Proposed SAMOS on the *RV Apalachee*

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Introduction

In fall 2014, the Center for Ocean Atmospheric Prediction Studies (COAPS) at the Florida State University (FSU) proposed to purchase and install a automated meteorological instrument suite that would meet SAMOS accuracy requirements on the *RV Apalachee*.

- The *RV Apalachee* is a 65' vessel operated by the Coastal and Marine Laboratory at FSU.
- The proposed instrumentation will be interfaced with a PC running NOAA's Scientific Computer System data acquisition software.
- The instrument suite is representative of an automated weather system that is capable of providing observations at the sampling rates and accuracies desired by the SAMOS user community.
- The proposed system will provide FSU with an operational vessel on which new SAMOS data protocols can be developed and tested.

SAMOS Accuracy Targets

Draft accuracy, precision, and random error targets for SAMOS. Accuracy estimates are currently based on time scales for climate studies (i.e., 10 W/m2 for Q_{net}). Several targets are still to be determined. Drafted: Summer 2004.

Parameter	Accuracy of Mean (bias)	Data Precision	Random Error (uncertainty)
Latitude and Longitude	0.001'	0.001'	
Heading	2°	0.1°	
Course over ground	2°	0.1°	
Speed over ground	Larger of 2% or 0.2 m/s	0.1 m/s	Greater of 10% or 0.5 m/s
Speed over water	Larger of 2% or 0.2 m/s	0.1 m/s	Greater of 10% or 0.5 m/s
Wind direction	2°	1°	
Wind speed	Larger of 2% or 0.2 m/s	0.1 m/s	Greater of 10% or 0.5 m/s
Atmospheric Pressure	0.5 hPa	0.01 hPa	
Air Temperature	0.1°C	0.05°C	
Dewpoint Temperature	1.5°C	0.1°C	
Wet-bulb Temperature	1.5°C	0.1°C	
Relative Humidity	1%	0.5%	
Specific Humidity	0.15 g/kg	0.1 g/kg	
Precipitation	~0.4 mm/day	0.25 mm	
Radiation (SW in, LW in)	2-3 W/m2	1 W/m2	
Sea Temperature	0.1°C	0.05°C	

Other Suggested Sensors

- Wind Speed and Direction: Sonic – RM Young 85000 (2-D), 81000 (3-D), Mechanical – RM Young Marine Wind Monitor (05106)
- Air temperature and Humidity – Meeting T and RH targets is hard!
- Atmospheric Pressure – Paroscientific (very accurate, but expensive)
- Precipitation – Optical Rain Gauge (limited experience)
- SW and LW Radiation – Kipp & Zonen SMP3 Pyranometer, CGR4 Pyrgeometer
- PAR – Biospherical makes similar sensors

RV Apalachee Operations

For more information on the *RV Apalachee*, visit:
http://www.marinelab.fsu.edu/marineops/rvapalachee
Or contact:
Jon Schneiderman
Marine Operations Manager and Dive Safety Officer
850-697-2078
jschneiderman@fsu.edu

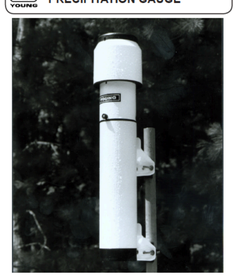
Acknowledgments

SAMOS is base funded by NOAA's Office of Climate Observation and the U. S. National Science Foundation's Oceanographic Instrumentation and Technical Services Program (grant #0917685). Starting in 2013, the Schmidt Ocean Institute (SOI) provided contract funding to recruit the RV Falkor to the SAMOS initiative. Additional contributions to this poster provided by NOAA/ESRL and NOAA/CIRES in Boulder, Colorado.

Proposed Instrumentation

Precipitation

MODEL 50202 PRECIPITATION GAUGE



PRECIPITATION GAUGE SPECIFICATION SUMMARY

Threshold: 1 mm (.04 in)

Accuracy: ± 1 mm (±.04 in)

Signal: 0 to 5.00 VDC = 0 to 50 mm precipitation

Chamber Drain Time: 30 seconds approx.

Power Requirement:
Measuring Circuit: 8 to 30 VDC unregulated
Heater: 48 Watts @ 28 VAC

Operating Temperature: -20°C to +50°C (-4°F to 122°F)

Dimensions:
Height: 65 cm (25.6 in)
Diameter: 14 cm (5.5 in)
Catchment Dia: 133 mm (4.4 in)
Catchment Area: 100 cm² (60.8 in²)

Mounting: U-bolts fit vertical pipe 25-50 mm (1-2 in) diameter.

Weight: 2.5 Kg (5.5 lb)

Shipping Weight: 4 Kg (9 lb)

INTRODUCTION

The Model 50202 Precipitation Gauge accurately measures rain or snow precipitation without moving parts.

Durable thermoplastic construction with no moving parts offers excellent corrosion resistance and long term reliability. Insulated housings and thermostatically controlled heaters permit operation at temperatures below freezing. Unique design with centrally located capacitive sensor is unaffected by unsteady conditions; making the instrument ideal for use on moving platforms such as buoys and ships. For extra security in extreme conditions, Model 50222, Heavy Duty Mounting Bracket is recommended.

Rain or snow collected in the catchment funnel is directed into the measuring chamber; 1mm of precipitation produces a 5mm rise in the chamber. Column level is sensed by a capacitive probe and converted to a linear voltage signal that can be read by external electronics. When the column level reaches a maximum of 250mm (50mm of precipitation), the chamber automatically empties and the process repeats. Total precipitation can be tracked by a datalogger or recorder.

Model 50203 is unheated.

THEORY OF OPERATION

Model 50202 Precipitation Gauge collects and measures precipitation. Unlike conventional tipping-bucket and weighing gauges the 50202 has no moving parts. Precipitation measurement is made with a capacitive transducer and electronic circuit that produces a calibrated voltage output. Standard output is 0 to 5.00 VDC for 0 to 50mm precipitation with an accuracy of ±1mm. The low power signal conditioning circuit requires 8 to 30 VDC at 3mA. Self contained thermostatically controlled heaters allow operation at temperatures as low as -20°C (-4°F). Collected snow is melted and measured as rainfall equivalent. The heaters operate from 28 volts AC at approximately 48 watts.

Precipitation is collected in a catchment funnel which has a cross sectional area of 100 cm². Captured precipitation drains from this funnel into a measuring tube which has a cross sectional area of 20cm². Since the area of the catchment funnel is 5 times that of the measuring tube, 1mm of captured precipitation produces a 5mm column of water in the measuring tube. A capacitive transducer in the center of the measuring tube senses the water column height. A self contained electronic circuit converts the capacitance value to a calibrated voltage output that is proportional to collected precipitation. Periodic interrogation by a data logging system allows computation of total precipitation and rate.

The full column height of the measuring tube is 250mm representing 50mm of collected precipitation. Additional precipitation starts a self siphon process which empties the measuring tube in approximately 30 seconds. The water column in the tube returns to a level representing 0mm of precipitation and the voltage output goes to 0 VDC. Additional precipitation begins filling the measuring tube again and the cycle is repeated. Evaporation of water remaining in the measuring tube is negligible between siphoning events.

LOCATION OF RAIN GAUGE

Precipitation measurement is greatly affected by location of the rain gauge. Select a location that is naturally protected from gusts and crosswinds. Avoid a site prone to contamination from debris such as falling leaves, dirt, etc...

Wind Speed and Direction

WindSonic™ GILL

Wind Speed & Direction Sensor

Key Features

- Wind Speed & Direction Sensor
- 0-60m/s (116 knots) Wind Speed
- 0-359º Wind Direction
- NMEA output
- Low Power consumption
- Fast start-up
- Solid-state – maintenance-free
- Corrosion Free

The Gill WindSonic is a low-cost anemometer, which utilises Gill's proven ultrasonic technology to provide wind speed and direction data via one serial or two analogue outputs. To confirm correct operation, outputs are transmitted together with an instrument status code.

With a robust, corrosion-free polycarbonate housing, this small, lightweight wind sensor is recommended for use in harsh environmental conditions and is particularly suited to marine & offshore (ships, data buoys) and land based installations. The WindSonic has no moving parts, offering maintenance-free operation in a wide range of applications.

WIND SPEED

Range	0 - 60 m/s (116 knots)
Accuracy	±2% @12 m/s
Resolution	0.01 m/s (0.02 knots)
Response Time	0.25 seconds
Threshold	0.01 m/s

DIRECTION

Range	0 - 359º (No dead band)
Accuracy	±2º @12 m/s
Resolution	1º
Response Time	0.25 seconds

MEASUREMENT

Ultrasonic Output Rate	0.25, 0.5, 1, 2 or 4 Hz
Parameters	Wind Speed & Direction or U and V (vector)
Units of Measure	m/s, knots, mph, kph, ft/min

OUTPUTS

Option 1	RS232
Option 2	RS232 + RS422 + RS485 + NMEA*
Option 3	RS232 + RS422 + RS485 + NMEA* 0-5 V or, 0-20mA or 4-20mA
Option 4	SDI-12 (refer to manual or separate data-sheet for technical specification)
Baud Rate	2400 to 38400
Anemometer Status	Supplied as part of standard message

*NMEA 0183
** Download software free from www.gill.co.uk

POWER REQUIREMENT

Anemometer	5-30VDC Option 1 & 2
	7-30VDC Option 3
	9-30VDC Option 4
Current Drain	Dependent on option selected e.g. < 2mA @ 12V (SDI-12) to 44mA @ 12V (4-20mA) Refer to manual for further advice
	Start up time < 5 seconds

MECHANICAL

External Construction	LURAN S KR 2861/1C ASA/PC
Size	142mm x 160mm
Weight	0.5kg

ENVIRONMENTAL

Protection Class	IP66
OperatingTemperature	-35°C to +70°C
Storage Temperature	-40°C to +80°C
Operating Humidity	< 5% to 100% RH
EMC	EN 61326: 1998

OPERATIONAL

MTBF	15 years
Warranty	2 years
Factory Calibration	Traceable to National Standards

ACCESSORIES

Pipe Mounting	44.45mm (1.75 in) diameter
Wind Software	Display / Logging**
Cables	Available to match output options
Display	See Gill Display datasheet

Air Temperature & Humidity

Technical Data Vaisalla HMP 60

Performance

RELATIVE HUMIDITY	
Measurement range	0 ... 100 %RH
Typical accuracy	
temperature range 0 ... 90 %RH	0 ... +40 °C ±3 %RH
90 ... 100 %RH	±5 %RH
temperature range 0 ... 90 %RH	-40 ... 0 °C, +40 ... +60 °C ±5 %RH
90 ... 100 %RH	±7 %RH
Humidity sensor	Vaisala INTERCAP®
TEMPERATURE	
Measurement range	-40 ... +60 °C
Accuracy over temperature range +10 ... +30 °C	±0.5 °C
-40 ... +10, +30 ... +60 °C	±0.6 °C
DEW POINT	
Measurement range	-40 ... +60 °C
Typical accuracy	
temperature range when dew point depression < 15 °C	0 ... +40 °C ±2 °C
temperature range when dew point depression < 10 °C	-40 ... 0 °C, +40 ... +60 °C ±3 °C
dew point depression = ambient temperature - dew point	
ANALOG OUTPUTS	
Accuracy at 20 °C	±0.2 % of FS
Temperature dependence	±0.01 % of FS/°C

Inputs and Outputs

Operating voltage (Use lowest available operating voltage to minimize heating.)	5 ... 28 VDC / 8 ... 28 VDC with 5 V output; 8 ... 28VDC with loop power converter
Current consumption	1 mA average, max. peak 5 mA
Start-up time	
probes with analog output	4 s at operating voltage; 13.5 ... 16.5 VDC; 2 s at other valid operating voltages
probes with digital output	1 s
Outputs	
2 channels	0 ... 1 VDC/0 ... 2.5 VDC / 0 ... 5 VDC/1 ... 5 VDC
1-channel loop-power converter (separate module, compatible with humidity accuracy only)	4 ... 20 mA
digital output (optional)	RS485 2-wire half duplex
External loads	
0 ... 1 V	R_L min 10 kΩ
0 ... 2.5 V /0 ... 5 V	R_L min 50 kΩ

Operating Environment

Operating temperature	-40 ... +60 °C
Electromagnetic compatibility	EN 61326-1: Electrical equipment for measurement, control and laboratory use – EMC requirements – for use in industrial locations.

Mechanics

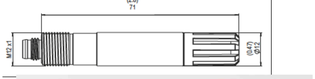
Materials	
body	stainless steel (AISI 316)
grid filter	chrome coated ABS plastic
cable	polyurethane or FEP
Housing classification	IP65
Body thread	M12x1 / 10 mm
Cable connector	4-pin M8 (IEC 60947-5-2)
Weight	
probe	17 g
probe with 0.3 m cable	28 g

Options and Accessories

Vaisala INTERCAP® Sensor, 1 piece	15778HM
Vaisala INTERCAP® Sensor, 10 pcs	INTERCAPSET-10PCS
Sensor protection	
plastic grid	DRW010522
membrane filter	DRW010525
stainless steel sintered filter	HM46670SP
4 ... 20mA loop power converter	UI-CONVERTER-1CB
Mounting bracket for converter	225079
Plastic M12 installation nuts, pair	18350SP
USB cable for PC connection	219690
Probe mounting clamp set, 10 pcs	226067
Probe mounting flange	226061
Connection cables	
0.3 m PU	HMP50Z032SP
3 m PU	HMP50Z300SP
180 °C 3 m FEP	226902SP

Dimensions

in mm (inches)



Atmospheric Radiation

- Shortwave (SPP) and Longwave Radiation (PIR) will be interfaced using an RMRCo RAD interface (http://www.rmrco.com/prod/rad/).
- Photosythetically Active Radiation (PAR) will be from a Licor quantum sensor.
- SAMOS plans to work with RMRCo to interface the PAR with the RAD.

Fig. 1. RV Apalachee ready for delivery from the ship yard.

Atmospheric Pressure

Model 278 Specifications

Performance Data

Pressure Range hPa/mb	500	600	800
Temperature @	Accuracy (hPa/mb)*		
20°C (+68°F)	±0.6	±0.5	±0.3
0 to 40 °C (+32° to +104°F)	±1.2	±1.0	±0.6
-20 to 50°C (-4° to +122°F)	±2.0	±1.5	±1
-40 to 60°C (-40° to +140°F)	±2.5	±2.0	±1.5
Non-Linearity	±0.5	±0.4	±0.25
Hysteresis	±0.06	±0.05	±0.03
Non-Repeatability	±0.04	±0.03	±0.02

Resolution 0.01 mb
Long Term Stability 0.1 mb/Yr
Warm-up down shift <1 sec. from Shut-Mode (Warm-up <0.1 mb maximum)
Response Time <100mSec
Proof Pressure 1500 hPa
Burst Pressure 2000 hPa

*The root sum squared (RSS) of end point non-linearity, hysteresis, non-repeatability, and calibration uncertainty.
**Units calibrated at nominal 70°F. Maximum thermal error computed from this datum.

Environmental Data

Temperature	
Operating	-40° to +60°C (-40°F to +140°F)
Storage	-60° to +120°C (-76°F to +248°F

Physical Description

Case	Stainless Steel and Polyester
Pressure Fitting	1/8" (ID dia.) Barbed Fitting
Electrical Connection	5-Pin Terminal Block
Dimensions	3.6"x 2.4"x 1.0"
Weight (approx.)	4.8 oz (135g)

Electrical Data

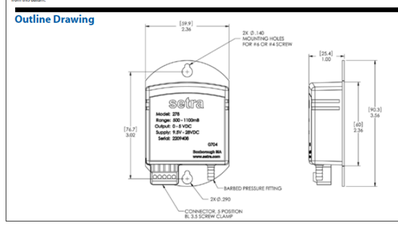
Electrical Circuit	3 or 4 Wire
Excitation**	9.5 to 28 VDC
Output***	0 to 2.5 VDC; 0 to 5 VDC
Output Impedance	<10 Ohms
Output Noise	<50 Microvolts
Current Consumption	3 mA Nominal (Operating Mode); 1 µA (Sleep Mode)

**Internal regulation minimizes effect of excitation variation, with <0.02 mb output change over 9.5 VDC to 28 VDC range...
*** Zero output saturates at about 20 mV

Pressure Media

Non-condensing air or gas.

Outline Drawing



Precipitation

STANDARD PRECISION PYRANOMETER

Model SPP

A pyranometer is used to measure the total energy from the sun. When leveled in the horizontal plane, this is called the Global Shortwave Irradiance (GLOBAL) and when positioned in a plane of a PV Array, it is called the Total Irradiance in the plane of array (TPA). Inverted, a pyranometer is used to measure the Reflected or Albedo Irradiance (ALBEDO). A pyranometer can also be shaded from the direct beam of the sun to measure the Diffuse Shortwave Irradiance (DIFFUSE).

Based on the design of the distinguished PSP Pyranometer, the new SPP has faster response time, a reduced nighttime thermal offset, an improved cosine response and a better temperature dependence. A thermistor is included for measuring instrument temperature.

There are two generally accepted Classification Systems used for Pyranometers. ISO classifies pyranometers as "Secondary Standards", "First Class" or "Second Class" while WMO uses "High Quality", "Good Quality" and "Moderate Quality". The SPP meets or exceeds the performance specifications of the ISO Secondary Standard (WMO High Quality Pyranometer) listed here.

SPECIFICATIONS (download .pdf copy)

ISO 9060 PYRANOMETER SPECIFICATIONS		ADDITIONAL SPECIFCATIONS	
Response Time	< 15 s	Sensitivity	approx. 8 µV / Wm-2
Zero Offset a)	± 7 Wm-2	Impedance	approx. 700 Ω
Zero Offset b)	± 2 Wm-2	Uncertainty*	
Non-Stability	± 0.8%	Calibration	less than 1%
Non-Linearity	± 0.5%	Measurement (Instant)	less than 10 Wm-2
Directional Response	± 10 Wm-2	Measurement (Hourly)	approx. 2%
Spectral Selectivity	± 3%	Measurement (Daily)	approx. 1%
Temperature Response	± 2%		
Traceability*	World Radiation Reference (WRR)	Application:	Working Standard or Network Measurements
Classification:	SECONDARY STANDARD / HIGH QUALITY		

* Recently, there has been much discussion on "uncertainty" and how it pertains to solar measurements. The RSS of the 9060 Secondary Standard specifications results in an uncertainty of approximately 3.5%. The typical uncertainty of Eppley's factory calibrations are less than 1%. The stated uncertainty of the WRR is 0.4%. Evidence from comparisons of PSP measurements to component sum derived values (using an AHF and B-48) show the PSP is capable of hourly averages better than 2% and daily averages better than 1%.

PRECISION INFRARED RADIOMETER

Model PIR

The Precision Infrared Radiometer, Pyrgeometer, is intended for unidirectional operation in the measurement, separately, of incoming or outgoing terrestrial radiation as distinct from net long-wave flux. The PIR comprises a circular multi-junction wire-wound Eppley thermopile which has the ability to withstand severe mechanical vibration and shock. Its receiver is coated with Parson's black lacquer (non-wavelength selective absorption). Temperature compensation of detector response is incorporated. Radiation emitted by the detector in its corresponding orientation is automatically compensated, eliminating that portion of the signal. A battery voltage, precisely controlled by a thermistor which senses detector temperature continuously, is introduced into the principle electrical circuit.

Isolation of long-wave radiation from solar short-wave radiation in daytime is accomplished by using a silicone dome. The inner surface of this hemisphere has a vacuum-deposited interference filter with a transmission range of approximately 3.5 to 50 µm.

SPECIFICATIONS

- Sensitivity: approx. 4 µV/Wm-2.
- Impedance: approx. 700 Ohms.
- Temperature Dependence: ±1% over ambient temperature range -20 to +40°C.
- Linearity: ±1% from 0 to 700 Wm-2.
- Response time: 2 seconds (1/e signal).
- Cosine: better than 5%.
- Mechanical Vibration: tested up to 20 g's without damage.
- Calibration: blackbody reference.
- Size: 5.75 inch diameter, 3.5 inches high.
- Weight: 7 pounds.
- Orientation: Performance is not affected by orientation or tilt.

LI190SB QUANTUM SENSOR

1. GENERAL

This manual provides information for interfacing a CR10(X), CR500, 21X, and CR7 datalogger to a LI190SB Quantum Sensor. An instruction manual provided by LI-COR contains the sensor calibration constant and serial number. Cross check this serial number against the serial number on your LI190SB to ensure that the given calibration constant corresponds to your sensor.

2. SPECIFICATIONS

Stability:	<±2% change over a 1 year period
Response Time:	10 µs
Temperature Dependence:	0.15% per °C maximum
Cosine Correction:	Cosine corrected up to 80° angle of incidence
Operating Temperature:	-40 to 65°C
Relative Humidity:	0 to 100%
Detector:	High stability silicon photovoltaic detector (blue enhanced)
Sensor Housing:	Weatherproof anodized aluminum case with acrylic diffuser and stainless steel hardware
Size:	0.94" dia x 1.00" H (2.38 x 2.54 cm);
Weight:	1 oz. (28 g)
Calibration:	±5% traceable to the U.S. National Institute of Standards Technology (NIST)
Sensitivity:	Typically 5 µA per 1000 µmoles $s^{-1}m^{-2}$
Linearity:	Maximum deviation of 1% up to 10,000 µmoles $s^{-1}m^{-2}$
Shunt Resistor:	604 ohms
Light Spectrum Waveband:	400 to 700 nm

NOTE: The black outer jacket of the cable is Santoprene® rubber. This compound was chosen for its resistance to temperature extremes, moisture, and UV degradation. However, this jacket will support combustion in air. It is rated as slow burning when tested according to U.L. 94 H.B. and will pass FMVSS302. Local fire codes may preclude its use inside buildings.

Instrumentation Costs

The estimated cost of the proposed sensor suite (without redundancy) in U. S. dollars is $14,450.

- Rain Gauge – $1,100
- Sonic Anemometer – $1,500
- Thermometer/Hygrometer w/ shield – $500
- Barometer w/ Gill port – $700
- RAD (including SPP and PiR) - $10,000
- PAR – $650

RM Young 61002