The MetOcean HRSST sensor and its implementation

Introduction

- HRSST Requirements from drifters
- How is SST measured?
- MetOcean Solution
- Calibration validation
- Results
- Conclusions

metocean telematics

- Engineering and manufacturing company located in Nova Scotia
- Iridium VAM and VAR
- 60+ employees
- ISO 9000 Quality Management system

MetOcean HRSST History

Time frame	Event	Incremental Cost
1995 – 2010	All sensors were +/- 0.1° K	--
2010 – 2011	Added a 0.05° K thermistor for the HRSST pilot project	$10
2011 – 2013	Designed digital thermometer	$600+
2014 to present	Use a 5-point calibration	$50

DBCP Pilot Project for HRSST

Requirements:

- Hourly Measurements and Transmissions
- Sensor located +/- 5 cm in calm water
- Report geographical location to +/- 500 meters
- Report SST accuracy to +/- 0.05° K (or better), with a resolution of 0.01° K
- Report the time of SST measurements to +/- 5 minutes

Background

A thermistor is a type of resistor whose resistance varies significantly with temperature. Assuming, as a first-order approximation, that the relationship between resistance and temperature is linear, then:

$$\Delta R = k\Delta T$$

where

ΔR = change in resistance

ΔT = change in temperature

k = first-order temperature coefficient of resistance

But in practice this linear approximation works only over a small temperature range. So, the resistance curve of a device must be described in more detail:

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Background

The Steinhart-Hart equation is a widely used third-order approximation:

$$\frac{1}{T} = a + b\,\ln(R) + c\,\ln^3(R)$$

Rearranging and solving this equation for T, we can apply the 3 coefficients (sample of 3 KΩ thermistor at 25 degrees C). The error in this equation is typically less than 20 millidegrees K.

$$a = 1.40 \times 10^{-3} \quad b = 2.37 \times 10^{-4} \quad c = 9.90 \times 10^{-8}$$

These are then entered in the circuit card ROM and the calibration applied. This allows the calibration to remain with the sensor and not the buoy and allows for recalibration if the buoys are recovered.

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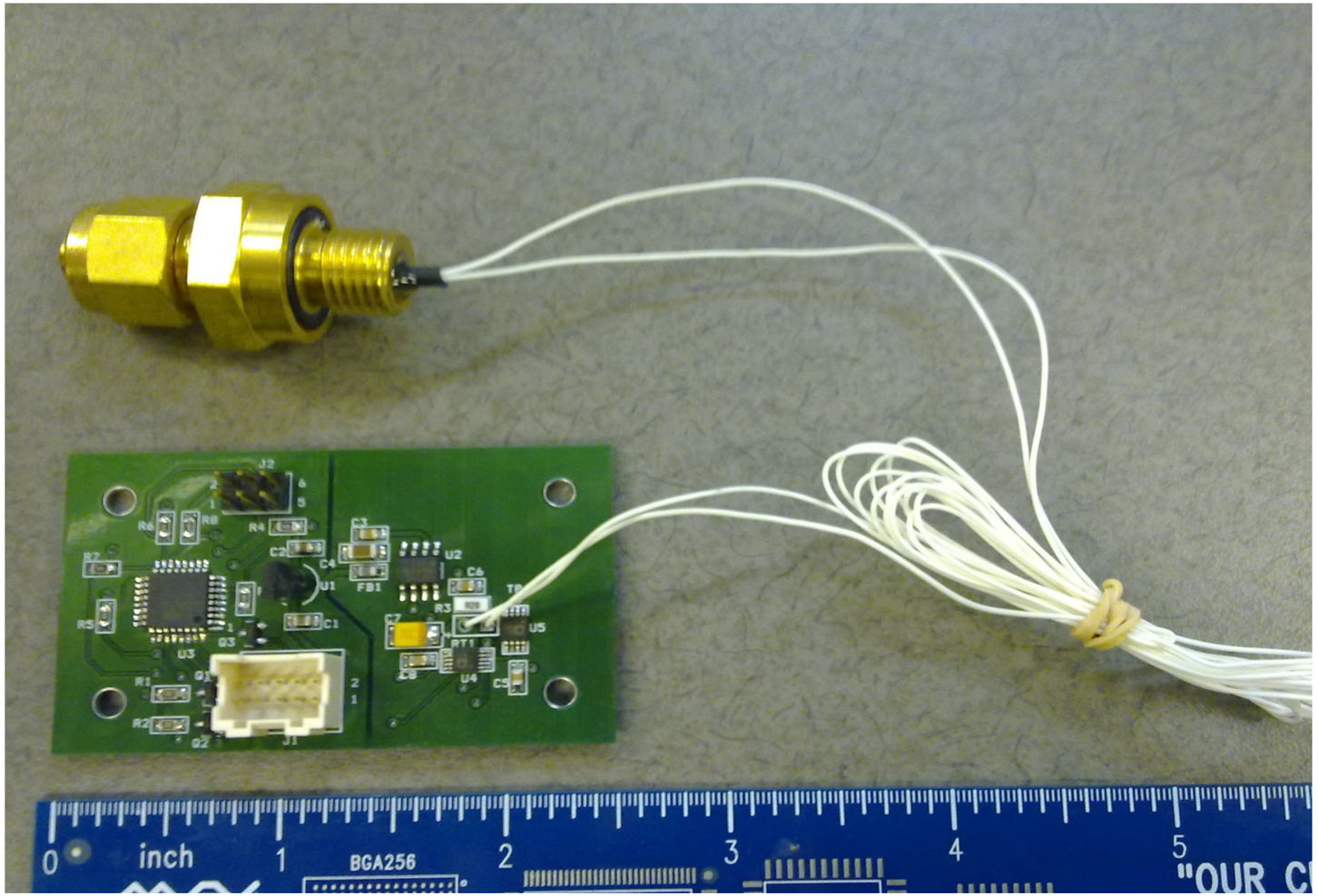
MetOcean HRSST module



Certificate of Calibration

measurement SPECIALTIES

Certificate of Calibration

Instrument : High Precision Temperature Sensor

Serial Number : 10020

Manufacturer : Measurement Specialties

Calibration Date : January 16, 2012

Thermistor assembly manufactured by MetOcean DataSystems was shipped to Measurement Specialties for calibration to assure measurement accuracy of ±0.05°C from 0°C to 40°C. The sensor incorporates the Measurement Specialties 55032 GEM thermistor, potted into a Swagelok style housing with 28AWG Teflon insulated lead wire, approximately 50cm in length. The thermistor assembly was connected to a sensor controller board, powered by the TTL to RS-232 converter via a 9V battery. Controller board calibration and testing was performed using a TTL to RS-232 converter connected to a laptop computer. Logging of data was performed via uConn terminal emulation software. System set-up, thermistor characterization and calibration were performed per MetOcean Data Systems Document #TD-11-043.

The thermistor assembly was calibrated using measurement data at 0.007°C, 25°C and 40°C. Measurement data was collected using temperature standards traceable to NIST. The sensor was powered for a minimum of one minute, followed by repeated measurements for another minute. The resistance values were averaged and entered into a Steinhart-Hart spreadsheet to derive thermistor coefficients. Next, the coefficients were entered into the sensor's controller board and were re-measured to confirm the measurement was within ±0.05°C at 0.007°C, 25°C and 40°C.

Measurement Specialties certifies that at the time of calibration and measurement, using the measurement process described above, the sensor measured within ±0.05°C of actual bath temperature.

Steinhart-Hart Values	Reference Bath Temperature (°C)	Measured Temperature (°C)	Difference (°C)
A=0.000914277	0.007	-0.0137	0.020
B=0.000224055	25	24.98	0.020
C=0.000000120	40	39.981	0.019

Phil Metz

Chief Metrologist

Measurement Specialties, Dayton OH

DATE: 01/17/2011

Measurement Specialties
Temperature Products Group

2670 Indian Ripple Road
Dayton, Ohio 45440-3605
USA

937 427-1231 937 427-1640 fax
www.meas-spec.com

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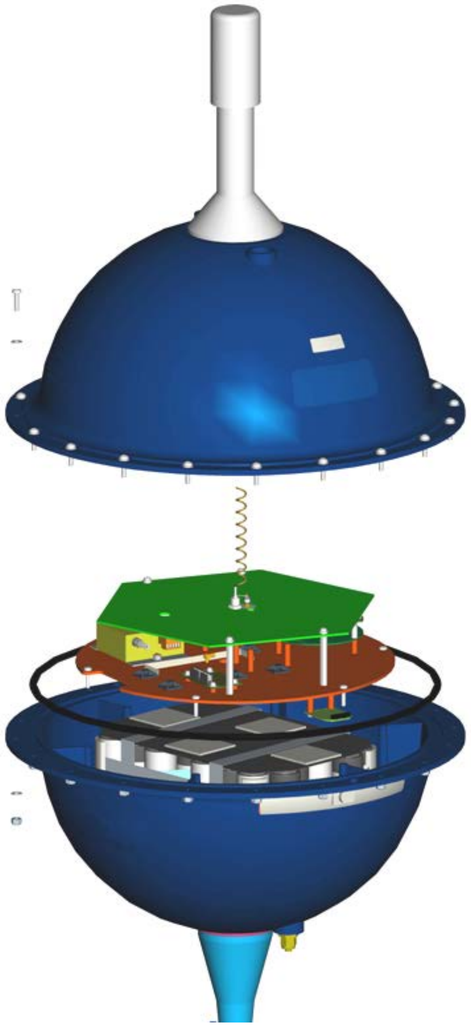
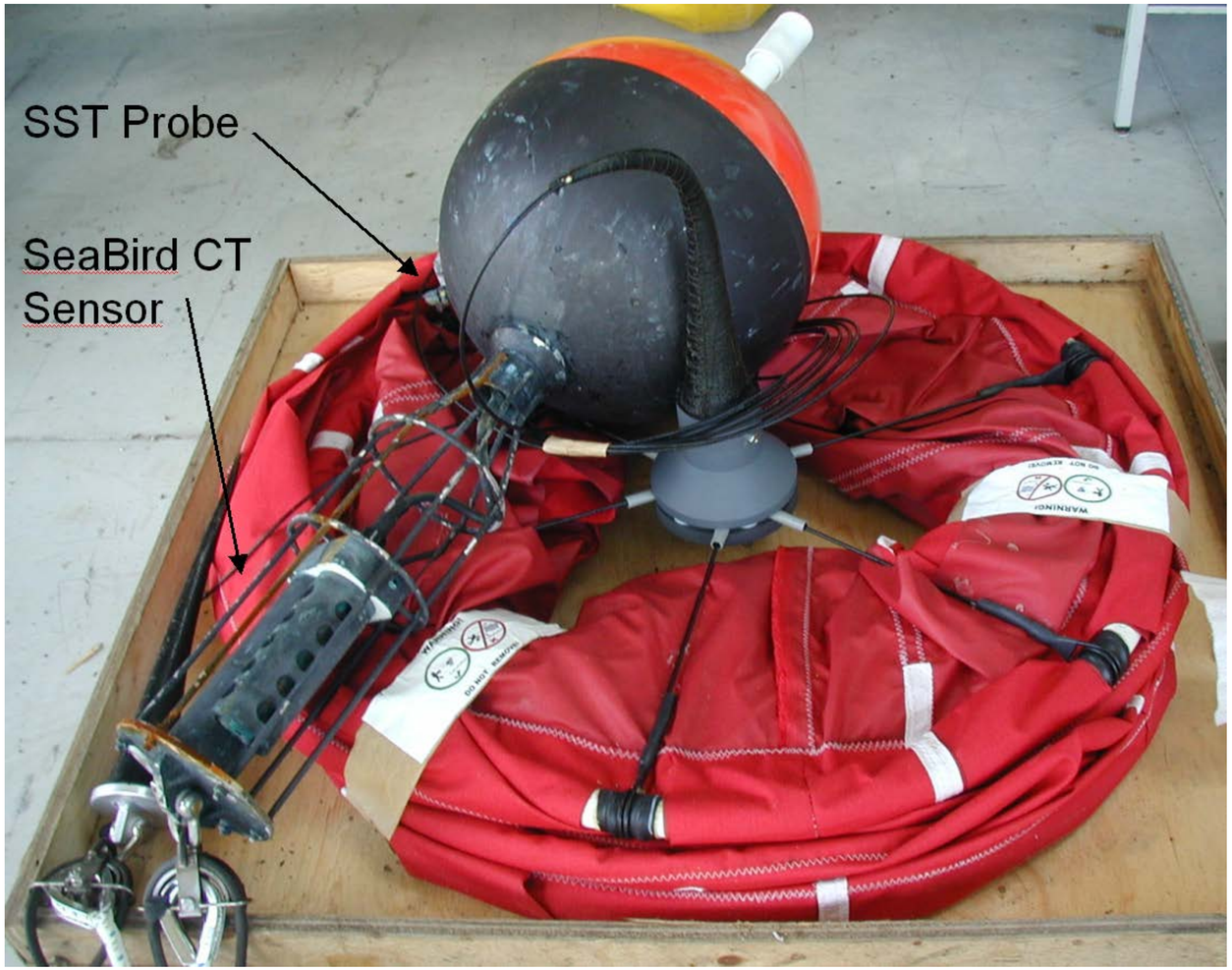
iSVP



iSVP/BP

How to prove that HRSST really works?

- Co-located sensor comparison
- SVP-CT buoys have two thermistors
- 15 buoys were compared



HRSST-2 Salinity Drifters

IMEI	WMO	Month	N	Bias	Sd
11977530	1300899	Aug-2013	211	-0.052	0.005
60446020	2300587	Aug-2013	217	-0.027	0.005
60476190	2300588	Aug-2013	141	-0.051	0.005
11544080	3100739	Dec-2012	217	-0.043	0.005
11544080	3100739	Mar-2013	101	-0.046	0.005
11976470	3100740	Dec-2012	98	-0.008	0.005
11129760	4100736	May-2012	162	-0.007	0.005
11129760	4100736	Oct-2012	333	-0.008	0.006
11589510	6100524	Mar-2013	208	-0.003	0.004
11583510	6100525	Mar-2013	200	-0.035	0.010
11549070	6100530	Mar-2013	184	0.000	0.013
11547080	6100788	Oct-2012	302	-0.043	0.008
11540090	6200501	Oct-2012	63	-0.046	0.008
11972540	6200504	Aug-2013	92	-0.059	0.006
11120780	6200505	May-2012	159	-0.018	0.004
11120780	6200505	Oct-2012	326	-0.023	0.006
11120780	6200505	Mar-2013	213	-0.019	0.004
60343390	6200509	Aug-2013	205	-0.058	0.005
11127760	6200513	May-2012	154	-0.112	0.004
11127760	6200513	Oct-2012	327	-0.103	0.005

Standard deviations < 0.015K

Mean differences up to 0.06K for all buoys but one (i.e. ~ the claimed accuracy)

- All slightly negative
- Constant for a given buoy

Slide from Pierre Blouch, « Capacity of HRSST-2 buoys to measure SST with a high degree of accuracy », presented at DBCP 29, Paris, 2013

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Toujours un temps d'avance

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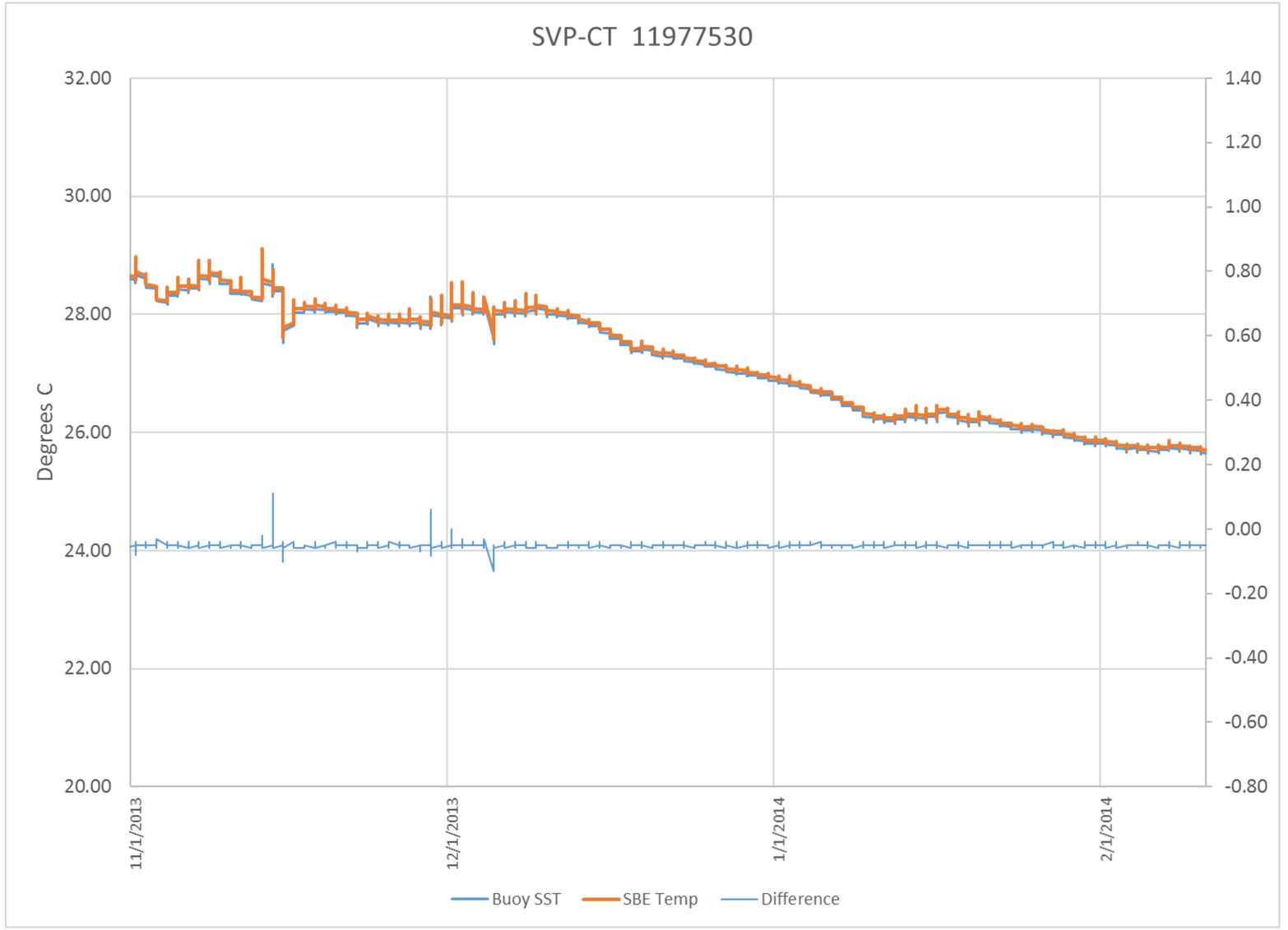
Sample Data


SVP-CT 11977530
32.00
30.00
28.00
26.00
24.00
22.00
20.00
Degrees C
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
11/1/2013
12/1/2013
1/1/2014
2/1/2014
Buoy SST
SBE Temp
Difference

Conclusions

- Digital thermometers can be implemented, but cost is a factor.
- A 5-point calibration is sufficient when properly done.
- System uncertainties tend to override sensor uncertainties.

Questions?

MetOcean Data Systems
21 Thornhill Drive, Dartmouth
Nova Scotia, Canada
B3B 1R9

USA: 1 844 728 2869
Canada: 1 902 468 2505
sales@metocean.com
www.metocean.com