

Measuring forest evaporation and transpiration rates with fibre optic temperature sensing

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Why a new method?

Evaporation is currently measured with techniques like Eddy Covariance, Bowen Ratio, or Scintillimeters.

Measuring evaporation with Distributed Temperature Sensing (DTS) has the advantage:

- Single sensor $\Rightarrow$ uncertainty $\downarrow$
- More profile information in vertical
- Spatial information (if horizontally applied)

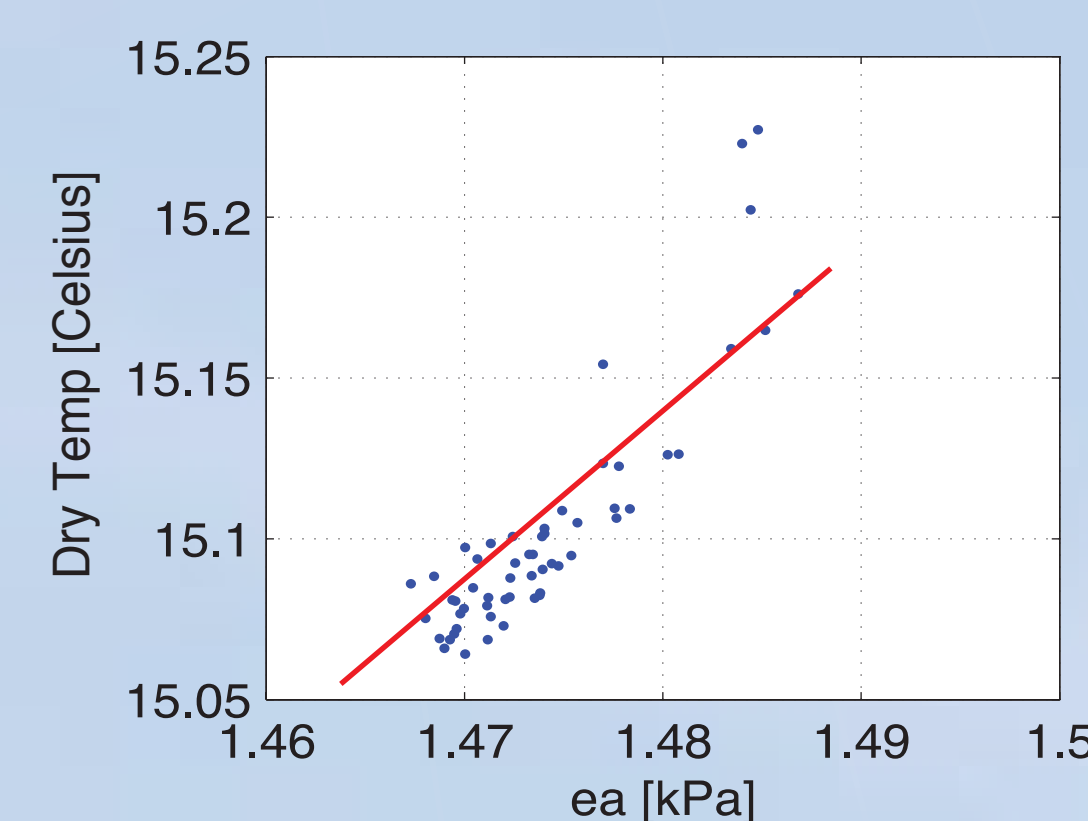
Methodology

- General Bowen Ratio:

$$\left. \begin{aligned} R_n &= H + \rho\lambda E + Q \\ \beta &= \frac{H}{\rho\lambda E} = \gamma \frac{\Delta T}{\Delta e_a} \end{aligned} \right\} \begin{aligned} \rho\lambda E &= \frac{R_n - Q}{1 + \beta} \\ H &= \frac{R_n - Q}{1 + 1/\beta} \end{aligned}$$

- Bowen ratio with DTS:

dry and wet fibre optic cable (principle of psychrometer)



$$e_a = e_s(T_w) - \gamma(T_a - T_w)$$

- Available energy:

above canopy:

$$R_n - Q = R_n^{above} - Q_g - Q_{bm} - Q_p - S_h - S_e = (H + \lambda E)_{EC}^{above}$$

below canopy:

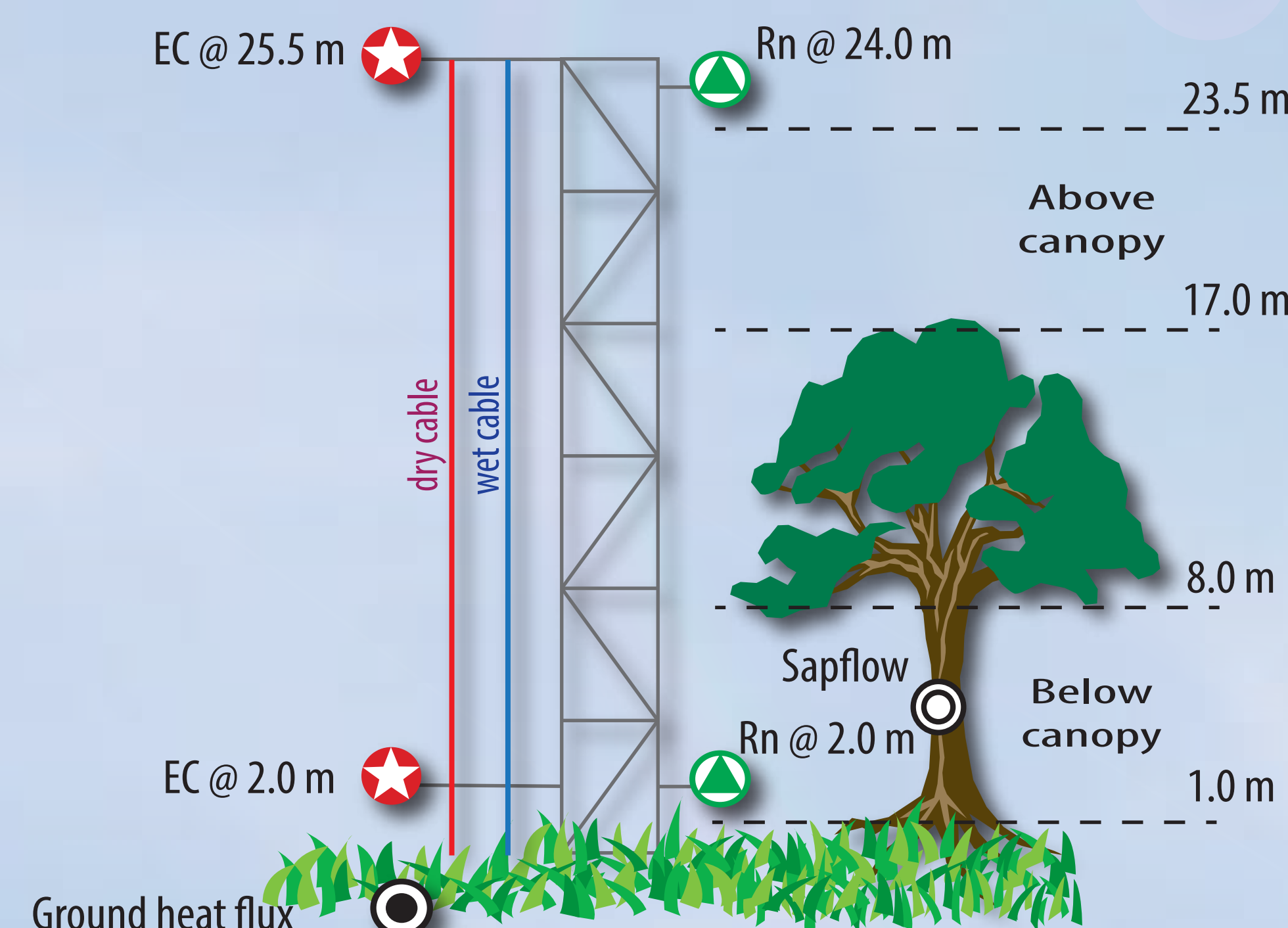
$$R_n - Q = R_n^{below} - Q_g - Q_{bm} - S_h - S_e = (H + \lambda E)_{EC}^{below}$$

with:

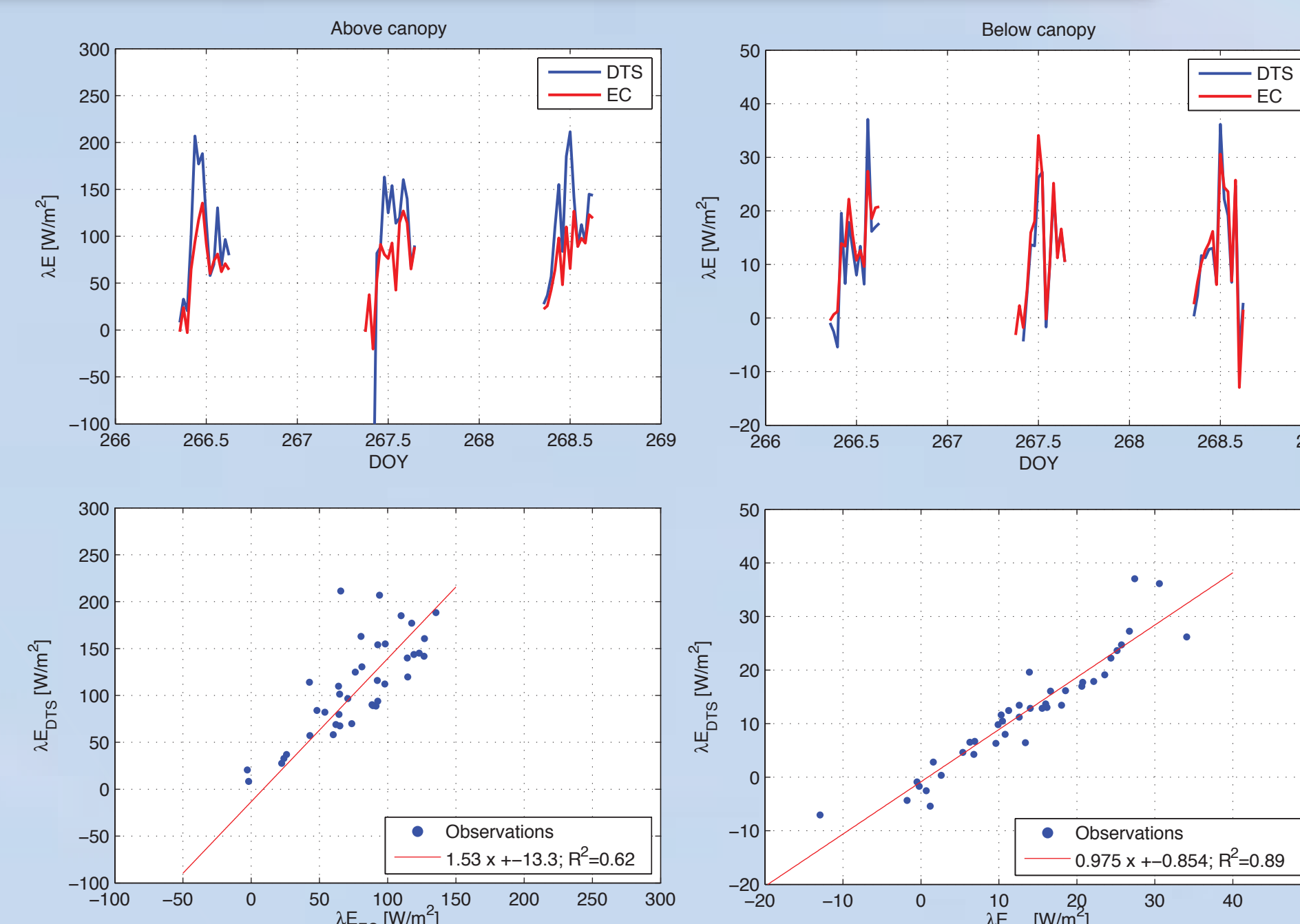
$$S_h = \int_0^z \rho c_p \frac{dT_a}{dz} dz \quad S_e = \int_0^z \rho \lambda \frac{dq}{dz} dz$$

Where and When?

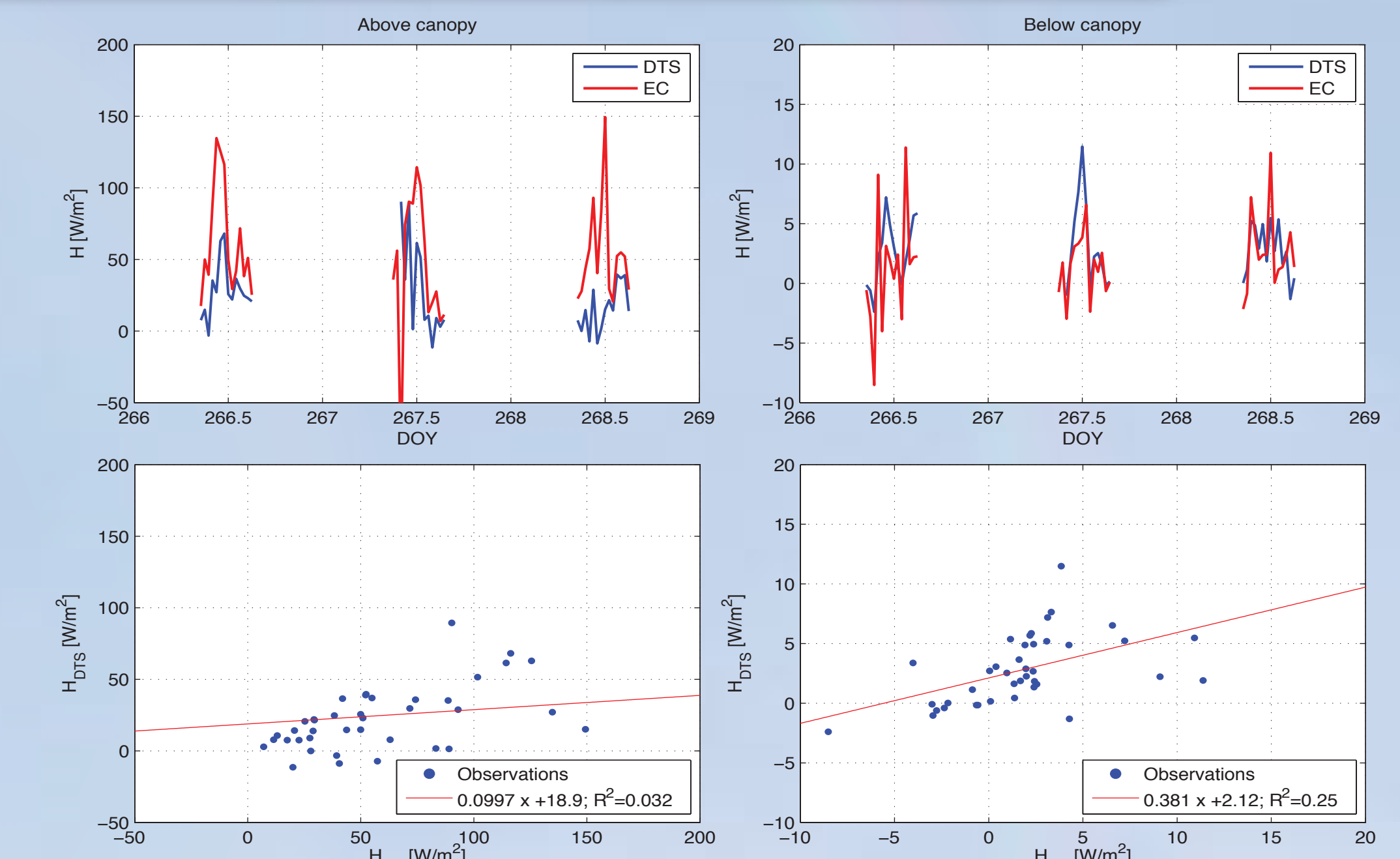
- Loobos, the Netherlands
- Scots pine (*Pinus Sylvestris*)
- 403 tree/ha ; LAI = 1.9 m²/m²
- Grass undergrowth
- September 23-25, 2013



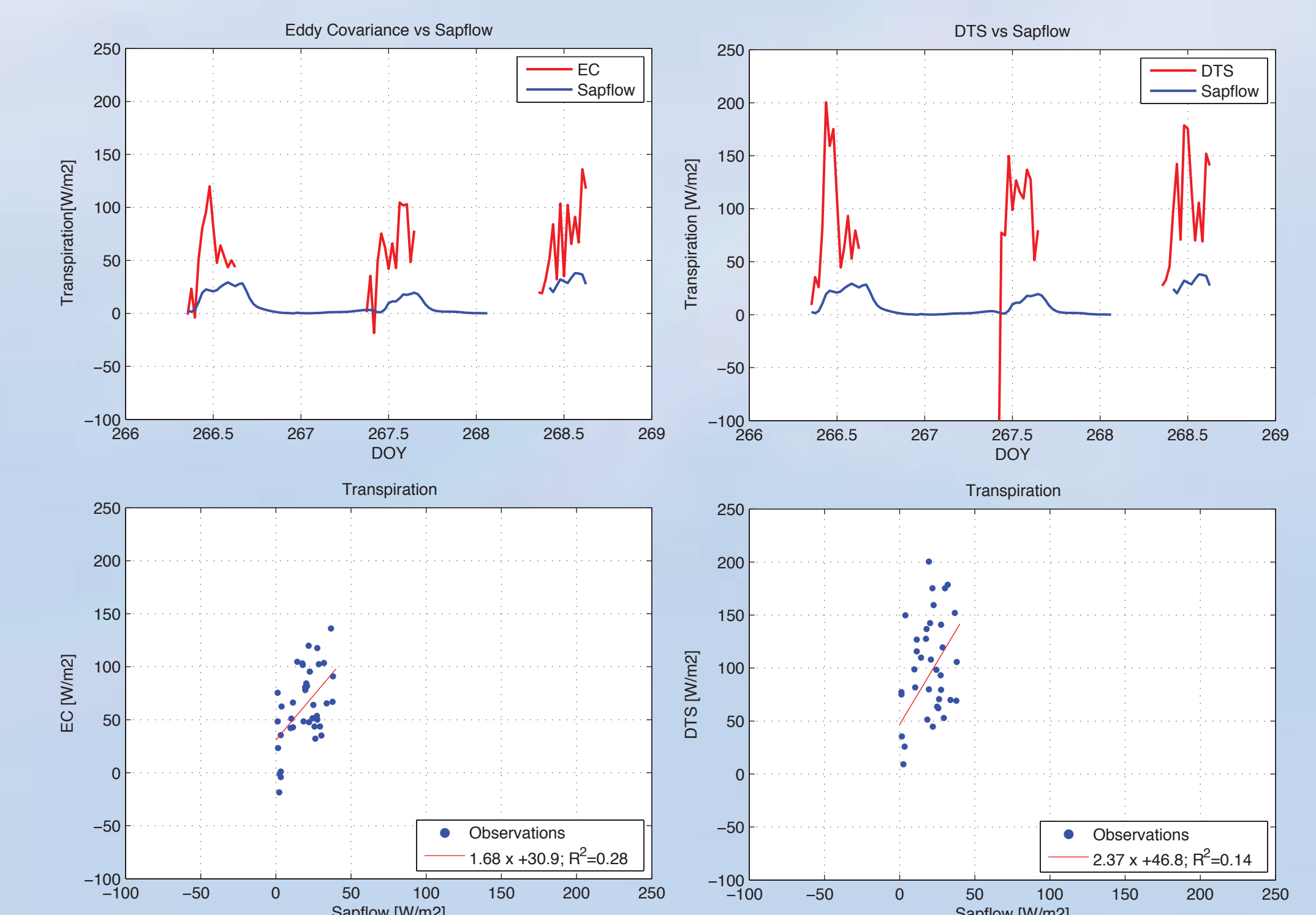
Latent Heat Comparison



Sensible Heat Comparison



Transpiration Comparison



Conclusions & Recommendations

- λE above reasonable $\Rightarrow$ extend cable for actual T_{wet}
- λE below excellent
- H poor $\Rightarrow$ derive H from wind profile
- Transpiration poor $\Rightarrow$ upscaling sapflow + footprint
- Longer measuring period