Sustainability of the Measurement ----- A panacea for achieving Automatic Weather stations for environmental intelligence in 21st century

by

Engr. Dr. Stella Uche Obikwelu (AGM Instrument) with the support of Director of Engineering & Technical Services Nigerian Meterological Agency

Tel:+2347038933848 Emai: Nnoye2k@yahoo.com

ABSTRACT:

The extent of climate variability and impact of weather elements in Automatic weather station installed in the six Geopolitical zones of Nigeria West Africa was determined using simulation, analysis of field data and point bisearer statistical model. The results/Findings gave an insight on the importance of sustainability of measurement in the 21st century from a recent concluded PhD research thesis.

The trend line with Y= 0.04X + 3.32 shows an upward trend in variation of this meteorological AWSs as servicing, preventive and corrective maintenance with replacement of parts ,protection of the sensor against vandalism and suitable location depicts good sustainability standards for the measurement in 21st century.

A model has been developed in this paper to tackle sensors mobility issue thus ensuring effective sustainability of location. It encompasses development of personnel and training on the component of AWss which consist of a set of sensors mounted outdoors to measure the various weather parameters and a console unit usually located indoor to collate and display the weather readings and optionally, a data logger to link the system to computer.

Findings on a survey conducted on calibration, control assessment for traceable and non-traceable quantities, environmental impact both dynamic and static on the sensors, operation of the AWSs in harsh environment and extreme weather conditions will be provided in order to ascertain the degree of sustainability of the measurement which is a panacea for achieving Automatic weather stations for environmental intelligence.

INTRODUCTION

This paper describe the extent of climate variability and impact of weather elements in Automatic weather station installed in the six geopolitical zones of Nigeria. Calibrations, intercomparisons, laboratory and field performance tests was carried out in this research work using stations within normal and harsh /extreme environmental condition as case studies. The trend line with $Y=0.04X + 3.32$ shows an upward trend in variation of this meteorological Awos using point biseria and pearson statistics models. It depict great need for good sustainability standards for the measurement in 21st century.The data and results are likely to be useful to the Nigerian Government in ensuring good planning because good planning using improper or unreliable data will bring about negative implications.

The data and results obtained from case study in this research work will be of great importance to world meteorological organization in assessing the extent of sustainability of the measurement thus providing a good standard policy in implementation of its sustainability drive which is a panacea in achieving Automatic Weather Station in 21st Century.

1.0 CALIBRATION, INTERCOMPARISMS, LABORATORY AND FIELD PERFORMANCE TESTS.

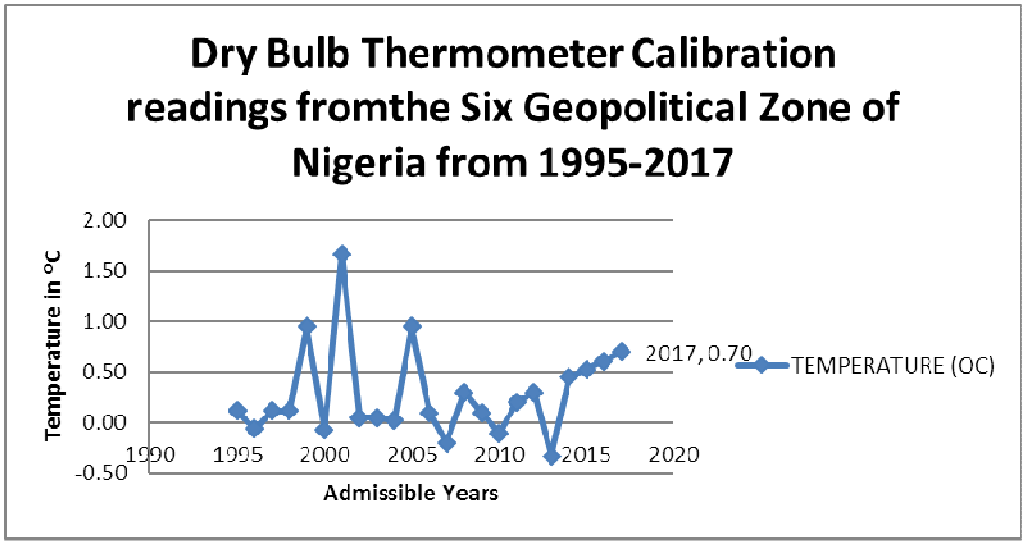
NIGERIAN METEOROLOGICAL AGENCY		CALIBRATION RELATED PROCESS	
Thermometer Calibration Certificate		Revision 0	
Ambient Condition		Not Applicable	
Name of Instrument: Automatic Weather Observing Station (AWOS)			

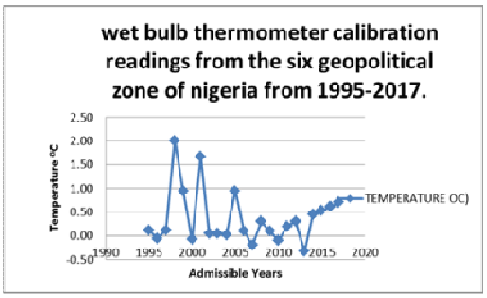
Project No:	
Measuring Range	-20 ^{0}C ---------- +60oc
Reference Instrument:	VAISALA PTB 220

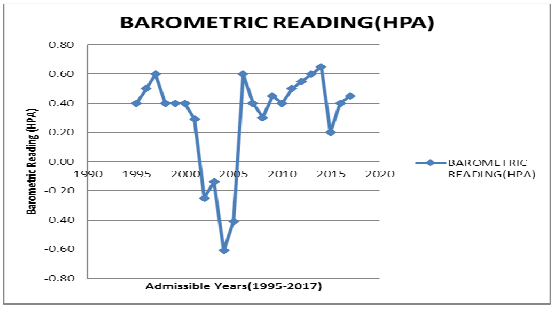
Remarks(**Write in Green ink if in tolerance and Red ink if out of tolerance)**	Date of Next Calibration
Vaisala Midas IV PTB 220 Digital Barometer is in tolerance with Reference instrument.	

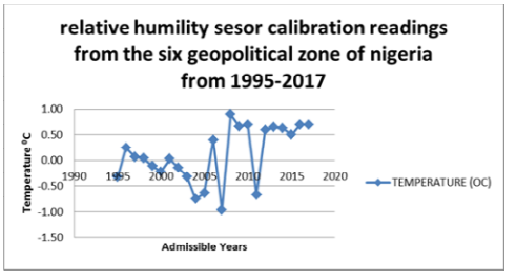
Reference Instr.	Temperature Instrument on calibration			
Reference Barometer (hpa)	Observed Barometric Reading	Deviation(^{o}C)	%Deviation	Admissible uncertainty(OC)
972.40	972.80	0.40	40%	1995
971.10	971.60	0.50	50%	1996
971.00	971.60	0.50	50%	1997
973.10	973.50	0.40	40%	1998
974.00	974.40	0.30	30%	1999
973.20	973.60	0.40	40%	2000
973.00	973.29	0.29	29%	2001
973.30	973.05	0.20	20%	2002
973.20	973.06	0.40	40%	2003
973.70	973.09	0.20	20%	2004
973.50	973.09	0.40	40%	2005
973.20	973.80	0.60	60%	2006
973.10	973.50	0.40	40%	2007
973.10	973.40	0.30	30%	2008
973.00	973.45	0.45	45%	2009
973.20	973.60	0.40	40%	2010
973.00	973.50	0.50	50%	2011
973.00	973.55	0.55	55%	2012
973.00	973.60	0.60	60%	2013
973.00	973.65	0.50	50%	2014
973.10	973.30	0.30	30%	2015
973.20	973.60	0.40	40%	2016
973.00	973.45	0.45	45%	2017

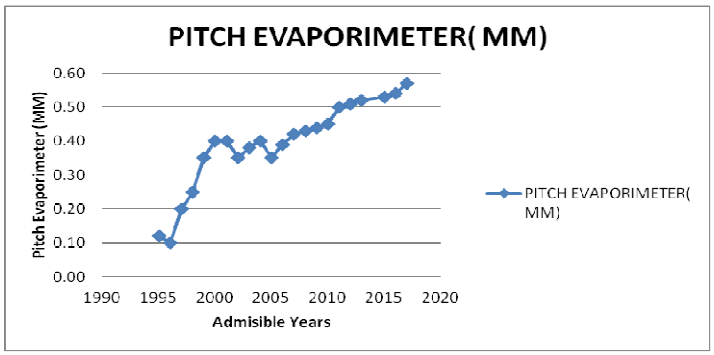
TEMPERATURE (^{0}C)	TEMPERATURE (^{0}C)	DEVIATION (^{0}C)	% DEVIATION	ADMISSIBLE YEARS	TEMPERATURE (^{O}C)
32.78	32.90	0.12	12%	1995	0.12
34.26	34.20	0.06	6%	1996	-0.06
33.88	34.00	0.12	12%	1997	0.12
30.00	30.12	0.12	12%	1998	0.12
29.05	30.00	0.95	95%	1999	0.95
28.87	28.80	0.07	7%	2000	-0.07
27.23	28.90	0.67	67%	2001	1.67
27.00	27.05	0.05	5%	2002	0.05
26.00	26.05	0.05	5%	2003	0.05
27.05	27.07	0.02	2%	2004	0.02
28.00	28.95	0.95	95%	2005	0.95
31.50	31.60	0.10	10%	2006	0.10
36.50	36.30	0.20	20%	2007	-0.20
25.80	26.10	0.30	30%	2008	0.30
29.30	29.40	0.10	10%	2009	0.10
33.70	33.60	0.10	10%	2010	-0.10
28.80	29.00	0.20	20%	2011	0.20
25.80	26.10	0.30	30%	2012	0.30
27.23	26.90	0.33	33%	2013	-0.33
24.25	24.70	0.45	45%	2014	0.45
25.27	25.80	0.53	53%	2015	0.53
23.29	23.90	0.61	61%	2016	0.61
22.10	22.80	0.70	70%	2017	0.70

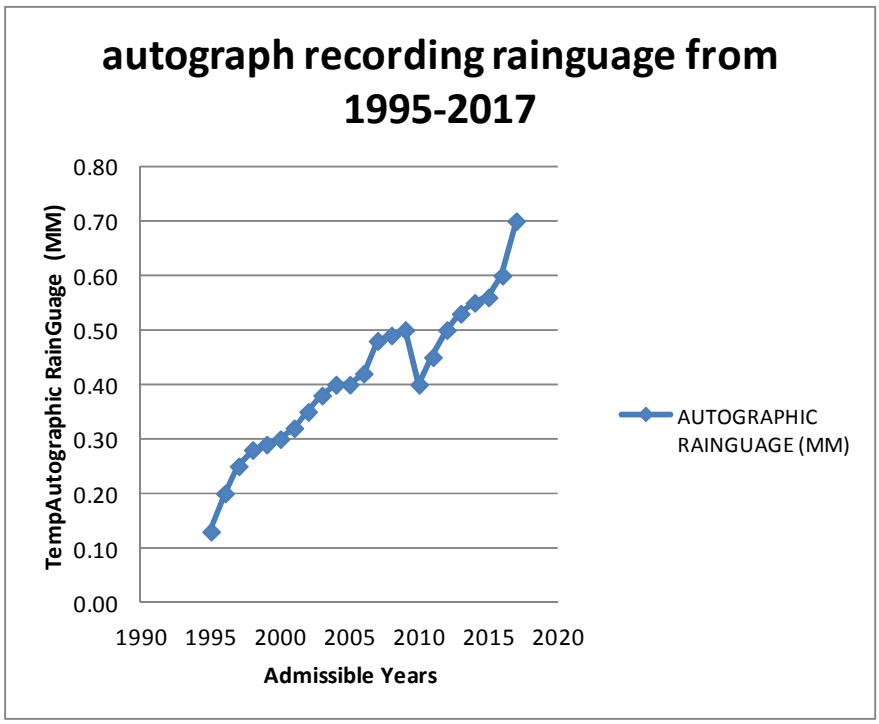


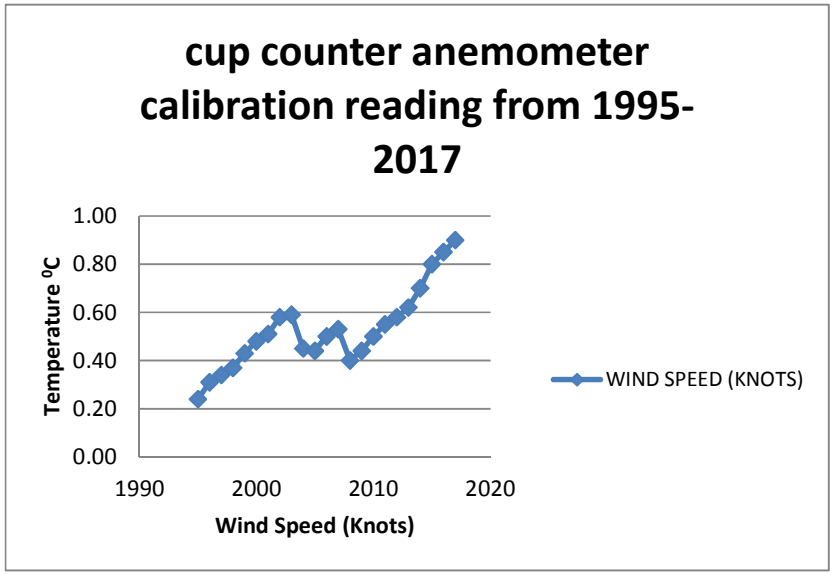

wet bulb thermometer calibration readings from the six geopolitical zone of nigeria from 1995-2017.
Temperature °C
Admissible Years
TEMPERATURE OC)


BAROMETRIC READING(HPA)
Barometric reading (HPA)
Admissible Years(1995-2017)
BAROMETRIC READING(HPA)


relative humility sesor calibration readings from the six geopolitical zone of nigeria from 1995-2017
Temperature °C
Admissible Years
TEMPERATURE (OC)


PITCH EVAPORIMETER(MM)
Pitch Evaporimeter (MM)
Admisible Years
PITCH EVAPORIMETER(MM)





From the findings of this study, the Automatic weather station sensors calibration readings from the six geopolitical zone of Nigeria from 1995-2017 depict a sharp continuous trend in Variation between 1995 and 2010.The mean standard deviation of the twenty three years with trend line equation Y=

-0.172x + 3.378.The sharp continuous trend in variation between the year 2005-2010 is noted and the trend shows climate variation on this meteorological instrument even up to the year 2017.it depicts that there is a great need for sustainability of the measurements.

2.0 PREVENTIVE AND CORRECTIVE MAINTENANCE WITH REPLACEMENT OF PARTS : A case study of University of Abuja Meteorological station, Abuja Nigeria

The trend line with Y= 0.04X + 3.32 shows an upward trend in variation of this meteorological AWSs as servicing, preventive and corrective maintenance with replacement of parts ,protection of the sensor against vandalism and suitable location depicts good sustainability standards for the measurement in 21st century.

Recommended Preventive Maintenance Schedule for Automatic Weather Observing system (Source: Coastal Environmental Systems,inc.,seattle Washington D.C).

2.1 Preventive Maintenance Procedures

Obstruction/Debris Inspection

Visually check all outdoor equipment for the following and correct as required.

a. Tree obstruction

b. Blow twigs, grass or plastic objects caught in the sensors

c. Spider webs, insect nests, bird nests e.t.c

b. Physical check

Physically check all outdoor equipments and correct as required

a. Lightning damage (Scorch marks)

b. Corrosion and Chemical deposits

c. Loose connection, tie wraps, grounding cable, or loose mountings.

d. Look for physical damage, abraded or frayed cable.

2.2 Scheduled Maintenance Intervals Summary (Days) for sustainability of the measurement.

EQUIPMENTS	GENERAL CLEANING	CORROSION CONTROL	FUNCTIONAL PERFORMANCE CHECK
Data Processing Unit (DPU)	84		
WIND SENSOR	84	84	84
CEILOMETER	84	84	84
RAIN GUAGE	84	84	84
PRESENT WEATHER DETECTOR	84	84	84
AT/RH SENSOR	84	84	84
THUNDERSTORM	84	84	84
VISIBILITY SENSOR	84	84	84
BAROMETER	84	84	84
FDCU	84	84	84
BAROMETER DESSICANT	84	84	84
FDCU BATTERY	84	84	84

Special tools and support Equipment and consumable items for sustainability of the measurement in 21st century.

Table 2.2.1 - Special Tools and Support Equipment

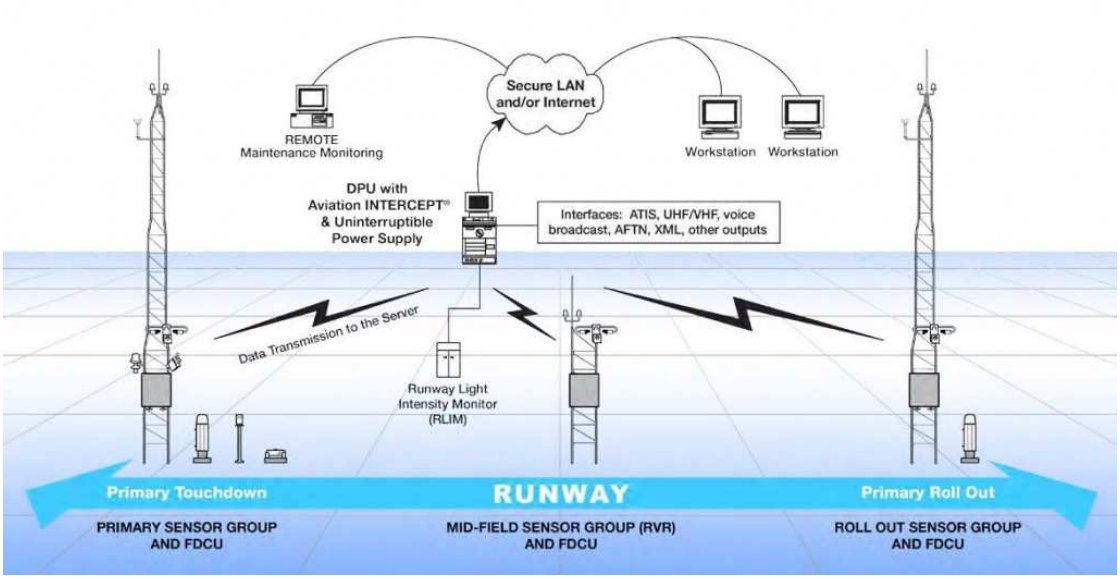
Items	Application	Type/model/part Number
1.Laptop with RS232 serial port and terminal program	Sensor Functional Tests	Dell Inspiron 1501 or comparable model
2.Cable,Serial,DB-9M to DB-9F	Sensor Functional Tests	Radio Shack 26-117B
3.Adapter,Serial to USB	Sensor Functional Tests	Radio Shack 26-117B
4.Sighting Compass	Wind Alignment	Suunto KB-14 or Equivalent
5.AT/RH Field reference	Temperature/Humidity Test	Vaisala HM70(M170 indicator and HM75b Probe) with carry case.
6.Barometer Pressure field reference	Barometer Test	CES p/n 2910000016
7.Gill Windsonic Packing Box	Wind Test	N/A
8.PWA11 Calibration Kit	PWD22/PWD20	Vaisala PWA11

Table 2.2.2 General Purpose Tools

Items	Application	Type/model/Part #
1.Phillips Screwdriver #2	Rain Guage Test	Any
2.Gloves (Skin Protection)	General Maintenance	Any
3.Goggles (eye Protection)	General Maintenance	Any
4.Snips	General Maintenance	Any
5.Digital Multimeter	FDCU Troubleshooting	Fluke 187 or equivalent
6.Metric hex wrench set	General Maintenance	Any
7.Standard Screwdriver	General Maintenance	Any

Table 2.2.3 Consumable items

Item	**Types/Model/Part Number**
1.Cloth,Cotton,Lint Free	Any
2.Alcohol,Isopropyl	Any
3.Detergent,mild	Any
4.Water	Any
5.Bag,Desiccant (Minimum 11/3oz)	ULINE p/n S-5163
6.Dessicant,Granule,indicating	IMPAK p/n 640AGO5
7.Cable Ties,14 in.,UV Res	TY527MX



3.0 To tackle sensor mobility issue , it encompasses development of personnel and training on the components of Automatic weather stations for its sustainability which is a panacea for achieving AWOs for environmental intelligence in 21st Century.

Sensor Functional Performance Checks required viewing sensor data on a laptop computer and thus briefly discuss laptop Terminal Emulator setup.

3.1 Laptop Terminal Emulator setup:

Support Equipment required are:Cable, DB-9F to DB-9M,Computer,Personal laptop with terminal emulation software (Such as Hyper-Terminal)

a. Connect Laptop to FDCU Maintenance port inside FDCU using DB-9F to DB –9M cable.With Laptop running Windows, select **Start,Program, Accessories, Communication, Hyper-Terminal**. The connection Description dialog box appears.

b. Type FDCU as the connection name, select any Icon and select **ok**.

c. To connect To dialog box appears. In connecting using the pull-down list, select Com 1,Com 2,Com 3or Com4(as approiprate) and select Ok

d.The **Com Properties** dialog opens,set port settings to **115200** bits per second, **8** data bits**, No parity 1 stop** bit.**No flow control** and select **ok.**

e.Press <enter>.

f. At the password prompt, type awos <enter>.

3.2 SUSTAINABILTY OF AWOS SENSOR

3.2.1 **CEILOMETER**: Support Equipment required for ceilometer are: Cable, DB-9F to DB-9M, Computer, Personal Laptop and Standard Screw driver.

a. Open ceilometer access cover and electronics housing door. Verify main power switch, ceilometer heater, Battery swiches are all in the ON position.

b. Connect Laptop to FDCU Maintenance port and at the prompt type chat cl131 <enter>.

c. Type OPEN to access the CL31 command prompt which will be “CEILO”

d. Type GET FAILURE STATUS at the CEILO> prompt

e. Verify all Alarms, Warnings and System fields read “OK”, and suspect module fields equals “None”.

f. Type CLOSE to exist out of the CEILO>Command prompt

g. Key <ctrl-a>q<enter>to exist out of sensor chart. At the prompt, type sum h<enter>.

h. Note values from CloudB1,CloudB2,and VertVis fields from the SSEM summary screen

i. wait 2-4 minutes ,type sum1<enter>,and the values should change if clouds are detected.

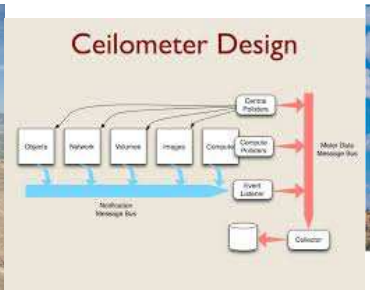
j. Turn to the ceilometer battery power switch, wait two minutes and verify the ceilometer battery failure message is present in the summary screen.

k. Turn on the ceilometer battery power switch, wait two minutes and verify the ceilometer battery failure no longer present.

l. Repeat steps k and l, substituting the main power switch for the battery power switch

m. Key <ctrl-c> to return to the SSEM prompt.

n. Close Ceilometer electronics housing door, close ceilometer front access door.



3.2.2 PRESENT WEATHER DETECTOR

For efficient sustainability of this measurements, Sensor support Equipment is required with cable, DB-9F to DB-9M, Computer, Personal Laptop,PWA11 calibration kit and standard screwdriver.

3.2.3 AIR TEMPERATURE (AT)/RELATIVE HUMIDITY (RH) SENSOR.

Support Equipment required is cable,DB-9F to DB-9M,computer,personal meter, Temperature/Humidity,standard screwdrivers.

a. Connect laptop to FDCU Maintenace port,and at the prompt,type sum1<enter>

b. Note air temperature field reading on Laptop

c. Set Temp/Humidity meter to read temperature

d. Position Temp/Humidity meter at mouth of AT/RH sensor shield assembly such that air drawn into aspirated shield is drawn across tep/Humidity meter.

e. Wait several minutes for Temp/Humidity meter is stabilize

f. Record temp/Humidity Meter and Laptop air temp field readings.

g. Wait 2 minutes and repeat f noting each reading for average of three trials and compare with average of laptop. Difference should not be less than 1.5oc which is a good sustainable standard.

3.2.4 RAIN GUAGE:

Support Equipment required are ,Cable, DB-9F to DB-9M,Computer,Personal laptop, Phillips Screw driver.

a. Connect Laptop to FDCU Maintenace port,and type sum1<enter>.

b. Record the value under rain accumulation as a start value. Do not use the rain accumulation (30s) Value.

c. Loosen three screws securing Rainguage cover to Rain guage base and remove cover from base.

d. Check bubble level in base for level mounting. If adjustment is required, adjust the leveling nuts under the base.

e. Tip the bucket once with your finger, wait about 5 seconds and tip it again with your finger. After approximate one minute, rain accumulation value should increase by 0.2mm (0.1mm per tip) from the start value.

g. Position the cover on the base and secure using the three screws.

3.2.5 WIND SENSOR

Support Equipment required are: Cable, DB-9F to DB -9M,Computer, Personal Laptop, Standard Screwdriver, Gill windsonic packaging Box.

a. Connect Laptop to FDCU Maintenance port, and at the prompt, type sum1<enter>.

b. Put the Gill Windsonic Packaging Box over the wind sensor

c. Wait 30 seconds before performing the text to ensure that the wind speed average has stabilized

d. Ensure that the resultant wind speed output is zero.

3.2.6 BAROMETER SENSOR

Support Equipment required is Cable,DB-9F to DB-9 M, Computer, Personal Laptop, Barometer ,Reference ,standard screwdriver.

a. Connect laptop to FCDU maintenance port and type sum 1<enter>

b. Turn Digital Barometer on and wait 5 minutes for Digital Barometer to stabilize

c. Note pressure indicated in barometer pressure field on laptop. The barometric pressure reading should be within 0.67hpa of Digital Barometer.

3.2.7 VISIBILITY SENSOR:

Cable,DB-9F to DB- 9M,Computer,Personal Laptop,PWA11 Calibration Kit and standard Screw driver.

PWD Functional Sustainabilty check: Clean the lenses accordingly and also the opaque glass plates if necessary.

a. Connect laptop to FDCU maintenace port per laptop terminal emulator procedures and at the prompt type chat visi< enter>

b. Place the blocking plate (with foam) in the receiver hood and wait for 30 seconds

c. Type open*<enter>.

Note:Window Cleaning procedure is very essential by moistening a soft ,lint – free cloth with isopropyl alcohol and wipe the lenses.Be careful not to scratch the lens surface.Check the hoods and lenses are free of condensed water,ice and snow deposits.Wipe the dust from the inner surfaces of the hoods.After the optical surfaces are properly cleaned,give the CLEAN command.

Check the Battery condition annually. Replace immediately if there is any sign of leaking electrolyte,ageing,white powder or corroded terminals

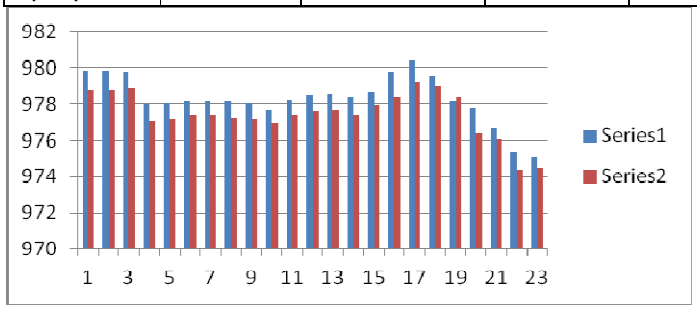
Sustain the FDCU by disconnecting the battery leads, turning off FDCU AC Power switch,opening its circuit breaker. At the bottom of the FDCU cabinent,inspect the pressure port assembly to ensure there is no foreign object or excessive moisture blocking the port opening.

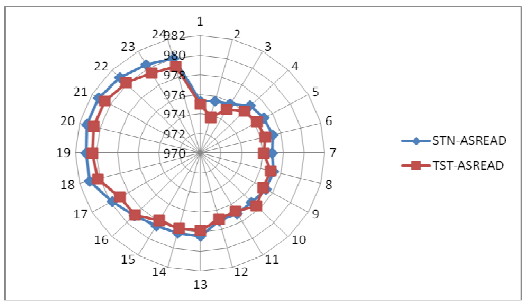
Purging Log Files: Go to start > My computer>D:\> Coastal Environmental Systems>AWOS 1.x.x (the current software version)>logs>data. The file folders inside are arranged by year, month and day. Delete all files that are older than one year.

4.0 Result of findings on a survey conducted on calibration, control assessment for traceable and non traceable quantities, environmental impact both dynamic and static sensors, operation of the AWSs in harsh environment region of Nigeria from 2012 – 2017 (A case study of Sokoto station Northwest Nigeria).

4.1. Comparism of Awos reading in harsh weather condition of Nigeria from 2012 -2013(A case study of Sokoto Station).

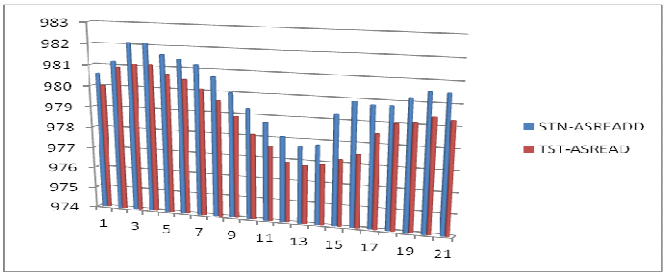
DATE	OBS-HOUR	STN-ASREAD	Attached	TST-ASREAD	**Error(stn-asread-tst-asread)**
9/1/2012	1700	975.3	26	975	26
9/2/2012	1800	975.5	26	973.8	26
9/1/2012	1900	975.8	25	975.1	25
9/4/2012	2000	976.8	23	976	23
9/5/2012	2100	977.1	24	976.3	24
9/6/2012	2200	977.2	24	976.5	24
9/7/2012	2300	976.9	24	976.1	24
9/8/2012	0000	977.3	23	977	23
9/9/2012	0100	977.3	23	977	23
9/10/2012	0200	977	27	977.6	27
9/11/2012	0300	977.1	26	976.8	26
9/12/2012	0400	977.1	25	976.9	25
9/1/2013	1500	978.4	28	977.8	29
9/2/2013	1600	978.4	26	977.9	26
9/3/2013	1700	978.5	24	977.9	24
9/4/2013	1800	979.0	24	978.9	24
9/5/2013	1900	979.8	24	978.9	24
9/6/2013	2000	981	24	980.2	24
9/7/2013	2100	981	22	980.4	22
9/8/2013	2200	981.3	24	980.6	24
9/9/2013	2300	981.3	24	980.6	24
9/10/2013	0000	980.9	24	980.1	24
9/11/2013	0100	980.4	23	979.4	23
9/12/2013	0200	980	23	979.1	23





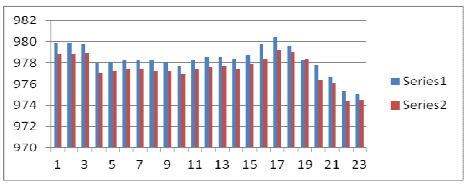
4.2 Comparison of AWOS Reading in Harsh /Extreme Weather Conditions in Nigeria 2014-2015(A case Portharcourt Met Station)

DATE	OBS-HOUR		Attached	TST-ASREAD	**Error(stn-asread-tst-asread)**
9/2/2014	0400	980.6	24	980	24
9/3/2014	0500	981.2	24	980.9	24
9/5/2014	0600	982.1	26	981.1	26
9/6/2014	0700	982.1	22	981.1	22
9/7/2014	0800	981.6	20	980.7	20
9/8/2014	0900	981.4	20	980.5	20
9/9/2014	1000	981.2	21	980.1	21
9/11/2014	1100	980.7	25	979.6	25
9/12/2014	1200	980	26	978.9	26
9/1/2015	1300	979.3	27	978.1	27
9/2/2015	1400	978.7	25	977.6	26
9/3/2015	1500	978.1	24	976.9	24
9/4/2015	1600	977.7	24	976.8	24
9/5/2015	1700	977.8	23	976.9	23
9/6/2015	1800	979.3	23	977.2	23
9/7/2015	1900	979.9	23	977.5	23
9/8/2015	2000	979.8	23	978.5	23
9/9/2015	2100	979.8	23	979	23
9/10/2015	2200	980.2	26	979.1	26
9/11/2015	2300	980.5	27	979.4	27
9/12/2015	0000	980.5	28	979.3	28



4.3 Comparision of AWOS Reading in Harsh / Extreme Weather Condition in Nigeria 2016-2017(A case study of Portharcourt met station.)

DATE	OBS-HOUR	STN-ASREAD	Attached	TST-ASREAD	**Error(stn-asread-tst-asread)**
9/1/2016	0100	979.9	25	978.8	25
9/2/2016	0200	979.9	27	978.8	27
9/3/2016	0300	979.8	27	978.9	27
9/4/2016	2000	978	27	977.1	27
9/5/2016	2100	978.1	27	977.2	27
9/6/2016	2200	978.2	28	977.4	28
9/7/2016	2300	978.2	27	977.4	27
9/8/2016	0000	978.2	27	977.3	27
9/9/2016	0100	978.1	27	977.2	27
9/10/2016	0200	977.7	27	977	27
9/11/2016	0300	978.3	27	977.4	27
9/12/2016	0400	978.5	27	977.6	27
9/1/2017	0500	978.6	27	977.7	27
9/2/2017	0600	978.4	27	977.4	27
9/3/2017	0700	978.7	27	977.9	27
9/4/2017	0800	979.8	27	978.4	27
9/5/2017	0900	980.4	27	979.2	27
9/6/2017	1000	979.6	27	979	28
9/7/2017	1100	978.2	27	978.4	27
9/8/2017	1200	977.8	28	976.4	28
9/9/2017	1300	976.7	27	976.1	27
9/10/2017	1400	975.3	28	974.39	28
9/11/2017	1500	975.1	28	974.5	28



Conclusion

The purpose of the paper is to share discussion and equally learn. The experiences obtained from this studys potrays the great need for sustainability of Automatic weather station .The extent of climate variability and impact of weather elements in Automatic Station installed in Nigeria can never be over emphazied.

Comparision of AWOS Reading in Harsh / Extreme Weather Condition in Nigeria 2012-2017(A case study of Sokoto, Portharcourt met station.with person statistical model of $Y = 0.04x + 3.32$ depict rising trends in variation of this metrological AWOS stationed in those harsh environment and thus, a great need its sustainability

The Automation process of this meterological instrument is a good step in the 21^{st} century,and thus WMO should look seriously into its sustainability.I hope my little contribution will help in policy making and setting of standards in ensuring possible mitigation in 21^{st} century.

Finally I would like to thank the world meteorological organization for its support and opportunity to share my experience. I sincerely appreciate the organizer of this technical conference in partnership with commission for instruments and methods of observations.