Estimation of evapotranspiration in heterogeneous woodland based on eddy covariance, porometry and thermal remote sensing

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Introduction and site

Data were collected betweem 2nd and 12th July, 2003, as part of the EU project WATERUSE (EVKI-2000-00079) on a cork oak plantation (*Quercus suber*) 35 km SE of Lisbon (38°38'N, 8°51'W) with 100 year-old trees spaced at c.76 trees/ha with canopy height of 10 m. The under storey was patchy with dry grass and *Cistus spp.* up to c.0.4 m. The weather conditions were stable and clear throughout the period.

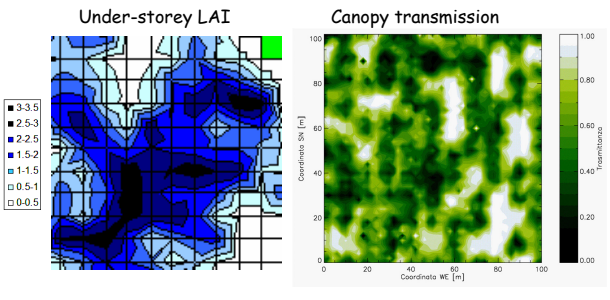
Methods

Eddy covariance and micrometeorological data included sonic measurements (Campbell CSAT3) and Li7500 open path gas analysers at z/h = 0.18, 0.77, 1.17, 1.4 and 2.07 . In addition surface temperatures were obtained from a nearby tower (22 m) using an Infrared solutions Snapshot 525 longwave imager, and a set of Calex EL101 thermal sensors recording temperatures of representative canopy components. In addition canopy surveys using an LAI2000 and a Sunscan canopy analyser were used to estimate tree and understorey LAI in the footprint area. Stomatal conductances were measured on typical canopy components (trees and shrubs) using an AP-4 (Delta-T) and a LiCor-1600 porometer.

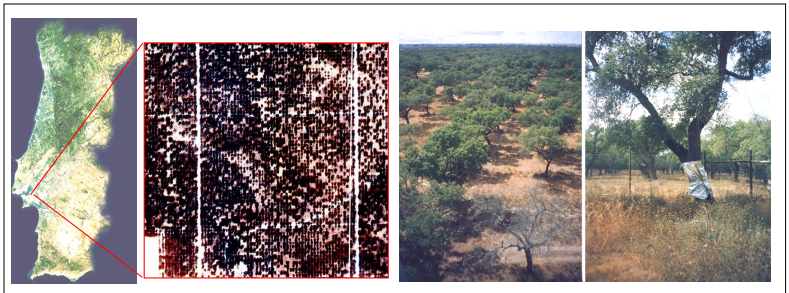
Sap flow estimates were made using a Granier system with 19 sensor points, absolute values were estimated by *in situ* calibration against an eddy covariance system, so only the relative changes are relevant here.

Results

The average diurnal trends in fluxes over the period are shown, for total fluxes (2a) and for the LE fluxes at different levels (2b), showing that the under-canopy evaporative flux averaged 18% of the total, or approximately 20 W m^{-2} at midday. The stomatal conductances and estimated LAI are shown in Table 1. The estimates of ET shown in Table 2 are *very preliminary* estimates from a limited number of sample data. Nevertheless there is a suggestion that the Penman-Monteith equation, based on estimates of stomatal conductance and local meteorological conditions and the thermal thermal measurements, again based on scaling up the local energy exchanges on the basis of leaf areas all substantially overstimated the actual ET as obtained from the Eddy covariance data (ECv).



Sunscan and LAI-2000 data for under-storey and canopy light transmission. LAI shown in table below



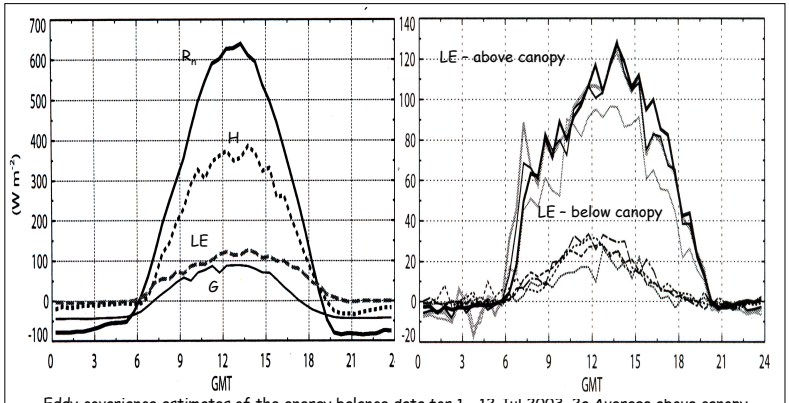
The *Quercus suber* site at Rio Frio, showing location, aerial view and vegetation

Calculations

Evaporation rates were estimated from (i) eddy covariance data, (ii) scaling up of stomatal conductance with met data, using Penman-Monteith equation, (iii) from thermal and met data, (iv) from sap flow data (though absolute estimates were not available from the sap-flow data). For (iii) three models were compared

- Model 1) λE = $\rho cp(gaH + gR)(Tdry - Tleaf)$ (*Jones, 1992*);
- Model 2) λE = $Rni\ (Tdry - Tleaf)/(Tdry - Ta)$ (*Qiu et al., 1996*)
- Model 3) $Ea/Ep = (1 - CWSI)$ VI; $CWSI = (Tleaf-Twet)/Tdry-Twet)$ (*Inoue & Moran, 1997*). [The third model was not included in the average calculations given below as it is an area-based measure.]

Temperatures were obtained from SnapView images from the tower, with the dry and wet values obtained from a vaseline-covered and a sprayed branch, respectively.



Eddy covariance estimates of the energy balance data for 1 – 12 Jul 2003. 2a Average above canopy fluxes; 2b Average latent heat fluxes

Table 1. Typical mid-day values of conductance and LAI for the 90% footfrint

	gs (mmol m^{-2} s^{-1})	LAI
Q. suber	136	1.40
Cistus	106	0.56

Table 2. Preliminary estimates of E at 14.00 h using different approaches. the thermal methods were those based on local fluxes only.

	λE(W m^{-2})		
	ECv	Thermal	P-M
Q. suber	100	*c.220*	*c.120*
Cistus	20	*c.40*	*c. 45*

Conclusions

Before definitive conclusions can be drawn the calculations need to be refined by using the full set of data available, though there are clear suggestions from the preliminary analysis that scaling up from the plant scale appears to overestimate the total evaporative fluxes (whether using the P-M equation or the thermal data). At appears that there is a substantial difficulty with integration of local fluxes . . .

References:

Jones HG 1992 Plants & microclimate, CUP; Qiu, G.-Y et al. (1996). Trans.of JSIDRE **183**: 47-56; Inoue, Y. and M. S. Moran (1997). International Journal of Remote Sensing **18**: 139-152..

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