

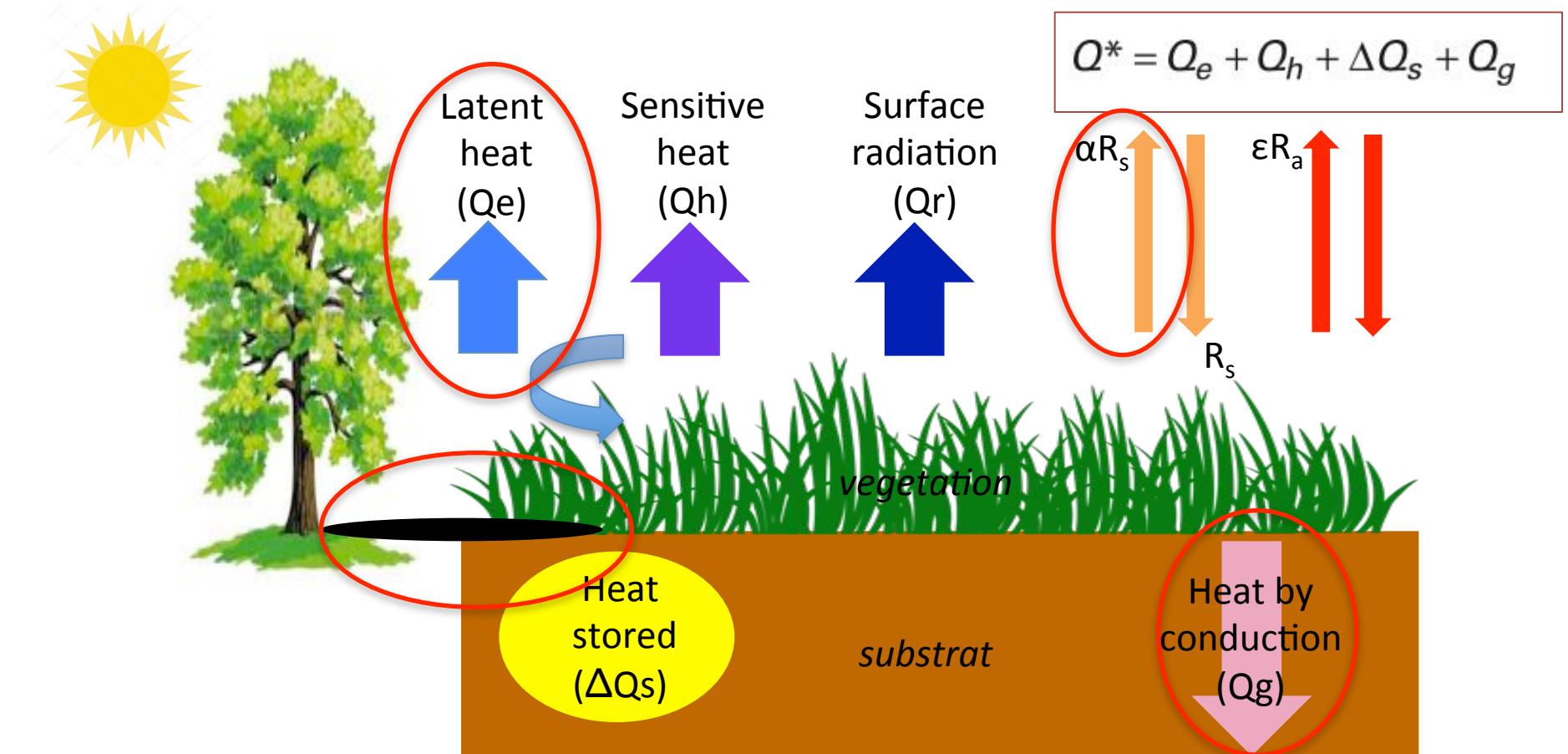
Evapotranspiration measurements

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David Ramier (Cerema IdF)

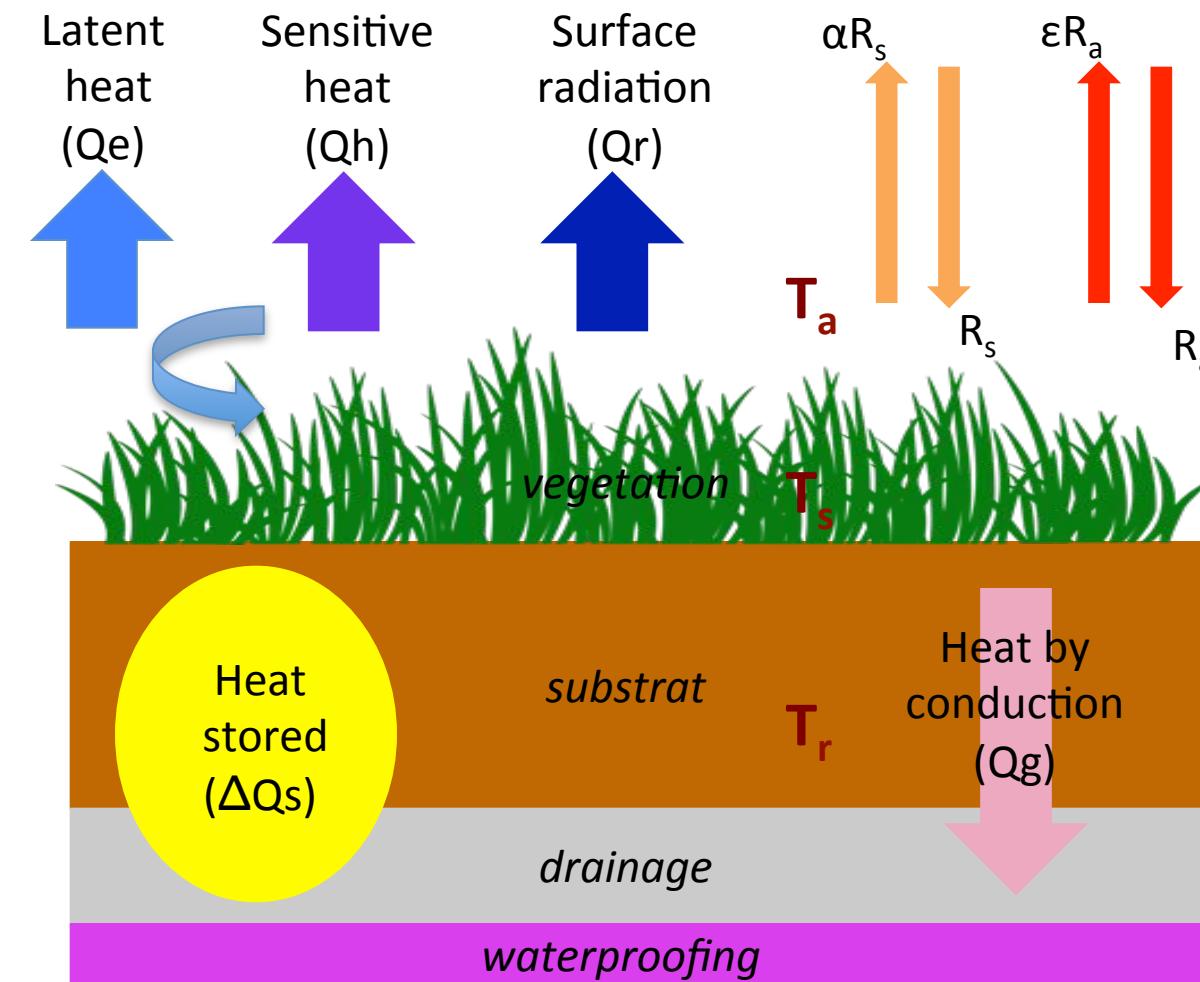


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Radiation balance – influence of vegetation



Radiation balance



$$Q^* = Q_e + Q_h + \Delta Q_s + Q_g$$

Evapotranspiration

Latent heat

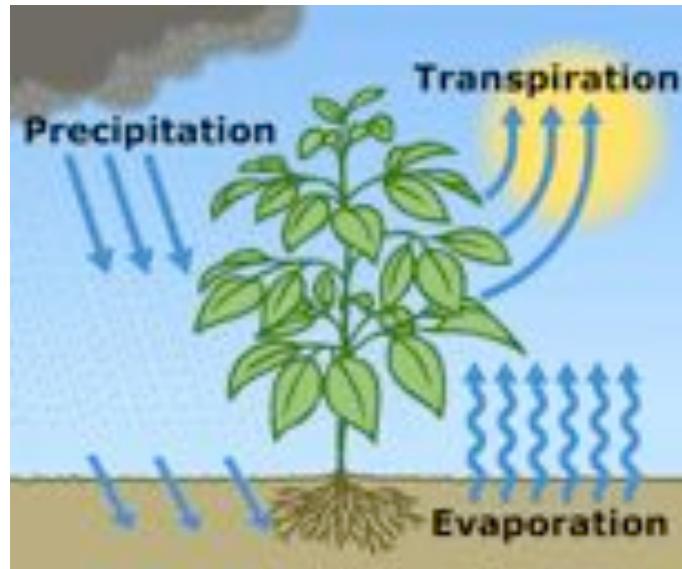
Enthalpy of vaporization

$Q_e = L ET$

$$Q_h = \rho \cdot C_p \cdot \Delta T \cdot u^*$$



Evapotranspiration



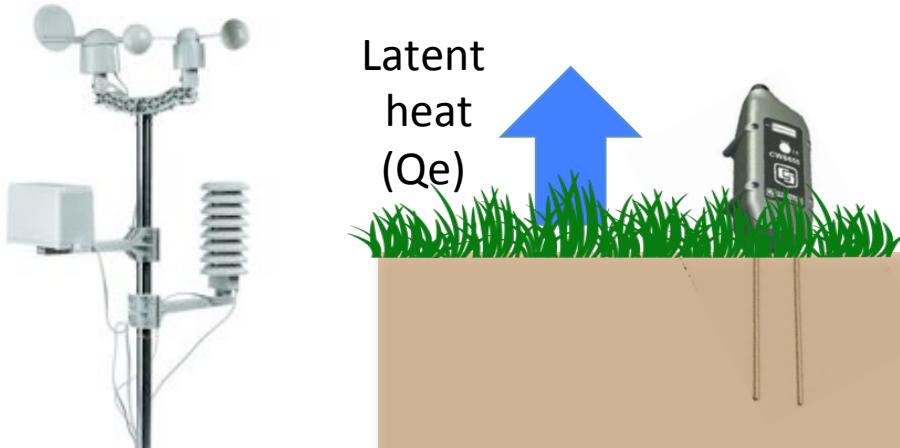
Penman-Monteith

$$ET_o = \frac{\Delta(R_n - G) + \rho_a c_p (\delta e) g_a}{(\Delta + \gamma (1 + g_a/g_s)) L_v}$$

Hypothetical reference in ideal conditions

Do not take into account :

- Soil moisture status
- Type of vegetation



Punctual measurement not sufficient !

Need of integrated values representative of surface heterogeneities



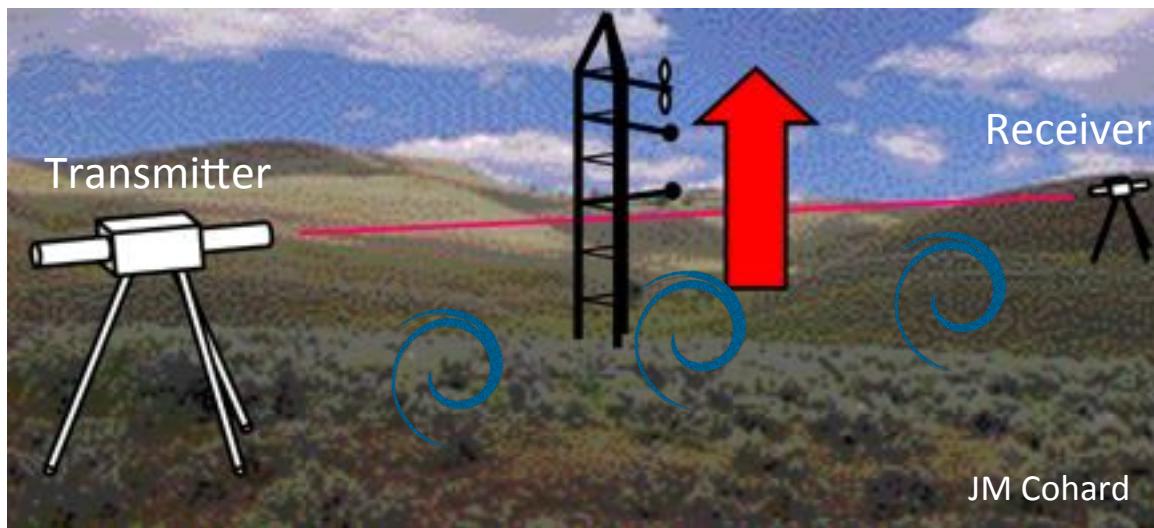
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Scintillometer

Measures the brightness change (C_n^2)

Scintillometer characterized by :

- beam diameter
- Wavelength emission



Electromagnetic wave modified by:

- Refraction (Temperature, Pressure, Humidity)
- Diffusion
- Absorption

} Turbulence

$$\delta n = A_p \frac{\delta p}{p} + A_q \frac{\delta q}{q} + A_T \frac{\delta T}{T}$$



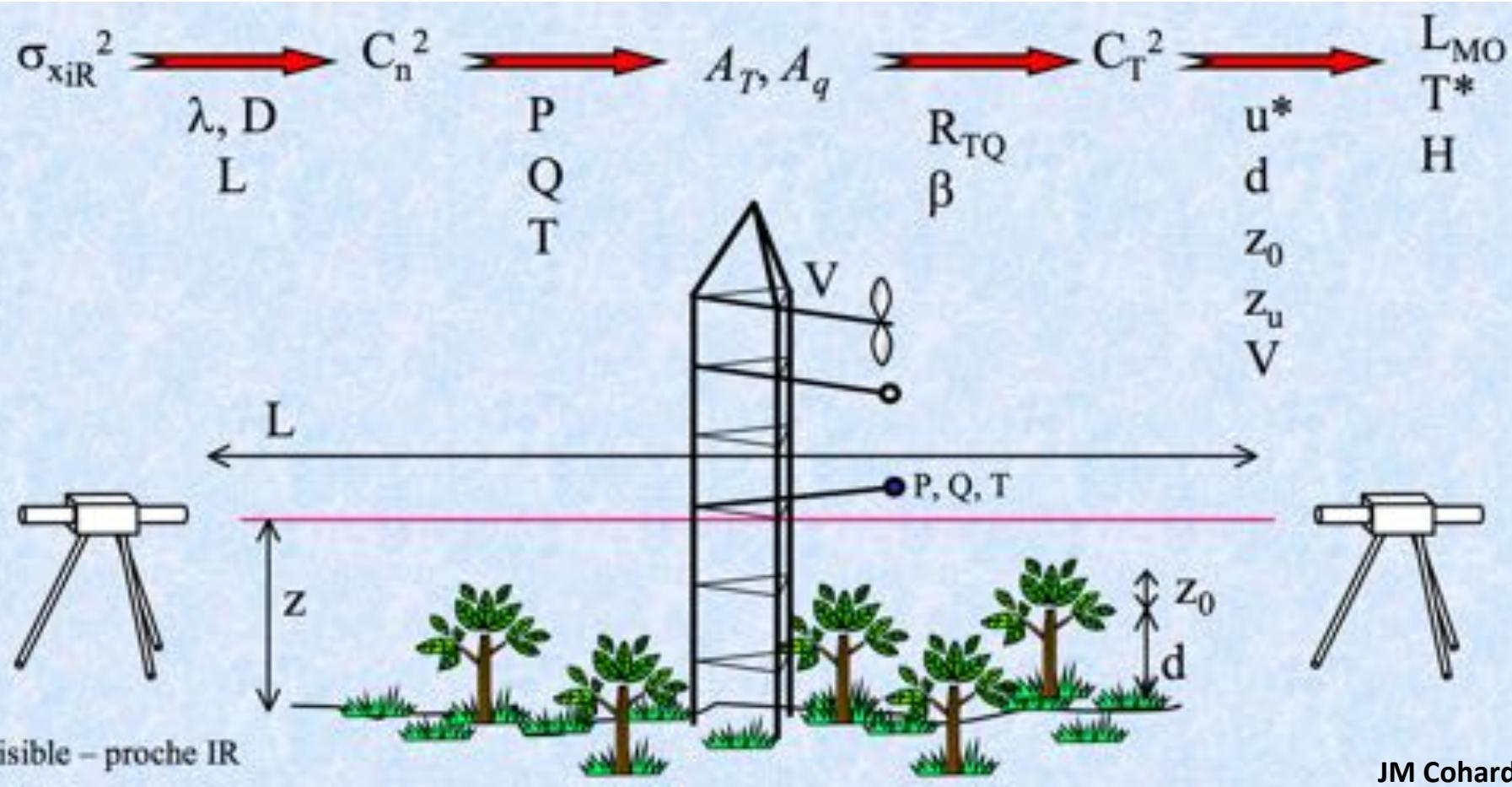
Sensitive heat

$$Qh = \rho \cdot C_p \cdot \Delta T \cdot u^*$$



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Scintillometer



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Scintillometer



Large Aperture Scintillometer (LAS): several km, visible / IR

Laser (ex: Surface layer scintillometer) : tens of m,
emission at 670 nm



Microwave: in development... To be combined with LAS



Require additional meteorological measurements



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Scintillometer

In search of the most relevant material...



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Evapotranspiration chamber

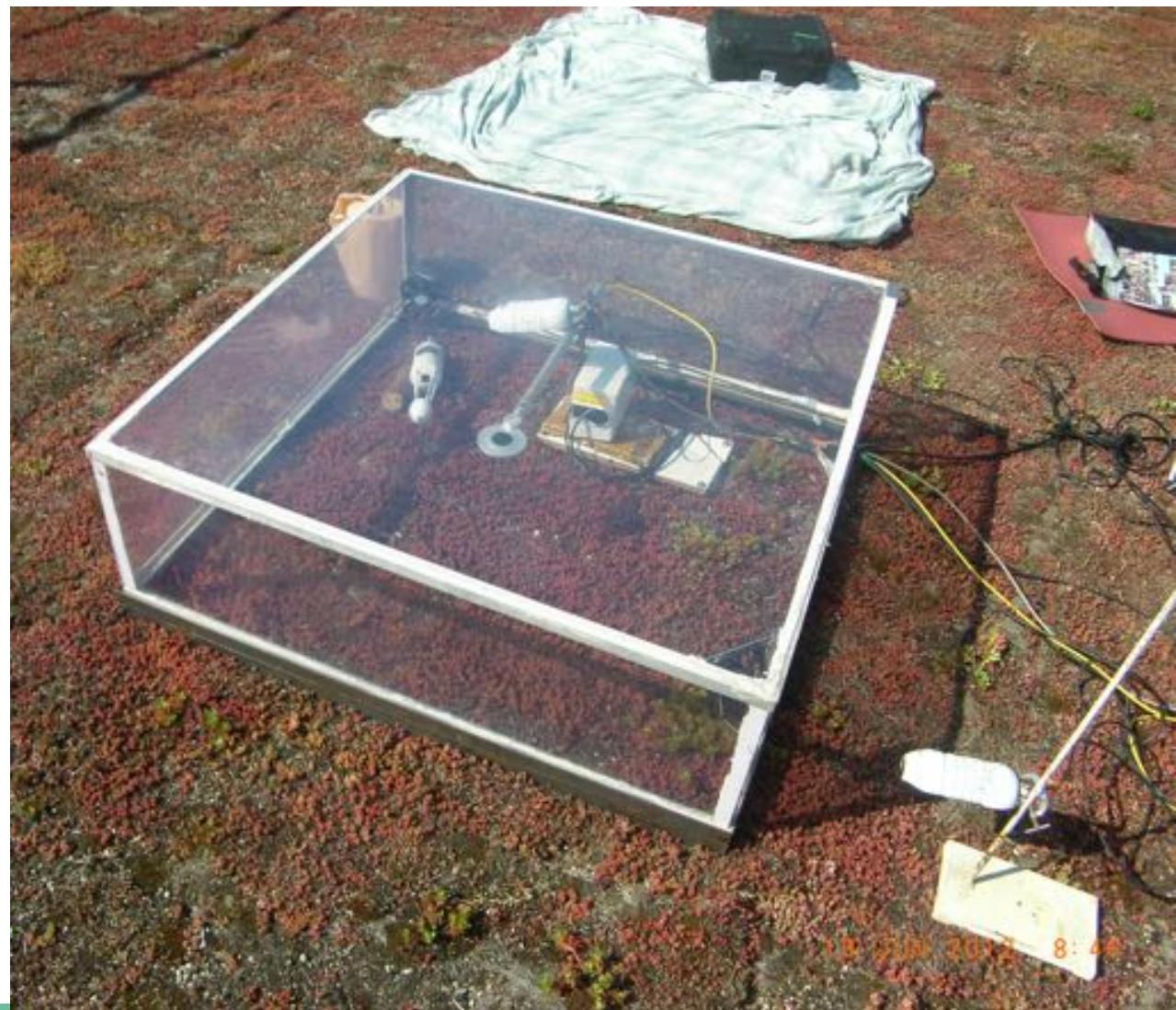
PMMA (Plexiglas)

or

PTFE (Teflon) Chamber

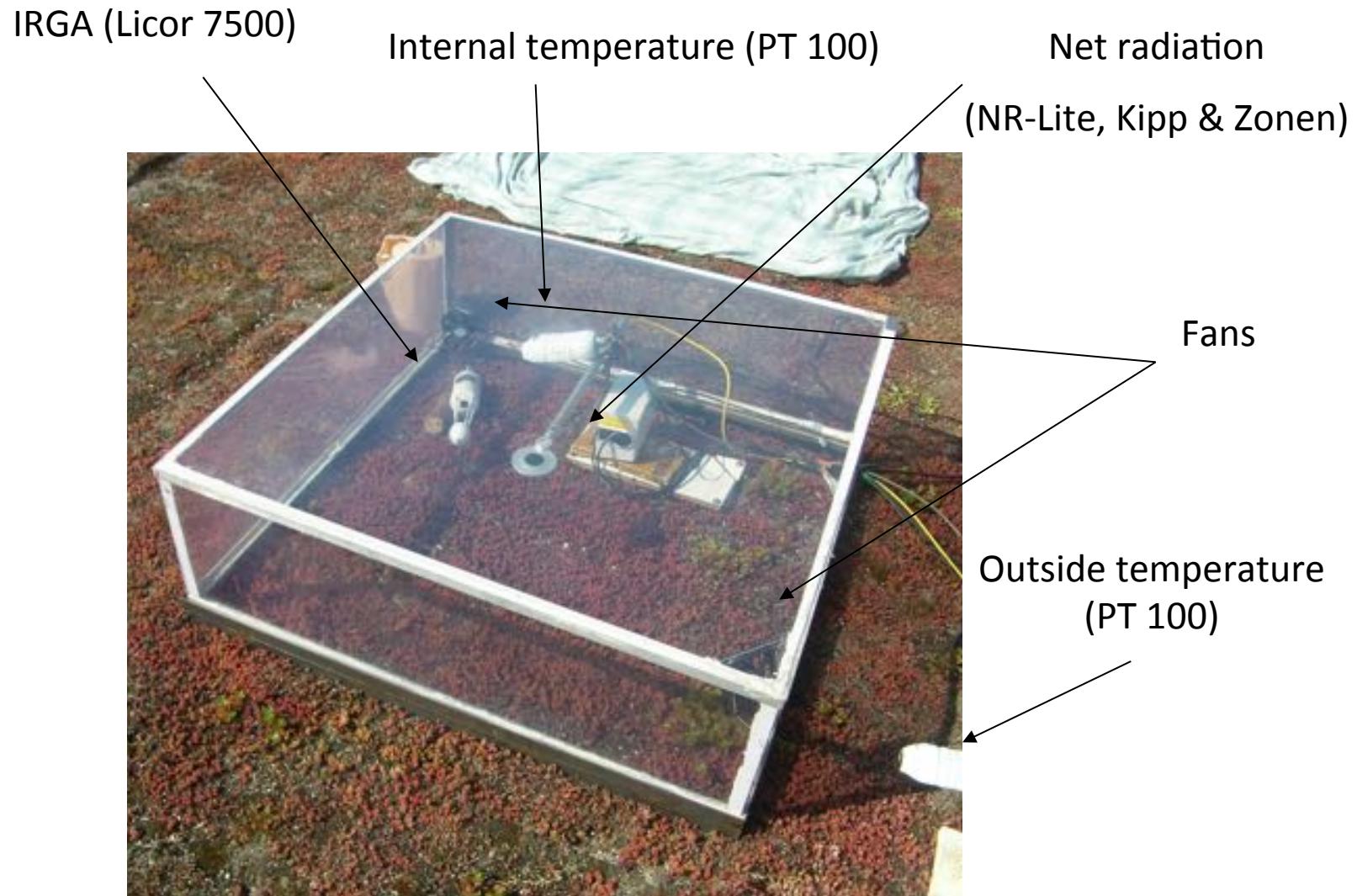
Height : 30 cm

Surface : 1 m²

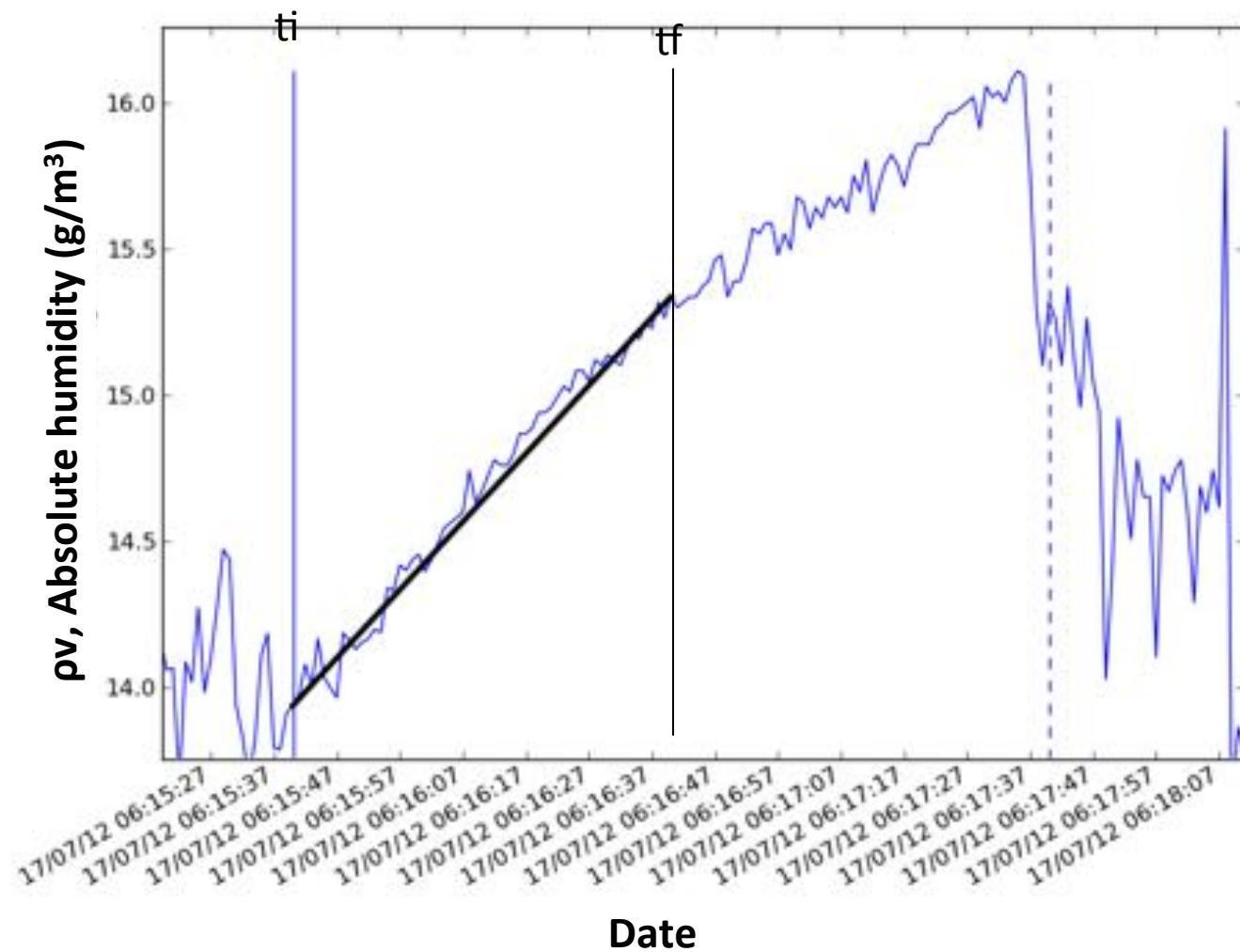


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Evapotranspiration chamber

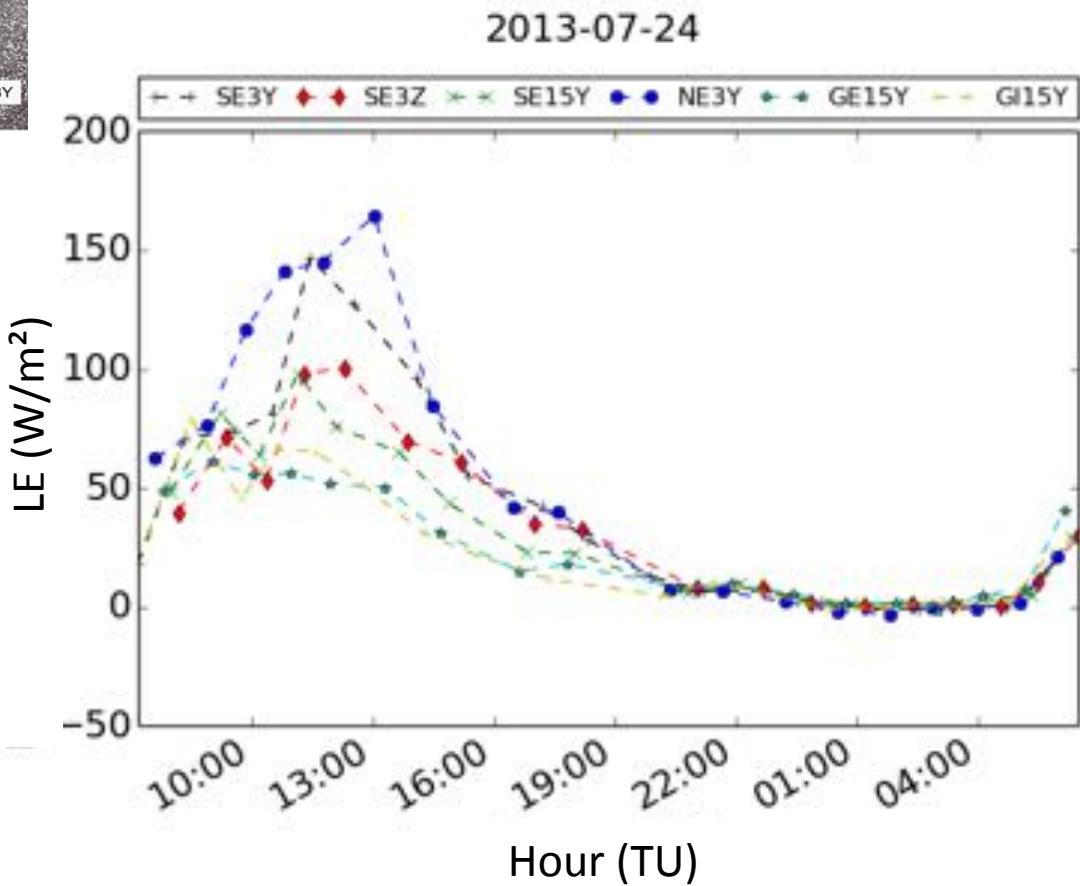


Evapotranspiration chamber



$$LE = 0,3 * 2,46 \cdot 10^6 * \frac{\rho_v[tf] - \rho_v[ti]}{tf - ti} * 0,001$$

Evapotranspiration chamber



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Eddy Covariance ?

Direct measurement of evapotranspiration



Eddy Covariance ?

General equation:

$$F = \overline{\rho_a} \overline{w' s'}$$

Sensible heat flux:

$$H = \rho_a C_p \overline{w' T'}$$

Latent heat flux:

$$LE = \lambda \frac{M_w / M_d}{p} \rho_a \overline{w' e'}$$

Carbon dioxide flux:

$$F_c = \overline{w' \rho_a'}$$

Problems of footprint on a roof ?

