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Understanding Evaporation and Latent Heat Flux
(New) Methods of Observation

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Session: Meet the expert in hydrology - The mystery of evaporation

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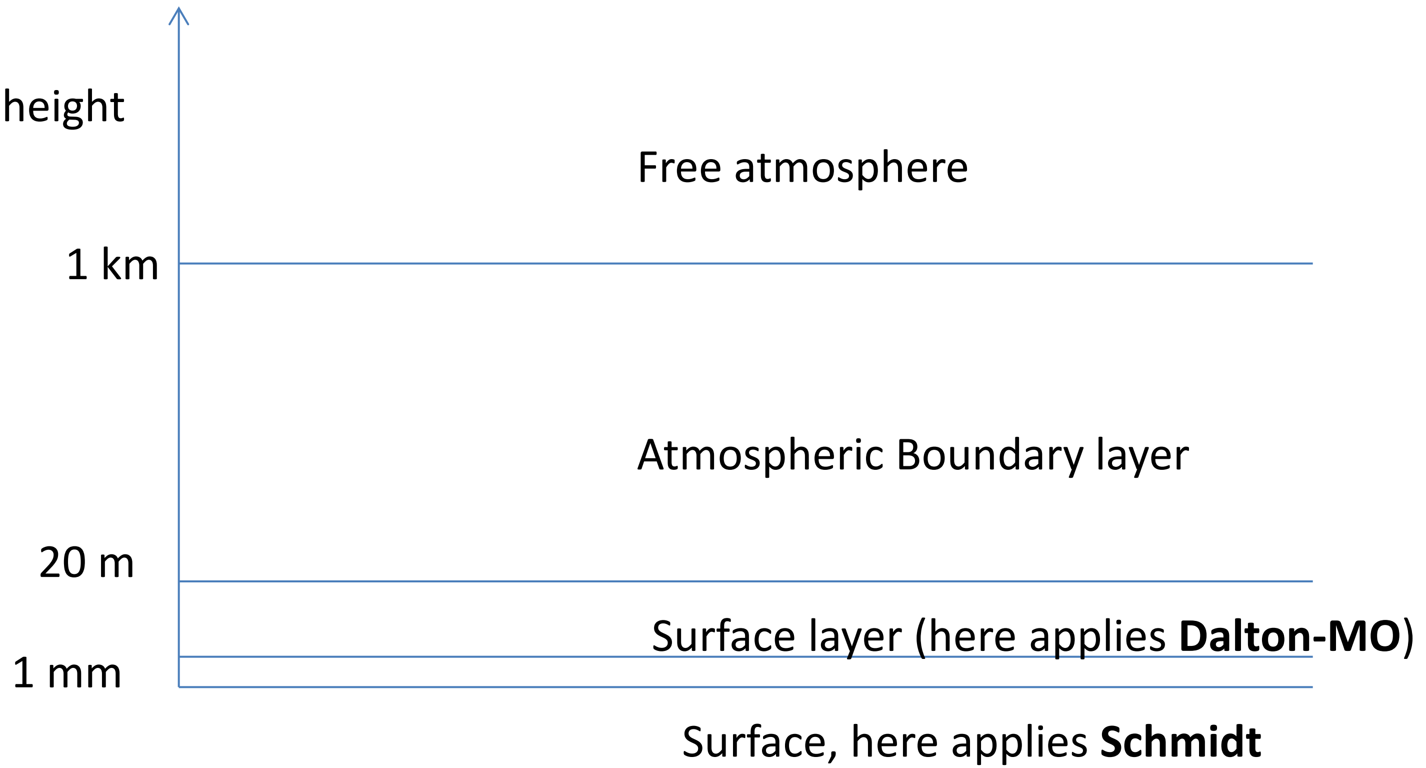
1) Wageningen University, Meteorology and Air Quality group, Wageningen, The Netherlands

Evaporation is about

a) Phase change at the surface: liquid into vapor (**Thermodynamics**, **Schmidt**)
b) Vertical water vapor transfer in atmospheric surface layer (**Dalton-Monin-Obukhov**)

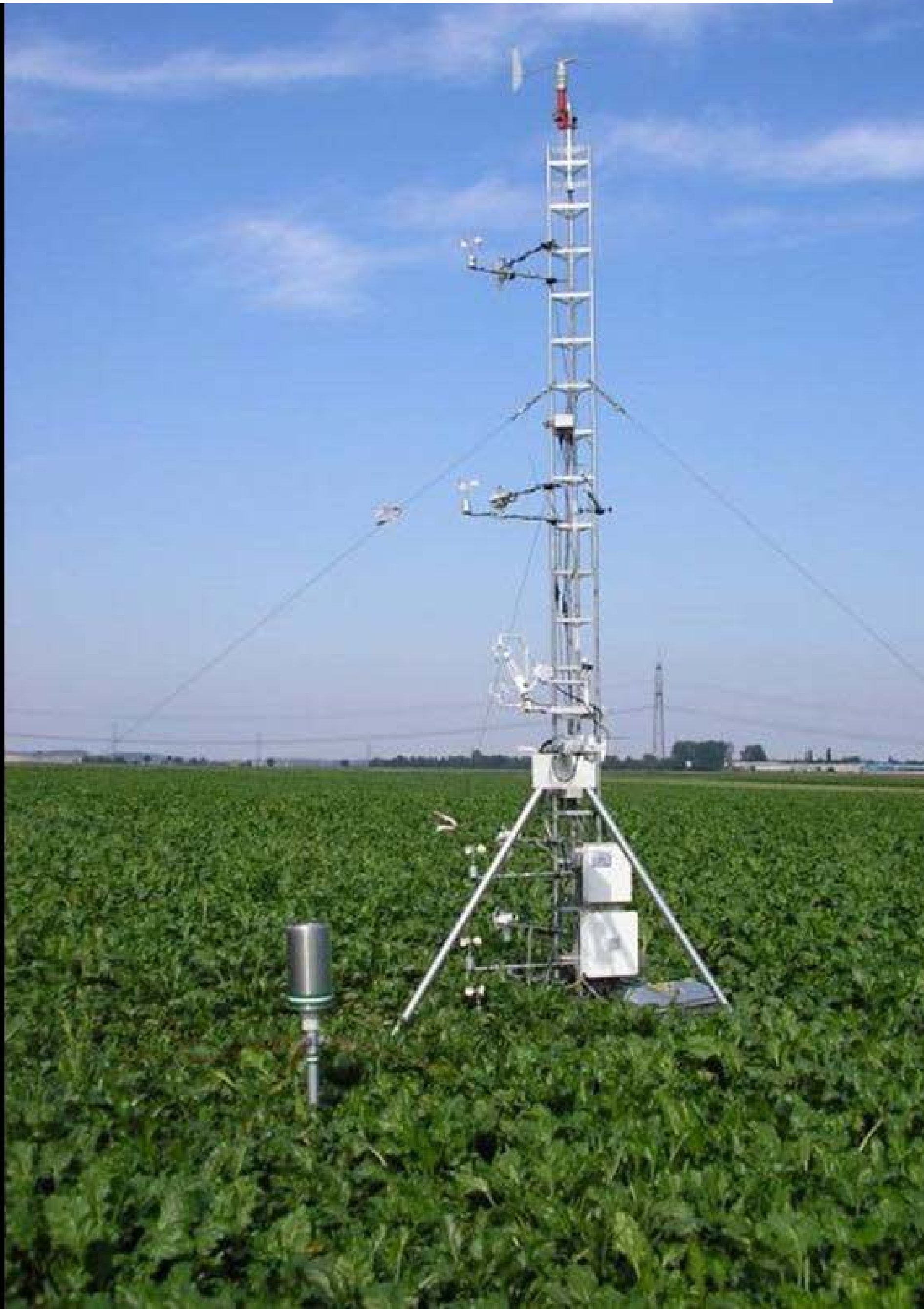


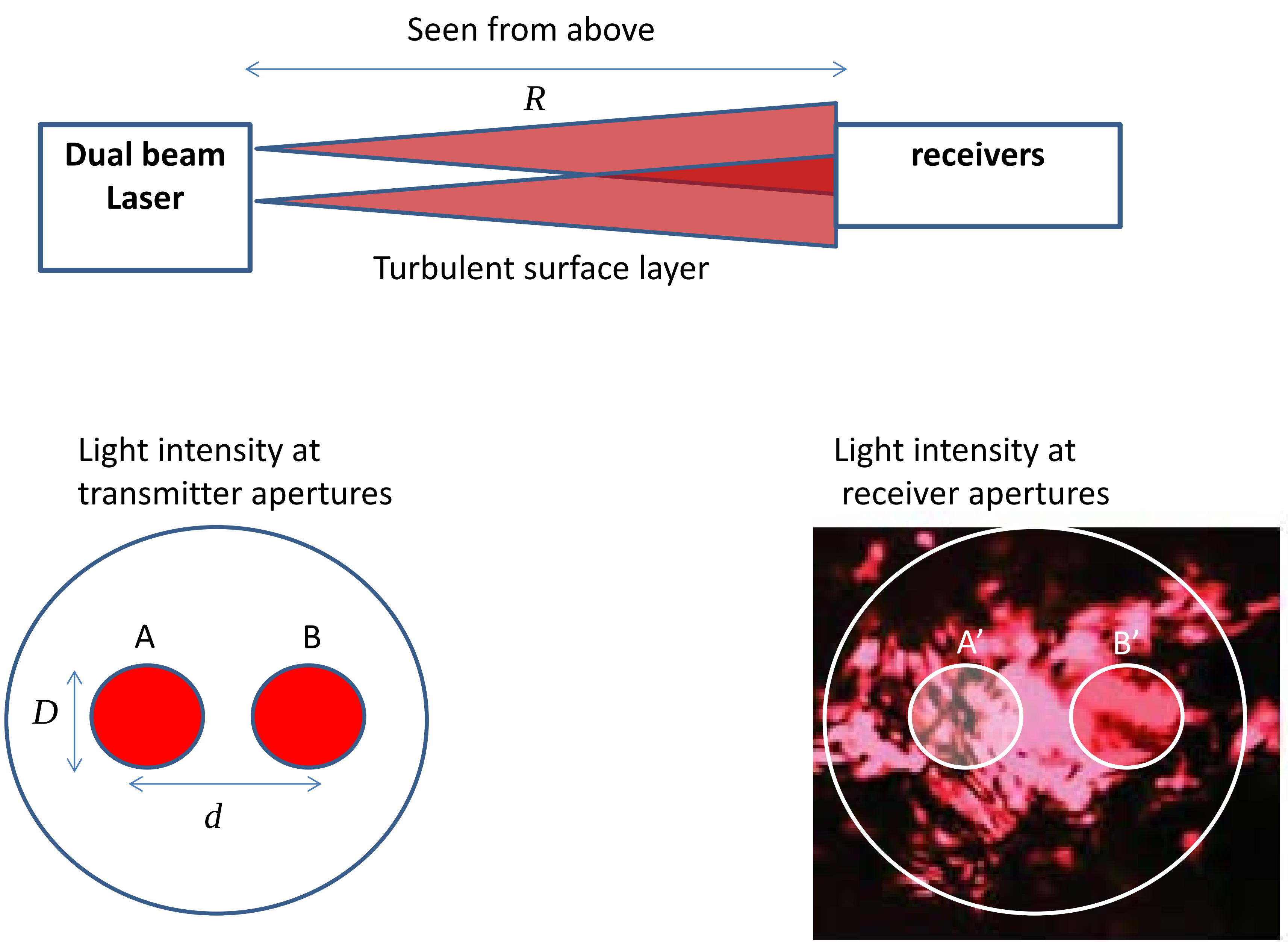
Measure the Myth

Avoid Parrotism

Science is not democratic

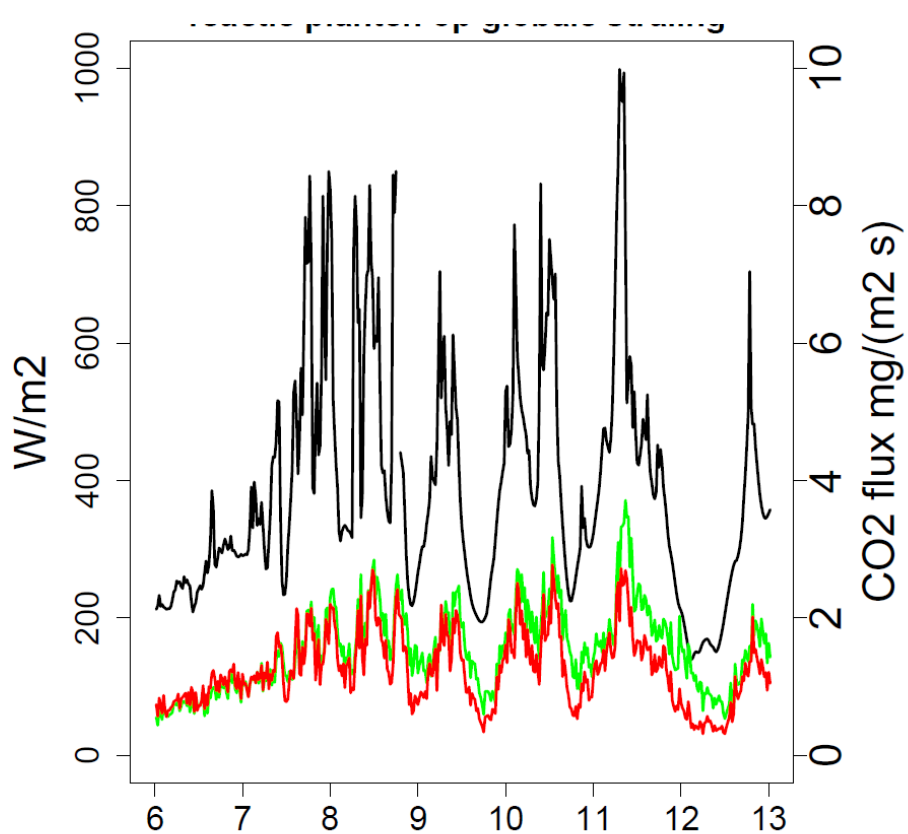
A laserscintillometer to measure 1-min fluxes of CO_2 and H_2O



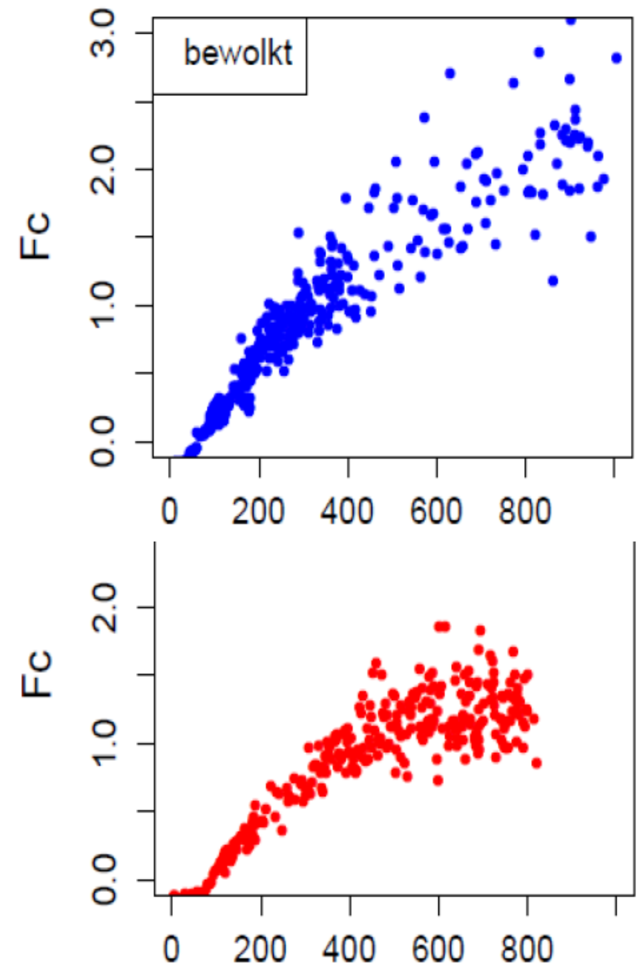


Seen from above
R
Dual beam Laser
receivers
Turbulent surface layer
Light intensity at transmitter apertures
A
B
D
d
Light intensity at receiver apertures
A′
B′

A laserscintillometer to measure 1-min fluxes of CO_2 and H_2O



1-min fluxes of H_2O (green) and CO_2 (red)
And global radiation (black)



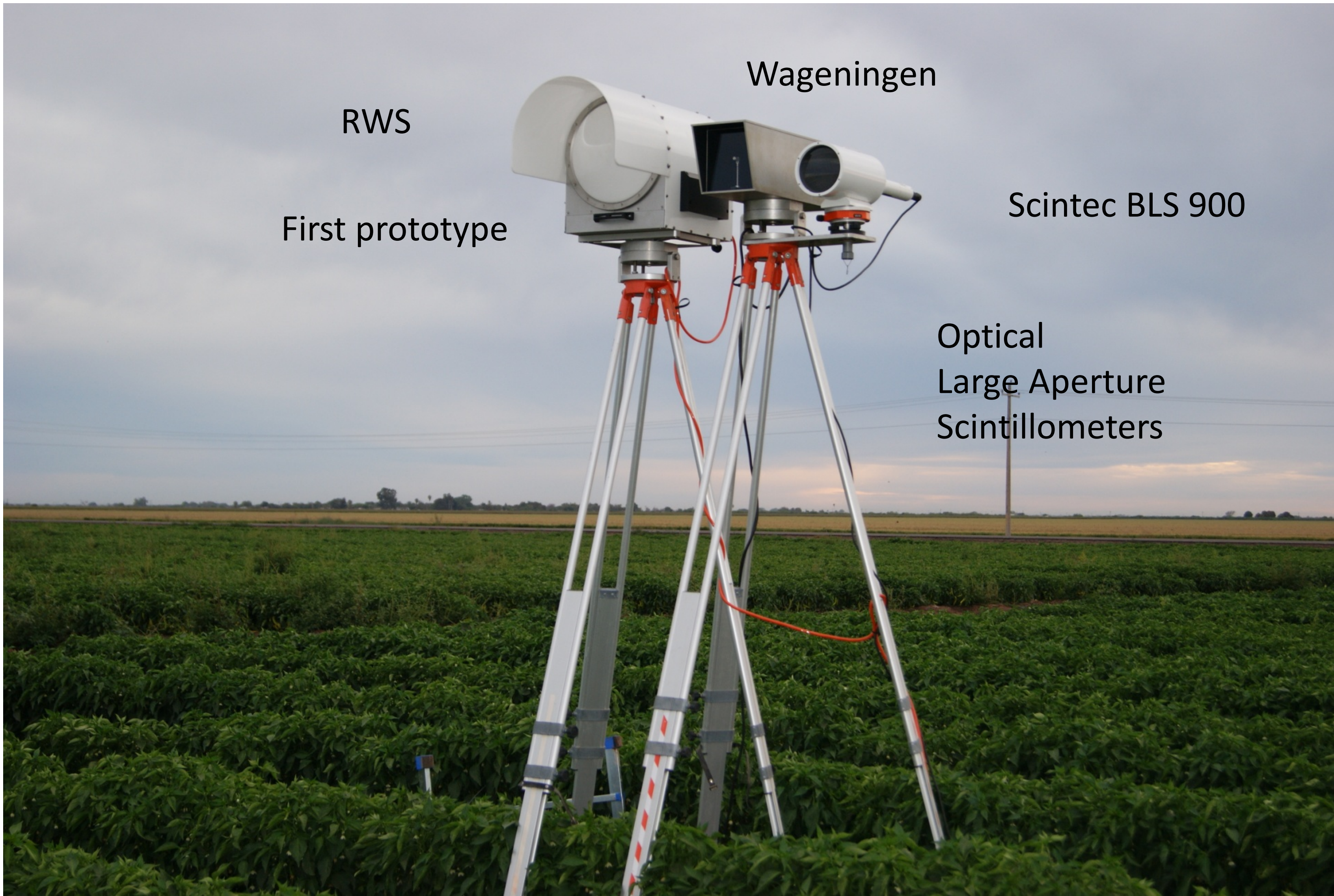
overcast

clear sky

Global radiation wm^{-2}

Measured response-curve for wheat

Challenge for young hydrologists:
test novel166 Ghz Radio-wave scintillometer combined with an optical scintillometer
Allows measurements of evaporation at scales of kilometers



John Dalton(1802)
Vertical transfer in surface layer

$$E = f(u)\left[e_s(T_s) - e_a\right]$$

Evaporation is driven by **wind** and **atmospheric 'demand**'

Modern approach: **Monin-Obukhov similarity theory (MOST):**
f(u) depends on stability, and thus on
($T_{surface} - T_{air}$) and u_2 and roughness lengths for water vapor and sensible heat

Wilhelm Schmidt (1915) evaporation oceans

A = available energy $s(T) = \left(\frac{de_s}{dT}\right)_T$

$\lambda \approx 2.5.10^6 \ J/kg$

$$\lambda E = \frac{s(T)}{s(T)+\gamma} A + cor$$

$\gamma = psych.const.$

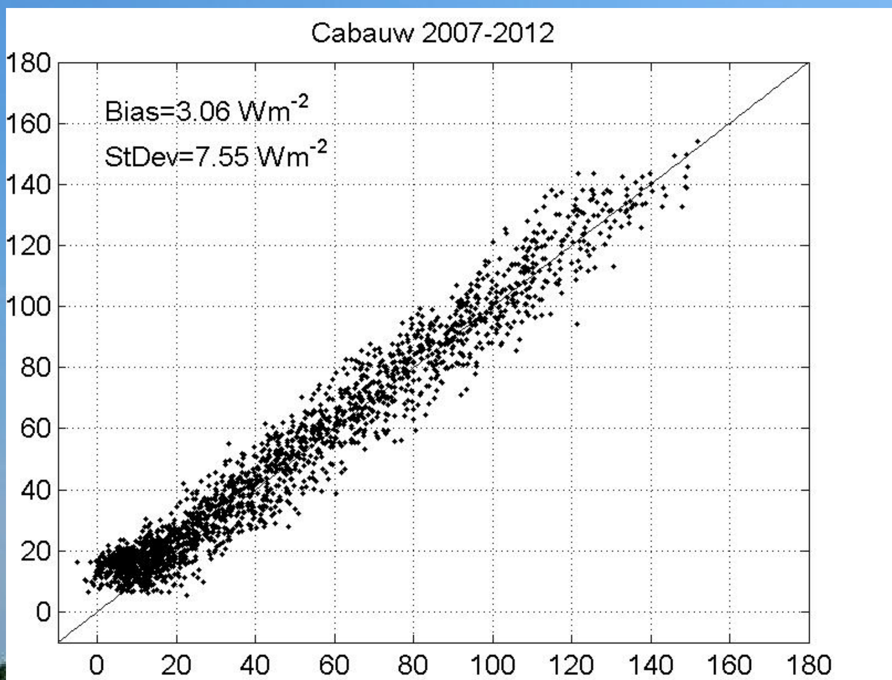
Physical picture: when water supply is not limited
Evaporation is driven by thermodynamics, i.e.
available energy and **temperature**

Cabauw, well-watered grass without advection

De Bruin, Bosveld, Meirink and Trigo, 2015 (under review)

Schmidt-based estimate of daily latent heat flux using MSG derived global radiation and air temperature

$$\lambda E = \frac{s(T)}{s(T)+\gamma} A + \beta$$



Estimated Wm^{-2}

Measured with EC –EB method Wm^{-2})

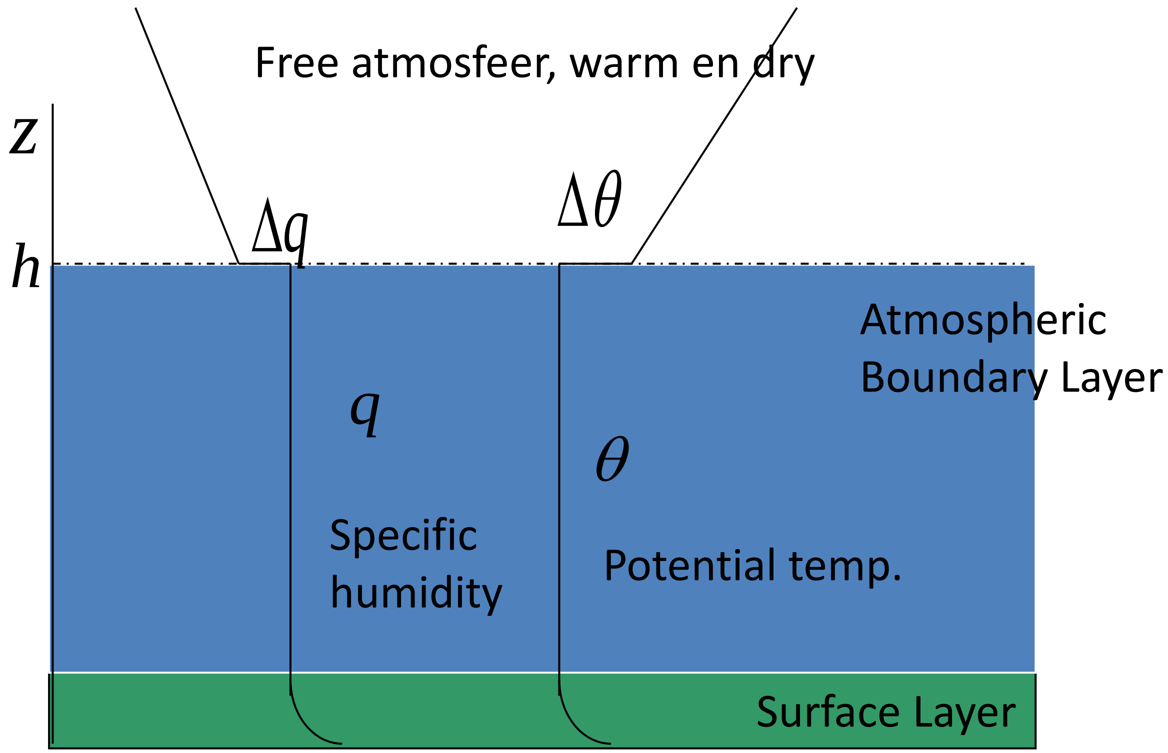
Confirmation of Schmidt's picture:
If water supply is not limited available energy and air temperature determine latent heat flux:

For very large fields (no advection) Global radiation is main external energy source.

Allowing remotely sensed estimates

Did not change since 1976

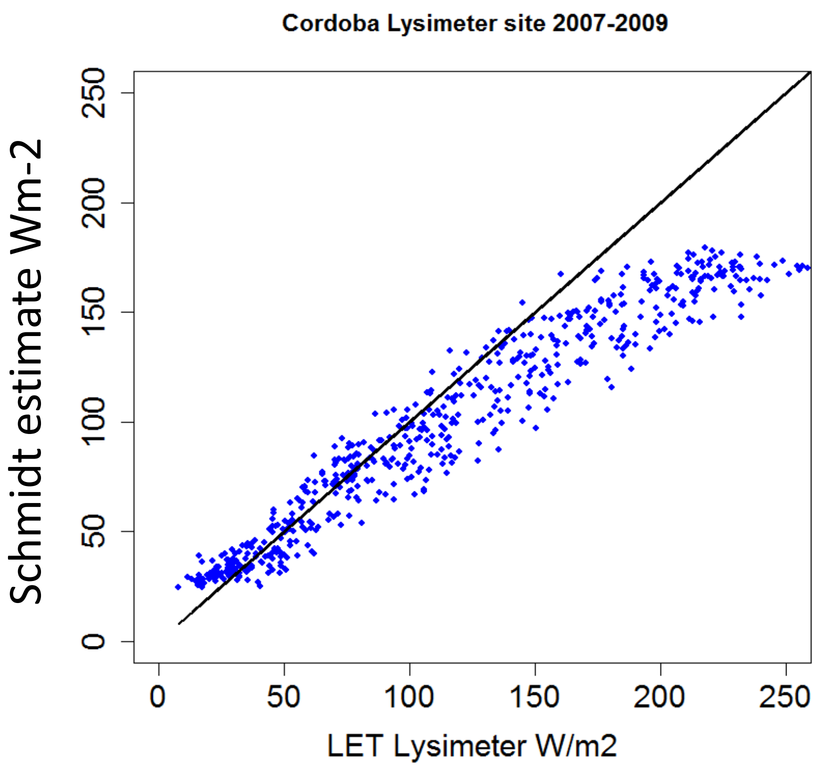
Schematic picture well-mixed atmospheric boundary layer (daytime)



After sunrise ABL growth
and at the top
warm, dry air is entrained
Into the ABL
This explains why relative
humidity is never 100%
Over well-watered
Surfaces
This explains why

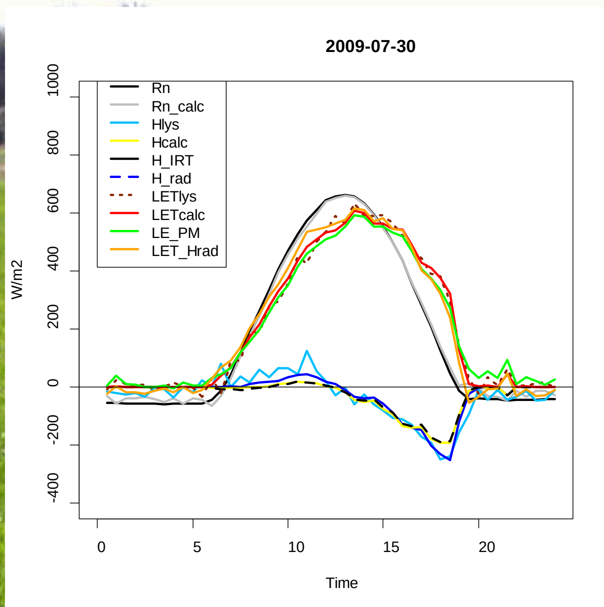
$$\beta > 0$$

IFAPA Lysimeter and RIA site, Cordoba

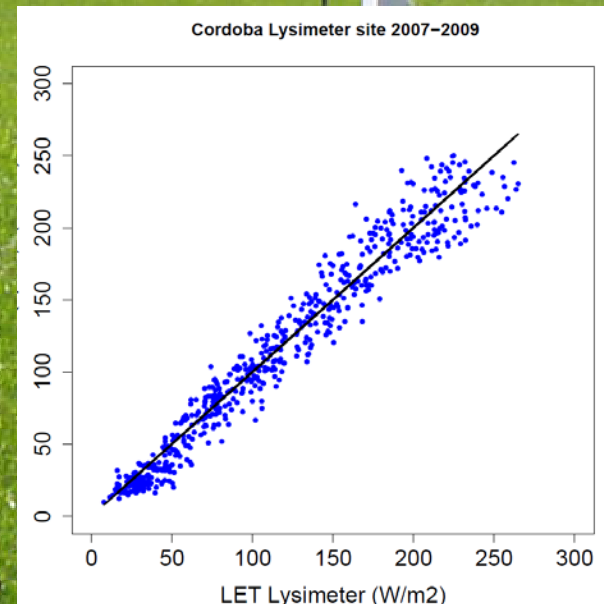


Now besides global radiation horizontally advected sensible heat is additional energy source

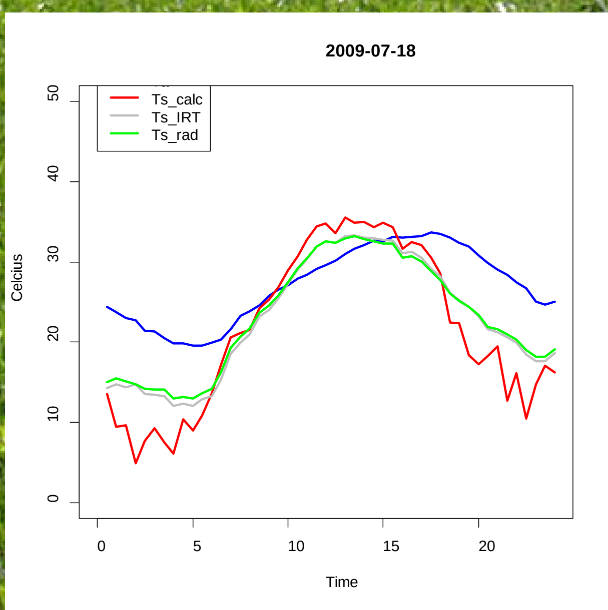
Typical advective day



Revised Schmidt-model with advection



Surface and air temperature



Using MSG global radition and Air temperature only!

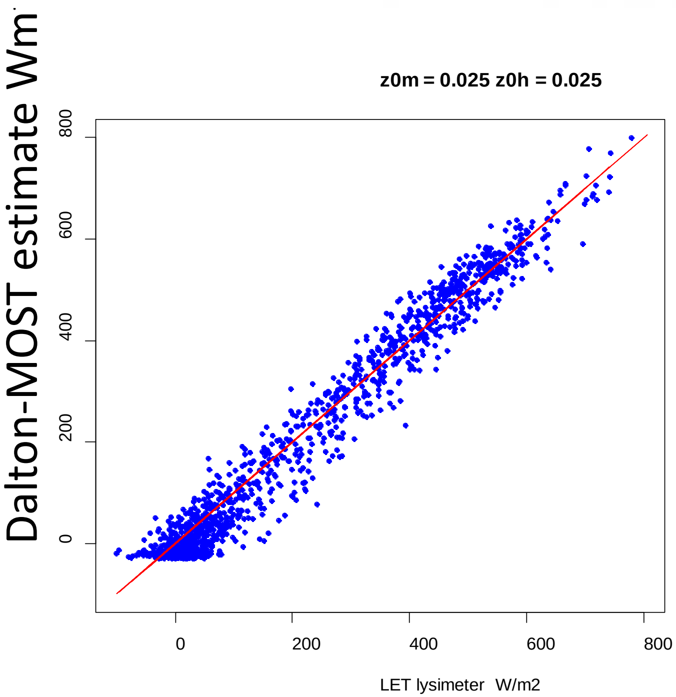
We proudly present a new method to measure actual *ET* from CNR 4 net radiometer

Step 1
$$T_s = \left[\frac{L^{\uparrow} - (1 - \varepsilon_s) L^{\downarrow}}{\varepsilon_s \sigma} \right]^{\frac{1}{4}} - 273.15$$

Step 2
$$H = \rho c_p \frac{[T_s - T_a]}{r_a (T_s - T_a, u_2; z_{0m}, z_{0h})}$$

Step 3
$$\lambda E = a R_{net} - H_{MOST}$$

Constant
a = 0.9 at day-time
a = 0.5 at night-time



Very sensitive to roughness lengths!

Dalton -Monin-Obukhov