9.5 DETERMINATION OF SCALAR FLUXES OVER MEDITERRANEAN VEGETATION

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1. INTRODUCTION

The surface renewal (SR) method for estimating fluxes from canopies involves high frequency measurements of scalar parameters. The high frequency data are analyzed for ramp-like characteristics and the amplitude and inverse ramp frequency are used in basic energy or mass conservation equations to estimate fluxes. In previous papers, good results were reported for estimating sensible (*H*) over a variety of vegetated surfaces. The results for latent heat (*LE*) flux density and CO_2 flux density (F_c) over an old-growth forest were less clear but show some promise. In this paper, we report on data collected over Mediterranean shrub vegetation.

2. MATERIALS AND METHODS

Data were collected near west coast of Sardinia, Italy, over a Mediterranean maquis in 2003 and 2004. The experimental site is located near Alghero, Italy (latitude: 38° N; longitude: 8° E; elevation: 50 m) and is characterized by vegetation of a maximum height of 2.0 m including sclerophyll species and some scattered shrubs. The climate is semi-arid with a significant water deficit from May through September. Even winter season can be dry and temperatures are not so low as to cause dormancy.

Vertical wind speed fluctuations and scalars were collected at a 10 Hz frequency using a Campbell Scientific eddy covariance system (CSAT3 sonic anemometer and Licor 7500 infrared gas analyzer). Thirty minute averaging period was used for all computations and *H*, *LE* and F_c were corrected for density fluctuations (Webb et *al.*, 1980). The same high frequency data were also used to determine *H*, *LE*, and F_c using the surface renewal method (Paw U et al., 1996; Snyder et al., 1996; Spano et al., 1997). The ramp amplitude (*a*) and inverse ramp frequency [1/(*d*+*s*)] were calculated during 30 minute sampling periods using a structure function (Van Atta, 1977) in simultaneous equations evaluated with four time lags (r = 0.20, 1.00, 1.50, and 2.00 s). The SR results were calibrated against EC values to determine a weighting factor (α) for uneven source and sink distribution within the canopy (Paw U et al., 1995). Net radiation was measured using a 4-component net radiometer (MR40, EKO Instruments, Tokyo, Japan and Kipp & Zonen CNR1, Delft, NL). The soil heat flux (G) was measured using 30-min means from four heat flux plates (HFP01SC, Hukseflux, Delft, NL) at 0.08 m depth in a different sun-shadow exposure to obtain a good estimate of the average for the ecosystem. Four thermocouples were buried near each plate location to measure the change in temperature between the plate and the soil surface and account for the stored energy above the plate.

3. RESULTS AND DISCUSSION

The energy balance closure from the eddy covariance system showed a discrepancy of about 5%, demonstrating accuracy of the data set (Figure 1).

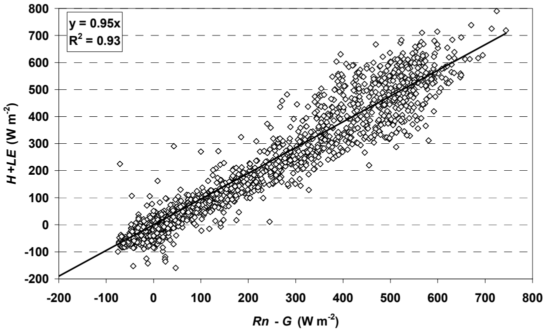

Figure 1. Sensible plus latent heat flux density from eddy-covariance (*H+LE*) versus net radiation minus soil heat flux density (R_n-G) from 2004 data set (April 6 – June 9).

Figure 2 shows how the α factor was determined for the *H* measurements using the mean uncalibrated *H* value from the four time lags. The slope of the regression line through the origin of EC versus SR *H* values in Figure 2 is the α factor for calibrating the SR estimates of *H*. Figure 3 is a plot of the calibrated SR and EC *H* estimates for the same period using the α factor equal to 0.60. The calibrated *H* values from SR gave good results with a RMSE = 40.7 W m^{-2}, which is clearly good for half-hour estimates and is about 5% of

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**Corresponding author address*: Donatella Spano, Università di Sassari, Dipartimento di Economia e Sistemi Arborei, Via de Nicola, 1, 07100 Sassari, Italy, e-mail: spano@ uniss.it the span in *H*.

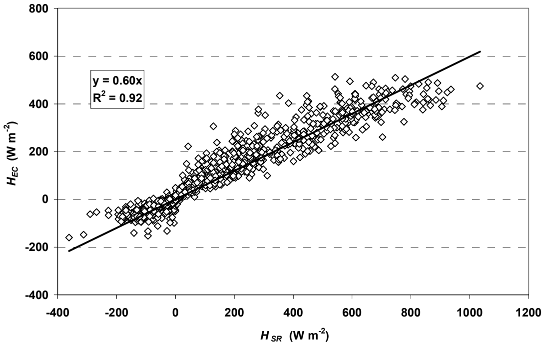

Figure 2. Uncalibrated half-hour H_{EC} vs. H_{SR} using the average values of the four time lags. Data were collected from April – June 2004.

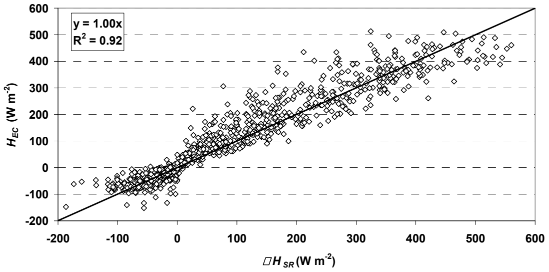

Figure 3. Half-hour H_{EC} vs. αH_{SR} from data collected from April – June 2004.

The surface renewal estimates of *LE* were calibrated in a similar fashion as the *H* values (Figure 4). Using the α = 1.29, surface renwal *LE* estimates were plotted in Figure 5. The LE_{SR} results showed more scatter than H_{SR} (R^2 = 0.63) and the RMSE = 34.9 W m^{-2}, which is about 7% of the span in *LE*, indicates a reasonably good match.

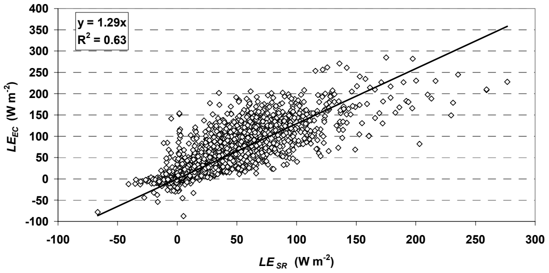

Figure 4. Uncalibrated half-hour LE_{EC} vs. LE_{SR} using the average values of the four time lags. Data were collected from April – June 2004.

The α factor for F_c was similar in magnitude to that of *LE;* however, there was more scatter in the data (R^2 = 0.40). After calibration, the results were not as good as for *LE*, so more analysis is needed to understand the difference.

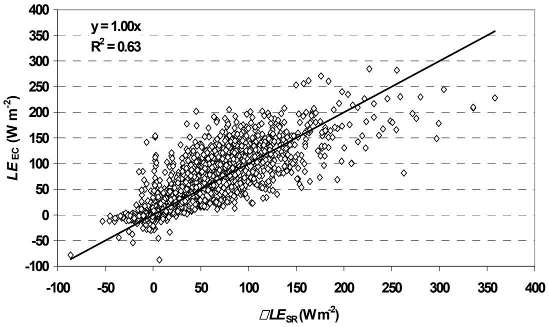

Figure 5 Half-hour LE_{EC} vs. αLE_{SR} from data collected from April – June 2004.

4. CONCLUSIONS

Based on these experiments, when the α weighting factor is known, the SR method provides a simple, low-cost method to estimate scalar fluxes without the need to measure stability or wind speed. Therefore, the SR method can be used to estimate scalar fluxes during periods with missing data, when more expensive equipment is unavailable or to obtain less expensive replication. The SR method worked best for estimating *H*. The method was less accurate for F_C and *LE.*

5. REFERENCES

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