Recovering longwave irradiance tainted with bad thermistor data

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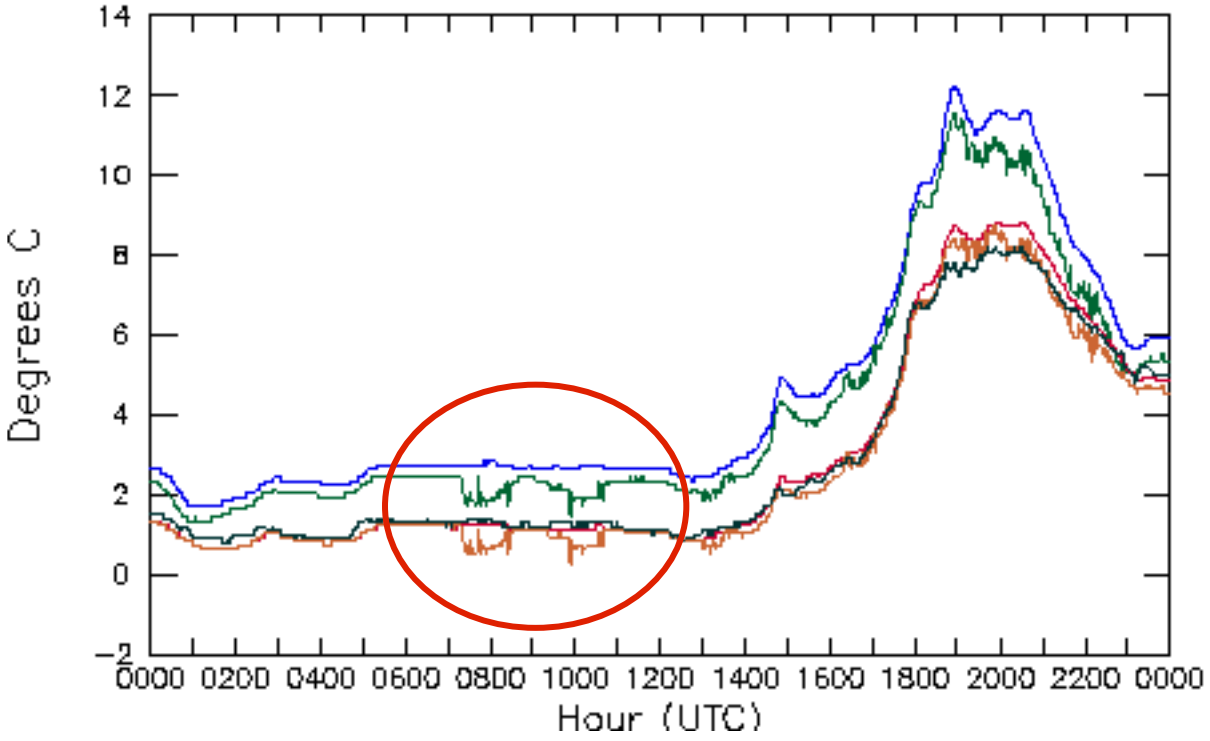

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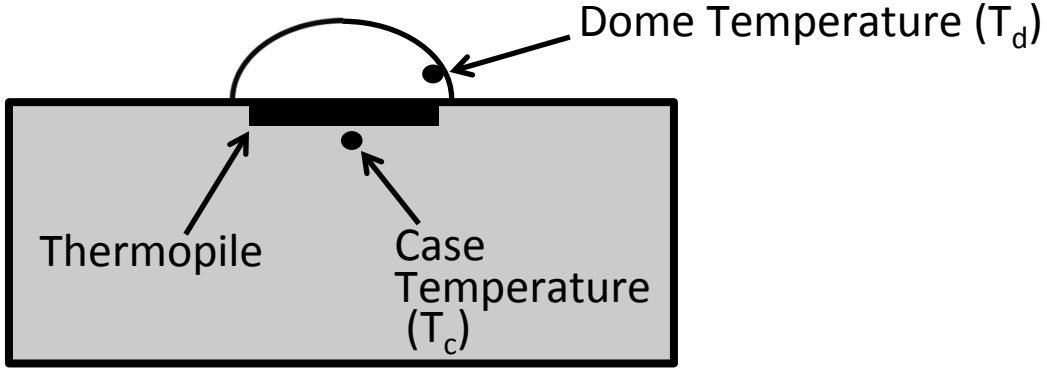
Pyrgeometer case and dome temperatures need to be measured correctly and accurately

$$LW = \text{Thermopile voltage}/C + \sigma T_c^4 - k\sigma (T_d^4 - T_c^4)$$

	Thermopile voltage / C	σT_c^4	$k\sigma (T_d^4 - T_c^4)$
clear	~18%	~81%	~1%
overcast	~7%	~93%	< 1%



LW irradiance errors associated with bad up-looking pyrgeometer case temperatures

Goodwin Creek station, 11 Nov. 2015, 1822 UTC
Actual Downwelling IR irradiance is 365.33 Wm^{-2}
Actual case temp = 300.93 K
Actual dome temp = 300.36 K

CaseT_ERR(K)	DomeT_ERR(K)	Rad ERR (Wm^-2)	Rad_ERR (%)
+0.1	0.0	2.214	0.606
+0.2	0.0	4.430	1.213
+0.3	0.0	6.649	1.820
+0.4	0.0	8.869	2.428
+0.5	0.0	11.092	3.036
+0.6	0.0	13.317	3.645
+0.7	0.0	15.544	4.255
+0.8	0.0	17.774	4.865
+0.9	0.0	20.006	5.476
+1.0	0.0	22.240	6.088

LW irradiance errors associated with bad up-looking pyrgeometer dome temperatures

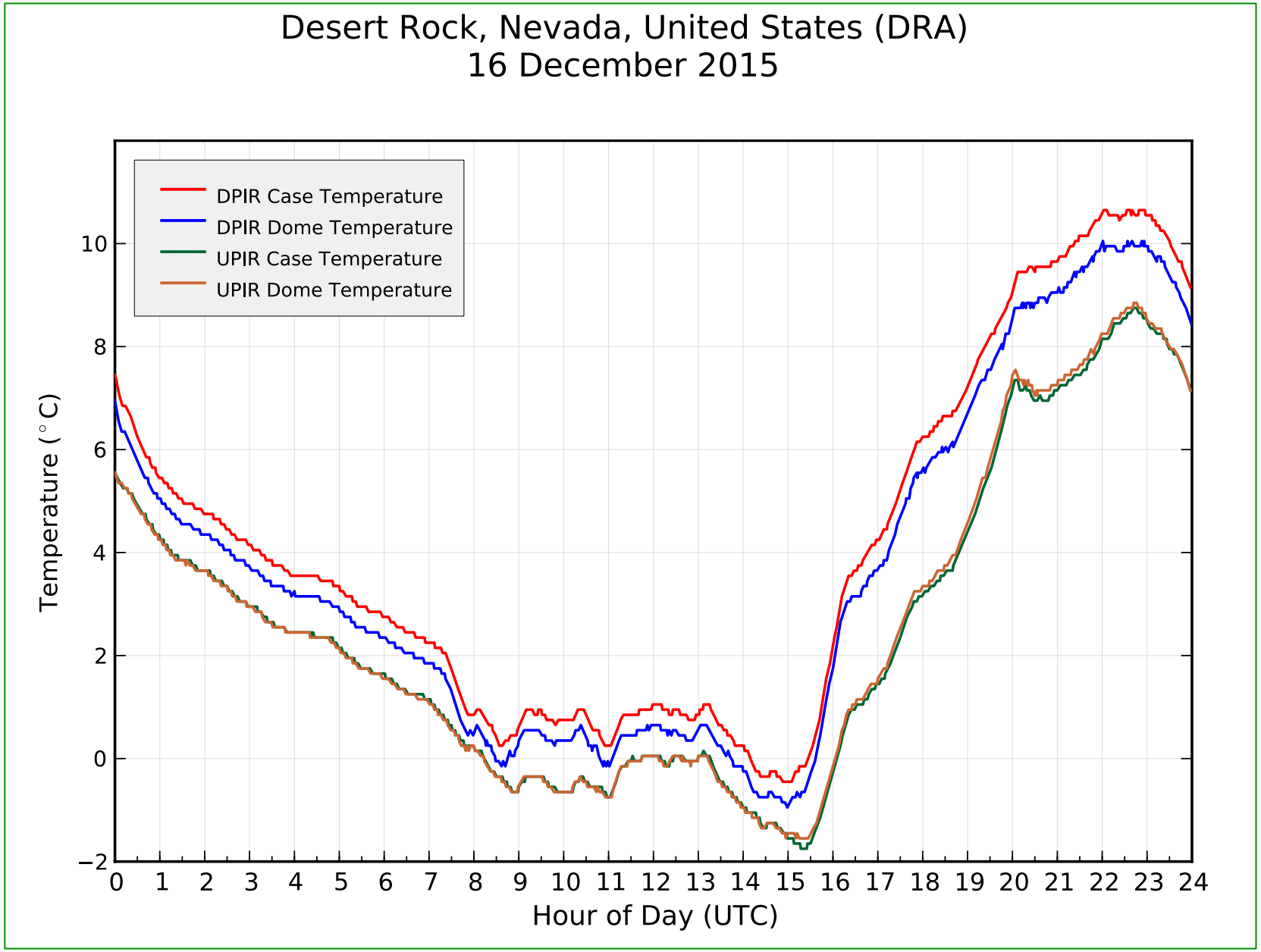
Goodwin Creek station, 11 Nov. 2015, 1822 UTC
Actual Downwelling IR irradiance is 365.33 Wm^{-2}
Actual case temp = 300.93 K
Actual dome temp = 300.36 K

CaseT_ERR(K)	DomeT_ERR(K)	Rad ERR (Wm^-2)	Rad_ERR (%)
0.0	+0.1	-1.587	-0.434
0.0	+0.2	-3.175	-0.869
0.0	+0.3	-4.765	-1.304
0.0	+0.4	-6.356	-1.740
0.0	+0.5	-7.949	-2.176
0.0	+0.6	-9.543	-2.612
0.0	+0.7	-11.139	-3.049
0.0	+0.8	-12.737	-3.486
0.0	+0.9	-14.336	-3.924
0.0	+1.0	-15.937	-4.362

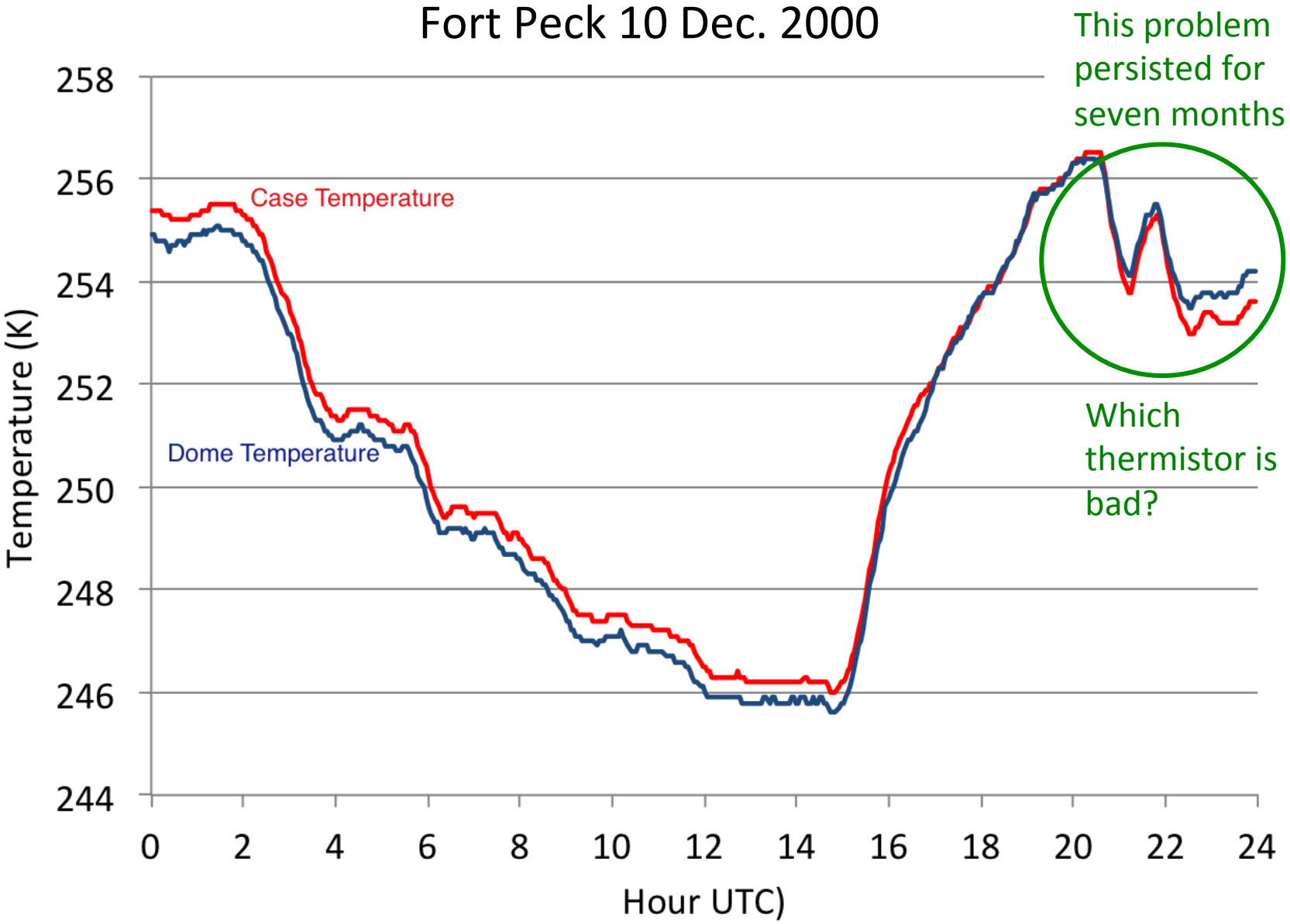
Motivation

- Subtle pyrgeometer thermistor problems can go unnoticed for months
- Problems persist when thermistor errors are typically small (< 1°C) and not readily perceptible in data QC
- Small thermistor temperature errors can result in significant longwave irradiance errors
- The ability to recover LW data tainted by bad thermistor measurements serves to preserve BSRN long term data records

Normal pyrgeometer thermistor data

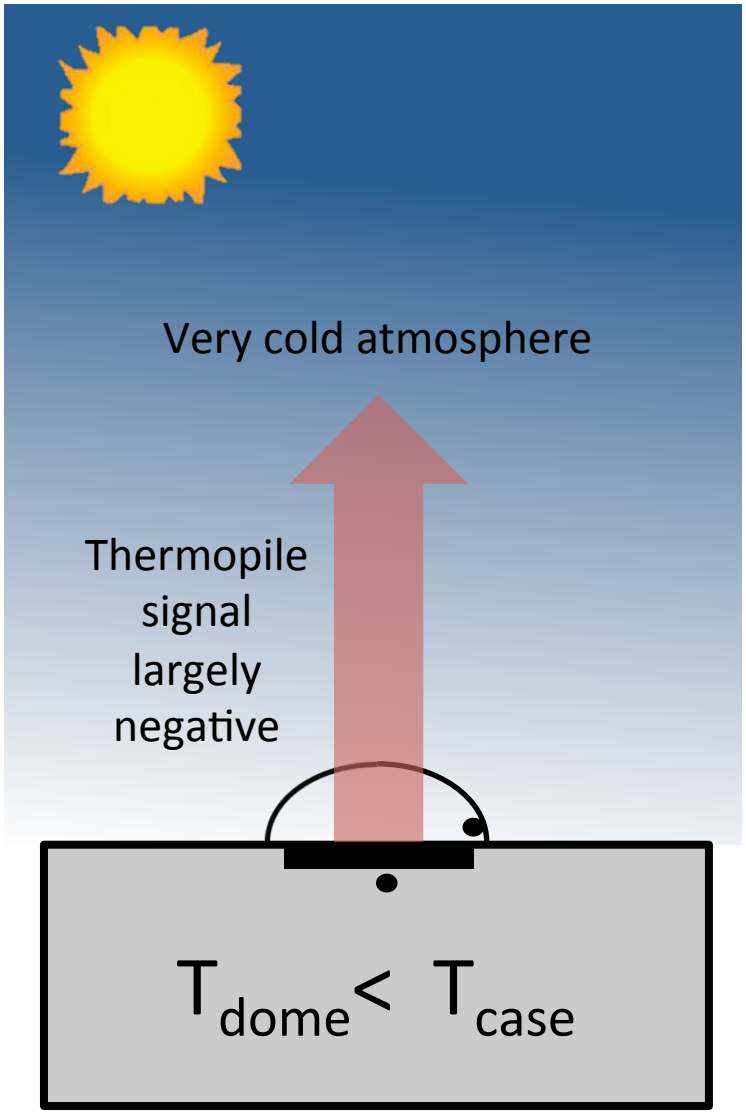


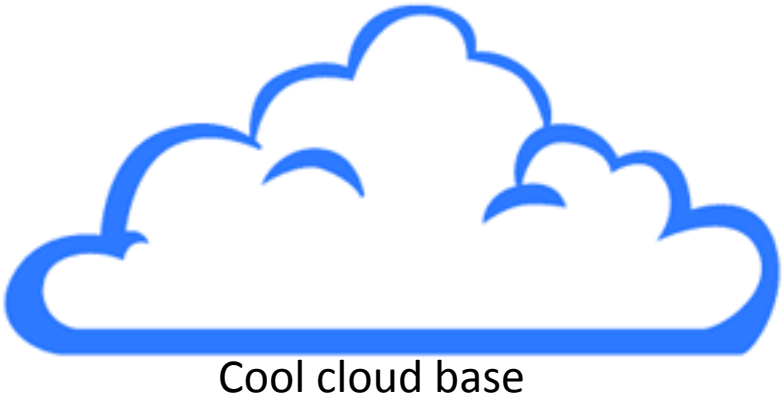
A strange reversal of the normal case - dome temperature order of the up-viewing pyrgeometer

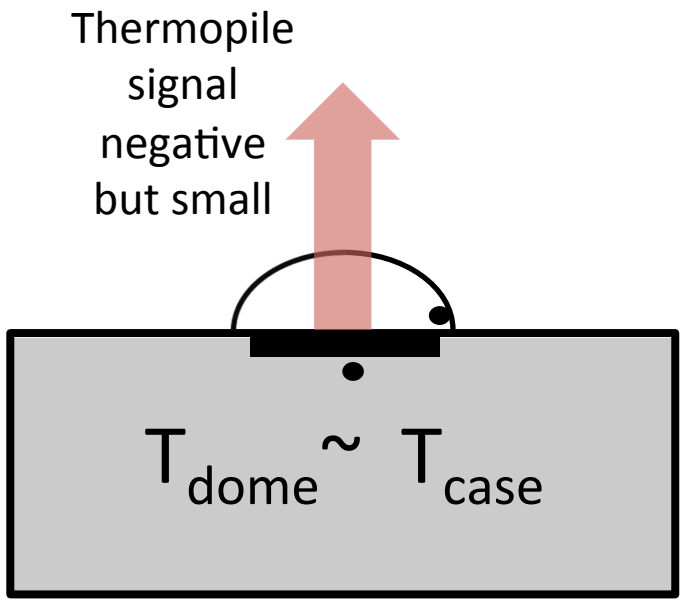


Premise of the correction method:

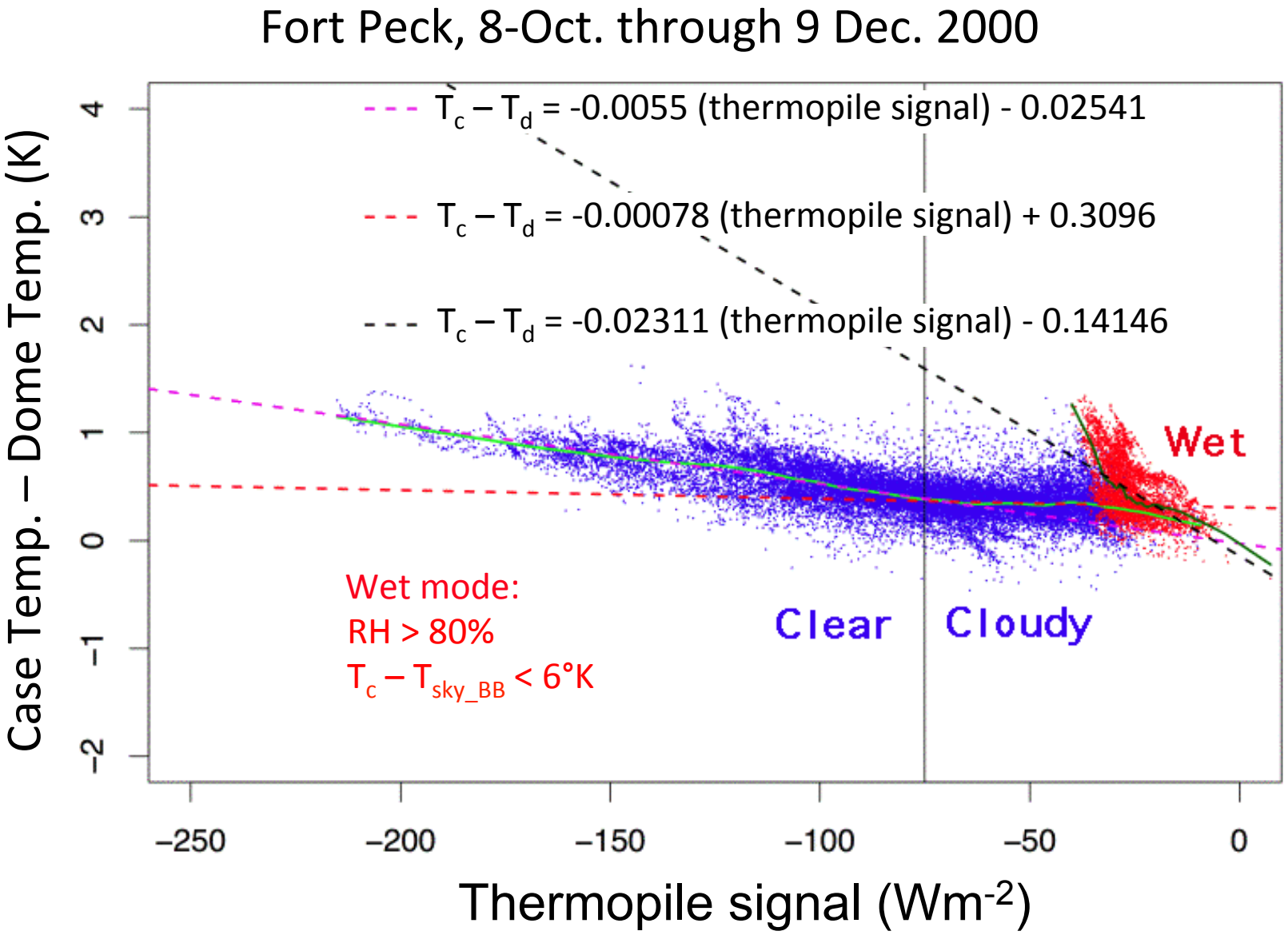
Pyrgeometer case – dome temperature difference is correlated with the thermopile signal



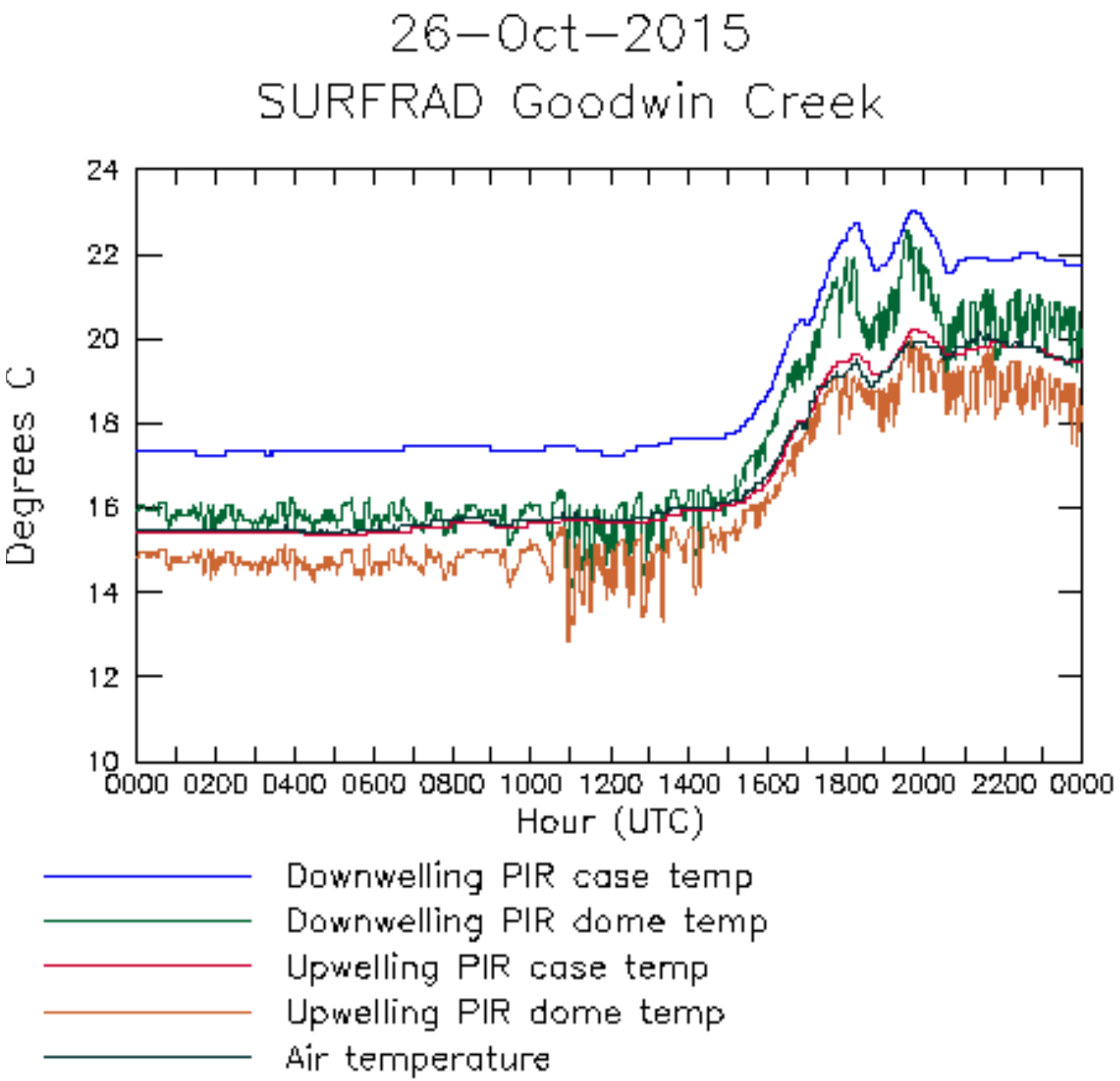




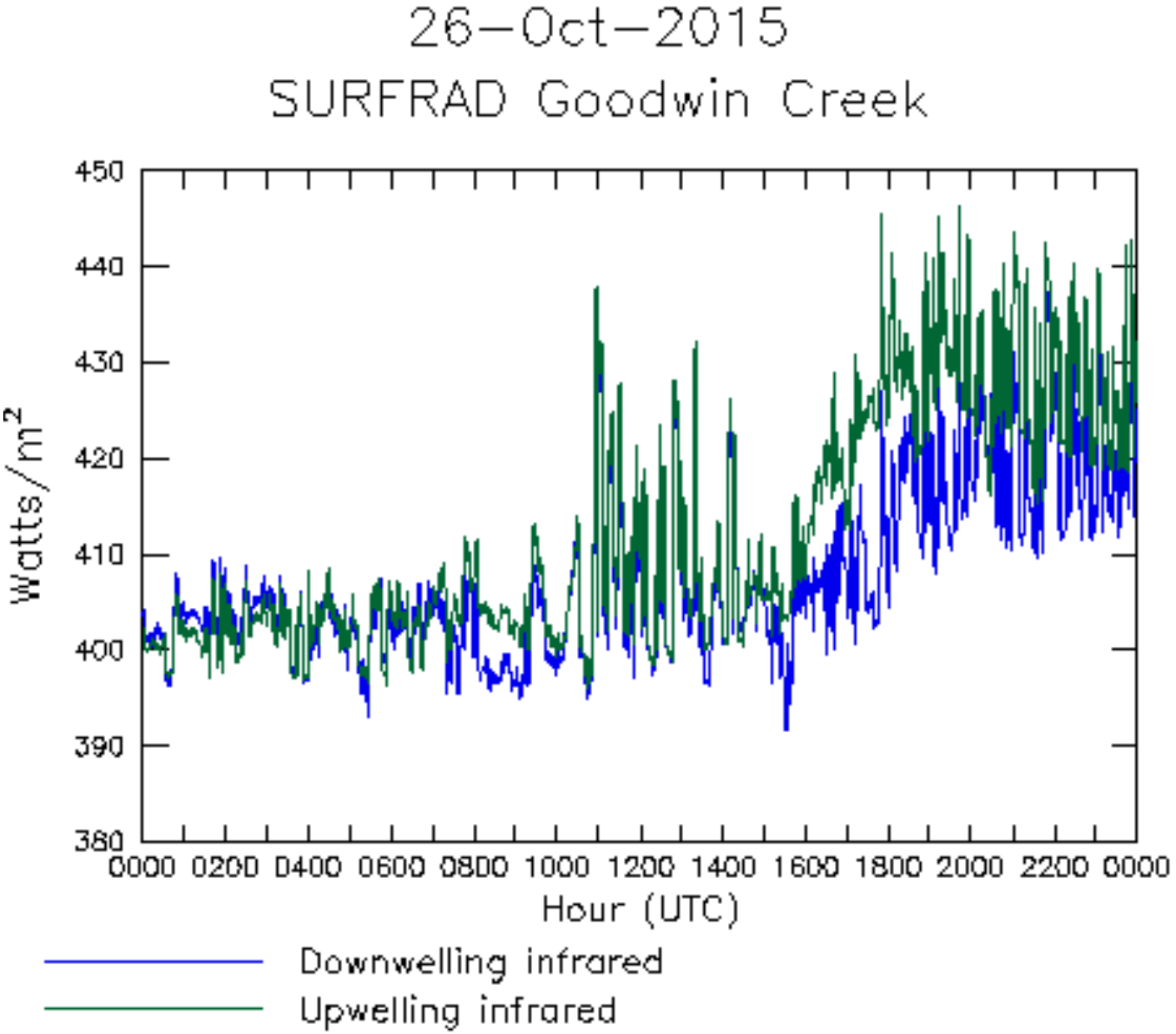
Up-looking pyrgeometer case-dome temperature difference versus the thermopile signal



Bad dome temperatures in both pyrgeometers

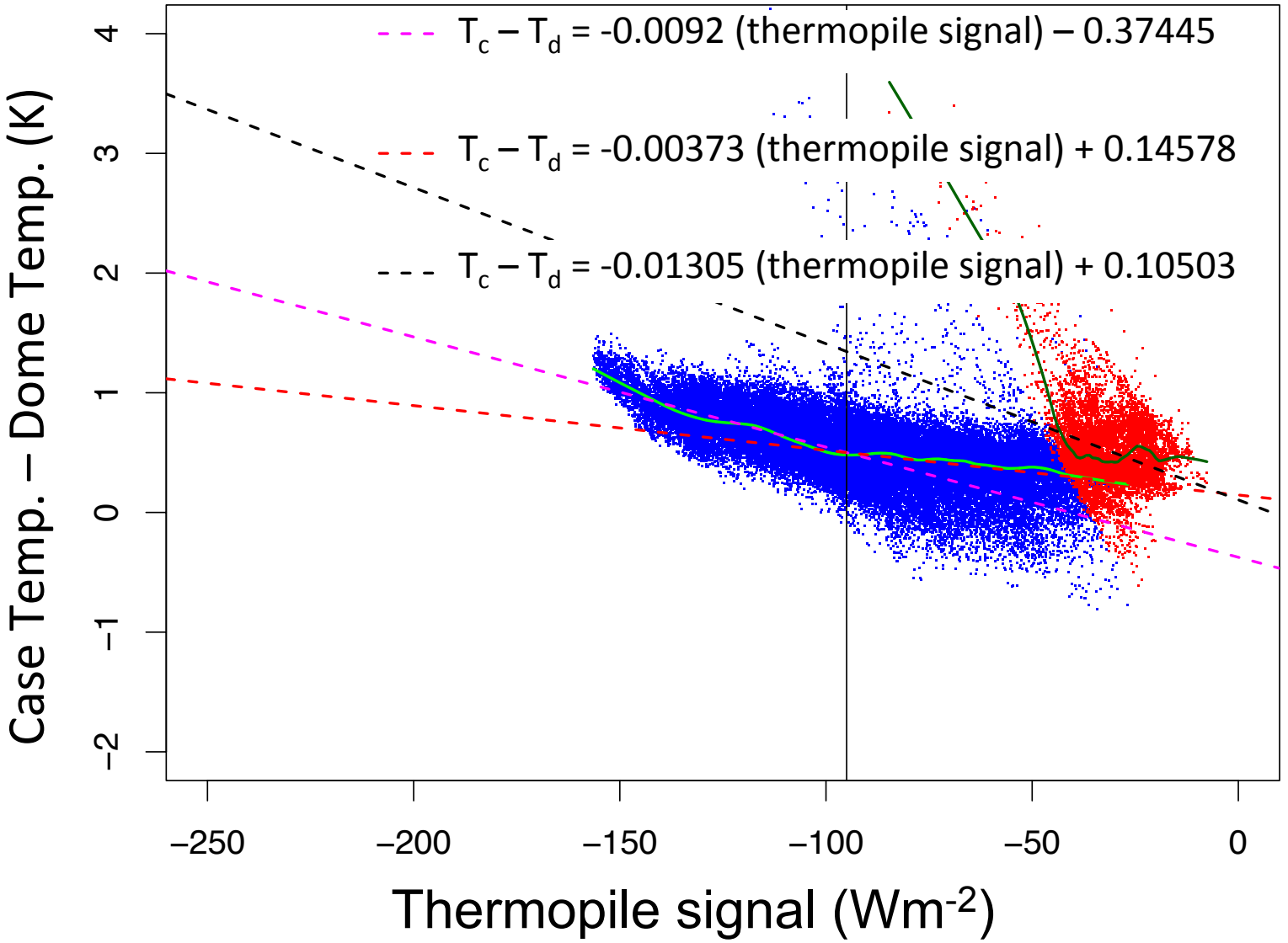


LW signals before correction



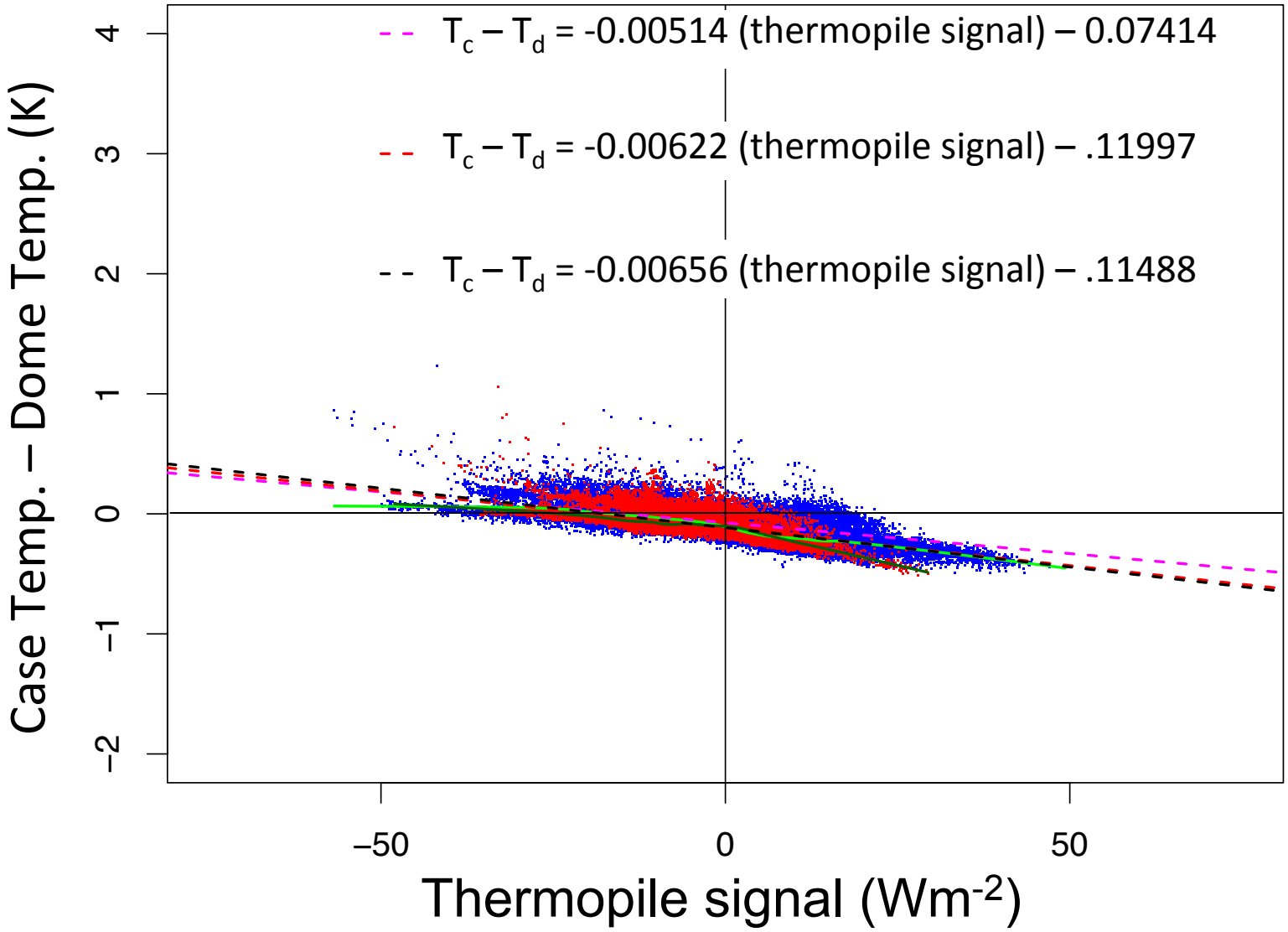
Up-looking pyrgeometer case-dome temperature difference versus the thermopile signal

Goodwin Creek 2 Jul – 29 Aug 2015

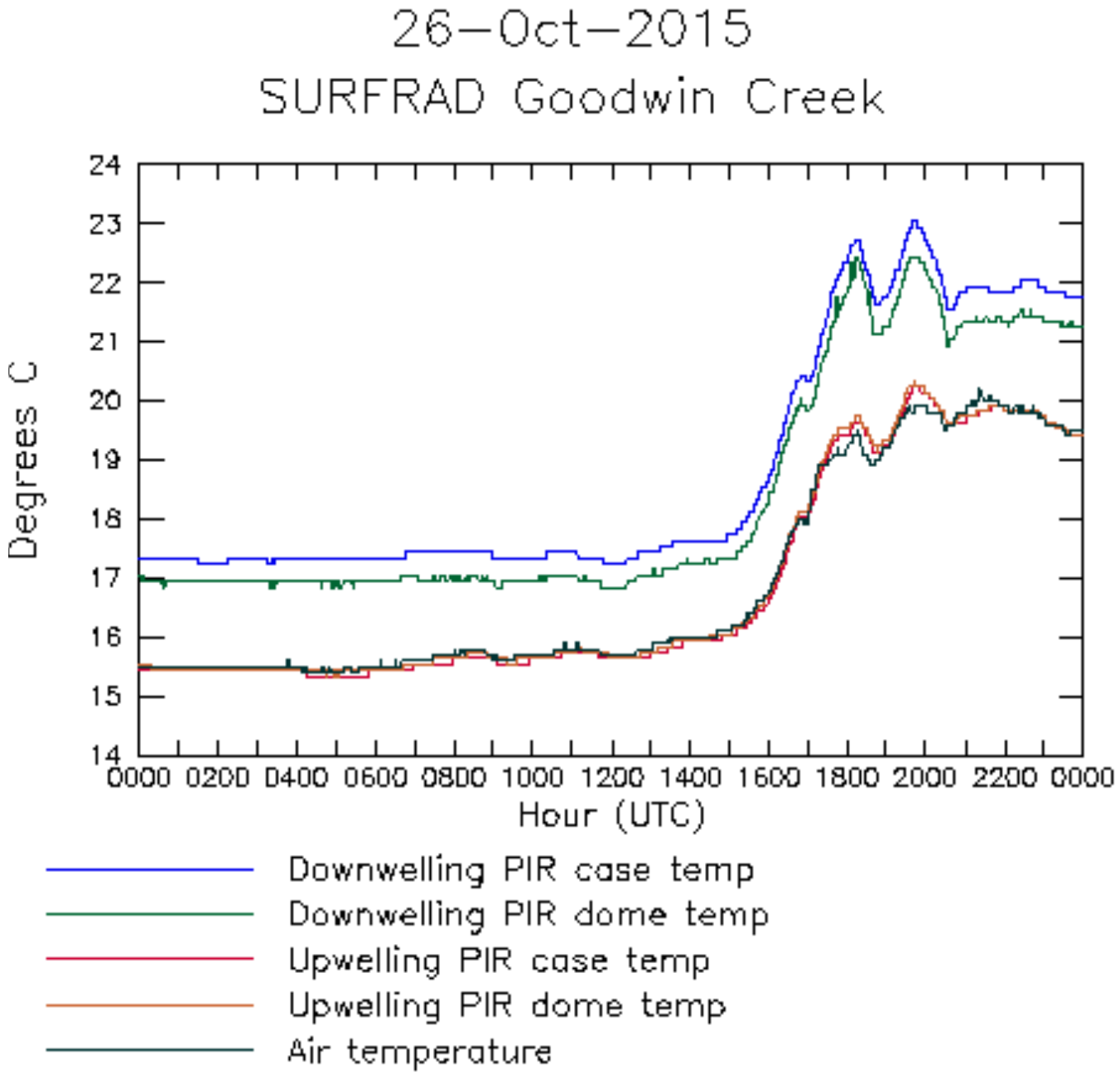


Down-looking pyrgeometer case-dome temperature difference versus the thermopile signal

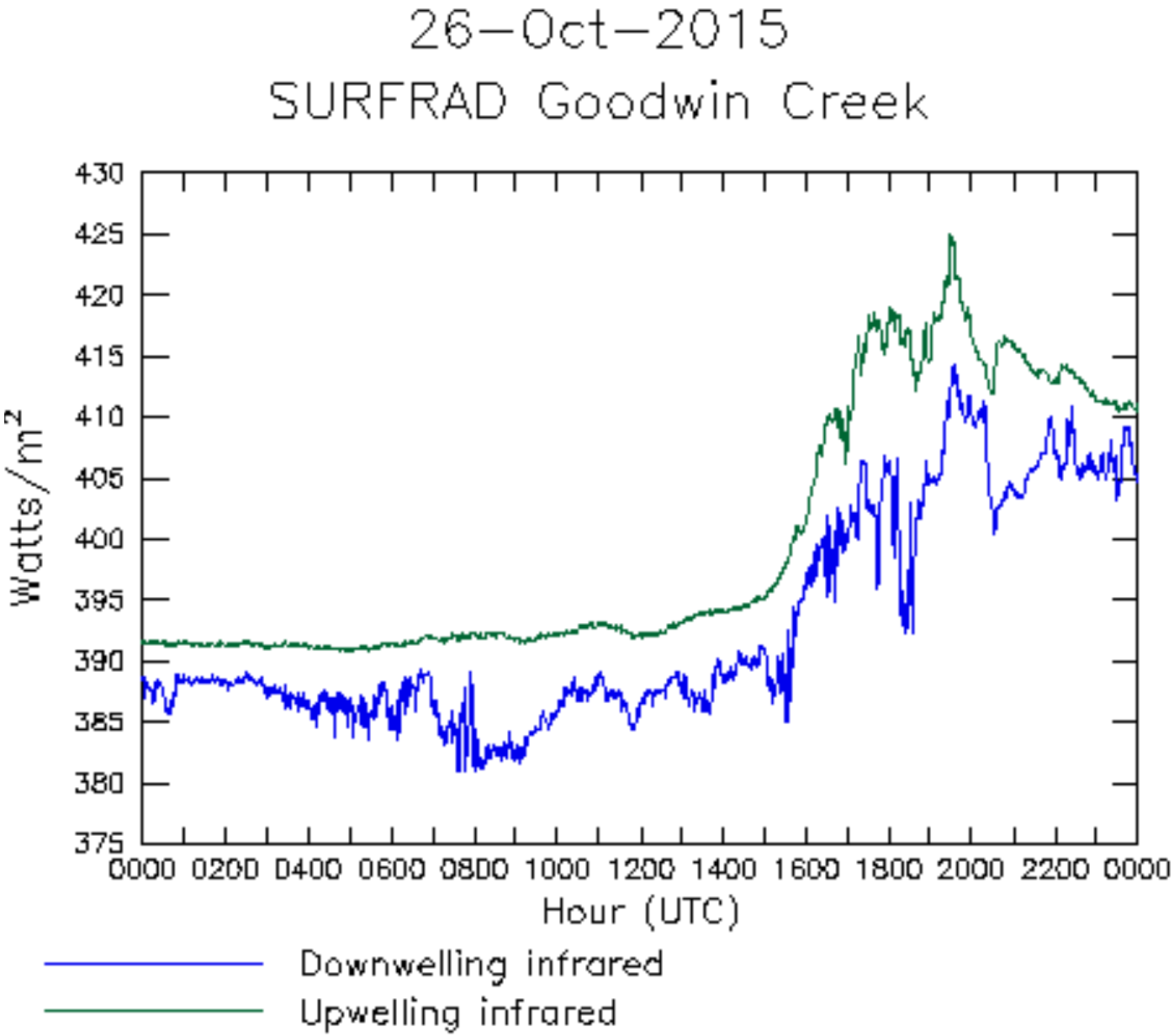
Goodwin Creek 2 Jul – 29 Aug 2015



Corrected dome temperatures



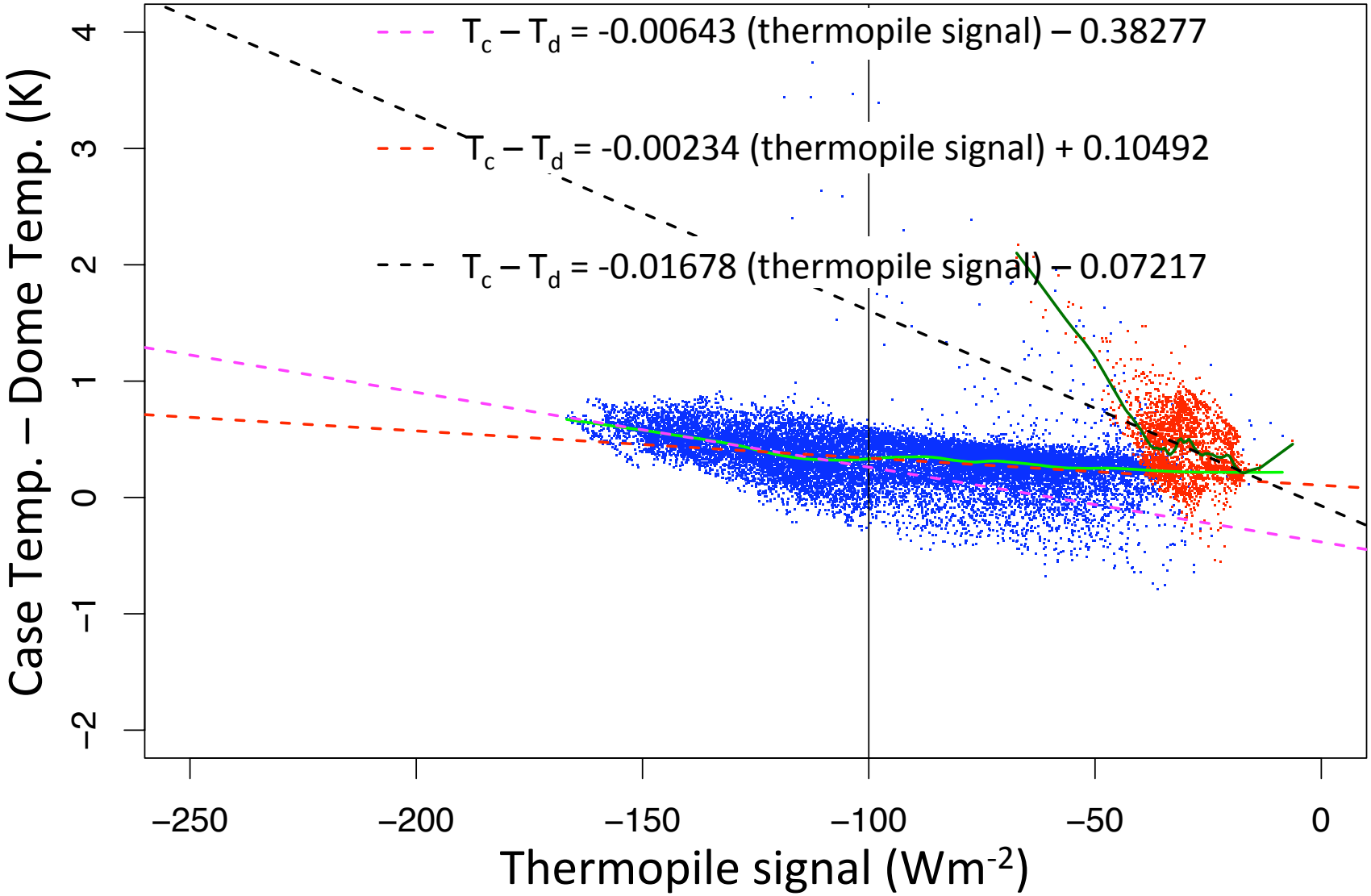
LW signals after correction



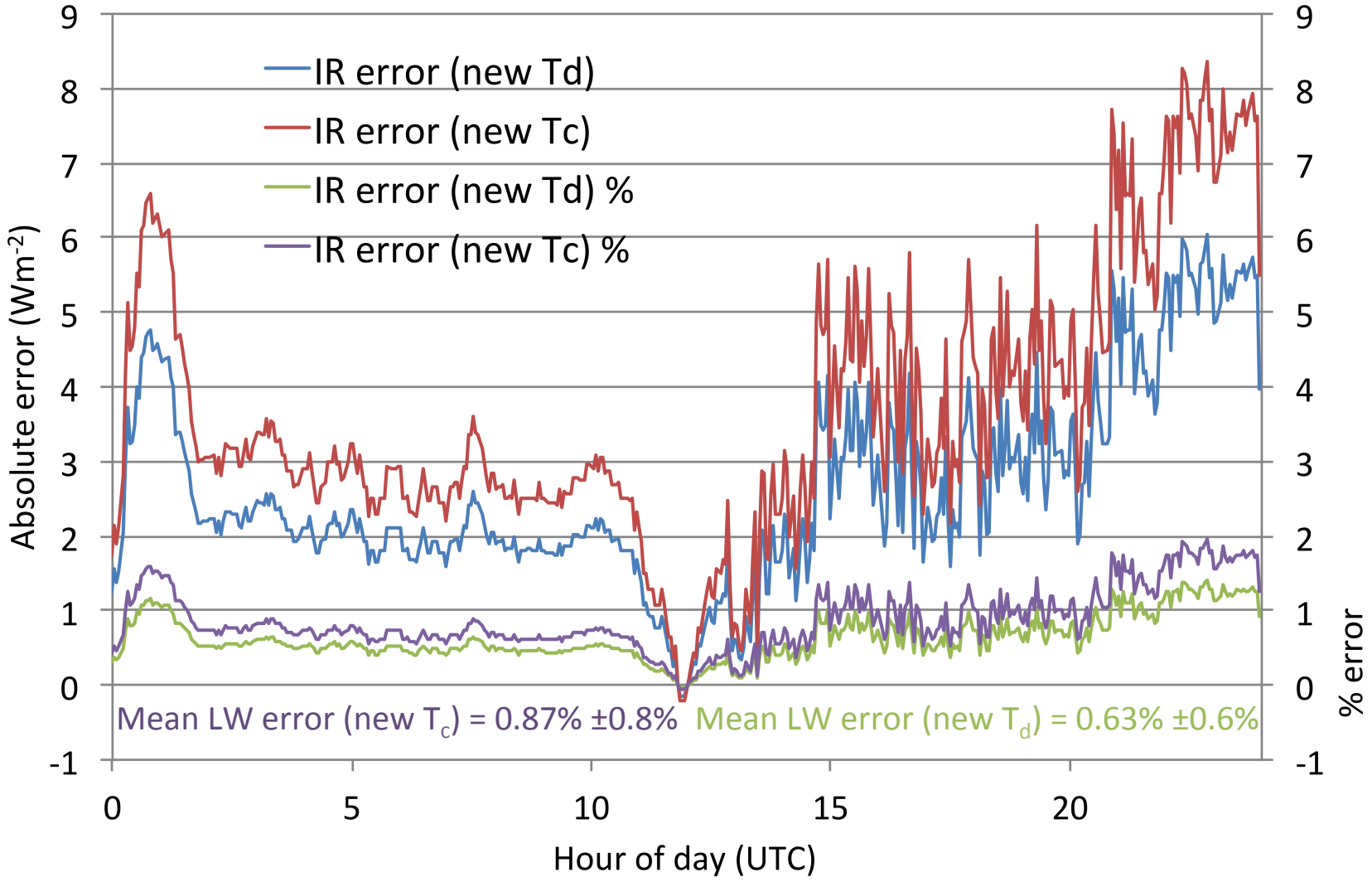
Error assessment of correction method

Up-looking pyrgeometer

Bondville, period used: 1-June to 15 July 2005

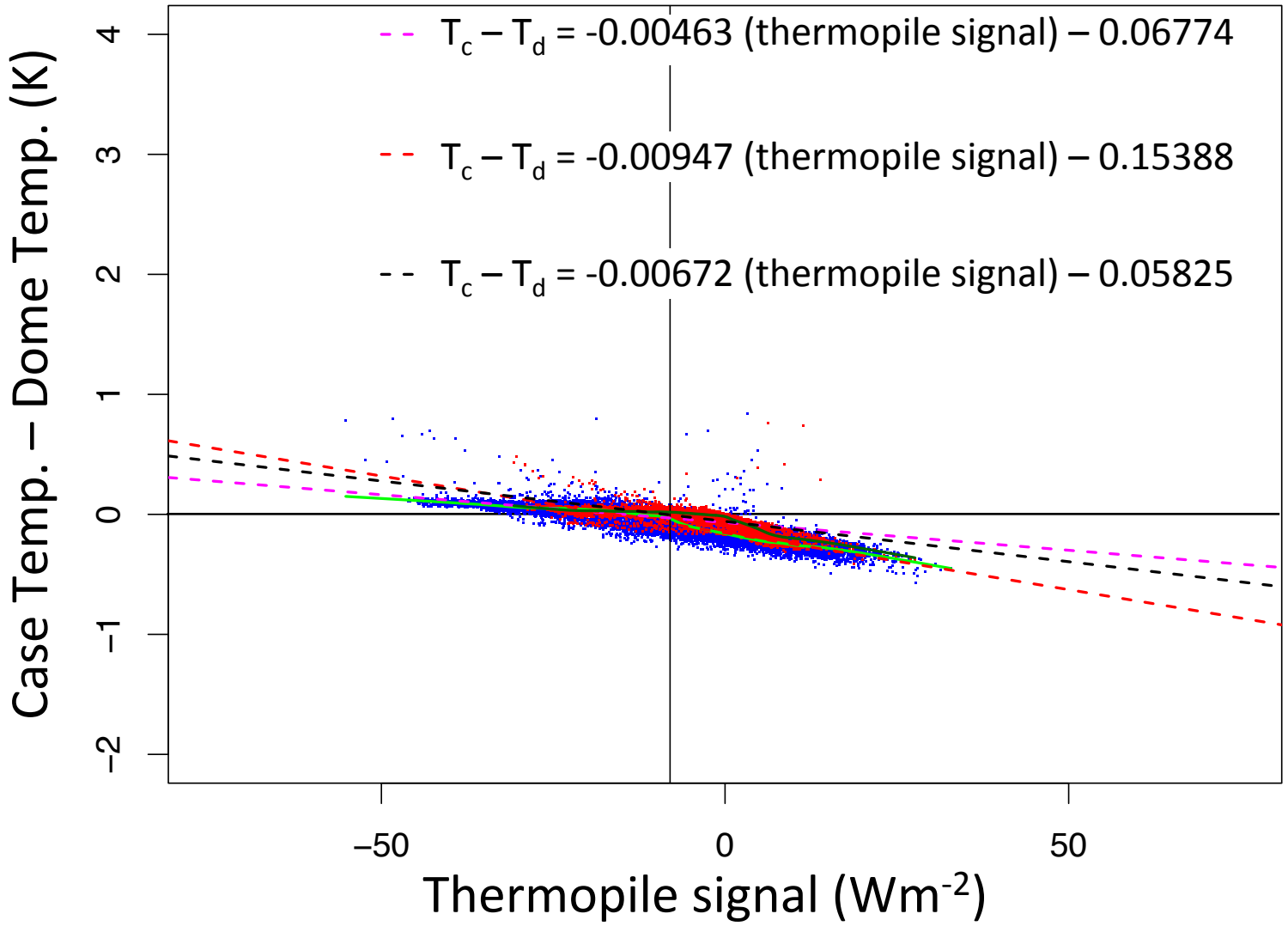


Errors associated with predicted case and dome temperatures for a up-looking pyrgeometer



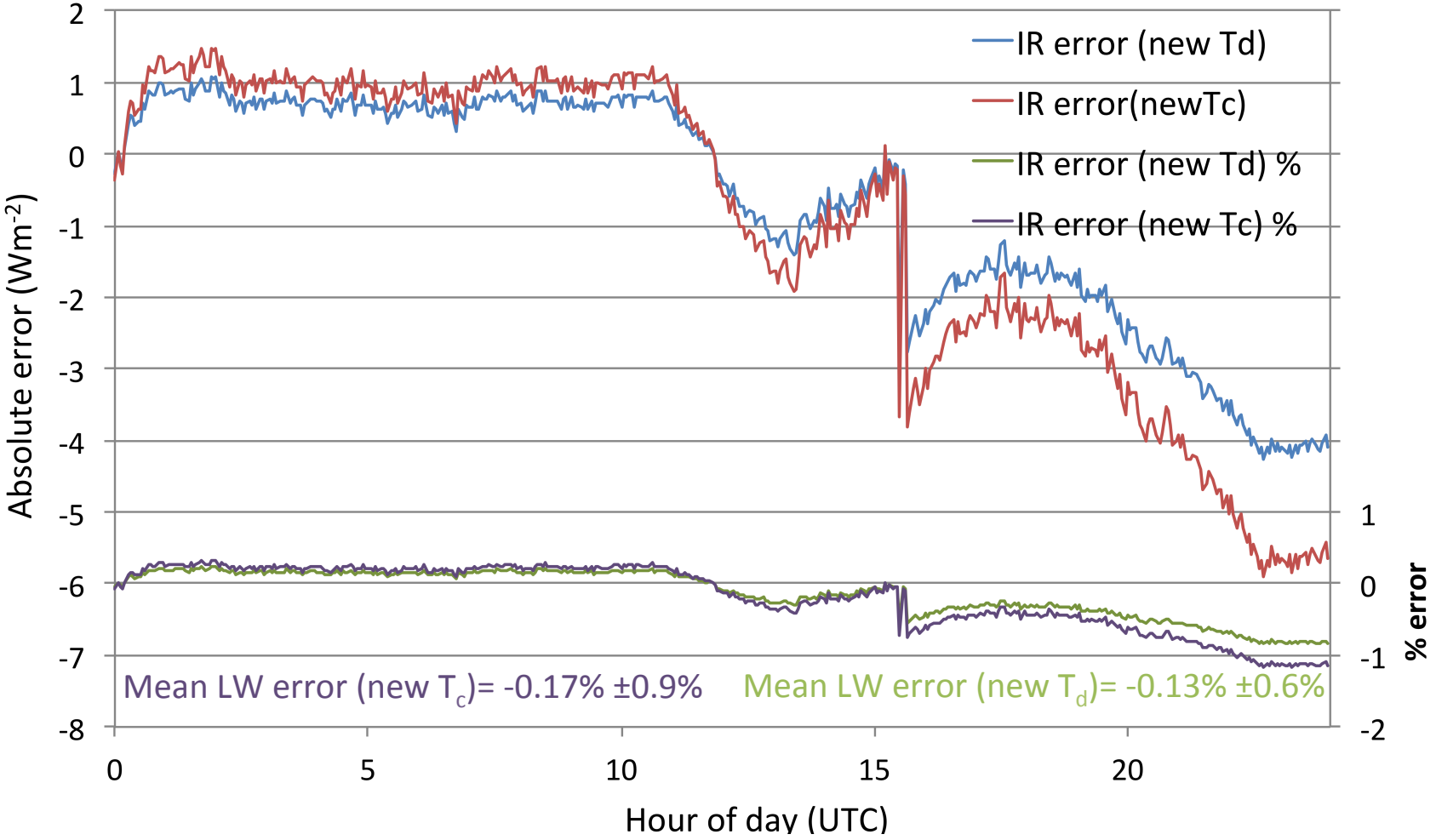
Error assessment of correction method for a down-looking pyrgeometer

Bondville, period used: 1-June to 15 July 2005



Errors associated with predicted case and dome temperatures for a down-looking pyrgeometer

Bondville 24-Jul-2005



Summary of method

- Determine which pyrgeometer thermistor is bad
- Use a period of good operation to develop relationship between the case-dome temperature difference and the thermopile signal (relationships are site and instrument dependent)
- Develop linear models of the case-dome temperature difference versus the thermopile signal separately for clear mode, cloudy mode, and wet mode
- Reprocess the pyrgeometer data substituting the predicted case or dome temperature for the bad measurements

Thank You

Questions?