Effect of Ship Heating on Dry-Bulb Temperature Measurements in GATE

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ABSTRACT

The effect of ship heating on dry-bulb temperature measurements made during GATE is investigated. It is found that measurements taken on a bow boom are less affected than those taken on the ship's bridge. It is also seen that the ship heating effect must be accounted for before meaningful estimates of the error content of dry-bulb temperature measurement systems can be determined.

1. Introduction

In spite of the ease with which dry-bulb temperature measurements can be made aboard ships, good accuracy is difficult to achieve. Roll (1965) examined many of the difficulties of making precise measurements of meteorological variables at sea aboard large research vessels and found that an important problem is the effect of ship heating upon temperature measurements. The heating results from the absorption of solar radiation by the ship. Seguin and Garstang (1971) showed that instrumentation mounted on bow booms suffers least from this effect. Boom and bridge temperature measurements during GATE are examined in the next section.

In order to determine the error content of GATE ship surface measurement systems, Goerss (1979) developed a scheme to estimate the drift (very low-frequency noise) in those systems during the observation phases of the experiment. The importance of the heating effect on the drift analysis is discussed in Section 3.

2. Observations of ship heating

Measurements of dry-bulb temperatures during GATE fall into two categories: the Type 1 measurements which consist of continuous and automatically recorded observations; and the Type 2 measurements, which consist of observations hand-recorded at 15 or 30 min intervals. Except for the *Meteor* buoy all Type 1 dry-bulb measurements were made from a boom on the ship's bow. All type 2 measurements were made on the bridge of the ship using mercury-in-glass thermometers. The effect of ship heating is graphically illustrated in Fig. 1 where afternoon observations for the *Oceanographer* Type 1 and Type 2 systems can be seen to differ by more than 2°C. Table 1 summarizes the results of computing day and night averages from hourly observations

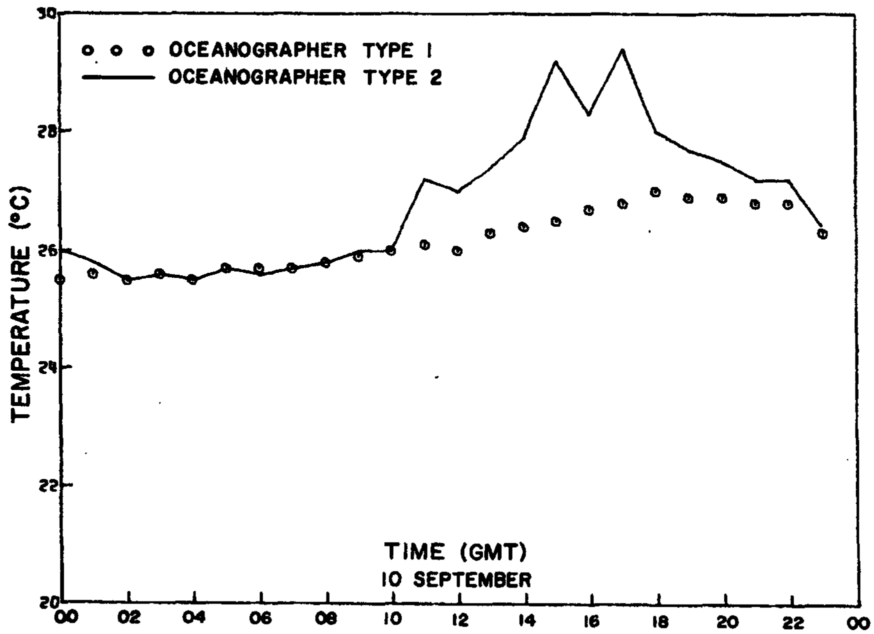

FIG. 1. A comparison of Type 1 and Type 2 temperature measurements made aboard the *Oceanographer* on 10 September 1974.

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during the third observation phase (30 August–19 September) for the GATE ships which carried both Type 1 and Type 2 systems. We conclude from the column of differences (day – night) that the dry-bulb temperature measurements made from a bow boom show significantly less heating effect than those made on a bridge.

3. Impact on drift analysis

In brief, the procedure in the drift analysis was as follows. Ship observations of dry-bulb temperature were low-pass filtered (a running mean with length on the order of days) and a second-degree polynomial in coordinates x and y (i.e., a parabolic surface) was fitted to the ship array of filtered observations. The drift value for a particular measurement system was estimated to be the difference between the filtered value for the system and the value obtained from the parabolic surface at the ship location, both for the same day. The details of the methodology can be found in Goerss (1979, 1978).

The temperature error resulting from ship heating is always positive and, consequently, cannot be removed by low-pass filtering. In order to determine the magnitude of the error that could occur in the drift analysis the following experiment was conducted. The dry-bulb temperatures recorded by the GATE ship systems during the third observation phase were segregated into day (0800–1900) and night (2000–0700) categories. The drift analysis scheme was applied to 13-day and 13-night averages of the observations (there was a maximum of 13 consecutive days during the third phase during which good data were available from all ships). The resulting drift corrections are shown in Table 2 for a number of the ship measurement systems. Except for the *Researcher* little difference is seen between the day and night drift corrections for the Type 1 systems. On the other hand, differences as large as 0.8°C are found for Type 2 systems. If the drift analysis had been performed without data segregation, the drift corrections so obtained for a particular system would have approximated the average of the two shown in Table 2 and thus could have been in error by as much as 0.4°C. For this reason, only nighttime data were used in the drift analysis of temperature measurement systems.

TABLE 1. Day (0800–1900) and night (2000–0700) average dry-bulb temperatures (°C) and differences for Type 1 and Type 2 systems during the third observation phase of GATE. All times GMT.

Ship	Number of observations	Day	Number of observations	Night	Day – night
Meteor 2	228	25.84	216	25.72	0.12
Meteor 1 (buoy)	192	25.77	180	25.80	−0.03
Quadra 2	216	26.11	204	25.83	0.28
Quadra 1	192	25.67	180	25.77	−0.10
Oceanographer 2	240	26.44	228	25.81	0.63
Oceanographer 1	228	25.73	216	25.63	0.10
Researcher 2	240	26.25	228	25.43	0.82
Researcher 1	240	25.87	228	25.52	0.35
Gilliss 2	240	26.17	228	25.77	0.40
Gilliss 1	228	25.97	216	25.95	0.02
Planet 2	240	26.10	228	25.98	0.12
Planet 1	156	25.50	144	25.76	−0.26
Dallas 2	240	26.40	228	25.89	0.51
Dallas 1	228	25.61	216	25.53	0.08

TABLE 2. A comparison of dry-bulb system drift corrections (°C) for the third observation phase of GATE determined using 13-day and 13-night averaging periods.

Ship	Day	Night
Researcher 1	−0.2	0.1
Researcher 2	−0.6	0.2
Oceanographer 1	0.1	0.1
Oceanographer 2	−0.6	0.0
Quadra 1	0.1	0.0
Quadra 2	−0.2	0.0
Dallas 1	0.3	0.2
Dallas 2	−0.5	−0.1
Gilliss 1	0.0	−0.1
Gilliss 2	−0.3	0.0
Vanguard 2	−0.8	−0.2

4. Conclusions

The analysis of the dry-bulb temperature data collected by the GATE ship measurement systems supports the finding of Seguin and Garstang (1971) that instrumentation mounted aboard a bow boom are much less affected by ship heating than measurements made on the bridge. In addition, we have shown that the ship heating effect must be taken into account in order to derive meaningful estimates of the error content of these measurement systems.

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