How to evaluate the representativity of reference long-term surface flux measurements in an heterogeneous landscape ?

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INTRODUCTION AND AIMS

An accurate evaluation of land-atmosphere (L-A) exchanges and their representation are needed for weather and climate forecasts. A survey[1] on systematic errors established that the modelling of surface fluxes is the second most important issue, highlighting the importance of improving the representation of the surface atmosphere interactions in the models. Large biases in the models are still pointed out in the representation of surface-atmosphere flux when compared to observations.

The Models and Observation for Surface-Atmosphere Interactions (MOSAI) project (https://mosai.aeris-data.fr/) aims at reducing those biases.

The main objective here corresponds to the first scientific objective of this project and concerns the investigation and determination of the **uncertainty and representativeness of L-A exchanges measured over heterogeneous landscapes** (**Fig. 2**).

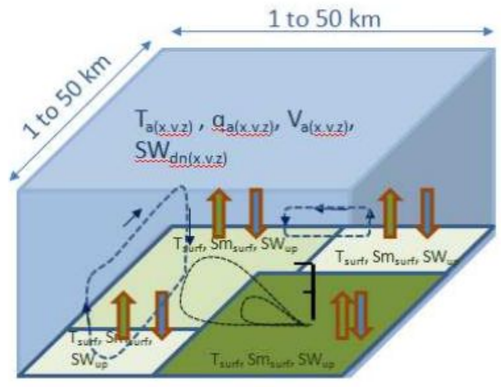


Fig.2: Schematic representation of the first MOSAI project objective

LONG-TERM OBJECTIVES :

- one family of indicators linked to the **surface fluxes measurement errors and bias**
- the other linked to the **horizontal representativeness of the local measured fluxes** in the heterogeneous landscape

STEPS TO THESE OBJECTIVES :

- **definition** of the **surface heterogeneity**
- establishment of a **relationship** between those **heterogeneities** and the **fluxes bias**

THE MÉTÉOPOLE CAMPAIGN

Dedicated field experiments are needed to document the variability of the land-atmosphere exchanges within a grid mesh. To do so, **three ACTRIS-FR** (The Aerosol, Clouds and Trace Gases Research Infrastructure) **sites** (Météopole/Toulouse, SIRTA/Paris, P2OA/close to the Pyrénées) **were instrumented for a one year-field campaign**, with up to six surface patches with different vegetation covers.

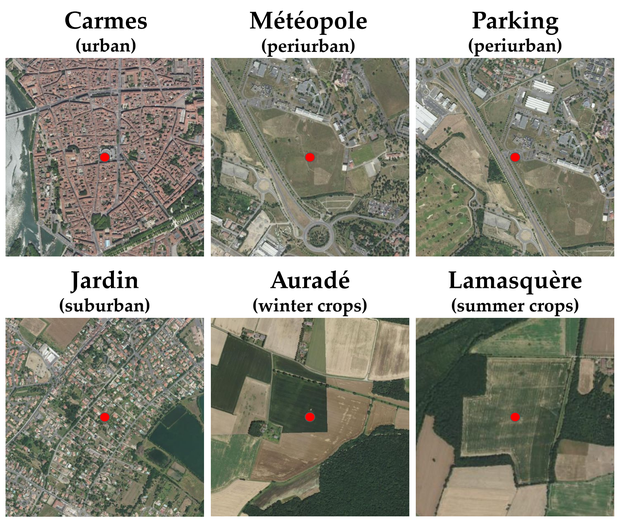
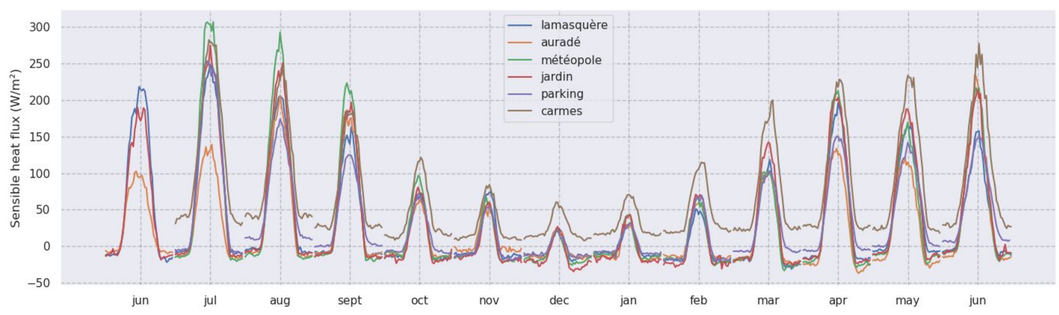


Fig3: Satellite images of the six instrumented sites for the Météopole campaign. The red dots represent the location of the EC station.

The data from the Météopole campaign are used to **develop a methodology that will later be applied to the two other campaigns**.

For this field campaign, six different vegetation covers were instrumented (**Fig. 3**). Those surfaces were chosen according to the high-resolution land-use map created by CESBIO, in order to measure L-A exchanges **(Fig.4)** over the main surfaces in the landscape at a grid-mesh scale.

Fig.4: Composite diurnal cycle of sensible heat flux for the six different observation sites instrumented during the Météopole campaign



SURFACE HETEROGENEITY INDICATORS

• Local spatial variability of the flux :

An **object identification algorithm** (Najda Villefranque, thesis) (**Fig.5**) was applied to land-use maps (CESBIO) to identify and characterise the different surface patches (**Fig.6**). For a 1x1km² grid-mesh, 90% of the surface is represented by patches larger than 41m.

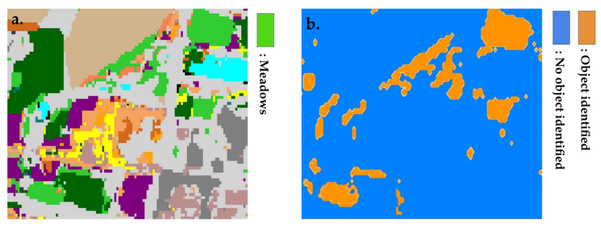


Fig.5: Example of object identification (1x1km² grid-mesh)

This arrangement corresponds to the "unstructured heterogeneity" defined by Bou-Zeid[2] (poorly studied but most realistic case).

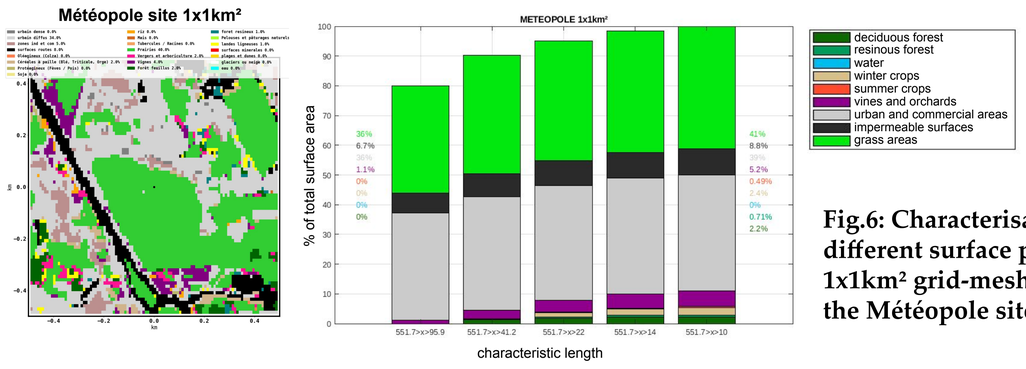


Fig.6: Characterisation of the different surface patches at a 1x1km² grid-mesh scale for the Météopole site

The local spatial variability of the flux is then defined using **two different standard deviations** : a classical one associated to the area of a 10x10m² pixel (pixel method), and a second one considering the surface of the identified object (object method) (**Fig.7**).

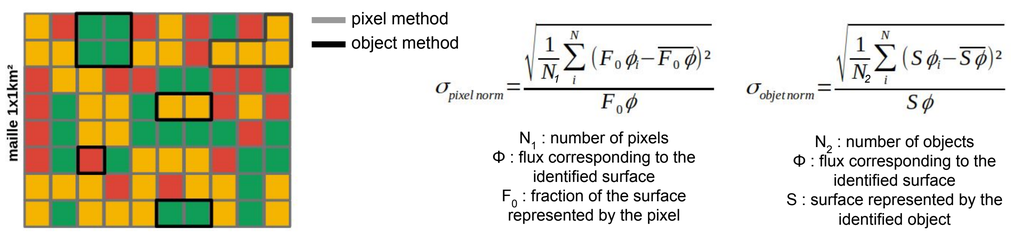


Fig.7: Definition of the two local spatial variability of the flux

• Flux footprint :

We use a simple two-dimensional parameterisation for the Flux Footprint Prediction[3] and the use-land maps to estimate the **surface source areas and their contribution to the measured fluxes (Fig.8)**.

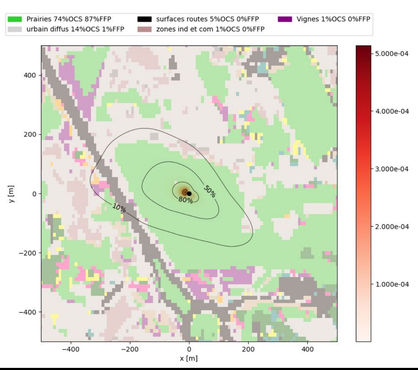


Fig.8: Flux footprint from july to september 2020 at the Météopole site

NON-CLOSURE AND HETEROGENEITY

Many recent studies have focused on the SEB non-closure issue that turned out to be multifactorial[4,5]. Surface heterogeneity is one of these factors and therefore, we investigate the **potential existence of a relationship between the non-closure of the SEB and the heterogeneity of the surface** using the two heterogeneity indicators previously defined for the **Météopole instrumented site**.

Normalized SEB non-closure = $\frac{Rnet - (H + LE + G)}{Rnet}$

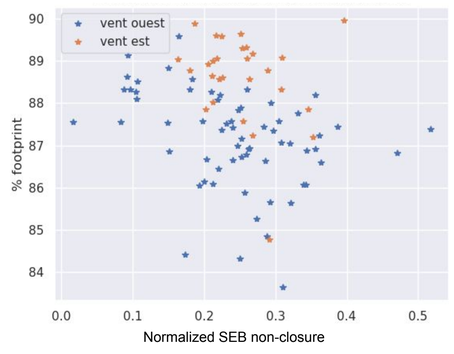


Fig.9: % of the grass areas in the Météopole site footprint as a function of normalized SEB non-closure from july to september 2020. Daily average for Rnet>50W/m².

TAKE HOME MESSAGE

- a **larger footprint** seems to be associated to a **better closure of the SEB** (expected)
- **larger SEB non-closure** observed for **larger local spatial variability of the H flux** (to be confirmed)
- no obvious conclusion for the LE flux

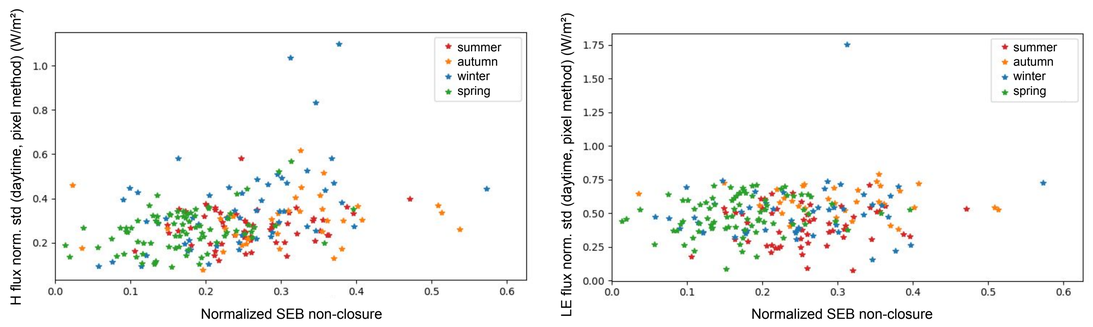


Fig.10: H flux (left) and LE flux (right) normalized standard deviation as a function of the normalized SEB non-closure for the Météopole site for a 1x1km² grid-mesh. Each point represents a daily average for Rnet>50W/m². The whole year of campaign is represented here.

PERSPECTIVES :

- repeat this study considering the **stability of the atmosphere**
- apply it on the **other stations** of the Météopole campaign
- studying the **horizontal representativeness of these fluxes** in the heterogeneous landscape

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[4] **Mauder, M., Foken, T. & Cuxart, J.** *Surface-Energy-Balance Closure over Land: A Review. Boundary-Layer Meteorol* **177**, 395–426 (2020). https://doi.org/10.1007

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