Large Aperture Scintillometer measurements above a large green roof to assess the evapotranspiration flux

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EGU General Assembly 2020

INTRODUCTION

The promotion of Blue and Green Solutions (BGS) like green roofs to regulate urban microclimate, encourage the study of their thermal and physical behaviour. Different methods to characterize the ET flux during the summer were carried out on the Blue Green Wave (BGW), an extensive green roof located in Champs-Sur-Marne (France).

The objective of this research is to analyse the surface energy balance (SEB) method that deduces the latent heat, from the measurements of sensible heat flux by scintillation.

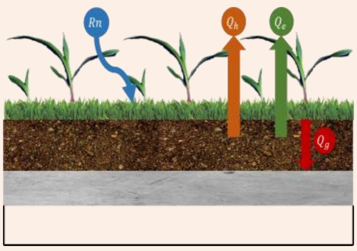
EVAPOTRANSPIRATION CHAMBER

$$Qe = 10^{-3}\lambda h \frac{\Delta\rho v}{\Delta t}$$

Q_e from SEB was compared with a direct method of measurement: the absolute humidity by a dynamic evapotranspiration chamber.

SURFACE ENERGY BALANCE

$$Q_e = Rn - Q_h - Q_g$$



- Rn — Net radiation: Solar and longwave radiation — CNR4
- Q_h — Sensible heat flux — LAS
- Q_g — Soil heat flux — Fourier's Law
- Q_e — Latent heat flux

LAS Setting	Value
Path length L [m]	100
Effective height LAS [m]	2.229
Zero displacement height [m]	0
Surface roughness [m]	0.25

*LAS: Large Aperture Scintillometer

SENSITIVITY ANALYSIS

The influence of the BGW vegetation height (h), soil thermal conductivity (k) and meteorological variables (pressure P, wind velocity U, wind direction WD, relative humidity RH) on the iterative process calculus of Qh was studied by a Latin Hypercube Sampling (LHS) method.

RESULTS

- Cloudy conditions result in multiple abrupt peaks of Cn_2 compared to sunny and clear days (Fig 1).
- In most cases, incoming energy (Rn) on the BGW is mainly transformed in Q_e (53%), followed by Q_h (43%) and Q_g (Fig 2).
- Low estimations of Q_g demonstrated poor heat conduction on the BGW soil.

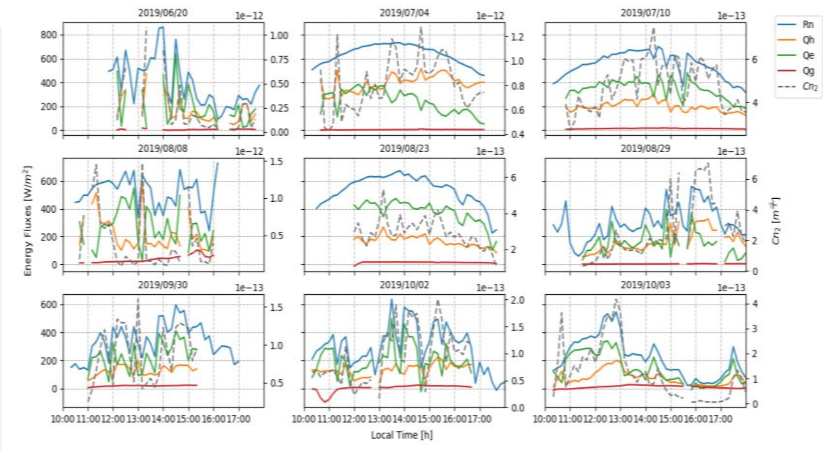


Fig 1. BGW Energy Balance

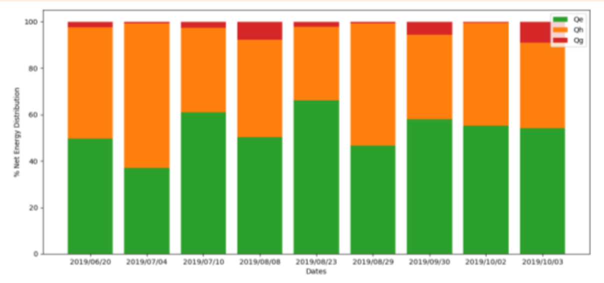


Fig 2. % Net Energy distribution SEB.

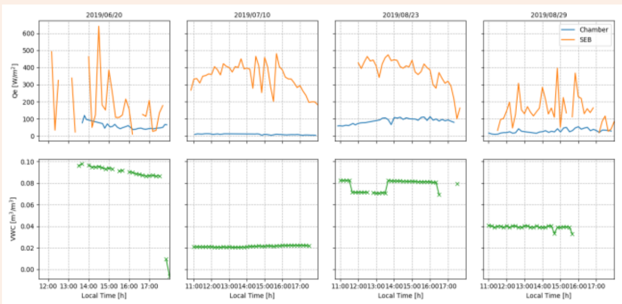


Fig 3. Qe, air temperature and Volumetric water content of the soil (VWC)

- Q_e rates measured from SEB were much larger than the ET chamber (Fig 4).
- Higher soil water content levels favours Q_e. This was reflected on the larger rates of Q_e measured with ET chamber (Fig 4).
- Sensitivity analysis results (Pearson correlation coefficient) proved that Q_h has a significant correlation with air temperature (0.68) and wind velocity (0.35). Meanwhile Q_e is highly correlated to Rn (0.76).

Fig 4. Pearson Correlation Coefficient

CONCLUSIONS AND PERPECTIVES

In order to respect SEB, most of the energy on the BGW is translated to Q_e (demonstrated with the sensitivity analysis). However, the comparison with the ET chamber and scientific literature proved an over estimation of Q_e from SEB. This may be due to accumulated uncertainties involved in each energy flux component, like the under estimations of Q_h from the LAS and the low heat conduction rates on the soil.

To study the uncertainties of LAS measurements, a new LAS setting was implemented during a much longer period. Few test of spectral analysis suggest a possibility to determinate the temporal and spatial multifractal variability of LAS measurements to better quantify the resulting uncertainties.

The authors greatly acknowledge the financial support from ANR EVNATURB project and the Chair Hydrology for Resilient Cities (endowed by Veolia) of the École des Ponts ParisTech.