# Small scale surface temperature heterogeneities: effect on the Surface Energy budget

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**BLLAST meeting, Bergen, August 2013**

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## 1. Description of the problem

The surface energy budget (***SEB***), taken as ***Rn-G-H-LE=0 (1)***, is a concept used in many applications
(Rn: net radiation, G: ground flux, H: sensible heat flux, LE: latent heat flux)

However, observations show that ***commonly the budget is not closed***, with errors typically between 5 and 20%, oftentimes even larger.

One of the processes that may be missing is the budget is the contribution of the horizontal heterogeneities, since the SEB as in (1) implicitly assumes homogeneity.

The corresponding term, in W/m2, is ***Adv(T)=ρ Cp Δz (u ΔT/Δx)***

For a ***sea breeze*** (u=5 m/s, ΔT= 5 K, Δx=20000m, Δz=10m) ~***15 W/m2***

For a ***microscale variation*** (u=1 m/s, ΔT= 1 K, Δx=100m, Δz=10m) ~***100 W/m2***

The latter is a very significant quantity: it is worth exploring! ***RPA may help***

## 2. BLLAST: a very convenient framework

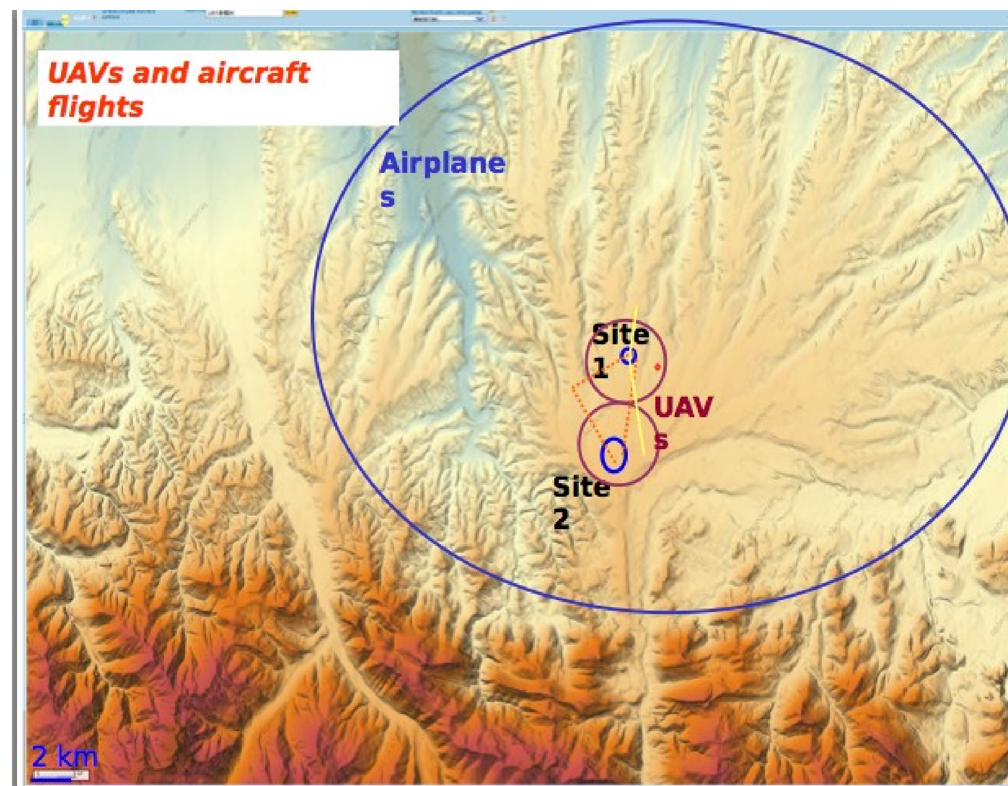
An experiment focused on the late afternoon and sunset transition

Developed in the Lannemezan plateau, at the Northern foothills of the Pyrenees, between 15 June and 8 July 2011.

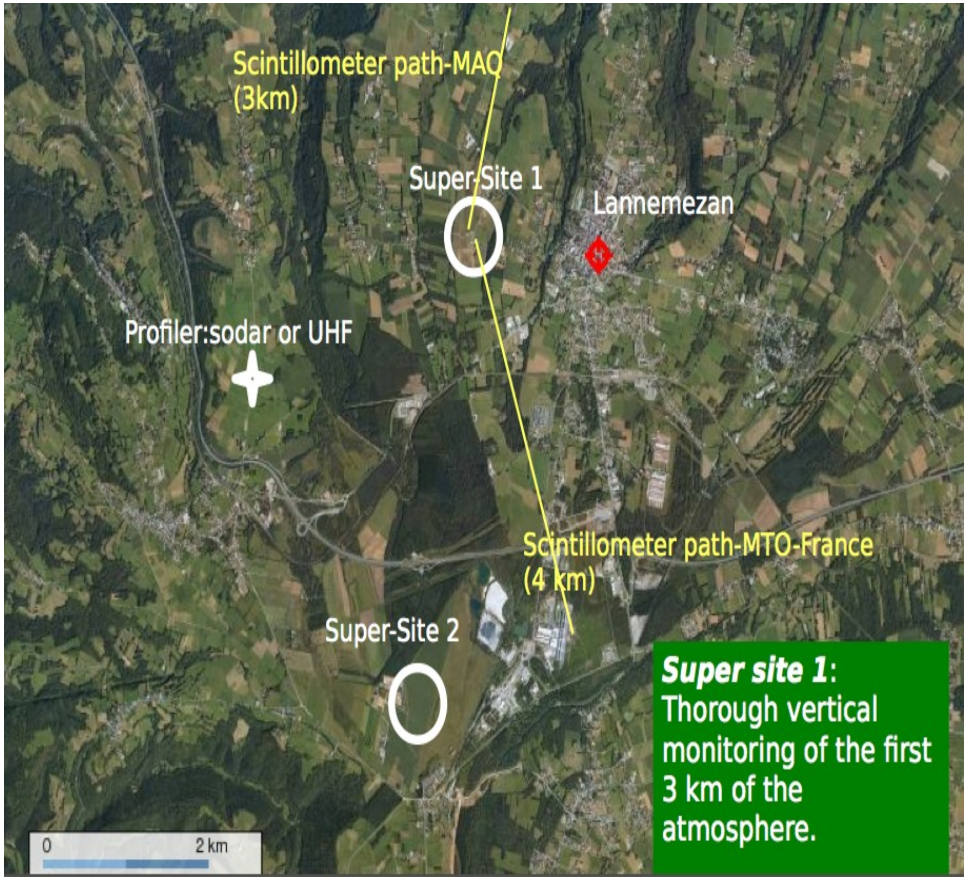
The Centre de Recherches Atmosphériques, hosted the experiment. It provided an instrumented site, a laboratory and leaded the action.

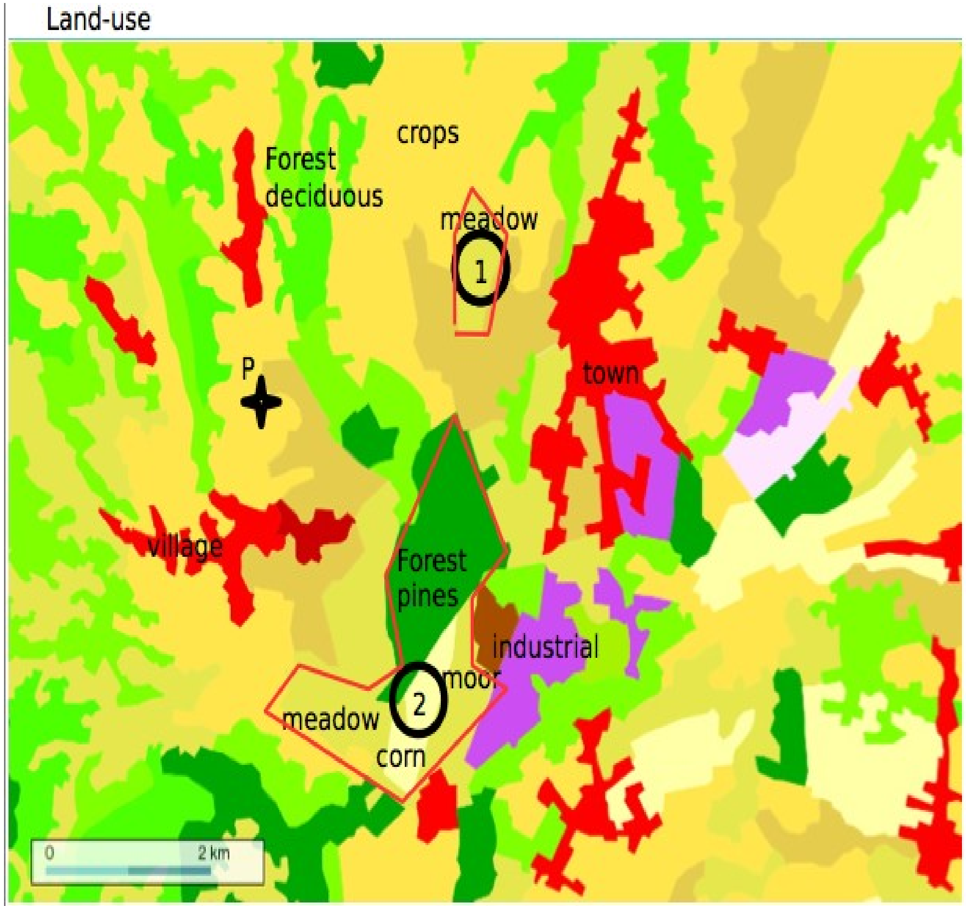
Piloted aircrafts, RPAs, remote sensing, soundings, multiple surface layer stations, tower, ...

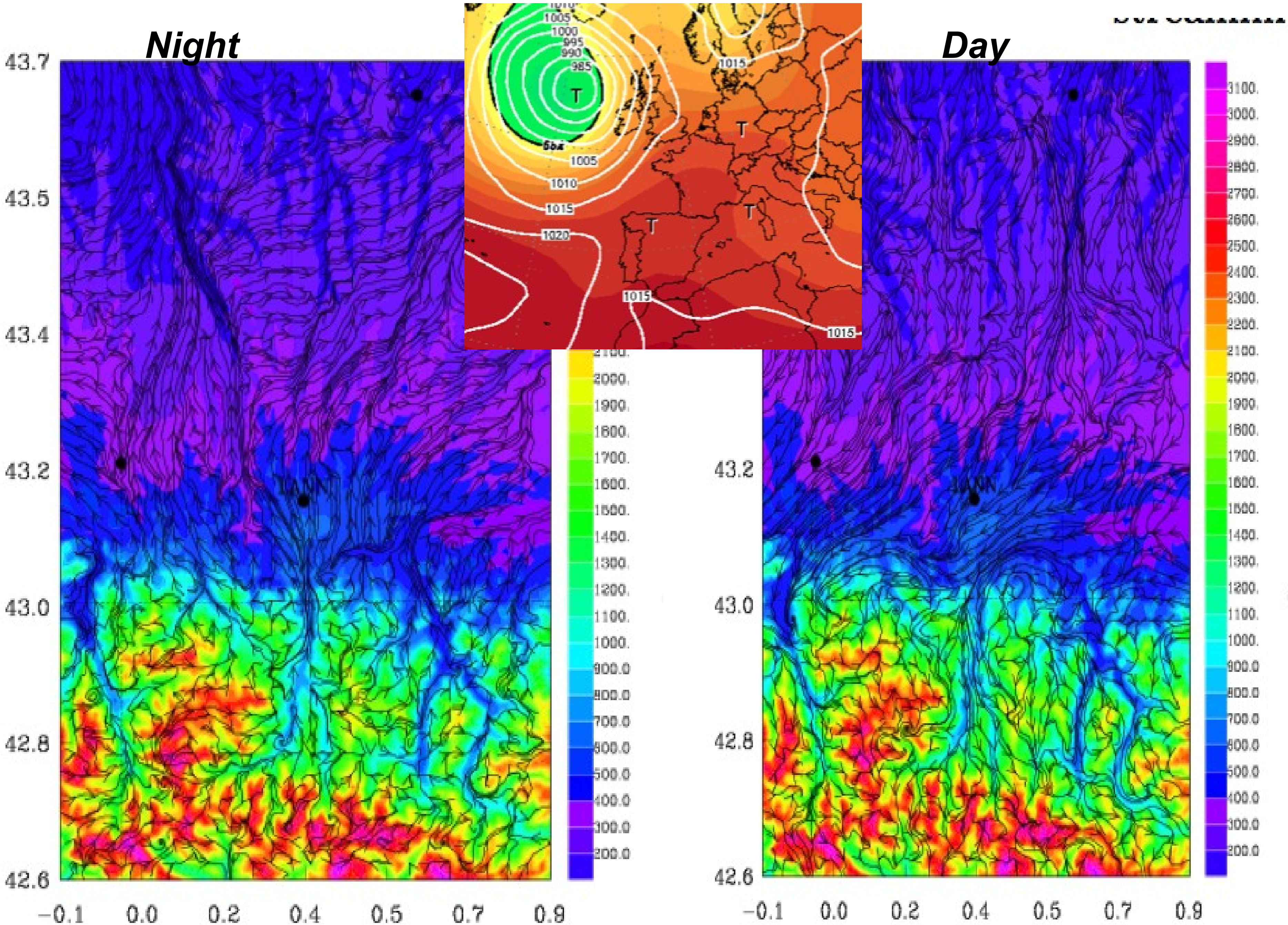
An RPA week linked to COST ES-0802 took place at the beginning of July, with several planes and one multicopter that made tests and contributed to the common effort.

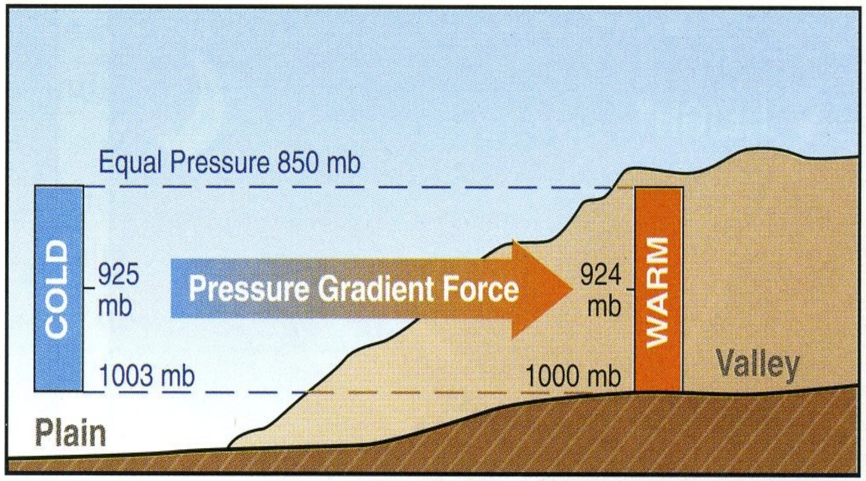


# 3. Meso-beta (20-200 km) and meso-gamma (2-20 km) heterogeneities

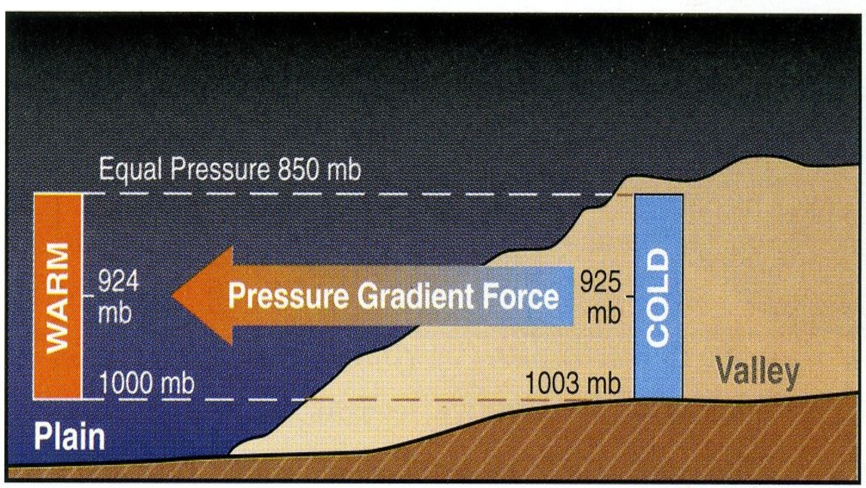


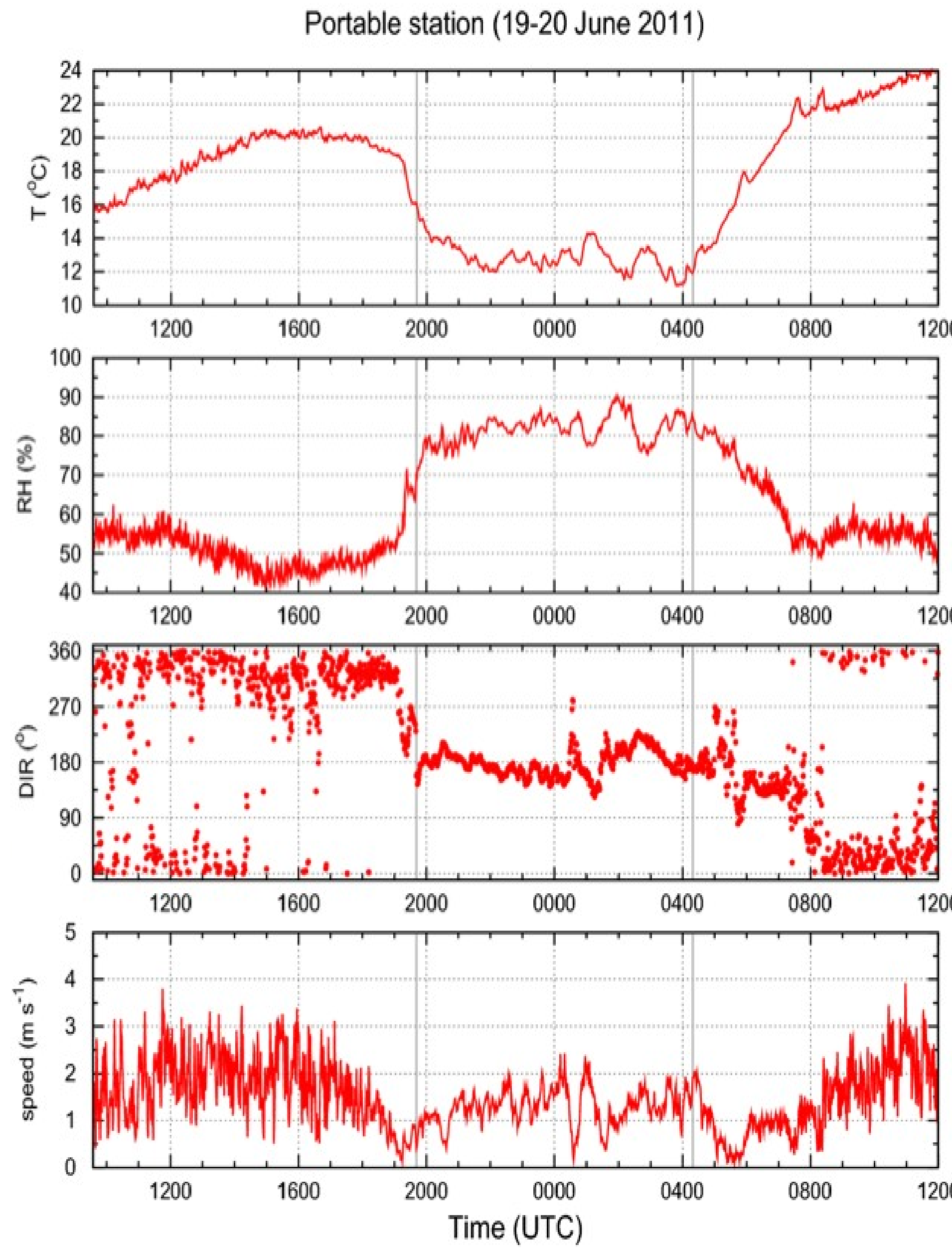

Night
Day




**Daytime**



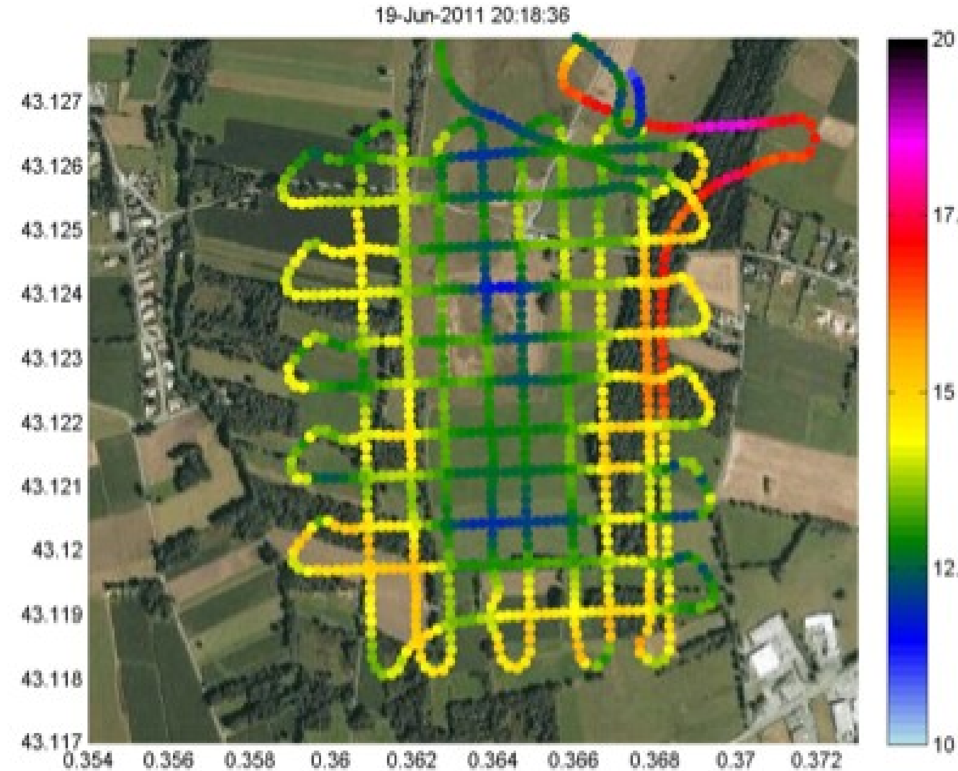

**Nighttime**

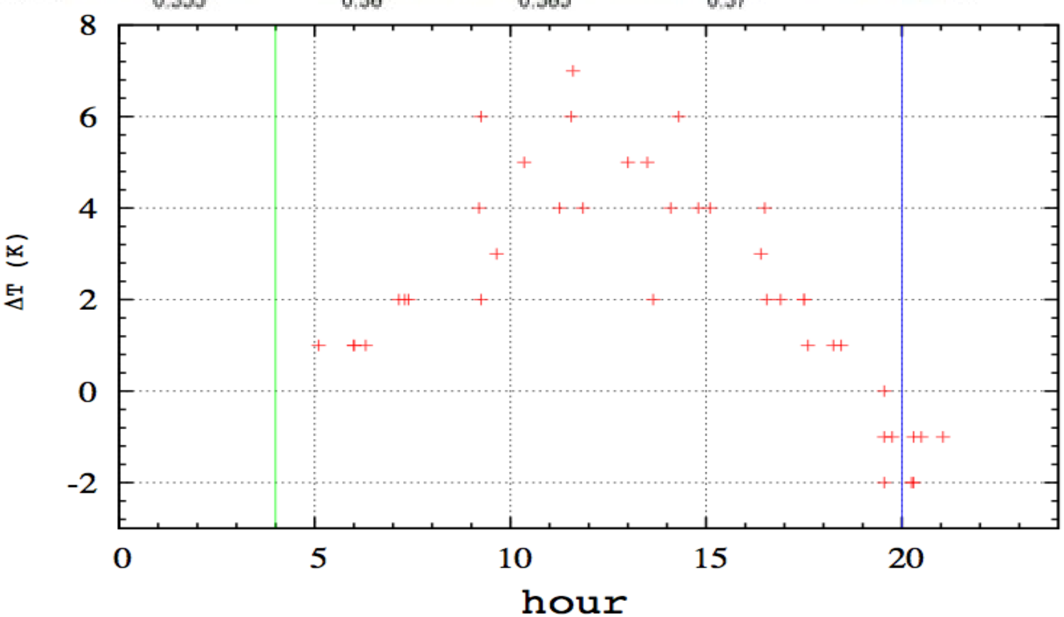


# 4. The hectometer scale: the SSH site. SUMO surveys

**Day**
**(before 17 UTC)**


**Night**
**(after 17 UTC)**



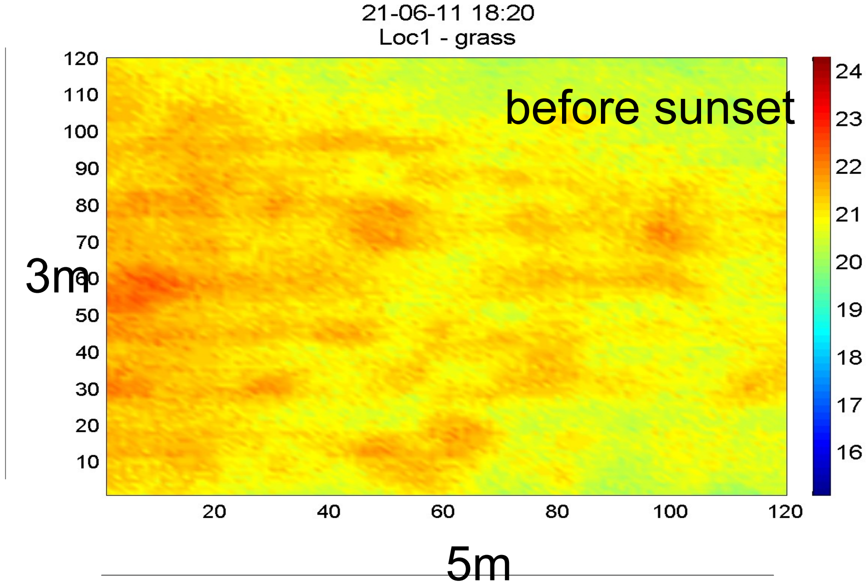

***Adv(T)=ρ Cp Δz (u ΔT/Δx)***

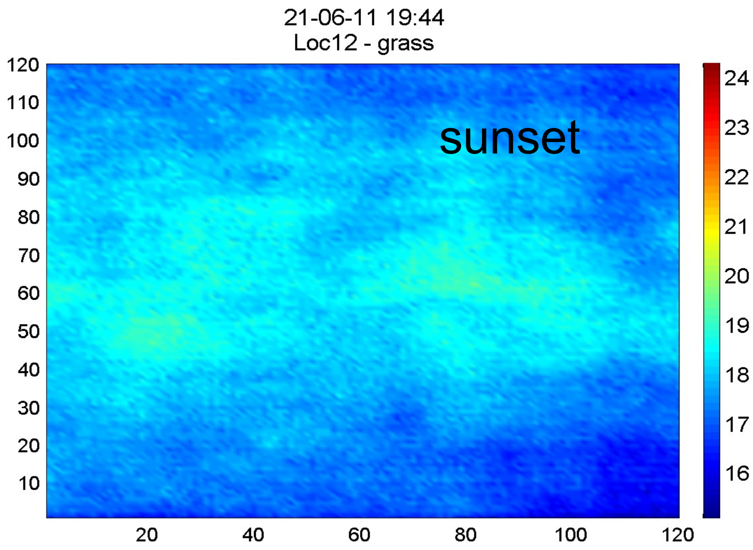
***Morning/evening:***
***u=1m/s, ΔT=1K, Δx=200m***
***Adv(T) ~50 W/m2***

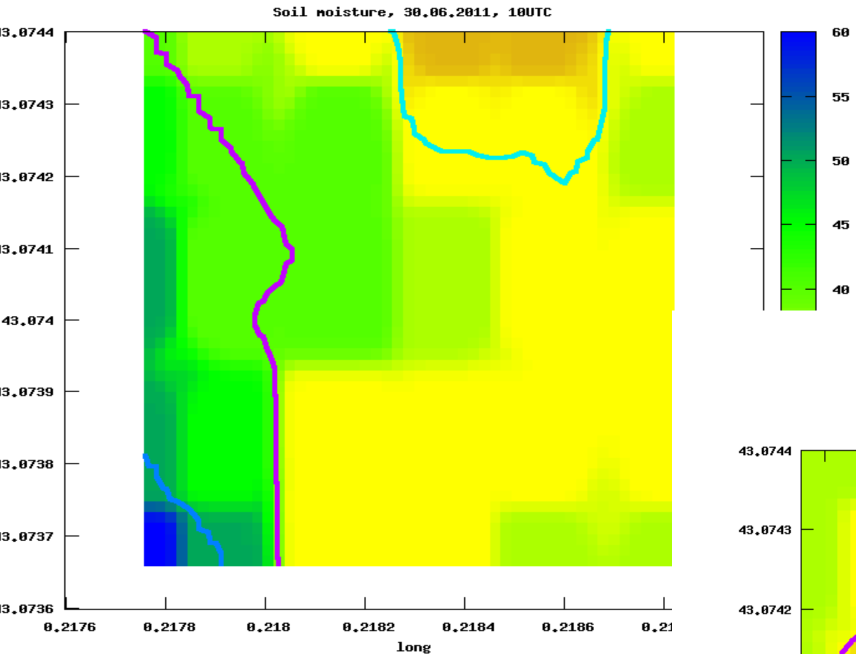
***Noon: 1m/s, ΔT=2K, Δx=200m***
***Adv(T) ~ 100 W/m2***

## 5. The decameter scale

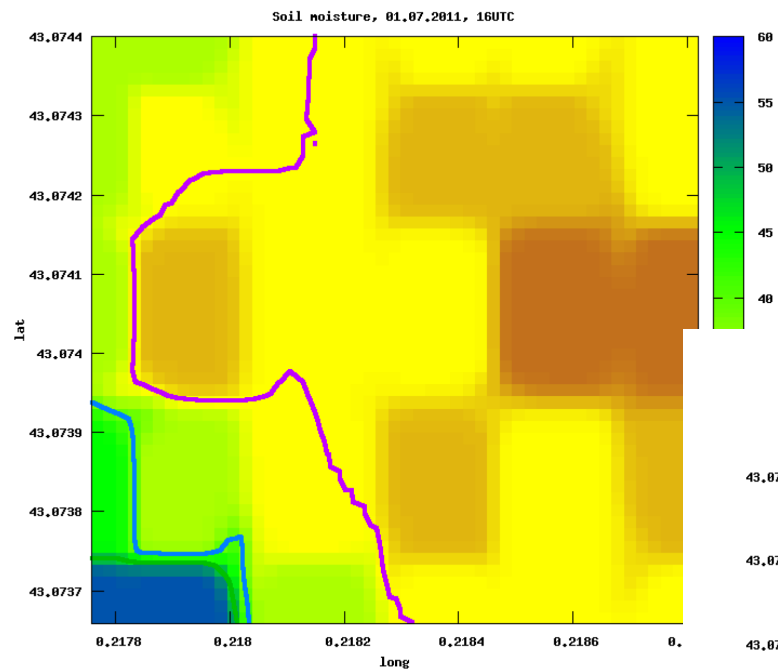
Thermal images from 2m a.g.l.



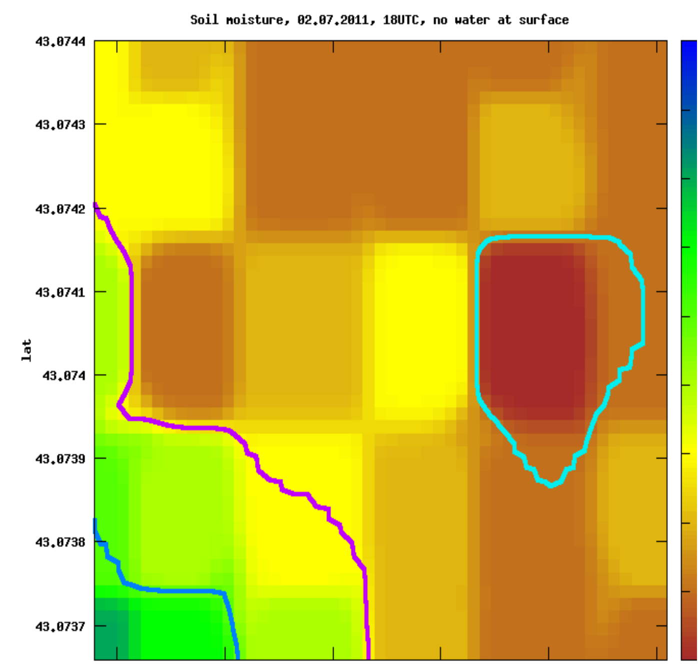



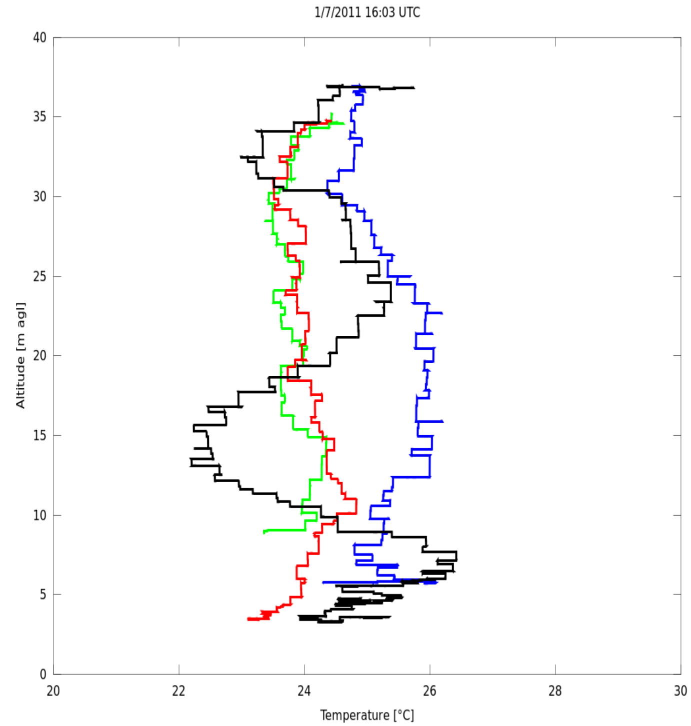

30 June, 1 day after rain

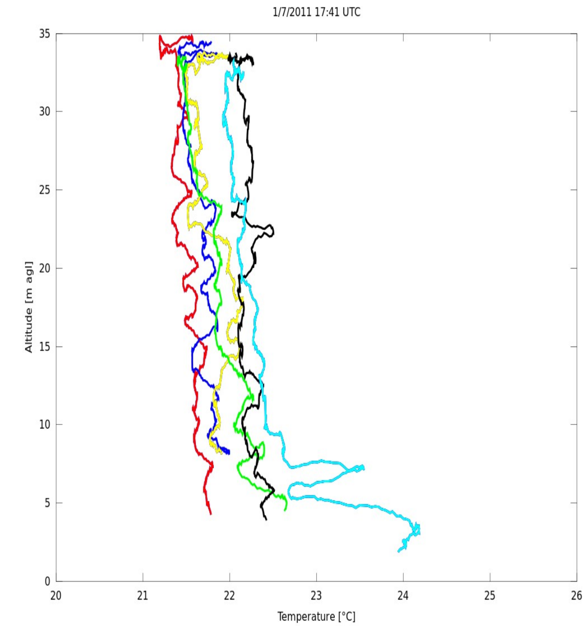



1 July




2 July

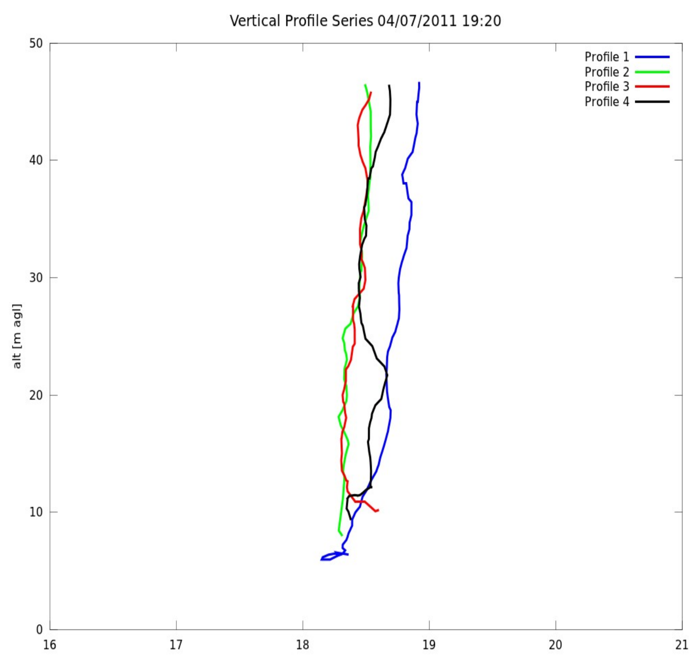



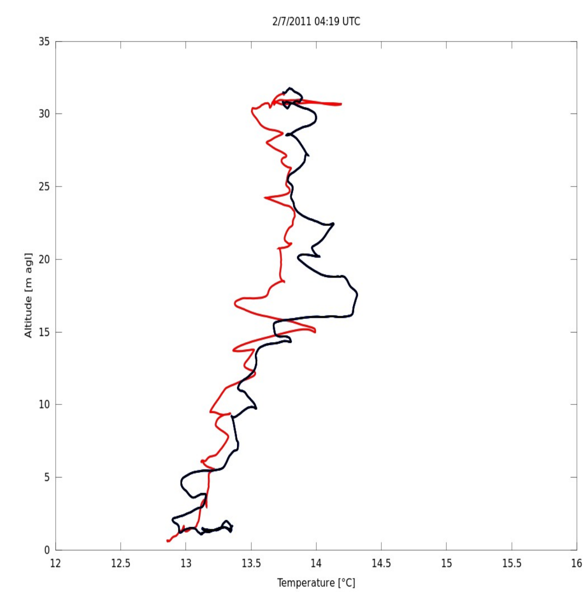

ΔT(16UTC)=1 K

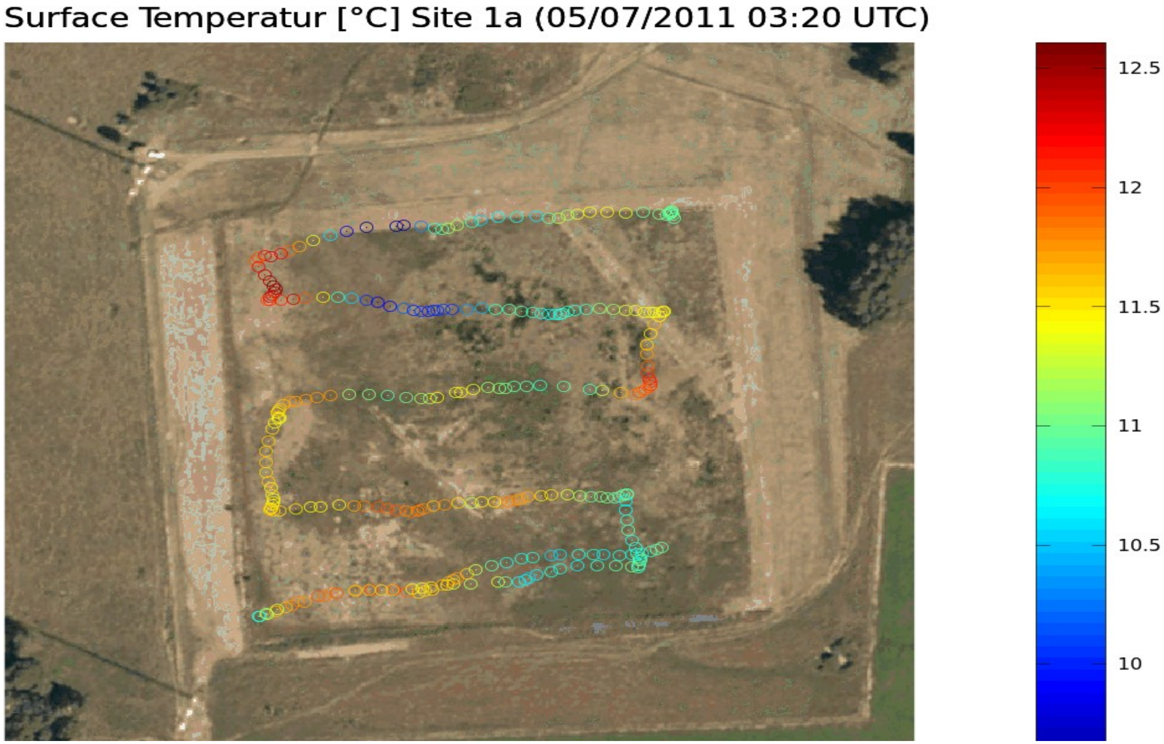
ΔT(1740UTC)=0.5 K

ΔT(1920UTC)=0.2 K

ΔT(0420UTC)=0.1 K







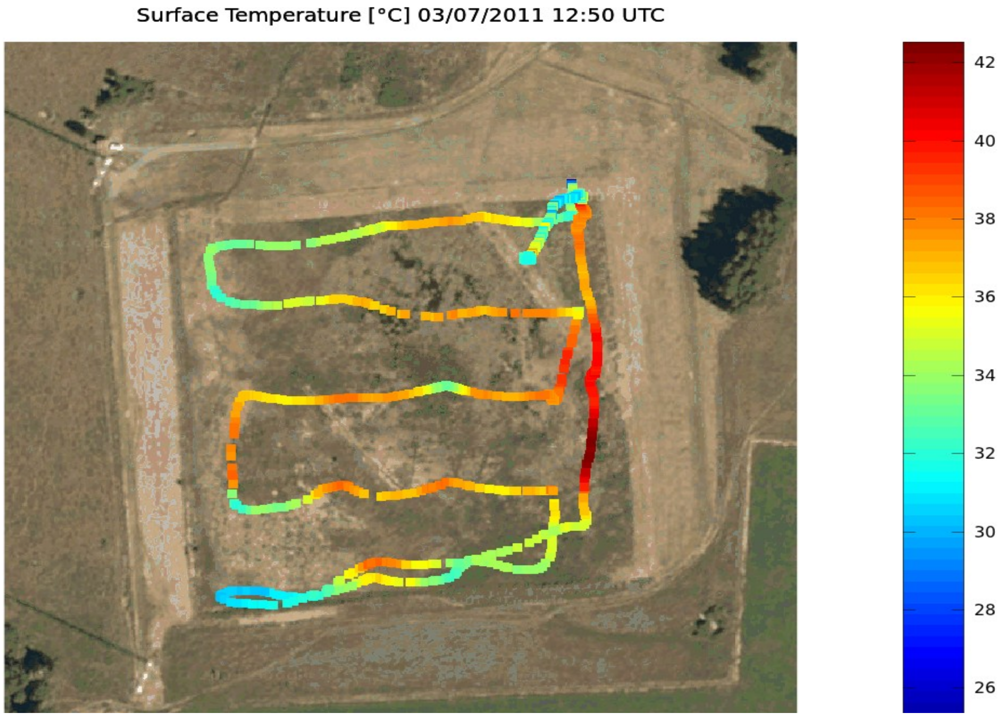
# <u>Multicopter transects</u>

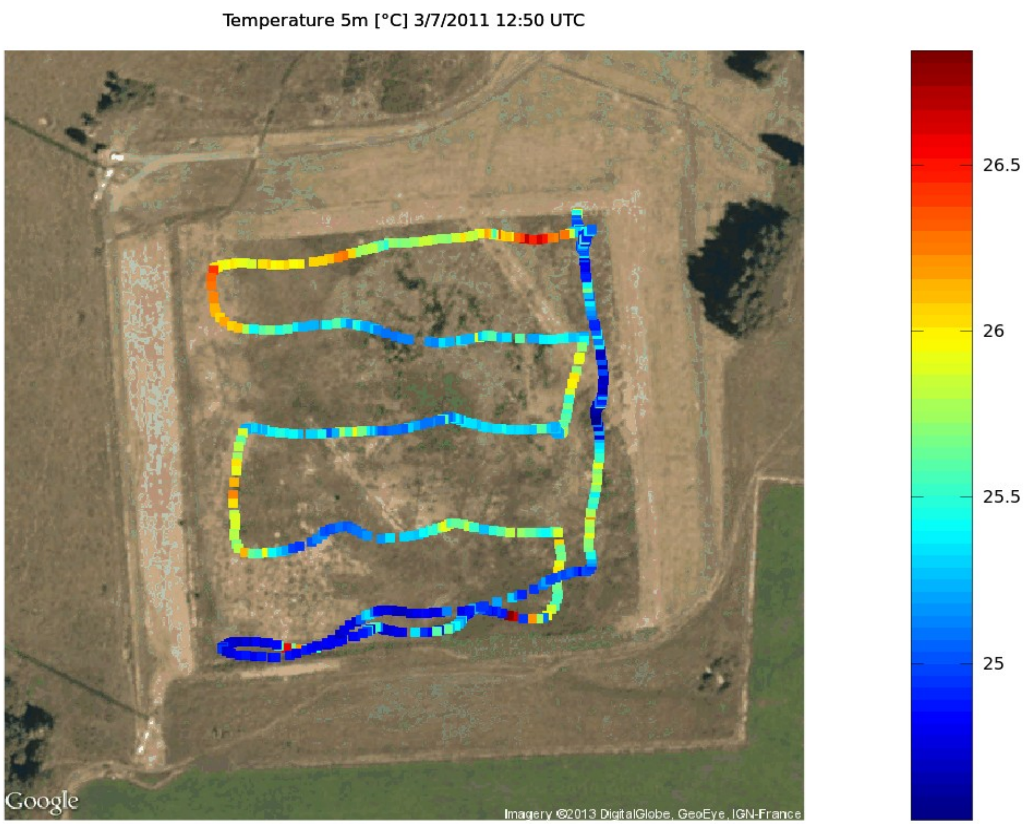
***Late night (1 h before sunrise)***

***Adv(T)=ρ Cp Δz (u ΔT/Δx)***

***Late night:***
***ΔT_surf=3K***
***ΔT_air=0.1K***
***u from south***

***u=0.5 m/s, ΔT=0.1K, Δx=30m***
***Adv(T) ~20 W/m2***




# Multicopter transects

***Center of the day (13 UTC)***

***Adv(T)=ρ Cp Δz (u ΔT/Δx)***

***Midday:***
***ΔT_surf=2K***
***ΔT_air=0.5K***
***u from north***

***u=1 m/s, ΔT=0.5K, Δx=30m***
***Adv(T) ~200 W/m2***

## 6. Perspectives

* RPAs provide a reliable estimation of surface and air thermal heterogenities

* These estimations indicate that microscale advection may be significant if surface heterogeneity patterns exist, especially if they are sustained in time

* It would be advisable to characterize this variability for measuring surface stations

* Natural microscale variability implies that there is an indetermination of the measurement of temperature of the order of 0.5 K

* Different kinds of aircraft are suited for varying heterogeneity scales:
-Piloted for 5-200 km, above 200 m a.g.l,
-RPA (plane) for 0.5-5 km, above 70 m a.g.l.
-Multicopters for 0.01 to 0.5 km, range 0-200 m a.g.l.

## Acknowledgements

* F. Molinos (formerly UIB) and BLLAST Technical team for the support in the field

* Wageningen U. Master students for providing thermal camera images

* COST Action ES-0802 for fostering interaction.

* Funding: Spanish Ministry of Science grants CGL2009-12797-C03-01 and CGL2012-37416.C04-01, supplied by Feder funds.

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