Assessment of thermal drift of the FLIR A325sc camera: limits and recommendations

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Abstract

Thermal drift of infrared cameras remains a major problem for the accuracy and repeatability of radiometric measurements. To control the thermal drift, we developed a cold box to adjust the temperature of the FLIR A325sc camera housing. An error diagram is proposed to estimate the optimal camera operating temperature as a function of the ambient temperature for which the thermal drift is properly managed. The effectiveness of thermal drift compensation is examined on both camera functional ranges. The use of a cold box improves the thermal drift compensation efficiency and reduces the non-repeatability of irradiance measurements.

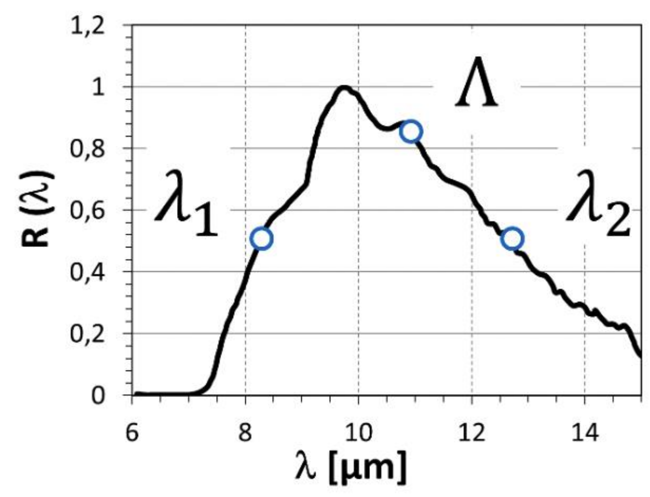
Camera features

FLIR A325sc (data sheet)	
Detector type	Uncooled microbolometer
Detector technology	Vanadium Oxyde VOx
Spectral range	7.5 - 13.0 µm
Resolution Pels	320 x 240
Detector pitch	25 µm

$$L_{\Delta\lambda}(T) = \frac{A}{exp\left(\frac{B}{T}\right) - C}$$

Temperature range	A	B	C
	OS	K^{-1}	_
[-20°C - 120°C]	14861,6	1395,6	1,0
[0°C - 350°C]	17019,3	1436,3	1,0

Spectral Response R(λ)			[-20°C - 120°C]	[0°C - 350°C]
Central wavelength	Λ	[µm]	10,93	
Gaussian ratio			0,507	
Gaussian Spectral band	λ_1	[µm]	8,28	
	λ_2	[µm]	12,72	
Metrological Spectral band	λ_1	[µm]	8.1(8) ± 6	8.0(4) ± 6
	λ_2	[µm]	13.0(0) ± 1	12.8(8) ± 2



Black body

We used the Fluke 9100s thermometer calibrator. This commercial device was chosen because of its temperature range [35°C - 375°C], its inter-cavity uniformity (0.07°C @ 50°C) and its accuracy of ±0.25°C @ 50°C.

Fig. 1. *Fluke 9100s Thermometer Calibrator*

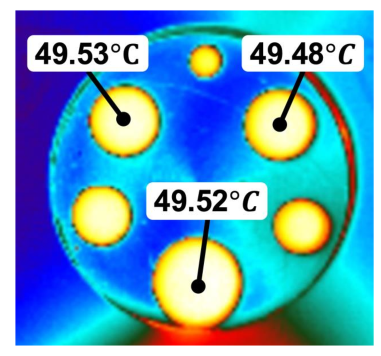


Fig. 2. *Apparent temperature of painted cavities (black body set at 50°C)*

Cavity index	# 1	# 2	# 3	# 4	# 5	# 6
Diameter Φ [mm]	1,6	3,2	4	4,8	4,8	6,4
d /(D x IFOV)	3,2	6,4	8,0	9,6	9,6	12,8
Average apparent emissivity	**0,962**	**0,973**	**0,984**	**0,988**	**0,987**	**0,988**
Reproducibility	0,004	0,005	0,007	0,005	0,006	0,006
Repeatability	0,002	0,002	0,002	0,002	0,002	0,002
Accuracy	0,004	0,005	0,004	0,004	0,004	0,004
Combined uncertainty	**0,006**	**0,007**	**0,008**	**0,007**	**0,008**	**0,008**

- Apparent emissivity of cavities is improved by coating wells using graphite based paint.
- Cavities with a size larger than 9 IFOV offer high apparent emissivity.

Thermal drift problem

In our activities, we noticed a non-repetitiveness of the temperatures detected by the thermal camera FLIR A325sc as a function of the ambient temperature.

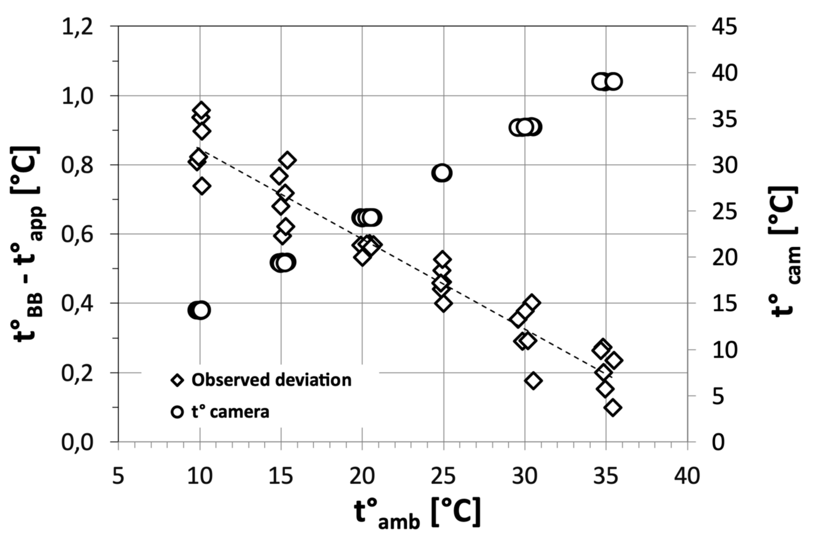


Fig. 3. *Observed deviations of $t°_{BB} - t°_{app}$ and $t°_{cam}$, versus $t°_{amb}$*

- In normal use, the camera temperature varies linearly with the ambient temperature.
- We observe an underestimation of apparent temperature about 1°C $@t°_{BB} = 50°C$ when the ambient temperature varies within [10°C-35°C].

Cold box

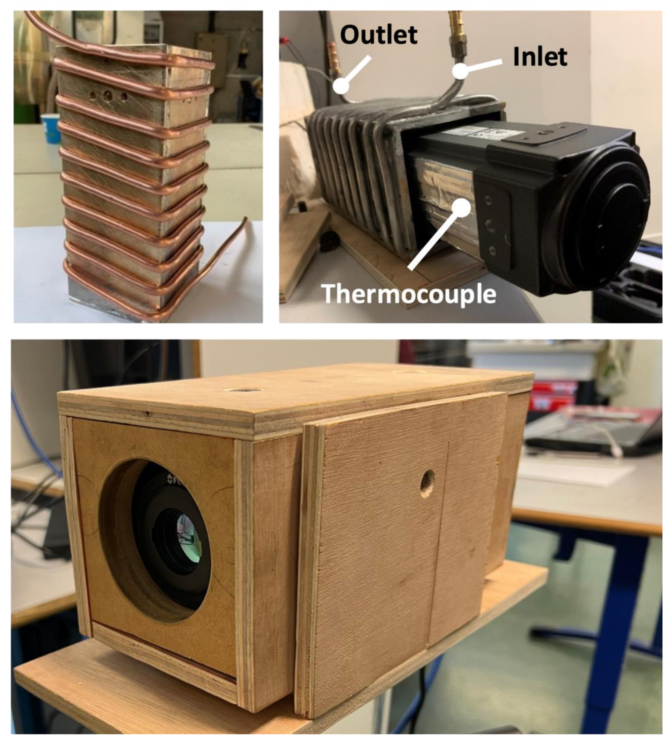


Fig. 4. *Cold box. A thermocouple indicates the temperature of camera housing*

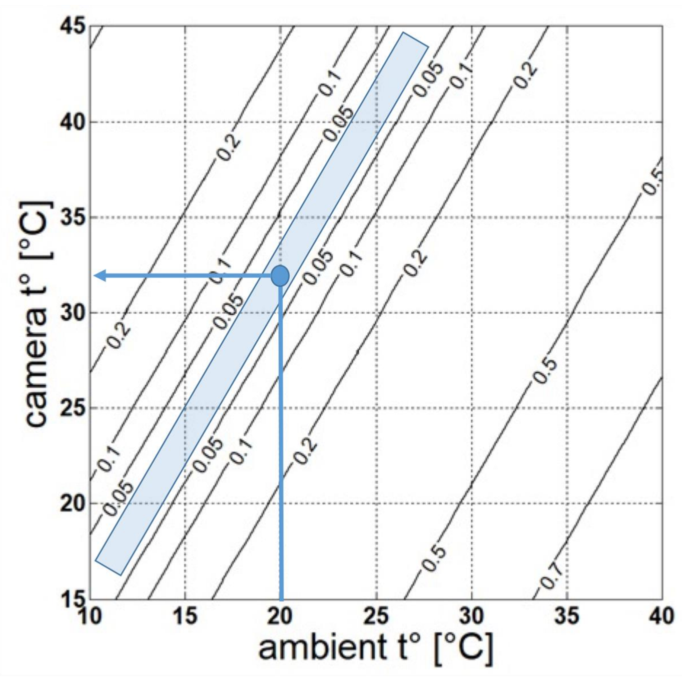
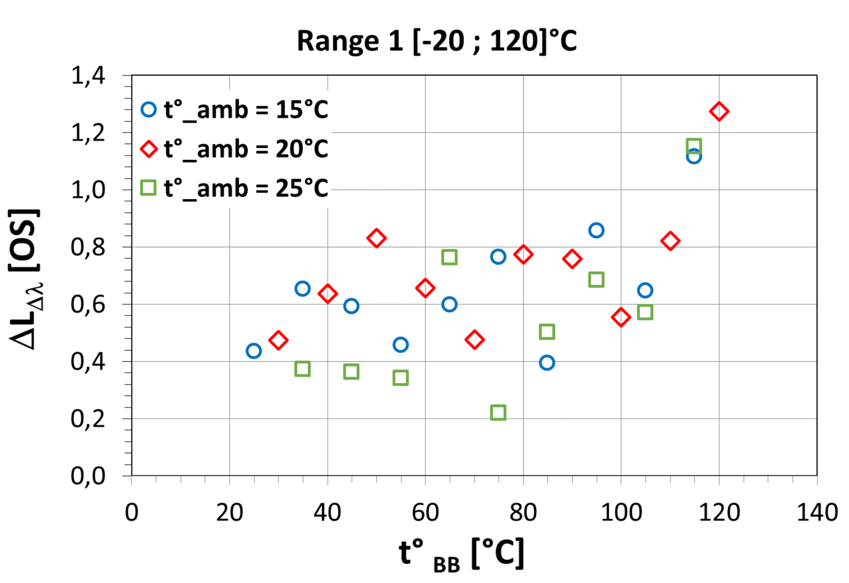


Fig. 5. *Error chart. Observed deviations $t°_{BB} - t°_{app}$ versus $(t°_{amb}, t°_{cam})$. $t°_{BB}$ is set to 50°C*

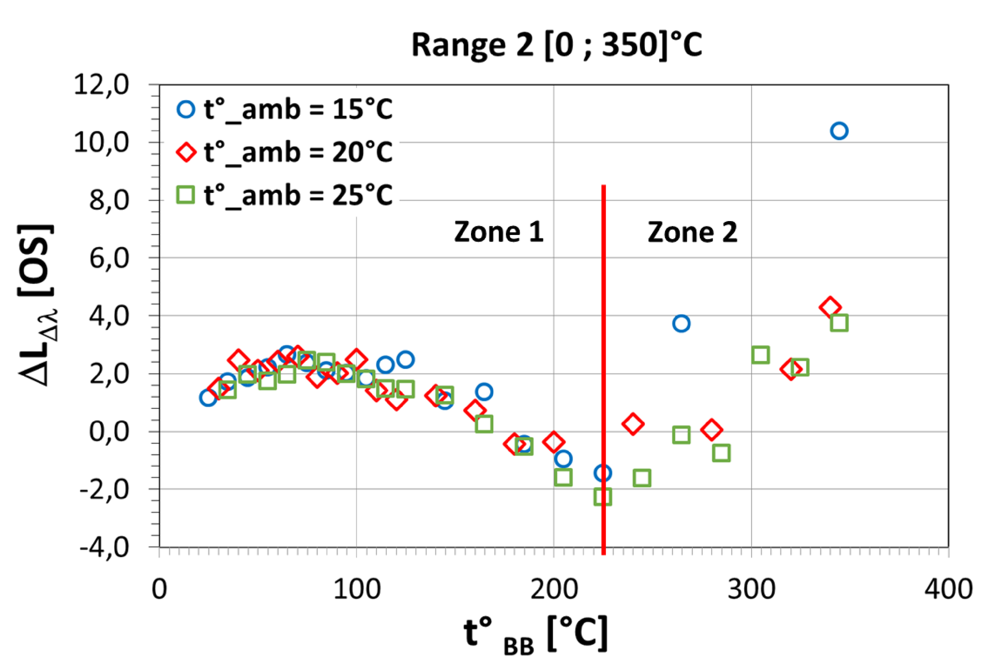
Thermal drift management

We verify the accuracy of the camera calibration within its two functional ranges : range 1: $[-20; 120]°C$ and range 2: $[0; 350]°C$.



t° amb °C	offset OS	offset °C	mae OS	mae °C
15°C	0,6	**0,20**	0,1	**0,04**
20°C	0,7	**0,22**	0,1	**0,03**
25°C	0,5	**0,15**	0,2	**0,03**

Table 1*. Analysis of deviations within range 1*



- Observed deviations within [20 – 110] °C are regular in range 1. The offset shown in table are in same order of magnitude of black body temperature uncertainty (±0.25°C). It means that the camera can be considered as calibrated over the range [20 – 110] °C. Thermal drift is well managed.
- Within range 2, deviations are consequent (2.5 $OS \equiv 1°C$ @ $60°C$) and exhibit an inflection at approximatively 225°C, denoting two different behaviors (**zone 1** and **zone 2**). 225°C correspond to a Wien wavelength (5,8 µm) for which the camera lens becomes progressively opaque.

Within **zone 1**, the thermal compensation is made difficult because of the self-heating of the measurement chain due to the black body irradiance. The cold box is not able to counteract this phenomenon because it thermalizes only the housing.

Within **zone 2**, compensation of thermal drift takes over. However, it is not enough to counteract the self-heating of the lens becoming more absorbent. The thermal drift is reversed with a very marked slope.

This effect can be avoided during calibration process (short exposure) but not during measuring situation for which the camera is continuously irradiated.

Conclusion

We checked the calibration of the FLIR A325sc camera. The latter is found calibrated for the range 1 [20- 110] °C. Analysis of range 2 [0-350] °C highlights two major behaviors: **1.** below 225°C, the thermal drift compensation is made difficult because of the self-heating of the measurement chain due to high intensity of black body irradiance and **2.** as the optics of the camera screens the irradiance, the compensation takes over. It is not enough to counteract the self-heating of the lens becoming more absorbent. This effect can't be avoided during measuring situation for which the camera is continuously irradiated. As these effects are systematic, corrections of object's thermosignal are possible.