Smithsonian Tropical Research Institute
Physical Monitoring Program
Metpark Crane Weather Station - Parameters

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1 Introduction

STRI's Physical Monitoring Program operates a weather station at Panama City's Parque Natural Metropolitano ($8^o59'41.55"N, 79^o32'35.22"W$). The station was established in January 1995 and it is installed on the park's Canopy Crane, at a height of 25m from the ground. The Metropolitan Park's canopy crane is 42m tall.

The Parque Natural Metropolitano (PNM) comprises an area of 270ha and is the only natural, undisturbed park in tropical Latin America located adjacent to a capital city. The area now occupied by the PNM underwent substantial ecological modification beginning in pre-Colombian times, but has remained largely undisturbed for the last 80 years during which time it has reverted from abandoned pasture to secondary dry, deciduous, lowland forest. The upper canopy is 25-30m high with emergent trees reaching 40m.

The PNM receives an average of 1850mm of rain per year. The meteorological year is divided into two parts: a pronounced dry season (approximately from mid-December to the end of April), and a wet season (May to mid-December). On average, only 140mm of rain falls during the dry season. In addition, relative humidity and solar radiation show marked wet/dry season differences, while temperature varies relatively little throughout the year.

2 Variables Measured

The Metropolitan Park weather station is fully automated. The station measures physical variables using a 10s sampling rate and records 15min average, maximum and minimum values for Solar Radiation, Air Temperature, Relative Humidity, Leaf Wetness, Wind Speed and Wind Direction. In addition the station records 15min rainfall totals. Prior to February 10, 2006 the station collected data on an hourly basis instead of 15 minutes.

The table below lists the variables measured, along with the corresponding units.

Variable	Units
Solar Radiation	W/m^2
Temperature	Celsius
Relative Humidity	%
Wind Speed	km/h
Wind Direction	Degrees from magnetic north
Rainfall	mm
Leaf Wetness	1/0
Leaf Wetness	kOhm

3 Data Files

3.1 Data File Descriptions

Description of the contents for each on the comma separated values (.csv) formatted files.

Filename	Contents
Metpark_crane_AT_m.csv	Average air temperature
Metpark_crane_ATMN_m.csv	Minimum air temperature
Metpark_crane_ATMX_m.csv	Maximum air temperature
Metpark_crane_SR_m.csv	Average solar radiation
Metpark_crane_SRMN_m.csv	Minimum solar radiation
Metpark_crane_SRMX_m.csv	Maximum solar radiation
Metpark_crane_RA_m.csv	Total rainfall
Metpark_crane_rh_m.csv	Average relative humidity
Metpark_crane_RHMN_m.csv	Minimum relative humidity
Metpark_crane_RHMX_m.csv	Maximum relative humidity
Metpark_crane_WDVM_m.csv	Wind direction vector mean
Metpark_crane_ws_m.csv	Average wind speed
Metpark_crane_WSMN_m.csv	Minimum wind speed
Metpark_crane_WSMX_m.csv	Maximum wind speed
Metpark_crane_LWET_m.csv	Average leaf wetness (1 wet, 0 dry)
Metpark_crane_LWkohm_m.csv	Average leaf wetness in kOhm

3.2 Data Labels

The data files listed in the previous section contain a header with labels describing the content of the corresponding data columns. The meaning of these labels is detailed in the table below. Missing data records are marked with either -1.00 or -9.00.

Label	Description
date_t	Datetime
at	Air Temperature
atmn	Air Temperature Minimum
atmx	Air Temperature Maximum
lwet	Leaf Wetness
lwet_kohm	kOhm readings from the leaf-wetness sensor
ra	Rain
rh	Relative Humidity
rhmn	Relative Humidity Minimum
rhmx	Relative Humidity Maximum
sr	Solar Radiation
srmn	Solar Radiation Minimum
srmx	Solar Radiation Maximum
wdsd	Wind Direction Standard Deviation
wdvm	Wind Direction Vector Mean
ws	Wind Speed
wsmn	Wind Speed Minimum
wsmx	Wind Speed Maximum
tag	Marks an unusual aspect of a data point
ss	Sensor Substitution Code (1)
ds	Datum Status Level (2)
pt	Point Measurement (3)

1. Sensor Substitution Code: Marks data that was substituted from another sensor.

2. Datum Status Level:As data is checked for errors it will move up a series of data quality levels - currently this mechanism in being designed. If this field is empty or if it contains an L (Legacy Data) it means that the data has not been checked for errors, i.e. raw data.

3. Point Measure: It indicates whether the measurement is a point measure, i.e. a sample, or not.

4 Current Instruments

List of the current instruments operating at the MetPark station.

- Datalogger - CR10XPB, Campbell Scientific Inc.
- Solar Radiation - LI200S, LI-COR Biosciences.
- Temperature and Relative Humidity - CS215, Campbell Scientific Inc.
- Wind Speed and Direction - RMY05103, R.M. Young.
- Rainfall - TB04/4m, Hydrological Services
- Leaf Wetness - CS317, Campbell Scientfic Inc.

4.1 Datalogger

CR10X series Data Logger with PakBus operating system. View the full specifications for this Data Logger at http://www.campbellsci.com/cr10x.

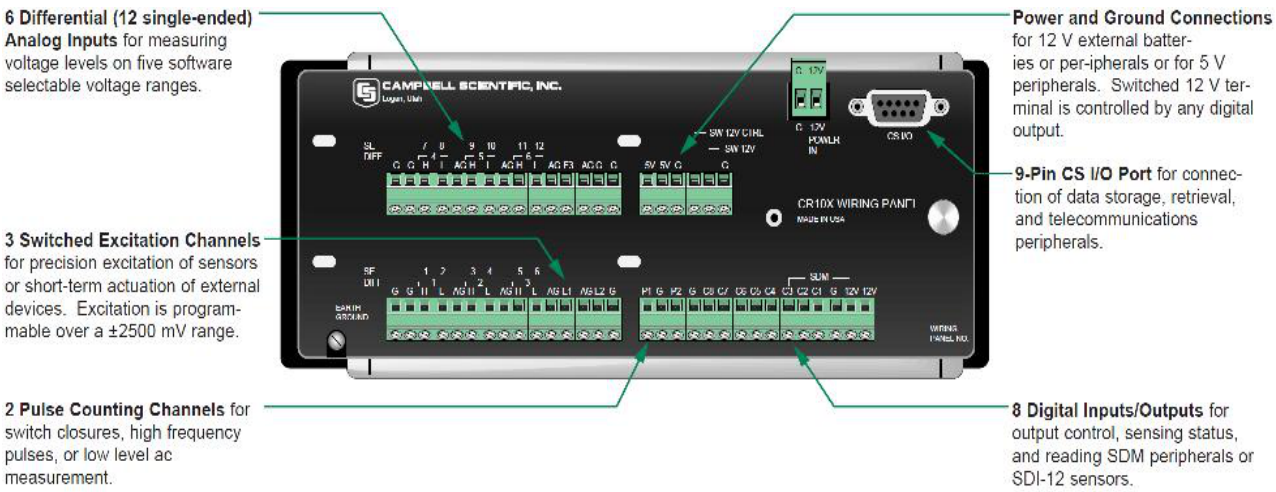

Figure 1: CR10XPB Datalogger

4.2 Solar Radiation Sensor

Solar radiation is measured with a LI-COR LI200S pyranometer. The LI-200S measures incoming solar radiation with a silicon photovoltaic detector mounted in a cosine-corrected head. The current output from the LI-200S, which is directly proportional to solar radiation, is calibrated against an Eppley Precision Spectral Pyranometer under natural daylight conditions (400 to 1100nm) in units of watts per square meter ($\frac{W}{m^2}$).

Figure 2: LI200S pyranometer

LI200S Specifications

Stability:	$< \pm 2\%$ change over a 1 year period
Response Time:	$10\mu s$
Cosine Correction:	Cosine corrected up to 80^o angle of incidence
Operating Temperature:	-40 to $+65\ ^oC$
Relative Humidity:	0 to 100%
Accuracy:	Absolute error in natural daylight is $\pm 5\%$ maximum; $\pm 3\%$ typical
Sensitivity:	$0.2kWm^{-2}mV^{-1}$
Linearity:	Maximum deviation of 1% up to $3000\frac{W}{m^2}$
Light Spectrum Waveband:	400 to $1100nm$

Spectral Response

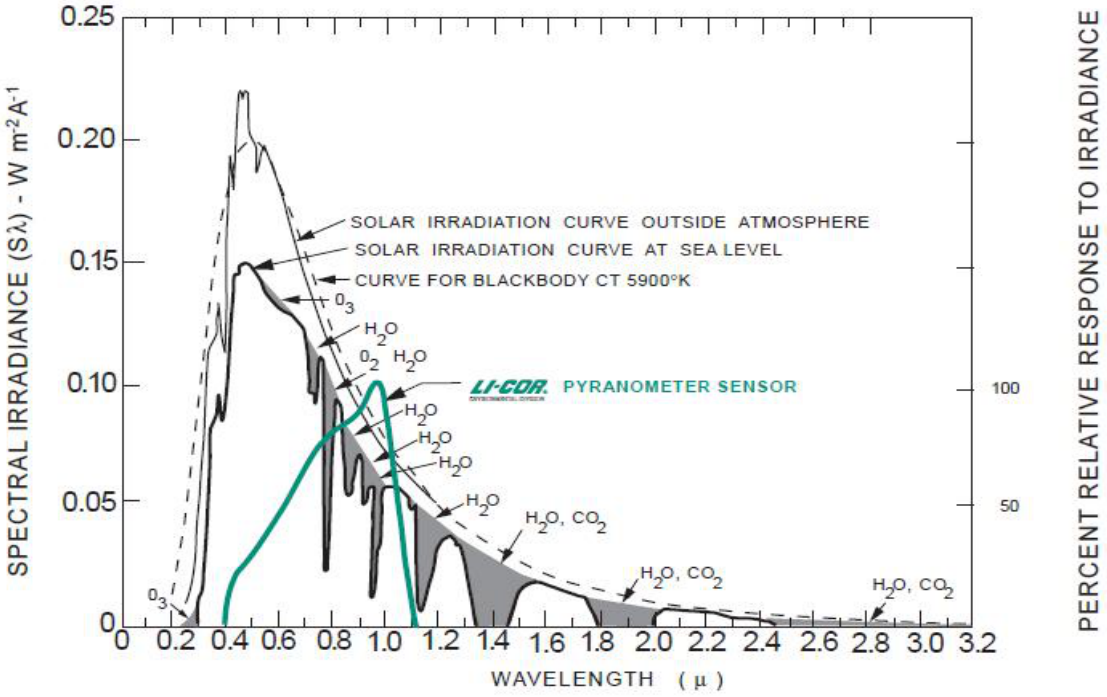

Figure 3: LI200S % of Relative Response

4.3 Temperature and Relative Humidity Sensor

Temperature and Relative Humidity are measured using a CS215 T&RH probe fom Campbell Scientific. The CS215 probe uses a single chip element (SHT75 from Sensirium AG) that incorporates both a Silicon Bandgap Temperature sensor and a Capacitive RH sensor. In the field, this sensor is deployed inside a non-aspirated radiation shield.

Figure 4: CS215 Sensor

CS215 Specifications

Temperature Measurement

Operating Range:	-40 to $+70^oC$
Accuracy:	$\pm 0.3^oC$ at 25^oC, $\pm 0.4^oC$ over $+5$ to $+40^oC$ $\pm 0.9^oC$ over -40 to $+70^oC$
Response Time:	$120s$ (63% response time in air moving at $1ms^{-1}$)

Relative Humidity

Operating Range:	0 to 100% RH (-20 to $+60\ ^oC$)
Accuracy:	$\pm 2\%$ over 10 to 90%, $\pm 4\%$ over 0 to 100%
Short Term Hysterisis:	$< 1\%$ RH
Temperature Dependence:	Compensated to better than $\pm 2\%$ over -20 to 60^oC
Stability:	Better that $\pm 1\%$ per year
Response Time:	$< 10s$ (63% response time in air moving at $1ms^{-1}$ and $< 85\%$ RH)

4.4 Wind Speed and Wind Direction Sensor

Wind Speed and Wind Direction are measured using a 05103 propeller type Wind Monitor from R.M.Young. The Wind Speed is measured with a helicoid-shaped, four-blade propeller and the Wind Direction, i.e. Vane position, is measured by the rotation of a 10 kOhm potentiometer.

Figure 5: 05103 Wind Monitor

05103 Specifications

Wind Speed

Range:	0 to $360 Km/hr$
Accuracy:	$\pm 1.08 Km/hr$ or 1% of the reading
Starting Threshold:	$3.6 Km/hr$
Distance Constant: (63% Recovery)	$2.7m$

Wind Direction

Range:	0 to 360^o mechanical 355^o electrical (5^o open)
Accuracy:	$\pm 3^o$
Starting Threshold at 10^o displacement:	$3.96 Km/hr$
Delay Distance (50% recovery):	$1.3m$
Damping Ratio:	0.3
Damped Natural Wavelength:	$7.4m$
Undamped Natural Wavelength:	$7.2m$

4.5 Rainfall Sensor

The rainfall is measured with a TB4 rain gauge from Hydrological Services Pty. The rain funnels into a tipping bucket mechanism that tips for every $0.25mm$ of rain collected. Each tip is marked by a dual reed switch closure that is recorded by the datalogger.

Figure 6: TB4 Rain Gauge

TB4 Specifications

Measurement Range:	0 to $500mm/hr$
Accuracy:	Better than $\pm 2.0\%$ at $500mm/hr$
Resolution:	$0.254mm$
Environmental Conditions	
Temperature:	0 to $+70^oC$
Humidity:	0 to 100%

4.6 Leaf Wetness Sensor

Leaf Wetness is measured with a 237 Leaf Wetness sensor from Campbell Scientific. The 237 sensor is designed to emulate the surface area of a leaf and determine the percentage of the time that a surface is wet versus dry.

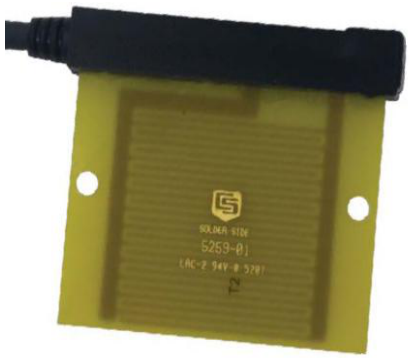

Figure 7: Leaf Wetness Sensor

LW237 Specifications

Temperature Range: 0 to 100^oC; Survival -40 to 150^oC

5 Sensor Deployment Notes

This section provides detailed background information on the sitting of the various sensors deployed at Parque Natural Metropolitano. The World Meteorological Organization (WMO) has a set of guidelines for sensor sitting and exposure. However, in the field, it is not always possible to strictly follow these guidelines and as a result sometimes sensors are deployed in non-ideal conditions. Also, it should be noted that the Physical Monitoring Program provides local environmental data at sites of interest to STRI Scientists, therefore it deploys sensors at such sites instead of deploying sensors at sites that strictly meet standard guidelines for sensors deployment. For sites where WMO guidelines are not met, the data may be used to look at inter-annual variation/comparison of a parameter but not to make overall statements on the climate. Here we point out any shortcomings on the sitting of the Metpark's sensors and the corresponding implications for the data collected from the site.

5.1 Solar Radiation

The solar radiation sensor is deployed on the southwest facing side the Metpark crane at about 25m from from the ground and 2.5 meters away from the crane's mast. In the parking position, the crane's boom extends over the southeastern side of the crane's the mast. For Panama City and at 12:00 noon the path of sun oscillates between an altitude position of about 57^o from the horizon due south (Northern hemisphere winter solstice) and an altitude position of about 75^o from the horizon due north (Northern hemisphere summer solstice). Based on the above information and observations carried out at the site the following applies for the exposure of the Metpark crane pyranometer:

- Throughout the year and with the boom in the parking position the crane will cast a shadow on the pyranometer, for a few minutes, between 11:30 and 12:00 noon.
- Between May 15 and July 27 the crane's mast casts a shadow on the on the pyranometer, for a few minutes, around 12:00 noon.

More material to be added here ....

6 Historical Notes - recent history

- January 29, 2010 - Uploaded a new datalogger program, built on loggernet 3.4.1, to the Metpark datalogger, i.e. datalogger CR10XPB $S/N : X35596$. The datalogger started to collect data on this date at 10:15 a.m.

- January 27, 2010 - The datalogger stopped working after the maintenance procedure done on Jan. 27. Probably due to building the Jan. 8 program on Loggernet 4.0. No data collected between Jan. 27, 11:45 a.m. and Jan. 29, 10:15 a.m.

- January 27, 2010 - The RMY anemometer 05103 S/N : 73886 was replaced a by a newly calibrated RMY 05103 S/N : 16401.

- January 27, 2010 - The leaf-wetness sensor, CS217, ($SO\#225073$) was replaced by a new sensor, $SO\#237924$. The CS217, $SO\#225073$, was tested at the Naos office on February 4th, 2010, and found to be working properly.

- January 8, 2010 - Leaf-wetness sensor is cleaned but it appears to be giving wrong readings - readings may be affected by the water dripping from AC unit on the crane's operator cabin.

- January 8, 2010 - The Vaissala HMP45C Temp&RH sensor was replaced by a CS215 Temp&RH sensor, $S/N : E3978$.

- March 27, 2009 - T&RH from sling-psychrometer at 12:10 p.m.: Dry-bulb 32^oC, Wet-bulb 25^oC, 56% RH.

- March 27, 2009 - Tipping bucket calibration procedure, 11:00 to 11:20 a.m.: 628cc of water poured into the tipping bucket, resulting in 85 tips or 21.59mm of rain. Tipping bucket in good operating condition.

- March 27, 2009 - Fixed the anemometer wiring at 7:40 a.m.

- March 27, 2009 - The LICOR LI200S pyranometer ($S/N : py61709$) was re-leveled.

- March 19, 2009 - The anemometer was not properly wired, i.e. wires got switched.

- March 19, 2009 - The leaf-wetness sensor (S/N : $7078 - 445705$) was replaced by a new leaf-wetness sensor ($SO\#225073$).
- March 19, 2009 - The Apogee pyranometer (S/N : 5340) was replaced by a LICOR LI200S pyranometer S/N : $py61709$.
- August 28, 2008 - The LICOR LI200X pyranometer, was replaced by a new Apogee pyranometer S/N : 5340.
- April 30, 2008 - New rain gauge (tipping bucket) from Hydrological services installed at the top of the crane; at 42m.
- April 16, 2008 - The rain gauge (tipping bucket) located at 25m was found to be broken.