.

The conversion factors used by the program are as follows:

- for transmitter output (volts)
 $\text{temperature} = 12.5 \times (\text{volts}) - 22.5^{\circ}\text{C}$
- for digitizer output (counts)
 $\text{temperature} = 0.01436471 \times (\text{counts}) - 22.5^{\circ}\text{C}$

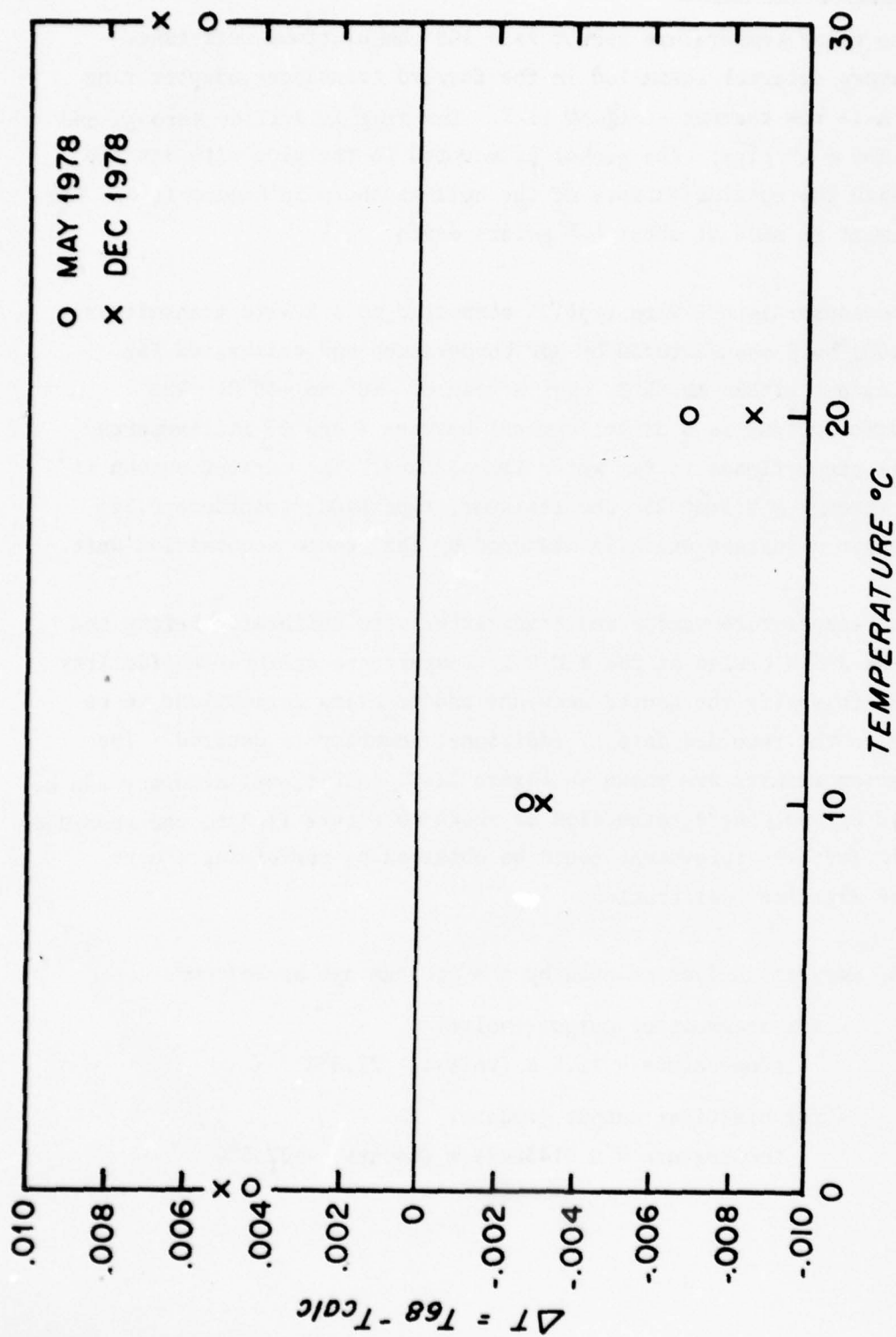


Figure II-7: Calibration of sea temperature detector before and after JASIN cruise. T₆₈ is the temperature of the calibration bath, T_{calc} is the temperature calculated from the detector's output.

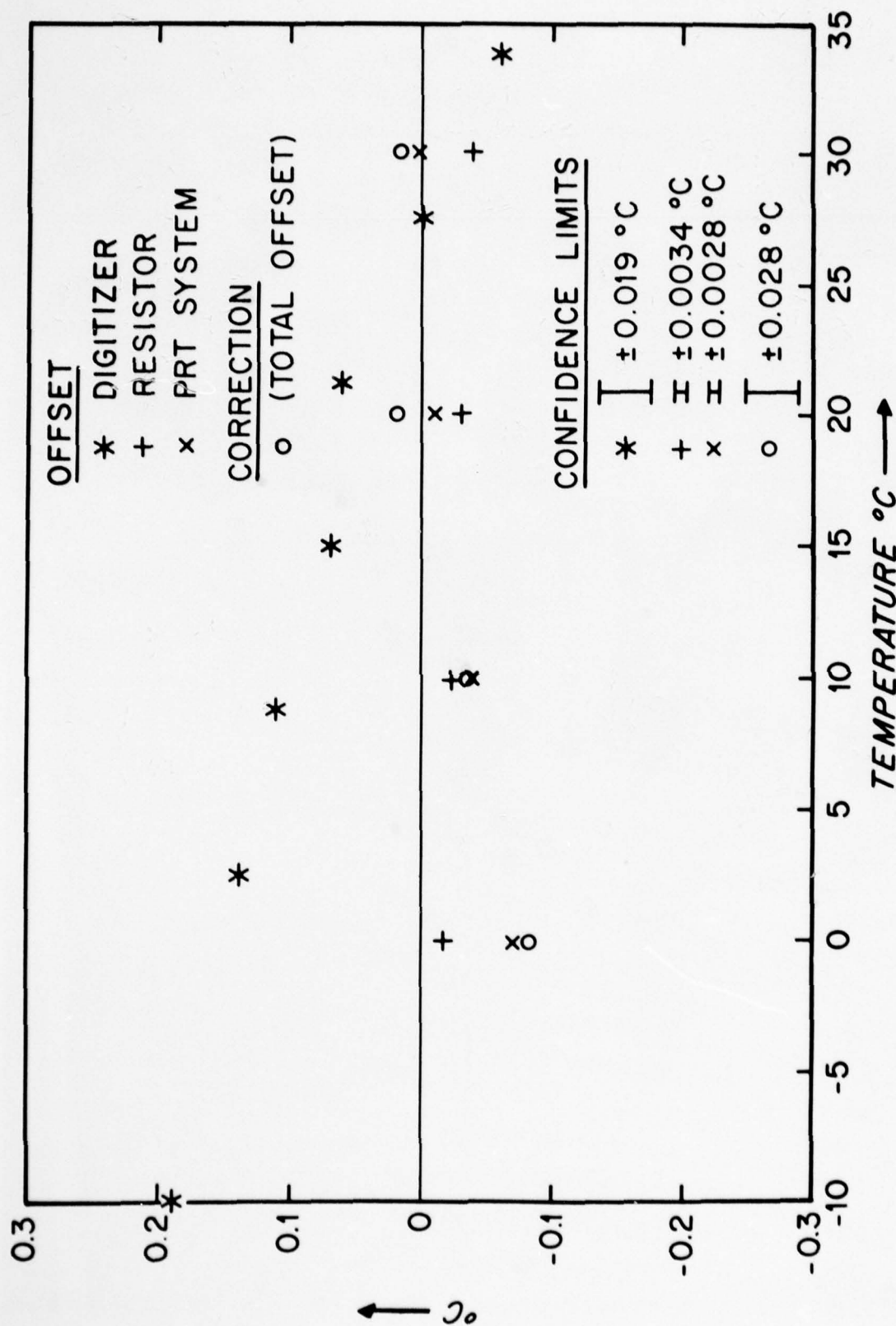


Figure II-8: Net error in observed sea surface temperature caused by digitizer, detector and resistor errors.

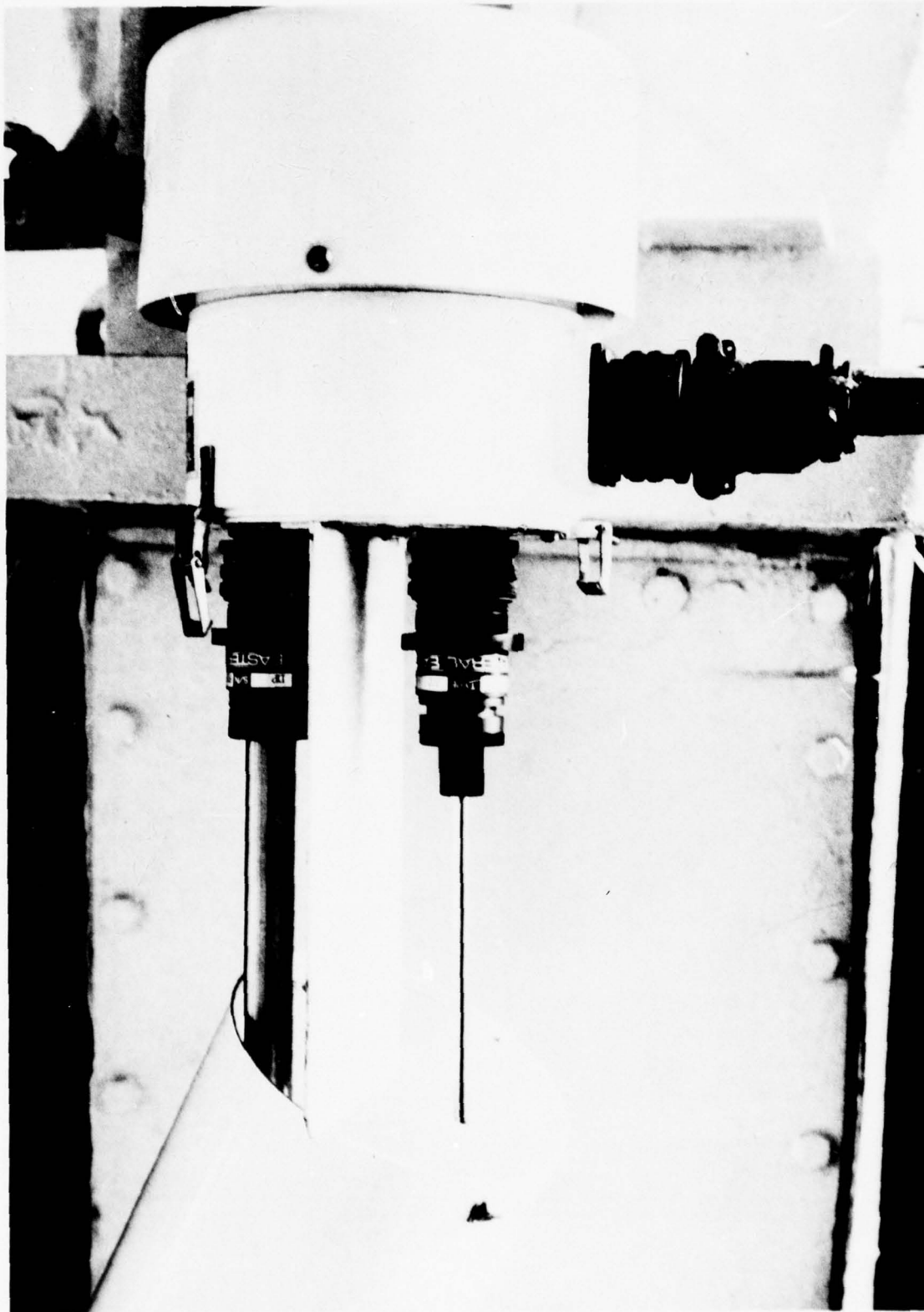


Figure II-9: Dewpoint and air temperature sensors mounted in aspirated sun shield with access cover removed.

Air temperature

The air temperature sensor is a 100 ohm platinum resistance temperature detector mounted in a motor-aspirated sun shield along with the dew point sensor - Figure II-9. The unit is installed on a stanchion on top of the top laboratory about 11.5 meters above the water surface.

The sensor is a model 612A with a model 650 AT transmitter manufactured by General Eastern. The sensor is mounted in a model 706 M aspirated sun shield. The transmitter provides a 0 to 5 VDC output for an air temperature range of -40° to $+50^{\circ}$ C with an accuracy of $\pm 1^{\circ}$ C. With 10 feet per minute aspiration, the response is approximately two minutes.

The conversion factors used by the program are as follows:

- for transmitter output
$$\text{temperature} = 18 \times (\text{volts}) - 40^{\circ}\text{C}$$
- for digitizer output
$$\text{temperature} = 0.2068519 \times (\text{counts}) - 40^{\circ}\text{C}$$

Dew point

The dew point sensor is a 100 ohm platinum resistance temperature detector surrounded by a teflon-sheathed stainless steel bobbin. On the bobbin is an elemental winding of inert platinum wire over a glass wick. The unit is mounted in a motor aspirated sun shield along with the air temperature sensor - Figure II-9. Prior to installation, the wick is coated with a saturated solution of lithium chloride. In operation, the platinum winding is heated to the point where evaporation of water balances condensation. This temperature measured by the platinum detector is a measure of the dew point of the surrounding air.

The sensor is a model 611 A with a model 650 DP transmitter manufactured by General Eastern. The sensor is mounted in a model 706 M aspirated sun shield. The transmitter provides a 0 to 5 VDC output for a dew point range of 0 to 200°F with an accuracy of $\pm 2^\circ\text{F}$. With 10 feet per minute aspiration the response is 3 to 5 minutes.

The conversion factors used by the program are as follows:

- for transmitter output
dew point = $18.6666 \times (\text{volts}) \text{ } ^\circ\text{C}$
- for digitizer output
dew point = $0.10725652 \times (\text{counts}) \text{ } ^\circ\text{C}$

RESULTS

The system was operating for acquisition and display a total of 27.7 days during the two legs of the JASIN cruise. During the first leg, the system operated from 0000, 2 August to 0800, 14 August. However, for an 8-hour period on 6 August some data are missing because of a bad dew point sensor. During the second leg the system operated from 1200, 22 August to 1200, 7 September with a 7-hour outage on 30 August when the computer program failed.

When evaluating a system for collecting data in a shipboard environment, component reliability is as important as accuracy of results. Thus, system operation should not be jeopardized by failure of one module.

In this case, the system failed to provide recorded data due to a hardware problem with the tape drive. The data presented here were logged by watchstanders from the CRT display and subsequently keypunched in a standard format for computer processing. In the future, a hardcopy printer will be added to provide access to previous data during the cruise and to serve as a backup for the tape system.

Reliability problems were encountered with certain sensors. Anemometers and air temperature sensors are required to operate in locations subject to high levels of radio frequency radiation. Modifications were necessary to the circuitry mounted in the sensor unit to provide filtering and decoupling in order to prevent damage and incorrect operation.

Lithium chloride dew point cells are relatively inexpensive but can be contaminated by salt deposits. To minimize this problem we provided a closed, aspirated shield for the dew point cell. In addition, we performed frequent inspection of the cell and we carried a spare cell to simplify servicing when required. The unit was serviced only once (6 August) and appeared to operate successfully for long periods - Figure III-12.

Platinum resistance temperature detectors were chosen in all cases for their long term stability. The calibration of the water temperature unit (Figure II-4) appears to support this choice.

In addition to reliability, however, data validity is important. To evaluate the PET data set, scatter plots were produced of several of the parameters against the corresponding parameters in the manual and the buoy data sets. These appear in Part III.

RECOMMENDED IMPROVEMENTS

In the interests of generating a more complete data set, the system should be upgraded to include inputs from a flow-through conductivity system, and from one or more navigation devices such as a satellite navigator or a Loran C receiver.

To simplify changes required for different cruises, the computer program should be changed to perform a running mean instead of a fixed-length average which it now performs.

Finally, an external digital clock should be added to provide better accuracy and display than the internal PET clock used during the cruise.

REFERENCE

Peal, K. R. and A. M. Bradley, Use of Industry Standards for Shipboard Data Systems, IEEE Oceans '78 Conference Record, 78CH1356-6, pp. 547-551, September, 1978.

PART III
METEROLOGICAL DATA

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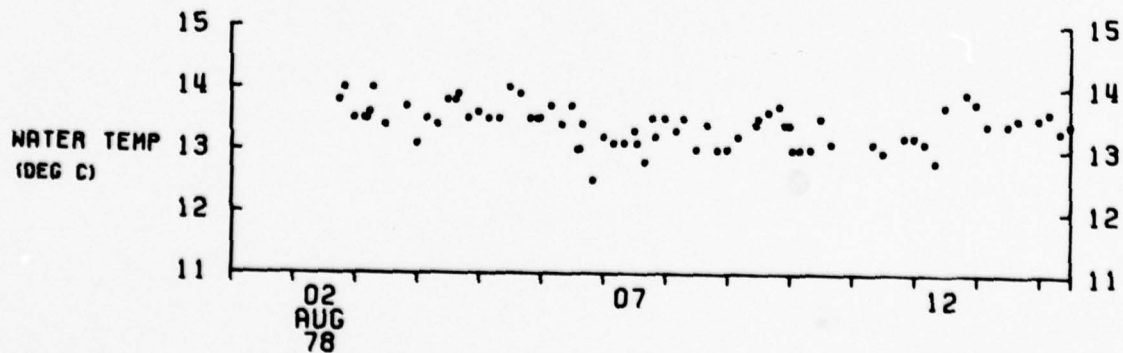
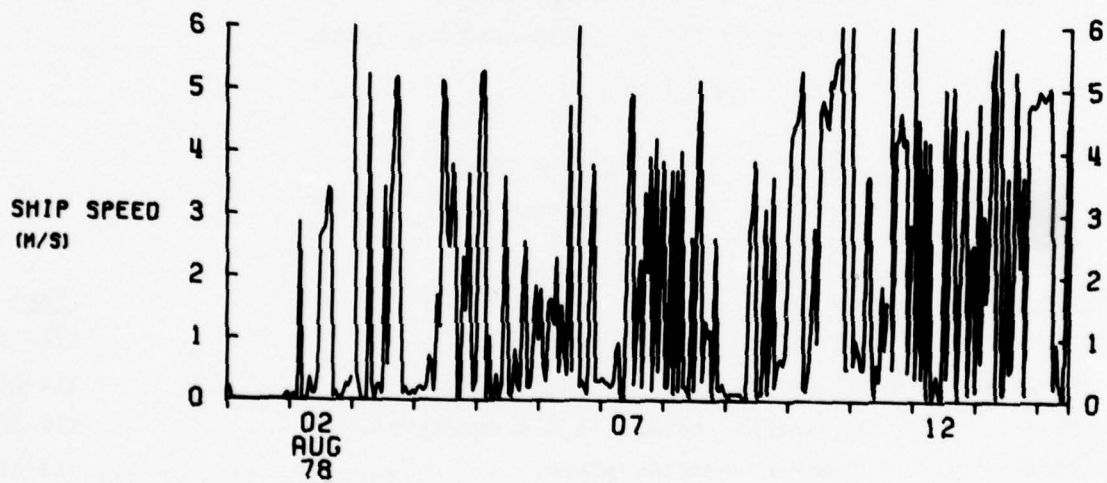
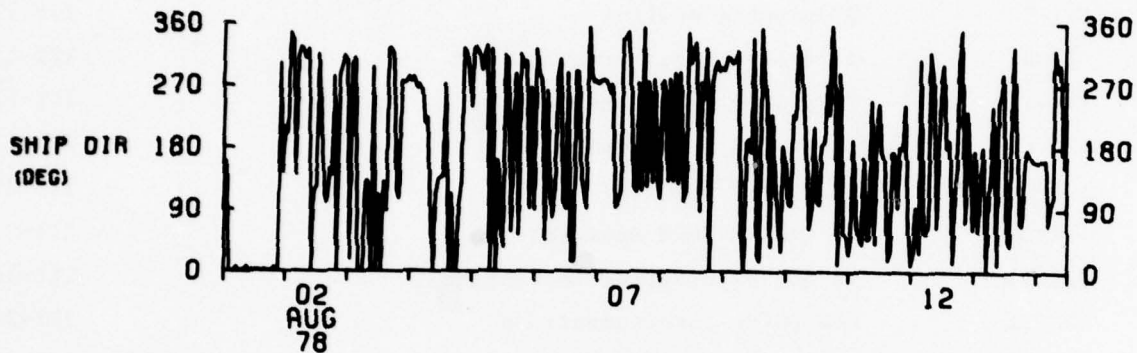
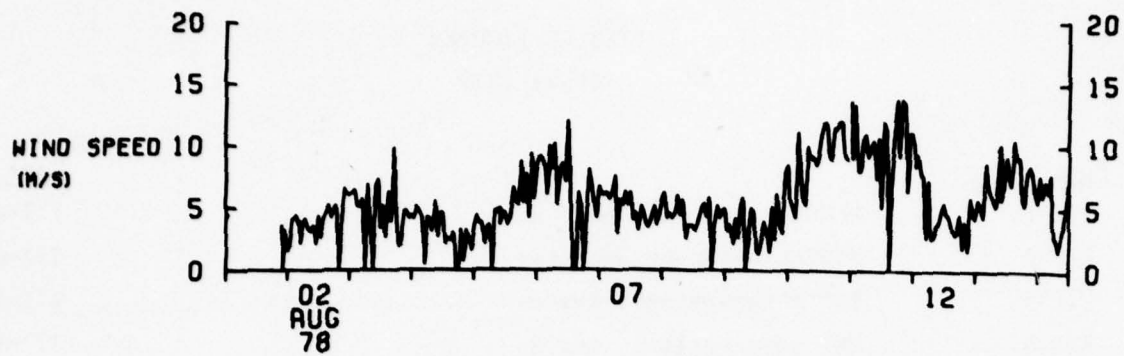


Figure III-1a: Leg 1 MANUAL hourly observations

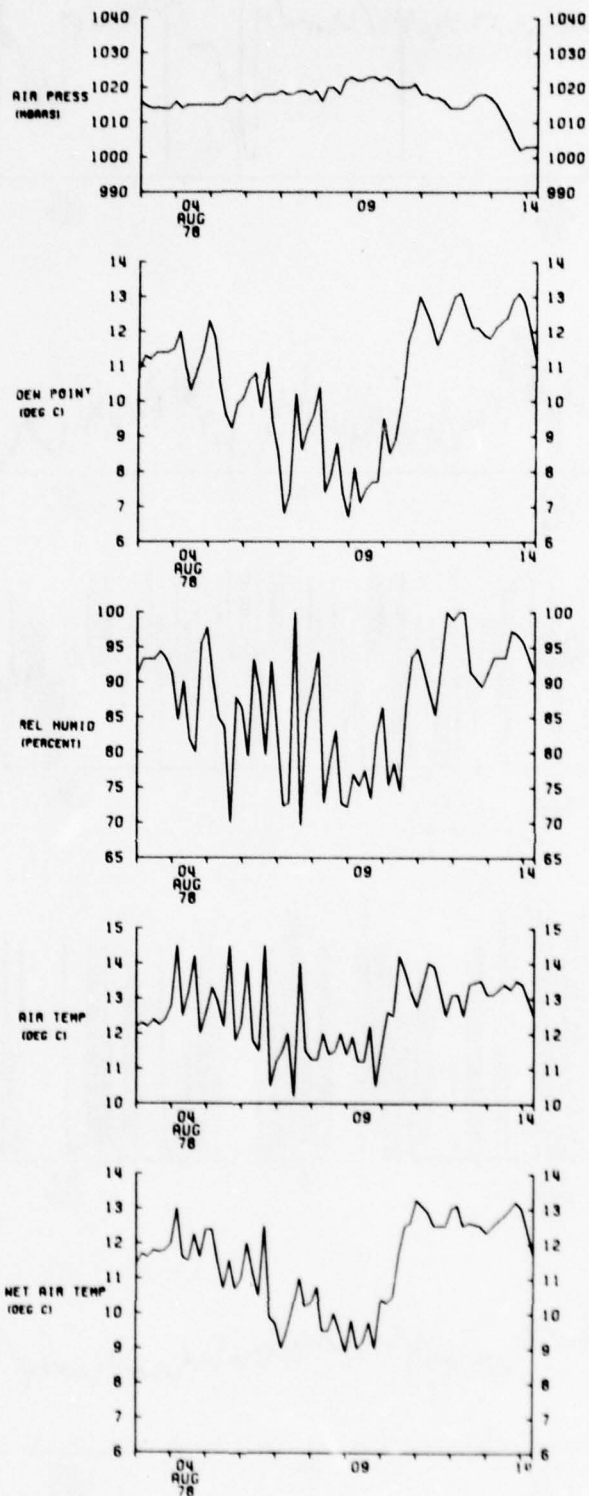


Figure III-1b: Leg 1 MANUAL 4 hour observations

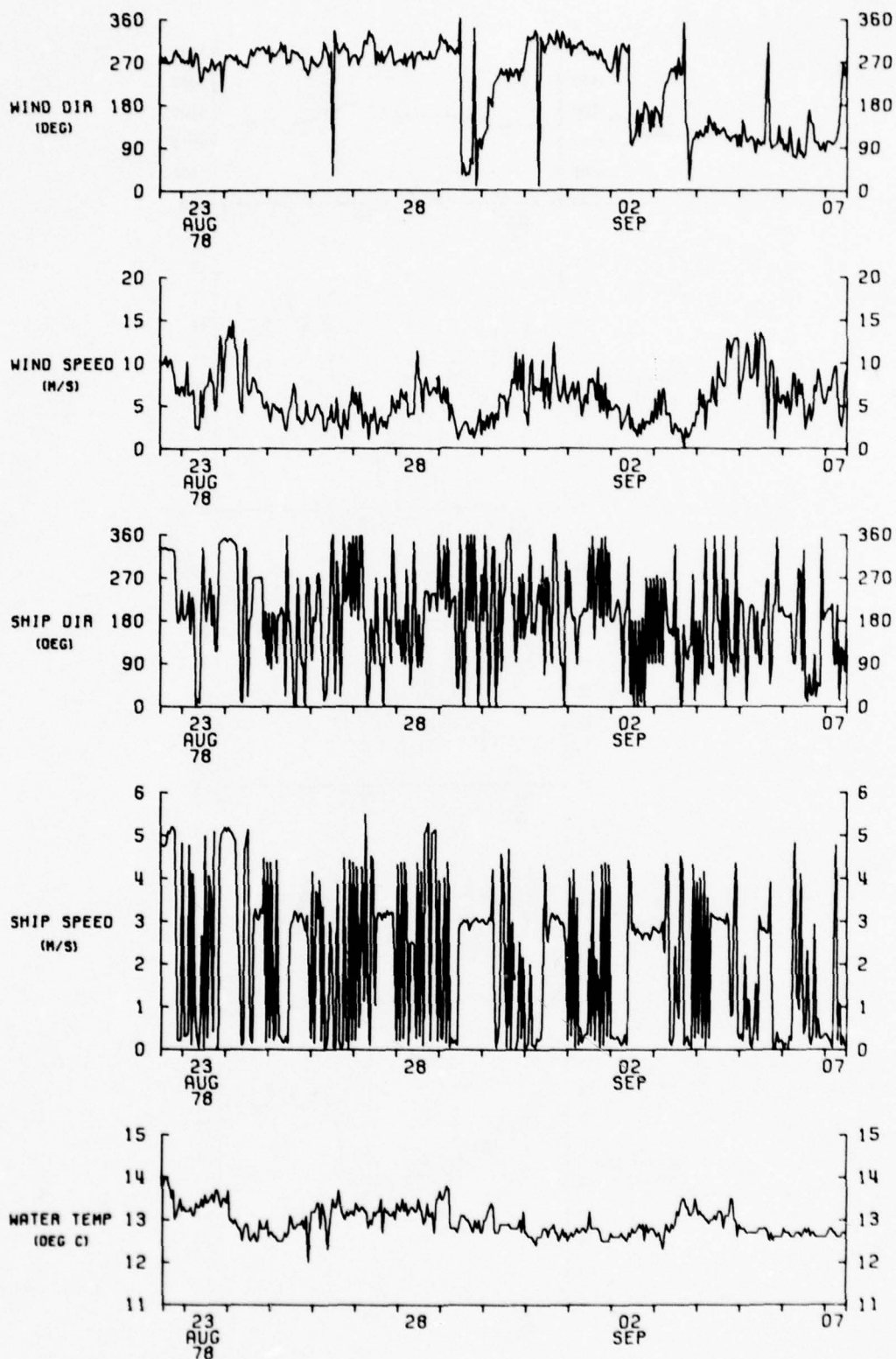


Figure III-2a: Leg 2 MANUAL hourly observations

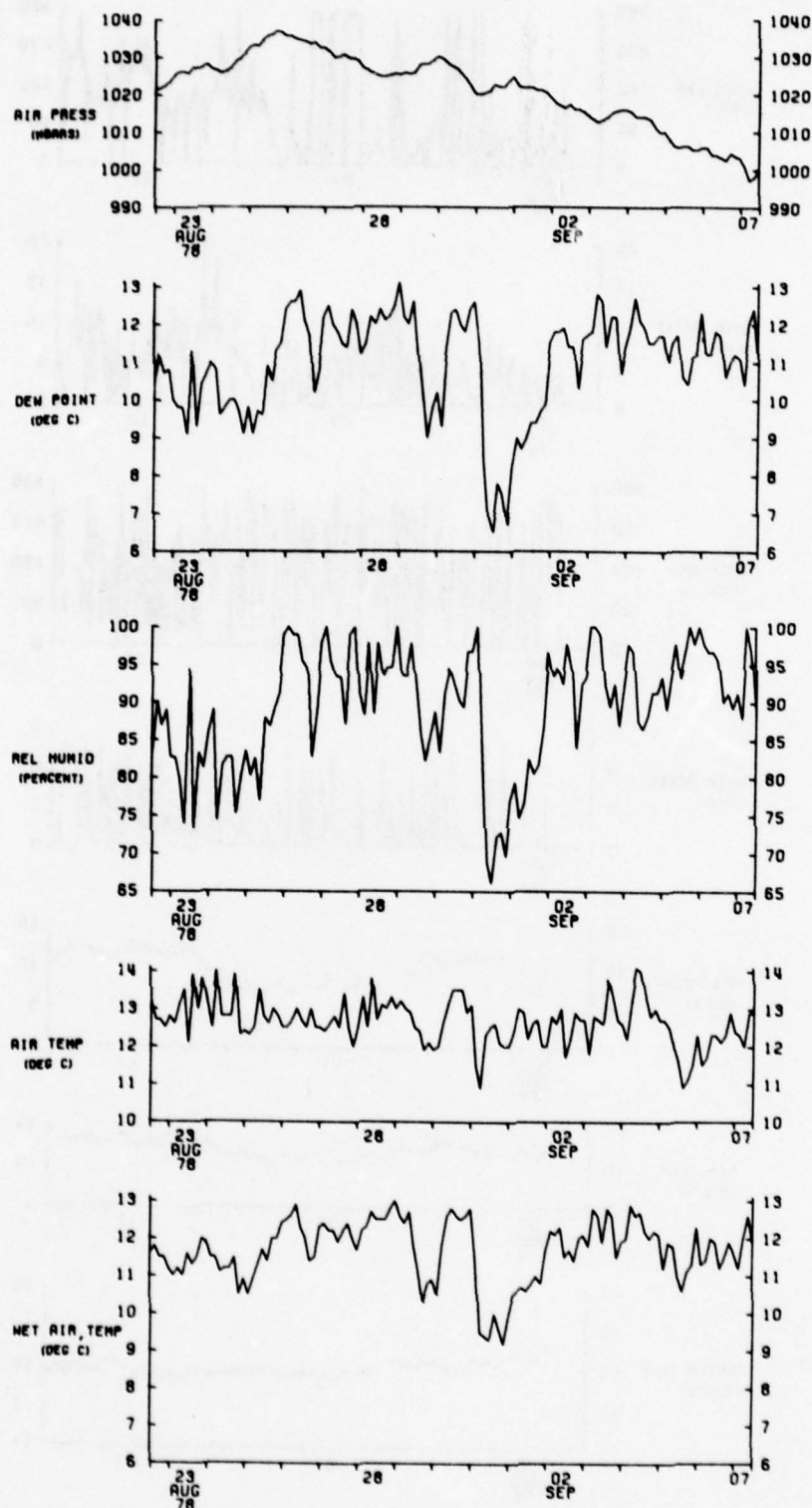


Figure III-2b: Leg 2 MANUAL 3 hour observations

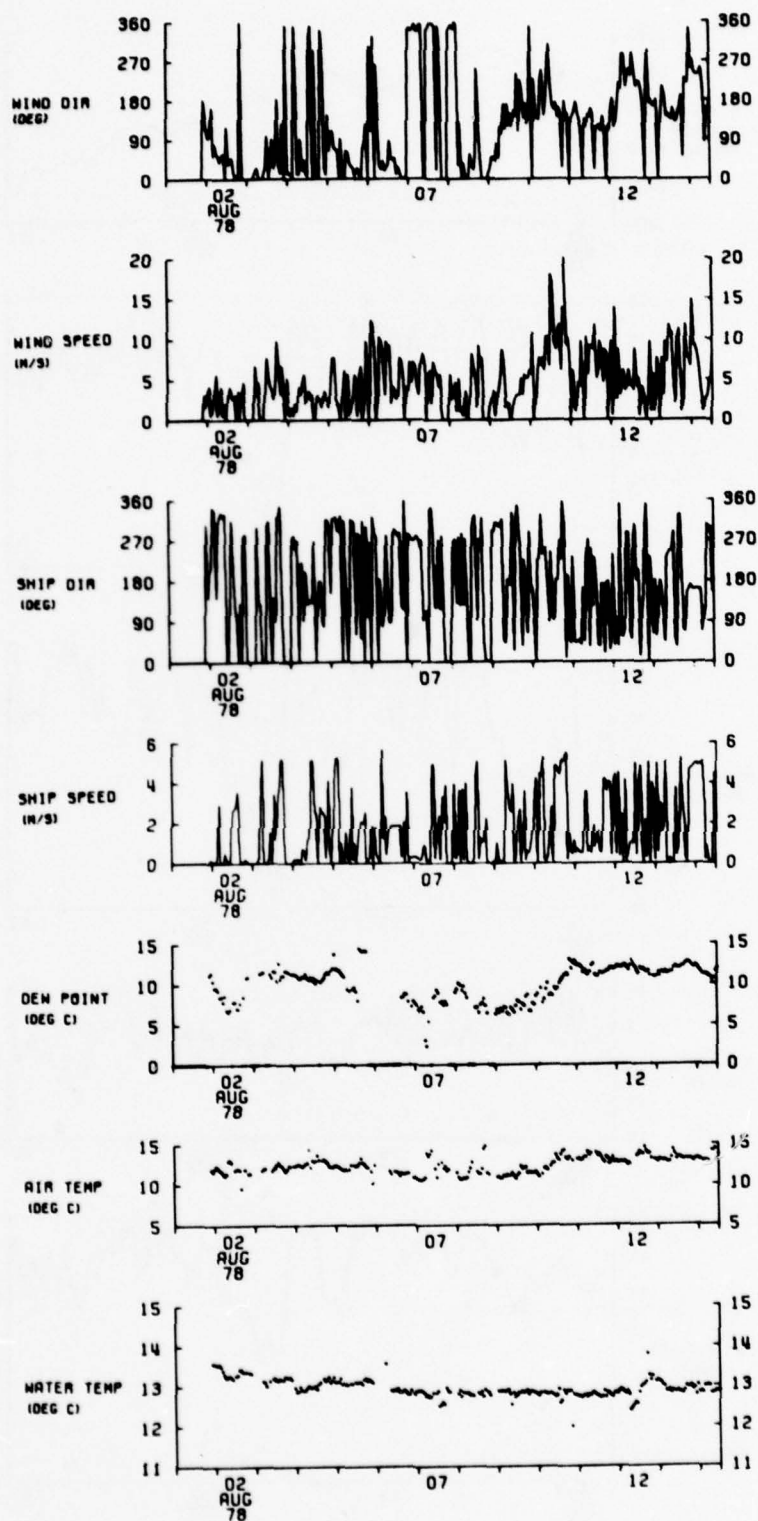


Figure III-3: Leg 1 PET observations

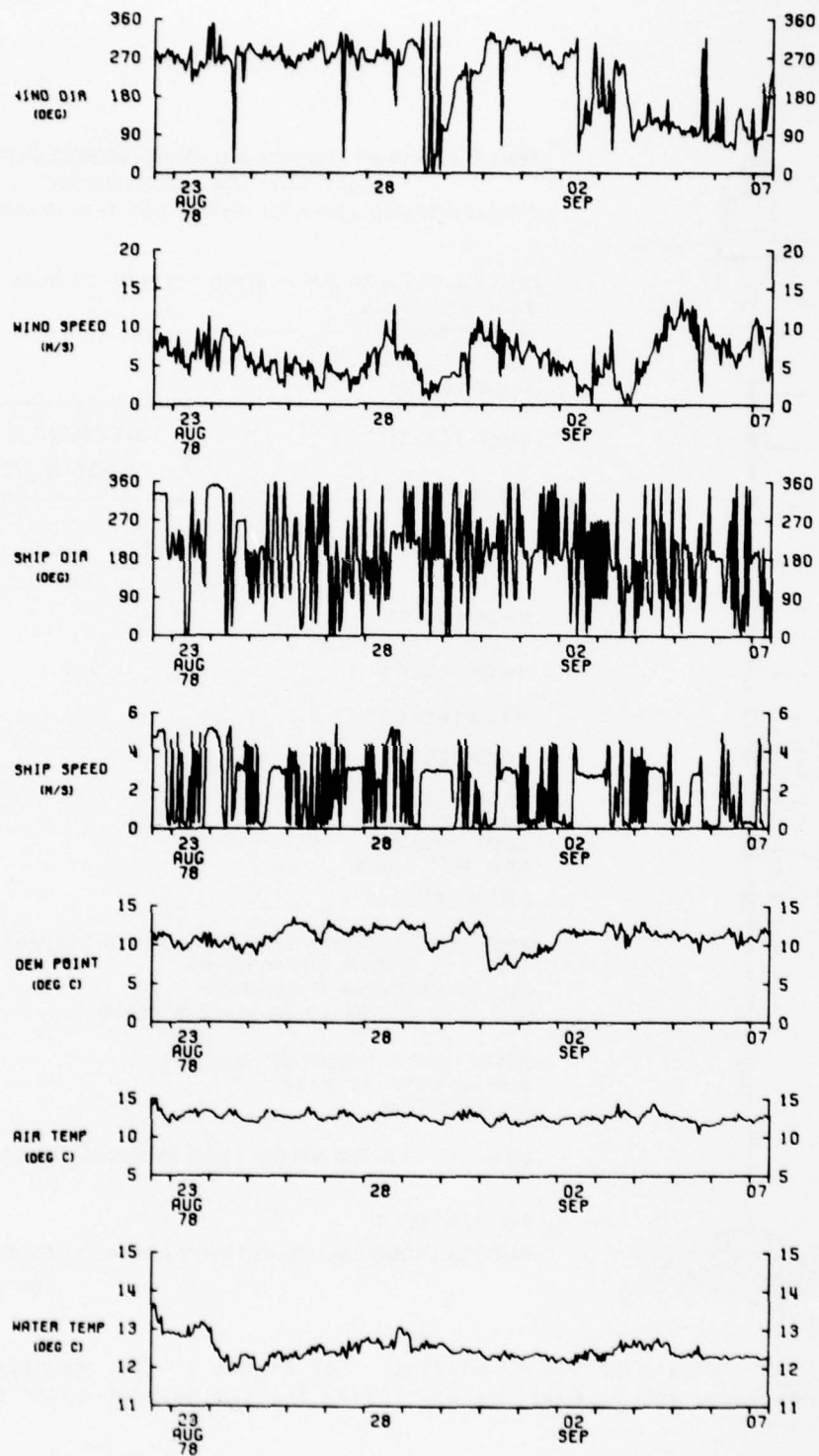


Figure III-4: Leg 2 PET observations

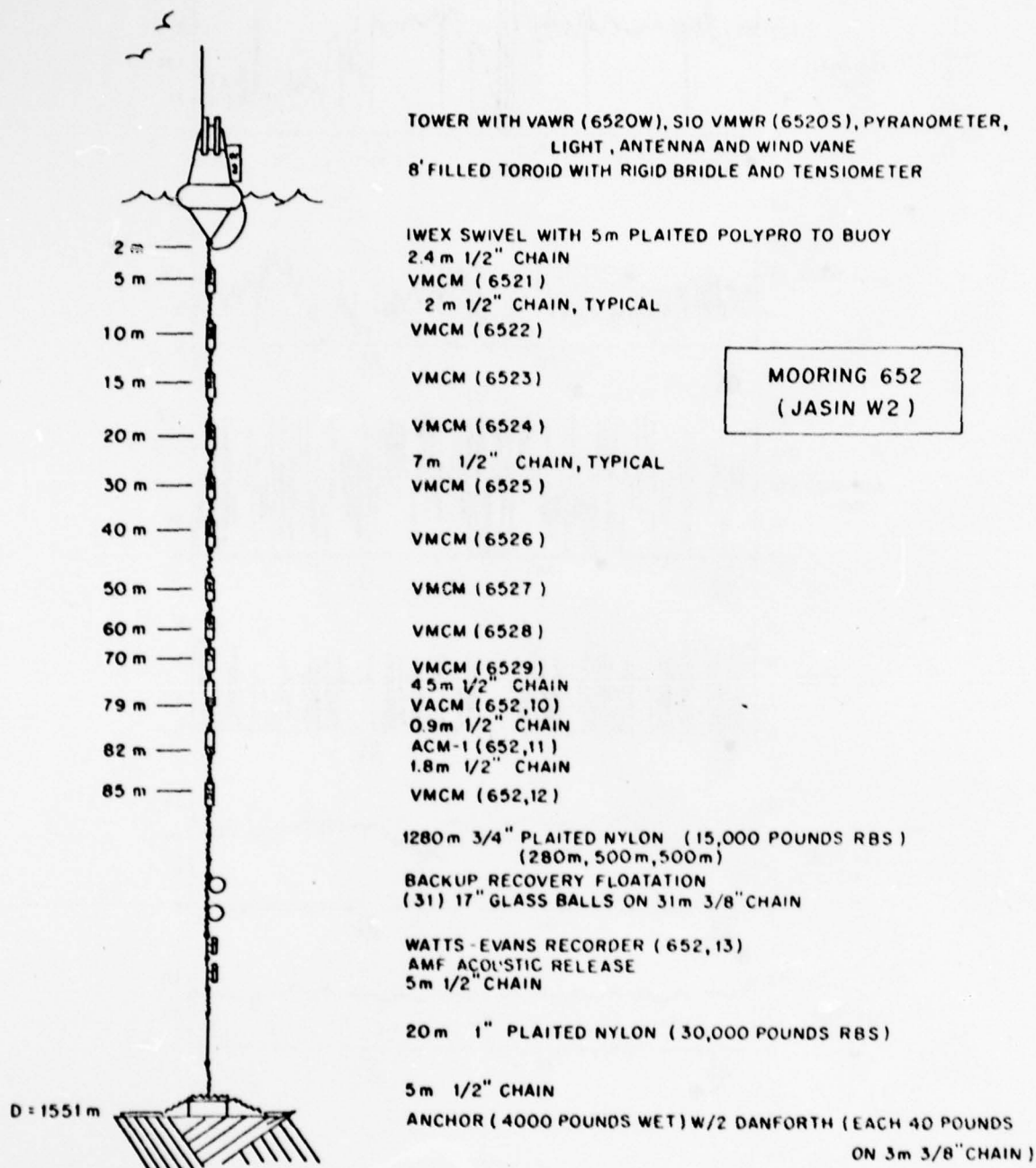


Figure III-5: Design of the W2 mooring. See Figure I-3 for details of the surface buoy, and Tarbell, et al. (1979) for the current meter data.

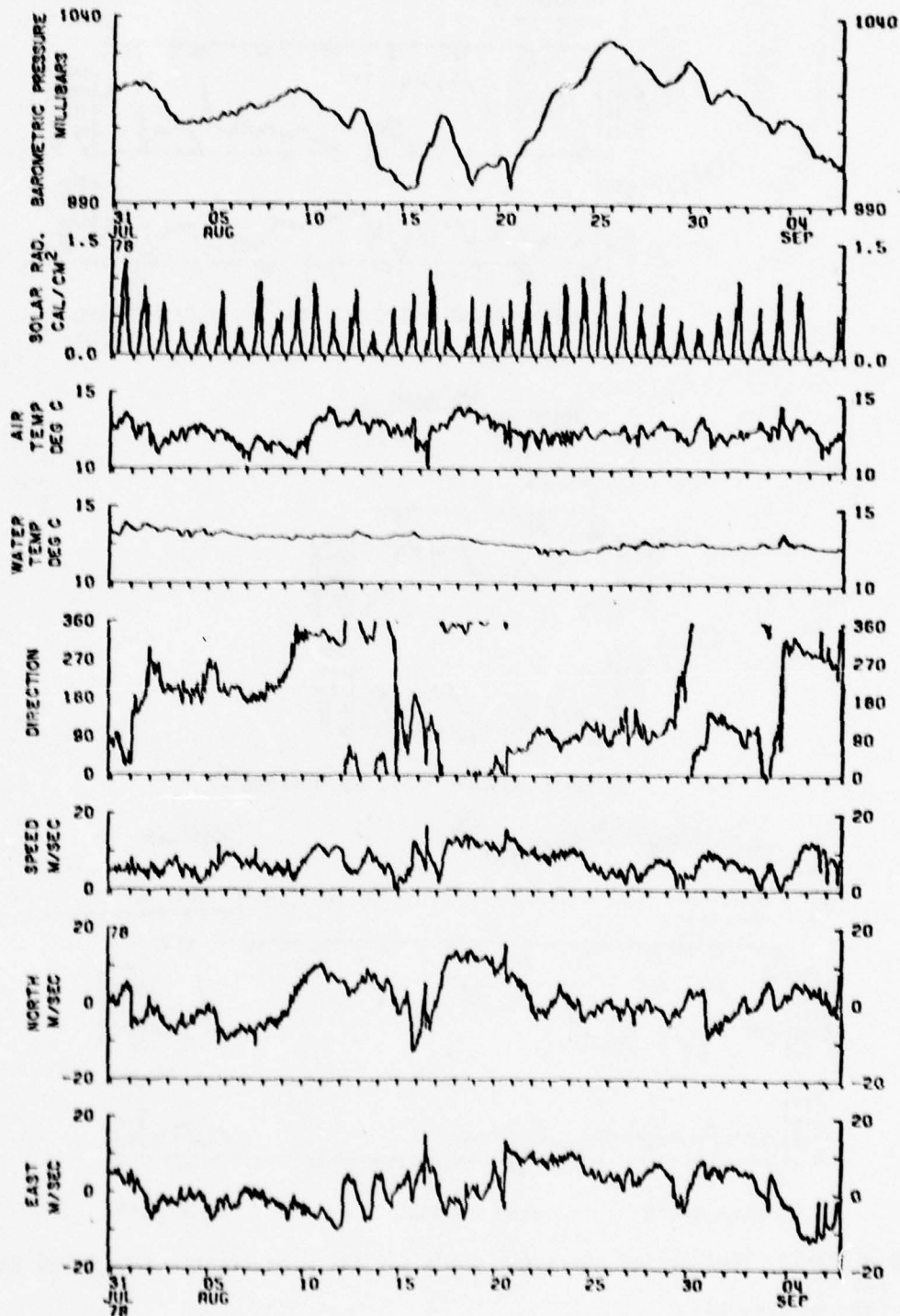


Figure III-6: W2 meteorology

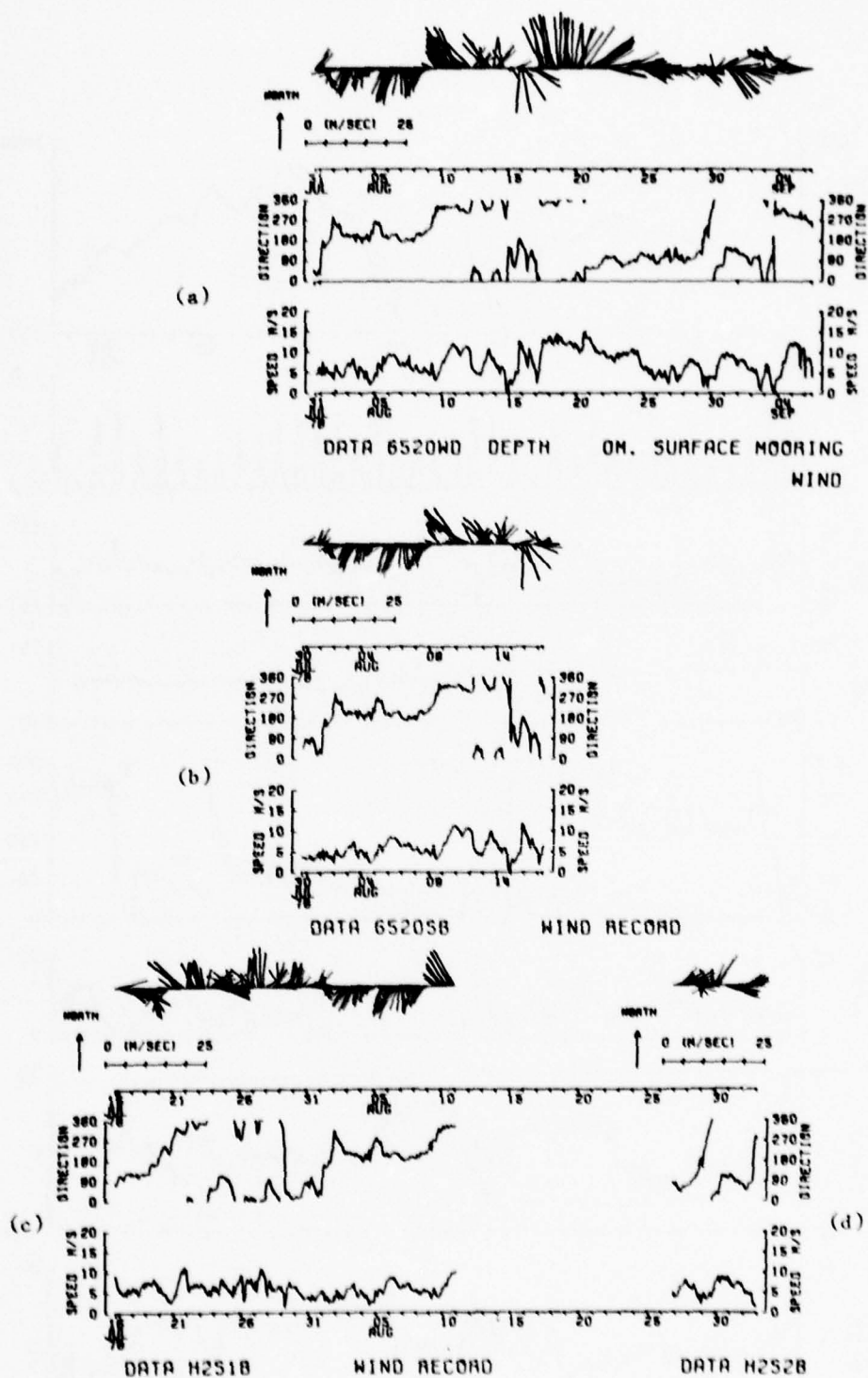


Figure III-7: Time series and stick plots for the wind records from buoys W2 and H2.

- (a) VAWR on W2
- (b) VMWR on W2
- (c) VMWR on H2 (first deployment)
- (d) VMWR on H2 (second deployment)

6520WD

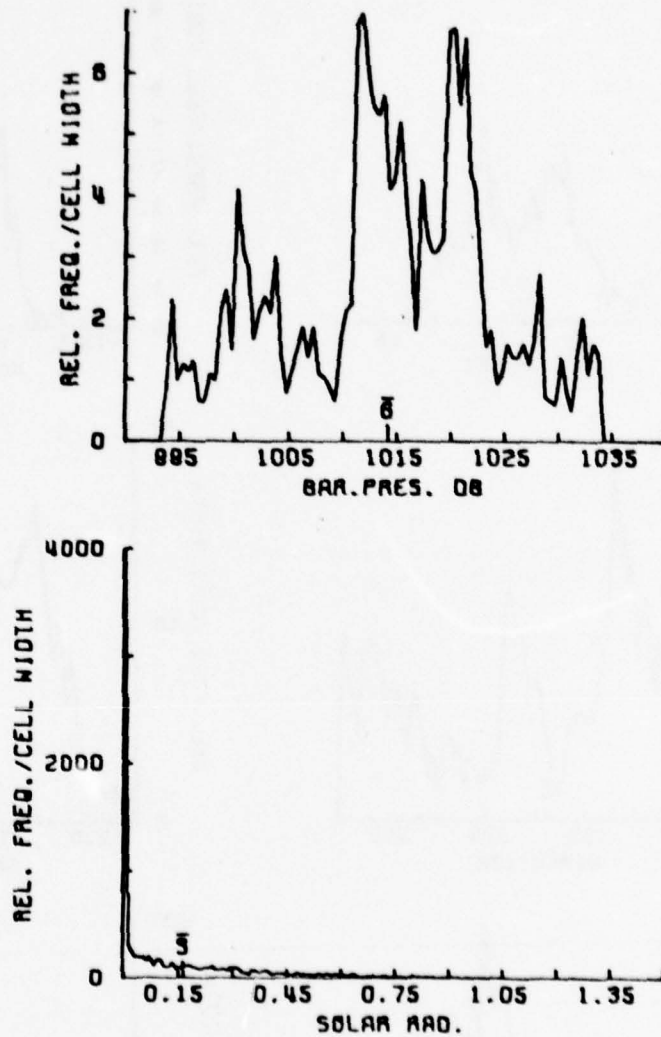


Figure III-8: Histograms of the buoy data from W2 and H2.
 (a) VAWR on W2 (6520WD)
 (b) VMWR on W2 (6520S)
 (c) VMWRs on H2

WIND RECORD

DEPTH -0- M.

6520WD

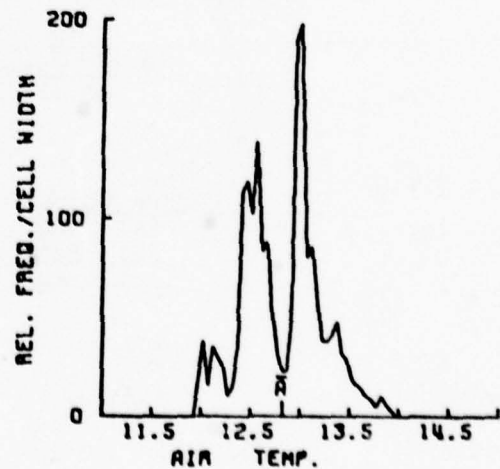
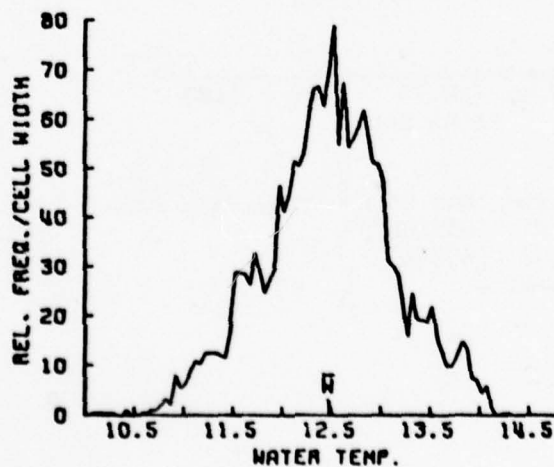
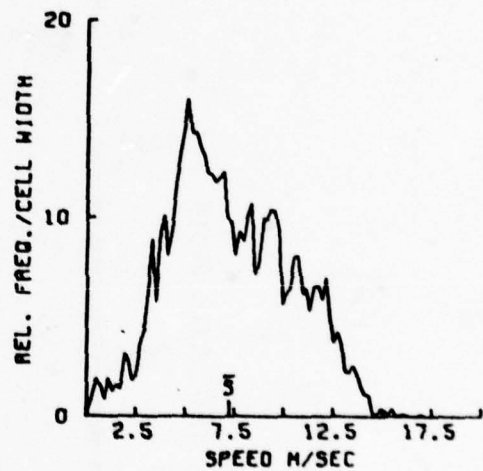
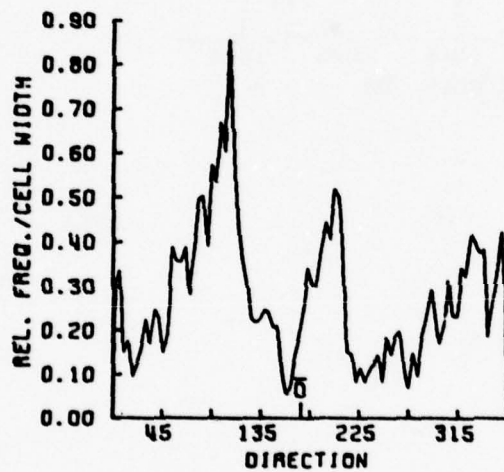
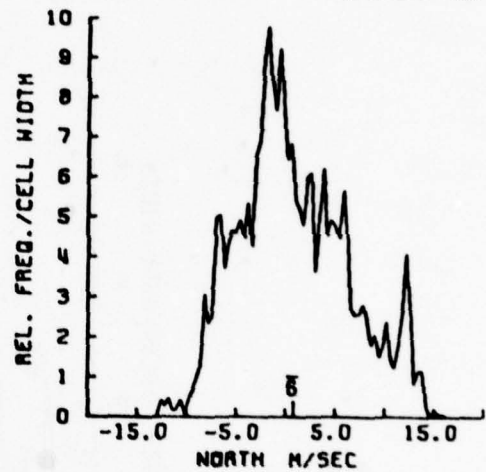
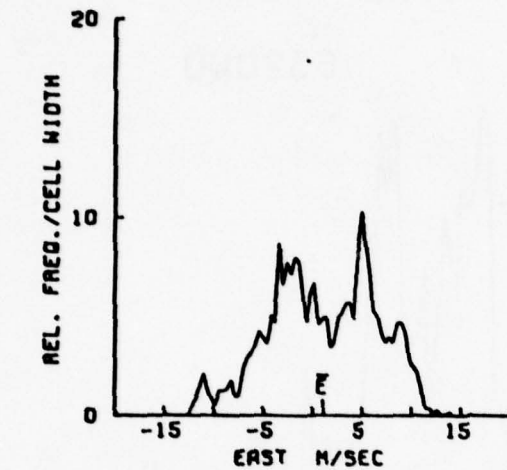


Figure III-8a (continued): VAWR on W2

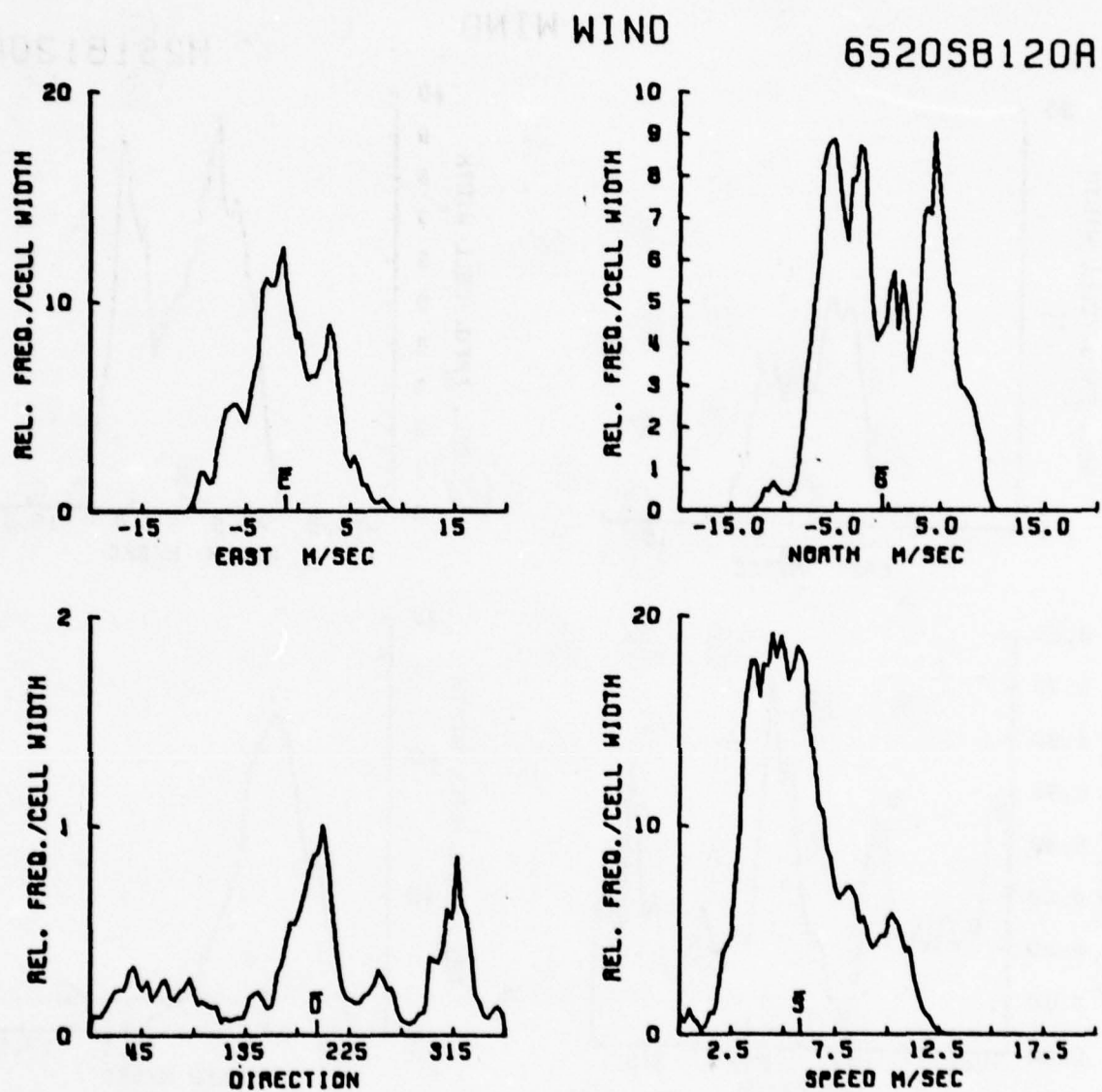


Figure III-8b: VMWR on W2

WIND

H2S1B120A

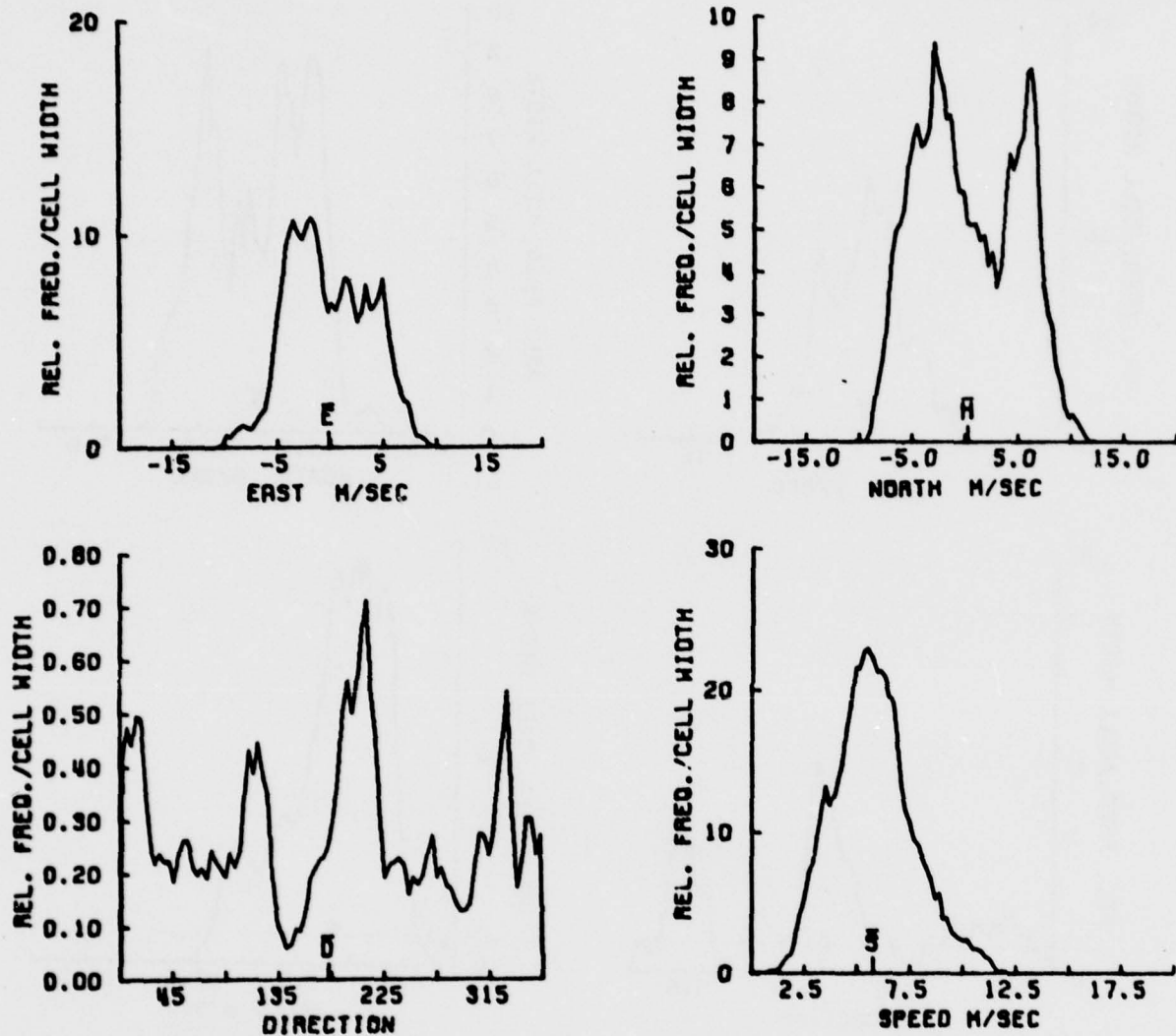


Figure III-8c: First deployment. VMWR on H2.

WIND

H2S2B120A

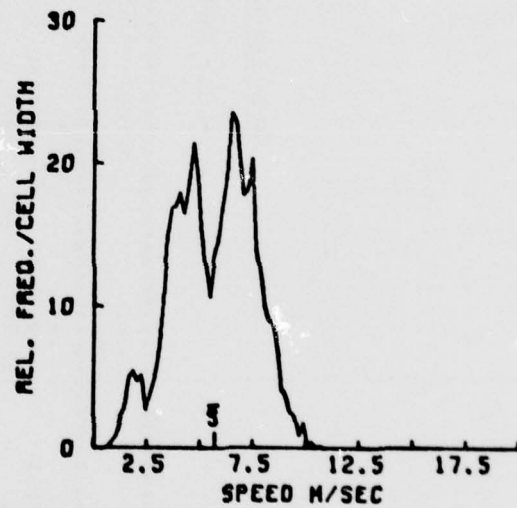
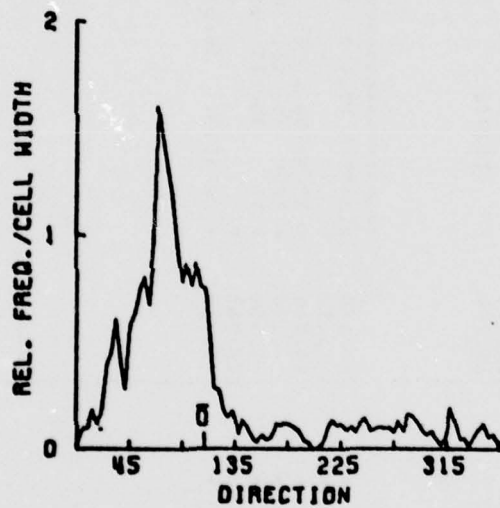
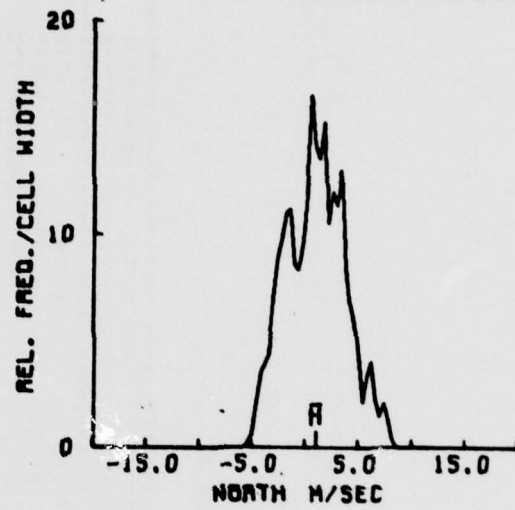
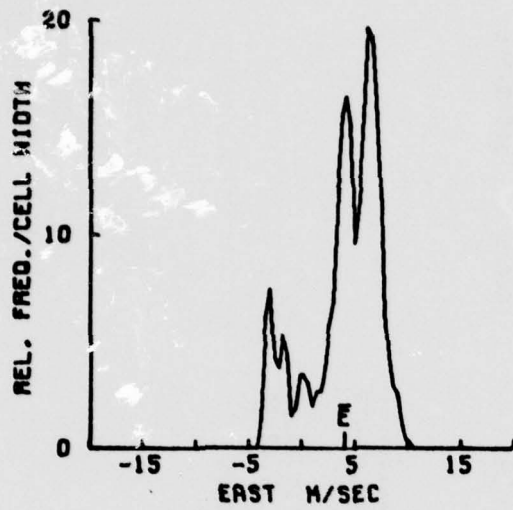


Figure III-8c (continued): Second deployment.

Table III-1a

Statistics for VAWR on W2.

VARIABLE	EAST	NORTH	SPEED	WATER TEMP.	AIR TEMP.	SOLAR RAD.	BAR. PRESS.
UNITS	M/SEC	M/SEC	M/SEC	CELSIUS	CELSIUS	HR/HR/2	MILLIBARS
MEAN	1.057	.822	7.242	12.823	12.476	2783.098	1014.205
STD. ERR.	.893E-1	.919E-1	.504E-1	.604E-2	.109E-1	64.145	.156
VARIANCE	29.101	30.826	9.275	.161	.434	15010068.150	94.874
STD. DEV.	5.394	5.552	3.045	.401	.659	3874.283	9.427
KURTOSIS	2.317	2.557	2.403	.558	.989	5.484	2.464
SKEWNESS	-.165	.353	.235	.902E-1	.979E-1	1.697	.194
MINIMUM	-12.496	-12.734	.106	11.835	10.085	.773	993.787
MAXIMUM	15.648	15.774	16.972	13.957	14.295	20953.211	1033.838

EAST & NORTH

COVARIANCE
STD. ERR. OF COVARIANCE
STD. DEV. OF COVARIANCE
CORRELATION COEFFICIENT
VECTOR MEAN
VECTOR VARIANCE
VECTOR STD. DEV.

-4.678
.412
24.866
-1.156
1.339
29.963
5.474

SAMPLE SIZE = 3648 POINTS
SPANNING RANGE
FROM 78- VII-30 17.07.30
TO 78- IX -06 17.52.30
DURATION 38.03 DAYS

DATA/ 652098120A Table III-lb: Statistics for VMWR on W2.

VARIABLE	EAST	NORTH	SPEED
UNITS	M/SEC	M/SEC	M/SEC
MEAN	-1.210	-0.561	0.779
STD. ERR.	-3.28E-1	-0.27E-1	-2.08E-1
VARIANCE	13.796	23.349	0.527
STD. DEV.	3.714	4.832	2.301
KURTOSIS	2.496	1.952	2.813
SKEWNESS	-0.116E-1	.112	.582
MINIMUM	-10.582	-12.550	.673E-1
MAXIMUM	9.218	10.287	12.609

EAST & NORTH		
COVARIANCE	-4.789	SAMPLE SIZE = 12810 POINTS
STD. ERR. OF COVARIANCE	.173	
STD. DEV. OF COVARIANCE	19.606	SPANNING RANGE
CORRELATION COEFFICIENT	-.267	FROM 78. VII-30 14.30.00
VECTOR MEAN	1.333	TO 78-VIII-17 09.28.00
VECTOR VARIANCE	18.573	
VECTOR STD. DEV.	4.310	DURATION 17.79 DAYS

DATA/ 42510120A Table III-lc: Statistics for VMWR on H2 (first deployment).

VARIABLE	EAST	NORTH	SPEED
UNITS	M/SEC	M/SEC	M/SEC
MEAN	-0.199	.289	0.767
STD. ERR.	-2.83E-1	.309E-1	.140E-1
VARIANCE	14.598	22.107	3.553
STD. DEV.	3.821	4.702	1.885
KURTOSIS	2.270	1.861	3.023
SKEWNESS	.976E-1	.129	.366
MINIMUM	-10.544	-10.276	.788E-1
MAXIMUM	10.091	12.250	12.403

EAST & NORTH		
COVARIANCE	-1.003	SAMPLE SIZE = 18180 POINTS
STD. ERR. OF COVARIANCE	.116	
STD. DEV. OF COVARIANCE	19.635	SPANNING RANGE
CORRELATION COEFFICIENT	-.558E-1	FROM 78. VII-16 16.30.00
VECTOR MEAN	.330	TO 78-VIII-10 22.28.00
VECTOR VARIANCE	18.353	
VECTOR STD. DEV.	4.284	DURATION 25.25 DAYS

DATA/ 42528120A Table III-ld: Statistics for VMWR on H2 (second deployment).

VARIABLE	EAST	NORTH	SPEED
UNITS	M/SEC	M/SEC	M/SEC
MEAN	4.037	1.004	0.660
STD. ERR.	.488E-1	.411E-1	.280E-1
VARIANCE	10.657	7.574	3.809
STD. DEV.	3.264	2.752	1.873
KURTOSIS	2.870	2.486	2.385
SKEWNESS	-.884	.128	-.143
MINIMUM	-3.897	-5.474	.788
MAXIMUM	10.305	8.494	10.752

EAST & NORTH		
COVARIANCE	-.168	SAMPLE SIZE = 4480 POINTS
STD. ERR. OF COVARIANCE	.195	
STD. DEV. OF COVARIANCE	13.056	SPANNING RANGE
CORRELATION COEFFICIENT	-.186E-1	FROM 78-VIII-26 14.09.00
VECTOR MEAN	4.160	TO 78- IX -01 23.27.00
VECTOR VARIANCE	9.119	
VECTOR STD. DEV.	3.019	DURATION 6.22 DAYS

Table III-2a: Five-day statistics for VAWR on W2. The five-day periods start at 0000Z/30 July 78; the final period is only 4 days and 7 hours long.

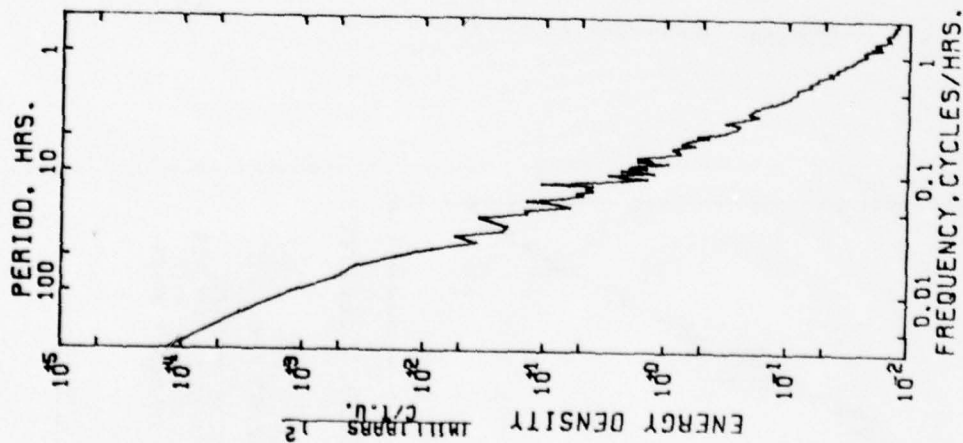
PERIOD	EAST	NORTH	SPEED	AIR TEMPERATURE	WATER TEMPERATURE	BAROMETRIC PRESSURE	STATISTIC
5 DAYS	M/SEC	M/SEC	M/SEC	CELSIUS	CELSIUS	DECIBARS	
(1)	.162	-2.328	5.420	13.465	12.420	1017.744	MEAN
(2)	-1.967	-5.371	6.167	13.127	11.894	1014.925	
(3)	-3.489	5.703	7.954	13.040	12.689	1013.884	
(4)	1.122	3.575	8.278	13.021	12.817	1001.649	
(5)	6.784	5.003	10.542	12.385	12.495	1008.759	
(6)	5.643	-1.106	5.951	12.417	12.488	1027.988	
(7)	4.000	-1.427	5.956	12.575	12.448	1020.291	
(8)	-5.635	2.559	7.472	12.590	12.574	1007.124	
(1)	12.236	12.977	1.287	.043	.430	17.273	VARIANCE
(2)	3.598	5.492	3.777	.022	.286	5.464	
(3)	14.887	10.323	6.651	.011	.731	30.799	
(4)	14.691	56.229	16.432	.011	.614	38.435	
(5)	16.496	26.562	2.970	.049	.268	73.753	
(6)	4.976	1.955	4.576	.057	.084	15.737	
(7)	11.414	12.053	6.028	.009	.183	18.884	
(8)	24.424	5.336	12.227	.041	.343	19.385	
(1)	3.498	3.602	1.134	.209	.656	4.156	STANDARD DEVIATION
(2)	1.897	2.343	1.944	.148	.535	2.338	
(3)	3.858	3.213	2.579	.107	.855	5.550	
(4)	3.833	7.499	4.054	.109	.785	6.200	
(5)	4.062	5.154	1.723	.222	.517	8.588	
(6)	2.231	1.398	2.139	.240	.291	3.967	
(7)	3.379	3.472	2.455	.097	.428	4.346	
(8)	4.942	2.310	3.497	.204	.585	4.403	
(1)	.039	.460	.522	.101	.058	-.537	SKEWNESS
(2)	-.494	.230	-.0845	.656	.010	.257	
(3)	.767	-1.065	-.181	1.139	-.821	-1.089	
(4)	.262	.283	-.143	.155	-.492	.547	
(5)	-.909	.017	.542	-.365	.351	.328	
(6)	.476	-.403	.444	-.316	.085	-.137	
(7)	-.872	-.123	-.289	.411	.415	.0588	
(8)	.513	-.222	-.255	1.385	-.015	-.0318	
(1)	1.780	2.024	3.101	2.597	2.266	1.588	KURTOSIS
(2)	2.825	2.204	2.651	2.618	2.114	2.033	
(3)	2.627	3.987	1.729	4.602	2.546	3.799	
(4)	2.642	2.084	1.779	4.088	3.285	2.031	
(5)	2.526	1.707	2.984	1.827	2.674	1.576	
(6)	2.755	2.932	2.600	2.013	2.743	1.621	
(7)	2.692	2.058	2.153	2.575	2.775	2.144	
(8)	2.259	2.199	1.978	4.729	2.811	1.388	
(1)	-7.164	-8.223	2.558	13.046	10.869	1011.086	MINIMUM
(2)	-7.268	-11.074	1.601	12.880	10.441	1011.283	
(3)	-9.551	-4.201	2.400	12.840	10.618	999.080	
(4)	-6.989	-12.734	.106	12.717	10.085	993.787	
(5)	-4.268	-4.327	6.686	11.895	11.139	993.898	
(6)	.573	-5.488	1.543	11.982	11.606	1021.572	
(7)	-4.821	-9.179	.555	12.386	11.512	1011.985	
(8)	-12.496	-3.083	.316	12.381	10.915	1000.457	
(1)	6.262	5.796	8.815	13.957	13.881	1027.466	MAXIMUM
(2)	1.611	.096	11.924	13.533	12.422	1020.130	
(3)	5.266	10.775	12.137	13.384	14.014	1020.829	
(4)	15.648	14.181	16.972	13.339	14.107	1013.659	
(5)	13.889	15.774	16.049	12.722	13.613	1021.859	
(6)	11.191	1.713	11.197	12.871	13.284	1033.838	
(7)	9.152	4.894	10.687	12.835	13.564	1028.480	
(8)	5.877	8.255	12.766	13.379	14.295	1013.237	

Table III-2b: Five-day statistics for VMWR on W2. The five-day periods start at 0000Z/30 July 78; the final (fourth) period is only 3 days 9.5 hours long.

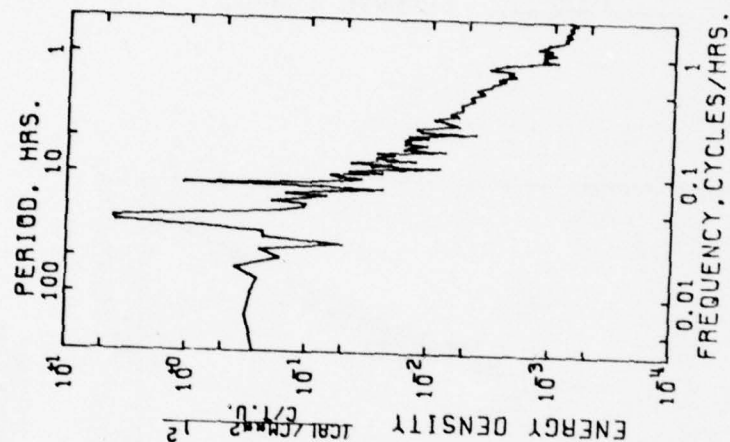
PERIOD	EAST	NORTH	520S WIND	STATISTIC
5 DAYS	M/SEC	M/SEC	M/SEC	
(1)	-.003	-1.885	4.356	MEAN
(2)	-1.668	-4.881	5.608	
(3)	-4.067	4.742	7.456	
(4)	2.111	-.292	5.403	
(5)				
(6)				
(7)				
(8)				
(1)	7.354	9.476	1.407	VARIANCE
(2)	3.405	4.147	2.698	
(3)	14.775	8.120	6.333	
(4)	10.752	20.792	6.898	
(5)				
(6)				
(7)				
(8)				
(1)	2.712	3.073	1.186	STANDARD DEVIATION
(2)	1.845	2.036	1.643	
(3)	3.844	2.850	2.517	
(4)	3.279	4.560	2.626	
(5)				
(6)				
(7)				
(8)				
(1)	-.130	.309	.715	SKEWNESS
(2)	-.415	.311	-.111	
(3)	.743	-1.126	-.0857	
(4)	-.301	-.926	.461	
(5)				
(6)				
(7)				
(8)				
(1)	1.520	1.955	2.767	KURTOSIS
(2)	2.562	2.306	2.542	
(3)	2.561	4.378	1.715	
(4)	2.250	3.198	3.071	
(5)				
(6)				
(7)				
(8)				
(1)	-6.462	-7.514	1.280	MINIMUM
(2)	-7.300	-9.442	1.475	
(3)	-10.582	-5.753	2.020	
(4)	-6.036	-12.550	.0673	
(5)				
(6)				
(7)				
(8)				
(1)	5.536	5.096	7.981	MAXIMUM
(2)	2.733	.487	9.525	
(3)	5.240	10.287	12.180	
(4)	9.218	6.926	12.609	
(5)				
(6)				
(7)				
(8)				

Table III-2c: Five-day statistics for VMWRs on H2. The five-day periods start at 0000Z/30 July 78. Periods 1-3 are the first deployment, 6-7 the second deployment. Period 3 is only 1 day 22.5 hours long. Period 6 starts late, is only 2 days 6 hours long. Period 7 is only 3 days, 23.5 hours long.

PERIOD	EAST	NORTH	WIND SPEED	STATISTIC
5 DAYS	M/SEC	M/SEC	M/SEC	
(1)	0.025	0.667	4.331	MEAN
(2)	2.233	4.544	5.538	
(3)	4.113	3.945	6.423	
(4)				
(5)				
(6)	0.407	0.980	5.243	
(7)	3.829	1.018	5.894	
(8)				
(1)	7.817	12.015	1.521	VARIANCE
(2)	2.884	4.984	2.835	
(3)	1.280	12.581	5.088	
(4)				
(5)				
(6)	3.778	5.768	2.437	
(7)	14.417	8.592	3.960	
(8)				
(1)	2.796	3.466	1.233	STANDARD DEVIATION
(2)	1.698	2.233	1.684	
(3)	1.131	3.547	2.256	
(4)				
(5)				
(6)	1.944	2.402	1.561	
(7)	3.797	2.931	1.990	
(8)				
(1)	0.194	0.190	0.319	SKEWNESS
(2)	0.278	0.495	0.0666	
(3)	0.414	0.255	0.242	
(4)				
(5)				
(6)	0.783	0.395	0.321	
(7)	0.698	0.284	0.232	
(8)				
(1)	1.679	1.895	2.469	KURTOSIS
(2)	2.252	2.471	2.692	
(3)	2.984	1.759	1.734	
(4)				
(5)				
(6)	2.974	2.180	2.325	
(7)	2.180	2.457	2.291	
(8)				
(1)	6.409	7.247	1.567	MINIMUM
(2)	6.719	9.333	0.937	
(3)	7.009	4.006	2.200	
(4)				
(5)				
(6)	0.791	0.912	0.982	
(7)	3.897	5.474	0.788	
(8)				
(1)	5.296	8.062	8.886	MAXIMUM
(2)	2.137	1.396	9.577	
(3)	0.353	10.039	11.246	
(4)				
(5)				
(6)	7.723	5.596	8.626	
(7)	10.305	8.494	10.752	
(8)				

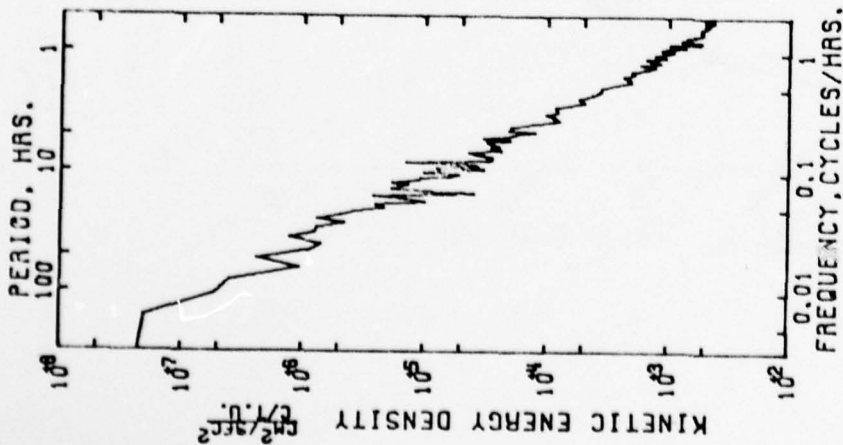


AUTO SPECTRUM
6520WD BAR. PRESS.
78-VII-30 TO 78-IX-06
1 PIECES WITH 1800 ESTIMATES
PER PIECE. AVERAGED OVER
3 ADJACENT FREQUENCY BANDS



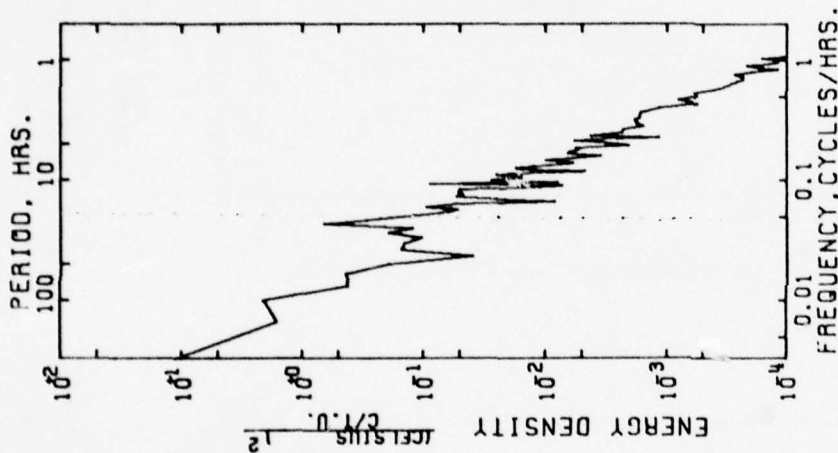
AUTO SPECTRUM
6520WD SOLAR RAD.
78-VII-30 TO 78-IX-06
1 PIECES WITH 1800 ESTIMATES
PER PIECE. AVERAGED OVER
3 ADJACENT FREQUENCY BANDS

Figure III-9: Spectra from VAWR on W2.



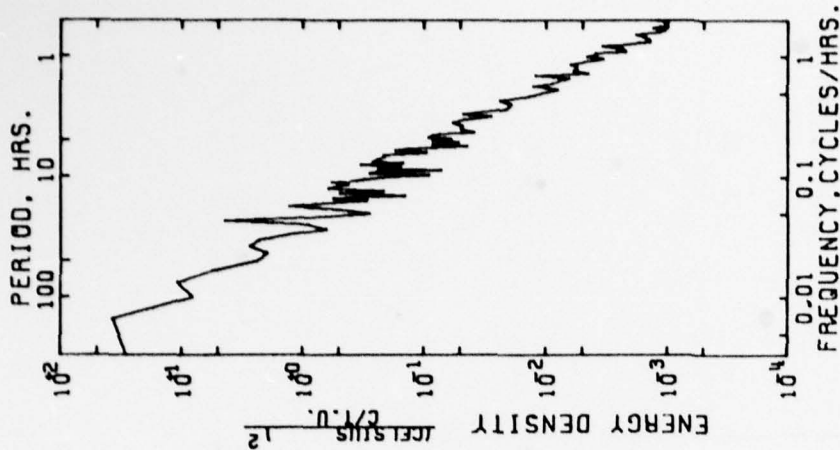
AUTO SPECTRUM
652040 EAST (W)
652040 NORTH (W)

78-VII-28 TO 78-IX-06
1 PIECES WITH 1875 ESTIMATES
PER PIECE. AVERAGED OVER
3 ADJACENT FREQUENCY BANDS



AUTO SPECTRUM
652040 WATER TEMP.

78-VII-30 TO 78-IX-06
1 PIECES WITH 1800 ESTIMATES
PER PIECE. AVERAGED OVER
3 ADJACENT FREQUENCY BANDS



AUTO SPECTRUM
652040 AIR TEMP.

78-VII-30 TO 78-IX-06
1 PIECES WITH 1800 ESTIMATES
PER PIECE. AVERAGED OVER
3 ADJACENT FREQUENCY BANDS

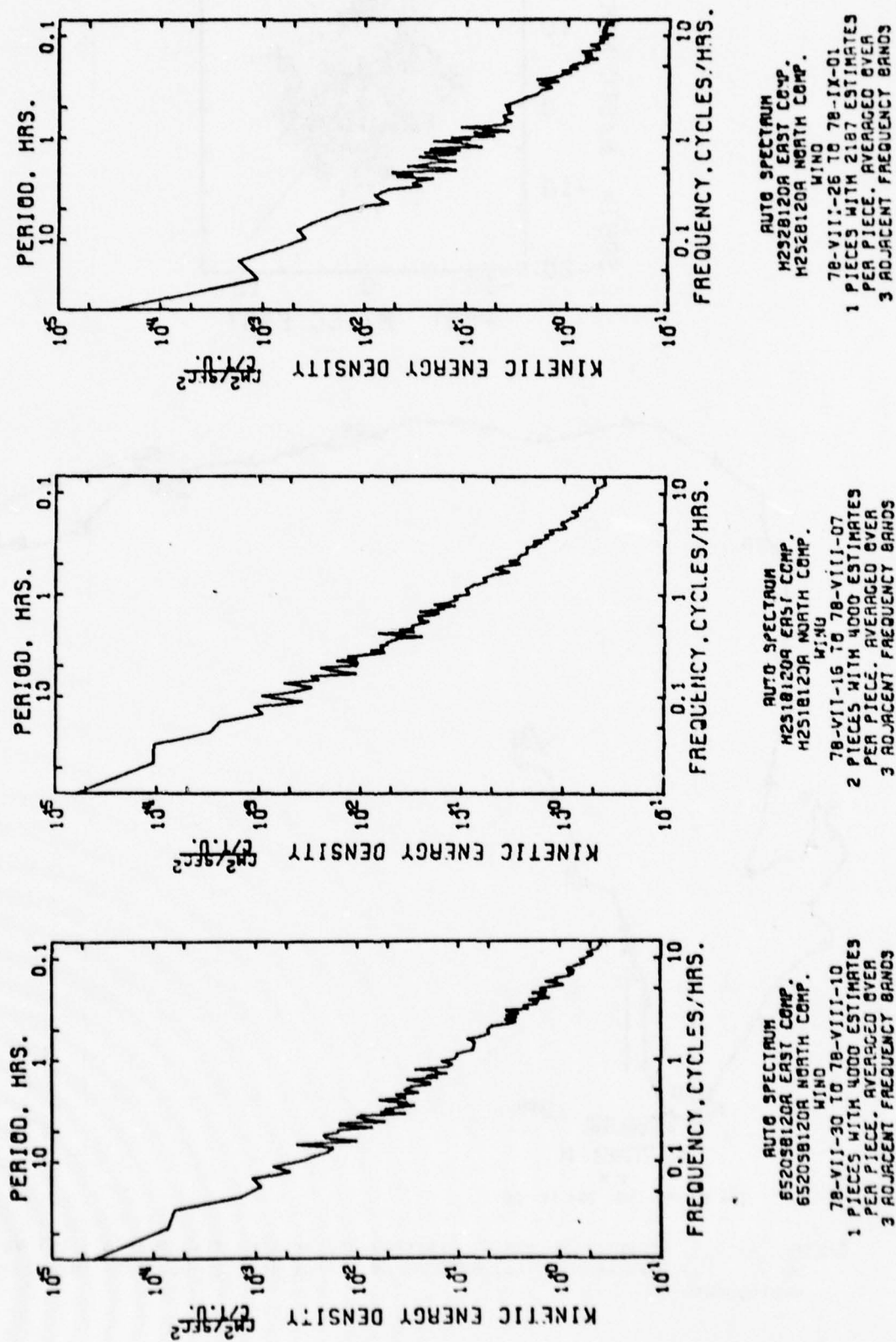
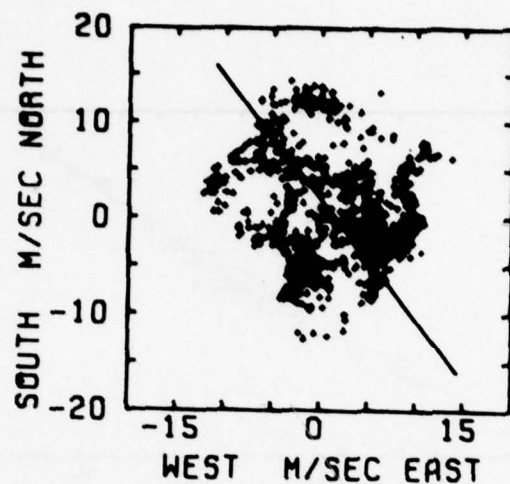


Figure III-10: Spectra from W2 and W2.



(a)

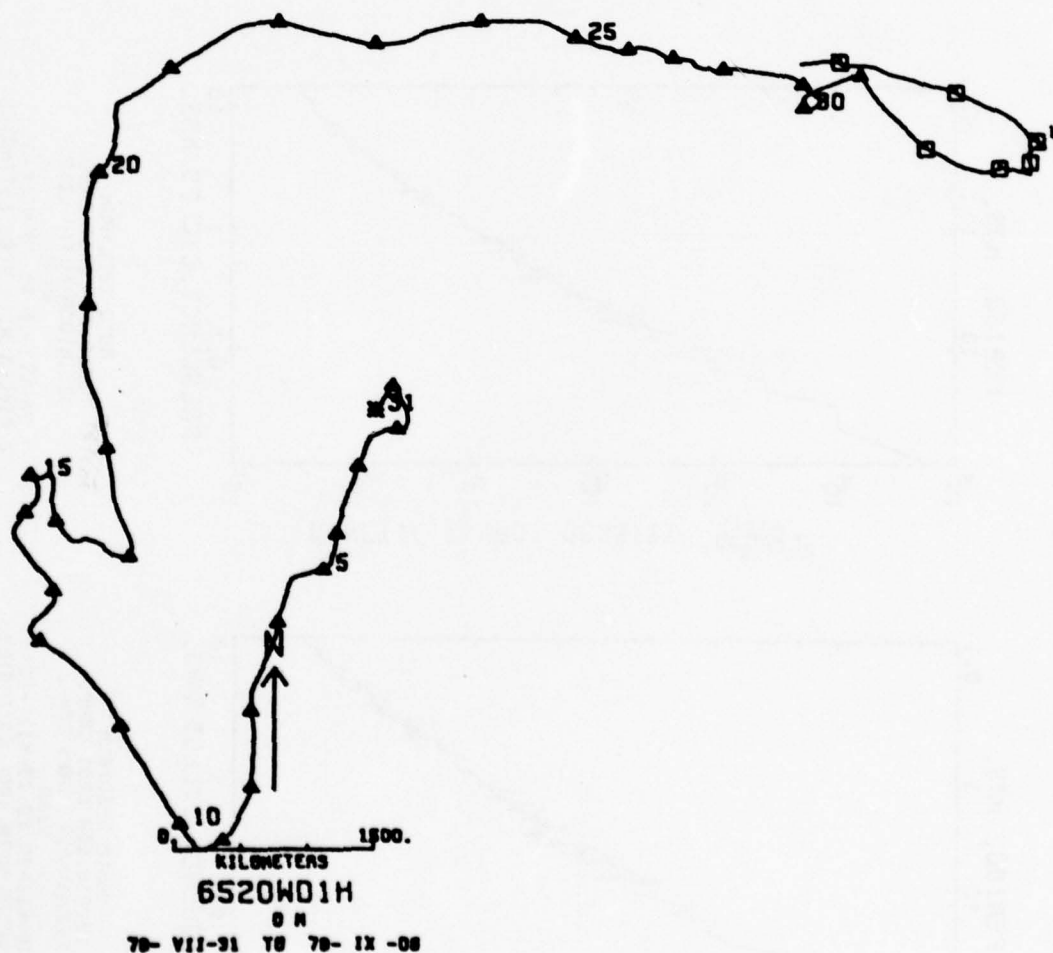
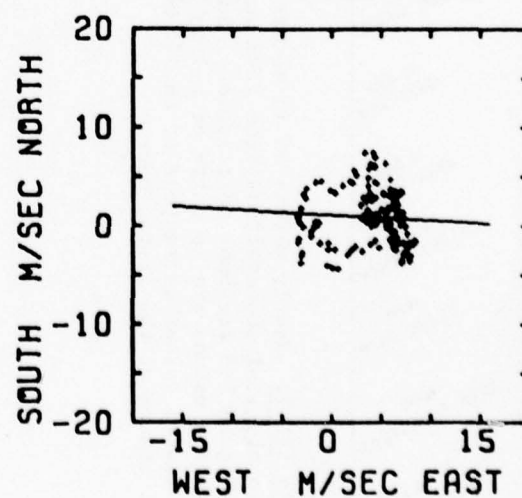
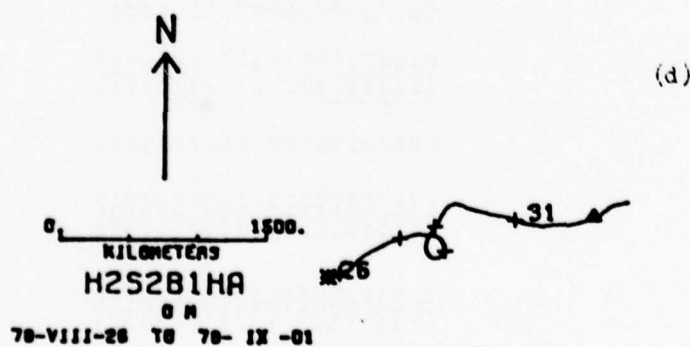
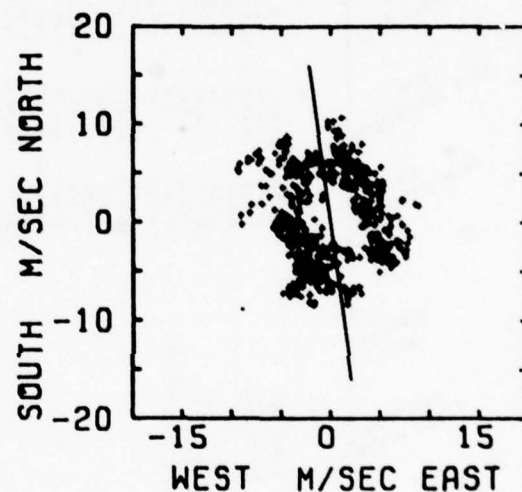
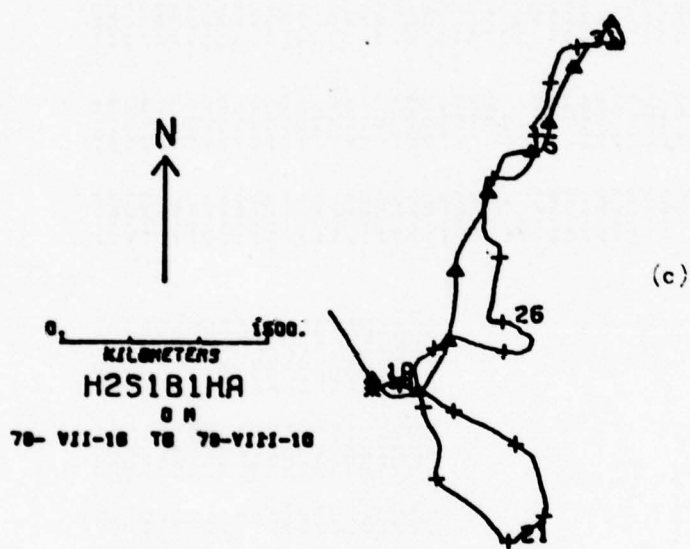
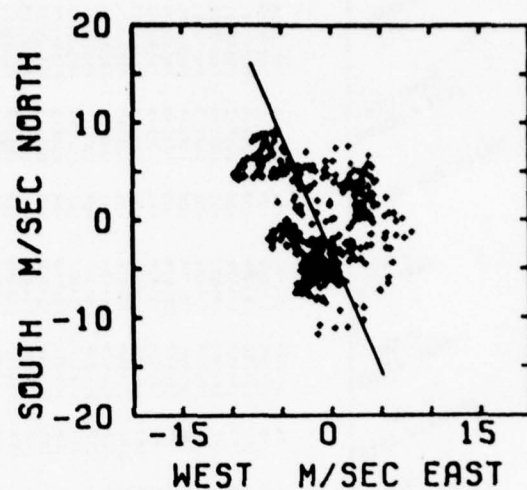
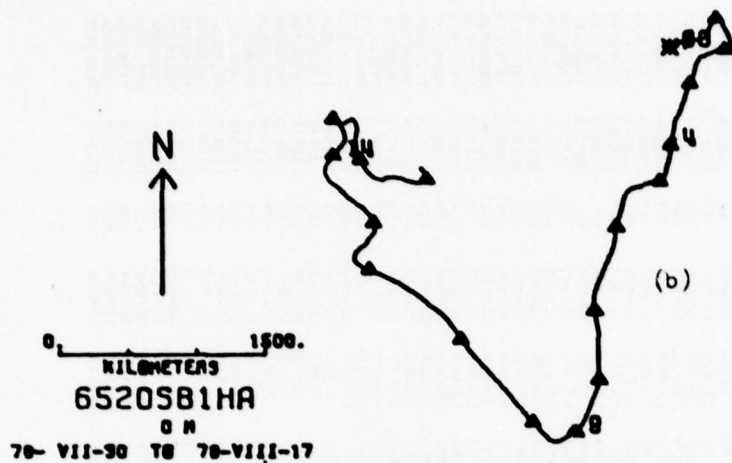


Figure III-11: Progressive vector diagrams and scatter diagrams for (a) VAWR on W2, (b) VMWR on W2, (c) VMWR on H2, first deployment, and (d) second deployment.



EASTWARD WIND (M/30)
 NORTHWARD WIND (M/30)
 WIND SPEED (M/30)
 WIND DIRECTION (DEG 71)
 WATER TEMP (DEG C)
 AIR TEMP (DEG C)
 SOLAR RADIATION
 BRDM PRESS (MILLIBARS)
 TIME (UTM0000H)

EASTWARD WIND (M/30)
 NORTHWARD WIND (M/30)
 WIND SPEED (M/30)
 WIND HEADING (DEG 71)
 WATER TEMP (DEG C)
 AIR TEMP (DEG C)
 SOLAR RADIATION
 BRDM PRESS (MILLIBARS)
 TIME (170000H)

Table III-3: Hourly values of 15 minute average meteorological observations from VAWR on buoy W2. See Figure I-3 for buoy description. Solar radiation values are in units of cal cm⁻² min⁻¹. The listed values correspond to the 15 minute period that starts at the listed hour.

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[illegible]

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EASTWARD WIND (M/3)
 NORTHWARD WIND (M/3)
 WIND SPEED (M/3)
 WIND HEADING (DEG)
 WATER TEMP (DEG F)
 AIR TEMP (DEG F)
 SOLAR RADIATION
 BRON PRESS (WILLIAMS)
 TIME (TYNDAL)

1.178	6.291	102	12.585	12.461	03	1023.7	7402806	74890	3.519	8.646	65	12.664	13.419	03	1021.4	7403018
1.178	6.291	96	12.585	12.461	09	1023.5	7402807	8437	2.916	9.312	71	12.664	13.176	01	1021.4	7403019
1.178	6.291	97	12.585	12.461	17	1023.4	7402808	8074	4.136	9.099	62	12.668	12.841	00	1023.4	7403020
1.178	6.291	98	12.585	12.461	17	1022.8	7402809	8464	4.041	9.052	64	12.569	12.833	00	1019.4	7403021
1.178	6.291	99	12.585	12.461	18	1022.5	7402810	9026	3.154	9.561	70	12.534	12.775	00	1019.4	7403022
1.178	6.291	99	12.585	12.461	22	1022.5	7402811	9126	2.045	9.340	77	12.534	12.840	00	1018.4	7403023
1.178	6.291	99	12.585	12.461	16	1022.5	7402812	8466	4.735	8.847	94	12.534	12.916	00	1018.4	7403024
1.178	6.291	99	12.585	12.461	57	1022.3	7402813	6209	4.732	7.812	127	12.534	12.776	00	1017.5	7403100
1.178	6.291	99	12.585	12.461	35	1022.2	7402814	4471	6.649	8.045	146	12.534	12.532	00	1017.5	7403101
1.178	6.291	99	12.585	12.461	17	1021.9	7402815	5472	9.917	8.045	146	12.534	12.532	00	1017.4	7403102
1.178	6.291	99	12.585	12.461	04	1021.5	7402816	6191	8.611	10.339	146	12.534	12.204	00	1017.5	7403103
1.178	6.291	99	12.585	12.461	02	1022.1	7402817	5472	7.745	8.949	152	12.534	11.820	01	1018.3	7403104
1.178	6.291	99	12.585	12.461	01	1022.4	7402818	5472	7.745	8.949	144	12.534	11.820	00	1018.3	7403105
1.178	6.291	99	12.585	12.461	00	1022.4	7402819	6438	6.658	9.140	135	12.432	11.897	10	1018.9	7403106
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1.178	6.291	99	12.585	12.461	00	1022.7	7402821	7450	6.440	9.848	130	12.502	12.107	49	1018.4	7403110
1.178	6.291	99	12.585	12.461	00	1022.6	7402822	7450	6.440	10.098	130	12.502	12.107	49	1018.4	7403111
1.178	6.291	99	12.585	12.461	00	1022.6	7402823	6416	5.445	8.445	130	12.512	12.277	52	1018.4	7403112
1.178	6.291	99	12.585	12.461	00	1022.8	7402824	7451	6.440	9.044	122	12.512	12.277	52	1018.4	7403113
1.178	6.291	99	12.585	12.461	00	1022.8	7402825	7451	6.440	9.044	122	12.512	12.277	52	1018.4	7403114
1.178	6.291	99	12.585	12.461	00	1022.8	7402826	6191	6.006	9.211	136	12.512	12.277	52	1018.4	7403115
1.178	6.291	99	12.585	12.461	00	1023.0	7402827	6191	6.006	9.211	136	12.512	12.277	52	1018.4	7403116
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1.178	6.291	99	12.585	12.461	00	1023.0	7402834	6191	6.006	9.211	136	12.512	12.277	52	1018.4	7403123
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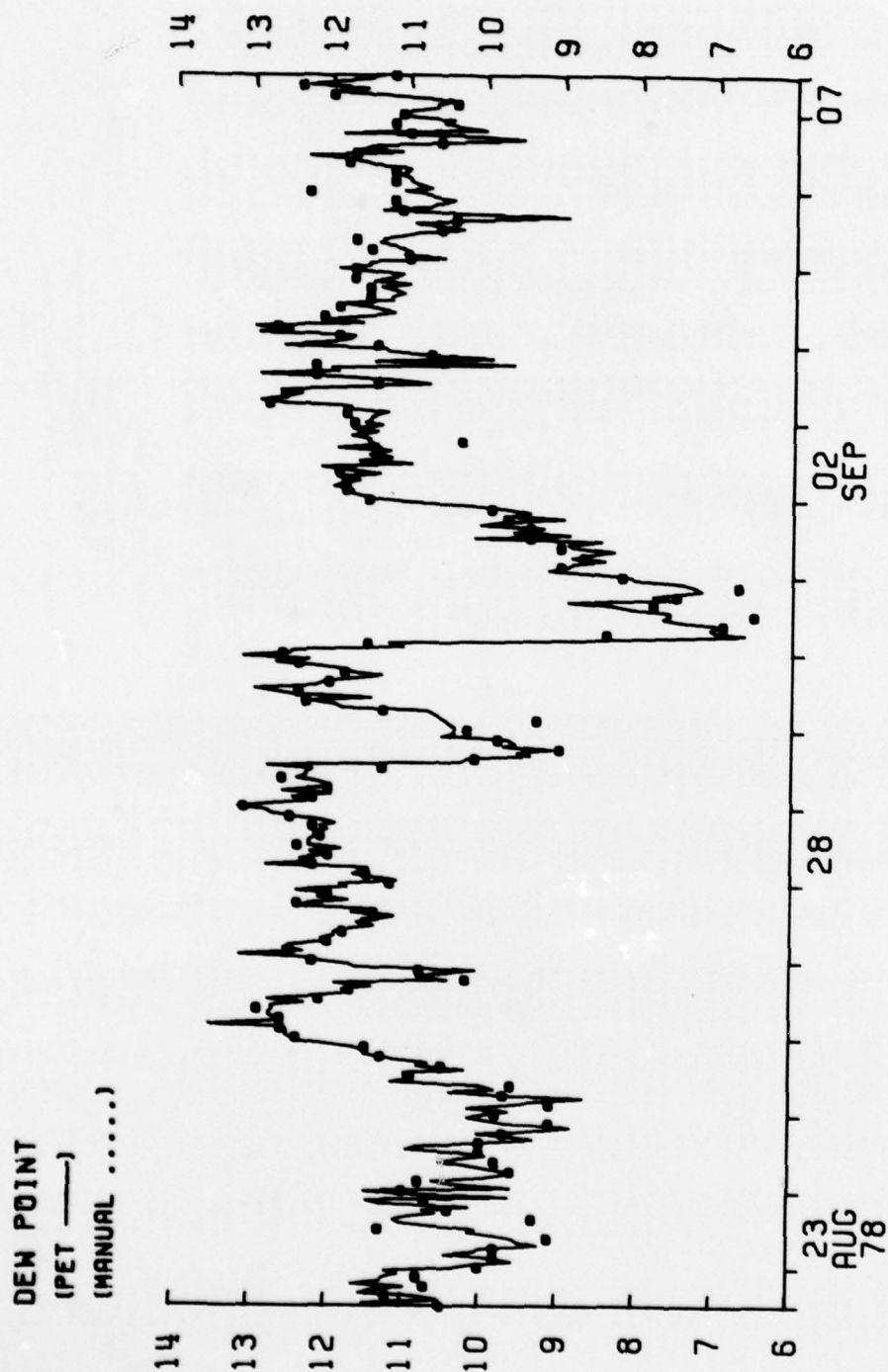
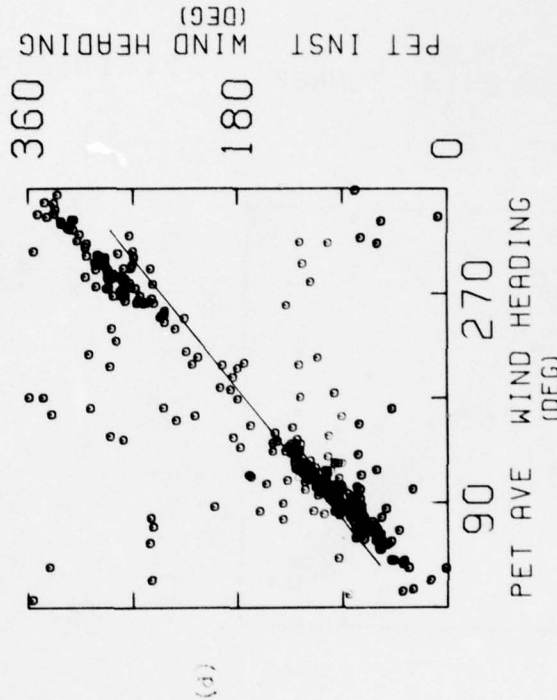
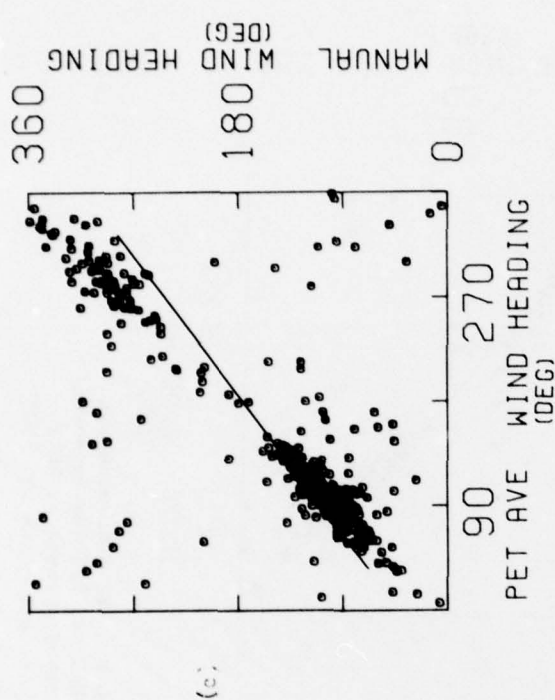
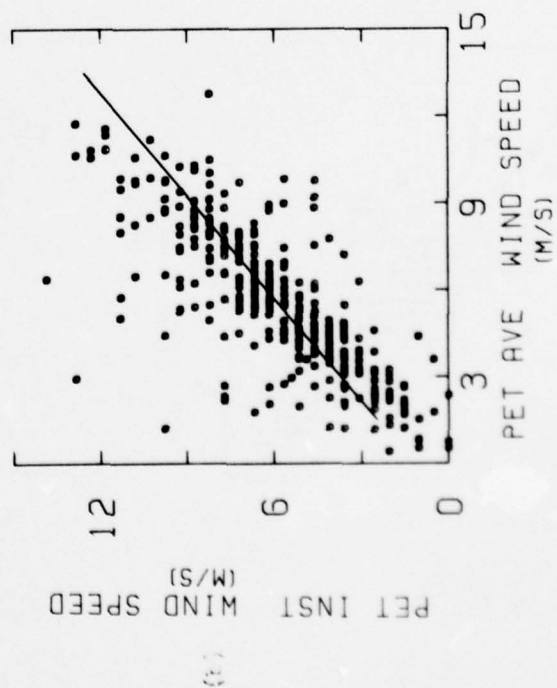
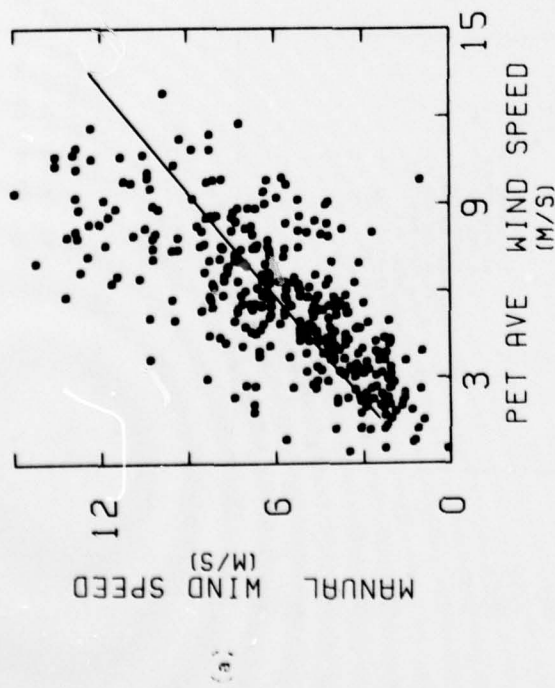


Figure III-12: Leg II Dew Point Intercomparison. PET reading from lithium chloride cell, MANUAL reading from Bendix psychrometer and conversion to dewpoint (see text).



(a) Figure 1.1-13: Wind Speed - MANUAL vs. PET Average
 (b) -14: Wind Heading - MANUAL vs. PET Average
 (c) -15: Wind Speed - PET Instantaneous vs. PET Average
 (d) -16: Wind Heading - PET Instantaneous vs. PET Average

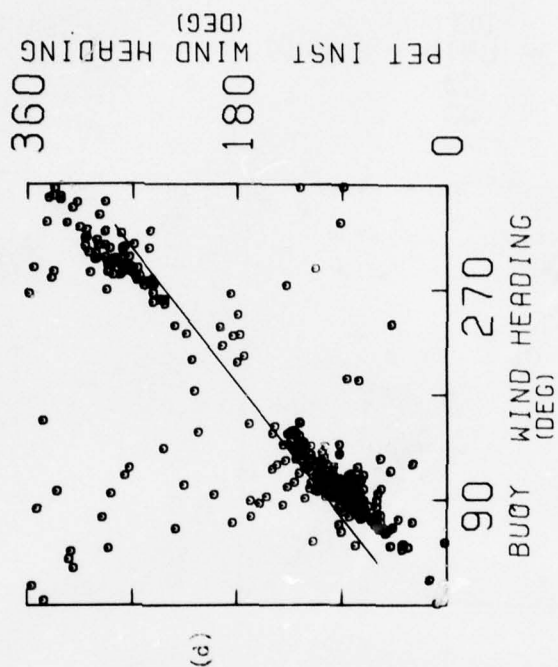
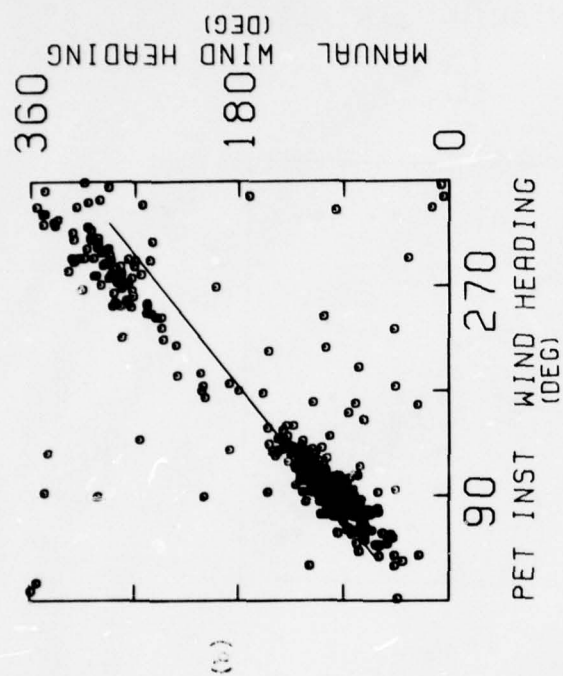
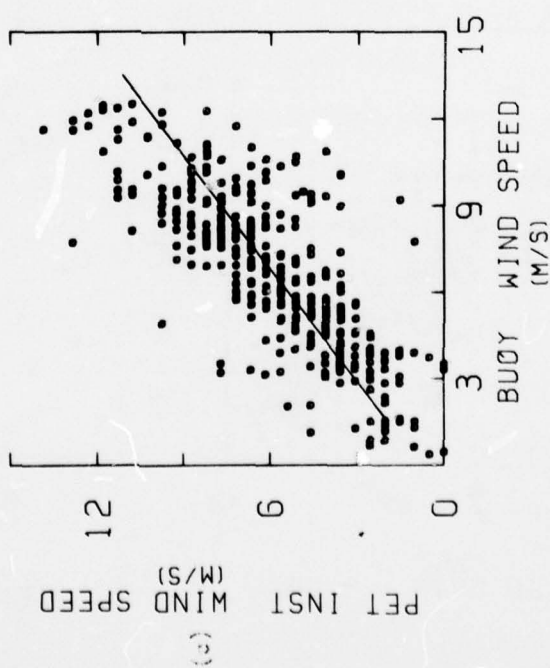
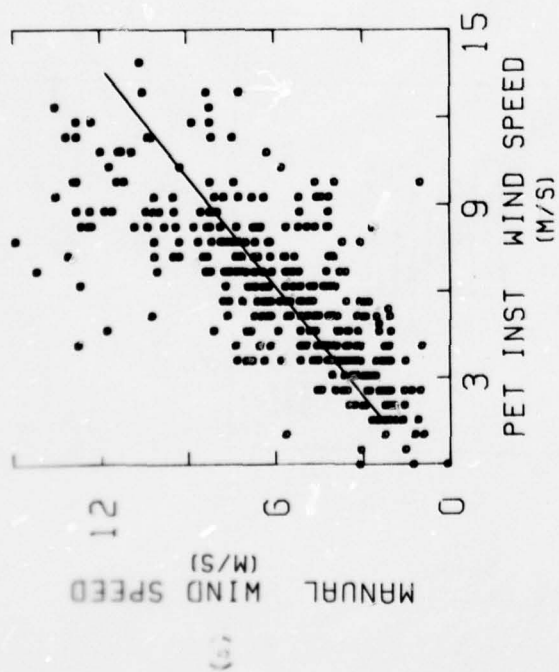


Figure III-17: Wind Speed - MANUAL vs. PET Instantaneous
 -18: Wind Heading - MANUAL vs. PET Instantaneous
 -19: Wind Speed - PET Instantaneous vs. BUOY
 -20: Wind Heading - PET Instantaneous vs. BUOY

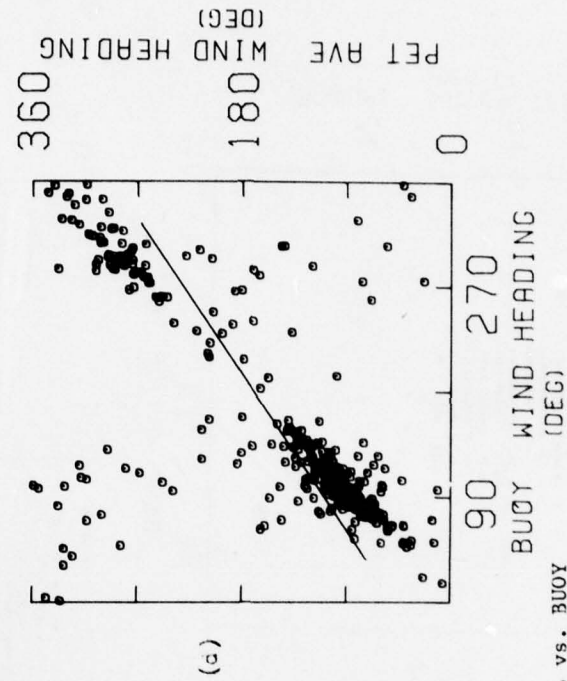
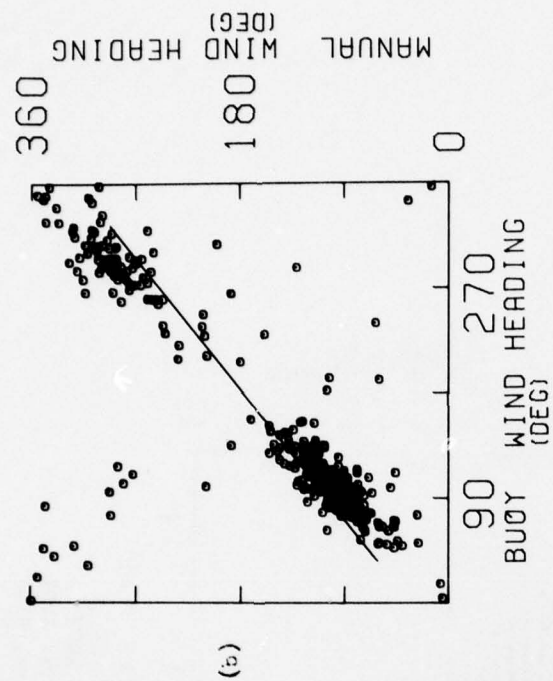
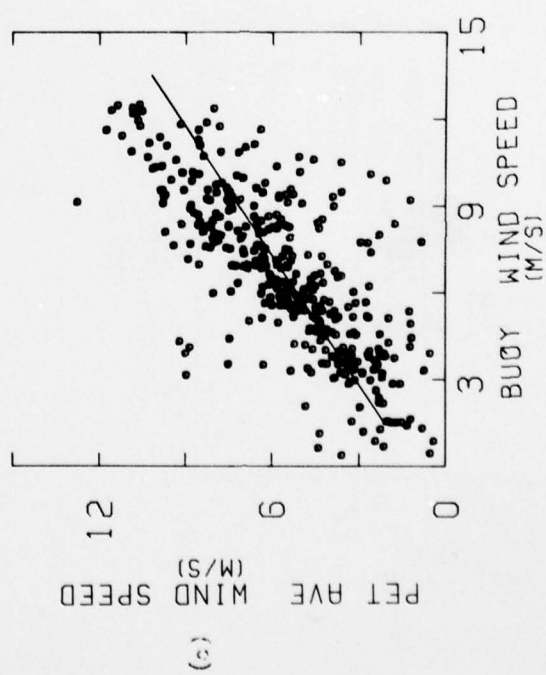
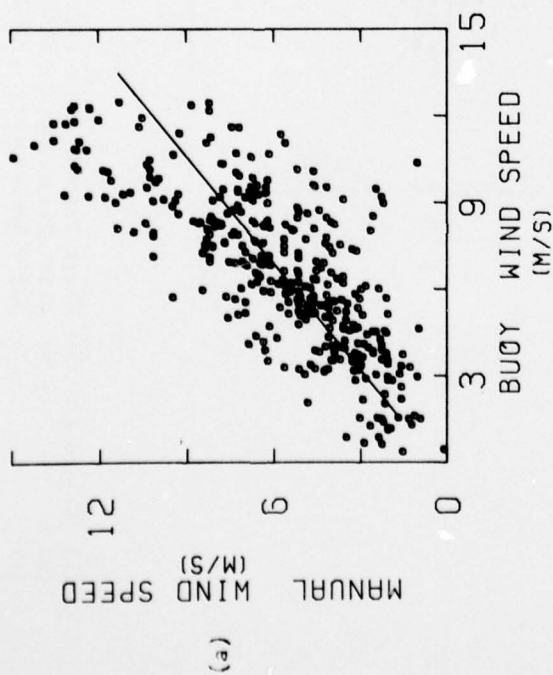


Figure III-21: Wind Speed - MANUAL vs. BUOY
 -22: Wind Heading - MANUAL vs. BUOY
 -23: Wind Speed - PET Average vs. BUOY
 -24: Wind Heading - PET Average vs. BUOY

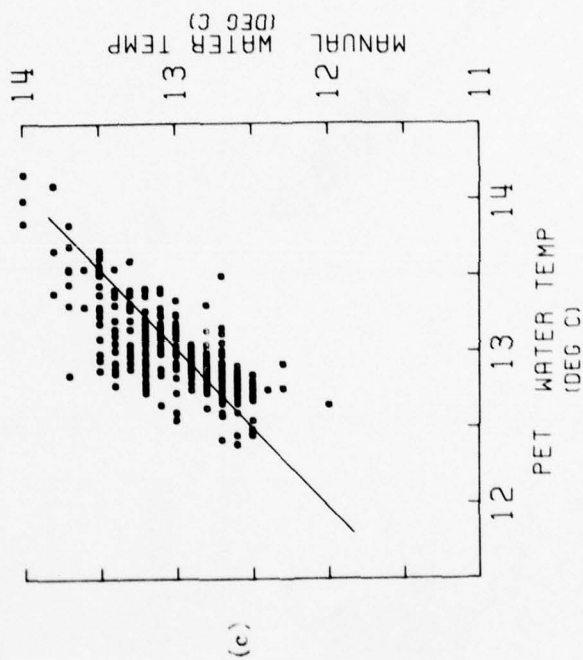
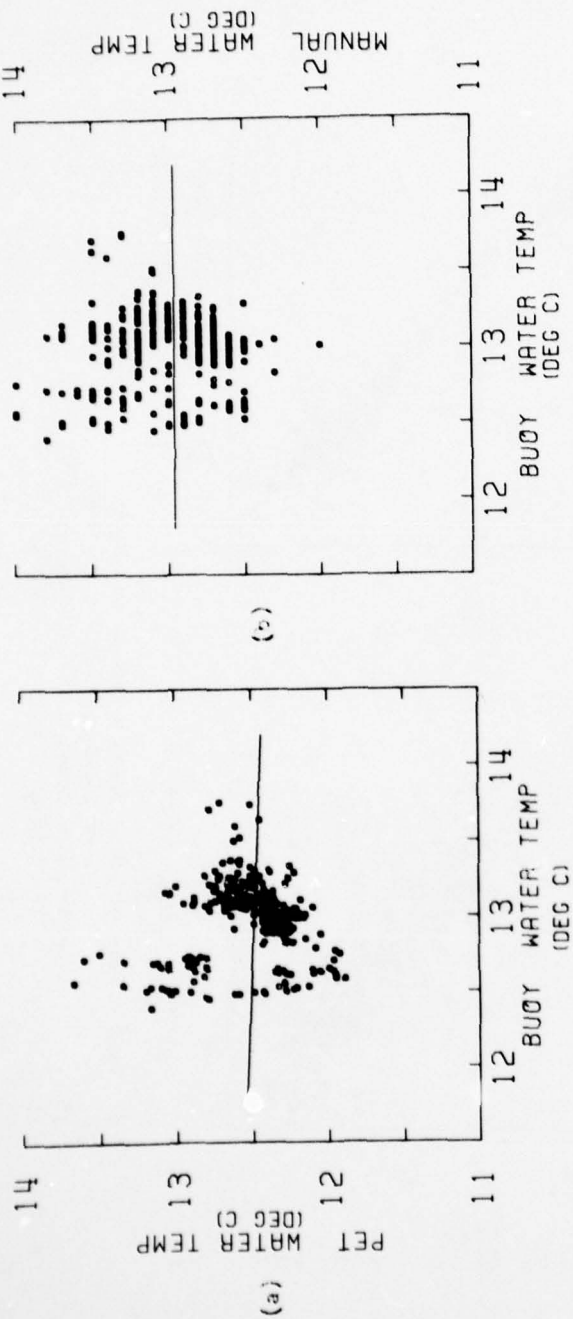
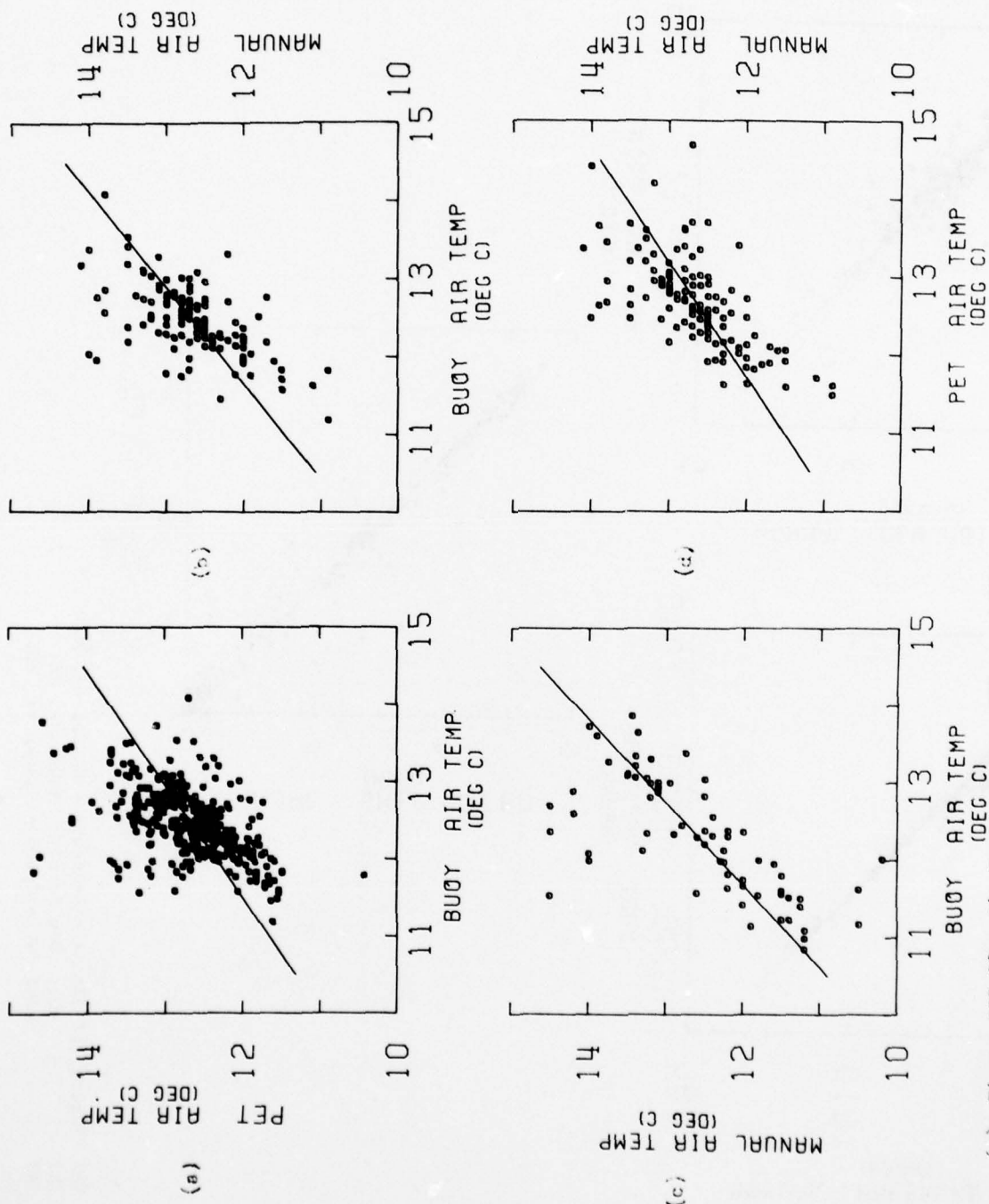


Figure III-25: Water Temperature - PET vs. BUOY
 -26: Water Temperature - MANUAL vs. BUOY
 -27: Water Temperature - MANUAL vs. PET



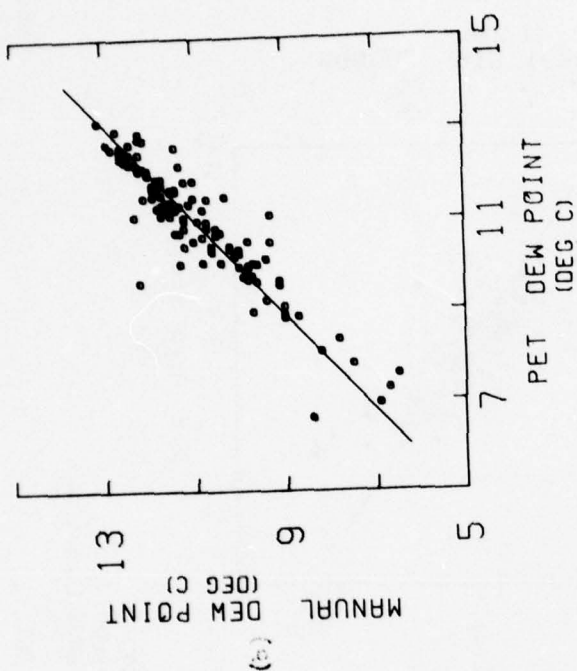
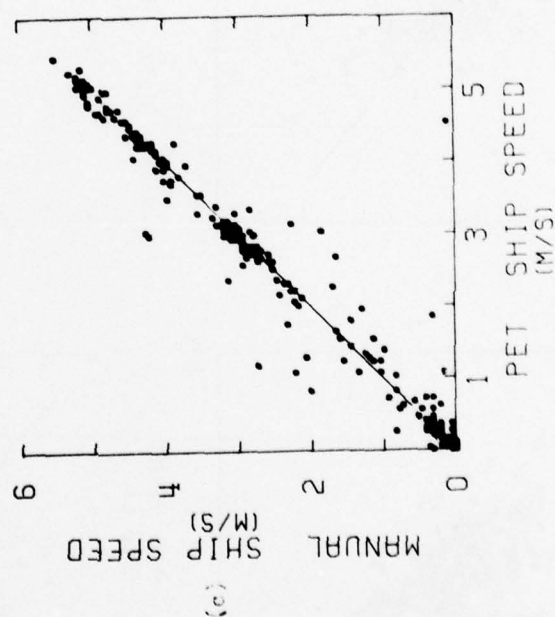
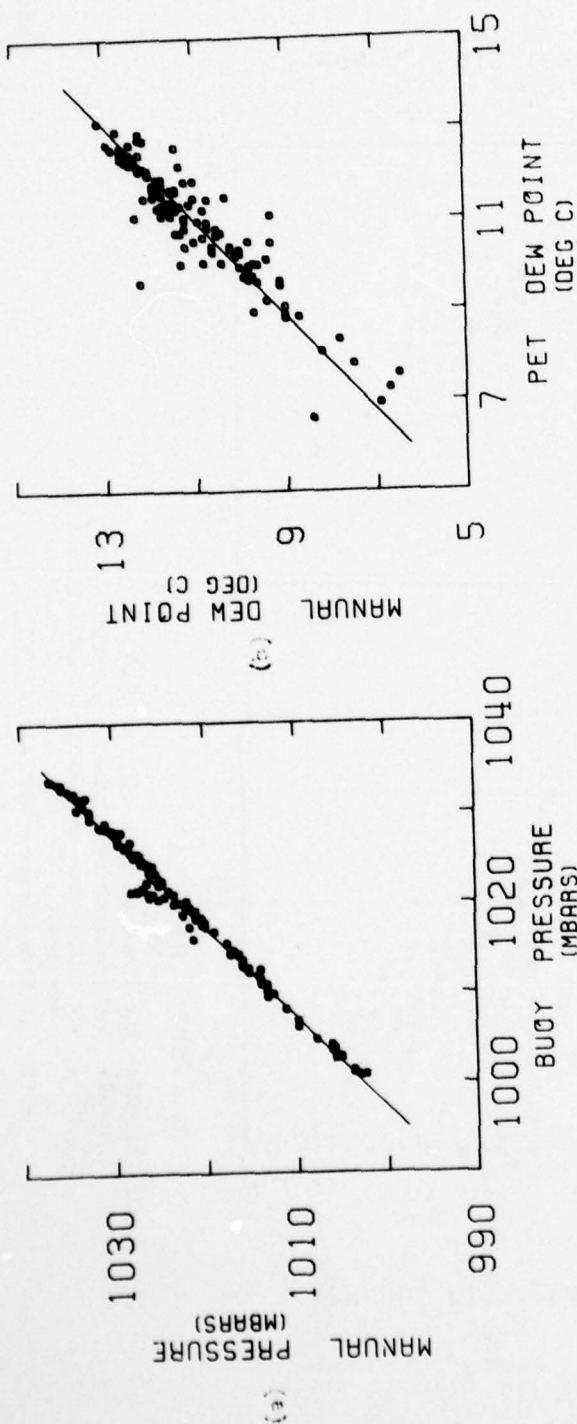
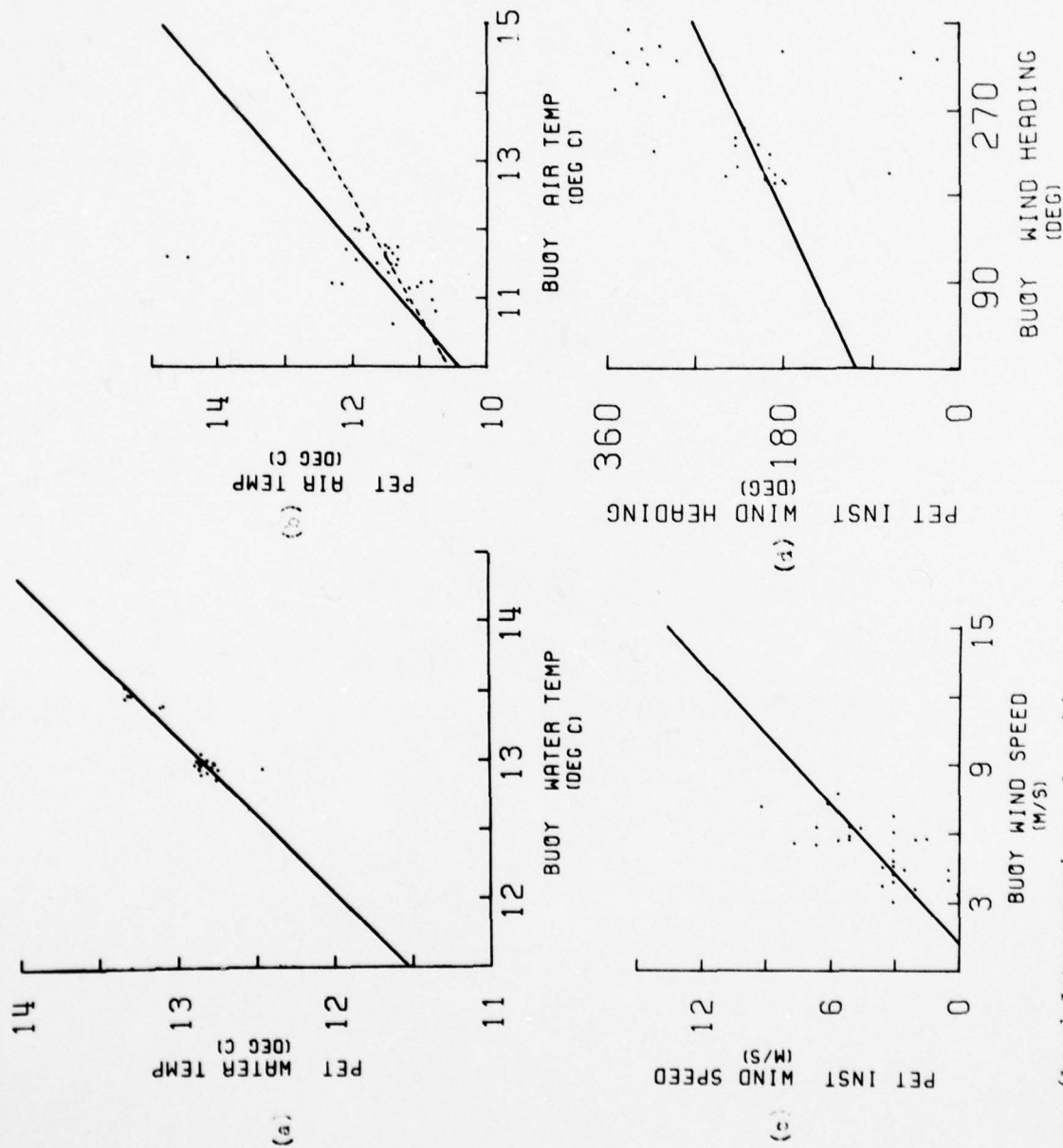


Figure III-32: Air Pressure - MANUAL vs. BUOY
 -33: Dew Point - MANUAL vs. PET
 -34: Ship Speed - MANUAL vs. PET



(Leg-1 Intercomparisons when ship was within 10 km of the buoy)

(a) Figure III-35: Water Temperature - PET vs. BUOY

(b) -36: Air Temperature - PET vs. BUOY

(c) -37: Wind Speed - PET Instantaneous vs. BUOY

(d) -38: Wind Heading - PET Instantaneous vs. BUOY

Table III-4: Index to Scatterplots ($Y = A + BX$)
for Leg-2 Data (except as noted)

Page No.	Figure No.	Variable	Y-Axis	X-Axis	Units	A	Standard Error	B
III-37	III-13	Wind Speed	MANUAL	PET Avg.	m s ⁻¹	1.15	2.12	0.833
	-14	Wind Heading	MANUAL	PET Avg.	deg	41.97	61.12	0.744
	-15	Wind Speed	PET Inst.	PET Avg.	m s ⁻¹	1.20	1.68	0.842
	-16	Wind Heading	PET Inst.	PET Avg.	deg	30.03	55.81	0.802
III-38	III-17	Wind Speed	MANUAL	PET Inst.	m s ⁻¹	1.13	2.08	0.792
	-18	Wind Heading	MANUAL	PET Inst.	deg	33.71	54.15	0.798
	-19	Wind Speed	PET Inst.	BUOY	m s ⁻¹	0.81	1.66	0.766
	-20	Wind Heading	PET Inst.	BUOY	deg	32.13	58.61	0.784
III-39	III-21	Wind Speed	MANUAL	BUOY	m s ⁻¹	0.43	1.96	0.808
	-22	Wind Heading	MANUAL	BUOY	deg	32.69	55.68	0.802
	-23	Wind Speed	PET Avg.	BUOY	m s ⁻¹	1.12	1.69	0.671
	-24	Wind Heading	PET Avg.	BUOY	deg	48.01	66.98	0.677
III-40	III-25	Water Temperature	PET	BUOY	°C	13.05	0.27	-0.045
	-26	Water Temperature	MANUAL	BUOY	°C	13.00	0.34	-0.003
	-27	Water Temperature	MANUAL	PET	°C	1.07	0.22	0.953
III-41	III-28	Air Temperature	PET	BUOY	°C	4.15	0.54	0.682
	-29	Air Temperature	MANUAL	BUOY	°C	2.51	0.49	0.814
	-30(1)	Air Temperature	MANUAL	BUOY	°C	1.10	0.75	0.933
	-31	Air Temperature	MANUAL	PET	°C	4.04	0.47	0.680
III-42	III-32	Air Pressure	MANUAL	BUOY	mbar	8.49	1.01	0.994
	-33	Dew Point	MANUAL	PET	°C	0.58	0.50	0.945
	-34	Ship Speed	MANUAL	PET	m s ⁻¹	0.02	0.34	0.992
III-43	III-35(2)	Water Temperature	PET	BUOY	°C	1.46	0.99	0.876
	-36(3)	Air Temperature	PET	BUOY	°C	1.60	5.52	0.881
	-37(2)	Wind Speed	PET Inst.	BUOY	m s ⁻¹	-1.20	1.34	0.987
	-38(2)	Wind Heading	PET Inst.	BUOY	deg	106.92	82.86	0.460

Notes (1) Leg 1 data, 4 h samples

(2) Leg 1 data, periods 1600Z/2 Aug to 0500Z/3 Aug, 1600Z/8 Aug to 0400Z/9 Aug, and 1100-2400Z/9 Aug; ship-to-buoy W2 separation less than 10 km.

(3) Dashed line is regression with two outliers (PET temp > 14°C) removed; constants are A = 4.74, Std Err = 2.23, B = 0.588.

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Woods Hole Oceanographic Institution WHOI-79-43	<p>ATLANTIS-II (CRUISE 102) MOORED AND SHIPBOARD SURFACE METEOROLOGICAL MEASUREMENTS DURING JASIN 1978 by Melbourne G. Briscoe, Carol A. Mills, Richard E. Payne, and Kenneth R. Peel. 80 pages. December 1979. Prepared for the National Science Foundation under Grants OCE77-25803 and OCE76-80174, and for the Office of Naval Research under Contract N00014-76-C-0197; NR 083-400.</p> <p>During cruise 102 of the R/V Atlantis-II in the Joint Air-Sea Interaction Project (JASIN), surface meteorological data were gathered by Woods Hole Oceanographic Institution personnel from two moored buoys and from the ship.</p> <p>One buoy (JASIN 02/MOI 651) carried a Vector Averaging Wind Recorder (VWR) and a Vector Measuring Wind Recorder (VMW); these instruments provided 18 days of intercomparison data and 38 days of meteorological data from 30 July to 6 September 1978. The other buoy (JASIN 02) carried a VMW and gave 25 total days of data from 16 July to 10 August, and from 28 August to 1 September.</p> <p>A PET computer, hardwired to sensors positioned on the ship, displayed data that were logged during both legs of the cruise. Manual data were gathered by the science watches.</p> <p>This report describes the PET system, and displays and compares all the data. VMW hourly meteorological data are listed for the 38 day period. Scientific interpretation of these data, such as calculations of heat fluxes, will be published separately.</p>	<p>1. Meteorology</p> <p>2. JASIN</p> <p>3. Air-Sea Interaction</p> <p>I. Briscoe, Melbourne G.</p> <p>II. Mills, Carol A.</p> <p>III. Payne, Richard E.</p> <p>IV. Peel, Kenneth R.</p> <p>V. OCE77-25803</p> <p>VI. OCE76-80174</p> <p>VII. N00014-76-C-0197; NR 083-400</p> <p>This card is UNCLASSIFIED</p>	<p>1. Meteorology</p> <p>2. JASIN</p> <p>3. Air-Sea Interaction</p> <p>I. Briscoe, Melbourne G.</p> <p>II. Mills, Carol A.</p> <p>III. Payne, Richard E.</p> <p>IV. Peel, Kenneth R.</p> <p>V. OCE77-25803</p> <p>VI. OCE76-80174</p> <p>VII. N00014-76-C-0197; NR 083-400</p> <p>This card is UNCLASSIFIED</p>
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