Journée Critex - le 11 mai 2017

EVAPO-TRANSPIRATION ESTIMATION AT CATCHMENT SCALE : MICRO-WAVE SCINTILLOMETRY

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AET: 73% of the Earth water budget

Trenberth et al. 2007, Lennart Bengtsson, ERL 2009

High Spatial and Temporal variability

Necessary for Critical Zone water budget

Scintillation is a marker of turbulence

Signal propagation is impacted by turbulence and their fluctuations are proportional to Cn^2, the refractive index structure parameter

Tatarskii 1961

$$\sigma_\chi^2 = \frac{1}{\alpha\left(D_e/D_r\right)}\overline{C_n^2}D_e^{-7/3}L^3$$

$$D_c\left(\vec{\rho}\right) = \left\langle \left(c'\left(\vec{r}+\vec{\rho},t\right)-c'\left(\vec{r},t\right)\right)^2 \right\rangle \approx \frac{1}{T}\int_0^T \left(c'\left(\vec{r}+\vec{\rho},t\right)-c'\left(\vec{r},t\right)\right)^2 dt = C_c^2\rho^{2/3}$$

AET estimation using scintillometry

$$C_{n^2} = \frac{A_T^2}{\overline{T^2}} C_{T^2} + \frac{A_q^2}{\overline{q^2}} C_{q^2} + 2\frac{A_q A_T}{\overline{qT}} C_{Tq}$$

A_T, A_q are wave length dependent

Visible, near Infra-Red (<1 μm) : $C_{n_{IR}^2} \approx \frac{A_{T\_IR}^2}{\overline{T^2}} C_{T^2}$

$$C_{n_{IR}^2} \Rightarrow C_{T^2} \Rightarrow T^* \Rightarrow H \Rightarrow LE$$

→ **WP1.2**

Micro-Wave (1mm ➔ 3cm) : $C_{n_{MW}^2} = \frac{A_{T\_MW}^2}{\overline{T^2}} C_{T^2} + \frac{A_{q\_MW}^2}{\overline{q^2}} C_{q^2} + 2\frac{A_{q\_MW} A_{T\_MW}}{\overline{qT}} C_{Tq}$

$$C_{n_{IR}^2}, C_{n_{MW}^2}, C_{n_{IR}n_{MW}} \Rightarrow C_{T^2}, C_{q^2}, C_{Tq} \Rightarrow T^*, q^* \Rightarrow H, LE$$

WP1.1

Andreas 1989, Ward 2015

Micro-Wave instrument … a British begining …

Chiboloton Facilities november 2014

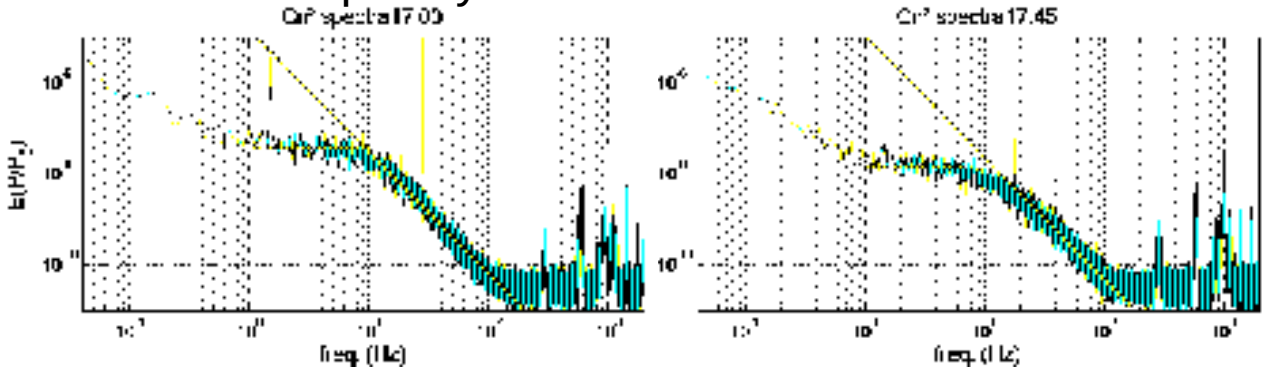
CRITEX Project : Innovative equipment for the Critical Zone

- Design and Build of a 94GHz Micro-Wave Scintillometer (Rutherford Appleton Laboratory (UK), LTHE)
- Test at Chibolton Facility site in November 2014

Puissance signal reçu
Cn^2

Scintillation frequency distribution

Scintillation Spectra
Kolmogorov ($k^{-8/3}$)
Scintillation Plateau



… a French CZ Story

Weird atmospheres …

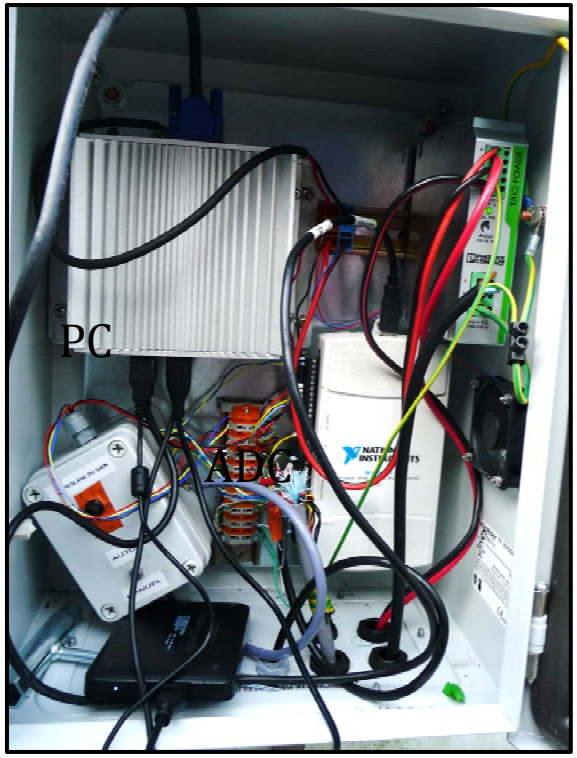
Typical french people

The weather …!

 Butte de Doue February 2015

Final Development

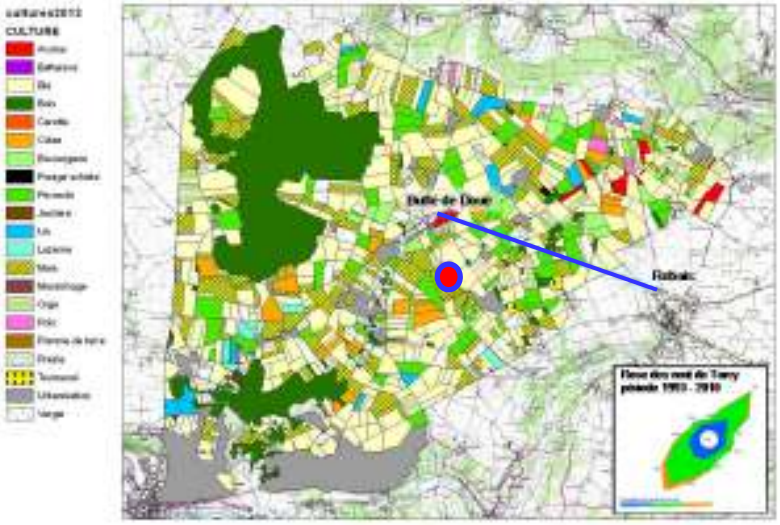
- Lab view data logger (High frequency ~1kHz) -
- Synchronisation of both scintillometers (IR & MW)



user friendly Labview command window

Evaluation on Orgeval Facility Site

Agricultural patchy Site (77)
Optical line of sight: 4.5km



Infra-Red and Micro-Wave Scintillometers on La butte de Doue and on the Water Tower in Rebais

Reference Eddy-covariance Station de

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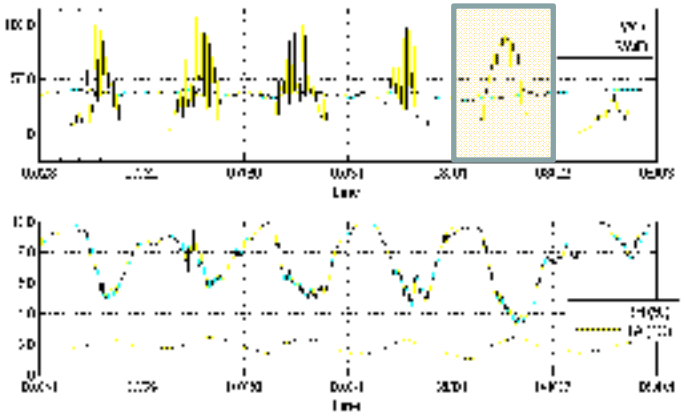
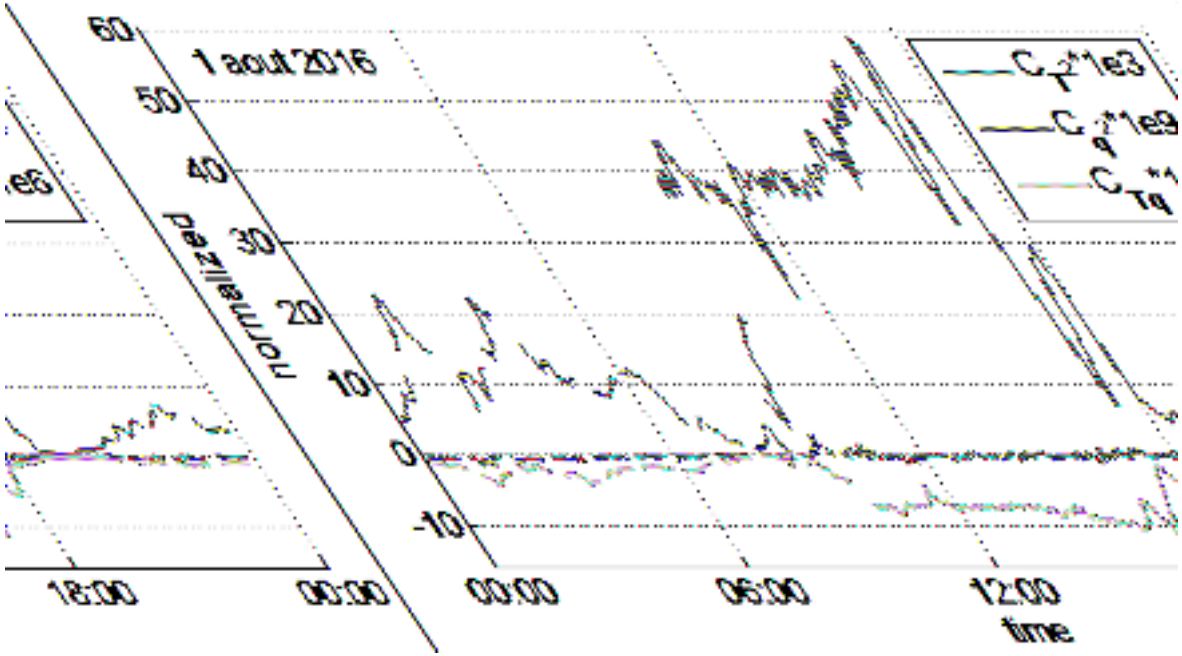
$$\sigma_\chi^2 = \frac{1}{\alpha\left(D_e/D_r\right)} \overline{C_n^2} D_e^{-7/3} L^3$$

- signal processing (from raw signal (1kHz) to C_n^2)
- Inverse problem C_n^2 to C_T^2, C_q^2





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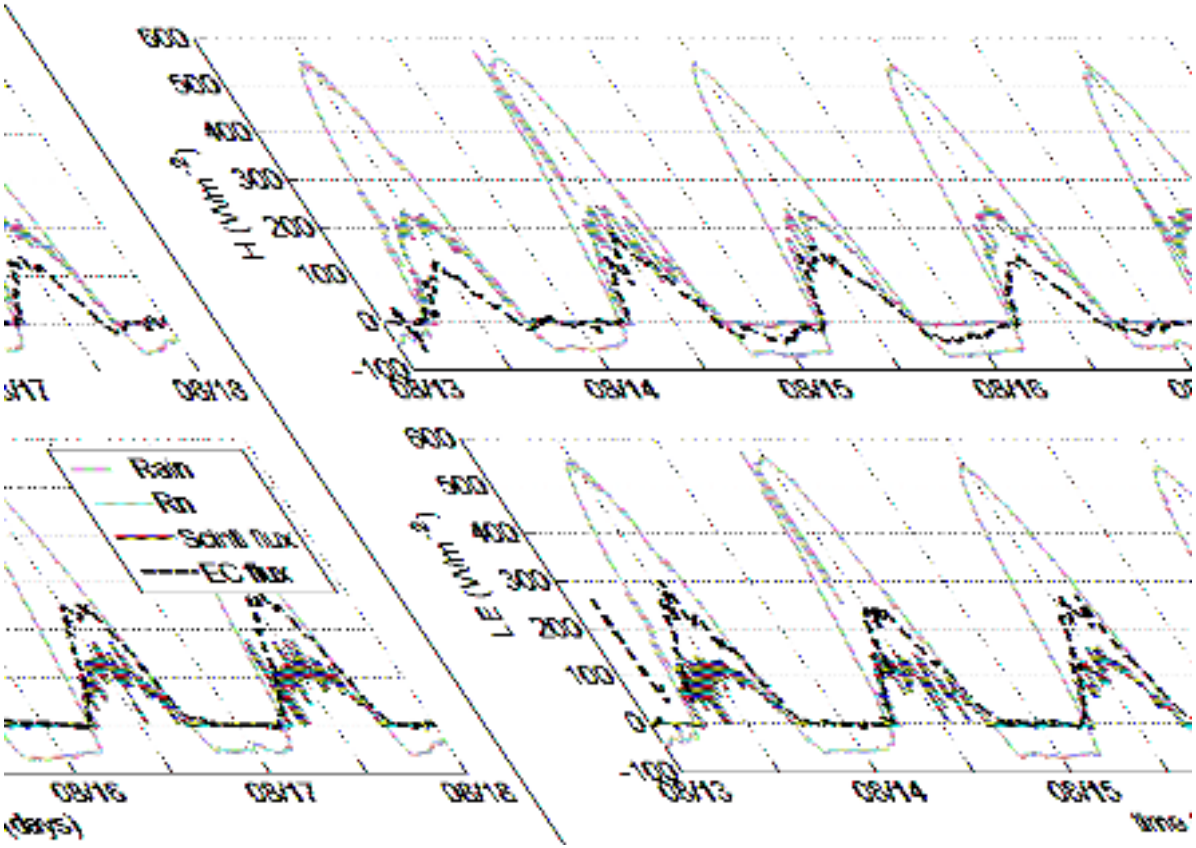

Parcel vs catchment

- Diurnal cycle respected
- Important differences between scales
- 5min flux estimation

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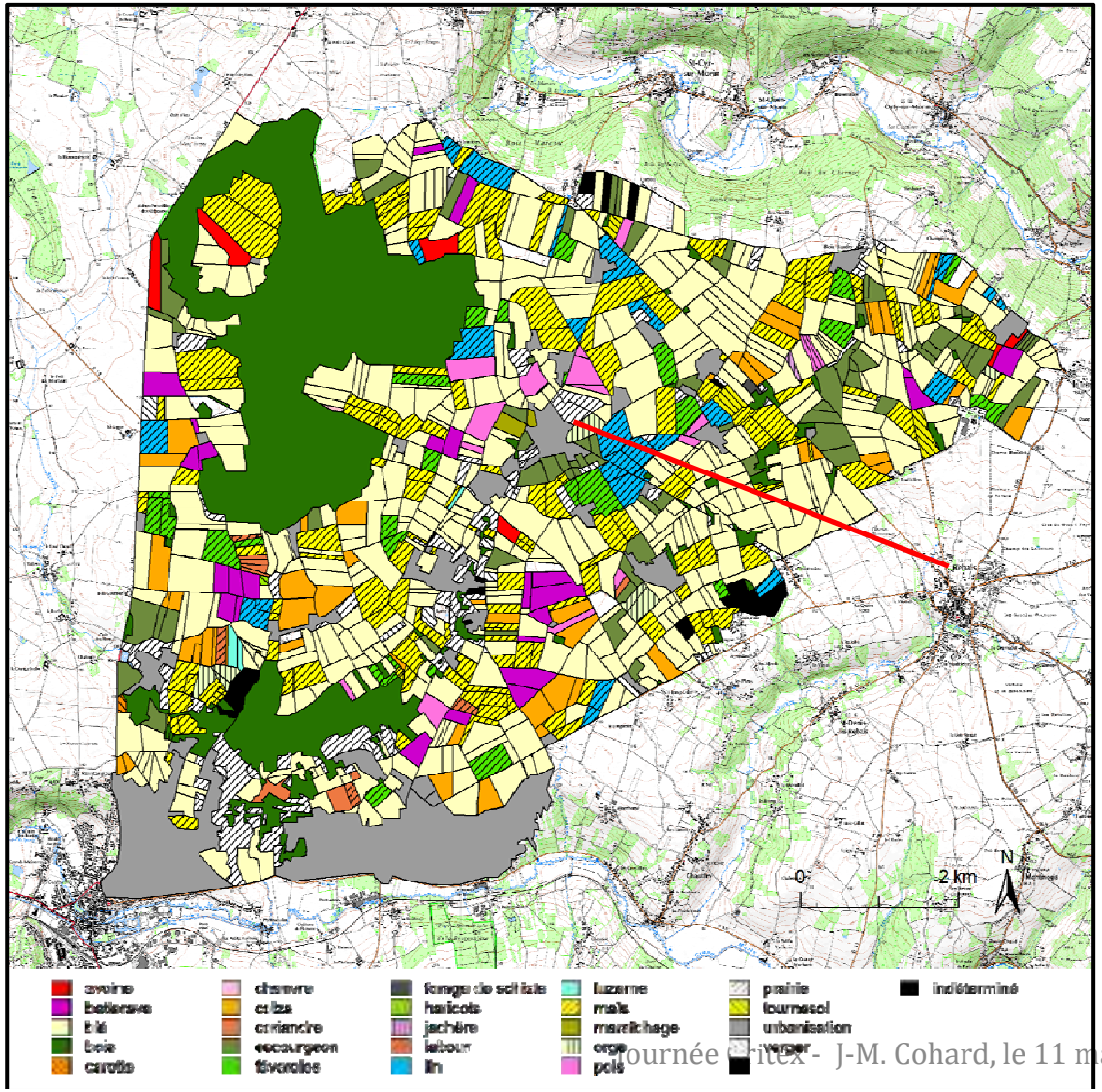

Vegetation state in August

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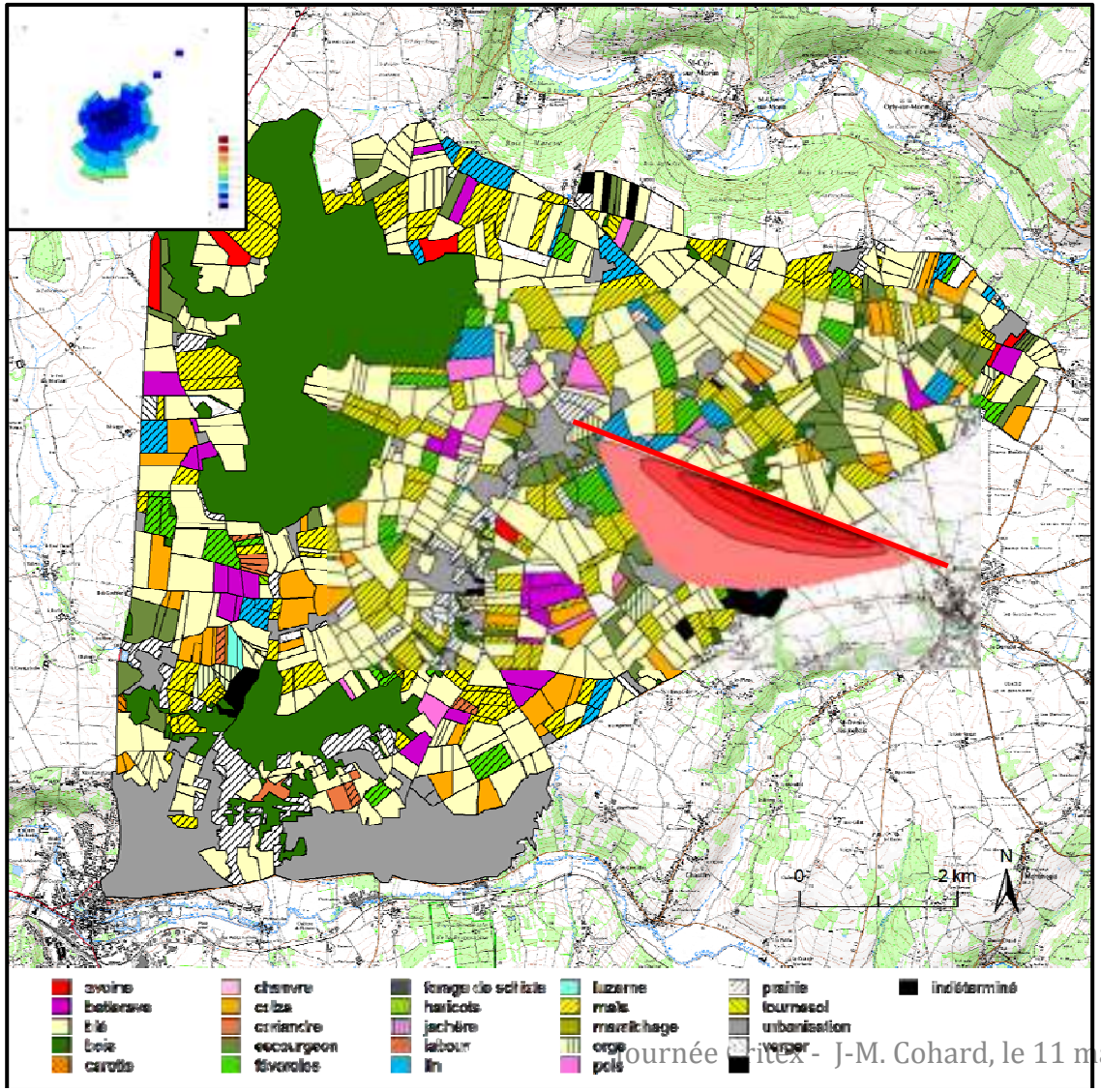
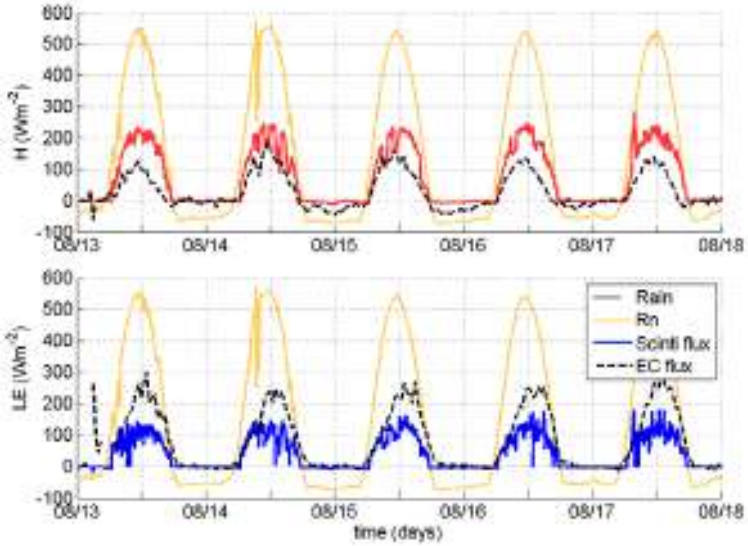


15% covered with corn



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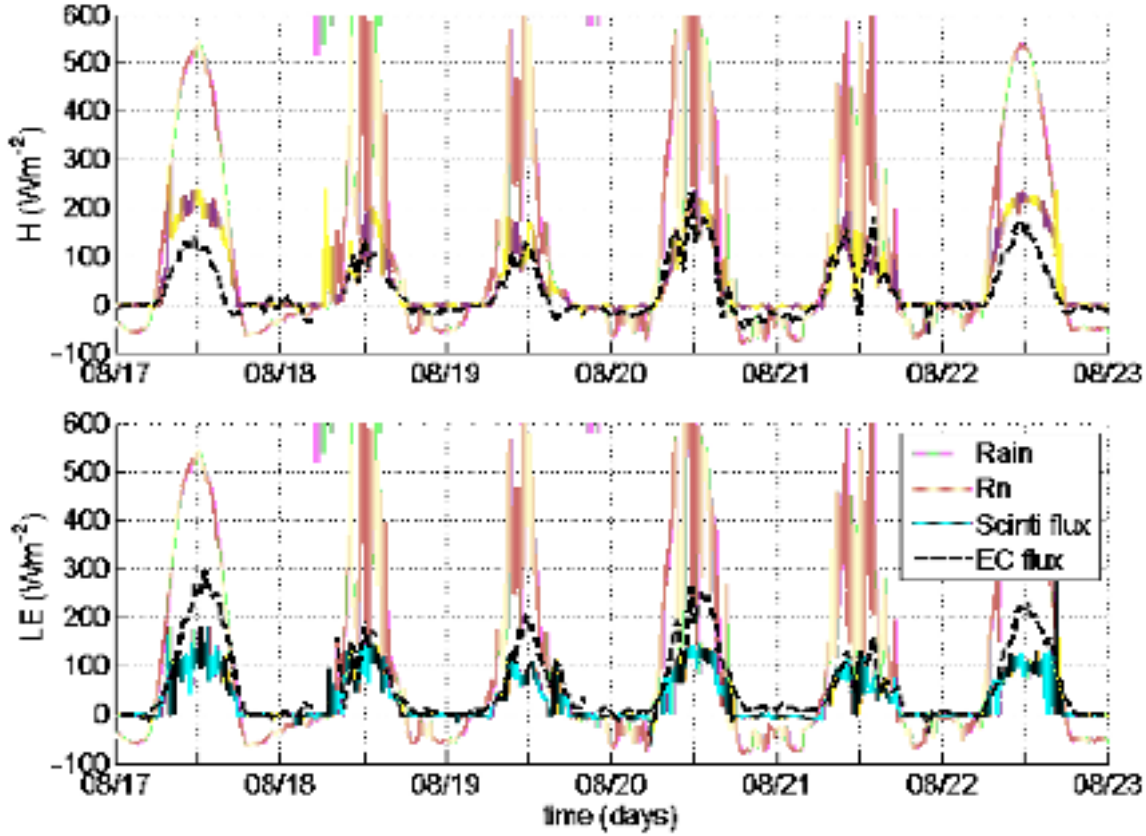


Response to a rain event

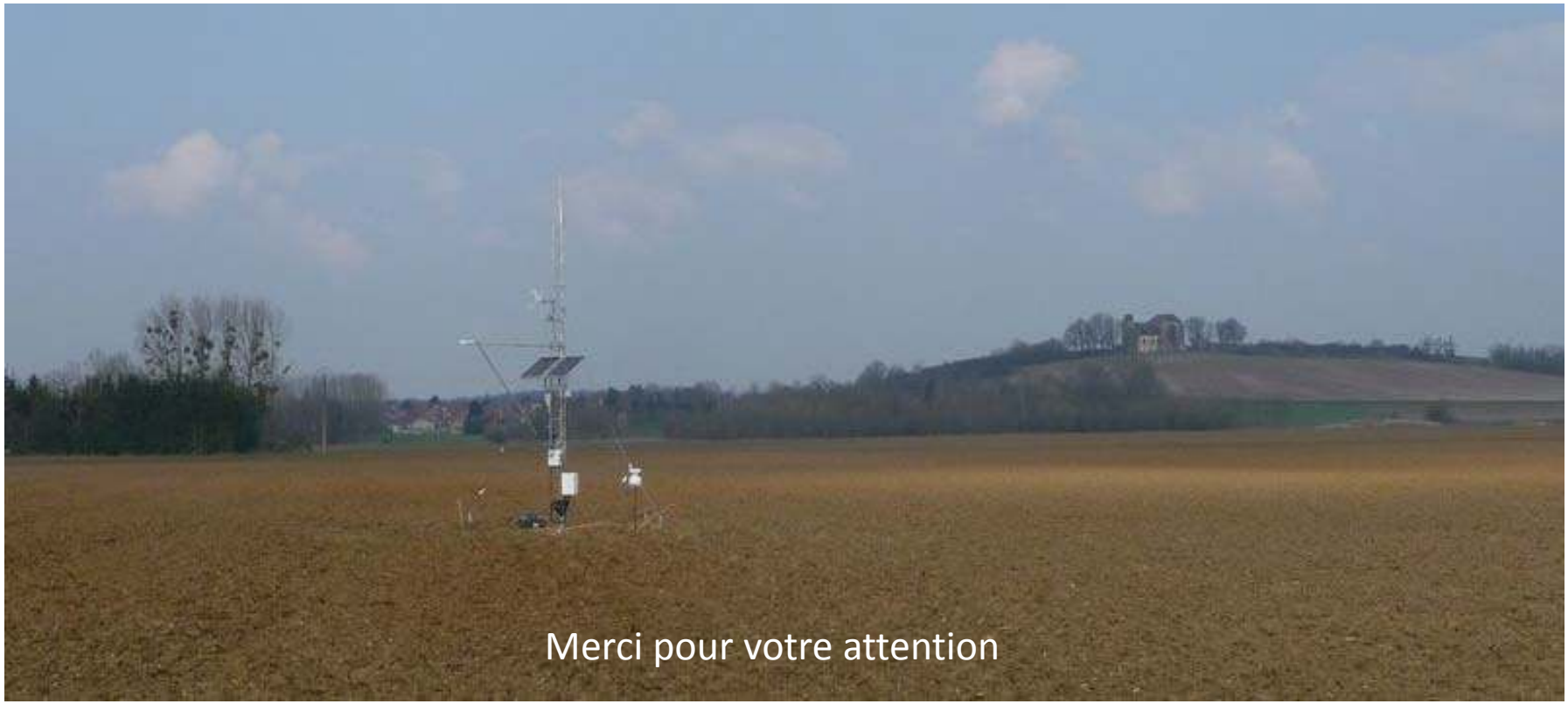
- Equivalent sensible heat fluxes when surface is wet
- latent heat fluxes are still different because of transpiration process

CONCLUSIONS & PERSPECTIVES

- A succesfull development thanks to CRITEX project
- The MW Scintillometer is working continuously since 10th of March 2016 (2 months gap because of a failure of the manufactured IR scintillomter)
- It gives comprehensive turbulent fluxes at catchment scale.

- Results need to be consolidated and validated

➔ Energy budget closure
➔ Detailed footprint analysis
➔ Specific experiment with 2 extra EC station during summer 2017
➔ Measurements are expected for a full year to give an annual water budget
➔ Data require further investigation to provide a robust AET estimation at catchment scale


Merci pour votre attention