Atmospheric Measurements from the R/V PUMA-UNAM During the North American Monsoon Experiment (NAME)

Ernesto Caetano and Abraham Onofre
Center for Atmospheric Science - UNAM
Tropical Meteorology Group
Av. Circuito Exterior S/N, Ciudad Universitaria
Mexico City, DF., 04510, Mexico
caetano@servidor.unam.mx

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1. Introduction

This data report describes atmospheric measurements and data obtained during a cruise of the *R/V Puma- UNAM* in the Eastern Pacific. These measurements were part of the North American Monsoon Experiment (NAME). The cruise occurred from 4 August 2004 to 16 August 2004 (Fig. 1a).

The *R/V PUMA* is a research vessel owned and operated by the National Autonomous University of Mexico (UNAM) in Mazatlán, Mexico (Fig. 1b). Funding to support this cruise was from the UNAM and Dr. Artemio Gallegos García was the Chief Scientist

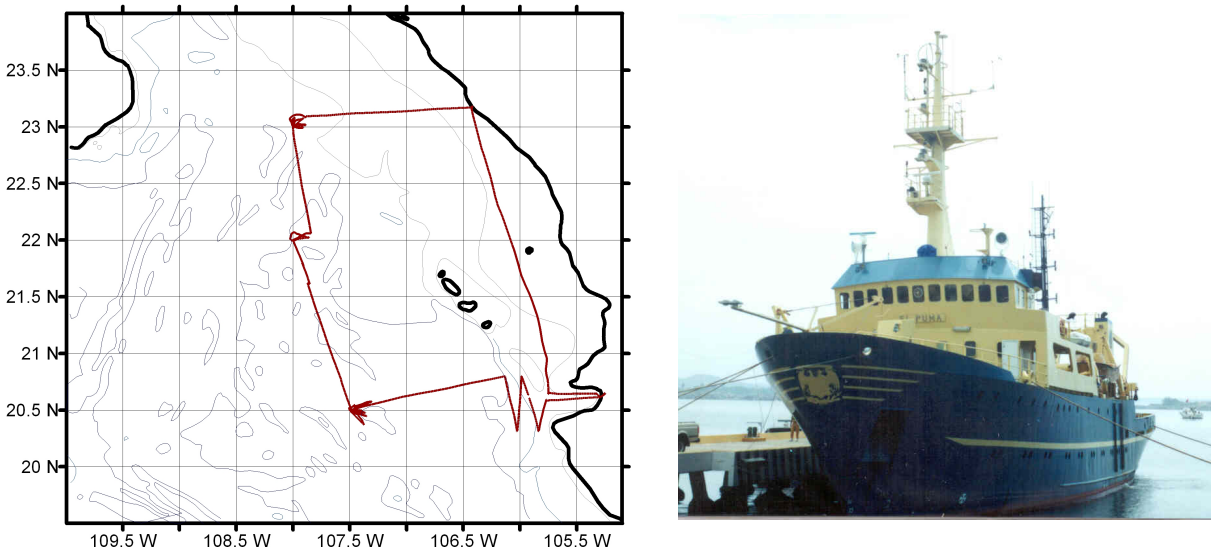

Figure 1: a) Cruise Track; b) R/V El PUMA

2. Measurements

This report describes two types of atmospheric measurements:

1. **Surface -** Continuous measurements from a 4 towers mounted on the deck of the *PUMA.* (Table 1, Figures 2)
2. **Upper-air -** Atmospheric measurements performed tethersondes

2.1 Surface Measurements

Data from all these measurements (except clouds) were obtained from the met towers (Figures 1) on the ship every 10 minutes and stored on a Davis station data logger The true wind speed can be determined using the relative wind vector (as measured from the ship) and the ship motion, based on the GPS data and compass (ship data logger -*Bitacora*). The data from the logger were transferred to a PC twice a day and stored and every evening all data were written on a CD (backup). All surface measurements were successful for the entire cruise.

The measurement average height for winds, temperature, pressure and humidity was: STATION1 5.0 m above sea level; STATION2 10.0 m above sea level; STATION3 15.0 m above sea level; STATION4 20.0 m above sea level; and STATION5 28.0 m above sea level. Observations of cloud conditions were undertaken every hour.

Based on the manufacturer's claims, the nominal meteorological variable accuracies are:

Primary variables

Wind speed: ±3 mph (3 kts, 5 km/h, 1.5 m/s) or ±5%, whichever is greater
Wind direction: ± 7°
Outside Air temperature: 1°F (±0.5°C) up to 110°F (43°C), ±2°F (±1°C) over 110°F (43°C)
Outside Relative Humidity: ±3% (0 to 90% RH), ±4% (90 to 100% RH)
Solar Radiation: ±5% of full scale (Reference: Eppley PSP at 1000 W/m2)
Ultra Violet Index: ± 5%
Barometric Pressure: ±0.04" Hg (±1.0 mm Hg, ±1.4 hPa/mb)

Secondary Variables

Dewpoint Temperature (calculated): ±3°F (±1.5°C) (typical)
Higher Air temperature: ± 0.5 °C
Lower Air temperature: ± 0.5 °C
Wind Chill (calculated): ±2°F (±1°C) (typical)
Evapotranspiration(calculated): Greater of 0.01" (0.25 mm) or ±5%
Heat Index(calculated): ±3°F (±1.5°C) (typical)
Temperature Humidity Sun Wind Index (THSW): ±4°F (±2°C) (typical)
Solar Energy: ± 5%
Higher solar energy: ± 5%
Ultra Violet (UV) Radiation: ±5% of full scale (Reference: Yankee UVB-1 at
UV index 10 (Extremely High): ±5%
Ultra Violet (UV) Radiation Dose: ±5% of daily total

Inside Temperature: ±1°F (±0.5°C) up to 110°F (43°C), ±2°F (±1°C) over 110°F (43°C)
Inside Relative Humidity: ±5%
Rain collector (rain rate) sensor does not work on ships. **But no rain was reported during all campaign**.
The Wind Samp is the sustainable wind (for an extra sensor);
The Wind Tx is reception percent of the extra sensor;
The ISS Recept is integrated sensor suite reception percent;
The Arc.Int is time interval of measurements (5 minutes).

Table 1. Surface Measurements

Parameter	Instrument	Manufacturer	Model
Relative Wind Speed	Wind cup with magnetic switch	Davis	Vantage Pro
Relative Wind Direction	Wind vane with potentiometer	Davis	Vantage Pro
Heading	Electronic Compass		
Speed/course over ground	GPS Receiver		
Air Temperature	Thermistor	Davis	Vantage Pro
Air Pressure	Barometer	Davis	Vantage Pro
Relative Humidity	Film capacitor element	Davis	Vantage Pro
Solar Radiation	Solar radiation sensor	Davis	Vantage Pro
Ultra Violet	Ultra Violet Sensor	Davis	Vantage Pro
Cloud amount and type	Human Eye		

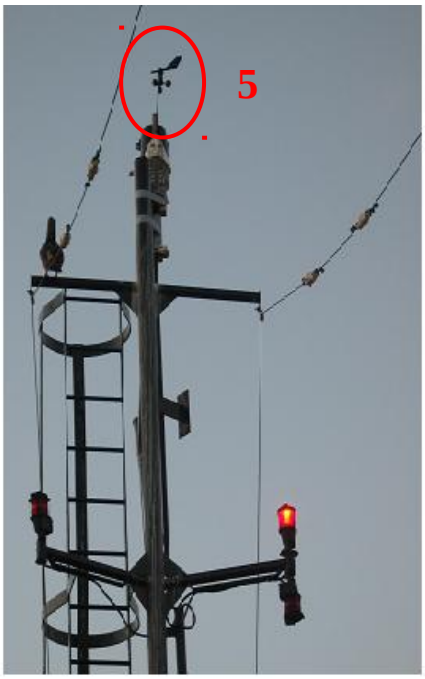

Figure 2. a)The *R/V PUMA a* with NPS met towers circled in red; b) station 5 close up.

2.1.1. Data ***Processing***

The procedure for processing the data from the met stations was as follows:

1. The raw 5 minutes data were examined graphically.
2. The wind and ship motion data had some obvious spikes that were removed to produce a quick look of clean values of dataset. However all wind dataset **must be** corrected by the final user. All information necessary to calculate the real wind is in the PUMA dataset.

2.2 Upper-Air Measurements

There were two instruments for upper air measurements; the Air tethersonde, AIR3B model, and theinstrument developed by the Instrumentation Division of the Center for Atmospheric Sciences- UNAM (Fig. 3).

2.2.1 *Air-tethered sounding*

The measurement accuracies are:

Variable	***Range***	***Resolution***	***Accuracy***
Wind speed	0 - 20 m/s	0.1 m/s	
Wind direction	0-360°	1°	
Pressure	500 a 1080 mb	0.1 hPa	±1.5hPa
Temperature	-50 a 60 ºC	0.1 °C	± 0.5 ºC
Relative Humidity	0 a 100%	0.1%	± 5.0%

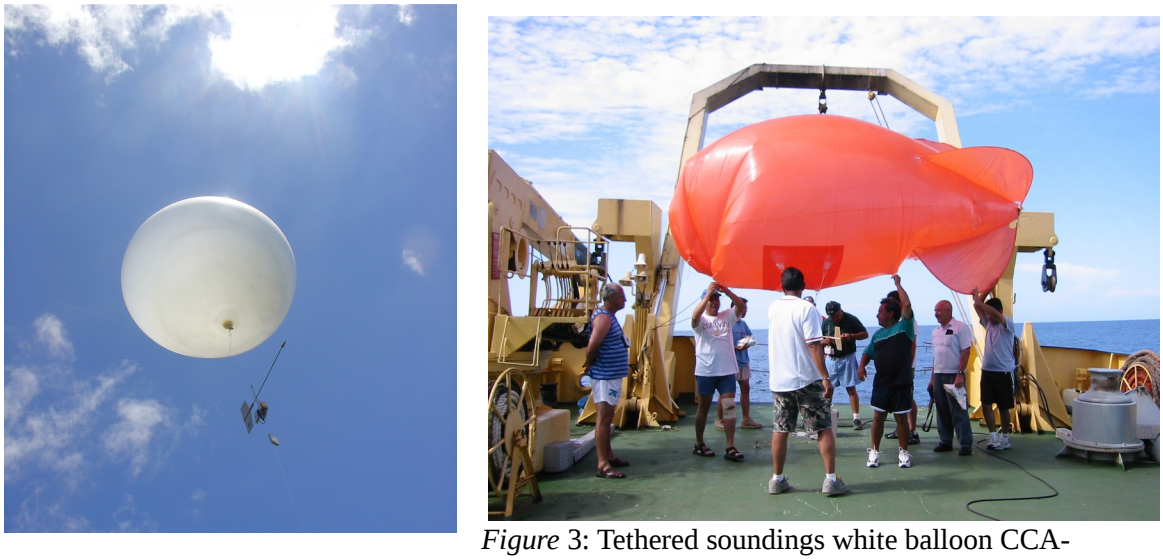

Figure 3: Tethered soundings white balloon CCA-UNAM equipment and red balloon Air equipment.

2.2.2 *CCA-UNAM tethered sounding description*

In order to measure the temperature and relative humidity commercial sensors of HoBo the model U-12 011 trade mark were used with twelve bits, with precisions of ±0.35 ºC and ± 2,5% respectively. The sensors have a data acquisition system integrated with capacity for 43000 measurements. In addition it has a direct interface to USB port to download the collected data to a computer. For the pressure and the speed of wind, an analogical four channels data logger, U12-006 model was used (with digital resolution of 12 bits, entrances of 0 to 2,5 C.D Volts., resolution of 0,6 mV and precision of ±2 mV (it figure 2). The sensors were prepared to provide compatible analogical output with the data logger. In order to obtain the speed and direction of wind a vane anemometer was constructed (fig. 5) The vane is made with aluminum tube and raft wood. In order to measure the atmospheric pressure a Motorola sensor (model MPX411A) was used with the characteristic of linearity and compensation with the temperature and voltage output proportional to the measured pressure.

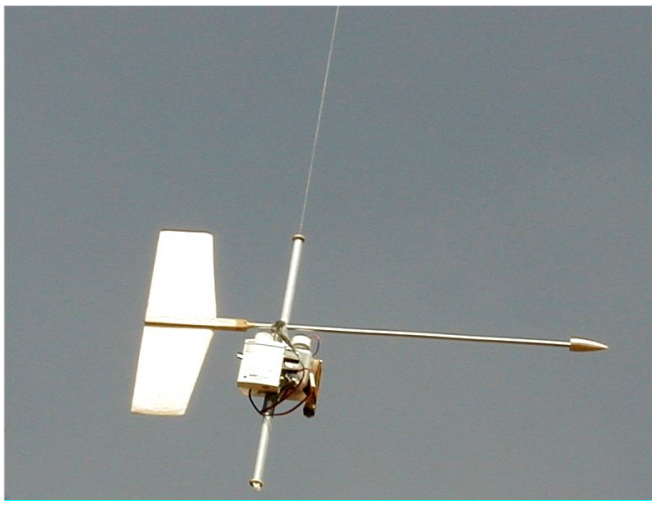

Figure 5 Vane anemometer

Variable	***Range***	***Resolution***	***Accuracy***
Wind speed V	0 - 60 m/s	0.1 m/s	± 3%
Pressure	150 a 1150 mbr	0.1328 mb	±1.5mb
Temperature	-20 a 70 ºC	12 bits	± 0.35 ºC de 0 a 50 ºC
Relative Humidity	5 a 95%	12 bits	± 2.5% de 10 a 90%

The upper air data were collected using a data logger trade mark hobo, U12-006 model, with digital resolution of 12 bits, input of 0-2.5 Volts of direct current and resolution of 0.6 mV (precision ±2 mV), and 8kb memory. These data are recovered or extracted from the data logger memory with the green line software which retrieves the data and creates files which can b exported to Excel. The temperature and humidity are obtained directly. In the case of the atmospheric pressure and the wind speed r a certain voltage values represents the is the variable. The instruments were calibrated and multiplication and offset factors were obtained according to a linear estimation, Y=mx+b, where: Y is

the wind speed and the atmospheric pressure; X is equal to the voltage measured in the hobo; is the multiplication factor; B is the additive value for the linear estimation 4.0 Data Format (in Excel are TXT format)

4. Results

4.1 Surface Time Series

Following are plots of the temperature, humidity, solar radiation and pressure for the Station 1, Station 2, Station 3, Station 4 and Station 5 (Fig. 5 Without going into detailed discussion, some of the major features of the surface meteorology will be mentioned. The air temperature had stronger diurnal variation during the cruise. The pressure during both cruises showed distinctive "tides" but no major synoptic systems are apparent.

a)

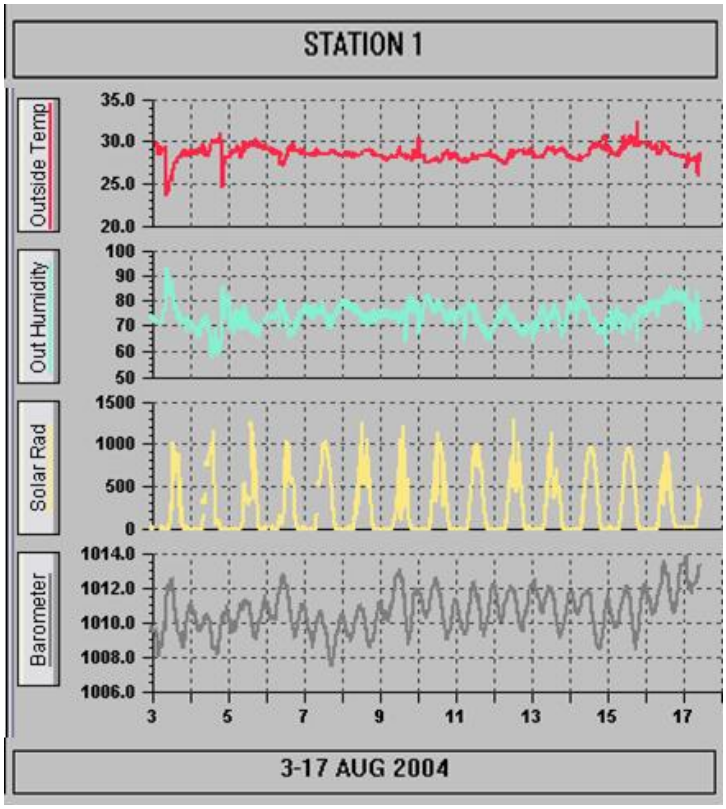

Figure 6 Time series of surface meteorology parameters. The panel displays air temperature (red),relative humidity (light green) solar radiation (yellow) and, pressure (gray); a) Station 1; b) Station 2; c) Station 3; d) Station 4 but solar radiation replaced by the dewpoint temperature (dark green); e) Station 5 the solar radiation replaced by the dewpoint temperature.

b)

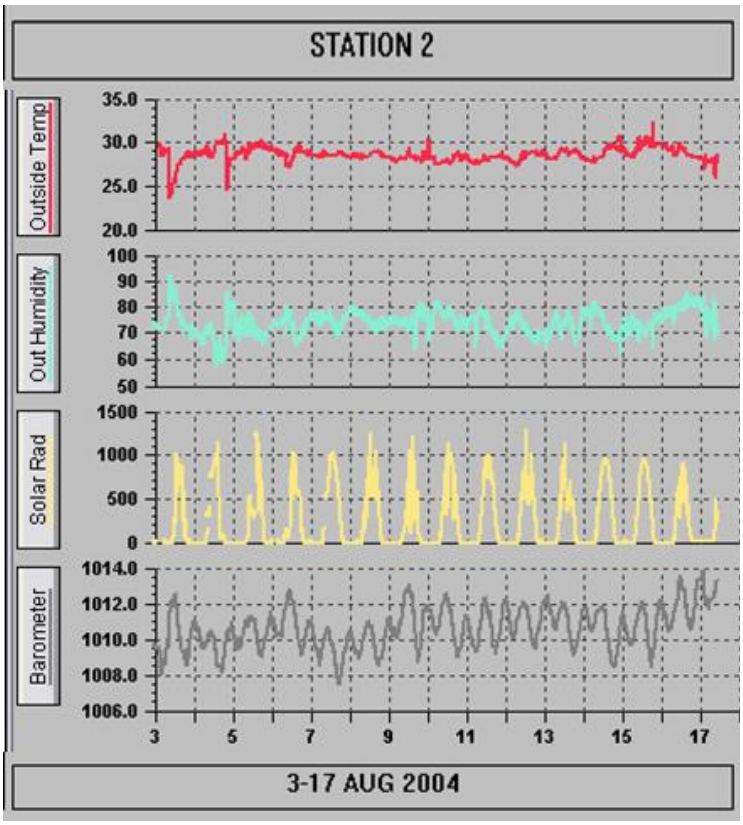

Figure 6 continue

c)

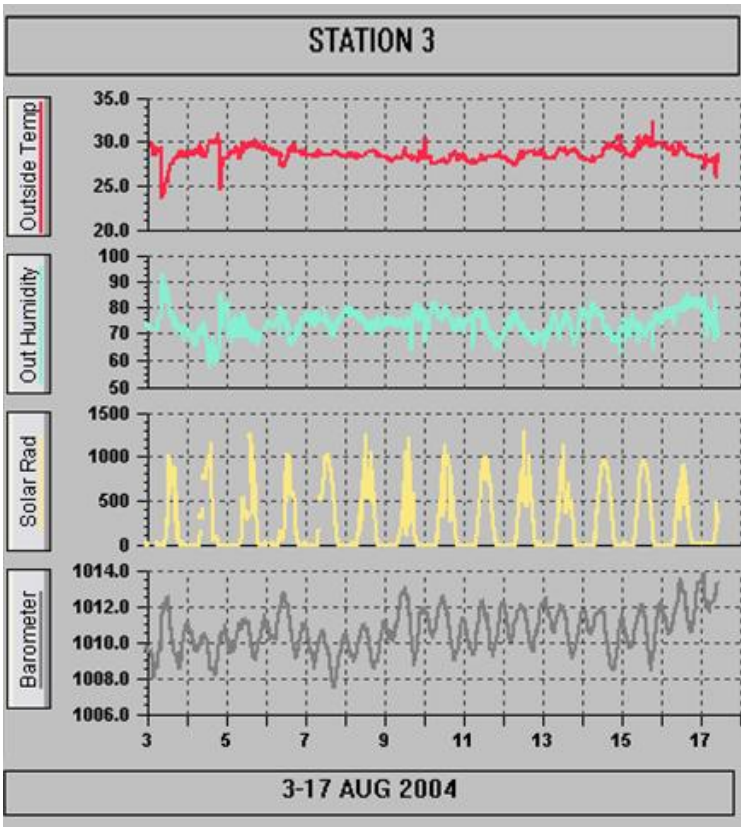

Figure 6 continue

d)

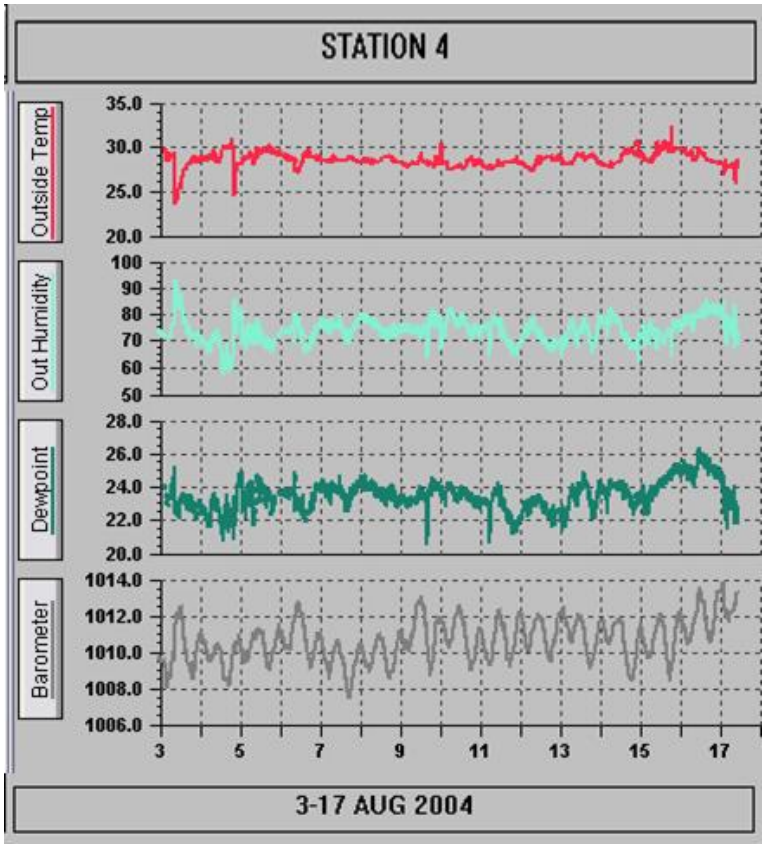

Figure 6 continue

e)

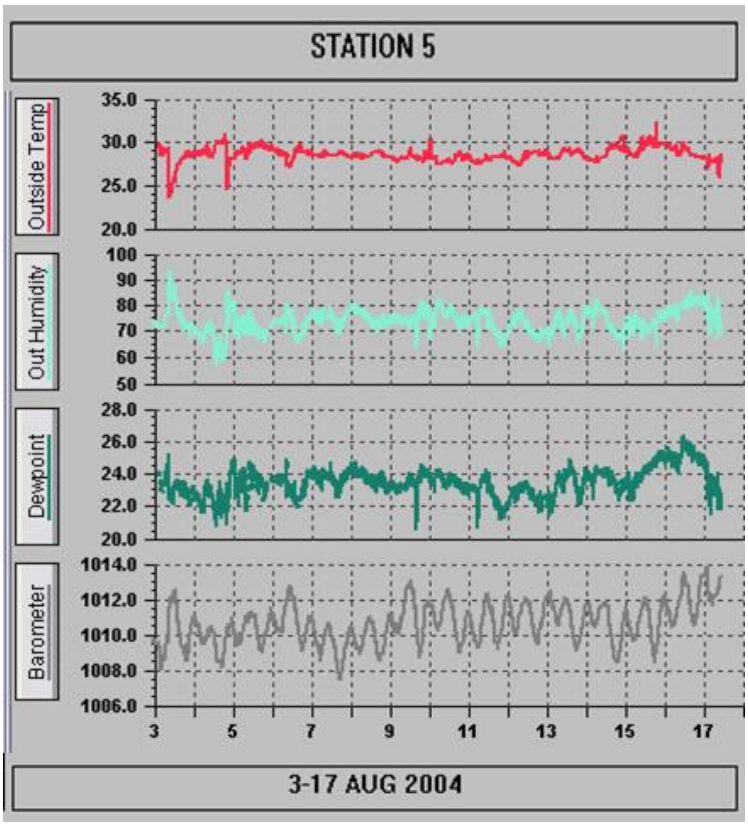

Figure 6 continue

4.2 Upper-air data

Plotting all the upper-air data is beyond the scope of this report, but these data are available for study (see next section.)

5.0 Data Sets

5.1 Surface data sets

All the data described here are available from the author. The primary data sets consist of 5 minute averages. Here is information on the files:

Filename: yymmdd_hhmm.txt
yy = last two year digits
mm = two digits month
dd = two digits day
hh = two digits local (Mazatlán hour)
mm=two digits minutes
Format: TXT or Excel
Column variable names:
Column 1 –date
Column 2 – time
Column 3 – outside air temperature
Column 4 – higher outside air temperature
Column 5 – lowest outside air temperature
Column 6 – outside relative humidity
Column 7 –dew point temperature
Column 8 – wind speed
Column 9 – wind direction
Column 10 – wind run
Column 11 – higher wind speed
Column 12– higher wind direction
Column 13– wind chill factor
Column 14– heat index
Column 15– THW index
Column 16 – THSW index
Column 17 - pressure
Column 18 – rain
Column 19 – rain rate
Column 20 – solar radiation
Column 21 – solar energy
Column 22 – higher solar radiation
Column 23 – UV index
Column 24 – UV dose
Column 25 –Higher UV
Column 26 –heat D-D

Column 27 – Coll D-D
Column 28 – inside air temperature
Column 29 – inside relative humidity
Column 30 – ET
Column 31 – wind samp
Column 32 – wind tx
Column 33 – ISS recept
Column 34 – Arc. Int.

In Excel, use the "open" command to open the data set. The above variable names will be assigned automatically. Missing values are given the value "---". These data are also available in ASCII format. The above variables are in columns in the order above and are represented in decimal format.

5.1 Upper air data sets

The Air sonde finename is: **adas-yymmddhh**, where:
yy = last two year digits
mm = two digits month
dd = two digits day
hh = two digits local Mazatlán hour.
For example adas-04080800 is the data set for the sounding that was started around 0000, 8 August, 2004 (LST). All files have no extension. The files are in ASCII format. Each file has a header line, followed by the sounding data. The first line of the sounding data is the variable labels and should be self-explanatory:
ETIME local time (second),
DT=DC temperature (°C),
WT=DC dew point temperature (°C),
PR=MB pressure (mb),
RH=PC relative humidity (%),
WD=DG wind direction (degrees),
WS=MS wind speed (m/s).
All the other lines represent data from the soundings. Missing data are represented by 88888888.

The CCA-UNAM sonde finename is: **ddmmyy**.xls where:
dd = two digits day
mm = two digits month
yy = last two year digits

The data for the Air and CCA-UNAM soundings were collected for the ascending and descending balloon launches: Un example of the data format is shown in figure 4 for both tethered sondes. Contact the authors if you have any questions.

a)

ETIME	DT=DC	WT=DC	PR=MB	RH=PC	WS=MS	WD=DG
002953	27.68	25.28	997.2	82.4	6.1	239
003004	27.59	25.16	997.2	82.4	6.5	244.
003014	27.48	25.08	996.1	82.3	6.0	254.
003025	27.41	25.02	995.0	82.3	6.0	248.

b)

Serial Number: 949876 Deployment #:5 hoboC
mult 0.013157
offset -0.18807

#	Time		Temp °C c:1	RH % c:1,2	DewPt °C c:1,2	Volt V c:3	Volt V c:4	mV	m/s
155	2/20/2006	07:12:50 a.m.	8.145	60.964	1.076	1.452	0.025	25	0.140862
156	2/20/2006	07:12:55 a.m.	8.145	61.587	1.217	1.455	0.026	26	0.1540192
157	2/20/2006	07:13:00 a.m.	8.12	60.904	1.039	1.454	0.026	26	0.1540192
158	2/20/2006	07:13:05 a.m.	8.12	60.875	1.032	1.455	0.026	26	0.1540192
159	2/20/2006	07:13:10 a.m.	8.12	60.677	0.987	1.454	0.026	26	0.1540192
160	2/20/2006	07:13:15 a.m.	8.12	60.506	0.948	1.454	0.025	25	0.140862

Figure 4 Tethered sonde data format, a) ADAS; b) CCA-UNAM system

The fig. 4b shows an example for the data format for CCA-UNAM sonde:
Column 1: measurement number
Column 2: date
Column 3: time
Column 4: air temperature
Column 5: dew point temperature
Column 6: pressure in volts unity
Column 7: wind speed in volts unity
Column 8: wind speed in mili volts unity
Column 9: wind speed converted to m/s

In Excel, use the "open" command to open the both data sets.. These data are also available in ASCII format. The above variables are in columns in the order above and are represented in decimal format.

Acknowledgements

This work was supported by the National Autonomous University of Mexico. I would like to thank all colleagues at CCA-UNAM provided invaluable support before, during and after the cruise. I thank the chief scientists Dr. Artemio Gallegos and Dr. Tomás Acoltzi and the other scientists and students on board, without whose help this data collection would not have been possibl. I also thank the captain and crew of the PUMA for their great support and professionalism.