iButton Placement Study:
Testing Scenarios for Field Implementation

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Introduction

Data to quantify the relationship between urban tree cover and ambient temperatures, and associated heating and cooling costs, are sparse due to the cost and logistical problems of using meteorological stations in sufficient density to adequately quantify temperature across a complex urban landscape. The use of micro-data loggers (e.g., iButtons) to record temperature would be dramatically less expensive and logistically less complex.

A replicated study was implemented to assess the effects of the height and placement (100- cm, shielded envelope on stake [standard] and open and reflective envelopes at 15-cm) of temperature data loggers on recorded temperatures. We hypothesized that the use of a reflective material for the placement of the logger at low-height would best mimic the standard meteorological logger placement.

Methods

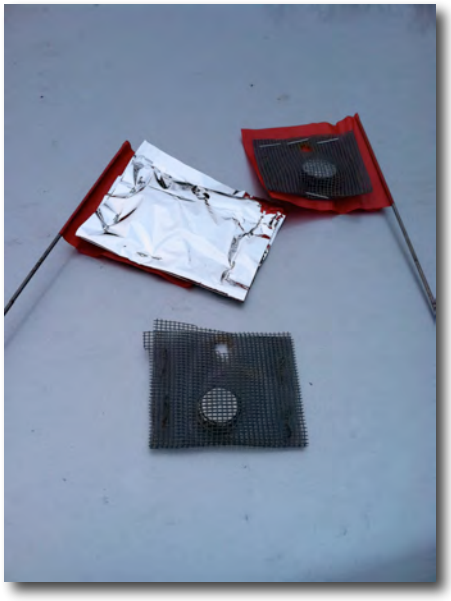
Three iButton temperature loggers were programmed to record hourly temperature simultaneously at two heights and three placements types. The iButtons were used at four locations (Amherst, Springfield [2], and Gill, Massachusetts) between 8 Feb and 26 Feb 2012.

All iButtons were placed in small, square envelopes constructed of window screen material. The reflective envelopes were further covered with reflective, aluminized polyester (emergency blanket). The low-height envelopes were attached to pin-flags. The high envelopes were hung from wooden stakes and shielded with painted aluminum flashing. The stake placement oriented so the iButton faced due North. The pin flag units were located in front of and at the base of a wooden stake to form a cluster (Fig. 1). iButton clusters were located in a secure spot with maximum solar exposure throughout the day.

Hourly, day-time sky conditions were recorded from the Springfield, Amherst, and Northfield (Gill) webpages of The Weather Channel. We categorized sky conditions into three groups: night-time (between sunset and sunrise), clear (i.e., sunny, mostly sunny, partly cloudy), and cloudy (i.e., cloudy, mostly cloudy and all precipitation).

Within each site, using similar sky condition classes, we compared the temperature records using a paired t-test.

iButton Placement Photos



Results

The iButtons operated successfully over the duration of the study. Due to disturbance, data collection from the Gill and Forest Park (Springfield) installations were terminated prior to 26 Feb 2012.

Mean hourly temperatures differed significantly ($p < 0.001$) between paired placements. However, ambient temperatures were very similar between the stake and the reflective envelope placement, with a mean difference of less than 0.5ºC, while differences between the stake and the open envelope and between the open- and reflective envelopes were frequently > 2ºC (Table 1).

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Table 1.							
		Mean temperature			Mean difference in temperature		
Location	Sky conditions	Stake (ST)	Open envelope (OE)	Reflective envelope (RE)	ST vs OE	ST vs RE	OE vs RE
Amherst (Brooks)	Clear	4.7	8.8	4.5	-4.087	0.203	4.29
	Clouds	4.6	6.1	4.2	-1.508	0.362	1.87
	Night	-1.8	-2.3	-2.5	0.539	0.679	0.14
Gill (Lerman)	Clear	3	6.7	2.5	-3.773	0.447	4.221
	Clouds	4.2	6	4	-1.79	0.193	1.983
	Night	-3.3	-4	-4	0.745	0.656	-0.89
Forest Park	Clear	4.8	6.1	4.5	-1.343	-0.249	1.591
	Clouds	3.7	4.5	3.5	-0.782	0.247	1.028
	Night	-2	-0.9	-0.5	-1.148	-1.546	-0.398
Springfield (Bloniarz)	Clear	5.9	7	5.1	-1.191	0.768	1.928
	Clouds	4.4	4.7	4	-0.357	0.382	0.739
	Night	0.05	-0.1	0.4	0.181	-0.314	-0.494
All locations	Clear	4.9	7.3	4.5	-2.415	0.424	2.839
	Clouds	4.2	5.3	3.9	-1.098	0.304	1.402
	Night	-1.5	-1.5	-1.3	0.017	-0.205	-0.221

Table 1. Mean hourly temperatures (ºC) by location, iButton placement, and sky conditions, and mean difference in temperatures from central Massachusetts, 8-27 February, 2012 (Gill from 8-19 Feb, Forest Park from 8-25 Feb).

Conclusion

The small absolute difference in temperature between the standard placement of the logger and the reflective-envelope placement supports the use of the reflective envelope in a design for an extensive (i.e., large number of loggers) survey of ambient urban temperatures in varied land-use types and with a range of tree canopy conditions.

The use of the reflective-envelope, attached to a pin-flag:

(1) Would result in reduced cost of both materials and labor for construction;

(2) Provide a less conspicuous installation, which should result in less theft or vandalism more willingness of landowners to accept a logger installation on their property.

The ideal design would co-locate the reflective-envelope placement of temperature loggers with a small number of standard weather stations to calibrate the logger data to standard statistics.