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MASS AND ENERGY FLUXES MONITORING USING EDDY COVARIANCE TECHNIQUES

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Climatic changes observed in last decades have made even more critical the surface water and the groundwater availability in southern Italy affected by recurrent and severe droughts. The use of adequate drought monitoring techniques represents a fundamental aspect to catch in time signals forecasting non ordinary drought events, in order to correctly manage the emergency.

The eddy covariance (EC) method is one of the most reliable approaches for measuring the vertical turbulent fluxes of heat, water vapor and CO_2 from the surface to the atmosphere, but the data collected in a number of field campaigns has revealed that the sum of sensible and latent fluxes estimated by the EC method is often less than the difference between the net radiation and the soil heat flux. The reasons for the energy imbalance problem are numerous and can be related both to uncertainties in observational conditions such as sites and instruments and to flow and turbulent structures in the atmospheric boundary layer (Kanda et al., 2004; Wilson et al., 2002).

The EC technique needs some restrictive conditions (Foken and Wichura, 1996; Göckede et al., 2004), generally fulfilled by large homogeneous flat sites, with a representative fetch (fetch to height ratio of 100 are usually considered adequate but longer fetches are desirable, Wieringa, 1993). These sites are seldom available in regions with few plain areas, intensively exploited by agriculture, such as those in southern Italy. In the present study data collected in a non-ideal site are analyzed, with the aim of verifying turbulence effects on the energy balance closure.

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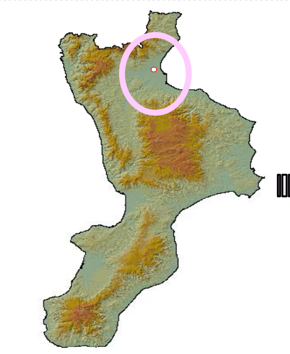
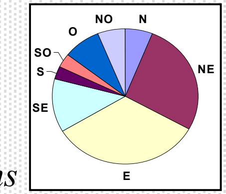
SITE DESCRIPTION



The study was carried out in the Sibari Plain (Calabria - southern Italy) in a field characterized by low vegetation surrounded by rows of cypresses, with prevalent winds from sea.

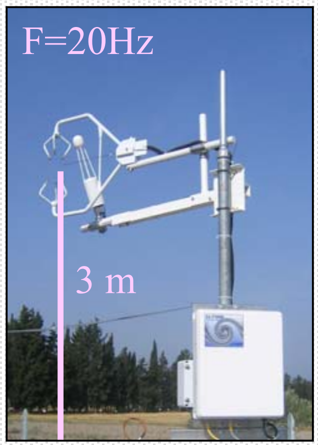


Wind directions

MATERIALS AND METHODS

Measures of turbulent fluxes

- *CSAT3-3D sonic anemometer and FW05 Thermocouples for CSAT3, Campbell Sci.*
- *LI-7500 CO_2/H_2O Analyzer, Li-Cor, Inc.*
- *CR5000 Datalogger, Campbell Sci., with personalized code for PC9000 software*



Supporting meteorological and energy balance measurements

- *CNR1 Net Radiometer, Kipp & Zonen*
- *2 Self Calibrating Heat Flux Sensors HFP01SC, Hukseflux, with 4 107 thermistors*

Furthermore:

- *2 InfraRed Temperature Sensors (IRTS-P, Campbell Sci.)*
- *Soil volumetric water content probe EasyAG50*

Data has been collected from 08.11.2004 to 12.07.2004 averaging every 30 minutes the raw data acquired with a 20 Hz frequency, and tested for stationarity and integral turbulence statistics using the methods described by Foken and Wichura (1996) and Thomas and Foken (2002). The presence of obstacles in the footprint led to a not fully developed and unperturbed turbulence and to low values of friction velocity *u**.

RESULTS

Overall energy balance closure

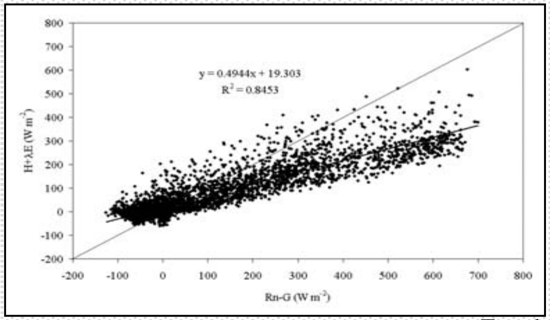


Fig. 1

The OLS slope of *λE+H* against *Rn-G* on all the about 5200 data (Fig. 1) is less than 0.5, indicating a considerable '*closure gap*'. The mean coefficient of determination (R^2) is comparable to literature data (e.g. Wilson et al., 2002).

Diurnal and stability variations in closure

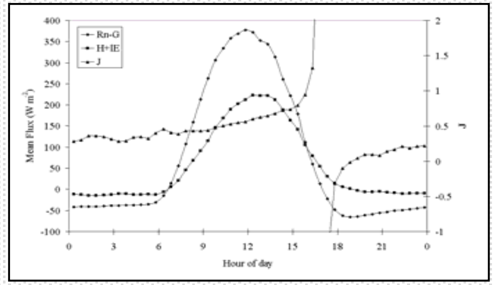


Fig. 2

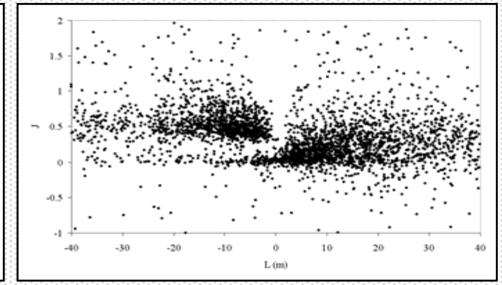


Fig. 3

Mean daily data were combined to compute the diurnal course of *J=(λE+H)/(Rn-G)* (Fig. 2), showing not significant values during evening transition periods, and greater *J* in the afternoon. The analysis of *J* against Obukhov length *L* (Fig. 3) showed a correlation between *J* and stability conditions, even if not marked.

Effects of turbulent mixing

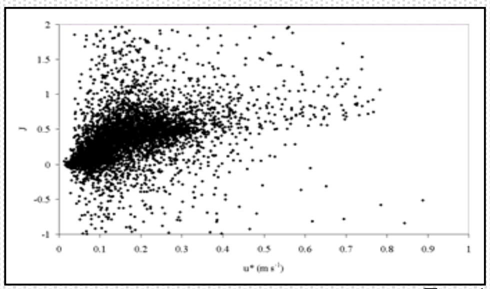


Fig. 4

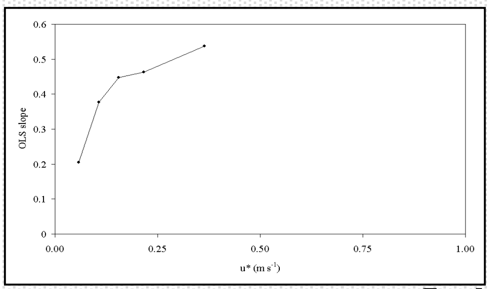


Fig. 5

A more evident correlation exists between *J* and *u** (Fig. 4). The graph of OLS slope against mean friction velocity of 5 20-percentile data groups sorted by *u** (Fig. 5) shows an higher closure increasing *u**. Specifically, data with *u** greater than 0.4 m s^{-1} has shown a 0.6232 OLS slope.

Wind directions/footprint analysis

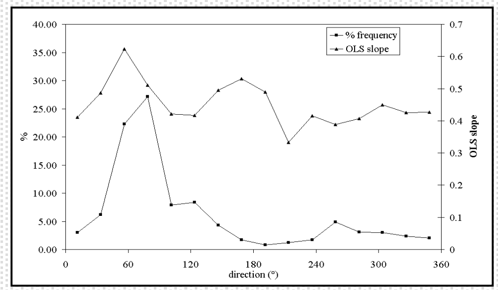


Fig. 6

An analysis of OLS slope against wind directions (Fig. 6) shows that winds coming from sea, which represent the major direction, have the biggest OLS slope. The analysis was made considering 16 different directions, with a 22.5° width. The class with the biggest OLS slope (45°-67.5°) has shown the highest mean *u**.

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RESULTS

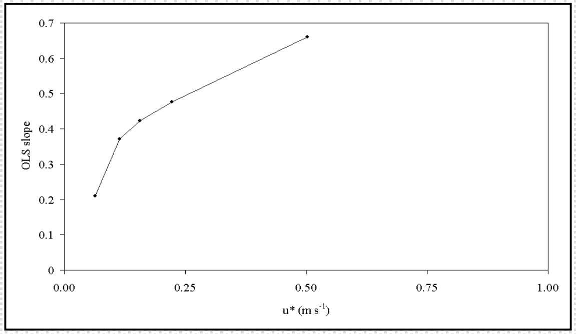

Fig. 7

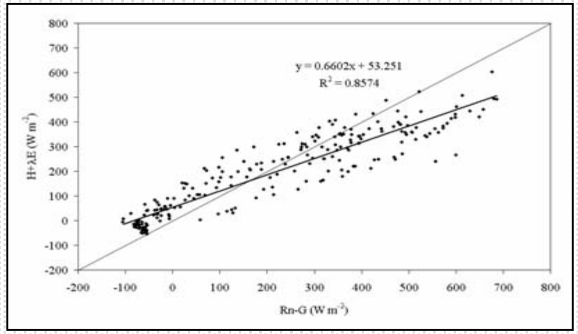

Fig. 8

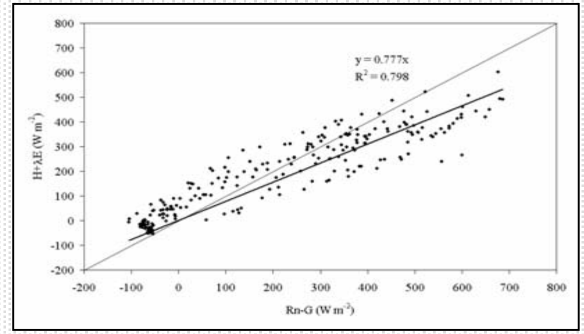

Fig. 9

The graph of OLS slope against mean friction velocity of 5 20-percentile data groups sorted by *u** for the 45°-67.5° wind direction (Fig. 7) shows an higher closure when *u** increases. The best results are obtained with a mean *u** equal to 0.50 with an OLS slope value of 0.66 and R^2 equal to 0.8574 (Fig. 8). Forcing intercept equal to 0 the OLS slope increase to 0.778 (Fig. 9).

DISCUSSION AND CONCLUSIONS

The best energy balance closures are obtained for the sea-direction characterized by highest *u** values. Better closures are obtained selecting the highest *u** values in this direction. Greatest *u** values for the sea-direction are not only due to the major wind frequency and intensity (typically in this area daytime winds blow from seaside), but also to the fact that in this direction the rows of cypresses surrounding the site are quite far from the EC system (about 150 m), allowing a better developed turbulence. Great problems in balance closure arise for other directions, especially during nighttime, when stable conditions occur.

The main variable in any case seems to be the friction velocity: not considering direction and other factors (that can be related to *u**), energy balance closure becomes to be acceptable for *u** values greater than 0.4 m s^{-1}. The dependence of the energy balance closure from *u** will be further investigated, together with the spectral and co-spectral characteristics of the EC measurements.

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