

Measurement and modelling of soil moisture and land surface evaporation

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Key questions

- Can time series of soil moisture content, θ , be measured accurately under a wide range of surface types? What about spatial averages?
- Can reliable measurements of evaporation, E , be derived from this?
- Do soil physical parameterisations in land surface models allow for reliable simulation of θ and E ?

Measurement of moisture content and evaporation

Reliable estimates of evaporation are important for agricultural and horticultural applications, but also for hydro-meteorological studies. The soil water balance method (SWB) is a cheap alternative to the eddy covariance method, but only if reliable sub-daily soil moisture (θ) data are available.

Diurnal estimates of evaporation, E , were obtained from the SWB method, using θ profiles obtained with various types of capacitance sensors installed in a bare soil, a rapeseed plot and a maize field. These sensors comprised Theta probes (TP), Profiles probes (PP), ECH₂O probes (EP) and Aquaflex sensors (AF), see Fig. 1. The output of the sensors contained significant perturbations due to noise and was affected by temperature causing spurious diurnal fluctuations (see Fig. 2). Smoothing and temperature-correction procedures were required to obtain reliable θ and E .

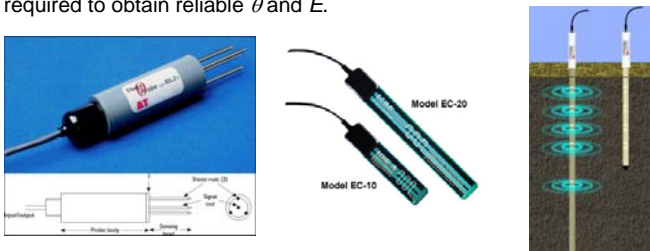


Fig. 1. Illustration of a Theta probe, ECH₂O probes and Profile probes, respectively

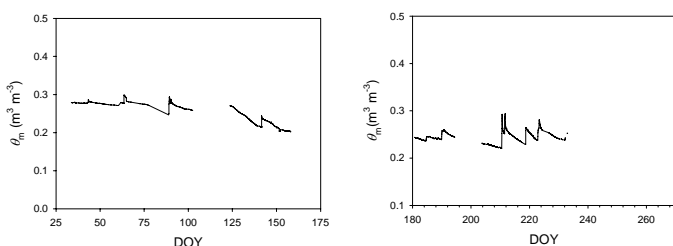
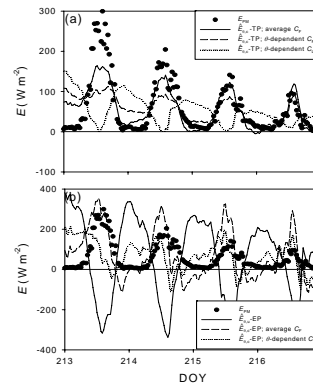
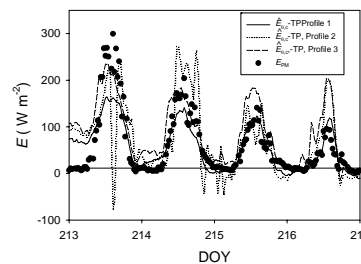


Fig. 2. Soil moisture content, ($\text{m}^3 \text{m}^{-3}$), as a function of Day of Year (DOY), as measured by TP, PP, EP, AF, gravimetric (GM) and Neutron Probe (NP) at 0.2 m below rapeseed and bare soil, respectively (Sonning experiment, 2003/2004).



It was found that a considerable difference existed between field- and laboratory-based temperature correction factors (C_T and C_L , respectively) and that they strongly depended on θ . Using C_L to correct field θ -profiles for temperature led to unsatisfactory estimates of E , as shown here. Subscript c indicates that the θ -signals were temperature-corrected, \wedge denotes that θ was first smoothed. The evaporation as calculated with the Penman-Monteith equation, E_{PM} (using atmospheric driving variables) is also shown, as a guide to illustrate what the diurnal course of E should look like.

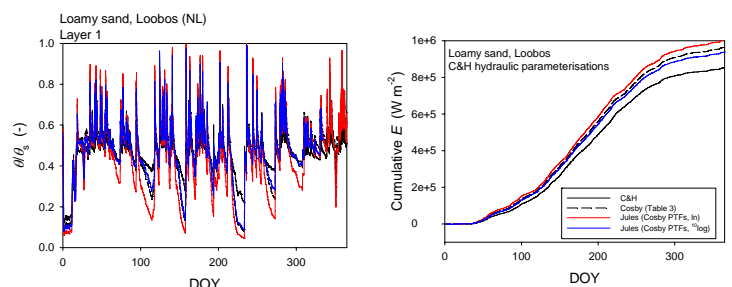
Spatial variation in θ and E is large



Bare soil E values (θ smoothed and temperature-corrected) for three different TP profiles. Estimates obtained with the Penman-Monteith equation are also shown.

Land surface modelling of moisture content and evaporation

An accurate parameterisation of the land surface is of key importance for reliable estimates of current and future climatic conditions. Our research (with NCAS-Climate and JCHM) uses a combination of micrometeorological field work and Soil-Vegetation-Atmosphere-Transfer modelling.



The figures above show the effect of choosing different soil hydraulic parameterisations on relative saturation and cumulative E simulated with the UKMO JULES model, for a temperate mixed forest on loamy sand. Parameterisations are: Clapp and Hornberger (1978), C&H, Cosby et al. (1984) and parameters calculated in the JULES ancillary file. θ and E , and hence the ensuing energy balance and atmospheric circulation, are clearly considerably dependent on choice of soil physical parameters.

Find out more...

Verhoef A, Fernandez-Galvez J, Diaz-Espejo A, Main BE, El-Bishti M (2006). The diurnal course of soil moisture as measured by various dielectric sensors: effects of soil temperature and the implications for evaporation estimates. *Journal of Hydrology* 321:147-162.

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