Comparison of Various Methods of Temperature Measurements

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Introduction

Accurate Sea Surface Temperature (SST) measurements are important in order to accurately initiate and run a number of meteorological and oceanographic models. SST is easily defined as the temperature of the surface of the sea but that is where the ease in understanding this parameter stops. Measuring SST is difficult. Different measurement techniques result in measuring different parameters.

Purpose

The purpose of this discussion will be to study and compare data acquisition techniques for two of these parameters: “Skin Temperature and SST. The “skin temperature” is a measure of the top 1-2 mm of the surface. The SST for this discussion will be the top 1-5 meters of the water column.

Methods of data collection

I. “Bucket Temperatures”. This is perhaps the oldest method of measuring the SST. The procedure calls for lowering a mercury thermometer enclosed in a PVC pipe overboard at the top of every hour. The thermometer is then allowed to stabilize whereby it is removed from the water and a reading is taken. This method takes a reading of the surface temperature between 1 and 2 meters.

A. Sources of error:

1. A person is required to manually lower the sensor and retrieve it from the ocean. This allowed errors due to the non standard time the thermometer spent in the water and the fact that from the time it left the water and it was read, the temperatures changed. This also introduced an error associated with the location of the measurement in relation to the ship.

2. Thermometer used had divisions of 2 degrees making interpolation inconsistent among data collectors.

B. Recommendations:

1. Mount a thermistor in a “bucket” that is permanently (for the cruise) off the side of the ship. This will allow it to be immersed throughout readings and give a

more standard location of measurement for comparison purposes. The device could even be set up to read automatically

2. Use of a thermistor capable of reading to an accuracy of .001 degrees would eliminate the need to interpolate between 2 degrees.

3. Utilize the boom mounted "skin" temperature device as yet another reading.

II. "Along Track System". This was an automated data collection method. Temperatures of the ships intake were taken every 52 to 56 seconds. In order to compare with the hourly hand held IR gun and the "bucket" temperatures, an average hourly reading was computed. This was accomplished by averaging the readings for 5 minutes prior to and 5 minutes after the hour. See figures 1 and 2. This method measures temperature between 1 and 5 meters of the surface.

A. Sources of error:

1. The exact depth of the reading is undetermined due to pitch and roll of the ship

2. The distance ocean water traveled within the ship prior to be read affected the temperature reading,

B. Recommendations: Since the system is hard wired to the ship, no recommendations given just be aware of these.

III. Hand Held IR Gun. The procedure called for a human observer to take a measurement every hour. A hand held IR gun was to be directed at a 45-degree angle at the surface of the undisturbed water off the bow. Immediately, a reading of the sky temperature was to be taken in order to eliminate atmospheric effects from the temperature. Then utilizing the following formula, the "skin" temperature was found.

$\varepsilon_{air} = 0.98$

$\varepsilon_{water} = 1.0$

$$T_{meas}^4 = \varepsilon_{water} T_{water}^4 + (1-\varepsilon_{air}) T_{air}^4$$

$$T_{water} \cong \sqrt[4]{\frac{T_m^4 - (1-\varepsilon) T_{air}^4}{\varepsilon}}$$

A. Sources of error:

1. Due to the roughness of the seas, measurements were not always taken of the undisturbed water.

2. Times of the measurements were not precisely every hour but the were documented on an hourly log.

B. Recommendations:

1. Take measurements both in and out of the ship's wake to compare the undisturbed with the disturbed water. Also, better inform the data takers as to the importance of making the measurements in each of these areas.

2. Use of the ship's mounted IR instrument would also provide a more standard reading as well as provide another measurement for comparison.

3. Record the exact times of the measurements.

IV. CTD Temperatures at the surface: CTD's were taken at various locations throughout the cruise. As an afterthought, the data from the CTD was used in this study. The first measurement from each CTD cast was recorded as the surface temperature at that location and time. This method measured the temperature within the first 5 meters of the water column.

A. Sources of error:

1. Only the first reading was taken with no regard as to weather the instrument had stabilized or as to weather the first reading was actually at the surface.

B. Recommendations

1. Look more closely at the readings to determine if the temperature was stabilized and at the surface

2. Average the first few readings as long as they are truly at the surface.

V. NOAA 12 and NOAA 16 satellites: These satellites are equipped with the Advanced Very High Resolution Radiometer (AVHRR), which scans the surface with a nadir resolution of 1.1 km. The techniques for estimating sea surface temperature are based on the physics of blackbody radiation. Solutions are also required to practical problems such as correcting for the effects of the intervening atmosphere, identifying cloud-free regions, and

navigating the measurements to ground coordinates. All this is done through complicated algorithms. AVHRR images were received approximately every 6 to 12 hours. These images were run through the algorithm to arrive at the Mean Sea Surface Temperature (MSST). This MSST is more closely thought of as a “skin’ temperature. These images were then compared to the track of the Pt. Sur.

A. Difficulties:

1. Since all the radiation comes from the top "skin" of the ocean, approximately the top 1 mm or less, it may not represent the bulk temperature of the upper meter of ocean. This makes it difficult to compare to measurements from shipboard methods, making comparisons to the Along Track and Bucket methods more difficult.

2. Satellites cannot look through clouds, creating a "fair weather bias" in the long-term trends of SST.

3. Leg 1 was very cloud. As such, collocating ships track with “good” satellite data was very tough.

B. This portion of the study had the least operator control. As such, the only recommendation is to stay flexible and hope for clear weather.

Conclusions

I. Correlations were calculated between various measurements.

	Leg 1	Leg 2
Intake to Hand Held Gun	0.4781	0.5431
Hand Held gun to AVHRR	0.4901	0.5420
Bucket to Ship Intake	0.6083	0.7763
AVHRR to Bucket	- 0.5116	0.4464
CTD to Ship Intake	0.9986	

II. See the attached graphics for the comparison discussion to see the charts and graphics.

III. The next study should incorporate as many of the aforementioned recommendations as possible.

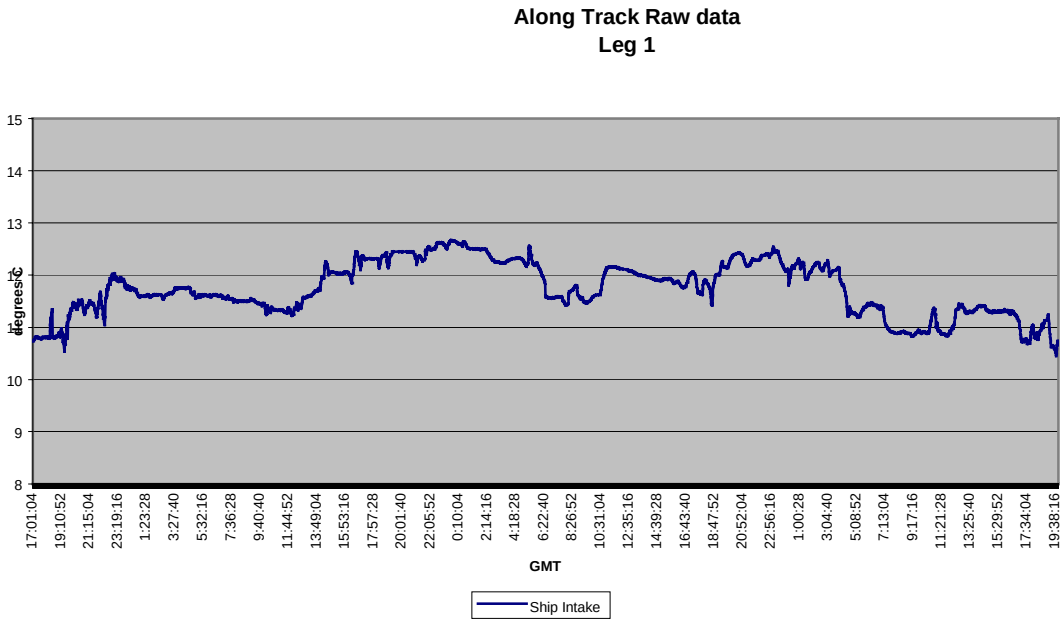

Figure 1

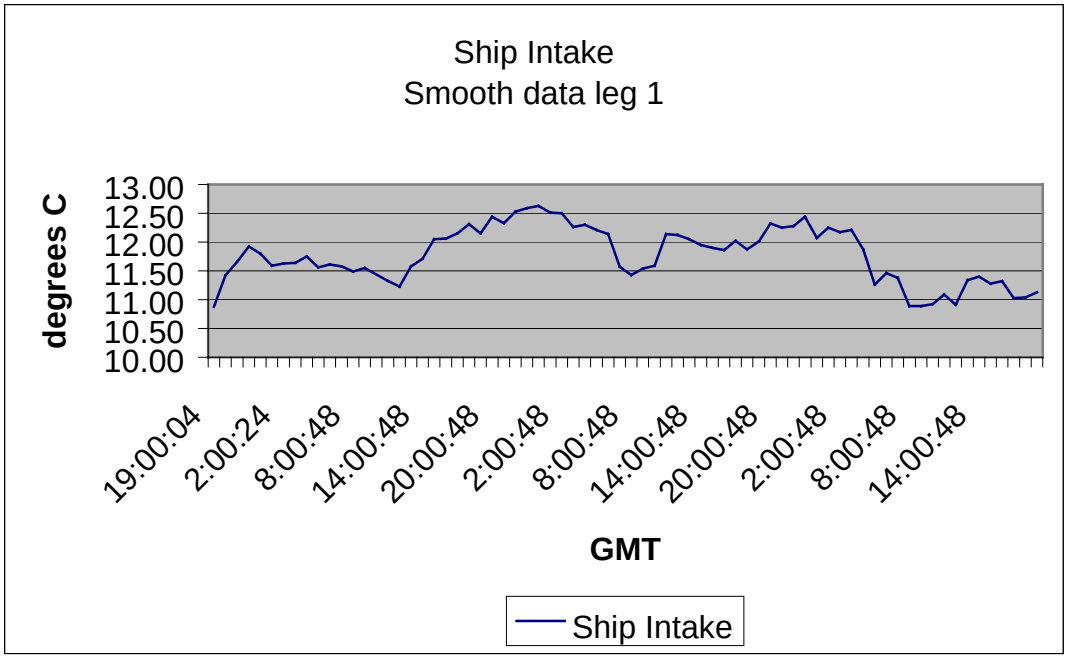

Figure 2