NOO-TR 256

NAVAL OCEANOGRAPHIC OFFICE TECHNICAL REPORT

EVAPORATION DUCT HEIGHT MEASUREMENTS IN THE MID-ATLANTIC

C. W. FAIRALL, K. L. DAVIDSON, G. E. SCHACHER,
AND T. M. HOULIHAN

Naval Postgraduate School, Monterey, California 93940

AUGUST 1978 (Reprinted 1980)

PREPARED FOR

COMMANDING OFFICER,
NAVAL OCEANOGRAPHIC OFFICE,
NSTL STATION, BAY ST. LOUIS, MS 39522

AND

COMMANDER
NAVAL OCEANOGRAPHY COMMAND
NSTL STATION, BAY ST. LOUIS, MS 39529

FOREWORD

Water vapor strongly influences the atmosphere's ability to refract electromagnetic (EM) waves. In particular, evaporation from the sea surface creates a vertical gradient of water vapor that causes horizontally-propagating EM wave trains to be refracted downward. When an EM wave train is refracted downward with curvature greater than that of the earth's surface, the wave train is said to be ducted. And when ducting of this kind is controlled by evaporation, the zone in which ducting occurs is called the evaporation duct.

To understand how EM wave trains are ducted in atmospheric layers overlying the sea surface, it is helpful to know the evaporation duct height (Z_*), the vertical distance from the sea surface to the point in the atmosphere where ducting first ceases (because of a diminished water vapor gradient).

To learn more about radar ducting (and about EM wave ducting in general), the Ocean Measurements Program (OMP) of the U. S. Naval Oceanographic Office (NAVOCEANO) contracted with the Environmental Physics Group of the Naval Postgraduate School (NPS) to determine: 1) some typical Mid-Atlantic Z_* values, 2) the validity of a simplified "bulk method" designed for routinely monitoring Z_* values, and 3) the parameters most likely to present measurement problems that could obstruct the routine monitoring of evaporation duct characteristics.

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
NOO TR-256

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (*and Subtitle*)
EVAPORATION DUCT HEIGHT MEASUREMENTS IN THE MID-ATLANTIC

5. TYPE OF REPORT & PERIOD COVERED

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
C. W. FAIRALL, K. L. DAVIDSON, G. E. SCHACHER, T. M. HOULIHAN

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
NAVAL POST GRADUATE SCHOOL
ENVIRONMENTAL PHYSICS GROUP
MONTEREY, CA 93940

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
U. S. NAVAL OCEANOGRAPHIC OFFICE
CODE 7004
NSTL STATION, MS 39522

12. REPORT DATE
AUGUST 1978

13. NUMBER OF PAGES
UNCLASSIFIED

14. MONITORING AGENCY NAME & ADDRESS (*if different from Controlling Office*)

15. SECURITY CLASS. (*of this report*)

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (*of this Report*)
~~DISTRIBUTION LIMITED TO U. S. GOVERNMENT AGENCIES OR ITS CONTRACTORS ONLY, TEST AND EVALUATION, AUGUST 1978. OTHER REQUESTS FOR THIS DOCUMENT MUST BE REFERRED TO THE COMMANDING OFFICER, U. S. NAVAL OCEANOGRAPHIC OFFICE.~~

DOWNGRADED
APPROVED FOR PUBLIC RELEASE

17. DISTRIBUTION STATEMENT (*of the abstract entered in Block 20, if different from Report*)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (*Continue on reverse side if necessary and identify by block number*)
ATMOSPHERIC DUCT HEIGHT
EVAPORATION DUCT
HUMIDITY PROFILES

20. ABSTRACT (*Continue on reverse side if necessary and identify by block number*)

Atmospheric boundary layer measurements were made in the Mid-Atlantic aboard USNS KANE during February and March of 1978. The results were analyzed to obtain Monin-Obukhov similarity parameters and EM wave train propagation characteristics within the evaporation ducts that overly the sea surface. Evaporation duct heights (Z_*) varied between 2 and 25 meters during the cruise; the mean Z_* value was 15 meters. In one instance, Z_* changed from 3 meters to 20 meters in about 4 hours following a frontal

passage.

A comparison of the results obtained using a simplified "bulk method" with those yielded by the established (but technically taxing) "profile method" did not convincingly establish that the bulk method could consistently predict accurate values of Z_*.

Two factors predominate in controlling the duct height Z_*: they are relative humidity and the air-sea temperature difference. Barring the development of radical new measurement techniques, the results of this work indicate that a program for routinely measuring Z_* is most likely to be obstructed by shortfalls in the quality of air-sea temperature difference data.

ACKNOWLEDGEMENTS

This document was assembled for the Ocean Measurements Program (OMP), U. S. Naval Oceanographic Office (NAVOCEANO). Jeff Haltiner (Environmental Impact Planning Corp., San Francisco) contributed to its preparation. The authors thank CDR Joe Spigai (OMP) and Vance Sprague (NAVOCEANO Chief Scientist on USNS KANE) for their leadership and assistance. Project support came from the Oceanographer of the Navy. This document was edited for presentation by Dr. B. J. Korgen.

CONTENTS

CONTENTS (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF APPENDICES

I. Summary

A. Introduction

This is a report on atmospheric measurements made by the Naval Postgraduate School Environmental Physics Group aboard the USNS Kane during operations in the North Atlantic in March of 1978. The primary goal of these measurements was to obtain measurements of the height of the radar evaporative (surface) duct from surface layer water vapor and temperature profiles and to evaluate the practicality of using a simplified (the so called "bulk" method) method for more routine estimations. The bulk method requires measurements of only four quantities: the sea surface temperature and the air temperature, wind velocity and relative humidity at some reference height (usually 10 meters). It also has the advantage of considerably less stringent measurement accuracy requirements. Due to the extreme difficulty in making accurate profile measurements at sea, the bulk method is essentially the standard for evaporative duct height calculations.

B. Description of the Problem

In a dielectric medium, electromagnetic wave propagation is influenced by the refractive index. Just as an abrupt change in refractive index causes EM waves to be "bent", so does a continuous gradient in refractive index. Since water vapor is a major contributor to N, there usually is a strong gradient in N over the sea surface because of evaporation. This gradient causes EM waves to be refracted downward. If a horizontally propagating wave experiences a refraction greater than the earth's curvature, the wave is said to be ducted. Since the surface based duct is caused by evaporation, it is often called evaporation duct. The water vapor gradient (and therefore the N gradient) over the ocean typically decreases with height in the surface layer. As a result, at some height, the N gradient has decreased below the value required for ducting, this is called the evaporation duct height, Z_*.

Since ducting can lead to signal enhancements of many orders of magnitude, knowledge of N and Z_* in the surface is very useful. Fortunately, the physics of the surface layer is well understood and the specifications of the N profile and Z_* can be reduced to the determination of only four scaling paramters. This theoretical framework, known as Monin-Obukhov Similarity (MOS), is based upon the relation of the surface layer profiles of temperature, wind speed, water vapor and turbulence with the surface fluxes of momentum and sensible and latent heat. As one might expect, the problem is simple in principle but difficult in practice, primarily because the fluxes cannot be easily measured from an unstable platform. At present, the best technique is to measure the profiles at several different heights, solve the MOS expressions "backwards" to determine the scaling parameters, thus determining the N profile and Z_*. This process, equivalent to inferring the surface fluxes from the profiles, is referred to as profile method.

Multi-level measurements necessary for the profile method are not trivial. For example, from measurements at heights of 10 and 25 meters above the sea surface, one can typically expect differences on the order of 10% in wind speed, 3% in relative humidity, and 0.2C in temperature. To determine the scaling parameters to a 10% accuracy, measurement accuracies required are: wind speed: 1%, relative humidity: 0.3% and temperature: 0.02C. Note that the distortions caused by the presence of the ship could exceed these accuracies. Atmospheric measurements even approaching this precision require highly trained scientific personnel with state-of-the-art instrumentation. These extremely taxing measurement accuracies have led to the interest in the bulk method.

If one considers the MOS expressions for the gradient as mathematical derivatives, then the integral of the gradient from the surface ($Z=Z_o \cong 0$) to some reference height (Z) specifies the variable (say temperature, T(Z)). Note that we have introduced two integration boundary conditions T(0) and Z_o, where T(0) is the sea surface temperature and Z_o is the roughness length. If we assume that the wind speed at the surface is zero (U(0) = 0) and the relative humidity at the surface is 100% (H(0) = 100), only four quantities need to be measured: T(0), T(Z), U(Z), and H(Z). However, an unknown quantity Z_o, which we have also introduced, must be empirically determined.

Average temperatures measured during the cruise were T(0) = 16.2C and T(Z) = 14.7C, a difference of 1.5C - an order of magnitude greater than the two level example given previously. In short, the bulk method has two advantages: fewer measurements are required and an order of magnitude greater toleration to error. This simplicity was obtained by introducing the quantity Z_o, which has been empirically studied by statistically averaging vast numbers of over-water measurements of bulk, profile, and turbulence data. One of the primary questions about the bulk method is the applicability of an "average" Z_o to a specific situation. An even more serious question deals with the validity of extrapolating the MOS gradient expressions (essentially Z^{-1}) down to the surface.

C. Summary of Measurement Results

The total data base for the cruise consists of 360 periods (half hour averages) of which 40 periods contained near surface (Z=2.8m) bouy profile measurements. A tabulation of the EM propagation data (Z_*, Fm, N, dN/dZ and C_n^2) is given in Appendix C. There are several ways of looking at the comparison of the profile or turbulence values with the bulk values. For instance, the bouy profile values for the water vapor scaling parameter, q_*, agreed very well with the bulk values, on the average, but the variance of individual values was about 50%. Since a considerable portion of this 50% is due to uncertainty in the profile measurements, these results are probably rather conservative. The comparison is summarized in the following table:

QUANTITY	SCALING PARAMETER	AVERAGE AGREEMENT	RMS VARIANCE	%VARIANCE
Water Vapor	q_*	excellent	.12 gm/kg	50%
Temperature	T_*	poor	.045C	50%
Wind Speed	U_*	fair	.06 m/sec	15%
Duct Height	Z_*	fair	10 M	100%

D. Conclusions

Duct heights calculated on the basis of bulk measurements are probably within a factor of 2 of the correct value, and possibly much closer. The actual calculation of Z_* from T(O), U(Z) and H(Z) can be done on a hand held programmable calculator. Given the sensitivity analysis of Section V, we feel that the real problem in routine applications is the temperature measurements. The wind speed can be obtained with sufficient accuracy using "eyeball" estimates and a Beaufort scale.

The relative humidity measurements can probably be made with a sling psychometer from a well exposed portion of the ship. However, there is no escaping the fact that the air sea surface temperature difference must be measured to better than 0.5C. This requires well calibrated and exposed temperature sensors (with low drift characteristics). The air temperature measurement needs to be made with a good aspirator in a location reasonably free of ship influence.

Typical bulk Z_* values estimated during the cruise were around 15 meters. Under high relative humidity conditions (rain and fog) Z_* was as low as 1 meter. The maximum Z_* was around 25 meters. Considerable time variations were observed, mostly associated with frontal passages. In view of this, measurements should probably be made several times a day.

One result of the theoretical analysis was the astounding volatility of Z_* under stable conditions (air warmer than water). For the example with $T(Z)-T(0)=1.4C$, a relative humidity of 90% gave $Z_* = 5$ meters whereas a relative humidity of 75% gave $Z_* = 60$ meters. Unstable conditions showed much less variability. In fact, since the relative humidity over the ocean is rarely less than 40%, we expect Z_* to almost always be less than 30 meters during unstable conditions. Therefore, stable conditions produce unusually strong surface ducting and the most variable ducting conditions. Although expected, the effect is larger than we would have anticipated.

E. General Comments and Recommendations

1. We feel another cruise is called for to clear up the uncertainties of the Kane data. We are now "on line" with improved temperature and humidity profile instruments, an IR sea surface temperature sensor and an improved computerized data logger and analyzer. One more cruise could do a great deal in establishing the bulk method procedures.

2. An EM propagation analysis of other NPS data could be compared to the Kane data or to climatological predictions. We have on file data from the Pacific, the North Atlantic and the Mediterranean.

3. More work needs to be done on the drag coefficients (related to Z_0). The wind speed coefficient is fairly well known but

real knowledge about the temperature and water vapor coefficients is quite rare.

4. Development of a simple system for routine shipboard measurements of sufficient quality to allow bulk calculations should probably be undertaken.

5. A great deal of boundary layer work needs to be done (above the surface layer) to allow extension of similarity scaling to greater heights. If successful, it may be possible to make estimates of elevated ducts from surface and remote sensing data.

II. Instrumentation

A. Sensors and Placement

Rather than embark upon a detailed description of the NPS instrumentation, we will include as Appendix A a report (Houlihan et al, 1977) on the subject and give only a brief sketch. The mean measurements are summarized in the following table:

MEASUREMENT	INSTRUMENT	ACCURACY
Temperature, T	Quartz oscillator	.01C
Relative Humidity, RH	LiCl cell	3%
Wind Velocity, V=U	Cup anemometer	4%

The relative humidity and temperature sensors are deployed in aspirated shelters to reduce errors from solar and IR radiation. These aspirators represent a weak point in the temperature profile measurements and do not produce reliable temperature profile data during the day. The turbulence data was based upon measurement of fluctuations of wind velocity (yielding the rate of dissipation of turbulent kinetic energy, ε) and temperature fluctuations (yielding the temperature structure function parameter, C_T^2). Constant temperature hot film sensors were used to measure ε and microthermal platinum wires were used to measure C_T^2. The frequency response of these measurements is greater than 500HZ.

The instruments are deployed at discrete levels: two levels on the NPS tower, one on the bow davit and (circumstances permitting) one on the buoy (see Figure 1a). The following are the level heights (Z) above the water:

Level #	1	2	3	4
Height, meters	2.8	9.1	18.6	24.7

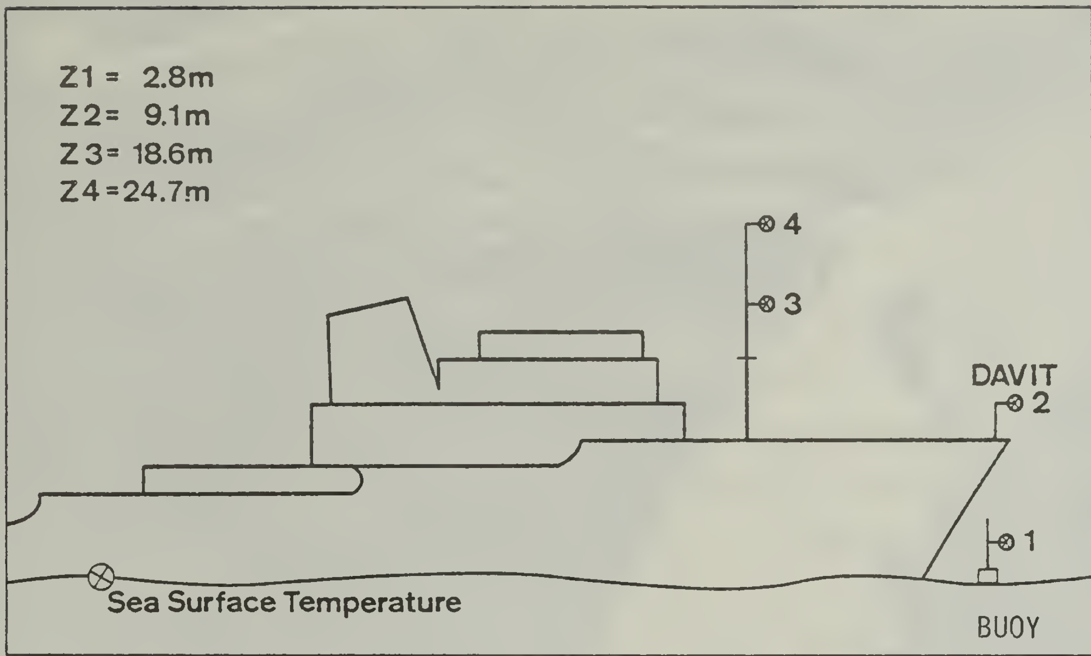


Figure 1a. Mounting Arrangement on USNS KANE for NPS Equipment.

B. BUOY

The buoy, which is lowered into the water by a crane on the bow of the ship, is used to obtain a measurement very close to the surface (Figure 1b). Since the gradients we wish to measure vary roughly as Z^{-1}, they are easier to measure near the surface. Unfortunately, the buoy can only be used when a) the ship is stationary, and b) the seas are moderate.

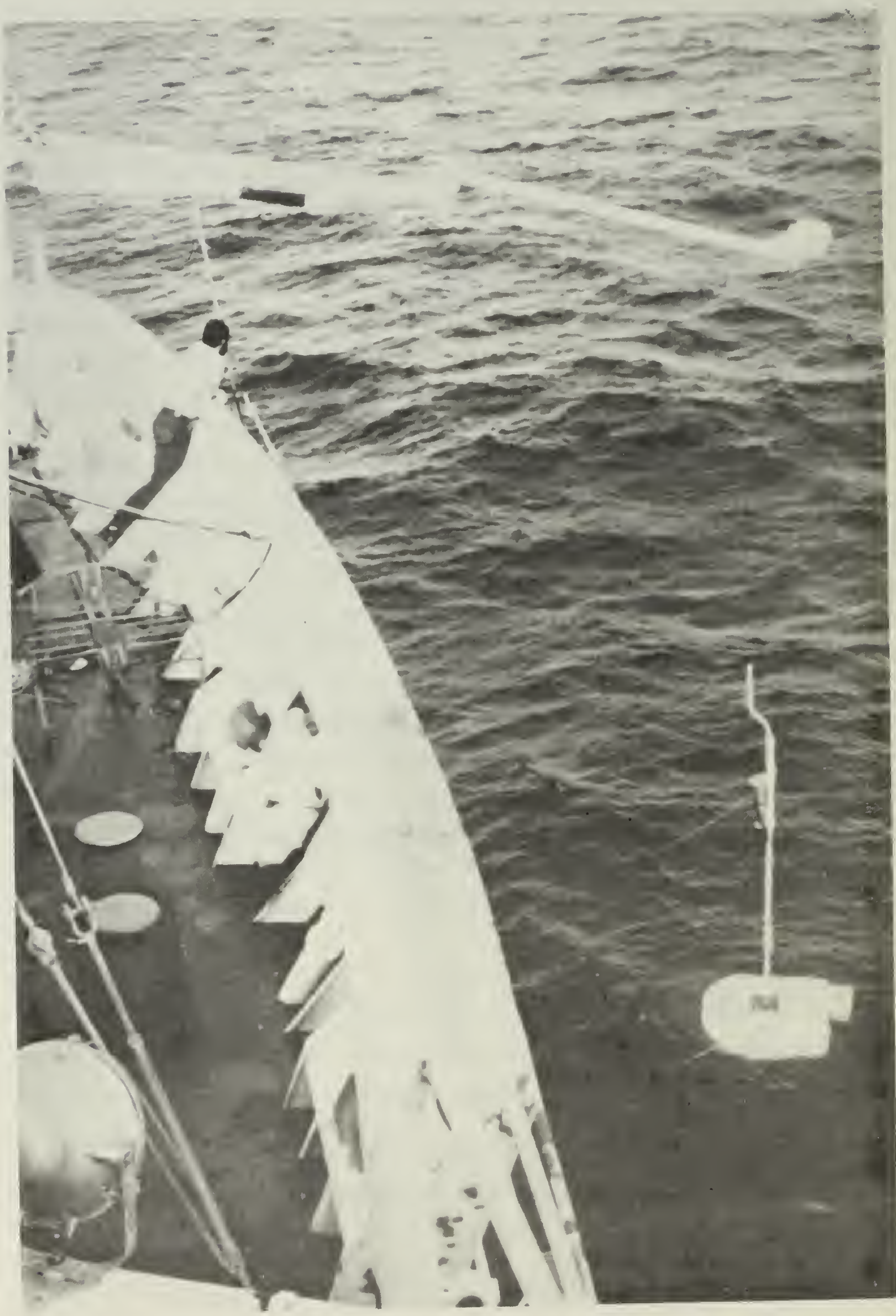


Figure 1b. The Bouy Deployed from USNS Kane

III. Theory

A. EM Propagation

1. Refractivity N and Ducting

The refractivity N (in N units) of the atmosphere for EM wave propagation is

$$N = 77.6\ P/T + 3.73 \times 10^5\ e/T^2 \qquad (1)$$

Where P is the atmospheric pressure, T the absolute temperature and e is the partial pressure of water vapor. The vertical gradient of N is

$$\frac{dN}{dZ} = C_1 \frac{\partial P}{\partial Z} + C_2 \frac{\partial q}{\partial Z} + C_3 \frac{\partial T}{\partial Z} \qquad (2)$$

where q is the water vapor mixing ratio (q = .625 e) in gm/kg and $C_1 \cong .3$, $C_2 \cong 7.2$ and $C_3 \cong -1.3$. A negative gradient in refractivity at height Z causes a horizontally propagating EM wave to be bent towards the surface. If the gradient is large enough, the amount of bending will exceed the curvature of the earth and the wave will be ducted at the height Z. Since the magnitude of the gradient decreases with increasing height in the surface layer, at some height (Z_*) the gradient will no longer be strong enough for ducting. Waves propagating below Z_* are ducted, those above are not. This height is called the evaporative duct height, and is defined by the critical gradient necessary for EM wave trapping.

$$\frac{dN}{dZ} = -.157\ m^{-1} \qquad (3)$$

Using Eq. 21 and noting that $dP/dZ = -\rho g$ (the normal hydrostatic balance for the atmosphere), the Z_* is defined by the following equation

$$-.157 = -.032 + C_2 \frac{\partial q}{\partial Z} + C_3 \frac{\partial T}{\partial Z} \qquad (4)$$

Since $\partial q/\partial Z$ and $\partial T/\partial Z$ are height dependent (approximately $\sim Z^{-1}$) there will exist a value of $Z = Z_*$ such that Eq. 4 is satisfied.

2. Structure Function C_N^2

Turbulence in the atmosphere produces fluctuations in N on a broad range of size scales (milimeters to kilometers). These fluctuations scatter the EM waves producing a loss of resolution and coherence. If N(x) and N(x+d) represent values of N at two points, separated a distance d, then

$$C_N^2 = \langle (N(x) - N(x+d))^2 \rangle d^{-2/3} \tag{5}$$

For EM Waves

$$C_N^2 = \left(\frac{AB}{T^2} \right)^2 \left[C_q^2 + \frac{2}{B} \left(1 + q \frac{B}{T} \right) C_{Tq}\right] \tag{6}$$

where A and B are constants C_q^2 is the water vapor structure function and C_{Tq} is the covariance function. Neglecting the C_{Tq} term (at sea level)

$$C_N^2 = \left[\frac{(77.6 \times 10^{-6})(7.67 \times 10^3)}{T^2} \right]^2 \tag{7}$$

B. Monin-Obukhov Similarity Surface Layer Equations

The vertical gradients of the wind speed (U), potential temperature (T) and water vapor mixing ratio (q) are given by

$$dX/dZ = \frac{X_*}{\alpha_T \kappa Z} \phi_x (\xi) \tag{8}$$

Where X = U, T or q, κ = Von Karmon's constant (35), α_x is the diffusivity constant (α_u=1.0), X_* is the scaling parameter and $\phi(\xi)$ is the MOS stability correction function (Appendix B). Also

$$\xi = Z/L \tag{9}$$

where L is the Monin-Obukhov stability length defined as

$$L = \frac{TU_*^2}{\kappa g(T_* + .18\, q_*)} \tag{10}$$

If we integrate Eq. 8 from $Z = Z_{ox}$ to Z, we obtain

$$X(Z) = X(Z_{ox}) + \frac{X_*}{\alpha_x \kappa} [\ln Z/Z_{ox} - \psi_x (\xi)] \tag{11}$$

Where $\psi_x(\xi)$ is the profile stability function (Appendix B).

The structure function parameter C_x^2 is related to X_* by the function $f_x(\xi)$ (Appendix B)

$$C_x^2 = X_*^2 Z^{-2/3} f_x (\xi) \tag{12}$$

A similar form exists for ε_x, the rate of dissipation of fluctuations of X

$$\varepsilon_x = \beta_x C_x^2 \varepsilon^{1/3} = \frac{X_*^2 U_*}{\kappa Z} E_x(\xi) \tag{13}$$

Where β_x is the Corrsin constant and $E_x(\xi)$ is the MOS dissipation function. In this format, $\varepsilon_u = \varepsilon$.

C. MOS Parameter Determination Methods

1. Profile Method

The profile method is based upon Eq. 11, expressed in the following form

$$X(Z) = \frac{X_*}{\alpha_X \kappa} [\ln Z - \psi_X(\xi)] + [X(0) - \frac{X_*}{\alpha_X \kappa} \ln Z_{oX}] \qquad (14)$$

This can be expressed as a linear regression of the form

$$X(Z) = mY + b \qquad (15)$$

Where Y = ln Z $\psi_X(\xi)$. If we have two or more levels of X(Z), we can fit the data to Eq. 16, the slope m, of the fit gives $X_* = \alpha_X \kappa m$. Note that it is not necessary to know the constant factor, b, (related to Z_{oX}) to find X_*. The actual process is done iteratively in the following manner:

a. Assume a value for L

b. For each data point at height Z, calculate ξ and $\psi_X(\xi)$.

c. Least squares fit the multi-level data to obtain U_*, T_*, and q_*.

d. Calculate a new value of L from Eq. 10

e. Return to b) until L converges

Since the wind speed profiles from the Kane were considerably influenced by the ship, we used the bulk method to calculate U_*.

2. Bulk Method

The bulk method is also based on Eq. 15. If one knows values for Z_{oX}, then X_* can be calculated simply from X(Z) and X(0). Rewriting Eq. 15

$$X_* = \alpha_X \kappa \frac{(X(Z) - X(0))}{(\ln Z/Z_{oX} - \psi_X(\xi))} \qquad (16)$$

We see the form of the standard drag coefficient equation

$$X_* = C_X^{1/2} (X(Z) - X(0)) \qquad (17)$$

Where C_X is the drag coefficient for X

$$C_X = \frac{C_{XN}}{[1 - (\alpha_X \kappa)^{-1} C_{XN}^{1/2} \psi_X(\xi)]^2} \qquad (18)$$

In this form, Z_{ox} is related to the neutral drag coefficient by

$$C_{XN}^{1/2} = \frac{\alpha_X \kappa}{\ln (Z/Z_{ox})} \tag{19}$$

The MOS stability parameter, ξ, can be obtained from Eq. 10 and Eq. 18.

$$\xi = \xi_o \frac{(1 - \kappa^{-1} C_{UN}^{1/2} \psi_u(\xi))^2}{(1 - (\alpha_T \kappa)^{-1} C_{TN}^{1/2} \psi_T(\xi))} \tag{20}$$

Where

$$\xi_o = \frac{\kappa g Z}{T} \frac{C_{TN}^{1/2}}{C_{UN}} \frac{[(T(Z) - T(0)) + .18(q(Z) - q(0))]}{U(Z)^2} \tag{21}$$

In this case, the process is somewhat simpler, one calculates ξ_o from the data and solves Eq. 21 iteratively for ξ. Given ξ, the MOS parameters are calculated straightforwardly from Eqs. 18 and 19.

3. Turbulence Method

Given a reasonable estimate of ξ (from either of the two previous methods) one can obtain an independent value of the scaling parameter from turbulence measurements of C_T^2, C_q^2 or ε. For instance (Eq. 12)

$$T_*^2 = C_T^2 Z^{2/3}/f_T(\xi) \tag{22}$$

or (Eq. 13)

$$U_*^3 = \varepsilon Z/E_U(\xi) \tag{23}$$

D. EM Propagation Equations in MOS Form

Near sea level, the gradient of N can be written (Eqs. 2 and 3)

$$dN/dZ = -.032 + \frac{\phi_T(\xi)}{\alpha_T \kappa Z} (7.2 q_* - 1.3 T_*) \tag{24}$$

The duct height, Z_*, is obtained from Eq. 24 by setting $dN/dZ = -.157$, the critical gradient for ducting.

$$Z_* = \frac{-(7.2 q_* - 1.3 T_*)}{\alpha_T \kappa (.125)} \phi_T(Z_*/L) \tag{25}$$

Given q_*, T_* and L, we solve Eq. 25 teratively to obtain Z_*. Note that no ducting will occur unless

$$7.2 q_* - 1.3 T_* < 0 \tag{26}$$

The refractive index structure parameter is calculated from Eqs. 7 and 12

$$C_N^2 = \left[\frac{(77.6 \times 10^{-6})(7.67 \times 10^3)}{T^2}\right]^2 \quad q_*^2 \; Z^{-2/3} \; f_T(\xi) \qquad (27)$$

IV. RESULTS

A. Discussion

Before presenting the results, it is worthwhile to consider several points about the absolute validity of the entire process. The various stability correction functions - $\phi(\xi)$, $f(\xi)$, $\dot{E}(\xi)$ - are empirically determined functions. In fact, they are based on overland measurements. The NPS group has spent a great deal of effort in evaluating the validity of these functions over water and, so far, they appear to be quite good. There are other problems with some of the empirical constants and the drag coefficients. The profile method is dependent upon the product $\alpha_T\kappa$, both measured empirically. The estimates we have used are α_T = 1.35 and κ = .35, from Businger et al (1971). The actual value of both constants is still a subject of controversy.

The bulk method is dependent upon the drag coefficients C_{UN}, C_{TN} and C_{qN}. For our analysis, we assumed that water vapor has the same characteristics as temperature, that is

$$\alpha_T = \alpha_q \; ; \; Z_{0T} = Z_{0q} \; ; \; \phi_T(\xi) = \phi_q(\xi)$$

There are theoretical reasons to believe that this is a good approximation but not exactly correct. Under these assumptions, $C_{TN} = C_{qN}$. For the actual form of the drag coefficients, we assumed C_{UN} had the wind speed dependence given by Kondo (1975). Based upon measurements summarized by Liu (1977) and NPS measurements of C_T^2, we assigned a value of $C_{TN} = 1.1 \times 10^{-3}$ and solved for ξ as a function of ξ_0. Thus, for each data value of ξ_0 we directly calculated ξ from the formula

$$\xi = \xi_0(1 + .14\xi_0^{.4}) \quad \xi_0 < 0 \qquad (28a)$$

$$\xi = \xi_0(1 + .13\xi_0^{.4} + .26\xi_0^{2.1}) \quad \xi_0 > 0 \qquad (28b)$$

B. EM Propagation Results

A listing of the bulk calculations of the EM data is given in Table C-1 (Appendix C). The data includes calculations of the Z=10 meter values of N, dN/dZ and C_N^2 as well as Z_* and Fm. Fm is the minimum frequency trapped by the duct as is calculated from

$$Fm = 3.6 \times 10^2 \ Z_*^{-3/2} \tag{29}$$

Where Fm is in GHz.

The following are two examples to illustrate the general behavior of Z_*. Figure 2 shows Z_* for a three day period at anchor approximately 80 miles west of the Straits of Gibraltar. The steady decrease of Z_* for this first part of the record was associated with high relative humidity and rain. The rapid increase of Z_* around 0200 hours on 3/3 corresponded to the passage of the front as indicated by clearing skies and a shift of the wind from 210^0 to 260^0. Figure 3 shows a very similar event on station in the survey area. In this case, the weather system was not strong enough to produce rain but fog was observed at 1800 hours on 3/10. The wind shifted from 200^0 to 300^0 between 1900 hours on 3/10 and 0700 hours on 3/11.

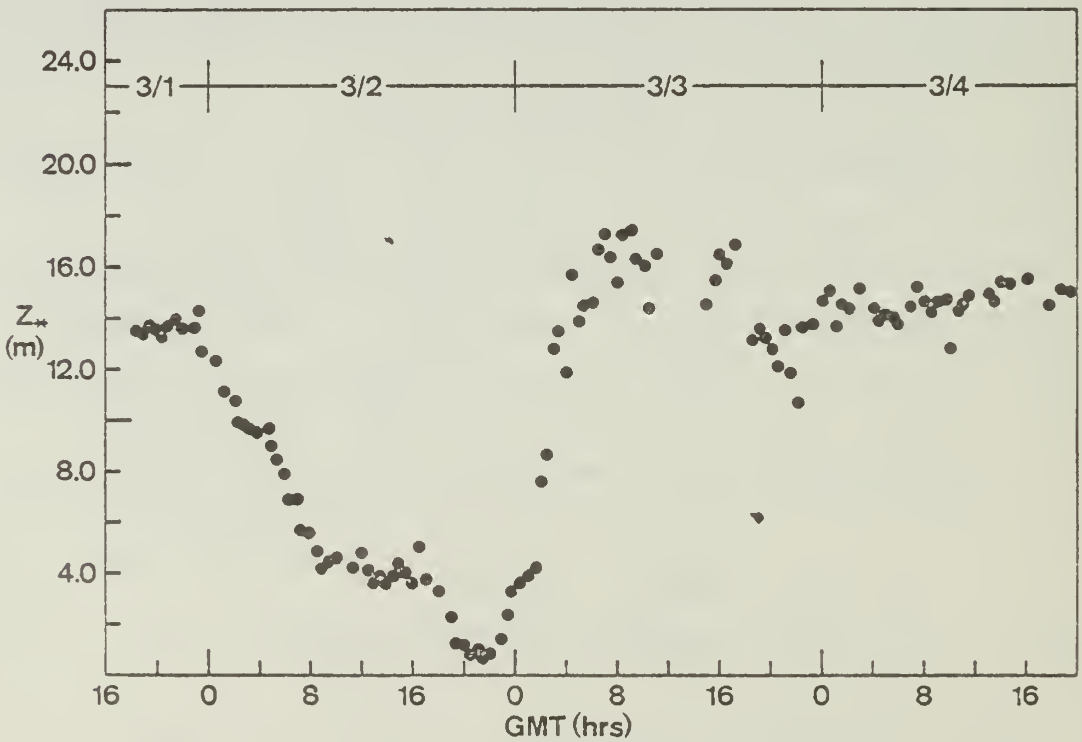


Figure 2. Z_* values for period 3/1 to 3/4 when KANE was anchored 80 miles west of Straits of Gibraltar.

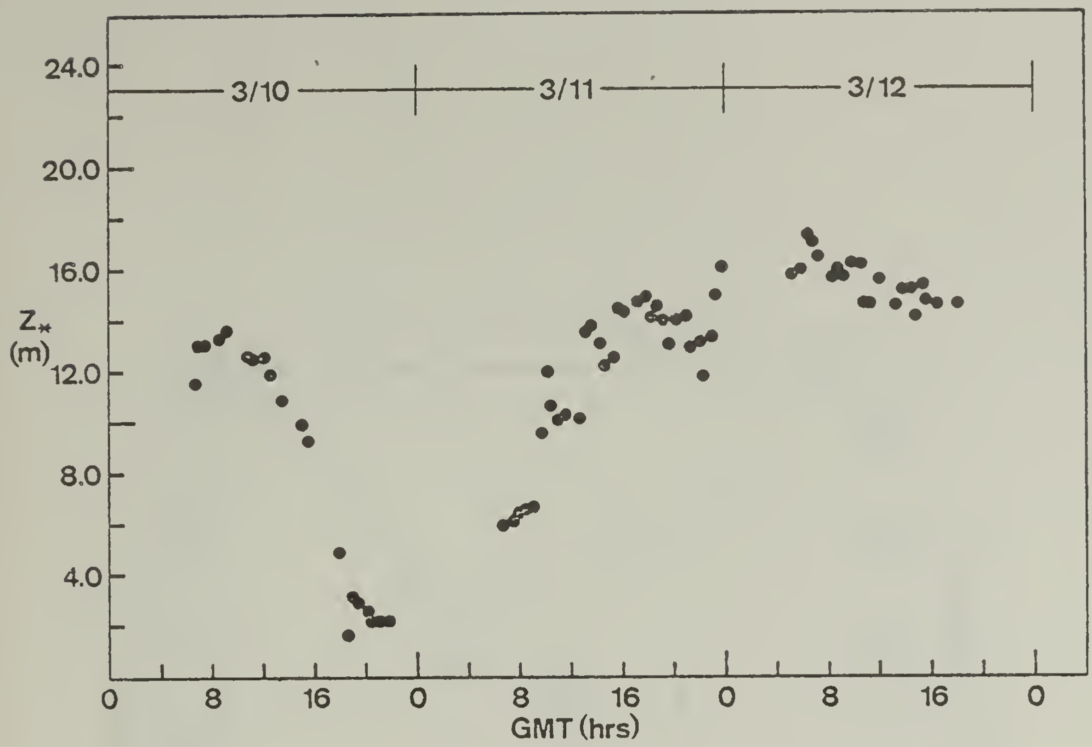


Figure 3. Z_* values for period 3/10 to 3/12 when KANE was in survey area.

C. Evaluation of the Bulk Method

1. Scaling Parameters

In order to make this evaluation more meaningful, we have analyzed the scaling parameters under those conditions of maximum profile accuracy. For instance, the humidity measurement were not accurate enough to give reliable profiles except when the buoy was deployed. The temperature profiles were only analyzed for the night time periods. The turbulence measurements of U_* were valid during all periods. A complete tabulation of comparisons for all periods is given in Table C-2 (Appendix C) but keep in mind that the graphs shown below are based on data selected from the table. Incidently, the buoy data comparison has been extracted for condensed viewing and is shown in Table C-3 (Appendix C).

The comparison of bulk and profile calculations of q_* are shown in Figure 4 from the buoy data. On average, the comparison is very good. The individual point scatter is about 50%. For this graph, and those following, the error bars are for the mean estimates and the number represents the number of data points in each bin.

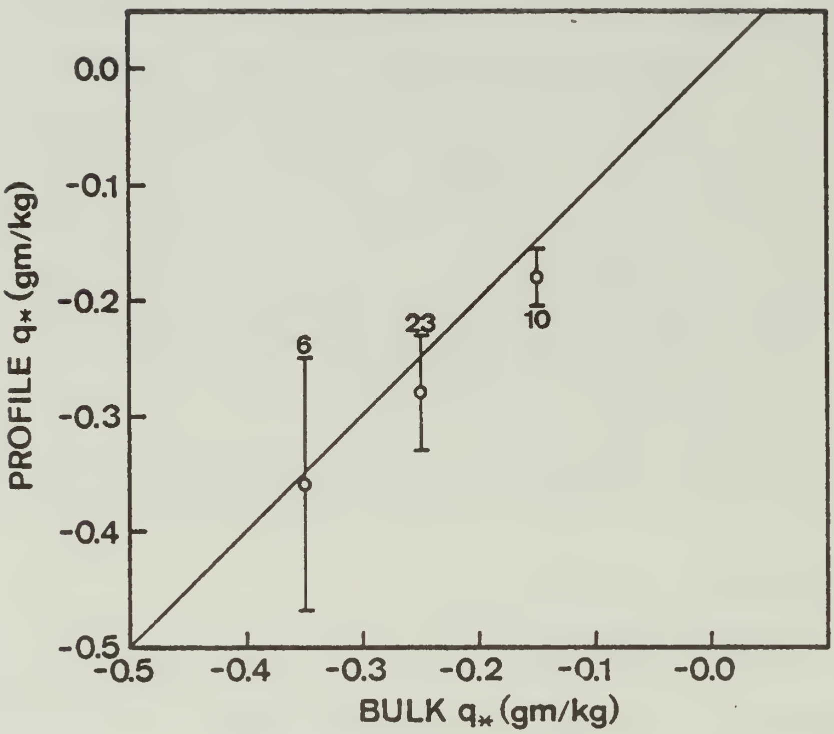


Figure 4. Calculation of water vapor mixing ratio scaling parameter, q_*, profile determination vs. bulk, bouy data only.

The comparison of bulk and profile calculations of T_* are shown in Figure 5. These results are very poor indeed. It is not clear if the lack of correlation is due to measurement problems ɔr is in fact failure of the bulk method.

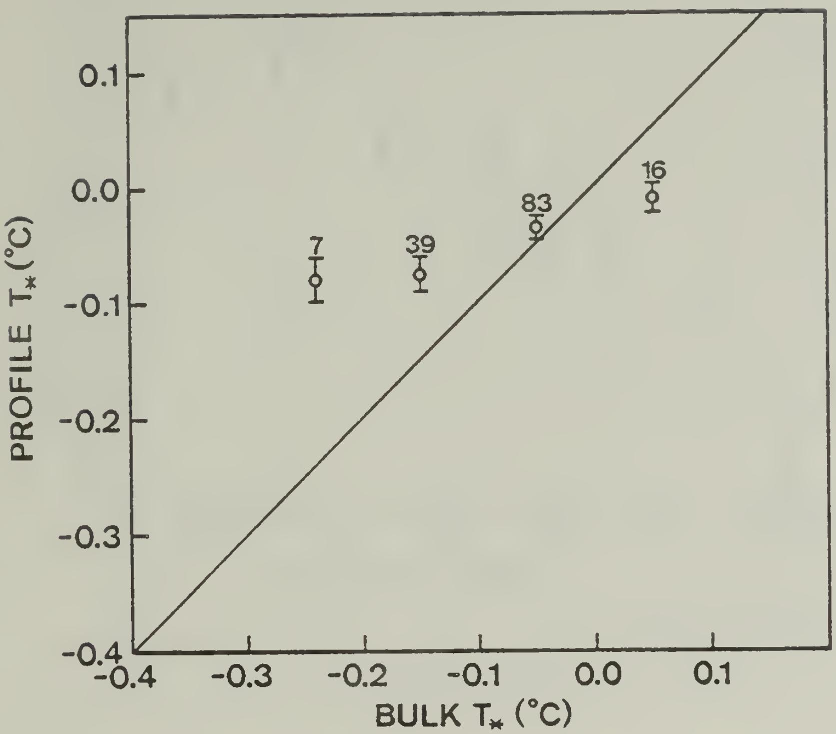


Figure 5. Calculation of potential temperature scaling parameter, T_*, profile determination vs. bulk, night time data.

The comparison of the bulk and turbulence calculations of U_* are shown in Figure 6. Although the correlation is not perfect, it is probably good enough for bulk determinations of Z_*. The complicated velocity dependence of C_{UN} that was used for these U_* bulk values did not give significantly better comparison than assuming a velocity independent value of $C_{UN} = 1.3 \times 10^{-3}$.

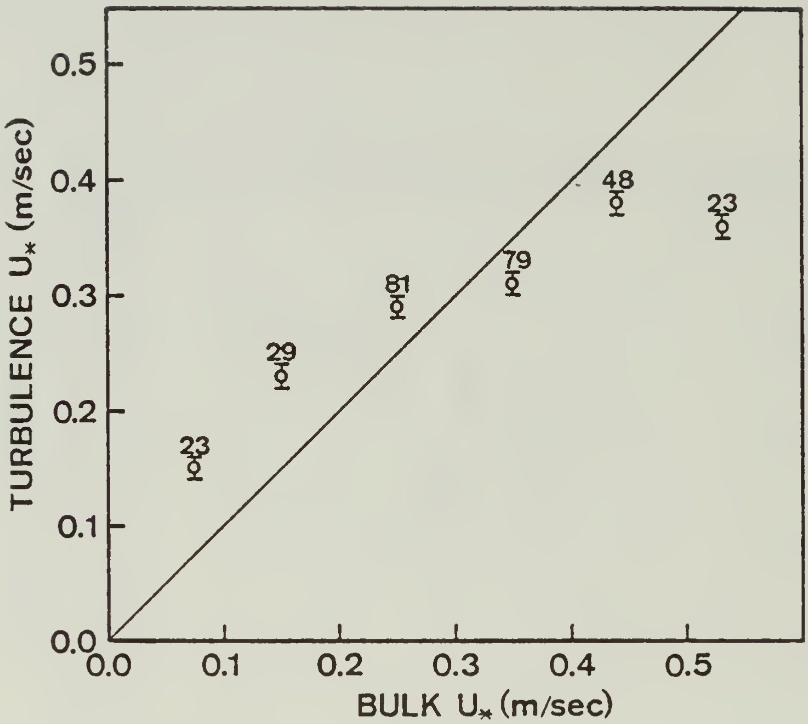


Figure 6. Calculation of friction velocity, U_*, turbulence determination vs. bulk, all data.

2. Duct Height

Evaporation duct height, Z_*, was calculated using the bulk and profile methods for all data. A comparison of these results is given in Figure 7.

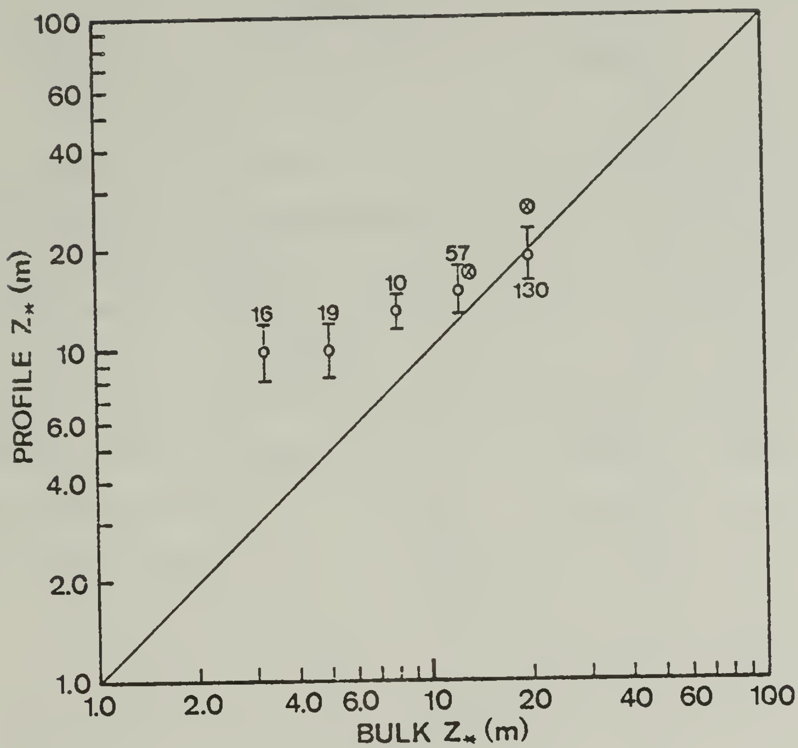


Figure 7. Calculation of evaporation duct height, Z_*, profile determination vs. bulk. The open circles represent all data, the circled x's are the buoy data only.

Although the correlation is only fair, it should be noted that the bins containing most of the points (187 out of 232) fall within the expected mean error. Also encouraging is the much better agreement obtained from the buoy data.

V. SENSITIVITY ANALYSIS

A. Data Distribution

Rather than consider many possible combinations of the meteorological parameters, the sensitivity analysis will be done within the framework of typical values measured during the cruise. A summary of the overall average data is given below.

QUANTITY	SYMBOL	AVERAGE	σ
Sea Surface Temp.	TS	16.25° C	0.40° C
Air Temperature	T(10)	14.67° C	1.19° C
Relative Humidity	H(10)	70%	17%
Wind Speed	U(10)	7.57 m/sec	2.84 m/sec
Mixing Ratio	q(10)	7.29 gm/kg	1.7 gm/kg

B. Sensitivity of Z_*

The sensitivity analysis was performed using the meteorological parameters as inputs into the bulk expressions. The predictions are shown in the form of Z_* as a function of relative humidity. Of course, one should keep in mind the extreme rarity of relative humidities (at Z=10 meters) less than 40% over the ocean. On each of the graphs shown, the solid line represents the "average" curve (TS-16.2, T(10)-14.7 and U(10)=7.6 m/sec). Since the average relative humidity was 70%, we expect an average Z_* = 16 meters. Figure 8a shows the effects of velocity variations on the order of the standard deviation found during the cruise. The effect of sea surface variation (at constant air-sea temperature difference) is given in Figure 8b. Z_* is moderately insentive to both parameters. The corresponding graph for sensitivity to the air-sea temperature difference is noticeably different (Figure 9). Not only can very large values of Z_* occur for stable conditions ($\Delta T>0$) but note the very steep variability of Z_* between 60% and 90% humidity. Of course, one must bear in mind that these are surface layer extrapolations, the maximum height of validity is probably less than 50 meters. Nevertheless, these results are quite significant.

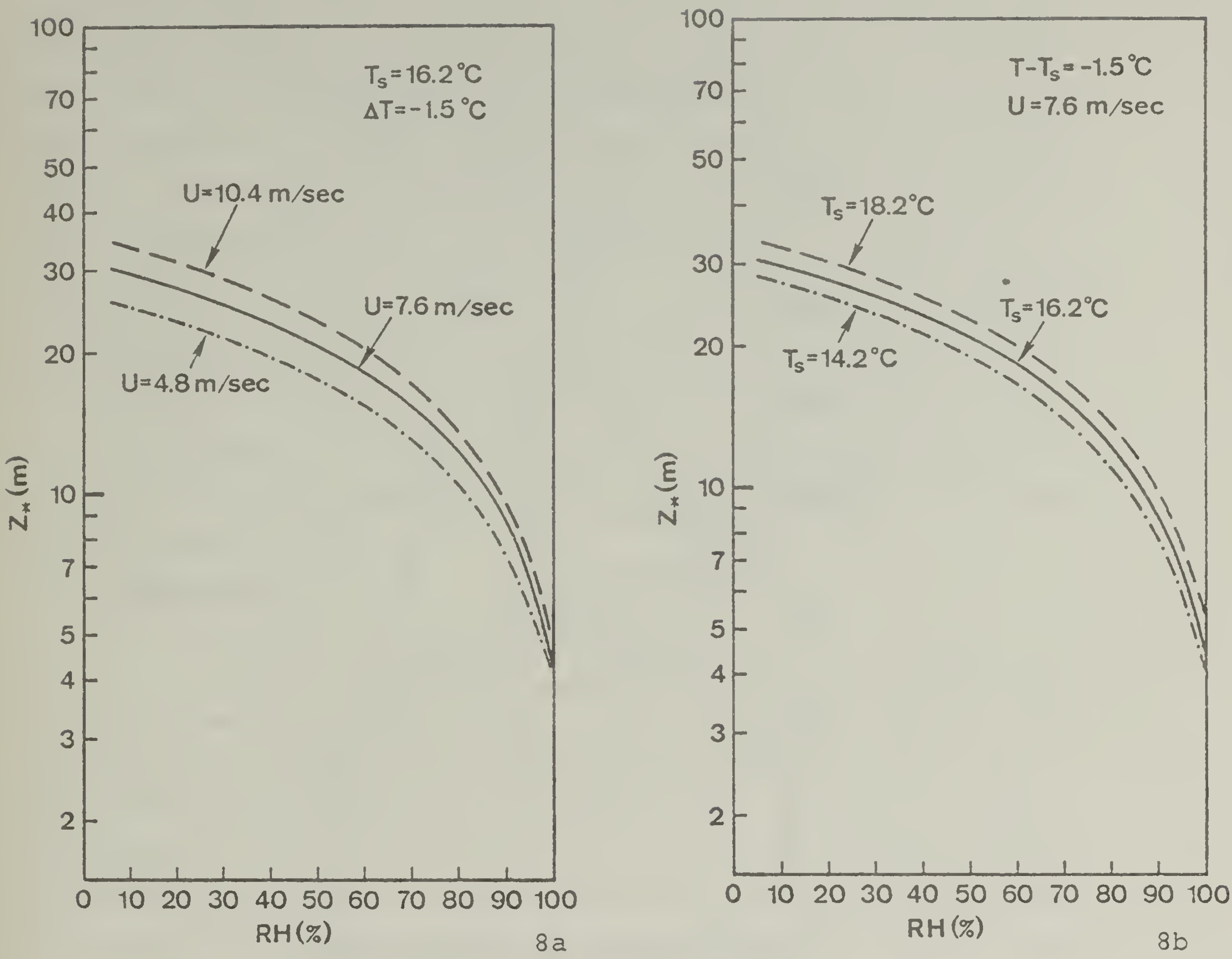


Figure 8. Duct height vs. relative humidity for typical meteorological conditions found during the Kane cruise; a) sensitivity to wind speed b) sensitivity to sea surface temperature.

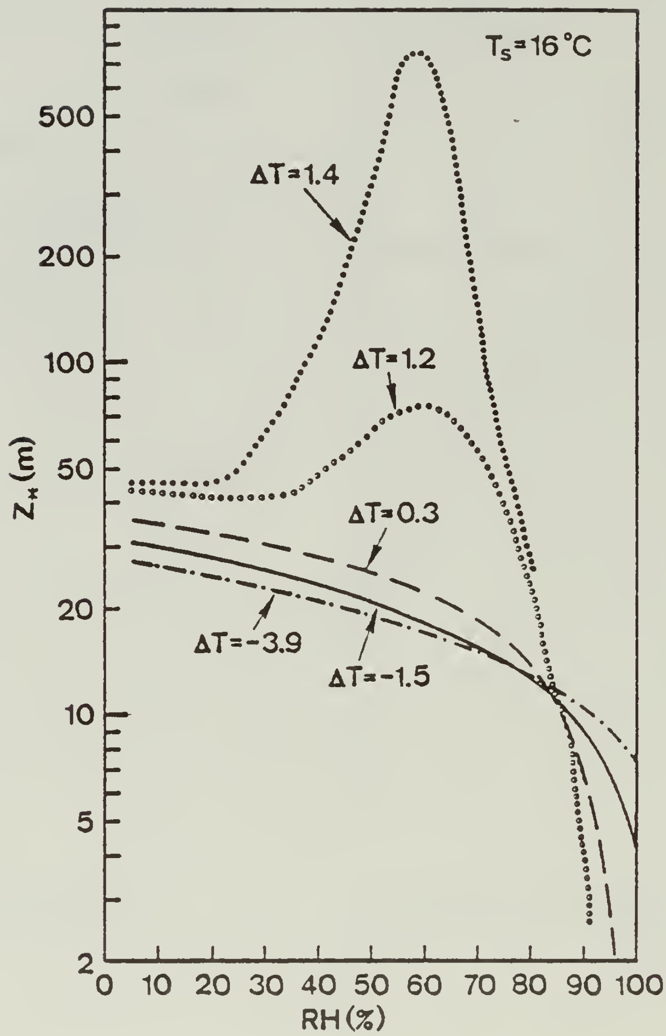


Figure 9. Duct height vs. relative humidity for typical meteorological conditions found during the Kane cruise: sensitivity to the air-sea temperature difference.(ΔT = T(Z) - T(0)).

The large difference in stable and unstable atmospheric evaporation ducting properties is a direct result of the behavior of the MOS gradient equations. Let us assume that very near the surface we have an N gradient great enough to permit ducting. Since the gradient very near the surfaces decreases with height as Z^{-1}, we expect the gradient to decrease with increasing height until $Z=Z_*$ and the critical gradient is reached. The atmospheric stability enters into the problem through its influence on the height dependence of the gradients. Under unstable conditions, the convective mixing quickly removes the gradients as Z increases, leading to a $Z^{-3/2}$ gradient height dependence. Consequently, the critical gradient is reached at a relatively low Z. Under stable conditions, the bouyancy forces are retarding the turbulent mixing as Z increases, leading to gradients that approach a constant independent of height. Therefore, the gradient decreases more slowly under stable conditions and the critical gradient can be reached at much greater heights.

VI. CONCLUSIONS

A. Variability of Z_*

Typical values of Z_* obtained during the cruise ranged from around 2.0 meters to 25 meters with a mean value of 15 meters. Transmissions at 10 GHz would have been ducted approximately 70% of the time, 20 GHz approximately 85% of the time. The two factors having the greatest influence on Z_* are the relative humidity and the air-sea temperature difference. In one instance the duct height changed from 3.0 meters to 20 meters in about four hours following a frontal passage.

B. Validity of the Bulk Method

The profile and turbulence data from this cruise do not give a clear validation of the bulk method. Although the water vapor and wind speed scaling parameters were reasonably well correlated in the mean, there was considerable scatter (on the order of 50% and 15% respectively) for individual measurements. Comparisons for T_* and Z_* were definitely a disappointment. We feel that much of the discrepancy can be attributed to inaccurate temperature and humidity profiles. Since both of these systems have been upgraded since the Kane cruise, another cruise should be made. Based upon comparison of turbulence T_* (from C_T^2)

with bulk T_* from other NPS data, we feel that the bulk T_* are much better than indicated by the Kane data.

C. Implications of the Sensitivity Analysis

The sensitivity analysis showed that the wind speed and sea surface temperature contributions to Z_*, though significant, were not highly critical. The relative humidity and air-sea temperature difference were definitely critical factors. Given the standard measurement capabilities of these two quantities, it is obvious that the air-sea temperature difference will be the primary roadblock to implementing a program of routine measurement of Z_* either from ship data or satellite data. Another result of the study was the large values of Z_* possible under stable conditions (stable conditions predominate off the east coast of the U.S. and Canada in the summer).

VI. REFERENCES

1. Businger, J. A., J. C. Wyngaard, Y. Izumi, and E. F. Bradley, "Flux Profile Relationships in the Atmospheric Surface Layer," J. Atmos. Sci. 28, 181-189 (1971).

2. Kondo, J., "Air-Sea Bulk Transfer Coefficients in a Diabatic Atmosphere," Boundary Layer Meteorology, 9, 91-112 (1975).

3. Liu, W. T., "Heat Transport and Thermal Structure in the Interfacial Boundary Layer Measured in an Open Tank of Water in Turbulent Free Convection," Ph.D. Thesis, Dept. of Atm. Sci., U of Washington (1977).

4. Wyngaard, J. C., Y. Izumi, and S. A. Collins, "Behavior of the Refractive Index-Structure Parameter Near the Ground," J. Opt. Soc. Am. 61, 1646-1650 (1971).

5. Wyngaard, J. C. and O. R. Cote, "The Budgets of Turbulent Kinetic Energy and Temperature Variance in the Atmospheric Surface Layer," J. Atmos. Sci. 28, (1971).

APPENDIX A

INSTRUMENTATION

Experimental Aspects of a Shipboard System Used in Investigation of Overwater Turbulence and Profile Relationships

T. Houlihan, K. L. Davidson, C. W. Fairall and G. E. Schacher
Environmental Physics Group
Naval Postgraduate School
Monterey, California 93940

ABSTRACT

Programs of investigation of optical propagation, marine fog, and boundary layer properties in the marine environment have led to the development of a shipboard system for measuring atmospheric stability and turbulence. This research requires very accurate multilevel measurements of mean and fluctuating temperature, wind velocity, and humidity. This paper is a description of the system including the following aspects: 1) instrumentation, 2) calibration, 3) analysis techniques, and 4) examination of the data and evaluation of the system.

Appendix A Figure Captions

Appendix A List of Tables

I. Introduction

There is currently considerable interest in turbulent transport processes in the marine boundary layer. Two problems which are of particular importance concern some turbulence properties and their influence on optical propagation, and the correlation between the transport of heat and moisture and the occurrence of marine fog. In the optical problem, turbulence causes beam wander and spreading and scintillation (twinkling), which cause energy density loss, resulting in information loss in the case of communication systems. The occurrence of marine fog is strongly dependent on the moisture/heat ratio in the atmosphere and the turbulent transport of these quantities is of critical importance. The goal of present investigations of turbulence properties is to enable predictions of the relevant atmospheric properties on the basis of relatively simple observations that are currently being used by weather centers. A sophisticated series of experiments is necessary at this stage of development because of the need to develop an adequate parameterization of the problem and because of the complications inherent in model development and verification.

The Naval Postgraduate School research vessel R/V Acania is the primary platform for overwater measurements and it is the system which is installed on this ship which is described here. A four-level system has been developed to measure both mean and fluctuating quantities. This system is augmented by a visiometer, a sea surface temperature probe, an acoustic sounder, and at times by balloons, kytoons or kites to make elevated measurements.

Since a ship is a non-stable platform there is always some question as to the validity of data obtained when turbulence parameters are being investigated. It is not possible to measure turbulence directly at low frequencies (<1Hz) aboard ship because the ship motion interferes in this region. At higher frequencies valid data can be obtained, and the experimental and analysis techniques described herein exploit this fact. An additional problem with shipboard measurements is the large physical size of a ship and the disturbance of the local air flow by the ship's presence. Fortunately, the R/V Acania is a fairly small and narrow ship and this effect is not large. Moreover, proper placement of sensors to take data only when the wind direction is favorable can minimize interference effects on the data. In this paper evidence is presented to show that neither ship motion nor physical presence invalidate the data displayed.

II. Shipboard Configuration

The shipboard sensor mounting arrangement is shown in Figure A-1. The sensors for mean and fluctuating wind, temperature and humidity were mounted on two towers, located approximately 2 feet and 16 feet behind the tip of the bow. The heights of the sensors above the sea surface were:

Level 1	4.2 meters
Level 2	6.6 meters
Level 3	7.6 meters
Level 4	13.9 meters

The following sensors were installed at the levels indicated on the masts:

Mean Wind	Cup Anemometer	All Levels
Mean Temperature	Quartz Thermometer	All Levels
Mean Humidity	Li Cl Cell	All Levels
Wind Fluctuation	Hot Wire	All Levels
Temperature Fluctuation	Cold Wire	All Levels
Humidity Fluctuation	Lyman - α	Levels 1 and 3

The heights and locations of the sensors were chosen in such a way to minimize shipboard influence and to measure over a wide enough height difference so that small gradients in the parameters would be detected. A subsequent improvement that allows data to be obtained much closer to the sea surface will be described at the end of this section.

The acoustic sounder was mounted on the fantail of the ship since this is the area that is most noise free. The vibrations of the deck when the ship is underway produce enough noise that useful signals can only be obtained up to about 400 meters.

The visiometer was mounted on top of the bridge on a 3-foot high support. This position placed the instrument in an uncontaminated airflow when the relative wind was within 90^{o} of the bow.

The sea surface temperature sensor was located approximately 4 feet from the starboard side of the ship and floats within one inch of the surface. The starboard side was chosen because the ship water exhausts were located on the port side.

In order to study near surface effects and to take advantage of larger gradients in the near surface region, a buoy system (Figure A-2) was developed for deployment off the bow of the Acania (Corbin, 1977). A heavy weight was suspended by cable through a hollow mast in the buoy, thus allowing the buoy to be rigidly controlled in the horizontal direction but to freely slide up and down with waves.

III. Instrumentation

A. Mean System

A block diagram of the mean system is shown in Figure A-3. The system consisted of two primary components, viz., the sensors and their associated electronics, and the data logging and readout.

The data logger was a microprogrammable integrated data acquisition system (MIDAS) which was developed at NPS specifically for acquiring shipboard meteorological data. MIDAS utilized an Intel Model 8008 Central Processor to control the sampling, averaging and recording of mean meteorological data. All software programs were written in PL/M to facilitate the writing of self-documenting programs (Plunkett, 1976).

The operator was interfaced with the system via teletype for full duplex input/output communications and program control. The operator exercised control over the sample start-time and the number of samples to be averaged before outputting. The operator could also alter the preset sample list by adding or deleting various sensors as they came on line or become inoperable. Once initiated, the system was fully automated to sample the tailored list of sensors every 30 seconds and periodically printed output values averaged over a selected interval from one to sixty minutes.

Output values were printed on the teletype in columnized format with the time of print as a leader. The teletype contained a paper tape punch that could be activated by the operator to produce a data copy concurrent with the printout. A magnetic cassette tape recorder was integrated into the system as a third data output device. This cassette is to be interfaced to a Hewlett-Packard Model 9831 Portable Computer so that profile and gradient flux estimates can be performed onboard automatically, using the BASIC programming capability of the HP 9831. Presently data cards are punched from the paper tape output and processed on the IBM 360 System at NPS.

Mean wind speeds were measured using Thornthwaite Cup Anemometer units featuring lightweight plastic sensors that ensured low wind speed response. The pulse outputs (one pulse per revolution) of the four anemometer units were fed directly to MIDAS where they were averaged and printed on the teletype at the conclusion of each preselected time period. Revolution counts were also displayed on Hewlett-Packard Model 5221A Counters for quick-look and calibration checks. The counts were converted to wind speed using the calibration parameters supplied by Thornthwaite, which were checked periodically in a wind tunnel.

The temperature transducers utilized were Hewlett-Packard Model 2833 Oceanographic (quartz crystal) Sensors, with a resolution of 0.01°C. The sensors and accompanying booster oscillators were sequentially multiplexed through a Hewlett-Packard Model 2801 Quartz Thermometer Readout Unit for monitoring.

The humidity sensors utilized were Hygrodynamics, Inc., Model 1818W Wide Range Sensors, which featured an integral thermistor probe with a resolution of 0.1°C. These units were sequentially multiplexed through a Hygrodynamics Digital II Readout Unit for monitoring both relative humidity and temperature data.

The temperature probes in the humidity sensor arrangements provided a check capability on the more sensitive quartz thermometer sensors colocated with the humidity sensors. While the resolution demanded for gradient measurements (0.01°C) could only be satisfied by the quartz thermometer system, the availability of back-up, bulk temperatures from the humidity units was useful on several occasions where conflicting profile trends were discerned in quartz temperature readings.

Temperature and humidity sensor outputs at each of the four measurement levels were multiplexed to their respective readout units using an NPS developed level selector which operated under the timing control of the MIDAS system. The level selector fulfilled two essential requirements. First, it allowed one readout unit to serve the entire profile array, thus decreasing the capital investment in equipment. Secondly, the level select unit contained the power elements for each level in the array. Thus, when individual sensors were selectively connected to their respective readout unit, only signal levels were switched at each junction. Maintaining constant powering at each level rather than switching in power concomitant with signal level switching kept line transients to a minimum and insured proper time constant response for the temperature and humidity equipment.

The quartz temperature sensors and oscillator circuit, and the humidity sensors at each level were contained within C.C. BREIDERT CO., Air-X-Houster Aspirated Weather Shelters. The mounting arrangement is shown in Figure A-4. The shelters served two purposes, viz., protecting the sensors from the marine environment, and reducing radiation effects. Radiation effects are especially severe in this application since some of the sensors are above the water and some above the deck of the ship, which is heated by the sun and radiates strongly. Because of radiation from the deck the shelters were modified by placing a shield at the base of the unit to reduce radiation from below.

B. Fluctuation System

A block diagram of the fluctuation system is shown in Figure A-5. It is immediately apparent that there are several output devices, allowing several methods of data analysis. The analog tape recorder was used to record the basic signals, which could then be analyzed in the laboratory subsequent to a field trip. The analog-digital converters and the averaging and storage were contained in the MIDAS system described above and their results were printed on the teletype at the same time as the mean system data. Averaging could also be accomplished directly on the strip chart records.

All sensors were mounted on wind vanes, with one vane per level, to maintain correct alignment with the relative wind directions.

The sensors for wind speed fluctuations were Thermo-Systems model 1210W-T1.5 probes (4.5 micron tungsten) operated as hot wires with a 50% overheat. The power and bridge for the probes was the Thermo-Systems model 1054 constant temperature anemometer, the output of which was processed by a Thermo-Systems model 1057 signal conditioner to remove the dc level. The dc level could cause the tape recorder to saturate when large fluctuation signals occurred. The signal conditioner also contained band pass filters, which were set for a range of 0.2 Hz to 1 kHz, reducing electronic noise. The 50% overheat used was high enough so that the system response to temperature fluctuations was well below the electronic noise level. The hot wire sensors were oriented with the axis of the wire in the vertical direction. With this orientation the sensor was insensitive to the vertical component of the wind, so that only horizontal fluctuations were recorded.

The sensors for air temperature fluctuations were Thermo-Systems model 1210W-P.8 (2.5 micron platinum) operated as cold wires. An ac resistance bridge, Sylvania model 140 thermosonde, which operated at 3 kHz, was adapted for shipboard use and acted as the detector. With this unit data could be obtained up to 1 kHz. It is necessary to use an ac bridge as the detector so that high sensitivity could be obtained with a very low current through the sensor. If the temperature of the sensor was elevated due to bridge current the system would sense wind speed fluctuations as well as temperature fluctuations. The bridge had a long time constant, automatic balance circuit so that slow drifts of ambient temperature were compensated.

The thermosonde configuration was such that external resistances would be used in both arms of the bridge. This allowed one to use a single sensor balanced by a precision decade resistance, or to use two cold wire sensors in the bridge. Thus, two methods were available for evaluating temperature fluctuations: (1) A single sensor, the signal being analyzed by a spectrum analyser-T' mode, and (2) two sensors spaced at a fixed separation-ΔT mode, the resulting signal being processed by an RMS module, with the average either recorded on a strip chart or by the MIDAS system.

Figure A-5 shows that the wind speed fluctuation signals were also processed by an RMS module after the signal had passed through a band pass filter. The band pass filter operated in the time domain and performed a function equivalent to the spatial filtering accomplished by the probe separation utilized in the ΔT mode for temperature fluctuations. Spatial filtering could not be used for wind speed fluctuations because it was not possible to operate two hot wires by a single bridge. Using two bridges and a different circuit introduced too much error into the process.

A final arrangement for evaluating fluctuation signals led to the differentiation of the bridge output prior to RMS analysis. Differentiation necessarily emphasizes high frequency components so that high frequency noise becomes a problem. To alleviate this problem a 1 kHz active filter with a 48 dB rolloff was used but noise problems were still severe enough so that no satisfactory results were obtained with this method.

Methods for analyzing data gathered utilizing the various experimental techniques will be described in Section VI.

Humidity fluctuations were detected with a Lyman-α cell. Difficulties were experienced in keeping this system in operation in the rigors of a marine environment and no results will be reported here.

C. <u>Auxiliary Equipment</u>

An Aerovironment model 300 Acoustic Radar was installed on the R/V Acania in order to monitor the height of the temperature inversion. The sounder transmitted a 1600 Hz pulse of sound which was scattered by small scale ambient temperature inhomogeneities. Using a facsimile recording device, the scattered return sound waves were then detected to produce the observed signal. The large temperature gradient and strong turbulence at the base of an inversion produced a strong reflected signal, so that the height of the inversion could be readily determined. It was possible to measure the strength of thermal turbulence with the acoustic sounder, but noise and calibration problems made such measurements impossible with our installation.

A Meteorology Research, Inc. model 1580A Fog Visiometer was installed on the bridge of the R/V Acania. The instrument measured the amount of light scattered from particulates and had a usable visibility range of 8 m to 13 km. The unit could be rotated so that the relative wind was incident directly on the open side of the scattering region. Rotation was necessary when the sun was low on the horizon in order to keep sunlight out of the receiving optics.

IV. Calibration

A. Mean System

1. Temperature

The mean temperature sensors (HP model 2833 Quartz) were calibrated using standard laboratory thermometric techniques. Since the system was used to measure the gradient of a temperature profile, the relative consistency of the sensors was considered more important than the absolute temperature calibration. All five sensors were greased and screwed into a 3-inch aluminum cylinder fitted with a center-mounted thermocouple. The aluminum cylinder was O-ring fitted into a copper pipe long enough (24 inches) to permit coiling of the majority of the armored sensor cable in the temperature controlled environment. The pipe and cylinder unit were immersed in a 15-liter glass Dewar flask filled with a mixture of water and ice. The cylinder and pipe combination allowed the sensors and cables to be surrounded by the bath without actually getting wet. The large mass and excellent thermal conductivity of the copper and aluminum eliminated transient fluctuations and reduced inter-sensor temperature differences to a few thousandths of a centigrade degree.

The normal calibration procedure was to cool the sensors to about 15^{o}C while monitoring their indicated temperatures with printout from MIDAS at one minute intervals. Once equilibrium was reached, the sensor oscillators were adjusted so that (if possible) all sensors read within .01^{o}C of each other. The temperature was then varied in 2-3^{o}C increments by adding ice or warm water and noting the MIDAS printout values when a new equilibrium was reached. Initially, the temperatures were compared to the thermocouple values (data set 1/7/76, Table A-1) but

TABLE A-1 Mean Temperature Calibrations

T, °C

	TC	0	1	2	3	4
	.01	.02	.00	.02	-.01	.02
	5.25	4.94	4.93	4.94	4.92	4.94
1/7/76	7.50	7.24	7.24	7.25	7.23	7.24
	9.45	9.21	9.22	9.22	9.21	9.21
	11.95	11.64	11.66	11.65	11.65	11.65
	13.35	13.05	13.08	13.06	13.06	13.06
	14.85	14.53	14.56	14.54	14.55	14.54
	23.25	22.86	22.89	22.87	22.88	22.87
		8.61	8.60	8.62	8.61	8.62
2/9/77		13.14	13.14	13.15	13.15	13.16
		20.54	20.50	20.51	20.52	20.53

this was later deemed unnecessary. One problem with the system developed due to using quartz sensors with different calibration properties. In data set 1/7/76 (Table A-1) sensors 1 and 3 are from a different batch than 0, 2 and 4. This led to increasing disagreement at the extremes of the calibration range. This problem was alleviated by ordering more sensors and specifying characteristics to match sensors 0, 2 and 4 (data set 2/9/77, Table A-1). With this improvement, the accuracy of a single sensor (relative to the average of all five) was no worse than ± .02°C over a reasonable operating range. Note that this is the accuracy of the temperature sensor only and does not include errors introduced by the aspirators. The relative aspirator temperature error depends most strongly on the amount and uniformity of solar heating; this error is quite small at night or under heavy clouds but may be as great as ± .1°C in bright sunlight with light winds.

2. Humidity

To determine their accuracy and reproducibility, detailed examination in laboratory conditions has been made of the calibration characteristics of the Hygrodynamics Digital Hygrosensor. The calibrations were based on ambient humidity variations (from 24% RH to 50% RH over a one month period), as measured with a Bendix Psychron Wet-Dry Bulb Psychrometer, and controlled humidity (from 40% RH to 99% RH), as measured by a wet-dry thermocouple in a 2-x 3-x 3-foot fog chamber adapted for these experiments. The air circulated through the chamber could be prehumidified in a column of wet glass beads giving nominal humidity of about 80%. High humidities (up to 99% RH) could be obtained by introducing varying amounts of water in the form of a fine mist into the chamber. In general, the humidity in the chamber could be stabilized for periods of several hours and was uniform throughout the chamber to within 1% RH.

The hygrosensor was a Dunmore-type lithium chloride sensor whose resistance varies in proportion to the relative humidity to which it is exposed. It is a slow-response sensor and is generally utilized in mean system measurements. The standard procedure of calibrating these sensors in a small chamber with a saturated salt solution of known vapor pressure was not satisfactory for a program of calibration of eight sensors. This was primarily due to a lack of confidence in our ability to reproduce humidity conditions in consecutive sensor calibrations. Attempts to calibrate all eight sensors simultaneously in a large volume chamber were complicated by temperature drifts that made it difficult to assure equilibrium conditions necessary to the accuracy of the technique. As a result, it was decided to use the humidity controlled chamber previously described. The quantitative results of a series of calibrations are given in Table A-2; in general, the eight-sensor average agreed with the psychrometer standard to -0.4 ± 2.9% RH for measurements taken with equilibrium times of order one hour. The individual total humidity accuracy of the sensor was of less importance than the relative consistency within the group of sensors, since they were used in a four-level system to determine humidity gradients. In this respect, they could be calibrated in the laboratory to ± 1% RH, subject to assurances of sufficient time for response.

The suitability of the hygrosensors for shipboard measurement of humidity gradients was reduced by two inherent properties of the device. An aspirated, teflon-coated sensor has a time constant of about 30 minutes, but this varies from sensor to sensor. Therefore, the humidity difference read between two sensors will be unreliable if the humidity is changing faster than about 10% RH per hour. A more serious deficiency appears if the sensors are exposed to humidities above 95% RH. At those high humidities, the sensors become sluggish and exposure to 99% RH may cause the sensors to be useless for as long as several days. Further uncertainties are introduced by the use of long cables in the shipboard system and by the accumulation of sea salt on or near the sensors.

TABLE A-2 Hygrodynamics Digital II Calibrations

Wet-Dry Bulb %RH	Ave Hygro %RH	1	2	3	4	5	6	7	8
33.	31.6	1.4	-1.4	-0.6	1.5	-0.2	-1.6	-0.9	1.8
36.	37.2	-0.5	-0.8	-0.3	1.6	0.5	-1.4	-0.1	1.2
44.	41.2	-0.8	-0.4	-0.3	0.6	0.9	0.4	-0.1	0.3
NA	41.5	-0.5	-0.4	-0.3	0.5	0.9	-0.4	-0.1	-0.1
NA	42.6	-1.2	-0.5	-0.5	-0.9	1.8	-0.4	-0.2	0.1
NA	65.8	-0.2	-1.4	-2.5	0.8	1.8	-0.3	1.3	0.3
74.8	73.6	0.2	0.2	-1.3	0.5	-0.2	0.4	-0.4	0.8
88.3	85.0	-0.7	0.9	-0.4	0.1	-0.6	0.0	0.4	0.2
82.6	86.7	-1.4	-0.6	-0.5	0.1	-0.2	0.3	0.7	0.3
82.6	87.0	-1.0	0.5	-0.7	0.0	0.3	0.7	0.0	0.2
85.0	88.0	-0.4	1.1	-0.1	0.1	-1.8	1.1	-0.6	-0.1
93.9	89.6	0.1	0.8	-0.2	0.3	-2.2	2.1	-1.5	0.4
94.4	92.3	-0.6	1.1	-0.5	-0.3	-0.4	1.2	-0.5	0.4
94.4	93.6	-0.8	1.0	-0.8	-0.3	0.4	-0.2	0.8	-0.4
Ave Deviat.		-0.5	-0.0	-0.6	0.3	0.1	0.1	-0.1	0.4
σ		0.7	0.9	0.6	0.7	1.1	1.0	0.7	0.6

The average deviation of the wet-dry bulb from the Ave Hygro reading 0.4% RH with a standard deviation of 2.9% RH.

3. Velocity

The mean wind velocity sensors (Thornthwaite cup anemometers) were calibrated in a wind tunnel with a nominal one meter square test section. The cups were calibrated four at a time with a symmetrical placement to reduce relative velocity differences. A summary of the calibration is shown in Figure A-6 expressed as individual cup velocity deviations from the wind tunnel velocity. From this data it can be concluded that, for gradient purposes, the cup anemometers were accurate to about ± 4%. The deviation of the calibration curve at low wind speeds is due to errors in the determination of wind tunnel velocity values.

B. Fluctuation System

The essence of the fluctuation calibrations is contained in establishing the relation between the instrumental voltage variation, V', about mean voltage, $\overline{V}$. with respect to the atmospheric fluctuation, X', about its mean value $\overline{X}$, i.e.

$$X' = F(\overline{V}, \overline{X})\, V' \qquad (1)$$

The calibration factor $F(\overline{V}, \overline{X})$ may be a function of individual sensors as well as the instrument being used. This process is usually accomplished by measuring the dependence of $\overline{X}$ on $\overline{V}$ and relating it to $F(\overline{V}, \overline{X})$ through the derivative,

$$F(\overline{V}, \overline{X}) = \left(\frac{d\,\overline{V}\,(\overline{X})}{d\,\overline{X}}\right)^{-1} \qquad (2)$$

1. Temperature

The appropriate temperature fluctuation expression is:

$$T' = (\alpha G R)^{-1} V' \quad (3)$$

where α is the temperature-resistivity coefficient of the platinum sensor wire, G is the gain factor of the thermosonde (set at G = 20 volt/Ω), and R is the resistance of the sensor. In a previous work (Schacher and Fairall, 1976) it was found that $\alpha = .0036\ ^{o}C^{-1}$ with little variation from sensor to sensor. The frequency response of the thermosonde units was about 1 kHz.

2. Humidity

The Lyman-alpha sensor measures humidity as a function of the absorption of ultraviolet light at the 1215Å Lyman-alpha transition of hydrogen in water vapor. It consists simply of a UV source tube and detector, separated by an absorbing air gap.

The detector voltage is proportional to the total light transmitted and is related to the absolute humidity, q (in mb), by the equation

$$V = V_o \exp(-\lambda \overline{q}) \quad (4)$$

The Lyman-alpha is a fast response device and is specifically used for measurement of humidity fluctuations, q'

$$q' = -\frac{1}{\lambda} \frac{V'}{\overline{V}} \quad (5)$$

The quantity V_o in Eq. (4) is the dry-air voltage which can be found by bathing the detector in dehumidified air. Since water soluble windows

(LiF or MgF_2) are required for transmission in the ultraviolet, V_o is a highly variable quantity, a property which makes the Lyman-alpha a poor device for measurement of total humidity, $\overline{q}$. However, Eq. (5) shows that the fluctuating part, q', depends only on λ, which is a property of water vapor and the gap setting only and is independent of the window condition so that q' can be reliably measured. The Lyman-alpha was calibrated in dry air, ambient air, and in the humidity chamber and it was found that $\lambda = .225\ mb^{-1}$ for source = 50 μa and a 1 cm air gap (Fig. A-7).

Feasibility of the Lyman-alpha sensor for shipboard humidity fluctuation measurements is subject to considerations of the survivability of the windows in the ocean environment of high humidity, sea spray, and rain. In the laboratory humidity chamber, V_o was found to be reduced by a factor of four after a three-day exposure to 85% humidity. Consequently, it was necessary to provide physical protection for the sensors during routine operations.

3. Velocity

The hot wires (or hot films) were calibrated using a TSI 1125 calibrator. It was important to use the actual cables from the shipboard system (or their equivalent) to prevent errors due to voltage drops in the cable. The appropriate mean dependence function is

$$\overline{V}\ (\overline{U}) = (V_o^{\,2} + B\sqrt{\overline{U}}\ )^{\frac{1}{2}} \qquad (6)$$

where V_o^2 and B are obtained for each sensor at a specific overheat. The derivative of (6) yields the fluctuation calibration factor

$$U' = \frac{4\,\overline{V}\sqrt{\overline{U}}}{B}\ V' \qquad (7)$$

The frequency response of the velocity bridge was about 20 kHz. The sensor frequency response depends on the sensor diameter and overheat, but was typically greater than 1 kHz (Fairall and Schacher, 1977).

V. Data Acquisition

Three criteria applied when deciding the methods for acquiring data: 1) data was to be taken for a wide range of local meteorological conditions, 2) a given condition should be tested several times, preferably on different days and/or locations to test the statistical validity of the data, and, most importantly, 3) shipboard conditions must be such that valid data can be obtained.

The most important consideration to insure validity of the data was the airflow over the ship. Since all of the sensors were located close to the bow of the ship the relative wind had to be from the bow or the ship could severely influence the data obtained. It was found that data could be taken when the wind was within 30° of the bow. When the wind was more than 45° from alignment with the bow the wind profiles were noticeably affected. The position of the sun was a second consideration. When the sun was low on the horizon and behind the ship the aspirators for levels 1 and 2 were in shadow and those for levels 3 and 4 were in sunlight. Under this condition the temperatures at the upper levels were elevated enough to make the obtained temperature profiles invalid.

Since data was acquired on a fluctuating system, a time average had to be performed to obtain final parameters. Averaging over 10-minute and 20-minute time spans was accomplished depending on the situation. Thus, data had to be acquired in such a way that the conditions remained constant over a time at least as long as the planned average time. This means that there had to be close coordination between scientific personnel and ship crew so that no course changes occurred during a data taking run. Of course, changes in local conditions also affected the data, such as moving through the edge of a fog bank. Even seemingly inconsequential occurrences such as moving into the lee of an island when the ship was several miles offshore could affect the data. A running log of all ship maneuvers and position, and of local conditions was maintained and no averages were performed for which it was suspected that any condition changed during the time period under consideration.

Several tests were made and it was found that data could be taken both with the ship at rest and underway. However, some of the subsequent calculations then required that the true wind over the surface of the water be known accurately. Uncertainties as to the ship's actual speed make calculation of true wind from the relative wind and ship heading and speed too inaccurate. Thus the ship was stopped frequently in order to obtain the true wind.

VI. Data Analysis

The analysis procedures changed considerably as the instrumentation evolved towards increased automation. Averaging of mean data, initially, a painstaking hand process, is now performed by MIDAS at specified time intervals (typically 10, 20 or 30 minutes). Rather than describing all techniques that have been used, discussion is limited to those of more recent application.

A. Mean Profile Analysis

The mean profiles and gradients were established under the assumption of the logarithmic height dependence.

$$\overline{X} = A \log Z + B \tag{8}$$

The gradient at the height Z is

$$\frac{d\overline{X}}{dz} = \frac{A}{Z} \tag{9}$$

In the case of temperature, one is interested in the potential temperature, θ,

$$\overline{\theta} = \overline{T} + .0098\ Z \tag{10}$$

and the virtual potential temperature, θ_v,

$$\overline{\theta}_v = \overline{\theta} + .61\ q\ \overline{T} \tag{11}$$

where q is the specific humidity in grams of water vapor per gram of dry air. The actual fits of the data were done either by the standard least squares method or by subjective ("eyeball") graphical techniques. The presence of individual erroneous values due to printer errors, microprocessor errors, and instrumental glitches required the data to be subjectively edited even in the least squares analysis. In either case, one is required to identify and reject "bad" values - a delicate and unsatisfying process. Figure A-8 shows examples of profiles in temperature, humidity and velocity.

B. Turbulence Analysis

There are four different methods available to calculate turbulence parameters from the fluctuations in the atmospheric variables: spectral, derivative (dissipation), difference, and RMS. The spectral method is based upon the assumption of "local isotropy" and the Kolmokorov -5/3 slope of the one-dimensional power spectral density, $\phi_x(k)$,

$$\phi_x(k) = .25\, C_x^{\,2}\, k^{-5/3} \qquad (12)$$

where C_x is the structure function for the parameter x and k is the wave number. Using Taylor's "frozen turbulence" hypothesis ($k = 2\pi f/\overline{U}$), C_x is found by performing a fourier spectrum analysis of a signal in the frequency domain (f),

$$f\,\phi_x(f) = k\,\phi_x(k) = .25\, C_x^{\,2} \left(\frac{2\pi f}{\overline{U}}\right)^{-2/3} \qquad (13)$$

Therefore,

$$C_x^{\,2} = 4\left(\frac{2\pi}{\overline{U}}\right)^{2/3} \left[f^{5/3}\,\phi_x(f)\right] \qquad (14)$$

which is expected to apply in the frequency range from about 0.1 to 100 Hz. (This is the inertial subrange of turbulence.) The structure function can also be found by measuring the variance of the difference in the variable X at two points separated by a known distance, d,

$$C_x^{\,2} = \overline{[X(r) - X(r+d)]^2}\; d^{-2/3} \qquad (15)$$

Defined in this manner, C_x^2 is independent of d in the inertial subrange. The RMS method is based upon measuring the variance of the signal fluctuations between selected frequency limits and relating this to C_x^2 through Eq. (13):

$$\int_{k_\ell}^{k_u} \phi_x (k)\, d\, k = \overline{X'^2} = (X'_{rms})^2 \qquad (16)$$

Again assuming $k = 2\pi f/\overline{U}$, then

$$C_x^2 = \frac{8}{3} \left(\frac{2\pi}{\overline{U}} \right)^{2/3} \frac{(X'_{rms})^2}{(f_\ell^{-2/3} - f_u^{-2/3})} \qquad (17)$$

where f_u and f_ℓ are the upper and lower frequency limits, and X'_{rms} represents the measured RMS fluctuations of the filtered signal. Since the rate of velocity turbulence dissipation, ε, is traditionally used, rather than C_u^2, one should use the relation

$$C_u^2 = 2.0\, \varepsilon^{2/3} \qquad (18)$$

to calculate ε. Due to the extreme sensitivity to high frequency noise, it was found that the derivative method was unsatisfactory for shipboard data.

The spectral method was used to calculate C_T^2, C_q^2 and ε (data shown in Figure A-9). This method has the advantage that the quality of the data is immediately obvious and noise spikes (60, 120, 130 Hz) can be ignored. The primary disadvantage of the spectral method is the time required to analyze four levels of data with two or three signals for each level. Although it requires two microthermal sensors per level, the difference method has proven to be an ideal technique for measuring C_T^2 because the RMS temperature difference fluctuations (Eq.15) can be automatically averaged using the ADC capability of MIDAS. Since this is a temperature difference measurement, it is less subject to external sources or error (such as humitity - salt induced temperature spikes (Friehe, 1977)). The RMS technique has proven to be quite satisfactory for measuring ε, since it too lends itself to automatic averaging on MIDAS. Comparison of spectral and RMS measurements of ε, through the quantity $U_* = (K Z \varepsilon)^{1/3}$, (Fig. A-10) are quite consistent. U_* is the friction velocity, K is Von Karmon's constant (.35) and Z is the height above the surface. This expression is valid for near neutral stability where most of the data was taken.

VII. Experiments Performed

Observational experiments were conducted aboard the R/V Acania (Figure A-1) during cruises to San Nicholas Island (SNI), in the vicinity of SNI, in Monterey Bay, and on an open ocean cruise in the fall of 1976. Dates and locations of the experiments which yielded results presented here are listed in Table A-3.

The route taken to and from SNI appears in Figure A-11 for that portion of the cruise for which data was taken. The ship's anchorage, position, and track in the vicinity of the northwest tip of SNI appear in Figure A-12. For Monterey Bay results, all data were collected while the R/V Acania was anchored. The general anchorage locations which were used in Monterey Bay appear in Figure A-13. The anchorage locations were changed to accommodate coincident ship to shore or shore to shore optical propagation experiments. Wind directions during the Monterey Bay experiments were generally from the north to northwest so the location of anchorage is not expected to be a factor in the results and they are not distinguished with regard to location. Details pertaining to the 1976 open ocean cruise appear in a separate report, Fairall, et al. (1978).

Changes were made in the shipboard measurement systems and sensor mounting arrangements during the sequence of experiments associated with these results. In general, mounting arrangements were changed to improve the vertical resolution of the measured parameters. During the first SNI cruise (1-4 March 1973), fluctuation (temperature and velocity) measurements were made at only two levels and mean wind, temperature and humidity measurements were made only at one level. Sea surface temperature was also measured. During the second SNI cruise (19-23 September 1973), both fluctuation and mean measurements were made at four levels which differed slightly from the final configuration shown in Figure A-1. All the Monterey Bay experiments were performed with the final mounting configurations described above. Sensors described for fluctuation and mean measurements were used in all experiments but the recording systems, particularly that for the mean data, were changed.

Additional discussions on analyses, instrumentation and experimental conditions, along with additional results, are contained in theses listed in the references, which utilized data from these experiments.

TABLE A-3

SUMMARY OF OBSERVATIONAL EXPERIMENTS TO FEBRUARY 1977

	Date	Location	Prevailing Condition
1973	1-5 Mar	SNI	Unstable
	18-21 Sep	SNI	Neutral-Stable
	15-19 Oct	Mtry Bay	Unstable
	26 Nov-5 Dec	Mtry Bay	Unstable
1974	15-18 Jan	Mtry Bay	Unstable
	25-26 Feb	Open Ocean	Stable
	27-29 Feb	Mtry Bay	Stable
	6-7 Mar	Mtry Bay	Stable
	13-15 Mar	Mtry Bay	Stable
	25-28 Mar	Mtry Bay	Unstable
	17-21 Jun	SNI	Neutral
	12-16 Aug	Mtry Bay	Neutral-Unstable
	16-21 Sep	Open Ocean	Unstable
	18-22 Nov	Mtry Bay	Neutral-Unstable
1975	9-10 Jan	Mtry Bay	Stable
	24-28 Mar	Mtry Bay	Unstable
	20-24 May	Mtry Bay	Neutral
	25-29 Aug	Mtry Bay	Neutral
	11-16 Sep	Open Ocean	Unstable
	9-11 Dec	Mtry Bay	Unstable
1976	29 Mar-2 Apr	Mtry Bay	Unstable
	26-30 Apr	Mtry Bay	Neutral-Unstable
	26-30 Jul	Mtry Bay	Neutral
	20 Sep-14 Oct	Open Ocean	Neutral-Unstable
1977	15-18 Feb	Mtry Bay	Neutral

VIII. System Evaluation

A. Mean System

Accurate measurements of atmospheric surface gradients, especially in the marine boundary layer, are extremely difficult. The severity of the problem can be illustrated by noting typical conditions in the marine boundary layer (Table A-4) in terms of the typical gradients ($\partial\overline{X}/\partial Z$ Z = 10 meters), scaling parameters (X_*) and total difference from Z = 5 to Z = 15 meters ($\Delta X = |\overline{X}(15) - \overline{X}(5)|$). The scaling parameter is defined by

$$\partial\overline{X}/\partial Z = \frac{X_*}{KZ} f_x \tag{19}$$

where f_x is a stability corrections factor (Businger, et al., 1971). To measure X_* to 10% accuracy requires the single level accuracies indicated in the table, compared to our present accuracies. The temperature, T, is used in the table rather than the virtual temperature because it is the variable actually measured.

Although the gradients are not required to calculate the turbulent parameters, they are of utmost importance in evaluating the theoretical behavior of the boundary layer through specification of the stability (Richardson number) and through normalization of the turbulence parameter, C_N^2 (Wyngaard, et al., 1971). This lack of gradient accuracy led to construction of a near surface buoy system to exploit the Z^{-1} dependence of the gradients. With the present systems, the gradient measurements represent the weak link in efforts to evaluate the turbulent boundary layer similarity expressions in the marine environment.

B. Fluctuation System

Despite a large array of factors influencing the performance of the turbulence measurement system (noise, ship effects, salt on sensors,

TABLE A-4

Typical Marine Boundary Layer Profile Parameters

	$\overline{T}$, °C	$\overline{U}$, m/sec	$\overline{q}$, gm/kgm
$(\partial\overline{X}/\partial z)_{10\ met}$	- .020	.040	- .025
X_*	- .07	.15	- .08
ΔX	.20	10 %	5 %
Present Accuracy	?	5 %	3 %
Required Accuracy	.04	2 %	1 %

calibration accuracy) the values of turbulence parameters were quite consistent. Figure A-14 is a time history of four levels of C_T^2 and ε showing the expected height dependence. Figure A-15 is a similar plot for three levels of ε. The scatter inherent in the ε data is nicely illustrated by removing the height dependence in a U_* time history (Fig. A-15) of buoy data. Note that the single level scatter is much smaller than the level-to-level disagreements. The average profile estimate (based on Eq. 19) of U_* is about .12 m/sec whereas the average turbulence estimate is about .10 m/sec. This is, in fact, good agreement and illustrates the superiority of the buoy system for gradient measurements. The compatability of gradient and turbulence measurements can be examined in calculations of normalized heat flux, F_h, using the profile method

$$F_h = - K_T (\partial\theta/\partial Z) \quad (20)$$

and the turbulence method

$$F_h = \pm C_T \varepsilon^{1/3} F(R_i) \quad (21)$$

where K_T and $F(R_i)$ are functions of stability. These methods have been favorably compared (Fairall, et al., 1978) for fog events during a marine fog study called CEWCOM-76 (Fig. A-16).

C. Summary

It is apparent that this line of research is permeated with instrumental difficulties. The atmospheric gradients over the ocean are small enough so that even state-of-the-art mean measurements give fairly poor accuracy. The turbulence measurements are inherently well above noise levels but the sensors are subject to an array of environmental problems: salt and water films, platform motion, aerodynamic flow distortion by the ship, radio and radar interference, and even corrosion. Despite these problems, the system described in this paper has yielded valuable and unique data about the open ocean boundary layer. Those theoretical discrepancies that still exist will hopefully be resolved through the continual evolution and improvement of instrumentation and measurement techniques.

References

1. Atkinson, H.E. III, "Turbulent flux estimates from shipboard mean wind and temperature profiles and dissipation rates", M.S. Thesis, Naval Postgraduate School, Monterey, California (1976).

2. Businger, J.A., J.C. Wyngaard, Y. Izumi, and E.F. Bradley, "Flux profile relationships in the atmospheric surface layer", J. Atmos. Sci. 28, 181-189 (1971).

3. Cavanaugh, M.P., "Examination of shipboard measurements of the vertical profiles of mean temperature, humidity, and wind speed", M.S. Thesis, Naval Postgraduate School, Monterey, California (1974).

4. Corbin, J.H., "Measurements of near surface turbulence and possible wave influence", M.S. Thesis, Naval Postgraduate School, Monterey, California (1977).

5. Fairall, C.W. and G.E. Schacher, "Frequency response of hot wires used for atmospheric turbulence measurements in the marine environment", Rev. Sci. Instrum. 47, 12-17 (1977).

6. Fairall, C.W., K.L. Davidson, T.M. Houlihan, and G.E. Schacher, "Atmospheric turbulence measurements in marine fog during CEWCOM-76", J. Geoph. Res. (submitted 1978).

7. Friehe, Carl A., "Estimation of refractive-index temperature structure parameter over the ocean", Appl. Opt. 16, 334-340 (1977).

8. Hughes, M.M., "An investigation of optically relevant turbulence parameters in the marine boundary layer", M.S. Thesis, Naval Postgraduate School, Monterey, California (1976).

9. Johnston, W.E., "Estimating boundary layer fluxes from dissipations of turbulent kinetic energy and temperature variance", M.S. Thesis, Naval Postgraduate School, Monterey, California (1974).

10. Karch, G.W., "An examination of turbulent dissipation in the marine boundary layer", M.S. Thesis, Naval Postgraduate School, Monterey, California (1976).

11. Lund, A.B., "Spectral estimates of marine turbulence data", M.S. Thesis, Naval Postgraduate School, Monterey, California (1975).

12. Macias, V. Jr., "An investigation of electro-optical turbulence parameters", M.S. Thesis, Naval Postgraduate School, Monterey, California (1977).

13. Plunkett, J.R., "A microprogrammable data acquisition and control system (MIDAS II A) with application to mean meteorological data", M.S. Thesis, Naval Postgraduate School, Monterey, California (1976).

14. Schacher, G.E. and C.W. Fairall, "Use of resistance wires for atmospheric turbulence measurements in the marine environment", Rev. Sci. Instrum. 47, 703-707 (1976).

15. Schutt, W.L., "An investigation of small scale humidity fluctuations in the marine boundary layer", M.S. Thesis, Naval Postgraduate School, Monterey, California (1976).

16. Smedley, G.W., "Investigations of vertical profiles of mean temperature, wind and humidity", M.S. Thesis, Naval Postgraduate School, Monterey, California (1975).

17. Welsh, P.T., "An investigation of ship related motion and its effect on turbulence measurements", M.S. Thesis, Naval Postgraduate School, Monterey, California (1974).

18. Wyngaard, J.C., Y. Izumi and S.A. Collins, "Behavior of refractive-index structure parameter near the ground", J. Opt. Soc. Am. 61, 1646-1650 (1971).

Figure A-1

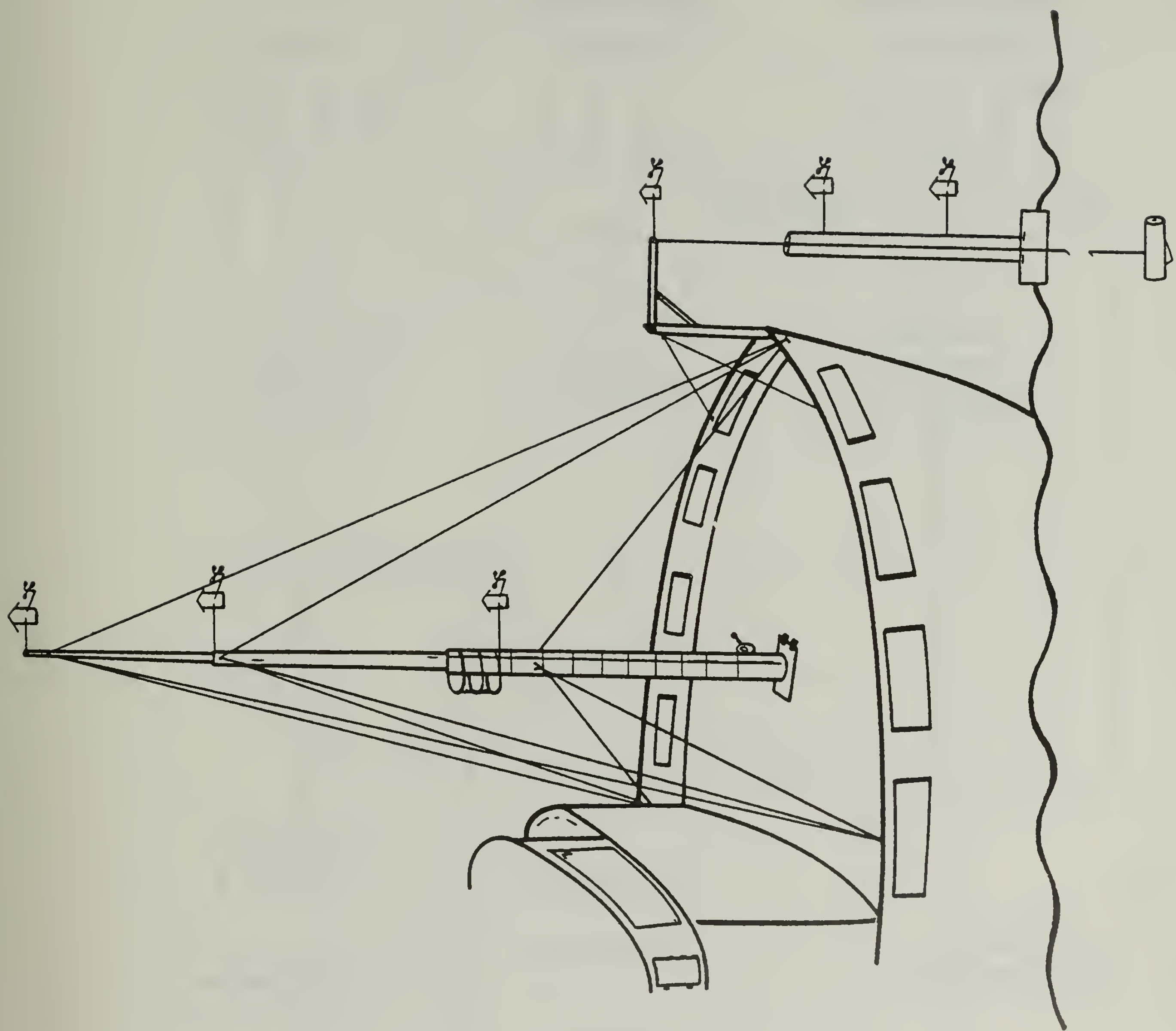


Figure A-2

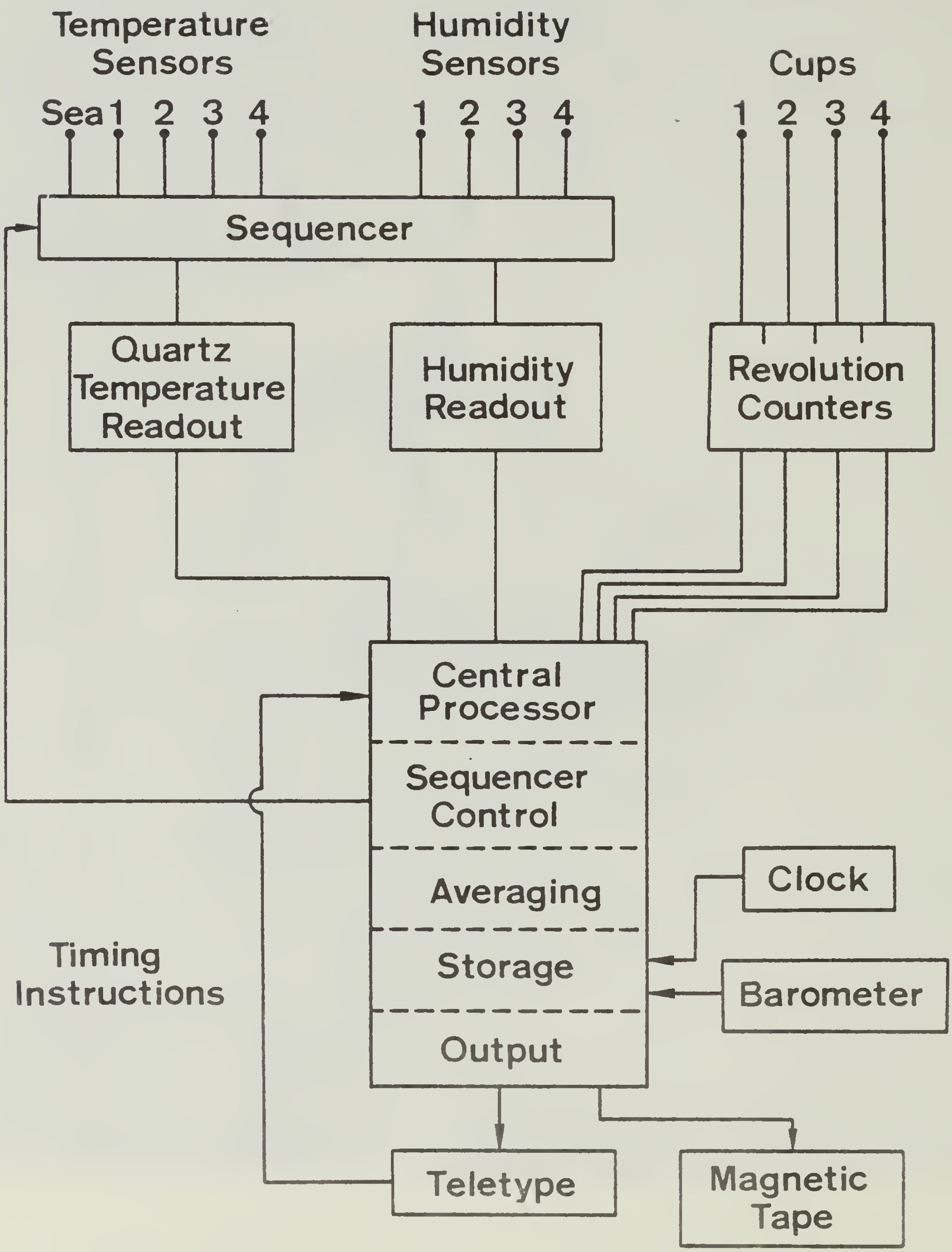

Temperature Sensors
Sea 1 2 3 4
Humidity Sensors
1 2 3 4
Cups
1 2 3 4
Sequencer
Quartz Temperature Readout
Humidity Readout
Revolution Counters
Central Processor
Sequencer Control
Averaging
Storage
Output
Clock
Barometer
Timing Instructions
Teletype
Magnetic Tape

Figure A-3

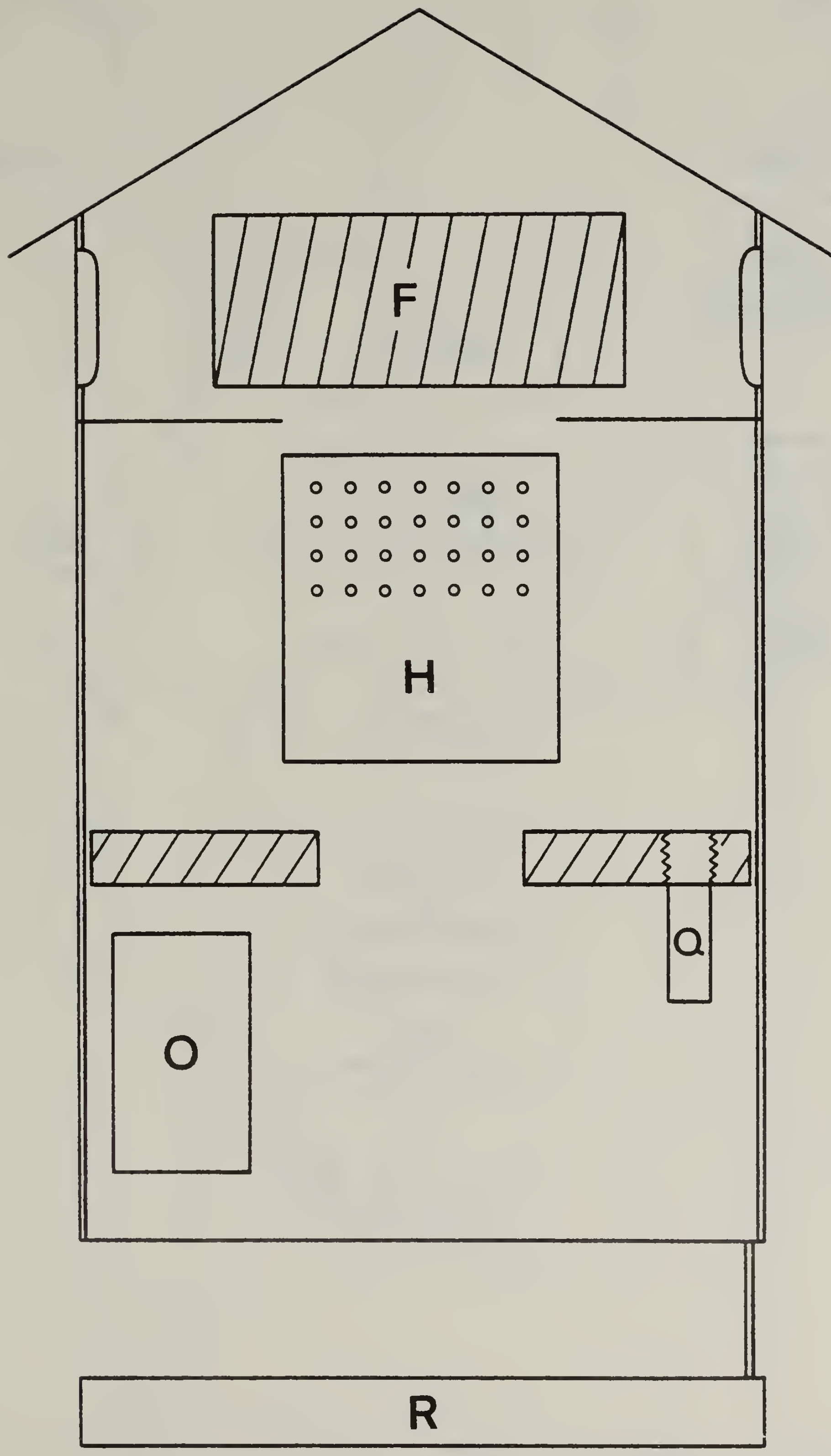


Figure A-4

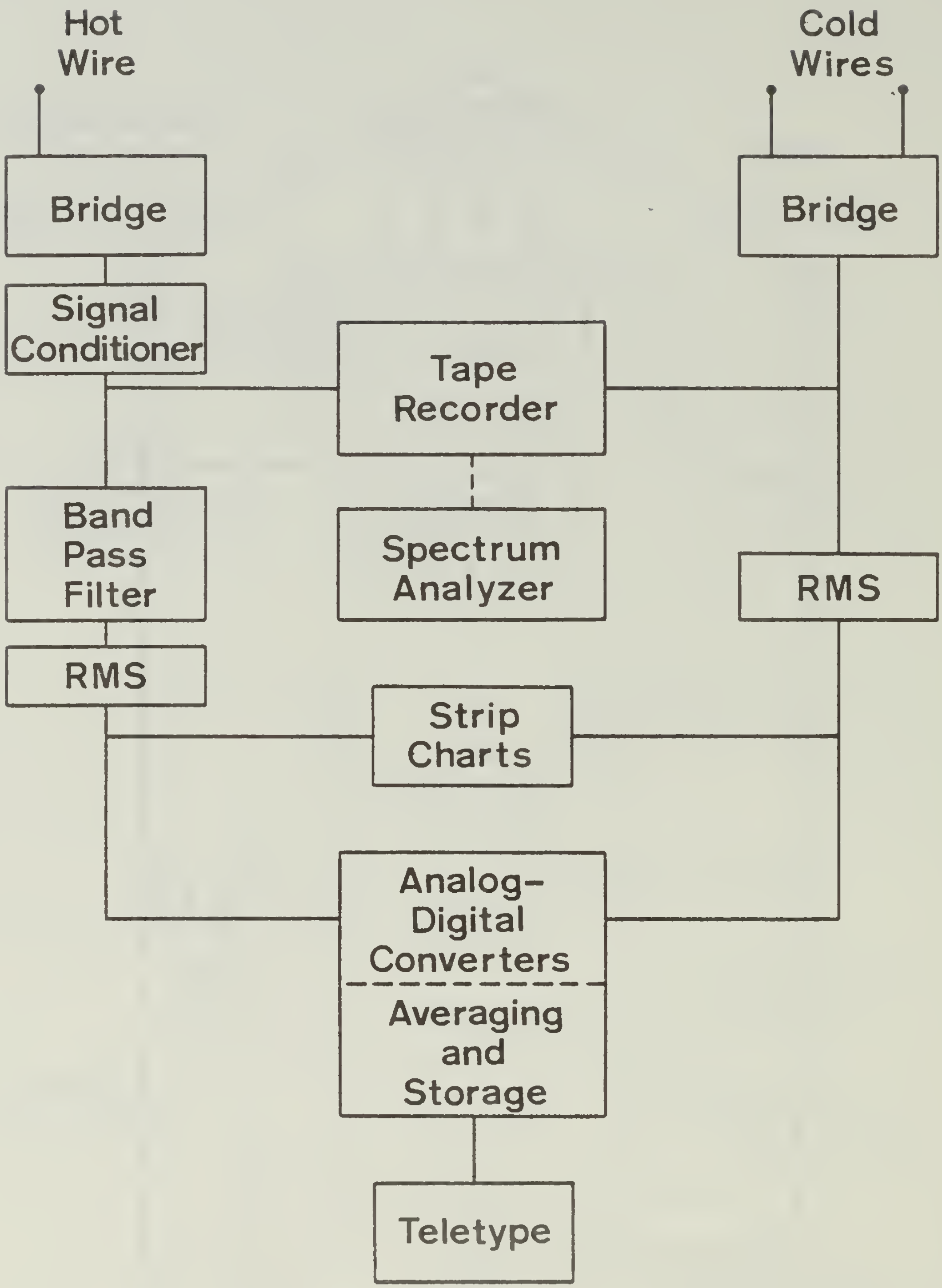

Hot Wire
Cold Wires
Bridge
Bridge
Signal Conditioner
Tape Recorder
Band Pass Filter
Spectrum Analyzer
RMS
RMS
Strip Charts
Analog-Digital Converters
Averaging and Storage
Teletype

Figure A-5

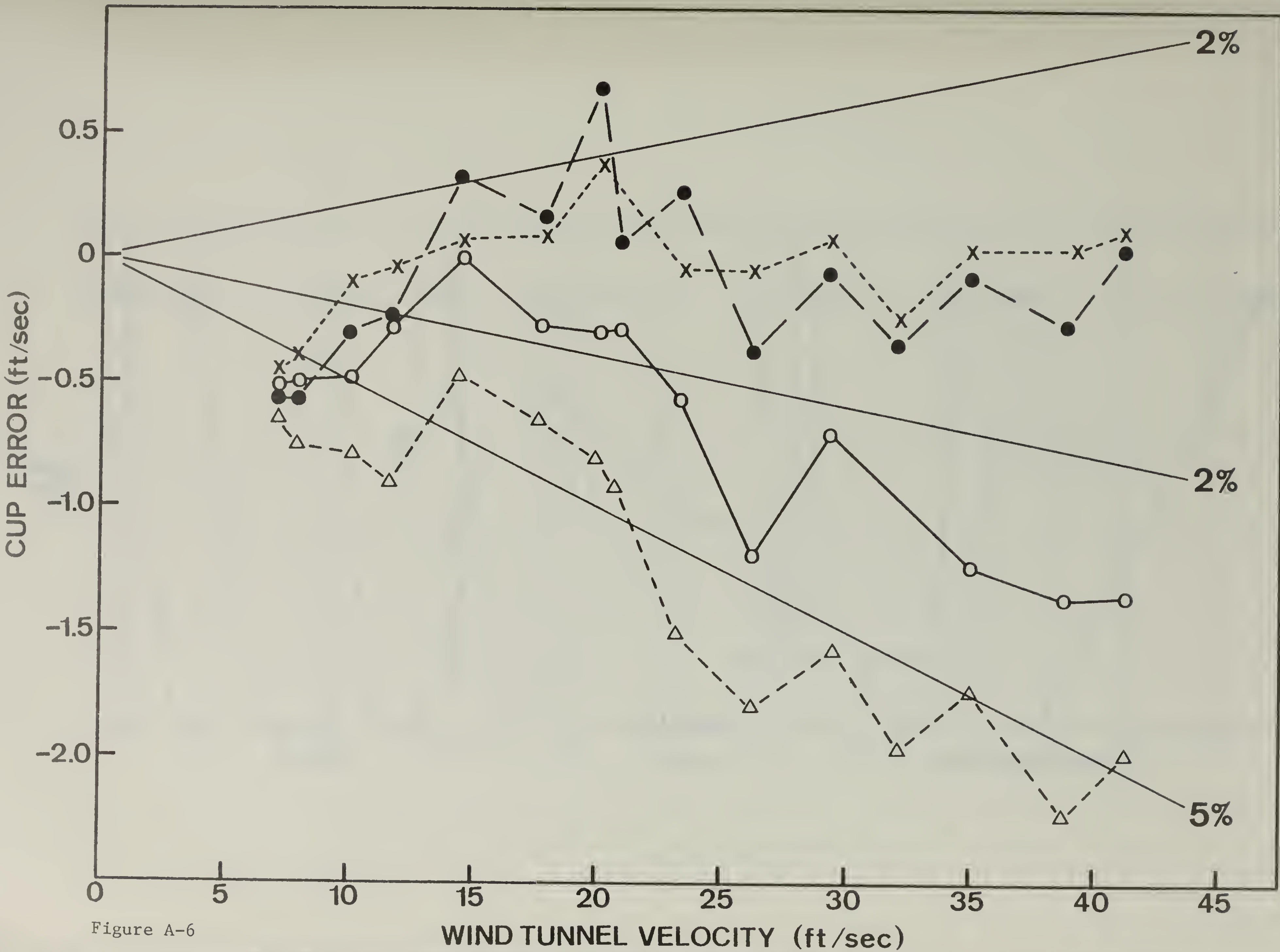

2%
2%
5%
0.5
0
-0.5
-1.0
-1.5
-2.0
CUP ERROR (ft/sec)
0
5
10
15
20
25
30
35
40
45
WIND TUNNEL VELOCITY (ft/sec)

Figure A-6

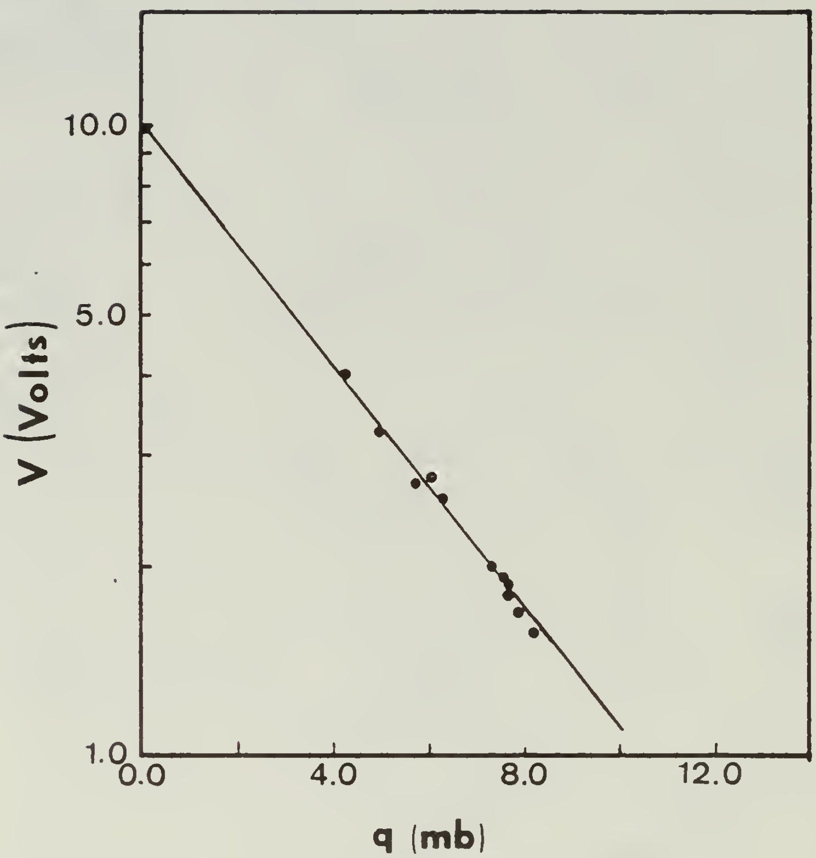
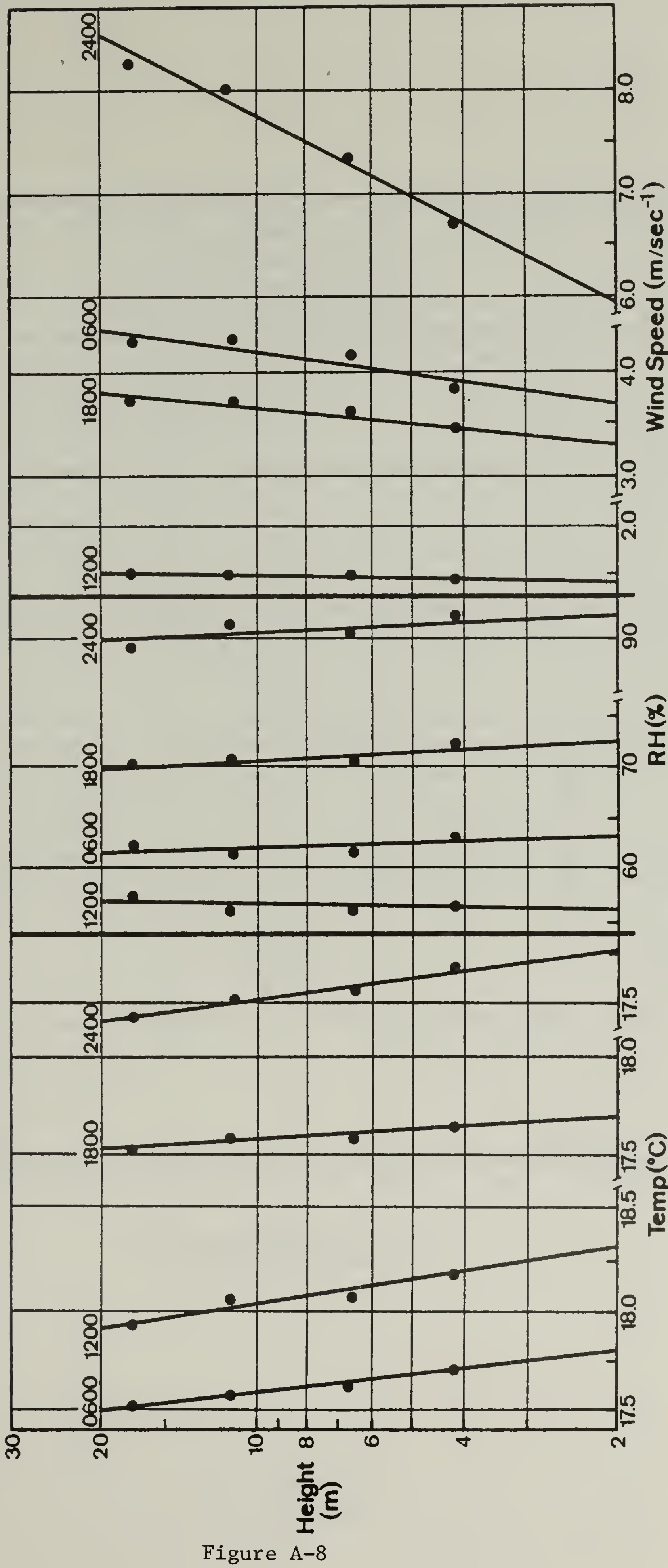


Figure A-7



Height (m)
30
20
10
8
6
4
2
0600
1200
1800
2400
17.5
18.0
18.5
Temp(°C)
60
70
90
RH(%)
2.0
3.0
4.0
6.0
7.0
8.0
Wind Speed (m/sec-1)

Figure A-8

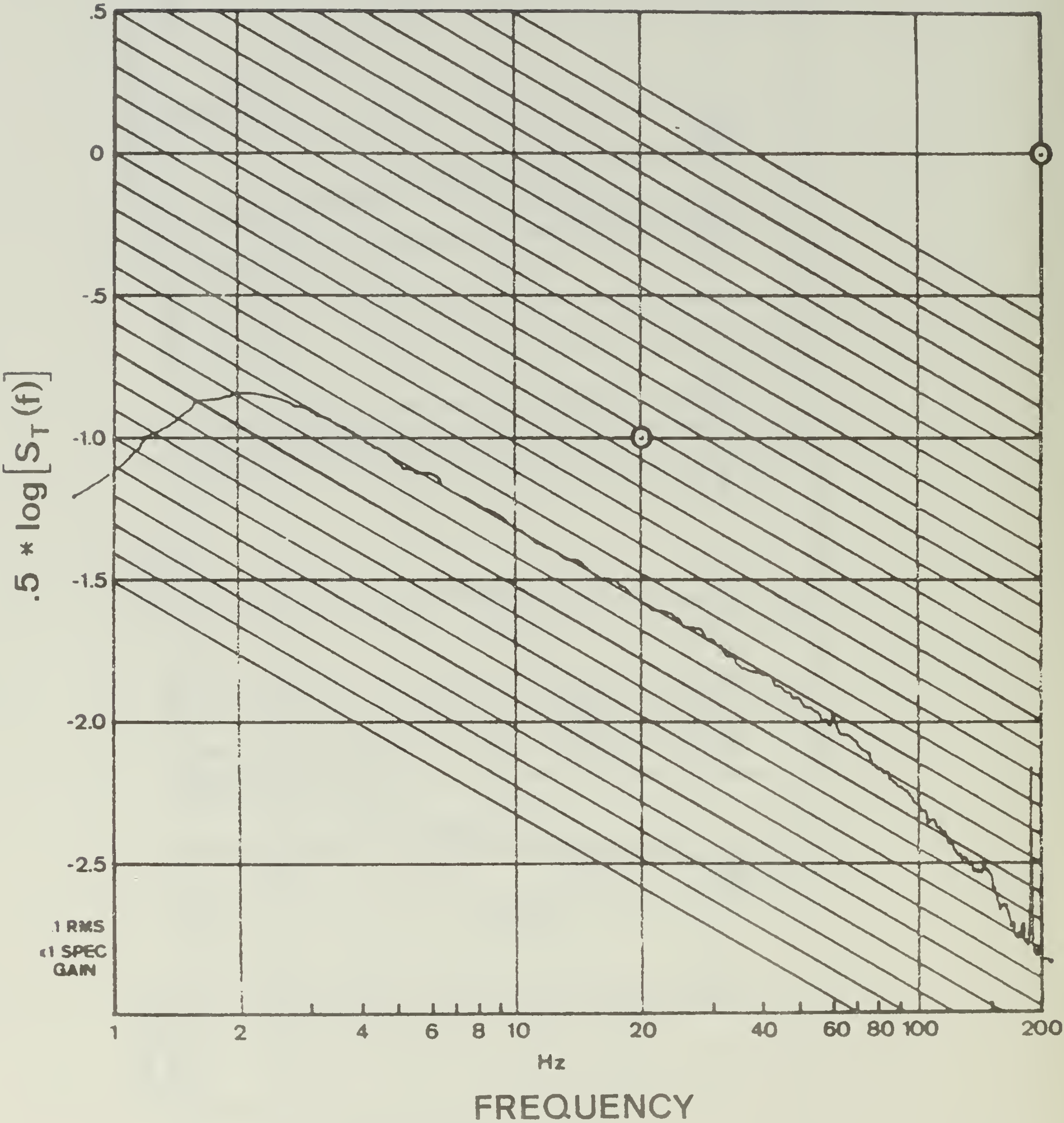

.5
0
-.5
-1.0
-1.5
-2.0
-2.5
.5 * log[S_T(f)]
.1 RMS
x1 SPEC
GAIN
1
2
4
6
8
10
20
40
60
80
100
200
Hz
FREQUENCY

Figure A-9a

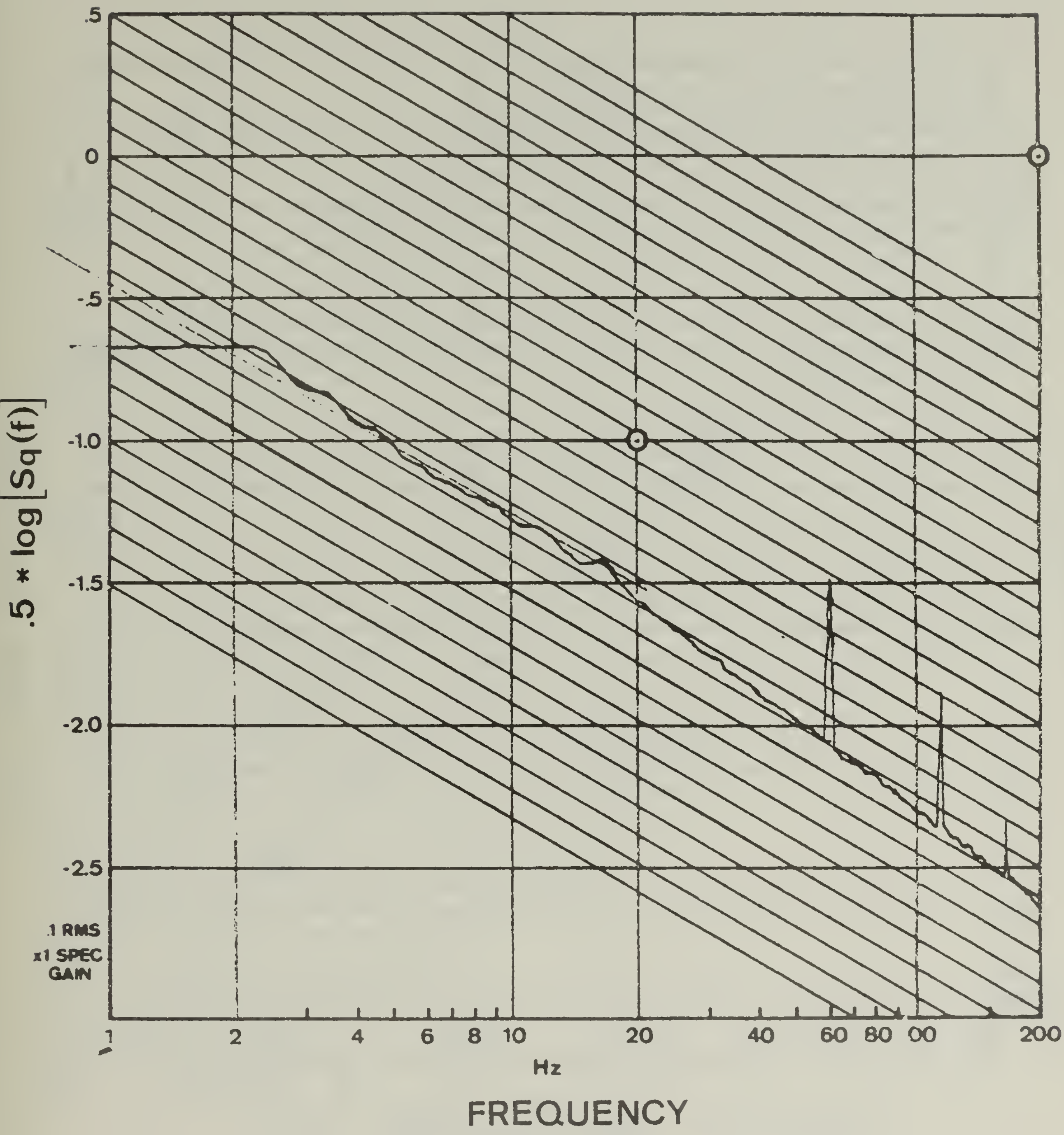
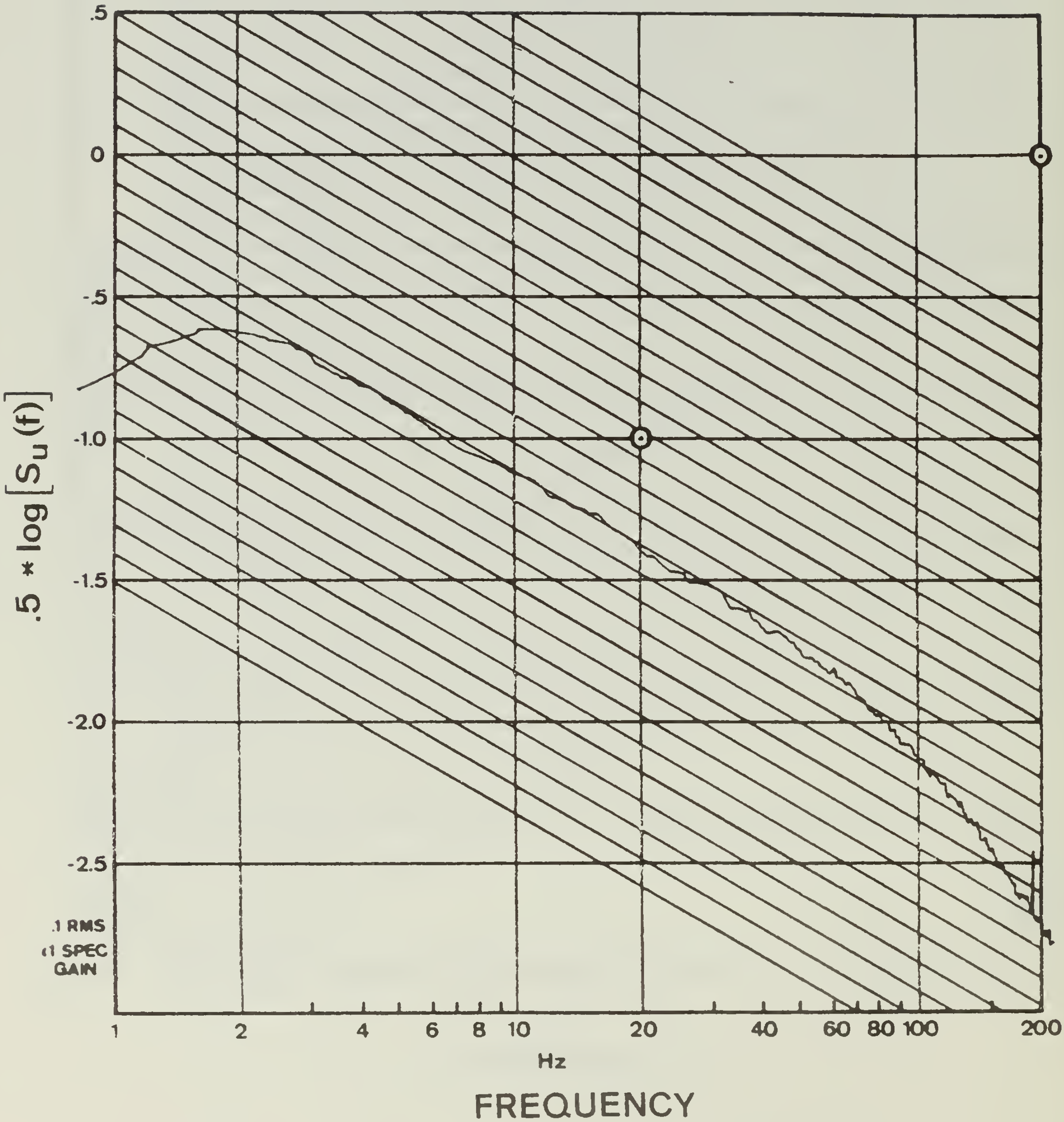

.5
0
-.5
-1.0
-1.5
-2.0
-2.5
.1 RMS
x1 SPEC
GAIN
.5 * log [Sq(f)]
1
2
4
6
8
10
20
40
60
80
00
200
Hz
FREQUENCY

Figure A-9b



.5
0
-.5
-1.0
-1.5
-2.0
-2.5
.1 RMS
1 SPEC
GAIN
.5 * log[Su(f)]
1
2
4
6
8
10
20
40
60
80
100
200
Hz
FREQUENCY

Figure A-9c

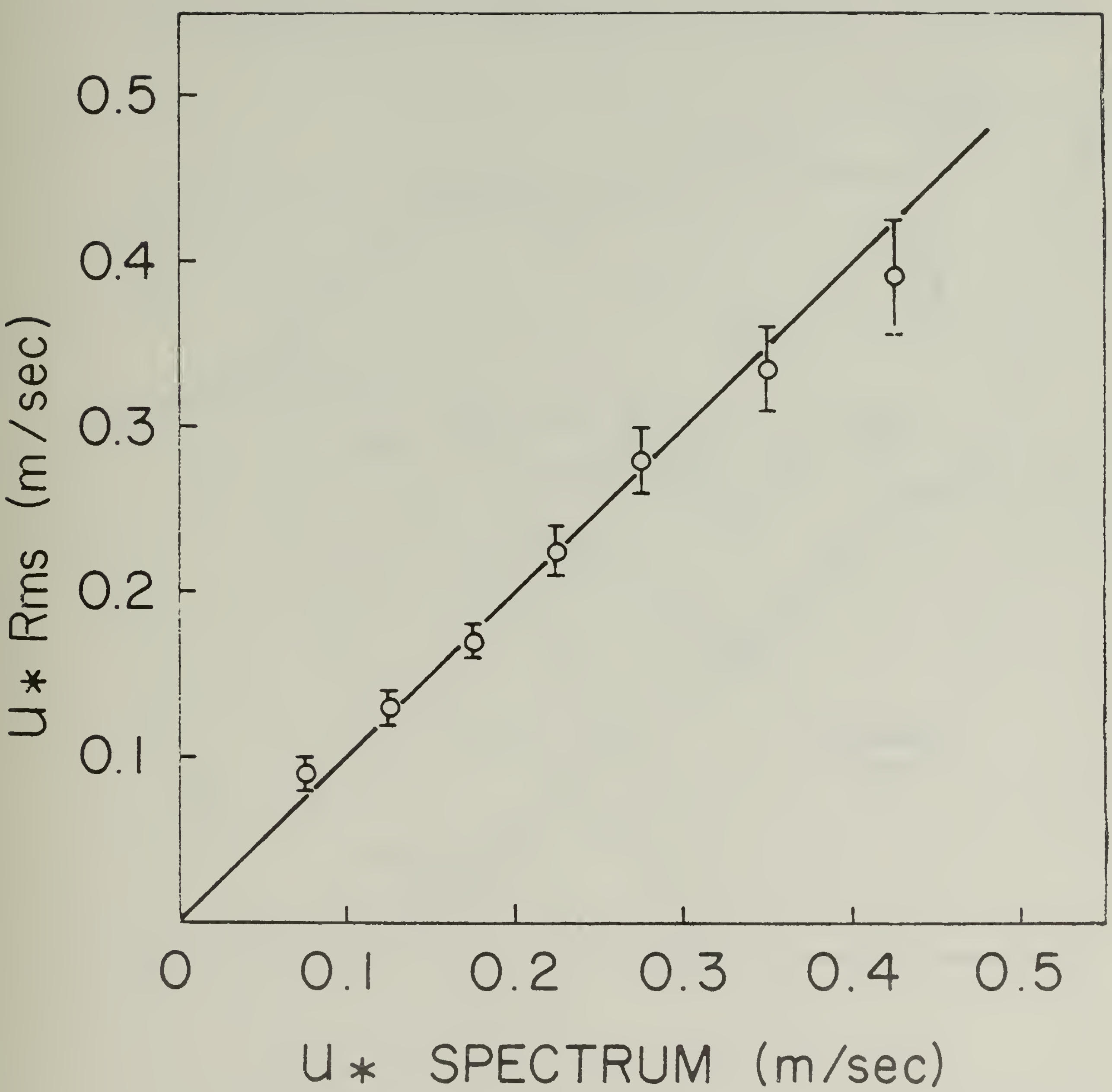


Figure A-10

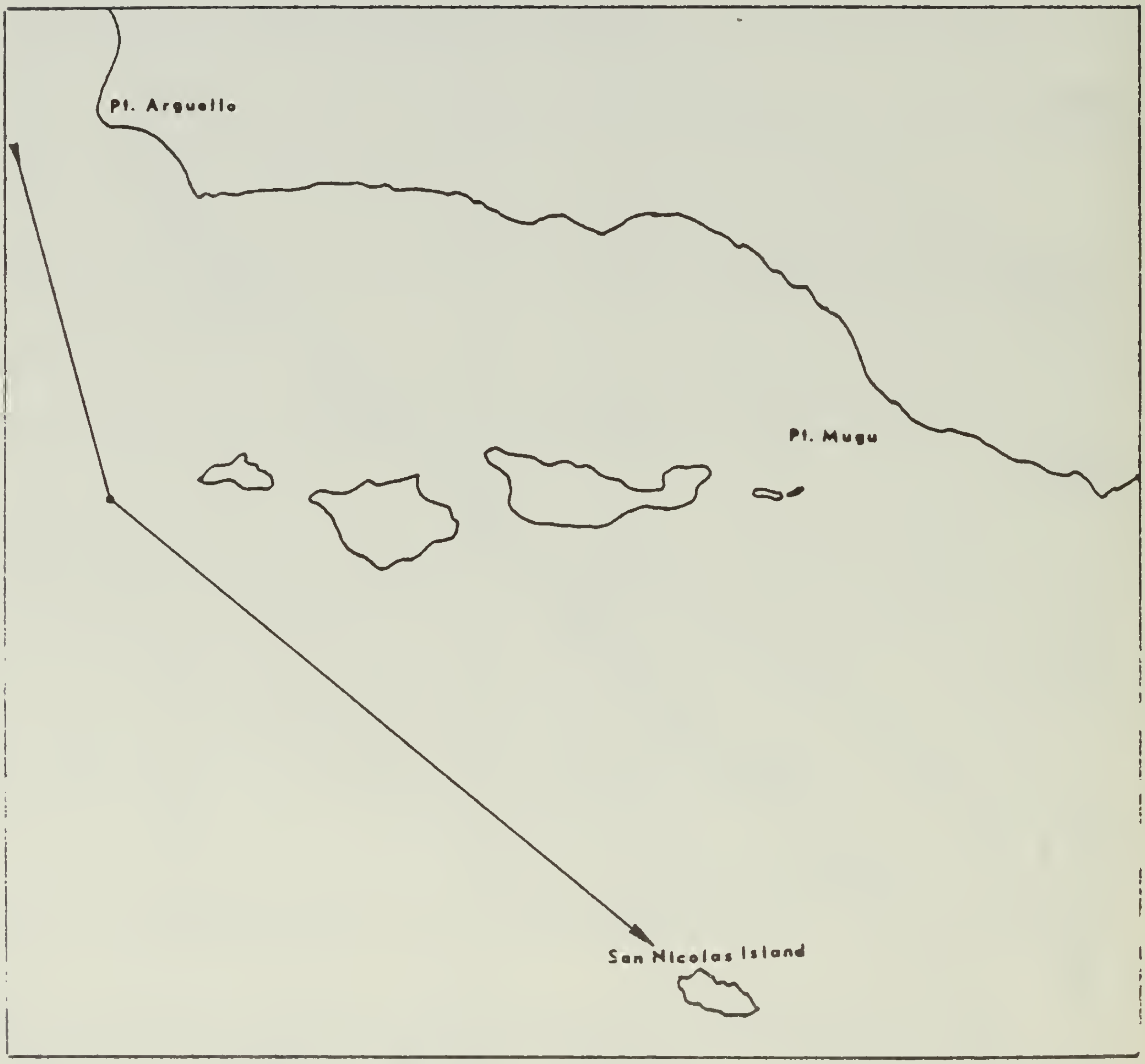


Figure A-11

Figure A-12

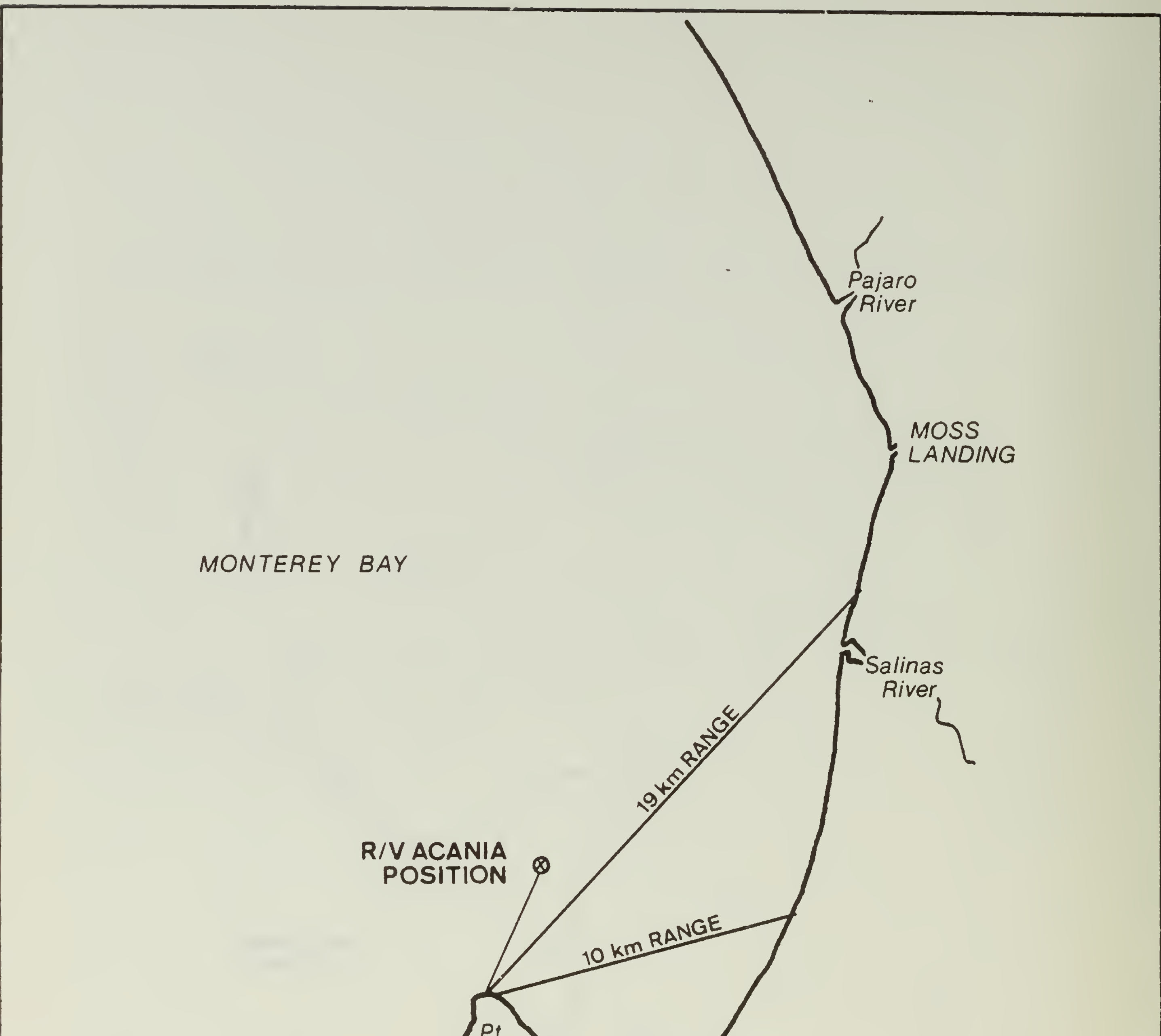

Pajaro
River
MOSS
LANDING
MONTEREY BAY
Salinas
River
19 km RANGE
R/V ACANIA
POSITION
10 km RANGE
Pt.
Pinos
MONTEREY
PENINSULA

Figure A-13

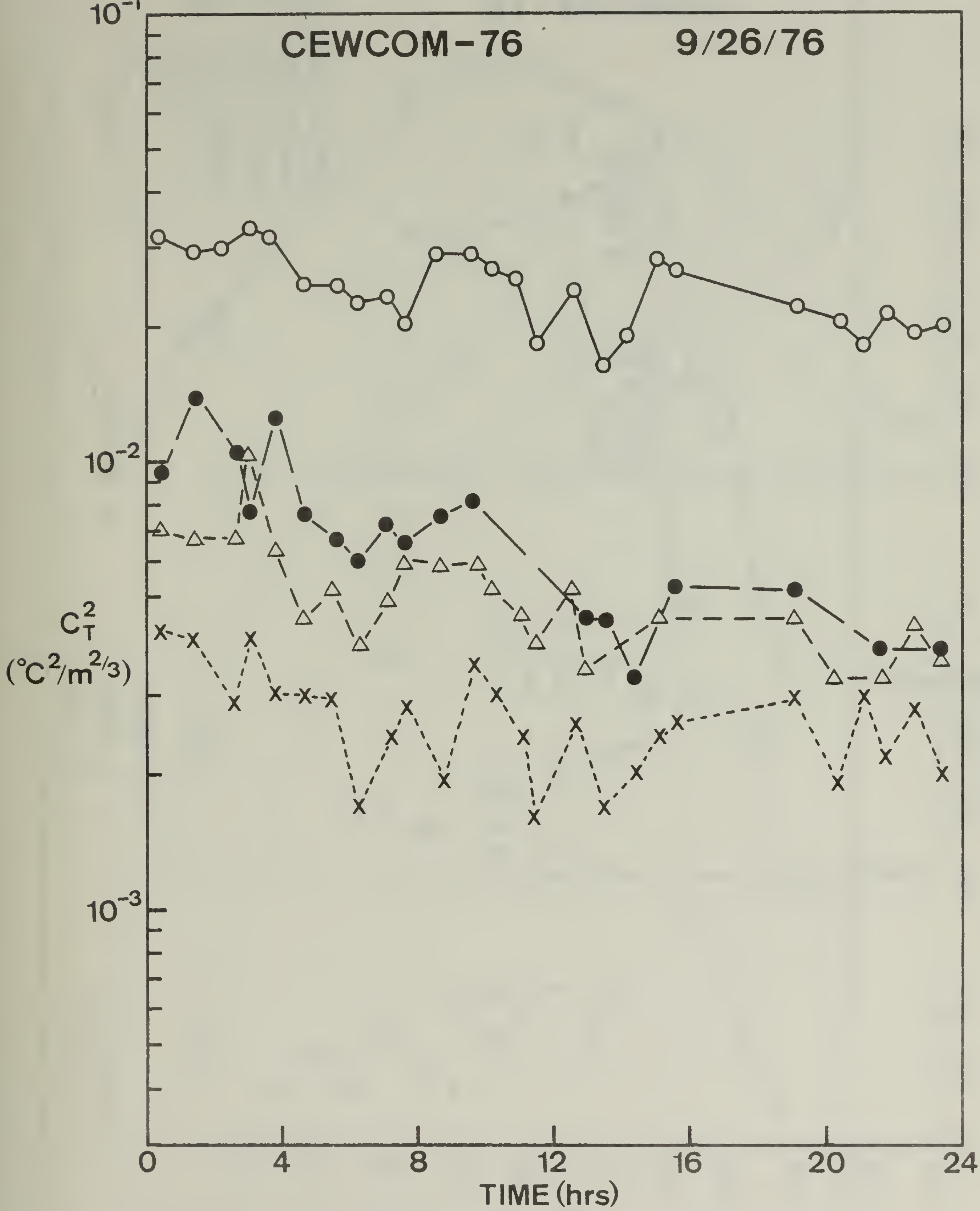


Figure A-14a

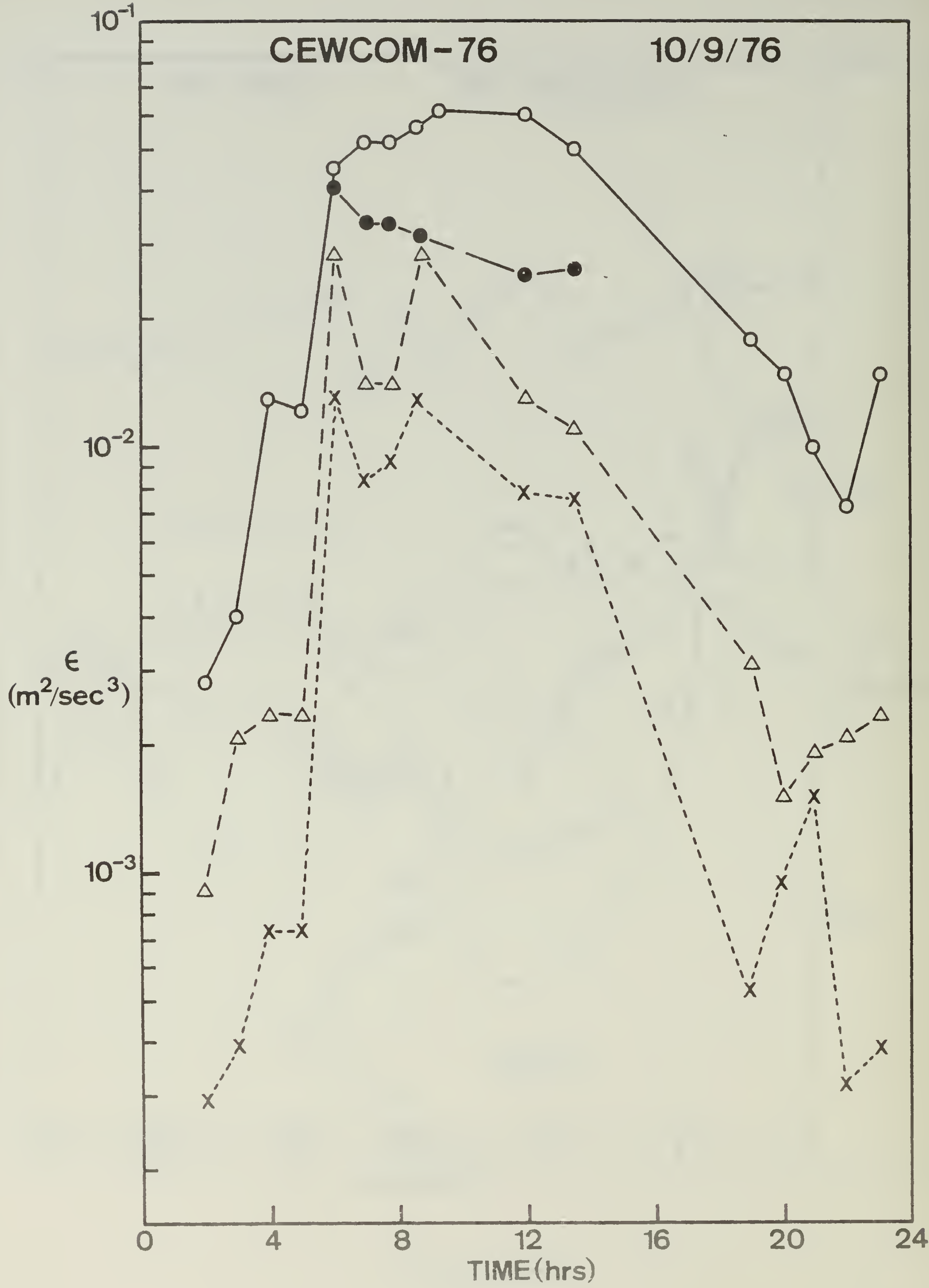
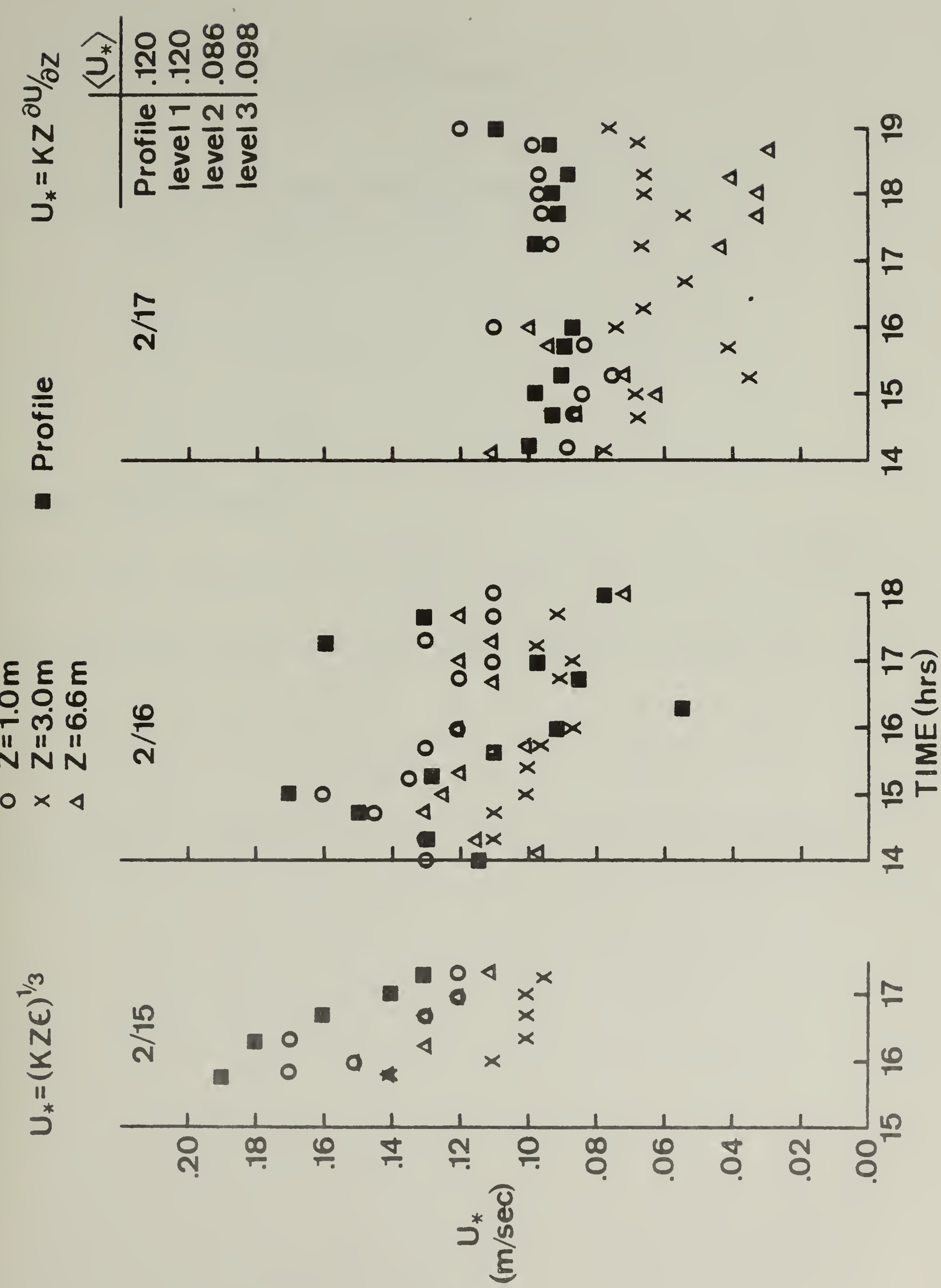


Figure A-14b



$U_* = (KZ\epsilon)^{1/3}$
○ Z=1.0m
× Z=3.0m
△ Z=6.6m
■ Profile
$U_* = KZ\, \partial U / \partial Z$
2/15
2/16
2/17
	$\langle U_* \rangle$
Profile	.120
level 1	.120
level 2	.086
level 3	.098
U_* (m/sec)
.20
.18
.16
.14
.12
.10
.08
.06
.04
.02
.00
15
16
17
14
15
16
17
18
14
15
16
17
18
19
TIME (hrs)

Figure A-15

APPENDIX B
MOS STABILITY FUNCTIONS

The forms of the mean gradient functions (Businger et al., 1971).

$$\phi_U(\xi) - (1 - 15\xi)^{-1/4} \qquad \xi < 0$$

$$\phi_U(\xi) = (1 + 4.7\xi) \qquad \xi > 0$$

$$\phi_T(\xi) = (1 - 19\xi)^{-1/3} \qquad \xi < 0$$

$$\phi_T(\xi) = (1 + 6.4\xi) \qquad \xi > 0$$

The mean profile function

$$\psi(\xi) = 1-\phi(\xi) - 3\ln\phi(\xi) + 2\ln\left(\frac{1 + \phi(\xi)}{2}\right) + 2\tan^{-1}\phi(\xi) - \pi/2 + \ln\left(\frac{1+\phi^2(\xi)}{2}\right)$$

The dimensionless velocity dissipation function (Wyngaard and Cote, 1971)

$$E_U(\xi) = (1 + .51\xi^{2/3})^{3/2} \qquad \xi < 0$$

$$E_U(\xi) = (1 + 2.5\xi^{2/3})^{3/2} \qquad \xi > 0$$

The dimensionless temperature structure function parameter (Wyngaard et al, 1971).

$$f_T(\xi) = 4.9(1 - 7\xi)^{-2/3} \qquad \xi < 0$$

$$f_T(\xi) = 4.9(1 + 2.4\xi^{2/3}) \qquad \xi > 0$$

APPENDIX C

DATA

LIST OF TABLES

TABLE C-1. EM Propagation data (bulk calculations).

Z_*	duct height (m)
Fm	Minimum Frequency tripped (GHz)
N	Refractivity (N Units)
dN/dZ	Refractivity gradient (m^{-1})
C_N^2	Refractive index structure function ($m^{-2/3}$)

#	Date	GMT	Z*	Fm	N	dN/dZ	Cn^2
1	2/28	1400	15.6	5.9	331.3	-0.244	1.39E-12
2	2/23	1500	17.4	5.0	332.7	-0.249	1.04E-12
3	2/28	1530	19.2	4.3	332.3	-0.264	1.16E-12
4	2/28	1600	18.7	4.5	333.9	-0.256	1.06E-12
5	2/28	1630	17.0	5.1	335.1	-0.238	8.98E-13
6	2/28	1700	16.8	5.2	334.6	-0.236	9.06E-13
7	2/28	1730	17.0	5.1	334.7	-0.240	9.11E-13
8	2/28	1800	13.8	7.0	335.4	-0.207	7.27E-13
10	3/01	1830	17.3	5.0	324.6	-0.277	2.04E-12
11	3/01	1900	16.9	5.2	324.5	-0.272	2.02E-12
12	3/01	1930	17.4	4.9	322.4	-0.282	2.19E-12
13	3/01	2000	17.1	5.1	322.9	-0.278	2.15E-12
14	3/01	2030	16.7	5.3	324.4	-0.269	1.97E-12
15	3/01	2100	17.6	4.9	324.3	-0.281	2.03E-12
16	3/01	2130	17.5	4.9	323.3	-0.282	2.15E-12
17	3/01	2200	17.3	5.0	323.4	-0.279	2.13E-12
18	3/01	2230	16.9	5.2	324.4	-0.273	2.01E-12
19	3/01	2300	17.3	5.0	324.6	-0.277	2.01E-12
20	3/01	2330	16.9	5.2	325.6	-0.269	1.39E-12
21	3/01	2400	15.6	5.9	329.0	-0.246	1.50E-12
22	3/02	30	15.3	6.0	329.0	-0.241	1.42E-12
23	3/02	100	15.1	6.1	330.9	-0.236	1.32E-12
24	3/02	130	14.2	6.8	332.9	-0.220	1.11E-12
25	3/02	200	13.8	7.0	333.9	-0.214	1.02E-12
26	3/02	230	12.8	7.9	335.6	-0.193	8.38E-13
27	3/02	300	12.8	7.3	335.9	-0.198	8.22E-13
28	3/02	330	12.6	8.1	336.1	-0.195	7.98E-13
29	3/02	400	12.3	8.4	336.6	-0.190	7.55E-13
30	3/02	430	12.5	8.2	336.6	-0.193	7.69E-13
31	3/02	500	11.7	9.0	337.3	-0.182	6.65E-13
32	3/02	530	11.1	9.7	338.9	-0.173	5.82E-13
33	3/02	600	10.5	10.5	340.1	-0.165	4.97E-13
34	3/02	630	8.9	13.5	342.2	-0.142	3.58E-13
35	3/02	700	6.2	23.6	344.4	-0.103	2.15E-13
36	3/02	730	5.0	32.7	346.4	-0.087	1.36E-13
37	3/02	800	4.6	36.4	347.0	-0.084	1.16E-13
38	3/02	830	3.7	50.4	349.3	-0.072	7.79E-14
39	3/02	900	3.3	59.6	349.0	-0.070	5.46E-14
40	3/02	930	3.7	50.1	349.1	-0.075	6.43E-14
41	3/02	1000	4.0	45.2	348.3	-0.080	6.53E-14
42	3/02	1130	4.4	38.4	349.3	-0.087	7.29E-14
43	3/02	1200	5.0	32.3	348.1	-0.093	9.68E-14
44	3/02	1230	3.8	49.4	349.5	-0.073	5.97E-14
45	3/02	1300	2.8	75.7	350.4	-0.065	3.67E-14
46	3/02	1330	2.8	76.3	350.2	-0.064	4.23E-14
47	3/02	1400	2.2	111.3	351.0	-0.057	2.90E-14
48	3/02	1430	2.6	86.7	350.2	-0.062	3.89E-14
49	3/02	1500	3.5	54.7	349.1	-0.073	6.32E-14

#	Date	GMT	Z*	Fm	N	dN/dZ	Cn^2
~~50~~	~~3/02~~	~~1530~~	~~3.2~~	~~64.0~~	~~349.8~~	~~-0.069~~	~~4.87E-14~~
51	3/02	1600	2.7	81.8	350.3	-0.064	3.56E-14
52	3/02	1630	3.7	49.7	348.1	-0.073	8.10E-14
~~53~~	~~3/02~~	~~1700~~	~~2.5~~	~~91.7~~	~~349.7~~	~~-0.057~~	~~3.55E-14~~
54	3/02	1830	3.0	68.1	350.5	-0.071	2.99E-14
55	3/02	1900	3.6	51.9	349.4	-0.076	5.15E-14
~~56~~	~~3/02~~	~~1930~~	~~2.3~~	~~105.6~~	~~351.0~~	~~-0.060~~	~~1.87E-14~~
57	3/02	2000	3.1	66.8	350.1	-0.070	3.27E-14
58	3/02	2030	2.7	79.8	350.7	-0.068	2.21E-14
~~59~~	~~3/02~~	~~2100~~	~~2.7~~	~~81.9~~	~~350.9~~	~~-0.067~~	~~2.23E-14~~
60	3/02	2130	2.7	81.9	350.9	-0.067	2.23E-14
61	3/02	2200	2.8	78.6	350.7	-0.068	2.38E-14
~~62~~	~~3/02~~	~~2230~~	~~3.2~~	~~62.1~~	~~349.9~~	~~-0.073~~	~~3.49E-14~~
63	3/02	2300	3.1	64.4	350.1	-0.072	3.34E-14
64	3/02	2330	4.5	38.0	348.5	-0.088	6.93E-14
~~65~~	~~3/02~~	~~2400~~	~~6.0~~	~~24.2~~	~~346.9~~	~~-0.108~~	~~1.24E-13~~
66	3/03	30	6.3	22.7	346.4	-0.111	1.37E-13
67	3/03	100	6.7	20.9	346.2	-0.116	1.54E-13
~~68~~	~~3/03~~	~~130~~	~~6.8~~	~~20.2~~	~~345.8~~	~~-0.117~~	~~1.64E-13~~
69	3/03	200	3.1	15.6	344.6	-0.133	2.26E-13
70	3/03	230	12.8	7.8	338.6	-0.194	6.22E-13
~~71~~	~~3/03~~	~~300~~	~~13.9~~	~~6.9~~	~~331.4~~	~~-0.216~~	~~1.24E-12~~
72	3/03	330	13.9	6.9	326.9	-0.220	1.65E-12
73	3/03	400	13.5	7.3	328.5	-0.214	1.41E-12
~~74~~	~~3/03~~	~~430~~	~~20.5~~	~~3.9~~	~~323.9~~	~~-0.317~~	~~2.32E-12~~
75	3/03	500	18.0	4.7	328.2	-0.275	1.71E-12
76	3/03	530	18.3	4.6	325.9	-0.285	1.99E-12
~~77~~	~~3/03~~	~~600~~	~~18.2~~	~~4.6~~	~~325.5~~	~~-0.285~~	~~2.03E-12~~
78	3/03	630	20.8	3.8	319.6	-0.333	2.94E-12
79	3/03	700	20.4	3.9	318.6	-0.329	3.02E-12
~~80~~	~~3/03~~	~~730~~	~~19.3~~	~~4.3~~	~~320.9~~	~~-0.308~~	~~2.63E-12~~
81	3/03	800	17.9	4.7	323.7	-0.285	2.21E-12
82	3/03	830	20.6	3.8	317.9	-0.334	3.13E-12
~~83~~	~~3/03~~	~~900~~	~~20.9~~	~~3.8~~	~~318.3~~	~~-0.336~~	~~3.10E-12~~
84	3/03	930	19.1	4.3	319.7	-0.309	2.75E-12
85	3/03	1000	19.3	4.2	321.4	-0.311	2.59E-12
~~86~~	~~3/03~~	~~1030~~	~~16.1~~	~~5.6~~	~~322.1~~	~~-0.259~~	~~2.18E-12~~
87	3/03	1100	18.5	4.5	320.3	-0.301	2.53E-12
88	3/03	1300	16.2	5.5	325.2	-0.258	1.96E-12
~~89~~	~~3/03~~	~~1330~~	~~17.4~~	~~5.0~~	~~324.8~~	~~-0.276~~	~~2.10E-12~~
90	3/03	1600	20.2	4.0	322.4	-0.317	2.52E-12
91	3/03	1630	19.6	4.2	323.9	-0.306	2.31E-12
~~92~~	~~3/03~~	~~1700~~	~~20.3~~	~~3.9~~	~~322.2~~	~~-0.318~~	~~2.56E-12~~
93	3/03	1830	14.2	6.8	330.3	-0.221	1.37E-12
94	3/03	1900	15.7	5.8	328.9	-0.246	1.56E-12
~~95~~	~~3/03~~	~~1930~~	~~16.9~~	~~5.2~~	~~329.2~~	~~-0.259~~	~~1.56E-12~~
96	3/03	2000	14.4	6.6	328.5	-0.225	1.51E-12
97	3/03	2030	14.0	6.9	329.7	-0.220	1.34E-12

#	Date	GMT	Z*	Fm	N	dN/dZ	Cn^2
~~98~~	~~3/03~~	~~2100~~	~~16.9~~	~~5.6~~	~~325.0~~	~~-0.253~~	~~1.81E-12~~
99	3/03	2130	13.7	7.1	329.8	-0.216	1.32E-12
100	3/03	2200	12.3	8.3	332.2	-0.193	1.05E-12
~~101~~	~~3/03~~	~~2230~~	~~16.7~~	~~5.3~~	~~323.9~~	~~-0.268~~	~~2.01E-12~~
102	3/03	2300	17.0	5.1	323.8	-0.272	2.04E-12
103	3/03	2330	15.2	6.1	327.7	-0.240	1.56E-12
~~104~~	~~3/03~~	~~2400~~	~~17.9~~	~~4.7~~	~~322.[illegible]~~	~~-0.287~~	~~2.26E-12~~
105	3/04	30	18.3	4.6	320.2	-0.297	2.57E-12
106	3/04	100	16.4	5.4	323.5	-0.264	2.03E-12
~~107~~	~~3/04~~	~~130~~	~~17.5~~	~~4.9~~	~~321.1~~	~~-0.283~~	~~2.36E-12~~
108	3/04	200	17.2	5.0	320.8	-0.280	2.37E-12
109	3/04	230	18.3	4.6	319.9	-0.296	2.60E-12
~~110~~	~~3/04~~	~~400~~	~~17.1~~	~~5.1~~	~~318.7~~	~~-0.279~~	~~2.50E-12~~
111	3/04	430	16.6	5.3	319.5	-0.270	2.35E-12
112	3/04	500	16.9	5.2	318.9	-0.275	2.44E-12
~~113~~	~~3/04~~	~~530~~	~~16.6~~	~~5.3~~	~~318.9~~	~~-0.272~~	~~2.39E-12~~
114	3/04	600	16.4	5.4	318.9	-0.268	2.34E-12
115	3/04	630	17.3	5.0	318.5	-0.282	2.55E-12
~~116~~	~~3/04~~	~~700~~	~~17.7~~	~~4.8~~	~~316.4~~	~~-0.291~~	~~2.82E-12~~
117	3/04	730	17.3	5.0	316.1	-0.284	2.75E-12
118	3/04	800	16.7	5.3	318.3	-0.273	2.47E-12
~~119~~	~~3/04~~	~~830~~	~~16.6~~	~~5.3~~	~~319.4~~	~~-0.270~~	~~2.34E-12~~
120	3/04	900	16.9	5.2	319.3	-0.276	2.44E-12
121	3/04	930	17.1	5.1	319.7	-0.279	2.43E-12
~~122~~	~~3/04~~	~~1000~~	~~13.9~~	~~6.9~~	~~324.9~~	~~-0.223~~	~~1.66E-12~~
123	3/04	1030	15.9	5.7	321.8	-0.256	2.13E-12
124	3/04	1100	17.2	5.0	319.7	-0.281	2.50E-12
~~125~~	~~3/04~~	~~1130~~	~~17.4~~	~~4.9~~	~~321.6~~	~~-0.282~~	~~2.35E-12~~
126	3/04	1330	17.0	5.1	319.2	-0.278	2.50E-12
127	3/04	1400	18.4	4.6	321.4	-0.297	2.50E-12
~~128~~	~~3/04~~	~~1430~~	~~17.5~~	~~4.9~~	~~319.1~~	~~-0.285~~	~~2.57E-12~~
129	3/04	1600	18.5	4.5	317.6	-0.303	2.85E-12
130	3/04	1800	16.7	5.3	318.9	-0.272	2.42E-12
~~131~~	~~3/04~~	~~1900~~	~~18.2~~	~~4.6~~	~~315.4~~	~~-0.300~~	~~2.94E-12~~
132	3/04	1930	18.2	4.7	315.1	-0.299	2.95E-12
133	3/04	2000	18.1	4.7	315.1	-0.299	2.94E-12
~~134~~	~~3/04~~	~~2030~~	~~18.3~~	~~4.6~~	~~314.2~~	~~-0.303~~	~~3.04E-12~~
135	3/04	2100	17.9	4.7	315.1	-0.296	2.91E-12
136	3/04	2130	19.0	4.3	312.4	-0.316	3.34E-12
~~137~~	~~3/04~~	~~2200~~	~~19.2~~	~~4.3~~	~~309.6~~	~~-0.322~~	~~3.61E-12~~
138	3/04	2230	18.4	4.5	312.2	-0.306	3.24E-12
139	3/04	2300	18.4	4.6	312.3	-0.305	3.22E-12
~~140~~	~~3/04~~	~~2330~~	~~17.6~~	~~4.9~~	~~315.2~~	~~-0.290~~	~~2.84E-12~~
141	3/05	100	16.3	5.5	315.5	-0.263	2.52E-12
142	3/05	130	15.8	5.8	316.7	-0.256	2.34E-12
~~143~~	~~3/05~~	~~200~~	~~15.5~~	~~5.9~~	~~316.3~~	~~-0.254~~	~~2.29E-12~~
144	3/05	300	15.2	6.0	315.4	-0.249	2.26E-12
145	3/05	330	15.1	6.1	315.2	-0.247	2.24E-12

#	Date	GMT	Z*	Fm	N	dN/dZ	Cn^2
~~146~~	~~3/05~~	~~400~~	~~15.1~~	~~6.2~~	~~314.4~~	~~-0.246~~	~~2.25E-12~~
147	3/05	430	15.2	6.0	313.0	-0.250	2.34E-12
148	3/05	500	15.4	6.0	312.5	-0.253	2.40E-12
~~149~~	~~3/05~~	~~530~~	~~14.0~~	~~6.9~~	~~313.7~~	~~-0.227~~	~~1.93E-12~~
150	3/05	600	14.1	6.8	311.8	-0.230	2.00E-12
151	3/05	630	13.4	7.3	309.8	-0.219	1.79E-12
~~152~~	~~3/05~~	~~700~~	~~13.0~~	~~7.7~~	~~309.9~~	~~-0.211~~	~~1.72E-12~~
153	3/05	730	12.8	7.9	308.3	-0.207	1.64E-12
154	3/05	800	13.0	7.7	306.8	-0.211	1.69E-12
~~155~~	~~3/05~~	~~830~~	~~12.3~~	~~8.3~~	~~308.5~~	~~-0.199~~	~~1.47E-12~~
156	3/05	900	12.1	8.6	308.6	-0.195	1.38E-12
157	3/05	930	12.1	8.6	307.1	-0.196	1.40E-12
~~161~~	~~3/05~~	~~1830~~	~~12.0~~	~~8.6~~	~~309.4~~	~~-0.195~~	~~1.39E-12~~
162	3/05	2000	23.5	3.2	311.5	-0.384	4.59E-12
163	3/05	2030	20.5	3.9	312.2	-0.340	3.90E-12
~~164~~	~~3/05~~	~~2100~~	~~23.8~~	~~3.1~~	~~310.7~~	~~-0.389~~	~~4.69E-12~~
165	3/05	2130	21.3	3.7	310.1	-0.355	4.33E-12
166	3/05	2200	21.0	3.7	310.4	-0.351	4.26E-12
~~167~~	~~3/05~~	~~2230~~	~~22.3~~	~~3.4~~	~~312.2~~	~~-0.366~~	~~4.34E-12~~
168	3/05	2300	20.0	4.0	312.0	-0.333	3.89E-12
169	3/05	2330	20.0	4.0	312.0	-0.333	3.89E-12
~~170~~	~~3/05~~	~~2400~~	~~20.0~~	~~4.0~~	~~311.1~~	~~-0.331~~	~~3.79E-12~~
171	3/06	30	21.0	3.8	312.3	-0.341	3.67E-12
172	3/06	100	21.3	3.7	311.1	-0.349	3.96E-12
~~173~~	~~3/06~~	~~130~~	~~19.6~~	~~4.1~~	~~310.9~~	~~-0.324~~	~~3.66E-12~~
174	3/06	200	22.4	3.4	310.1	-0.365	4.20E-12
175	3/06	230	21.6	3.6	308.4	-0.357	4.30E-12
~~176~~	~~3/06~~	~~300~~	~~21.5~~	~~3.6~~	~~308.3~~	~~-0.356~~	~~4.26E-12~~
177	3/06	330	21.1	3.7	308.5	-0.351	4.38E-12
178	3/06	400	21.0	3.7	309.7	-0.351	4.54E-12
~~179~~	~~3/06~~	~~430~~	~~21.0~~	~~3.7~~	~~309.4~~	~~-0.351~~	~~4.52E-12~~
180	3/06	530	20.2	4.0	311.7	-0.335	4.14E-12
181	3/06	600	20.4	3.9	313.2	-0.336	3.87E-12
~~182~~	~~3/06~~	~~630~~	~~19.2~~	~~4.3~~	~~313.9~~	~~-0.317~~	~~3.54E-12~~
183	3/06	730	17.3	4.8	317.2	-0.289	2.90E-12
196	3/07	730	12.6	8.1	320.7	-0.201	1.41E-12
~~197~~	~~3/07~~	~~800~~	~~12.1~~	~~8.5~~	~~321.4~~	~~-0.193~~	~~1.23E-12~~
200	3/07	930	16.5	5.3	320.7	-0.263	1.93E-12
201	3/07	1000	14.8	6.3	320.8	-0.237	1.69E-12
~~202~~	~~3/07~~	~~1030~~	~~17.6~~	~~4.9~~	~~321.9~~	~~-0.276~~	~~1.98E-12~~
203	3/07	1100	16.8	5.2	324.6	-0.260	1.65E-12
204	3/07	1130	17.0	5.1	324.0	-0.268	1.91E-12
~~205~~	~~3/07~~	~~1230~~	~~16.4~~	~~5.4~~	~~327.7~~	~~-0.252~~	~~1.55E-12~~
206	3/07	1300	14.9	6.2	329.6	-0.232	1.39E-12
207	3/07	1500	8.3	14.9	327.5	-0.131	4.98E-13
~~208~~	~~3/07~~	~~1530~~	~~8.3~~	~~15.2~~	~~326.8~~	~~-0.130~~	~~4.58E-13~~
209	3/07	1800	7.4	17.7	332.5	-0.117	3.68E-13
211	3/07	1900	8.0	16.0	332.5	-0.125	4.01E-13

#	Date	GMT	Z*	Fm	N	dN/dZ	Cn^2
212	3/07	1930	8.6	14.2	329.9	-0.135	5.12E-13
213	3/07	2000	8.6	14.3	329.6	-0.135	5.14E-13
214	3/07	2030	9.5	12.4	326.4	-0.149	6.41E-13
215	3/07	2100	11.2	9.7	323.2	-0.177	9.59E-13
216	3/07	2130	9.3	12.7	324.0	-0.147	6.09E-13
217	3/07	2200	10.2	11.0	323.5	-0.161	7.55E-13
218	3/07	2230	10.2	11.0	322.8	-0.162	7.72E-13
219	3/08	130	14.3	6.7	322.8	-0.230	1.64E-12
220	3/08	730	12.9	7.7	317.9	-0.209	1.66E-12
221	3/08	800	16.8	5.2	318.4	-0.276	2.70E-12
222	3/08	830	16.9	5.2	318.3	-0.276	2.67E-12
223	3/08	900	17.7	4.8	317.3	-0.291	2.97E-12
224	3/08	930	13.8	7.1	317.5	-0.223	1.88E-12
225	3/08	1100	14.5	6.5	318.2	-0.236	2.15E-12
226	3/08	1130	16.9	5.2	316.5	-0.263	1.52E-12
227	3/08	1230	21.9	3.5	313.3	-0.364	4.44E-12
228	3/08	1400	20.3	3.9	315.1	-0.336	3.95E-12
229	3/08	1430	18.8	4.4	315.4	-0.314	3.62E-12
230	3/08	1500	18.1	4.7	316.2	-0.300	3.39E-12
231	3/08	1530	14.3	6.7	314.4	-0.234	2.17E-12
232	3/08	1700	13.7	7.1	315.3	-0.224	1.99E-12
233	3/08	1930	13.6	7.2	316.4	-0.221	1.87E-12
234	3/08	2000	18.1	4.7	317.0	-0.300	3.18E-12
235	3/08	2030	11.7	9.0	318.1	-0.188	1.29E-12
236	3/08	2200	11.7	9.0	317.7	-0.188	1.29E-12
237	3/08	2230	11.7	8.9	318.6	-0.189	1.31E-12
238	3/08	2300	11.7	9.0	318.4	-0.187	1.29E-12
241	3/09	1000	10.5	10.5	318.8	-0.168	1.00E-12
242	3/09	1030	14.6	6.5	320.4	-0.237	2.05E-12
243	3/09	1200	9.7	12.0	323.0	-0.152	7.81E-13
244	3/09	1230	9.5	12.3	323.0	-0.150	7.25E-13
245	3/09	1300	10.0	11.4	321.5	-0.158	8.33E-13
246	3/09	1400	18.0	4.7	322.3	-0.289	2.47E-12
247	3/09	1430	18.8	4.4	320.5	-0.303	2.80E-12
248	3/09	1500	19.5	4.2	321.7	-0.310	2.79E-12
249	3/09	1530	13.6	7.1	321.9	-0.220	1.71E-12
250	3/09	1600	18.4	4.5	322.3	-0.296	2.67E-12
251	3/09	1630	18.8	4.4	323.7	-0.299	2.58E-12
252	3/09	1700	18.5	4.5	324.4	-0.293	2.47E-12
253	3/09	1800	16.1	5.6	325.3	-0.258	2.10E-12
254	3/09	1830	12.9	7.3	326.0	-0.207	1.50E-12
255	3/09	1900	11.6	9.1	328.2	-0.184	1.12E-12
256	3/09	2030	12.3	7.9	328.4	-0.204	1.32E-12
257	3/09	2100	12.7	8.0	327.9	-0.202	1.31E-12
258	3/09	2130	12.8	7.8	329.2	-0.204	1.28E-12
259	3/09	2200	13.7	7.1	326.9	-0.221	1.51E-12
260	3/09	2230	14.6	6.4	325.7	-0.235	1.73E-12
261	3/09	2300	13.4	7.3	327.9	-0.215	1.43E-12

#	Date	GMT	Z*	Fm	N	dN/dZ	Cn^2
~~262~~	~~3/10~~	~~630~~	~~14.8~~	~~5.3~~	~~334.3~~	~~-0.230~~	~~1.20E-12~~
263	3/10	700	15.1	6.2	331.2	-0.238	1.46E-12
264	3/10	730	15.3	6.0	331.2	-0.242	1.49E-12
~~265~~	~~3/10~~	~~830~~	~~15.4~~	~~5.7~~	~~330.1~~	~~-0.245~~	~~1.53E-12~~
266	3/10	900	15.8	5.7	329.6	-0.252	1.66E-12
267	3/10	1100	15.6	5.9	335.0	-0.240	1.23E-12
~~268~~	~~3/10~~	~~1130~~	~~15.4~~	~~5.9~~	~~335.4~~	~~-0.238~~	~~1.21E-12~~
269	3/10	1200	15.4	6.0	335.7	-0.237	1.19E-12
270	3/10	1230	14.6	6.5	337.5	-0.223	1.00E-12
~~271~~	~~3/10~~	~~1330~~	~~13.6~~	~~7.2~~	~~339.9~~	~~-0.207~~	~~9.03E-13~~
272	3/10	1500	12.1	8.6	341.3	-0.187	6.73E-13
273	3/10	1530	11.5	9.3	343.1	-0.177	5.46E-13
~~274~~	~~3/10~~	~~1800~~	~~3.8~~	~~48.9~~	~~351.0~~	~~-0.072~~	~~8.57E-14~~
275	3/10	1830	4.5	37.3	350.9	-0.082	9.92E-14
276	3/10	1900	4.3	40.2	351.5	-0.080	8.32E-14
~~277~~	~~3/10~~	~~1930~~	~~4.2~~	~~41.2~~	~~351.7~~	~~-0.080~~	~~7.74E-14~~
278	3/10	2000	4.3	41.0	351.8	-0.083	6.85E-14
279	3/10	2030	3.7	50.9	352.5	-0.075	5.25E-14
~~280~~	~~3/10~~	~~2100~~	~~3.3~~	~~60.1~~	~~352.7~~	~~-0.071~~	~~3.99E-14~~
281	3/10	2130	3.7	51.2	352.5	-0.075	5.06E-14
282	3/11	700	7.1	18.8	343.0	-0.114	3.28E-13
~~283~~	~~3/11~~	~~730~~	~~7.3~~	~~18.3~~	~~342.3~~	~~-0.116~~	~~3.48E-13~~
284	3/11	800	7.8	16.4	341.3	-0.124	4.09E-13
285	3/11	830	8.0	15.8	341.4	-0.127	4.25E-13
~~286~~	~~3/11~~	~~900~~	~~8.3~~	~~15.2~~	~~341.6~~	~~-0.131~~	~~4.35E-13~~
287	3/11	930	11.0	9.8	336.4	-0.174	8.31E-13
288	3/11	1000	13.7	7.1	331.0	-0.219	1.37E-12
~~289~~	~~3/11~~	~~1030~~	~~12.0~~	~~8.7~~	~~334.0~~	~~-0.190~~	~~1.04E-12~~
290	3/11	1100	11.3	9.5	335.3	-0.179	9.05E-13
291	3/11	1130	11.6	9.2	335.4	-0.183	9.50E-13
~~292~~	~~3/11~~	~~1230~~	~~11.5~~	~~9.3~~	~~335.1~~	~~-0.181~~	~~9.22E-13~~
293	3/11	1300	16.0	5.5	324.6	-0.261	2.11E-12
294	3/11	1330	16.5	5.4	324.2	-0.269	2.21E-12
~~295~~	~~3/11~~	~~1400~~	~~15.5~~	~~5.9~~	~~323.3~~	~~-0.253~~	~~2.00E-12~~
296	3/11	1430	14.0	6.9	327.6	-0.225	1.62E-12
297	3/11	1500	14.3	6.7	328.0	-0.230	1.69E-12
~~298~~	~~3/11~~	~~1530~~	~~17.2~~	~~5.1~~	~~321.1~~	~~-0.282~~	~~2.56P-12~~
299	3/11	1600	16.9	5.2	322.9	-0.277	2.42E-12
300	3/11	1700	17.8	4.8	323.9	-0.286	2.19E-12
~~301~~	~~3/11~~	~~1730~~	~~17.9~~	~~4.7~~	~~322.1~~	~~-0.294~~	~~2.63E-12~~
302	3/11	1800	16.8	5.3	322.9	-0.274	2.36E-12
303	3/11	1830	18.3	4.6	321.6	-0.301	2.71E-12
~~304~~	~~3/11~~	~~1900~~	~~17.4~~	~~5.0~~	~~321.6~~	~~-0.286~~	~~2.52E-12~~
305	3/11	1930	16.0	5.6	322.4	-0.261	2.18E-12
306	3/11	2000	17.1	5.1	319.3	-0.282	2.61E-12
~~307~~	~~3/11~~	~~2030~~	~~17.5~~	~~4.9~~	~~320.2~~	~~-0.283~~	~~2.62E-12~~
308	3/11	2100	15.2	6.1	326.7	-0.245	1.89E-12
309	3/11	2130	15.6	5.9	324.0	-0.252	2.10E-12

#	Date	GMT	Z*	Fm	N	dN/dZ	Cn^2
310	3/11	2200	14.3	6.7	326.1	-0.230	1.74E-12
311	3/11	2230	15.9	5.7	322.0	-0.259	2.25E-12
312	3/11	2300	17.8	4.8	322.3	-0.289	2.59E-12
313	3/11	2330	16.3	5.5	318.5	-0.267	2.64E-12
314	3/12	500	18.4	4.6	311.9	-0.307	3.48E-12
315	3/12	530	18.6	4.5	309.1	-0.314	3.71E-12
316	3/12	600	20.4	3.9	304.3	-0.349	4.59E-12
317	3/12	630	18.6	4.5	310.3	-0.312	3.64E-12
318	3/12	700	18.4	4.6	309.2	-0.309	3.69E-12
319	3/12	730	17.3	5.0	311.5	-0.289	3.23E-12
320	3/12	830	17.4	5.0	311.1	-0.290	3.28E-12
321	3/12	900	17.9	4.8	309.7	-0.300	3.49E-12
322	3/12	930	17.6	4.9	311.6	-0.293	3.27E-12
323	3/12	1000	18.5	4.5	308.5	-0.310	3.68E-12
324	3/12	1030	18.2	4.6	306.2	-0.307	3.62E-12
325	3/12	1100	16.3	5.5	312.1	-0.270	2.81E-12
326	3/12	1130	17.1	5.1	310.0	-0.285	3.14E-12
327	3/12	1200	18.0	4.7	305.3	-0.305	3.67E-12
328	3/12	1330	16.9	5.2	305.1	-0.284	3.17E-12
329	3/12	1400	17.6	4.9	305.1	-0.297	3.46E-12
330	3/12	1430	17.3	5.0	306.6	-0.291	3.36E-12
331	3/12	1500	15.8	5.7	310.0	-0.262	2.75E-12
332	3/12	1530	17.6	4.9	304.5	-0.297	3.51E-12
333	3/12	1600	16.9	5.2	304.7	-0.285	3.19E-12
334	3/12	1630	16.8	5.2	304.3	-0.282	3.15E-12
335	3/12	1800	16.7	5.3	305.5	-0.280	3.07E-12
336	3/12	1830	17.5	4.9	304.2	-0.295	3.42E-12
340	3/13	830	18.3	4.4	303.0	-0.310	3.84E-12
341	3/13	900	21.6	3.6	302.2	-0.369	5.00E-12
342	3/13	930	19.4	4.2	308.2	-0.324	3.73E-12
343	3/13	1000	24.7	2.9	309.2	-0.395	4.46E-12
344	3/13	1030	16.9	5.2	309.0	-0.280	2.80E-12
345	3/13	1100	17.1	5.1	307.5	-0.284	2.93E-12
346	3/13	1130	21.0	3.7	305.4	-0.358	4.78E-12
347	3/13	1300	23.2	3.2	309.1	-0.379	4.32E-12
348	3/13	1330	24.6	3.0	308.5	-0.398	4.63E-12
349	3/14	1930	10.8	10.1	334.1	-0.171	8.57E-13
350	3/14	2000	10.8	10.1	334.3	-0.171	8.42E-13
351	3/14	2030	11.0	9.9	333.3	-0.173	8.74E-13
352	3/14	2100	14.2	6.7	327.5	-0.227	1.55E-12
353	3/14	2130	13.7	7.1	325.7	-0.221	1.56E-12
354	3/14	2200	15.1	6.1	322.5	-0.245	1.96E-12
356	3/15	1130	12.0	8.6	315.8	-0.193	1.39E-12
357	3/15	1230	14.6	6.4	316.8	-0.239	2.17E-12
358	3/15	1300	12.2	8.4	316.8	-0.196	1.44E-12
359	3/15	1330	12.4	8.3	315.8	-0.200	1.52E-12
360	3/15	1400	12.4	8.2	316.2	-0.200	1.50E-12

TABLE C-2 MOS scaling parameters and EM propagation results. Comparison of the bulk method (first line) with turbulence U_* and profile T_*, q_* (second line).

Z/L	Monin-Obukhov stability parameter, ξ
U_*	Velocity scaling parameter (m/sec)
T_*	Potential temperature scaling parameter (^{o}C)
q_*	Water vapor mixing ratio scaling parameter (gm/kg)
Z_*	Duct height (m)
Fm	Minimum frequency trapped (GHz)

#	Date	GMT	Z/L	u*	T*	q*	Z*	Fm
16	3/01	2130	-9.65E-02	0.28	-0.02	-0.24	17.5	4.9
			-8.77E-02	0.27	-0.04	-0.12	9.7	11.9
17	3/01	2200	-1.04E-01	0.28	-0.02	-0.24	17.3	5.0
			-9.52E-02	0.26	-0.04	-0.12	9.8	11.8
18	3/01	2230	-9.96E-02	0.28	-0.02	-0.23	16.9	5.2
			-6.50E-02	0.27	-0.03	-0.05	4.5	37.7
19	3/01	2300	-8.36E-02	0.30	-0.02	-0.22	17.3	5.0
			-7.74E-02	0.28	-0.04	-0.09	8.0	15.8
20	3/01	2330	-8.26E-02	0.30	-0.02	-0.22	16.9	5.2
			-5.89E-02	0.28	-0.03	-0.05	5.0	32.2
21	3/01	2400	-6.95E-02	0.31	-0.02	-0.19	15.6	5.8
			-6.06E-02	0.29	-0.03	-0.09	7.9	16.3
22	3/02	30	-6.34E-02	0.32	-0.02	-0.18	15.3	6.0
			-6.24E-02	0.31	-0.03	-0.11	10.1	11.3
23	3/02	100	-5.48E-02	0.34	-0.02	-0.17	15.1	6.1
			-5.68E-02	0.32	-0.03	-0.12	11.1	9.7
24	3/02	130	-5.07E-02	0.34	-0.02	-0.16	14.2	6.8
			-5.62E-02	0.30	-0.03	-0.14	12.6	8.0
25	3/02	200	-4.43E-02	0.34	-0.02	-0.15	13.8	7.0
			-5.58E-02	0.31	-0.03	-0.15	13.5	7.3
26	3/02	230	-4.24E-02	0.34	-0.02	-0.14	12.8	7.9
			-5.95E-02	0.33	-0.03	-0.16	13.6	7.2
27	3/02	300	-3.62E-02	0.36	-0.01	-0.13	12.8	7.8
			-5.23E-02	0.31	-0.03	-0.15	13.7	7.1
28	3/02	330	-3.94E-02	0.34	-0.01	-0.13	12.6	8.1
			-6.64E-02	0.33	-0.04	-0.16	13.3	7.4
29	3/02	400	-3.98E-02	0.34	-0.01	-0.13	12.3	8.4
			-6.34E-02	0.34	-0.03	-0.17	14.7	6.4
30	3/02	430	-3.64E-02	0.35	-0.01	-0.13	12.5	8.2
			-6.52E-02	0.35	-0.04	-0.14	12.2	8.4
31	3/02	500	-3.47E-02	0.35	-0.01	-0.12	11.7	9.0
			-5.34E-02	0.34	-0.03	-0.15	13.0	7.7

#	Date	GMT	Z/L	u*	T*	σ*	Z*	Fm
32	3/02	530	-3.10E-02	0.35	-0.01	-0.11	11.1	9.7
			-6.07E-02	0.34	-0.04	-0.15	12.9	7.8
33	3/02	600	-2.46E-02	0.37	-0.01	-0.10	10.5	10.5
			-5.19E-02	0.34	-0.03	-0.15	13.0	7.7
34	3/02	630	-3.00E-02	0.34	-0.01	-0.09	8.9	13.5
			-8.10E-02	0.33	-0.05	-0.18	14.5	6.5
35	3/02	700	-1.97E-02	0.34	-0.01	-0.07	7.6	17.1
			-1.20E-01	0.35	-0.08	-0.19	13.3	7.4
36	3/02	730	-1.24E-02	0.31	0.00	-0.05	6.4	22.4
			-2.15E-01	0.32	-0.12	-0.28	16.0	5.6
37	3/02	800	-6.57E-03	0.37	0.00	-0.05	5.9	25.2
			-6.81E-02	0.36	-0.05	-0.16	13.4	7.3
38	3/02	830	-4.95E-03	0.32	0.00	-0.04	4.9	32.8
			-1.64E-01	0.41	-0.10	-0.24	15.2	6.1
39	3/02	900	1.30E-02	0.35	0.02	-0.03	4.5	37.3
			-7.83E-02	0.33	-0.05	-0.19	15.3	6.0
40	3/02	930	1.44E-02	0.38	0.02	-0.03	5.0	32.3
			-5.32E-02	0.33	-0.03	-0.17	14.5	6.5
41	3/02	1000	2.24E-02	0.40	0.03	-0.03	5.3	29.2
			-1.96E-02	0.33	-0.01	-0.08	9.1	13.1
42	3/02	1130	2.95E-02	0.40	0.04	-0.04	5.9	24.9
			9.44E-03	0.32	0.02	-0.05	7.4	17.9
43	3/02	1200	2.48E-02	0.40	0.04	-0.04	6.6	21.4
			6.89E-03	0.34	0.02	-0.07	8.8	13.7
44	3/02	1230	1.93E-02	0.43	0.04	-0.03	5.1	31.4
			-5.62E-03	0.35	0.01	-0.10	11.4	9.3
45	3/02	1300	1.70E-02	0.42	0.03	-0.03	4.0	45.6
			-2.10E-02	0.42	-0.01	-0.14	14.4	6.6
46	3/02	1330	7.88E-03	0.44	0.02	-0.03	3.9	46.6
			-9.48E-03	0.37	0.00	-0.10	11.3	9.5
47	3/02	1400	6.27E-03	0.47	0.02	-0.02	3.2	61.9
			-9.93E-03	0.39	0.00	-0.12	13.8	7.1

#	Date	GMT	Z/L	u*	T*	q*	Z*	Fm
48	3/02	1430	4.37E-03	0.49	0.01	-0.03	3.6	51.7
			-2.12E-03	0.43	0.01	-0.08	9.7	11.8
49	3/02	1500	5.40E-03	0.47	0.02	-0.03	4.6	35.9
			-2.56E-02	0.43	-0.03	-0.12	11.8	8.9
50	3/02	1530	9.93E-03	0.47	0.02	-0.03	4.3	40.5
			-1.56E-02	0.37	-0.01	-0.10	10.8	10.1
51	3/02	1600	1.25E-02	0.45	0.02	-0.03	3.8	48.8
			-4.20E-03	0.35	0.01	-0.08	9.6	12.1
52	3/02	1630	-6.71E-03	0.35	0.00	-0.04	4.9	32.9
			-1.05E-02	0.35	0.00	-0.08	9.3	12.6
53	3/02	1700	9.85E-03	0.23	0.01	-0.03	3.7	51.2
			-1.84E-01	0.28	-0.04	-0.23	14.5	6.5
54	3/02	1830	6.82E-03	0.37	0.01	-0.02	3.0	62.1
			-2.50E-02	0.37	-0.01	-0.12	12.5	8.1
55	3/02	1900	-8.66E-03	0.39	-0.01	-0.03	3.6	51.9
			6.80E-03	0.39	0.02	-0.06	7.5	17.6
56	3/02	1930	-2.96E-03	0.37	0.00	-0.02	2.3	105.6
			-9.93E-02	0.39	-0.07	-0.22	15.9	5.7
57	3/02	2000	-2.70E-04	0.37	0.00	-0.02	3.1	66.8
			-7.63E-02	0.35	-0.04	-0.23	20.6	3.8
58	3/02	2030	1.08E-02	0.38	0.02	-0.02	2.7	79.8
			-2.56E-02	0.30	-0.02	-0.05	6.2	23.2
59	3/02	2100	1.08E-02	0.34	0.01	-0.02	2.7	81.9
			-2.38E-02	0.38	-0.01	-0.09	10.1	11.2
60	3/02	2130	1.08E-02	0.34	0.01	-0.02	2.7	81.9
			-2.38E-02	0.33	-0.01	-0.09	10.1	11.2
61	3/02	2200	1.19E-02	0.32	0.01	-0.02	2.8	78.6
			-3.05E-02	0.29	-0.00	-0.13	13.5	7.3
62	3/02	2230	4.97E-03	0.36	0.01	-0.02	3.2	62.1
			-4.27E-03	0.32	0.01	-0.09	11.3	9.5
63	3/02	2300	3.62E-03	0.38	0.01	-0.02	3.1	64.4
			-4.85E-02	0.35	-0.03	-0.18	15.9	5.7

#	Date	GMT	Z/L	u*	T*	q*	Z*	Fm
64	3/02	2330	1.36E-03	0.41	0.01	-0.04	4.5	38.0
			-2.74E-02	0.40	-0.02	-0.11	10.8	10.2
65	3/02	2400	4.16E-03	0.42	0.01	-0.05	6.0	24.2
			-1.76E-02	0.39	-0.01	-0.08	9.0	13.3
66	3/03	30	2.01E-03	0.42	0.01	-0.05	6.3	22.7
			-2.30E-02	0.39	-0.02	-0.10	10.3	10.9
67	3/03	100	1.57E-03	0.43	0.01	-0.05	6.7	20.9
			-1.98E-02	0.43	-0.01	-0.12	13.1	7.6
68	3/03	130	-1.52E-03	0.47	0.01	-0.05	6.3	23.2
			-1.67E-02	0.45	-0.01	-0.11	12.1	8.5
69	3/03	200	1.19E-03	0.49	0.01	-0.06	3.1	15.6
			-9.55E-03	0.53	0.01	-0.14	15.9	5.7
70	3/03	230	-5.71E-03	0.46	0.01	-0.11	12.8	7.3
			-2.07E-02	0.50	-0.00	-0.18	18.2	4.6
71	3/03	300	-4.99E-02	0.54	-0.09	-0.17	13.9	6.0
			4.96E-03	0.51	0.03	-0.10	12.9	7.7
72	3/03	330	-9.93E-02	0.52	-0.18	-0.21	13.9	6.9
			-6.17E-02	0.61	-0.06	-0.45	32.2	2.0
73	3/03	400	-1.24E-01	0.38	-0.11	-0.20	13.5	7.3
			-3.59E-01	0.36	-0.34	-0.57	23.9	3.1
74	3/03	430	-3.00E-02	0.47	-0.01	-0.22	20.5	3.9
			-2.67E-02	0.57	-0.03	-0.10	9.6	12.1
75	3/03	500	-2.70E-02	0.53	-0.03	-0.19	18.0	4.7
			-1.79E-02	0.53	-0.01	-0.17	17.9	4.8
76	3/03	530	-3.93E-02	0.50	-0.04	-0.21	18.3	4.6
			-3.38E-02	0.39	-0.04	-0.18	16.5	5.4
77	3/03	600	-4.30E-02	0.49	-0.05	-0.21	18.2	4.6
			-4.70E-02	0.42	-0.05	-0.23	19.5	4.2
78	3/03	630	-5.29E-02	0.48	-0.05	-0.26	20.8	3.8
			-4.31E-02	0.39	-0.06	-0.14	12.4	8.3
79	3/03	700	-3.66E-02	0.50	-0.03	-0.26	22.7	3.3
			-2.34E-02	0.35	-0.04	-0.07	7.0	19.5

#	Date	GMT	Z/L	u*	T*	σ*	Z*	Fm
80	3/03	730	-3.58E-02	0.49	-0.03	-0.24	21.5	3.6
			-2.18E-02	0.41	-0.02	-0.11	11.2	9.6
81	3/03	800	-3.36E-02	0.47	-0.02	-0.22	20.2	4.0
			1.73E-02	0.40	0.05	-0.11	17.5	4.9
82	3/03	830	-3.84E-02	0.43	-0.01	-0.27	23.3	3.2
			1.61E-02	0.00	0.02	0.01	0.0	0.0
83	3/03	900	-3.31E-02	0.46	-0.01	-0.26	23.6	3.1
			3.30E-02	0.33	0.06	0.00	0.8	501.9
84	3/03	930	-4.80E-02	0.41	-0.02	-0.26	21.4	3.6
			1.08E-01	0.29	0.16	-0.01	5.8	25.7
85	3/03	1000	-2.37E-02	0.39	0.01	-0.24	22.6	3.4
			5.01E-02	0.32	0.07	-0.04	7.5	17.6
86	3/03	1030	-1.00E-01	0.36	-0.06	-0.25	17.6	4.9
			1.48E-01	0.19	0.17	-0.03	25.0	2.9
87	3/03	1100	-4.67E-02	0.35	-0.00	-0.25	21.3	3.7
			1.41E-01	0.00	0.15	0.01	2.5	93.6
88	3/03	1300	-5.30E-02	0.46	-0.05	-0.22	17.9	4.3
			-1.04E-01	0.43	-0.11	-0.41	25.0	2.7
89	3/03	1330	-3.71E-02	0.46	-0.02	-0.22	19.5	4.2
			6.67E-02	0.38	0.13	-0.05	15.6	5.9
90	3/03	1600	-1.62E-02	0.48	0.01	-0.23	23.5	3.2
			1.16E-02	0.38	0.04	-0.09	13.4	7.4
91	3/03	1630	-1.48E-02	0.49	0.01	-0.22	22.8	3.3
			-6.29E-03	0.46	0.02	-0.17	19.7	4.1
92	3/03	1700	-1.85E-02	0.54	-0.00	-0.23	23.1	3.2
			3.82E-03	0.47	0.03	-0.09	11.6	9.1
93	3/03	1830	-6.11E-02	0.52	-0.10	-0.18	14.2	6.8
			-7.28E-02	0.41	-0.11	-0.31	21.9	3.5
94	3/03	1900	-5.04E-02	0.49	-0.06	-0.19	15.7	5.8
			-4.99E-02	0.41	-0.06	-0.23	19.3	4.3
95	3/03	1930	-3.07E-02	0.53	-0.04	-0.18	16.9	5.2
			-3.36E-02	0.48	-0.04	-0.24	21.6	3.6

#	Date	GMT	Z/L	u*	T*	q*	Z*	Fm
96	3/03	2000	-7.57E-02	0.50	-0.11	-0.19	14.4	6.6
			-1.27E-01	0.40	-0.18	-0.44	25.8	2.8
97	3/03	2030	-7.68E-02	0.43	-0.08	-0.18	14.0	6.9
			-5.96E-02	0.37	-0.05	-0.25	19.7	4.1
98	3/03	2100	-7.33E-02	0.46	-0.09	-0.21	16.0	5.6
			-6.52E-02	0.38	-0.08	-0.21	16.6	5.3
99	3/03	2130	-8.68E-02	0.41	-0.08	-0.18	13.7	7.1
			-6.75E-02	0.32	-0.05	-0.23	18.0	4.7
100	3/03	2200	-9.62E-02	0.38	-0.08	-0.15	12.3	8.3
			-1.03E-01	0.30	-0.07	-0.31	20.8	3.8
101	3/03	2230	-8.96E-02	0.37	-0.06	-0.23	16.7	5.3
			-8.35E-02	0.30	-0.04	-0.30	21.7	3.6
102	3/03	2300	-8.26E-02	0.38	-0.06	-0.23	17.0	5.1
			-7.38E-02	0.34	-0.04	-0.25	19.1	4.3
103	3/03	2330	-7.30E-02	0.39	-0.06	-0.20	15.2	6.1
			-7.68E-02	0.33	-0.05	-0.29	21.4	3.6
104	3/03	2400	-7.20E-02	0.42	-0.06	-0.23	17.9	4.7
			-5.41E-02	0.37	-0.04	-0.21	17.3	5.0
105	3/04	30	-9.45E-02	0.39	-0.07	-0.26	18.3	4.6
			-5.04E-02	0.32	-0.04	-0.16	14.1	6.8
106	3/04	100	-1.01E-01	0.38	-0.08	-0.23	16.4	5.4
			-8.68E-02	0.32	-0.05	-0.31	22.1	3.5
107	3/04	130	-1.03E-01	0.38	-0.08	-0.25	17.5	4.9
			-8.16E-02	0.27	-0.05	-0.27	19.9	4.1
108	3/04	200	-1.23E-01	0.35	-0.08	-0.26	17.2	5.0
			-9.60E-02	0.31	-0.06	-0.24	17.6	4.9
109	3/04	230	-9.65E-02	0.40	-0.08	-0.26	18.3	4.6
			-6.13E-02	0.34	-0.05	-0.19	15.7	5.8
110	3/04	400	-1.68E-01	0.32	-0.09	-0.28	17.1	5.1
			-2.00E-01	0.00	-0.12	-0.27	15.8	5.7
111	3/04	430	-1.85E-01	0.30	-0.09	-0.27	16.6	5.3
			-1.71E-01	0.21	-0.08	-0.26	16.1	5.5

#	Date	GMT	Z/L	U*	T*	Q*	Z*	Fm
112	3/04	500	-1.79E-01	0.31	-0.09	-0.23	16.9	5.2
			-1.62E-01	0.23	-0.08	-0.28	17.3	5.0
113	3/04	530	-1.91E-01	0.30	-0.09	-0.28	16.6	5.3
			-1.19E-01	0.23	-0.05	-0.22	15.4	6.0
114	3/04	600	-2.10E-01	0.28	-0.09	-0.28	16.4	5.4
			-1.16E-01	0.19	-0.04	-0.21	14.9	6.2
115	3/04	630	-1.62E-01	0.33	-0.09	-0.28	17.3	5.0
			-1.34E-01	0.28	-0.08	-0.24	16.1	5.5
116	3/04	700	-1.18E-01	0.35	-0.06	-0.29	19.3	4.2
			-1.21E-01	0.27	-0.09	-0.18	12.7	8.0
117	3/04	730	-1.41E-01	0.33	-0.07	-0.29	18.8	4.4
			-7.39E-02	0.20	-0.05	-0.11	9.5	12.3
118	3/04	800	-1.33E-01	0.30	-0.05	-0.28	18.4	4.6
			-2.42E-03	0.00	0.01	-0.09	10.8	10.2
119	3/04	830	-1.13E-01	0.29	-0.03	-0.26	18.5	4.5
			2.63E-02	0.25	0.03	-0.07	11.0	9.9
120	3/04	900	-1.05E-01	0.31	-0.04	-0.27	18.8	4.4
			-2.64E-01	0.25	-0.17	-0.28	15.0	6.2
121	3/04	930	-9.20E-02	0.32	-0.03	-0.26	19.1	4.3
			-1.80E-01	0.21	-0.11	-0.24	14.5	6.5
122	3/04	1000	-1.36E-01	0.32	-0.07	-0.23	15.3	6.0
			4.36E-02	0.00	0.06	-0.15	42.6	1.3
123	3/04	1030	-1.01E-01	0.36	-0.07	-0.24	17.4	5.0
			5.20E-03	0.32	0.04	-0.17	22.7	3.3
124	3/04	1100	-9.27E-02	0.35	-0.05	-0.26	19.0	4.3
			9.12E-02	0.23	0.10	-0.04	12.5	3.2
125	3/04	1130	-6.06E-02	0.36	-0.02	-0.24	19.7	4.1
			-3.77E-01	0.27	-0.34	-0.42	18.3	4.6
126	3/04	1330	-1.12E-01	0.31	-0.04	-0.27	18.9	4.4
			1.63E-01	0.26	0.13	-0.01	7.0	19.5
127	3/04	1400	-4.50E-02	0.36	-0.00	-0.25	21.2	3.7
			-7.59E-02	0.28	-0.04	-0.21	16.5	5.4

#	Date	GMT	Z/L	u*	T*	q*	Z*	Fm
128	3/04	1430	-9.42E-02	0.32	-0.03	-0.27	19.4	4.2
			1.61E-01	0.00	0.14	-0.00	5.9	25.4
133	3/04	2000	-1.74E-01	0.33	-0.10	-0.30	18.1	4.7
			-9.28E-02	0.00	-0.05	-0.18	13.9	6.9
134	3/04	2030	-1.81E-01	0.33	-0.10	-0.31	18.3	4.6
			-8.82E-02	0.00	-0.05	-0.19	14.5	6.5
135	3/04	2100	-1.84E-01	0.33	-0.11	-0.30	17.9	4.7
			-1.06E-01	0.00	-0.06	-0.19	13.9	6.9
136	3/04	2130	-1.80E-01	0.34	-0.11	-0.32	19.0	4.3
			-1.06E-01	0.00	-0.06	-0.22	16.0	5.6
147	3/05	430	-5.82E-01	0.21	-0.17	-0.36	15.2	6.0
			-3.44E-01	0.29	-0.11	-0.14	7.8	16.6
148	3/05	500	-5.88E-01	0.21	-0.17	-0.36	15.4	6.0
			-3.27E-01	0.23	-0.09	-0.16	9.4	12.6
149	3/05	530	-9.78E-01	0.16	-0.17	-0.37	14.0	6.9
			-1.15E 00	0.21	-0.21	-0.26	9.6	12.1
150	3/05	600	-1.19E 00	0.15	-0.19	-0.40	14.1	6.3
			-7.78E-01	0.20	-0.10	-0.29	12.4	3.2
151	3/05	630	-2.35E 00	0.11	-0.20	-0.47	13.4	7.3
			-2.50E 00	0.19	-0.15	-0.63	16.9	5.2
152	3/05	700	-2.11E 00	0.11	-0.17	-0.46	13.7	7.1
			-1.36E 00	0.17	-0.07	-0.66	19.2	4.3
153	3/05	730	-3.33E 00	0.09	-0.19	-0.52	13.4	7.3
			-4.96E 00	0.14	-0.16	-1.01	20.6	3.9
154	3/05	800	-3.90E 00	0.08	-0.19	-0.55	13.6	7.2
			-6.79E 00	0.16	-0.15	-1.39	24.5	3.0
155	3/05	830	-5.18E 00	0.07	-0.18	-0.56	12.9	7.8
			-6.79E 00	0.11	-0.09	-1.16	21.5	3.6
156	3/05	900	-7.59E 00	0.06	-0.19	-0.62	12.5	8.1
			-5.07E 01	0.12	-1.19	-2.34	20.7	3.3
157	3/05	930	-1.62E 01	0.05	-0.25	-0.78	12.4	8.3
			-6.07E 01	0.10	-0.71	-2.55	21.8	3.5

#	Date	GMT	Z/L	u*	T*	σ*	Z*	Fm
162	3/05	2000	-6.11E-02	0.67	-0.16	-0.33	23.5	3.2
			-1.71E-02	0.29	-0.03	-0.18	18.7	4.5
163	3/05	2030	-1.21E-01	0.47	-0.15	-0.33	20.5	3.9
			-4.48E-02	0.37	-0.05	-0.20	17.3	5.0
164	3/05	2100	-5.98E-02	0.68	-0.15	-0.33	23.8	3.1
			-1.52E-02	0.37	-0.02	-0.20	20.9	3.8
165	3/05	2130	-1.27E-01	0.47	-0.16	-0.35	21.3	3.7
			-4.71E-02	0.28	-0.04	-0.26	21.3	3.7
166	3/05	2200	-1.31E-01	0.47	-0.17	-0.35	21.0	3.7
			-5.14E-02	0.35	-0.05	-0.26	21.2	3.7
167	3/05	2230	-7.34E-02	0.63	-0.17	-0.32	22.3	3.4
			-1.98E-02	0.35	-0.03	-0.18	17.7	4.8
168	3/05	2300	-1.38E-01	0.46	-0.18	-0.33	20.0	4.0
			-5.02E-02	0.33	-0.05	-0.21	17.5	4.9
169	3/05	2330	-1.38E-01	0.46	-0.18	-0.33	20.0	4.0
			-5.02E-02	0.33	-0.05	-0.21	17.5	4.9
170	3/05	2400	-1.32E-01	0.46	-0.17	-0.33	20.0	4.0
			-8.25E-02	0.33	-0.10	-0.27	19.3	4.2
171	3/06	30	-7.35E-02	0.59	-0.15	-0.30	21.0	3.3
			-2.93E-02	0.34	-0.05	-0.19	17.9	4.7
172	3/06	100	-7.98E-02	0.60	-0.17	-0.31	21.3	3.7
			-2.49E-02	0.34	-0.04	-0.21	19.7	4.1
173	3/06	130	-1.34E-01	0.47	-0.17	-0.32	19.6	4.1
			-3.58E-02	0.34	-0.03	-0.22	19.8	4.1
174	3/06	200	-6.22E-02	0.58	-0.17	-0.31	22.4	3.4
			-1.56E-02	0.36	-0.02	-0.22	22.2	3.4
175	3/06	230	-9.45E-02	0.57	-0.18	-0.33	21.6	3.6
			-2.72E-02	0.35	-0.02	-0.27	24.7	2.9
176	3/06	300	-9.57E-02	0.56	-0.18	-0.33	21.5	3.6
			-3.08E-02	0.35	-0.03	-0.29	25.3	2.8
177	3/06	330	-1.18E-01	0.54	-0.21	-0.35	21.1	3.7
			-3.28E-02	0.32	-0.03	-0.28	24.6	2.9

#	Date	CMT	Z/L	u*	T*	σ*	Z*	Fm
178	3/06	400	-1.30E-01	0.54	-0.23	-0.36	21.0	3.7
			-4.10E-02	0.32	-0.05	-0.27	22.7	3.3
179	3/06	430	-1.35E-01	0.52	-0.23	-0.36	21.0	3.7
			-3.30E-02	0.30	-0.03	-0.26	23.0	3.3
180	3/06	530	-1.39E-01	0.51	-0.22	-0.35	20.2	4.0
			-2.30E-02	0.23	-0.02	-0.19	18.4	4.6
181	3/06	600	-1.00E-01	0.56	-0.19	-0.32	20.4	3.9
			-3.91E-02	0.24	-0.07	-0.17	15.1	6.1
182	3/06	630	-1.33E-01	0.48	-0.18	-0.32	19.2	4.3
			-5.05E-02	0.21	-0.07	-0.16	13.9	7.0
183	3/06	730	-8.98E-02	0.50	-0.13	-0.28	19.1	4.3
			-4.36E-02	0.27	-0.08	-0.07	6.4	22.2
196	3/07	730	-2.49E-01	0.24	-0.08	-0.24	13.8	7.0
			-6.37E-02	0.11	-0.05	0.11	0.0	0.0
197	3/07	800	-2.01E-01	0.24	-0.06	-0.21	13.5	7.3
			3.04E-02	0.27	0.00	0.07	0.0	0.0
200	3/07	930	-3.87E-02	0.47	-0.03	-0.21	18.7	4.5
			1.79E-02	0.27	0.02	0.07	0.0	0.0
201	3/07	1000	-8.20E-02	0.30	-0.02	-0.22	16.8	5.2
			4.92E-02	0.26	0.02	0.07	0.0	0.0
202	3/07	1030	-2.43E-02	0.54	-0.02	-0.21	19.3	4.1
			3.51E-02	0.31	0.07	0.10	0.0	0.0
203	3/07	1100	-1.59E-02	0.55	-0.01	-0.19	19.2	4.3
			3.13E-02	0.25	0.06	0.14	0.0	0.0
204	3/07	1130	-2.99E-02	0.49	-0.02	-0.20	19.2	4.3
			3.53E-02	0.25	0.05	0.12	0.0	0.0
205	3/07	1230	-1.53E-02	0.64	-0.02	-0.18	18.4	4.5
			4.72E-02	0.34	0.13	0.18	0.0	0.0
206	3/07	1300	-2.60E-02	0.50	-0.02	-0.17	16.9	5.2
			8.22E-02	0.26	0.14	0.20	0.0	0.0
207	3/07	1500	-7.37E 00	0.04	-0.05	-0.37	8.9	13.5
			6.46E-01	0.09	-0.00	0.06	0.0	0.0

#	Date	GMT	Z/L	u*	T*	q*	Z*	Fm
208	3/07	1530	-3.27E 00	0.04	0.01	-0.30	9.3	12.6
			-3.09E 01	0.12	-0.74	2.00	0.0	0.0
209	3/07	1800	-9.37E-01	0.07	-0.01	-0.18	8.7	14.0
			4.84E-01	0.17	0.00	0.11	0.0	0.0
211	3/07	1900	-1.64E 00	0.07	-0.04	-0.20	8.0	16.0
			6.20E-01	0.17	0.01	0.09	0.0	0.0
212	3/07	1930	-1.98E 00	0.07	-0.06	-0.24	8.6	14.2
			4.03E-01	0.14	-0.00	0.11	0.0	0.0
213	3/07	2000	-2.38E 00	0.07	-0.07	-0.25	8.6	14.3
			4.22E-01	0.14	-0.00	0.10	0.0	0.0
214	3/07	2030	-2.34E 00	0.07	-0.06	-0.28	9.5	12.4
			3.27E-01	0.13	-0.00	0.09	0.0	0.0
215	3/07	2100	-1.25E 00	0.09	-0.04	-0.28	11.2	9.7
			2.16E-01	0.20	0.00	0.07	0.0	0.0
216	3/07	2130	-4.11E 00	0.05	-0.05	-0.33	9.3	12.7
			3.82E-01	0.12	-0.00	0.06	0.0	0.0
217	3/07	2200	-1.82E 00	0.07	-0.03	-0.28	10.2	11.0
			2.78E-01	0.15	-0.00	0.07	0.0	0.0
218	3/07	2230	-2.19E 00	0.07	-0.05	-0.30	10.2	11.0
			2.27E-01	0.18	-0.00	0.06	0.0	0.0
219	3/08	130	-2.58E-01	0.22	-0.06	-0.24	14.3	6.7
			1.54E-02	0.24	-0.01	0.11	0.0	0.0
220	3/08	730	-3.39E-01	0.16	-0.14	-0.35	13.8	7.0
			-4.24E-02	0.20	-0.01	0.02	0.0	0.0
221	3/08	800	-1.52E-01	0.35	-0.11	-0.29	18.1	4.7
			-1.08E-02	0.26	-0.02	0.03	0.0	0.0
222	3/08	830	-1.40E-01	0.37	-0.10	-0.29	18.2	4.6
			-1.55E-02	0.25	-0.02	0.03	0.0	0.0
223	3/08	900	-1.34E-01	0.33	-0.10	-0.30	19.0	4.3
			3.43E-03	0.25	0.00	0.01	0.0	0.0
224	3/08	930	-6.11E-01	0.18	-0.12	-0.34	14.7	6.4
			4.11E-02	0.22	0.01	0.01	0.0	0.0

#	Date	GMT	Z/L	u*	T*	q*	Z*	Fm
225	3/08	1100	-5.40E-01	0.20	-0.14	-0.35	15.4	5.9
			4.45E-02	0.24	0.01	0.01	0.0	0.0
226	3/08	1130	1.00E-01	0.18	0.06	-0.16	449.4	0.0
			1.52E-01	0.22	0.04	0.01	0.0	0.0
227	3/08	1230	-7.89E-02	0.53	-0.11	-0.34	23.4	3.2
			4.81E-02	0.29	0.11	0.01	1.6	179.7
228	3/08	1400	-9.97E-02	0.49	-0.13	-0.33	21.6	3.6
			2.89E-02	0.28	0.06	0.00	1.0	349.2
229	3/08	1430	-1.64E-01	0.38	-0.13	-0.34	20.1	4.0
			2.52E-02	0.26	0.03	0.00	0.2	6169.4
230	3/08	1500	-1.70E-01	0.38	-0.14	-0.33	19.3	4.2
			4.62E-02	0.26	0.05	0.01	0.0	0.0
231	3/08	1530	-1.13E 00	0.16	-0.18	-0.43	15.0	6.2
			2.21E-01	0.21	0.05	-0.00	1.2	269.2
232	3/08	1700	-1.29E 00	0.15	-0.19	-0.43	14.5	6.6
			2.48E-01	0.18	0.04	0.00	0.7	608.1
233	3/08	1930	-1.35E 00	0.15	-0.21	-0.40	13.6	7.2
			-4.32E-02	0.22	-0.00	-0.02	2.1	122.4
234	3/08	2000	-1.94E-01	0.37	-0.16	-0.32	18.1	4.7
			-1.41E-02	0.00	-0.02	0.01	0.0	0.0
235	3/08	2030	-3.58E 00	0.09	-0.23	-0.46	11.7	9.0
			-7.22E-01	0.13	-0.06	0.08	0.0	0.0
236	3/08	2200	-3.72E 00	0.09	-0.24	-0.46	11.7	9.0
			-1.86E 00	0.14	-0.14	0.04	0.0	0.0
237	3/08	2230	-2.90E 00	0.10	-0.22	-0.43	11.7	8.9
			-4.02E-01	0.15	-0.05	0.08	0.0	0.0
238	3/08	2300	-3.18E 00	0.10	-0.23	-0.44	11.7	9.0
			-2.14E-01	0.17	-0.03	0.06	0.0	0.0
241	3/09	1000	-5.52E 00	0.07	-0.18	-0.48	11.1	9.8
			2.47E-01	0.16	0.01	0.02	0.0	0.0
242	3/09	1030	-3.26E-01	0.23	-0.10	-0.30	15.7	5.3
			5.24E-02	0.27	0.01	0.06	0.0	0.0

#	Date	GMT	Z/L	u*	T*	q*	[illegible]	Fn
243	3/09	1200	-4.54E 00	0.07	-0.13	-0.40	10.2	11.0
			5.71E-01	0.18	0.02	0.03	0.0	0.0
244	3/09	1230	-3.73E 00	0.06	[illegible]	-0.36	10.2	11.1
			4.39E-01	0.20	0.01	0.04	0.0	0.0
245	3/09	1300	-4.35E 00	0.06	-0.12	-0.11	10.6	10.4
			4.03E-01	0.23	0.01	0.03	0.0	0.0
246	3/09	1400	-4.98E-02	0.50	-0.06	-0.24	19.8	4.1
			3.86E-02	0.34	0.06	0.10	0.0	0.0
247	3/09	1430	-5.75E-02	0.48	-0.06	-0.26	20.5	3.9
			2.81E-02	0.40	0.04	0.07	0.0	0.0
248	3/09	1500	-3.81E-02	0.60	-0.06	-0.25	21.2	3.7
			8.68E-03	0.36	0.01	0.09	0.0	0.0
249	3/09	1530	-3.43E-01	0.20	-0.07	-0.28	14.9	6.3
			8.28E-02	0.30	0.02	0.07	0.0	0.0
250	3/09	1600	-5.47E-02	0.51	-0.07	-0.25	20.1	4.0
			2.11E-02	0.34	0.03	0.09	0.0	0.0
251	3/09	1630	-3.77E-02	0.61	-0.07	-0.24	20.5	3.9
			1.33E-02	0.42	0.02	0.13	0.0	0.0
252	3/09	1700	-3.68E-02	0.61	-0.06	-0.23	20.2	4.0
			1.73E-02	0.42	0.03	0.14	0.0	0.0
253	3/09	1800	-7.11E-02	0.46	-0.08	-0.23	17.6	4.9
			1.43E-02	0.34	-0.01	0.17	0.0	0.0
254	3/09	1830	-5.21E-01	0.20	-0.13	-0.28	12.9	7.3
			3.11E-02	0.30	-0.02	0.15	0.0	0.0
255	3/09	1900	-5.64E-01	0.17	-0.10	-0.24	11.6	9.1
			2.08E-02	0.24	-0.03	0.19	0.0	0.0
256	3/09	2030	-2.87E-01	0.23	-0.09	-0.22	12.8	7.0
			1.30E-02	0.23	-0.03	0.20	0.0	0.0
257	3/09	2100	-3.35E-01	0.21	-0.09	-0.23	12.7	8.0
			5.95E-02	0.27	-0.01	0.17	0.0	0.0
258	3/09	2130	-2.41E-01	0.23	-0.07	-0.21	12.8	7.3
			2.75E-02	0.29	-0.02	0.19	0.0	0.0

#	Date	GMT	Z/L	u*	T*	q*	Z*	Fm
259	3/09	2200	-2.54E-01	0.23	-0.07	-0.23	13.7	7.1
			1.33E-02	0.29	-0.02	0.16	0.0	0.0
260	3/09	2230	-2.12E-01	0.26	-0.08	-0.24	14.6	6.4
			2.89E-02	0.30	-0.01	0.15	0.0	0.0
261	3/09	2300	-2.49E-01	0.23	-0.07	-0.23	13.4	7.3
			2.53E-02	0.28	-0.02	0.18	0.0	0.0
262	3/10	630	-5.04E-02	0.30	-0.01	-0.16	14.8	6.3
			6.77E-02	0.34	0.00	0.27	0.0	0.0
263	3/10	700	-2.07E-02	0.31	0.02	-0.18	18.8	4.4
			3.81E-02	0.37	-0.01	0.24	0.0	0.0
264	3/10	730	-1.91E-02	0.32	0.02	-0.18	19.0	4.4
			3.73E-02	0.37	-0.01	0.24	0.0	0.0
265	3/10	830	-2.36E-02	0.29	0.02	-0.19	19.3	4.3
			6.16E-02	0.37	0.01	0.20	0.0	0.0
266	3/10	900	-2.11E-02	0.29	0.02	-0.20	20.0	4.0
			9.40E-02	0.36	0.03	0.19	0.0	0.0
267	3/10	1100	2.54E-02	0.30	0.05	-0.15	28.7	2.3
			1.68E-01	0.35	0.08	0.23	0.0	0.0
268	3/10	1130	2.16E-02	0.31	0.04	-0.15	26.5	2.6
			1.50E-01	0.30	0.08	0.25	0.0	0.0
269	3/10	1200	2.68E-02	0.30	0.05	-0.15	23.6	2.3
			1.54E-01	0.31	0.07	0.24	0.0	0.0
270	3/10	1230	2.75E-02	0.32	0.05	-0.14	25.4	2.3
			1.15E-01	0.31	0.04	0.30	0.0	0.0
271	3/10	1330	3.73E-02	0.31	0.05	-0.12	25.1	2.9
			6.57E-02	0.33	-0.02	0.38	0.0	0.0
272	3/10	1500	2.73E-02	0.31	0.04	-0.11	19.5	4.2
			2.30E-02	0.35	0.03	-0.04	6.8	20.1
273	3/10	1530	3.91E-02	0.31	0.05	-0.10	19.4	4.2
			2.65E-02	0.33	0.03	-0.05	8.1	15.5
274	3/10	1800	-2.16E-02	0.27	-0.01	-0.04	5.0	32.1
			-1.17E-02	0.40	0.00	-0.04	5.1	30.9

#	Date	GMT	Z/L	u*	T*	σ*	Z*	Fn
275	3/10	1830	-6.60E-02	0.26	-0.03	-0.05	4.5	37.3
			-6.13E-03	0.31	0.00	-0.04	5.3	29.4
276	3/10	1900	-5.09E-02	0.25	-0.02	-0.04	4.3	40.2
			-2.40E-02	0.31	-0.00	-0.07	7.3	18.4
277	3/10	1930	-4.33E-02	0.24	-0.01	-0.04	4.2	41.2
			5.31E-01	0.32	0.24	0.17	0.0	0.0
278	3/10	2000	-1.44E-02	0.27	-0.00	-0.04	4.3	41.0
			-1.45E-02	0.40	0.00	-0.07	8.6	14.3
279	3/10	2030	-2.19E-02	0.24	-0.00	-0.03	3.7	50.9
			-2.28E-02	0.32	0.00	-0.07	8.2	15.4
280	3/10	2100	-1.35E-02	0.22	-0.00	-0.03	3.3	60.1
			-3.75E-02	0.31	-0.00	-0.07	7.4	18.0
281	3/10	2130	-1.90E-02	0.22	-0.00	-0.03	3.7	51.2
			-1.16E-02	0.36	0.01	-0.06	6.7	20.8
282	3/11	700	-1.04E-01	0.19	-0.01	-0.10	8.8	13.9
			-1.15E-01	0.27	-0.01	-0.15	11.8	8.3
283	3/11	730	-1.29E-01	0.18	-0.02	-0.11	8.9	13.5
			-1.24E-01	0.26	-0.01	-0.15	11.4	9.4
284	3/11	800	-1.28E-01	0.18	-0.02	-0.12	9.4	12.4
			-1.69E-01	0.26	-0.01	-0.19	13.0	7.6
285	3/11	830	-1.06E-01	0.19	-0.01	-0.12	9.8	11.3
			-1.19E-01	0.28	-0.00	-0.18	13.9	6.9
286	3/11	900	-7.45E-02	0.20	-0.01	-0.11	10.2	11.0
			-5.36E-02	0.29	0.01	-0.15	13.5	7.3
287	3/11	930	-6.52E-02	0.23	-0.00	-0.15	13.4	7.3
			-1.12E-01	0.29	-0.01	-0.19	14.6	6.5
288	3/11	1000	-6.62E-02	0.26	-0.00	-0.19	16.2	5.5
			-3.26E-02	0.31	0.02	-0.20	19.2	4.3
289	3/11	1030	-8.36E-02	0.23	-0.01	-0.18	14.2	6.3
			-4.68E-02	0.31	0.02	-0.20	17.9	4.8
290	3/11	1100	-8.12E-02	0.24	-0.01	-0.16	13.4	7.3
			-7.26E-02	0.30	0.00	-0.20	16.2	5.5

#	Date	GMT	Z/L	u*	T*	q*	Z*	Fm
291	3/11	1130	-8.04E-02	0.24	-0.01	-0.17	13.7	7.1
			-7.72E-02	0.30	0.00	-0.22	17.6	4.9
292	3/11	1230	-7.47E-02	0.26	-0.01	-0.16	13.5	7.3
			-2.31E-02	0.31	0.02	-0.18	18.5	4.5
293	3/11	1300	-1.02E-01	0.25	-0.01	-0.25	18.3	4.6
			9.72E-03	0.30	0.03	-0.13	18.2	4.6
294	3/11	1330	-8.65E-02	0.25	-0.00	-0.25	19.2	4.3
			6.42E-03	0.31	0.03	-0.17	23.2	3.2
295	3/11	1400	-1.62E-01	0.22	-0.02	-0.27	17.5	4.9
			3.45E-02	0.29	0.04	-0.12	22.6	3.4
296	3/11	1430	-1.56E-01	0.23	-0.03	-0.24	15.7	5.8
			6.69E-02	0.29	0.06	-0.15	137.9	0.2
297	3/11	1500	-1.33E-01	0.26	-0.04	-0.23	16.0	5.6
			7.07E-02	0.30	0.07	-0.15	148.5	0.2
298	3/11	1530	-1.24E-01	0.26	-0.02	-0.28	19.3	4.3
			1.27E-01	0.30	0.09	-0.10	709.1	0.0
299	3/11	1600	-1.04E-01	0.28	-0.02	-0.27	19.1	4.3
			-1.03E 01	0.31	-6.58	-1.25	2.2	111.2
300	3/11	1700	-2.43E-02	0.31	0.02	-0.22	22.1	3.5
			1.17E-01	0.35	0.12	-0.14	543.3	0.0
301	3/11	1730	-7.82E-02	0.30	-0.01	-0.27	20.4	3.9
			6.40E-02	0.38	0.07	-0.14	74.1	0.6
302	3/11	1800	-1.07E-01	0.26	-0.01	-0.27	19.0	4.3
			4.37E-02	0.30	0.05	-0.16	48.9	1.1
303	3/11	1830	-1.46E-01	0.27	-0.04	-0.28	18.3	4.6
			2.71E-02	0.30	0.05	-0.17	34.8	1.8
304	3/11	1900	-1.94E-01	0.24	-0.05	-0.29	17.4	5.0
			-1.04E-02	0.28	0.03	-0.22	24.1	3.0
305	3/11	1930	-2.57E-01	0.23	-0.07	-0.28	16.0	5.6
			-2.30E-01	0.33	-0.03	-0.42	22.9	3.3
306	3/11	2000	-2.50E-01	0.25	-0.07	-0.31	17.1	5.1
			-1.63E-01	0.34	-0.02	-0.34	21.1	3.7

#	Date	GMT	Z/L	u*	T*	q*	Z*	Fm
307	3/11	2030	-1.97E-01	0.26	-0.06	-0.29	17.5	4.9
			-1.55E-01	0.30	-0.03	-0.34	21.3	3.7
308	3/11	2100	-1.65E-01	0.32	-0.09	-0.24	15.2	6.1
			-1.16E-01	0.32	-0.03	-0.36	23.3	3.2
309	3/11	2130	-2.08E-01	0.30	-0.10	-0.26	15.6	5.9
			-1.26E-01	0.36	-0.04	-0.32	20.9	3.8
310	3/11	2200	-2.52E-01	0.27	-0.11	-0.25	14.3	6.7
			-1.52E-01	0.30	-0.03	-0.32	20.0	4.0
311	3/11	2230	-2.38E-01	0.28	-0.10	-0.28	15.9	5.7
			-1.90E-01	0.32	-0.05	-0.43	24.2	3.0
312	3/11	2300	-1.14E-01	0.40	-0.10	-0.27	17.8	4.8
			-1.13E-01	0.41	-0.07	-0.43	26.7	2.6
313	3/11	2330	-2.78E-01	0.32	-0.18	-0.32	16.3	5.5
			-2.44E-01	0.37	-0.08	-0.69	32.6	1.9
314	3/12	500	-2.77E-01	0.32	-0.17	-0.36	18.4	4.6
			-3.67E-01	0.36	-0.12	-1.09	42.0	1.3
315	3/12	530	-3.44E-01	0.29	-0.18	-0.39	18.6	4.5
			-4.87E-01	0.30	-0.12	-1.31	45.2	1.2
316	3/12	600	-3.19E-01	0.31	-0.18	-0.43	20.4	3.9
			-4.99E-01	0.30	-0.12	-1.56	51.1	1.0
317	3/12	630	-3.05E-01	0.31	-0.17	-0.38	18.6	4.5
			-4.77E-01	0.30	-0.15	-1.31	45.1	1.2
318	3/12	700	-2.76E-01	0.31	-0.15	-0.38	19.5	4.2
			-4.24E-01	0.31	-0.11	-1.28	45.9	1.2
319	3/12	730	-3.05E-01	0.29	-0.15	-0.37	18.4	4.6
			-6.29E-01	0.20	-0.19	-1.36	43.3	1.3
320	3/12	830	-3.13E-01	0.29	-0.15	-0.37	18.5	4.5
			-4.90E-01	0.20	-0.12	-1.26	43.6	1.2
321	3/12	900	-3.12E-01	0.29	-0.15	-0.38	19.0	4.4
			-4.09E-01	0.29	-0.06	-1.24	45.5	1.2
322	3/12	930	-2.83E-01	0.29	-0.13	-0.36	18.7	4.4
			-1.92E-01	0.30	0.04	-0.97	45.8	1.2

#	Date	GMT	Z/L	u*	T*	c*	Z*	/Fr
323	3/12	1000	-3.01E-01	0.23	-0.13	-0.39	19.6	4.1
			-1.29E-01	0.30	0.09	-0.98	51.0	1.0
324	3/12	1030	-3.33E-01	0.27	-0.13	-0.40	19.4	4.2
			-5.50E-02	0.29	0.11	-0.82	54.4	0.9
325	3/12	1100	-4.33E-01	0.23	-0.13	-0.38	17.3	5.0
			-1.53E-01	0.31	0.10	-0.91	46.3	1.1
326	3/12	1130	-4.15E-01	0.24	-0.13	-0.39	18.2	4.7
			-1.80E-01	0.27	0.10	-1.03	49.0	1.0
327	3/12	1200	-5.46E-01	0.22	-0.15	-0.45	19.0	4.3
			-5.59E-01	0.25	0.08	-1.70	53.9	0.9
328	3/12	1330	-8.15E-01	0.17	-0.14	-0.47	17.8	4.8
			-2.72E 00	0.23	-0.22	-2.62	49.6	1.0
329	3/12	1400	-6.82E-01	0.19	-0.14	-0.47	18.6	4.5
			-2.33E 00	0.23	-0.27	-2.57	50.7	1.0
330	3/12	1430	-6.37E-01	0.20	-0.15	-0.45	18.3	4.6
			-9.38E-01	0.24	0.01	-1.79	49.2	1.0
331	3/12	1500	-9.34E-01	0.17	-0.17	-0.46	16.6	5.3
			-1.45E 00	0.26	-0.00	-1.95	47.1	1.1
332	3/12	1530	-7.13E-01	0.19	-0.15	-0.48	18.5	4.5
			-8.20E-01	0.23	0.07	-1.82	51.6	1.0
333	3/12	1600	-9.42E-01	0.16	-0.14	-0.49	17.8	4.8
			-3.48E-01	0.21	0.17	-1.40	53.0	0.9
334	3/12	1630	-9.91E-01	0.16	-0.16	-0.50	17.6	4.9
			-1.23E 00	0.00	0.10	-2.11	52.4	0.9
335	3/12	1800	-8.54E-01	0.17	-0.14	-0.47	17.6	4.9
			-5.16E-01	0.26	0.15	-1.55	51.7	1.0
336	3/12	1830	-1.02E 00	0.17	-0.19	-0.50	17.5	4.9
			-2.30E-01	0.21	0.17	-1.25	54.0	0.9
340	3/13	830	-3.96E-01	0.22	-0.10	-0.43	20.0	4.0
			-6.37E-02	0.35	0.13	-0.90	56.5	0.8
341	3/13	900	-1.88E-01	0.35	-0.11	-0.41	22.9	3.3
			-4.59E-02	0.29	0.11	-0.88	59.2	0.8

#	Date	GMT	Z/L	u*	T*	q*	Z*	Fm
342	3/13	930	-1.61E-01	0.34	-0.09	-0.35	20.8	3.8
			-1.36E-01	0.36	0.04	-0.95	49.0	1.1
343	3/13	1000	-2.90E-02	0.79	-0.08	-0.31	25.5	2.6
			-1.53E-02	0.40	0.03	-0.61	54.4	0.9
344	3/13	1030	-2.69E-01	0.24	-0.07	-0.34	18.3	4.6
			-9.40E-02	0.35	0.10	-0.81	47.8	1.1
345	3/13	1100	-3.08E-01	0.23	-0.07	-0.36	18.4	4.6
			-3.52E-02	0.35	0.11	-0.70	52.9	0.9
346	3/13	1130	-2.00E-01	0.35	-0.13	-0.41	22.3	3.4
			-1.69E-02	0.35	0.11	-0.70	61.4	0.7
347	3/13	1300	-4.37E-02	0.63	-0.08	-0.31	25.0	2.9
			1.96E-02	0.38	0.16	-0.51	348.5	0.1
348	3/13	1330	-3.52E-02	0.71	-0.08	-0.32	26.3	2.7
			9.65E-03	0.38	0.14	-0.54	119.9	0.3
349	3/14	1930	-2.60E-01	0.21	-0.07	-0.18	10.8	10.1
			-1.11E-01	0.26	-0.05	0.03	0.0	0.0
350	3/14	2000	-2.47E-01	0.21	-0.06	-0.17	10.8	10.1
			-3.28E-01	0.27	-0.12	0.03	0.0	0.0
351	3/14	2030	-2.92E-01	0.19	-0.06	-0.18	11.0	9.9
			-3.81E-01	0.27	-0.11	-0.02	0.0	0.0
352	3/14	2100	-1.96E-01	0.24	-0.06	-0.22	14.2	6.7
			-1.89E-01	0.30	-0.05	-0.25	15.9	5.7
353	3/14	2130	-3.11E-01	0.21	-0.07	-0.25	13.7	7.1
			-8.32E-01	0.29	-0.19	-0.62	21.9	3.5
354	3/14	2200	-2.87E-01	0.23	-0.08	-0.27	15.1	6.1
			-3.58E-01	0.27	-0.07	-0.49	23.1	3.2
356	3/15	1130	-2.01E 00	0.11	-0.15	-0.41	12.7	7.9
			-2.98E 00	0.20	-0.20	-0.47	12.7	8.0
357	3/15	1230	-4.62E-01	0.21	-0.12	-0.34	15.6	5.8
			-1.95E-01	0.25	-0.04	-0.22	14.1	6.8
358	3/15	1300	-1.59E 00	0.12	-0.14	-0.39	13.0	7.7
			-5.05E-01	0.22	-0.01	-0.28	14.0	6.9

#	Date	GMT	Z/L	u*	T*	q*	Z*	Fm
359	3/15	1330	-1.87E 00	0.11	-0.16	-0.42	13.1	7.6
			1.60E-01	0.21	0.03	-0.06	39.3	1.5
360	3/15	1400	-1.70E 00	0.11	-0.14	-0.40	13.2	7.5
			-4.15E 00	0.21	-0.30	-0.80	17.6	4.9

TABLE C-3. Similar to TABLE C-2, but for Bouy Data Only.

#	Date	GMT	Z/L	u*	T*	σ*	Z*	Fr
133	3/04	2000	-1.74E-01	0.33	-0.10	-0.30	18.1	4.7
			-9.28E-02	0.00	-0.05	-0.18	13.9	6.9
134	3/04	2030	-1.81E-01	0.33	-0.10	-0.31	18.3	4.6
			-8.82E-02	0.00	-0.05	-0.19	14.5	6.5
135	3/04	2100	-1.84E-01	0.33	-0.11	-0.30	17.9	4.7
			-1.06E-01	0.00	-0.06	-0.19	13.9	6.9
136	3/04	2130	-1.80E-01	0.34	-0.11	-0.32	19.0	4.3
			-1.06E-01	0.00	-0.06	-0.22	16.0	5.6
282	3/11	700	-1.04E-01	0.19	-0.01	-0.10	8.8	13.9
			-1.15E-01	0.27	-0.01	-0.15	11.8	8.8
283	3/11	730	-1.29E-01	0.18	-0.02	-0.11	8.9	13.5
			-1.24E-01	0.26	-0.01	-0.15	11.4	9.4
284	3/11	800	-1.28E-01	0.18	-0.02	-0.12	9.4	12.4
			-1.69E-01	0.26	-0.01	-0.19	13.0	7.6
285	3/11	830	-1.06E-01	0.19	-0.01	-0.12	9.8	11.8
			-1.19E-01	0.28	-0.00	-0.18	13.9	6.9
286	3/11	900	-7.45E-02	0.20	-0.01	-0.11	10.2	11.0
			-5.36E-02	0.29	0.01	-0.15	13.5	7.3
287	3/11	930	-6.52E-02	0.23	-0.00	-0.15	13.4	7.3
			-1.12E-01	0.29	-0.01	-0.19	14.6	6.5
288	3/11	1000	-6.62E-02	0.26	-0.00	-0.19	16.2	5.5
			-3.26E-02	0.31	0.02	-0.20	19.2	4.3
289	3/11	1030	-8.86E-02	0.23	-0.01	-0.18	14.2	6.8
			-4.68E-02	0.31	0.02	-0.20	17.9	4.8
290	3/11	1100	-8.12E-02	0.24	-0.01	-0.16	13.4	7.3
			-7.26E-02	0.30	0.00	-0.20	16.2	5.5
291	3/11	1130	-8.04E-02	0.24	-0.01	-0.17	13.7	7.1
			-7.72E-02	0.30	0.00	-0.22	17.6	4.9
292	3/11	1230	-7.47E-02	0.26	-0.01	-0.16	13.5	7.3
			-2.31E-02	0.31	0.02	-0.18	18.5	4.5
293	3/11	1300	-1.02E-01	0.25	-0.01	-0.25	18.3	4.6
			9.72E-03	0.30	0.03	-0.13	18.2	4.6

#	Date	GMT	Z/L	u*	T*	q*	Z*	Fm
294	3/11	1330	-8.65E-02	0.25	-0.00	-0.25	19.2	4.3
			6.42E-03	0.31	0.03	-0.17	23.2	3.2
295	3/11	1400	-1.62E-01	0.22	-0.02	-0.27	17.5	4.9
			3.45E-02	0.29	0.04	-0.12	22.6	3.4
296	3/11	1430	-1.56E-01	0.23	-0.03	-0.24	15.7	5.8
			6.69E-02	0.29	0.06	-0.15	137.9	0.2
297	3/11	1500	-1.33E-01	0.26	-0.04	-0.23	16.0	5.6
			7.07E-02	0.30	0.07	-0.15	148.5	0.2
298	3/11	1530	-1.24E-01	0.26	-0.02	-0.28	19.3	4.3
			1.27E-01	0.30	0.09	-0.10	709.1	0.0
299	3/11	1600	-1.04E-01	0.28	-0.02	-0.27	19.1	4.3
			-1.03E 01	0.31	-6.58	-1.25	2.2	111.2
300	3/11	1700	-2.43E-02	0.31	0.02	-0.22	22.1	3.5
			1.17E-01	0.35	0.12	-0.14	543.3	0.0
301	3/11	1730	-7.82E-02	0.30	-0.01	-0.27	20.4	3.9
			6.40E-02	0.38	0.07	-0.14	74.1	0.6
302	3/11	1800	-1.07E-01	0.26	-0.01	-0.27	19.0	4.3
			4.37E-02	0.30	0.05	-0.16	48.9	1.1
303	3/11	1830	-1.46E-01	0.27	-0.04	-0.28	18.3	4.6
			2.71E-02	0.30	0.05	-0.17	34.8	1.3
304	3/11	1900	-1.94E-01	0.24	-0.05	-0.29	17.4	5.0
			-1.04E-02	0.28	0.03	-0.22	24.1	3.0
305	3/11	1930	-2.57E-01	0.23	-0.07	-0.28	16.0	5.6
			-2.30E-01	0.33	-0.03	-0.42	22.9	3.3
306	3/11	2000	-2.50E-01	0.25	-0.07	-0.31	17.1	5.1
			-1.63E-01	0.34	-0.02	-0.34	21.1	3.7
307	3/11	2030	-1.97E-01	0.26	-0.06	-0.29	17.5	4.9
			-1.55E-01	0.30	-0.03	-0.34	21.3	3.7
308	3/11	2100	-1.65E-01	0.32	-0.09	-0.24	15.2	6.1
			-1.16E-01	0.32	-0.03	-0.36	23.3	3.2
309	3/11	2130	-2.08E-01	0.30	-0.10	-0.26	15.6	5.9
			-1.26E-01	0.36	-0.04	-0.32	20.9	3.8

#	Date	GMT	Z/L	u*	T*	q*	Z*	Fm
310	3/11	2200	-2.52E-01	0.27	-0.11	-0.25	14.3	6.7
			-1.52E-01	0.30	-0.03	-0.32	20.0	4.0
311	3/11	2230	-2.38E-01	0.28	-0.10	-0.28	15.9	5.7
			-1.90E-01	0.32	-0.05	-0.43	24.2	3.0
312	3/11	2300	-1.14E-01	0.40	-0.10	-0.27	17.8	4.8
			-1.13E-01	0.41	-0.07	-0.43	26.7	2.6
356	3/15	1130	-2.01E 00	0.11	-0.15	-0.41	12.7	7.9
			-2.98E 00	0.20	-0.20	-0.47	12.7	8.0
357	3/15	1230	-4.62E-01	0.21	-0.12	-0.34	15.6	5.8
			-1.95E-01	0.25	-0.04	-0.22	14.1	6.3
358	3/15	1300	-1.59E 00	0.12	-0.14	-0.39	13.0	7.7
			-5.05E-01	0.22	-0.01	-0.28	14.0	6.9
359	3/15	1330	-1.87E 00	0.11	-0.16	-0.42	13.1	7.6
			1.60E-01	0.21	0.03	-0.06	39.3	1.5
360	3/15	1400	-1.70E 00	0.11	-0.14	-0.40	13.2	7.5
			-4.15E 00	0.21	-0.30	-0.80	17.6	4.9

TABLE C-4. Meteorological data. The data is given by level number (ie., U2 is the wind speed at level 2).

U	Relative wind speed (m/sec)
PHI	Relative wind direction (degrees)
TS	Sea surface temperature (^{o}C)
T	Air temperature (^{o}C)
H	Relative humidity (%)

Date	GMT	U2	U3	U4	PHI	TS	T1	T2	T3	T4	H1	H2	H3	H4
			(m/sec)		(deg)			(centigrade)				(%)		
2/28	1400	0.0	15.0	16.0	346	16.37	0.00	0.00	16.61	16.53	0.0	0.0	74.6	70.8
2/28	1500	0.0	0.0	15.0	348	15.78	0.00	0.00	16.65	16.48	0.0	0.0	75.0	72.3
2/28	1530	0.0	11.0	12.2	319	15.81	0.00	0.00	16.83	16.71	0.0	0.0	74.7	71.0
2/28	1600	0.0	11.0	12.2	319	15.93	0.00	0.00	16.99	16.86	0.0	0.0	76.0	72.1
2/28	1630	0.0	12.2	12.6	329	15.87	0.00	0.00	16.97	16.72	0.0	0.0	76.8	73.5
2/28	1700	0.0	12.2	12.6	326	15.80	0.00	0.00	16.71	16.49	0.0	0.0	77.4	74.2
2/28	1730	0.0	12.5	12.6	328	15.90	0.00	0.00	16.83	16.59	0.0	0.0	76.6	73.7
2/28	1800	0.0	11.2	12.0	333	15.74	0.00	0.00	16.41	16.29	0.0	0.0	79.8	76.6
2/28	1830	0.0	12.0	12.4	234	15.81	0.00	0.00	16.41	16.29	0.0	0.0	81.2	77.7
3/01	1830	7.5	8.2	8.2	354	16.23	0.00	15.75	15.59	15.49	0.0	0.0	67.1	66.6
3/01	1900	7.2	6.9	8.2	321	16.26	0.00	15.63	15.49	15.40	0.0	0.0	67.7	67.1
3/01	1930	7.2	7.7	7.7	324	16.14	0.00	15.63	15.50	15.42	0.0	0.0	64.9	64.5
3/01	2000	7.2	7.2	7.5	319	16.22	0.00	15.67	15.54	15.46	0.0	0.0	65.3	64.9
3/01	2030	7.2	7.2	7.5	335	16.21	0.00	15.71	15.57	15.49	0.0	0.0	67.2	66.6
3/01	2100	7.7	7.7	8.7	330	16.19	0.00	15.75	15.59	15.50	0.0	0.0	67.3	66.9
3/01	2130	7.2	7.7	8.3	340	16.19	0.00	15.63	15.54	15.46	0.0	65.6	64.7	64.5
3/01	2200	7.2	7.5	8.1	345	16.21	0.00	15.63	15.54	15.46	0.0	65.7	64.8	64.6
3/01	2230	6.9	7.2	8.2	345	16.21	0.00	15.62	15.54	15.45	0.0	67.0	67.3	66.7
3/01	2300	7.7	8.2	8.7	350	16.18	0.00	15.63	15.54	15.45	0.0	67.2	67.0	66.3
3/01	2330	8.0	7.5	8.7	345	16.18	0.00	15.62	15.53	15.45	0.0	68.4	68.7	68.0
3/01	2400	8.2	7.5	9.0	340	16.18	0.00	15.64	15.56	15.47	0.0	72.5	72.4	71.6
3/02	30	8.2	8.0	9.3	325	16.18	0.00	15.64	15.56	15.47	0.0	73.6	73.3	72.2
3/02	100	8.5	8.2	9.8	317	16.18	0.00	15.65	15.57	15.48	0.0	74.8	74.2	73.2
3/02	130	8.2	8.0	9.8	316	16.18	0.00	15.67	15.59	15.51	0.0	77.2	76.5	75.2
3/02	200	8.7	9.3	10.0	317	16.16	0.00	15.70	15.62	15.54	0.0	78.2	77.4	76.0
3/02	230	9.0	8.7	9.8	318	16.14	0.00	15.70	15.62	15.54	0.0	80.4	79.6	78.2
3/02	300	9.0	9.0	10.3	322	16.13	0.00	15.72	15.64	15.56	0.0	80.6	79.7	78.4
3/02	330	8.7	9.3	9.8	338	16.13	0.00	15.73	15.64	15.56	0.0	80.8	79.9	78.8
3/02	400	9.0	9.3	9.8	355	16.14	0.00	15.72	15.64	15.56	0.0	81.5	80.4	79.1
3/02	430	9.4	9.6	10.1	331	16.16	0.00	15.76	15.66	15.58	0.0	81.3	80.6	79.6
3/02	500	9.0	9.5	10.1	328	16.14	0.00	15.74	15.66	15.58	0.0	82.8	82.0	80.8
3/02	530	8.9	9.8	10.2	341	16.14	0.00	15.77	15.67	15.60	0.0	84.0	83.3	82.1
3/02	600	9.1	10.1	10.7	337	16.14	0.00	15.81	15.72	15.64	0.0	85.3	84.5	83.4
3/02	630	8.8	9.3	10.0	332	16.14	0.00	15.73	15.63	15.54	0.0	88.2	87.2	86.1
3/02	700	9.0	9.3	9.9	331	16.14	0.00	15.47	15.32	15.24	0.0	92.5	91.9	90.9
3/02	730	8.5	8.1	9.1	325	16.14	0.00	15.59	15.41	15.33	0.0	94.2	93.5	92.1
3/02	800	9.5	9.7	10.7	321	16.13	0.00	15.61	15.52	15.41	0.0	94.9	94.1	93.1
3/02	830	8.2	8.7	9.4	324	16.15	0.00	15.66	15.50	15.42	0.0	96.2	95.2	94.4
3/02	900	9.4	9.5	10.4	323	16.07	0.00	15.90	15.80	15.71	0.0	95.5	94.2	93.4

Date	GMT	U2	U3	U4	PHI	TS	T1	T2	T3	T4	H1	H2	H3	H4
			(m/sec)		(deg)			(centigrade)				(%)		
3/02	930	9.6	10.5	11.1	328	16.17	0.00	16.08	15.99	15.91	0.0	94.6	93.6	92.6
3/02	1000	10.1	10.8	11.7	328	16.10	0.00	16.25	16.19	16.12	0.0	93.2	93.0	92.0
3/02	1130	10.0	11.1	11.8	330	16.23	0.00	16.58	16.64	16.53	0.0	91.8	91.3	90.4
3/02	1200	10.0	11.3	11.8	340	16.17	0.00	16.42	16.49	16.36	0.0	91.4	89.6	90.1
3/02	1230	11.3	11.3	12.6	355	16.19	0.00	16.34	16.34	16.25	0.0	93.5	91.5	92.0
3/02	1300	10.5	11.3	12.3	356	16.17	0.00	16.20	16.15	16.08	0.0	95.4	93.5	93.4
3/02	1330	10.8	11.8	12.6	325	16.18	0.00	15.97	15.97	15.86	0.0	96.5	94.5	95.1
3/02	1400	11.6	12.1	13.4	325	16.20	0.00	15.95	15.96	15.84	0.0	97.6	95.2	95.7
3/02	1430	12.1	12.9	13.9	350	16.16	0.00	15.87	15.89	15.78	0.0	97.2	95.2	96.0
3/02	1500	12.1	12.9	13.4	340	16.14	0.00	15.90	15.78	15.75	0.0	95.6	94.2	94.3
3/02	1530	11.6	12.3	13.4	350	16.16	0.00	16.06	16.03	15.92	0.0	95.5	94.0	94.3
3/02	1600	10.8	11.3	12.9	330	16.14	0.00	16.08	16.07	15.99	0.0	96.0	94.4	94.8
3/02	1630	9.5	8.7	10.3	320	16.12	0.00	15.58	15.56	15.48	0.0	96.4	95.1	95.2
3/02	1700	6.7	7.2	7.2	20	16.08	0.00	15.72	15.62	15.56	0.0	97.5	95.7	95.8
3/02	1830	9.5	10.0	10.8	340	16.08	0.00	16.16	16.11	16.04	0.0	95.7	93.6	94.3
3/02	1900	9.4	10.4	11.3	340	16.10	0.00	15.85	15.89	15.79	0.0	96.3	94.6	95.3
3/02	1930	9.8	10.3	10.8	340	16.08	0.00	15.93	15.77	15.71	0.0	97.8	95.8	96.1
3/02	2000	0.0	10.1	10.9	355	16.06	0.00	15.99	15.88	15.82	0.0	96.3	85.6	96.1
3/02	2030	0.0	10.8	11.1	345	16.03	0.00	16.20	16.10	16.06	0.0	95.7	94.9	95.6
3/02	2100	9.3	10.3	10.0	350	16.07	0.00	16.19	16.12	16.08	0.0	96.0	94.5	95.0
3/02	2130	9.0	10.3	10.0	350	16.07	0.00	16.19	16.12	16.08	0.0	96.0	94.5	95.0
3/02	2200	0.0	9.3	9.5	360	16.06	0.00	16.18	16.14	16.07	0.0	95.9	93.8	94.2
3/02	2230	0.0	10.5	10.5	355	16.03	0.00	16.07	16.05	16.00	0.0	95.6	93.7	94.0
3/02	2300	0.0	10.8	11.1	360	16.06	0.00	16.08	15.98	15.93	0.0	95.8	93.9	93.6
3/02	2330	0.0	11.8	11.8	5	16.04	0.00	16.05	15.96	15.91	0.0	94.0	92.4	93.0
3/02	2400	0.0	12.1	12.1	350	16.04	0.00	16.17	16.11	16.04	0.0	91.4	90.0	90.6
3/03	30	0.0	12.1	12.1	350	16.03	0.00	16.11	16.04	15.97	0.0	91.2	90.0	90.1
3/03	100	0.0	11.8	12.3	350	16.06	0.00	16.14	16.08	16.02	0.0	90.7	88.8	89.0
3/03	130	0.0	12.9	13.4	360	16.05	0.00	16.04	16.01	15.90	0.0	90.8	89.0	89.3
3/03	200	0.0	13.9	14.1	20	16.06	0.00	16.18	16.18	16.08	0.0	88.6	86.5	86.0
3/03	230	0.0	13.4	13.1	15	16.10	0.00	16.14	16.11	16.02	0.0	81.7	79.0	78.7
3/03	300	0.0	16.0	15.1	30	16.12	0.00	14.36	14.46	14.32	0.0	82.0	79.5	79.4
3/03	330	0.0	14.1	14.4	20	16.15	0.00	12.80	12.64	12.60	0.0	84.0	77.8	75.9
3/03	400	0.0	10.3	10.8	310	16.16	0.00	14.03	13.70	13.55	0.0	79.8	76.8	75.8
3/03	430	0.0	13.4	13.4	20	16.14	0.00	15.72	15.63	15.54	0.0	65.9	65.5	64.5
3/03	500	0.0	14.4	14.8	10	16.14	0.00	15.50	15.47	15.36	0.0	72.2	70.4	68.8
3/03	530	0.0	14.1	14.0	360	16.14	0.00	15.23	15.14	15.04	0.0	70.5	69.1	67.5
3/03	600	0.0	13.4	13.9	15	16.15	0.00	15.14	15.03	14.92	0.0	70.4	68.8	66.5
3/03	630	0.0	13.6	13.4	15	16.19	0.00	15.12	14.99	14.90	0.0	63.0	60.7	61.6

Date	GMT	U2	U3 (m/sec)	U4	PHI (deg)	TS	T1	T2 (centigrade)	T3	T4	H1	H2 (%)	H3	H4
3/03	700	0.0	13.6	14.1	350	16.15	0.00	15.10	15.00	14.91	0.0	61.8	59.7	61.6
3/03	730	0.0	13.7	13.9	360	16.14	0.00	15.10	15.04	14.93	0.0	64.8	63.2	63.2
3/03	800	0.0	13.0	13.2	360	16.15	0.00	15.25	15.47	15.27	0.0	67.7	65.4	64.0
3/03	830	0.0	12.4	12.4	360	16.19	0.00	15.44	15.63	15.36	0.0	59.6	57.0	60.8
3/03	900	0.0	12.1	13.0	335	16.20	0.00	15.49	15.81	15.52	0.0	60.0	56.7	60.7
3/03	930	0.0	11.1	11.8	350	16.20	0.00	15.27	15.80	15.81	0.0	62.6	58.4	60.8
3/03	1000	0.0	10.8	11.3	340	16.22	0.00	15.81	16.12	15.92	0.0	62.5	59.1	61.3
3/03	1030	0.0	10.0	10.3	10	16.23	0.00	14.56	15.38	15.17	0.0	68.7	64.2	64.7
3/03	1100	0.0	10.0	10.3	10	16.24	0.00	15.62	16.34	16.13	0.0	62.5	58.9	61.2
3/03	1300	0.0	12.3	13.1	360	16.20	0.00	14.67	14.50	14.37	0.0	72.2	68.1	67.0
3/03	1330	0.0	12.6	13.1	360	16.24	0.00	15.23	15.80	15.55	0.0	69.2	64.9	66.1
3/03	1600	0.0	13.1	13.6	10	16.18	0.00	15.85	16.05	15.82	0.0	63.6	59.6	61.6
3/03	1630	0.0	13.4	13.9	10	16.20	0.00	15.86	15.95	15.77	0.0	65.4	60.8	62.3
3/03	1700	0.0	15.2	15.2	0	16.17	0.00	15.59	15.85	15.48	0.0	64.4	62.0	62.4
3/03	1830	0.0	13.8	14.6	350	16.18	0.00	14.16	13.96	13.85	0.0	81.5	79/8	77.0
3/03	1900	0.0	11.8	13.9	350	16.17	0.00	14.81	14.72	14.57	0.0	76.4	75.0	72.6
3/03	1930	0.0	14.9	14.9	40	16.12	0.00	15.28	15.20	15.09	0.0	74.5	73.2	69.8
3/03	2000	0.0	13.1	13.9	25	16.13	0.00	13.87	13.57	13.49	0.0	80.6	77.4	75.3
3/03	2030	0.0	11.8	12.2	30	16.09	0.00	14.42	14.32	14.22	0.0	79.4	77.5	75.5
3/03	2100	0.0	12.5	12.9	350	16.11	0.00	14.38	14.24	14.13	0.0	74.7	74.0	71.5
3/03	2130	0.0	11.3	11.6	330	16.10	0.00	14.40	14.28	14.20	0.0	79.6	78.0	76.2
3/03	2200	0.0	10.3	10.8	350	16.09	0.00	14.43	14.30	14.21	0.0	82.6	80.6	78.4
3/03	2230	0.0	10.5	10.5	20	16.06	0.00	14.85	14.77	14.67	0.0	69.7	67.4	65.2
3/03	2300	0.0	10.8	10.8	360	16.06	0.00	14.89	14.81	14.70	0.0	69.4	67.4	65.7
3/03	2330	0.0	11.8	11.1	10	16.06	0.00	14.79	14.70	14.60	0.0	74.9	73.2	70.3
3/03	2400	0.0	11.6	11.8	10	16.10	0.00	14.87	14.81	14.67	0.0	63.2	66.9	64.8
3/04	30	0.0	10.5	11.1	10	16.12	0.00	14.68	14.60	14.50	0.0	65.6	64.1	63.2
3/04	100	0.0	11.1	10.8	10	16.07	0.00	14.53	14.43	14.34	0.0	70.6	68.6	65.8
3/04	130	0.0	10.8	10.8	5	16.09	0.00	14.56	14.50	14.35	0.0	67.4	65.0	63.5
3/04	200	0.0	10.0	10.0	10	16.14	0.00	14.60	14.50	14.40	0.0	66.8	65.0	63.5
3/04	230	0.0	10.8	11.3	15	16.12	0.00	14.56	14.47	14.36	0.0	65.8	64.4	62.9
3/04	400	0.0	9.0	9.1	5	16.12	0.00	14.37	14.20	14.10	0.0	65.0	63.3	62.4
3/04	430	0.0	8.3	8.6	360	16.12	0.00	14.42	14.29	14.20	0.0	65.8	64.0	63.1
3/04	500	0.0	8.7	8.8	25	16.12	0.00	14.39	14.27	14.17	0.0	65.2	63.0	62.2
3/04	530	0.0	8.2	8.5	15	16.10	0.00	14.39	14.29	14.21	0.0	65.2	63.5	62.5
3/04	600	0.0	8.2	8.2	350	16.10	0.00	14.36	14.27	14.19	0.0	65.3	63.4	62.8
3/04	630	0.0	9.3	9.3	20	16.11	0.00	14.34	14.24	14.11	0.0	64.8	62.5	62.2
3/04	700	0.0	9.3	9.9	25	16.11	0.00	14.41	14.27	14.16	0.0	61.8	58.0	60.9
3/04	730	0.0	9.0	9.4	10	16.09	0.00	14.25	14.15	14.06	0.0	62.0	59.4	61.4

Date	GMT	U2	U3 (m/sec)	U4	PHI (deg)	TS	T1	T2 (centigrade)	T3	T4	H1	H2 (%)	H3	H4
3/04	800	0.0	8.6	8.7	10	16.13	0.00	14.68	14.65	14.62	0.0	63.1	60.3	61.5
3/04	830	0.0	8.4	8.5	5	16.10	0.00	14.95	14.94	14.97	0.0	63.5	61.2	61.4
3/04	900	0.0	8.5	9.0	360	16.14	0.00	14.93	14.73	14.62	0.0	63.4	60.9	61.7
3/04	930	0.0	9.0	9.3	5	16.13	0.00	15.00	14.82	14.74	0.0	63.6	61.3	61.8
3/04	1000	0.0	9.0	9.1	40	16.15	0.00	14.31	14.56	14.40	0.0	73.5	68.8	67.8
3/04	1030	0.0	10.3	10.4	40	16.11	0.00	14.37	14.48	14.35	0.0	69.1	65.3	64.3
3/04	1100	0.0	10.3	10.0	20	16.19	0.00	14.82	15.48	15.01	0.0	64.4	60.8	62.0
3/04	1130	0.0	9.5	10.4	340	16.17	0.00	15.23	14.84	14.78	0.0	65.1	62.8	62.9
3/04	1330	0.0	9.0	9.0	20	16.23	0.00	14.94	15.61	15.44	0.0	63.2	59.1	61.1
3/04	1400	0.0	9.3	10.3	350	16.25	0.00	15.65	15.70	15.41	0.0	63.1	59.4	61.0
3/04	1430	0.0	9.3	9.3	350	16.21	0.00	15.07	15.71	15.62	0.0	62.6	58.1	60.7
3/04	1600	0.0	9.3	10.3	350	16.14	0.00	14.99	15.53	15.34	0.0	0.0	60.8	61.0
3/04	1800	0.0	9.4	9.5	25	16.06	0.00	14.52	14.39	14.28	0.0	0.0	65.7	64.6
3/04	1900	0.0	9.4	9.5	25	16.05	14.34	14.13	14.02	13.90	0.0	0.0	61.5	61.5
3/04	1930	0.0	9.1	9.4	360	16.04	14.29	14.09	13.99	13.89	0.0	0.0	61.7	61.3
3/04	2000	0.0	8.8	9.5	360	16.02	14.28	14.03	13.92	13.83	66.0	61.5	60.8	60.0
3/04	2030	0.0	8.8	9.3	20	16.00	14.27	14.04	13.95	13.85	65.2	60.2	59.2	59.0
3/04	2100	0.0	8.7	9.3	350	16.02	14.28	13.99	13.91	13.80	66.3	61.6	60.9	60.5
3/04	2130	0.0	8.7	9.6	30	16.01	14.14	13.92	13.77	13.66	62.8	58.2	56.1	55.4
3/04	2200	0.0	9.1	9.0	35	16.00	0.00	13.73	13.65	13.54	0.0	0.0	56.5	55.0
3/04	2230	0.0	9.5	9.3	40	16.01	0.00	13.65	13.54	13.45	0.0	0.0	59.9	59.0
3/04	2300	9.0	9.0	9.3	50	16.01	0.00	13.63	13.51	13.40	0.0	0.0	60.7	59.2
3/04	2330	9.0	9.0	9.3	50	15.99	0.00	13.83	13.63	13.53	0.0	0.0	64.3	62.4
3/05	100	7.7	8.2	8.0	40	15.98	0.00	13.64	13.48	13.38	0.0	0.0	64.7	63.7
3/05	130	7.7	8.0	8.0	20	15.97	0.00	13.51	13.36	13.27	0.0	0.0	66.7	65.8
3/05	200	7.2	7.5	7.5	20	15.97	0.00	13.52	13.34	13.25	0.0	0.0	65.7	65.3
3/05	300	6.4	6.4	6.9	30	15.97	0.00	13.42	13.32	13.14	0.0	0.0	65.4	64.4
3/05	330	6.2	6.2	6.7	30	16.00	0.00	13.34	13.24	13.14	0.0	0.0	65.0	64.4
3/05	400	6.7	6.9	6.4	35	16.00	0.00	13.33	13.13	13.11	0.0	0.0	63.6	63.4
3/05	430	6.0	6.4	6.2	30	16.00	0.00	13.25	13.12	13.03	0.0	61.7	63.3	63.2
3/05	500	5.5	5.8	6.2	20	16.01	0.00	13.24	13.12	13.03	0.0	61.0	62.3	62.4
3/05	530	5.4	5.4	4.9	15	16.01	0.00	13.29	13.12	13.03	0.0	62.5	62.0	62.0
3/05	600	4.7	5.0	4.6	360	16.04	0.00	13.17	13.07	12.98	0.0	60.3	60.7	60.9
3/05	630	3.6	3.6	3.4	20	16.04	0.00	13.25	13.15	13.06	0.0	57.1	56.7	57.8
3/05	700	3.9	4.0	3.4	35	16.05	0.00	13.22	13.15	13.07	0.0	57.3	54.9	56.8
3/05	730	3.3	3.3	2.8	25	16.06	0.00	13.21	13.12	13.03	0.0	55.1	53.7	55.5
3/05	800	2.6	2.7	2.6	40	16.08	0.00	13.30	13.22	13.13	0.0	52.6	50.8	51.7
3/05	830	2.3	2.1	2.2	45	16.07	0.00	13.47	13.35	13.35	0.0	54.4	53.3	53.2
3/05	900	2.1	2.1	1.8	50	16.11	0.00	13.62	13.28	13.29	0.0	54.0	53.5	52.0

Date	GMT	U2	U3	U4	PHI	TS	T1	T2	T3	T4	H1	H2	H3	H4
			(m/sec)		(deg)			(centigrade)				(%)		
3/05	930	1.8	1.6	1.3	45	16.15	0.00	13.49	13.35	13.23	0.0	52.4	52.3	52.2
3/05	1130	1.3	1.3	1.0	80	16.52	0.00	14.27	14.06	13.96	0.0	56.0	53.7	53.0
3/05	1400	2.6	2.6	2.3	70	16.81	0.00	13.92	13.96	13.95	0.0	59.1	54.9	53.3
3/05	1600	0.0	0.0	2.7	60	16.97	0.00	0.00	14.32	14.38	0.0	0.0	53.2	50.6
3/05	1830	0.0	2.1	1.1	350	16.47	0.00	0.00	13.31	13.21	0.0	0.0	57.9	56.3
3/05	2000	6.7	0.0	6.2	35	16.36	0.00	13.32	13.22	13.14	0.0	59.2	57.5	56.0
3/05	2030	8.0	0.0	6.2	30	16.25	0.00	13.35	13.24	13.15	0.0	60.1	58.1	56.2
3/05	2100	6.9	0.0	6.4	35	16.29	0.00	13.26	13.18	13.10	0.0	58.3	56.6	54.8
3/05	2130	6.9	0.0	6.4	30	16.33	0.00	13.25	13.15	13.06	0.0	57.5	55.6	53.8
3/05	2200	6.7	0.0	6.2	30	16.34	0.00	13.18	13.07	12.98	0.0	58.2	56.2	54.0
3/05	2230	6.4	0.0	6.2	40	16.36	0.00	13.07	12.98	12.88	0.0	61.2	59.1	57.4
3/05	2300	5.9	0.0	5.7	30	16.31	0.00	13.00	12.88	12.79	0.0	61.2	59.0	57.5
3/05	2330	5.9	0.0	5.7	30	16.31	0.00	13.00	12.88	12.79	0.0	61.2	59.0	57.5
3/05	2400	5.9	0.0	5.4	30	16.00	0.00	12.89	12.78	12.59	0.0	60.3	58.0	56.1
3/06	30	5.9	0.0	4.9	40	15.73	0.00	12.89	12.75	12.68	0.0	62.1	59.6	57.8
3/06	100	5.9	0.0	5.1	40	15.85	0.00	12.66	12.56	12.47	0.0	61.3	59.3	57.6
3/06	130	6.2	0.0	5.9	30	15.83	0.00	12.57	12.49	12.41	0.0	61.2	59.2	57.8
3/06	200	6.7	0.0	6.7	10	15.75	0.00	12.51	12.44	12.35	0.0	60.3	58.4	56.8
3/06	230	6.2	0.0	6.4	350	15.77	0.00	12.37	12.29	12.21	0.0	58.4	56.8	55.1
3/06	300	6.2	0.0	6.2	350	15.72	0.00	12.34	12.25	12.17	0.0	58.3	56.5	54.5
3/06	330	5.1	0.0	5.1	350	16.01	0.00	12.17	12.09	12.00	0.0	59.2	57.4	55.6
3/06	400	5.1	0.0	5.1	350	16.47	0.00	12.17	12.05	11.96	0.0	61.1	58.7	56.8
3/06	430	4.4	0.0	4.4	350	16.43	0.00	12.25	12.17	12.08	0.0	60.3	58.2	56.7
3/06	530	3.7	0.0	3.6	350	16.52	0.00	12.46	12.39	12.32	0.0	63.0	60.7	59.5
3/06	600	3.6	0.0	2.8	355	16.28	0.00	12.74	12.61	12.48	0.0	64.0	61.4	60.4
3/06	630	2.3	0.0	2.1	360	16.27	0.00	12.83	12.67	12.60	0.0	64.7	61.6	61.0
3/06	730	2.8	0.0	2.1	40	16.08	0.00	13.15	13.00	12.88	0.0	68.2	64.9	64.0
3/06	900	0.0	0.0	1.8	125	15.65	0.00	13.39	13.26	13.05	0.0	68.3	64.9	63.8
3/06	930	0.0	0.0	2.3	135	15.70	0.00	13.67	13.35	13.17	0.0	68.9	64.8	64.2
3/06	1000	0.0	0.0	2.8	135	15.87	0.00	14.34	13.54	13.37	0.0	65.6	63.2	63.2
3/06	1030	0.0	0.0	3.3	90	15.70	0.00	13.54	13.32	13.23	0.0	63.4	62.9	63.5
3/06	1100	0.0	0.0	3.6	100	15.71	0.00	13.53	13.31	13.23	0.0	66.0	64.2	64.2
3/06	1130	0.0	0.0	3.6	100	15.71	0.00	13.52	13.28	13.18	0.0	67.5	65.2	65.3
3/06	1300	0.0	0.0	4.1	90	16.04	0.00	13.90	13.86	13.82	0.0	67.1	65.0	64.8
3/06	2230	0.0	0.0	6.7	70	15.32	0.00	13.89	13.83	13.70	0.0	62.5	60.0	62.1
3/06	2300	0.0	0.0	6.7	70	15.35	0.00	13.92	13.86	13.75	0.0	62.3	60.9	62.4
3/06	2330	0.0	0.0	6.7	70	15.26	0.00	13.96	13.87	13.78	0.0	63.4	61.8	62.5
3/06	2400	0.0	0.0	6.9	75	15.52	0.00	14.07	13.98	13.87	0.0	64.2	63.0	63.0
3/07	30	0.0	0.0	6.7	70	15.77	0.00	14.20	14.10	14.06	0.0	65.9	65.2	65.1

Date	GMT	U2	U3 (m/sec)	U4	PHI (deg)	TS	T1	T2 (centigrade)	T3	T4	H1	H2 (%)	H3	H4
3/07	730	0.0	0.0	5.7	50	15.33	0.00	13.34	13.23	13.14	0.0	72.3	72.3	71.6
3/07	800	6.4	0.0	5.9	50	15.01	0.00	13.46	13.48	13.34	0.0	72.8	72.0	71.4
3/07	830	6.4	0.0	5.8	60	15.09	0.00	13.54	13.52	13.40	0.0	72.0	70.1	70.0
3/07	900	5.9	0.0	5.2	60	15.04	0.00	13.87	13.92	13.79	0.0	71.1	69.1	69.2
3/07	930	5.1	4.9	4.5	55	15.22	0.00	14.11	14.15	14.06	0.0	68.8	68.0	67.9
3/07	1000	4.7	4.5	4.1	50	15.25	0.00	14.32	14.44	14.27	0.0	68.0	66.9	67.8
3/07	1030	3.9	3.9	3.6	40	15.41	0.00	14.49	14.80	14.57	0.0	68.7	66.8	68.4
3/07	1100	3.6	3.6	3.3	35	15.41	0.00	14.75	15.08	14.77	0.0	71.1	68.5	69.7
3/07	1130	3.9	3.9	3.6	360	15.77	0.00	14.81	15.15	14.81	0.0	70.0	67.0	68.3
3/07	1230	5.1	5.4	5.1	355	15.82	0.00	14.95	15.44	15.26	0.0	74.1	70.3	71.0
3/07	1300	4.3	4.6	4.1	350	16.04	0.00	15.08	15.68	15.47	0.0	76.0	71.6	72.2
3/07	1500	1.5	1.5	1.6	50	16.36	0.00	15.29	15.27	15.16	0.0	72.3	71.2	71.3
3/07	1530	1.0	1.0	1.3	45	15.89	0.00	15.42	15.20	15.14	0.0	70.8	70.7	71.0
3/07	1800	2.6	2.3	2.3	305	15.80	0.00	15.05	15.05	14.94	0.0	79.8	79.5	78.1
3/07	1830	2.1	1.8	1.8	300	15.87	0.00	15.09	15.07	15.09	0.0	78.5	78.2	76.6
3/07	1900	2.1	2.1	2.1	360	15.78	0.00	15.12	15.15	15.11	0.0	79.4	79.0	76.8
3/07	1930	2.3	2.6	2.3	355	15.90	0.00	14.91	14.87	14.79	0.0	77.2	77.1	75.3
3/07	2000	2.6	2.3	2.2	345	15.96	0.00	14.86	14.85	14.74	0.0	77.0	77.3	75.5
3/07	2030	2.1	1.9	2.1	350	15.86	0.00	14.98	14.92	14.85	0.0	72.3	72.7	70.5
3/07	2100	2.6	2.6	2.8	330	15.81	0.00	15.02	14.99	14.92	0.0	68.0	68.1	66.2
3/07	2130	1.8	2.1	1.5	330	15.67	0.00	14.98	14.92	14.85	0.0	69.3	70.3	68.0
3/07	2200	2.6	2.3	2.1	330	15.53	0.00	14.97	14.93	14.85	0.0	68.6	69.3	67.1
3/07	2230	2.6	2.3	2.1	330	15.61	0.00	14.87	14.83	14.75	0.0	68.2	68.0	66.1
3/08	130	3.6	3.6	3.6	320	15.90	0.00	14.72	14.66	14.57	0.0	69.8	69.3	67.0
3/08	730	4.1	3.9	3.9	320	16.47	0.00	13.79	13.73	13.66	0.0	66.4	66.1	65.5
3/08	800	5.4	5.1	5.1	325	16.46	0.00	14.04	13.98	13.89	0.0	66.0	65.9	64.9
3/08	830	4.6	4.6	4.7	350	16.43	0.00	14.09	14.01	13.93	0.0	66.3	65.9	64.8
3/08	900	4.6	4.9	4.6	335	16.48	0.00	14.09	14.07	13.99	0.0	64.2	64.0	63.6
3/08	930	4.7	4.7	4.6	340	16.44	0.00	14.03	14.04	13.95	0.0	64.9	64.5	64.3
3/08	1100	6.2	6.2	6.2	315	16.85	0.00	14.14	14.18	14.07	0.0	65.2	64.4	63.8
3/08	1130	6.7	6.2	6.4	315	13.59	0.00	14.23	14.41	14.37	0.0	62.4	62.2	62.8
3/08	1230	6.4	6.8	6.7	330	16.85	0.00	14.21	14.75	14.43	0.0	58.3	59.8	62.0
3/08	1400	6.4	6.4	6.4	330	16.87	0.00	13.97	14.31	13.99	0.0	61.7	62.1	63.3
3/08	1430	5.4	5.7	5.4	335	17.01	0.00	14.21	14.42	14.15	0.0	61.2	61.4	63.1
3/08	1500	5.4	5.4	5.6	335	16.90	0.00	13.84	14.16	13.87	0.0	63.8	64.0	64.3
3/08	1530	5.7	5.7	5.7	340	17.04	0.00	13.90	14.28	14.00	0.0	61.0	61.7	62.9
3/08	1700	3.6	3.1	3.3	320	17.04	0.00	13.81	14.18	13.94	0.0	62.7	62.7	63.6
3/08	1930	3.6	3.1	3.3	320	16.77	0.00	13.73	13.70	13.61	0.0	64.5	0.0	64.0
3/08	2000	0.0	0.0	5.7	350	16.75	0.00	13.86	13.80	13.71	0.0	64.8	0.0	64.8

Date	GMT	U2	U3 (m/sec)	U4	PHI (deg)	TS	T1	T2 (centigrade)	T3	T4	H1	H2 (%)	H3	H4
3/08	2030	2.6	2.6	2.8	20	16.76	0.00	13.92	13.84	13.76	0.0	66.0	0.0	66.0
3/08	2200	2.8	2.8	2.8	330	16.73	0.00	13.76	13.66	13.57	0.0	66.2	0.0	65.5
3/08	2230	3.1	3.1	3.1	330	16.70	0.00	13.77	13.70	13.61	0.0	67.4	0.0	67.1
3/08	2300	3.1	3.1	3.0	330	16.71	0.00	13.72	13.65	13.58	0.0	67.4	0.0	67.0
3/09	730	6.9	6.9	6.2	65	16.60	0.00	13.74	13.65	13.57	0.0	70.0	0.0	68.7
3/09	930	0.0	0.0	5.4	65	16.59	0.00	14.13	14.10	13.99	0.0	70.0	0.0	69.3
3/09	1000	6.7	7.2	6.2	50	16.58	0.00	14.08	14.10	14.00	0.0	66.3	0.0	66.1
3/09	1030	6.7	7.3	6.7	45	16.61	0.00	14.46	14.52	14.38	0.0	66.8	0.0	66.4
3/09	1200	8.2	8.6	7.6	50	16.47	0.00	14.40	14.65	14.46	0.0	70.6	0.0	67.9
3/09	1230	8.7	8.7	7.5	50	16.33	0.00	14.67	14.79	14.65	0.0	70.5	0.0	68.4
3/09	1300	8.7	8.7	7.5	50	16.37	0.00	14.48	14.42	14.46	0.0	68.2	0.0	67.1
3/09	1400	9.8	11.0	9.7	335	16.30	0.00	14.69	15.03	14.75	0.0	68.4	0.0	67.0
3/09	1430	8.7	9.8	9.0	335	16.40	0.00	14.76	15.03	14.73	0.0	65.7	0.0	65.4
3/09	1500	10.5	11.3	10.8	335	16.44	0.00	14.69	14.79	14.58	0.0	67.6	0.0	66.5
3/09	1530	9.0	10.0	9.3	340	16.42	0.00	14.66	14.82	14.57	0.0	67.9	0.0	66.8
3/09	1600	9.8	10.8	9.9	335	16.55	0.00	14.74	14.94	14.68	0.0	68.1	0.0	66.8
3/09	1630	9.8	12.9	9.8	330	16.57	0.00	14.78	14.89	14.70	0.0	69.8	0.0	68.5
3/09	1700	9.8	10.3	9.8	330	16.55	0.00	14.79	14.91	14.75	0.0	70.6	0.0	69.3
3/09	1800	9.8	10.3	9.8	325	16.59	0.00	14.60	14.57	14.47	0.0	73.3	0.0	72.4
3/09	1830	6.4	6.4	5.9	15	16.82	0.00	14.55	14.47	14.39	0.0	73.8	0.0	71.8
3/09	1900	5.7	5.7	5.1	350	16.48	0.00	14.73	14.62	14.53	0.0	75.8	0.0	73.4
3/09	2030	6.7	7.2	6.7	20	16.46	0.00	14.84	14.72	14.64	0.0	75.6	0.0	73.4
3/09	2100	6.4	6.9	6.2	355	16.45	0.00	14.88	14.81	14.74	0.0	74.8	0.0	73.0
3/09	2130	7.2	7.2	6.9	10	16.42	0.00	14.99	14.89	14.81	0.0	75.9	0.0	72.9
3/09	2200	7.4	7.7	6.7	10	16.45	0.00	15.11	15.03	14.93	0.0	72.4	0.0	70.0
3/09	2230	7.5	8.0	7.5	10	16.47	0.00	15.02	14.95	14.88	0.0	71.3	0.0	69.6
3/09	2300	6.9	7.7	6.7	350	16.47	0.00	15.14	15.06	14.96	0.0	73.5	0.0	71.0
3/10	630	8.2	9.3	8.7	360	16.60	0.00	16.31	16.27	16.21	0.0	75.8	75.3	72.8
3/10	700	9.0	9.9	9.0	360	16.59	0.00	16.36	16.29	16.21	0.0	71.9	71.4	69.2
3/10	730	9.5	10.1	9.5	360	16.59	0.00	16.35	16.28	16.21	0.0	71.9	71.7	69.3
3/10	830	9.3	9.8	8.7	5	16.59	0.00	16.37	16.38	16.29	0.0	70.5	70.0	67.3
3/10	900	8.7	9.5	8.7	360	16.61	0.00	16.44	16.56	16.46	0.0	69.6	68.5	67.2
3/10	1100	8.7	9.5	9.0	360	16.71	0.00	17.09	17.52	17.37	0.0	72.9	70.3	68.7
3/10	1130	9.0	9.5	9.3	350	16.74	0.00	17.08	17.44	17.31	0.0	73.4	71.2	69.4
3/10	1200	9.3	9.5	9.0	360	16.75	0.00	17.14	17.48	17.35	0.0	73.4	70.8	69.1
3/10	1230	9.0	10.0	9.5	350	16.73	0.00	17.13	17.33	17.19	0.0	75.5	73.9	71.9
3/10	1330	8.7	9.8	9.3	355	16.77	0.00	17.25	17.19	17.08	0.0	77.6	77.4	75.5
3/10	1500	8.7	9.5	9.3	350	16.78	17.08	17.07	17.18	17.04	0.0	80.0	0.0	78.9
3/10	1530	8.7	9.5	9.3	345	16.78	17.14	17.21	17.25	17.11	0.0	81.3	81.1	80.0

Date	GMT	U2	U3 (m/sec)	U4	PHI (deg)	TS	T1	T2 (centigrade)	T3	T4	H1	H2 (%)	H3	H4
3/10	1800	8.2	9.0	8.2	340	16.73	0.00	16.07	16.05	15.96	0.0	96.9	97.8	96.1
3/10	1830	7.5	8.2	7.7	310	16.76	0.00	16.08	16.07	15.98	0.0	96.7	97.5	95.8
3/10	1900	7.2	8.2	7.5	340	16.75	0.00	16.24	16.21	16.13	0.0	96.4	96.4	95.5
3/10	1930	6.9	8.0	7.4	350	16.74	0.00	16.31	16.29	19.21	0.0	96.2	95.9	95.2
3/10	2000	7.7	8.7	8.0	360	16.68	0.00	16.49	16.48	16.39	0.0	95.3	94.9	94.1
3/10	2030	7.2	8.2	7.2	360	16.69	0.00	16.45	16.42	16.35	0.0	96.3	96.1	95.2
3/10	2100	6.2	6.7	6.7	360	16.61	0.00	16.45	16.41	16.34	0.0	96.5	96.6	95.6
3/10	2130	5.9	6.7	6.7	360	16.67	0.00	16.48	16.45	16.39	0.0	96.1	96.1	95.2
3/11	700	5.7	6.2	5.9	20	16.60	15.88	15.78	15.70	15.63	90.8	89.0	0.0	86.6
3/11	730	5.1	5.9	5.5	345	16.60	15.87	15.76	15.71	15.62	90.6	88.2	88.0	86.1
3/11	800	5.4	6.4	5.7	345	16.62	15.90	15.76	15.70	15.63	90.0	87.0	0.0	85.3
3/11	830	6.2	6.7	5.9	360	16.65	15.94	15.86	15.78	15.71	89.8	86.6	0.0	84.4
3/11	900	6.2	6.4	6.2	360	16.64	16.03	15.98	15.92	15.85	89.1	86.1	0.0	84.0
3/11	930	6.4	7.2	6.9	355	16.66	16.28	16.08	16.07	16.01	83.3	79.4	78.4	77.5
3/11	1000	7.7	8.7	7.7	5	16.65	16.16	16.05	16.12	16.01	79.6	73.0	0.0	71.6
3/11	1030	7.2	7.7	6.9	5	16.73	16.09	16.03	16.06	15.91	81.7	76.8	0.0	74.2
3/11	1100	6.7	7.7	7.2	360	16.73	16.09	15.98	15.99	15.84	84.0	79.2	78.6	76.8
3/11	1130	6.7	7.7	7.2	360	16.74	16.12	16.01	16.04	15.87	84.3	78.5	77.8	76.5
3/11	1230	7.2	8.0	7.7	355	16.76	16.11	15.96	16.15	15.92	83.4	79.6	76.5	75.4
3/11	1300	6.9	7.7	7.5	360	16.77	16.19	16.04	16.32	16.06	71.5	65.4	63.6	64.9
3/11	1330	7.2	8.0	7.5	360	16.78	16.33	16.21	16.52	16.21	70.8	64.2	60.8	62.5
3/11	1400	6.7	7.7	6.7	360	16.78	15.92	15.85	16.08	15.89	70.1	64.6	62.3	62.8
3/11	1430	6.9	8.0	6.9	360	16.79	15.80	15.72	16.13	15.94	78.4	70.4	68.6	66.0
3/11	1500	7.5	8.2	7.7	350	16.85	15.61	15.67	15.92	15.90	77.9	71.2	67.4	66.3
3/11	1530	7.2	8.2	7.7	350	16.81	15.59	15.89	16.28	16.08	71.0	61.8	0.0	61.1
3/11	1600	8.0	9.0	8.2	350	16.83	15.62	15.91	0.00	16.22	74.3	63.9	0.0	61.5
3/11	1700	9.0	9.5	9.0	345	16.30	15.77	16.16	16.66	16.45	75.1	64.1	0.0	61.8
3/11	1730	8.0	9.0	8.7	345	16.81	16.15	16.08	16.56	16.41	71.6	62.3	0.0	61.3
3/11	1800	7.6	8.7	7.7	345	16.81	16.15	16.02	16.43	16.24	72.3	63.5	0.0	61.6
3/11	1830	7.5	8.0	8.0	350	16.81	16.00	15.92	16.20	16.06	72.2	62.3	0.0	61.5
3/11	1900	6.9	7.4	7.2	350	16.78	15.92	15.81	16.01	15.84	72.1	62.8	0.0	61.7
3/11	1930	6.9	7.7	6.8	350	16.69	15.55	15.41	15.34	15.23	74.0	65.4	62.5	63.2
3/11	2000	7.2	7.7	7.2	340	16.78	15.50	15.37	15.29	15.20	71.7	62.3	61.0	62.3
3/11	2030	7.7	8.7	7.7	360	16.66	15.55	15.41	15.31	15.22	72.0	62.6	62.0	62.1
3/11	2100	8.2	9.3	9.0	360	16.72	15.17	14.95	14.91	14.81	82.2	72.8	71.9	70.2
3/11	2130	8.0	9.0	3.5	350	16.69	14.93	14.73	14.66	14.56	79.0	70.4	69.9	68.5
3/11	2200	7.5	8.2	7.7	340	16.67	14.86	14.73	14.62	14.50	80.3	73.1	72.0	70.2
3/11	2230	8.2	8.7	8.0	10	16.64	14.91	14.72	14.63	14.52	77.9	67.8	0.0	65.6
3/11	2300	10.8	11.3	11.3	360	16.64	15.01	14.69	14.60	14.47	79.2	68.3	0.0	65.6

Date	GMT	U2	U3 (m/sec)	U4	PHI (deg)	TS	T1	T2 (centigrade)	T3	T4	H1	H2 (%)	H3	H4
3/11	2330	9.5	11.1	9.0	360	16.67	0.00	13.53	13.41	13.32	0.0	68.3	0.0	65.6
3/12	500	8.7	9.3	9.0	360	16.50	0.00	13.52	13.39	13.28	0.0	59.0	57.7	54.3
3/12	530	8.2	9.0	8.3	350	16.50	0.00	13.44	13.31	13.22	0.0	55.4	54.3	51.9
3/12	600	8.7	9.5	8.7	345	16.50	0.00	13.43	13.31	13.20	0.0	48.7	47.9	45.4
3/12	630	8.5	9.5	8.7	350	16.50	0.00	13.46	13.32	13.20	0.0	57.0	55.3	50.9
3/12	700	8.5	9.0	8.7	350	16.50	0.00	13.46	13.34	13.24	0.0	55.4	54.2	50.3
3/12	730	0.0	8.7	8.2	360	16.51	0.00	13.53	13.35	13.25	0.0	58.5	56.2	53.2
3/12	830	0.0	8.7	8.2	355	16.51	0.00	13.46	13.33	13.24	0.0	58.1	56.1	53.0
3/12	900	8.2	9.0	8.2	350	16.51	0.00	13.50	13.41	13.33	0.0	56.0	54.5	50.9
3/12	930	8.2	9.3	8.2	360	16.51	0.00	13.78	13.79	13.73	0.0	57.7	55.1	50.8
3/12	1000	8.0	8.7	8.0	355	16.50	0.00	13.83	13.91	13.86	0.0	53.2	50.5	46.5
3/12	1030	7.5	8.0	7.7	355	16.50	0.00	13.78	13.90	13.90	0.0	52.9	49.7	46.2
3/12	1100	6.7	7.7	6.7	355	16.50	0.00	13.84	13.92	13.87	0.0	58.1	55.0	50.2
3/12	1130	6.9	7.7	6.9	360	16.51	0.00	13.83	13.93	13.85	0.0	55.2	51.9	47.9
3/12	1200	6.4	6.9	6.4	10	16.70	0.00	13.81	13.81	13.79	0.0	48.8	41.7	44.3
3/12	1330	5.6	5.6	5.2	20	16.76	0.00	14.09	13.86	13.90	0.0	49.0	49.9	44.8
3/12	1400	5.9	5.9	5.7	5	16.75	0.00	14.00	13.91	13.71	0.0	47.9	47.3	44.8
3/12	1430	5.9	6.4	5.9	5	16.75	0.00	13.93	13.97	13.80	0.0	50.2	49.4	46.1
3/12	1500	5.4	5.7	5.1	360	17.00	0.00	13.95	14.04	13.79	0.0	54.8	51.9	48.0
3/12	1530	5.7	5.9	5.7	360	16.75	0.00	13.86	14.00	13.76	0.0	47.6	45.8	44.6
3/12	1600	5.1	5.1	4.9	360	16.76	0.00	14.09	14.82	13.93	0.0	47.1	44.7	43.4
3/12	1630	0.0	0.0	4.9	360	16.78	0.00	13.94	14.14	13.84	0.0	47.7	44.7	44.0
3/12	1800	5.1	5.7	5.1	360	16.77	0.00	14.08	14.26	14.08	0.0	49.6	46.8	44.7
3/12	1830	5.1	5.4	5.1	350	16.76	0.00	13.89	14.09	13.97	0.0	47.1	44.9	43.8
3/12	1900	5.9	5.1	5.4	300	16.56	0.00	13.82	13.85	13.67	0.0	45.6	44.8	43.6
3/12	1930	6.4	5.1	5.7	300	16.60	0.00	13.63	13.55	13.42	0.0	51.2	49.7	46.1
3/12	2000	6.4	5.1	5.7	300	16.61	0.00	13.48	13.41	13.31	0.0	49.2	48.8	45.6
3/13	830	8.7	8.6	8.2	320	16.10	0.00	13.97	14.15	14.10	0.0	45.2	45.0	44.2
3/13	900	7.7	6.4	6.9	315	16.16	0.00	13.66	13.83	13.76	0.0	45.0	44.6	43.6
3/13	930	8.0	6.9	7.5	315	15.84	0.00	13.65	13.68	13.59	0.0	53.4	52.4	48.8
3/13	1000	8.5	8.7	8.2	330	15.65	0.00	13.55	13.64	13.49	0.0	55.2	55.0	52.0
3/13	1030	8.2	7.7	7.5	320	15.44	0.00	13.70	13.91	13.72	0.0	54.3	53.2	51.3
3/13	1100	8.2	7.5	8.0	320	15.49	0.00	13.70	13.93	13.80	0.0	52.3	51.9	49.5
3/13	1130	7.2	6.2	6.9	315	16.59	0.00	13.86	14.16	13.97	0.0	48.8	47.7	45.5
3/13	1300	7.5	6.5	6.5	310	15.66	0.00	13.62	14.10	13.99	0.0	54.8	52.2	49.1
3/13	1330	7.5	6.5	6.5	305	15.74	0.00	13.67	14.07	13.96	0.0	53.8	51.3	48.5
3/14	1930	6.4	6.4	6.3	55	16.47	0.00	15.15	15.06	14.97	0.0	81.3	81.0	79.7
3/14	2000	6.9	6.9	6.2	50	16.45	0.00	15.26	15.12	15.01	0.0	81.0	80.5	79.4
3/14	2030	7.2	7.2	5.7	45	16.43	0.00	15.29	15.12	15.08	0.0	79.6	78.8	78.0

Date	GMT	U2	U3 (m/sec)	U4	PHI (deg)	TS	T1	T2 (centigrade)	T3	T4	H1	H2 (%)	H3	H4
3/14	2100	8.2	8.2	7.2	50	16.46	0.00	15.28	15.19	15.11	0.0	72.4	71.3	70.0
3/14	2130	8.2	8.0	6.2	40	16.44	0.00	15.07	14.93	14.80	0.0	71.0	67.3	67.1
3/14	2200	7.2	7.7	6.7	20	16.46	0.00	14.99	14.90	14.81	0.0	67.3	67.0	66.2
3/14	2230	7.2	7.7	6.7	295	16.27	0.00	14.84	14.81	14.65	0.0	71.5	71.0	70.0
3/15	1130	3.5	3.7	3.3	5	16.34	14.17	13.74	13.64	13.74	68.0	63.7	0.0	63.3
3/15	1230	3.5	3.7	6.3	5	16.48	14.03	13.92	13.83	13.64	70.1	64.3	63.6	64.4
3/15	1300	4.0	4.0	3.6	20	16.40	14.00	13.89	13.93	13.69	70.4	64.4	64.2	64.3
3/15	1330	3.3	3.8	3.5	5	16.55	14.00	13.80	14.13	13.96	69.4	63.4	62.5	64.1
3/15	1400	3.7	3.5	3.5	315	16.50	14.41	14.02	14.02	13.70	70.6	63.1	62.2	63.8

Distribution List

UNSECDEF (R&E)	1
ASN (R&D)	1
CNO (Op-02, -021, -095, -0952)	8
COMNAVOCEANCOM	2
CNR (Code 103T, 480)	2
NISC	1
NORDA	2
NRL	3
NUSC	2
NAVPGSCOL	2
NFOIO	1
DARPA	1
DIRSSP (SP-202, -2025)	4
DTIC	12
DMAODS (Code IMMH)	1
DMADC-Phila	80
NAVOCEANO (Code 025)	21
APL/JHU (STE)	6

TR 256

EVAPORATION DUCT HEIGHT MEASUREMENTS
IN THE MID-ATLANTIC

AUGUST 1978
(Reprinted 1980)