

# ATMOSPHERIC CORRECTIONS OF LOW ALTITUDE THERMAL INFRARED AIRBORNE IMAGES ACQUIRED OVER A TROPICAL CROPPED AREA

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## 1. INTRODUCTION

This study focuses on simple atmospheric corrections of airborne thermal infrared imagery for precision farming management in tropical areas.

Surface temperature of canopy is known to be strongly related with the water status of the crop and is widely used for development of water deficit indices ([2], [5]). Several factors affect the thermal infrared response of a vegetative canopy as its temperature is both determined by external environmental factors and by internal plant factors ([1]).

The availability of bolometric cameras at affordable price used in combination with ultralight aircraft or unmanned aerial vehicle pave the way for new water stress survey methods in precision farming applications.

When remotely sensed, the thermal infrared signal emitted by the crop has to be corrected for atmospheric effects ([4]). This correction can be calculated using radiative transfer models and need accurate measurements of many parameters at different layers between the target and the sensor as the temperature, pressure, and chemical composition of the atmosphere in aerosols and molecular gazes ([3]). But these atmospheric parameters need radiosoundings profiles with complex sensors and are more often unavailable. Moreover, in tropical zones, changes of low-altitude atmospheric conditions can occur rapidly and near real-time parameters should be taken into account for a good estimation of the atmospheric effect in the temperature measurement.

This paper presents a simple method to estimate approximately the transfer function that corrects the atmosphere effect on the thermal measurement using on board cost effective sensors. This empirical method assumes that the thermal signal measured by the camera is a mix of an attenuated part of the emitted signal from the crop and the own particular atmospheric signal. The proportions in this mix are derived from on-board atmosphere temperature and relative humidity measurements. Assessment of this method is made using two approaches: comparing to truth-ground acquisitions, and using an atmospheric radiative transfer model software.

The experiment was conducted in Reunion Island (a French tropical overseas department located in the Indian Ocean), over sugarcane fields during 5 month in 2007

## 2. DATA ACQUISITION

Airborne and ground acquisitions have been done twice a month around mid-day in order to obtain a large contrast of temperature between cold and hot parts of the observed site.

### 2.1. The airborne acquisition system

The airborne acquisition system consisted of an Ultra Light Aircraft equipped with a B20 HSV FLIR micro-bolometer thermal infrared camera. The radiance, detected over the 7.5 – 13  $\mu\text{m}$  spectral interval, is expressed in temperature, assuming a target emissivity of 1. The system provides 240 pixel x 320 pixel images with a radiometric resolution of 0.1°C and an absolute precision of 2°C.

To achieve the meteorological and location measurements, a temperature and relative humidity probe coupled to a data logger were loaded in the Ultra-Light Aircraft, as well as a GPS that recorded the altitude and position during the flight. These measurements are used to generate a temperature and relative humidity profile functions of altitude.

Images were taken from 300 m to 1300 m in order to study the sensitivity of the signal to atmospheric transmissivity. Furthermore, the study campaign took place from may to September 2007 that allows acquisition of a wide range of sky conditions because of season effects which are very important in terms of humidity and temperature.

### 2.1. Ground acquisition

Ground data were acquired simultaneously with airborne acquisitions on a cold (sugarcane canopy), hot (dark tissue) and intermediate (grassy road) targets using a hand-held infrared thermometer HEITRONICS KT19 (Fig1.a.). Due to the height of the sugarcane, this thermometer was mounted on a mast for vertical acquisitions over the canopy to avoid angular variation between airborne and in situ measurements.

In-situ meteorological factors (air temperature, relative humidity) were also collected using the same probe as the one previously mentioned.

### 3. DATA ANALYSIS AND RESULTS

First of all we tried to relate with a linear function the ground thermal infrared measurements with the airborne thermal images. Thus the mean temperature of each target was calculated in the image data set and compared with ground-truth measurements.

The linear regression shows (see example in Fig1.b) a variable slope decreasing with the altitude, linked to the attenuation of ground signal (hotter than the atmosphere). On the contrary, the constant term increases with the altitude, linked with the atmospheric signal proportion. For measured temperatures closer to air temperature, altitude effects are lower as can be seen in Fig1.b for cold targets (surrounded with blue color).

Same kind of relation is observed for the other acquisition dates. Thus, to calculate an estimation of the regression parameters, to allowing the retrieval of the ground temperature, it could be sufficient to acquire reference images at different altitudes.

To go further, we try to establish a more precise function between ground and airborne temperature measurement using sensors data. First results in the data analysis seem to give a major weight to the atmosphere temperature in the profile. Different simulations using an atmospheric radiative transfer model software are currently in process in order to assess these assumptions.

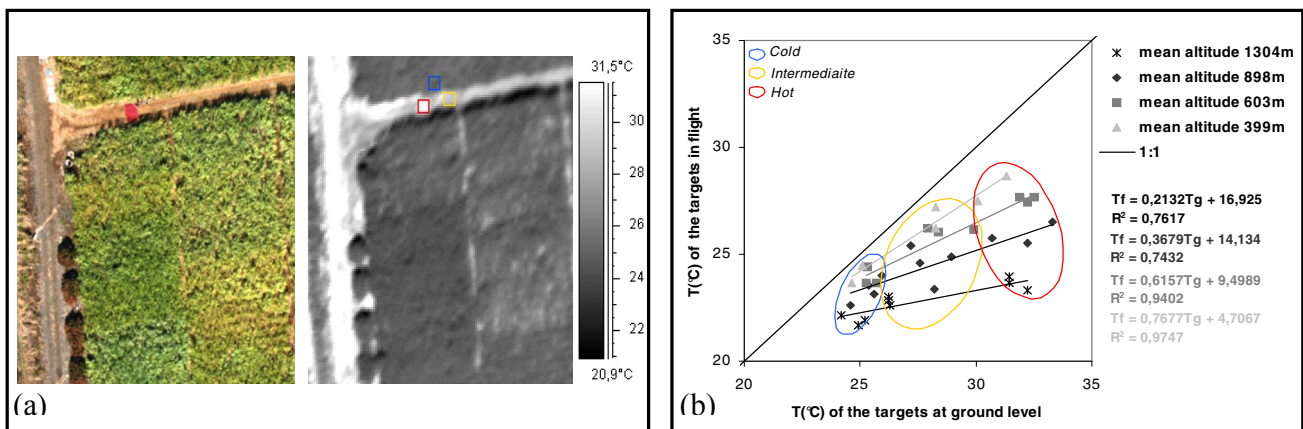


Fig1.: (a) Location of the targets on a visible (left) and thermal infrared image (right). Targets are surrounded in red (hot), yellow (intermediate) and blue (cold) color. (b) Relation between ground (Tg) and airborne temperature (Tf) measurements acquired on 27th July 2007 at different altitudes. Coloured circles indicate the type of target.

### 4. CONCLUSION

Results show that a simple approach based on combined use of ground and airborne data, or airborne data at different altitude can provide a good transfer function for correction of atmospheric effects. This simplifies the use of thermal imagery for water stress application in precision farming. Further analyses try to establish more precise algorithms using on-board temperature and humidity measurements.

### REFERENCES

- [1] P. Boissard, G. Guyot, and al., "Factors affecting the radiative temperature of a vegetative canopy," *Applications of remote sensing in agriculture*, pp. 45-72, 1990.
- [2] R. D. Jackson, S. B. Idso, and al., "Canopy temperature as a crop water stress indicator," *Water Resource Research*, vol. 17, pp. 1133-1138, 1981.
- [3] F. Jacob, F. Petitcolin, T. Schmugge, and al., "Comparison of land surface emissivity and radiometric temperature derived from MODIS and ASTER sensors," *Remote Sensing of Environment*, vol. 90/2, pp. 137-152, 2004.
- [4] J. C. Jimenez-Munoz and J. A. Sobrino, "Error sources on the land surface temperature retrieved from thermal infrared single channel remote sensing data," *International Journal of Remote Sensing*, vol. 27/5-6, pp. 999-1014, 2006.
- [5] M. S. Moran, T. R. Clarke, and al., "Estimating crop water deficit using the relation between surface-air temperature and spectral vegetation index," *Remote Sensing of Environment*, vol. 46/2, pp. 246-263, 1994.