

Short Communication

Temperature error in digital bathythermograph data

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Received 4 October 2002, revised 3 June 2003

Simultaneous Digital Bathythermograph (DBT) and Nansen Cast data collected during two cruises of *R.V. Gaveshani* (GV-117 and GV-118) and archived in Indian Oceanographic Data Centre (IODC) are used to determine existing temperature errors in DBT. The resulting mean error for DBT data from the GV-117 cruise varies from -0.5 to -1 °C, while it varied between -0.3 and -0.6 °C for data from cruise GV-118. For both the data sets, the error shows consistently negative bias from surface to 800 m depth, however there is no apparent or measurable systematic dependence of the error on depth. Considering the given temperature accuracy of 0.05 °C, the observed DBT error, varying from -0.3 to -1 °C, is significant and such offsets should be removed from DBT archives. It is found that a corrective measure of +0.5 °C, equivalent to the mean surface offset obtained from two cruises, can considerably reduce the temperature error at all DBT depths.

[**Key words:** Digital bathythermograph, Indian Ocean, temperature error, systematic bias]

Digital bathythermograph (DBT) records¹ seawater temperature versus depth with a temperature accuracy of 0.05 °C. DBT has depth sensor and it is likely to have better depth accuracy compared to the Expendable bathythermograph (XBT)², which doesn't have a depth sensor and depth of the probe is derived from its fall rate. Though not in use at present, DBT was widely used in the 1980s mainly by oceanographic community in the Pacific Rim. Under the National Oceanographic Program (NOP) DBT data were collected and archived in Indian Oceanographic Data Centre (IODC). Table 1 shows the known estimate of the global DBT archive^{3,4}.

Peshwe & Desa⁵, in an investigation to validate Electronic Bathythermograph (EBT), compared the EBT temperature with temperatures from DBT, XBT, hydrographic profiles (Nansen Cast) and bucket thermometer. In their comparative study, DBT surface temperature has been found to be lower than surface temperature from bucket thermometer, Nansen Cast and XBT. In present study, we examine the existence of offsets in DBT temperature, not only at the surface but also in deeper layers. For this purpose, simultaneous observations of Nansen cast and DBT data have been selected from the IODC data archive.

Simultaneous DBT and Nansen Cast data collected during two cruises of *R.V. Gaveshani* (GV-117 cruise around Gulf of Mannar during 18 March to 9 April 1983 and GV-118 cruise in the Northern Arabian Sea during 17 April to 5 May 1983) and archived in the Indian Oceanographic Data Centre (IODC) are used

for this study. The DBT data are available at 1 m depth intervals, Nansen cast data is limited at standard depths and bucket samples are surface measurements. Nansen cast data from the archive are corrected for wire angle error and the quality is compared with the T-S diagram of the composite hydrocast stations. Vertical profiles of DBT and Nansen data are plotted for checking profile-to-profile consistency and any profile showing unrealistic features are not considered for the present error analysis.

In order to check the temperature offset in DBT surface temperature, DBT-surface temperature is plotted along with the surface temperature from bucket thermometer, collected from the same station (Fig. 1). DBT surface temperatures (DBT-SST) are lower than the bucket-temperature and the mean SST-offset is -0.5 °C. The bucket temperature data used here is not having any systematic bias. Figure 2 gives the scatter plot of surface temperature (bucket thermometer) and Nansen cast data from the same stations. There is no obvious bias in bucket temperature and leads to the conclusion that the offset in Fig. 1 is caused by DBT data.

Table 1— Known global estimate of DBT stations

Agency	No. of stations
US National Oceanographic Data Center (US-NODC)	63,866
Indian Oceanographic Data Centre	267
Japan Oceanographic Data Centre (JODC)	17,305

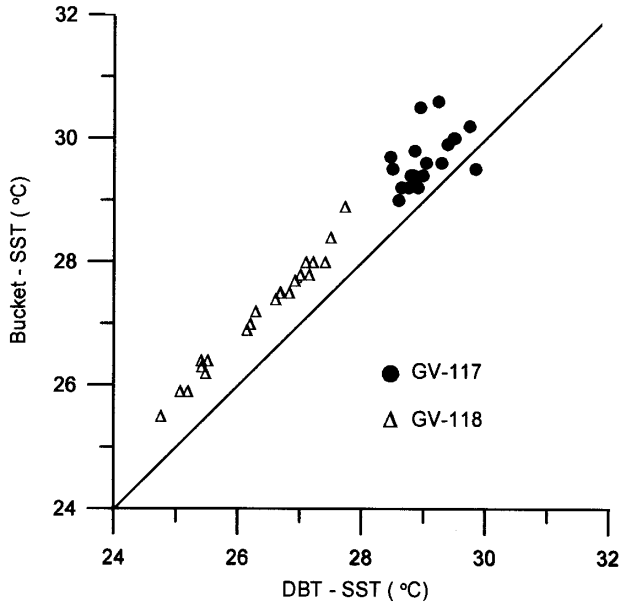


Fig. 1—Scatter plot of bucket versus DBT-surface temperature.

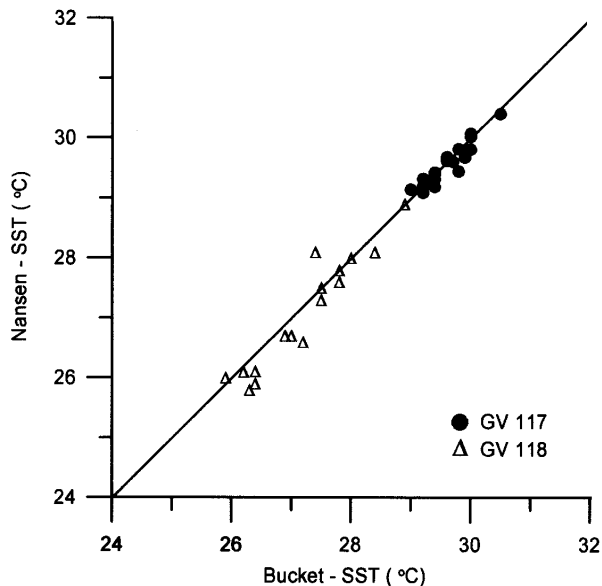


Fig. 2—Scatter plot of bucket versus Nansen-surface temperature.

Mean difference between DBT and Nansen temperature (here after referred to 'error') from surface to 800 m depth and for the two cruises is given in Fig. 3. Error bars are provided for one standard deviation. While the mean error curve for DBT data from GV-117 cruise varies from -0.5 to -1 °C, for GV-118 stations it varies between -0.3 and -0.6 °C. In both the cruises, though the error is consistently negative from surface to 800 m depth.

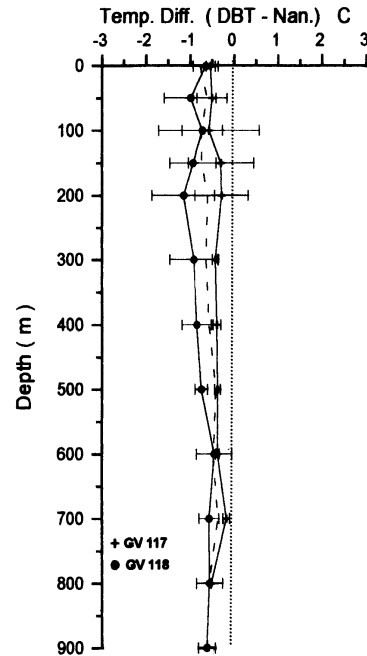


Fig. 3—Mean temperature error curves for cruises GV-117 and CGV-118.

There is not any systematic dependence of the error on depth. Both the random (Standard deviation) and systematic (mean) errors are found to be maximum in the surface layer, extending up to 200 m.

Considering the given accuracy of 0.05 °C, the observed DBT error, varying from -0.3 to -1 °C, is significant and such offsets have to be removed from DBT archives. In large-scale oceanographic studies, the data sets are made available using observations from various instruments like CTD, XBT, Nansen cast, etc. For generating a blended reliable data set from observations of various instruments, the instrument-to-instrument bias should be reduced. The large random as well as systematic error in the surface 200 m layer may be exaggerated due to the probable depth error in Nansen cast data within this depth range caused by wire angle. Since the wire angle correction is not very precise, existence of depth error even after wire angle correction cannot be ruled out. Certain percentage of the observed large random error in the surface layer, especially within 100 m, could be caused by the residual depth error, existing in Nansen cast even after the wire angle correction. In deeper layers, such offsets, caused by instrument bias, may be altered due to the existence of internal waves with periodicity corresponding to the time lag in DBT and Nansen Cast operations. Figure 4 represents difference between Nansen and CTD temperature,

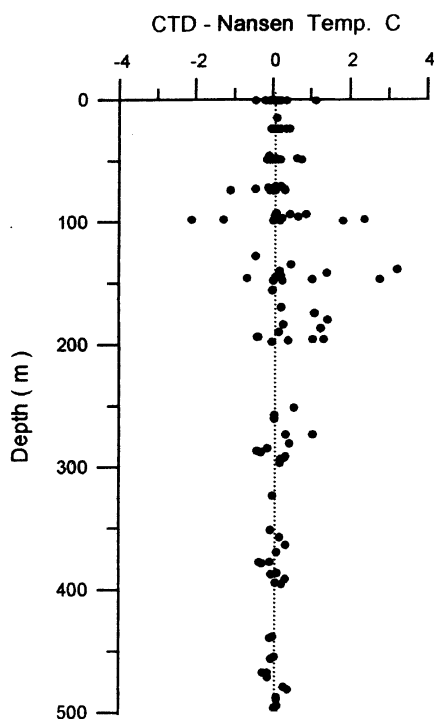


Fig. 4 — Difference between CTD and Nansen temperature from SK-1 cruises as a function of depth.

derived from the data collected onboard *ORV. Sagar Kanya* (SK-1) from co-located stations. Obviously, there is no systematic bias in temperature. However, large random error exists in the depth range 50-150 m. Non-existence of any systematic bias in Nansen cast data on comparison with CTD, further confirms that the observed mean errors in Fig.3 was caused by DBT.

As given in Table 1, DBT was widely used in the Pacific Ocean by the US and Japan oceanographic community (81171 profiles). Existence of temperature bias, as seen in the IODC-DBT archive, was not reported for the DBT archives in US-NODC and JODC (Personal communication). Therefore, the observed bias in IODC-DBT archive appears to be an isolated case, caused by improper calibration of the DBT.

Since the offset does not show dependence on depth, it is difficult to form an appropriate error function for removing the offsets completely from the data. As an alternative an estimate of the offset, applicable to all depths can be arrived at from Fig.2. A corrective measure of $+0.5^{\circ}\text{C}$, equivalent to the mean surface offset obtained from two cruises reduces the error considerably at all DBT depths.

The authors are grateful to their colleagues, for their effort put in while collecting the DBT data.

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