

Atmospheric Measurements from the R/V Ulloa During the North American Monsoon Experiment (NAME)

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1 November, 2004

1. Introduction

This data report describes atmospheric measurements and data obtained during a cruise of the *R/V Francisco de Ulloa* in the Gulf of California. These measurements were part of the North American Monsoon Experiment (NAME). The first leg of the cruise occurred from 5 June 2004 to 21 June 2004, the second leg occurred from 6 August 2004 to 22 August 2004.

The *R/V Ulloa* is a research vessel owned and operated by the University of Baja California (UBC) in Ensenada, Mexico. The cruise was a collaborative effort between UBC, the Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), the National Severe Storms Laboratory (NSSL), Norman, Oklahoma and the Naval Postgraduate School (NPS), Monterey, CA. Funding to support this cruise was from the National Oceanographic and Atmospheric Administration (NOAA) and the participating Mexican institutions. Rubén Castro, UBC, and Emilio Beier, CICESE, were the Chief Scientists for leg 1 and leg 2, respectively.

2. Measurements

This report describes two types of atmospheric measurements:

1. **Surface** - Continuous measurements from a tower mounted on the top deck (above the bridge) of the *Ulloa*. (Table 1, Figures 1, 2 and 3)
2. **Upper-air** - Atmospheric measurements performed regularly using weather balloons and tethersondes

Table 1. Surface Measurements			
Parameter	Instrument	Manufacturer	Model
Relative Wind Speed	Sonic Anemometer	Climatronics	TACMET II
Relative Wind Direction	Sonic Anemometer	Climatronics	TACMET II
Heading	Electronic Compass	Climatronics	TACMET II
Speed over ground	GPS Receiver	Garman	
Course over ground	GPS Receiver	Garman	
Air Temperature	Fan Aspirated Sensor	Rotronic	HydroClip S3, One levels
Relative Humidity			
Sea Surface Temperature	Bucket Temperature		Glass encased
Air Pressure	Barometer	Climatronics	TACMET II
Cloud amount and type	Human Eye		

2.1 Surface Measurements

Data from all these measurements (except sea surface temperature and clouds) were obtained from the met tower (Figures 1 and 2) on the ship every two seconds and stored on a Campbell data logger. The true wind speed was determined using the relative wind vector (as measured from the ship) and the ship motion, based on the GPS data and compass. The data from the logger were transferred to a PC (Figure 3) every hour and stored on the hard disc. All surface measurements were successful for the entire cruise.

The measurement height for winds was 9.14 m above sea level. The measurements height for temperature, pressure and humidity was 7.92 m above sea level.

Sea surface temperature was obtained (usually) every hour by dipping a bucket over the side of the ship and measuring water temperature by placing a glass thermometer in the bucket. Observations of cloud conditions were undertaken every hour.

Based on the manufacturer's claims, estimated ship influence on the measurements and the author's experience, the following absolute accuracies (95% confidence for each datum point) were estimated.

Wind speed and direction: 1 ms^{-1} (vector)

Air temperature: 0.3 C

Sea Surface Temperature : 0.2 C

Relative Humidity: 5%

Pressure: 2 mb

Latent Heat Flux: 20 Wm^{-2}

Sensible Heat Flux: 3 Wm^{-2}



Figure 1. The *R/V Francisco de Ulloa* with NPS met tower circled in red.



Figure 2. Close up of NPS met tower on the *Ulloa* during the NAME cruise.



Figure 3. Meteorology data acquisition system. The rawinsonde/tethersonde receiver is on the left. The PC on the right stored and displayed the surface and upper-air data.

2.2 Upper-Air Measurements

These were collected with a Vaisala Marwinsonde system using model RS-80G and RS-80N rawinsondes . Typically, four balloon soundings were performed each day, alternating between two rawinsonde models (Figure 4). The RS-80G models provided temperature, humidity, pressure and wind vector as a function of height. These were "fresh" rawinsondes and were expected to provide data within the accuracy of the manufacturer's specifications (0.5 mb, 0.2 C and 3% for pressure, temperature and

relative humidity). The RS-80N rawinsondes were older and there may have been some larger biases in the humidity measurements. The RS-80N did not provide wind information. There were 67 successful soundings the first leg and 41 for the second leg.

During the second cruise, a tether system provided by the NSSL (using the NPS data collection system) provided detailed soundings of the boundary layer temperature and humidity. They were usually performed once or twice a day.

Also, pibals (balloons without rawinsondes) were used to measure winds using a marine theodolite. These data were not collected by NPS systems and are not presented in this report.



Figure 4. A rawinsonde launch. The green enclosure on the left was used to fill up the balloon.

3. Data Processing

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

1. The raw two-second data were examined graphically. The wind and ship motion data had some obvious spikes that were removed to produce a clean data set.
2. The magnetic compass values were corrected for magnetic deviation and compared to the ship course over ground (COG) values from the GPS when the ship speed was greater than 2 ms^{-1} . These did not match exactly because the magnetic field produced by the ship distorted the magnetic field. The raw compass values were divided into 10 degree bins and an average difference was determined for each bin. The difference in each bin (linearly interpolated between bin center points) provided a correction that was used to correct the compass heading values. This was necessary because when the ship is not moving the compass was the only way to determine the ship heading and hence true wind speed and direction.
3. The clean two-second data were then averaged into 10 minute periods, using a vector average for the relative and true winds, and the ship motion.
4. The hand-written sea surface temperature (SST) values were manually digitized and merged into the 10 minute data set.
5. The sensible and latent heat fluxes were calculated using a bulk method (Smith, 1998). These were based on a 20 minute average air temperature, humidity and wind speed for each period that was centered by an available SST value. The surface of the ocean was assumed to be 98% saturated with respect to the SST.

No processing was required for the upper-air data.

4. Results

4.1 Surface Time Series

Following are plots of the wind vector, temperature, humidity and turbulent heat flux for both legs (Figures 5-7). Time is represented as Julian Day, which is the number of days and fractional days, using Universal Time (UT) from the start of 2004 (plus one). For example June 5 at 1200 UT was represented by JD 157.5 and August 6 at 1800 is JD 219.75.

Without going into detailed discussion, some of the major features of the surface meteorology will be mentioned. The air and sea temperatures had stronger diurnal variation during the first leg of the cruise. The pressure during both cruises showed distinctive "tides" but no major synoptic systems are apparent. The most common wind direction for both legs was southeast, but many other wind directions also occurred. The strongest winds came on the last day of leg 2.

The average latent heat flux for leg 1 and leg 2 were 91 Wm^{-2} and 118 Wm^{-2} . The dry wind event on Julian Day 235 (August 22) created very large latent heat fluxes, reaching a maximum of 656 Wm^{-2} . This event occurred in the northern part of the Gulf of California.

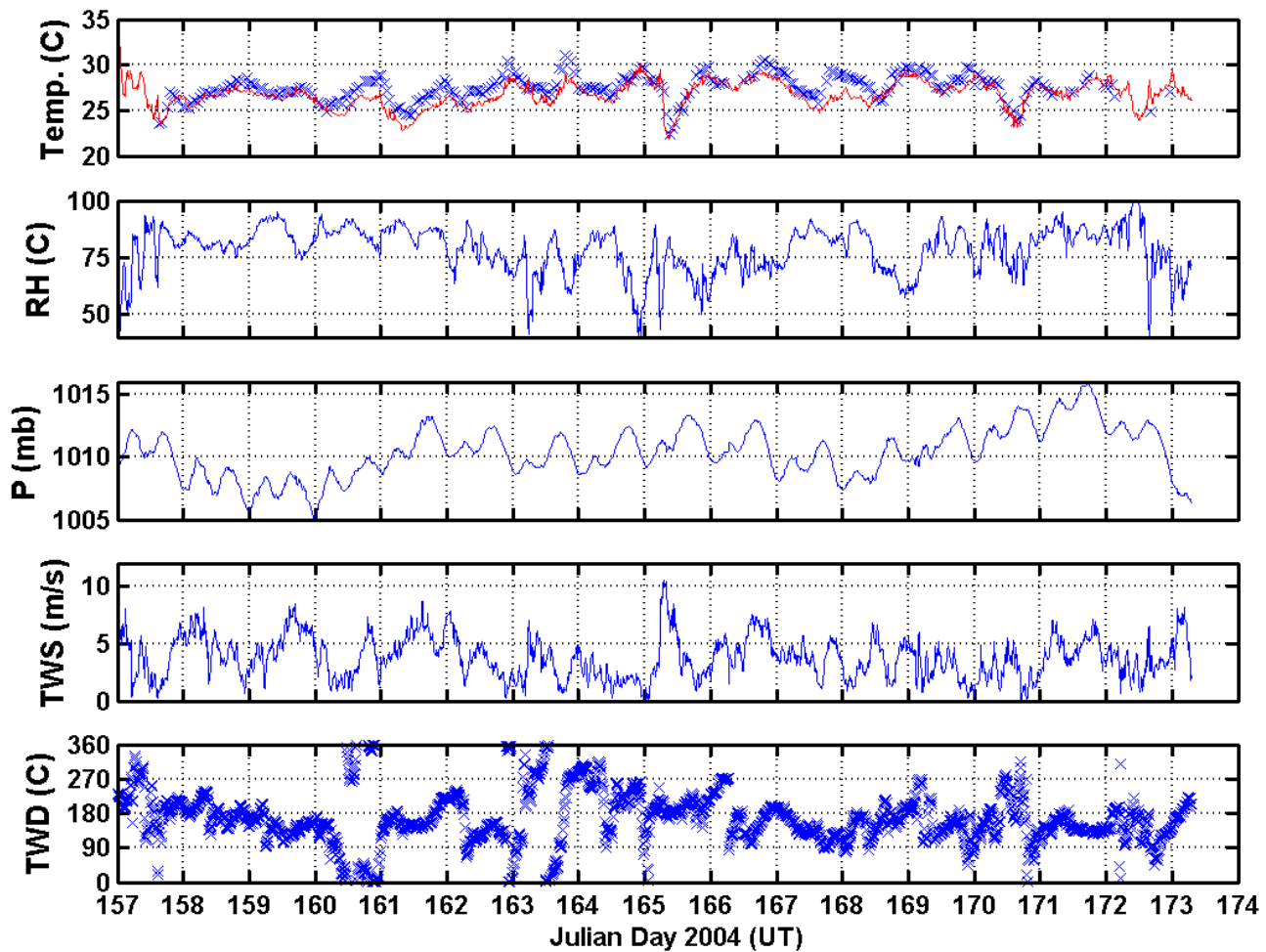


Figure 5. Time series of surface meteorology parameters for leg 1. The top panel displays air temperature (red) and sea surface temperature (blue). The next panels display relative humidity (RH), pressure (P), true wind speed (TWS) and true wind direction (TWD), respectively. The true wind values have been corrected for ship motion.

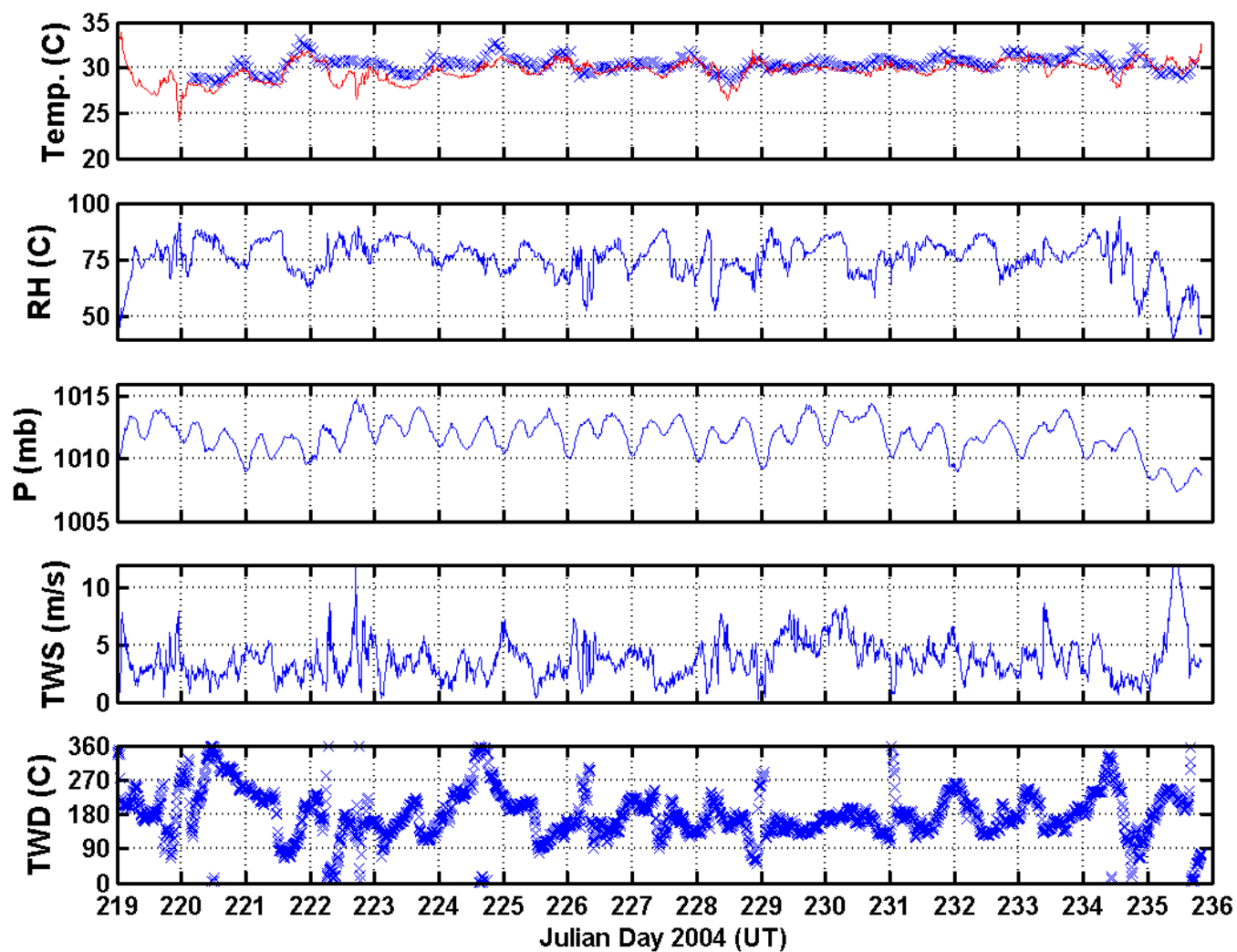


Figure 6. Same as Figure 5 for leg 2.

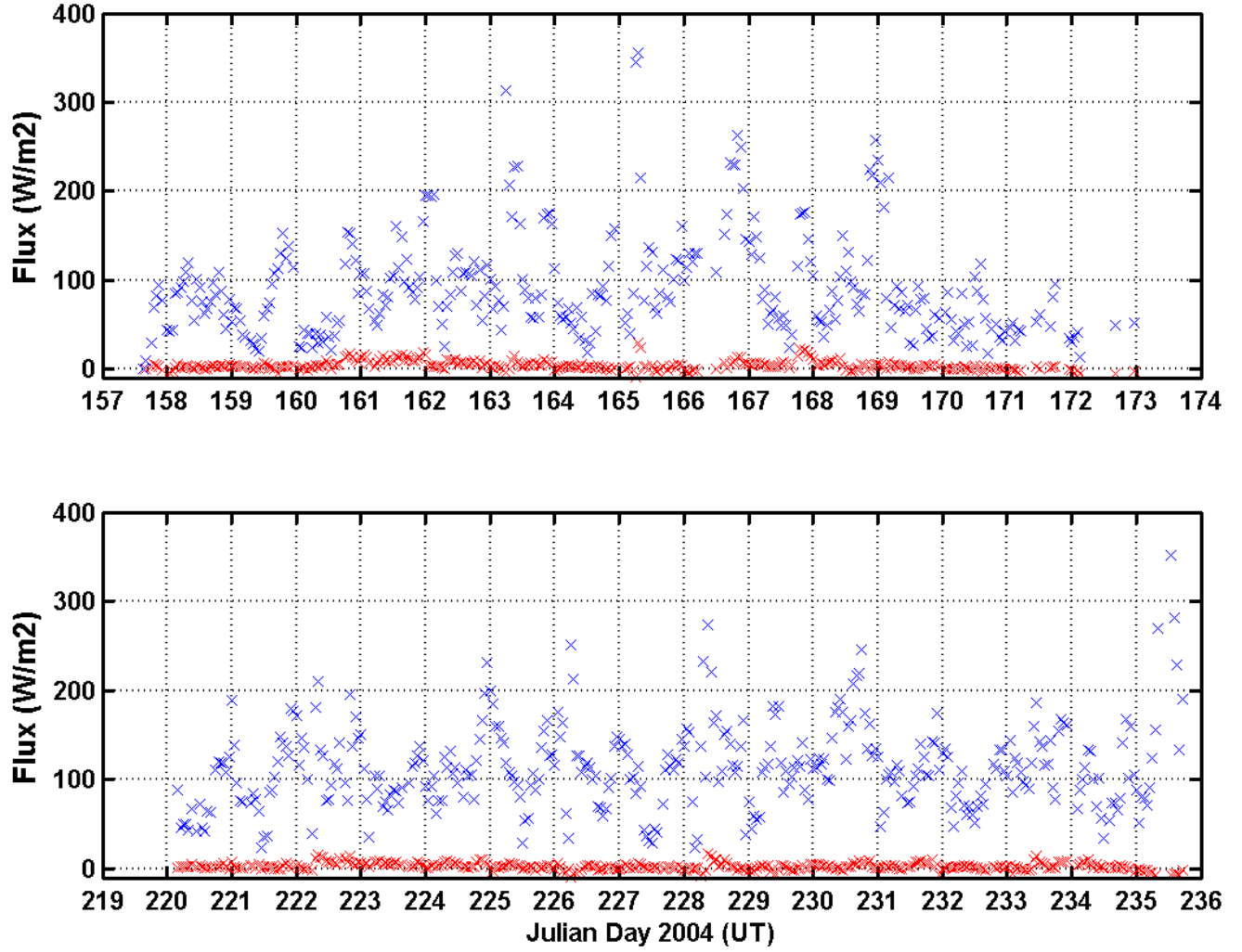


Figure 7. Time series of estimated turbulent fluxes for leg 1 (top) and leg 2 (bottom). Sensible heat flux is indicated as red and latent heat flux is blue. On Julian Day 235 during leg 2 there was an event that caused the latent heat to reach 656 Wm^{-2} . This is not visible on the scale used for this figure.

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 10 minute averages. Contact the author if you need access to the 2-second data. There is one file for each of the legs. Here is information on the files:

Filenames: NAMEleg1_final.mat, NAMEleg2_final.mat

Format: MATLAB 6

Variable Names:

- jd - Julian Day (Fractional Days, Universal Time)
- lat - Latitude (Fractional degrees)
- lon - Longitude (Fractional degrees) All longitudes are negative, indicating west.
- cog - Course over ground (degrees) Direction ship is moving
- sog - Speed over ground (ms^{-1}) Speed of ship
- rwd - Relative wind direction (degrees) Wind direction relative to ship bow
- rws - Relative wind speed (i.e. as measured) (ms^{-1})
- twd - True wind direction (degrees from north) Corrected for ship motion
- twc - True wind speed (ms^{-1}) Corrected for ship motion
- ta - Air temperature (C)
- ts - Sea surface temperature (C)
- rh - Relative Humidity (%)
- q - Specific Humidity (g/Kg)
- p - Pressure (mb)
- shf - Sensible heat flux (Wm^{-2})
- lhf - Latent heat flux (Wm^{-2})
- stress - Surface wind stress (Nm^{-2})

In MATLAB, use the "load" command to open the data set. The above variable names will be assigned automatically. Missing values are given the value "NaN" (not a number). The only missing data are the sea temperature and fluxes during periods when the sea temperature was not measured.

These data are also available in ASCII format. The above variables are in columns in the order above and are represented in exponential format. Missing data appears as "NaN". Use a text editor to change "NaN" to -9999 or some other number if all numeric input is required.

5.1 Upper-air data sets

These name of these files is expressed as

YearYearMonthMonthDayDayHourHour.cap

For example 04060917.cap is the data set for the sounding that was started around 1700, 9 June, 2004 (UT). All files have the .cap extension. The files are in ASCII format. Each file has several header lines, followed by the sounding data. The first line of the sounding data (height of 1 meter) is what was typed in as a "surface observation" and is therefore not based on data from the actual rawinsonde. All the other lines represent data from the soundings. Missing data are represented by three to five slashes "///". The variables are labeled at the top and should be self-explanatory.

There are three types of soundings: 1. Rawinsonde with winds, 2. Rawinsonde without winds, 3. Tethersonde without winds. All types have the same format. The filenames do not indicate type. Types 2 and 3 will have slashes for winds (except for 1 meter level). Sometimes the data were collected for type 1 and type 2 while the rawinsonde was descending. Contact the author if you have any questions.

6.0 Reference

Smith, S.D. 1988: Coefficients of sea surface wind stress, heat flux, and wind profiles as a function of wind speed and temperature. *J. Geophys. Res.*, **93**, 15,467-15,472

7. Acknowledgements

This work was supported by the NOAA Office of Global Programs, NAME project (Michael Patterson). I would like to thank Mike Douglas for inviting me to participate in this project. Miguel Lavin and his colleagues at CICESE provided invaluable support before, during and after the cruise. I thank the chief scientists Rubén Castro and Emilio Beier and the other scientists on board, without whose help this data collection would not have been possible (Dorothea Ivanova, Teresa Cavazos, Freddy, Anna, Maria, Lupina, Carlos (sorry your last names have escaped me). I also thank the captain and crew of the *Ulloa* for their great support and professionalism.