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 Scintillometers. Measuring evaporation with Distributed Temperature Sensing (DTS) has the advantage:
- Single sensor ⇒ uncertainty ↓
- More profile information in vertical
- Spatial information (if horizontally applied)

Methodology

- General Bowen Ratio:

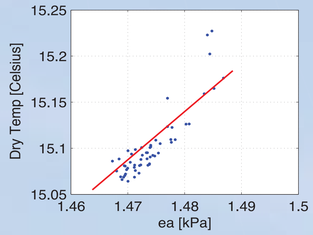
$$R_n = H + \rho\lambda E + Q$$

$$\beta = \frac{H}{\rho\lambda E} = \gamma \frac{\Delta T}{\Delta e_a}$$

$$\rho\lambda E = \frac{R_n - Q}{1+\beta}$$

$$H = \frac{R_n - Q}{1+1/\beta}$$

- Bowen ratio with DTS:
  dry and wet fibre optic cable (priniple 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:

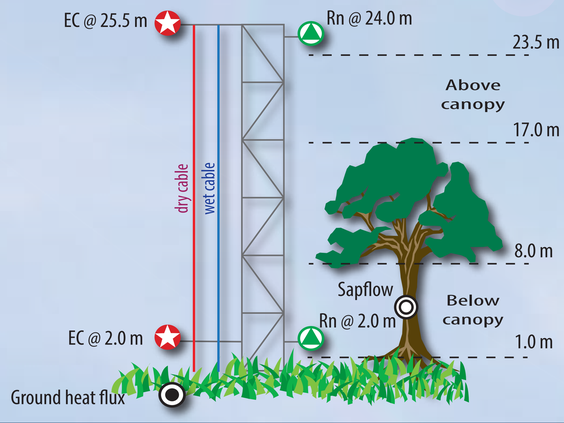
$$R_n - Q = R_n^{below} - Q_g - Q_{bm} - S_h - S_e = (H + \lambda E)_{EC}^{below}$$

  with:

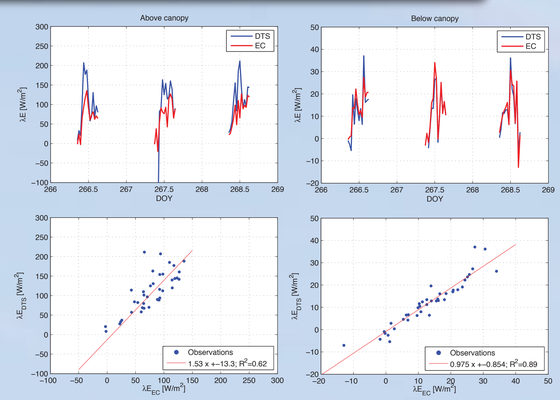
$$S_h = \int_0^z \rho c_p \frac{dT_a}{dt} dz \qquad S_e = \int_0^z \rho\lambda \frac{dq}{dt} dz$$

Where and When?

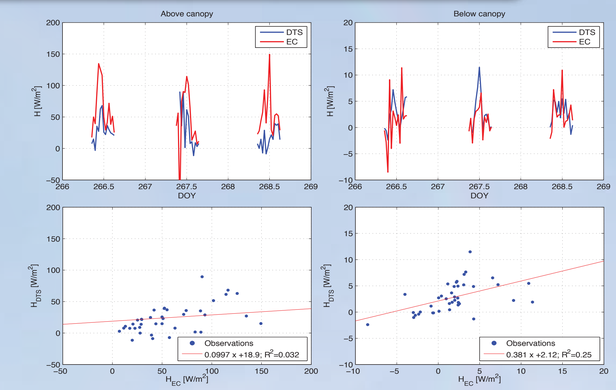
- Loobos, the Netherlands
- Scots pine (*Pinus Sylvestris*)
- 403 tree/ha ; LAI = 1.9 m²/m²
- Grass undergrowth
- September 23-25, 2013



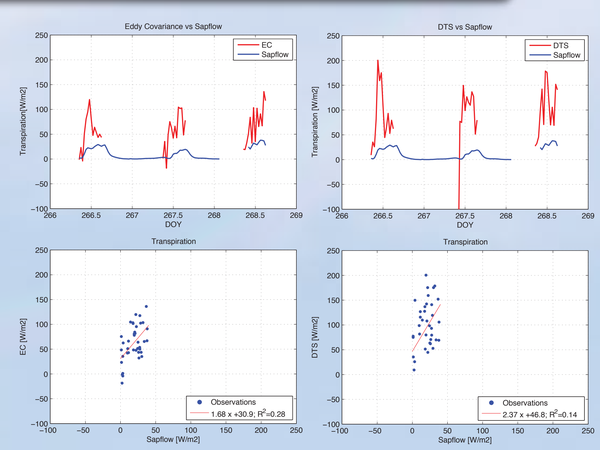
Latent Heat Comparison



Sensible Heat Comparison



Transpiration Comparison



Conclusions & Recommendations

- λ*E* above reasonable ⇒ extend cable for actual *Twet*
- λ*E* below excellent
- *H* poor ⇒ derive *H* from wind profile
- Transpiration poor ⇒ upscaling sapflow + footprint
- Longer measuring period

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