The Impact of Installation on the Measurement of Black Globe Temperature

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Introduction:

Heat stress risk influenced by temperature, humidity, wind speed & solar radiation

- Wet-bulb globe temperature (WBGT) developed to assess heat stress risk for soldiers
  - $WBGT = 0.7T_{nwb} + 0.2T_{bg} + 0.1T_{air}$
- Black globe temp. (T_{bg}) measured by Campbell Scientific BLACKGLOBE-L (BG)
  - Installation errors may introduce cool biases to T_{bg} measurement

Objective: test performance across a series of cable gland orientation/temp. probe insertion depth manipulations

Methodology:

Instrumentation:

- 5x BG sensors with 108 temperature probe (108)
  - BGs 1, 2 and 4 selected for manipulation

Procedure:

- Manipulation 1: center 108 within BG
- Manipulation 2: center 108 within BG & orient BG cable glands along vertical
- Manipulation 3: orient BG cable glands along vertical



Figure 1: BG sensors used in study. BGs are numbered 1 through 5 from left to right

Literature:

Secretariat Range Commanders Council U.S. Army, White Sands Missile Range, NM. (2023). *Finding Improvements in the Measurement and Estimation of Wet-Bulb Globe Temperature.* (Rep. WP-23-001). Retrieved from https://apps.dtic.mil/sti/citations/trecms/AD1207940

Yaglou, C. P., & Minard, D. (1956). Prevention of heat casualties at Marine Training Corps Centers. *Office of Naval Research Physiology Branch report* (Vol. 48, pp. 31). Washington, D C.

Results[3]:

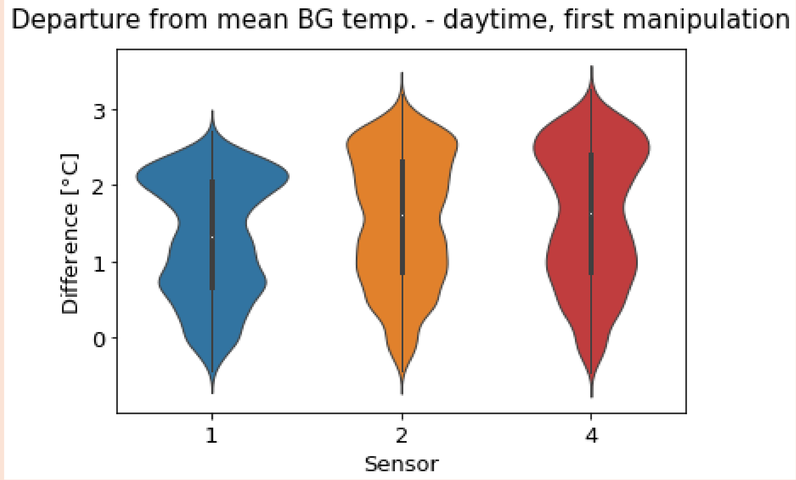


Figure 2: Violin plots for test sensors during manipulation 1. The mean BG temp. Is the average of the two control sensors. The maximum difference between the control and test sensors is approximately 3°C

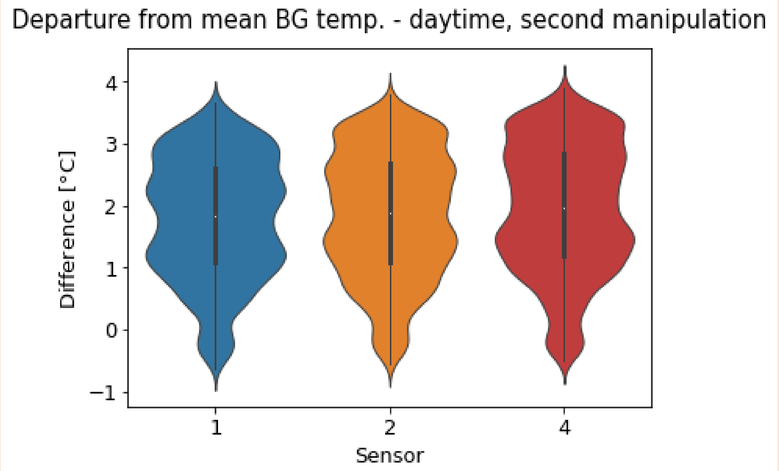


Figure 3: Violin plots for test sensors during manipulation 2. The maximum difference between the control and test sensors has increased to approximately 4°C

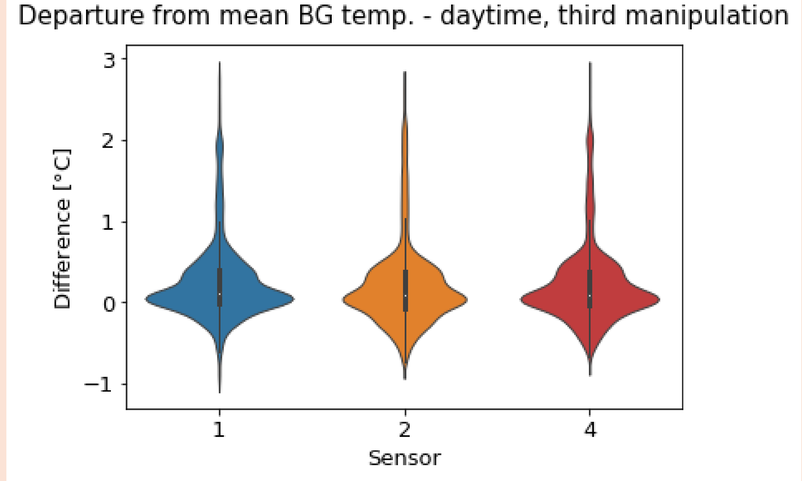


Figure 4: Violin plots for test sensors during manipulation 3. The maximum difference between the control and test sensors is approximately 3°C, but most values fall between 0-1°C

	Mean [°C]	Median [°C]	Std. Dev. [°C]
Manip. 1 BG 1	1.3069	1.325	0.7837
Manip. 1 BG 2	1.5509	1.61	0.8491
Manip. 1 BG 4	1.5902	1.625	0.8951
Manip. 2 BG 1	1.7897	1.845	0.981
Manip. 2 BG 2	1.8499	1.8925	1.0127
Manip. 2 BG 4	1.9503	1.96	1.0451
Manip. 3 BG 1	0.2492	0.11	0.492
Manip. 3 BG 2	0.2095	0.085	0.5231
Manip. 3 BG 4	0.2239	0.09	0.5058

Table 1: Descriptive statistics (mean, median, std. dev.) for test sensors during manipulations 1, 2 & 3

[3] For this study, 'daytime' is defined as 6am to 8pm MST

Discussion:

- Altering the 108 insertion depth results in the largest change in the measured BG temp.
- Vertically orienting the cable gland results in smaller changes to measured BG temp., with some outlying values
- A higher reading is not necessarily more accurate; a deeper understanding of the physiological conditions being modeled is needed
- Future studies will use thermal modeling to decide where a 'representative' measurement can be made